Chapter 2A: Status of Water Quality in the Everglades Protection Area

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SUMMARY

This chapter is intended as an update to the *2002 Everglades Consolidated Report* (2002 ECR) and provides a review of the water quality status for each Everglades Protection Area (EPA) region during Water Year 2002 (WY02)(May 1, 2001 through April 30, 2002). The status of water quality in the Everglades Protection Area was determined by an analysis of the water quality parameters that did not meet the water quality criteria specified in Section 62-302.530 of the Florida Administrative Code (F.A.C.). Discussion of any temporal or spatial trends observed for parameters identified as concerns or potential concerns is also provided. Annual excursion rates were summarized in a manner similar to methods employed in the 1999 *Everglades Interim Report* and in previous Everglades Consolidated Reports. For the 2003 ECR, parameters not meeting existing standards were classified into three categories based on excursion frequencies statistically tested using the binomial hypothesis test. This chapter also provides a discussion of the factors contributing to excursions from applicable water quality criteria and an evaluation of the natural background condition, where existing standards are not appropriate. The results of the evaluation detailed in this chapter are summarized below.

- Dissolved oxygen (DO) was designated as a parameter of concern for all EPA regions and classes due to ubiquitous concentrations below the current 5.0-mg/L criterion. However, the Florida Department of Environmental Protection (FDEP) has developed a Site Specific Alternative Criterion (SSAC) that recognizes the naturally low DO regime characteristic of periphyton-dominated wetlands, such as the Everglades. The SSAC is currently being evaluated. Application of the SSAC to DO data collected during WY02 resulted in a reduction (from 139 to 36) in the number of monitoring stations at which DO was identified as a concern. The DO regime at most of the remaining 36 sites can be shown to be depressed either by nutrient enrichment or groundwater infiltration. These sites are accurately designated by the SSAC as being below natural marsh background levels.
- As in previous years, alkalinity was classified as a concern for the interior of the Arthur R. Marshall Loxahatchee National Wildlife Refuge (Refuge) during WY02 due to an excursion rate of 18.2 percent. The low alkalinity levels in the interior of the Refuge result from natural hydrologic patterns and should not be considered in violation of the current criterion. In contrast to other parts of the Everglades, the interior of the Refuge is a soft-water system that receives most of its hydrologic load from rainfall rather than from canal inflows.

- Similar to previous periods, conductivity was categorized as a concern for Refuge inflows and as a potential concern for the Water Conservation Area 2 (WCA-2) interior in WY02. All the conductivity excursions occurred in close proximity to water control structures or canals and are probably associated with the pumping or seepage of high ionic-strength groundwater into the surface water in the canals. Groundwater can be introduced to the surface water through normal operation due to morphology of the water conveyance system and as a result of agricultural activities in the Everglades Agricultural Area (EAA). The importance of each of these factors in contributing to the observed conductivity excursions is unclear and warrants further evaluation.
- Un-ionized ammonia was categorized as a concern for WCA-2 inflows during WY02 due to a large number of excursions (19) at sites E0 and F0 in the spreader canal that receives inflows from the Hillsboro canal. The WY02 excursion frequency for WCA-2 inflows was substantially above all previous periods of record. In fact, the un-ionized ammonia excursion frequency has only ranged from 0 to 8 percent for all previous water years since 1978, compared to approximately 24 percent during WY02. Elevated dissolved ammonia concentrations were the primary cause of the WY02 excursions at stations E0 and F0.
- Beryllium was categorized as a concern for WCA-3 inflows due to excursions at three inflow structures (G-205, G-206 and S-8) during WY02. Average beryllium concentrations at these stations during WY02 ranged from 0.39 to 0.92 µg/L, compared to the current criterion of 0.15 µg/L.
- Fifteen pesticides were detected in the Everglades Protection Area (EPA) during the reporting period from December 2000 through November 2001. Atrazine, diazinon, endosulfan (total alpha and beta) and simazine each had exceedances of either Class III criteria or chronic toxicity guidelines and were classified as parameters of concern. Pesticide excursions for the period of record were limited to inflows to the Refuge and WCA-2.
- Total phosphorus (TP) concentrations at inflow stations to the Water Conservation Areas for WY02, measured either as medians or as a geometric mean, were lower than the historic period and also declined slightly from WY01 levels. During WY02, Everglades National Park (ENP or Park) inflow TP concentrations returned to pre-drought conditions, with a geometric mean concentration of 9.1 µg/L (median = 8.0 µg/L). Interior marsh geometric mean TP concentrations ranged from 4.8 to 15.3 µg/L.

PURPOSE

The primary purpose of this chapter is to provide an overview of the status of water quality in the Everglades Protection Area during WY02 (May 1, 2001 through April 30, 2002). The water quality evaluations presented herein build on previous analyses presented in the 1999 *Everglades Interim Report* and the 2000, 2001, and *2002 Everglades Consolidated Report*. More specifically, this chapter and its associated appendices are intended to use water quality data collected during WY02 to achieve the following objectives:

1. Present a refined excursion evaluation methodology designed to be consistent with other State of Florida ambient water programs and U.S. Environmental Protection Agency (USEPA) guidance.
2. Summarize areas and times where water quality criteria are not being met, and indicate trends in excursions over space and time.
3. Discuss factors contributing to excursions from water quality criteria and provide an evaluation of natural background conditions where existing standards are not appropriate.
4. Summarize total phosphorus (TP) and total nitrogen concentrations in the EPA and indicate spatial and temporal trends.
5. Summarize sulfate concentrations in the EPA and indicate spatial and temporal trends.
6. Provide an update concerning the status of an alternative criterion for DO in Everglades marsh waters.
7. Present an updated review of pesticide and priority pollutant data made available during WY02.

METHODS

An approach similar to the regional synoptic approach used in previous Everglades Consolidated Reports was applied to WY02 data to provide an overview of the status of compliance with water quality criteria in the EPA. The consolidation of regional water quality data, while providing for analysis over time, limits spatial analyses within each region. However, spatial analyses can be made 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.

WATER QUALITY DATA SOURCES

The majority of the water quality data evaluated in this chapter were retrieved from the South Florida Water Management District's (SFWMD's or District's) DBHYDRO database. Water quality data from the nutrient gradient sampling stations monitored by the Everglades Systems Research Division in the northern part of WCA-2A, the southwestern part of the Refuge, the west central portion of Water Conservation Area 3A (WCA-3A), and Taylor Slough in Everglades National Park were obtained from the SFWMD's Everglades Research Database. Before water quality data are entered into either database, the SFWMD follows strict quality assurance/quality control (QA/QC) procedures approved by the Florida Department of Health under the National Environmental Laboratory Accreditation Conference (NELAC) certification process. Both sampling and analytical methods are documented in the SFWMD Quality Assurance manual and in Standard Operating Procedures (SOPs) that are annually reviewed and updated. Contract laboratories used by the District must also be NELAC certified and must maintain a Quality Assurance manual and field SOPs.

EVERGLADES PROTECTION AREA WATER QUALITY SAMPLING STATIONS

The surface water in the portion of the Everglades represented by the sampling stations used in this report is classified as Class III freshwater of the state (section 62-302.400, F.A.C.). Class III water quality criteria were established to protect recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlife (section 62-302.400, F.A.C.). Additionally, the Arthur R. Marshall Loxahatchee National Wildlife Refuge and Everglades National Park are classified as Outstanding Florida Waters (section 62-302.700, F.A.C.). Beyond the requirements of Class III water quality criteria, no degradation of water quality other than that allowed in rule 62-4.242(2) and (3), F.A.C. is to be permitted in Outstanding Florida Waters (section 62-302.700, F.A.C.).

Water quality sampling stations located throughout the Water Conservation Areas and the Park were categorized as inflow, interior, or outflow sites within each region based on their location and function (**Figure 2A-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 are therefore 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 WCA-2. Additionally, the S-11 structures are designated as both outflows from WCA-2 and inflow points to WCA-3. The S-12 structures S-355A, S-355B and S-333 are outflows from WCA-3 and are also inflow sites to the Park. The interior sites of each region consist of marsh and canal stations and 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 Refuge interior is conveyed in rim canals that border the east and west levees of the Refuge. 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-2A through the S-10 structures. The extent (distance) to which rim canal overflows permeate the marsh depends on the relative stages of the L-7 rim canal and the Refuge interior.

Several changes to the monitoring network classification system have been made for purposes of the *2003 Everglades Consolidated Report*. In previous ECRs, canal stations within the EPA that did not directly discharge to the marsh (E0, F0, C-123SR84, and S-151) were classified as interior stations; however, these stations more accurately reflect inflow water quality rather than interior marsh conditions. Since the water monitored at these stations is eventually discharged to the marsh, these stations were reclassified as inflow stations. Additionally, several new monitoring stations were added to reflect hydrologic modifications to the system and to further refine the ambient monitoring network. Gradient transect stations within WCA-3A and the Park were added as interior monitoring sites. The G-310 structure was added as an additional inflow to the Refuge from STA-1 West. Structures S-355A and S-355B in the L-29 canal were constructed to enable the release of water from WCA-3B (outflow) and into the Park (inflow). Pump station S-332D was added to allow inflow to the Park. In response to the Comprehensive Everglades Restoration Plan (CERP), it is anticipated that future, additional alterations will be made to the monitoring network that will require project-specific, system-wide monitoring. The location and categorization of monitoring stations used in the 2003 ECR are shown in **Figures 2A-2** through **2A-5**.

Though much of the data from the non-Everglades Construction Project (non-ECP) structures are used in the regional analysis of water quality conditions in the EPA, each of the non-ECP structures are required by permit to be analyzed individually. The analysis of data collected at the non-ECP structures, as well as all other permit-required analyses and data presentations are provided in Chapter 8 of the *2003 Everglades Consolidated Report*.

The current SFWMD Everglades monitoring programs are described by Germain (1998). Sampling frequency varies by site, depending on site classification, parameter group, and hydrologic conditions (water depth and flow). In general, inflow and outflow structures are monitored more frequently than interior marsh stations. Two examples help illustrate the variation in sampling regimes. At the S-5A inflow structure to the Refuge, nutrients and physical parameters (e.g., DO, conductivity, pH), pesticides, and trace metals are monitored weekly (when flowing), quarterly, and bi-annually, respectively. Monitoring at marsh stations within the Refuge is conducted monthly for most parameter groups. Trace metals are monitored quarterly, and pesticides are not routinely sampled. Additionally, the District continually updates and refines a Website that provides information about SFWMD water quality monitoring projects, including project descriptions and objectives. Currently, the SFWMD Website provides limited, site-specific information.

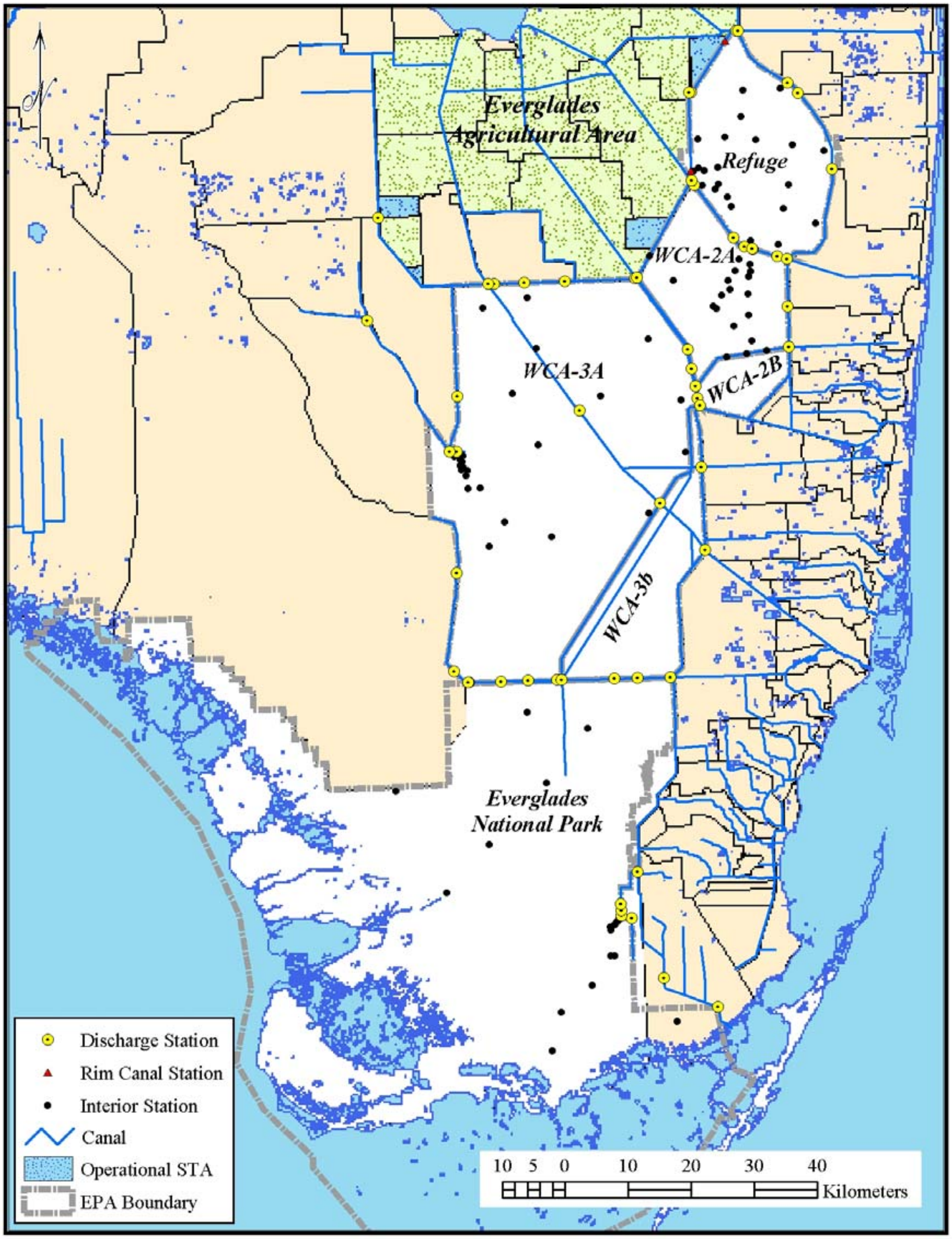

Figure 2A-1. Everglades Protection Area regions and water quality monitoring stations

