Chapter 2C: Status of Phosphorus and Nitrogen in the Everglades Protection Area

Grover Payne and Kenneth Weaver

SUMMARY

The Everglades ecosystem has evolved as a highly oligotrophic (nutrient-poor), phosphorus-limited system, with the natural flora and fauna being adapted to successfully exist under these harsh conditions. Research has shown that relatively small additions of nutrients, especially phosphorus (P), can have dramatic effects on the biological conditions of the natural ecosystem. The primary purposes of this chapter are to provide an update regarding the development of a numeric phosphorus criterion for the Everglades Protection Area (EPA) and to present an overview of the status of phosphorus and nitrogen levels in the surface waters within the EPA during Water Year 2003 (WY2003) (May 1, 2002 through April 30, 2003).

TOTAL PHOSPHORUS CRITERION

Given the importance of phosphorus in controlling the natural biological communities, the Florida Department of Environmental Protection (FDEP) has used the results of extensive research to numerically interpret the existing narrative criterion, as directed by the Everglades Forever Act (EFA), to propose a total phosphorus (TP) criterion of 10 micrograms per liter (µg/L) (or 10 parts per billion [ppb]) for the EPA. The 10-µg/L TP criterion was approved by the Environmental Regulation Commission (ERC) during a July 8, 2003 hearing.

The TP criterion rule for the EPA, as approved by the ERC, is composed of nine sections. These sections are: (1) purpose and scope, (2) findings, (3) definitions, (4) the numeric criterion for Class III waters in the EPA, (5) methods for determining achievement of the criterion, (6) requirements for long-term compliance permits for phosphorus discharges into the EPA, (7) moderating provisions for discharges into the EPA that do not achieve the 10-ppb criterion, (8) documents incorporated by reference, and (9) contingencies. The approved rule has been challenged by both environmental and agricultural interest groups. Therefore, it is expected that the TP criterion will become effective following the resolution of all challenges and once the criterion is formally incorporated into rule (Section 62-303.540, Florida Administrative Code [F.A.C.]) by the secretary of the FDEP and has received approval from the U.S. Environmental Protection Agency.

TOTAL PHOSPHORUS CONCENTRATIONS WITHIN THE EVERGLADES PROTECTION AREA

Since the approved total phosphorus criterion has not become effective and the required monitoring networks have not been established to date, this criterion and the associated achievement methodology were not applied to the current data presented in the *2004 Everglades Consolidated Report*. It is anticipated that subsequent versions of this chapter in future Everglades Consolidated Reports will be expanded to include a more detailed evaluation of EPA

marsh phosphorus levels consistent with the requirements of the final criterion. To provide an overview of the current nutrient status of the Everglades and to demonstrate the existence of any temporal and spatial patterns, TP concentrations measured during WY2003 are compared to those levels found during previous monitoring periods.

As documented during previous years, TP concentrations measured during WY2003 exhibited a decreasing north-to-south gradient, with the highest levels present in the inflow to the Arthur R. Marshall Loxahatchee National Wildlife Refuge (Refuge) and Water Conservation Area 2 (WCA-2), and with concentrations decreasing to a minimum within the Everglades National Park (ENP or Park). This gradient is indicative of the P-rich canal discharges, composed primarily of agricultural runoff originating in the Everglades Agricultural Area (EAA), entering the northern portions of the EPA with biogeochemical processes (e.g., settling, sorption, and biological assimilation) resulting in decreasing concentrations as the water flows southward through the marsh.

TP concentrations measured during WY2003 in the inflows to all portions of the EPA were below the levels reported for the historical period from WY1978 through WY2001 and were comparable to or slightly above the WY2002 levels. The inflows to the Park during WY2003 contained the lowest mean TP concentrations recorded for any of the three reporting periods.

The geometric mean TP concentrations measured across interior marsh stations in all portions of the EPA during WY2003 were the lowest recorded for any of the three reporting periods. During WY2003, interior marsh geometric mean TP concentrations ranged from a high of 14.8 µg/L in WCA-2 to a minimum of 4.6 µg/L in the Park compared to ranges from 15.2 to 4.8 µg/L and 17 to 5.6 µg/L for WY2002 and the historical period from WY1978 through WY2001, respectively. The slightly lower marsh TP levels measured during WY2003 likely reflect more typical rainfall patterns following several drier-than-normal years, changes in water management practices, and a general improvement in nutrient conditions in the marsh. Overall, these results further indicate that the TP concentrations at interior marsh sites have decreased slightly during recent years.

TOTAL NITROGEN CONCENTRATIONS WITHIN THE EVERGLADES PROTECTION AREA

As in previous years, total nitrogen (TN) concentrations in the EPA exhibited a north-to-south gradient during WY2003. This gradient likely reflects the higher concentrations in agricultural discharges to the northern portions of the system, with a gradual reduction in levels resulting from assimilative processes in the marsh as water flows southward. The highest average TN concentrations were observed in the inflows to the Refuge and WCA-2, with levels decreasing to a minimum in the Park.

