FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

Division of Environmental Assessment and Restoration

CENTRAL DISTRICT • INDIAN RIVER LAGOON BASIN

Final TMDL Report

Nutrient TMDL for Goat Creek Marine Segment (WBID 3107A)

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April 9, 2013

Acknowledgments

This TMDL report was developed based on the Indian River Lagoon main stem seagrass nutrient TMDL, which was in turn developed based on the Pollutant Load Reduction Goal (PLRG) for seagrass restoration in the Indian River Lagoon (IRL) and Banana River Lagoon (BRL), created by the St. Johns River Water Management District (SJRWMD). We would like to sincerely thank Mr. Joel Steward and Mr. Whitney Green from SJRWMD, who developed the seagrass PLRG. In addition, during the process of developing this TMDL, both Dr. Phlips from University of Florida and Mr. Steward and Mr. Green provided very thoughtful analyses on possible causes of the observed elevation of chlorophyll a concentration in IRL and BRL in 2009-2011. Mr. Green also provided thorough explanations on questions from the Department about the structure of the PLSM watershed model and a latest delineation of the Goat Creek watershed. Special thanks also go to Ms. Virginia Barker and Mr. John Royal from Brevard County Natural Resource Management, who conducted a field survey and helped the Department answer the question whether several borrow pits that discharge into the impaired segment of Goat Creek were sources of elevated total phosphorus concentration in the impaired segment. The TMDL could not have been done without the kind help from all these individuals and entities.

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Websites

Florida Department of Environmental Protection, Bureau of Watershed Restoration

Total Maximum Daily Load Program

http://www.dep.state.fl.us/water/tmdl/index.htm

Identification of Impaired Surface Waters Rule

http://www.dep.state.fl.us/legal/Rules/shared/62-303/62-303.pdf

STORET Program

http://www.dep.state.fl.us/water/storet/index.htm

2012 305(b) Report

http://www.dep.state.fl.us/water/docs/2012_integrated_report.pdf

Criteria for Surface Water Quality Classifications

http://www.dep.state.fl.us/water/wqssp/classes.htm

Basin Status Reports and Water Quality Assessment Reports

http://www.dep.state.fl.us/water/tmdl/stat_rep.htm

U.S. Environmental Protection Agency

Region 4: Total Maximum Daily Loads in Florida
http://www.epa.gov/region4/water/tmdl/florida/
National STORET Program
http://www.epa.gov/storet/

Chapter 1: INTRODUCTION

1.1 Purpose of Report

This report presents the nutrient Total Maximum Daily Load (TMDL) for the marine segment of Goat Creek, located in the Indian River Lagoon (IRL) Basin. The waterbody was verified for nutrient impairment based on annual average corrected chlorophyll a (*ChlaC*) values that exceeded the historic minimum of 3.1 µg/L (calculated based on annual *ChlaC* values in 1999 – 2003) by more than 50% in two consecutive years (2009 and 2010). The waterbody was added to the Verified List of impaired waters for the IRL Basin by the Secretarial Order on February 7, 2012. The purpose of this TMDL is to establish allowable loads of nutrients to the marine segment of Goat Creek such that the waterbody will meet the applicable water quality criteria for nutrients.

1.2 Identification of the Waterbody

Goat Creek is located in southeast Brevard County, along the east central Florida Coast. The watershed of the creek is located immediately south of City of Malabar (**Figure 1.1**). Together with the Eau Gallie River, Crane Creek, and Turkey Creek to the north and Kid Creek and Trout Creek to the south, Goat Creek drains the part of the north central IRL basin that is physiographically designated as the Cocoa-Sebastian Ridge (Brooks, 1982). The Cocoa-Sebastian Ridge is part of the Atlantic Coastal Ridge, which is a series of old dune ridges that formed when the sea level was high (White, 1970). The ridge is parallel to the lagoon, and with the lagoon proper located to the east of the ridge, forms a narrow drainage basin that is mostly just a few miles wide in the west to east direction. Based on data collected during a 30-year period, from 1980 through 2010, at a weather station located at the Melbourne International Airport (Lat: 28.10 degree, Long: -80.64 degree), the long-term average rainfall was about 50.6 inches /year and the mean annual average air temperature was about 72.5 degree Fahrenheit (22.5^{0}C).

Goat Creek drains a watershed of about 7161acres (11 square miles). The watershed of the creek has a significant amount of wetland areas that are poorly drained. The dominant land cover types in watershed of the creek are natural lands such as rangeland, upland forest, and wetlands. The creek flows in a southwest to northeast direction. It was divided by the Department into a freshwater segment and marine segment with a dividing point roughly located at about 100 meters southwest of the junction of Duane Street and Lynn Street. The freshwater segment drains about 99% of the Goat Creek watershed. The immediate watershed area of the marine segment, which is about 0.8 miles long, is only about 1% of the total watershed area.

For assessment purposes, the Department has divided the IRL Basin into water assessment polygons with a unique **w**ater**b**ody **id**entification (WBID) number for each watershed or stream reach. The freshwater segment of Goat Creek is designated as WBID 3107B. The marine segment is designated as WBID 3017A. This TMDL report addresses nutrient impairment of the Goat Creek marine segment (WBID 3107A) in the IRL Basin. However, the nutrient target setting is applicable to the entire Goat Creek watershed. **Figure 1.2** shows the location of WBID 3017A and WBID 3017B in the Indian River Lagoon basin. These WBID boundaries define the segments of the creek in which the nutrient condition were assessed. The WBID boundaries do not necessarily match the watershed boundary of the creek.

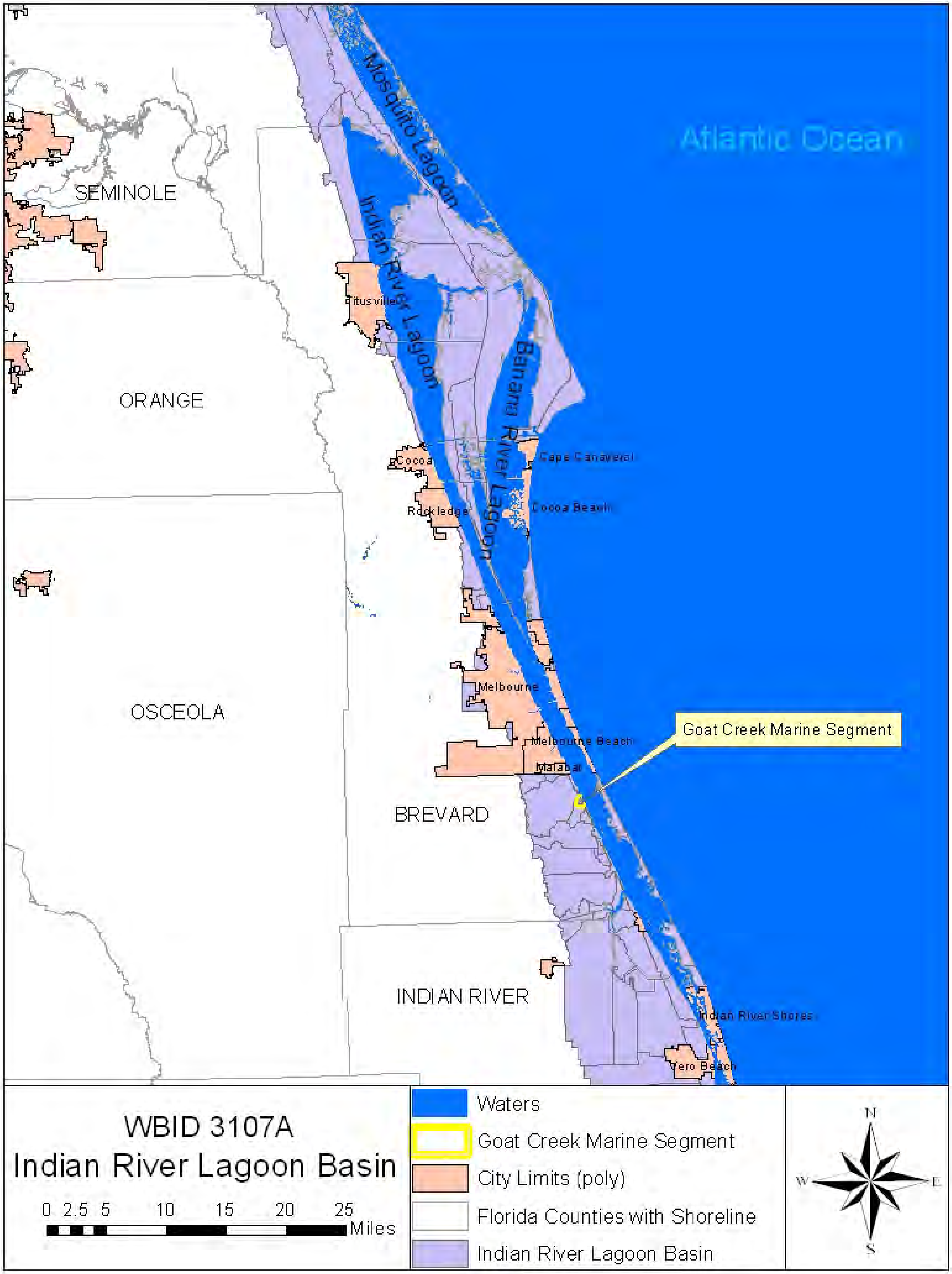

Figure 1.1. General Location of Goat Creek Marine Segment in the Indian River Lagoon Basin

