Numeric Nutrient Criteria Recommendations for the Sarasota Bay Estuary Program

Prepared for:

Sarasota Bay Estuary Program

Prepared by:

Janicki Environmental, Inc.

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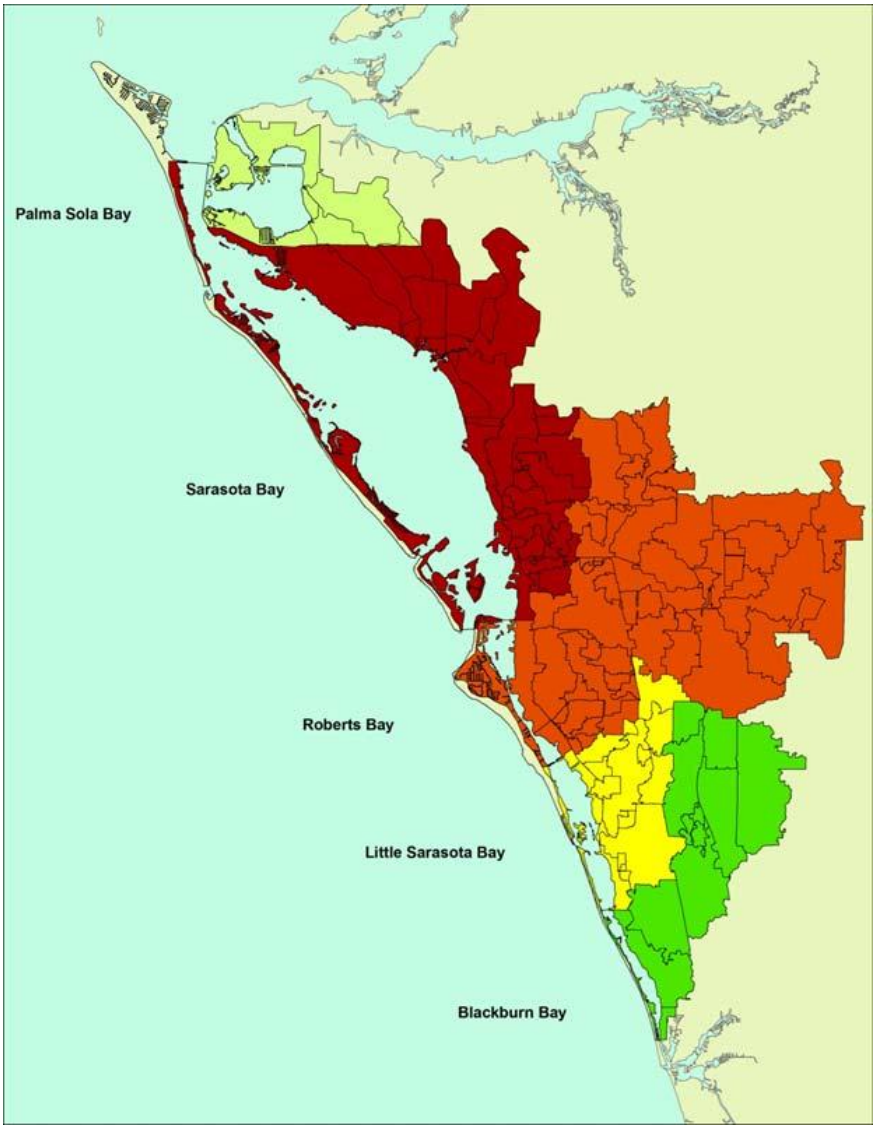
Objective

The objective of this document is to provide a summary of the recent work conducted by the Sarasota Bay Estuary Program (SBEP) to provide the U.S. Environmental Protection Agency (EPA) recommendations regarding the establishment of numeric nutrient criteria for the SBEP area. For reference, the following map of SBEP area depicts the five segments referred to in this document along with their respective watersheds.



The Need for Numeric Nutrient Criteria

The Florida Department of Environmental Protection (FDEP) began development of numeric nutrient standards in December 2001. The FDEP formed a technical advisory committee and an agency work group to assist in identifying appropriate nutrient standards. FDEP has conducted a number of workshops and meetings as well as several studies since 2002.