Mean and median TN concentrations measured during WY2003 were similar to or slightly lower than those measured during WY2002 and the historical period from WY1978 through WY2001 across all portions of the EPA. During WY2003, mean TN concentrations at inflow stations ranged from 0.9 to 2.2 milligrams per liter (mg/L), with median TN concentrations ranging from 0.8 to 2.0 mg/L. Similarly, mean TN concentrations at the interior marsh stations during WY2003 ranged from 1.1 to 2.1 mg/L, with median concentrations ranging from 1.1 to 2.0 mg/L.

PURPOSE

The primary purpose of this chapter is to provide an overview of the status of phosphorus (P) and nitrogen (N) levels in the surface waters within the Everglades Protection Area (EPA) during Water Year 2003 (WY2003) (May 1, 2002 through April 30, 2003). The water quality evaluations presented in this section update previous analyses presented in the *1999 Everglades Interim Report* and the 2000, 2001, 2002, and *2003 Everglades Consolidated Report*. More specifically, this section and its associated appendices are intended to achieve the following objectives:

1. Summarize P and N concentrations measured in the surface waters within different portions of the EPA, and describe spatial and temporal trends observed
2. Discuss factors contributing to any spatial and temporal trends observed
3. Present an update on the progress made towards the establishment of a P-specific criterion for the EPA

This section represents a combination of the nutrient levels for total phosphorus (TP) and total nitrogen (TN) presented in the chapter evaluating the overall water quality status of the EPA (Chapter 2A) and the information provided in previous reports detailing the development of the P-specific criterion for the EPA (Payne et al., 2000, 2001, 2002, and 2003).

Once the final TP criterion becomes effective, and data becomes available from the appropriate monitoring network, it is anticipated that future versions of this section will be expanded to include a more detailed evaluation of the EPA marsh P levels consistent with the requirements of the final criterion.

METHODS

A regional synoptic approach used for water quality evaluations in previous Everglades Consolidated Reports (ECRs) was applied to WY2003 P and N data to provide an overview of the nutrient status within the EPA. The consolidation of regional water quality data provides for analysis over time, but limits spatial analysis within each region. However, spatial analysis can be performed between regions because the majority of inflow and pollutants enter the northern one-third of the EPA and the net water flow is from north to south.

As described for the evaluation of other water quality constituents, the majority of the water quality data evaluated in this chapter were retrieved from the South Florida Water Management District's (SFWMD or District) DBHYDRO database. Water quality data from the nutrient gradient sampling stations monitored by the Everglades Systems Research Division in the northern part of Water Conservation Area 2A (WCA-2A), the southwestern part of the Arthur R. Marshall Loxahatchee National Wildlife Refuge (Refuge), the west-central portion of Water Conservation Area 3A (WCA-3A), and Taylor Slough in Everglades National Park (ENP or Park) were obtained from the SFWMD's Everglades research database.

The P and N data summarized in this section were collected at the same monitoring stations described in Chapter 2A of this report (Figure 2A-1). Likewise, the water quality sampling stations located throughout the Park and the WCAs were categorized as inflow, rim canal, interior, or outflow sites within each region based on their location and function as previously described. During the data analysis for the *2004 Everglades Consolidated Report*, several changes were made to the classification of inflow and outflow monitoring stations to accurately reflect how the system currently functions. The station classification currently reflects the diversion of S-5A and S-6 flows into STA-1W and STA-2, respectively, by the removal of the S-5A and S-6

sites as inflows to the Refuge beginning in July and November 2000, respectively. STA-1W diversion structures G-300 and G-301 were added as inflows to the Refuge. Likewise, G-339 was added as an inflow to WCA-2 to capture diversions from STA-2. For the STA diversion structures (G-300, G-301, and G-339), only water quality data collected during diversion events were utilized in the evaluations presented in this section. Additionally, the STA-2 discharge structure G-335 was added as an inflow to WCA-2. It is anticipated that in future years, additional alterations will be made to the monitoring network in response to the Everglades Construction Project (ECP) and the Comprehensive Everglades Restoration Plan (CERP). Due to these changes to the station classifications, some of the statistics for P and N presented in the *2004 Everglades Consolidated Report* are slightly different from those presented in previous ECRs. For example, the *2003 Everglades Consolidated Report* reported a geometric mean TP concentration of 40 micrograms per liter (µg/L) for WCA-2 inflows during WY2002, whereas **Table 2C-1** of this chapter reports a concentration of 29.6 µg/L for WY2002. The location and categorization of the monitoring stations used for the analysis of the WY2003 P and N data are the same as those utilized for the evaluation of other water quality constituents, as described in Chapter 2A of this report (Figures 2A-2 through 2A-5).

The current SFWMD monitoring programs are described by Germain (1998). The frequency of nutrient sampling varies by site depending on site classification and hydrologic conditions (water depth and flow). Additionally, the District has created a Website describing its water quality monitoring projects, including project descriptions and objectives. This Website currently provides limited, site-specific information. Generally, interior monitoring stations were sampled monthly, with water control structures (inflows and outflows) typically being sampled bi-weekly when flowing, and monthly otherwise. For more information, refer to the District's Website at http://www.sfwmd.gov/org/ema/envmon/wqm/index.html.

The quality assurance/quality control (QA/QC) procedures followed during data collection, as well as the data screening performed on the nutrient data presented in this section, are the same as those described in Chapter 2A of this document. For purposes of summary statistics presented in this chapter, data reported as less than the method detection limit (MDL) were assigned a value of one-half the MDL. All data presented in this section, including historical results, were handled consistently with regard to screening and MDL replacement.

