Technical Support Document for U.S. EPA's Proposed Rule for Numeric Nutrient Criteria for Florida's Estuaries, Coastal Waters, and South Florida Inland Flowing Waters

Volume 1: Estuaries

November 30, 2012

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Disclaimer

This document supports the U.S. Environmental Protection Agency's (hereafter EPA or the Agency) numeric nutrient criteria proposed on November 30, 2012, pursuant to section 303(c)(4) of the Clean Water Act (CWA) (Title 40 of the *Code of Federal Regulations* [CFR] section 131.43). The information provided herein does not substitute for the CWA or EPA's regulations; nor is this document a regulation itself. Thus, this document cannot and does not impose any legally binding requirements on EPA, states, authorized tribes, the regulated community, or any other party, and might not apply to a particular situation or circumstance.

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Abbreviations and Acronyms

%	percent
°C	degrees Celsius
°F	degrees Fahrenheit
ADEM	Alabama Department of Environmental Management
BOD	biochemical oxygen demand
$CaCO_3$	calcium carbonate
CBOD	carbonaceous biochemical oxygen demand
CDOM	colored dissolved organic matter
CE-QUAL-ICM	three-dimensional eutrophication model
CFR	Code of Federal Regulations
cfs	cubic feet per second
chl-a	chlorophyll *a*
CWA	Clean Water Act
DIN	dissolved inorganic nitrogen
DO	dissolved oxygen
DON	dissolved organic nitrogen
DPVs	downstream protective values
DRP	dissolved reactive phosphorus
EFDC	Environmental Fluid Dynamics Code
EPA	United States Environmental Protection Agency
F.A.C.	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FDNR	Florida Department of Natural Resources
FFWCC	Florida Fish and Wildlife Conservation Commission
FWRI	Fish and Wildlife Research Institute
GAEPD	Georgia Environmental Protection Division
GIS	geographic information system
GLUT	Georgia Land Use TrendsGMFR geometric mean function regression
GSD	geometric standard deviation
GTMNERR	Guana-Tolomato-Matanzas National Estuarine Research Reserve
GTMP	Guana, Tolomato, Matanzas, Pellicer
HAB	harmful algal bloom
HUC12	12-digit hydrologic units
HUC8	8-digit hydrologic units
IWR	Impaired Waters Rule

K. brevis	*Karenia brevis*
K_d	light attenuation coefficient
lbs	pounds
LSPC	Loading Simulation Program in C++
m	meter
m^3/s	cubic meters per second
mg/L	milligrams per liter
mgd	million gallons per day
µg/L	micrograms per liter
µM	micromoles
µmhos	micromhos
NEP	National Estuary Program
NH_3	ammonia
NH_4	ammonium
NHD	National Hydrography Dataset
NO_2	nitrite
NO_3+NO_2	nitrate+nitrite
NO_3	nitrate
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NTU	nephelometric turbidity units
NWFWMD	Northwest Florida Water Management District
OFW	Outstanding Florida Water
PO_4	orthophosphate or phosphate
ppb	parts per billion
ppt	parts per thousand
PCU	platinum-cobalt unit
PLSM	Pollutant Load Simulation Model
PSU	practical salinity unit
RSY	reference segment year
S	normalized sensitivity coefficient
SAV	submerged aquatic vegetation
SBEP	Sarasota Bay Estuary Program
SFWMD	South Florida Water Management District
SJRWMD	St. Johns River Water Management District
SOD	sediment oxygen demand

SRP	soluble reactive phosphorus
SRWMD	Suwannee River Water Management District
SSAC	Site-Specific Alternative Criteria
STORET	STOrage and RETrieval of Water-Related Data
SWFWMD	Southwest Florida Water Management District
SWIM	Surface Water Improvement and Management
TAC	Technical Advisory Committee
TBEP	Tampa Bay Estuary Program
TBNMC	Tampa Bay Nitrogen Management Consortium
TDN	total dissolved nitrogen
TDP	total dissolved phosphorus
TKN	total Kjeldhal nitrogen
TMDL	total maximum daily load
TME	Tolomato–Matanzas Estuary
TN	total nitrogen
TP	total phosphorus
TSD	Technical Support Document
TSI	Trophic State Index
TSS	total suspended solids
U.S.	United States
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WASP7	Water Quality Analysis Simulation Program Version 7.3
WBID	water body identification number
WSE	water surface elevation
WWTF	wastewater treatment facility
WWTP	wastewater treatment plant
Z_c	depth of colonization

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SJRWMD. 2011. *27010037 (Halifax River): Basin Characterization*. St. Johns River Water Management District. http://www.sjrwmd.com/watershedfacts/factPages/27010037.html. Accessed June 2011.

Steward, J.S., and E.F. Lowe. 2010. General empirical models for estimating nutrient load limits for Florida's estuaries and inland waters. Limnology and Oceanography 55(1):433–445.

Steward, J.S., W.C. Green, and J.D. Miller. 2010. *Using multiple lines of evidence for developing numeric nutrient criteria for Halifax River Estuary*. St. Johns River Water Management District. Palatka, FL.

US Census Bureau. 2012. *2010 Census Interactive Population Search: Daytona Beach City, Port Orange City, Ormond Beach City, and New Smyrna Beach City, Florida*. U.S. Census Bureau. http://2010.census.gov/2010census/popmap/ipmtext.php. Accessed May 2012.

USGS. 1985. *Ground-water Hydrology of Volusia County, Florida, with Emphasis on Occurance and Movement of Brackish Water*. ed. R. T. Rutledge. Water-Resources Investigations Report 84-4206. U.S. Geological Survey. http://fl.water.usgs.gov/PDF_files/wri84_4206_rutledge.pdf. Accessed July 2011.