In 2008, several environmental groups filed suit against EPA in Federal Court alleging that EPA had determined in 1998 that Florida's current narrative nutrient standard did not comply with the Clean Water Act and that EPA had not established numeric nutrient standards pursuant to Section 303(c)(4)(B) of the Clean Water Act. As a consequence of this lawsuit, EPA sent FDEP a letter on January 14, 2009 finding that FDEP's narrative nutrient standard did not comply with the Clean Water Act and directing the State of Florida to develop its own numeric nutrient standards for rivers and lakes by January 2010 and estuarine and coastal waters by January 2011 or EPA would adopt its own nutrient standards. In August 2009, these groups and EPA agreed to a Consent Decree formally establishing these deadlines and EPA would be responsible for establishing these criteria.

Management of the SBEP Area

The SBEP published their Comprehensive Conservation and Management Plan (CCMP) in 1995 (SBEP, 1995). One of the primary goals of the SBEP is to maintain and/or restore seagrass coverage to its historic extent. The seagrass target project provides technically-defensible quantitative seagrass targets for the SBEP ecosystem. Establishment of seagrass targets provides a necessary basis for management decisions regarding water quality and other issues that can influence the distribution and persistence of this resource. The target of 9,997 acres for the entire SBEP area was defined through an analysis of historic and recent aerial surveys. In establishing and addressing this goal, a conceptual paradigm was developed to identify the primary, manageable factors thought to influence the recovery and sustainability of seagrass resources within the bay. Reduced water clarity as a result of excessive nitrogen loads to the bay and resulting light attenuation by phytoplankton responding to these loadings were the key water quality indicators by which seagrass recovery could be managed.

The Southwest Florida Water Management District recently reported on the seagrass acreage in the SBEP area from its survey conducted in 2010. The results from this survey show an increase of approximately 50 acres since the 2008 survey (Figure 1). During the last two surveys, seagrass coverage has surpassed the target established for the area (9,997 acres) by more than 25%, with 12,646 acres in 2008 and 12,696 acres in 2010.

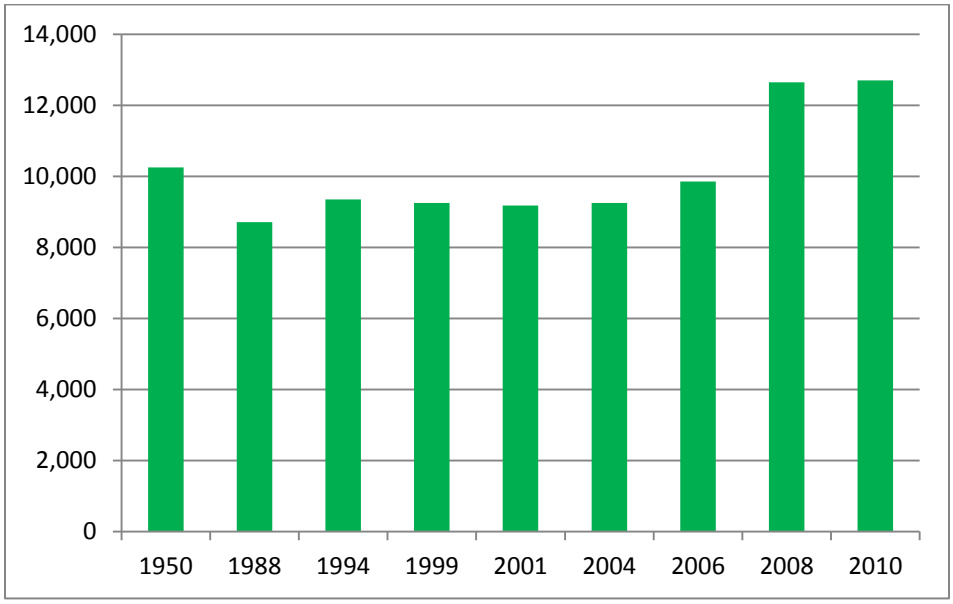


Figure 1. SBEP seagrass coverage (acres).