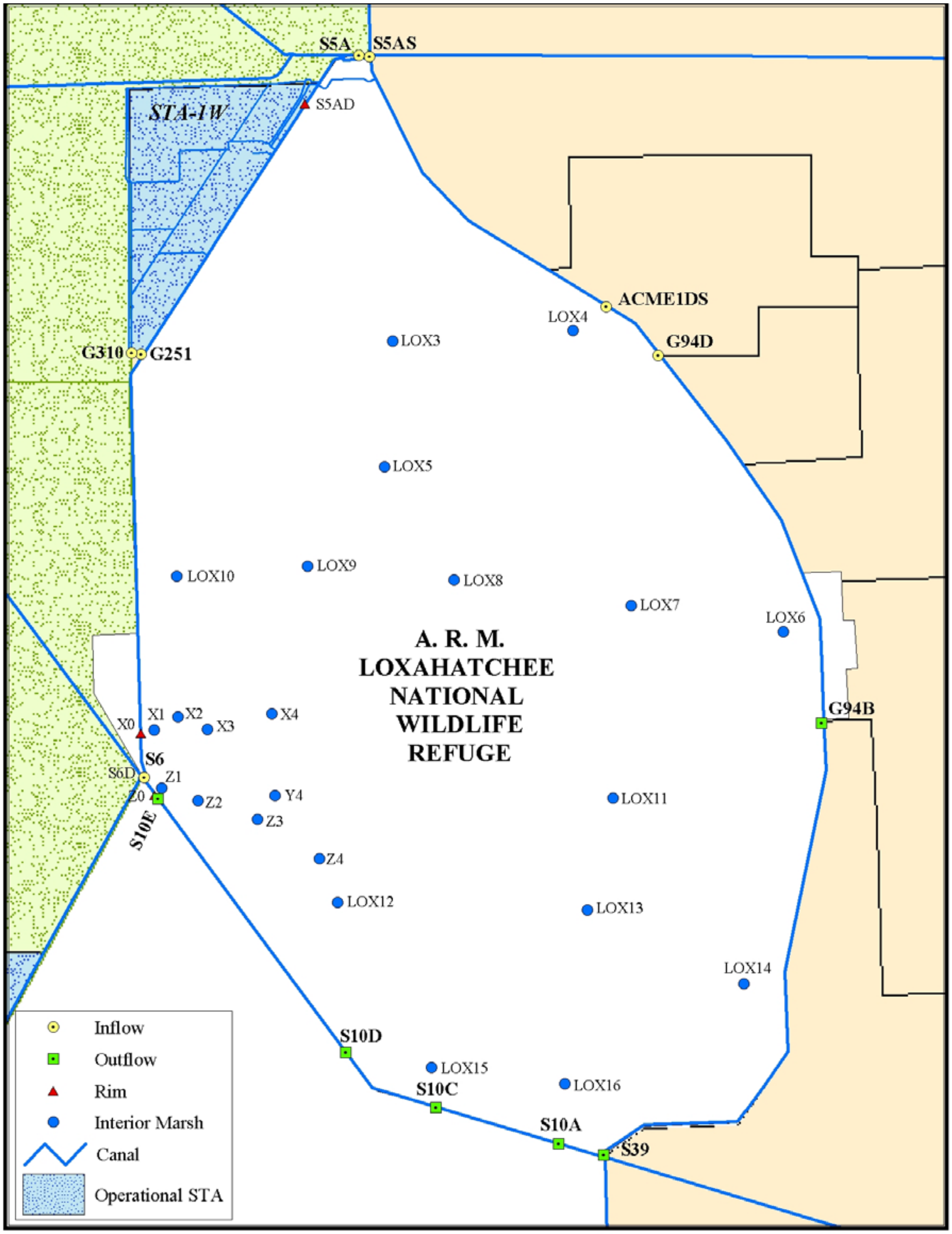

Figure 2A-2. Location and classification of water quality monitoring stations in the Arthur R. Marshall Loxahatchee National Wildlife Refuge

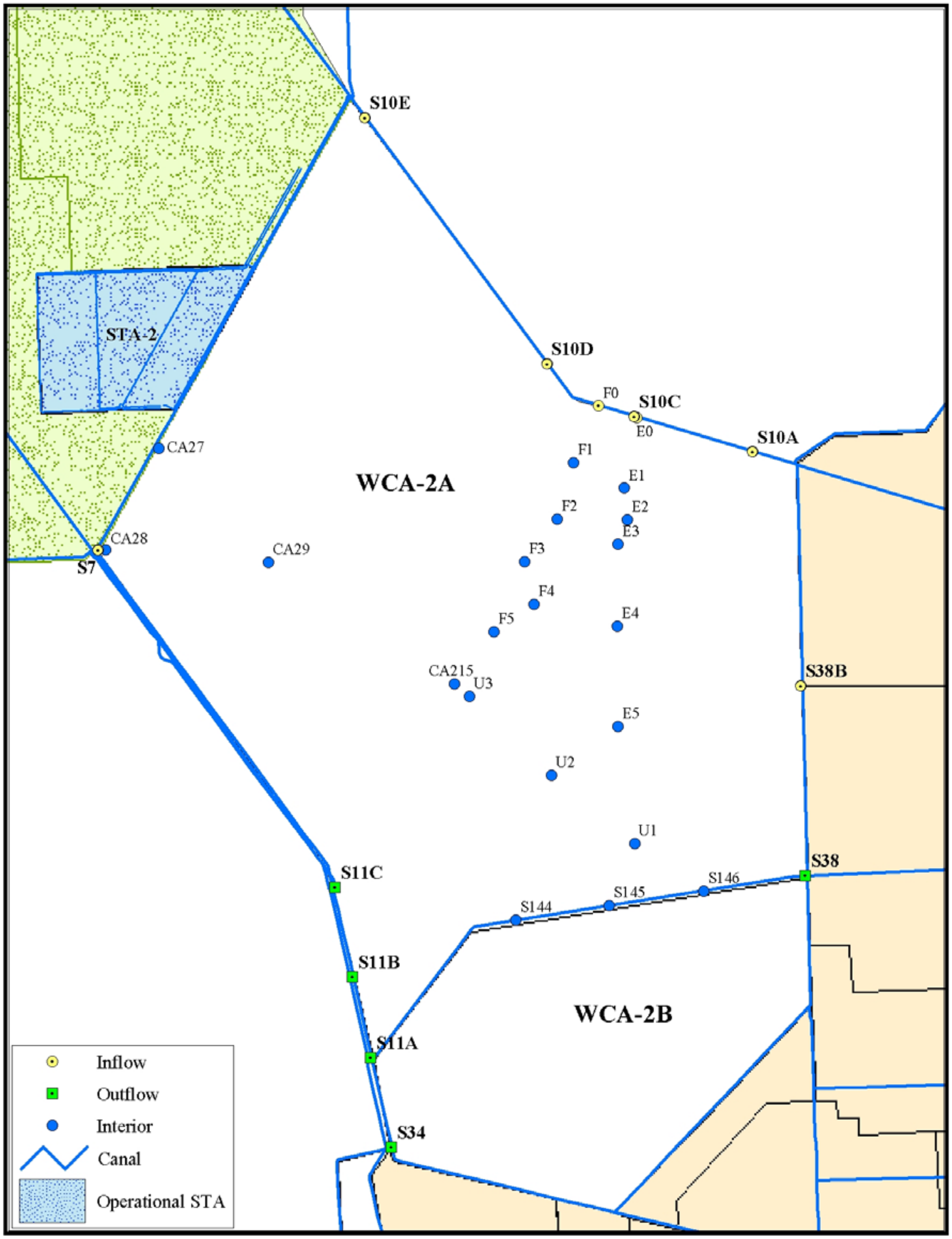

Figure 2A-3. Classification of water quality monitoring stations in Water Conservation Area 2

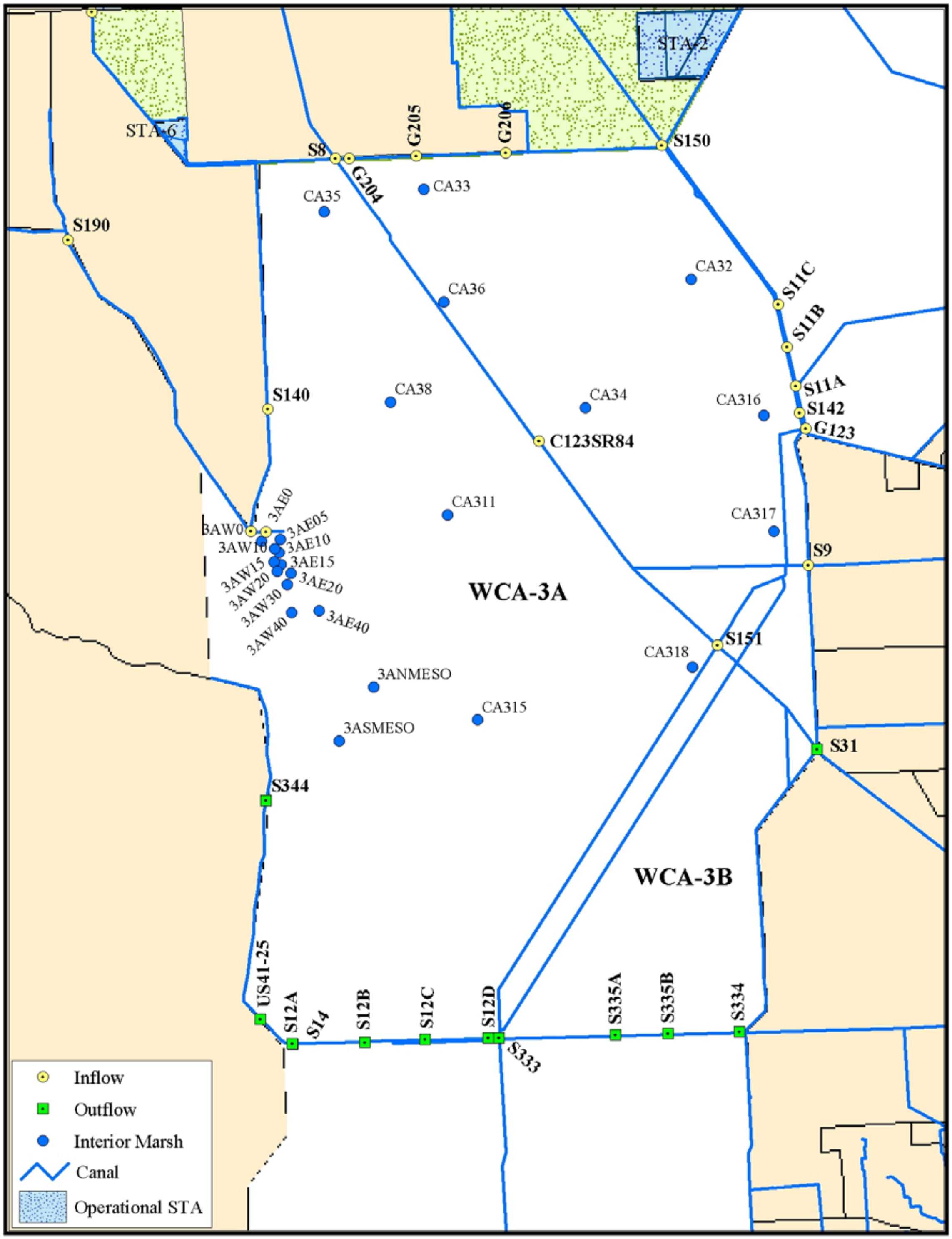

Figure 2A-4. Location and classification of water quality monitoring stations in Water Conservation Area 3

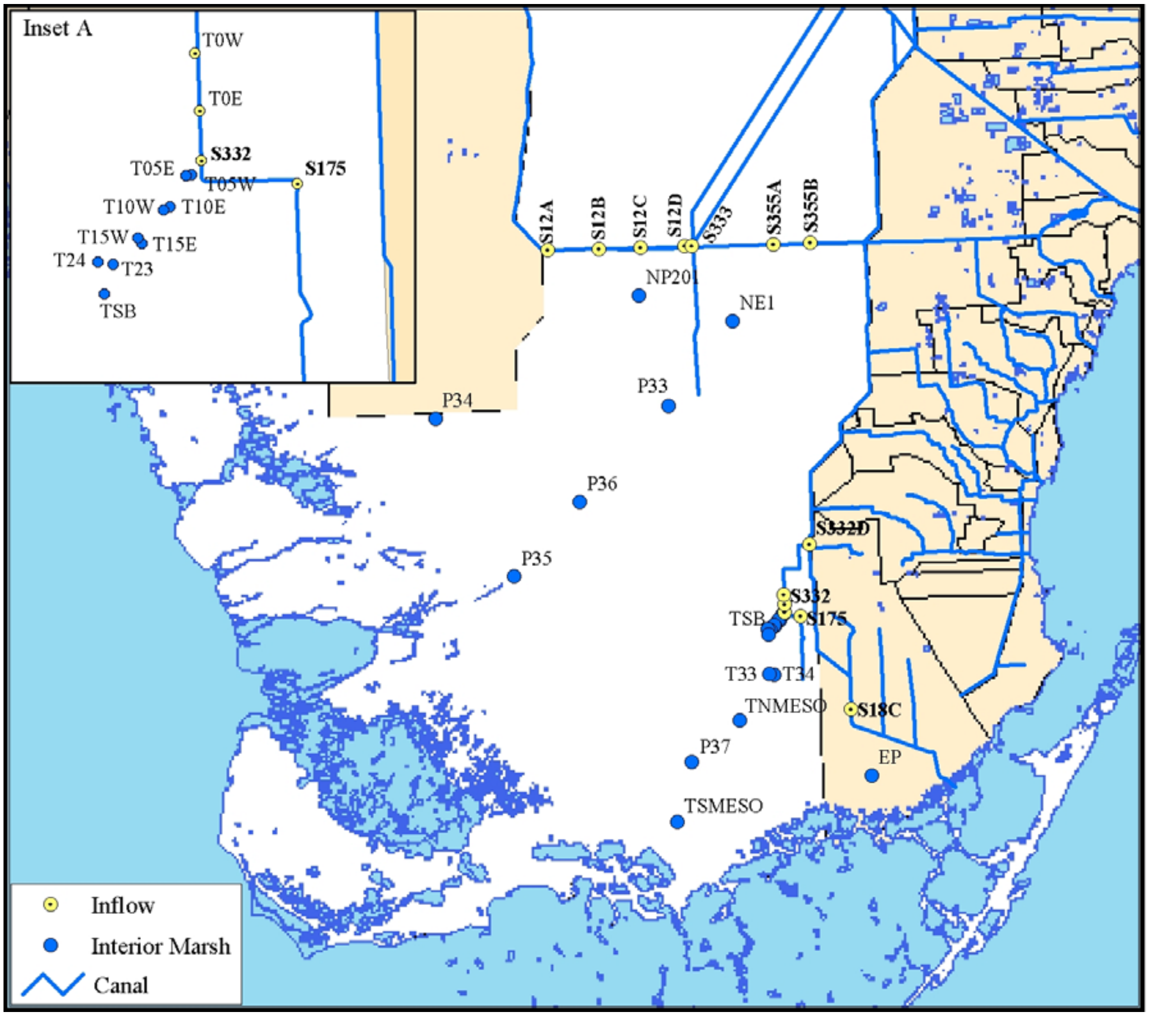

Figure 2A-5. Location and classification of water quality monitoring stations in Everglades National Park. Inset "A" provides the location of transect monitoring stations downstream of C-111 inflows in Taylor Slough

EVERGLADES PROTECTION AREA DATA ANALYSIS PERIOD

Water quality data collected from monitoring stations within EPA regions during WY02 (May 1, 2001 through April 30, 2002) are evaluated and discussed in this chapter. Additionally, pesticide data presented herein were collected during quarterly sampling events conducted between December 2000 and November 2001. The period of record for pesticides was selected as an update to data presented in the *2002 Everglades Consolidated Report*, rather than reflecting a water year.