USGS. 2010. *Seasonal and Spatial Distribution Patterns of Finfish and Selected Invertebrates in Coastal Lagoons of Northeastern Florida, 2002-2004*. ed. M. Turtora and E. M. Schotman. Scientific Investigations Report 2010-5131. U.S. Geological Survey. http://pubs.usgs.gov/sir/2010/5131/pdf/SIR2010-5131.pdf. Accessed July 2011.

Volusia County. 2011. *Volusia County Weather*. http://www.volusia.org/weather.htm. Volusia County, FL. Accessed June 2011.

2.20. Guana, Tolomato, Matanzas, Pellicer System

2.20.1. Proposed Numeric Nutrient Criteria

Proposed numeric nutrient criteria for TN, TP, and chl-a in Guana, Tolomato, Matanzas, and Pellicer (GTMP)[90] River Estuary segments are summarized in Table 2-152.

Table 2-152. Proposed numeric nutrient criteria for GTMP River Estuary segments

Segment Name	Segment Number	TN (mg/L)	TP (mg/L)	Chl-a (µg/L)
Tolomato River	1701	0.77	0.144	9.5
Matanzas River	1702	0.53	0.108	6.1

[90] The Guana, Tolomato, Matanzas, and Pellicer River Estuary is also called GTM Estuary.

2.20.2. General Characteristics

2.20.2.1. System Description

The GTMP River Estuary is on the northeast coast of Florida near St. Augustine in St. Johns and Flagler counties (Haydt and Frazel 2003). [91] The GTMP Estuary is a long, narrow, marshy, tidal lagoon between mainland Florida and barrier beaches to the east. The GTMP Estuary connects through the Intracoastal Waterway to the St. Johns River Estuary to the north and the Halifax River Estuary to the south and directly to the Atlantic Ocean via two inlets—the St. Augustine Inlet to the north and the Matanzas Inlet to the south (FDEP 2008). The GTMP Estuary is a shallow estuary approximately 50 mi (80 km) long and has an average width of 0.5 mi (0.8 km) in St. Johns County and 0.2 mi (0.3 km) in Flagler County. The GTMP watershed area (395 mi^2 [1,023 km^2]) to estuary area (17 mi^2 [44 km^2]) ratio is approximately 23-to-1, indicative of a potentially large volume of runoff to a proportionally small receiving estuarine system (Steward et al. 2010a).

A large portion of the GTMP Estuary is within the boundaries of the Guana-Tolomato-Matanzas National Estuarine Research Reserve (GTMNERR). The reserve covers an area approximately 101 mi^2 (261 km^2), including salt marsh and tidal wetlands, estuarine lagoons, upland habitat, and offshore seas (FDEP 2009; Frazel 2009).

The GTMP Estuary has undergone significant hydromodification. In 1961 the Guana Dam was built along with a series of smaller canals and dams for improved fishing and hunting. In addition, the Intracoastal Waterway was constructed through the Northern Coastal Basin, connecting many of those estuaries through canals, and requiring continual maintenance with dredging to keep channels clear. Other hydromodifications have included mosquito ditching, dikes, wells, drainage ditches, and land clearing (FDEP 2008; Frazel 2009).

The GTMNERR watershed is characterized by a humid, subtropical, marine climate with heavy rainfall in the summers and mild, dry winters (Frazel 2009). Whereas prevailing winds are easterly, winds from all directions are fairly common. Periodic thunderstorms, northeasters, tropical storms, and hurricanes occur in the GTMP Estuary. In 2004 three tropical storms passed through the area causing extensive beach erosion in St. Augustine (Frazel 2009).

Despite significant population growth, the watershed remains largely undeveloped with around 80 percent of the overall area in forests, wetlands, or surface water in 2000 (SJRWMD 2011b). Urban and residential development is most prevalent in the north Matanzas watershed around St. Augustine (28.1%) (Steward et al. 2010a). The population is centered along the coast and surrounding waterways, with the largest communities bordering the GTMP Estuary (US Census Bureau 2012).

Two ocean inlets, the St. Augustine and Matanzas, and the Intracoastal Waterway connections to the north and south provide tidal flushing and create three tidal nodes in the GTMP Estuary where net flow is zero (Steward et al. 2010a). Both inlets allow substantial tidal exchange, with

[91] The information presented in this system description was compiled to summarize local information pertaining to the proposed numeric nutrient criteria for this estuary. For more information on EPA's process of delineating, segmenting, and deriving numeric nutrient criteria for this estuary, please see Section 1.3.

an average tidal amplitude of around 4.10 ft (1.25 m) (Frazel 2009; Steward et al. 2010a). Closer to the tidal nodes, the tidal amplitude decreases greatly (Haydt and Frazel 2003).

Research in the GTMP Estuary has shown that water residence time is useful in explaining nutrient concentration spatial variations and phytoplankton populations (Phlips et al. 2004; Sheng et al. 2008). Phlips et al. (2004) and Sheng et al. (2008) estimated residence times or residence time indices for each estuary segment. As noted in both studies, tidal flushing is the primary mode of water exchange in the Halifax River Estuary and GTMP Estuary; the flushing time for segments is faster closer to the inlets, and residence time is shorter.

2.20.2.2. Impaired Waters[92]

Nine Class II and Class III marine WBIDs in the GTMP Estuary have been listed for a nutrient-related parameter on Florida's CWA section 303(d) list approved by EPA. Of the nine WBIDs, five are Class II WBIDs, and four are Class III marine WBIDs. Of the five Class II WBIDs, three are impaired for DO (WBIDs 2363F, 2363I, and 2451), one is impaired for nutrients and chl-a (WBID 2320F), and one is impaired for nutrients, chl-a, and DO (WBID 2320). Of the four Class III marine WBIDs, three are impaired for DO (WBIDs 2363H, 2400, and 2491), and one is impaired for nutrients, chl-a, and DO (WBID 2320A).[93] No Class II or Class III marine WBIDs with nutrient-related TMDLs are documented for this region.[94]

The GTMP Estuary was designated a priority water under the SWIM Act. In 2003 a SWIM plan was completed, which created a framework for projects to be completed to reduce point and nonpoint source nutrient contributions (Haydt and Frazel 2003).

