# Chapter 3A: Status of Water Quality in the Everglades Protection Area

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## SUMMARY

This chapter was prepared by the Florida Department of Environmental Protection (FDEP), with the support of the South Florida Water Management District (District or SFWMD), to provide an assessment of water quality within the Everglades Protection Area (EPA) during Water Year 2008 (WY2008) (May 1, 2007–April 30, 2008). This chapter is intended to fulfill numerous requirements of the Everglades Forever Act (EFA), and a number of related permits and to update the information provided in Chapters 3A and 3C of the *2008 South Florida Environmental Report – Volume I*. In addition, a preliminary assessment of total phosphorus (TP) criterion achievement as well as an annual update of the comprehensive overview of nitrogen and phosphorus levels throughout the EPA are provided in this chapter.

### WATER QUALITY CRITERIA EXCURSION ANALYSIS

The analyses and summaries presented in this chapter provide a synoptic view of water quality conditions on a regional scale, including Arthur R. Marshall Loxahatchee National Wildlife Refuge (Refuge), Water Conservation Areas 2 and 3 (WCA-2 and WCA-3), and the Everglades National Park (ENP or Park). For parameters with water quality criteria, regional analyses were conducted based on the frequency of exceedances of the applicable criteria, similar to the methods employed in the 1999 Everglades Interim Report, 2000–2004 Everglades Consolidated Reports (ECRs), and 2005–2007 South Florida Environmental Reports (SFERs). For WY2008, water quality parameters that did not meet existing standards were classified into three categories based on excursion frequencies that were statistically tested using the binomial hypothesis test. Any parameter with a criterion exceedance frequency statistically greater than 10 percent was categorized as a concern. Likewise, any parameter with an exceedance frequency statistically greater than 5 percent but less than 10 percent was categorized as a potential concern. Parameters with exceedance frequencies less than 5 percent but greater than zero were categorized as minimal concerns.

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With a few exceptions, water quality was in compliance with existing state water quality criteria during WY2008. Comparisons of WY2008 water quality data with applicable Class III water quality criteria revealed excursions for four parameters: (1) dissolved oxygen, (2) alkalinity, (3) pH, and (4) specific conductance. Similar to previous periods, these excursions were localized to specific areas of the EPA, with the exception of dissolved oxygen, which exhibited excursions in all regions except the Park.

As in previous years, exceedances of the alkalinity and pH criteria were restricted to the Refuge, which is a soft water system hydrologically dominated by rainfall that is naturally low in alkalinity. Therefore, the FDEP considers the low alkalinity values to be representative of the natural range of variability within the Refuge and, therefore, these should not be considered violations of state water quality standards. The pH excursions in the Refuge have been linked to the natural low alkalinity conditions and generally occur at interior Refuge sites well away from the influence of inflows. Therefore, the FDEP does not consider the observed pH excursions within the interior of the Refuge to be in violation of state water quality standards.

During WY2008, specific conductance was categorized as a minimal concern for Refuge inflows and a potential concern for WCA-2 inflows and interior sites. Site specifically, higher exceedance frequencies resulted in specific conductance being categorized as a concern for the S-363 inflow to the Refuge, the G-335 inflow to WCA-2, and WCA-2 interior sites E1, F1, F2, F3, CA27, and CA28. Previous ECRs and SFERs explained that the elevated conductivity levels at water control structures (e.g., S-362 and G-335) and interior stations near canal inflows were probably linked to groundwater intrusion into canal surface waters (Weaver et al., 2001, 2002).

This groundwater intrusion can be caused by (1) seepage into canals, (2) pumping station operations (which can pull additional groundwater into surface water), and (3) agricultural dewatering practices. The majority of the exceedances of the specific conductance criteria at WCA-2 interior sites during WY2008 and the last five water years have occurred during periods of no flow through the upstream structures (i.e., S-10s). The excursions during these periods may be related to either the concentration of ions associated with the evaporation of marsh water or the seepage of groundwater into the marsh, practically at sites nearest the canal. Recent studies south of the S-10 structures support the hypothesis that groundwater seepage occurs during dry periods.

Specific conductance excursion frequency in WCA-2 inflows declined significantly from 25.2 and 9.3 percent for the baseline (WY1979–WY1993) and Phase I (WY1994–WY2004) periods, respectively, to 8.6 percent in WY2008. Likewise, excursion frequencies in Refuge inflows fell from 39.6 and 14.4 percent during the baseline and Phase I periods, respectively, to 3.6 percent in WY2008. The reductions in specific conductance excursions in inflows to the northern EPA are most likely related to reduced inflow volumes during WY2008. Reductions in inflow volumes would likely reduce the amount and frequency of high conductivity canal water entering the EPA, thus reducing the exceedance frequency.

Sulfate concentrations exhibit a general north-to-south gradient extending from the sources in the north to relatively unenriched areas in the south. The highest concentrations within the EPA have been observed at the Refuge and WCA-2 inflow stations. Due to this hydrologic characteristic, the Refuge interior has remained relatively uninfluenced by the inflow of sulfate-rich water. The interior of WCA-2 is the marsh area most affected by Everglades Agricultural Area (EAA) runoff and, consequently, exhibits the highest sulfate concentrations. During WY2008, the interior sites in WCA-2 exhibited a median sulfate concentration of 15.9 milligrams per liter (mg/L) compared to a minimum median concentration of 0.7 mg/L observed in the Park.

During WY2008, the sulfate concentrations at both the inflow and interior sites measured in the northern portions of the EPA (i.e., Refuge and WCA-2), which are more directly influenced by runoff from the EAA and Lake Okeechobee discharges, were the lowest among the baseline, Phase I, and Phase II (WY2005–WY2008) monitoring periods. The lower sulfate concentrations in the northern EPA are likely the result of less runoff from the EAA and reduced discharges from Lake Okeechobee during the dry conditions experienced during much of WY2007 and WY2008 and the subsequent reductions in inflow volumes observed during WY2008.

In addition, nine pesticides, or pesticide breakdown products, [i.e., atrazine, ametryn, hexazinone, simazine, norflurazon, metribuzin, chlorpyrifos ethyl, 2,4-dichlorophenoxy acetic acid (2-4-D), and endosulfan sulfate] were detected at levels above the Method Detection Limit (MDL) within the EPA during WY2008. Only atrazine and chlorpyrifos ethyl exceeded the toxicity guideline concentrations. No other parameters exceeded state water quality criteria during WY2008. Atrazine levels exceeded the guideline concentration in six samples during WY2008 with the level of chlorpyrifos ethyl exceeding the guideline concentration in a single sample.

## TOTAL PHOSPHORUS STATUS WITHIN THE EVERGLADES PROTECTION AREA

During WY2008, total phosphorus concentrations exhibited a general decreasing north-to-south gradient, with the highest levels present in the inflow to the Refuge and concentrations decreasing to a minimum within the Park. Annual geometric mean inflow TP concentrations during WY2008 ranged from 46.9 micrograms per liter (µg/L) for the Refuge to 11.2 µg/L in the Park. TP concentrations in the inflows to the Refuge, WCA-2, and WCA-3 for WY2008 were the lowest of the baseline, Phase I, and Phase II monitoring periods. The lower inflow TP concentrations are likely the result of multiple causes, including improved treatment by the Stormwater Treatment Areas (STAs), lower stormwater volumes resulting from the drought, and general recovery from the damage resulting from the WY2005 hurricanes. In the Park, the mean inflow TP concentration observed for WY2008 was slightly higher than the historical periods. The likely cause of the elevated inflow TP concentration for the Park is the dry conditions in upstream areas resulting in oxidation of the sediment and subsequent release of bound phosphorus, which is supported by the higher outflow TP concentrations recorded for WCA-3 during WY2008.

During WY2008, geometric mean TP concentrations at interior sites within all portions of the EPA were generally lower than the levels measured during the baseline and Phase II periods and similar to or slightly above the levels for the Phase I period. Total phosphorus concentrations at interior sites within the EPA ranged from a maximum of 12.0 µg/L in WCA-2 to a minimum of 5.2 µg/L in the Park. The annual geometric mean TP concentration across interior marsh sites in WCA-3 and the Park during WY2008 were below the 10.0 µg/L five-year limit and 11.0 µg/L annual limit for assessing achievement with the TP criterion rule. In the Refuge, the annual mean TP concentration of 10.6 µg/L is above the 10.0 µg/L five-year limit, but below the 11.0 µg/L annual TP criterion limit. Although TP levels at interior sites in WCA-2 have improved in recent years, the geometric mean TP levels for WY2008 (i.e., 12.0 µg/L) remain slightly above the 11.0 µg/L annual limit.

Annual geometric mean TP concentrations for individual interior marsh monitoring stations during WY2008 ranged from less than 4.0 µg/L in some unimpacted portions of the marsh to 61 µg/L at a Refuge site highly influenced by canal inputs. During WY2008, 81.4 percent of the interior marsh sites in the EPA exhibited annual geometric mean TP concentrations of 15.0 µg/L or less with 66.3 percent of the marsh sites having annual geometric mean TP concentrations of 10.0 µg/L or less.

## TOTAL PHOSPHORUS LOADS TO THE EVERGLADES PROTECTION AREA

During WY2008, total phosphorus loads from surface sources to the EPA totaled approximately 36.7 metric tons (mt), with a flow-weighted mean concentration of 24.0 µg/L; another 193 mt of TP is estimated to have entered the EPA through atmospheric deposition. The 36.7 mt TP load in the surface inflows to the EPA represents a decrease of approximately 61 percent compared to the previous year (93.8 mt in WY2007). The lower TP loads to the EPA observed during WY2008 primarily resulted from reduced flow volumes associated with the WY2008 drought. The 1,249,307 acre-feet (ac-ft) of surface water flow to the EPA determined for WY2008 is approximately 8 percent lower than the 1,361,269 ac-ft reported for WY2007, which was also a drought year.

The effectiveness of the Best Management Practices (BMPs) and STA phosphorus removal efforts is demonstrated by the decreased TP loading to the Refuge, WCA-2, and WCA-3 during the Phase I and Phase II periods compared to the baseline period (despite increased flows to the EPA). The effect of the phosphorus removal efforts is less apparent in the Park, where inflow concentrations have remained near background levels and TP loading responds more directly to changes in flow and climatic conditions.

The average flow and TP load for the more recent Phase II period were influenced by the effects of extreme climatic events, including both multiple tropical rainfall events (WY2005 and WY2006) and prolonged periods of drought (WY2007–WY2008). Additional years of monitoring are needed before the effects of the current Phase II BMP/STA optimization projects can be seen in the Refuge. In general, TP levels for WY2008 across all areas and classes of sites, except for inflows to the Park, were similar to or lower than those for the WY2005–WY2008 period and were within the range exhibited during the earlier periods. Future SFERs are expected to continue to track long-term trends in TP levels throughout the EPA.

## TOTAL PHOSPHORUS CRITERION ACHIEVEMENT ASSESSMENT

Analyses of total phosphorus criterion achievement are mandated for the most recent five reporting years; for this SFER, the period of record is WY2004–WY2008. The results of WY2004–WY2008 TP criterion assessment indicate that the unimpacted (i.e., non-phosphorus-enriched) portions of each conservation area passed all four parts of the compliance test as expected and, therefore, are in compliance with the 10 µg/L TP criterion. Occasionally, individual sites within the unimpacted portions of the conservation areas exhibited an annual site geometric mean TP concentration above 10 µg/L, but in no case did the values for the individual unimpacted sites cause an overall exceedance of the annual or long-term network limits.

During WY2008, none of the annual geometric mean TP concentrations for the individual unimpacted sites exceeded the 15 µg/L annual site limit, and during the WY2004–WY2008 period, only one exceedance of the 15 µg/L annual site limit occurred at an unimpacted site. The single exceedance, 19.8 µg/L, occurred at station X4 in the Refuge during WY2005 when TP levels throughout the EPA were elevated due to climatic extremes.

In contrast, the impacted (i.e., phosphorus-enriched) portions of each water body failed one or more parts of the test. The impacted portions of the WCAs routinely exceeded the annual and five-year network TP concentration limits of 11 µg/L and 10 µg/L, respectively. Occasionally, selected individual sites within the impacted areas exhibited annual geometric mean TP concentrations below the 15 µg/L annual site limit. In rare instances, the annual mean for individual impacted sites was below 10 µg/L; however, none of the impacted sites were consistently below the 10 µg/L long-term limit.

Future TP criterion achievement assessments conducted with increasingly complete datasets are expected to provide a better understanding of phosphorus concentrations in the EPA.

## TOTAL NITROGEN CONCENTRATIONS WITHIN THE EVERGLADES PROTECTION AREA

Due to the nitrogen-enriched agricultural discharges to the northern portions of the system and assimilative processes in the marshes resulting in a gradual reduction in levels as the water moves to the south, total nitrogen (TN) concentrations in the EPA during WY2008 exhibited a north-to-south gradient as documented in previous years. The highest average TN concentrations were observed in the inflows to the Refuge with levels decreasing to a minimum at sites within the Park.

During WY2008, the geometric mean TN concentrations for inflow and interior sites in the Refuge and WCA-2, and interior sites within the Park, were considerably lower than the levels for any of the preceding periods. The lower concentrations observed during WY2008 may have been caused by several factors, including lower volumes of nutrient-enriched inflow from the EAA and Lake Okeechobee during dry periods observed during much of WY2008, and improved nutrient removal effectiveness of the STAs, especially during low water conditions. Geometric mean TN concentrations at inflow stations during WY2008 ranged from 1.08 mg/L in the Park to 1.94 mg/L in WCA-2. Similarly, mean TN concentrations at interior marsh stations during WY2008 ranged from 0.85 mg/L in the Park to 1.75 mg/L in WCA-2.

# PURPOSE

The primary purpose of this chapter is to provide an assessment of water quality within the Everglades Protection Area (EPA) during Water Year 2008 (WY2008) (May 1, 2007–April 30, 2008) and an update to the information provided in the *2008 South Florida Environmental Report – Volume I* (SFER). In response to comments received from the 2008 SFER peer-review panel, this chapter consolidates information previously found in Chapters 3A: Status of Water Quality in the Everglades Protection Area, and 3C: Status of Phosphorus and Nitrogen in the Everglades Protection Area, of earlier SFERs.

This chapter is intended to fulfill the requirement of the Everglades Forever Act (EFA) that the annual report "shall identify water quality parameters, in addition to phosphorus, which exceed state water quality standards or are causing or contributing to adverse impacts in the Everglades Protection Area." In addition, this chapter provides an annual update of the comprehensive overview of nitrogen (N) and phosphorus (P) levels throughout the EPA along with a preliminary assessment of total phosphorus (TP) criterion achievement utilizing the protocol provided in the 2007 SFER – Volume I, Chapter 3C.

More specifically, this chapter and its associated appendices use water quality data collected during WY2008 to achieve the following objectives:

1. Summarize areas and times where water quality criteria are not being met and indicate trends in excursions over space and time.
2. Discuss factors contributing to excursions from water quality criteria and provide an evaluation of natural background conditions where existing standards may not be appropriate.
3. Summarize sulfate concentrations in the EPA and indicate spatial and temporal trends.
4. Present an updated review of pesticide and priority pollutant data made available during WY2008.
5. Summarize water quality data in fulfillment of the non-Everglades Construction Project (non-ECP) permit requirements.
6. Summarize P and N concentrations measured in surface waters within different portions of the EPA.
7. Summarize water quality data in fulfillment of the Interim Operational Plan (IOP) for Protection of the Cape Sable Seaside Sparrow (*Ammodramus maritimus mirabilis*) and C-111 Canal Project's Ninth Amended Emergency Final Order (C-111 EO #9) requirements.
8. Describe and discuss factors contributing to any spatial and temporal trends observed.
9. Provide a summary of the flow and P loads entering different portions of the EPA during WY2008 and describe spatial and temporal trends observed.
10. Present a preliminary phosphorus criterion achievement assessment for different areas within the EPA for the most recent five-year period (i.e., WY2004–WY2008).

# METHODS

A regional synoptic approach similar to that used for water quality evaluations in previous SFERs was applied to phosphorus and nitrogen data for WY2008 to provide an overview of water quality status within the EPA. Consolidating regional water quality data provides for analysis over time but limits spatial analyses within each region. However, spatial analyses can be made between regions because the majority of inflow and pollutants enter the northern third of the EPA and the net water flow is from north to south.

## WATER QUALITY DATA SOURCES

The majority of the water quality data evaluated in this chapter was retrieved from the South Florida Water Management District's (SFWMD or District) hydrometeorologic database DBHYDRO. The DBHYDRO monitoring projects evaluated for WY2008 included C111D, CAMB, ENP, EVER, EVPA, HOLY, LOXA, NECP, STA1E, STA1W, STA2, and PEST. Additionally, water quality data from the nutrient gradient sampling stations monitored by the District in the northern part of Water Conservation Area 3A (WCA-3A), the southwestern part of the Arthur R. Marshall Loxahatchee National Wildlife Refuge (the Refuge), the west-central portion of WCA-3A, and Taylor Slough in Everglades National Park (ENP or Park) were obtained from the District's Everglades Division database.

## WATER QUALITY SAMPLING STATIONS IN THE EVERGLADES PROTECTION AREA

A network of water quality monitoring stations was selected from existing long-term District monitoring projects to perform the water quality evaluations presented in this chapter (**Figure 3A-1**). These stations were carefully selected to be representative of either the EPA boundary conditions (i.e., inflow or outflow) or ambient marsh conditions (interior). Furthermore, an effort has been made to utilize a consistent group of stations among previous annual consolidated reports in order to ensure consistent and comparable results.

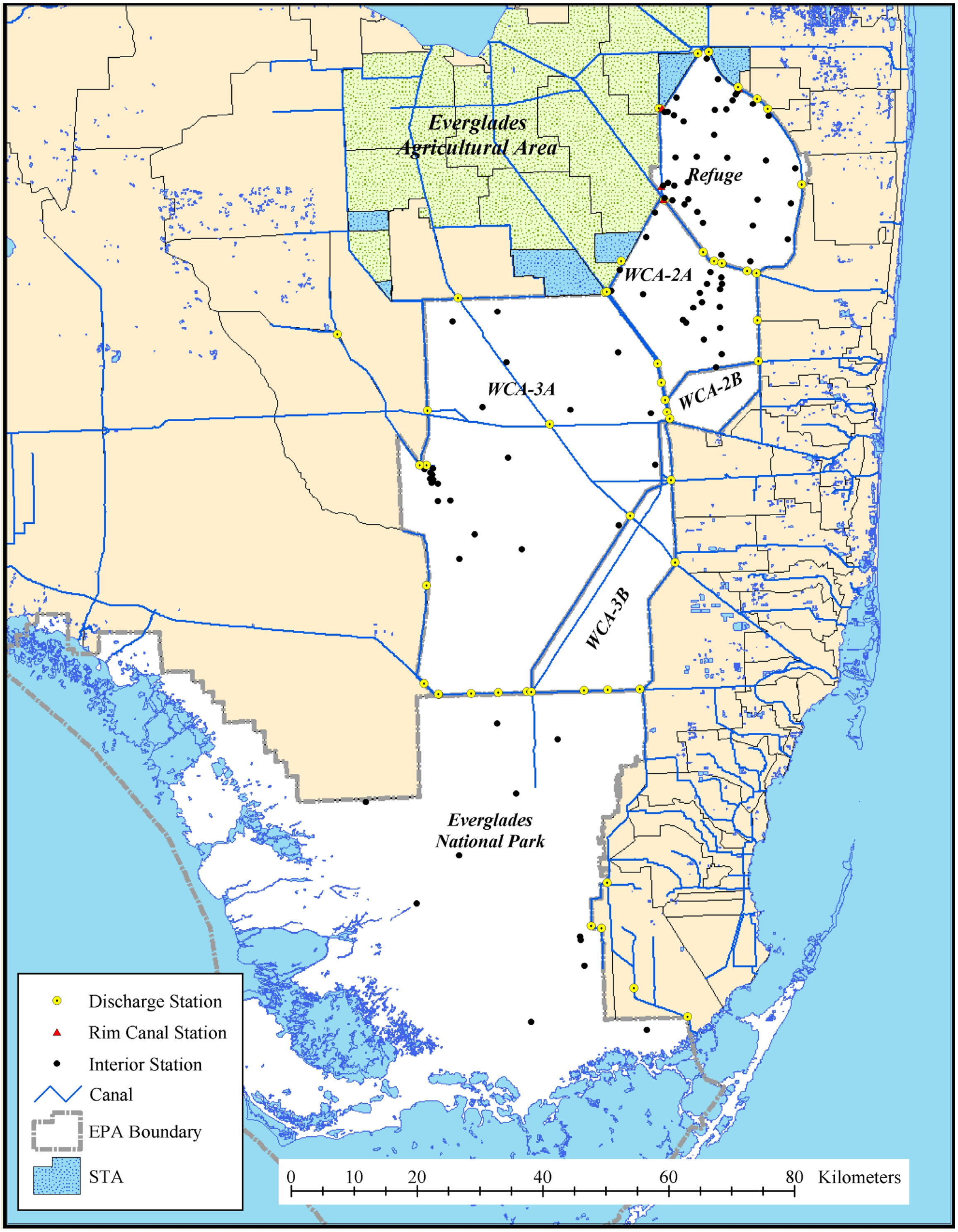



**Figure 3A-1.** Everglades Protection Area (EPA) regions and water quality monitoring stations.

Water quality sampling stations located throughout the WCAs and the Park were categorized as inflow, interior, or outflow sites within each region based on their location and function (**Figure 3A-1**). This organization of monitoring sites allowed a more detailed analysis of the water quality status in each region of the EPA and assisted in the evaluation of potential causes for observed excursions from Class III water quality criteria.

Several interior structures convey water between different regions in the EPA and, therefore, are designated as both inflow and outflow stations based on this categorization system. For example, the S-10 structures act as both outflow stations for the Refuge and inflow sites to Water Conservation Area 2 (WCA-2) (**Figures 3A-2** and **3A-3**). Additionally, the S-11 structures are designated as outflows from WCA-2 as well as inflow points to WCA-3 (**Figures 3A-3** and **3A-4**). The S-12 structures, S-355A, S-355B, and S-333 are outflows from WCA-3 and are also inflow sites to the Park (**Figures 3A-4** and **3A-5**). The interior sites of each region consist of marsh and canal stations as well as structures that convey water within the area.

In addition to inflow, outflow, and interior sites, the Refuge has an additional site category (rim canal sites) to account for the fact that much of the water entering the interior of the Refuge is conveyed in rim canals that border the east and west levees of the Refuge (**Figure 3A-2**). Waters discharged to the L-7 rim canal will either overflow into the Refuge interior when canal stages exceed the levee height or will bypass the marsh and be discharged to WCA-3A through the S-10 structures. The extent (distance) to which rim canal overflows penetrate the marsh depends on the relative stages of the L-7 rim canal and the Refuge interior.

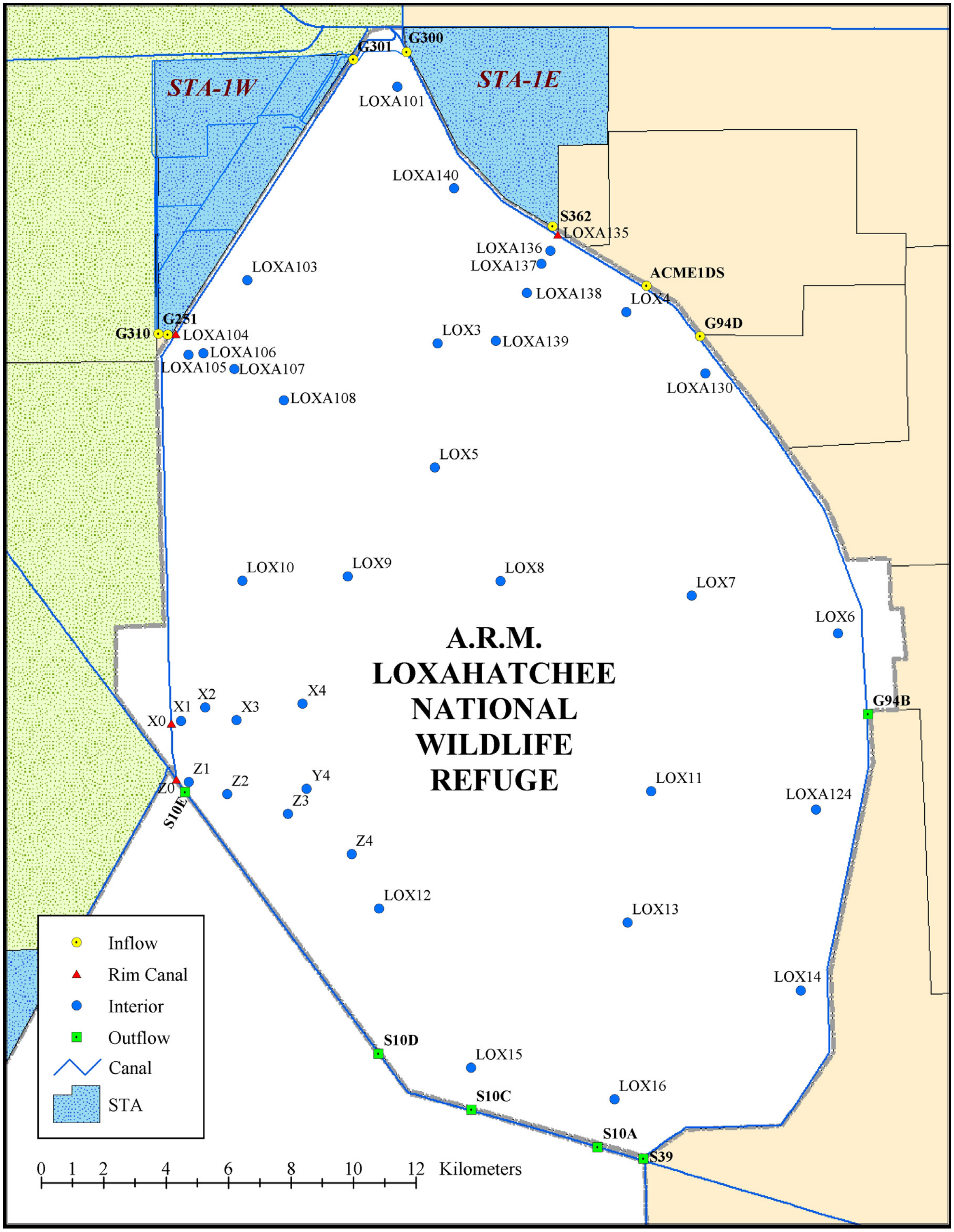



**Figure 3A-2.** Location and classification of water quality monitoring stations in the Arthur R. Marshall Loxahatchee National Wildlife Refuge (Refuge).