WATER QUALITY DATA EVALUATED

The District monitors approximately 109 water quality parameters within the EPA (Bechtel et al., 1999 and 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 included total phosphorus (TP), total nitrogen, sulfate, 62 pesticides, and the following 19 water quality constituents:

- Alkalinity
- Dissolved oxygen (*in situ*)
- Specific conductance @ 25°C (*in situ*)
- pH (*in situ*)
- Total silver
- Total antimony
- Total arsenic
- Total beryllium
- Total cadmium
- Trivalent chromium
- Total copper
- Total iron
- Total mercury
- Total lead
- Total selenium
- Total thallium
- Total zinc
- Turbidity
- Un-ionized ammonia

State water quality criteria and standards are reviewed triennially and revised when appropriate. During 2002, Florida's Environmental Regulation Commission (ERC) adopted revised hardness-based criteria for trivalent chromium, total copper and total zinc. These revisions were made in accordance with recent USEPA recommendations (USEPA, 1999). The revised criteria were applied to both WY02 and to previous water years (WY78 through WY01) to maintain consistency in comparison among periods.

DATA SCREENING AND HANDLING

Water quality data were screened based on laboratory qualifier codes. Any datum with an associated fatal qualifier (e.g., contamination, out-of-holding time, matrix interference, or reversal) was removed from the analysis. Values were excluded if they exceeded possible physical or chemical measurement constraints (e.g., pH greater than 14), had temperatures well outside seasonal norms (e.g., 6°C in July), or represented data transcription errors. All data passing the qualifier screening were used in the analysis. Statistical outlier analysis was not performed, although a conductivity result of 3,686 μmhos/cm at site LOX15 on November 6, 2001 was deemed to be well outside anticipated values based on comments received from Refuge staff and, therefore, was excluded from analysis. 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.

An additional consideration in water quality data handling is 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 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 that is present at 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 (PQL) represents a practical and routinely achievable quantification level for which there is 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 half the MDL unless otherwise noted. All data presented herein, including historic results, are handled consistently with regard to screening and MDL replacement.

EXCURSION ANALYSIS

The FDEP and the District have developed and clearly documented herein an excursion analysis protocol for use in the 2003 ECR. This protocol was developed to balance consistency with previous Everglades Consolidated Reports and with USEPA recommendations and other State of Florida ambient water quality evaluation methodologies (e.g., Impaired Waters 303(d) designations), as well as to provide a concise summary to decision makers and the public. It is hoped that this will ensure that the results of this evaluation are compatible with information provided to water managers from other sources.

To evaluate compliance with water quality criteria in WY02, constituent concentrations were compared to their respective Class III criteria specified in chapter 62-302, F.A.C. In addition to Class III criteria, pesticides were evaluated based on chronic toxicity values. An excursion was recorded when a reported value above the given MDL exceeded the applicable numeric criteria (62-302.530, F.A.C.) or was chronically toxic. The excursions for each region of the EPA were tabulated, providing both the total number of samples and the percent of samples exceeding the criteria.

Previous Everglades Consolidated Reports utilized a raw-score approach to rank and categorize the severity of excursions from state water quality criteria (Bechtel et al., 1999, 2000; Weaver et al., 2001, 2002). Using this raw-score method, a parameter was classified as a "concern" when more than five percent of the measurements exceeded numeric criteria. Though not previously stated, the underlying premise of this approach is that a parameter is of management concern if its true exceedance (excursion) probability exceeds 5 percent. However, because the true exceedance probability cannot be measured, it must be estimated from a set of samples (i.e., a subset of the entire population), which introduces statistical uncertainty. The degree of uncertainty in the estimate depends on the true exceedance probability and sample size (smaller sizes are associated with greater uncertainty). For example, one of six measurements above the criterion is clearly a weaker (more uncertain) case for impairment than six of 36; however, both cases result in an excursion frequency of 16.7 percent (National Research Council [NRC], 2001). A statistically valid assessment of the estimate requires that some accounting for uncertainty in the estimate be incorporated into the analysis (Riggs and Aragon, 2002). Smith et al. (2001) and the NRC (2001) suggested that a binomial hypothesis test, which evaluates the statistical significance of the frequency of excursions, could be used in water quality evaluations to account for sampling uncertainty. Recent adoption of the state's Impaired Waters Rule (Chapter 62-303, F.A.C., IWR), which uses a binomial hypothesis test to delineate impaired waters, establishes precedence for the use of this statistical method in Florida. In support of development of the state's IWR, Lin et al. (2000) reviewed statistical procedures for standards compliance assessments and recommended a nonparametric procedure for identifying impaired water body reaches in Florida based on binomial distribution theory. Although the binomial hypothesis test better accounts for uncertainty than a raw score approach, sample size is still an important consideration in the reliability of excursion frequency estimation. Specifically, in water quality attainment decisions, both Type I and Type II errors are a concern (Type I errors are those wherein there is a probability that an excursion was falsely listed as a concern when no real concern existed, resulting in a false positive; Type II errors are those wherein there is a probability that an excursion was not listed as a concern when a genuine concern existed, resulting in a false negative). Sample sizes of at least 28 balance average error rates to below 15 percent and below 10 percent at sample sizes greater than 40 when a binomial approach is used (Smith et al., 2001; Riggs and Aragon, 2002)[1]. Riggs and Aragon (2002) stated that error rates for samples sizes of less than 28 are probably too high to be acceptable to most regulators. As long as sample sizes are maintained at acceptable levels ($\geq$ 28), then binomial methodologies can be used to balance and manage error rates better than the raw-score approach[2]. Based on these considerations and a review of the literature (e.g., Lin et al., 2000; Smith et al., 2001; Donohue and Looij, 2001; Riggs and Aragon, 2002), the raw-score approach has been replaced herein with a binomial hypothesis test.

An additional weakness of the evaluation methodology employed in previous Everglades Consolidated Reports is that the 5 percent excursion frequency that was selected to categorize a parameter as a concern does not reflect current USEPA guidance, which recommends that a 10 percent rate of exceedance (excursion) from applicable water quality standards be used to delineate impaired water bodies for conventional pollutants or constituents (e.g., DO, metals, conductivity, turbidity, ammonia, dissolved ions) (USEPA, 1997; USEPA, 2002). Essentially, the conventional pollutants are constituents, which are expected to naturally occur and vary within the environment due to natural biogeochemical processes. The 10 percent USEPA guidance frequency accounts for natural background variability, as well as for sampling and measurement errors. This guidance does not apply to constituents with human health-based criteria (e.g., beryllium and 2,4-dinitrophenol) or to unconventional pollutants (e.g., pesticides and herbicides). Since the authors are seeking to increase consistency among assessments, the excursion categories were revised from previous ECRs to reflect USEPA guidance for water quality assessments while maintaining a multi-tiered, categorical system similar to that employed in previous ECRs (**Table 2A-1**).

The binomial hypothesis test was adopted to evaluate water quality criteria excursions in the 2003 ECR for conventional water quality constituents (i.e., constituents other than pesticides or with human health-based criterion [beryllium]). Parameters without excursions were categorized as "no concern" and are not discussed in this chapter. For any parameter having excursions and

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[1] Error rates for the raw score approach are also substantially above acceptable levels at sample sizes of less than 28 to 30. Furthermore, Type I error rates (> 40 percent) associated with the raw-score approach are unacceptably high, even at large sample sizes (Smith et al., 2001); e.g., at sample sizes greater than 100, the Type-I error rate exceeds 40 percent.

[2] At sample sizes of less than 20, neither a binomial nor a raw-score approach can be confidently employed to adequately control error rates (Smith et al., 2001; Riggs and Aragon, 2002).

having at least 28 samples during the period of record, 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 of more 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 exceeding 5 to 10 percent) or a minimal concern (an excursion rate of 5 percent or less, i.e., H_0: $f \leq 0.05$, minimal concern; H_A: $f > 0.05$, potential concern). Because the binominal hypothesis test does not adequately balance statistical error rates at sample sizes of less than 28, parameters with reported excursions and with fewer than 28 samples were initially categorized as a concern and a potential concern based on excursion frequencies (raw scores) of greater than 20 percent and less than 20 percent, respectively[3]. It is assumed that an observed excursion frequency greater than 20 percent provides a substantial reason to suspect that the true exceedance frequency might exceed 10 percent and warrants further investigation. Furthermore, given the high degree of uncertainty associated with small sample sizes (< 28), any excursions warrant further review. However, caution must be exercised when interpreting results drawn from such small samplings. For any parameter initially identified as a concern or a potential concern and which was based on fewer than 28 samples, longer-term (2 to 5 years) excursion rates will be evaluated and presented within the discussion of WY02 monitoring results. 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; therefore, beryllium was categorized as a concern for periods exhibiting any exceedances of the current Class III criterion. The excursion categories are meant to provide guidance in the interpretation of monitoring results by ranking the severity of excursions from water quality criteria, allow tracking of temporal and spatial trends, and provide a venue for more detailed evaluations.

Because the USEPA-recommended 10 percent excursion frequency does not apply to pesticides, the pesticide evaluation method presented herein is identical to the method used in both the 2000 and the 2001 ECR. Pesticides were categorized based on exceedance of Class III criteria or chronic toxicity values and detection (measurement >MDL) frequency (**Table 2A-1**).

[3]At sample sizes of below 28, the binomial hypothesis test is associated with unacceptably high Type II error rates (> 20 to 93 percent). A 20-percent raw-score criteria was selected because it provides a better balance between error rates than either a binomial test or a 10-percent raw-score; i.e., at sample sizes of between 1 and 27, both Type I and Type II error rates are intermediate (between) those associated with a binomial test or a 10-percent raw score. However, this error rate compromise does not fully address the uncertainty inherent in the analysis of such small samples. Analysis of longer periods of record or increased sampling frequencies is required to confidently categorize excursion frequencies and acceptably balance Type I and Type II error rates.

Table 2A-1. Definitions of excursion categories for water quality constituents in the 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	N/A
No Concern	No excursions	≤MDL

[1] For sample sizes of less than 28, an excursion frequency of greater than 20 percent was used to define the "concern" category.

[2]At sample sizes of less than 28, "potential concern" was defined as an excursion frequency less than or equal to 20 percent.

[3]MDL = Method Detection Limit.

The Environmental Regulation Commission (ERC) is currently conducting hearings for the purpose of establishing a numeric phosphorus criterion for the Everglades. Since the ERC adoption process is ongoing and is not expected to be complete until early 2003, a criterion and measurement methodology have not yet been established. Therefore, total phosphorus (TP) results were evaluated following the same procedure as that used in previous Everglades Consolidated Reports. TP data were divided into three categories based on the frequency of measurements above 10 parts per billion (ppb) and above 50 ppb. These categories (TP ranges) were selected based on levels specified in the Federal Settlement Agreement (1991) and Everglades Forever Act (EFA) default criterion. The Federal Settlement Agreement requires the SFWMD's Stormwater Treatment Areas (STAs) to achieve a long-term TP discharge concentration average of 50 ppb, and also requires long-term TP averages of approximately 10 ppb in the Refuge interior marshes and the inflows to the Park. The EFA specifies a 10-ppb default criterion in the event the FDEP does not adopt by rule a criterion by December 31, 2003. It is anticipated that when the ERC adopts a numeric phosphorus criterion, the method of evaluating TP levels in the EPA will be revised in subsequent Everglades Consolidated Reports to be consistent with the new rule.

SUMMARY OF FINDINGS OF PREVIOUS EVERGLADES CONSOLIDATED REPORTS

1999 TO 2001 EVERGLADES CONSOLIDATED REPORTS

Previous Everglades Consolidated Reports (ECRs) have demonstrated that, with few exceptions, water quality has been in compliance with existing state water quality criteria, though some excursions have been noted (Bechtel et al., 1999, 2000; Weaver et al., 2001, 2002). Reported excursions have generally been localized to specific areas of the EPA, with the exception of dissolved oxygen (DO), which exhibited excursions in all areas. Furthermore, alkalinity, conductivity, iron, pH, and turbidity were identified as a concern for at least one EPA region in all previous Everglades Consolidated Reports. Additionally, the 1999 *Everglades*

Interim Report and the *2000 Everglades Consolidated Report* identified total beryllium and un-ionized ammonia as concerns in localized areas of the EPA. However, the *2001 Everglades Consolidated Report* demonstrated that most of the reported beryllium excursions were due to misapplication of the standard and were not true excursions. Previous ECRs have also evaluated pesticide monitoring results and have identified chloriphyros ethyl, endosulfan, ethion, parathion methyl, diazinon, DDT, DDE and DDD as a concern in localized areas for various years during the period of record.

Each of the previous years' ECRs have delineated DO as a concern for the entire Everglades, with nearly all monitoring stations exhibiting excursions during each year of the period of record. However, a majority of the DO excursions were the result of natural conditions and processes within the marsh and do not necessarily constitute violations of state water quality standards. To more accurately characterize the natural DO regime within the marsh, the FDEP developed a potential Site Specific Alternative Criterion (SSAC), which used a mathematical model to describe the relationship between DO, time of day, and temperature to define a measurement methodology. This SSAC was presented in the *2001 Everglades Consolidated Report*. Application of the present DO SSAC resulted in a significant reduction in the number of interior marsh stations at which DO was designated as a concern.

2002 EVERGLADES CONSOLIDATED REPORT

Chapter 2A of the *2002 Everglades Consolidated Report* provided an overview of the status of compliance with water quality criteria in the EPA for WY01 (May 1, 2000 through April 30, 2001). The chapter built upon and provided an update to water quality analyses presented in previous ECRs. Comparison of the water quality data with applicable Class III water quality criteria found excursions for eight parameters during WY01. These excursions were localized to specific areas of the EPA, with the exceptions of DO and un-ionized ammonia, both of which exhibited excursions in all regions. For at least one EPA region, alkalinity, conductivity, DO, iron, pH, total silver and turbidity were each delineated as a parameter of concern. Conductivity, iron, pH and turbidity were also designated as a potential concern in one or more additional areas. Due to excursion rates of less than 5 percent, un-ionized ammonia was designated as a parameter of potential concern throughout many EPA regions and site classes. Diazinon was the only pesticide to be classified as a concern during the water year due to an exceedance of its chronic toxicity guideline concentration.

WY01 was hydrologically dominated by a persistent, severe drought. Based on known soil/water interactions associated with drydown and re-wetting, the drought probably influenced water quality conditions throughout the year, and could be at least partly responsible for some of the observed changes in excursion frequencies. The diminished rainfall altered water management practices, including distribution, timing and quantity of water, resulting in dramatic reductions ranging from 32 to 64 percent in surface water inflows to the WCAs and Everglades National Park. These alterations had the potential to change both the distribution of constituent loads at inflow structures and biogeochemical processes within the marsh, which in turn likely influenced the concentration of water quality constituents and excursion rates.

Median inflow TP concentrations were lower than those in historic periods, with the exception of Everglades National Park, where inflow concentrations were higher during WY01. As in previous years, inflow TP concentrations decreased from north to south, with the highest phosphorus concentrations entering the Refuge and WCA-2 (median concentration = 45 to 47 ppb), and the lowest phosphorus concentrations flowing into the Park (median = 13 ppb). Similar to those from historic periods, median interior marsh concentrations were low in WY01, ranging from 6.0 to 12.0 ppb across the various EPA areas.