2.20.2.3. Water Quality

Nonpoint sources have been estimated to contribute approximately 68 percent of the overall nutrient loading, followed by wastewater treatment dischargers, which contribute 27 percent (Steward et al. 2010a). Septic tanks are also prevalent in some areas of the GTMP Estuary and have been identified as a potential source of nutrients to surface waters (FDEP 2008; SJRWMD 2000b).

Median DO readings at SJRWMD sites at Tolomato River and Pellicer Creek were 6.0 and 4.2 mg/L, respectively, between 1996 and 2011. Median DO levels in the upper and lower Matanzas River are both approximately 6.5 mg/L (SJRWMD 2011a). The extent to which DO concentrations in the GTMP Estuary are influenced by anthropogenic nutrient inputs,

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[92] For more information about the data source, see Volume 1, Appendix A.

[93] The nutrient-related 303(d) list was a compilation of EPA-approved 303(d) listing information for nutrients, chl-a, and DO provided in three decision documents: September 2, 2009, Basin Groups 1, 2, and 5 EPA Decision Document (http://www.epa.gov/region4/water/tmdl/florida/documents/fl09303d_decisiondoc_090209.pdf);
May 13, 2010, Basin Group 3 EPA Decision Document
(http://www.epa.gov/region4/water/tmdl/florida/documents/fl303d_%20partialapproval_decision_docs051410.pdf);
and the December 21, 2010, Basin Group 4 EPA Decision Document
(http://www.epa.gov/region4/water/tmdl/florida/documents/group_4_final_dec_doc_and_partial_app_letter_12_21_10.pdf).

[94] TMDLs were identified in February 2011 by compiling nutrient-related draft/final TMDLs from the following three sources:
FDEP TMDL website (http://www.dep.state.fl.us/water/tmdl/index.htm)
EPA Region 4 website (http://www.epa.gov/region4/water/tmdl/florida/index.html)
EPA National WATERS expert query tool (http://www.epa.gov/waters/tmdl/expert_query.html).

biochemical oxygen demand (BOD) inputs, and import of low-DO water from freshwater streams has not been determined (FDEP 2008).

Phlips et al. (2004) reported mean chl-a concentrations at four sampling locations in the GTMNERR from monthly samples taken May 2002 through August 2003. Overall, chl-a concentrations were lower for GTMP sites than for other sites sampled in estuaries farther north on Florida's Atlantic Coast. Among the four sites studied by Phlips et al. (2004), mean chl-a concentrations were lowest at the San Sebastian and Fort Matanzas sites. Chl-a concentrations at all sites were generally elevated during summer months, associated with increased temperature, increased nutrient loading (wet season), or a combination of the two (Phlips et al. 2004). Median and mean chl-a concentrations measured in North Matanzas, South Matanzas, and Tolomato were low (maximum wet season medians of 4.0–6.4 µg/L), and few samples exceeded 12 µg/L (Steward et al. 2010a).

Steward et al. (2010a) also report turbidity ranges for water quality monitoring locations along the GTMP Estuary from 1986–2009. The Tolomato region had the highest median value (9.4 NTU) compared to the North Matanzas (7.5 NTU) and South Matanzas (7.8 NTU) regions, but the differences were within confidence intervals. Wet-season turbidity was higher than dry-season turbidity at all stations, with seasonal differences in the 1–4 NTU range. The highest turbidities (both wet and dry season) occurred at sampling locations with little or no tidal influence (the southernmost sampling point in the Intracoastal Waterway). High turbidity throughout the GTMP Estuary is consistent with other estuaries along the south Atlantic Coast with limited tidal connections (Steward et al. 2010a).

There were statistically significant increasing trends in TP and chl-a concentrations over a 23-year period (1986–2009) in the GTMP Estuary. The early portion of the time series coincided with several drought years, during which concentrations would have been lower because of reduced nutrient inputs. Long-term median and mean TP concentrations were 0.072–0.084 and 0.087–0.10 mg/L, respectively. For the same period, TN concentrations were similar throughout the estuary, with the exception of the southernmost station where the TN concentrations were significantly higher. The long-term median and mean TN concentrations in the GTMP Estuary were 0.41–0.53 and 0.43–0.58 mg/L, respectively (Steward et al. 2010a).

2.20.2.4. Biological Characteristics

The GTMP Estuary is primarily characterized by tidal salt marshes and oyster reefs (Dame et al. 2000; Sargent et al. 1995; Steward et al. 2010a). Wetlands compose about one-third of the overall area of the GTMP Estuary watershed (Steward et al. 2010a). Salt marshes are the predominant wetland community and make up about 20 percent of the overall land cover of the GTMNERR (Frazel 2009). SAV is largely absent, as it is in much of northeastern coastal Florida, from lack of suitable habitat and elevated turbidity (Dame et al. 2000; Sargent et al. 1995; Steward et al. 2010a).

Documented impacts on shoreline vegetation in the GTMP Estuary have been linked to factors other than anthropogenic nutrient loading. Shoreline erosion and resultant loss of shoreline habitat occurs at relatively high rates in many places along the Intracoastal Waterway, which runs through GTMNERR (Price 2005).

Oyster populations occur along the full length of the GTMNERR. As of 2009, two delineated shellfish harvest areas in the GTMNERR allowed limited recreational oyster and hard clam harvesting. In addition, four active aquaculture leases for oysters and two leases for hard clams exist (Frazel 2009). Inclusion in the GTMNERR and other reserves has likely helped preserve these oyster reefs (Steward et al. 2010b).