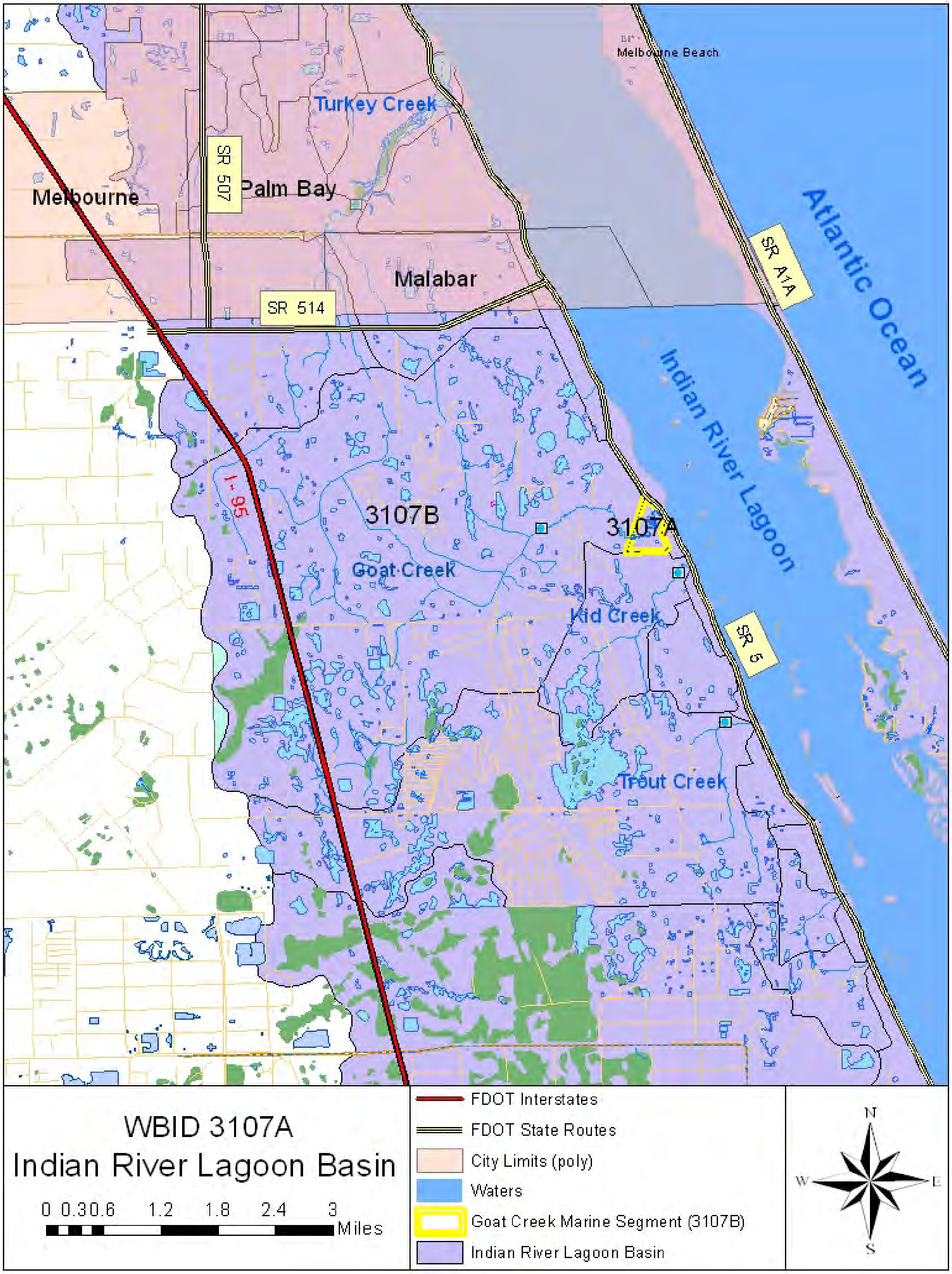

Figure 1.2. Goat Creek Freshwater Segment (WBID 3107B) and Marine Segment (WBID 3107A)

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 Florida Watershed Restoration Act (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 2009, the Department adopted a set of nutrient TMDLs for the IRL and Banana River Lagoon (BRL) mainstem segments to restore seagrass distribution in these lagoon segments (FDEP, 2009). These TMDLs were based on the Pollutant Load Reduction Goal (PLRG) developed by the SJRWMD (Steward et al. 2005). The Goat Creek watershed is part of the drainage basin that contributes nutrients to the IRL. Specifically, Goat Creek drains to segment IR-13 of the central IRL mainstem, part of a segmentation system used in SJRWMD's PLRG modeling. As the impaired segment is located at the mouth of the creek and is tidally influenced, its water quality condition is not only influenced by the nutrient loading from the Goat Creek watershed, but also by the water quality condition of the IRL mainstem segment. As discussed later in this report, based on measured water quality data, nutrient concentrations, especially the total phosphorus (TP) concentration of the upstream segment, have been consistently and significantly lower than the nutrient concentrations of the impaired marine segment throughout the history of the period of record. In addition, even when the marine segment showed elevated concentrations of *ChlaC* and TP in 2009 and 2010, which is a phenomenon observed at all sampling sites located in the IRL mainstem segment IR-13, the upstream freshwater segment showed no significant change in *ChlaC* and TP concentrations compared to historic data. Therefore, it is Department's understanding that the observed elevations in *ChlaC* and TP concentrations in 2009 and 2010 in the marine segment of the creek are more influenced by the physical, chemical, and biological processes happened in the lagoon proper than by elevated nutrient loading from the Goat Creek watershed. Achieving the nutrient loading targets established for the central IRL mainstem segments to restore seagrass distribution should help address the nutrient condition of the mouth of the creek. For now, the Department's Watershed Planning and Coordination Section is actively working with local stakeholders in the IRL basin to development a basin management action plan (BMAP) to implement the mainstem nutrient TMDLs. These activities will also help reduce the amount of nutrients from the watershed that could have at least partially caused the verified impairment of the creek. These activities will depend heavily on the active participation of the 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 Florida Watershed Restoration Act (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 16 waterbodies in the IRL Basin. 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 rule was modified in 2006 and 2007. 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

As described in the IWR, the primary tool for assessing the nutrient condition of an estuary is the annual average *ChlaC* concentration. A waterbody can be verified for nutrient impairment if the annual average concentration of the *ChlaC* exceeds the 11 µg/L assessment threshold during the verified period. A waterbody can also be verified for nutrient impairment if the annual average *ChlaC* concentration exceeds the historic minimum by more than 50% in two consecutive years during the verified period. The IWR also allows verifying nutrient impairment based on information other than *ChlaC* concentration. This other information includes, but not limited to, algal blooms, excessive macrophyte growth, decrease in the distribution (either in density or areal coverage) of seagrasses or other submerged aquatic vegetation, changes in algal species richness, and excessive diel oxygen swings, can be considered for verifying nutrient impairment. The state DO water quality criteria for predominant marine water is that the DO concentration shall not average less than 5.0 mg/L in a 24-hour period and shall never be less than 4.0 mg/L. Normal daily and seasonal fluctuations above these levels shall be maintained.

The Goat Creek marine segment, which was originally assigned a WBID number of 3107, was listed on the 1998 303(d) list for dissolved oxygen (DO) and nutrients impairment. During Department's Cycle 1 water quality assessments for Group 5 IRL Basin (based on *ChlaC* data collected in the period from January 1, 1999 through June 30, 2006), the nutrient impairment of the creek was delisted from the 1998 303(d) list because the annual average *ChlaC* concentration of the creek did not exceed the 11 µg/L assessment threshold in any year of the Verified Period. The WBID number of the marine segment of the creek was re-assigned as 3107A in Department's Cycle 2 water quality assessments for the IRL basin (based on *ChlaC* data collected in the period from January 1, 2004 through June 30, 2011). In the Cycle 2 assessment, although the annual average *ChlaC* concentration in no Verified Period year exceeded the 11 µg/L threshold, the annual *ChlaC* concentration exceeded the historic minimum (3.1 µg/L, based on data collected in the period from 1999 through 2003) by more than 50% in 2008, 2009 and 2010. The nutrient condition of the marine segment of the creek was therefore considered impaired. The waterbody was put on Department's Verified List adopted through a Secretarial Order signed on February 7, 2012. **Table 2.1** shows the assessment results that caused the waterbody to be verified for nutrient impairment. Based on a median TN/TP ratio of about 10, the phytoplankton communities of the creek appear to be phosphorus and nitrogen co-limited, but are, generally, more limited by nitrogen. The DO concentration of the creek segment was found lower than the daily average of 5.0 mg/L and the 4.0 mg/L lowest allowable value during both Cycle 1 and Cycle 2 assessments. However, because median values of total nitrogen (TN), TP, and biochemical oxygen demand (BOD) did not exceed their corresponding assessment thresholds, no causative pollutant could be identified. Therefore, the DO impairment was never verified for the creek segment.

Table 2.1. Information Used to List WBID 3107A for Nutrient Impairment

Parameter	Summary of Observation
Annual Average *ChlaC* Concentration	2004 5 µg/L 2005 2 µg/L 2006 4 µg/L 2007 2 µg/L 2008 6 µg/L 2009 6 µg/L 2010 11 µg/L
Historic Minimum Annual Average *ChlaC*	3.1 µg/L based on data from 1999 through 2003
Median TN Concentration	0.89 mg/L (# of samples = 168)
Median TP Concentration	0.08 mg/L (# of samples =172)
TN/TP Ratio	10
Final Assessment Result	Impaired because the annual average *ChlaC* in 2009 and 2010 exceeded the historic minimum. Nitrogen and Phosphorus co-limiting

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)**

WBID 3107A is a Class II marine waterbody, with a designated use of shellfish propagation or harvesting. This designated use requires the waterbody to also support the Class III designated use of recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlife, and, at the same time, also has more stringent criteria on human health related parameters, such as fecal coliform concentration, than those required by the Class III waters.

The proposed TMDL addresses the water quality criteria for nutrients that applies to both Class II and III waterbodies.

3.2 Applicable Water Quality Standards and Interpretation of the Narrative Nutrient Criteria

While the Department is actively involved in developing nutrient criteria for Florida estuaries, the State's existing nutrient criterion for estuary marine waters is, so far, 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 numeric target was needed to represent levels at which an imbalance in flora or fauna is expected to occur. A threshold commonly used for assessing the nutrient impairment in estuaries is the annual average *ChlaC* concentration of 11µg/L, which is defined in the IWR (Chapter 62-303, F.A.C.). In addition, a waterbody can be verified for nutrient impairment if the annual average *ChlaC* concentration increases above the historic minimum by more than 50% in at least two consecutive years. The IWR also allows the use of other information indicating an imbalance in flora or fauna due to nutrient enrichment, including, but not limited to, algal blooms, excessive macrophyte growth, a decrease in the distribution (either in density or areal coverage) of seagrasses or other submerged aquatic vegetation, changes in algal species richness, and excessive diel oxygen swings.

As discussed in Chapter 2, WBID 3107A was verified for nutrient impairment based on the observation that the annual average *ChlaC* concentration in the marine segment of the creek was elevated more than 50% above the historic minimum (3.1 µg/L, based on data collected in 1999 – 2003) in 2009 and 2010, and therefore was verified for nutrient impairment during the Department's Cycle 2 water quality assessment process.

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 National Pollutant Discharge Elimination System (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 Pollutants in the Goat Creek Watershed

4.2.1 Point Sources

4.2.1.1 Wastewater Point Sources

Within the Goat Creek watershed, there are no NPDES permitted wastewater facilities that discharge into the creek.

4.2.1.2 Municipal Separate Storm Sewer System Permittees

Like other nonpoint sources of pollution, urban stormwater discharges are associated with land uses and human activities, and are driven by rainfall and runoff processes leading to the intermittent discharge of pollutants in response to storms. The 1987 amendments to the Clean Water Act designated certain stormwater discharges from urbanized areas as point sources requiring NPDES stormwater permits. In October 2000, the EPA authorized the Department to implement the NPDES Stormwater Program in all areas of Florida, except for Indian tribal lands. The Department’s authority to administer the NPDES Program is set forth in Section 403.0885, F.S. The three major components of the NPDES stormwater regulations are as follows:

(1) ***Municipal Separate Storm Sewer System (MS4) permits*** *that are issued to entities that own and operate master stormwater systems, primarily local governments. Permittees are required to implement comprehensive stormwater management programs designed to reduce the discharge of pollutants from the MS4 to the maximum extent practicable.*

(2) ***Stormwater Associated with Industrial Activities,*** *which is regulated primarily by a multisector general permit that covers various types of industrial facilities. Regulated industrial facilities must obtain NPDES stormwater permit coverage and implement appropriate pollution prevention techniques to reduce contamination of stormwater.*

(2) ***Construction Activity Generic Permits*** *for projects that ultimately disturb one or more acres of land and that require the implementation of stormwater pollution prevention plans to provide erosion and sediment control during construction.*

In addition to the NPDES stormwater construction permitting regulations, Florida was the first state in the country to require the treatment of stormwater for all new developments with the adoption of the state Stormwater Rule in late 1981. The Stormwater Rule is a technology-based program that relies on the implementation of best management practices (BMPs) designed to achieve a specific level of treatment (i.e., performance standards), as set forth in Chapter 62-40, F.A.C. In 1994, state legislation created the Environmental Resource Permitting Program to consolidate stormwater quantity, stormwater quality, and wetlands protection into a single permit. Currently, the majority of Environmental Resource Permits are issued by the state's five water management districts, although the Department continues to do the permitting for specified projects.