WATER YEAR 2002 RESULTS

WY02 data, for water quality parameters with Class III numeric criteria, are summarized in **Appendix 2A-1**. Comparison of the WY02 water quality data with applicable Class III water quality criteria resulted in excursions for seven identified parameters. These excursions were localized to specific areas of the EPA, with the exception of DO, which exhibited excursions in all regions. Alkalinity, conductivity, un-ionized ammonia and total beryllium were classified as a parameter of concern for the Refuge interior, Refuge inflow, WCA-2 inflows and WCA-3 inflows, respectively (**Table 2A-2**). Additionally, conductivity was classified as a potential concern for the WCA-2 interior (**Table 2A-2**). Conductivity, pH, turbidity, and un-ionized ammonia were categorized as parameters of minimal concern for several EPA regions due to infrequent and localized excursions. Parameters classified as minimal concerns will not be discussed further in this chapter. Fifteen pesticides were detected between December 2000 and November 2001. Atrazine, diazinon, endosulfan (alpha + beta), and simazine were all classified as a concern. No other parameters exceeded state water quality criteria during WY02 and, therefore, are not discussed in this chapter.

Excursion frequencies and categories for parameters with any recorded excursions in the last five water years (WY98 through WY02) are summarized in **Table 2A-3** for three time periods (i.e., the historical period encompassing WY78 through WY99, WY01 and WY02) to evaluate any temporal trends present. Excursion categories for all periods are based on the methodology described in this chapter (**Table 2A-1**). Excursion frequencies for WY02 were generally within the range of the historic periods for most parameters. Notable differences between WY02 and the two other periods include increased DO excursion frequencies within the Refuge rim canal and inflows and in the WCA-3 interior; an increase in the number of un-ionized ammonia excursions for WCA-2 inflows; a decrease in pH excursions within the Refuge interior; and a decrease in conductivity excursions for Refuge outflows and WCA-2 inflows. These and additional differences are discussed below in greater detail.

Parameters categorized as a concern or a potential concern for WY02 are also reviewed below in greater detail. The review includes discussions concerning the environmental significance associated with the observed excursions, potential causes of the excursions, and any actions taken to resolve the associated concerns, including evaluation of the applicable criteria and natural background conditions within the EPA.

Table 2A-2. Summary of water quality data and excursions from applicable criteria in the EPA for WY02. Only parameters that have excursions in the given region and class are listed. Excursion categories of concern, potential concern, and minimal concern are denoted by "C," "PC," and "MC," respectively

Region	Class	Parameter	Class III Criteria	N	Mean	Std. Deviation	Min.	Max	Excursion %	Excursion Category
Refuge	Inflow	Dissolved Oxygen	≥5	256	3.29	1.98	0.05	9.8	79.3%	C
		Specific Conductance	≤1,275[1]	256	1054	299	209	1607	19.1%	C
		Turbidity	≤29[2]	143	4.6	5.3	0.6	36.8	1.4%	MC
		Un-ionized ammonia	≤0.02	142	0.0036	0.0035	0.00003	0.0218	0.7%	MC
	Interior	Alkalinity	≥20	187	98	77	6	296	18.2%	C
		Dissolved Oxygen	≥5	235	3.13	1.56	0.27	7.2	85.5%	C
		pH	≥6.0,≤8.5	235	6.89	0.49	5.6	7.9	4.3%	MC
		Un-ionized ammonia	≤0.02	138	0.00076	0.0031	0.000002	0.0295	0.7%	MC
	Outflow	Dissolved Oxygen	≥5	66	4.15	2.02	0.21	10.3	66.7%	C
		Turbidity	≤29[2]	66	3.0	5.0	0.6	36.7	1.5%	MC
	Rim	Dissolved Oxygen	≥5	45	3.72	1.48	0.55	7.2	80.0%	C
		Specific Conductance	≤1,275[1]	45	963	259	429	1490	6.7%	MC
WCA-2	Inflow	Dissolved Oxygen	≥5	82	3.92	1.75	0.21	10.3	73.2%	C
		Turbidity	≤29[2]	55	3.2	5.2	0.5	36.7	1.8%	MC
		Un-ionized ammonia	<0.02	79	0.013	0.024	0.0001	0.1070	24.1%	C
	Interior	Dissolved Oxygen	≥5	269	3.48	2.46	0.2	16.1	80.7%	C
		Specific Conductance	≤1,275[1]	270	943	275	185	2069	10.7%	PC
	Outflow	Dissolved Oxygen	≥5	65	4.38	1.94	0.8	8.6	53.8%	C
WCA-3	Inflow	Dissolved Oxygen	≥5	275	4.26	2.08	0.73	11	65.5%	C
		pH	≥6.0,≤8.5	280	7.46	0.33	6.32	8.6	0.7%	MC
		Total Beryllium	≤0.13[3,4]	3	0.71	0.29	<0.1	0.92	100%	C
	Interior	Dissolved Oxygen	≥5	269	3.25	1.64	0.21	8	84.0%	C
	Outflow	Dissolved Oxygen	≥5	212	3.84	1.83	0.63	12.4	78.3%	C
		pH	≥6.0,≤8.5	214	7.36	0.3	6.16	9	1.4%	MC
		Turbidity	≤29[2]	164	2.8	7.5	0.4	71.4	1.8%	MC
Everglades National Park	Inflow	Dissolved Oxygen	≥5	293	3.95	1.89	0.22	12.4	72.0%	C
		pH	≥6.0,≤8.5	297	7.38	0.29	6.16	9	1.0%	MC
		Turbidity	≤29[2]	177	2.8	7.3	0.4	71.4	1.7%	MC
	Interior	Dissolved Oxygen	≥5	113	5.36	1.93	1.56	10.5	46.9%	C
		pH	≥6.0,≤8.5	119	7.58	0.37	4.45	8.3	0.8%	MC

1. Specific conductance shall not be increased 50% above background, or to 1,275 µmho/cm, whichever is greater.
2. Turbidity ≤ 29 NTU above natural background conditions.
3. Beryllium criterion measured as an annual average.
4. Human health-based criterion; therefore,10% excursion frequency does not apply.

Table 2A-3. Summary of excursions from Class III criteria in the Everglades Protection Area for WY02, WY01, and historical data (WY78 through WY00). Note: In the "Number of Excursions" columns, the first number represents the number of excursions, while the number in parentheses represents the number of samples collected. Excursion categories of concern, potential concern, and minimal concern are denoted by "C," "PC," and "MC," respectively, and are provided within parentheses in the "Percent Excursions" columns. An asterisk (*) associated with an excursion category indicates an insufficient sample size (<28) to confidently characterize the excursion frequency; therefore, categorization is preliminary and further evaluation is required

Region	Class	Parameter	1978 to 2000		2001		2002	
			Number of Excursions	Percent Excursions (category)	Number of Excursions	Percent Excursions (category)	Number of Excursions	Percent Excursions (category)
Refuge	Inflow	Dissolved Oxygen	1,592 (2,135)	74.6 (C)	212 (278)	76.3 (C)	203 (256)	79.3 (C)
		pH	11 (2,121)	0.5 (MC)	2 (278)	0.7 (MC)	0 (256)	0.0 (NC)
		Specific Conductance	599 (2,134)	28.1 (C)	15 (278)	5.4 (MC)	49 (256)	19.1 (C)
		Total Beryllium	2 (2)	100.0 (C)	--	--	--	--
		Total Iron	19 (504)	3.8 (MC)	1 (30)	3.3 (MC)	0 (23)	0.0 (NC*)
		Total Silver	2 (27)	7.4 (PC*)	1 (11)	9.1 (PC*)	--	--
		Turbidity	58 (1,815)	3.2 (MC)	3 (126)	2.4 (MC)	2 (143)	1.4 (MC)
		Un-ionized ammonia	38 (1,849)	2.1 (MC)	1 (124)	0.8 (MC)	1 (142)	0.7 (MC)
	Interior.	Alkalinity	422 (1,543)	27.3 (C)	26 (180)	14.4 (C)	34 (187)	18.2 (C)
		Dissolved Oxygen	1,013 (1,341)	75.5 (C)	205 (230)	89.1 (C)	201 (235)	85.5 (C)
		pH	170 (1,497)	11.4 (C)	35 (239)	14.6 (C)	10 (235)	4.3 (MC)
		Specific Conductance	9 (1,403)	0.6 (MC)	0 (239)	0.0 (NC)	0 (226)	0.0 (MC)
		Total Copper	3 (273)	1.1 (MC)	0 (10)	0.0 (NC*)	--	--
		Total Lead	43 (269)	16.0 (C)	0 (10)	0.0 (NC*)	--	--
		Un-ionized ammonia	2 (1,189)	0.2 (MC)	0 (129)	0.0 (NC)	1 (138)	0.7 (MC)
	Outflow	Dissolved Oxygen	698 (1,039)	67.2 (C)	47 (73)	64.4 (C)	44 (66)	66.7 (C)
		pH	3 (1,019)	0.3 (MC)	0 (73)	0.0 (NC)	0 (65)	0.0 (NC)
		Specific Conductance	151 (1,043)	14.5 (C)	1 (72)	1.4 (MC)	0 (65)	0.0 (NC)
		Turbidity	10 (1,020)	1.0 (MC)	0 (60)	0.0 (NC)	1 (66)	1.5 (MC)
		Un-ionized ammonia	11 (1,005)	1.1 (MC)	1 (58)	1.7 (MC)	0 (65)	0.0 (NC)
	Rim	Dissolved Oxygen	443 (607)	73.0 (C)	34 (48)	70.8 (C)	36 (45)	80.0 (C)
		pH	3 (607)	0.5 (MC)	0 (50)	0.0 (NC)	0 (46)	0.0 (NC)
		Specific Conductance	98 (610)	16.1 (C)	2 (50)	4.0 (MC)	3 (45)	6.7 (MC)
		Total Beryllium	1 (2)	50.0 (C)	--	--	--	--
		Total Iron	3 (289)	1.0 (MC)	0 (15)	0.0 (NC*)	0 (7)	0.0 (NC*)
		Turbidity	9 (370)	2.4 (MC)	2 (24)	8.3 (PC*)	0 (20)	0.0 (NC*)
		Un-ionized ammonia	3 (556)	0.5 (MC)	0 (36)	0.0 (NC)	0 (32)	0.0 (NC)

Table 2A-3. Continued

Region	Class	Parameter	1978-2000		2001		2002	
			Number of Excursions	Percent Excursions (category)	Number of Excursions	Percent Excursions (category)	Number of Excursions	Percent Excursions (category)
WCA-2	Inflow	Dissolved Oxygen	955 (1,316)	72.6 (C)	70 (98)	71.4 (C)	60 (82)	73.2 (C)
		pH	6 (1295)	0.5 (MC)	0 (98)	0.0 (NC)	0 (82)	0.0 (NC)
		Specific Conductance	208 (1,321)	15.7 (C)	2 (97)	2.1 (MC)	0 (82)	0.0 (NC)
		Turbidity	13 (1,153)	1.1 (MC)	0 (58)	0.0 (NC)	1 (55)	1.8 (MC)
		Un-ionized ammonia	28 (1,263)	2.2 (MC)	4 (81)	4.9 (MC)	19 (79)	24.1 (C)
	Interior	Alkalinity	2 (3,539)	0.1 (MC)	0 (191)	0.0 (NC)	0 (237)	0.0 (NC)
		Dissolved Oxygen	2,288 (2,861)	80.0 (C)	203 (244)	83.2 (C)	217 (269)	80.7 (C)
		pH	20 (3,049)	0.7 (MC)	0 (244)	0.0 (NC)	0 (270)	0.0 (NC)
		Specific Conductance	262 (2,972)	8.8 (PC)	19 (244)	7.8 (PC)	29 (270)	10.7 (PC)
		Un-ionized ammonia	12 (2,625)	0.5 (MC)	0 (144)	0.0 (NC)	0 (161)	0.0 (NC)
	Outflow	Dissolved Oxygen	884 (1,321)	66.9 (C)	30 (61)	49.2 (C)	35 (65)	53.8 (C)
		pH	6 (1,304)	0.5 (MC)	0 (61)	0.0 (NC)	0 (66)	0.0 (NC)
		Un-ionized ammonia	5 (1,289)	0.4 (MC)	1 (61)	1.6 (MC)	0 (66)	0.0 (NC)
WCA-3	Inflow	Dissolved Oxygen	2,788 (3,913)	71.2 (C)	167 (285)	58.6 (C)	180 (275)	65.5 (C)
		pH	27 (3,876)	0.7 (MC)	1 (286)	0.3 (MC)	2 (280)	0.7 (MC)
		Specific Conductance	62 (3,938)	1.6 (MC)	2 (286)	0.7 (MC)	0 (269)	0.0 (NC)
		Total Beryllium	1 (12)	8.3 (C)	0 (4)	0.0 (NC)	3 (3)	100.0 (C)
		Total Iron	8 (798)	1.0 (MC)	0 (50)	0.0 (NC)	0 (35)	0.0 (NC)
		Turbidity	53 (3,549)	1.5 (MC)	2 (169)	1.2 (MC)	0 (176)	0.0 (NC)
		Un-ionized ammonia	5 (3,511)	0.1 (MC)	4 (201)	2.0 (MC)	0 (205)	0.0 (NC)
	Interior	Alkalinity	3 (1,515)	0.2 (MC)	1 (135)	0.7 (MC)	0 (224)	0.0 (NC)
		Dissolved Oxygen	937 (1,183)	79.2 (C)	150 (187)	80.2 (C)	226 (269)	84.0 (C)
		Dissolved Oxygen	2520 (3,444)	73.2 (C)	182 (234)	77.8 (C)	166 (212)	78.3 (C)
	Outflow	pH	41 (3,398)	1.2 (MC)	0 (234)	0.0 (NC)	3 (214)	1.4 (MC)
		Turbidity	0 (2,684)	0.0 (NC)	0 (142)	0.0 (NC)	3 (164)	1.8 (MC)
		Un-ionized ammonia	3 (2,620)	0.1 (MC)	3 (138)	2.2 (MC)	0 (162)	0.0 (NC)
Everglades National Park	Inflow	Dissolved Oxygen	2,725 (3,874)	70.3 (C)	237 (321)	73.8 (C)	211 (293)	72.0 (C)
		pH	51 (3,839)	1.3 (MC)	0 (321)	0.0 (NC)	3 (297)	1.0 (MC)
		Total Lead	4 (1,110)	0.4 (MC)	0 (72)	0.0 (NC)	--	--
		Turbidity	0 (3,103)	0.0 (NC)	0 (153)	0.0 (NC)	3 (177)	1.7 (MC)
		Un-ionized ammonia	17 (3,032)	0.6 (MC)	3 (162)	1.9 (MC)	0 (184)	0.0 (NC)
	Interior	Dissolved Oxygen	573 (1,260)	45.5 (C)	62 (110)	56.4 (C)	53 (113)	46.9 (C)
		pH	20 (1,131)	1.8 (MC)	0 (110)	0.0 (NC)	1 (119)	0.8 (MC)
		Total Copper	6 (1,177)	0.5 (MC)	0 (62)	0.0 (NC)	--	--
		Total Iron	106 (1,237)	8.6 (PC)	7 (63)	11.1 (PC)	--	--
		Total Lead	5 (1,199)	0.4 (MC)	0 (62)	0.0 (NC)	--	--
		Un-ionized ammonia	19 (1,077)	1.8 (MC)	2 (103)	1.9 (MC)	0 (115)	0.0 (NC)

DISSOLVED OXYGEN

Oxygen is a necessity for most forms of plant and animal life on Earth. Because of oxygen's importance to life, it is essential to understand the processes that influence dissolved oxygen (DO) concentrations in the Everglades. In any aquatic system, water column DO concentrations are regulated by a variety of sources and sinks. In healthy systems, these controlling factors are balanced. In the Everglades open-water slough communities, where light penetration is high, high photosynthetic rates by periphyton and submerged aquatic vegetation (P/SAV) result in increasing oxygen concentrations during daylight hours (Belanger and Platko, 1986; McCormick et al., 1997). At night, respiration and sediment oxygen demand (SOD) draw oxygen concentrations down. Under natural conditions, oxygen production exceeds respiration during the photoperiod, allowing the accumulation of an oxygen reserve, which prevents concentrations from decreasing to extremely low levels at night (< 1.0 to 2.0 mg/L). Cultural eutrophication results in increased productivity in the system and an increased accumulation of organic matter in the sediments. The breakdown of this organic matter increases SOD, which results in oxygen declines throughout the diel cycle. Additionally, nutrient enrichment in the Everglades dramatically reduces the native P/SAV community and increases emergent aquatic vegetation coverage (Rutchey and Vilchek, 1994; McCormick et al., 1998; Payne et al., 1999, 2000 and 2001b). Emergent aquatic vegetation contributes little oxygen to the water column while shading periphyton and SAV, resulting in further reductions in DO production.