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 Everglades, however, evolved as a highly oligotrophic (nutrient-poor), P-limited system, with the natural flora and fauna being adapted to successfully exist under these harsh conditions. Research has demonstrated that relatively small additions of these nutrients, especially P, can have dramatic effects on the biological conditions of the natural ecosystem.

Currently, the concentrations of P and N in the EPA's surface waters are regulated by the Class III narrative criterion. This criterion specifies that nutrient concentrations in a water body cannot be altered to cause an imbalance in the natural populations of flora or fauna and shall be limited to prevent violations of other water quality standards. Additionally, given the importance of P in controlling the natural biological communities, the Florida Department of Environmental Protection (FDEP) has numerically interpreted the narrative criterion, as directed by the Everglades Forever Act (EFA), to propose a TP criterion of 10 µg/L for the EPA. The ERC approved this 10-µg/L TP criterion during a July 8, 2003 hearing. A number of petitions challenging the FDEP's rule have been received and a hearing is scheduled for November 2003.

Table 2C-1. Summary of total phosphorus (TP) concentrations (µg/L) in the Everglades Protection Area (EPA) for WY2003, WY2002, and WY1978 through WY2001.

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	1978-2001	2833	70.4	87.2	77	<4	1415
		2002	143	33.4	32.9	27	14	196
		2003	127	48.4	42.9	46	20	315
	Interior	1978-2001	2083	10.1	23.0	9	<4	494
		2002	237	10.2	12.6	9	4	120
		2003	222	9.4	8.0	9	<4	45
	Outflow	1978-2001	1139	57.2	123.3	55	7	3435
		2002	66	32.0	32.2	29	14	210
		2003	65	40.4	24.1	42	12	143
	Rim	1978-2001	662	64.5	51.2	62	12	473
		2002	44	53.6	50.2	48	19	215
		2003	32	85.1	43.3	83	36	206
WCA-2	Inflow	1978-2001	1734	62.0	106.4	62.3	7	3435
		2002	143	29.6	27.1	25	10.5	210
		2003	147	31.6	23.3	34	10.5	128
	Interior	1978-2001	4426	17.0	112.4	13	<4	3189
		2002	266	15.2	24.4	14	4	210
		2003	279	14.8	22.1	13	<4	170
	Outflow	1978-2001	1396	20.4	39.0	19	<4	556
		2002	64	18.5	16.3	16.5	6	77
		2003	55	20.9	16.4	20	6	93
WCA-3	Inflow	1978-2001	4715	35.4	67.5	36	<4	1286
		2002	410	27.1	33.2	26	7	408
		2003	385	29.9	30.4	29	8	212.5
	Interior	1978-2001	1733	9.0	28.6	8	<4	438
		2002	272	8.8	24.0	8	<4	310
		2003	320	8.0	15.1	7	<4	120
	Outflow	1978-2001	3817	10.7	22.1	10	<4	593
		2002	208	14.0	19.0	12	4	132
		2003	202	11.9	9.0	11	5	53
Park	Inflow	1978-2001	4381	9.1	19.3	9	<4	593
		2002	294	9.1	16.1	8	<4	132
		2003	287	8.8	7.6	8	<4	52
	Interior	1978-2001	1442	5.6	40.8	5	<4	1137
		2002	135	4.8	7.4	5	<4	53
		2003	83	4.6	3.4	5	<4	20

The TP criterion will become effective following the resolution of the issues which have been challenged and upon approval by the U.S. Environmental Protection Agency (USEPA).

Due to the importance of nutrient levels within the Everglades Protection Area (EPA), the concentrations of P and N measured during WY2003 are further discussed in this chapter with a comparison to results from previous monitoring years. Once the TP criterion becomes effective and data are made available from the appropriate monitoring network, it is anticipated that future versions of this chapter will be expanded to include a more detailed evaluation of EPA marsh P levels consistent with the requirements of the final criterion.

TOTAL PHOSPHORUS

STATUS OF PHOSPHORUS CRITERION RULEMAKING

The Everglades Forever Act (Section 373.4592, Florida Statutes [F.S.]) specifically states that waters flowing into a part of the remnant Everglades (also known as the Everglades Protection Area or EPA) contain excessive phosphorus levels, and a reduction in phosphorus levels will benefit the ecology of the EPA. The EFA further directs the FDEP to develop a numeric total phosphorus criterion by numerically interpreting the existing Class III narrative criterion as it applies to the Everglades Protection Area.

In response to the requirements of the EFA, the FDEP and the District conducted research necessary to establish a numeric TP criterion. The research program consisted of the following: (1) the field transect monitoring along existing, man-made nutrient gradients, (2) field perturbations (dosing experiments), and (3) laboratory experiments. The three-pronged research approach was recommended by the Everglades Technical Oversight Committee's *Everglades Nutrient Threshold Research Plan* (Lean et al., 1992) to ensure that sufficient data were available to support the development of the numeric TP criterion for the Everglades Protection Area.