The NPDES Stormwater Program was implemented in phases, with Phase I MS4 areas including municipalities having a population above 100,000. Because the master drainage systems of most local governments in Florida are interconnected, the EPA implemented Phase 1 of the MS4 Permitting Program on a countywide basis, which brings in all cities, Chapter 298 urban water control districts, and the Florida Department of Transportation (FDOT) throughout the 15 counties meeting the population criteria. Phase II of the NPDES Program was expanded in 2003 and requires stormwater permits for construction sites between 1 and 5 acres, and for local governments with as few as 10,000 people.

Although MS4 discharges are 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. All Phase 1 MS4 permits issued in Florida include a reopener clause allowing permit revisions for implementing TMDLs once they are formally adopted by rule. Florida's Phase II MS4 Generic Permit has a "self-implementing" requirement once TMDLs are adopted that requires the MS4 permittee to update its stormwater management program (as needed) to meet its TMDL allocations.

Although the Goat Creek watershed is located within the boundary of Brevard County, which has a Phase II MS4 permit (FLR04E052), the watershed of the creek is not located in any urban areas as defined by year 2000 census (http://www.dep.state.fl.us/water/stormwater/npdes/docs/census/UA_PalmBay_Melbourne_roads.pdf). Therefore, the Brevard County Phase II MS4 permit does not apply to the Goat Creek watershed. The watershed of the creek is currently covered by no MS4 permit.

4.2.2 Nonpoint Sources

Nonpoint source nutrient loads are loads discharged into Goat Creek from diffused sources instead of through pipes or fixed outfalls. For Goat Creek, the major nutrient loads come from the runoff created in watershed, possible ground water input, and atmospheric deposition directly onto the surface of the creek.

For this TMDL, nutrient loads generated in the watershed were estimated using a Pollutant Load Screening Model (PLSM) developed by SJRWMD (Steward and Green 2006). The model was originally designed by Adamus and Bergman (1995). It is a GIS model that takes advantage of spatially differentiated information such as watershed land use pattern, soil distribution, hydrologic boundaries, and rain gauge networks. This model uses the following equation to estimate pollutant loads from the watershed:

$$L = \sum Ai * Ci * P * EMCi * (1 - T) \qquad \text{Equation 1}$$

Where:

L is the total nutrient load from a given watershed.
A_i is the acreage of the land use – soil type combination i in the watershed.
C_i is the runoff coefficient for the land use – soil type combination i in the watershed.
P is the annual rainfall.
$EMCi$ is the event mean concentration for a given land use type i.
T is the removal rate of pollutant through best management practice (BMP) measures.

In assessing the model's reliability in predicting nutrient pollutant loads, the PLSM model was calibrated for model-simulated discharge volume and TN and TP loads to measured flow and loading data in four IRL drainage basins: Crane Creek, C-1 Canal of Turkey Creek, South Prong of Sebastian River, and Briar Creek (Green and Steward 2003). The SJRWMD study concluded that PLSM predicted flow, and TN, TP, and TSS loadings derived from measured concentrations and flow within an acceptable margin of error.

Ground water input from the Floridan aquifer does not represent a significant portion of the total water budget for the IRL system (Martin et al. 2004). Depending on the season, input from the surficial aquifer to the lagoon could be important. Nutrient contributions from the surficial aquifer were implicitly included in the SJRWMD's model simulations as part of the budget for watershed flow and nutrient loadings because the modeled flow was calibrated against the total flow instead of only surface runoff.

Atmospheric nutrient loadings include those loads depositing into the watershed of the creek and those depositing directly onto the surface of the creek. The amount of the atmospheric loadings depositing into the watershed were implicitly included in the nutrient loading calculations that used measured event mean concentrations (EMCs) that are influenced by the atmospheric deposition. The atmospheric nutrient loadings depositing directly onto the surface of the creek were not calculated in this analysis because the creek surface area, which is about 1,300 m (marine segment length) x 20 m (average creek width) = 26,000 m^2 = 6.4 acres (refer to **Chapter 5** for more details), is less than 0.1% of the total watershed area (7,161 acres). Loadings from the atmospheric direct deposition are therefore considered negligible.

In addition to the nutrient loads created through watershed runoff, because the mouth of Goat Creek is tidally influenced by IRL mainstem segments, especially Segment IRL-13, it is reasonable to believe that Goat Creek may also receives nutrient-containing waters from the IRL mainstem segment. As there were no measured data or reliable existing model to quantify the total loads entering and leaving the Goat Creek marine segment from the mainstem segment at the time this TMDL was developed, detailed loadings calculation of the hydrodynamics of the lagoon were not conducted in this TMDL. The pollutant loading calculation of this TMDL focuses on nutrient loads from the immediate watershed. While the Goat Creek watershed needs to reduce nutrient loadings in order to restore the creek's nutrient condition, as well as to protect the seagrass distribution in the IRL mainstem segments, the watersheds of the central IRL also need to fulfill their seagrass nutrient loading targets established in the mainstem seagrass nutrient TMDLs (FDEP, 2009) to protect both the seagrass in the lagoon system and the nutrient condition of the marine segment of Goat Creek.

4.2.2.1 Land Uses

Land use distribution is a critical factor that determines the nutrient loads created in a given watershed. Land use patterns influence the imperviousness of the watershed and determine the amount of runoff that can be generated in a given watershed area. Land use patterns also determine the concentrations of pollutants in the runoff produced in different land use areas and therefore determine the amount of a given pollutant that can be produced per acre of drainage basin. Land use information is a key spatially parameter for simulating nutrient load using the PLSM model.

Table 4.1 summarizes the land use distribution in the Goat Creek watershed. Although this TMDL only addresses the nutrient impairment in the marine segment of the creek, the marine segment receives nutrient loading from the entire Goat Creek watershed. Therefore, nutrient loads under the existing condition and target condition were estimated for the entire Goat Creek watershed. The watershed delineation used for this TMDL development was provided by the SJRWMD (Mr. Whit Green, personal communication). The WBID boundary was only used for the purpose of water quality assessment to indicate what water feature was assessed. The WBID boundary does not necessarily match the watershed boundary. **Figure 4.1** shows WBID boundaries of the freshwater segment (WBID 3107B) and marine segment (WBID 3107A) of Goat Creek and the watershed boundary of the creek. As the figure shows, there are some discrepancies between the WBID boundary and the watershed boundary, especially for the area between the northern WBID boundary and the northern watershed boundary. Some areas in between the WBID boundary and watershed boundary drain toward Turkey Creek to the north while the northeast corner of the areas between the WBID and watershed boundaries drains mostly toward Indian River Lagoon directly (Mr. Whit Green, personal communication). This TMDL used the watershed delineation to characterize the distributions of land use and soil. The watershed boundary was also used to quantify the TN and TP loads that enter Goat Creek.

The PLSM model simulates nutrient loads based on the Level III land use of the Florida Land Use, Cover, and Forms Classification System (FLUCCS). The land use information used in this TMDL analysis was SJRWMD's year 2000 land use. In addition to the land use acreage for areas represented by each FLUCCS code, **Table 4.1** also tabulates the acreage of aggregated Level I land uses and the percent distribution of each Level I land use category in the entire watershed.

Table 4.1. Land Use Summary for the Goat Creek Watershed

FLUCCS	Description	Acreage	Percent Level I Land Use
1000	**Level 1 - Urban and Build-up**	**1303.4**	**18%**
1100	Low Density Residential	1030.9	-
1200	Medium Density Residential	44.5	-
1400	Commercial and Service	60.6	-
1480	Cemeteries	31.1	-
1600	Extractive	50.0	-
1660	Holding Ponds	23.1	-
1700	Institutional	6.5	-
1820	Golf Courses	54.7	-
1920	Inactive Land	2.1	-
2000	**Level 1 - Agriculture**	**366.3**	**5%**
2110	Improved Pastures	115.4	-
2120	Unimproved Pastures	65.6	-
2130	Woodland Pastures	101.1	-
2140	Row Crops	10.3	-
2150	Field Crops	9.4	-
2210	Citrus Groves	40.6	-
2430	Ornamentals	23.9	-
3000	**Level 1 - Rangeland**	**1549.3**	**22%**
3100	Herbaceous	148.1	-
3200	Shrub and Brushland	1346.9	-
3300	Mixed Rangeland	54.3	--
4000	**Level 1 - Upland Forest**	**2243.1**	**31%**
4110	Pine Flatwoods	2009.7	-
4130	Sand Pine	72.8	-
4200	Upland Hardwood Forests	13.3	-
4340	Hardwood - Conifer Mixed	147.3	-
5000	**Level 1 - Water**	**281.8**	**4%**
5100	Streams and Waterways	5.2	-
5200	Lakes	82.8	-
5250		31.6	-
5300	Reservoirs	162.2	-
6000	**Level 1 - Wetlands**	**1192.2**	**17%**
6170	Mixed Wetland Hardwoods	224.0	-
6210	Cypress	64.4	-
6220	Pond Pine	2.6	-
6250	Hydric pine flatwoods	37.5	-
6300	Wetland Forested Mixed	73.6	-
6410	Freshwater Marshes	281.8	-
6430	Wet Prairies	203.6	-
6440	Emergent Aquatic Vegetation	1.9	-

FLUCCS	Description	Acreage	Percent Level I Land Use
6460	Mixed scrub-shrub wetland	302.7	-
7000	**Level 1 - Barren Lands**	**46.3**	**1%**
7400	Disturbed Lands	35.5	-
7410	Rural Land in Transition	10.9	-
8000	**Level 1 - Trans, Comm & Utilities**	**178.9**	**2%**
8110	Airports	78.6	-
8140	Roads and Highways	100.3	-
Total	**Total Land Use**	**7161.4**	**100%**