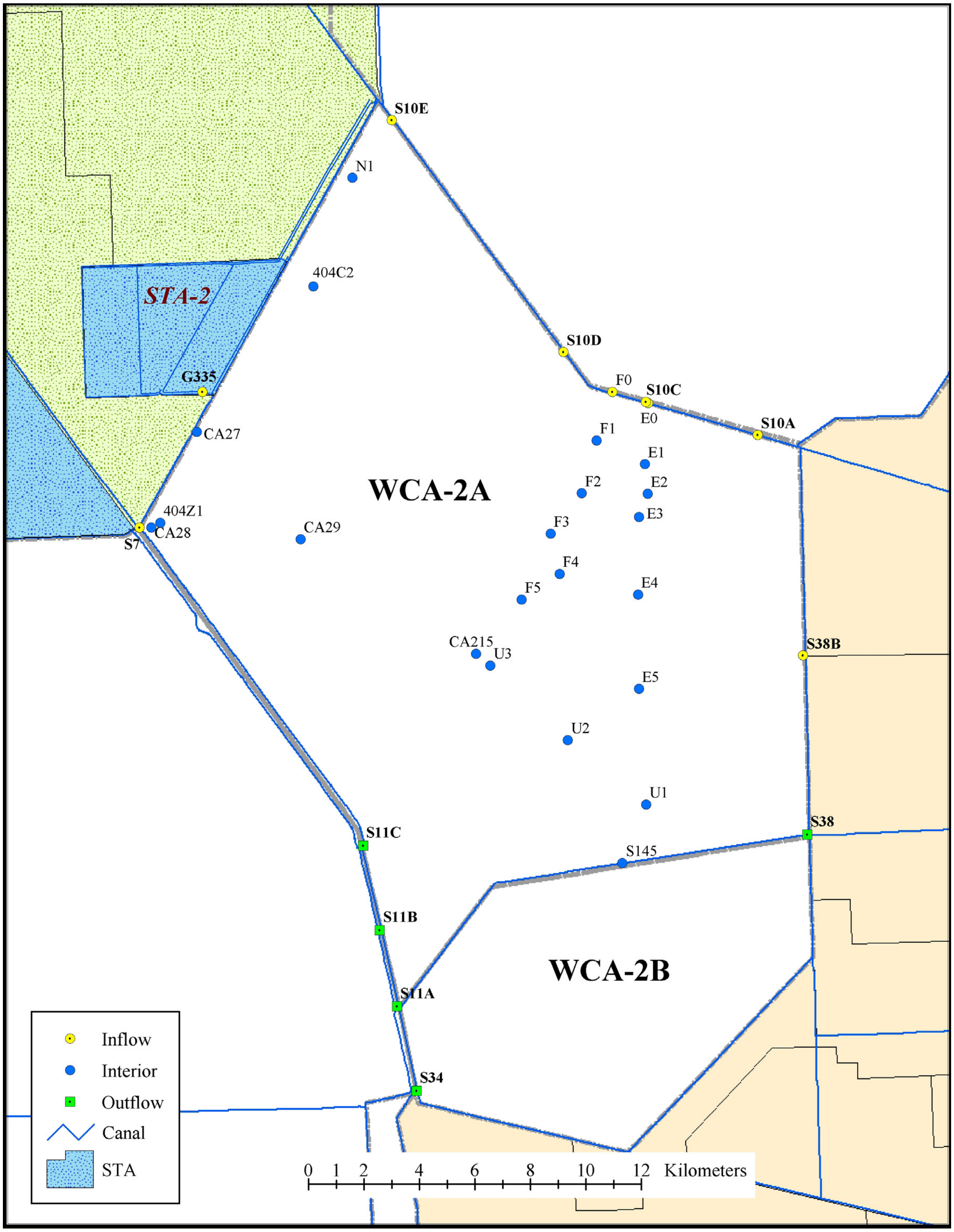



**Figure 3A-3.** Location and classification of water quality monitoring stations in Water Conservation Area 2 (WCA-2).

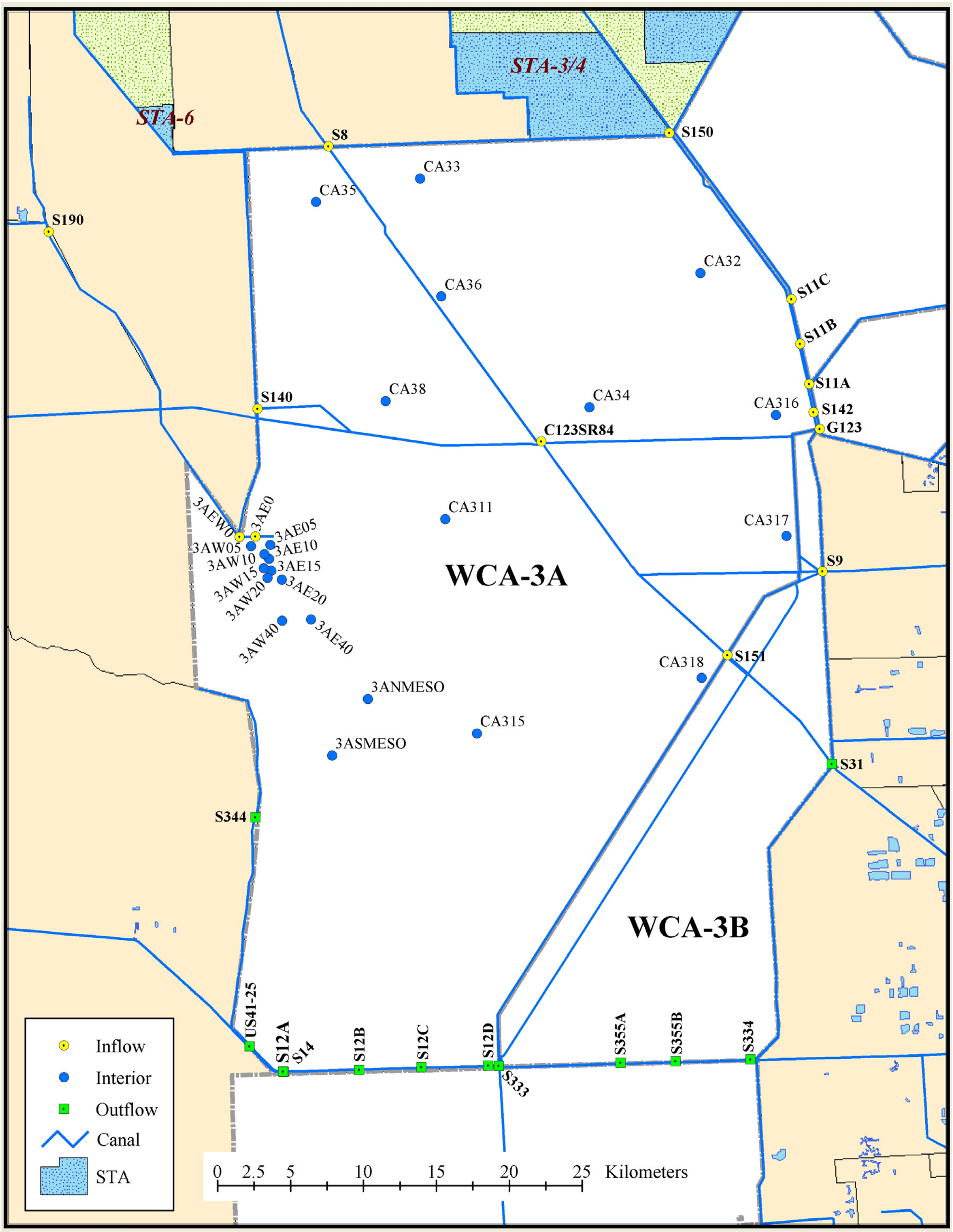



**Figure 3A-4.** Location and classification of water quality monitoring stations in Water Conservation Area 3 (WCA-3).

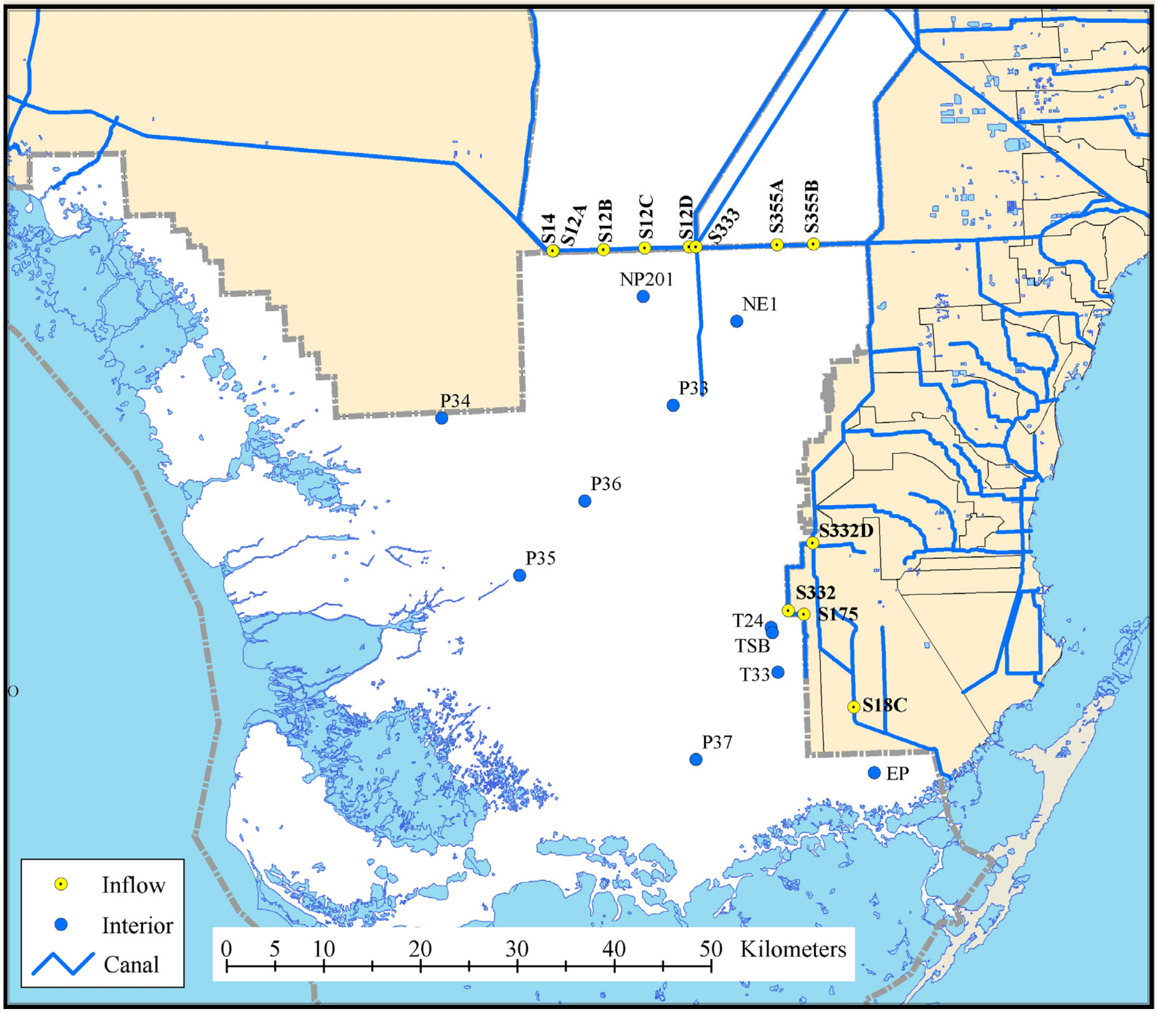



**Figure 3A-5.** Location and classification of water quality monitoring stations in the Everglades National Park (ENP or Park).

The current District monitoring programs were described by Germain (1998). Sampling frequency varies by site depending on site classification, parameter group, and hydrologic conditions (water depth and flow). Water control structures (inflows and outflows) were typically sampled biweekly when flowing; otherwise, sampling was performed monthly. Generally, interior monitoring stations were sampled monthly for most parameters reported in this chapter. Pesticide monitoring is conducted across the entire SFWMD at 34 sites on a quarterly basis. An overview of the water quality monitoring projects, including project descriptions and objectives with limited, site-specific information, is available on the District's web site at www.sfwmd.gov, under the *What We Do, Environmental Monitoring, Water Quality Monitoring* tabs.

## ANALYSIS PERIODS

As previously noted, the primary focus of this chapter is to summarize the status of water quality within the EPA during WY2008 and to describe trends or changes in water quality conditions over time. To accomplish this objective, comparisons are made across discrete multiple periods corresponding to major restoration activities occurring within the EPA. The periods utilized are the historical WY1979–WY1993 period (baseline), which corresponds to the time frame prior to implementation of the Everglades Agricultural Area (EAA) Best Management Practices (BMPs) program and Everglades Construction Project (ECP) [i.e., the Stormwater Treatment Areas (STAs)]; WY1994–WY2004 (Phase I) and the Phase II BMP/STA implementation period after WY2004 (i.e., WY2005–WY2008).

The Phase I period represents the time in which implementation of the BMP program was increasing and all the initial STAs were constructed and became operational. The Phase II BMP/STA implementation period corresponds to the time in which the performance of the BMPs and STAs are being optimized and enhanced, and various Long-Term Plan for Achieving Water Quality Goals in the Everglades Protection Area (Long-Term Plan) and Comprehensive Everglades Restoration Plan (CERP) projects are being implemented. Because optimization and enhancement (and other restoration activities) are expected to continue for a number of years, the Phase II period will be expanded in future SFERs to include the current water year at the time of the report. In addition, data for the current water year (in this case, WY2008) will be used to make comparisons with the historical periods. Individual station assessments and certain mandated reporting (e.g., phosphorus criterion achievement) were based on the previous five water years (WY2004–WY2008), rather than on the single year used for regional analysis (e.g., WY2008). Reporting periods are specified in each section of this chapter.

## DATA SCREENING AND HANDLING

Water quality data were screened based on laboratory qualifier codes, consistent with the state's Quality Assurance Rule [Chapter 62-160, Florida Administrative Code (F.A.C.)]. Any datum with an associated fatal qualifier (H, J, K, N, O, V, Q, Y, or ?) was removed from the analysis (SFWMD, 2008). Values that exceeded possible physical or chemical measurement constraints [e.g., if resulting pH is greater than ( > ) 14], had temperatures well outside seasonal norms (e.g., 6°C in July), or represented data transcription errors were excluded. Statistical outlier analysis was not performed for these data. Overall, approximately 2 percent of the WY2008 data, including nutrients, were excluded due to quality assurance/quality control (QA/QC) issues (see Appendix 3A-1 of this volume). All data passing the qualifier screening were used in the analysis. Multiple samples collected at the same location on the same day were considered as one sample, with the arithmetic mean used to represent the sampling period.

Additional considerations in the handling of water quality data are the accuracy and sensitivity of the laboratory method used. Each analytical method for a particular water quality constituent has a Method Detection Limit (MDL) that defines the minimum concentration or the level at which the constituent can be identified. The MDL is usually statistically above the background noise level associated with the analytical method. A constituent present in a concentration at or below the MDL may not be quantified within established limits of accuracy or precision using that method. The Practical Quantitation Limit represents a practical and routinely achievable quantification level with a relatively good certainty that a value determined using that method is reliable (APHA, 1995). For purposes of summary statistics presented in this chapter, data reported as less than the MDL were assigned a value of one-half the MDL unless otherwise noted. All data presented in this chapter, including historical results, were handled consistently with regard to screening and MDL replacement. The percentages of results below detection (i.e., < MDL) for each constituent are reported in Appendix 3A-1 of this volume.

## WATER QUALITY DATA PARAMETERS

The District monitors approximately 109 water quality parameters within the EPA (Bechtel et al., 1999, 2000). Given this chapter's focus on water quality criteria, the evaluation was primarily limited to parameters with Class III criteria pursuant to Chapter 62-302, F.A.C. The parameters evaluated for this chapter include 62 pesticides and the following water quality constituents:

- Alkalinity
- Dissolved oxygen (in situ)
- Specific conductance (in situ)
- pH (in situ)
- Total selenium
- Total thallium
- Total zinc
- Turbidity
- Un-ionized ammonia
- Sulfate
- Total nitrogen (total Kjeldahl nitrogen + nitrate/nitrite)
- Total cadmium
- Total iron
- Total lead
- Total nickel
- Total silver
- Total antimony
- Total arsenic
- Total beryllium
- Total copper
- Total phosphorus
- Orthophosphate

## WATER QUALITY CRITERIA EXCURSION ANALYSIS

The Florida Department of Environmental Protection (FDEP) and the District have developed and clearly documented an excursion analysis protocol for use in the annual SFER (Weaver and Payne, 2005). The primary objective of the protocol is to provide a synoptic view of water quality criteria compliance on a regional scale (i.e., the Refuge, WCA-2, WCA-3, and the Park). This protocol was developed to balance consistency with previous versions of the report, other state of Florida ambient water quality evaluation methodologies [e.g., Impaired Waters 303(d) designations], and the U.S. Environmental Protection Agency (USEPA) exceedance frequency recommendations, as well as to provide a concise summary for decision makers and the public. This methodology is being used in order to ensure the results will be compatible with information from other sources provided to water managers.

A multi-tiered categorical system was used in this chapter to rank the severity of excursions from state water quality criteria (**Table 3A-1**). Categories were assigned based on sample excursion frequencies evaluated using a statistically valid assessment methodology (i.e., binomial hypothesis test) that accounted for uncertainty in monitoring data. The basis for selecting the binomial approach is presented in Weaver and Payne (2004, 2005). Parameters without excursions were categorized as "no concern" and are not discussed further in this chapter.

**Table 3A-1**. Definitions of excursion categories for water quality constituents in the Everglades Protection Area (EPA). For conventional water quality constituents with at least 28 samples, frequencies were statistically tested using the binomial hypothesis test at the 90 percent confidence level.

| Excursion Category | Conventional Water Quality Constituents | Pesticides |
|---|---|---|
| Concern | > 10% Excursion[1] | Class III criterion and/or toxicity levels exceeded |
| Potential Concern | > 5% and ≤ 10% Excursions[2] | ≥ MDL[3] |
| Minimal Concern | ≤ 5% Excursions | Not Applicable |
| No Concern | No Excursions | < MDL |

1. For sample sizes < 28, an excursion frequency of > 20 percent was used to define the concern category.
2. For sample sizes < 28, an excursion frequency of ≤ 20 percent was used to define the potential concern category.
3. MDL = Method Detection Limit.

For any parameter with excursions and at least 28 samples during the period of record (POR), the binomial hypothesis test at the 90 percent confidence level was applied to evaluate whether the given parameter was a concern; that is, whether it exhibited an excursion rate greater than 10 percent. If the binomial hypothesis test failed to reject the null hypothesis ($H_0$: $f \leq 0.10$; $H_A$: $f > 0.10$), then the binomial test at the 90 percent confidence level was used to determine whether the parameter was a potential concern (excursion rate from 5 to 10 percent, i.e., $H_A$: $f > 0.05$) or a minimal concern (an excursion rate of 5 percent or less, i.e., $H_0$: $f \leq 0.05$).

Because the binominal hypothesis test does not adequately balance statistical error rates at sample sizes of less than 28, parameters with reported excursions and fewer than 28 samples were initially categorized as a concern or potential concern based on excursion frequencies (raw scores) of greater than 20 percent and less than (<) 20 percent, respectively. It is assumed that an observed excursion frequency of greater than 20 percent provides substantial reason to suspect that the true exceedance frequency may exceed 10 percent and warrants further investigation. Furthermore, given the high degree of uncertainty associated with small sample sizes (fewer than 28), any excursions warrant further review.

However, extreme caution must be exercised when interpreting results drawn from such small samplings. As a means to reduce uncertainty, any parameter initially identified as a concern or potential concern based on fewer than 28 samples was further evaluated based on longer term (five-year) excursion rates. Utilization of a longer period of record assumes that exceedance frequencies are constant among years, that is, there is no trend. Parameters with human health-based criteria were evaluated under the assumption that the Class III criteria values represent instantaneous maximum concentrations for which any exceedance constitutes a non-attainment of designated use.

Additionally, methods to detect and delineate localized exceedance patterns within each water body were utilized to supplement and refine the regional analyses (Weaver and Payne, 2005). The binomial hypothesis test and excursion criterion were applied to individual station data. Individual station assessments were based on the previous five water years (WY2004–WY2008), rather than on the single year used for regional analyses. The use of a five-year period provided sufficient data for most parameters. No determination was made for any parameter with less than 28 samples. If one or more monitoring stations were categorized at a higher level of concern than the region as a whole, then a localized exceedance was recorded. Localized exceedances are noted in the summary tables of this chapter.

Because the USEPA recommended that a 10 percent excursion frequency does not apply to pesticides (USEPA, 1997, 2002), the pesticide evaluation method presented in this chapter is identical to the method used in previous Everglades Consolidated Reports (ECRs) and SFERs. Pesticides were categorized based on the exceedance of Class III criteria or chronic toxicity values and detection (measurement ≥ MDL) frequency.

## PHOSPHORUS CRITERION ACHIEVEMENT ASSESSMENT

A preliminary evaluation to determine achievement of the TP criterion was performed in accordance with the protocol provided in the 2007 SFER – Volume I, Chapter 3C, and the four-part test specified in the TP criterion rule (**Table 3A-2**). The available data from the 58 sites comprising the TP criterion monitoring network for the most recent five-year period (i.e., WY2004–WY2008) were utilized in the evaluation.

The TP criterion rule requires that a network be established for the purpose of evaluating compliance with the TP criterion. In establishing this network, existing sites being monitored for different purposes were selected wherever possible. However, to get the required spatial coverage, new sites were added. The location of the TP criterion network monitoring sites used in this assessment and their classification as "impacted" or "unimpacted" are provided in **Figure 3A-6**.

**Table 3A-2.** Summary of the four-part test as required by Section 62-302.540, Florida Administrative Code (F.A.C.).

| Component | TP Criterion Achievement Value | Noted in This Chapter As |
|---|---|---|
| Five-year geometric mean TP concentration averaged across the monitoring network | 10 µg/L or less | five-year network limit |
| Annual geometric mean TP concentration averaged across all stations | 10 µg/L or less for three out of each five years | multiyear network limit |
| Annual geometric mean TP concentration averaged across all stations | 11 µg/L or less | annual network limit |
| Annual geometric mean TP concentration at all individual monitoring stations | 15 µg/L or less | annual site limit |

Data collection from the complete TP criterion monitoring network, which includes the new site, was initiated in January 2007. It should be noted that due to the relatively recent inception of the network monitoring, not all sites have data available for the full five-year assessment period. In addition, due to extremely dry conditions that have prevailed since WY2007, data availability is further limited for certain portions of the EPA. Because the results of the TP criterion compliance assessment presented in this chapter could be affected by these data limitations, this evaluation should be considered preliminary and the results cautiously interpreted. It is expected that future assessments will improve as additional datasets for all sites within the monitoring network are added. Data were screened according to the quality QA/QC procedures described in the protocol on the FDEP's web site (as of August 2008) at www.dep.state.fl.us/water/wqssp/everglades/docs/DataQualityScreeningProtocol.pdf.

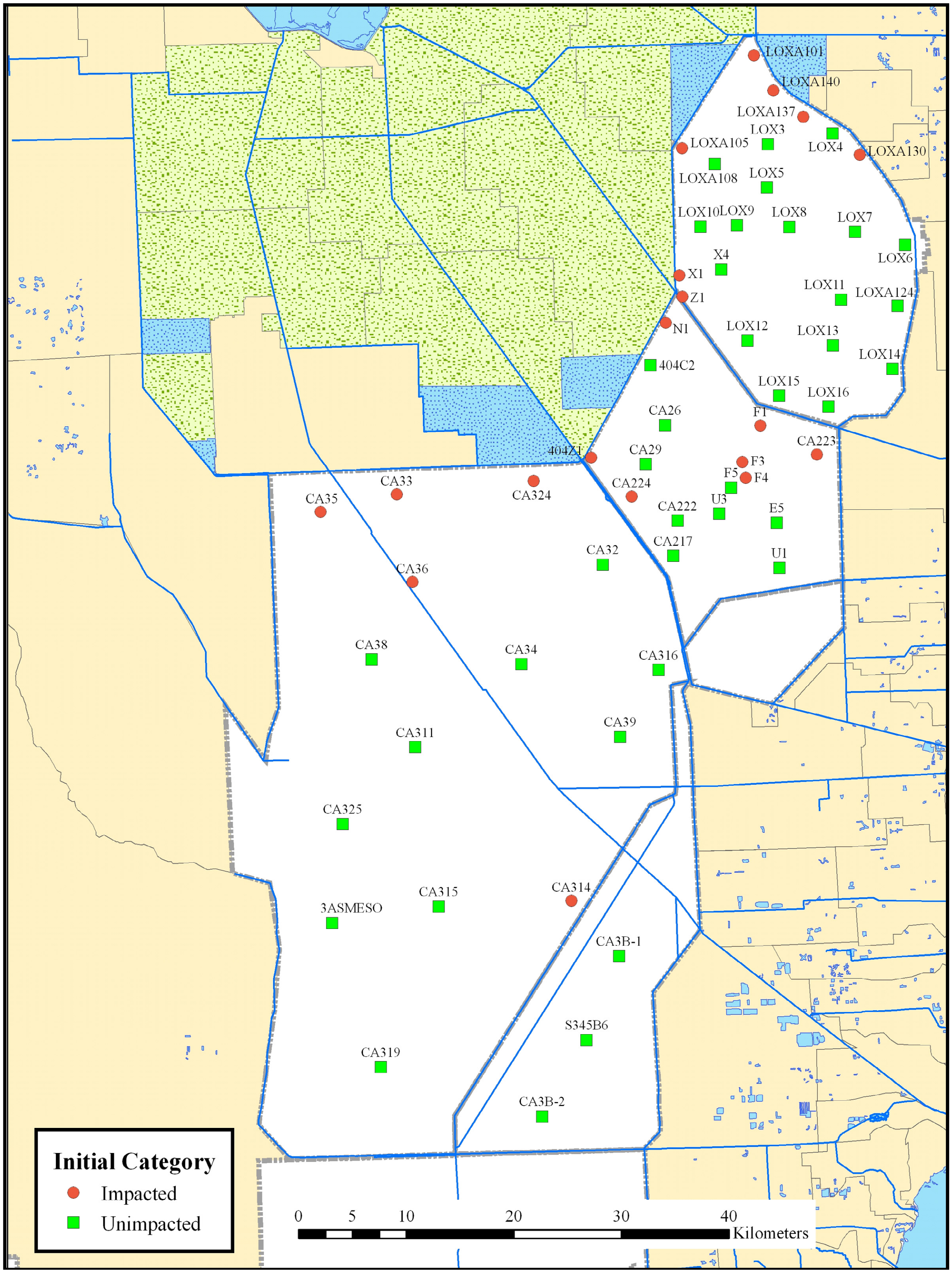



**Figure 3A-6.** Location of total phosphorus (TP) criterion assessment monitoring network sties used in the Water Years 2004–2008 (WY2004–WY2008) evaluation.

# WATER YEAR 2008 WATER QUALITY RESULTS

## WATER QUALITY CRITERIA EXCURSION ANALYSIS

Water Year 2008 data for water quality parameters with Class III numeric criteria are summarized by region and monitoring station in Appendices 3A-1 and 3A-2, respectively. Comparisons of WY2008 water quality data with applicable Class III water quality criteria resulted in excursions for four water quality parameters: (1) dissolved oxygen (DO), (2) alkalinity, (3) pH, and (4) specific conductance (**Tables 3A-3** and **3A-4**).

Similar to previous periods, these excursions were localized to specific areas of the EPA, with the exception of DO, which exhibited excursions in all regions. Because Everglades DO is assessed as an annual station average rather than as point measures, there were insufficient data to confidently apply the binomial hypothesis test to the regional assessment units on an annual basis. Therefore, excursion categories for DO were assessed based on a five-year period of record (WY2004–WY2008) for all areas.

Water quality parameters with exceedances of applicable criteria are discussed in greater detail below with the excursion frequencies summarized for four time periods (WY1979–WY1993, WY1994–WY2004, WY2005–WY2008, and WY2008) to evaluate the presence of any temporal trends (see **Table 3A-4**).

During the WY2008 period, nine pesticides, or pesticide breakdown products, [i.e., atrazine, ametryn, hexazinone, simazine, norflurazon, metribuzin, chlorpyrifos ethyl, 2-4-D, and endosulfan sulfate] were detected at levels above the MDL within the EPA. Only atrazine and chlorpyrifos ethyl exceeded the toxicity guideline concentrations (**Table 3A-5**). No other parameters exceeded state water quality criteria during WY2008.