Phytoplankton abundance in the GTMP is primarily regulated by a balance between water residence time and nutrient loading, with water residence time determined by multiple factors including proximity to inlets, freshwater inputs, and vertical mixing (Phlips et al. 2004). In the 2002–2003 study conducted by Phlips et al. (2004), the authors attribute low chl-a concentrations (as a surrogate measure for phytoplankton crop) in the vicinity of the GTMP Estuary to its close proximity to tidal inlets and lower residence time.

Frazel (2009) reported that little research has been done on plankton communities in the GTMNERR, but that there are periodic blooms of *K. brevis* (a ride tide organism) on Florida's east coast. A *K. brevis* bloom occurred in GTMNERR waters in October 2007 (Frazel 2009). Abbott et al. (2009) classified the GTMP Estuary and associated coastal waters as affected by toxins associated with HABs, including neurotoxic shellfish poisoning. Blooms can arise from either chronic or episodic nutrient loading (Heisler et al. 2008).

A study conducted for the SJRWMD in 2000 included five benthic macroinvertebrate sampling sites in the GTMP Estuary. While the coverage was limited, all five sites had moderate to high species diversity scores (Shannon-Weiner Diversity Index).[95] The three southern sites exhibited species compositions that were dominated by pollution-tolerant species, indicating the possible presence of pollutants in Moultrie Creek, Pellicer Creek, and the South Matanzas River. The two sites in the northern areas on the North Matanzas River and the Tolomato River had low-tolerant taxa dominance (SJRWMD 2000a).

Research has identified 303 fish species in the GTMNERR. A number of commercially important species are in the estuary, as are many recreationally valuable sport fish (Frazel 2009). Twenty-five accounts of fish kills resulting from algae or red tide were reported from 2000 to 2010 in Flagler and St. Johns counties, some of which were not in the GTMP Estuary. Overall, 68 percent of those reports were the result of a red tide event in 2007 that was documented to have drifted into the GTMP Estuary from further north up the Atlantic Coast (FFWCC 2011; Frazel 2009).

For a more detailed summary of this water body, see Volume 1, Appendix A.

[95] Shannon-Weiner Species Diversity Index is "a calculated index value expressing the degree of species diversity in a given sample or group of samples. The calculation is influenced by both the number of species present as well as the evenness of abundance among the species. Values generally range from 0 to 5, with values at the high range indicating high species diversity" (SJRWMD 2000a).

2.20.3. Data Used

Several data sources specific to the GTMP System were used in addition to those sources described in Section 1.4.3, as summarized in Table 2-153.

Table 2-153. Data sources specific to GTMP System models

Data	Source	Location Used
Hydrologic group soils data	St. Johns River Water Management District (SJRWMD 2011c)	Daytona watershed model
FDEP Level III Florida Land Use	St. Johns River Water Management District (SJRWMD 2006)	Daytona watershed model

2.20.4. Segmentation

The GTMP system was divided on the basis of its geomorphological structure and the different river systems feeding into it. Figure 2-57 shows the resulting two segments for the GTMP Estuary system.