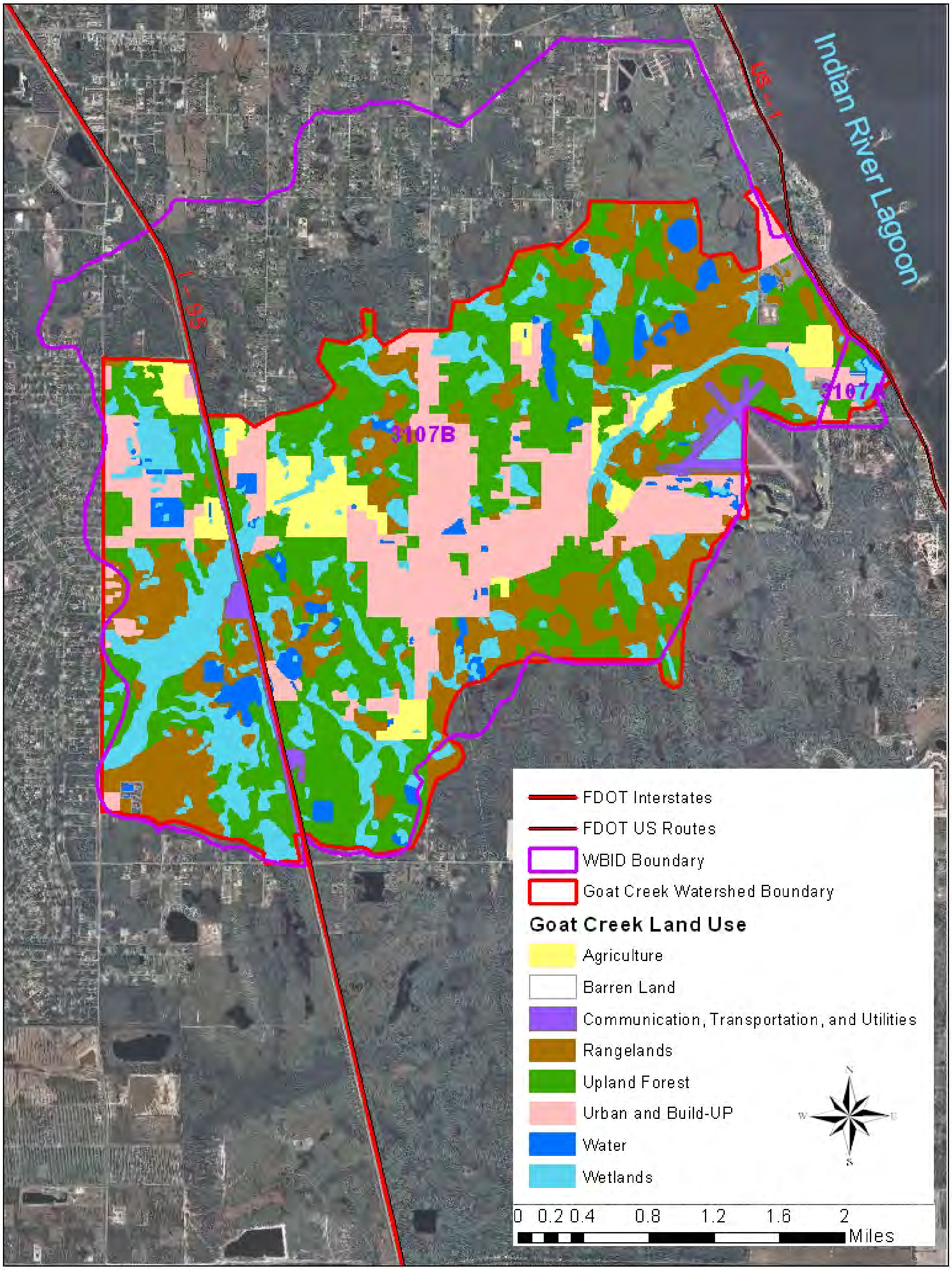

Figure 4.1. Spatial Distribution of Land Use Pattern (Year 2000) in the Goat Creek Watershed

According to **Table 4.1**, the land cover type that occupies the largest watershed area of Goat Creek is Upland Forest, which is about 2,243 acres and accounts for about 31% of the total watershed areas. Rangeland areas (1,549 acres) ranked second, occupying about 22% of the watershed. About 17% of the watershed is covered by wetlands (about 1,192 acres). Urban and build-up land, another large land cover type in the watershed, occupies about 1303 acres and accounts for about 18% of the total watershed area.

The vast majority of the 1,303 acres of urban and build-up lands are low density residential areas(1,031 acres), which account for about 79% of the total urban and build-up area. High intensity urban land areas including 45 acres of medium density residential and 61 acres of commercial and service lands. In total, these high intensity urban lands account for about 8% of the urban land use areas. Other urban land uses are of relatively low intensity, including cemeteries, extractive, holding ponds, golf courses, and inactive lands.

The majority of the 366 acres of agricultural lands are pasturelands, which occupy about 282 acres, and account for about 77% of the agricultural area. The remaining agricultural land areas include row crops, field crops, citrus groves, and ornamentals, and occupied about 23% of the agricultural area.

The remaining part of the circa 2000 watershed is occupied by 282 acres of water, 79 acres of transportation, communication, and utility land areas, and 46 acres of barren lands, accounting for about 4%, 2%, and 1% of the total watershed area, respectively.

A general impression, based on **Table 4.1**, is that the Goat Creek watershed is relatively rural. Most watershed areas are covered by natural lands. Where the watershed is occupied by human land uses, the intensity of human activities is low, such as low density residential areas. Compared to other watersheds of the IRL basin, it is expected that the nutrient loading impact originating from the Goat Creek watershed will be low.

Because SJRWMD's PLSM model used the year 2000 land use to simulate the existing loads, it is desirable to examine the year 2009 land use for the possible change of land use patterns over the years in the Goat Creek watershed. **Table 4.2** lists both the 2000 and 2009 land use acreages and comparison of the land use change between the two land use shapefiles. **Figure 4.2** shows the spatial distribution of land uses in the Goat Creek watershed in 2009 shapefile.

Table 4.2. Comparison of 2000 and 2009 Land Uses in the Goat Creek Watershed

FLUCCS	Description	2000 Land Use (acre)	2009 Land Use (acre)	Level 1 Land Use Difference (acre)
1000	**Level 1 - Urban and Build-Up**	**1303.4**	**1594.6**	**291.2**
1100	Low Density Residential	1030.9	1267.8	
1180	Residential - Rural	0.0	8.3	
1190	Low Density Residential - under Construction	0.0	0.9	
1200	Medium Density Residential	44.5	37.0	
1400	Commercial and Service	60.6	75.3	
1480	Cemeteries	31.1	32.0	
1600	Extractive	50.0	49.0	

FLUCCS	Description	2000 Land Use (acre)	2009 Land Use (acre)	Level 1 Land Use Difference (acre)
1660	Holding Ponds	23.1	21.4	
1700	Institutional	6.5	8.0	
1820	Golf Courses	54.7	45.3	
1900	Open Land	0.0	49.6	
1920	Inactive Land	2.1	0.0	
2000	**Level 1 - Agriculture**	**366.3**	**485.5**	**119.2**
2110	Improved Pastures	115.4	173.3	
2120	Unimproved Pastures	65.6	20.4	
2130	Woodland Pastures	101.1	126.2	
2140	Row Crops	10.3	0.0	
2150	Field Crops	9.4	5.3	
2210	Citrus Groves	40.6	35.7	
2410	Tree Nursery	0.0	43.8	
2430	Ornamentals	23.9	2.9	
2510	Horse Farm	0.0	77.8	
3000	**Level 1 - Rangeland**	**1549.3**	**1541.8**	**-7.6**
3100	Herbaceous	148.1	51.5	
3200	Shrub and Brushland	1346.9	1169.8	
3300	Mixed Rangeland	54.3	320.5	
4000	**Level 1 - Upland Forest**	**2243.1**	**1678.2**	**-564.9**
4110	Pine Flatwoods	2009.7	1383.5	
4130	Sand Pine	72.8	0.0	
4200	Upland Hardwood Forests	13.3	4.4	
4340	Hardwood - Conifer Mixed	147.3	290.3	
5000	**Level 1 - Water**	**281.8**	**192.4**	**-89.5**
5100	Streams and Waterways	5.2	6.8	
5200	Lakes	82.8	2.6	
5250		31.6	0.0	
5300	Reservoirs	162.2	183.0	
6000	**Level 1 - Wetlands**	**1192.2**	**1430.2**	**238.1**
6170	Mixed Wetland Hardwoods	224.0	201.8	
6181	Cabbage palm hammock	0.0	156.0	
6210	Cypress	64.4	57.9	
6220	Pond Pine	2.6	0.0	
6250	Hydric pine flatwoods	37.5	104.6	
6300	Wetland Forested Mixed	73.6	76.5	
6410	Freshwater Marshes	281.8	255.7	
6430	Wet Prairies	203.6	250.2	
6440	Emergent Aquatic Vegetation	1.9	5.7	
6460	Mixed scrub-shrub wetland	302.7	321.8	
7000	**Level 1 - Barren Land**	**46.3**	**28.5**	**-17.9**
7400	Disturbed Lands	35.5	5.8	
7410	Rural Land in Transition	10.9	22.6	
8000	**Level 1 - Transportation, Communication, and Utilities**	**178.9**	**210.2**	**31.3**

FLUCCS	Description	2000 Land Use (acre)	2009 Land Use (acre)	Level 1 Land Use Difference (acre)
8110	Airports	78.6	91.5	
8140	Roads and Highways	100.3	97.7	
8320	Electrical power transmission lines	0.0	15.1	
8370	Surface water collection basins	0.0	5.9	
Total	**Total Land Use**	**7161.4**	**7161.4**	**0.0**

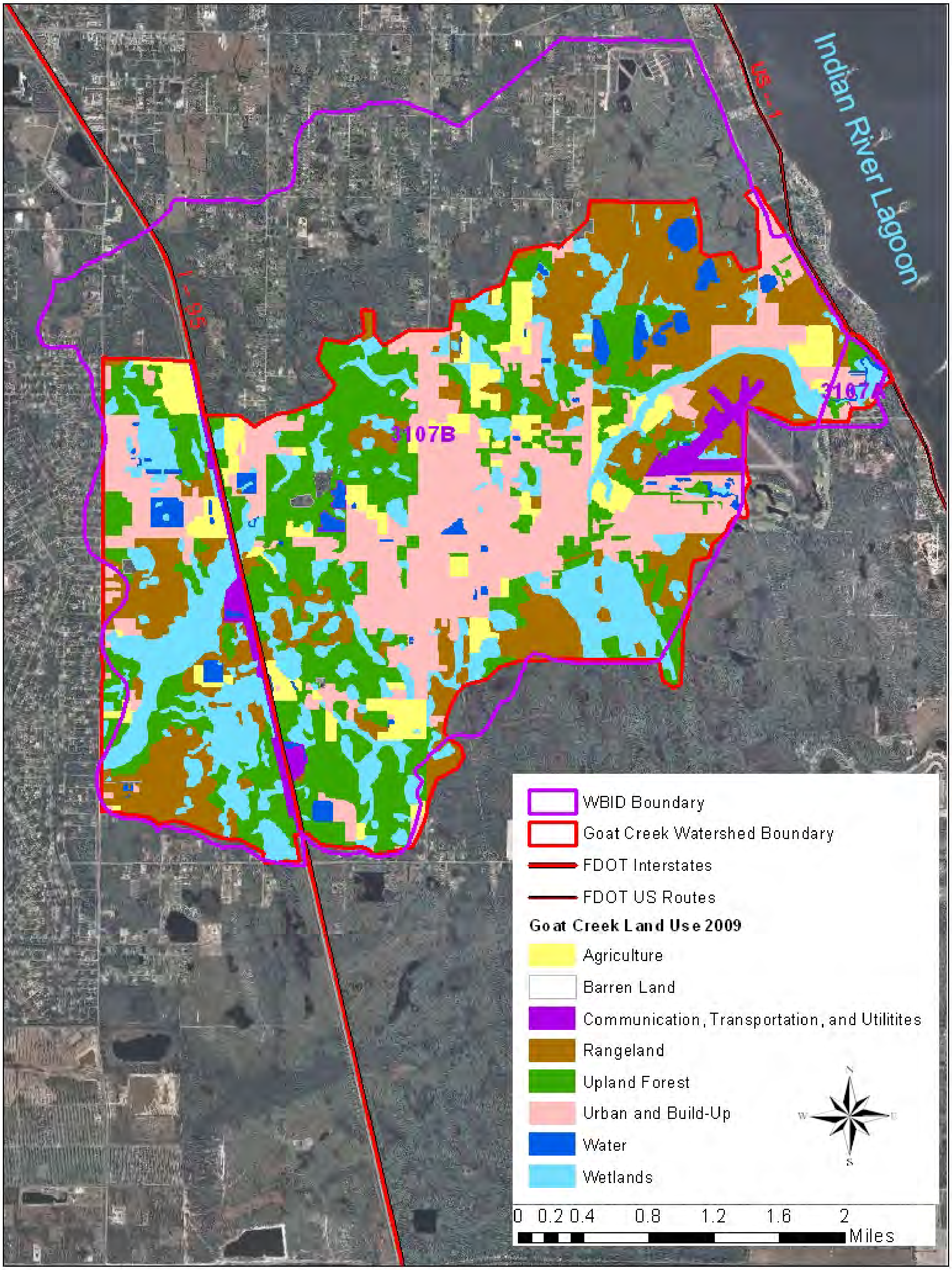

Figure 4.2. Spatial Distribution of Land Use Pattern (Year 2009) in the Goat Creek Watershed