In line with the goal of restoring and protecting seagrass populations, the SBEP had a goal of improving water clarity (e.g., by reducing algal abundance). Recent results from ambient water quality monitoring programs indicate that the chlorophyll *a* concentrations have declined in all segments for the period 1998 to 2009. Further analysis of the chlorophyll concentration data using non-parametric trend tests (Kendall-Tau) revealed significant decreasing trends in chlorophyll in all segments except Roberts Bay (Figure 2). This finding, in conjunction with the increased seagrass acreage, provide strong evidence that the management efforts of the SBEP are bearing fruit with improved water quality and increased seagrass abundance.

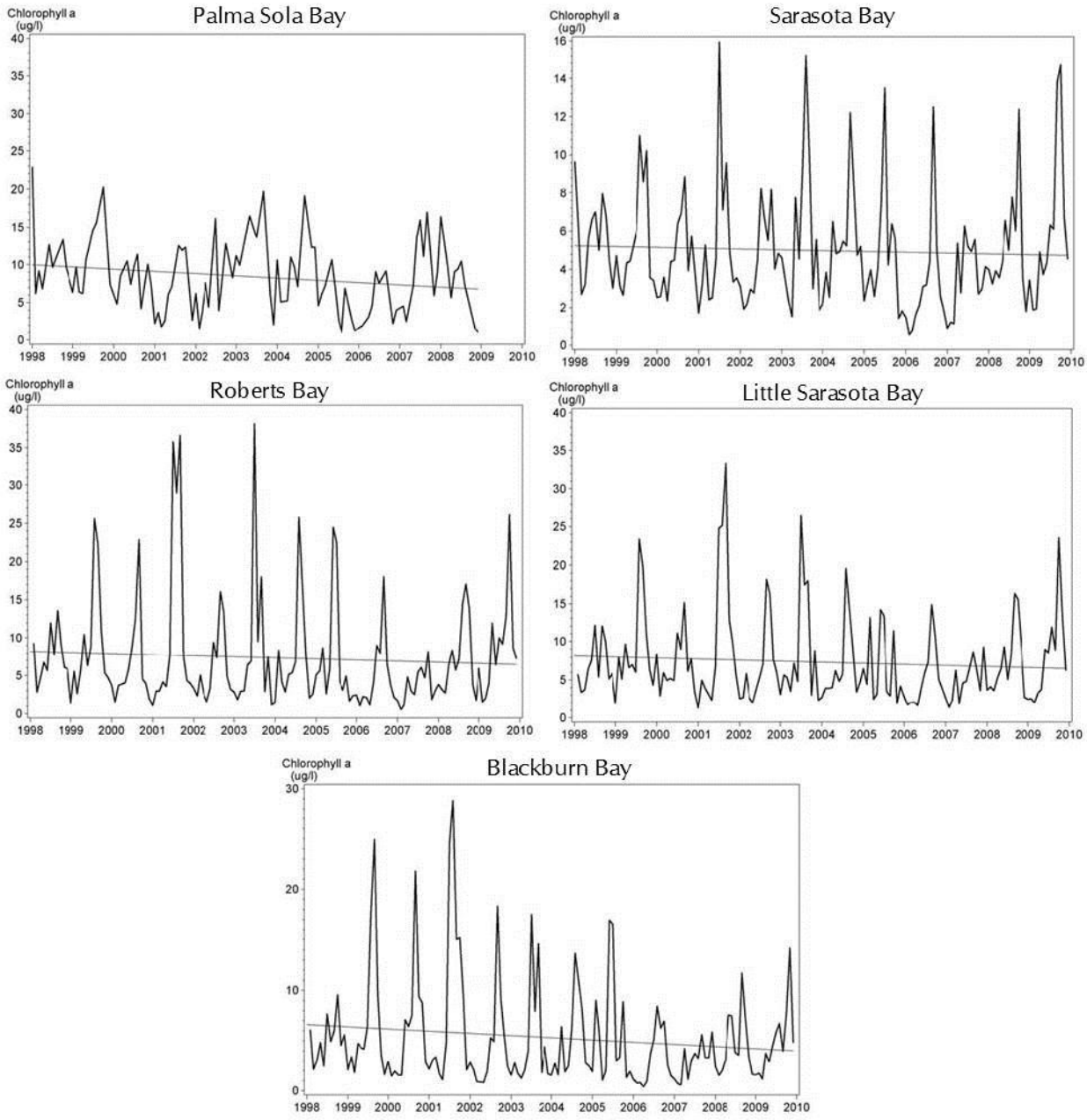


Figure 2. Sarasota Bay monthly chlorophyll *a* concentrations.

Recommendation for SBEP Numeric Nutrient Criteria

In October 2009, the SBEP Policy and Management boards directed the Technical Advisory Committee (TAC) to develop numeric nutrient criteria for the estuarine waters of the SBEP system. A water quality subcommittee of the TAC began the NNC development process by reviewing existing seagrass and chlorophyll *a* data and proposing a set of chlorophyll *a* targets to support the development of the NNC. This review confirmed that the recent extents of seagrasses are meeting the established targets; the subcommittee thus determined that the recent chlorophyll *a* concentrations and resultant water clarity must be protective of the seagrasses in each of the segments. Segment-specific chlorophyll a targets and thresholds were identified. Empirical methods were then used to develop TN concentrations that correspond to the chlorophyll thresholds (Janicki Environmental, 2010a). The TN concentration criteria are:

- Palma Sola Bay TN = 0.93 mg/L
- Sarasota Bay TN = 0.28 - 1.34 mg/L
- Roberts Bay TN = 0.54 mg/L
- Little Sarasota Bay TN = 0.60 mg/L
- Blackburn Bay TN = 0.43 mg/L

Continuing TBEP Input to EPA Regarding Numeric Nutrient Criteria