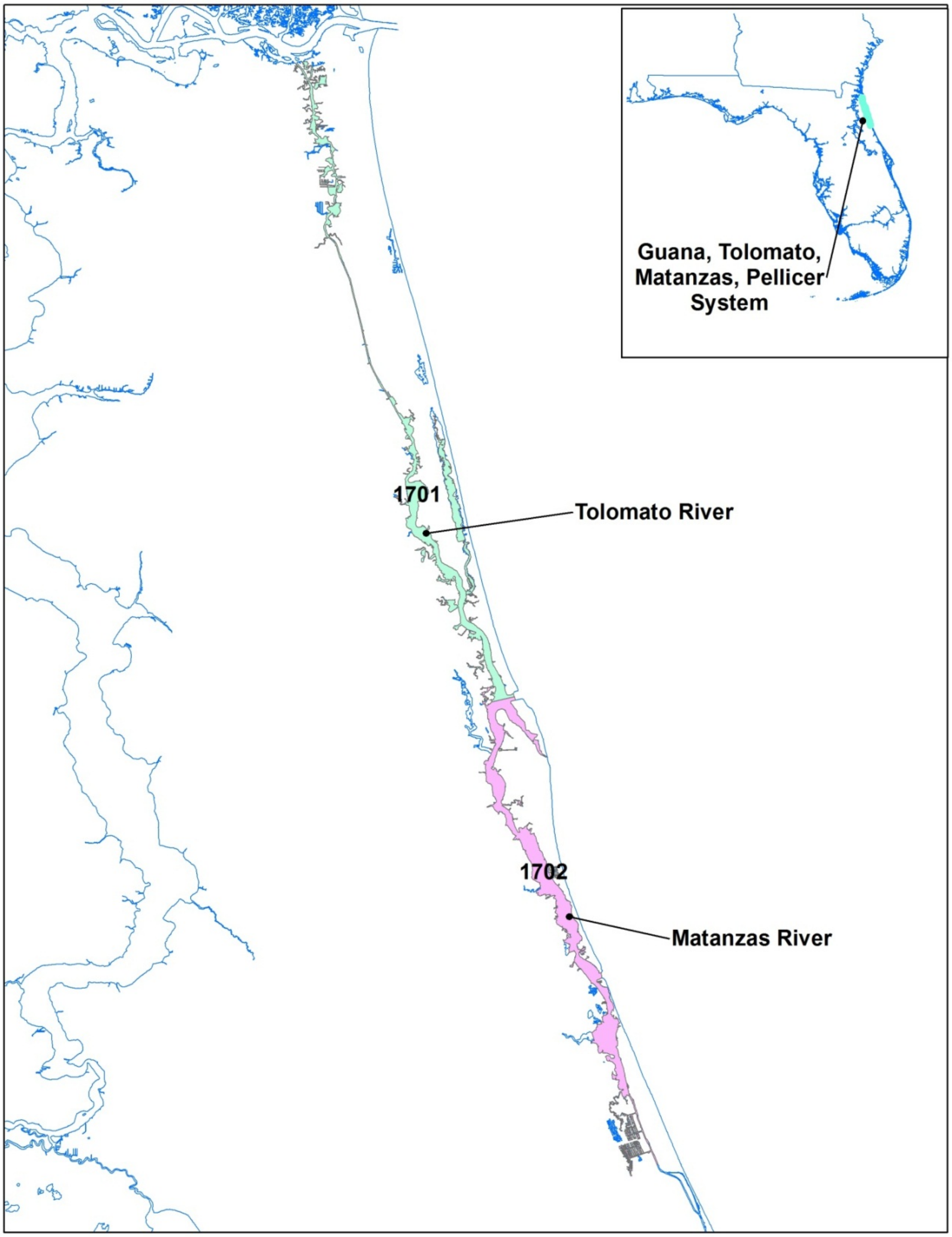

Figure 2-57. Results of GTMP Estuary segmentation

2.20.5. Water Quality Targets

2.20.5.1. Seagrass Depth and Water Clarity Targets

Seagrass is not historically present in the GTMP Estuary.

2.20.5.2. Chlorophyll a Target

To prevent nuisance algal blooms and protect the estuary's designated uses, chl-a levels must not exceed 20 µg/L more than 10 percent of the time. The rationale for that target is provided in Section 1.2.2.

2.20.5.3. Dissolved Oxygen Targets

On the basis of the rationale that sufficient DO is necessary to protect aquatic life, as described in Section 1.2.3, the following DO targets were established:

- Minimum allowable DO of 4.0 mg/L as a water column average for each estuary segment 90 percent of the time over the simulation's time span
- Daily average DO of 5.0 mg/L as a water column average for each estuary segment 90 percent of the time over the simulation's time span
- Minimum 3-hour average DO of 1.5 mg/L in the bottom two layers for each estuary segment over the simulation's time span

2.20.6. Results of Analyses

2.20.6.1. Mechanistic Model Analysis

The GTMP system was not evaluated using mechanistic model analysis.

2.20.6.2. Statistical Model Analysis

Analysis of available empirical data indicated a strong relationship between the bloom frequency endpoint and annual geometric mean chl-a concentration (Figure 2-58). In both segments, the derived chl-a concentration was greater than the upper bound of the observed annual geometric mean, so chl-a criteria are based on this upper bound.

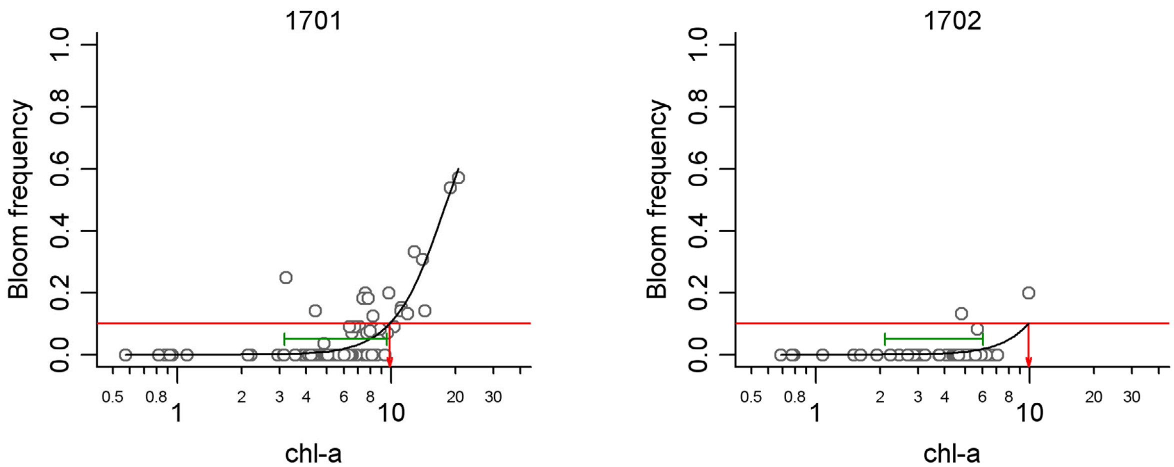

Figure 2-58. Estimates of annual geometric chl-a concentrations associated with bloom frequency of 0.1 in GTMP. Red horizontal line: bloom frequency of 0.1, red vertical arrow: annual geometric mean chl-a concentration associated with 0.1 bloom frequency, green line segment: 5th to 95th percentile range of observed data.

In general, chl-a concentrations increased with increasing concentrations of TN and TP. However, in segment 1702, a negative correlation between TN and chl-a was observed, suggesting that TN in this segment is primarily composed of recalcitrant forms (Figure 2-59). TN and TP concentrations that were associated with the candidate chl-a criterion were all greater than the upper bound of observed annual geometric means, and therefore, proposed criteria were based on the upper bound (Table 2-154). A TN criterion in segment 1702 was based on the dilution model described below.

