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FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

Division of Water Resource Management, Bureau of Watershed Management

CENTRAL DISTRICT • UPPER ST. JOHNS RIVER BASIN

TMDL Report

Nutrient and DO TMDLs for the St. Johns River above Lake Poinsett (WBID 2893L), Lake Hell n' Blazes (WBID 2893Q), and St. Johns River above Sawgrass Lake (WBID 2893X)

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Chapter 1: INTRODUCTION

1.1 Purpose of Report

This report presents the Total Maximum Daily Loads (TMDLs) for nutrients and Biochemical Oxygen Demand (BOD) for three waterbodies in the Upper St. Johns River Basin (USJRB), including the St. Johns River above Lake Poinsett (SJRALP), Lake Hell n' Blazes (LHB), and the St. Johns River above Sawgrass Lake (SJRASGL). These waterbodies were verified as impaired for nutrients and/or DO, and were included on the Verified List of impaired waters for the Upper St. Johns Basin that was adopted by Secretarial Order on June 17, 2005. According to the 1999 Florida Watershed Restoration Act (FWRA), Chapter 99-223, Laws of Florida, once a waterbody is included on the Verified List, a TMDL must be developed. The purpose of the TMDL is to establish the allowable loadings of pollutants to these waterbodies that would restore their water quality condition so that they meet their applicable water quality criteria for nutrients and DO.

1.2 Identification of Waterbody

The three waterbodies covered in this study are all segments of the Upper St. Johns River (USJR). The USJR Basin extends from the southern boundary of Indian River County and the middle of Okeechobee County in the south to the confluence with the Econlockhatchee River near Lake Harney (Seminole County) in the north and southeast part of Volusia County in the northeast (**Figure 1.1**). The USJR flows from south to north and drains a watershed area of about 1,209,000 acres. The movement of the water in the first 30 miles (headwater area) of the river is dominated by sheetflow until reaching the discernable channel at the Three Forks Marsh area. The river then flows northward through about 90 miles of river channel and seven major lakes including Lake Hell n' Blazes, Little Sawgrass Lake, Sawgrass Lake, Lake Washington, Lake Winder, Lake Poinsett, and Puzzle Lake.

In the early 1900s, the 405,000 acre floodplain of the USJR was a broad shallow marsh. By the 1970s, however, about 70% of the wetlands were converted into agricultural fields to support the production of citrus, row crops, and beef cattle. The loss of wetland habitats due to floodplain encroachment by farming practices greatly reduced floodplain storage and conveyance capacities in the river and severely altered the natural hydrologic and ecological regime of the marsh ecosystem. Pollutant loads from the agriculture and urban areas also caused water quality problems in the USJRB.

To address these problems, the State of Florida and the U.S. Army Corps of Engineers (USACE) started a USJRB restoration project in1980s. The project, which primarily focuses on the watershed area south of Lake Washington, is a combination of structural and operational modifications to the system that include water management areas, marsh conservation areas, and marsh restoration areas (**Figure 1.2**). The goals of these components are to improve flood control, improve water quality downstream, reduce freshwater inputs to the Indian River Lagoon, provide for water supply needs, and restore critical wildlife habitats. Two waterbody segments covered in this study, LHB and the SJRASGL, fall within the northern boundary of the USJRB restoration project.

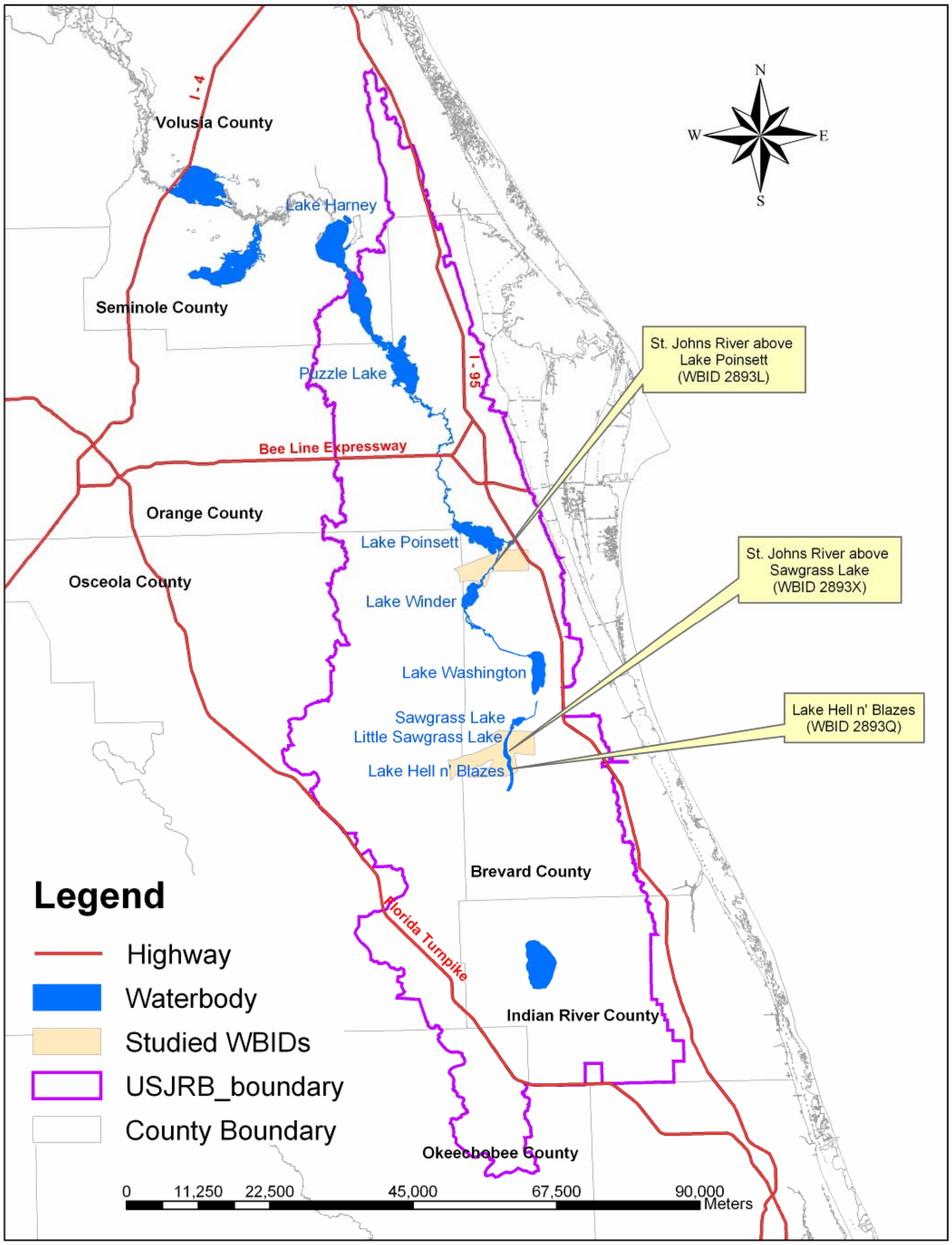

Figure 1.1.   Locations of the USJRB and waterbodies covered in this study.

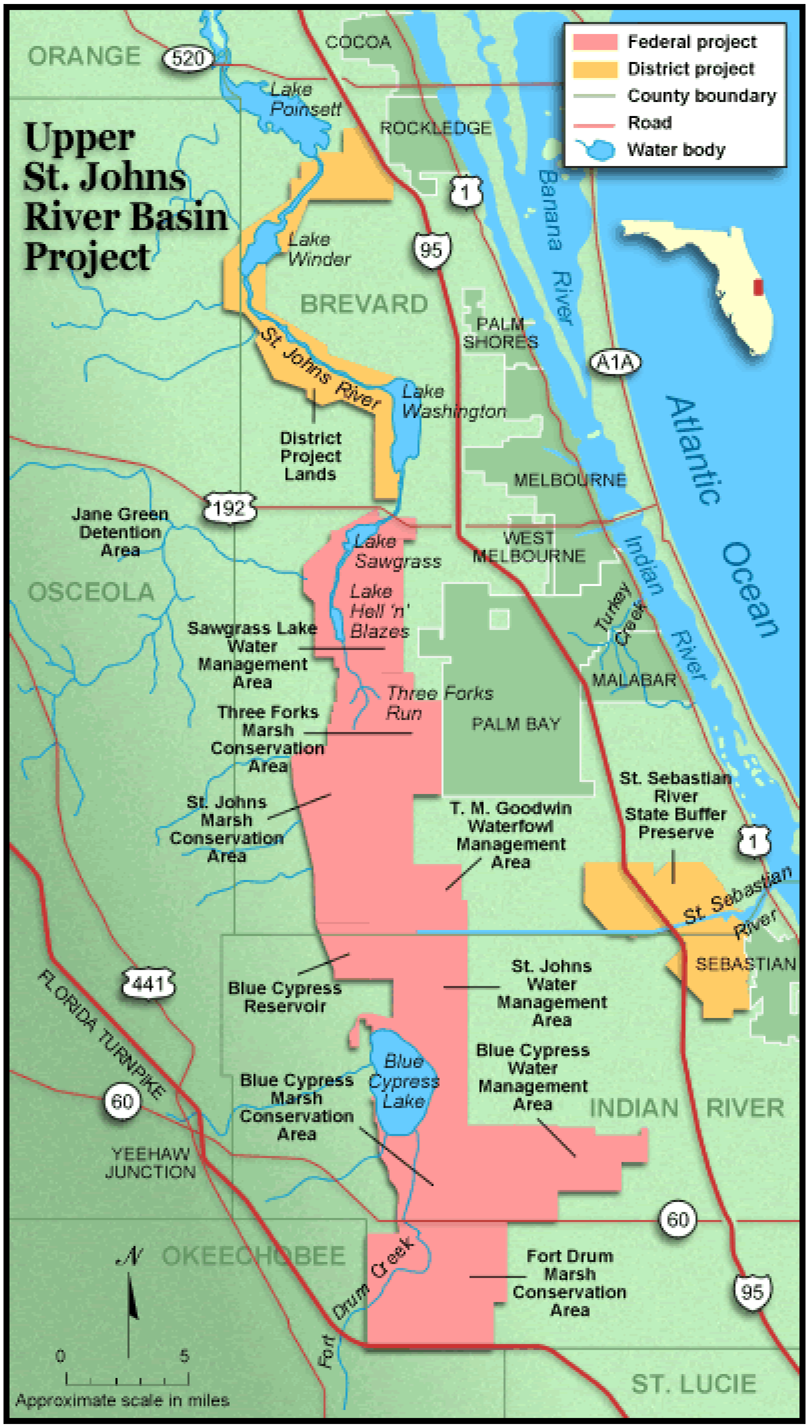

Figure 1.2.   Areas of USJRB Restoration Project (from SJRWMD)

For assessment purposes, the Department has divided the USJRB into water assessment polygons with a unique **w**ater**b**ody **id**entification (WBID) number for each watershed or stream reach. SJRALP, SJRASGL, and LHB are represented by WBIDs 2893L, 2893X, and 2893Q, respectively. This TMDL report addresses nutrients and DO impairments of WBIDs 2893L and 2893Q, and DO impairment of WBID 2893X.

1.3 Background

This report was developed as part of the Department's watershed management approach for restoring and protecting state waters and addressing TMDL Program requirements. The watershed approach, which is implemented using a cyclical management process that rotates through the state's 52 river basins over a 5-year cycle, provides a framework for implementing the TMDL Program–related requirements of the 1972 federal Clean Water Act and the FWRA.

A TMDL represents the maximum amount of a given pollutant that a waterbody can assimilate and still meet water quality standards, including its applicable water quality criteria and its designated uses. TMDLs are developed for waterbodies that are verified as not meeting their water quality standards, and provide important water quality restoration goals that will guide restoration activities.

In 2004, the United States Environmental Protection Agency (USEPA) developed nutrient TMDLs for the three waterbodies covered in this study based on the Pollutant Load Reduction Goal (PLRG) for the waters developed by the St. Johns River Water Management District (SJRWMD) (Keenan, et al. 2003). After reviewing USEPA's TMDL report (EPA 2004), the Department found that TMDLs for these waterbodies were not explicitly addressed. Instead, target nutrient loadings into these waterbodies were addressed indirectly through addressing the loadings into upstream lakes. In addition, after analyzing the major pollutants that control the DO concentrations in the three waterbodies, the Department found that concentrations of BOD are elevated in WBIDs 2893L and 2893X, and that spatial distributions of DO and BOD concentrations across the Upper St. Johns River Basin (USJRB) suggest that BOD could be an important pollutant, in addition to phosphorus, causing the low DO concentrations in these waterbodies. Allowable BOD loadings to these waterbodies therefore needed to be calculated. To ensure that the method used to calculate TP loadings into the three studied waterbodies was consistent with the method used to calculate BOD loadings, the Department calculated the TP loadings into these waterbodies explicitly, instead of adopting the TP TMDLs from EPA.

This TMDL report will be followed by the development and implementation of a Basin Management Action Plan, or BMAP, to reduce the amount of nutrients and BOD that caused the verified impairment. These activities will depend heavily on the active participation of the St. Johns River Water Management District (SJRWMD), local governments, businesses, and other stakeholders. The Department will work with these organizations and individuals to undertake or continue reductions in the discharge of pollutants and achieve the established TMDLs for impaired waterbodies.

Chapter 2: DESCRIPTION OF WATER QUALITY PROBLEM

2.1 Statutory Requirements and Rulemaking History

Section 303(d) of the Clean Water Act requires states to submit to the EPA a list of surface waters that do not meet applicable water quality standards (impaired waters) and establish a TMDL for each pollutant source in each of these impaired waters on a schedule. The Department has developed these lists, commonly referred to as 303(d) lists, since 1992. The list of impaired waters in each basin is also required by the FWRA (Subsection 403.067[4)] Florida Statutes [F.S.]), and the list is amended annually to include updates for each basin statewide.