As in previous water years, DO was classified during WY02 as a parameter of concern for all EPA regions and classes. Overall, 75 percent of the 2,180 DO measurements collected during WY02 were below the existing 5.0-mg/L Class III criterion. The frequency of DO measurements falling below 5.0 mg/L ranged from 47 to 86 percent among EPA regions. Though the overall EPA excursion frequency was similar to that of previous periods, differences for specific regions and classes were noted. DO excursion frequencies increased (from 3 to 9 percent) at Refuge rim canal and inflow stations and at sites in the WCA-3 interior compared to either WY01 or the historical period. Within the interior marsh regions of the Refuge, WCA-2 and the Park, DO excursion frequencies were lower (2.5 to 9.5 percent) than in WY01, though the excursion frequency for the Refuge remained substantially above (10 percent) the levels recorded in the WY78 through WY00 historic period. The decreases in excursion frequency observed at interior areas were likely related to marsh recovery from the severe drought experienced during much of WY01, as was noted in the *2002 Everglades Consolidated Report* (Weaver et al., 2002).

As discussed above, it is widely accepted that DO concentrations are normally low (i.e., naturally less than 5.0 mg/L) in periphyton-dominated marsh environments, such as the Everglades, due to the natural processes of photosynthesis and respiration (Belanger and Platko, 1986; McCormick et al., 1997). Since the low DO concentrations often measured in the Everglades represent the natural variability of this type of ecosystem, the FDEP does not consider these excursions to be violations of the DO standard. Therefore, the current Class III criterion of 5.0 mg/L is not believed to be appropriate for the Everglades.

To formally recognize the natural background conditions in the EPA marshes, the FDEP has developed a Site Specific Alternative Criterion (SSAC) for DO that was presented in the *2001 Everglades Consolidated Report* (Weaver 2000; Weaver et al., 2001). The SSAC uses a mathematical model to define a DO threshold based on sample collection time and water column temperature. Weaver (2000) provided a DO SSAC measurement methodology that is in development and is based on an annual average concentration. It was suggested that the annual average DO at an individual station should be maintained above the annual limit calculated from the DO SSAC mathematical model. It was also argued that a one-year period would provide a characterization of the DO regime at a site and would account for the infrequent occurrence of naturally low values. The DO SSAC model and measurement methodology are undergoing continued calibration and evaluation. Continuing efforts to formally adopt an Everglades DO SSAC require public notice and hearing and final approval by the FDEP secretary.

To further evaluate the DO concentrations measured during WY02, the SSAC was applied to WY02 DO data from interior, rim canal, inflow, and outflow stations in the EPA. The DO SSAC allows a more accurate differentiation between impacted and background conditions relative to DO, and provides more realistic information on ecosystem status than that obtained from applying the existing Class III criterion. Although the SSAC was developed for open-water marsh stations, water discharging to the Everglades should meet the SSAC to prevent violations in the receiving waters of the marsh. The Class III standard would still be applicable to canal waters that do not immediately discharge to the marsh. Applying the SSAC to WY02 data resulted in a substantially lower excursion rate than did the analysis based on the current 5.0-mg/L criterion. To restate, DO concentrations at most stations were within the range of natural background conditions (**Table 2A-4**). Site-specific results are provided in **Appendix 2A-2**.

Stations that failed to meet the SSAC were generally influenced either by altered hydrogeomorphic conditions caused by canal construction and operation of water control structures, or by nutrient enrichment. Similar to results reported in both the *2001* and the *2002 Everglades Consolidated Report* (Weaver et al., 2001 and 2002), numerous water control structures (inflow and outflow sites) failed the SSAC test during WY02. This pattern of non-compliance is likely due to a combination of factors, including the disturbance of bottom sediments, intrusion of low-DO groundwater into the surface water at these structures, and the effects of nutrient enrichment. Sediments are commonly mixed with canal surface waters during pumping events. These sediments typically increase oxygen demand within the water column and subsequently result in reduced DO concentrations (Environmental Services & Permitting, Inc., 1992). Groundwater intrusion is common at Everglades pumping stations and canals that are dug below the water table. The influence of groundwater on DO at these structures represents a potentially “human-induced condition, which cannot be controlled or abated” and should be addressed separately. The second group of stations failing the SSAC is the interior marsh stations known to be biologically impaired as a result of phosphorus enrichment (E1, F1, Z1 and 3AW05). Conditions at these stations are expected to remain impaired until phosphorus concentrations in the surface water and sediment are reduced and the biological communities recover.

Table 2A-4. Comparison between the number of stations categorized as concerns using the current Class III criterion and the SSAC currently undergoing evaluation for WY02

Region	Class	Number of Stations	Class III Criterion	SSAC
			Percent of Stations (Number)	Percent of Stations (Number)
Refuge	Inflow	7	100 (7)	14 (1)
	Interior	23	100 (23)	17 (4)
	Outflow	6	83 (5)	0 (0)
	Rim	4	100 (4)	0 (0)
WCA-2	Inflow	8	88 (7)	13 (1)
	Interior	20	90 (18)	25 (5)
	Outflow	5	100 (5)	20 (1)
WCA-3	Inflow	17	88 (15)	24 (4)
	Interior	23	96 (22)	39 (9)
	Outflow	12	92 (11)	0 (0)
Park	Inflow	13	77 (10)	8 (1)
	Interior	21	57 (12)	0 (0)

ALKALINITY

Alkalinity is a measure of water's acid neutralization capacity and provides a measure of water's buffering capacity. In most surface water bodies, the buffering capacity is primarily the result of the equilibrium between carbon dioxide and carbonate and bicarbonate ions (CO_2, HCO_3^-, CO_3^{2-}). The dissociation of calcium carbonate, magnesium carbonate, or other carbonate-containing compounds entering the surface water through weathering of carbonate-containing rocks and minerals (e.g., limestone and calcite) contributes to water's buffering capacity. Therefore, in certain areas, such as WCA-2, WCA-3 and the Park, which are influenced by canal inflows primarily composed of mineral-rich agricultural runoff and groundwater, alkalinity levels are relatively high. Conversely, other areas, such as the interior of the Refuge, which receives most of its hydrologic load through rainfall, have very low alkalinity levels. Alkalinity protects aquatic life against dramatic pH changes. Rapid pH changes are difficult for living organisms to adapt to and can result in severe stress and even death for sensitive species. Therefore, it is crucial that surface waters exhibit a minimal level of alkalinity or buffering capacity to restrict dramatic pH swings. The current Class III criterion for alkalinity specifies that alkalinity shall not be depressed below 20 mg $CaCO_3$/L.

Violations of the 20 mg $CaCO_3$/L criterion have historically occurred in the interior of the Refuge (Bechtel et al., 1999 and 2000; Weaver et al., 2001 and 2002). As in previous years, alkalinity was designated as a parameter of concern for the interior of the Refuge during WY02 due to an excursion rate of 18.2 percent. As stated above, the low alkalinity values in the Refuge are primarily a result of the area's hydrologic nature. Most of the water entering the Refuge (54 percent) is low-alkalinity rainwater (SFWMD, 1992). Along the area's western periphery, harder canal waters from the S-5A and S-6 structures permeate the marsh along the L-7 rim canal.

However, canal waters tend to penetrate only a few kilometers into the marsh and therefore have little or no influence on the soft-water conditions within the interior. The dichotomy of the soft-water interior and the hard-water periphery creates steep pH, alkalinity, and other ionic gradients in the Refuge from the canals into the marsh (Swift and Nicholas, 1987; Richardson et al., 1990; Weaver et al., 2001).

Alkalinity within the Refuge decreases in proportion to its distance from the rim canal and S-6 inflow structure (Payne et al., 2000; Weaver et al., 2001). In fact, stations in the central part of the Refuge (i.e., LOX5, LOX7, LOX9, LOX11 and LOX13) have the lowest alkalinity levels, with average concentrations at or below the state criterion of 20 mg $CaCO_3$/L. Alkalinity excursions within the Refuge are therefore not a result of a controlled discharge or pollution source; rather, these excursions are due to the system's natural soft-water, rainfall-driven nature. The low alkalinity values represent the normal background condition typical of this ecosystem; therefore, the FDEP does not consider these low values in the interior of the Refuge to be in violation of the state alkalinity standard.

SPECIFIC CONDUCTANCE

Specific conductance (conductivity) is a measure of water's ability to conduct an electrical current and is an indirect measure of the total concentration of ionized substances (e.g., Ca^{2+}, Mg^{2+}, Na^{+}, Cl^{-}, HCO_3^{-}, SO_4^{2-}) in the water. Conductivity will vary with the number and type of these ions in solution. In some cases it can be used to differentiate among various water sources, such as groundwater, rainwater, agricultural runoff and municipal wastewater. Changes in conductivity beyond natural background variability can result in potentially deleterious effects to aquatic life. For example, very high conductivities would be detected under conditions of saltwater intrusion. The current state water quality criteria for Class III freshwaters, which allows a 50-percent increase in the specific conductance, or 1,275 µmho/cm, whichever is greater, is intended to preserve natural background conditions and protect aquatic organisms from stressful ion concentrations. Since background conductivities are low within the EPA, excursions were calculated using the 1,275-µmho/cm criterion (Weaver et al., 2001 and 2002).

Similar to previous periods, conductivity was categorized as a concern and a potential concern for Refuge inflows and for the WCA-2 interior, respectively, for WY02. Also, as in previous years a majority of the conductivity excursions (52) during WY02 occurred either at water control structures or within canals. Most of the recorded excursions (16) within the interior of both the Refuge and WCA-2 occurred at stations located near canal inflows. Recent Everglades Consolidated Reports explained that the elevated conductivity levels were probably linked to groundwater intrusion into canal surface waters (Weaver et al., 2001 and 2002). Groundwater intrusion can occur due to seepage into canals, via pumping station operation (which can pull additional groundwater into the surface water), and as a result of agricultural de-watering practices. The FDEP plans to continue its evaluation of conductivity in the EPA and EAA canals.

UN-IONIZED AMMONIA

Ammonia is a colorless gas that has a pungent odor that is very soluble in water at low pH. Ammonia can serve as an important source of nitrogen for plant life but is deleterious when present in excess. In water that has both a low temperature and a low pH, ammonia undergoes hydrolysis to produce ammonium (NH_4^{+}) and hydroxide (OH^{-}) ions. The ammonium ions produced during this reaction are not toxic to aquatic life. However, at high pH levels the hydrolysis is not as complete and increasing amounts of un-ionized ammonia (NH_3) remain. For example, in freshwater at 25°C, an increase in pH from 7 to 8 results in an increase in the percent of ammonia in the un-ionized form from 0.5 to 5.4 percent. At a pH of 9, more than a third (36 percent) of the total dissolved ammonia (i.e., the concentration of ammonia measured in the water column) is un-ionized. The resulting un-ionized ammonia is able to diffuse across cell membranes more readily and is acutely toxic to aquatic life.

Ammonia is unique among regulated water quality constituents because it is both a source of nitrogen (a nutrient required for life) and an endogenously produced toxicant for which organisms have developed a variety of strategies to excrete it as a waste product. Toxicity levels of ammonia are highly variable because they are affected by temperature, pH, DO concentrations, carbon dioxide concentrations, previous acclimation to ammonia, and the presence of other toxic compounds. Plants are more tolerant of ammonia than are animals, and invertebrates are more tolerant than fish. Increases in both pH and temperature lead to increased levels of un-ionized ammonia. High external, un-ionized ammonia concentrations reduce or reverse diffusion gradients that organisms use to excrete excess ammonia. This excess ammonia can accumulate in an organism, resulting in altered metabolism, loss of equilibrium, hyperexcitability, increased respiratory activity and oxygen uptake, and increased heart rate. Even slightly elevated concentrations of ammonia have been associated with a reduction in hatching success in some animals, a reduction in growth rate and morphological development in others, and injuries to gill tissue, the liver and the kidneys. In fish, extremely high levels of ammonia can result in convulsions, coma, and even death.

The current state Class III water quality un-ionized ammonia criterion is ≤ 0.02 mg/L. This value is derived from pH, temperature and total dissolved ammonia measurements from the same sample. During WY02, 21 calculated values above this criterion were recorded. A large number of these excursions (19) occurred at stations E0 and F0, which resulted in un-ionized ammonia being classified as a parameter of concern for the WCA-2 inflow stations. The excursion frequency during WY02 for WCA-2 inflows was substantially above all previous periods of record. In fact, the un-ionized ammonia excursion frequency at the WCA-2 inflows has ranged from just 0 to 8 percent for all previous water years since 1978 compared to an excursion rate of approximately 24 percent during WY02.

Stations E0 and F0 are located within the WCA-2A spreader canal, which receives Hillsboro canal discharges from the S-10A, S-10C, and S-10D structures and, in turn, flows over into the marsh when canal stages exceed the height of a low berm. A review of hydrologic and water quality monitoring records suggests that the unprecedented level of un-ionized ammonia excursion at sites E0 and F0 were likely related to the stagnant, low-water conditions in the spreader canal during WY02. This canal can become stagnant and anaerobic during periods of no or low flow, such as when the S-10A, S-10C and S-10D structures are closed, resulting in substantial changes in the biogeochemical conditions and constituent concentrations in the canal. Flow records indicate that discharges via the S-10A, S-10C and S-10D structures were limited during WY02, with no flow during the un-ionizoned ammonia excursion episodes (**Figure 2A-6**). This is supported by reports submitted by SFWMD sampling personnel that during WY02 the canal was often stagnant and had an associated hydrogen sulfide (rotten egg) smell, which is characteristic of anaerobic conditions, (Tim Bechtel, personal communication).