The SBEP, in cooperation with the Tampa Bay Estuary Program and Charlotte Harbor National Estuary Program, supported the development of a document that identified the potential methods for the estimation of numeric nutrient criteria for southwest Florida estuaries (Janicki Environmental. 2010b). This document identified several methods currently being considered by both EPA (2010) and FDEP (2010) to establish numeric nutrient criteria for Florida estuarine waters.

In addition to the methods document, the SBEP has addressed several other issues associated with the establishment of numeric nutrient criteria for the SBEP area. These include:

- Expression of recommended TP criteria as concentrations.
- Expression of recommended TN and TP criteria as loads.
- Demonstration that the proposed criteria provide full aquatic life support, especially achievement of dissolved oxygen (DO) standards.
- Establishment of downstream protective values (DPVs) for terminal reaches that drain directly into the segments of the SBEP area.
- Consideration of the influence of infrequent non-anthropogenic events, such as hurricanes and El Niño conditions, on implementation of the proposed criteria.

The following summarizes the SBEP recommendations regarding these issues.

- **Concentration-based TP Criteria**

EPA has noted its intention to develop numeric criteria for estuarine TP concentrations as well. Establishment of numeric nutrient criteria is dependent on an understanding of the limiting nutrient within the water body of concern. For Sarasota Bay, extensive data exist for evaluation of which

nutrient, nitrogen or phosphorus, is limiting. Ambient water quality data strongly indicate that four of the SBEP segments are nitrogen limited while a fifth (Palma Sola Bay) displays some degree of co-limitation.

The relationships between segment TN concentrations and segment TP concentrations are not evident within any bay segment, and thus cannot be used to translate established TN concentration criteria to TP concentration criteria. The relationships between chlorophyll *a* concentrations and segment TP concentrations are not sufficient to derive TP concentration criteria based on established chlorophyll *a* thresholds. The Reference Period (2001-2005) approach provides an internally consistent method for establishing concentration-based TP criteria (Janicki Environmental, 2010c). The following are the proposed numeric TP concentration criteria for the respective SBEP bay segments:

- Palma Sola Bay TP = 0.26 mg/L
- Sarasota Bay TP = 0.19 mg/L
- Roberts Bay TP = 0.23 mg/L
- Little Sarasota Bay TP = 0.21 mg/L
- Blackburn Bay TP = 0.21 mg/L

- **Loading-based TN and TP Criteria**

EPA has expressed a desire to have nutrient criteria developed in terms of concentrations and loadings. Regarding SBEP monthly loadings data, relationships between either TN or TP loadings and chlorophyll *a* concentrations do not explain a significant proportion of the variability in the chlorophyll *a* concentrations to support development of loading-based numeric nutrient criteria based on these relationships in any bay segment. Similarly, the relationships between TN and TP loadings and in-bay TN and TP concentrations do not provide a defensible approach for establishing loading-based numeric nutrient criteria in any bay segment. Given this, the Reference Period (2001-2005) provides the most defensible method to define loading-based numeric nutrient criteria for the SBEP segments (Janicki Environmental, 2010c). The following are the proposed TN and TP loading-based criteria for the respective SBEP bay segments:

- Palma Sola Bay TN = 41.3 tons/year TP = 7.1 tons/year
- Sarasota Bay TN = 211.8 tons/year TP = 31.5 tons/year
- Roberts Bay TN = 213.3 tons/year TP = 42.4 tons/year
- Little Sarasota Bay TN = 40.8 tons/year TP = 7.4 tons/year
- Blackburn Bay TN = 55.4 tons/year TP = 9.3 tons/year

- **Aquatic Life Support - Dissolved Oxygen**

The numeric nutrient criteria eventually promulgated will need to provide full aquatic life support in each estuary. The aquatic life forms specifically influenced by excessive nutrients in estuaries include seagrasses (affected by reduced water clarity due to excessive chlorophyll *a* concentrations) and fish and benthic communities (affected by reduced DO conditions). Seagrass support is provided by maintenance of appropriate nutrient conditions and the resulting chlorophyll *a*

concentrations as discussed above. Support of fish and benthic communities is provided by maintenance of appropriate nutrient conditions and the resulting DO conditions.

The spatial and temporal distributions of DO concentrations in the SBEP segments have been characterized, the principal drivers of DO conditions in SBEP segments have been investigated, and the relevance of the empirical distribution of DO concentrations to the FDEP's Impaired Water Rule standard for DO have been evaluated with respect to the proposed numeric nutrient criteria for the Sarasota Bay Estuary Program area (Janicki Environmental, 2010d). The following conclusions can be drawn from these efforts:

- Based on an assessment similar to FDEP's Impaired Waters Rule, the empirical evidence presented here suggests that all major segments of Sarasota Bay are meeting full aquatic life uses with respect to DO.

- The most obvious principal factor affecting DO in Sarasota Bay is temperature. That is evident in both the descriptive temporal plots and in the generalized linear model assessed in the quantitative assessment of those factors affecting the probability of DO being less than 4 mg/L. The model results indicate that stratification, bottom type, and sample depth were other factors that contributed to the probability of low DO conditions (i.e., < 4 mg/L). Furthermore, it was determined that chlorophyll *a* concentrations were not a significant factor contributing to probability of low DO conditions in Sarasota Bay. In other words, the occurrence of DO values below 4 mg/L were not significantly related to observed chlorophyll *a* concentrations at the time of sampling.

- Based on the weight-of-evidence presented here, it is reasonable to conclude that the numeric nutrient criteria proposed by the Sarasota Bay Estuary Program are protective of full aquatic life uses with respect to DO.

- **Downstream Protection Values**

Downstream Protection Values (DPVs) are defined by EPA as those water quality criteria in flowing waters that ensure protection of designated uses in the downstream estuarine waters as required by the Clean Water Act under 40 CFR 131.10(b). Though EPA has decided to delay promulgation of DPVs until 2011, DPVs will be required for all tributaries that flow into the segments of the SBEP area.