Based on **Table 4.2**, between 2000 and 2009, acreage of several human land uses, including urban and build-up, agriculture, and transportation, communication, and utilities, increased by about 442 acres, accounting for about 6.2% of the total watershed area. The increase was mainly caused by the increase of urban and build-up areas, which amounted to about 291 acres, and accounted for about 4.1% of the total watershed area and 66% of the total human land use increase. Increase of the low density residential acreage, which was 236 acres and accounted for about 81% of the total urban land increase, was the most important increase in the total urban land use. In addition, slight increases in the acreage of rural residential, commercial and service, and some open land areas, also contributed to the increase of urban land and the overall human land use increase. In addition to the increase in urban land use area, the total acreage of agricultural lands also increased about 119 acres, which represented about 33% increase in agricultural land, but only accounted for about 1.7% of the total watershed area. Most of the agricultural land increase appears to be due to the increased acreage of tree nurseries and horse farms. A general conclusion from the comparison is that the increase in human land use is relatively minor in total acreage. Also, most of the increase was due to the increase in the low density residential area, which is a relatively low intensity human land use type. Overall, land use change alone between 2000 and 2009 should not cause dramatic change in the production of nutrient loads from the watershed.

4.2.2.2 Soil Type

Another important aspect of the watershed is the soil type. Soil type affects the hydrologic characteristics of the watershed through influencing the water transmission capacity of the soil, which in turn determines the potential of the watershed to produce runoff and pollutant loads. Based on United States Department of Agriculture/Natural Resource Conservation Service (USDA/NRCS), soils can be classified based on their hydrologic characteristics into hydrologic soil groups (HSGs). The HSGs are generally determined by the water transmitting soil layer with the lowest saturated hydraulic conductivity and depth to any layer that is more or less water impermeable. A four-HSG classification is generally used to group soils based on their hydrologic characteristics (**Table 4.3**):

Table 4.3. Hydrologic Characteristics of the Four HSGs (NRCS, 2007)

HSGs	Runoff Potential	Clay Content	Sand Content	Saturated Conductivity (inch/hour)	Depth to Impervious Layer (inch)	Depth to Water Table (inch)
Group A	Low	< 10%	> 90%	5.67	> 20	> 24
Group B	Moderately low	10% - 20%	50% - 90%	1.42 – 5.67	> 20	> 24
Group C	Moderately high	20% - 40%	< 50%	0.14 – 1.42	> 20	> 24
Group D	High	>40%	< 50%	< 0.14	< 20	< 24

Certain wet soils are placed in group D based solely on the presence of a water table within 24 inches of the surface even though the saturated hydraulic conductivity may be favorable for water transmission. If these soils can be adequately drained, they are assigned to dual hydrologic soil groups (A/D, B/D, and C/D) based on their saturated hydraulic conductivity and the water table depth when drained. The first letter applies to the drained conduction and the second to the undrained condition. For the purpose of hydrologic soil group classification, adequately drained means that the seasonal high water table is kept at least 24 inches below the surface in a soil where it would be higher in a natural state (NRCS, 2007).

The soil coverage used by SJRWMD in developing the PLSM model was from the USDA/NRCS's 1:24,000 Soil Survey Geographic (SSURGO) coverage. This soil coverage was created by NRCS around 1990. In addition to the four HSGs and their related dual soil groups, this coverage also include a "W" soil group to represent soil areas that are constantly covered by water, and a "U" soil group to represent those soils whose HSG designation could not be determined. **Table 4.4** summarizes the acreages of the Goat Creek watershed that are covered by different soil types. **Figure 4.3** shows the spatial distribution of HSGs in the watershed.

Based on **Table 4.4**, B/D and D soil groups occupy the largest areas, which account for 73% and 11% of the watershed area. As shown in **Figure 4.3**, B/D soil covers most part of the watershed. D soil is scattered across the watershed, but covers much smaller areas than the B/D soil. C soil, which covers about 8.5% of the total watershed area, is mainly distributed around the western end of the watershed and downstream of the creek, especially around the mouth of the creek. For the remaining soil groups, A soil covers about 2.6% of the watershed, and is mainly distributed in the eastern part of the watershed, especially around the mouth of the creek and around an airport. C/D soil mainly appears in the northwestern portion of the watershed, and occupies about 2.4% of the watershed area. W soil mostly appears in the western and eastern ends of the watershed, but also appears in central part of the watershed. The U soil only appears in the airport area. No B type soils were identified in the watershed. A general impression from **Figure 4.3** is that the Goat Creek watershed should have relatively low runoff potential under dry conditions because of the dominance of the B/D soil. However, also because of the dominance of the B/D soil, under wet conditions, especially when the soil is saturated, the runoff potential can be high.

Table 4.4. Acreage of the Goat Creek Watershed Occupied by Different Hydrologic Soil Groups (NRCS 1990 Data)

HSG	Acreage	Percent Acreage
A	185.2	2.6%
B/D	5211.4	72.8%
C	607.7	8.5%
C/D	174.3	2.4%
D	785.0	11.0%
U	53.8	0.8%
W	144.0	2.0%
Total	7161.4	100.0%

In 2010, NRCS published its updated SSURGO soil coverage. It is therefore desirable to examine the difference between the 2010 SSURGO HSG distribution and the HSG distribution used in SJRWMD's PLSM model. **Table 4.5** listed the acreage of different HSGs in the Goat Creek watershed based on the 2010 SSURGO shapefile. **Figure 4.4** shows the spatial distribution of HSGs in the watershed based on the 2010 GIS data.

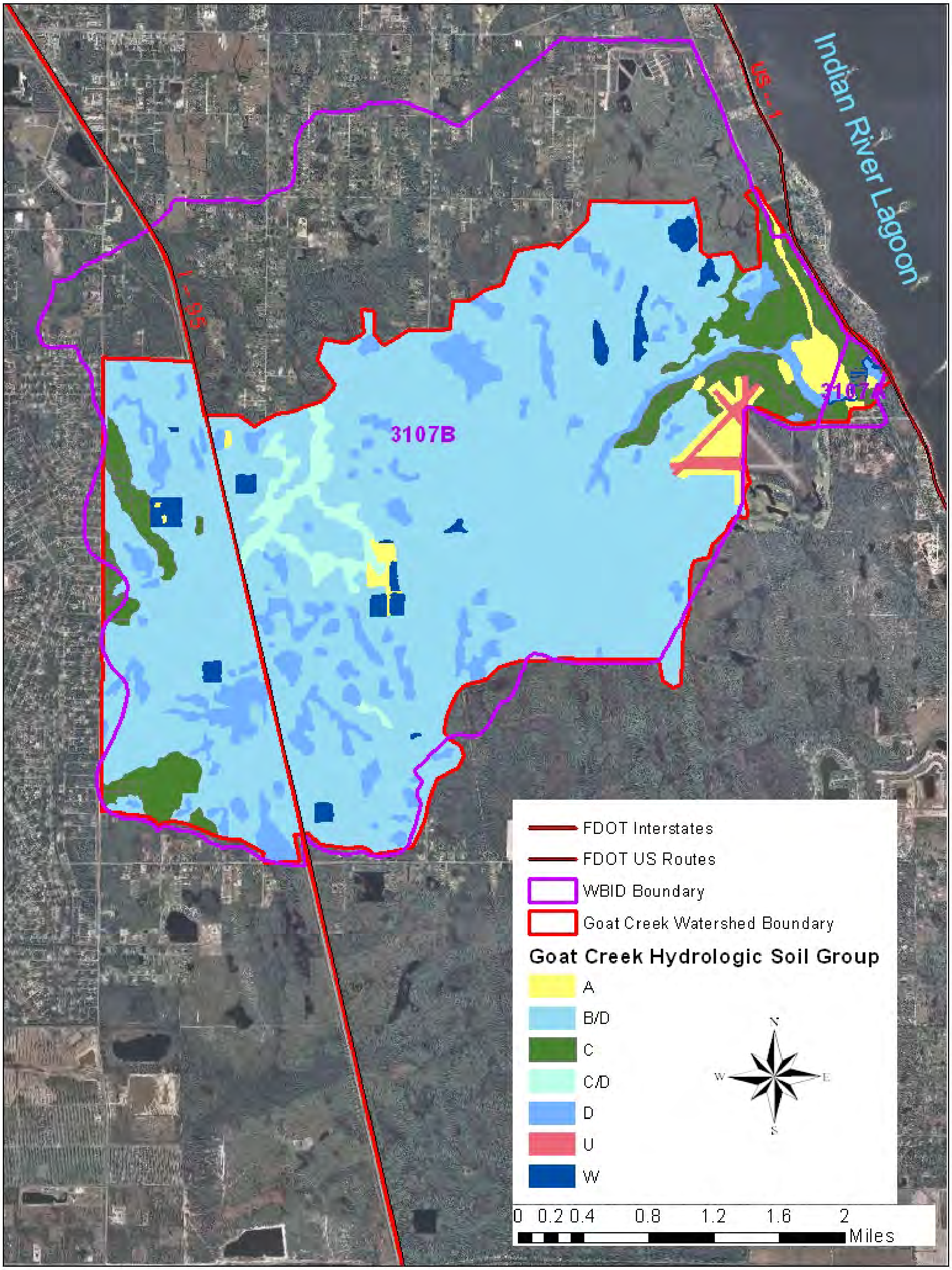

Figure 4.3. Hydrologic Soil Distribution in the Goat Creek Watershed (NRCS 1990 Data)