**Table 3A-3**. Summary of excursions from Class III criteria in the EPA for the pre-Best Management Practices (BMPs) baseline period (WY1979–WY1993), Phase I (WY1994–WY2004), Phase II (WY2005–WY2008), and WY2008 (May 1, 2007–April 30, 2008).

| Area | Class | Parameter | WY1979–WY1993 | | WY1994–WY2004 | | WY2005–WY2008 | | WY2008 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Number of Excursions[1] | Percent Excursions[2] | Number of Excursions[1] | Percent Excursions[2] | Number of Excursions[1] | Percent Excursions[2] | Number of Excursions[1] | Percent Excursions[2] |
| Refuge | Inflow | Dissolved Oxygen | 13 (61) | 21.3 (C[3]) | 8 (68) | 11.8 (PC[3]) | 4 (24) | 16.7 (PC[3]) | 1 (7) | 14.3 (PC[3]) |
| | | pH | 9 (890) | 1.0 (MC) | 4 (1782) | 0.2 (MC) | 3 (886) | 0.3 (MC) | 0 (280) | 0.0 (NC) |
| | | Specific Conductance | 355 (896) | 39.6 (C) | 258 (1786) | 14.4 (C) | 76 (880) | 8.6 (PC) | 10 (280) | 3.6 (MC) |
| | | Turbidity | 28 (1109) | 2.5 (MC) | 34 (1034) | 3.3 (MC) | 1 (299) | 0.3 (MC) | 0 (54) | 0.0 (NC) |
| | | Un-ionized ammonia | 36 (867) | 4.2 (MC) | 2 (1255) | 0.2 (MC) | 4 (448) | 0.9 (MC) | 0 (135) | 0.0 (NC) |
| | Rim | Specific Conductance | 36 (118) | 30.5 (C) | 71 (634) | 11.2 (PC) | 4 (130) | 3.1 (MC) | 0 (19) | 0.0 (NC*) |
| | Interior | Alkalinity | 91 (367) | 24.8 (C[4]) | 477 (1971) | 24.2 (C[4]) | 142 (884) | 16.1 (C[4]) | 43 (192) | 22.4 (C[4]) |
| | | Dissolved Oxygen | 0 (12) | 0.0 (NC[3]) | 66 (210) | 31.4 (C[3]) | 40 (117) | 34.2 (C[3]) | 6 (23) | 26.1 (C[3]) |
| | | pH | 59 (238) | 24.8 (C[5]) | 164 (2204) | 7.4 (PC[5]) | 41 (1072) | 3.8 (MC[5]) | 14 (224) | 6.3 (MC[5]) |
| | | Un-ionized ammonia | 0 (177) | 0.0 (NC) | 3 (1698) | 0.2 (MC) | 1 (662) | 0.2 (MC) | 0 (104) | 0.0 (NC) |
| | Outflow | pH | 1 (579) | 0.2 (MC) | 4 (692) | 0.6 (MC) | 0 (218) | 0.0 (NC) | 0 (53) | 0.0 (NC) |
| | | Specific Conductance | 128 (595) | 21.5 (C) | 21 (696) | 3.0 (MC) | 0 (216) | 0.0 (NC) | 0 (53) | 0.0 (NC) |
| | | Turbidity | 7 (572) | 1.2 (MC) | 4 (708) | 0.6 (MC) | 2 (217) | 0.9 (MC) | 0 (53) | 0.0 (NC) |
| WCA-2 | Inflow | Dissolved Oxygen | 21 (51) | 41.2 (C[3]) | 22 (84) | 26.2 (C[3]) | 0 (29) | 0.0 (NC) | 0 (7) | 0.0 (NC[3]) |
| | | pH | 2 (621) | 0.3 (MC) | 6 (1230) | 0.5 (MC) | 0 (616) | 0.0 (NC) | 0 (152) | 0.0 (NC) |
| | | Specific Conductance | 161 (640) | 25.2 (C) | 152 (1233) | 12.3 (C) | 57 (616) | 9.3 (PC) | 13 (152) | 8.6 (PC) |
| | | Turbidity | 9 (732) | 1.2 (MC) | 6 (721) | 0.8 (MC) | 2 (284) | 0.7 (MC) | 0 (63) | 0.0 (NC) |
| | | Un-ionized ammonia | 6 (616) | 1.0 (MC) | 62 (1012) | 6.1 (PC) | 17 (335) | 5.1 (MC) | 0 (75) | 0.0 (NC) |
| | Interior | Dissolved Oxygen | 17 (52) | 32.7 (C[3]) | 97 (211) | 46.0 (C[3]) | 35 (81) | 43.2 (C) | 6 (20) | 30.0 (C[3]) |
| | | pH | 17 (869) | 2.0 (MC) | 4 (3294) | 0.1 (MC) | 3 (971) | 0.3 (MC) | 0 (254) | 0.0 (NC) |
| | | Specific Conductance | 86 (762) | 11.3 (PC) | 335 (3344) | 10.0 (PC) | 132 (982) | 13.4 (C) | 29 (252) | 11.5 (PC) |
| | | Un-ionized ammonia | 6 (777) | 0.8 (MC) | 6 (2691) | 0.2 (MC) | 1 (584) | 0.2 (MC) | 0 (108) | 0.0 (NC) |

**Table 3A-3.** Continued.

| Area | Class | Parameter | WY1979–WY1993 | | WY1994–WY2004 | | WY2005–WY2008 | | WY2008 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Number of Excursions[1] | Percent Excursions[2] | Number of Excursions[1] | Percent Excursions[2] | Number of Excursions[1] | Percent Excursions[2] | Number of Excursions[1] | Percent Excursions[2] |
| WCA-3 | Inflow | Dissolved Oxygen | 51 (160) | 31.9 (C[3]) | 42 (163) | 25.8 (C[3]) | 3 (58) | 5.2 (MC[3]) | 0 (13) | 0.0 (NC[3]) |
| | | pH | 19 (2300) | 0.8 (MC) | 16 (2814) | 0.6 (MC) | 2 (1587) | 0.1 (MC) | 1 (396) | 0.3 (MC) |
| | | Specific Conductance | 59 (2354) | 2.5 (MC) | 7 (2803) | 0.2 (MC) | 0 (1589) | 0.0 (NC) | 0 (398) | 0.0 (NC) |
| | | Un-ionized ammonia | 3 (2141) | 0.1 (MC) | 8 (2125) | 0.4 (MC) | 1 (677) | 0.1 (MC) | 0 (106) | 0.0 (NC) |
| | Interior | Dissolved Oxygen | 1 (14) | 7.1 (PC[3]) | 50 (140) | 35.7 (C[3]) | 22 (77) | 28.6 (C[3]) | 0 (13) | 0.0 (NC[3]) |
| | | pH | 0 (427) | 0.0 (NC) | 0 (2102) | 0.0 (NC) | 2 (931) | 0.2 (MC) | 0 (184) | 0.0 (NC) |
| | Outflow | Dissolved Oxygen | 22 (91) | 24.2 (C[3]) | 14 (100) | 14.0 (PC[3]) | 2 (43) | 4.7 (MC[3]) | 0 (12) | 0.0 (NC[3]) |
| Park | Inflow | Dissolved Oxygen | 15 (95) | 15.8 (C[3]) | 11 (105) | 10.5 (PC[3]) | 2 (39) | 5.1 (MC[3]) | 0 (9) | 0.0 (NC[3]) |
| | | Specific Conductance | 0 (2132) | 0.0 (NC) | 1 (2901) | 0.0 (MC) | 0 (1012) | 0.0 (NC) | 0 (246) | 0.0 (NC) |
| | Interior | Dissolved Oxygen | 1 (62) | 1.6 (MC[3]) | 2 (115) | 1.7 (MC[3]) | 2 (35) | 5.7 (MC[3]) | 0 (9) | 0.0 (NC[3]) |
| | | Specific Conductance | 20 (542) | 3.7 (MC) | 2 (1117) | 0.2 (MC) | 0 (313) | 0.0 (NC) | 0 (81) | 0.0 (NC) |
| | | Un-ionized ammonia | 17 (455) | 3.7 (MC) | 4 (1019) | 0.4 (MC) | 1 (265) | 0.4 (MC) | 0 (52) | 0.0 (NC) |

1 For the "Number of Excursions" columns, the number in front of the parentheses specifies the number of excursions, while the number inside the parentheses specifies the number of samples collected.
2 Excursion categories of concern, potential concern, minimal concern, and no concern are denoted by "C," "PC," "MC," and "NC," respectively, and are provided within parentheses in the "Percent Excursions" columns.
3 Insufficient sample size ( < 28) to confidently characterize the excursion frequency; categorization is preliminary, and further evaluation is required.
4 The low alkalinity levels in the Refuge are natural and, therefore, not considered by the FDEP to be violations of state water quality standards.
5 Because pH excursions within the interior of the marsh are linked to natural background alkalinity conditions, the FDEP does not consider pH levels within the interior of the Refuge to be in violation of state water quality standards.

**Table 3A-4.** Summary of water quality data and excursions from applicable criteria in the EPA for WY2008. Only water quality parameters with excursions in the given region and class are listed.

| Area | Class | Parameter | Units | Class III Criteria | N | Mean | Standard Deviation | Min. | Max. | Excursion | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | % ± 90% C.I. | Category[1] |
| Refuge | Inflow | Dissolved Oxygen | mg/L | SSAC[2] | 7 | 4.49 | 2.49 | 0.3 | 13 | 14.3±21.8 | PC |
| Refuge | Inflow | Specific Conductance | µmhos/cm | ≤ 1,2753[3] | 280 | 804.7 | 215.6 | 359.3 | 1440 | 3.6±1.8 | MC (C) |
| Refuge | Interior | Alkalinity | mg/L | ≥ 20 | 192 | 52.5 | 46.3 | 6 | 229.5 | 22.4±4.9 | C |
| Refuge | Interior | Dissolved Oxygen | mg/L | SSAC[2] | 23 | 4.08 | 1.98 | 0.12 | 9.43 | 26.1±15.1 | C |
| Refuge | Interior | pH | units | ≥ 6.0, ≤ 8.5 | 224 | 6.59 | 0.41 | 5.8 | 7.8 | 6.3±2.7 | MC (C)[5] |
| WCA-2 | Inflow | Specific Conductance | µmhos/cm | ≤ 1,275[3] | 152 | 907.4 | 293.7 | 202.6 | 1612 | 8.6±3.7 | PC (C) |
| WCA-2 | Interior | Dissolved Oxygen | mg/L | SSAC[2] | 20 | 3.89 | 2.04 | 0.22 | 9.81 | 30.0±16.9 | C |
| WCA-2 | Interior | Specific Conductance | µmhos/cm | ≤ 1,275[4] | 252 | 954.9 | 332.6 | 244.5 | 2590 | 11.5±3.3 | PC (C) |
| WCA-3 | Inflow | pH | units | ≥ 6.0, ≤ 8.5 | 396 | 7.6 | 0.32 | 6.7 | 8.7 | 0.3±0.4 | MC |

1 Category entries denote data not available (NA), and categories of concern (C), potential concern (PC), and minimal concern (MC). Parentheses indicate a localized exceedance rate greater than the regional (area and class) classification; that is, one or more stations had higher exceedance rates between WY2003–WY2008 than in WY2008.
2 The Everglades dissolved oxygen (DO) site-specific alternative criterion (SSAC) is based on a mathematical equation that models the sinusoidal diel cycle.
3 Specific conductance shall not be increased 50 percent above background or 1,275 micromhos per centimeter (µmhos/cm), whichever is greater. Assessment presented in this report is based only on the 1,275 µmhos/cm component of the criterion.
4 The low alkalinity levels in the Refuge are natural and, therefore, not considered by FDEP to be violations of state water quality standards.
5 Because pH excursions within the interior of the marsh are linked to natural background alkalinity conditions, the FDEP does not consider pH levels within the interior of the Refuge to be in violation of state water quality standards.

## Dissolved Oxygen

Dissolved oxygen conditions within the EPA were assessed against the Everglades DO site-specific alternative criterion (SSAC). Because a single value criterion does not adequately account for the wide-ranging natural daily fluctuations observed in the Everglades marshes, the SSAC provides a mechanism to account for the major factors (e.g., time of day and season) influencing natural background DO variation in the Everglades (Weaver, 2004). The SSAC is based on an algorithm that uses sample collection time and water temperature to model the observed natural sinusoidal diel cycle and seasonal variability. This model provides a lower DO limit (DOL) for an individual monitoring station and is described by the equation:

$$\begin{aligned} DOL_i = & [-3.70 - \{1.50 \cdot \text{sine}(2\pi/1440 \cdot t_i) - (0.30 \cdot \text{sine}[4\pi/1440 \cdot t_i])\} \\ & + 1/(0.0683 + 0.00198 \cdot C_i + 5.24 \cdot 10^{-6} \cdot C_i^2)] - 1.1 \end{aligned}$$

Where:

$DOL_i$ = lower limit for the $i^{th}$ annual DO measurement in milligrams per liter (mg/L)

$t_i$ = sample collection time in minutes (Eastern Standard Time) since midnight of the $i^{th}$ annual DO measurement

$C_i$ = water temperature associated with the $i^{th}$ annual DO measurement in °C

The SSAC is assessed based on a comparison between the annual average measured DO concentration and the average of the corresponding DO limits specified by the above equation. DO excursion results for individual stations are provided in Appendix 3A-3 of this volume.

Because DO is assessed as an annual station average rather than as point measures, there were insufficient data to confidently apply the binomial hypothesis test to the regional assessment units. Therefore, excursion categories for DO were assigned based on a five-year period of record (WY2005–WY2008) for all areas. Dissolved oxygen was categorized as a concern for the Refuge interior and WCA-2 interior (**Table 3A-4**). Additionally, DO was categorized as a potential concern for inflows to the Refuge. No conclusions regarding differences (trends) in DO excursion rates between individual water years and the previous periods can or should be made, given the large disparity in sample sizes among time periods.

The majority of interior marsh stations failing to achieve the SSAC during WY2008 are located within phosphorus impacted areas (e.g., E1, F2, CA224, Z1, and X1); that is, areas with long-term surface water TP above 10 parts per billion (ppb) and sediment TP concentrations in excess of 500 milligrams per kilogram (mg/kg). The FDEP recognizes that DO impairments in the phosphorus impacted areas are related to biologically impaired conditions caused by the phosphorus enrichment (Weaver, 2004). Phosphorus levels in excess of the numeric phosphorus criterion produce a variety of system changes in the Everglades that ultimately depress the DO regime in the water column (Payne et al., 2000, 2001; Weaver, 2004).

To achieve the level of nutrients necessary to meet the phosphorus standard, the District is implementing a comprehensive restoration program through the Long-Term Plan (see Chapter 8 of this volume). Dissolved oxygen levels at the nutrient impacted sites are expected to remain below the SSAC levels until phosphorus concentrations in surface water and sediment are reduced and the biological communities recover. For marsh sites with TP concentrations less than 10 micrograms per liter (µg/L), the only excursion of the DO SSAC occurred at LOX16 in the Refuge. The cause of this exceedance is uncertain, although phosphorus enrichment does not appear to be a major factor.

## Alkalinity and pH

The current Class III water quality criterion specifies that alkalinity shall not be lowered below 20 milligrams of calcium carbonate per liter (mg $CaCO_3$/L). Excursions from this water quality criterion have historically occurred in the interior of the Refuge (Bechtel et al., 1999, 2000; Weaver et al., 2001, 2002, 2003; Weaver and Payne, 2004, 2005, 2006; Weaver et al., 2007). Similar to previous years, alkalinity was designated as a concern for the interior of the Refuge for WY2008 due to an excursion rate of 22.4 ± 4.9 percent (**Tables 3A-2** and **3A-4**). However, as discussed in previous SFERs (e.g., Weaver and Payne, 2004; Weaver et al., 2007), the interior of the Refuge is hydrologically dominated by rainfall, which is naturally low in alkalinity. Therefore, the FDEP considers the low alkalinity values to be representative of the natural range of variability within the Refuge and, therefore, these should not be considered violations of state water quality standards. Excursion rates for alkalinity in the interior of the Refuge during WY2008 were very similar to previous periods in which excursion rates of 24.8 percent, 24.2 percent, and 16.1 percent were reported for the baseline, Phase I (WY1994–WY2004), and Phase II (WY2005–WY2008) periods, respectively.

Although pH was categorized as a minimal concern for the Refuge interior based on the aggregated regional analysis, all of the excursions occurred at seven of the 26 monitoring sites in the Refuge interior (i.e., LOX3, LOX5, LOX7, LOX8, LOX11, LOXA108, and LOXA137). Since the pH excursions within the interior of the Refuge generally occur at sites well away from the influence of inflows and have been linked to natural low background alkalinity conditions, as described in previous consolidated reports, the FDEP does not consider the observed pH excursions within the interior of the Refuge to be in violation of state water quality standards.

## Specific Conductance

The current state water quality criteria for Class III fresh waters, which allows for a 50 percent increase in the specific conductance, or 1,275 micromhos per centimeter (µmhos/cm), whichever is greater, is meant to preserve natural background conditions and protect aquatic organisms from stressful ion concentrations. Given that background conductivities are low within the EPA, excursions were calculated using the 1,275 µmhos/cm criterion (Weaver et al., 2001, 2002).

For WY2008, conductivity was categorized as a minimal concern for Refuge inflows and a potential concern for the WCA-2 inflows and interior sites (**Tables 3A-3** and **3A-4**). Site specifically, specific conductance was categorized as a concern for the S-363 inflow to the Refuge and the G-335 inflow to WCA-2, as well as the WCA-2 interior sites E1, F1, F2, F3, CA27, and CA28, due to higher excursion rates based on an evaluation of the last five water years. Previous ECRs and SFERs explained that the elevated conductivity levels at water control structures (e.g., S-362 and G-335) and stations near canal inflows (e.g., CA27, F1) were probably linked to groundwater intrusion into canal surface waters (Weaver et al., 2001, 2002). This groundwater intrusion can occur due to seepage into canals via pumping station operation (which can pull additional groundwater into surface water), and as a result of agricultural dewatering practices.

The majority of the exceedances of the specific conductance criteria at WCA-2 interior sites E1, F1, F2, and F3 during WY2008 and the last five water years occurred during periods of no recorded flows through the upstream structures (i.e., S-10A, S-10C, and S-10D). The excursions during these periods may be related to either the concentration of ions associated with the evaporation of marsh water or the seepage of groundwater into the WCA-2 marsh, practically at sites nearest the canal (i.e., E1 and F1). Recent studies south of the S-10 structures support the hypothesis that groundwater seepage occurs during dry periods (Krest and Harvey, 2003).

The frequency of specific conductance excursions in WCA-2 inflows declined significantly from the 25.2 and 9.3 percent for the baseline and Phase I periods, respectively, to 8.6 percent in WY2008. Likewise, the excursion frequency for Refuge inflows fell from 39.6 and 14.4 percent during the baseline and Phase I periods, respectively, to 3.6 percent in WY2008. The reductions in specific conductance excursions in inflows to the northern EPA are most likely related to reduced inflow volumes during WY2008. Reductions in inflow volumes would have likely reduced the amount and frequency of high conductivity canal water entering the EPA, thus reducing the exceedance frequency.

Although the dramatic WY2008 reductions in specific conductance excursions are most likely linked to hydrologic conditions, these reductions are also part of a steady long-term decrease in specific conductance within the Refuge and WCA-2 inflows since WY1979 (**Figure 3A-7**). In fact, median annual specific conductance levels in Refuge inflows have decreased by 200 to 300 μmhos/cm over the period of record. Similarly, specific conductance has decreased by approximately 100 μmhos/cm in WCA-2 inflows over the same period.

## Pesticides

The District has maintained a pesticide monitoring program in South Florida since 1984. The pesticide monitoring network includes sites designated in the Park Memorandum of Agreement (MOA), the Miccosukee Tribe MOA, the Lake Okeechobee Operating Permit, and the non-ECP permit. The current monitoring program in the EPA consists of 21 sites and is conducted on a quarterly basis (**Figure 3A-8**). These sites were grouped by basin for analysis.

Surface water concentrations of pesticides are regulated under criteria established in Chapter 62-302, F.A.C. Chemical-specific numeric criteria for a number of pesticides and herbicides (e.g., DDT, endosulfan, and malathion) are listed in Section 62-302.530, F.A.C. Compounds not specifically listed, including many contemporary pesticides (e.g., ametryn, atrazine, and diazinon), are evaluated based on acute and chronic toxicity. A set of toxicity-based guidelines for non-listed pesticides was presented in the 2001 ECR (Weaver et al., 2001). These guideline concentrations were developed based on the requirement in Subsection 62-302.530(62), F.A.C., which calls for Florida's surface waters to be free from "substances in concentrations, which injure, are chronically toxic to, or produce adverse physiological or behavioral response in humans, plants, or animals."

This chapter analyzes data collected during pesticide monitoring events conducted from May 2007–March 2008. The POR was selected as an update to the 2008 SFER – Volume I, Chapter 3A, and reflects the availability of data at the time this report was written. Monitoring results were evaluated relative to Class III water quality criteria, chronic toxicity guidelines, and detected concentrations. Pesticides exceeding either the Class III criteria or chronic toxicity guideline concentrations were classified as a concern for the basin in which the exceedance occurred.

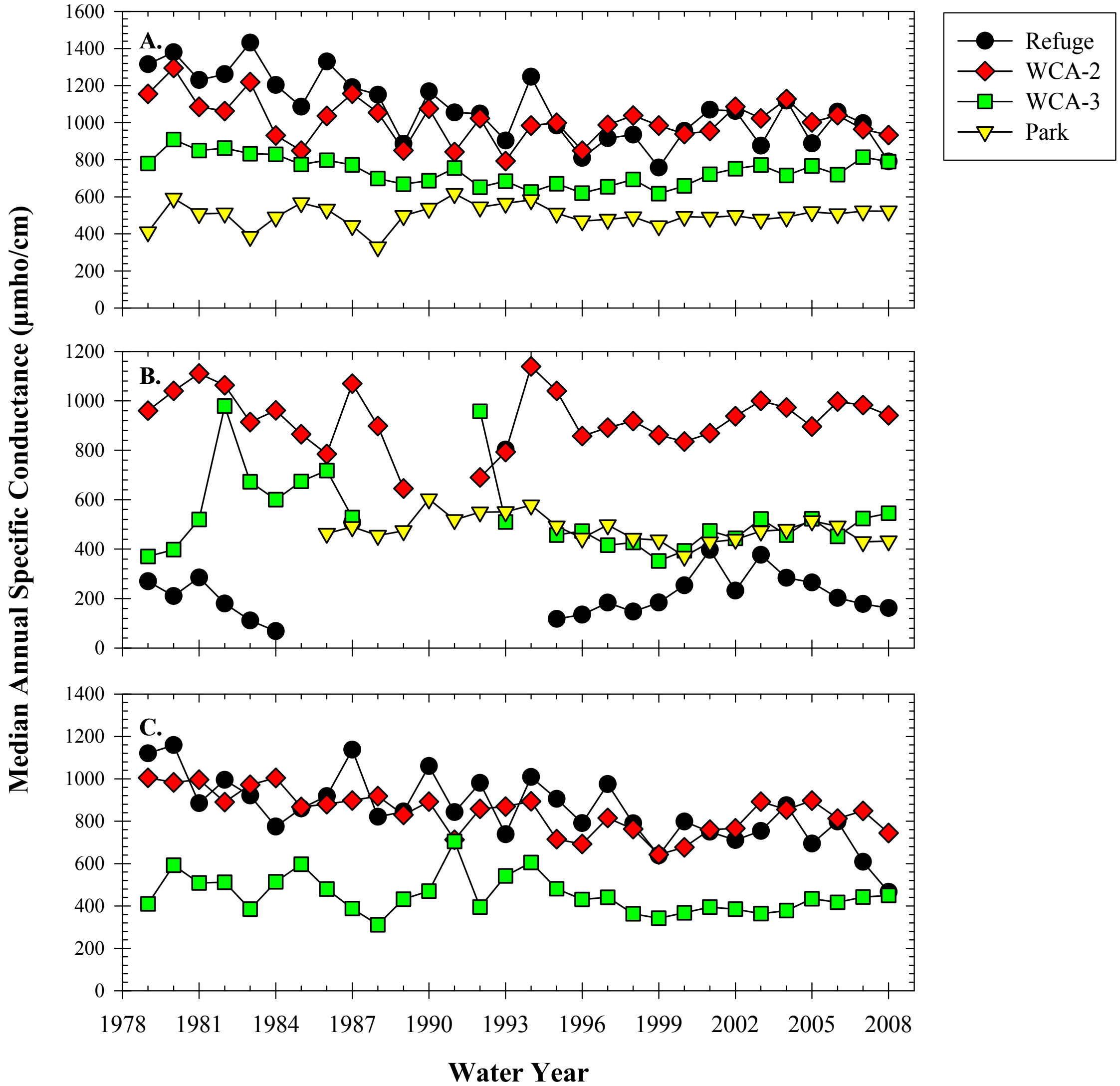



**Figure 3A-7.** Annual median specific conductance levels in the EPA (panel A) inflows, (panel B) interior, and (panel C) outflows for the period from WY1978–WY2008.

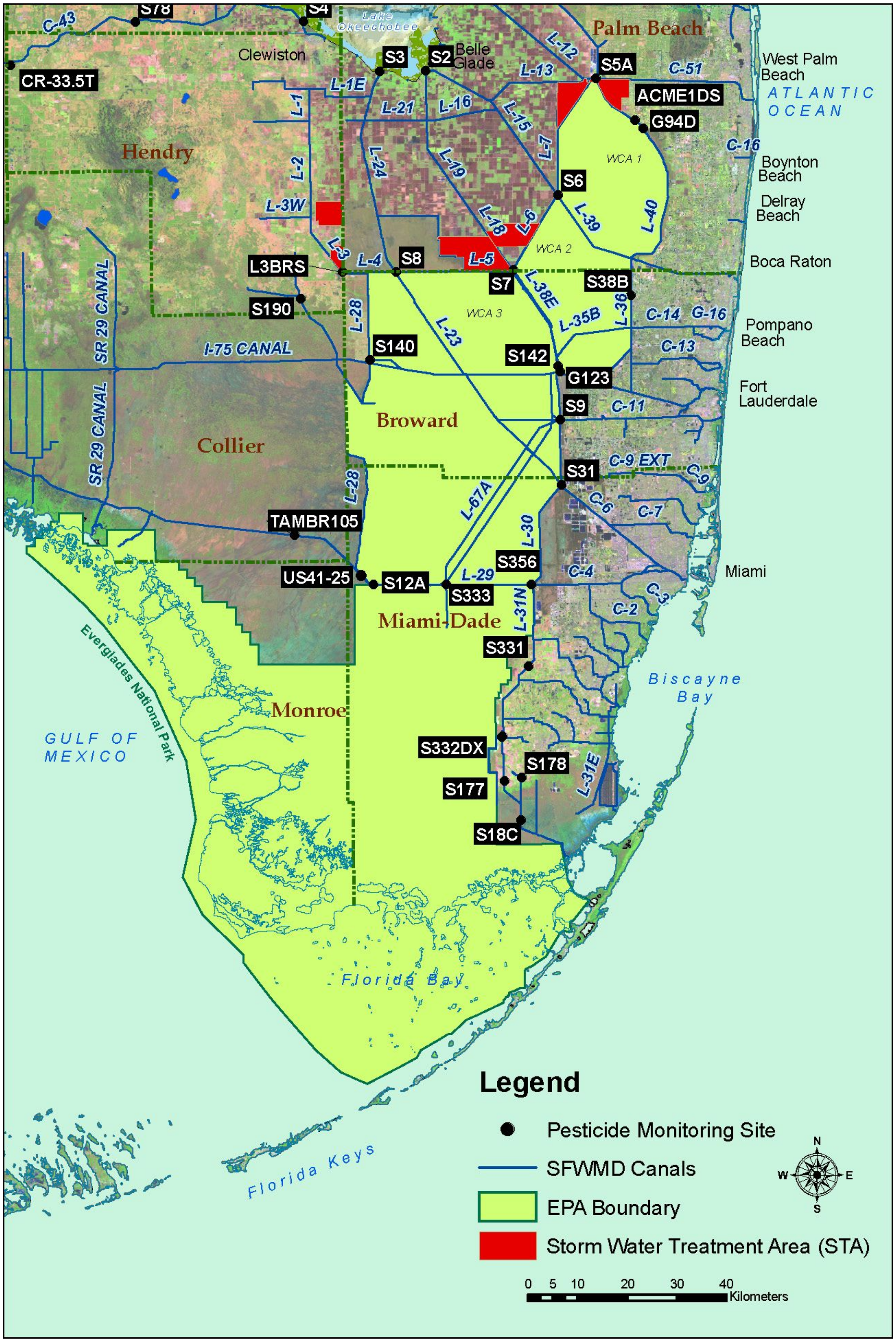



**Figure 3A-8.** Pesticide monitoring sites in the EPA.

Parameters classified as "concerns" have a likelihood of resulting in an impairment of the designated use of the water body. Detected water quality constituents ( ≥ MDL) that did not exceed either a guideline or criterion were categorized as a "potential concern." This classification signifies that the water quality constituent is known to be present within the basin at concentrations reasonably known to be below levels that can result in adverse biologic effects, but may only result in a problem at some future date or in interaction with other compounds. The "no concern" category was used to designate pesticides that were not detected at sites within a given area.