Florida's 1998 303(d) list included 17 waterbodies in the USJRB. However, the FWRA (Section 403.067, F.S.) stated that all previous Florida 303(d) lists were for planning purposes only and directed the Department to develop, and adopt by rule, a new science-based methodology to identify impaired waters. After a long rulemaking process, the Environmental Regulation Commission adopted the new methodology as Chapter 62-303, Florida Administrative Code (F.A.C.) (Identification of Impaired Surface Waters Rule, or IWR), in April 2001. The list of waters for which impairments have been verified using the methodology in the IWR is referred to as the Verified List.

2.2 Information on Verified Impairment

The Department used the IWR to assess water quality impairments in the USJRB and verified impairments for SJRALP, SJRASGL, and LHB **(Table 2.1).** The SJRALP was verified impaired for nutrients and DO based on the observation that, in two consecutive years (2000 and 2001), the annual average *Chl* a concentration of the waterbody exceeded the 5-year average historical minimum of 6.1 µg/L (calculated based on the data from 1981 through 1985) by more than 50% and based on the fact that 51 out of 93 DO measurements were lower than the 5.0 mg/L state water quality criteria. The Department determined that nutrients were the causative pollutant for the observed low DO concentrations. For LHB, nutrients were considered impaired because the annual average trophic state index (TSI) exceeded the impairment threshold of 60 (for high colored lakes) in 1998 and 1999. The DO of LHB was also assessed as impaired because 63 out of 81 DO measurements taken during the verified period were lower than 5.0 mg/L, and nutrients were identified as the causative pollutant. The SJRASGL was assessed as being impaired for low DO based on the observation that 17 out of 34 DO measurements taken in the Verified Period were lower than 5.0 mg/L. Since the median value of BOD measurements of this waterbody was higher than the 2.0 mg/L screening value for streams, BOD was considered the causative pollutant. **Table 2.2** and **2.3** summarize the water quality data that were the basis for the impairment determination.

Table 2.1. Verified impaired waterbody segments and parameters covered in this report

WBID	Waterbody Segment	Parameters of Concern
2893L	St. Johns River above Lake Poinsett	Nutrients and DO
2893Q	Lake Hell n' Blazes	Nutrient and DO
2893X	St. Johns River above Lake Sawgrass	DO (BOD)

Table 2.2. Summary of nutrient data in the verified period for the SJRALP (WBID 2893L) and LHB (WBID 2893Q)

WBID	Parameter	Summary of observation
2893L	Exceedance of annual *Chl a* concentration	No
	Exceedance of 50% of the 5-year historic minimal *Chl a* (6.1 µg/L)	Exceeded in two consecutive years (2000 and 2001)
	Range of *Chl a* concentration (µg/L)	1.0 – 117.0
	Median *Chl a* concentration (µg/L)	7.6
	Range of TN concentration (mg/L)	0.94 – 2.04
	Median TN concentration (mg/L)	1.90
	Range of TP concentration (mg/L)	0.02 – 0.36
	Median of TP concentration (mg/L)	0.109
	Median TN/TP ratio	16.6
2893Q	Exceedance of annual TSI (60)	Exceeded in 1998 and 1999
	Exceedance of the 5-year average historic minimal TSI	No
	Range of *Chl a* concentration (µg/L)	1.0 – 63.0
	Median of *Chl a* concentration (µg/L)	6.5
	Range of TN concentration (mg/L)	0.82 – 3.53
	Median of TN concentration (mg/L)	1.71
	Range of TP concentration (mg/L)	0.04 – 0.60
	Median of TP concentration (mg/L)	0.151
	Median TN/TP ratio	11.5

Table 2.3. Summary of DO Monitoring Data in the verified period for the SJRALP (WBID 2893L), LHB (WBID 2893Q), and the SJRASGL (WBID 2893X)

WBID	Parameter	Summary of observation

2893L	Total number of samples	93
	IWR required number of exceedances for the verified list	14
	Number of observed exceedances	51
	Number of observed non-exceedances	42
	Number of seasons during which samples were collected	4
	Highest observation (mg/L)	9.18
	Lowest observation (mg/L)	0.29
	Median observation (mg/L)	4.49
	Mean observation (mg/L)	5.02
	Median value for 12 BOD observations (mg/L)	2.90
	Median value for 99 TN observations (mg/L)	1.90
	Median value for 99 TP observations (mg/L)	0.11
	Possible causative pollutant by IWR	Nutrient + BOD
	FINAL ASSESSMENT	Impaired
2893Q	Total number of samples	81
	IWR required number of exceedances for the verified list	13
	Number of observed exceedances	63
	Number of observed non-exceedances	18
	Number of seasons during which samples were collected	4
	Highest observation (mg/L)	8.6
	Lowest observation (mg/L)	0.1
	Median observation (mg/L)	2.8
	Mean observation (mg/L)	3.1
	Median value for BOD observations (mg/L)	N/A
	Median value for 91 TN observations (mg/L)	1.71
	Median value for 91 TP observations (mg/L)	0.15
	Possible causative pollutant by IWR	Nutrients
	FINAL ASSESSMENT	Impaired
2893X	Total number of samples	34
	IWR required number of exceedances for the verified list	7
	Number of observed exceedances	17
	Number of observed non-exceedances	17
	Number of seasons during which samples were collected	4
	Highest observation (mg/L)	8.6
	Lowest observation (mg/L)	0.1
	Median observation (mg/L)	4.8
	Mean observation (mg/L)	4.6

	Median value for 20 BOD observations (mg/L)	2.8
	Median value for 14 TN observations (mg/L)	1.69
	Median value for 19 TP observations (mg/L)	0.08
	Possible causative pollutant by IWR	BOD
	FINAL ASSESSMENT	Impaired

2.3 Seasonal variation of nutrients and DO in the studied waterbodies

Seasonal variation of *Chl a*, TN, TP, and DO concentrations were analyzed using the data collected during the verified period. **Figure 2.1**, **2.2**, and **2.3** show seasonal trends of these parameters in the three waterbodies covered in this study.

For the SJRALP, peaks of *Chl a* concentration were usually observed during February through early July (**Figure 2.1 A**). This trend did not correlate with TP, TN, and DO annual patterns. Peaks of TP concentration appeared in almost every quarter of the years under study. However, the majority of TP peak concentrations occurred between June and October (**Figure 2.1 B**). This trend appeared to correlate with the trend of DO concentrations, which most of the time reached its lowest points between June and October (**Figure 2.1 D**). No clear seasonal trend was identified for TN (**Figure 2.1 C**).

Multiple *Chl a* peaks were observed throughout sampling years for LHB (**Figure 2.2 A**). Once again, these peaks were not associated with the temporal distribution of TP. In some years, *Chl a* dynamics appeared to be correlated with TN concentrations to a certain extent, but not consistently (**Figure 2.2 C**). TP concentrations showed a very clear seasonal trend, with the highest concentrations consistently appearing between June and October (**Figure 2.2 B**), which was also the time when the lowest DO concentrations appeared.

Limited amount of data were available for the SJRASGL for the Verified Period. Therefore, data before the Verified Period were included in the trend analyses. The seasonal trend of *Chl a*, TN, TP, and DO at this river segment was not as clear as those of the SJRALP and LHB. The general trend was that most of the high concentrations of *Chl a*, TN, and TP appeared between May and October, along with the lowest DO concentrations.

The inverse correlation between seasonal DO and TP levels implies that phosphorus could be one of the most important factors that control DO concentrations in the waterbodies under study.

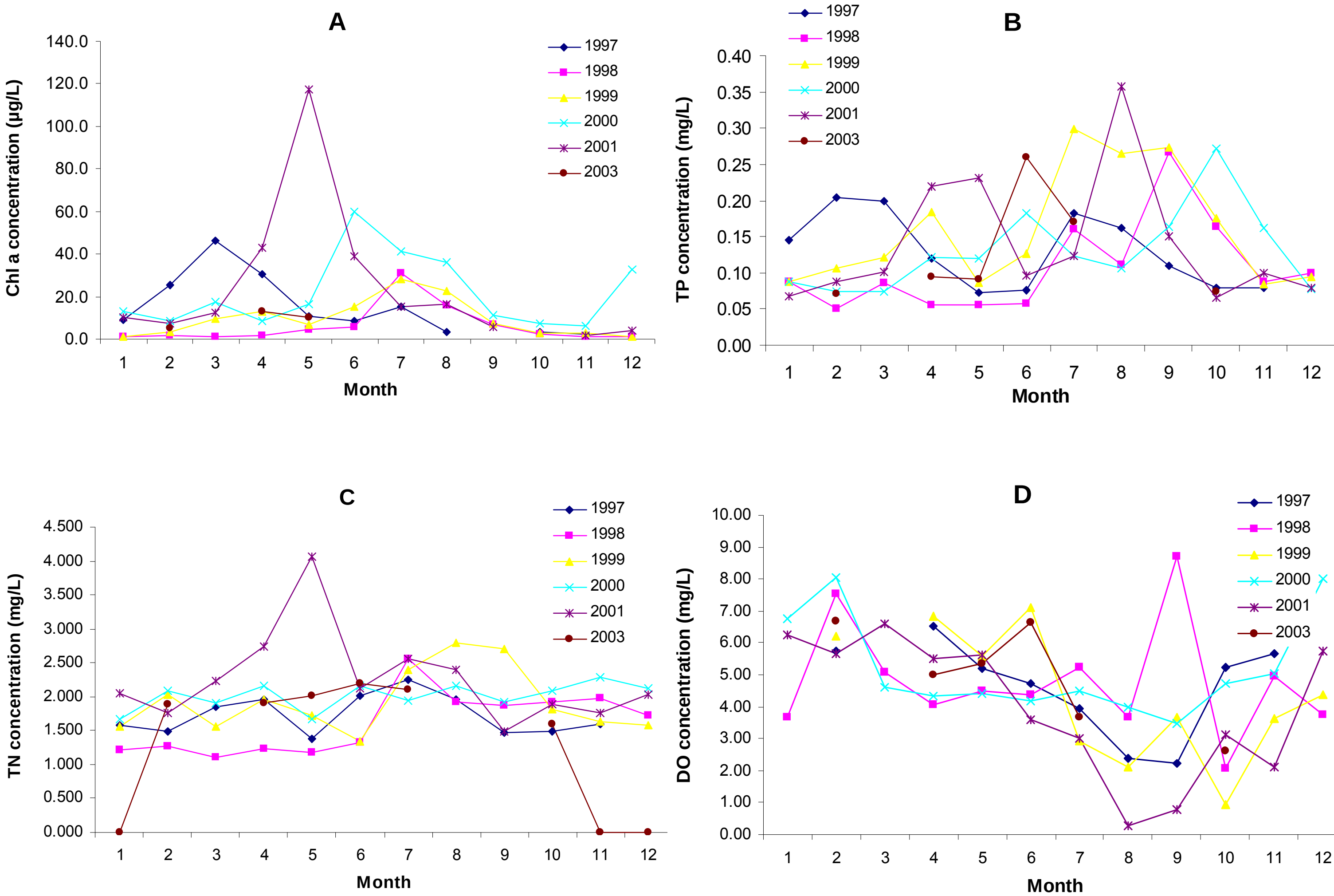

Figure 2.1. Monthly dynamics of Ch a (A), TP (B), TN (C), and DO (D) at the SJRALP