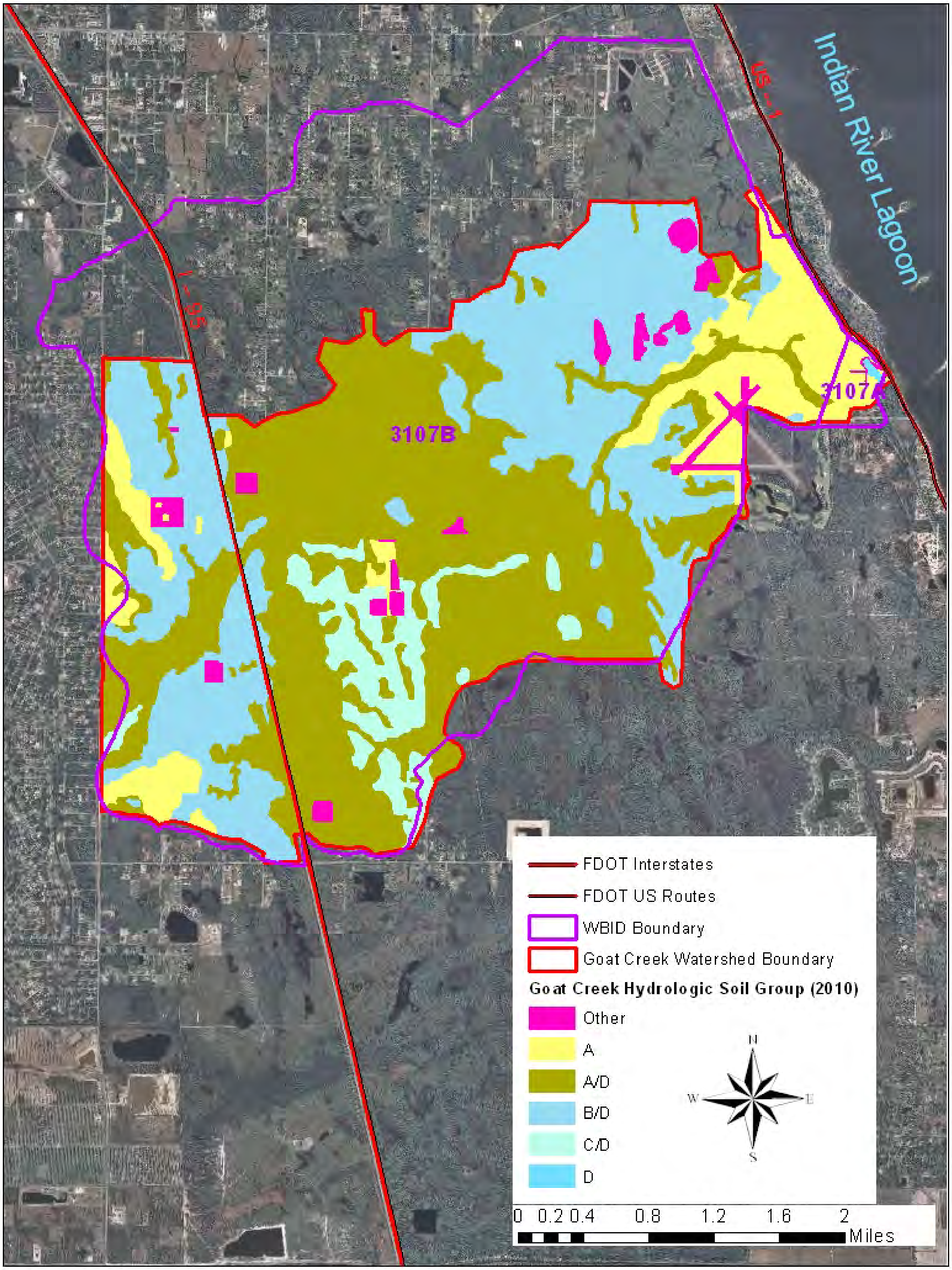

Figure 4.4. Hydrologic Soil Distribution in the Goat Creek Watershed (NRCS 2010 Data)

Table 4.5. Acreage of the Goat Creek Watershed Occupied by Different Hydrologic Soil Groups (NRCS 2010 Data)

HSG	Acreage	Percent
A	812.4	11.3%
A/D	3397.9	47.4%
B/D	2306.3	32.2%
C/D	440.9	6.2%
D	5.9	0.1%
Other	198.0	2.8%
Total	7161.4	100.0%

The differences between the 1990 and 2010 HSG distributions are significant (**Tables 4.4 and 4.5**). The C soil in the 1990 shapefile completely disappears in the 2010 shapefile. Almost all C soils are reclassified as A soils. In addition, a significant amount of the B/D soils were re-classified into A/D soils in the 2010 dataset. A/D soils do not exist in the 1990 dataset. Another significant change in the 2010 dataset is that soils classified as W and U soils in the 1990 dataset become unclassified in the 2010 dataset. In **Table 4.5**, all unclassified soils are aggregated into the Other soil group.

Compared to the 1990 dataset, the A/D soil, which does not exist in the 1990 dataset, becomes the soil type that occupied the largest areas in the Goat Creek watershed, occupying about 3398 acres and accounting for about 47% of the total watershed area in the 2010 dataset. The second largest soil group in the 2010 dataset is the B/D soil, which occupies about 2306 acre of the watershed and accounts for about 32% of the watershed areas. More than 50% of the B/D soils in the 1990 dataset are reclassified into the A/D type soil. The percent watershed area occupied by the D soil decreased from about 11% in the 1990 dataset to about 0.1% in the 2010 dataset, mostly being reclassified into B/D or C/D soil. The watershed areas occupied by the C/D soil increases from 2% in the 1990 dataset to about 6% in the 2010 dataset. The general direction of the change is that the infiltration potential of the watershed increased under dry weather conditions, which can cause the runoff and nutrient loadings through runoff to decrease under the dry weather condition. Runoff under wet weather conditions may also decrease because of the increase of the A soil coverage from 3% in the 1990 dataset to 11% in the 2010 dataset.

4.2.2.3 Runoff Coefficient and Land Use/Soil Group Combinations

One of the most important parameters for PLSM to simulate the annual discharge volume is the runoff coefficient. In theory, this parameter represents the percent of total rainfall falling onto a given watershed that becomes runoff. In application for TMDL modeling, the coefficients were used to simulate total watershed discharge volume. The runoff coefficient is influenced by the land use type and soil patterns in the watershed. When setting up the PLSM model, SJRWMD staff assigned a unique runoff coefficient to each land use – HSG combination. These runoff coefficients were mostly from Adamus and Bergman (1998) and later modified with data from Harper (1994). Several other modifications were conducted as follows (Whit Green, personal communication):

(1) The runoff coefficients for U soil were calculated as the mean of runoff coefficients of types A, B, C, and D soil group of particular land use.
(2) The runoff coefficients for W soil were assigned runoff coefficients of U soils if the soil survey results did not completely match up with the land use results. Otherwise, the runoff coefficients of W soil would be assigned as 1.000.
(3) The runoff coefficients for C/D and B/D soil groups used the runoff coefficients of D for underdeveloped area. For developed area, the C/D and B/D runoff coefficients were assigned as C or B runoff coefficients.
(4) For low density residential areas, if the housing density is less than 1 unit/acre, the runoff coefficients assumed the runoff coefficients for the D soil. Otherwise, runoff coefficients of B or C soils were used.
(5) For low density residential areas with certain drainage improvements, but the improvement were not sufficient to lower the water table over the entire site, the runoff coefficients of B/D soils assumed the average values of B and D soil for a given land use category. This was used only for select areas subject to on-site assessment

Table 4.6 shows the runoff coefficients assigned to each land use – HSG soil combination in the Goat Creek watershed. The red-font highlighted runoff coefficients are for those land use – HSG soil combinations that do not exist in the Goat Creek watershed, but are provided to show the runoff coefficients relationship among different HSG groups of the same land groups.

4.2.2.4 Event Mean Concentrations (EMCs) and Land Uses

Event mean concentrations (EMCs) represent the concentrations of pollutants contained in the runoff, and are required components of the PLSM model in estimating nutrient loads from a given watershed. Most of the EMCs used in this TMDL were cited from Adamus and Bergman (1998), and supplemented with literature values from Dierberg (1991), Harper (1994), Hendrickson and Konwinski (1998), Pandit and Youn(2002), Riekerk (1982), Trefry and Feng (1991), and Zhang et al., (2002). EMC values were also adjusted based on results from local studies and through model calibration. **Table 4.7** shows a summary of TN and TP EMCs for different land use types included in SJRWMD's PLSM model that covers the Goat Creek watershed.

It should be noted that the PLSM model assumes that the net nutrient loads from wetland areas are zero. This assumption was used primarily because the wetland areas can be either sink or source of nutrients, depending on the vegetative and soil composition, hydroperiod, and hydrological connectivity. At the time when the PLSM model was developed, no detailed local information was available regarding which wetlands were nutrient sources verses sinks, Therefore, the SJRWMD assumed a neutral role for wetlands nutrient dynamics.

Table 4.6. Runoff Coefficients Assigned to Each Land Use - HSG Soil Combination

FLUCCS Code	A	B	C	D	B/D	C/D
1100	0.174	0.230	0.286	0.342	0.342	0.342
1200	0.220	0.304	0.389	0.473	0.304	0.389
1400	0.886	0.887	0.888	0.900	0.887	0.888
1480	0.583	0.629	0.674	0.720	0.629	0.674
1600	0.220	0.304	0.389	0.473	0.304	0.389
1660	0.127	0.155	0.182	0.210	0.183	0.196
1700	0.696	0.741	0.786	0.856	0.741	0.786
1820	0.182	0.222	0.258	0.298	0.222	0.258
1920	0.151	0.193	0.234	0.276	0.193	0.234
2110	0.251	0.305	0.359	0.405	0.405	0.405
2120	0.189	0.250	0.334	0.411	0.411	0.411
2130	0.189		0.334	0.411	0.411	0.411
2140	0.204	0.281	0.358	0.435	0.281	0.358
2150	0.189	0.256	0.334	0.411	0.411	0.411
2210	0.251	0.268	0.285	0.302	0.268	0.285
2430	0.251	0.268	0.285	0.302	0.268	0.285
3100	0.100	0.195	0.300	0.411	0.411	0.411
3200	0.060	0.176	0.287	0.400	0.400	0.400
3300	0.060	0.176	0.287	0.400	0.400	0.400
4110	0.102	0.206	0.309	0.413	0.413	0.413
4130	0.102	0.206	0.309	0.413	0.413	0.413
4200	0.102	0.206	0.309	0.413	0.413	0.413
4210	0.102		0.309	0.413	0.413	0.413
4340	0.102	0.206	0.309	0.413	0.413	0.413
5100	1.000	1.000	1.000	1.000	1.000	1.000
5200	0.500	0.500	0.500	0.500	0.500	0.500
5250	0.500	0.500	0.500	0.500	0.500	0.500
5300	0.500	0.500	0.500	0.500	0.500	0.500
6170	0.191	0.228	0.266	0.303	0.303	0.303
6210	0.191	0.228	0.266	0.303	0.303	0.303
6220	0.191	0.228	0.266	0.303	0.303	0.303
6250	0.191	0.228	0.303	0.303	0.303	0.303
6300	0.191	0.228	0.266	0.303	0.303	0.303
6410	0.191	0.228	0.266	0.303	0.303	0.303
6430	0.191	0.228	0.266	0.303	0.303	0.303
6440	0.191		0.266	0.303	0.303	0.303
6460	0.191	0.228	0.266	0.303	0.303	0.303
7400	0.160	0.181	0.202	0.223	0.223	0.223
7410	0.151	0.193	0.234	0.276	0.234	0.234
8110	0.326	0.399	0.473	0.546	0.399	0.473
8140	0.630	0.703	0.777	0.850	0.703	0.777