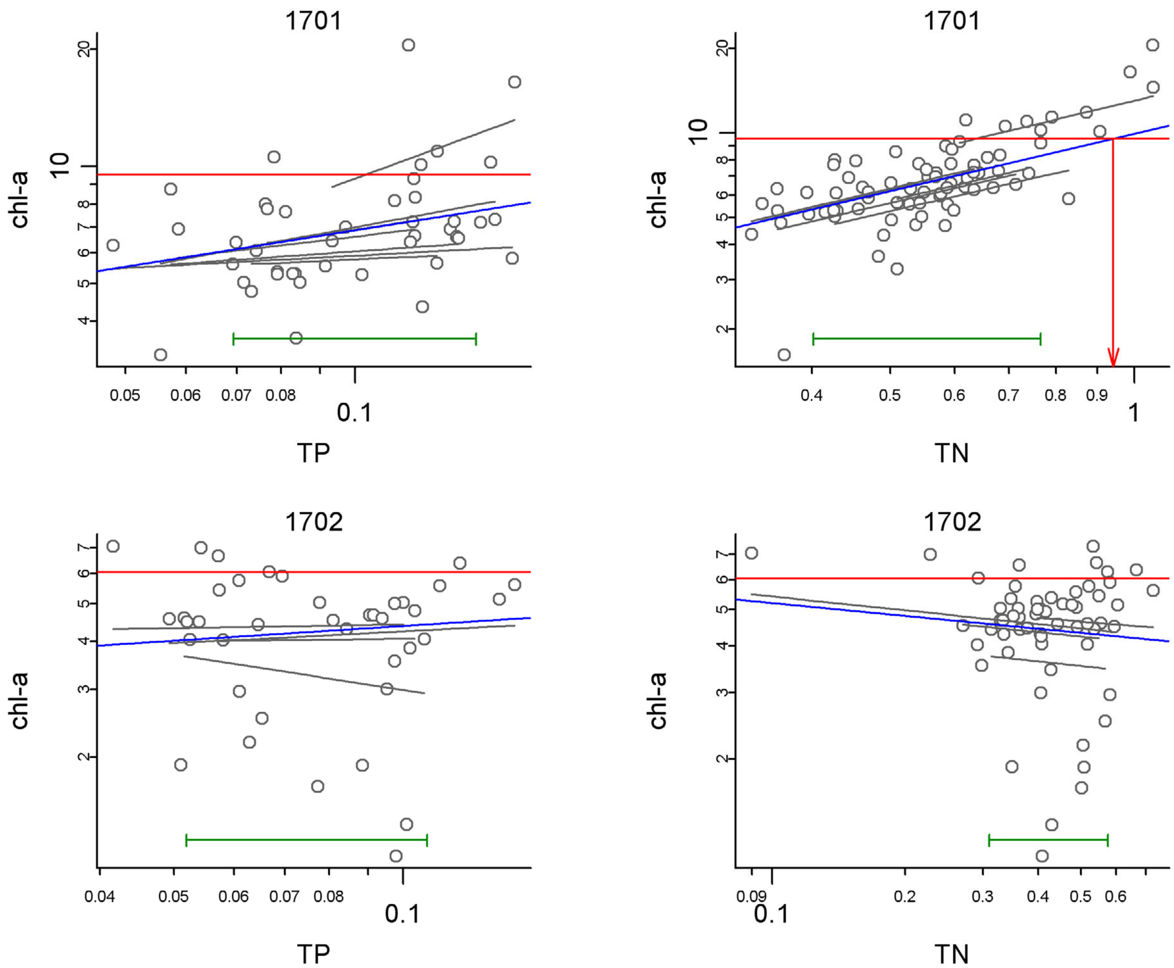

Figure 2-59. Relationships between TN, TP, and chl-a in GTMP. Open circles: observed annual average values of TN, TP, and chl-a, red horizontal line: chl-a criterion, red vertical arrow: TN and TP criteria associated with chl-a criterion, blue line: estimated segment-wide relationship between TN, TP, and chl-a, grey lines: estimated station-specific relationships between TN, TP, and chl-a, green line segment: 5th to 95th percentile range of observed annual geometric mean TN and TP concentrations.

Table 2-154. Summary of candidate criteria for GTMP. TN criterion for segment 1702 is based on dilution model. Asterisks indicate that criteria are based on the upper or lower bound of observed data.

Segment	TN (mg/L)	TP (mg/L)	Chl-a (µg/L)
1701	0.77*	0.144*	9.5*
1702	0.53	0.108*	6.1*

2.20.7. Application of Analyses for Proposed Numeric Nutrient Criteria

In GTMP data were sufficient to use statistical modeling analyses as the primary line of evidence when deriving criteria. Seagrass has not been historically present in GTMP, so EPA evaluated the following endpoint in the statistical modeling approach: chl-a concentrations associated with balanced phytoplankton biomass. Through evaluating the observed data, EPA found that, in some segments, the TN, TP, and chl-a concentrations associated with achieving the chl-a target were greater than the range of TN, TP, or chl-a concentrations observed in the available data for GTMP. For these segments, EPA is proposing to set numeric nutrient criteria derived from statistically modeled relationships at the upper bound of the distribution of available data instead of deriving criteria outside the range of data observations (see Volume 1, Appendix B). This approach defines criteria values that maintain balanced natural populations of aquatic flora and fauna within the limits of available data.

Proposed numeric nutrient criteria for TN, TP, and chl-a in GTMP segments are summarized in Table 2-155.

Table 2-155. Proposed and candidate numeric nutrient criteria for Guana, Tolomato, Matanzas, Pellicer segments

		Proposed Criteria			Statistical Modeling		
SEGMENT	SEGMENT ID	TN (mg/L)	TP (mg/L)	Chl-a (µg/L)	TN (mg/L)	TP (mg/L)	Chl-a (µg/L)
Tolomato River	1701	0.77	0.144	9.5	0.77	0.144	9.5
Matanzas River	1702	0.53	0.108	6.1	0.53	0.108	6.1

2.20.8. Downstream Protective Values

In GTMP mechanistic models were not available to derive DPVs for TN and TP. In lieu of the preferred approach, a mixing/dilution model was applied to calculate the allowable freshwater TN and TP load. This mixing/dilution model assumes that TN and TP loads in freshwater mix conservatively with saline seawater. Using this assumption, the model predicts freshwater concentrations necessary to achieve proposed nutrient criteria in each segment (Figure 2-60 and Figure 2-61). DPVs are tabulated in Table 2-156.