To derive an appropriate numeric TP criterion, the FDEP conducted extensive analyses of the data from the District's research with data from other sources also being incorporated, where appropriate. Since P gradients exist in some areas of the EPA as the result of receiving P-rich runoff for as long as 40 years, the FDEP had an excellent opportunity to study the effects of long-term P enrichment on the natural biological communities in the marsh. Due to this and other advantages of the gradient transect studies (i.e., studies of full-scale natural marsh systems in which the biological responses to P-enrichment are unrestricted by experimental design), the FDEP's derivation of the P criterion relied heavily on data collected along a series of transects traversing the existing man-made P gradients in each portion of the EPA (i.e., the Refuge, WCA-2A, WCA-3, and the Park). Additionally, results from experimental dosing and laboratory experiments were used to establish a cause and effect relationship between observed biological changes and P enrichment and to further support the conclusions obtained from the field studies. The results of the FDEP's analyses and the derivation of the TP criterion are provided in previous ECRs (McCormick, et al., 1999; Payne, et al., 2000, 2001, 2002, and 2003), with additional detail provided in the FDEP's Everglades Phosphorus Criterion Development Support Documents (Payne, et al., 2000, 2001, and 2002).

Further statistical analyses of the data from the Refuge and WCA-2A to evaluate the uncertainty around the average TP levels indicate that the maintenance of a long-term (five-year), annual geometric mean TP concentration at or below 10 µg/L would be protective of the natural flora and fauna without being overly protective or below the natural background levels. However, FDEP's analyses also indicate that, over shorter periods (less than or equal to 1 year), TP levels can naturally vary significantly above 10 µg/L without long-term biological impacts (Payne et al., 1999 and 2000).

Based on the results of the FDEP's extensive analyses, the agency filed a notice of rulemaking and recommended a 10-µg/L TP criterion (to be measured as a five-year geometric mean) for approval by the Environmental Regulation Commission (ERC) in December 2001, which was ahead of the deadline specified in the EFA. As previously noted, following a series of hearings, the ERC approved the 10-µg/L TP criterion for the EPA during a July 8, 2003 hearing. A number of petitions challenging the FDEP's rule have been received, and a follow-up hearing is currently scheduled for November 2003. The TP criterion will become effective following the resolution of the issues which have been challenged and upon approval by the U.S. Environmental Protection Agency (USEPA). If the challenges to the proposed rule are not resolved by December 31, 2003, then the EFA specifies that a default TP criterion of 10 µg/L will be in effect until the challenges are resolved and a specific criterion is formally adopted. Once the administrative challenges are resolved, the rule is subject to approval by the USEPA prior to becoming effective.

The complete TP criterion rule for the EPA, as approved by the ERC, is composed of nine sections. Sections (1), (2), and (3) comprise the purpose and scope, findings, and definitions sections, respectively. Section (4) establishes the numeric criterion for Class III waters in the EPA as a long-term geometric mean of 10 µg/L (or parts per billion [ppb]). Section (5) provides methods for determining achievement of the criterion, which take into account spatial and temporal variability, natural background conditions, and confidence in laboratory results. Section (6) establishes long-term compliance permit requirements for phosphorus discharges into the EPA. Section (7) establishes two new moderating provisions for discharges into the EPA that do not achieve the 10-ppb criterion. The two moderating provisions are a net improvement moderating provision for discharges into impacted areas of the EPA and a hydropattern restoration moderating provision for discharges into unimpacted areas of the EPA. The net improvement moderating provision authorizes discharges into impacted areas where the permittee uses the Best Available Phosphorus Reduction Technology, which is defined by the rule as implementation of the SFWMD's Everglades Protection Area Tributary Basins Conceptual Plan for Achieving Long-Term Water Quality Goals Final Report. Sections (8) and (9) of the rule contain a list of documents incorporated by reference and contingencies. A copy of the TP criterion rule for the EPA (Section 62-303.540, Florida Administrative Code [F.A.C.]) approved by the ERC is provided in Appendix 2C-1.

As specified above, section (5) of the rule provides a methodology to determine achievement of the numeric TP criterion in an objective and scientifically reliable manner. The methodology, developed by the FDEP in cooperation with the SFWMD, is based on information obtained during the TP criterion development. The measurement methodology is designed to allow the TP criterion to be applied so that it protects the natural biological communities within the EPA without restricting the natural heterogeneity of the ecosystem while taking into account natural spatial and temporal variability, including variability above 10 µg/L, as required by the EFA. Therefore, the FDEP's recommended measurement methodology consists of (1) the maintenance of a long-term, average TP concentration that will protect against imbalances in the natural flora and fauna, and (2) the upper annual TP concentration limits that allow for the natural temporal and spatial variability.

The TP criterion achievement methodology consists of two major components: (1) the maintenance of a long-term (five-year) geometric mean TP concentration across a network of evenly distributed marsh sites, and (2) a series of three components intended to protect against localized or shorter-term imbalances in the natural flora and fauna while allowing for natural temporal and spatial variability. The approved methodology specifies the following:

> The water body will have achieved the criterion if the five year geometric mean is less than or equal to 10 ppb. In order to provide protection against imbalances of aquatic flora or fauna, the following provisions must also be met:
>
> a. the annual geometric mean averaged across all stations is less than or equal to 10 ppb for three of five years; and
>
> b. the annual geometric mean averaged across all stations is less than or equal to 11 ppb; and
>
> c. the annual geometric mean at all individual stations is less than or equal to 15 ppb.