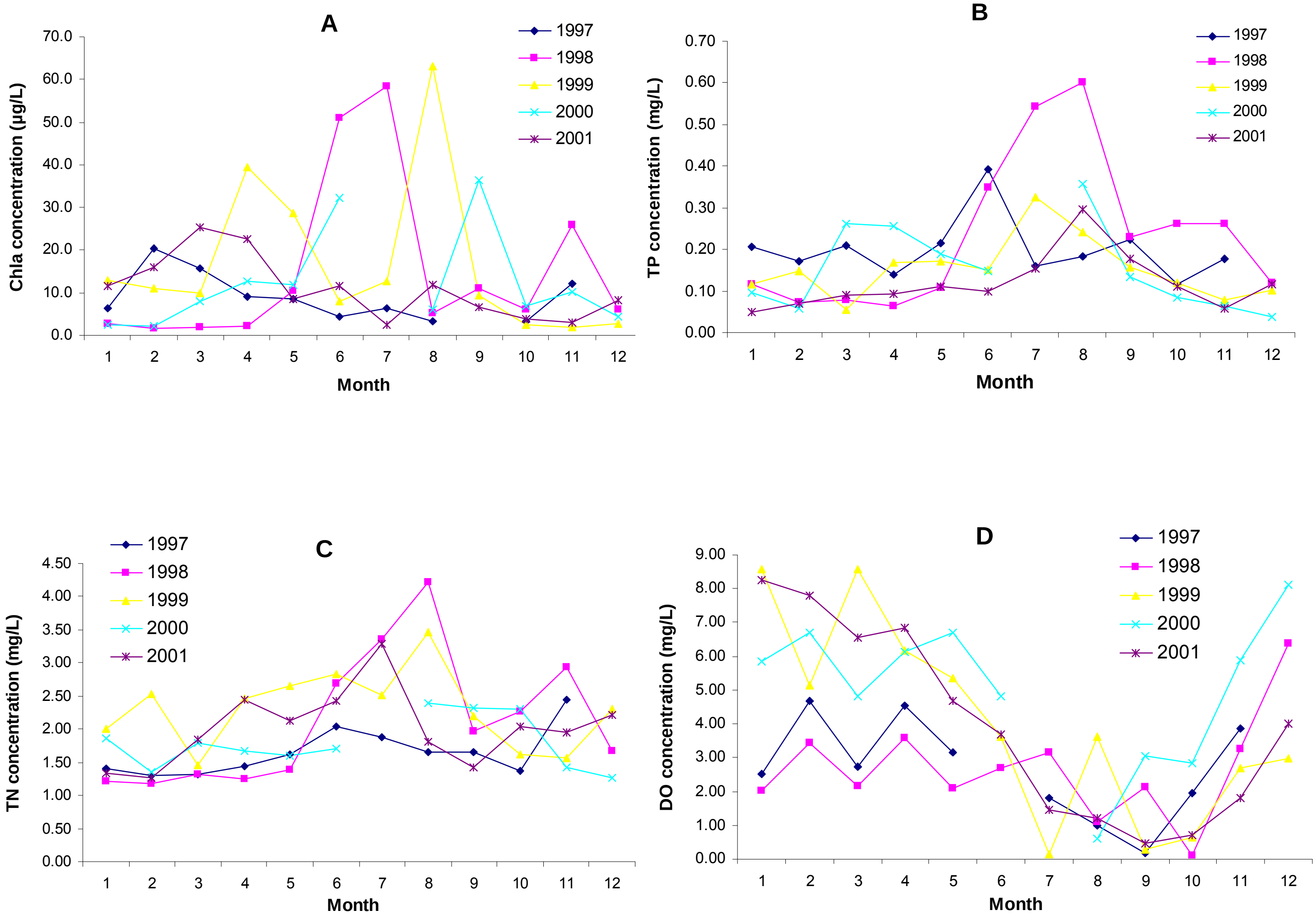

Figure 2.2. Monthly dynamics of Chl a (A), TP (B), TN (C), and DO (D) at the LHB

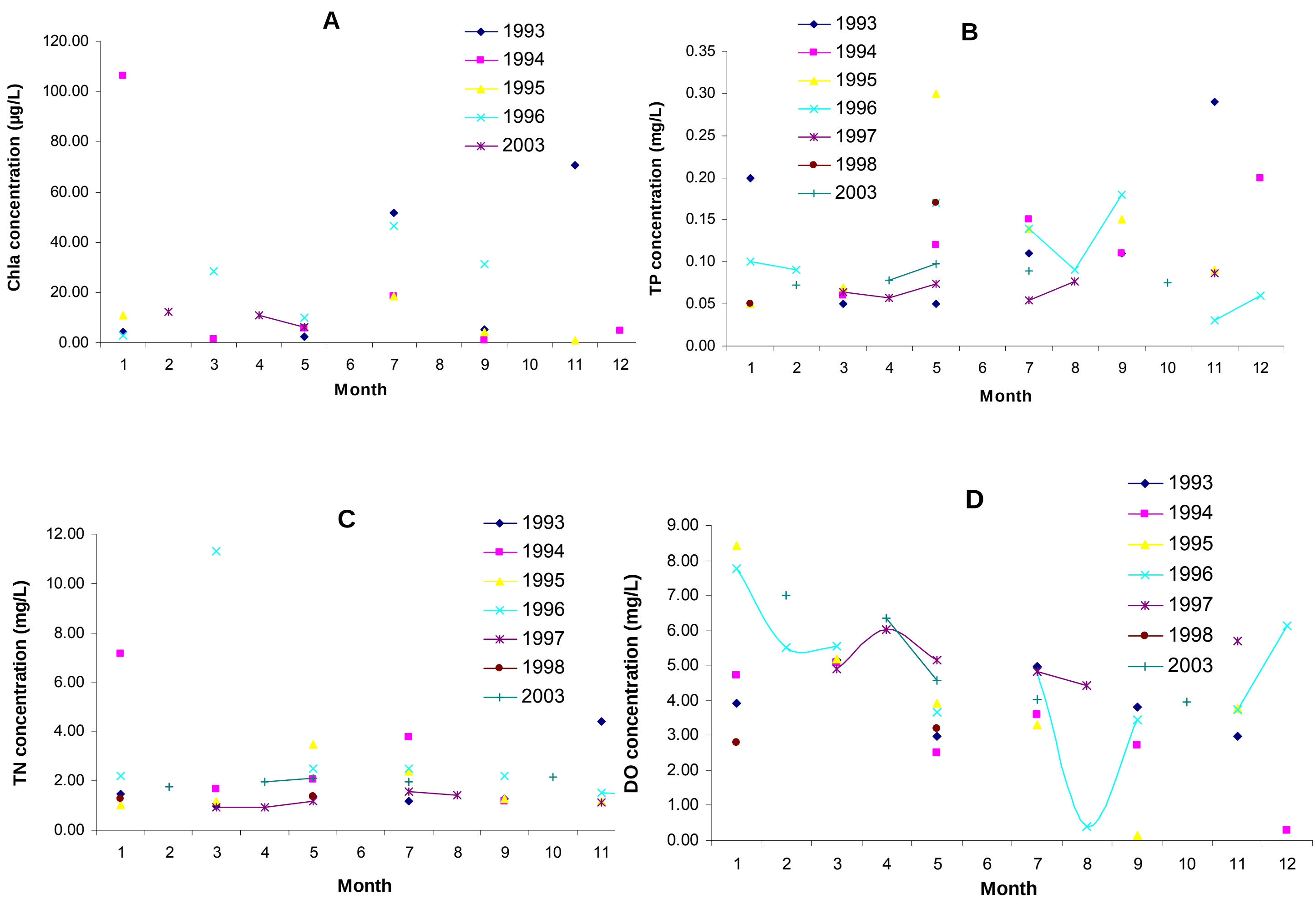

Figure 2.3. Monthly dynamics of Chl a (A), TP (B), TN (C), and DO (D) at the SJRASGL

Chapter 3. DESCRIPTION OF APPLICABLE WATER QUALITY STANDARDS AND TARGETS

3.1 Classification of the Waterbody and Criteria Applicable to the TMDL

Florida's surface waters are protected for five designated use classifications, as follows:

Class I	**Potable water supplies**
Class II	**Shellfish propagation or harvesting**
Class III	**Recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlife**
Class IV	**Agricultural water supplies**
Class V	**Navigation, utility, and industrial use (there are no state waters currently in this class)**

The SJRALP is a Class III waterbody, with a designated use of recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlife. LHB and the SJRASGL are Class I waterbodies, with a designated use of drinking water supplies. The Class I and III water quality criteria applicable to the impairment addressed by this TMDL report are nutrients and DO.

3.2 Applicable Water Quality Standards and Numeric Water Quality Target

3.2.1 Interpretation of Narrative Nutrient Criterion

Florida's nutrient criterion is narrative only—i.e., nutrient concentrations of a body of water shall not be altered so as to cause an imbalance in natural populations of aquatic flora or fauna. Accordingly, a nutrient-related target was needed to represent levels at which an imbalance in flora or fauna is expected to occur. While the IWR provides thresholds for nutrient impairment for lakes based on annual average TSI levels and on annual average *Chl a* levels for streams, these thresholds are not standards and need not be used as the nutrient-related water quality target for TMDLs. In fact, in recognition that the IWR thresholds were developed using statewide average conditions, the IWR (Subsection 62-303.450, F.A.C.) specifically allows the use of alternative, site-specific thresholds that more accurately reflect conditions beyond which an imbalance in flora or fauna occurs in a waterbody.

The nutrient target used in this study, specifically, the phosphorus target, was based on the target TP concentration established by SJRWMD (Keenan, et al. 2003), which is 0.09 mg/L for the river channel and chain of lakes of the USJR. The target was established based on the observation that the total biovolume of blue-green algae substantially increased when the TP concentration became higher than 0.09 mg/L. Neither *Chl a* nor TSI was used in this study to define the nutrient target for several reasons. First, no significant correlation was found between *Chl a* concentrations and TP concentrations. The SJRALP was verified for nutrient impairment based on the exceedance of annual *Chl a* concentration over a 5-year average historic minimum of 6.1 µg/L by more than 50% in two consecutive years (2000 and 2001). However, because no significant correlation between the *Chl a* and TP concentrations could be established for the SJRALP, it was impossible to translate the historic minimum *Chl a* concentration to a target TP concentration. In fact, for the several years in which the *Chl a* concentration was close to the historic minimum, for example, 1996, 1998, and 1999, in which *Chl a* concentrations averaged 5.1, 4.9, and 7.6 µg/L, the annual average TP concentrations were 0.13, 0.10, and 0.17 mg/L, respectively, which were not significantly lower than TP concentrations in 2000 and 2001 (0.13 and 0.17 mg/L, respectively). Therefore, using the TP concentration in years that *Chl a* concentrations were equal to or lower than the 5-year historic minimum as the target concentration was not feasible.

Second, using a *Chl a* – based index, such as *Chl a* itself or TSI, is not as sensitive as, and therefore, not as protective as using the blue-green algal bloom – based TP target proposed by the SJRWMD. According to SJRWMD, a blue-green algal bloom could become substantial in the USRJ long before the total algal biomass, which is usually represented by *Chl a* concentration, was significantly stimulated by the increase of TP concentration, (Keenan et al. 2003). As the increase of blue-green algae in the phytoplankton communities could significantly disrupt normal functions of phytoplankton communities, it is desirable to effectively control the portion of the blue-green algae in the total phytoplankton biomass even when the total algal biomass (*Chl a*) is not significantly enhanced. Therefore, the 0.09 mg/L of TP, which is proposed based on the appearance of the blue-algal bloom was used in this study as the target TP concentration.

A TN target was not included in the PLRG and was not used in this study. TN/TP ratios for all the water segments covered in this study fall in between 10 and 30, which suggests that phytoplankton communities were co-limited by phosphorus and nitrogen. In fact, in most cases, the TN/TP ratio of these waterbodies were only slightly higher than 10, suggesting that the communities were more limited by nitrogen than by phosphorus. However, as it was pointed out by the SJRWMD, the nitrogen limitation happened primarily because the phosphorus concentration was too high. Controlling the phosphorus input would be more effective than controlling the nitrogen input. In addition, nitrogen limitation usually favors the growth of blue-green algae, especially those blue-algal species that have nitrogen fixation capability. Further reduction of the nitrogen input will increase the extent of the nitrogen limitation and thus shift the communities more toward being dominated by blue-green algae. This would be contrary to the goal of nutrient loading control for the USJRB. Therefore, this TMDL focuses on the reduction of phosphorus loading into the system. Reductions in phosphorus loading will help return the community to the state of phosphorus limitation and, at the same time, best management practices (BMPs) used for controlling phosphorus loading will also reduce nitrogen loading as well.

3.2.2 Dissolved Oxygen

Florida's DO criterion for for Class I and III freshwater bodies states that DO "shall not be less than 5.0 mg/L, and the normal daily and seasonal fluctuations above this levels shall be maintained." However, DO concentrations in ambient waters can be controlled by many factors, including the DO solubility, which is controlled by temperature and salinity; DO enrichment processes influenced by reaeration, which is controlled by flow velocity; photosynthesis of phytoplankton, periphyton, and other aquatic plants; DO consumption from the decomposition of organic materials in the water column and sediment and oxidation of some reductants such as ammonia and metals; and respiration by aquatic organisms.

The St. Johns River is a blackwater system (Whitney et al. 2004) in which the DO concentration in some seasons could be naturally low because of the high bacteria respiration supported by a large and constant supply of dissolved organic carbon (DOC) originating from the wetland areas that discharge into the river. Although the major portion of the DOC pool is usually recalcitrant to most bacteria species, some bacteria species adapted to living in blackwater systems can readily use this DOC pool to support their growth. Bacteria activities can be significantly stimulated if nitrogen and phosphorus are added into the system because they provide bacteria with nutrients. Further stimulation of bacteria activities can be observed if DOCs of human origin (usually represented with the biochemical oxygen demand – BOD) are added to the system. Human DOCs are usually easy to decompose and can be readily used by bacteria. These DOCs not only can enhance the metabolic activities of bacteria species that use recalcitrant DOCs, but also provide the carbon source to those bacteria species that can not use recalcitrant DOCs. Therefore, input of human DOC into a blackwater system should be properly controlled to improve the DO condition in these waters.

Another source of DO consumption may originate from the organic materials accumulated in the floodplain of the river and at the bottom of contributing wetlands. Due to the limited amount of time available to this study, factors that control DO concentration in the three studied waterbodies were not examined by measuring the actual DO consumption rate from each source. Instead, TN, TP, and BOD concentrations were treated as the focus of this study. Possible impacts of these nutrients and organic carbon on the DO level of studied waterbodies were analyzed by examining the correlations between DO and TN, TP, and BOD concentrations.

In this study, correlations between DO and nutrients were analyzed by examining the seasonal variation, annual variation, and spatial variation. Because there were insufficient data, the possible influence of BOD on DO concentrations was only analyzed through examining the spatial distribution of DO and BOD.

1. Seasonal correlation between DO and nutrients

Figure 3.1 shows the correlations between long-term monthly average DO percent saturation and monthly average TP concentrations in the studied waterbodies. Because the DO concentration in ambient waters usually does not respond to the change of nutrient concentrations in an instantaneous manner, monthly average DO, TN, and TP concentrations were calculated using the data from the verified period (for WBID 2893X, data from 1993 through 2003 were used for the analysis because there was insufficient data in the verified period). Because each month had only one set of DO and nutrient data in many cases, monthly DO and TN and TP concentrations from all the years in the verified period were averaged and used to create a set of long-term monthly average DO, TN, and TP concentrations. These