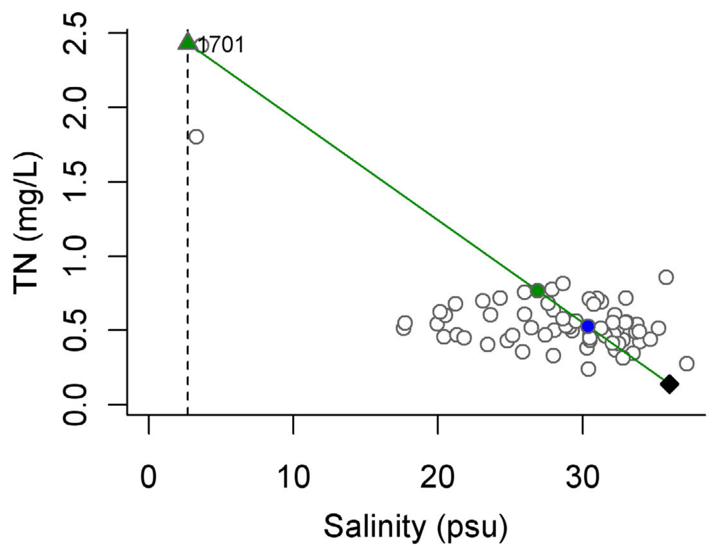

Figure 2-60. Calculation of TN DPVs for GTMP. Black diamond shows seawater conditions, filled green circles show proposed TN criteria values for each segment, and green triangles show calculated DPVs. Open circles show observed long-term station average TN concentrations and salinities. Filled blue circle shows TN criteria computed for segment 1702.

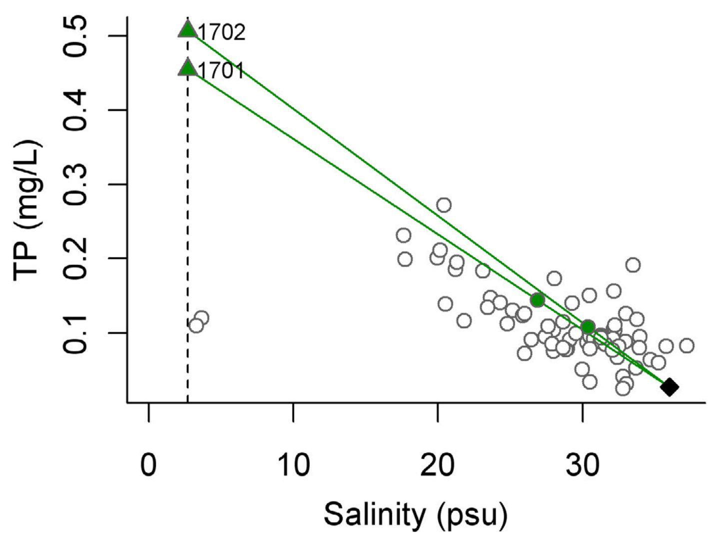

Figure 2-61. Calculation of TP DPVs for GTMP. Black diamond shows seawater conditions, filled green circles show proposed TP criteria values for each segment, and green triangles show calculated DPVs. Open circles show observed long-term station average TP concentrations and salinities.

Table 2-156. Proposed DPVs for TN and TP for GTMP

Segment	DPV (TP) (mg/L)	DPV (TN) (mg/L)
1701	0.455	2.43
1702	0.507	2.43

2.20.9. Alternate Analysis

2.20.9.1. Tolomato–Matanzas Estuary

SJRWMD submitted documents to EPA suggesting approaches to derive numeric criteria for the Tolomato–Matanzas Estuary (TME). A weight-of-evidence approach using several analytical techniques was proposed to derive numeric criteria (Table 2-157). The techniques included a reference period analysis, chl-a versus concentration of TN or TP regression analyses, and two general models (Dettmann 2001; Steward and Lowe 2010).

TN and TP loading, chl-a target concentrations, and TN and TP concentration criteria were based on an approach that analyzed water quality and estimated loading during a reference period from 2000 to 2009. The period of reference was selected on the basis of a desirable TSI score (< 50), rainfall amounts typical of average conditions, and completeness of the data record. Criteria magnitudes were proposed as an annual median or mean and a maximum wet-season (June–September) median or mean. The reference period approach results were supported by an additional line of evidence using regression analyses of chl-a versus TN and TP. Target chl-a values were based on the reference period analyses. The general nutrient models of Steward and Lowe (2010) and Dettmann (2001) were also used as an additional method by which to estimate loading limits and concentrations associated with those limits. Documentation of SJRWMD-proposed numeric nutrient criteria and methods for their derivation can be found in Volume 1, Appendix G.

Table 2-157. SJRWMD-proposed TME loading limits for TN, TP, and chl-a according to reference period results (adapted from Steward et al. 2010a)

Estuary Segment	Chl-a (µg/L) median (mean)	TN (mg/L) median (mean)	TP (mg/L) median (mean)
Tolomato	4.5 (5.3)	0.52 (0.56)	0.085 (0.096)
North Matanzas	3.1 (3.5)	0.37 (0.41)	0.073 (0.083)
South Matanzas	4.3 (5.0)	0.45 (0.49)	0.089 (0.103)

2.20.10. References

Abbott, G.M., J.H. Lansberg, A.R. Reich, K.A. Steidinger, S. Ketchen, and C. Blackmore. 2009. *Resource Guide for Public Health Response to Harmful Algal Blooms in Florida*. FWRI Technical Report TR-14. Florida Fish and Wildlife Conservation Commission. St. Petersburg, FL.

Dame, R., M. Alber, D. Allen, M. Mallin, C. Montague, A. Lewitus, A. Chalmers, R. Gardner, C. Gilman, B. Kjerfve, J. Pinckney, and N. Smith. 2000. Estuaries of the South Atlantic coast of North America: Their geographical signatures. *Estuaries* 23:793-819.