Achievement of the criterion in WCA-2 and WCA-3 shall be determined based upon the application of the above methodology to data collected monthly from stations that are evenly distributed and located in freshwater open-water sloughs within each water body (i.e., areas similar to those utilized during the derivation of the numeric TP criterion). The achievement methodology will be applied to each water body separately. Furthermore, achievement of the TP criterion will also be determined separately in impacted and unimpacted areas within each water body.

To ensure compatibility with the federal Settlement Agreement (i.e., Settlement Agreement dated July 26, 1991, entered in Case No. 88-1886-Civ-Hoeveler, U.S. District Court for the Southern District of Florida, as modified by the Omnibus Order entered in the case on April 27, 2001), the approved rule specifies that achievement of the TP criterion in the Park and the Refuge will be based on the methods set forth in Appendices A and B, respectively, of the Settlement Agreement until this agreement is rescinded or terminated. If the Settlement Agreement is no longer in effect, then achievement of the TP criterion will be determined based on the method provided for WCA-2 and WCA-3.

The measurement methodology contained in the approved TP criterion is used: (1) to provide for an objective and scientifically reliable assessment of the TP status at sampling stations representative of the EPA, (2) to take into account natural spatial and temporal variability without being significantly biased by extreme events, and (3) to allow the TP criterion to be applied so that it protects the natural biological communities present within the EPA without restricting the natural heterogeneity of the ecosystem or being below background levels.

PHOSPHORUS STATUS IN THE EVERGLADES PROTECTION AREA

Since the required monitoring networks have not been established and the sites have not been classified as impacted or unimpacted, it is not appropriate to apply the TP criterion achievement methodology to the current data. Therefore, the 10-µg/L TP criterion approved by the ERC (and the default TP criterion specified in the EFA) and the preliminary 50 µg/L limit for the STAs are used in this chapter as comparisons to the current data. It is anticipated that after the TP criterion rule becomes effective (following any administrative/legal challenges and approval by USEPA) and once the appropriate monitoring stations are established, the achievement methodology specified in the final rule will be applied in future Everglades Consolidated Reports as the necessary data become available.

To provide an overview of the current nutrient status of the Everglades and to demonstrate the existence of any temporal and spatial patterns, TP concentrations measured during WY2003 are compared to the TP levels determined during WY2002 and the historical period from WY1978 through WY2001. **Table 2C-1** provides a summary of the TP concentrations measured within different portions of the EPA during WY2003, WY2002, and WY1978 through WY2001

using both geometric mean and median values. Geometric means were used to summarize and compare TP concentrations based on requirements in the EFA and the approved TP criterion rule that specify that achievement of the TP criterion be based on the long-term geometric mean. Since the EFA and TP criterion were designed to provide long-term conditions that are ecologically protective, they require the use of geometric means, which smooth out short-term variability in water quality data to provide a more reliable long-term value for assessing and comparing phosphorus status.

As documented during previous years, TP concentrations measured during WY2003 exhibited a decreasing north-to-south gradient, with the highest levels present in the inflow to the Refuge and WCA-2, and with concentrations decreasing to a minimum within the Park. This gradient is indicative of the P-rich canal discharges, composed primarily of agricultural runoff originating in the Everglades Agricultural Area (EAA), entering the northern portions of the EPA with settling, sorption (both adsorption and absorption), biological assimilation, and other biogeochemical processes, thereby resulting in decreasing concentrations as the water flows southward through the marsh.

TP concentrations (expressed either as median or geometric mean values) measured during WY2003 in the inflows to all portions of the EPA were below the levels reported for the historical period from WY1978 through WY2001 and were comparable to or slightly above the WY2002 levels (**Table 2C-1**). The inflows to the Park during WY2003 contained the lowest mean TP concentrations recorded for any of the three reporting periods (i.e., geometric mean of 8.8 µg/L in WY2003 versus 9.1 µg/L in other periods). This provides further evidence that the increased TP concentrations in the inflow to the Park that were reported for WY2001 in the 2002 ECR (Weaver et al., 2002) were a temporary, natural phenomenon associated with the drought conditions and the increased release of P from sediments as portions of the system dried.

The geometric mean TP concentrations measured across interior marsh stations in all portions of the EPA during WY2003 were the lowest recorded for any of the three reporting periods. During WY2003, interior marsh geometric mean TP concentrations ranged from 14.8 µg/L (WCA-2) to 4.6 µg/L (Park) compared to ranges of 15.2 µg/L to 4.8 µg/L and 17 µg/L to 5.6µg/L for WY2002 and the historical period from WY1978 through WY2001, respectively (**Table 2C-1**). The slightly lower marsh TP levels measured during WY2003 likely reflect more typical rainfall patterns following several drier-than-normal years, changes in water management practices, and a general improvement in nutrient conditions in the marsh.