During the WY2008 period, nine pesticides [i.e., atrazine, ametryn, hexazinone, simazine, norflurazon, metribuzin, chlorpyrifos ethyl, 2,4-dichlorophenoxy acetic acid (2-4-D), and endosulfan sulfate] were detected at levels above the MDL within the EPA (see **Table 3A-5**). Only atrazine and chlorpyrifos ethyl exceeded the toxicity guideline concentrations.

The atrazine concentrations in six samples collected during WY2008 exceeded the 1.8 µg/L guideline concentration with levels ranging from 2.0 to 6.9 µg/L. Samples exceeding the atrazine guideline concentration were collected at station S-5A inflow station to STA-1W on May 17, 2007, and March 20, 2008; S-7 on March 19, 2008; S-38B on May 17, 2007; L3BRS on March 19, 2008; and G-335 on March 20, 2008. The maximum atrazine concentration of 6.9 µg/L was measured at the S-5A inflow structure to STA-1W on May 17, 2007. In addition, a chlorpyrifos ethyl concentration of 0.01 µg/L measured at S-177 on December 10, 2007, exceeded the toxicity based guideline of 0.001 µg/L.

**Table 3A-5**. Pesticide detection and exceedance categories in the EPA inflows, canals, and structures between May 2007 and March 2008. The categories of "concern" and "potential concern" are denoted by "C" and "PC," respectively; all others are considered "no concern." Number of detections and total number of samples are in parentheses. Typical Method Detection Limit (MDL) values are the median MDLs for the given period of record.

| Parameter | Refuge[1] | WCA-2[2] | WCA-3[3] | Park[4] | C-111[5] | Typical MDL (µg/L) |
|---|---|---|---|---|---|---|
| Ametryn | PC (11:12) | PC (10:10) | PC (8:30) | (0:8) | (0:7) | 0.0095 |
| Atrazine | C (12:12) | C (13:13) | C (14:27) | PC (3:9) | PC (1:9) | 0.0095 |
| Chlorpyrifos ethyl | (0:24) | (0:20) | (0:60) | (0:18) | C (2:18) | 0.0095 |
| 2-4-D | PC (1:10) | (0:8) | (0:20) | (0:6) | (0:9) | 0.2 |
| Endosulfan sulfate | (0:6) | PC (1:6) | (0:15) | (0:4) | (0:2) | 0.0046 |
| Endosulfan (alpha + beta) | (0:6) | (0:6) | (0:15) | (0:4) | PC (1:2) | 0.0038 |
| Hexazinone | PC (9:12) | (0:10) | (0:30) | (0:9) | (0:9) | 0.01 |
| Metribuzin | PC (1:12) | PC (2:10) | PC (2:30) | (0:8) | (0:7) | 0.02 |
| Norflurazon | (0:12) | (0:10) | PC (6:30) | (0:9) | (0:9) | 0.019 |
| Simazine | PC (1:12) | PC (3:10) | PC (3:30) | (0:8) | (0:7) | 0.0095 |

1. ACME1DS, G-94D, and S-5A (via STA-1W)
2. S-38B, S-6 (via STA-2), and S-7
3. G-123, L3BRS, S-140, S-190, S-8, S-9, S-142, and S-31
4. S-12C, S-18C, and US41-25
5. S-176, S-177, S-178, and S-331

## Sulfate

The sulfate monitoring results for the EPA are presented in this chapter to provide an overview of current concentrations and evaluate temporal and spatial patterns. Sulfate in the surface waters of the Everglades is derived from a variety of natural and human sources. Chapter 3B of this volume and its appendices summarize the current state of scientific understanding and uncertainties of the effects of sulfate on the ecology and biogeochemical processes of the Everglades.

Currently, the state of Florida has no surface water criterion nor has the USEPA issued any guidance for sulfate ($SO_4^{2-}$). However, recent research has provided evidence of a link between sulfur biogeochemistry in sediment and pore water and mercury methylation (Atkeson and Parks, 2002; Atkeson and Axelrad, 2003; Axelrad et al., 2005; Axelrad et al., 2006).

Sulfate concentrations are summarized in **Table 3A-6** for WY2008 and the baseline, Phase I, and Phase II periods based on median, quartile, minimum, and maximum values. Individual station summaries are included in Appendix 3A-2 of this volume.

Given that one of the primary sources of sulfate entering the EPA is runoff from the north, particularly the EAA, sulfate concentrations in the inflow and interior marsh generally follow trends similar to those observed for total phosphorus and total nitrogen; that is, sulfate concentrations exhibit a general north-to-south gradient extending from the sources in the north to relatively unenriched areas in the south (**Figure 3A-9**).

During WY2008, the highest sulfate concentrations within the EPA were observed for the Refuge and WCA-2 inflow stations. Despite elevated concentrations in the inflows, the Refuge interior has remained relatively uninfluenced by the sulfate-rich water since much of the surface water entering the Refuge remains in the rim canal around the periphery of the area and is discharged to WCA-2 through STA-2 and the S-10 structures. Among EPA marsh areas, the interior of WCA-2 is the area most affected by EAA runoff and, consequently, exhibits the highest sulfate concentrations. During WY2008, the interior sites in WCA-2 exhibited a median sulfate concentration of 15.9 mg/L compared to the lowest median concentration of 0.7 mg/L observed in the Park.

In the northern areas more directly influenced by runoff from the EAA and Lake Okeechobee discharges (i.e., the Refuge and WCA-2), the sulfate concentrations at both the inflow and interior sites measured during WY2008 were the lowest among the four monitoring periods. As discussed for other parameters, the lower sulfate concentrations in the northern EPA are likely the result of less runoff from the EAA and reduced discharges from Lake Okeechobee and the subsequent reductions in inflow volumes observed during WY2008. The sulfate concentrations in the Park inflow and interior sites during WY2008 were lower and exhibited a similar decreasing trend with median concentrations being lower than the historical periods. For WCA-3, sulfate concentrations measured in WY2008 were below the levels reported for the baseline period and more comparable to those for the Phase I and Phase II periods.

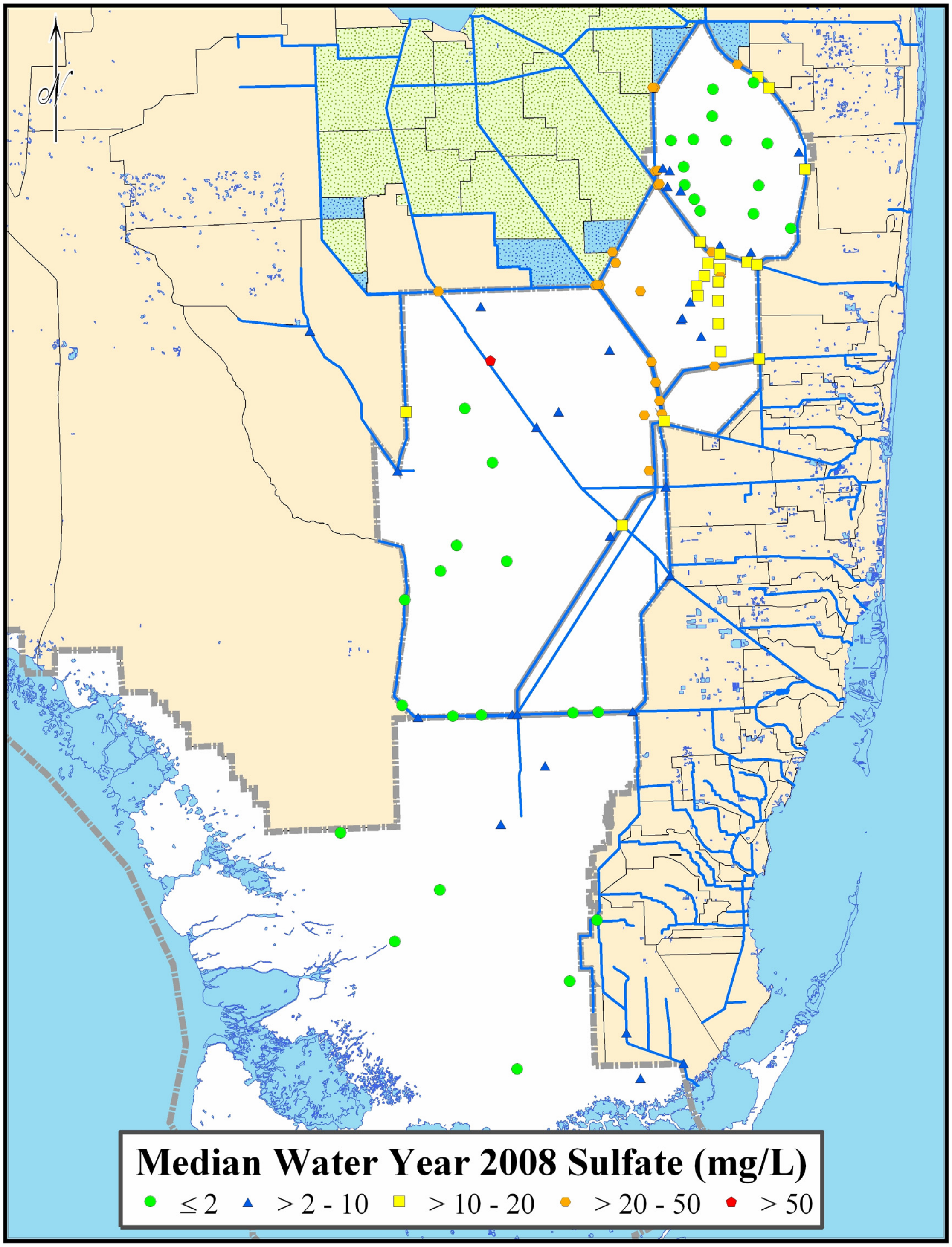



**Figure 3A-9.** Summary of median WY2008 sulfate concentrations [milligrams per liter (mg/L)] at stations across the EPA. Median sulfate concentrations are classified utilizing five levels: ≤ 2 mg/L, > 2–10 mg/L, > 10–20 mg/L, > 20–50 mg/L, and > 50 mg/L.

**Table 3A-6.** Summary of sulfate concentrations (mg/L) in the EPA for the baseline (WY1979–WY1993), Phase I (WY1994–WY2004), Phase II (WY2005–WY2008), and WY2008 periods.

| Region | Class | Period (Water Year) | N | Min. | 25th Percentile | Median | 75th Percentile | Max. |
|---|---|---|---|---|---|---|---|---|
| Refuge | Inflow | 1979–1993 | 307 | 8.3 | 39 | 61 | 90 | 436 |
| | | 1994–2004 | 589 | <0.10 | 33 | 48 | 66 | 461 |
| | | 2005–2008 | 307 | 2.4 | 31.4 | 48.3 | 64.9 | 172 |
| | | 2008 | 86 | 5 | 23.3 | 35.8 | 51.4 | 172 |
| | Rim | 1979–1993 | 84 | 2.5 | 12 | 36 | 72 | 140 |
| | | 1994–2004 | 524 | 1.6 | 38 | 50 | 69 | 140 |
| | | 2005–2008 | 134 | 7.8 | 34.3 | 45.5 | 66 | 110 |
| | | 2008 | 20 | 15 | 24.3 | 31.5 | 41.5 | 57.9 |
| | Interior | 1979–1993 | 325 | 2.5 | 5.5 | 9.8 | 16 | 663 |
| | | 1994–2004 | 2040 | <0.10 | 0.6 | 2.4 | 19 | 2900 |
| | | 2005–2008 | 1054 | 0.05 | 0.4 | 1.4 | 5.1 | 84.3 |
| | | 2008 | 217 | 0.05 | 0.05 | 0.8 | 2.8 | 45 |
| | Outflow | 1979–1993 | 158 | 7.3 | 23 | 39 | 71 | 571 |
| | | 1994–2004 | 232 | 1.4 | 28 | 41 | 58 | 419 |
| | | 2005–2008 | 86 | 2.3 | 13.7 | 27.9 | 51.7 | 85.9 |
| | | 2008 | 20 | 2.3 | 7.9 | 15.8 | 19.4 | 27.7 |
| WCA-2 | Inflow | 1979–1993 | 194 | 7.3 | 35 | 51 | 72 | 644 |
| | | 1994–2004 | 603 | 6.2 | 32 | 46 | 61 | 419 |
| | | 2005–2008 | 259 | 2.5 | 29.5 | 40.7 | 58.4 | 106 |
| | | 2008 | 60 | 2.5 | 21.4 | 30.5 | 39.9 | 64.8 |
| | Interior | 1979–1993 | 742 | 2.5 | 23 | 37 | 51 | 344 |
| | | 1994–2004 | 2884 | 0.1 | 27 | 42 | 58 | 1400 |
| | | 2005–2008 | 805 | 1.8 | 19.1 | 35 | 50 | 200 |
| | | 2008 | 204 | 1.8 | 7.8 | 15.9 | 35.4 | 200 |
| | Outflow | 1979–1993 | 209 | 2.5 | 23 | 36 | 49 | 224 |
| | | 1994–2004 | 190 | 2.3 | 19 | 28 | 37 | 73 |
| | | 2005–2008 | 97 | 4.5 | 25.3 | 36.3 | 48.2 | 86.1 |
| | | 2008 | 20 | 4.5 | 10.6 | 23.9 | 37.2 | 41.4 |
| WCA-3 | Inflow | 1979-1993 | 580 | 1 | 11 | 22 | 45.0 | 286 |
| | | 1994-2004 | 568 | 0.5 | 7.6 | 14 | 28.0 | 73 |
| | | 2005-2008 | 284 | 0.05 | 6.3 | 15.1 | 36.5 | 86.1 |
| | | 2008 | 58 | 0.05 | 6.7 | 11.9 | 30.6 | 55.7 |
| | Interior | 1979-1993 | 459 | 2 | 6.3 | 11 | 17.0 | 262 |
| | | 1994–2004 | 1890 | <0.10 | 1.3 | 3.4 | 10.0 | 120 |
| | | 2005–2008 | 796 | 0.05 | 1.1 | 3.0 | 15.7 | 110 |
| | | 2008 | 125 | 0.05 | 0.4 | 3.2 | 20.5 | 110 |

**Table 3A-6.** Continued.

| Region | Class | Period (Water Year) | N | Min. | 25th Percentile | Median | 75th Percentile | Max. |
|---|---|---|---|---|---|---|---|---|
| WCA-3 | Outflow | 1979–1993 | 278 | 1.0 | 6.7 | 13 | 21 | 113 |
| | | 1994–2004 | 300 | <0.10 | 0.27 | 1.7 | 8.5 | 36 |
| | | 2005–2008 | 160 | 0.05 | 0.1 | 1.1 | 10.9 | 69.3 |
| | | 2008 | 34 | 0.05 | 0.2 | 1.5 | 7.8 | 19.4 |
| Park | Inflow | 1979–1993 | 265 | 1.0 | 6.6 | 12 | 21 | 113 |
| | | 1994–2004 | 284 | <0.10 | 0.49 | 2.2 | 8.1 | 36 |
| | | 2005–2008 | 129 | 0.05 | 0.2 | 1.6 | 9.3 | 35.8 |
| | | 2008 | 22 | 0.05 | 0.2 | 1.1 | 8.7 | 19.4 |
| | Interior | 1979–1993 | 568 | 0.75 | 2.5 | 4.3 | 7.3 | 206 |
| | | 1994–2004 | 980 | <0.10 | 1.0 | 2.2 | 4.9 | 403 |
| | | 2005–2008 | 267 | 0.05 | 0.5 | 1.7 | 4.6 | 242 |
| | | 2008 | 55 | 0.05 | 0.1 | 0.7 | 2.6 | 147 |

# PHOSPHORUS AND NITROGEN IN THE EVERGLADES PROTECTION AREA

As primary nutrients, phosphorus and nitrogen are essential to the existence and growth of aquatic organisms in surface waters. The native flora and fauna in the Everglades, though, are adapted to successfully exist under nutrient-poor conditions — hence, relatively small additions of nutrients, especially of phosphorus, have dramatic effects on the ecosystem.

Until recently, phosphorus and nitrogen concentrations in EPA surface water were only regulated by the Class III narrative criterion. The narrative criterion specifies that nutrient concentrations in a water body cannot be altered to cause an imbalance in the natural populations of aquatic flora or fauna. Because of the importance of phosphorus in controlling the natural biological communities, the FDEP has numerically interpreted the narrative criterion, as directed by the EFA, to establish a 10.0 μg/L TP criterion for the EPA.

In addition to presenting analyses of individual TP and TN levels, this chapter provides an evaluation of spatial and temporal trends in nutrient levels within the EPA as measured during WY2008 and compares the results to those from previous monitoring periods to provide an overview.

## Total Phosphorus Concentrations in the Everglades Protection Area

One of the primary objectives of this chapter is to document temporal changes in TP concentrations across the EPA using long-term geometric means to summarize and compare TP concentrations in accordance with the EFA and TP criterion rule requirements. The EFA and TP criterion were designed to provide long-term, ecologically protective conditions and, therefore, require the use of geometric means. This methodology accounts for short-term variability in water quality data to provide a more reliable, long-term value for assessing and comparing the status of phosphorus.

**Figures 3A-10** through **3A-13** illustrate the temporal changes in annual geometric mean TP concentrations during the POR from WY1978–WY2008 at inflow and interior sites as well as in each portion of the EPA, including the Refuge, WCA-2, WCA-3, and the Park. The figures also provide the geometric mean TP concentrations for the baseline, Phase I, and WY2005–WY2008 periods for comparison.

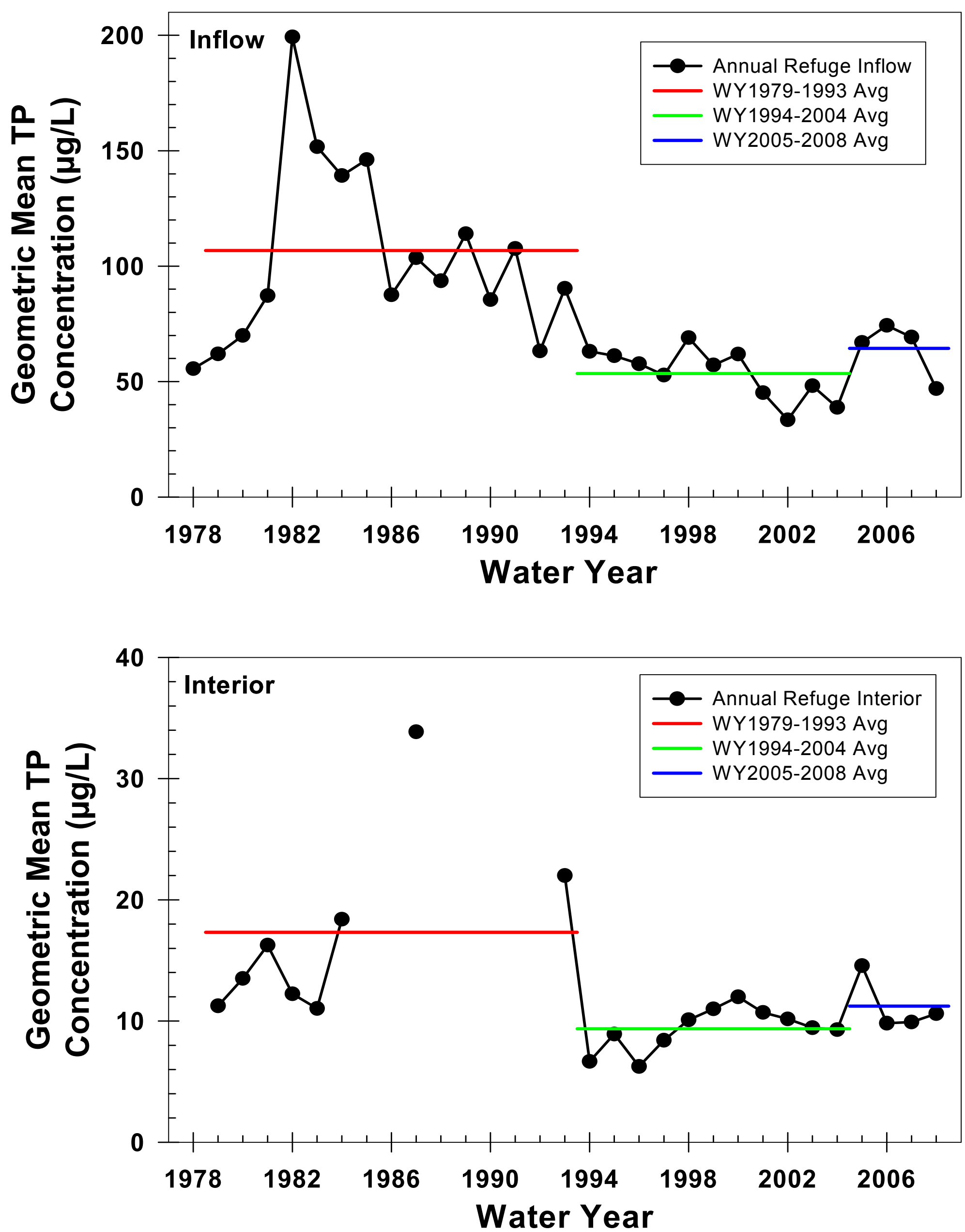



**Figure 3A-10.** Annual geometric mean TP concentrations [micrograms per liter (µg/L)] for inflow (upper graph) and interior (lower graph) areas of the Refuge from WY1978–WY2008. The horizontal lines indicate the average annual geometric mean TP concentrations for the WY1979–WY1993, WY1994–WY2004, and WY2005–WY2008 periods.

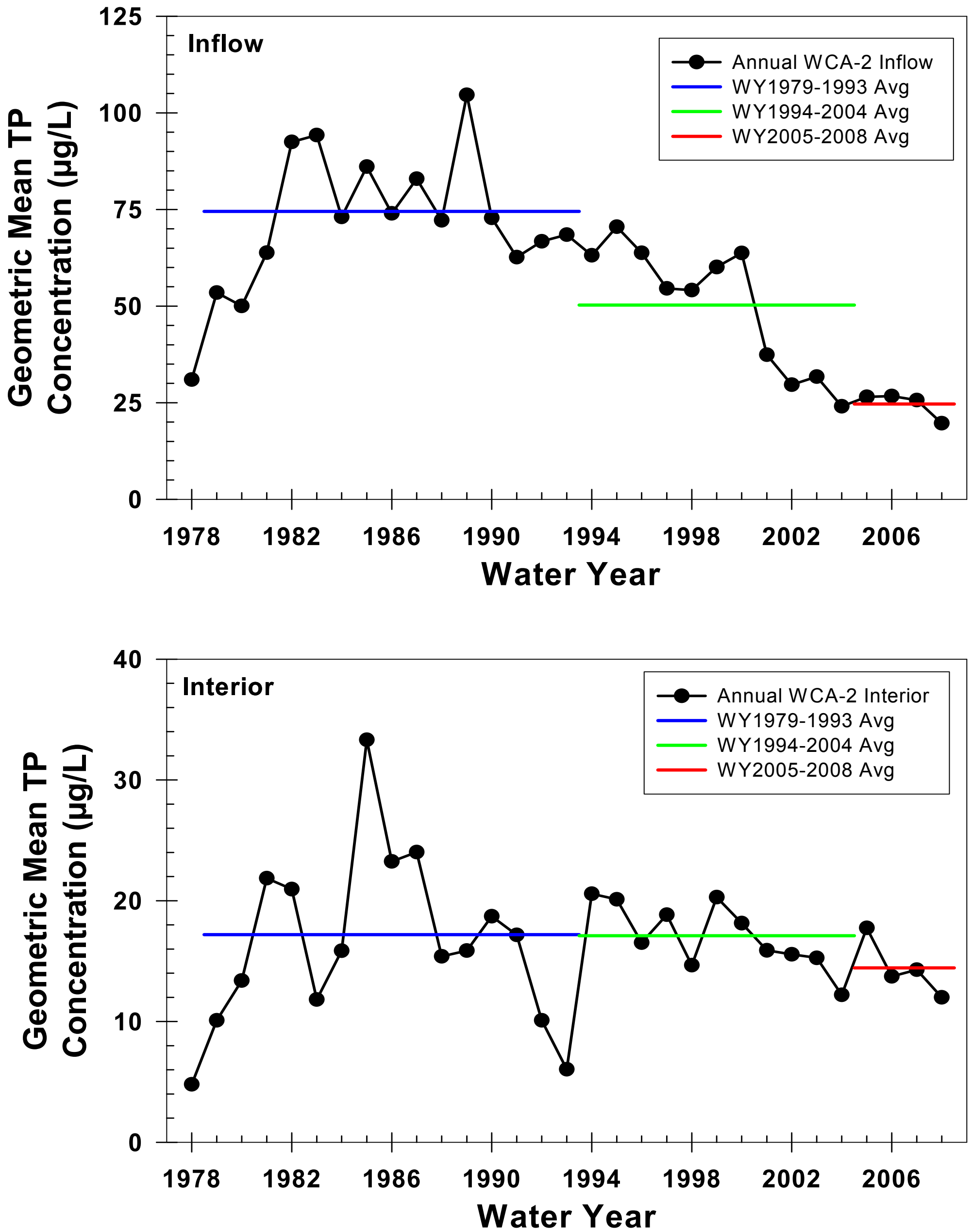



**Figure 3A-11.** Annual geometric mean TP concentrations (µg/L) for inflow (upper graph) and interior (lower graph) areas of WCA-2 from WY1978–WY2008. The horizontal lines indicate the average annual geometric mean TP concentrations for the WY1979–WY1993, WY1994–WY2004, and WY2005–WY2008 periods.