The nutrient-enriched surface water in the spreader canal can support substantial algae growth when the canal is stagnant and is not being flushed by incoming water from the Hillsborough canal. When the accelerated growth of algae can no longer be supported, the algae die, fall to the bottom, and decay, resulting in the release of ammonia and the consumption of oxygen (causing the observed anaerobic conditions). This theory is supported by both the elevated total dissolved ammonia concentrations measured in the canal and the reports of anaerobic conditions. Additionally, lower water levels in the canal may have exposed some of the sediment, resulting in more rapid oxidation of organic material in the sediment, which would also cause more ammonia to be released.

Elevated total dissolved ammonia levels were the proximal cause of the E0 and F0 un-ionized ammonia excursions (**Figure 2A-7**), as would be expected if the cause were related to the release of ammonia caused by low-flow or stagnant conditions. Median WY02 total dissolved ammonia concentrations at sites E0 and F0 were 1.0 and 0.93 mg/L, respectively and were significantly above the site median concentrations (E0 = 0.20 mg/L, F0 = 0.33 mg/L) for WY94 through WY01 (Kruskal-Wallis; p = 0.014 to 0.001). Furthermore, WY02 un-ionized ammonia concentrations at these two sites were highly correlated with total dissolved ammonia concentrations ($R^2 = 0.67$; $p < 0.0001$). The pH values associated with the WY02 excursions at stations E0 and F0 ranged from 7.3 to 8.0 (median = 7.7). As previously noted, pH values in the 7.3 to 8.0 range result in only small fractions (0.96 to 7.6 percent) of the total dissolved ammonia present in the un-ionized form. Over the entire monitoring record at these two stations (WY94 through WY02), elevated total dissolved ammonia concentrations were the proximal cause of all 41 un-ionized ammonia excursions within the WCA-2 spreader canal (i.e., stations E0 and F0) and were highly correlated with the calculated un-ionized ammonia concentrations ($R^2 = 0.49$; $p < 0.0001$). During all other un-ionized ammonia excursion events at stations E0 and F0, the pH ranged from just 7.2 to 8.0 (median = 7.5). The significant influence of total dissolved ammonia concentrations on WCA-2 spreader canal un-ionized ammonia excursions is dissimilar from most excursions in other areas, attributed primarily to high pH values (Bechtel et al., 1999 and 2000; Weaver et al., 2001 and 2002). This phenomenon of periodically elevated total dissolved ammonia concentrations is apparently isolated to the spreader canal and has not contributed to excursions in the marsh adjacent to the spreader canal. Total dissolved ammonia concentrations (WY9 through WY02) at marsh transect stations F-1 and E-1 downstream (1.8 - 2.2 km) of the spreader canal have been significantly lower (Kruskal-Wallis; $p < 0.0001$; median = 0.05 mg/L) than concentrations observed at stations E0 and F0 (median = 0.31 mg/L). The FDEP and SFWMD will continue to evaluate ammonia in this area to better define the nature and causes of these excursions. Results of these evaluations will be provided in future Everglades Consolidated Reports.

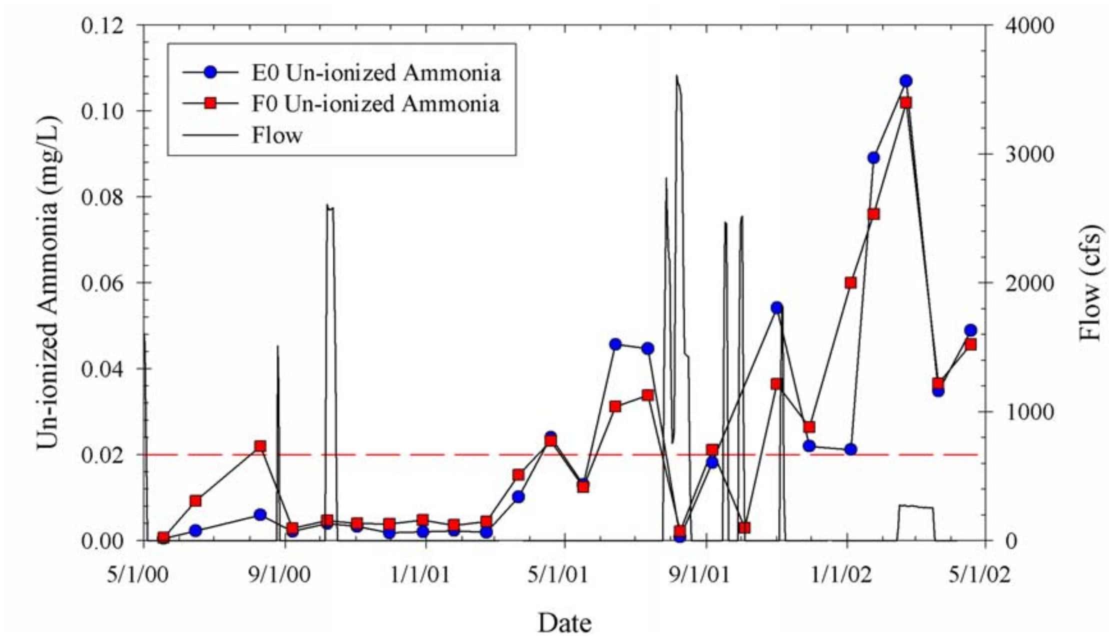

Figure 2A-6. Total average daily inflow volume through the S-10A, S-10C and S-10D structures, and calculated un-ionized ammonia concentrations for sites E0 and F0 during WY01 and WY02. Horizontal red dashed line is the Class III un-ionized ammonia criterion (0.02 mg/L)

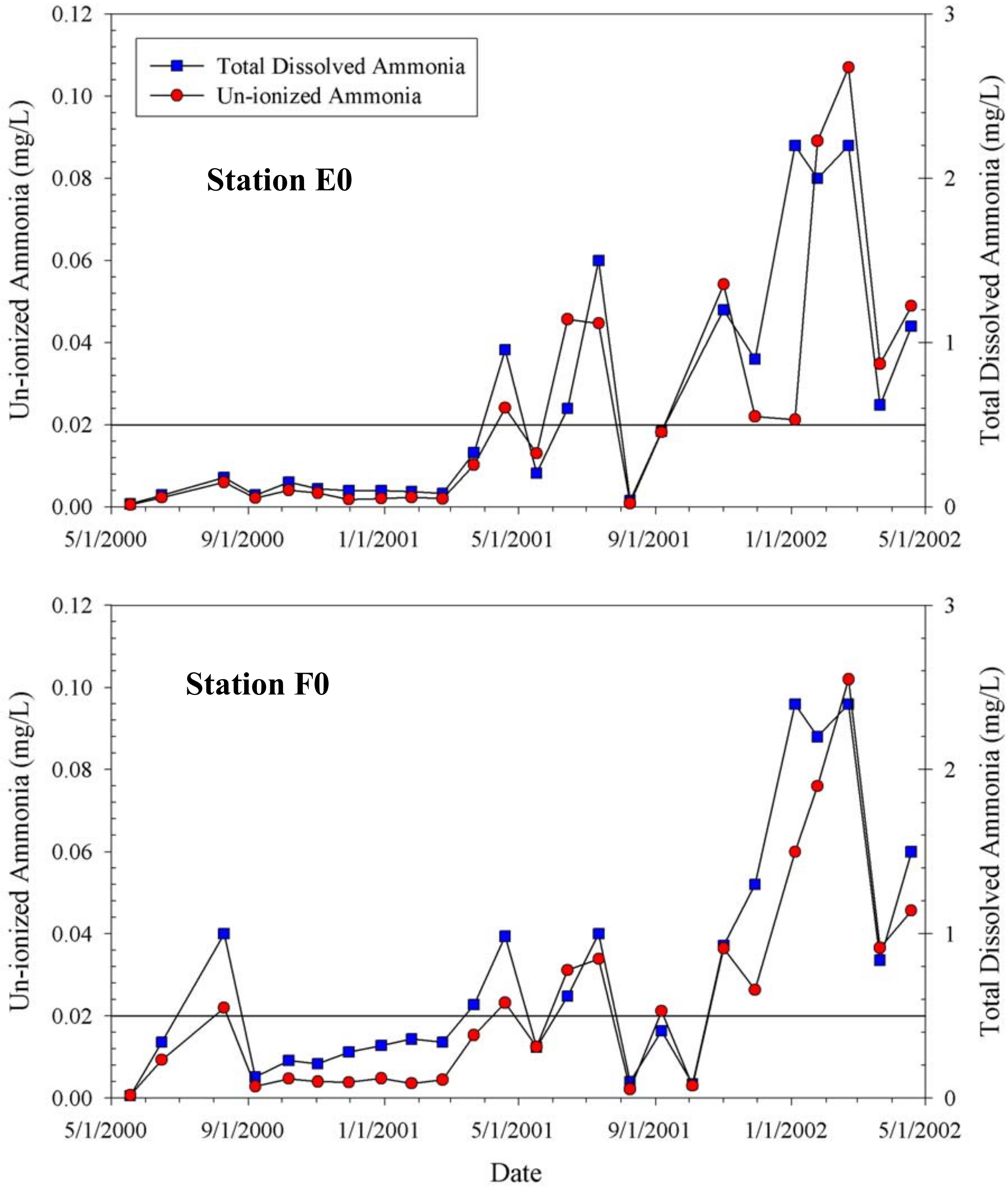

Figure 2A-7. Dissolved ammonia concentrations and calculated un-ionized ammonia values for sites E0 (top) and F0 (bottom) during WY01 and WY02. Horizontal solid black line is the Class III un-ionized ammonia criterion (0.02 mg/L)

TOTAL BERYLLIUM

Beryllium is a light, stable, bivalent metal belonging to the alkaline earth family. It is used in metal alloys, particularly in beryllium-copper alloy, and in high-performance products in the metallurgical, aerospace and nuclear industries. Beryllium can enter water, air and soil as a result of natural and human activities, such as industrial waste discharges, coal and oil combustion, and the weathering of rocks and soils. The primary anthropogenic emission source of beryllium is coal and fuel oil combustion, which releases beryllium-containing particulates and fly ash. The general population is exposed to beryllium through the inhalation of air and the consumption of food and drinking water (USEPA, 1998).

The current state water quality criterion for beryllium in Class III waters is less than or equal to an annual average of 0.13 μg/L. This criterion was established based on the USEPA's Human Health Criterion for beryllium. Beryllium was categorized as a concern for WCA-3 inflows for WY02 due to excursions at three inflow structures (G-205, G-206 and S-8). Average beryllium concentrations during WY02 for these stations ranged from 0.39 to 0.92 μg/L based on one sample from the G-205 and G-206 sites and on three samples from the S-8 site. Individual sample results ranged from < 0.10 to 0.92 μg/L.

Although WCA-3 inflow beryllium concentrations exceeded the current state criterion, it is highly unlikely that the observed concentrations represent a threat to designated use or the health of aquatic life. The USEPA guidance on which the state based its criterion was established based on an inhalation potency factor (carcinogenicity). Surface water human health criteria are usually based on oral intake cancer potency factors. In 1992 the USEPA withdrew its human health-based surface water criteria for beryllium pending evaluation of relevant data regarding beryllium's toxicity (USEPA, 1992). Based on the weight of limited human and sufficient animal evidence, the USEPA currently classifies beryllium as a probable human carcinogen (B1) when it is airborne and inhaled. However, the human carcinogenic potential of ingested beryllium (in water or food) cannot be determined because of inadequate data (USEPA, 1998). The state is likely to revise its beryllium criterion to reflect chronic toxicity to freshwater aquatic life (5.3 μg/L) or the protection of human health (1140 μg/L), whichever is lower, based on USEPA guidance (USEPA, 1980; USEPA, 1998). All beryllium concentrations that were reported during WY02 and during all preceding years at the WCA-3 inflows were below these thresholds.

TOTAL PHOSPHORUS AND TOTAL NITROGEN

Though phosphorus and nitrogen do not currently have numeric criteria, the concentration of these nutrients in Class III waters is regulated by a narrative criterion that specifies that nutrient concentrations in a water body cannot be altered so as to cause an imbalance in the natural populations of flora or fauna and shall be limited to prevent violations of other water quality standards. In an attempt to prevent further adverse biological impacts resulting from nutrient enrichment within the EPA, the FDEP has proposed a 10 μg/L phosphorus criterion to the Environmental Regulation Commission (ERC). The ERC is currently considering this proposal. Further details concerning the development of the phosphorus criterion and the rulemaking process are provided in Chapter 5 of the *2003 Everglades Consolidated Report*, as well as in the *2001* and the *2002 Everglades Consolidated Report* (Payne et al., 2001a and 2002). Due to the importance of nutrient levels within the EPA, the concentrations of nitrogen and phosphorus measured during WY02 are discussed below and are compared to results from previous monitoring years.

Total Phosphorus

Since no numeric criterion or measurement methodology has been approved for total phosphorus (TP), phosphorus concentrations are summarized to provide an overview of the current nutrient status of the Everglades and to demonstrate the existence of any temporal and spatial patterns. No excursion analysis can be performed at this time; however, both the 10 µg/L phosphorus criterion (which is also the EFA default phosphorus criterion) that the FDEP has proposed to the ERC, and the 50 µg/L long-term limit for the STAs are used as a basis for comparison. TP concentrations observed in WY02, WY01 and a historic period (WY78 through WY00) are summarized in **Table 2A-5**. For comparison, data for the current water year are presented against historical data. Note that due to the reclassification of several monitoring sites, the addition of new monitoring sites, and a change in the method used to deal with values reported as less than the MDL (i.e., half the MDL replacement), summary statistics for TP presented herein are slightly different from those presented in previous ECRs. For example, the 2002 ECR reported a median concentration of 13 µg/L for Park inflows during WY01, whereas **Table 2A-5** reports a median concentration of 11 µg/L for WY01.

Table 2A-5 summarizes TP concentrations for WY02, WY01, and WY78 through WY00 using both median and geometric mean values. The geometric mean is used to evaluate the WY02 TP concentrations, and replaces the arithmetic mean used in previous Everglades Consolidated Reports based on a requirement in the EFA that specifies that geometric means be used for the TP criterion measurement methodology. As with previous years, a decreasing north-to-south gradient indicative of settling, sorptive (both adsorptive and absorptive), assimilative (biological), and other biogeochemical processes in the marsh was apparent. High concentrations in the north are related to canal discharges composed primarily of agricultural runoff originating in the EAA. Water Conservation Area inflow concentrations measured either as medians or geometric means for WY02 were less than the historic period and also declined slightly from WY01. Chapter 2A of the 2002 ECR (Weaver et al., 2002) reported an increased TP concentration within the inflows to the Park. The 2002 ECR attributed these increases to drought conditions and recycling of phosphorus from marsh sediments. During WY02, Park inflow concentrations returned to pre-drought conditions, with a geometric mean TP concentration of 9.1 µg/L (median = 8.0 µg/L). These results support the 2002 ECR's conclusion and further illustrate the potential influence that severe climatic conditions can have on water column TP concentrations. During WY02, interior marsh geometric mean TP concentrations ranged from 15.3 µg/L (WCA-2) to 4.8 µg/L (Park) and demonstrated the same north-to-south gradient observed during previous periods (Bechtel et al., 1999 and 2000; Weaver et al., 2001 and 2002). As is typically observed, the highest phosphorus concentrations observed during WY02 were in the northern Water Conservation Areas and declined throughout WCA-3 and the Park. For WY02, individual interior marsh monitoring station geometric means ranged from < 4.0 to 61 µg/L, with 63.4 percent of the sites exhibiting annual geometric mean concentrations that were less than or equal to 10 µg/L (**Figure 2A-8**). A few sites (X4, LOX13, F5 and CA33) in relatively unenriched areas (sediment phosphorus ≤ 600 mg/kg; Payne et al., 2001a and 2002) slightly exceeded 10 µg/L (range = 10.5 to 12.5 µg/L). More detailed site-specific annual TP concentration and WY02 area-specific load summaries are provided in **Appendices 2A-3** and **2A-4**, respectively. Loads for individual structures (EAA and non-ECP sites) are presented in Chapter 8.