Annual geometric mean TP concentrations for individual interior marsh monitoring stations during WY2003 ranged from less than 4.0 to 49.7 µg/L, with 63.6 and 79.2 percent of the marsh sites across the EPA exhibiting annual geometric mean TP concentrations that were less than or equal to 10 µg/L and 15 µg/L, respectively (**Figure 2C-1**). For comparison, 63.4 percent of the sites monitored during WY2002 had annual geometric mean TP concentrations less than or equal to 10 µg/L. Given that the location of interior monitoring sites has remained relatively constant over the past several years, the temporal comparison of statistics from individual sites can be used to distinguish trends in measured concentrations. However, since the monitoring sites are not evenly distributed across the EPA, it is not possible to accurately estimate the percentage of the marsh exceeding a TP concentration of 10 µg/L, or any other specified level based on these results. During WY2003, TP concentrations in a few individual sites (X4, F5, CA33, and CA35) located in areas relatively uninfluenced by canal inflows slightly exceeded 10 µg/L (ranged from 10.3 to 12.0 µg/L). The CA33 and CA35 sites are located in the northern portion of WCA-3, where low water levels and dry conditions often result in elevated TP levels. A more detailed, site-specific summary of the TP concentrations for WY2003 is provided in Appendix 2C-2. Calculated TP loads for individual water control structures within the EPA (EAA and non-ECP sites) are presented in Chapter 8B of the *2004 Everglades Consolidated Report*.

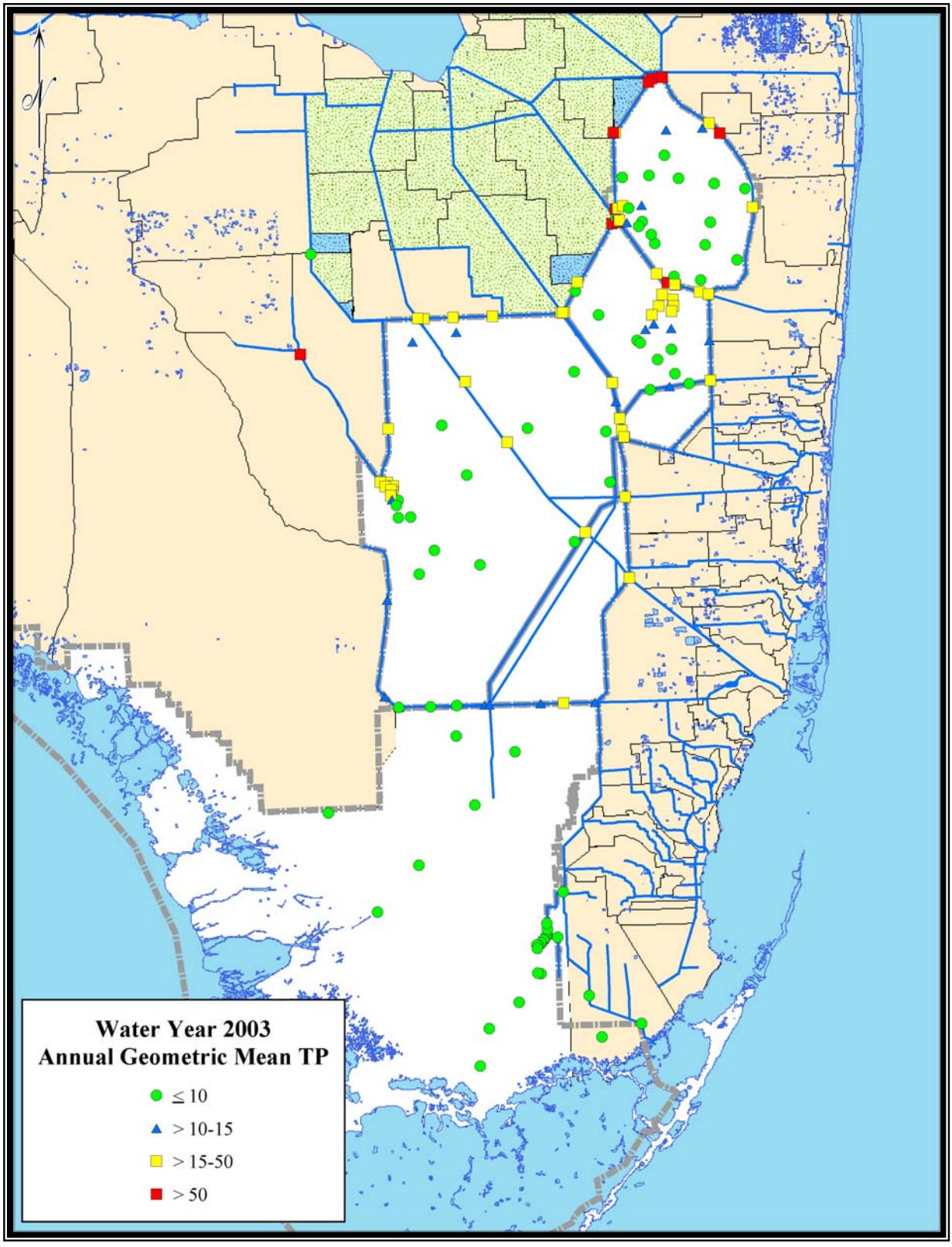

Figure 2C-1. Summary of geometric mean TP concentrations (µg/L) at stations across the EPA. Geometric mean TP concentrations are classified utilizing four levels: ≤ 10 µg/L, 10 to 15 µg/L, 15 to 50 µg/L, and > 50 µg/L.