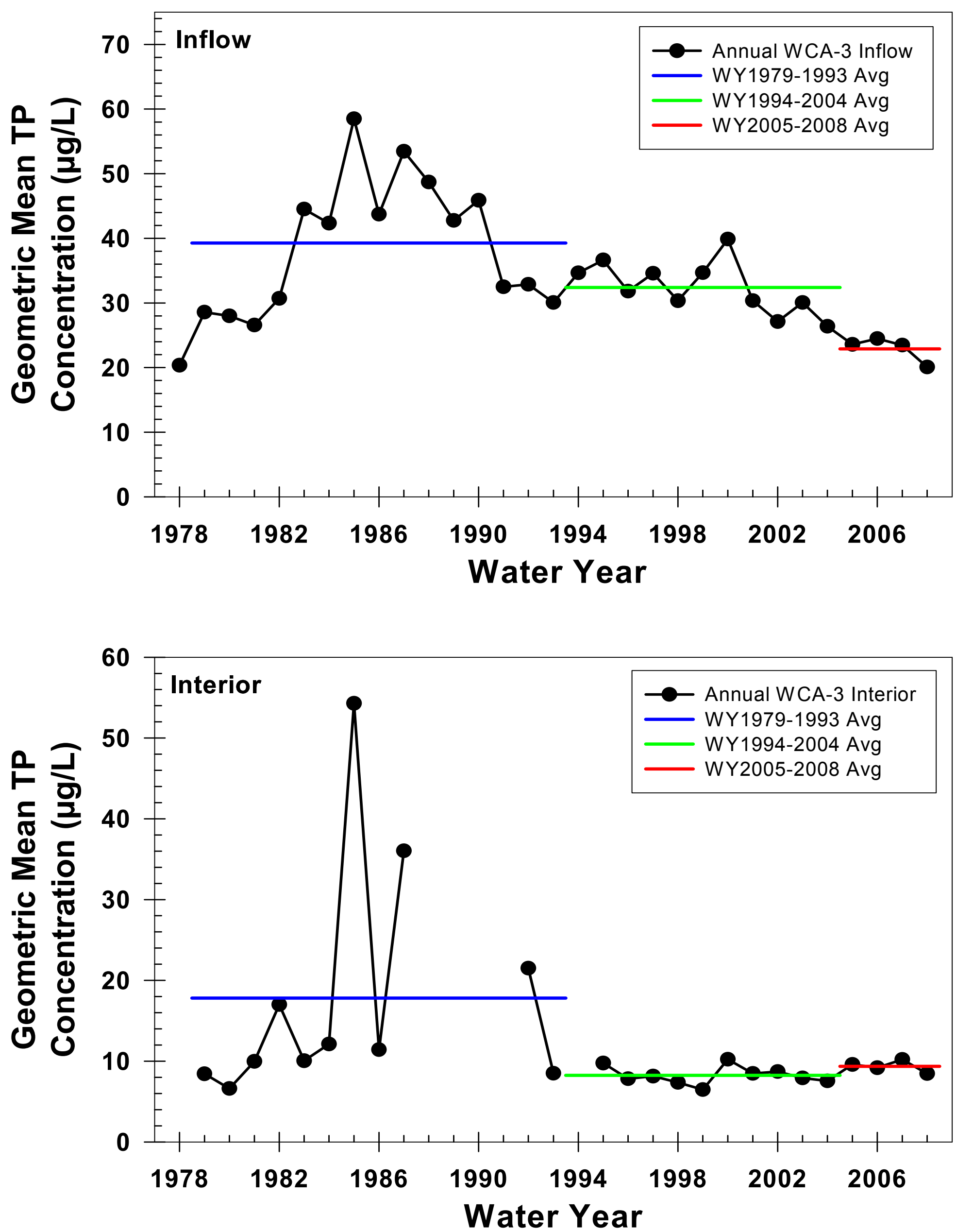



**Figure 3A-12.** Annual geometric mean TP concentrations (µg/L) for inflow (upper graph) and interior (lower graph) areas of WCA-3 from WY1978–WY2008. The horizontal lines indicate the average annual geometric mean TP concentrations for the WY1979–WY1993, WY1994–WY2004, and WY2005–WY2008 periods.

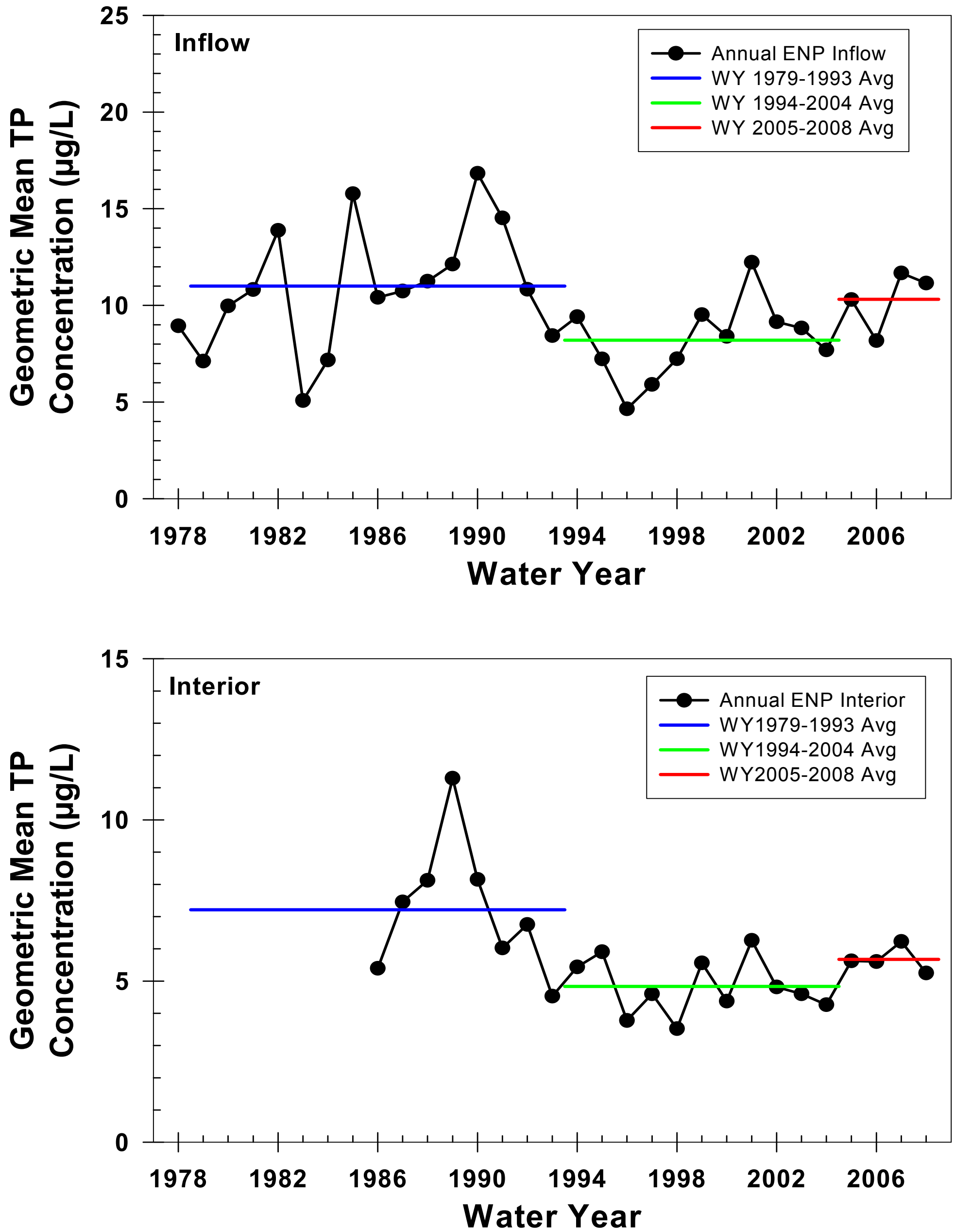



**Figure 3A-13.** Annual geometric mean TP concentrations (µg/L) for inflow (upper graph) and interior (lower graph) areas of the ENP from WY1978–WY2008. The horizontal lines indicate the average annual geometric mean TP concentrations for the WY1979–WY1993, WY1994–WY2004, and WY2005–WY2008 periods.

**Table 3A-7** provides a summary of the TP concentrations measured within different portions of the EPA during WY2008, and the baseline, Phase I, and WY2005–WY2008 periods using both geometric mean and median values.

During the baseline period, annual geometric mean TP concentrations at inflow and interior marsh sites across the EPA reached peak historic levels and were highly variable, as shown in **Figures 3A-10** through **3A-13**. As the agricultural Best Management Practices and Stormwater Treatment Area programs were initiated and became operational during the Phase I period, annual mean TP concentrations at inflow and interior sites within all portions of the EPA were reduced markedly and became less variable compared to levels observed during the baseline period. As the performance of the BMPs and STAs continue to be optimized and enhanced during the Phase II period, the TP concentrations for the inflow and interior sites within the EPA have shown mixed results.

Total phosphorus levels during the WY2005–WY2008 period have been dramatically influenced by climatic extremes. These extremes include the influence of both active hurricane seasons with intense rainfall, and periods of extended drought with little or no rainfall and subsequent marsh dryout. In general, the greatest effect from the climatic extremes was experienced during WY2005 and WY2006 when tropical activity (e.g., Hurricane Wilma) resulted in elevated inflow concentrations in concert with storm damage to STA vegetative communities that resulted in decreased STA nutrient removal for many months. WY2005 was also affected by prolonged periods of marsh dryout because of sharply decreased rainfall that resulted in increased oxidation of the organic sediment and the subsequent release of phosphorus into the water column, resulting in elevated TP concentrations observed at marsh sites across the EPA.

During WY2006, much of the EPA experienced varying levels of recovery from the WY2005 climatic effects. However, TP levels in portions of the EPA were again influenced by extended periods of limited rainfall and the subsequent marsh dryout experienced during much of WY2007 and WY2008 (**Figures 3A-10** through **3A-13)**. As the Phase II BMP/STA implementation period is expanded, the results will most likely be influenced less by single atypical years (e.g., WY2005) and the long-term effects of continuing restoration efforts will become more clear.

As documented for previous years, TP concentrations measured during WY2008 exhibited a general decreasing north-to-south gradient, with the highest levels present in the inflow to the Refuge and concentrations decreasing to a minimum within the Park. This gradient results from the phosphorus-rich canal discharges, composed primarily of agricultural runoff originating in the EAA, entering the northern portions of the EPA. Settling, sorption (both adsorption and absorption), biological assimilation, and other biogeochemical processes result in decreasing concentrations as the water flows southward through the marsh.

Total phosphorus concentrations in the northern portions of the EPA (i.e., Refuge and WCA-2) during WY2008 generally continued to decrease following the elevated concentrations observed in WY2005. Annual geometric mean inflow TP concentrations during WY2008 ranged from 46.9 µg/L for the Refuge to 11.2 µg/L in the Park with the inflow levels for the Refuge, WCA-2, and WCA-3 being the lowest of the four monitoring periods (**Table 3A-7** and **Figures 3A-10** through **3A-13**). During WY2008, the inflows to the Refuge had a geometric mean TP concentration of 46.9 µg/L compared to levels of 90.7 µg/L, 53.8 µg/L, and 61.7 µg/L found for the baseline, Phase I, and WY2005–WY2008 periods, respectively (**Table 3A-7**).

**Table 3A-7.** Summary of TP concentrations (µg/L) in the EPA for the WY1979–WY1993,WY1994–WY2004, WY2005–WY2008, and WY2008 periods.

| Region | Class | Period | Sample Size (N) | Geometric Mean (µg/L) | Std. Deviation (Geometric Mean) | Median (µg/L) | Min. (µg/L) | Max. (µg/L) |
|---|---|---|---|---|---|---|---|---|
| Refuge | Inflow | 1979–1993 | 1213 | 90.7 | 2.3 | 97.5 | 6.0 | 1415.0 |
| | | 1994–2004 | 1975 | 53.8 | 2.2 | 54.0 | 2.0 | 722.0 |
| | | 2005–2008 | 888 | 61.7 | 2.0 | 58.0 | 13.0 | 928.5 |
| | | 2008 | 285 | 46.9 | 2.2 | 40.0 | 13.0 | 928.5 |
| | Interior | 1979–1993 | 364 | 13.3 | 2.6 | 12.0 | 1.0 | 494.0 |
| | | 1994–2004 | 2430 | 9.6 | 1.9 | 9.0 | 2.0 | 200.0 |
| | | 2005–2008 | 1199 | 11.1 | 2.0 | 9.0 | 2.0 | 238.0 |
| | | 2008 | 311 | 10.6 | 1.9 | 9.0 | 4.0 | 171.0 |
| | Outflow | 1979-1993 | 613 | 65.0 | 2.1 | 63.0 | 8.0 | 3435.0 |
| | | 1994-2004 | 702 | 45.4 | 1.9 | 43.0 | 10.0 | 495.0 |
| | | 2005-2008 | 215 | 36.0 | 2.1 | 32.0 | 11.0 | 515.0 |
| | | 2008 | 52 | 21.9 | 1.6 | 20.0 | 13.0 | 89.0 |
| | Rim | 1979–1993 | 118 | 75.7 | 1.9 | 81.0 | 12.0 | 473.0 |
| | | 1994–2004 | 632 | 60.7 | 1.7 | 57.0 | 17.0 | 290.0 |
| | | 2005–2008 | 136 | 57.3 | 2.1 | 62.0 | 8.0 | 653.0 |
| | | 2008 | 20 | 30.5 | 1.7 | 26.0 | 18.0 | 83.0 |
| WCA-2 | Inflow | 1979–1993 | 789 | 69.8 | 2.0 | 68.0 | 10.0 | 3435.0 |
| | | 1994–2004 | 1383 | 45.0 | 2.1 | 49.0 | 7.0 | 493.0 |
| | | 2005–2008 | 620 | 24.5 | 1.9 | 21.5 | 7.0 | 245.0 |
| | | 2008 | 150 | 19.7 | 1.5 | 18.5 | 9.0 | 68.0 |
| | Interior | 1979–1993 | 1698 | 16.2 | 3.4 | 13.0 | 1.0 | 3189.0 |
| | | 1994–2004 | 3599 | 16.9 | 2.8 | 14.0 | 1.0 | 2400.0 |
| | | 2005–2008 | 1113 | 14.0 | 2.4 | 12.0 | 1.0 | 530.0 |
| | | 2008 | 360 | 12.0 | 2.1 | 10.0 | 1.0 | 250.0 |
| | Outflow | 1979–1993 | 893 | 23.2 | 2.6 | 23.0 | 1.0 | 556.0 |
| | | 1994–2004 | 682 | 17.6 | 2.2 | 17.0 | 2.0 | 199.0 |
| | | 2005–2008 | 321 | 15.8 | 1.8 | 15.0 | 6.0 | 179.0 |
| | | 2008 | 73 | 15.8 | 1.7 | 15.0 | 6.0 | 47.0 |

**Table 3A-7.** Continued.

| Region | Class | Period | Sample Size (N) | Geometric Mean (µg/L) | Std. Deviation (Geometric Mean) | Median (µg/L) | Min. (µg/L) | Max. (µg/L) |
|---|---|---|---|---|---|---|---|---|
| WCA-3 | Inflow | 1979–1993 | 2537 | 37.4 | 2.6 | 37.0 | 1.0 | 933.0 |
| | | 1994–2004 | 3325 | 31.5 | 2.3 | 30.0 | 2.0 | 1286.0 |
| | | 2005–2008 | 1643 | 22.9 | 1.9 | 21.0 | 6.0 | 288.5 |
| | | 2008 | 397 | 20.1 | 1.7 | 20.0 | 6.0 | 203.0 |
| | Interior | 1979–1993 | 628 | 10.2 | 3.2 | 10.0 | 1.0 | 438.0 |
| | | 1994–2004 | 2097 | 8.1 | 2.2 | 7.0 | 1.0 | 310.0 |
| | | 2005–2008 | 1066 | 9.3 | 2.2 | 8.0 | 2.0 | 560.0 |
| | | 2008 | 259 | 8.5 | 1.8 | 7.0 | 3.0 | 69.0 |
| | Outflow | 1979–1993 | 1971 | 12.1 | 2.3 | 11.0 | 1.0 | 593.0 |
| | | 1994–2004 | 2412 | 10.1 | 2.0 | 10.0 | 2.0 | 171.0 |
| | | 2005–2008 | 795 | 15.0 | 1.9 | 13.4 | 4.0 | 1235.1 |
| | | 2008 | 220 | 15.3 | 1.7 | 14.0 | 4.0 | 1235.1 |
| Park | Inflow | 1979–1993 | 2172 | 10.6 | 2.3 | 10.0 | 1.0 | 593.0 |
| | | 1994–2004 | 3053 | 8.0 | 1.9 | 8.0 | 2.0 | 145.0 |
| | | 2005–2008 | 1021 | 10.2 | 1.9 | 9.0 | 2.0 | 1235.1 |
| | | 2008 | 247 | 11.2 | 1.9 | 12.0 | 3.0 | 1235.1 |
| | Interior | 1979–1993 | 564 | 7.0 | 2.9 | 6.0 | 0.5 | 1137.0 |
| | | 1994–2004 | 1199 | 4.7 | 2.1 | 5.0 | 1.0 | 117.0 |
| | | 2005–2008 | 334 | 5.7 | 2.1 | 5.0 | 1.0 | 291.0 |
| | | 2008 | 86 | 5.2 | 1.7 | 5.0 | 1.0 | 31.0 |

Similarly, inflows to WCA-2 have progressively decreased from 69.8 µg/L in the baseline period to 45.0 µg/L in the Phase I period to 24.5 µg/L during WY2005–WY2008 to 19.7 µg/L for WY2008 (**Table 3A-7**). Inflow TP concentrations for WCA-3 have also exhibited continual but less dramatic decreases, dropping from 37.4 µg/L in the baseline period to 20.1µg/L in WY2008. The lower TP concentrations in the inflows to the Refuge, WCA-2, and WCA-3 during WY2008 are likely the result of multiple causes, including improved treatment by the STAs, lower stormwater volumes resulting from the drought, and general recovery from the damage resulting from the WY2005 hurricanes.

In contrast, the TP concentrations in the Park during WY2008 were influenced by recent drought conditions and low water levels. The mean TP concentration in the inflows to the Park observed for WY2008 were slightly higher than reported for the historical periods (**Table 3A-7**). The cause of these elevated inflow TP concentrations was most likely the dry conditions in upstream areas, resulting in oxidation of the sediment and subsequent release of bound phosphorus. This hypothesis is supported by the higher outflow TP concentrations recorded for WCA-3 during WY2008 (**Table 3A-7**). **Figure 3A-13** illustrates the temporal changes in annual geometric mean TP concentrations during the period of record at inflow sites for the Park.

Total phosphorus concentrations at interior sites within the EPA ranged from a maximum of 12.0 µg/L in WCA-2 to a minimum of 5.2 µg/L in the Park. During WY2008, geometric mean TP concentrations at interior sites within all portions of the EPA were generally lower than the levels measured during the baseline and WY2005–WY2008 periods and comparable to or slightly higher than levels for the Phase I period. However, the geometric mean TP concentration of 12.0 µg/L observed in the interior sites of WCA-2 during WY2008 was the lowest among the four monitoring periods (16.2 µg/L, 16.9 µg/L, and 14.0 µg/L mean concentrations recorded for the baseline, Phase I, and Phase II periods, respectively) (**Table 3A-7** and **Figure 3A-11**). The continued decreases observed in WCA-2 likely reflect both the recovery from the WY2005 hurricanes and improved conditions in the impacted portions of the marsh downstream of the S-10 structures, where the quantity of discharge has been significantly reduced and the quality of the discharge has improved since STA-2 began operation.

The annual geometric mean TP concentration across interior marsh sites in WCA-3 and the Park during WY2007 were below the 10.0 µg/L five-year limit and 11.0 µg/L annual limit for assessing achievement with the TP criterion rule. In the Refuge, the annual mean TP concentration of 10.6 µg/L is above the 10.0 µg/L five-year limit but below the 11.0 µg/L annual TP criterion limit. Although TP levels at interior sites in WCA-2 have improved in recent years, the geometric mean TP level for WY2008 (i.e., 12.0 µg/L) remains slightly above the annual 11.0 µg/L annual limit.

Annual geometric mean TP concentrations for individual interior marsh monitoring stations sampled four or more times during WY2008 ranged from less than 4.0 µg/L in some unimpacted portions of the marsh to 61 µg/L at a Refuge site highly influenced by canal inputs. Across the entire EPA, 66.3 percent of the interior marsh sites exhibited annual geometric mean TP concentrations of 10.0 µg/L or less, with 81.4 percent of the interior sites in the EPA having annual geometric mean TP concentrations of 15.0 µg/L or below during WY2008. In comparison, 40.5 percent, 67.3 percent, and 58.7 percent of the interior marsh sites exhibited geometric mean TP concentrations less than or equal to 10.0 µg/L during baseline, Phase I, and Phase II periods, respectively.

During the three historical periods, 64.7 percent, 80.2 percent, and 75.0 percent of the interior sites, respectively, had annual geometric mean concentrations of 15.0 µg/L or less. Given the relatively constant location of interior monitoring sites in recent years, the temporal comparison of statistics from individual sites can be used to distinguish changes in measured concentrations. However, it should be noted that since the existing monitoring network was not designed to allow the results to accurately estimate the percentage of the marsh exceeding a TP concentration of 10.0 µg/L (or other threshold), it is not appropriate to use the results for that purpose.

Spatially, interior marsh TP concentrations measured during WY2008 exhibited the same north-to-south gradient observed during previous periods (Bechtel et al., 1999, 2000; Weaver et al., 2001, 2002, 2003; Payne and Weaver, 2004, Payne et al., 2006, 2007, 2008). Typically, the highest TP concentrations obtained during WY2008 were collected from the northern WCAs and declined throughout WCA-3 and the Park. During WY2008, 50 percent of the monitoring sites in WCA-2 had annual geometric mean TP concentrations of 10.0 µg/L or less, with an increase to 100 percent in the Park (**Figure 3A-14**). Likewise, 57.7 percent of interior sites within WCA-2 had annual geometric mean TP concentrations of 15.0 µg/L or less during WY2008, increasing to 100 percent in the Park. A detailed, site-specific summary of the TP concentrations for WY2008 is provided in Appendix 3A-4 of this volume.

The distribution of TP concentrations in samples collected at inflow, interior, and outflow stations from each EPA region for WY2008 is presented in **Figure 3A-15,** along with a comparison of the concentrations measured in samples reported for the baseline, Phase I, and Phase II periods. Future SFERs are expected to continue tracking long-term trends in phosphorus levels throughout the EPA.

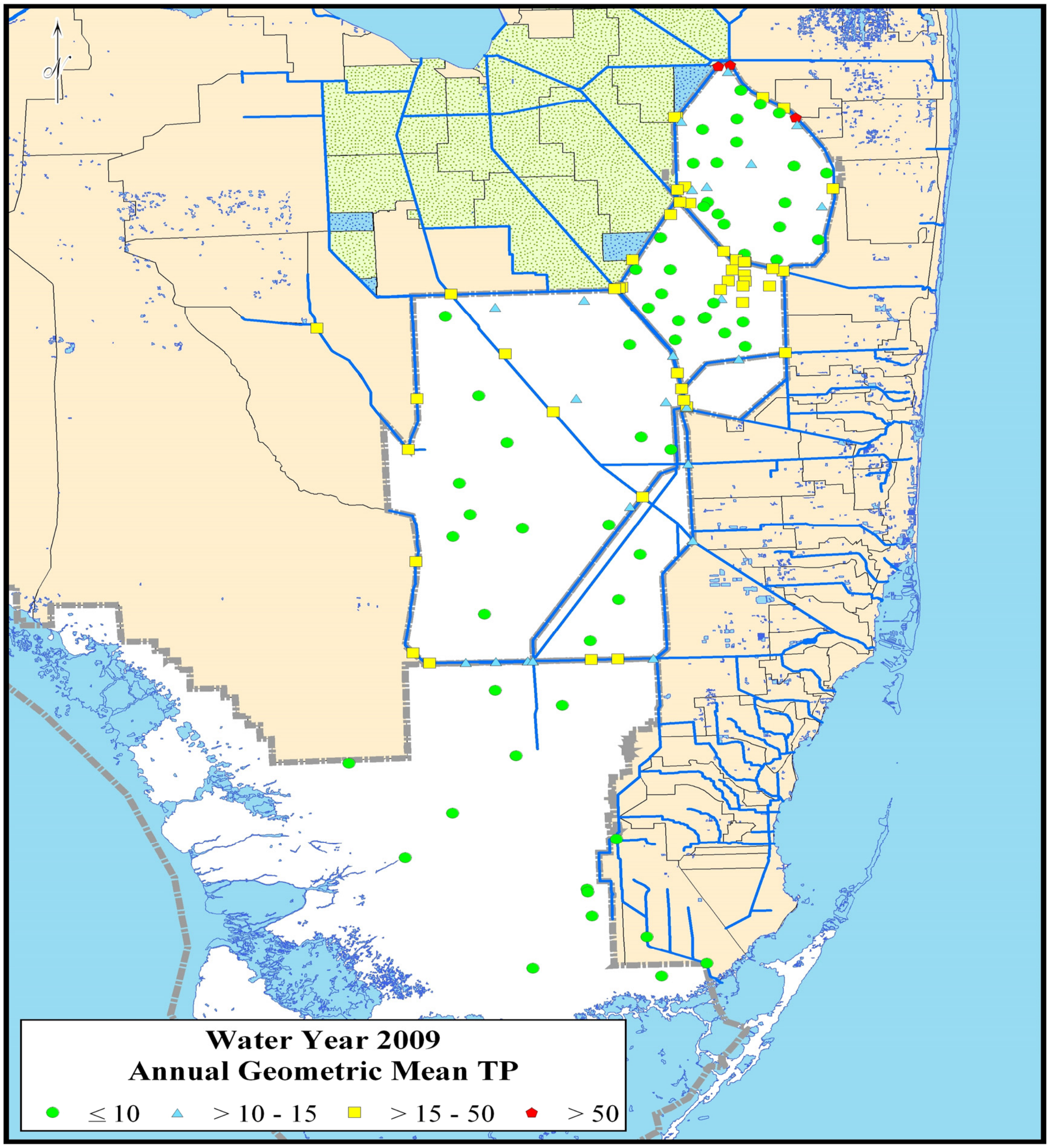



**Figure 3A-14.** Summary of geometric mean TP concentrations (µg/L) for WY2008 at stations across the EPA. Geometric mean TP concentrations are classified utilizing four levels: ≤ 10 µg/L, > 10–15 µg/L, > 15–50 µg/L, and > 50 µg/L.

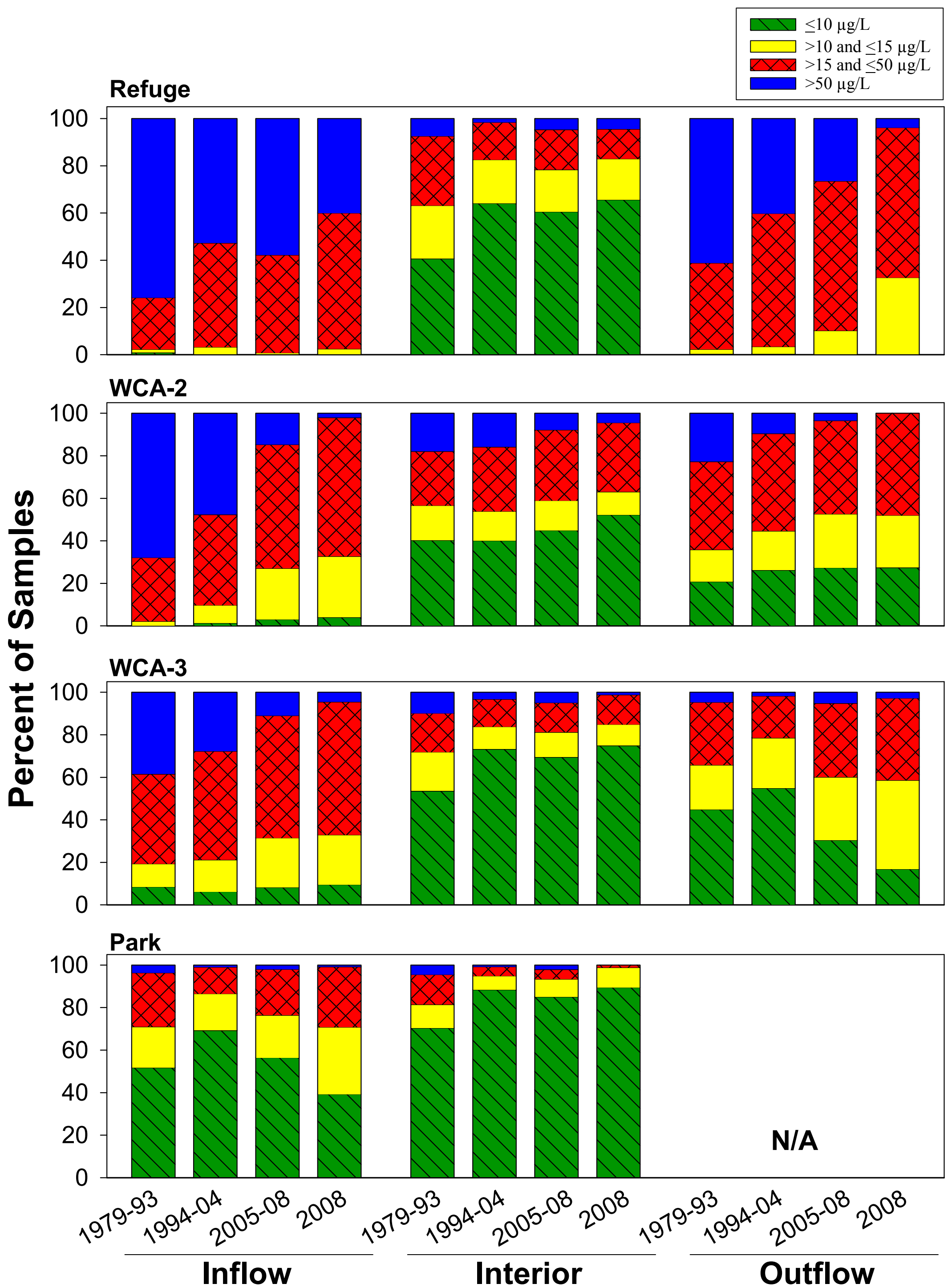



**Figure 3A-15.** Comparison of TP concentrations (µg/L) measured in samples collected in the EPA during the WY1979–WY1993, WY1994–WY2004, WY2005–WY2008, and WY2008 periods. N/A = Not available. Outflow is not monitored for the Park.