Given that the water quality within the tributaries must be protective of the downstream estuarine waters, a stressor-response relationship that links tributary water quality to a downstream endpoint would be a defensible approach to defining a DPV. Sufficient water quality data do not exist for some of the terminal reaches in the SBEP system, making it impossible to develop defensible criteria using stressor-response relationships. Therefore, an alternative approach for defining DPVs for the SBEP terminal reaches is necessary.

The approach EPA is considering for the development of DPVs is based on protective TN and TP loads (EPA, 2010; Hagy, 2010). These DPVs are expressed as concentrations from the terminal reaches, or "pour point" concentrations, that are protective of the designated uses in the downstream estuarine receiving waters. For the terminal reaches of tributaries that drain to a bay segment, the protective loads, expressed as annual loads, are divided by the average flow entering

the estuary to arrive at nutrient criteria (DPVs) for TN and TP concentrations in the tributaries that discharge into the estuary.

EPA's proposed approach may have some shortcomings (Janicki Environmental, 2010e). In cases where multiple tributaries deliver loads to the estuarine waterbody, this approach assumes that all terminal reaches would have the same DPV. Clearly, factors other than anthropogenic factors can influence nutrient concentrations in stream channels. The result could be that while the downstream waterbody is meeting its criterion, an exceedance could still manifest in one or more terminal reaches. The segment-specific proposed TN and TP DPVs for the tributaries of the SBEP area based on the Protective Load approach are:

- Palma Sola Bay TN = 1.42 mg/L TP = 0.29 mg/L
- Sarasota Bay TN = 1.47 mg/L TP = 0.28 mg/L
- Roberts Bay TN = 1.38 mg/L TP = 0.28 mg/L
- Little Sarasota Bay TN = 1.31 mg/L TP = 0.27 mg/L
- Blackburn Bay TN = 1.42 mg/L TP = 0.24 mg/L

Given the issues with the protective load approach to DPV development, an alternative method was preferred. If water quality targets for the estuarine segments are being met, it logically follows that the water quality in the tributaries that drain to those segments is protective of the downstream estuarine segments. Therefore, as with the estuarine criteria developed for TP, the Reference Period (2001-2005) approach provides an internally consistent method for establishing concentration-based TN and TP DPVs (Janicki Environmental, 2010e). The tributary-specific proposed TN and TP DPVs for the tributaries of the SBEP area have been calculated for tributaries that have sufficient data. These proposed TN and TP DPVs based on the Reference Period approach are:

- Bowlees Creek TN = 1.45 mg/L TP = 0.32 mg/L
- Hudson Bayou TN = 0.89 mg/L TP = 0.75 mg/L
- Philippi Creek TN = 1.04 mg/L TP = 0.32 mg/L
- Matheny Creek TN = 1.17 mg/L TP = 0.41 mg/L
- Elligraw Bayou TN = 1.46 mg/L TP = 0.39 mg/L
- Clowers Creek TN = 1.24 mg/L TP = 0.35 mg/L
- Catfish Creek TN = 1.35 mg/L TP = 0.26 mg/L
- North Creek TN = 1.46 mg/L TP = 0.34 mg/L

- **Implementation**

SBEP has addressed two key issues identified by the EPA regarding successful implementation of the proposed numeric nutrient criteria in the SBEP area, namely the method to account for non-anthropogenic events, such as El Niño and hurricanes, and the allowable exceedance criteria (how often criteria may be exceeded before non-compliance is observed). Analyses were performed to direct input on these subjects (Janicki Environmental, 2010f), with the following conclusions:

- The annual response time to recover from the maximum monthly chlorophyll *a* concentration during a year is relatively short. Median annual response times are three

months or less in all segments, as are average annual response times. This indicates that the bay segments recover very quickly from normal loading events.

- The typical response times to unusual events, such as El Niño, are longer and, depending upon the timing of such events, can span over parts of two successive years.
- It is important to consider the effects of natural variability in establishing the compliance assessment scheme.
- Comparison of the two temporal assessment schemes, 1-in-3 years vs. 2-in-5 years, suggested that the 2-in-5 rule was less likely to result in a violation due solely to natural variability.