Of the 77 interior marsh stations sampled during WY2003, 62.3 percent exhibited long-term (five-year) geometric mean TP concentrations of 10 µg/L or less during the period from WY1999 through WY2003. Additionally, 76.6 percent of the stations were determined to have a long-term geometric mean TP concentration of 15 µg/L or below. Overall, these results further indicate that the TP concentrations at interior marsh sites have decreased slightly during recent years.

Spatially, interior marsh TP concentrations measured during WY2003 exhibited the same north-to-south gradient observed during previous periods (Bechtel et al., 1999 and 2000; Weaver et al., 2001, 2002, and 2003). As a typical observation, the highest TP concentrations obtained during WY2003 were collected from the northern WCAs and declined throughout WCA-3 and the Park. During WY2003, 38.9 percent of the monitoring sites in WCA-2 had annual geometric mean TP concentrations of 10 µg/L or less, with the percentage of sites at or below 10 µg/L and increasing to 100 percent in the Park (**Figure 2C-1**). Likewise, 61.1 percent of interior sites within WCA-2 were determined to have annual geometric mean TP concentrations of 15 µg/L or less for WY2003. The percentages increased in other areas of the EPA and all the sites in the interior of the Park were below 15 µg/L.

The distribution of TP concentrations in all EPA regions for WY2003 is presented in **Figure 2C-2**. Inflow stations to the Refuge and the WCAs had the highest percentage of measurements above 50 µg/L (22 to 41 percent). In contrast, less than 1 percent of the TP measurements at the Park inflow sites were above 50 µg/L, and 69 percent were below 10 µg/L. Likewise, WCA-2, the most highly P-enriched area, exhibited the lowest percentage of samples from interior sites at or below 10 µg/L (41 percent), while 66 and 74 percent of samples collected from the interior of the Refuge and WCA-3, respectively, had TP concentrations of 10 µg/L or below. Additionally, more than 95 percent of the samples collected in the interior of the Park had TP concentrations of 10 µg/L or less.

Over the entire EPA (all areas and site classifications), 88 percent of the TP measurements collected during WY2003 were below 50 µg/L, with 40 percent of the measurements at or below 10 µg/L. These WY2003 results are slightly improved compared to the WY2002 results in which the TP concentrations in 87 percent of the samples were less than 50 µg/L, and 38 percent of the measured concentrations were at or below 10 µg/L.