## Orthophosphate Concentrations In The Everglades Protection Area

Orthophosphate (OP) is an inorganic, soluble form of phosphorus readily utilized by biological organisms and, therefore, has the greatest and most rapid effect on the Everglades ecosystem. During WY2008, OP concentrations in the inflows to all areas within the EPA were dramatically lower than the levels observed during the baseline, Phase I, and Phase II periods (**Table 3A-8**) ranging from 6.0 µg/L in the Refuge to 1.3 µg/L in WCA-3 and the Park.

The greatest decreases in OP concentrations were observed for inflow and rim canal sites in the Refuge and the inflows to WCA-2. The large decreases observed for the northern portions of the EPA likely result from multiple factors, including the recovery of the STAs following the damage resulting from the WY2005 and WY2006 active tropical seasons, and less inflow from Lake Okeechobee and the EAA, and improved STA performance, especially under low water levels.

Likewise, the OP levels at interior sites during WY2008 were low, ranging from 1.2 µg/L in the Park to 2.0 µg/L in WCA-2. The mean OP concentrations for WCA-2, WCA-3, and the Park are the lowest among the four monitoring periods. The annual mean OP concentration determined for the Refuge (1.8 µg/L) remained low and was comparable to that observed during the previous monitoring periods.

**Table 3A-8.** Summary of orthophosphate concentrations (µg/L) in the EPA for the WY1979–WY1993, WY1994–WY2004, WY2005–WY2008, and WY2008 periods.

| Region | Class | Period | Sample Size (N) | Geometric Mean (µg/L) | Std. Deviation (Geometric Mean) | Median (µg/L) | Min. (µg/L) | Max. (µg/L) |
|---|---|---|---|---|---|---|---|---|
| Refuge | Inflow | 1979–1993 | 1175 | 32.1 | 4.4 | 44 | 1 | 1106 |
| | | 1994–2004 | 1231 | 15.8 | 3.0 | 14 | 2 | 294 |
| | | 2005-2008 | 825 | 12.1 | 4.8 | 14 | 1 | 854 |
| | | 2008 | 279 | 6.0 | 5.0 | 5 | 1 | 854 |
| | Interior | 1979-1993 | 370 | 1.5 | 2.1 | 1 | 1 | 72 |
| | | 1994-2004 | 1610 | 1.8 | 2.3 | 2 | 0.5 | 380 |
| | | 2005-2008 | 854 | 2.9 | 2.2 | 2 | 1 | 193 |
| | | 2008 | 193 | 1.8 | 2.2 | 2 | 1 | 34.5 |
| | Outflow | 1979–1993 | 605 | 20.0 | 4.3 | 25 | 1 | 1290 |
| | | 1994-2004 | 691 | 14.7 | 3.0 | 13 | 2 | 383 |
| | | 2005-2008 | 217 | 6.0 | 4.2 | 4 | 1 | 461 |
| | | 2008 | 53 | 1.8 | 1.9 | 2 | 1 | 23 |
| | Rim | 1979-1993 | 118 | 28.9 | 3.2 | 35 | 1 | 408 |
| | | 1994–2004 | 408 | 20.4 | 3.2 | 24 | 0.5 | 190 |
| | | 2005–2008 | 122 | 16.0 | 4.0 | 15 | 2 | 544 |
| | | 2008 | 20 | 4.3 | 2.3 | 4 | 2 | 42 |
| WCA-2 | Inflow | 1979–1993 | 759 | 25.2 | 3.8 | 31 | 1 | 1290 |
| | | 1994–2004 | 836 | 11.6 | 3.0 | 9 | 2 | 352 |
| | | 2005–2008 | 473 | 4.5 | 3.3 | 4 | 1 | 190 |
| | | 2008 | 118 | 1.9 | 1.9 | 2 | 1 | 18 |
| | Interior | 1979–1993 | 1689 | 3.3 | 4.2 | 2 | 1 | 2398 |
| | | 1994–2004 | 2079 | 4.4 | 3.8 | 4 | 0.5 | 2790 |
| | | 2005–2008 | 817 | 3.5 | 2.6 | 2 | 1 | 405 |
| | | 2008 | 216 | 2.0 | 2.0 | 2 | 1 | 53 |
| | Outflow | 1979–1993 | 882 | 5.0 | 3.8 | 4 | 1 | 396 |
| | | 1994–2004 | 684 | 5.9 | 2.5 | 6 | 2 | 156 |
| | | 2005–2008 | 325 | 2.9 | 2.3 | 2 | 1 | 153 |
| | | 2008 | 73 | 1.5 | 1.9 | 1 | 1 | 14 |
| WCA-3 | Inflow | 1979–1993 | 2349 | 9.1 | 4.4 | 9 | 1 | 586 |
| | | 1994–2004 | 2084 | 8.8 | 3.2 | 7 | 2 | 297 |
| | | 2005–2008 | 777 | 4.0 | 2.9 | 3 | 1 | 180 |
| | | 2008 | 162 | 1.9 | 2.2 | 2 | 1 | 20 |
| | Interior | 1979–1993 | 617 | 1.9 | 2.8 | 1 | 1 | 152 |
| | | 1994–2004 | 1878 | 1.8 | 2.5 | 2 | 0.5 | 190 |
| | | 2005–2008 | 762 | 2.5 | 2.2 | 2 | 1 | 180 |
| | | 2008 | 118 | 1.3 | 1.6 | 1 | 1 | 15 |
| | Outflow | 1979–1993 | 1704 | 2.7 | 2.3 | 2 | 1 | 149 |
| | | 1994–2004 | 1603 | 2.9 | 1.7 | 2 | 2 | 97 |
| | | 2005–2008 | 515 | 2.0 | 1.6 | 2 | 1 | 70 |
| | | 2008 | 113 | 1.3 | 1.6 | 1 | 1 | 6 |

**Table 3A-8.** Continued.

| Region | Class | Period | Sample Size (N) | Geometric Mean (µg/L) | Std. Deviation (Geometric Mean) | Median (µg/L) | Min. (µg/L) | Max. (µg/L) |
|---|---|---|---|---|---|---|---|---|
| Park | Inflow | 1979–1993 | 1902 | 2.6 | 2.2 | 2 | 1 | 77 |
| | | 1994–2004 | 1913 | 2.8 | 1.7 | 2 | 2 | 97 |
| | | 2005–2008 | 569 | 2.0 | 1.6 | 2 | 1 | 20 |
| | | 2008 | 118 | 1.3 | 1.5 | 1 | 1 | 6 |
| | Interior | 1979–1993 | 546 | 2.9 | 1.9 | 2 | 2 | 63 |
| | | 1994–2004 | 1059 | 2.7 | 1.6 | 2 | 2 | 45 |
| | | 2005–2008 | 264 | 2.1 | 1.7 | 2 | 1 | 19 |
| | | 2008 | 55 | 1.2 | 1.4 | 1 | 1 | 5 |

## Phosphorus Loads to the Everglades Protection Area

The Everglades Protection Area is a complex system of marsh areas, canals, levees, and inflow and outflow water control structures covering almost 2.5 million acres. In addition to rainfall inputs, surface water inflows regulated by water control structures from agricultural tributaries, such as the EAA and the C-139 basin, feed the EPA from the northern and western boundaries. The EPA also receives surface water inflows originating from Lake Okeechobee to the north and from predominantly urbanized areas to the east. The timing and distribution of the surface inflows from the tributaries to the EPA are based on a complex set of operational decisions that account for natural and environmental system requirements, water supply for urbanized and natural areas, aquifer recharge, and flood control. It is also recognized that a certain amount of TP loading to the EPA emanates from atmospheric deposition.

The long-term average range of atmospheric deposition of TP is between 107 and 143 metric tons (mt) per year as the total contribution to the WCAs. Atmospheric TP deposition rates are highly variable, very expensive to monitor, and, as such, are not routinely monitored. The range (expressed spatially as 20–35 mg/m$^2$/yr) is based on data obtained from long-term monitoring that was evaluated by the District, as reported in Redfield (2002).

Each year, the EPA receives variable amounts of surface water inflows based on the hydrologic variability within the upstream basins. These inflows, regulated according to previously mentioned operational decisions, also contribute a certain amount of TP loading to the EPA system. **Table 3A-9** provides estimates of the flow and TP load to each portion of the EPA for WY2008. Flows and TP loads are also provided for the baseline, Phase I, and Phase II periods for comparison.

Detailed estimates of TP loads by structure for WY2008 are presented in Appendix 3A-5 of this volume. This appendix summarizes contributions from all connecting tributaries to the EPA: Lake Okeechobee, the EAA, the C-139 basin, other agricultural and urbanized areas, and the STAs. In some cases, surface water inflows represent a mixture of water from several sources as the water passes from one area to another before finally arriving in the EPA. For example, water discharged from Lake Okeechobee can pass through the EAA and then through an STA before arriving in the EPA. Similarly, runoff from the C-139 basin can pass through STA-5 and then into the EAA before ultimately arriving in the EPA.

**Table 3A-9.** Summary of average annual flow, flow-weighted mean TP concentrations, and TP loads in the EPA for the WY1979–WY1993, WY1994–WY2004, WY2005–WY2008, and WY2008 periods.

| Area | Period | Average Annual Flow (1,000 ac-ft) | Average Annual Flow-Weighted Mean TP (µg/L) | Average Annual Load (kg) |
|---|---|---|---|---|
| Refuge | WY1979–1993 | 506 | 186 | 111436 |
| | WY1994–2004 | 647 | 100 | 83977 |
| | WY2005–2008 | 310 | 113 | 43103 |
| | WY2008 | 242 | 36 | 10749 |
| WCA-2 | WY1979–1993 | 581 | 119 | 78670 |
| | WY1994–2004 | 704 | 65 | 57391 |
| | WY2005–2008 | 737 | 34 | 30695 |
| | WY2008 | 488 | 20 | 12275 |
| WCA-3 | WY1979–1993 | 1181 | 72 | 108357 |
| | WY1994–2004 | 1396 | 49 | 84335 |
| | WY2005–2008 | 1341 | 43 | 62217 |
| | WY2008 | 867 | 20 | 21037 |
| Park | WY1979–1993 | 815 | 12 | 11450 |
| | WY1994–2004 | 1477 | 9 | 15912 |
| | WY2005–2008 | 819 | 10 | 9966 |
| | WY2008 | 259 | 10 | 3046 |

As detailed in Appendix 3A-5 of this volume, TP loads from surface sources to the EPA totaled approximately 36.7 mt, with a flow-weighted mean (FWM) TP concentration of 24.0 µg/L. Another 193 mt of TP is estimated to have entered the EPA through atmospheric deposition. Surface discharges from the EPA account for approximately 9.2 mt of total phosphorus. The 36.7 mt TP load in the surface inflows to the EPA represents a decrease of approximately 61 percent compared to the previous year (WY2007 = 93.8 mt). The lower TP loads to the EPA observed during WY2008 primarily resulted from reduced flow volumes associated with the drought conditions experienced during much of WY2007 and WY2008. The 1,249,307 acre feet (ac-ft) of surface water flow to the EPA determined for WY2008 is approximately 8 percent lower than the 1,361,269 ac-ft reported for WY2007 (Payne et al., 2008).

**Figures 3A-16** through **3A-19** provide a summary of the annual flows and TP loads to each portion of the EPA for the period from WY1979 through WY2008 along with the annual averages for the baseline, Phase I, and WY2005–WY2008 (Phase II) periods. The effectiveness of the BMP and STA phosphorus removal efforts is demonstrated by the decreased TP loading to WCA-2 and WCA-3 during the WY1994–WY2004 and WY2005–WY2008 periods compared to the WY1979–WY1993 baseline period despite increased flows (**Figures 3A-17** and **3A-18**). The effect of the phosphorus removal efforts is less apparent in the Park, where inflow concentrations have remained near background levels and the TP loading responds more directly to changes in flow and climatic conditions (**Figure 3A-19**).

It should be noted that the average flow and TP loads to the EPA, especially the Refuge, during the recent WY2005–WY2008 period have been highly influenced by the effects of climatic extremes, including both hurricanes and prolonged drought as previously discussed. For example, the total TP load from all sources to the Refuge was approximately 10.7 mt during WY2008, which represents an approximate 66 percent reduction from the previous year (31.3 mt). The reduction reflects the continued recovery of the STAs following the WY2005 hurricane damage and the initiation of STA-1W operation and lower flows. More than half (approximately 54 percent) of the load entering the Refuge during WY2008 was discharged through various structures prior to entering the marsh. Additional years of monitoring are needed before the effects of the Phase II BMP/STA optimization projects can be observed.

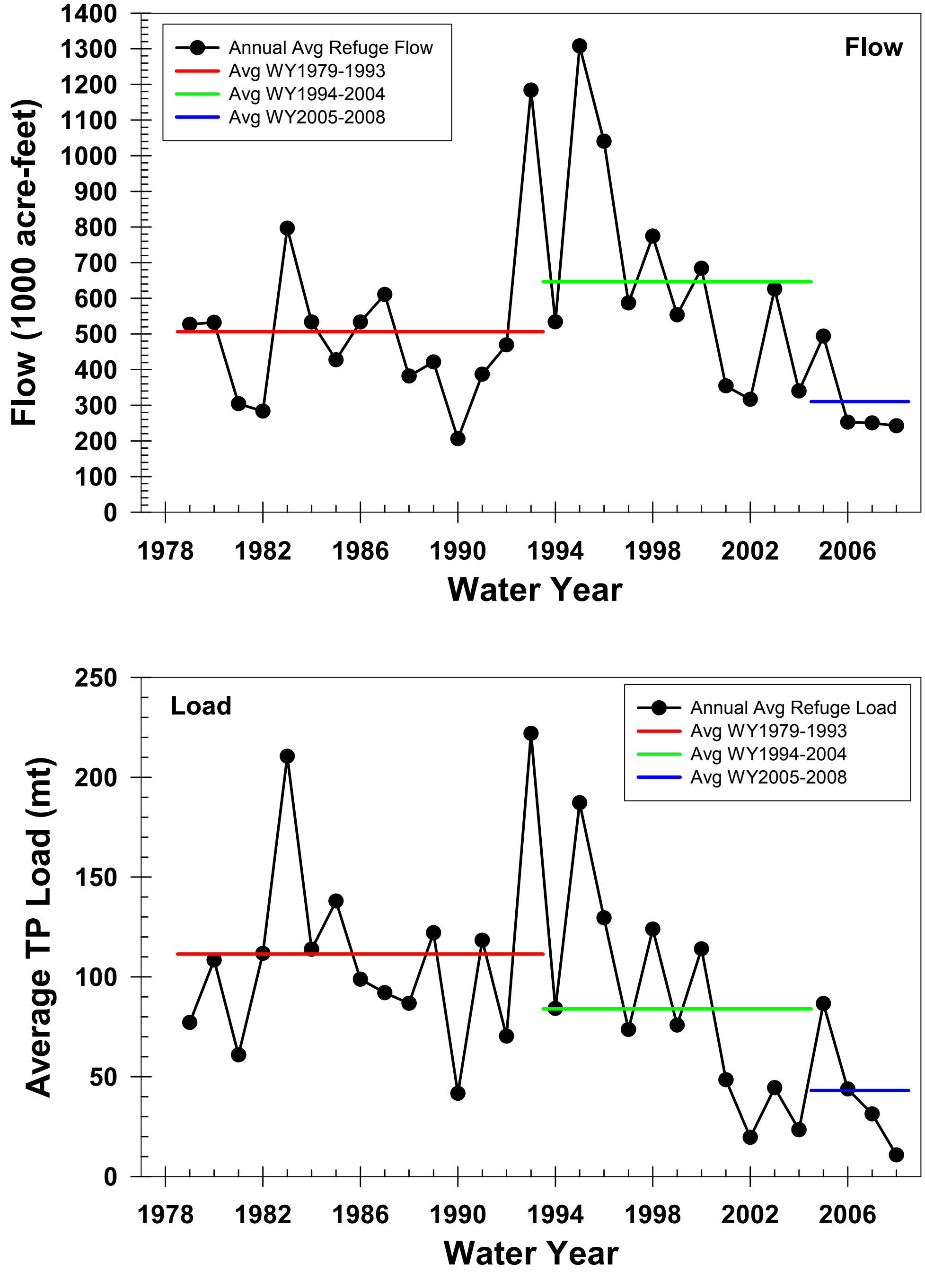



**Figure 3A-16.** Annual flow (upper graph) and average TP load (lower graph) to the Refuge from WY1978–WY2008. The horizontal lines indicate the average annual flows and loads for the WY1979–WY1993, WY1994–WY2004, and WY2005–WY2008 periods, respectively.

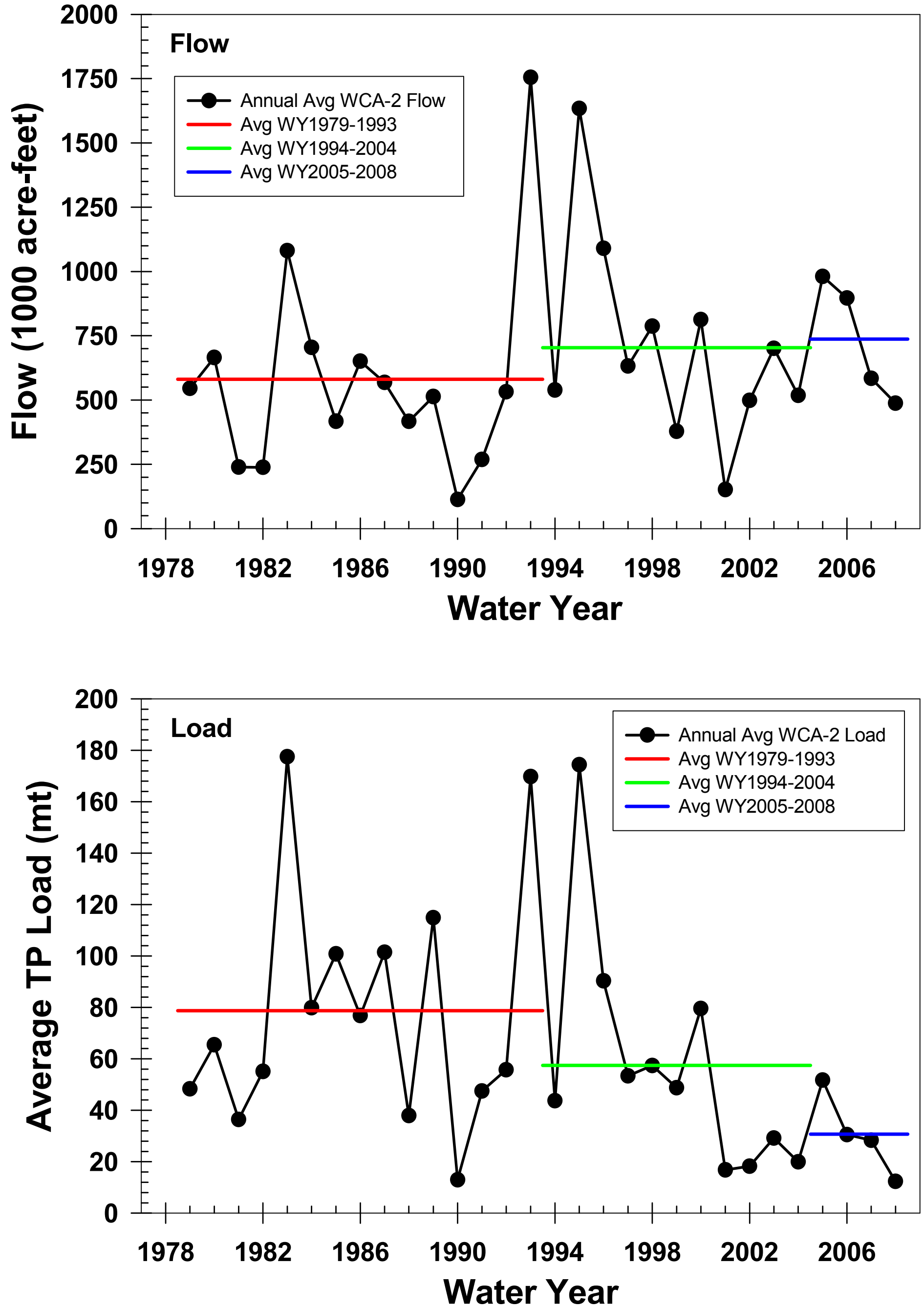
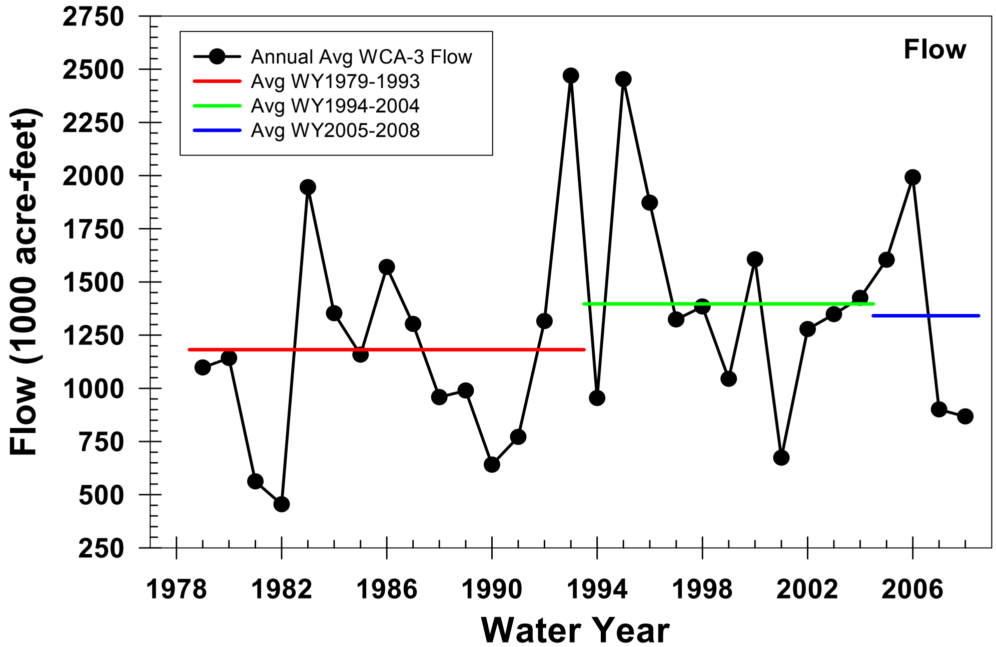



**Figure 3A-17.** Annual flow (upper graph) and average TP load (lower graph) to WCA-2 from WY1978–WY2008. The horizontal lines indicate the average annual flows and loads for the WY1979–WY1993, WY1994–WY2004, and WY2005–WY2008 periods, respectively.



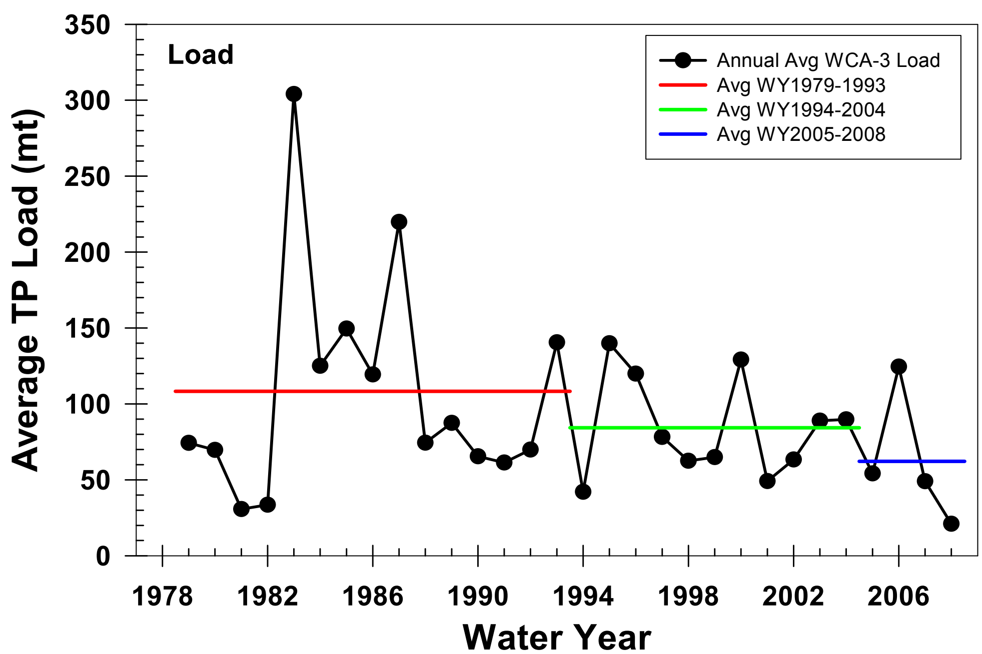




**Figure 3A-18.** Annual flow (upper graph) and average TP load (lower graph) to WCA-3 from WY1978–WY2008. The horizontal lines indicate the average annual flows and loads for the WY1979–WY1993, WY1994–WY2004, and WY2005–WY2008 periods, respectively.