- **Recommendation for Consideration of Tidal Creeks as Unique Entities**

Questions have been raised as to whether the numeric nutrient criteria proposed for the estuary proper should apply to tidal creeks that drain to the estuary. Tidal creeks play an integral role in the ecological function of coastal estuaries (Janicki Environmental, 2010g). The treatment of tidal creeks in the implementation of the estuarine numeric nutrient criteria is, therefore, a significant issue. A thorough understanding of the ecological elements (e.g., faunal and floral species and communities), processes (e.g., primary productivity, nutrient cycling, secondary production), dynamics of tidal creeks (e.g., temporal fluctuations in dissolved oxygen) and function in exporting energy to estuarine and coastal ecotones is paramount to the establishment of ecologically appropriate nutrient criteria. Numeric nutrient criteria established for tidal creeks must consider the different ecological processes and functions that distinguish them from both from the freshwater systems upstream and the open estuary downstream. Only with careful consideration of these attributes can criteria be developed that will maintain the function of tidal creeks in support of the greater estuarine ecosystem.

Based on recent studies of nearby Tampa Bay tidal creeks have revealed compelling evidence that these systems represent unique ecotones within the greater Tampa Bay estuary. There is no reason to believe that this is not also the case for tidal creeks in Sarasota Bay. Tidal creeks play an integral role in the ecological function of coastal estuaries as sites of high primary and secondary production, nursery and refuge habitat for several species of economically important fish and decapods crustaceans, and foraging areas for large-bodied fishes, wading birds, and other piscivorous species. Higher nutrient concentrations in tidal creeks relative to the greater estuary may be required to support the higher levels of primary and secondary production in these systems.

Analysis of fish collections in tidal creeks suggests that fishes inhabiting tidal creeks appear to be very tolerant to the typical DO conditions found in these systems. Both fish abundance and species richness data indicate that fish communities are relatively invariant to DO levels between 2-10 mg/L. There are indications that at DO concentrations below 2 mg/L, both fish abundance and species richness decline. Species richness of fish and decapods crustaceans may be a more sensitive indicator of the aquatic-life support function of tidal creeks; however, these need further quantification to eliminate the possibility that seasonal recruitment patterns of estuarine-dependent fishes are not correlated with seasonal variation in DO concentrations due to temperature.

The most desirable approach to establish numeric nutrient criteria would be to develop stressor-response models. Stressor-response models require the identification of an indicator variable that can be used to evaluate the condition of the tidal creek. Moreover, stressor-response models

require identification of a threshold value above (or below) which the system would no longer fully support its designated use. Due to a current lack of data with which to develop stressor-response models for Sarasota Bay's tidal creeks, potential interim criteria based on chlorophyll a targets for the downstream estuary from the 2001-2005 reference period could provide preliminary numeric nutrient criteria for tidal creeks.

Numeric nutrient criteria established for tidal creeks must consider the different ecological processes and functions that distinguish them from both the freshwater systems upstream and the open estuary downstream. It is important that the established criteria for tidal creeks also account for the fact that these systems by nature are more variable than their upstream or downstream counterparts. This variability is in part what makes these systems so productive and also so difficult to generalize. Implementation of criteria for tidal creeks should rely heavily on quantifying the uncertainties in both the derivation of the criteria and in the evaluation of potential remediation effort associated with failure of the criteria. Only with careful consideration of these attributes can criteria be developed that will maintain the function of tidal creeks in support of the greater estuarine ecosystem.

- **Final Implementation and Assessment**

The goal of the estuarine numeric nutrient criteria is to provide full aquatic-life support within the estuary. Similar to the TBEP, the SBEP has determined that seagrasses are important indicators of desirable conditions in the bay and has defined the water-quality conditions (i.e., chlorophyll *a* concentrations) that allow for the maintenance and growth of seagrass beds in the SBEP area. Therefore, SBEP bases its compliance assessment on the comparison of both observed chlorophyll *a* concentrations and seagrass extent to the goals that have been established. As discussed above, this has proven to be a successful adaptive management approach for abating nutrient eutrophication in the SBEP area. If the estuarine segments are meeting their respective criteria, there is no need to implement DPVs.

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