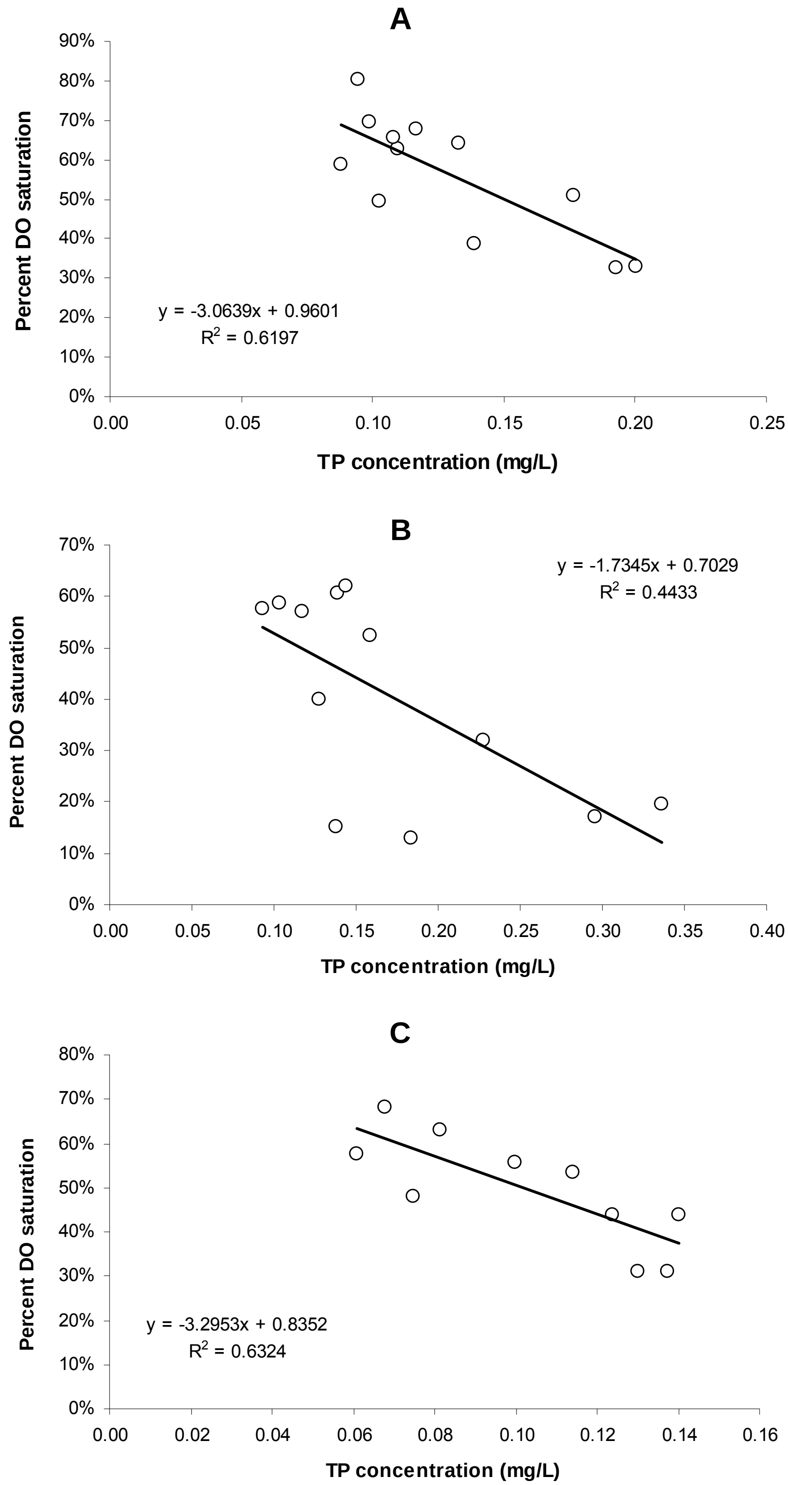

Figure 3.1. Correlation between the long-term monthly percent DO saturation and monthly TP concentration. (A) SJRALP; (B) LHB; and (C) SJRASGL

long-term monthly average results were then used for the correlation analyses. To avoid the potential influence from the differences in temperature in difference months, percent DO saturation, instead of DO concentration, for each month was used in the correlation analysis.

Significant negative correlations ($P<0.05$) between the long-term monthly average DO and TP concentrations were found for all three waterbodies under study. Based on **Figure 3.1**, it appears that between 44 – 63% of the DO variance can be explained by the variance of the TP concentration. Correlation between DO and TN concentrations varied. A reasonably close correlation between DO and TN was observed for LHB, in which TN variance explained about 48% of the DO variance ($P = 0.01$). DO-TN correlations for the SJRALP and the SJRASGL, however, were statistically insignificant.

2. Annual correlation between DO and nutrients

The influence of TP on the DO concentrations in the studied waterbodies were also examined on an annual average basis. The annual average DO and TP concentrations were calculated for each year using the monthly averages. To ensure that a reasonably wide range of DO and TP variations were included in the correlation analyses, the periods of record were expanded from only the data from the verified period to including all of the data available to the Department from the Impaired Waters Rule (IWR) database (Run20_1), which fell in the period between 1992 and 2003. **Table 3.1** shows the correlation coefficients between DO and TP concentrations for the three waterbodies covered in this study.

Table 3.1. Correlation between annual DO and TP concentrations

Water Body	Equation	R^2	P	Years of data used in the analysis
SJRALP (WBID 2893L)	Y = -16.96X + 6.84	0.37	0.045	1992 through 2001, and 2003. There were no data in 2002
LHB (WBID 2893Q)	Y = -13.73X + 5.59	0.22	0.170	1992 through 2001
LHB (WBID 2893Q) (with 1993, 1994, and 1995 data removed)	Y = -17.35X + 6.59	0.56	0.031	1992, 1996 through 2001
SJRASGL (WBID 2893X)	Y = -23.68X + 6.94	0.73	0.05	1993 through 1997, and 2003. There were no data in 1999 through 2002. 1998 data were not used to calculate the annual mean because there were only two data points for the entire year

Eleven years of annual average DO, TN, and TP concentrations (year 1992 through 2001, and 2003; no data were available in year 2002) were used for correlation analysis for the SJRALP (**Table 3.1**). Three DO readings were removed from the DO-TP correlation analysis for this waterbody. These include the DO reading of January 21, 1997, which was 14.17 mg/L, as well as those for January 7 and March 4, 1999, which were 10.11 and 9.18 mg/L. These DO readings represented saturated or super-saturated DO concentrations under temperatures at the time of sampling. *Chl a* readings at the time that these DO readings were taken were 7.8

µg/L for January 1997 and 1.2 and 9.8 µg/L for January and March 1999, respectively. These *Chl* a concentrations would not be expected to generate super-saturated DO concentrations, especially in a blackwater system. Therefore, these DO readings were considered suspicious and were not used in the analyses. The correlation between annual average DO and TP concentrations were significant (P = 0.045). TP variance explained about 37% of the DO variance.

When using the entire period of record (1992 through 2001) to analyze the DO-TP correlation for LHB, the correlation coefficient was only about 0.22 and the correlation was statistically insignificant (P = 0.170, **Table 3.1**). A detailed examination of the data indicated that the annual average DO concentrations for this waterbody were abnormally low in 1993, 1994 and 1995. What caused the low annual average DO in these years remains unknown but it may be a natural condition. If the annual average DO from these three years were not included in the analyses, the DO-TP correlation became significant (P = 0.031), with a correlation coefficient of about 0.56.

DO-TP correlation for the St. Johns River above Sawgrass is statistically significant (P= 0.050), with a correlation coefficient of about 0.73.

The correlations between DO and TN concentrations for all the three waterbodies were statistically insignificant.

3. Spatial correlation between DO and nutrients

The impact of TP on the DO concentration in the USJR were also examined by analyzing the spatial distribution of long-term average DO and TP concentrations across the basin for WBIDs with data. **Figure 3.2 A** and **B** show the spatial distribution of long-term average DO and TP concentrations in the basin. Except for several isolated waterbodies in the southern part of the basin that had high DO and low TP concentrations, there was a general trend of a gradual increase in DO concentration from the south to the north, and an opposite trend of a decrease of TP concentration from the south to the north. The majority of the USJR segments located on the northern end of the basin, such as Lake Poinsett (WBID 2893K), St. Johns River above Puzzle Lake South (WBID 2893), St. Johns River above Puzzle Lake (WBID 2893I), and Puzzle Lake (WBID 2964B), had long-term average DO concentrations above 5.0 mg/L. Long-term TP concentrations of these waterbodies were all at or below 0.09 mg/L.

Table 3.2 lists the long-term average DO and TP concentrations in waterbodies along the main channel of the USJR from the central part of the basin, where a distinct river channel begins, to the northern end of the basin. Based on this table, long-term average DO concentrations for lakes south of Lake Poinsett were usually lower than 5.0 mg/L, except for Lake Washington, while the long-term average DO concentrations of those waterbodies north of Lake Poinsett, including Lake Poinsett, were usually higher than 5.0 mg/L. Long-term TP concentrations showed the opposite trend. Waterbodies south of Lake Poinsett usually had long-term TP concentration higher than 0.11 mg/L, while waterbodies north of Lake Poinsett had long-term TP concentrations that were usually lower than 0.09 mg/L. Plotting the long-term DO concentrations in these waterbodies (except Lake Washington) against the TP concentrations shows a reasonably tight correlation between DO and TP concentrations (R^2 = 0.49, P = 0.035),

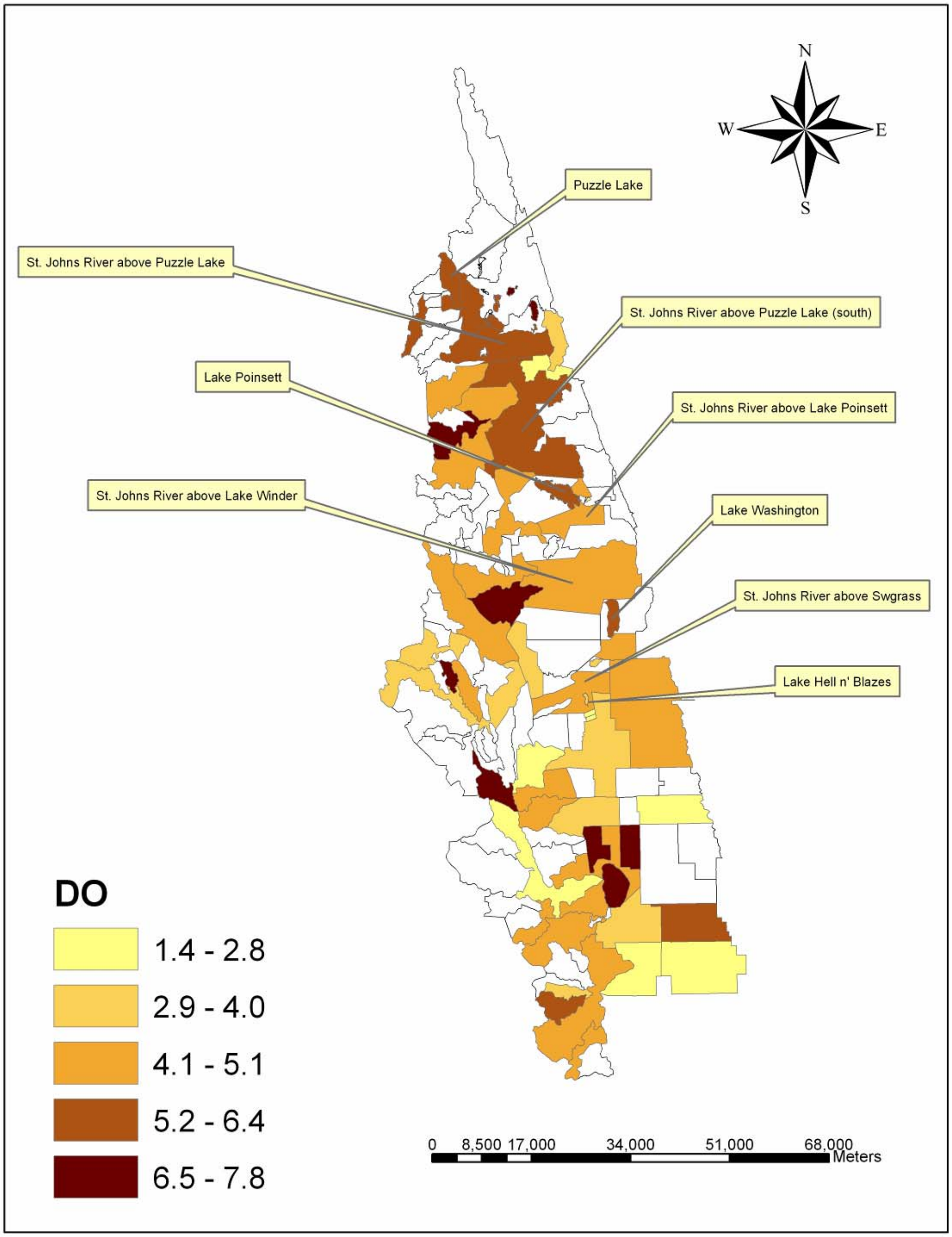

Figure 3.2- A. Spatial distribution of DO in the Upper St. Johns River Basin

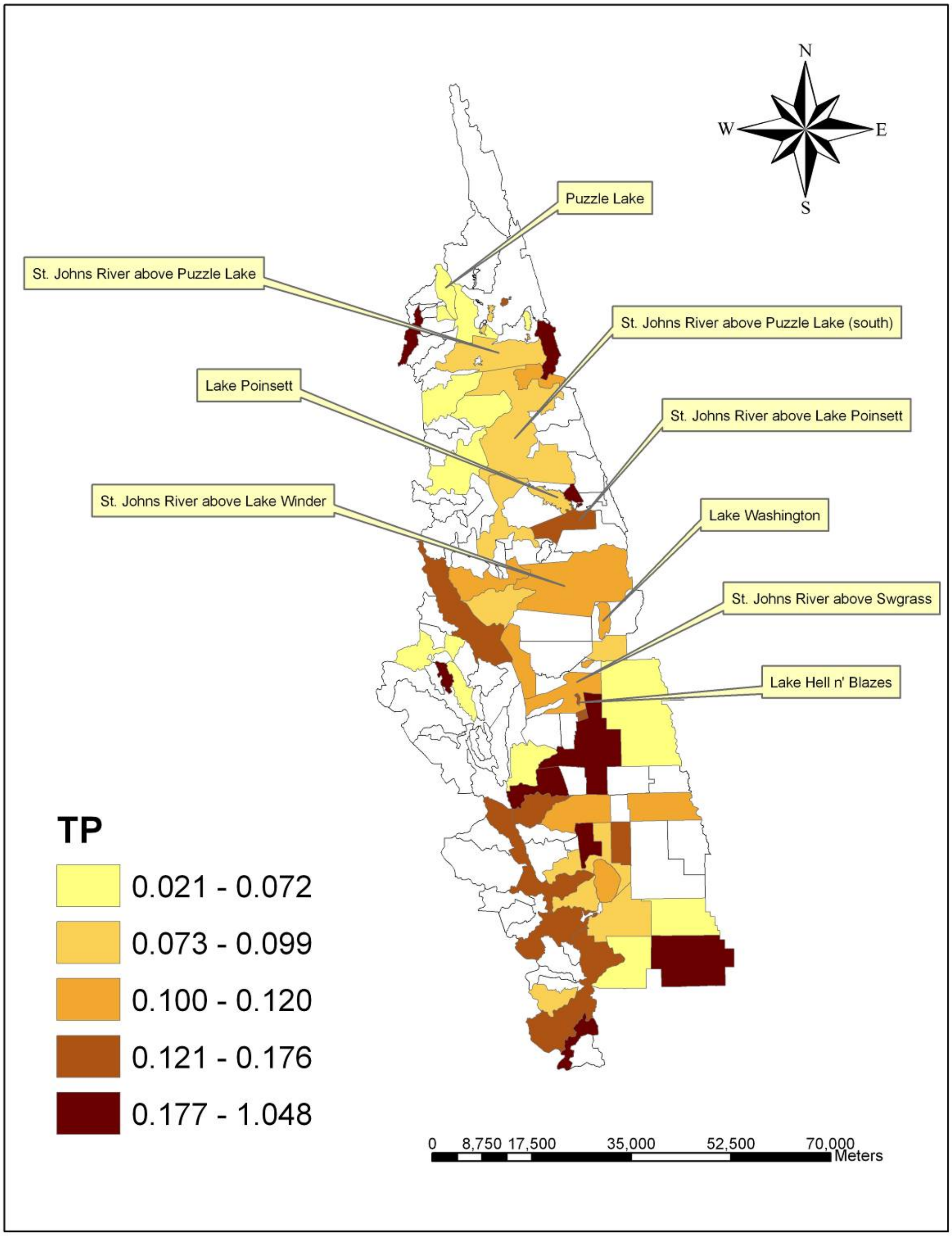

Figure 3.2 – B. Spatial distribution of TP concentration in the Upper St. Johns River Basin

suggesting that a significant portion of the DO spatial variation can be explained by the spatial variation of the TP concentration. Why the DO concentration in Lake Washington was significantly higher than the other waters south of Lake Poinsett remains unknown. SJRWMD suggested that the difference could result from the larger depth of Lake Washington than lakes south of it, i.e. Lake Hell n' Blazes and Sawgrass Lake.