Table 2A-5. Summary of total phosphorus concentrations (µg/L) in the Everglades Protection Area for WY02, WY01, and WY78 through WY00

Region	Class	Period	N	Geometric Mean	Std. Deviation (Geometric Mean)	Median	Min.	Max.
Refuge	Inflow	1978-2000	2634	72.8	2.3	80	<4	1415
		2001	282	44.5	2.1	40	12	305
		2002	256	42.7	2.0	38	14	274
	Interior	1978-2000	1856	10.0	2.1	9	<4	494
		2001	227	10.7	1.7	10	<4	99
		2002	237	10.2	1.7	9	4	120
	Outflow	1978-2000	1068	57.9	2.1	56	7	3435
		2001	71	46.9	1.8	45	13	306
		2002	66	32.0	1.8	29	14	210
	Rim	1978-2000	617	64.7	1.8	63	12	473
		2001	45	62.3	1.6	53	36.5	263
		2002	44	53.6	1.9	48	19	215
WCA-2	Inflow	1978-2000	1597	64.8	2.0	64	7	3435
		2001	106	48.6	1.9	49	9	306
		2002	92	40.0	1.7	43.5	12	210
	Interior	1978-2000	4167	17.1	3.2	13	<4	3189
		2001	259	15.8	2.7	12	<4	240
		2002	265	15.3	2.2	14	4	210
	Outflow	1978-2000	1335	20.6	2.5	19	<4	556
		2001	61	17.7	2.0	17	4	87
		2002	64	18.5	1.9	16.5	6	77
WCA-3	Inflow	1978-2000	4331	35.9	2.6	36	<4	933
		2001	384	30.4	2.2	28	8	1286
		2002	410	27.1	1.9	26	7	408
	Interior	1978-2000	1557	9.0	2.6	8	<4	438
		2001	176	8.6	1.8	8	<4	150
		2002	272	8.8	2.3	8	<4	310
	Outflow	1978-2000	3585	10.3	2.2	10	<4	593
		2001	232	19.1	1.8	18	5	145
		2002	208	14.0	2.0	12	4	132
Everglades National Park	Inflow	1978-2000	4059	8.9	2.2	9	<4	593
		2001	322	12.2	1.9	11	<4	145
		2002	294	9.1	2.0	8	<4	132
	Interior	1978-2000	1314	5.5	2.5	5	<4	1137
		2001	128	6.3	2.3	6	<4	68
		2002	135	4.8	2.1	5	<4	53

The distribution of TP concentrations in all EPA regions for WY02 is presented in **Figure 2A-8**. Inflow stations to the Refuge and the water conservation areas had the highest percentage of measurements above 50 µg/L (18 to 45 percent). In contrast, only 3.4 percent of the TP measures from Park inflows were above 50 µg/L. Over the entire EPA, 87 percent of TP measurements were below 50 µg/L, with 38 percent of the measurements at or below 10 µg/L. The percentage of measurements at or below 10 µg/L increased from WY01 levels (30 percent). It should be noted that the percentage of measurements at or below 10 µg/L for Park inflows during WY02 (70 percent) was substantially above both the percentage observed during WY01 (49 percent), when phosphorus concentrations were apparently impacted by severe drought conditions, and the percentage reported for the WY78 through WY00 historical period (61 percent). Again, this finding supports conclusions made in the *2002 Everglades Consolidated Report* concerning the impact of drought conditions on phosphorus concentrations in the Everglades Protection Area.

Total Nitrogen

Total nitrogen (TN) is not measured directly; rather, it is calculated as the sum of total Kjeldahl nitrogen (TKN [organic nitrogen plus ammonia]) and nitrite plus nitrate (NO_2+NO_3). For the *2003 Everglades Consolidated Report*, TN values were calculated only for samples for which both TKN and NO_2+NO_3 results were available. **Table 2A-6** summarizes WY02, WY01, and WY78 through WY00 TN concentrations using arithmetic and mean and median values. Median WY02 inflow and interior TN concentrations ranged from 0.9 and 2.5 mg/L and from 0.9 to 2.1 mg/L, respectively, were similar to WY01 concentrations, and were also generally lower than those observed in the more historic period. As in previous years a north-to-south gradient was apparent in the TN data, which likely reflects agricultural discharges in the north and a gradual reduction in levels as water flows southward, resulting from assimilative processes in the marsh. The highest concentrations were observed in the inflows to the Refuge and WCA-2, with decreasing concentrations through the Water Conservation Areas and further declines into Everglades National Park.

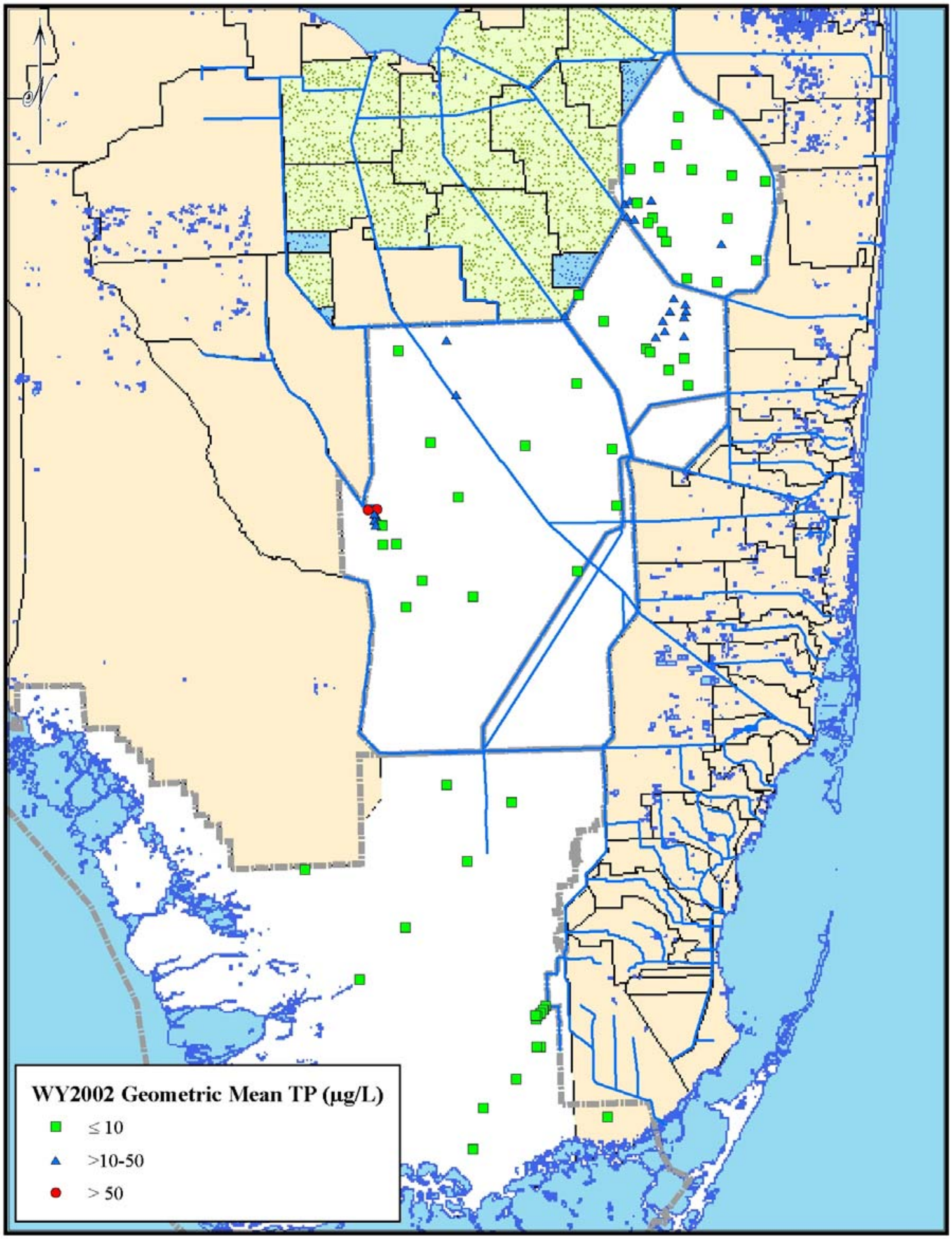

Figure 2A-8. Geometric mean TP concentrations across the EPA. Geometric mean TP concentrations are summarized at three levels: ≤ 10 µg/L, > 10 to 50 µg/L, and > 50 µg/L)

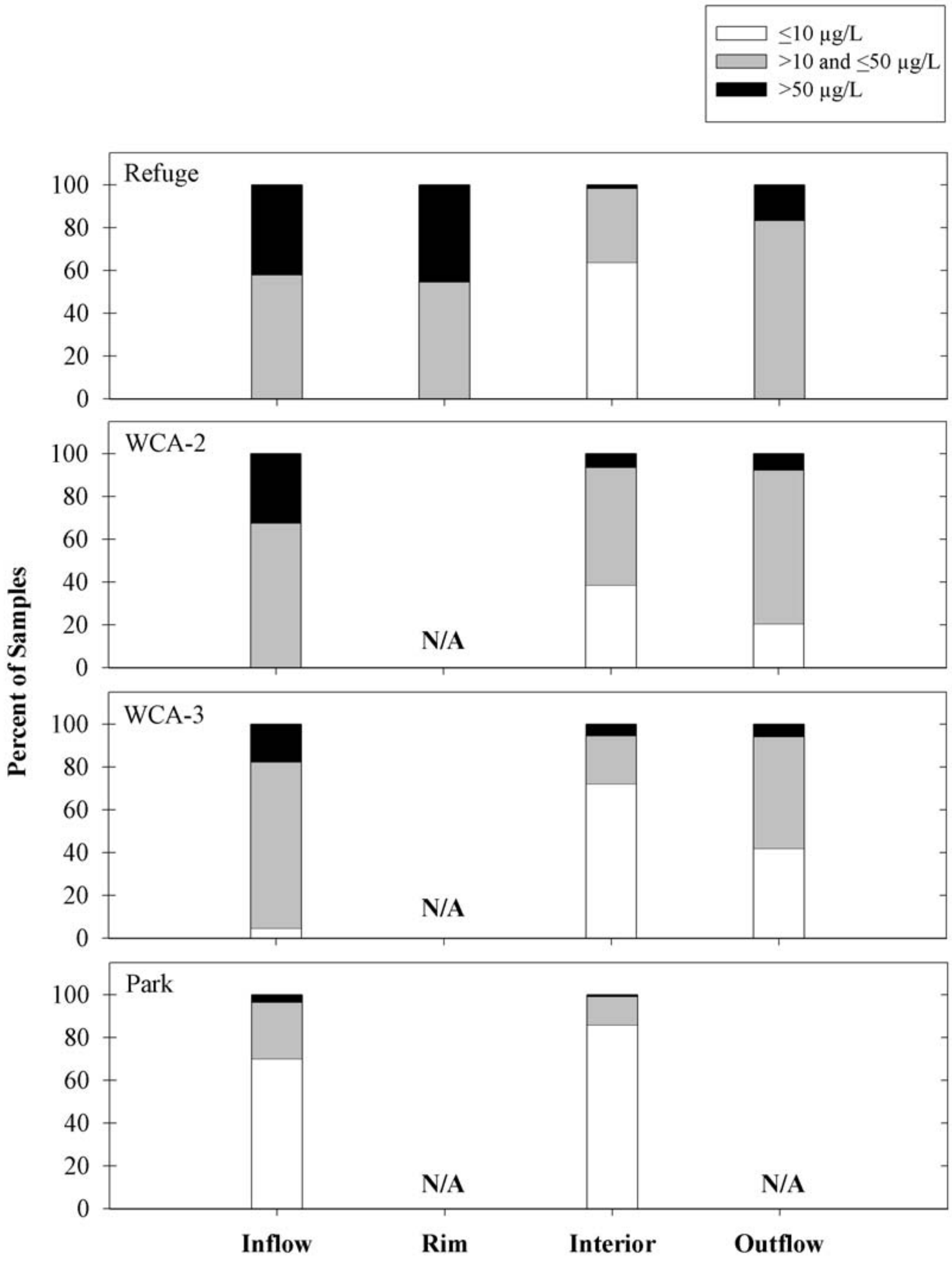

Figure 2A-9. Total phosphorus concentrations in samples collected in the EPA during WY02. "N/A" indicates that the given component (e.g., rim, outflow) is not present within the EPA area

Table 2A-6. Summary of total nitrogen concentrations (mg/L) in the Everglades Protection Area for WY02, WY01, and WY78 through WY00

Region	Class	Period	N	Arithmetic Mean	Std. Deviation	Median	Min.	Max.
Refuge	Inflow	1978-2000	2520	3.6	2.4	3.0	<0.5	48.2
		2001	156	2.5	0.9	2.4	1.11	6.5
		2002	167	2.6	1.0	2.5	1.01	6.0
	Interior	1978-2000	1508	1.6	1.4	1.3	0.45	36.7
		2001	176	1.8	0.6	1.8	0.64	3.2
		2002	145	1.5	0.7	1.2	0.58	4.8
	Outflow	1978-2000	1064	2.8	1.7	2.4	<0.5	22.8
		2001	60	2.2	0.8	2.1	1.10	5.0
		2002	66	1.8	0.6	1.6	0.92	3.9
	Rim	1978-2000	589	2.8	1.5	2.3	0.77	10.9
		2001	46	2.6	1.0	2.4	0.68	5.6
		2002	31	2.4	0.7	2.3	1.22	3.9
WCA-2	Inflow	1978-2000	1585	3.0	1.6	2.7	<0.5	22.8
		2001	84	2.3	0.9	2.2	0.79	5.7
		2002	88	2.6	1.1	2.3	0.70	6.4
	Interior	1978-2000	3734	2.5	1.7	2.3	<0.5	37.2
		2001	165	2.1	0.8	2.0	0.74	5.6
		2002	164	2.1	0.6	2.1	0.85	4.0
	Outflow	1978-2000	1326	2.2	0.9	2.0	<0.5	7.7
		2001	61	1.6	0.4	1.6	0.76	2.9
		2002	66	1.7	0.6	1.6	0.95	4.1
WCA-3	Inflow	1978-2000	4076	2.1	1.1	1.8	<0.5	10.8
		2001	236	1.7	0.6	1.5	0.72	4.6
		2002	240	1.6	0.6	1.5	0.89	5.2
	Interior	1978-2000	1442	1.6	0.9	1.4	0.43	10.0
		2001	129	1.3	0.4	1.3	<0.5	2.9
		2002	116	1.2	0.4	1.1	0.72	3.4
	Outflow	1978-2000	2720	1.5	0.7	1.4	<0.5	14.9
		2001	137	1.1	0.4	1.1	<0.5	3.3
		2002	159	1.1	0.3	1.0	<0.5	2.7
Everglades National Park	Inflow	1978-2000	3131	1.3	0.7	1.3	<0.5	14.9
		2001	163	1.0	0.5	1.0	<0.5	3.3
		2002	183	0.9	0.4	0.9	<0.5	2.7
	Interior	1978-2000	1185	1.4	1.6	1.2	<0.5	40.8
		2001	111	1.2	0.7	1.0	<0.5	4.0
		2002	116	0.9	0.4	0.9	<0.5	2.2

SULFATE

The state currently has no surface water criterion 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 as reported in previous ECRs (Atkeson and Parks, 2002). Sulfate in Everglades surface waters is derived from a variety of natural and human sources. Sulfate of both natural and anthropogenic origin is deposited from the atmosphere. Additionally, stormwater runoff from the EAA contains high concentrations of sulfate that arise from the widespread use of sulfur-containing fertilizers and soil amendments. Additionally, under some conditions in the Everglades, groundwater containing elevated sulfate levels can rise to the surface (Atkeson and Parks, 2002).