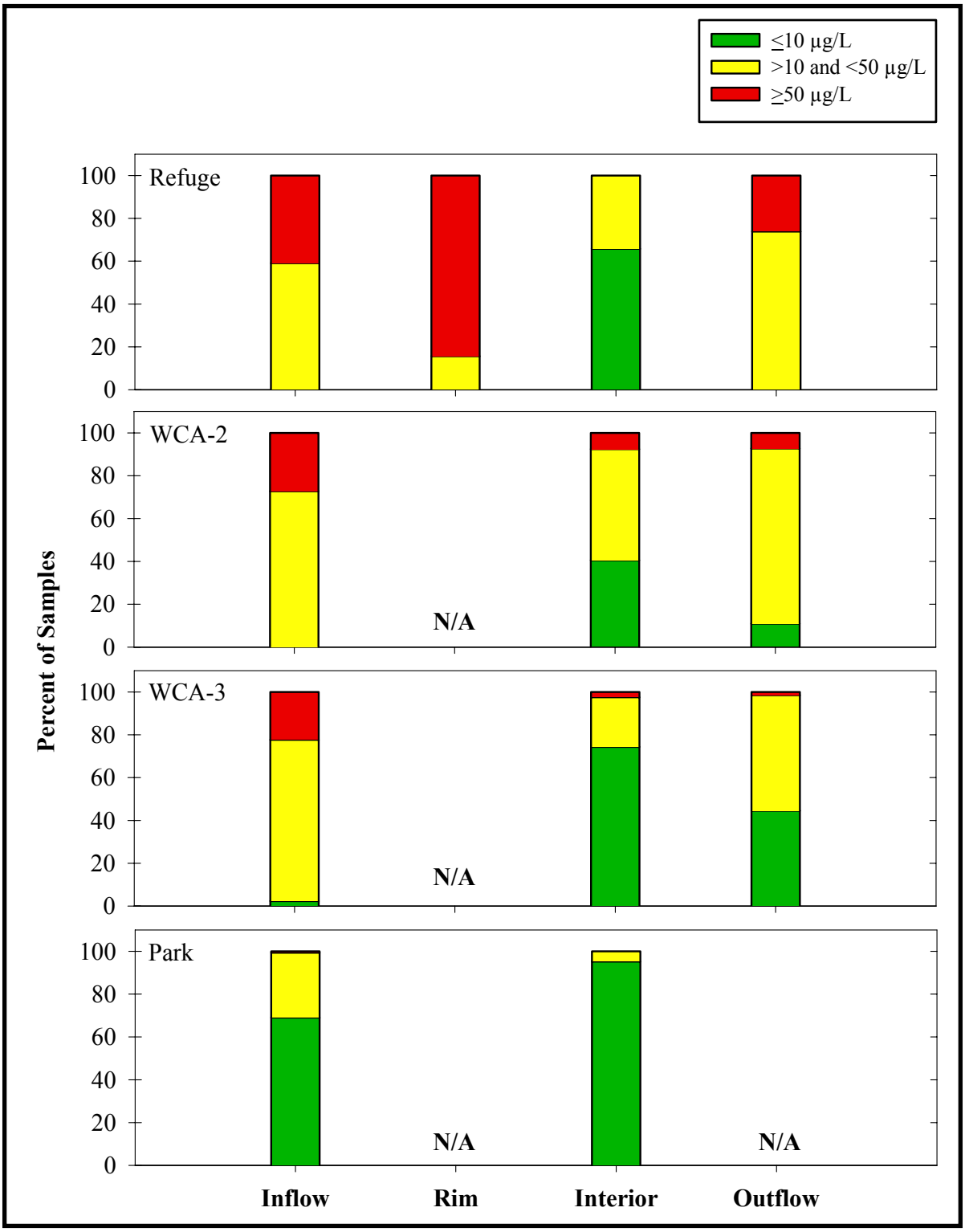

Figure 2C-2. Summary of TP concentrations (µg/L) in samples collected in the EPA during WY2003. "N/A" indicates that the given component (e.g., rim and outflow) is not present within that area of the EPA.

TOTAL NITROGEN

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_2+NO_3). For the *2004 Everglades Consolidated Report*, TN values were calculated only for samples for which both TKN and NO_2+NO_3 results were available. **Table 2C-2** provides a summary of the TN concentrations from WY2003, WY2002, and WY1978 through WY2001 that were measured in the different portions of the EPA. Mean and median TN concentrations measured during WY2003 were similar to or slightly lower than those measured during WY2002 and the historical period from WY1978 through WY2001 across all portions of the EPA. During WY2003, mean TN concentrations at inflow stations ranged from 0.9 to 2.2 milligrams per liter (mg/L), and median TN concentrations ranged from 0.8 to 2.0 mg/L. Similarly, mean TN concentrations at the interior marsh stations during WY2003 ranged from 1.1 to 2.1 mg/L, and median TN concentrations ranged from 1.1 to 2.0 mg/L.

As in previous years, TN concentrations in the EPA exhibited a north-to-south gradient during WY2003. This gradient likely reflects the higher concentrations in agricultural discharges to the northern portions of the system, with a gradual reduction in levels resulting from assimilative processes in the marsh as water flows southward. The highest average TN concentrations were observed in the inflows to the Refuge and WCA-2, with levels decreasing to a minimum in the Park.

Table 2C-2. Summary of total nitrogen (TN) concentrations (mg/L) measured in the EPA during WY2003, WY2002, and WY1978 through WY2001.

Region	Class	Period	Sample Size (N)	Arithmetic Mean (mg/L)	Std. Deviation	Median (mg/L)	Min. (mg/L)	Max. (mg/L)
Refuge	Inflow	1978-2001	2626	3.5	2.3	2.9	<0.5	48.2
		2002	84	2.1	0.6	2.1	1.0	3.4
		2003	71	1.8	0.5	1.7	1.2	3.3
	Interior	1978-2001	1684	1.7	1.4	1.3	<0.5	36.7
		2002	149	1.5	0.7	1.2	0.6	4.8
		2003	203	1.4	0.4	1.4	0.7	2.6
	Outflow	1978-2001	1124	2.7	1.7	2.3	<0.5	22.8
		2002	66	1.8	0.6	1.6	0.9	3.9
		2003	65	1.7	0.4	1.5	1.0	3.2
	Rim	1978-2001	635	2.8	1.5	2.3	0.7	10.9
		2002	33	2.4	0.7	2.3	1.2	3.9
		2003	32	2.1	0.7	1.8	1.4	4.6
WCA-2	Inflow	1978-2001	1670	3.0	1.6	2.7	<0.5	22.8
		2002	109	2.5	1.0	2.4	0.7	6.4
		2003	103	2.2	0.9	2.0	1.0	5.7
	Interior	1978-2001	3899	2.5	1.7	2.2	<0.5	37.2
		2002	164	2.1	0.6	2.1	0.9	4.0
		2003	240	2.1	0.6	2.0	1.1	4.6
	Outflow	1978-2001	1387	2.2	0.9	2.0	0.3	7.7
		2002	66	1.7	0.6	1.6	0.9	4.1
		2003	57	1.9	0.6	1.8	1.1	4.0
WCA-3	Inflow	1978-2001	4312	2.1	1.0	1.8	<0.5	10.8
		2002	240	1.6	0.6	1.5	0.9	5.2
		2003	230	1.7	0.7	1.6	0.9	5.3
	Interior	1978-2001	1570	1.6	0.9	1.3	<0.5	10.0
		2002	116	1.2	0.4	1.1	0.7	3.4
		2003	278	1.3	0.3	1.2	0.7	2.1
	Outflow	1978-2001	2857	1.5	0.7	1.4	<0.5	14.9
		2002	159	1.1	0.3	1.0	<0.5	2.7
		2003	147	1.0	0.3	1.0	0.6	2.1
Park	Inflow	1978-2001	3294	1.3	0.7	1.3	<0.5	14.9
		2002	183	0.9	0.4	0.9	<0.5	2.7
		2003	165	0.9	0.3	0.8	<0.5	2.1
	Interior	1978-2001	1296	1.4	1.5	1.2	<0.5	40.8
		2002	116	0.9	0.4	0.9	<0.5	2.2
		2003	79	1.1	0.4	1.1	<0.5	2.8

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