Table 3.2. Long-term average DO and TP concentrations of waterbodies from the central to the northern parts of the basin

Water Body	DO (mg/L)	TP (mg/L)	Correlation Equation	R^2	P
Lake Hell n' Blazes	3.96	0.16	Y = -16.44X + 6.53	0.49	0.035
St. Johns River above Sawgrass	4.59	0.12			
Sawgrass Lake	4.10	0.11			
St. Johns River above Lake Winder	4.20	0.11			
Lake Washington	6.42	0.10			
St. Johns River above Lake Poinsett	4.98	0.11			
Lake Poinsett	5.53	0.09			
St. Johns River above Puzzle Lake (WBID 28935)	5.51	0.09			
St. Johns River above Puzzle Lake (WBID 2893I)	5.46	0.09			
Puzzle Lake	5.24	0.06			

No significant correlation was observed between long-term DO and TN concentrations.

One interesting observation was that DO-TP correlation equations derived from various correlation analyses all indicated a similar target TP concentration, if the annual or long-term average DO target was set at 5.0 mg/L. For example, an annual average DO concentration can be translated into an annual average percent DO saturation of about 59%. To achieve this target, the DO-TP correlations shown in **Figure 3.1 A**, **B**, and **C** require a TP concentration of 0.12, 0.07, and 0.07 mg/L for the SJRALP, LHB, and SJRASGL, respectively. The average of these target TP concentrations is 0.09 mg/L. Using the DO-TP correlation equations shown in **Table 3.1**, and assuming an annual average DO of 5.0 mg/L, the target TP concentrations for the SJRALP, LHB, and SJRASGL should be 0.11, 0.09, and 0.08 mg/L, respectively. The average TP target to achieve the annual average DO concentration was, once again, 0.09 mg/L. Using the equation shown in **Table 3.2**, and assuming a long-term average DO concentration of 5.0 mg/L, the target TP concentration is, once again 0.09 mg/L. In addition, for all the waterbodies shown in Table 3.2, as long as their long-term average TP concentration is at or lower than 0.09 mg/L, their long-term DO concentration appears to be higher than 5.0 mg/L. All these observations suggest that, if the phosphorus concentration can be effectively controlled in the upper St. Johns River basin, the low DO condition in the USJRB should be ameliorated.

DOC with human origin, which is usually represented by BOD concentration, could also impact the DO concentration in the study waters. As it was shown in **Table 2.3**, the median BOD concentrations of the SJRALP and SJRASGL are higher than 2.0 mg/L, which is the screening levels used by the Department. BOD in these waterbodies was therefore considered as one of the causative pollutants for the low DO condition of these waterbodies.

Because there were only limited BOD measurements available to the Department for the SJRALP and SJRASGL at the time this study was conducted and these measurements were all taken in 2003, only once or twice for each quarter, it was not feasible to conduct any statistical analysis. However, when the long-term average BOD concentrations for each waterbody in the USJRB were calculated using available data, there was a trend of declining BOD concentration from the southern to the northern parts of the basin (**Figure 3.3**), apparently opposite to the spatial distribution of long-term average DO concentration in the basin (**Figure 3.2-A**). The spatial variation of BOD in the basin is most likely not caused by the change of humic DOC input from the natural environment because, as shown in **Figure 3.4**, the water color of the main channel of USJR does not decrease significantly from the south to the north. The spatial variation of BOD in the basin likely reflects the extent of the human impact in the basin, which is heavier in the southern part than the northern part of the basin.

Table 3.3 lists long-term average DO and BOD concentrations of several waterbodies along the USJR from the central part to the northern end of the basin. These average concentrations were calculated using the entire period of record for each waterbody. Because of the limited amount of data available, the periods of record of each water are not the same.

Table 3.3. Long-term average DO and TP concentrations of waterbodies from the central to the northern parts of the basin

Waterbody	DO (mg/L)	BOD (mg/L)
Lake Hell n' Blazes	3.96	N/A
St. Johns River above Sawgrass	4.59	3.22
Sawgrass Lake	4.10	3.34
St. Johns River above Lake Winder	4.20	2.76
Lake Washington	6.42	1.31
St. Johns River above Lake Poinsett	4.98	3.03
Lake Poinsett	5.53	N/A
St. Johns River above Puzzle Lake (WBID 28935)	5.51	2.25
St. Johns River above Puzzle Lake (WBID 2893I)	5.46	1.97
Puzzle Lake	5.24	1.93

As shown in **Table 3.3**, for most of the waterbodies along the main channel of the USJR, as long as the long-term average BOD concentration is close to or lower than 2.0 mg/L, the long-term average DO concentration is higher than 5.0 mg/L. Therefore, in this study, the target BOD concentration was set at 2.0 mg/L.

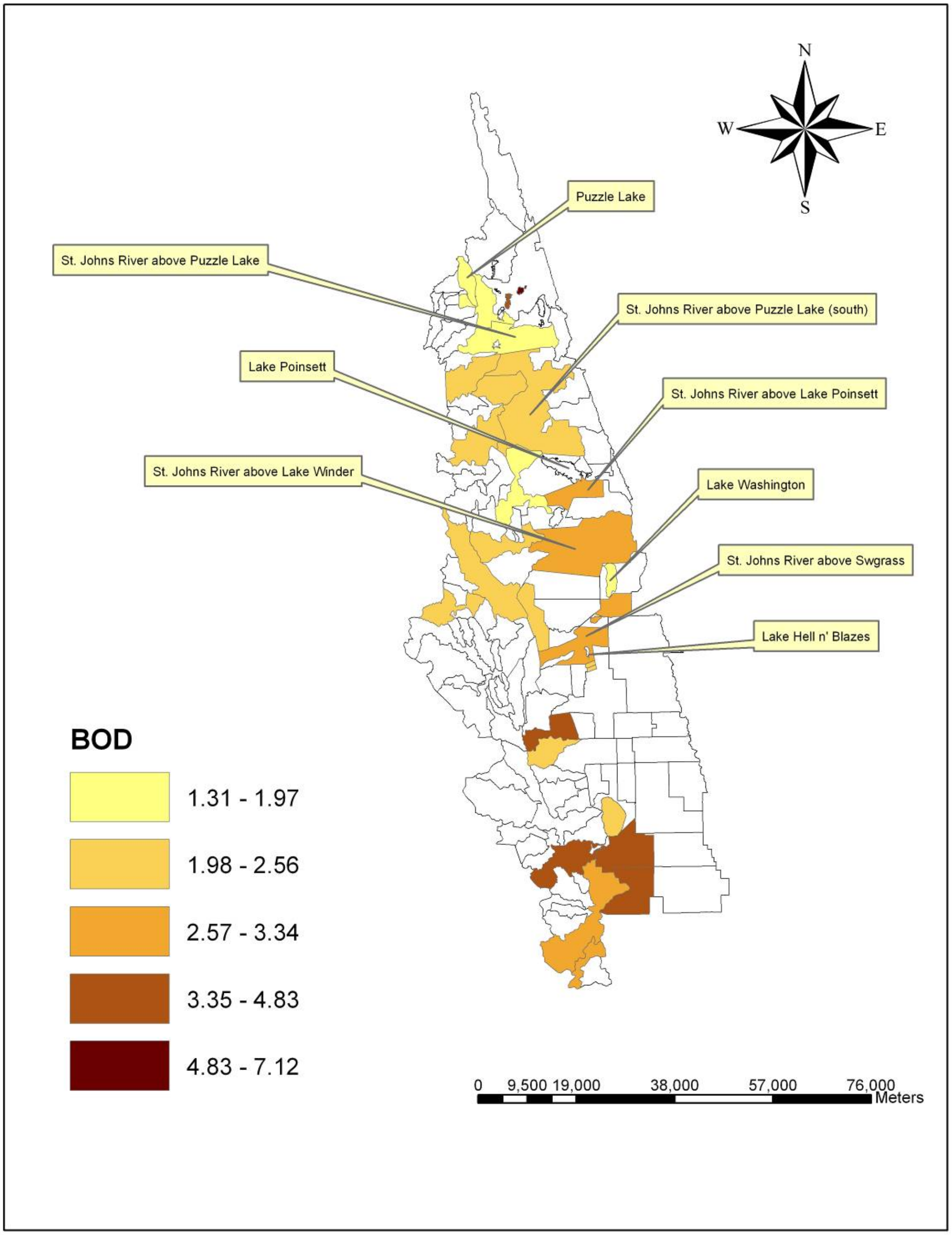

Figure 3.3. Spatial distribution of BOD concentration in the Upper St. Johns River Basin

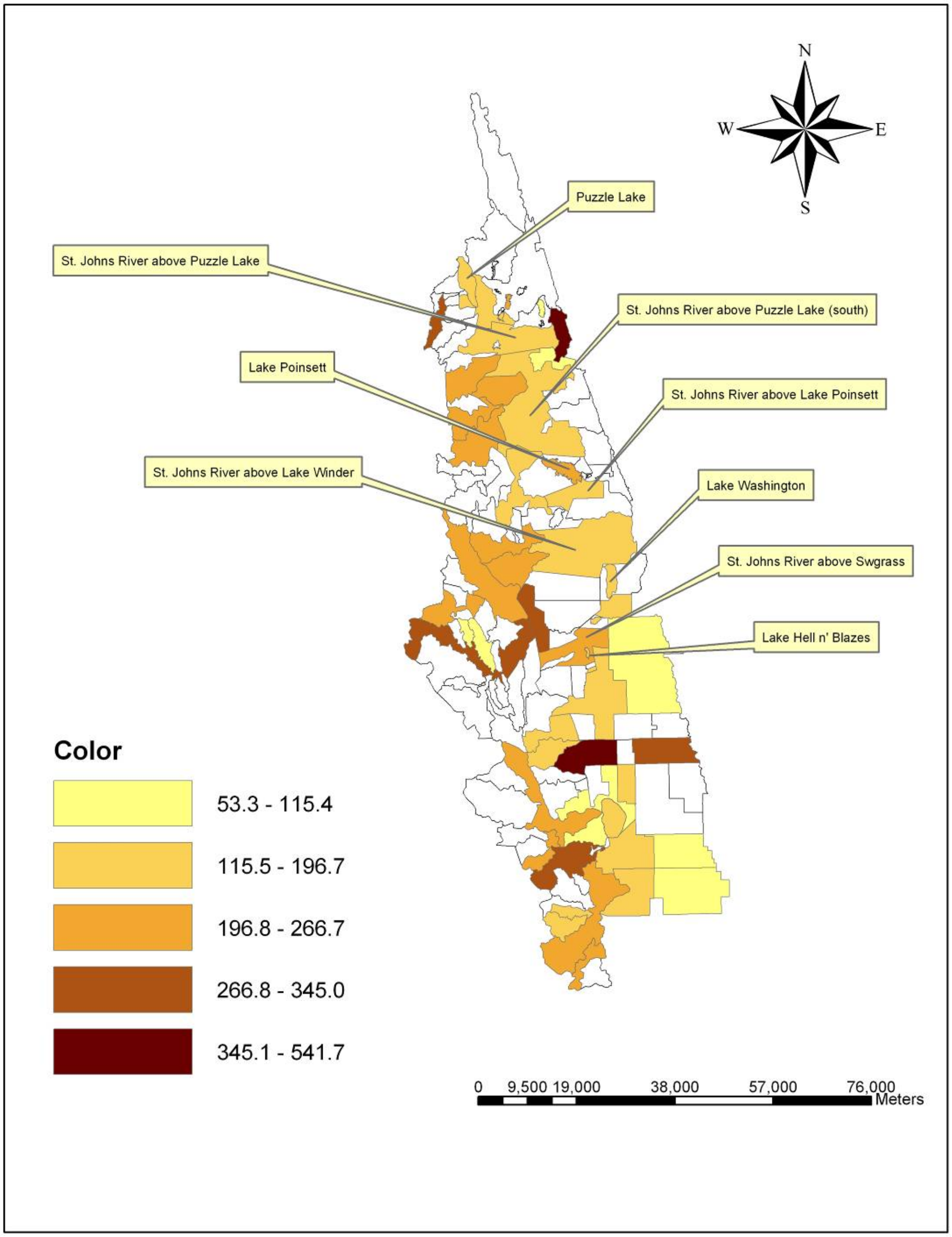

Figure 3.4. Spatial distribution of color concentration in the Upper St. Johns River Basin

3.2.3 Summary of Applicable Water Quality Targets

Based on the Upper St. Johns River Basin (USJRB) TP PLRG developed by the SJRWMD, achieving an annual average TP concentration target of 0.09 mg/L should result in a significant reduction of cyanobacteria biovolume (i.e., reduce the frequency of harmful algal blooms) in the Upper St. Johns River waterbodies. In turn, the control of harmful blooms can be considered a control of the imbalance of aquatic flora and fauna. Thus, achieving the annual average TP concentration target should result in achieving the narrative nutrient criteria for the USJRB system. Based on the analyses on the relationships between DO and TP and DO and BOD, it appears that the low DO condition in some USJRB waters are at least partially caused by the elevated TP and BOD caused by human activities. Therefore, by addressing the critical parameters of TP and BOD, anthropogenically induced depression of dissolved oxygen should be ameliorated.