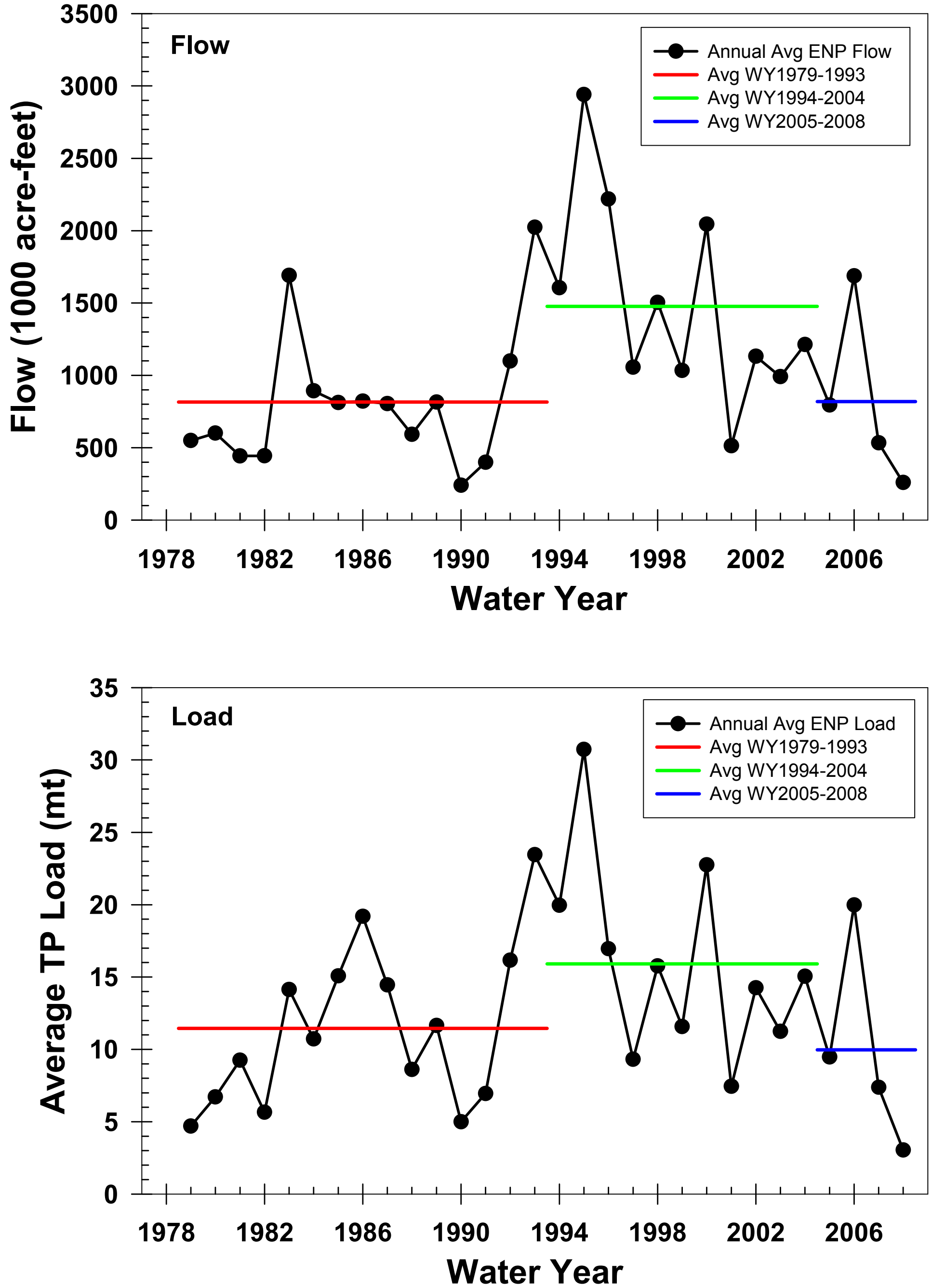



**Figure 3A-19.** Annual flow (upper graph) and average TP load (lower graph) to the ENP from WY1978–WY2008. The horizontal lines indicate the average annual flows and loads for the WY1979–WY1993, WY1994–WY2004, and WY2005–WY2008 periods, respectively.

## Everglades Protection Area Phosphorus Criterion Achievement Assessment

The TP criterion rule specifies that while the Settlement Agreement is in effect, compliance with the criterion in the Park will be assessed in accordance with the methodology specified in Appendix A of the Settlement Agreement using flow-weighted mean TP concentrations at inflow sites instead of ambient marsh TP concentrations, as done in the other portions of the EPA. The Settlement Agreement assessments for the Park are conducted by the District and reported on a quarterly basis to satisfy other mandates and, therefore, are not replicated in this chapter. The quarterly Settlement Agreement reports prepared by the District can be found at the District's web site at www.sfwmd.gov under the *What We Do, Environmental Monitoring, Reports* tabs.

In addition to establishing the numeric TP criterion for the EPA, the TP criterion rule (Section 62-302.540, F.A.C.) also provides a four-part test to be used to determine achievement of the numeric TP criterion. Each of the four components of the assessment test, as specified in **Table 3A-2,** must be achieved for a water body to be considered in compliance with the TP criterion.

The detailed results of the preliminary evaluation to assess achievement of the TP criterion using available data for the five-year period WY2004–WY2008 are provided in Appendix 3A-6 of this volume. As described previously, the results of this assessment were affected by data limitations in many parts of the EPA during some years caused in part by the extremely dry conditions that have prevailed throughout the area. Additionally, monitoring at nine new sites (which were added to the existing sites to form the TP criterion monitoring network) was not initiated until January 2007. During WY2008, 52 of the 58 TP criterion monitoring network sites had sufficient data (i.e., ≥ six samples specified by the screening protocol referenced by the TP Criterion Rule, per Section 62-302.540, F.A.C.) to be included in the TP criterion assessment. In contrast, only 30 of the 58 sites had a sufficient number of samples during WY2007, with less than 50 percent of the monitoring sites in the Refuge and WCA-3 having the minimum number of samples required for inclusion in the TP criterion assessment.

The results of the WY2004–WY2008 TP criterion assessment indicate that, even with the data limitations, the unimpacted portions of each WCA passed all four parts of the compliance test (as expected) and, therefore, are in compliance with the 10 µg/L TP criterion. Occasionally, individual sites within the unimpacted portions of the conservation areas exhibited an annual site geometric mean TP concentration above 10 µg/L; but in no case did the values for the individual unimpacted sites cause an exceedance of the annual or long-term network limits. During WY2008, none of the annual geometric mean TP concentrations for the individual sites exceeded the 15 µg/L annual site limit, and during the entire WY2004–WY2008 period, only one exceedance of the 15 µg/L annual site limit occurred at an unimpacted site, station X4 in the Refuge.

The single exceedance (19.8 µg/L) at station X4 occurred in the Refuge during WY2005 when TP levels throughout the EPA were elevated due to climatic extremes as discussed in detail in the 2006 SFER (Payne et al., 2006). Of the more than 140 TP measurements collected at station X4 since it was established in 1996, the highest value (130 µg/L) was observed on March 10, 2005, when water levels were increasing following a dry period with low water stage in the marsh. This highly elevated value is nearly nine times the five-year average for this site, and much higher than the TP concentration in the inflows and surrounding sites during this period. Because this site is not located near any anthropogenic inputs, the high measurement likely reflects the effects of the low water levels during this period and/or the difficulty in collecting a representative sample during periods of low water level. During WY2006 and WY2007, the TP concentrations measured for station X4 returned to more typical levels, with annual geometric site means of 9.1 µg/L and 11.4 µg/L, respectively. It is expected that changes in TP concentrations at station X4 and other sites throughout the marsh will continue to be tracked in future SFERs.

In contrast, the impacted portions of each water body failed one or more parts of the test and, therefore, exceeded the criteria. The impacted portions of the WCAs consistently exceeded the annual and five-year network TP concentration limits of 11 µg/L and 10 µg/L, respectively. Occasionally, selected individual sites within the impacted areas exhibited annual geometric mean TP concentrations below the 15 µg/L annual site limit. Rarely, the annual mean for individual impacted sites was below 10 µg/L; however, none of the impacted sites were consistently below the 10 µg/L long-term limit.

Future TP criterion achievement assessments conducted with more robust datasets are expected to provide a better understanding of phosphorus concentrations in the EPA.

## Total Nitrogen Concentrations in the Everglades Protection Area

The concentration of total nitrogen (TN) in surface waters is not measured directly, but is calculated as the sum of total Kjeldahl nitrogen (TKN; organic nitrogen plus ammonia) and nitrite plus nitrate ($NO_3 + NO_2$). The TN values for the 2008 SFER – Volume I were calculated only for samples for which both TKN and $NO_3 + NO_2$ results were available. **Table 3A-10** provides a summary of the TN concentrations measured in the different portions of the EPA during the baseline period, the Phase I period, the WY2005–WY2008 period, and the WY2008 period.

As in previous years, TN concentrations during WY2008 exhibited a general north-to-south spatial gradient across the EPA. This gradient likely reflects the higher concentrations associated with discharges to the northern portions of the system from agricultural areas and Lake Okeechobee. A gradual reduction in TN levels results from assimilative processes in the marsh as water flows southward. The highest geometric mean TN concentrations were observed in the inflows to the Refuge and WCA-2, and decreased to a minimum concentration in the Park.

During WY2008, the geometric mean TN concentrations for the inflow and interior sites in the Refuge and WCA-2 and the interior sites within the Park were considerably lower than the levels for any of the preceding periods. The lower concentrations observed during WY2008 may have been caused by several factors, including lower volumes of nutrient-enriched inflow entering the EPA from the EAA and Lake Okeechobee during dry periods observed during much of WY2008, and improved nutrient removal effectiveness of the STAs, especially during low water conditions. Also, as described for TP, due to the dry conditions experienced during WY2008, there were fewer samples collected in the drier portions of the marsh that are influenced by nutrient-enriched canal inflows. This phenomenon may also contribute to the differences observed among periods.

During WY2008, geometric mean TN concentrations at inflow stations ranged from 1.08 mg/L in the Park to 1.94 mg/L in WCA-2, and median TN concentrations ranged from 0.87 mg/L to 2.01 mg/L. Similarly, mean TN concentrations at the interior marsh stations during WY2008 ranged from 0.85 mg/L in Park to 1.75 mg/L in WCA-2, with median concentrations ranging from 0.87 mg/L to 1.78 mg/L.

**Table 3A-10.** Summary of total nitrogen concentrations (mg/L) in the EPA for the WY1979–WY1993, WY1994–WY2004, WY2005–WY2008, and WY2008 periods.

| Region | Class | Period | Sample Size (N) | Geometric Mean (mg/L) | Std. Deviation (Geometric Mean) | Median (mg/L) | Min. (mg/L) | Max. (mg/L) |
|---|---|---|---|---|---|---|---|---|
| Refuge | Inflow | 1979–1993 | 1206 | 3.68 | 1.79 | 3.83 | 0.25 | 18.68 |
| | | 1994–2004 | 1601 | 2.42 | 1.59 | 2.33 | 0.25 | 48.23 |
| | | 2005–2008 | 465 | 2.05 | 1.38 | 2.11 | 0.63 | 5.17 |
| | | 2008 | 146 | 1.81 | 1.40 | 1.89 | 0.86 | 5.09 |
| | Interior | 1979–1993 | 359 | 2.41 | 1.63 | 2.32 | 0.72 | 36.71 |
| | | 1994–2004 | 1887 | 1.28 | 1.47 | 1.22 | 0.45 | 9.50 |
| | | 2005–2008 | 693 | 1.26 | 1.39 | 1.22 | 0.54 | 6.41 |
| | | 2008 | 154 | 1.13 | 1.30 | 1.11 | 0.65 | 2.29 |
| | Outflow | 1979–1993 | 602 | 2.65 | 1.69 | 2.58 | 0.25 | 22.84 |
| | | 1994–2004 | 696 | 2.00 | 1.53 | 1.89 | 0.25 | 7.91 |
| | | 2005–2008 | 189 | 1.65 | 1.44 | 1.65 | 0.78 | 5.52 |
| | | 2008 | 41 | 1.22 | 1.25 | 1.19 | 0.81 | 2.03 |
| | Rim | 1979–1993 | 118 | 2.76 | 1.65 | 2.64 | 0.80 | 10.91 |
| | | 1994–2004 | 592 | 2.38 | 1.51 | 2.26 | 0.68 | 9.66 |
| | | 2005–2008 | 92 | 2.22 | 1.34 | 2.24 | 1.31 | 5.22 |
| | | 2008 | 12 | 1.55 | 1.18 | 1.50 | 1.31 | 2.14 |
| WCA-2 | Inflow | 1979–1993 | 784 | 2.91 | 1.66 | 2.91 | 0.25 | 22.84 |
| | | 1994–2004 | 1192 | 2.40 | 1.49 | 2.42 | 0.67 | 7.91 |
| | | 2005–2008 | 377 | 2.13 | 1.39 | 2.13 | 0.70 | 5.48 |
| | | 2008 | 84 | 1.94 | 1.38 | 2.01 | 0.90 | 4.53 |
| | Interior | 1979–1993 | 1669 | 2.62 | 1.56 | 2.50 | 0.25 | 37.17 |
| | | 1994–2004 | 2914 | 2.03 | 1.42 | 2.10 | 0.25 | 37.10 |
| | | 2005–2008 | 684 | 2.07 | 1.32 | 2.08 | 0.75 | 6.27 |
| | | 2008 | 177 | 1.75 | 1.35 | 1.78 | 0.75 | 5.32 |
| | Outflow | 1979–1993 | 894 | 2.25 | 1.41 | 2.18 | 0.75 | 7.65 |
| | | 1994–2004 | 675 | 1.66 | 1.35 | 1.65 | 0.25 | 4.44 |
| | | 2005–2008 | 305 | 1.80 | 1.26 | 1.83 | 0.94 | 3.93 |
| | | 2008 | 70 | 1.74 | 1.28 | 1.60 | 1.06 | 2.99 |
| WCA-3 | Inflow | 1979–1993 | 2401 | 2.02 | 1.57 | 1.95 | 0.25 | 10.80 |
| | | 1994–2004 | 2561 | 1.67 | 1.44 | 1.59 | 0.54 | 7.79 |
| | | 2005–2008 | 906 | 1.62 | 1.29 | 1.64 | 0.83 | 6.11 |
| | | 2008 | 191 | 1.65 | 1.28 | 1.70 | 0.91 | 2.99 |
| | Interior | 1979–1993 | 590 | 1.91 | 1.55 | 1.87 | 0.43 | 10.01 |
| | | 1994–2004 | 1686 | 1.18 | 1.39 | 1.15 | 0.25 | 9.00 |
| | | 2005–2008 | 709 | 1.35 | 1.38 | 1.36 | 0.49 | 4.50 |
| | | 2008 | 111 | 1.48 | 1.27 | 1.53 | 0.82 | 3.66 |
| | Outflow | 1979–1993 | 1721 | 1.51 | 1.47 | 1.51 | 0.25 | 14.86 |
| | | 1994–2004 | 1534 | 1.05 | 1.44 | 1.09 | 0.25 | 4.10 |
| | | 2005–2008 | 579 | 1.18 | 1.31 | 1.20 | 0.25 | 2.70 |
| | | 2008 | 172 | 1.19 | 1.32 | 1.20 | 0.25 | 2.49 |

**Table 3A-10.** Continued.

| Region | Class | Period | Sample Size (N) | Geometric Mean (mg/L) | Std. Deviation (Geometric Mean) | Median (mg/L) | Min. (mg/L) | Max. (mg/L) |
|---|---|---|---|---|---|---|---|---|
| Park | Inflow | 1979–1993 | 1929 | 1.37 | 1.63 | 1.45 | 0.25 | 14.86 |
| | | 1994–2004 | 1828 | 0.88 | 1.59 | 0.93 | 0.25 | 3.60 |
| | | 2005–2008 | 642 | 1.05 | 1.39 | 1.09 | 0.25 | 2.70 |
| | | 2008 | 174 | 1.08 | 1.40 | 1.11 | 0.25 | 2.49 |
| | Interior | 1979–1993 | 565 | 1.28 | 1.90 | 1.37 | 0.25 | 40.84 |
| | | 1994–2004 | 1007 | 1.03 | 1.64 | 1.06 | 0.25 | 5.70 |
| | | 2005–2008 | 255 | 1.04 | 1.64 | 0.99 | 0.25 | 7.68 |
| | | 2008 | 54 | 0.85 | 1.46 | 0.87 | 0.25 | 1.98 |

# WATER YEAR 2008 PERMIT-REQUIRED MONITORING RESULTS

## WATER QUALITY MONITORING AND ANALYSIS FOR THE NON-ECP STRUCTURES

The purpose of this section is to address water quality at the “into,” “within,” and “from” structures relative to the EPA. There are eight basins discharging directly to the EPA that are not part of the ECP. Five of these basins have “into” structures that are operated and maintained by the District and are permitted under the non-ECP permit: C-11 West, North New River Canal (NNRC), Feeder Canal, L-28, and C-111 basins. The three remaining non-ECP basins that discharge directly to the EPA are not permitted under the non-ECP permit because the discharge structures are not owned or operated by the District; these three basins are the Village of Wellington’s (VOW) ACME Improvement District, North Springs Improvement District (NSID), and Boynton Farms. These basins have structures that discharge into the EPA and are owned and operated by private or local drainage district entities. The location of non-ECP structures, the boundaries of the respective hydrologic contributing basins, and the EPA boundaries are indicated in Appendix 3A-7, Figure 1, of this volume.

### Non-ECP Permit Requirements

The non-ECP permit requires District monitoring of all discharges for phosphorus, the parameter of primary concern, in addition to general water quality parameters to track the progress toward achieving compliance with water quality standards. The District is responsible for carrying out the programs mandated by the Everglades Forever Act (EFA) through compliance requirements stipulated in permits issued by the FDEP. On April 20, 1998, the FDEP issued the non-ECP permit (Permit No. 06.502590709), pursuant to Section 9(k) of the EFA. The permit was renewed on April 21, 2003 (Permit No. 0237803). The permit authorizes the continued operation of water control structures that are operated, maintained, and controlled by the District that discharge waters “into,” “within,” or “from” the EPA which are not included in the permits issued for the ECP.

Specific Condition 5 of the non-ECP permit requires the District to submit an annual report that includes results of the evaluation of water quality data and the Mercury Screening Program. Information contained in this volume fulfills the reporting requirements as detailed in the specific conditions of the non-ECP permit. The requirements are summarized in **Table 3A-11.** This information was previously described in detail (Trost et al., 2001).

**Table 3A-11.** Non-Everglades Construction Project (non-ECP) permit reporting requirements.

| Specific Condition | Reporting Requirement | Location[2] |
|---|---|---|
| 4[1] | New permit or permit modifications | Extended on April 21, 2008, with renewal expected in late 2008 |
| 5 | Submittal of Annual Report | Chapters 1, 3A, 3B, 4, 5, 7, and 8 |
| 6 | Land acquisition and water treatment facility status update | Volume II |
| 7 | First and second data evaluation reports | Completed in 1998 Annual Report |
| 8 | Regulatory Action Report | Chapter 4 |
| 9 | Update on implementation of schedules and strategies | Chapters 1, 3A, 3B, 4, 5, 7, and 8 |
| 10 | Laboratory Quality Assurance Manual | Current FDEP-approved manual |
| 11 | Mercury Screening Program Report | Chapters 3A and 3B |
| 12 | Annual Report, data requirements | See Specific Conditions 12 (b) – 12 (h) |
| 12 (b) | Dates of sampling | Appendix 3A-7 |
| 12 (c) | Field Quality Assurance Manual | Current FDEP-approved manual |
| 12 (d) | Map of sampling locations | Appendix 3A-7, Figure 1 |
| 12 (e) | Statement of sampling authenticity | Appendix 5-1 |
| 12 (f) | Quality Assurance Manual | Current FDEP-approved manual |
| 12 (g) (i-v) | Water quality data and associated information | Appendix 3A-7 |
| 12 (g) (iv) | Monthly flow volumes | Appendix 3A-7 |
| 12 (h) | Water quality data evaluation | Appendix 3A-7 |
| 12(i) | Recommendations for improving water quality monitoring | Completed in 1998 Annual Report |
| 12 (j) | Implementation of strategies | Chapters 1, 3A, 3B, 4, 5, 7, and 8 |
| 16 | Monitoring Locations Report | Submitted to the FDEP in 1998 |
| 19 | Additional strategies (if developed) | Not applicable at this time |

1 Specific conditions 1–3 do not deal with reporting requirements and, therefore, are not referenced in this table.
2 All cross-referenced chapters and appendices are applicable to the 2009 SFER – Volume I unless noted otherwise.

Non-ECP permit conditions require the District to document the accuracy of collected data and to measure progress toward achieving and maintaining compliance with state water quality standards. The non-ECP water quality sampling sites, monitoring schedule, and flow volumes are presented in Appendix 3A-7 of this volume. Although phosphorus is of primary concern, the permit specifies that all state water quality standards should be met. To fulfill the requirements of the permit conditions, the District has completed an annual analysis of water quality data at non-ECP structures by comparing the data with state water quality standards. Unlike the ECP basins, which are required to decrease TP levels in discharges based on historical loads, no phosphorus-specific requirement was established at the point of discharge for the non-ECP basins in WY2008. Hence, new technology-based effluent limitations (TBEL) have been drafted for all non-ECP basins with discharge.

## Water Quality Compliance of the Non-ECP Permit

To document the accuracy of the collected data and measure progress toward achieving and maintaining compliance with state water quality standards, the District has compared WY2008 water quality data from non-ECP structures to state water quality standards. **Table 3A-12** provides a WY2008 summary of FWM TP concentrations for each non-ECP basin. Results of all water quality analyses are included in Appendix 3A-7 of this volume.

In compliance with Specific Condition 5, the appendices of this chapter include an annual update of the non-ECP permit monitoring program, report non-ECP program monitoring results, and a comparison of WY2008 water quality data from samples collected at non-ECP structures to state water quality standards. The comparisons fulfill non-ECP permit requirements to document the accuracy of the collected data and measure progress toward achieving and maintaining compliance with state water quality standards.

The data for the groups of water quality parameters — including physical parameters, nutrients, major ions, and trace metals — were evaluated for WY2008. The evaluation indicated that few excursions from Class III water quality standards were found in samples collected at non-ECP structures, except for various incidences of DO. The excursions include results for turbidity at S-178 as well as pH at S-190 and NSID1.

Based on the analysis provided in Appendix 3A-7 of this volume, the quarterly surface water and semiannual sediment pesticide sampling events at the 14 non-ECP sites for WY2008 were conducted during May, September, and December 2007, and March 2008. The upstream sampling site at S-176 was moved to a platform on the west side of the canal just upstream of the S-332D pump inflow canal and is identified as S-332DX, starting with the September 2007 sampling event.

Modifications to the non-ECP permit changed the requirement for sampling at S-142 and S-38B to only during discharge or flow events. The only pesticide detection of concern was the chlorpyrifos ethyl concentration of 0.0094 µg/L at S-177. This concentration should not have an acute, harmful impact on fish. However, for aquatic invertebrates, this level is greater than the calculated chronic toxicity for water flea (*Daphnia magna*). At this level, exposure can cause impacts to macroinvertebrate populations, but the pulsed nature of agricultural runoff releases to the canal system precludes drawing any conclusions about the effects of long-term average exposures.

**Table 3A-12.** Non-ECP basins annual flow-weighted mean TP concentrations and loads for WY2008.

| Hydrologic Basin | Structure | Water Quality Station ID | Total Flow Volume (ac-ft) | Number of Days with Positive Flow | Sample Type | Sample Size (Grab) | Arithmetic Average (Grab) (ppb) | Sample Size (Comp) | Flow-Weighted Mean[1] Concentration (ppb) | Flow-Weighted Mean[2] Concentration (ppb) | TP Load (kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ACME Improvement District | ACME1DS | ACME1DS | 0[3] | 0[3] | G | 11 | 33 | 0 | N/F | N/F [4] | 0 |
| | ACME1 | VOW1 | 0 | 0 | | 0 | 0 | 0 | N/F | N/F [4] | 0 |
| | ACME2 | VOW2 | 0 | 0 | | 0 | 0 | 0 | N/F | N/F [4] | 0 |
| North Springs Improvement District (NSID) | NSID1 | NSIDSP01 | 0 | 0 | A, G | 27 | 20 | 2 | NDF | NDF | 0 |
| | | S-38B (WCA-2A near NSID1) | 0[5] | 0[5] | G | 0 | 0 | 0 | NDF | NDF | 0 |
| North New River Canal | G-123 | G123 | 0 | 0 | A, G | 52 | 16 | 0 | N/F | N/F | 0 |
| C-11 West | S-9 | S9 | 52,632 | 42 | A, G | 53 | 13 | 15 | 20 | 20 | 1,282 |
| | S-9A | S9A | 87,799 | 314 | A, G | 53 | 12 | 47 | 14 | 14 | 1,523 |
| C-111 | S-174 | S174 | 0 | 0 | A, G | 53 | 7 | 0 | N/F | N/F | 0 |
| | S-332D | S332D | 32,689 | 134 | A, G | 52 | 6 | 41 | 6 | 6 | 262 |
| | S-18C | S18C | 124,381 | 197 | A, G | 51 | 5 | 23 | 8 | 8 | 1,163 |
| L-28 | S-140 | S140 | 90,340 | 217 | A, G | 52 | 32 | 36 | 36 | 36 | 4,046 |
| Feeder Canal | S-190 | S190 | 25,310 | 150 | A, G | 53 | 30 | 17 | 97 | 101 | 3,151 |
| Boynton Farms | Various[6] | Various[6] | N/D | N/D | G | 16 | 1,099 | N/D | N/D | N/D | N/D |

1. Based on days of flow and monitored TP data only.
2. Based on estimation algorithm to determine TP concentration on non-monitored days combined with monitored days.
3. Flow data from upstream pump structures, ACME1 and ACME2, is representative of the flow through the ACME1DS and G94D culverts, respectively.
4. Calculated using the flow data at upstream structures.
5. Flow data from upstream structure NSIDSP01 is representative of flow into the EPA at S-38B.
6. Pumps that have no flow recording devices attributed include the following: BFBAFCP, BFBAFNP, BFBAFSP, BFBDFCP, BFBDFNP, BFBDFSP, BFBDFWP, and BFBMFSP.

G - Samples collected by grab sampling methodology.
A - Samples collected by automatic composite samples.
NDF - No data with flow available.
N/F - No flow.
N/D - No data available.

Pesticides were detected in the sediment samples collected during WY2008. Pesticides with concentrations greater than the Practical Quantitation Limit were assigned to the "potential concern" excursion category. Dichlorodiphenyltrichloroethane (DDT) and dichlorodiphenyldichloroethylene (DDE, the environmental dehydrochlorination product of DDT) were detected at S-331/S-173 and S-178, respectively. Endosulfan and endosulfan sulfate, were detected at S-178 at levels of "potential concern."

The non-ECP permit was amended on January 21, 2005, to remove the S-10E structure because it was no longer needed and has since been decommissioned. The non-ECP permit was again amended on May 18, 2005, to remove monitoring of all trace metals, all major ions (except sulfate), and some nutrient and physical parameters. Hence, monitoring and reporting for these parameters was discontinued in WY2007. The non-ECP permit was amended once more on July 13, 2006, to (1) reclassify the S-332 and S-175 structures as "within" structures, (2) incorporate the S-332D and S-174 structures as "into" structures, (3) add berm B3 as a "within" structure, and (4) take out the G-71 structure as a structure required to be monitored since this structure has been decommissioned and was removed in 2002. An additional revision to the permit was made on May 3, 2007, to deactivate the G-69 structure since it had not been operational in nearly a decade. The permit was revised again on April 18, 2008, to remove the S-174 as an "into" structure.

Comparisons of state water quality standards to water quality data obtained from non-ECP structures can be found in Chapter 11 of the 2001 ECR; Chapter 8B of the 2002–2004 ECRs; Chapter 3 of the 2005 SFER; and Chapter 3A of the 2006–2008 SFERs. These historical analyses found that few excursions from Class III numeric water quality criteria for any parameter in the eight non-ECP contributing basins except for DO. There were excursions from the existing standard for DO, but the FDEP has completed an evaluation of DO levels in the EPA and developed a SSAC to formally recognize the natural background conditions in the EPA marshes. Additional information on the DO SSAC can be found in the *Dissolved Oxygen* section of this chapter.

## Total Phosphorus at the Non-ECP Structures

Because phosphorus is the primary parameter of concern for Everglades restoration, it is the focus of water quality considerations for the non-ECP basins. Although no load limitations have been established for the basins, TP concentrations are monitored to determine progress toward the goals established in the non-ECP permit. **Table 3A-12** summarizes the FWM TP concentrations, total flow volumes, and TP loads for all non-ECP basins during WY2008.