Everglades Protection Area sulfate-monitoring results are presented herein to provide an overview of current concentrations, evaluate temporal and spatial patterns, and provide materials in support of discussions in Chapter 2B of the 2003 ECR. Sulfate concentrations are summarized in **Table 2A-7** for WY02, WY01, and WY78 through WY00 using arithmetic mean and median values.

Since one of the primary sources of sulfate entering the EPA is stormwater runoff from the EAA, sulfate concentrations in the inflow and interior marsh generally follow trends similar to those described for TP and TN. Additionally, sulfate concentrations also exhibit a general north-to-south gradient similar to that for nutrient levels and which extends from the sources in the north to relatively unenriched areas in the south. High inflow concentrations in EAA runoff enter the Refuge, WCA-2 and, to a lesser extent, WCA-3. The highest concentrations within the EPA have been observed at Refuge inflow stations during all three periods of record. However, as has been discussed previously, a significant amount of the surface water entering the Refuge does not permeate deeply in the marsh but instead remains around the periphery of the area in the rim canal and is discharged to WCA-2 through the S-10 structures. Due to this hydrologic characteristic, the Refuge interior has remained relatively uninfluenced by the inflow of sulfate-rich water. During WY01, however, sulfate concentrations at interior marsh stations in the Refuge (15.0 mg/L) were substantially elevated above either the historic period (3.0 mg/L) or that of WY02 (2.3 mg/L). These elevated concentrations were most likely related to a reduction in the rainwater dilution effect during the recent drought. Among the EPA marsh areas, the interior of WCA-2 exhibits the highest sulfate concentrations and is the area most affected by EAA runoff, with a WY02 median concentration of 29.3 mg/L, which was not dramatically different from the area's inflow concentration of 34.0 mg/L. Sulfate concentrations at stations in the WCA-3 interior have also been elevated by inputs of sulfate-enriched runoff, though this is not readily apparent from the 3.0-mg/L median concentration for WY02. As was demonstrated by the 1995, 1996 and 1999 USEPA REMAP studies, a pronounced north-to-south sulfate gradient is evident in WCA-3 (Atkeson and Parks, 2002). This gradient is also apparent within the District's monitoring network. The highest WY02 sulfate concentrations within the WCA-3 interior were observed in the marsh near the Miami Canal in the northwest part of the area at site CA36 (median = 24.0 mg/L). Concentrations decreased through the marsh, following the southerly flow of water. The lowest median sulfate concentration observed during WY02 at sites in the WCA-3 marsh (median = 0.18 mg/L) was observed at station CA315, the southernmost sampling location in WCA-3.

Table 2A-7. Summary of sulfate concentrations (mg/L) in the Everglades Protection Area for WY02, WY01, and WY78 through WY00

Region	Class	Period	N	Arithmetic Mean	Std. Deviation	Median	Min.	Max.
Refuge	Inflow	1978-2000	650	59	48	50	<0.1	461
		2001	92	51	20	50	10.3	118
		2002	113	61	24	61	3.2	113
	Interior	1978-2000	1526	14	78	3.0	<0.2	2900
		2001	178	23	23	15	<0.2	81
		2002	220	11	18	2	<0.1	110
	Outflow	1978-2000	288	50	51	39	4.2	571
		2001	24	43	15	43	5.9	63
		2002	27	34	20	34	1.4	79
	Rim	1978-2000	465	53	28	46	1.6	140
		2001	50	52	15	51	17.0	110
		2002	47	55	25	55	14.1	110
WCA-2	Inflow	1978-2000	527	53	47	47	6.2	644
		2001	50	43	11	42	21.0	63
		2002	51	37	16	34	12.9	79
	Interior	1978-2000	2675	46	28	44	<0.2	370
		2001	161	30	17	30	3.7	84
		2002	224	34	23	29	4.3	180
	Outflow	1978-2000	319	37	28	32	2.5	224
		2001	21	28	20	27	2.3	70
		2002	20	25	13	23	5.8	54
WCA-3	Inflow	1978-2000	870	28	27	19	<1.0	286
		2001	68	19	16	12	1.1	61
		2002	71	16	13	11	1.8	56
	Interior	1978-2000	1353	12	16	7.3	<0.2	262
		2001	134	8.1	17	3.4	<0.2	120
		2002	242	6.5	12	3.0	<0.1	120
	Outflow	1978-2000	430	15	18	10	<0.1	113
		2001	41	3.6	4.4	1.5	0.2	16
		2002	49	4.7	5.9	1.4	<0.1	23
Everglades National Park	Inflow	1978-2000	384	16	18	11	<0.1	113
		2001	52	3.1	4.0	1.7	<0.1	16
		2002	56	5.0	5.6	2.5	<0.1	23
	Interior	1978-2000	1206	6.5	15	3.2	<0.1	207
		2001	65	5.9	15	1.9	<0.1	117
		2002	102	11	42	2.2	<0.1	403

PESTICIDES

The South Florida Water Management 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, the Miccosukee Tribe Memorandum of Agreement, the Lake Okeechobee Operating Permit and the non-ECP Structure Permit. The current monitoring program in the EPA consists of 29 sites (**Figure 2A-10**), which were grouped by basin for analysis.

Surface water concentrations of pesticides are regulated under criteria established in Chapter 62-302, F.A.C. 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 Everglades Consolidated Report* (Weaver et al., 2001). These guideline concentrations were developed based on the requirement in subsection 62-302.530(62) F.A.C. that surface waters of the state shall be free from "substances in concentrations, which injure, are chronically toxic to, or produce adverse physiological or behavioral response in humans, plants, or animals."

The *2003 Everglades Consolidated Report* analyzes data collected during pesticide monitoring events conducted between December 2000 and November 2001. Monitoring results were evaluated relative to Class III 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. Parameters of concern have a high likelihood of resulting in an impairment of the designated use of the water body. Detected parameters (> MDL) that did not exceed either a guideline or a criterion were categorized as a potential concern. The potential concern classification signifies that the parameter is known to be present within the basin at concentrations reasonably believed to be below levels that result in adverse biologic effects, but might at some future date, or in interaction with other compounds, become a problem. A third category (no concern) was used to designate pesticides that were not detected at sites within a given area.

During the December 2000 through November 2001 period of record, 15 pesticides were detected in the EPA (**Table 2A-8**). Atrazine, diazinon, endosulfan (total alpha and beta), and simazine each had exceedances of either their Class III criteria or chronic toxicity guideline concentrations. During the March 20 through 21, 2001 sampling event, atrazine exceeded its guideline concentration at one WCA-2 inflow structure (S-7) and two Refuge inflow structures (S-5A and S-6). During the same sampling event, simazine exceeded its chronic toxicity guideline concentration at the S-5A inflow structure for the Refuge. On August 15, 2001 diazinon exceeded its guideline concentration at structure S-38B in WCA-2. Additionally, total alpha and beta endosulfan concentrations in excess of the Class III criterion (≤0.056 μg/L) were detected at Refuge inflow Stations G-94C and G-94D on March 19, 2001 and March 21, 2001, respectively.

Both the *2001 Everglades Consolidated Report* and the *2002 Everglades Consolidated Report* noted a reduction in pesticide exceedances entering the northern Everglades from the EAA (Weaver et al., 2001 and 2002). The most recent data, presented herein, suggest that this trend may have been reversed. All WY02 exceedances of Class III numeric criteria or chronic toxicity guidelines occurred in the northern Everglades (the Refuge and WCA-2). Excursions for the triazine pesticides (atrazine and simazine) occurred at structures discharging EAA runoff into the EPA. These pesticides likely originated through agricultural applications in either the EAA or

Lake Okeechobee basins. The endosulfan and diazinon excursions originated from the largely urban ACME and North Springs Improvement District (NSID) basins, respectively. The ACME basin includes some agriculture, including sod production; therefore, the endosulfan excursion may have originated through agricultural, rather than through urban, application. The diazinon excursion in NSID discharges continues a pattern noted in the two previous Everglades Consolidated Reports (Weaver et al., 2001 and 2002). Given the urban nature of the NSID basin and the common use of diazinon as an insecticide to control lawn pests, particularly fire ants, it is probable that diazinon is entering the surface water through runoff from residential lawn maintenance.

Table 2A-8. Pesticide detections and exceedance categories in the EPA inflows, canals and structures between December 2000 and November 2001. 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

Parameter	C111[1]	Park[2]	Refuge[3]	WCA-2[4]	WCA-3[5]
Ametryn	(0:12)	(0:16)	PC (11:15)	PC (4:4)	PC (4:18)
Atrazine	PC (9:12)	PC (7:16)	C (15:15)	C (4:4)	PC (13:17)
Bromacil	(0:12)	(0:16)	(0:9)	(0:4)	PC (2:17)
Diazinon	(0:12)	(0:16)	(0:9)	C (1:4)	(0:17)
Diuron	(0:12)	(0:16)	(0:12)	PC (1:6)	PC (3:24)
Endosulfan (total alpha and beta)[6]	PC (2:11)	(0:16)	C (3:9)	(0:4)	(0:17)
Endosulfan sulfate	PC (2:10)	(0:16)	PC (2:8)	(0:4)	PC (2:17)
Ethoprop	(0:12)	(0:16)	PC (1:9)	(0:4)	(0:17)
Hexazinone	(0:12)	(0:16)	(0:9)	(0:4)	PC (1:18)
Imidacloprid	(0:12)	(0:16)	PC (1:12)	(0:6)	(0:24)
Metalaxyl	(0:12)	(0:16)	PC (2:9)	(0:4)	(0:17)
Metolachlor	(0:12)	(0:16)	PC (2:7)	(0:4)	(0:17)
Norflurazon	(0:12)	(0:16)	(0:9)	(0:4)	PC (4:18)
Prometryn	(0:12)	(0:16)	PC (1:9)	(0:4)	(0:17)
Simazine	(0:12)	(0:16)	C (3:9)	PC (1:4)	PC (1:17)

1. G211, G310, S6, S176, S177, S178 and S331.
2. S12C, S18C, S332, S335A, S355B and US41-25.
3. ACME1DS, ENR012, G4D, and S5A.
4. S38B and S7.
5. G123, G606, L3BRS, S140, S190, S8, S9, S142, and S31.
6. Classification of "concern" is based on exceedance of state Class III criterion.

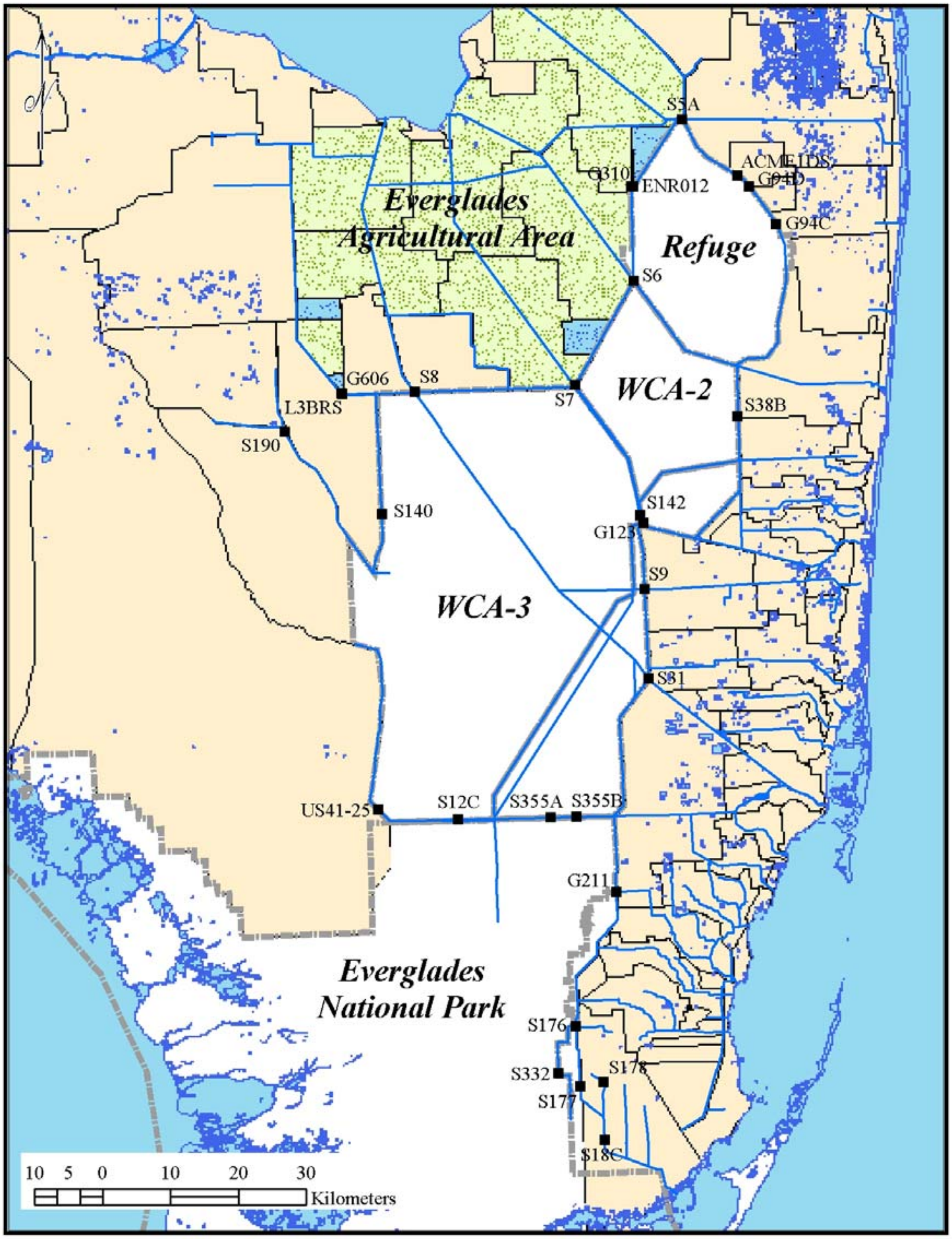

Figure 2A-10. SFWMD pesticide monitoring sites in the EPA

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