Chapter 4: ASSESSMENT OF SOURCES

4.1 Types of Sources

An important part of the TMDL analysis is the identification of pollutant source categories, source subcategories, or individual sources of the pollutant of concern in the target watershed and the amount of pollutant loading contributed by each of these sources. Sources are broadly classified as either "point sources" or "nonpoint sources." Historically, the term point sources has meant discharges to surface waters that typically have a continuous flow via a discernable, confined, and discrete conveyance, such as a pipe. Domestic and industrial wastewater treatment facilities (WWTFs) are examples of traditional point sources. In contrast, the term "nonpoint sources" was used to describe intermittent, rainfall-driven, diffuse sources of pollution associated with everyday human activities, including runoff from urban land uses, agriculture, silviculture, and mining; discharges from failing septic systems; and atmospheric deposition.

However, the 1987 amendments to the Clean Water Act redefined certain nonpoint sources of pollution as point sources subject to regulation under the EPA's NPDES Program. These nonpoint sources included certain urban stormwater discharges, including those from local government master drainage systems, construction sites over five acres, and a wide variety of industries (see **Appendix A** for background information on the federal and state stormwater programs).

To be consistent with Clean Water Act definitions, the term "point source" is used to describe traditional point sources (such as domestic and industrial wastewater discharges) **AND** stormwater systems requiring an NPDES stormwater permit when allocating pollutant load reductions required by a TMDL (see **Section 6.1** on **Expression and Allocation of the TMDL).** However, the methodologies used to estimate nonpoint source loads do not distinguish between NPDES and non-NPDES stormwater discharges, and as such, this source assessment section does not make any distinction between the two types of stormwater.

4.2 Potential Sources of Nutrients and BOD in the part of the USJRB that discharges to the studied waterbodies

4.2.1 Point Sources

4.2.1.1 Wastewater Point Sources

Eight NPDES permitted facilities were identified in the parts of the USJRB that discharge to the studied waterbodies. These include Paul Calcaterra Alligator Farm (FL0174696), Macho Products, Inc. (FLRNEE078), Melbourne/Joe Mullins DC (FL0043443), Melbourne Potable Water Plant (Well Flushing), BCUD/South Central Regional WWTF (FL0102679), Cemex/Melbourne Concrete Batch Plant (FLG110186), BRP US Inc. (FLRNEE370), and Larson Dairy-Barn (FLA139254). Most of these facilities do not discharge a significant amount of phosphorus or BOD to surface waters due to the nature of the business or the treatment system. For example, Macho Products, Inc. primarily produces plastic foam products. The facility has a Generic Permit that does not require routine monitoring. Other facilities having generic permits include Cemex/Melbourne Concrete Batch Plant and BRP US Inc. BRP is a commercial test laboratory. Neither of these permits require routine effluent monitoring. Larson Dairy Barn is a dairy farm, and the effluent from this facility is disposed through spray irrigation (land application), which results in zero discharge to surface waters. The Melbourne Potable Water Plant only discharges groundwater for the purpose of testing the performance of wells. The discharge from the facility is occasional and therefore is negligible. In addition, the facility is not required to routinely monitor TP and BOD concentration of its discharge. The Paul Calcaterra Alligator Farm has a similar situation as the permit only allows conditional discharges in excess of the 10-year/24-hour storm. The threshold rainfall depth for this type of storm is established at 7.5 inches for any one day, or 10 inches for any three consecutive days. This is a very rare event and routine discharge from the facility is negligible.

The only facility that discharges a significant load of nutrients or BOD to any of the studied waterbodies is the BCUD/South Central Regional WWTF. This facility is owned by the City of Melbourne and is located to the north of Lake Washington and Southwest of Lake Winder. The facility has a design capacity of 5.5 MGD and currently uses a Bardenpho activated sludge advanced wastewater treatment (AWT) system. The majority of the treated water is reclaimed and used for on-site irrigation at the plant and irrigation of residential lawns, parks, cemeteries, golf courses, highway medians/shoulders, and other landscape areas within the Reuse Service Area. A remaining 2.5 MGD annual average daily flow is permitted to discharge from a created wetland to the 4-Mile Canal to Lake Winder and then to St. Johns River. This facility would not impact the water quality in LHB and SJRASGL because they are located upstream of the facility. However, discharge form this facility could influence the water quality of SJRALP.

Table 4.1 lists the annual average discharge, TP and BOD concentrations of the discharge, and annual TP and BOD loadings from BCUD/South Central Regional WWTF.

Table 4.1. Annual TP and BOD loadings from BCUD/South Central Regional WWTF

Year	Annual average flow (MGD)	Annual average TP concentration (mg/L)	Annual average BOD concentration (mg/L)	Total annual TP loading (tons/year)	Total annual BOD loading (tons/year)
2001	0.008	0.10	2.50	0.001	0.028
2002	0.202	0.05	3.60	0.014	1.005
2003	0.165	0.10	3.30	0.023	0.752
2004	0.071	0.02	1.04	0.002	0.102
Mean	0.110	0.07	2.61	0.010	0.472

As discussed in the following chapters, the annual TP and BOD loadings into the SJRALP for the existing condition are about 140 and 2,964 tons/year, respectively. TP and BOD loadings from BCUD/South Central Regional WWTF are negligible compared to the total TP and BOD loadings into the studied waterbody.

4.2.1.2 Municipal Separate Storm Sewer System Permittees

Within the USJRB, the stormwater collection systems owned and operated by Seminole and Orange Counties and those systems owned by DOT within Seminole and Orange Counties are covered by an NPDES MS4 Phase I permit. The other counties that are part of the USJRB, including Volusia, Osceola, Brevard, Indian River, and Okeechobee counties, all hold Phase II MS4 permits.

4.2.2 Nonpoint Sources

The majority of the TP and BOD loadings to the USJRB come from nonpoint sources, including surface runoff, groundwater input, nutrient sediment release, and atmospheric deposition directly on to the surface of studied waters, especially on to the surface of lakes.

4.2.2.1 Land Uses

Surface runoff could be a very important source of pollutants in the basin. The amount of surface runoff and pollutant concentrations of the surface runoff are significantly influenced by the landuse types of the basin. The landuses of the part of the USJRB that discharges to the studied waterbodies were classified based on the Level 1 Florida Land Use, Cover and Forms Classification System (FLUCCS) using the SJRWMD's 2000 landuse GIS coverage (**Table 4.2**). **Figure 4.1** shows the spatial distribution of landuse types across the basin area that discharges to the studied waters.

Table 4.2. Classification of land use categories in the project area of the USJRB

Land Use	Acreage	Percent
Urban and Built-Up	45759	5%
Agriculture	361715	43%
Rangeland	81133	10%
Upland Forest	61145	7%
Water	36401	4%
Wetlands	244249	29%
Barren Land	5128	1%
Transportation, Communication, and Utilities	5322	1%
Total	840852	100%

The part of the basin area that discharges to waterbodies covered in this study is about 840,852 acres. Agriculture has the highest acreage among all the landuse types (361,715 acres), which accounts for about 43% of the total studied area (**Table 4.2**). Improved pastures appeared to be the dominant agriculture landuse type, which accounts for about 62% of the total agriculture landuse (**Table 4.3**). Based on the FLUCCS, Improved Pastures is defined as the landuse category "in most cases composed of land which has been cleared, tilled, reseeded with specific grass types and periodically improved with brush control and fertilizer application." The

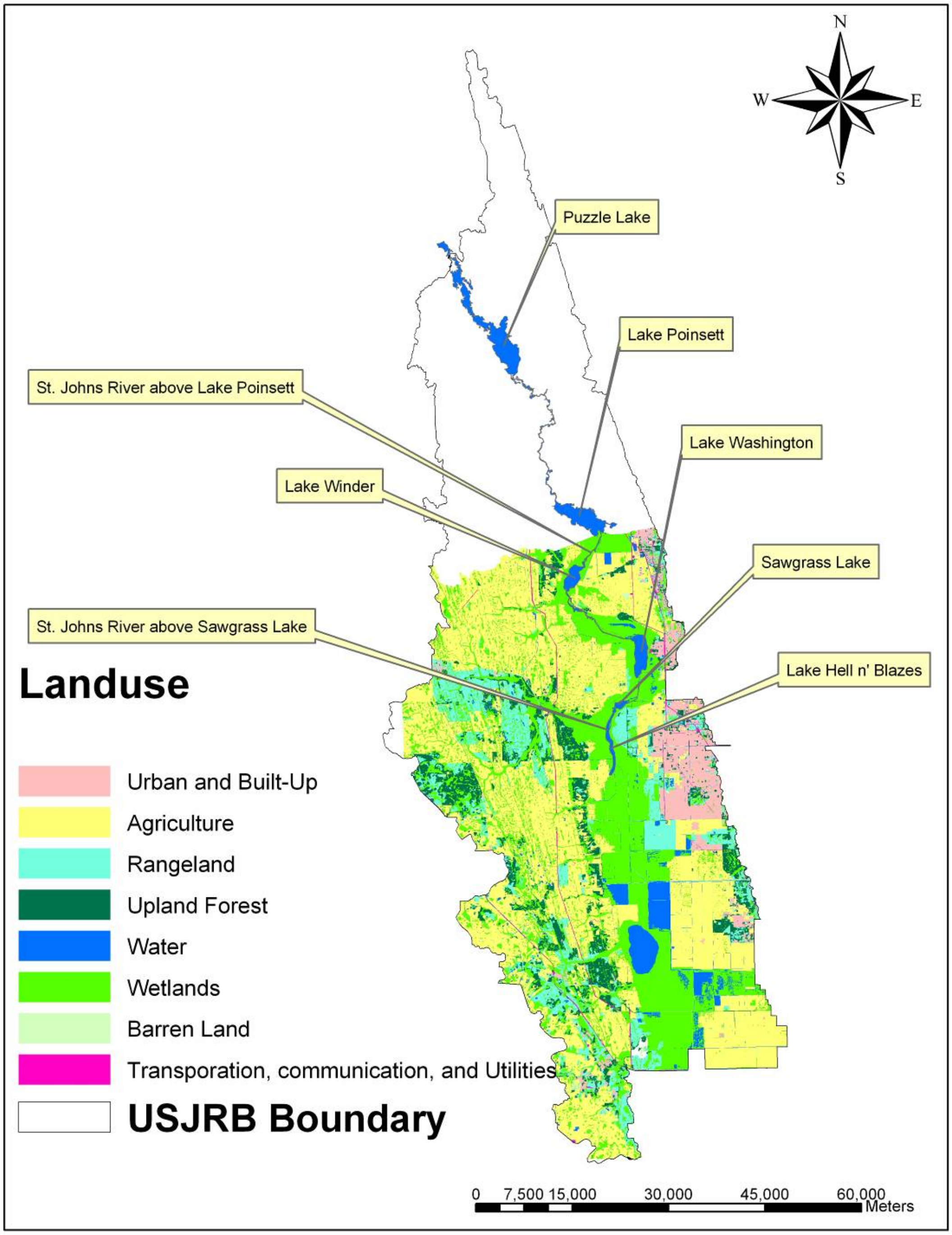

Figure 4.1. Principal landuse types in the part of the USJRB that discharge to studied waterbodies.

modified soil structure and the fertilizer application of this landuse type could contribute significant amounts of nutrients and BOD to ambient waters through surface runoff.

Table 4.3. Major agricultural practices in the part of the USJRB that discharge to studied waterbodies

Landuse	Acreage	Percent acreage
2110: Improved pastures (monoculture, planted forage crops)	223854	61.89%
2120: Unimproved pastures	44152	12.21%
2130: Woodland pastures	15733	4.35%
2140: Row crops	1210	0.33%
2150: Field crops	11814	3.27%
2160: Mixed crop	59	0.02%
2200: Tree crops	104	0.03%
2210: Citrus groves	59069	16.33%
2240: Abandoned tree crops	329	0.09%
2300: Feeding operations	11	0.00%
2310: Cattle feeding operations	687	0.19%
2320: Poultry feeding operations	9	0.00%
2410: Tree nurseries	88	0.02%
2420: Sod farms	4040	1.12%
2430: Ornamentals	43	0.01%
2500: Specialty farms	65	0.02%
2510: Horse farms	25	0.01%
2520: Dairies	160	0.04%
2540: Aquaculture	238	0.07%
2610: Fallow cropland	27	0.01%
Total	361715	100.00%

Another important agriculture landuse is citrus groves, which account for about 16% of the agriculture landuse. Areas used for citrus are usually intensively managed, and nutrient and BOD loadings from these areas could be substantial.

About 29% (244,249 acres) of the studied area are wetlands. Although wetlands can help to remove pollutant loadings from the human landuse categories, decay of wetland aquatic plants, oxygen consumption from the organic materials accumulated at the bottom, and a consistent supply of humic organic carbon from these areas can significantly contribute to the naturally low DO condition in the USJR.

The USJRB is not extensively urbanized. The urban and built-up landuse area only account for about 5% of the total studied basin area. However, human landuse categories, which include urban and built-up, agriculture, rangeland, and roads, occupy about 59% of the total studied area, while the natural landuses, including upland forest, barren land, waters, and wetlands account for about 41% of the basin area.

Based on an analysis conducted by USEPA on the per acre TP loadings for different landuses in the USJRB (EPA 2004), TP loading (and percent TP loading) from each landuse category in the basin were estimated and listed in **Table 4.4**. These numbers, while not used in establishing the final TMDL, provide a general picture of the relative TP contribution from different sources.