Table 4.7. TN and TP EMCs for Different Land Uses in the Goat Creek Watershed

FLUCCS	TN EMC (mg/L)	TP EMC (mg/L)
1100	1.85	0.22
1200	2.23	0.32
1400	1.93	0.50
1480	1.58	0.18
1600	1.18	0.15
1660	0.60	0.11
1700	1.80	0.48
1820	1.78	0.38
1920	1.20	0.15
2110	2.70	0.58
2120	2.55	0.09
2130	2.52	0.09
2140	4.56	1.00
2150	2.52	0.27
2210	1.92	0.51
2430	2.30	0.57
3100	1.20	0.06
3200	1.20	0.06
3300	1.20	0.06
4110	0.70	0.09
4130	0.70	0.09
4200	0.70	0.09
4210	0.70	0.09
4340	0.70	0.09
5100	0.60	0.05
5200	0.60	0.11
5250	0.25	0.11
5300	0.60	0.14
6170	0.00	0.00
6210	0.00	0.00
6220	0.00	0.00
6250	0.00	0.00
6300	0.00	0.00
6410	0.00	0.00
6430	0.00	0.00
6440	0.00	0.00
6460	0.00	0.00
7400	1.38	0.11
7410	1.51	0.12
8110	1.15	0.15
8140	1.18	0.48

4.2.2.5 Rainfall

Rainfall is the driving force in a watershed to create pollutant loads. In simulating the watershed nutrient contribution under the existing condition, SJRWMD's PLSM model used a 30-year long-term average annual rainfall for the period from 1975 through 2005. In the Indian River Lagoon and adjacent areas, stations that have 30-years of rainfall records are all National Weather Service stations, which include stations located at the Daytona Beach International Airport, City of Titusville, Melbourne International Airport, Vero Beach Airport, and Fort Pierce. A 30-year rainfall record was also available at Patrick Air Force Base. The rainfall amount used in a specific IRL basin area in the PLSM model was calculated as the mean average annual rainfall from nearby stations using the Thiessen Polygon method. Runoff and nutrient loads from the Goat Creek watershed was estimated using the 30-year mean long-term annual rainfall from the weather station located at the Melbourne International Airport. The 30-year long-term mean annual total rainfall for the station was 48.3 inches. **Figure 4.5** shows the location of the weather station relative to the Goat Creek watershed.

4.2.2.6 BMPs

At the time when the PLSM model was developed for the IRL basin, no information was available regarding the detailed spatial distribution, types, and treatment efficiencies of stormwater treatment facilities in the IRL-BRL basin. Therefore, the PLSM model assumed that any urban construction that took place after 1984 (when the state stormwater rule was implemented) was developed with stormwater treatment facilities. Generalized treatment efficiencies were applied in the PLSM model, which include 30% removal of TN and 50% removal of TP by these stormwater treatment facilities. No stormwater treatment types were distinguished in the PLSM model. **Figure 4.6** shows areas of the Goat Creek watershed that are covered by generalized stormwater treatment facilities.

4.2.2.7 Summary of Nutrient Loads from the Goat Creek Watershed

Based on the information provided previously, nutrient loads from the Goat Creek watershed were calculated using Equation (1) on page 11. Estimated watershed nutrient loads for aggregated Level I land uses are summarized in **Table 4.8**.

Based on **Table 4.8**, the largest contributor of nutrients in the Goat Creek watershed is the urban and built-up area, which contributes about 8,017 lbs/year of TN and 987 lbs/year of TP, accounting for about 27.9% and 29.4% of the TN and TP loads from the entire watershed, respectively. Other human land use areas, such as areas occupied by agriculture, rangeland, barren land, and transportation, communication, and utilities, contribute about 3,866 (13.5%), 7,659 (26.7%), 148 (0.5%), and 1,237 (4.3%) lbs/year of TN loads, respectively, and 499 (14.9%), 408 (12.2%), 12 (0.3%), and 378 (11.3%) lbs/year of TP, respectively. In total, all human land use areas contributed about 20,926 lbs/year of TN and 2,285 lbs/year of TP, accounting for about 72.9% of the TN and 68.1% of the TP loads from the entire watershed. Nutrient loads from natural land areas, including upland forest and water, are about 7,797 lbs/year of TN and 1,072 lbs/year of TP, accounting for about 27.1% of the TN loads and 31.9% of the TP loads from the watershed. As is pointed out in **Section 4.2.2.4**, because the EMCs of TN and TP of the runoff from the wetland areas were assumed to be zero, annual loads from wetlands are assumed to be zero.

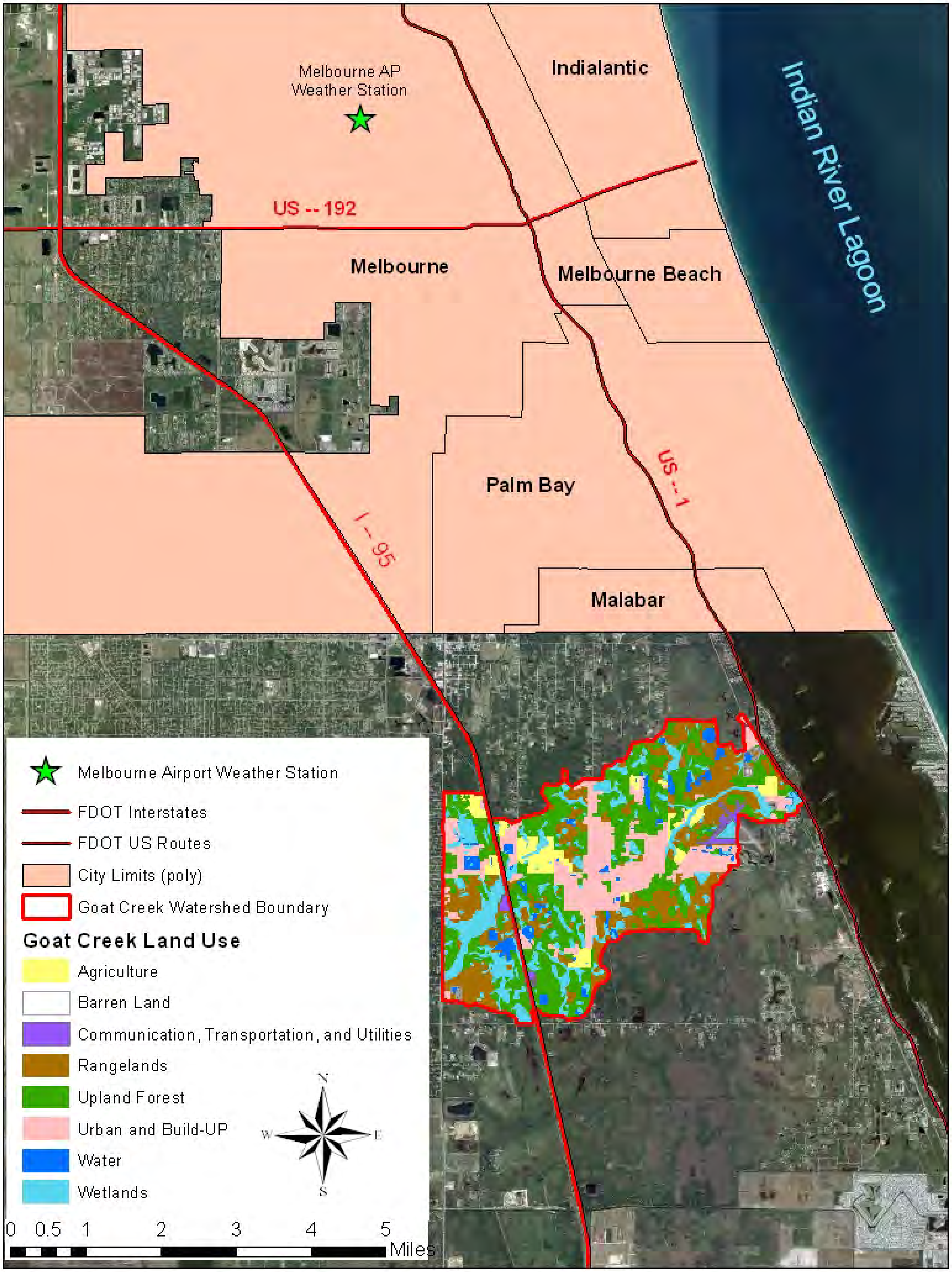

Figure 4.5. Location of the Melbourne Airport Weather Station Relative to the Goat Creek Watershed