The WY2008 flows reported in **Table 3A-12** from ACME Improvement District were no flow, and there was no TP load from this basin in WY2008. Some of the highest TP concentrations for non-ECP structures discharging directly to the EPA were observed during WY2008 for Feeder Canal through S-190. The ACME1DS and G-94D culverts, operated by the VOW, closed in January 18, 2007, and no longer discharge into the Refuge when upstream pump stations ACME1 or ACME2 are operating. On April 18, 2008, the G-94D structure was changed from an "into" structure to a "from" structure. Sampling at VOW1 and VOW2 was discontinued on January 1, 2007, because of no flow at the structures.

As shown in Appendix 3A-7, Table 3, of this volume, more than 75 percent of the data collected at the upstream ACME1DS monitoring sites were below 61 ppb, with a median TP value of 21 ppb (grab). There was no discharge from the ACEM1DA, ACME1, and ACME2 to reflect the new change in operation and permit.

There were no flows and, therefore, no TP loads from the NNRC, NSID, and ACME Improvement District basins for WY2008. A comparison with WY2007 data indicates a slight increase of TP load from the C-11 West and C-111 basins and a decrease of TP loads from the Feeder Canal and L-28 basins. The changes in loads from these basins are predominantly associated with changes in flow volumes, which were higher for C-11 West through S-9 and S-9A as well as C-111 through S-174, S-332D, and S-18C, and lower for Feeder Canal through S-190. There was more flow from L-28 through S-140 in WY2008 than in WY2007 (90,340 versus 88,518 ac-ft), but less TP load (4,046 kg versus 5,117 kg).

The FWM TP concentrations vary greatly among different basins. In WY2008, the highest TP concentrations are identified in the Feeder Canal Basin, whereas the C-11 West basins have TP concentrations below 50 ppb. There was a decrease in TP concentration for the L-28 basin (FWM TP of 36 ppb for WY2008 versus 47 ppb in WY2007). The TP concentrations observed for the Feeder Canal Basin showed median TP concentrations of 28 ppb for grab samples and 61 ppb for auto samplers. The TP concentrations observed for the L-28 basin showed median TP concentrations of 33 ppb for grab samples and 35 ppb for auto samplers.

During WY2008, the Feeder Canal basin discharged 25,310 ac-ft, and the L-28 basin discharged 90,340 ac-ft into the western portion of WCA-3A. It should be noted that the flow-weighted TP concentration was significantly lower in WY2008 (101 ppb) than in WY2007 (215 ppb) at S-190. The same trend was observed at S-140, where FWM TP concentration decreased in WY2008 (36 ppb) from WY2007 (47 ppb). Though many of these concentrations are relatively low, all concentrations greater than approximately 10 ppb will have to be addressed further.

**Table 3A-12** also presents information for the S-9A and S-9 pump stations. In WY2008, the FWM TP concentration of water discharged from the S-9A pump station was 14 ppb, compared with a FWM TP concentration of 20 ppb through the S-9 pump station. The total flows pumped through both the S-9 and S-9A stations increased by 8 percent at S-9A and 24 percent at S-9, respectively, for WY2008 (52,632 ac-ft for S-9 and 87,799 ac-ft for S-9A) compared with WY2007 (42,459 ac-ft for S-9 and 81,353 ac-ft for S-9A). Furthermore, the total flow through both structures combined had a FWM TP concentration of 16 ppb in WY2008, which was slightly higher than in WY2007 (15 ppb).

As in WY2007, no flow into the EPA occurred at the NSID1, ACME Improvement District, and G-123 structures due to the operational changes implemented by the NSID, North New River, and the District, respectively. The C-111 basin had the lowest TP concentrations observed at S-174, S-332D, and S-18C, which discharge into the ENP, specifically to Taylor Slough (by way of the L-31N borrow and L-31W borrow canals) and the ENP's panhandle (by way of the C-111 canal). The TP data for monitoring location S-18C had an observed median concentration of 4 ppb (grab) and 8 ppb (auto); seventy-five percent of the samples had concentrations below 5 ppb (grab) and 10 ppb (auto). The TP data for monitoring station S-332D had an observed median concentration of 6 ppb (grab) and 8 ppb (auto); seventy-five percent of the samples had concentrations below 6 ppb (grab) and 10 ppb (auto). The TP data for monitoring station S-174 had an observed median concentration of 7 ppb (grab); seventy-five percent of the samples had concentrations below 8 ppb (grab).

During WY2008, the S-174 did not discharge into the ENP, and S-332D discharged 32,689 ac-ft to the Park. The S-18C structure discharged approximately 124,381 ac-ft to the lower C-111 canal, significantly lower than WY2007 at S-332D (45,048 ac-ft) and significantly higher than WY2007 at S-18C (80,357 ac-ft).

Historically, the Boynton Farms basin exhibits the highest TP concentrations (average of 973 ppb, see 2005 SFER – Volume I, Chapter 3) of any basin. This average is based on a total of 63 samples at 11 locations, on 18 sampling events from April 2000 through November 2003. In WY2006, three sampling locations, representing one farm, have been eliminated since the farm removed the pumps and was no longer discharging to the Refuge. There was no flow for this basin and, therefore, no FWM concentrations could be determined. The Boynton Farms basin water quality monitoring program is still ongoing, and 16 grab samples were collected with an average TP concentration of 1,099 ppb for WY2008, which was significantly lower than in WY2007 (1,433 ppb).

It is anticipated that the implementation of the water quality improvement plans as recommended in the Long-Term Plan for the non-ECP basins will significantly contribute to achieving long-term water quality standards in the EPA. Water quality data are tracked for increasing and decreasing trends, so the action plan may be modified as necessary by employing an adaptive management process to ensure optimization measures for TP reduction and for other parameters of concern.

## Water Quality Conditions at the Non-ECP Structures

An evaluation of the non-ECP basin data indicates that the quality of water discharging into the EPA is generally acceptable. However, there are exceptions for phosphorus, DO, and occasional excursions from standards for turbidity and pH. The only pesticide detection of concern was the chlorpyrifos ethyl concentration of 0.0094 µg/L in surface water at S-177. For the sediment samples, dichlorodiphenyltrichloroethane (DDT) and DDE, (the environmental dehydrochlorination product of DDT) were detected at S-331/S-173 and S-178 respectively; endosulfan and endosulfan sulfate were also detected at S-178 at levels of "potential concern" in the C-111 basin.

Analysis of TP concentrations in WY2008 continues to indicate significant differences between non-ECP basins. Phosphorus is categorized as a concern (above 50 ppb) for the Feeder Canal; a potential concern (10 ppb < TP < 50 ppb) for the L-28 basins and C-11 West basins. There were no levels of concern or potential concern (TP < 10 ppb) at the C-111 basins. There was no discharge in the North Springs Improvement District, ACME Improvement District, and NNRC basins. Except for phosphorus levels, the quality of water discharging into the EPA is generally acceptable.

The portion of the District's water quality monitoring program that has been implemented as a result of the EFA and the non-ECP permit indicates that phosphorus concentrations are greater than 10 ppb in discharges from three of the eight non-ECP basins (Feeder Canal, L-28, and C-11 West). There was no discharge from four basins (NSID, ACME Improvement District, North New River Canal, and Boynton Farms). The average TP concentration for WY2008 was 1,099 ppb, excluding Boynton Farms, which had no discharge during WY2008. The District will continue to monitor water quality in accordance with the non-ECP permit to measure progress toward achieving compliance with state water quality standards.

# WATER QUALITY MONITORING REPORT FOR INTERIM OPERATIONAL PLAN FOR PROTECTION OF THE CAPE SABLE SEASIDE SPARROW

The Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*) was added to the list of endangered species in 1967. The population of this isolated, non-migratory species has dropped by 60 percent since 1981 to less than 3,000 individuals. The entire viable population of this species resides in Everglades National Park. The U.S. Fish and Wildlife Service (USFWS) issued a "jeopardy" Biological Opinion on February 19, 1999, concerning six sub-populations of endangered sparrows in the ENP. The Biological Opinion includes a recommendation for "reasonable and prudent alternatives" to avoid jeopardizing the endangered sparrow. To meet the requirement of the Biological Opinion, the U.S. Army Corps of Engineers (USACE) developed the December 14, 1999, Interim Structure and Operational Plan, which involved moving water out of WCA-3A eastward via the L-29 borrow canal and southward via the L-31N borrow canal. The complete annual report is presented in Appendix 3A-8 of this volume.

The C-111 Canal Project modifications, authorized by the 1994 General Reevaluation Report (GRR), along with the Modified Water Deliveries to Everglades National Park (MWD ENP) Project, authorized by the 1992 General Design Memorandum (1992 GDM) must be completed before the decompartmentalization components of CERP can be initiated. Considerable portions of the C-111 Canal Project modification have been constructed and are currently operating under the Interim Operational Plan (IOP) for the Protection of the Cape Sable Seaside Sparrow (CSSS), available at http://hpm.saj.usace.army.mil/csssweb/index.html, as of August 2008. This interim plan will be replaced by the Combined Structural and Operational Plan (CSOP) for the MWD ENP and C-111 canal projects upon their completion.

The USACE is authorized to construct and operate the accelerated (emergency) features of the C-111 Canal Project (S-332B to S-332C Detention Areas Offset Connector and Land Swap Detention Areas), as described in the IOP for Protection of the CSSS Emergency Contract and the modified weir scenario identified in Specific Condition 25(g).

The FDEP found that this state of emergency is expected to continue until the implementation of the CSOP. Therefore, the C-111 Emergency Final Order (C111 EO #9) will remain in effect until implementation of the CSOP, unless rescinded, modified, or extended by further order of the FDEP. This Emergency Final Order was effective as of January 31, 2003. This is the fifth annual water quality monitoring report under the Emergency Final Order and presents water quality results for WY2008.

## Sampling Sites

In addition to authorizing the operation and maintenance of certain structures, C111 EO #9 requires a routine water quality monitoring program. This program characterizes the quality of water discharged through the three pump stations that move water from the L-31N canal reach between S-331/S-173 and S-176 into the detention areas (S-332B, S-332C, and S-332D); two interior detention areas (CULC1 and CULC2); four diversion structures (DS-1, DS-2, DS-3, and DS-4); and one outflow structure (BERMB3). CULC1 is an interior detention area of S-332B, and CULC2 is an interior detention area of S-332C. Appendix 3A-8, Figure 12, of this volume shows these structures.

The DS-1 and DS-3 structures are the emergency overflow weirs for S-332B and S-332C, which both discharge to the east and, therefore, cannot discharge into the ENP. The DS-2 structure can discharge into the ENP (to the west) if the stage within the detention area exceeds the crest elevation of approximately 8.39 feet NGVD along the 1,700 lineal feet of weir. The DS-4 structure consists of manually operated sluice gates that are opened only for emergencies (e.g., a detrimental fire) requiring more rapid delivery of water than provided by the S-332D detention system.

The District typically collects water quality samples at the structure or at a nearby location representative of the quality of water flowing through a structure. The District previously submitted a monitoring plan to the FDEP on January 4, 2004, which included detailed information about the specific locations for sample collection for S-332B, S-332C, and S-332D and associated structures. The current monitoring program encompasses 10 locations that provide representative information to characterize the quality of water discharged through all structures.

The water quality characterization includes an evaluation of compliance with Class III criteria for each monitoring location representative of C-111 EO #9 structures. This report provides the annual update of the C-111 EO #9 monitoring program and a comparison of water quality data at structures to state water quality standards for WY2008. These comparisons fulfill the C-111 EO #9 requirements to measure progress toward achieving and maintaining compliance with state water quality standards.

## Excursion Analysis for Class III Constituents and Pesticides

To evaluate compliance with water quality criteria, constituent concentrations were compared to their respective Class III numeric criteria. If a constituent concentration exceeded its numeric criterion, then an excursion was recorded and the total number and percent of excursions for the C-111 EO #9 structures were tabulated.

This section presents an update of constituent concentrations and physical properties measured during WY2008. For standards with numeric criteria, the data from the structures were assessed for compliance with those standards using the procedures in Chapter 62-4.246, F.A.C. For parameters that have narrative water quality criteria, the concentrations obtained at each structure were reported using plots and summary statistics.

### *Mercury*

As a result of an approved mandate modification in August 2006, surface water sampling was terminated under project C111-D; therefore, no surface samples are reported for WY2008. Under the same approved mandate, largemouth bass and sunfish were eliminated from the C111-D project, and mosquitofish (*Gambusia holbrooki*) monitoring was reduced to annual collection. Due to low water levels, the 2006 interior mosquitofish collection site CULC1 was replaced with CULC2 in 2007, and outflow site BERMB3 was replaced by diversion sites DS4 and DS2. Largemouth bass and sunfish were eliminated from C111-D monitoring following the approved mandate modification in 2006.

### *Dissolved Oxygen*

Of the 10 parameters listed, only DO exhibited excursions during WY2008. Dissolved oxygen concentrations exhibited consistent excursions from Class III criteria during WY2008. About 61.1 percent (88 out of 144 samples) of DO concentrations measured at the C-111 EO #9 monitoring locations were less than the minimum criterion of 5 mg/L.

It should be noted that even unimpacted areas of the Everglades commonly have DO concentrations below the 5 mg/L standard as part of the natural water conditions found in South Florida. Because natural levels commonly fall below the existing standard, the FDEP has recently adopted a SSAC for DO in the EPA that better reflects naturally occurring conditions. See the *Dissolved Oxygen* section under the *Water Year 2008 Water Quality Results* section of this chapter.

### *Total Dissolved Solids and Dissolved Organic Carbon*

Sampling for total dissolved solids and dissolved organic carbon are required at inflow sites on a quarterly basis. Monthly monitoring for dissolved organic carbon was proposed for the two interior structures; it was also proposed that monitoring for total dissolved solids, total organic carbon, and dissolved organic carbon occur when there is a flow at the diversion structures.

The concentration of total dissolved solids was 309 mg/L in the surface water inflow sampled. No total dissolved solids were measured at the diversion structures and the outflow structure (BERMB3) during WY2008 because there was no flow at the diversion structures (DS-1, DS-2, DS-3, and DS-4) or at the outflow structure. The total dissolved solids varied from 176 to 346 mg/L in groundwater locations sampled, which is in the same range as in the surface water inflow.

The dissolved organic carbon ranged from 7.5–24.0 mg/L in the surface water sampled at the inflow structures. There was no total organic carbon measured for the surface water sampled at the interior structures, the diversion structures, and the outflow structure (BERMB3) during WY2008 because there was no flow at these structures. There was very little variation in dissolved organic carbon concentrations among all structures.

## Evaluation of Total Phosphorus

The C-111 EO #9 established the monitoring schedule shown in Appendix 3A-8 of this volume for the collection of TP at C-111 EO #9 structures. Sample collection is accomplished mainly through a grab sample collection program. Grab samples are collected biweekly for the inflow and outflow structures, monthly for the interior structures, and in the event of diversion during flood events or to move water directly to the ENP from the diversion structures. Nutrients are the most frequently sampled parameters in this monitoring program.

During WY2008, auto-samplers collected TP samples on a weekly basis at the inflow structures S-332B, S-332C, and S-332D structures (water quality site ID S-332DAS changed to S-332DX for auto-sampler on October 2, 2007). No samples were collected at the two interior detention areas (CULC1 and CULC2) and four diversion structures (DS-1, DS-2, DS-3, and DS-4). One TP sample was collected at outflow site BERMB3.

- **Inflow Structures**. The TP concentrations for the C-111 EO #9 structures discharging directly into the detention areas during WY2008 varied around 10 ppb for all pump stations. More than 75 percent of the TP data collected at the S-332B monitoring sites were below 8 ppb (grab) and 8 ppb (auto), with a median value of 6 ppb for grab and 7 ppb for auto. More than 75 percent of the TP data collected at the S-332C monitoring sites were below 7 ppb (grab) and 8 ppb (auto), with a median value of 6 ppb for grab and 7 ppb for auto. Discharge data monitored at pump stations during WY2008 (26,499 ac-ft for S-332B and 49,156 ac-ft for S-332C, respectively) indicate the magnitude and occurrence of flow through the structures. Similar TP concentrations were observed for structure S-332D. During WY2008, structure S-332D discharged 32,689 ac-ft into the detention area. More than 75 percent of the TP data collected at the S-332D monitoring sites were below 7 ppb (grab) and 11 ppb (auto), with median concentrations of 6 ppb for grab and 8 ppb for auto samples.

- **Interior Structures**. Because there was no flow for the two interior structures (CULC1 and CULC2), no samples were collected in WY2008; therefore, no TP data were collected at these sites.
- **Diversion Structures**. DS-2 and DS-4 are the only diversion structures that could actually discharge into the ENP. However, no flow occurred at any of the four diversion structures (DS-1, DS-2, DS-3, and DS-4); therefore, no samples were collected.
- **Outflow Structures**. BERMB3 is the only surface water outflow structure to the ENP. During WY2008, there were no flow data from the detention area to the ENP via the BERMB3 structure. One TP sample was collected at BERMB3 with a TP concentration of 32.0 ppb. Flow rarely occurs over BERMB3 due to high seepage rates.

### *Flow-Weighted Mean Total Phosphorus Concentrations for All Structures*

Flow-weighted mean TP concentrations were calculated for each of the structures for WY2008 (**Table 3A-13**). This analysis is useful for determining whether additional sampling is required during flow events, and provides a more accurate depiction of expected concentrations during flow events. The calculation for FWM TP concentrations was accomplished for structures having sufficient TP and flow data for WY2008.

The FWM TP concentration for all the inflow structures during WY2008 was very similar, with 7.6 ppb at the S-332B, 7.1 ppb at the S-332C, and 6.5 ppb at the S-332D structures. Flow-weighted mean TP concentrations were below 10 ppb at all inflow structures. No flow data (or inadequate data) were available at interior, diversion, and outflow structures; therefore, FWM TP concentrations could not be calculated for those sites.

**Table 3A-13.** Flow volumes and flow-weighted mean TP concentrations of surface water during WY2008.

| Type | Structure | Water Quality Station ID | Total Flow Volume (ac-ft) | Sample Size (Grab) | Number of Days with Positive Flow | Arithmetic Average (Grab) (μg/L) | Sample Size (Comp) | Sample Type | Total Samples Collected During Flow | Flow-Weighted Mean Concentration (μg/L) | TP Load (kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Inflow | S-332B | S332B | 26,499 | 53 | 99 | 6.8 | 21 | Auto[1] & Grab[2] | 26/74 [3] | 7.6 | 248 |
| | S-332C | S332C | 49,156 | 51 | 122 | 6.4 | 23 | Auto & Grab | 31/74 | 7.1 | 433 |
| | S-332D | S332D, S332DAS & S332DX | 32,689 | 52 | 134 | 6.5 | 41 | Auto & Grab | 39/93 | 6.5 | 262 |
| Interior | C1 | CULC1 | 0 | 0 | N/D | N/D | N/D | Grab | 0/0 | N/F [5] | N/F |
| | C2 | CULC2 | 0 | 0 | N/D | N/D | N/D | Grab | 0/0 | N/F | N/F |
| Diversion | DS-1 | DS1 | 0 | 0 | N/D | N/D | N/D | Grab | 0/0 | N/F | N/F |
| | DS-2 | DS2 | 0 | 0 | N/D | N/D | N/D | Grab | 0/0 | N/F | N/F |
| | DS-3 | DS3 | 0 | 0 | N/D | N/D | N/D | Grab | 0/0 | N/F | N/F |
| | DS-4 | DS4 | 0 | 0 | N/D | N/D | N/D | Grab | 0/0 | N/F | N/F |
| Outflow | BERMB3 | BERMB3 | 0 | 1 | N/D | 32.0 | N/D | Auto Grab | 0/1 | N/F | N/F |

1. Auto indicates that samples were collected by automatic composite samples.
2. Grab indicates samples collected by grab sampling methodology.
3. 26/74 indicates 26 samples collected during flow events among 74 total collected samples.
4. N/D - no data available.
5. N/F - no flow.

## Evaluation of Total Nitrogen

During WY2008, auto-samplers collected total nitrogen (TN) samples weekly at the S-332B and S-332C structures. Deployment of the auto-samplers at these locations was previously identified as an improvement in the monitoring program for collecting TN data at inflow structures. Auto-samplers also collected samples at the S-332D structures located in the C-111 basin, which discharges water into the S-332D detention area east of the ENP. Samples were collected from the auto-sampler at the S-332DAS site, and the new sample identification S-332DX has been used since October 2, 2007.

- **Inflow Structures**. There was a similar average TN concentration in grab samples for all inflow structures (0.742 mg/L for S-332B; 0.720 mg/L for S-332C; and 1.003 mg/L for S-332D) discharging into the detention area during WY2008. Weekly auto-sampler (time-proportional) collection and biweekly grab samples at the S-332B, S-332C, and S-332D monitoring locations were initiated in 2003. Auto-samplers were changed to flow-proportional in 2003 at S-332D and in 2005 at S-332B and S-332C. More than 75 percent of the TN data collected at the S-332B monitoring site were below 0.744 mg/L (grab) and 1.047 mg/L (auto), with median values of 0.672 mg/L (grab) and 0.711 mg/L (auto). More than 75 percent of the TN data collected at the S-332C monitoring site were below 0.685 mg/L (grab) and 0.815 mg/L (auto), with median values of 0.640 mg/L (grab) and 0.665 mg/L (auto).
- **Interior Structures**. As shown in **Table 3A-13**, there was no flow for the two interior structures (CULC1 and CULC2) and, therefore, no TN grab samples were collected at those sites during WY2008.
- **Diversion Structures**. There was no flow data for the four diversion structures (DS-1, DS-2, DS-3, and DS-4). As a result, no samples were collected from any of the diversion structures during WY2008.
- **Outflow Structures**. BERMB3 is the only outflow structure to the ENP. During WY2008, there were no discharges from the detention area to the ENP through the BERMB3 structure. One outflow TN sample was collected from the upstream (north) side of the berm. This sample had a TN concentration of 0.610 mg/L.

### *Flow-Weighted Mean Total Nitrogen Concentrations for All Structures*

Flow-weighted mean TN concentrations were calculated for all inflow structures during WY2008. The analysis is useful for determining whether additional sampling is required during flow events and provides a more accurate depiction of expected concentrations during flow events. The calculation for FWM TN concentrations was accomplished for structures having sufficient TN and flow data for WY2008. Similar FWM TN concentrations were observed at all inflow structures (0.891 mg/L for S-332B, 0.671 mg/L for S-332C, and 0.668 mg/L for S-332D).

## Groundwater Quality

Total phosphorus concentrations were less than 10 ppb at all 10 groundwater wells except S-332CED, where the TP concentration was ranked as a concern (91.3 ppb, or µg/L). However, this may be an anomaly since the TP concentrations in the other wells east of the detention areas (S-332BES, S-332BED, S-332DES, and S-332DED) are considerably lower than S-332CED, and groundwater flows east when the detention areas have flow. This means the high TP levels at S-332CED may indicate either direct runoff into the well (e.g., improperly sealed casing) or the introduction of surface water via an adjacent agricultural well. The well and adjacent area will be inspected in WY2009. In addition, a casing seal of grout will be installed, and S-332CED is expected to be redeveloped in case the TP concentration is the result of surface water being introduced.

The flow pumped into the detention areas contained 248 kg of TP at S-332B, 433 kg of TP at S-332C, and 262 kg of TP at S-332D. These numbers assume that rainfall did not contribute to TP. Since no measurable surface water discharge occurred during this monitoring period, none of this load left the detention areas through surface flows. With the notable exception of the TP measured at S-332CED, the groundwater wells located on both the western and eastern sides of the detention areas have average water quality — similar to inflow concentrations. The average inflow (pumped) TP concentrations ranged from 6.5–6.8 ppb, whereas the average concentration ranged from 5.3–9.3 ppb in the western wells and 5.3–8.8 ppb in the eastern wells (with the notable exception of S-332CED).

It is difficult to ascertain with any certainty that this slight improvement is due to treatment provided by the detention areas. Other factors, such as dilution by rainfall and the heterogeneous nature of flow in the highly transmissive layers of the Surficial aquifer system limit the conclusions that can be made based on the water quality data obtained from the monitor wells. In addition, in order to calculate loading to the ENP, it would be necessary to quantify how much of the seepage flows west.

The TN concentrations in wells were generally slightly lower than TN concentrations of inflow structures. Average TN levels ranged from 0.096–0.753 mg/L. TN concentrations are less than 1 mg/L, which is similar to or slightly lower than the TN in surface water (from 0.742 to 1.003 mg/L). Water quality data for WY2008 are available from the District's database DBHYDRO. The inflow (pumped) TN load was 29,130 kg at S-332B, 40,655 kg at S-332C, and 26,954 kg at S-332D. The average inflow (pumped) TN concentrations ranged from 0.720–1.003 mg/L, whereas the average concentration ranged from 0.514–0.753 mg/L in the western wells and 0.096–0.638 mg/L in the eastern wells.

## Pesticide Monitoring

Atrazine desethyl (DEA) and atrazine desisopropyl (DIA) are biotic degradation products of atrazine. These degradation products are both persistent and mobile in water; however, DEA is more stable and the dominant initial metabolite. Since DEA and DIA are structurally and toxicologically similar to atrazine, the concentrations of total atrazine residue (atrazine + DEA + DIA) may also be a significant consideration in the surface water environment. However, neither Section 62-302.530, F.A.C., criteria nor toxicity information are available to make a determination of environmental impact.

A modification was implemented on September 10, 2007, to eliminate pesticide monitoring at S-332B and S-332C sites and use S-331 and S-173 as surrogate pesticide monitoring sites. The results of the quarterly surface water pesticide sampling events are presented in Appendix 3A-8, Table 7, of this volume. The detected concentrations of endosulfan (alpha and/or beta) do not exceed the Florida Class III surface water standard under Section 62-302, F.A.C. (0.056 μg/L).

The highest ametryn surface water concentration found was 0.031 μg/L. Using these criteria, these observed surface water concentrations should not have an acute, detrimental impact on fish or aquatic invertebrates (Appendix 3A-8, Table 8, of this volume).

The draft atrazine ambient aquatic life water quality criteria identify a one-hour average concentration that does not exceed 1,500 μg/L more than once every three years on the average (USEPA, 2003). The highest atrazine surface water concentrations detected (0.96 μg/L) should not have an acute or chronic detrimental impact on fish or invertebrates (Appendix 3A-8, Table 8, of this volume).

## Mercury Monitoring at the C-111D Project

As a result of an approved mandate modification in August 2006, surface water sampling was terminated under monitoring project C111D; therefore, no surface samples are reported for WY2008. Under the same approved mandate, largemouth bass and sunfish were eliminated from the C111D project, and mosquitofish (*Gambusia holbrooki*) monitoring was reduced to annual collection. Due to low water levels, the 2006 interior mosquitofish collection site CULC1 was replaced with CULC2 in 2007, and outflow site BERMB3 was replaced by diversion structures DS-4 and DS-2. In 2007, the median mosquitofish concentration for site CULC2 was 0.018 mg/kg. For D4-S and D2-S, the median mosquitofish concentration was 0.01 mg/kg.

In WY2008, mosquitofish levels were well below both the Southern Everglades 75$^{th}$ percentile concentration of 0.91 mg/kg (for the period of record up to 2006) and the USFWS predator protection criteria of 0.1 mg/kg — thus demonstrating no threat to piscivorous avian and mammalian wildlife. Except for the interior site (CUCLI), there is a visible temporal decrease in mosquitofish concentrations for the POR. Mercury levels in all fish species are below the average levels found in fish from all STAs and downstream Everglades monitoring locations (see Appendices 3B-1 and 5-6 of this volume). During the course of the entire project, THg surface water levels were well below the Florida Class III numerical water quality standard of 12 nanograms per liter (ng/L).

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