Table 4.4. TP annual loads from different landuse categories in basin areas that discharge to studied waterbodies

Land Use	Acreage	Unit load** (lbs/acre/year)	Annual load (lbs/year)	Percent contribution
Urban and Built-Up	45759	1.44	65893	6.3%
Agriculture	361715	2.11	763219	73.4%
Rangeland	81133	0.32	25963	2.5%
Upland Forest	61145	0.45	27515	2.6%
Water	36401	0.68	24753	2.4%
Wetlands	244249	0.49***	119682	11.5%
Barren Land	5128	0.25	1282	0.1%
Transportation, Communication, and Utilities	5322	2.1	11176	1.1%
Total	840852		1039482	100.0%

**: These values were from an analysis conducted by USEPA for TMDLs in the USJRB (USEPA 2004)
***: Per acre TP loading for wetland area was cited from Harper (1994).

Per acre TP loadings for different landuses were from an analysis conducted by USEPA for several TMDLs within the USJRB (USEPA 2004). According to EPA, these values were derived using the Pollutant Load Screening Model (PLSM) and runoff coefficients (RCs) and Event Mean Concentrations (EMCs) calibrated in the Indian River Lagoon basin, which is east of the USJRB. In this model, the wetland TP EMC was assumed to be zero, possibly because wetlands have the capability to remove the TP loadings of human origin. Based on EPA's per acre TP loading values, the total amount of TP created in the part of the USJRB that discharge to studied waterbodies is about 919,801 lbs/year (417 tons/year). The majority of this loading comes from agriculture areas, which represent about 73.4% of the TP that discharge to studied waterbodies. While the Department suggests caution when interpreting EPA's results because of the extremely low (0%) contribution from wetland areas, the analysis points out that agriculture accounts for about 88% of the 866,251lbs/year TP contributed by human sources (including Urban and Built-up, Agriculture, Rangeland, and Transportation, Communication, and Utilities). This suggests that agriculture should be the focus for phosphorus loading control in the part of the basin area that discharges to studied waterbodies.

4.2.2.2 Estimating TP and BOD loadings under existing conditions

Annual TP and BOD loadings to the studied waters under existing conditions were calculated by aggregating the monthly TP and BOD loadings. Monthly loadings were estimated by multiplying monthly TP (Keenan et al. 2003, EPA 2004) and BOD concentrations with the average monthly flow. In this study, mean total monthly flows were calculated using validated flow measurements obtained between 1996 and 2002 from three USGS gauging stations (Station 02232000, Station 02231600, and Station 02232400). **Table 4.5** identifies the stations and calculations used to determine flows to the studied waterbodies. **Figure 4.2** shows the locations of these gauging stations in the basin.

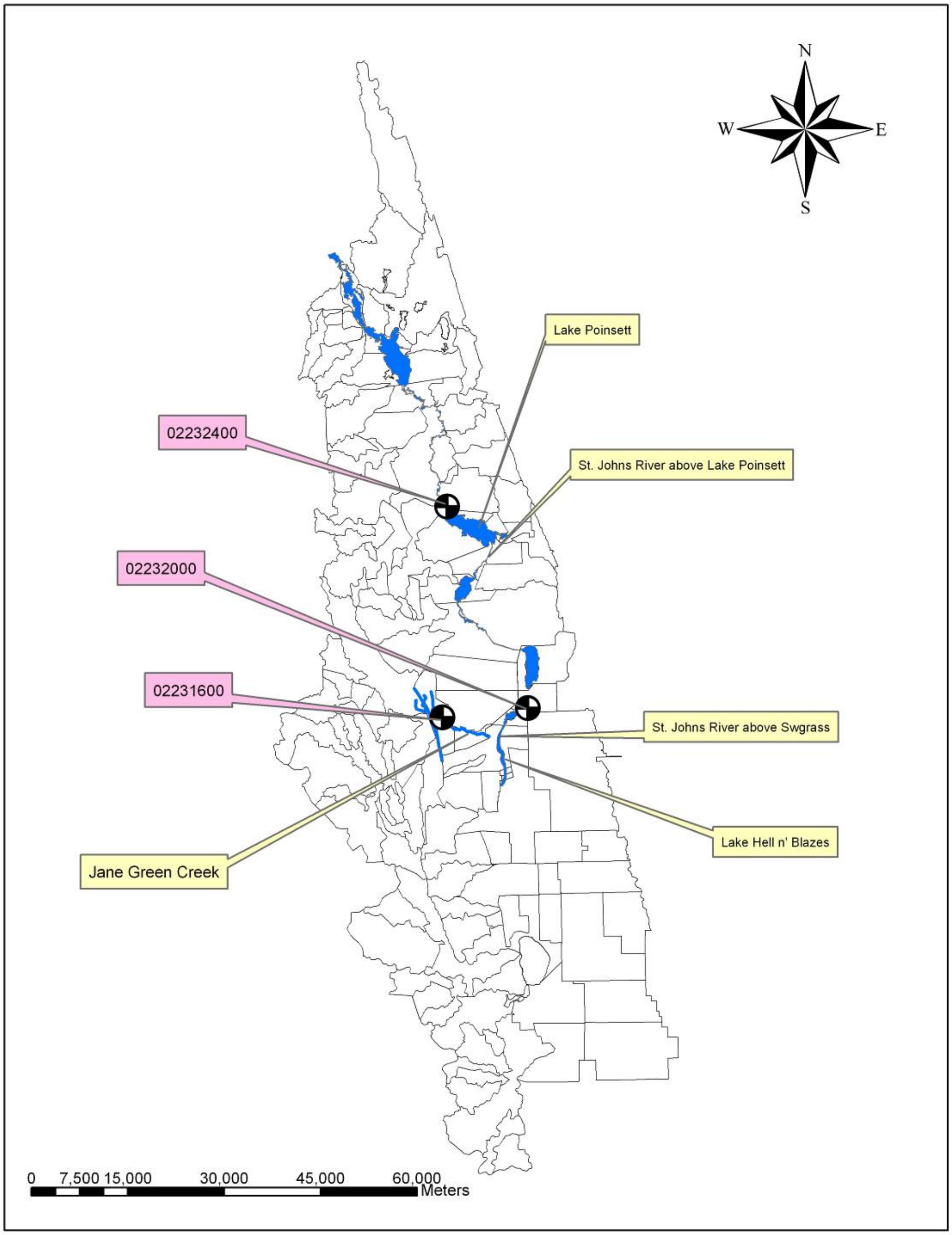

Figure 4.2. Locations of the three USGS gauging stations used in this study to calculate the inflow to studied waterbodies

Table 4.5. USGS gauging stations used to calculate annual average inflow to studied waterbodies

Waterbody	Inflow volume
Lake Hell n' Blazes	Flow at 02232000 minus flow at 02231600
St. Johns River above Sawgrass Lake	Flow at 02232000
St. Johns River above Lake Poinsett	Flow at 02232400

Station 02232000 is located on the main river channel downstream of Sawgrass Lake, which receives water from LHB and the SJRASGL. Station 02231600 is a tributary station located on Jane Green Creek. This stream discharges into the main channel downstream of LHB and upstream of Sawgrass Lake, i.e. the river segment designated as the SJRASGL in this study. The inflow to LHB was calculated as the difference between the flow measured at 02232000 and 02231600 (Table 4.3). Because Jane Green Creek flows into the main channel in the middle of the SJRASGL, the flows measured at 02232000 were used as the flow for this waterbody. This may overestimate the actual flow into the SJRASGL considering the surface runoff discharge directly into Sawgrass Lake and the river segment between Sawgrass Lake and station 02232200. But since the basin area discharging to the river segment downstream of the outlet of SJRASGL and station 02232200 is negligible comparing to the total basin area that discharges to 02232000, the overestimation of the flow to the SJRASGL using this method should be negligible.

Station 02232400 is located at the outlet of Lake Poinsett. Using flow measurements from this gauging station as the surrogate for the inflow of the SJRALP could cause some overestimation considering the surface runoff directly to Lake Poinsett. However, the basin area immediately connected to Lake Poinsett is insignificant when compared to the total basin area that discharges to 02232400, and as such, the flow overestimation for SJRALP using measurements from 02232400 should be negligible.

The monthly TP loadings under existing conditions were calculated by multiplying the mean monthly TP concentrations by the monthly inflows into the studied waters. To avoid the load underestimation that may be caused by TP sedimentation within a given waterbody, TP concentrations at the inlet and outlet of the waterbody were analyzed. If the TP concentration at the outlet of the waterbody was significantly lower than the inlet concentration, only the inlet TP concentration was used in calculating the TP loading into the waterbody. For example, the inlet and outlet TP concentrations of LHB were significantly different. Therefore, when calculating the TP loading into this lake, only the monthly mean TP concentrations at the inlet of the lake were used.

If the TP concentration of a given waterbody was significantly lower than the TP concentration at the outlet of its immediate upstream waterbody, the TP concentration at the outlet of the upstream waterbody was used to calculate the TP loading into the waterbody under question. For example, the TP concentration for the SJRASGL was significantly lower than the TP concentration at the outlet of the waterbody immediately upstream of this water segment (the LHB). Therefore, when calculating the TP loading into the SJRASGL, the TP concentration at the outlet of LHB was used. If the inlet and outlet TP concentrations were not significantly different, the TP concentration across the entire length of the water segment was used to include more data points for the calculation. This approach was used to calculate the monthly TP concentrations of the SJRALP.

Mean monthly TP concentrations were calculated using the data retrieved from the Department's IWR database. The periods of record used for the calculations were between 1995 and 2002. Mean monthly TP concentrations calculated for different years were then averaged to get the long-term monthly averages for each waterbody. Long-term monthly average TP concentrations were then multiplied by the long-term monthly flows to obtain the month TP loadings. Monthly TP loadings were further aggregated to calculate the annual TP loadings into the studied waters.

It should be noted that the Department did not use Vollenweider's model (Vollenweider and Kerekes, 1980) to estimate the TP loading based on the TP concentration and total flow to the studied waterbodies. This was due to the lack of unequivocal sedimentation coefficients for the studied waterbodies. According to SJRWMD, sediment core studies were conducted in Lake Hell n' Blazes, Sawgrass Lake, and Lake Washington (Keenan et al. 2003). However, the annual TP depositions calculated using the core data were substantially different from the annual TP depositions calculated using the mass balance technique. This raised questions about which sedimentation coefficient should be used in TP loading estimation. In addition, water column TP can be removed through pathways other than pure deposition, for example, both floating macrophytes and submerged aquatic vegetation can remove phosphorus from the water column. Phosphorus removed in this way may not be reflected in the sediment core studies.

This appears to support the use of the sedimentation coefficients derived from the mass balance technique. However, using mass balance derived sediment coefficient raised another question: should the sediment coefficient derived based on the mass balance technique for existing conditions be used when calculating the target TP loadings? The answer could be no because the so-called "sedimentation coefficient" derived from the mass-balance technique is not exactly the sedimentation coefficient. It is the consequence of multiple TP removal pathways, including the pure sedimentation and nutrient removals by floating and submerged aquatic plants and periphyton and biofilm attached to the aquatic plants. The specific sedimentation coefficient may not change with the change of TP concentration of the water column. The TP removal from other pathways, however, will most likely change when the nutrient availability changes. In addition, sedimentation coefficients derived from mass balance techniques is a net deposition, which is the difference between gross deposition and sediment nutrient release. The gross deposition could be significantly different between existing condition and target condition and therefore cause significant changes on the net deposition. This could cause the change of even the specific sedimentation coefficient. Therefore, using the "sedimentation coefficient" derived from the existing condition using the mass-balance technique to predict the target TP loading may not be appropriate.

Sedimentation rates were not needed in this study because loading into each studied waterbody was calculated as the loading at the inlet of the waterbody if TP concentrations were found to be different between the inlet and outlet. This loading was not influenced by TP removal processes inside the waterbody and should approximate the actual loadings into studied waterbodies.

Table 4.6 shows the long-term mean monthly flow, long-term mean monthly TP concentrations, monthly TP loadings, and annual TP loadings under existing conditions.

Table 4.6 Long-term mean monthly flow (ac-ft/month), long-term mean monthly TP concentration (mg/L), monthly TP loading (tons/month), and annual total TP loading (tons/year)

Month	LHB (WBID 2893Q)			SJR_above_SGL (WBID 2893 X)			SJR_above_LP (WBID 2893L)		
	Long-term Monthly flow	Long-term monthly average TP	Monthly TP loading	Long-term Monthly flow	Long-term monthly average	Monthly TP loading	Long-term Monthly flow	Long-term monthly average	Monthly TP loading
1	24138	0.13	4.0	30654	0.19	7.2	51266	0.09	6.0
2	21541	0.11	2.9	29401	0.19	6.7	45190	0.10	5.8
3	21740	0.15	4.1	31533	0.16	6.3	52631	0.12	7.6
4	25898	0.19	6.0	29880	0.09	3.1	39343	0.14	6.8
5	12352	0.19	2.9	12772	0.13	2.1	21807	0.11	3.0
6	10801	0.27	3.6	12485	0.31	4.7	14913	0.11	2.0
7	39226	0.29	13.9	50251	0.12	7.4	60064	0.18	13.1
8	59256	0.31	22.6	78359	0.09	8.9	94081	0.20	23.2
9	61201	0.17	12.4	74830	0.13	12.1	109974	0.19	26.1
10	59542	0.15	11.1	78227	0.10	9.4	143678	0.15	26.8
11	38945	0.13	6.5	45546	0.13	7.1	98406	0.10	12.4
12	25939	0.10	3.3	39202	0.19	9.0	68818	0.09	7.5
Annual total	400578		93	513141		84	800173		140

BOD measurements were only available for the SJRALP and SJRASGL. These measurements were all taken in the 2003, usually once every quarter of the year. Therefore, BOD loading under existing conditions was only calculated for these two waterbodies. No monthly mean BOD concentrations were calculated due to the lack of monthly BOD measurements for every month of the year. BOD annual loading was calculated by multiplying the annual average BOD concentrations by the annual flows into these two waterbodies (**Table 4.7**).