Dettmann, E.H. 2001. Effect of water residence time on annual export and denitrification of nitrogen in estuaries: A model analysis. *Estuaries* 24(4):481-490.

FDEP. 2008. *Water Quality Assessment Report: Upper East Coast*. Florida Department of Environmental Protection. http://tlhdwf2.dep.state.fl.us/basin411/uppereast/assessment/G5AS_Upper_East_Coast-LORES_Merged.pdf. Accessed June 2011.

FDEP. 2009. *Guana Tolomato Matanzas National Estuarine Research Reserve: Management Plan, July 2009-June 2014*. Florida Department of Environmental Protection, Coastal and Aquatic Managed Areas. Tallahassee, FL. http://www.dep.state.fl.us/coastal/sites/gtm/pub/GTM_Management_Plan_2009.pdf. Accessed July 2011.

FFWCC. 2011. *Fish Kill Database Search*. Florida Fish and Wildlife Conservation Commission. http://research.myfwc.com/fishkill/. Accessed June 2011.

Frazel, D.W. 2009. *Site Profile of the Guana Tolomato Matanzas National Estuarine Reserve*. Guana Tolomato Matanzas National Estuarine Research Reserve. Ponte Vedra, FL. http://www.dep.state.fl.us/coastal/sites/gtm/pub/GTM_Site_Profile.pdf. Accessed July 2011.

Haydt, P.J., and Frazel Inc. 2003. *Northern Coastal Basin Surface Water Improvement and Management Plan*. St. Johns River Water Management District. Palatka, FL. http://www.sjrwmd.com/SWIMplans/2003_NCB_SWIM_plan.pdf. Accessed September 2011.

Heisler, J., P.M. Glibert, J.M. Burkholder, D.M. Anderson, W. Cochlan, W.C. Dennison, Q. Dortch, C.J. Gobler, C.A. Heil, E. Humphries, A. Lewitus, R. Magnien, H.G. Marshall, K. Sellner, D.A. Stockwell, D.K. Stoecker, and M. Suddleson. 2008. Eutrophication and harmful algal blooms: A scientific consensus. *Harmful Algae* 8(1):3-13.

Phlips, E.J., N. Love, S. Badylak, P. Hansen, J. Lockwood, C.V. John, and R. Gleeson. 2004. A comparison of water quality and hydrodynamic characteristics of the Guana Tolomato Matanzas National Estuarine Research Reserve and the Indian River Lagoon of Florida. *Journal of Coastal Research* 45:93-109.

Price, F.D. 2005. *Quantification, Analysis, and Management of Intracoastal Waterway Channel Margin Erosion in the Guana Tolomato Matanzas National Estuarine Research Reserve*, Department of Urban and Regional Planning, Florida State University.

Sargent, F., T. Leary, D.W. Crewz, and C.R. Kruer. 1995. Scarring of Florida's seagrasses: assessment and management options. *Florida Marine Research Institute Technical Report* 1:43.

Sheng, Y.P., B. Tutak, J.R. Davis, and V. Paramygin. 2008. Circulation and flushing in the lagoonal system of the Guana Tolomato Matanzas National Estuarine Research Reserve (GTMNERR), Florida. *Journal of Coastal Research* 55:9-25.

SJRWMD. 2000a. *Benthic Macroinvertebrate Data from 148 Surface Water Sites Within the St. Johns River Water Management District*. Special Publication SJ2000-SP7. St. Johns River Water Management District. Palatka, FL. http://www.sjrwmd.com/technicalreports/pdfs/SP/SJ2000-SP7.pdf. Accessed July 2011.

SJRWMD. 2000b. *The Guana Marsh Renovation Project*. St. Johns River Water Management District. http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CFgQFjAA&url=http%3A%2F%2Fagcj.tamu.edu%2F404%2Fpdf%2Ffs-guana-ex.pdf&ei=SwisT-LpGYTJgQef2Zy_DQ&usg=AFQjCNFeC0GAGenOjsDFJ9AFHdry8rH9fg. Accessed July 2011.

SJRWMD. 2006. *SJRWMD 2004 Land Use*. St. Johns River Water Management District. Palatka, FL.

SJRWMD. 2011a. *Monitoring Stations by Waterbody*. St. Johns River Water Management District. http://www.floridaswater.com/watershedfacts/stationswaterbody.html. Accessed July 2011.

SJRWMD. 2011b. *Watershed Facts*. St. Johns River Water Management District. http://www.sjrwmd.com/watershedfacts/stationswaterbody.html. Accessed October 2011.

SJRWMD. 2011c. *Soil Survey Geographic (SSURGO) Data*. National Resources Conservation Service.

Steward, J.S., and E.F. Lowe. 2010. General empirical models for estimating nutrient load limits for Florida's estuaries and inland waters. *Limnology and Oceanography* 55(1):433–445.

Steward, J.S., W.C. Green, and J.D. Miller. 2010a. *DRAFT Using multiple lines of evidence for developing numeric nutrient criteria for Tolomato–Matanzas Estuary, Florida*. St. Johns River Water Management District. Palatka, FL.

Steward, J.S., W.C. Green, and J.D. Miller. 2010b. *Using multiple lines of evidence for developing numeric nutrient criteria for Halifax River Estuary*. St. Johns River Water Management District. Palatka, FL.

US Census Bureau. 2012. *2010 Census Interactive Population Map: Palm Coast City, St. Augustine, St. Augustine Shore, St. Augustine Beach City, St. Augustine South, Butler Beach, Nocatee, Villano Beach, Crescent Beach, St. Johns County, and Flagler County, Florida*. U.S. Census Bureau. http://2010.census.gov/2010census/popmap/. Accessed May 2012.