Table 4.7. Annual BOD loadings into studied waterbodies

Waterbodies	St. Johns River above Sawgrass (WBID 2893 X)	St. Johns River above Lake Poinsett (WBID 2893L)
Annual average BOD concentration (mg/L)	3.19	3.01
Long-term annual average flow (ac-ft/y)	513141	800173
BOD annual loading (tons/year)	2013	2964

Chapter 5: DETERMINATION OF ASSIMILATIVE CAPACITY

5.1 Overall Approach

The goal of TMDL development for the waterbodies covered in this study is to identify the maximum allowable TP and BOD loadings to these waterbodies so that they will meet water quality standards and maintain their designated uses as Class I and III waters. As discussed in Chapter 3, the target TP concentrations of 0.09 mg/L proposed by the SJRWMD addresses the nutrient impairments in these waters through controlling the development of blue-green algal blooms. Based on the correlation analyses between DO and TP concentrations in USJRB waters, it appears that any decreases in in-stream DO levels caused by TP of human origin should also be addressed if TP concentrations are reduced to 0.09 mg/L. In addition, based on the spatial distribution of DO and BOD concentrations in the USJRB, it appears that BOD of human origin could be another factor that controls the DO concentration in the basin. As the long-term average DO concentrations in most of the waterbodies located in the northern part of the basin are above 5.0 mg/L and BOD concentration in these waters were close to or lower than 2.0 mg/L, 2.0 mg/L was established as the target BOD concentration in this study. The target reductions for TP and BOD loadings were calculated based on these target concentrations.

5.2 Estimating the target TP and BOD loadings

Target TP and BOD loadings into each waterbody were estimated by multiplying 0.09 mg/L TP and 2.0 mg/L BOD by the annual flow into each waterbody. Since no sedimentation was considered using this approach, the estimated TMDLs could be lower than the TP and BOD loadings that can be assimilated in studied waters. This makes the TMDL estimate more conservative and therefore adds to the margin of safety. **Table 5.1** lists TP and BOD loadings under existing conditions, target TP and BOD loadings, and the percent reduction required to achieve target TP and BOD loadings.

Table 5.1. Existing and target loadings for TP and BOD and percent load reduction required to achieve the target loadings.

Parameter	TP			BOD	
Waterbodies	Lake Hell n' Blazes (WBID 2893Q)	St. Johns River above Sawgrass (WBID 2893 X)	St. Johns River above Lake Poinsett (WBID 2893L)	St. Johns River above Sawgrass (WBID 2893 X)	St. Johns River above Lake Poinsett (WBID 2893L)
Existing annual loading (tons/year)	93	84	140	2013	2964
Target annual loading (tons/year)	44	57	89	1264	1970

Percent reduction required	52%	32%	37%	37%	34%

The target TP loadings for LHB (WBID 2893Q), SJRASGL (WBID 2893X), and SJRALP (WBID 2893L) are 44, 57, and 89 tons/year, respectively. These target loadings represent about a 52%, 32%, and 37% reduction from the TP loadings under the existing condition. The target BOD loadings are 1264 and 1970 tons for the SJRASGL and SJRALP, respectively. These target loadings represent about a 37% and 34% reduction from the BOD loadings into these waterbodies under existing condition.

Chapter 6: DETERMINATION OF THE TMDL

6.1 Expression and Allocation of the TMDL

The objective of a TMDL is to provide a basis for allocating acceptable loads among all of the known pollutant sources in a watershed so that appropriate control measures can be implemented and water quality standards achieved. A TMDL is expressed as the sum of all point source loads (Waste Load Allocations, or WLAs), nonpoint source loads (Load Allocations, or LAs), and an appropriate margin of safety (MOS), which takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

$$\text{TMDL} = \sum \text{WLAs} + \sum \text{LAs} + \text{MOS}$$

As discussed earlier, the WLA is broken out into separate subcategories for wastewater discharges and stormwater discharges regulated under the NPDES Program:

$$\text{TMDL} \cong \sum \text{WLAs}_{\text{wastewater}} + \sum \text{WLAs}_{\text{NPDES Stormwater}} + \sum \text{LAs} + \text{MOS}$$

It should be noted that the various components of the revised TMDL equation may not sum up to the value of the TMDL because 1) the WLA for NPDES stormwater is typically based on the percent reduction needed for nonpoint sources and is also accounted for within the LA, and 2) TMDL components can be expressed in different terms (for example, the WLA for stormwater is typically expressed as a percent reduction, and the WLA for wastewater is typically expressed as mass per day).

WLAs for stormwater discharges are typically expressed as “percent reduction” because it is very difficult to quantify the loads from MS4s (given the numerous discharge points) and to distinguish the loads from MS4s from other nonpoint sources (given the nature of stormwater transport). The permitting of stormwater discharges also differs from the permitting of most wastewater point sources. Because stormwater discharges cannot be centrally collected, monitored, and treated, they are not subject to the same types of effluent limitations as wastewater facilities, and instead are required to meet a performance standard of providing treatment to the “maximum extent practical” through the implementation of BMPs.

This approach is consistent with federal regulations (40 CFR § 130.2[I]), which state that TMDLs can be expressed in terms of mass per time (e.g., pounds per day), toxicity, or **other appropriate measure**. TMDLs for the USJR waterbodies covered in this study are expressed in terms of tons per year (tons/year) and percent reduction of TP and BOD, and represent the maximum long-term annual average TP and BOD loadings each waterbody can assimilate and maintain a balanced aquatic flora and fauna **(Table 6.1).** Because TP and BOD loadings from point sources in the basin are several orders of magnitude lower than the final TMDLs, and the only major discharger, SCUD/South Central Regional WWTF, is currently at AWT, it is reasonable to allow the facility to discharge at its current loading rate..

Table 6.1. TMDL components for waterbodies covered in this study

WBID	Parameter	TMDL (tons/year)	$WLA_{wastewater}$ (tons/year)	$WLA_{NPDES\ Stormwater}$	LA	MOS
2893L	TP	89	0.023	37%	37%	Implicit
2893L	BOD	1970	1.0	34%	34%	Implicit
2893Q	TP	44	N/A	52%	52%	Implicit
2893X	TP	57	N/A	32%	32%	Implicit
2893X	BOD	1264	N/A	37%	37%	Implicit

6.2 Load Allocation

Because TP and BOD loadings from wastewater dischargers were orders of magnitude lower than the nonpoint loadings, the TMDLs for TN and TP were primarily assigned to the LA (and, as discussed below, to the MS4 as well). The long-term annual average LAs for TP into SJRALP, LHB, and SJRASGL are 89, 44 and 57 tons/year, respectively. The long-term annual LAs for BOD into SJRALP and SJRASGL are 1,970 and 1,264 tons/year, respectively. Nonpoint sources (including the loadings from MS4 stormwater) are responsible for almost all these loadings. The current long-term annual average TP loadings into the SJRALP, LHB, and SJRASGL are 140, 93, and 84 tons/year, respectively. The current long-term annual BOD loadings into SJRALP and SJRASGL are 2,964 and 2,013 tons/year, respectively. These figures include the loadings from all the possible sources including surface runoff, groundwater input, and sediment nutrient release.

To achieve the LA, current TP loadings into SJRALP, LHB, and SJRASGL require a 37%, 52%, and 32% reduction, respectively. BOD loadings into SJRALP and SJRASGL require a 34% and 37% reduction, respectively. The load reductions need to apply to primarily to the surface runoff, especially to the runoff from agriculture areas.

6.3 Wasteload Allocation

6.3.1 National Pollutant Discharge Elimination System Wastewater Discharges

The only major discharger of TP and BOD, BCUD/South Central Regional WWTF, is located downstream of LHB and SJR_above_SGL and therefore will not influence the water quality of these river segments. In addition, the facility is currently on AWT and reclaims most of its treated wastewater. TP and BOD loadings from the facility to the only downstream river segment, the SJR_above_LP, is orders of magnitude lower than nonpoint source loadings from the watershed and will not cause significant impact on the water quality of the SJR_above_LP. Therefore, it is recommended that the facility keep its current discharge loadings and no load reduction is recommended in this study. The wasteload allocations assigned to this facility are 0.023 tons TP/year and 1.0 tons BOD/year (Table 6.1). These were the highest loads produced by this facility based on data from 2001 through 2004 (Table 4.1).

6.3.2 National Pollutant Discharge Elimination System Stormwater Discharges

Because no information was available to the Department at the time this study was conducted regarding the boundaries and locations of all the NPDES stormwater dischargers, the exact stormwater TP and BOD loadings from MS4 areas were not explicitly estimated. The USJRB covers parts of Seminole, Orange, Volusia, Osceola, Brevard, Indian River, and Okeechobee Counties. Among these counties, Seminole and Orange counties are lead permittees for Phase I MS4 permits that cover the stormwater facilities owned and operated by these counties. DOT is the co-permittee for Phase I permit in both of these two counties. Volusia, Osceola, Brevard, Indian River, and Okeechobee counties do not have Phase I MS4 permits. Within the basin area that discharge to studied waterbodies, the stormwater collection systems owned and operated by Osceola, Brevard, Indian River, and Okeechobee counties and the Florida DOT are covered by MS4 Phase II permits. The $WLA_{NPDESStormwater}$ was set as the same percent reduction required to achieve the TMDL as for the other conventional nonpoint sources, which are a 37%, 52%, and 32% for TP loadings into SJRLP, LHB, and SJRASGL, respectively, and 34% and 37% for BOD loadings into SJRALP and SJRASGL.

6.4 Margin of Safety

Consistent with the recommendations of the Allocation Technical Advisory Committee (Florida Department of Environmental Protection, February 2001), an implicit MOS was used in the development of this TMDL. An implicit MOS was provided by the conservative decisions associated with a number of modeling assumptions, the development of site-specific alternative water quality targets, and the development of the assimilative capacity, which did not account for in-stream losses of TP or BOD.

This study estimated pollutant loadings by multiplying the pollutant concentrations by the flow. This process addresses the pollutant loadings that eventually reach studied waters after the attenuation during the overland transport. TMDLs estimated using this method could be significantly lower than the pollutant loadings that would be allowed to generate in the watershed, and are therefore very conservative and adds to the implicit margin of safety. In addition, estimating the TMDLs by multiplying the target concentrations by the flow could produce lower TMDL estimates than using the Vollenweider model because the multiplication method does not take into consideration of the part of assimilative capacity resulted from the pollutant deposition. The multiplication method not only makes the TMDL estimation more conservative, but also increases the percent load reduction requirement, which adds to the margin of safety of this TMDL.

Chapter 7: NEXT STEPS: IMPLEMENTATION PLAN DEVELOPMENT AND BEYOND

7.1 Basin Management Action Plan

Following the adoption of this TMDL by rule, the next step in the TMDL process is to develop an implementation plan for the TMDL, referred to as the BMAP. This document will be developed over the next two years in cooperation with local stakeholders, who will attempt to reach consensus on detailed allocations and on how load reductions will be accomplished. The BMAP will include, among other things:

- Appropriate load reduction allocations among the affected parties,
- A description of the load reduction activities to be undertaken, including structural projects, nonstructural BMPs, and public education and outreach,
- A description of further research, data collection, or source identification needed in order to achieve the TMDL,
- Timetables for implementation,
- Confirmed and potential funding mechanisms,
- Any applicable signed agreement(s),
- Local ordinances defining actions to be taken or prohibited,
- Any applicable local water quality standards, permits, or load limitation agreements,
- Milestones for implementation and water quality improvement, and
- Implementation tracking, water quality monitoring, and follow-up measures.

An assessment of progress toward the BMAP milestones will be conducted every five years, and revisions to the plan will be made as appropriate, in cooperation with basin stakeholders.

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Appendices

Appendix A: Background Information on Federal and State Stormwater Programs

In 1982, Florida became the first state in the country to implement statewide regulations to address the issue of nonpoint source pollution by requiring new development and redevelopment to treat stormwater before it is discharged. The Stormwater Rule, as authorized in Chapter 403, F.S., was established as a technology-based program that relies on the implementation of BMPs that are designed to achieve a specific level of treatment (i.e., performance standards) as set forth in Chapter 62-40, F.A.C. In 1994, the Department's stormwater treatment requirements were integrated with the stormwater flood control requirements of the state's water management districts, along with wetland protection requirements, into the Environmental Resource Permit regulations.

Chapter 62-40, F.A.C., also requires the water management districts to establish stormwater pollutant load reduction goals (PLRGs) and adopt them as part of a SWIM plan, other watershed plan, or rule. Stormwater PLRGs are a major component of the load allocation part of a TMDL. To date, stormwater PLRGs have been established for Tampa Bay, Lake Thonotosassa, the Winter Haven Chain of Lakes, the Everglades, Lake Okeechobee, and Lake Apopka. No PLRG had been developed for Newnans Lake when this report was published.

In 1987, the U.S. Congress established Section 402(p) as part of the federal Clean Water Act Reauthorization. This section of the law amended the scope of the federal NPDES permitting program to designate certain stormwater discharges as "point sources" of pollution. The EPA promulgated regulations and began implementing the Phase I NPDES stormwater program in 1990. These stormwater discharges include certain discharges that are associated with industrial activities designated by specific standard industrial classification (SIC) codes, construction sites disturbing 5 or more acres of land, and master drainage systems of local governments with a population above 100,000, which are better known as municipal separate storm sewer systems (MS4s). However, because the master drainage systems of most local governments in Florida are interconnected, the EPA implemented Phase I of the MS4 permitting program on a countywide basis, which brought in all cities (incorporated areas), Chapter 298 urban water control districts, and the Florida Department of Transportation throughout the 15 counties meeting the population criteria. The Department received authorization to implement the NPDES stormwater program in 2000.

An important difference between the federal NPDES and the state's stormwater/environmental resource permitting programs is that the NPDES Program covers both new and existing discharges, while the state's program focuses on new discharges only. Additionally, Phase II of the NPDES Program, implemented in 2003, expands the need for these permits to construction sites between 1 and 5 acres, and to local governments with as few as 1,000 people. While these urban stormwater discharges are now technically referred to as "point sources" for the purpose of regulation, they are still diffuse sources of pollution that cannot be easily collected and treated by a central treatment facility, as are other point sources of pollution such as domestic and industrial wastewater discharges. It should be noted that all MS4 permits issued in Florida include a re-opener clause that allows permit revisions to implement TMDLs when the implementation plan is formally adopted.

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