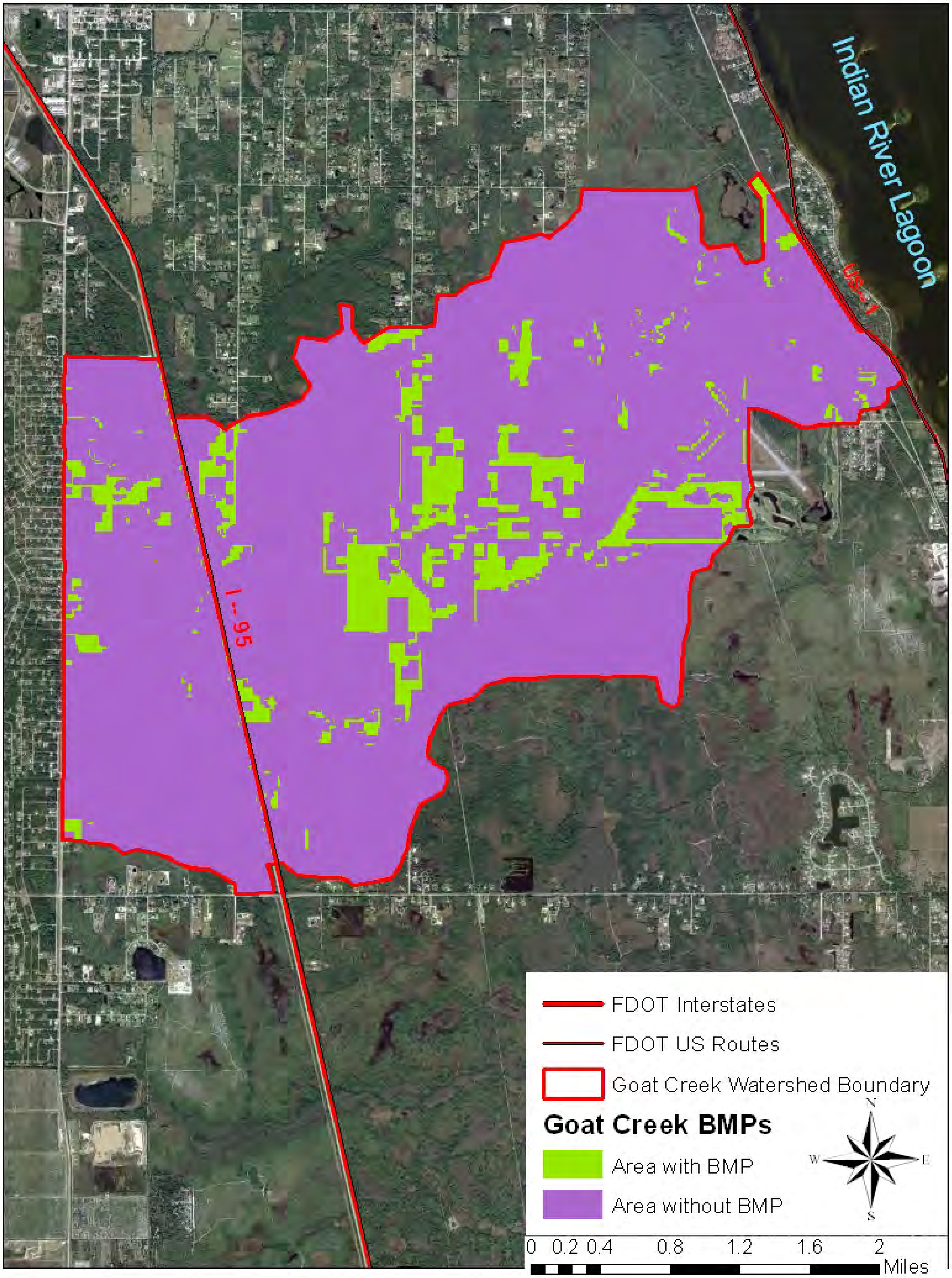

Figure 4.6. BMP Distribution in the Goat Creek Watershed

Table 4.8. Nutrient Loads from the Goat Creek Watershed

Land Use	Acreage	TN Annual Load (lbs/year)	TP Annual Load (lbs/year)	Percent TN Load	Percent TP Load
Urban and Build-Up	1,303	8,017	987	27.9%	29.4%
Agriculture	366	3,866	499	13.5%	14.9%
Rangelands	1,549	7,659	408	26.7%	12.2%
Upland Forest	2,243	6,951	894	24.2%	26.6%
Water	282	845	178	2.9%	5.3%
Wetlands	1,192	0	0	0.0%	0.0%
Barren Land	46	148	12	0.5%	0.3%
Transportation, Communication, and Utilities	179	1,237	378	4.3%	11.3%
Total	7,161	28,723	3,356	100.0%	100.0%

As discussed in **Sections 4.2.2.1** and **4.2.2.2**, the 2009 land use dataset shows that there is a 6.2% increase in human land uses, including urban and build-up, agriculture, and transportation, communication, and utilities. In addition, the NRCS 2010 soil classification shows a significant increase in A and A/D soils and a decrease in C, B/D, and D soils, suggesting that the overall rainfall infiltration potential may increase and the potential of nutrient load production may decrease with the new dataset, especially under a continuous dry condition and for non-anthropogenic land areas. It is, therefore, desirable to examine how these changes may impact the nutrient load estimation from the watershed. To do this, following steps were taken by the Department to update the original PLSM model using the new land use and HSG soil information.

(1) The 2010 NRCS SSURGO soil coverage was clipped using the Goat Creek watershed boundary shapefile to create a SSURGO soil shapefile for the watershed.
(2) As discussed in Section 4.2.2.2, soil types in about 2.8% of the watershed areas are not classified into any HSGs. For these areas, the missing soil HSG classification was populated by referring to the “MUNAME” (soil name) information provided in the NRCS SSURGO shapefile attribute table. Those unclassified soils with a “MUNAME” of Water, were assigned an HSG classification of “W”. Those unclassified soils with a “MUNAME” of Urban Land were assigned an HSG classification of “U”. This HSG classification appeared to be consistent with the “W” and “U” classification in SJRWMDL PLSM model.
(3) The SJRWMD 2009 land use shapefile was clipped using the Goat Creek watershed boundary shapefile to create a 2009 land use shapefile for the watershed.
(4) A spatial union operation was conducted on shapefiles created in (2) and (3) to bring both land use and soil information into the same attribute table. The product shapefile from the spatial union operation was then spatially united with SJRWMD’s PLSM model shapefile to incorporate into the final product shapefile information on rain zones and BMPs.
(5) Two lookup tables, including one for runoff coefficients for different land use – HSG soil combinations and one for EMCs for different land uses, were created using SJRWMD’s PLSM model that covers the Central Indian River Lagoon basin. The runoff coefficients and EMCs were then incorporated into the product shapefile created in (4) using

ArcGIS's Join operation. Due to the reclassification of the HSGs in NRCS's 2010 SSURGO soil coverage and land use in SJRWMD's 2009 land use shapefile, several land uses and land use – HSG combinations that had not appeared in previous versions of the PLSM model appeared in updated model. For example, A/D soil is an HSG that had not appeared in previous versions of the PLSM model. To assign runoff coefficients to land use – A/D soil group combinations, the method used by SJRWMD described in **Section 4.2.2.3** was implemented. If the A/D soil combines with a human land use, the A soil runoff coefficient of the land use would be used. If the A/D soil combines with a natural land, the D soil runoff coefficient of the land use would be assigned to the combination. Several land use types did not exist in the previous version of the PLSM model for the Central Indian River Lagoon, such as "Horse Farm (FLUCCS code 2510)," "Tree Nursery (FLUCCS code 2410)," "Surface water collection basin (FLUCCS code 8370)," etc. The runoff coefficients and EMCs for these land uses were borrowed from the PLSM models developed from the North Indian River Lagoon and Banana River Lagoon drainage basin PLSM models.

(6) After the above processes were conducted, nutrient loads from the Goat Creek watershed were re-calculated using Equation (1) on page 11. The re-calculated nutrient loads are tabulated in **Table 4.9**.

Table 4.9. Nutrient Loads through runoff from the Goat Creek Watershed Based on 2009 Land Use and NRCS 2010 SSURGO Soil Coverage

Land Use	Acreage	TN Annual Load (lbs/year)	TP Annual Load (lbs/year)	Percent TN Loading	Percent TP Loading
Urban and Build-Up	1,595	8,245	1,210	31.9%	35.4%
Agriculture	486	3,850	632	14.9%	18.5%
Rangeland	1,542	6,460	345	25.0%	10.1%
Upland Forest	1,678	5,224	672	20.2%	19.7%
Water	192	654	140	2.5%	4.1%
Wetlands	1,430	0	0	0.0%	0.0%
Barren Land	28	117	9	0.5%	0.3%
Transportation, Communication, and Utilities	210	1,333	406	5.1%	11.9%
Total	7,161	25,883	3,413	100.0%	100.0%

As shown in **Table 4.9**, the recalculated TN and TP loads are 25,883 lbs/year and 3,413 lbs/year, respectively. Compared to the TN and TP loads calculated using the previous PLSM model developed by SJRWMD, which are 28,723 lbs/year of TN and 3,356 lbs/year of TP, the re-calculated TN loadings decreased by about 9.9% while the re-calculated TP loadings increased by about 1.7%. Compared to the large increase in A/D soil and decrease in B/D soil in the NRCS's 2010 soil coverage (**Tables 4.4** and **4.5**), which are expected to decrease the runoff and nutrient loads more significantly, the decrease of TN loadings is relatively small. This could be a result from much of the B/D to A/D soil re-classification that happened in natural land areas. As discussed in **Section 4.2.2.3**, the runoff coefficients in B/D and A/D soils in natural and low intensity human land areas are assigned the runoff coefficients of the D soil. Therefore, re-classifying the B/D soil to A/D soil in natural land areas may not cause change of runoff and nutrient loadings production in these areas. The relatively small percent reduction in TN might have been caused by the relatively small increase in A soils and decrease in D soils. But this small change may not be enough to offset the increase in human land use areas and decrease of natural land areas, which results in the slight increase of TP loadings in PLSM calculation using the 2009 land use information.

SJRWMD's PLSM model was calibrated against the total stream flow instead of just surface runoff. The calibration was conducted using the available flow gauge stations located in several major tributaries in the central IRL basin and then applied to the remaining ungauged areas in the basin. Therefore, it could be considered that SJRWMD's PLSM model for the Goat Creek watershed also implicitly includes a baseflow component. When the model was updated using the reclassified NRCS HSG dataset, the slight increase in A soils and decrease in D soils may cause the overall rainfall soil infiltration to increase and therefore results in low runoff production. Because of the small size of the Goat Creek watershed, the infiltration would likely reach the creek through the baseflow path. Therefore, using the load simulation from SJRWMD's version of the PLSM model, which implicitly includes the baseflow component of the loading, appears to be more appropriate to estimate the total nutrient loads from the Goat Creek watershed than assuming that all increased infiltration due to re-classified soil coverage will be lost from the system. Therefore, for this TMDL, SJRWMD's PLSM model was used to estimate the nutrient loads from the watershed under the existing condition.

4.2.2.8 Nutrient Loads from the Atmospheric Deposition Directly onto the Water Surface of Goat Creek

Because the surface area of Goat Creek marine segment is less than 0.1% of the area of the entire watershed, it is considered negligible. Therefore, for this TMDL, the atmospheric deposition directly onto the surface of Goat Creek was not calculated.

4.2.2.9 Summary of the Nonpoint Source Loads

Human land use and natural land areas in the Goat Creek watershed are major sources of nutrients to the creek. Nutrient loads created in the watershed area are primarily driven by the rainfall into the watershed and can enter the creek through either the runoff or baseflow pathway. The quantity of the nutrient loads entering the creek was estimated using SJRWMD's PLSM model, which implicitly includes both the runoff and baseflow loadings into consideration. Under the existing condition, about 28,723 lbs of TN and 3,356 lbs of TP enter the creek on the annual basis. To control the nutrient condition of the marine segment of the creek, controlling the nutrient sources in the Goat Creek basin should be the first step to take. However, because of the hydrodynamic relationship between the tidal segment of Goat Creek and the Indian River Lagoon proper, nutrient loads entering the marine segment of the creek from the watershed are not the only nutrients affecting the nutrient condition of the segment. The nutrient condition of the tidal segment of the creek can also be influence by the nutrient loads entering the IRL lagoon proper from other land areas and sources in the Indian River Lagoon basin. In addition, nutrient loads coming from inside the lagoon, e.g. sediment nutrient release or nutrient cycling through components of the lagoon biocommunities, such as phytoplankton, macro algae, seagrass and associated epiphyte, may also influence the nutrient condition of the tidal segment of the creek. A healthy nutrient condition at the marine segment of the creek depends on proper management of nutrient loadings from the watershed of the creek, as wells the nutrients loading from the lagoon from various sources.

Chapter 5: DETERMINATION OF ASSIMILATIVE CAPACITY

5.1. Observed Elevation of *ChlaC* in 2009 and 2010

Before a nutrient reduction target can be established to address the observed elevation of ChlaC concentration in 2009 and 2010, a critical question to ask is whether the observed elevation was due to the elevated nutrient loads from the watershed in the first place. To answer this question, the Department examined the historic rainfall pattern in the general area of Goat Creek. The goal of examining the rainfall pattern is to demonstrate, during the 2009 and 2010 period, whether there was a trend of increased rainfall that brought more nutrients into the impaired creek segment. In addition, the Department also examined the historic concentration pattern of several nutrient related parameters, including TN, TP, ortho-phosphate (PO4), and ChlaC concentrations collected from two stations in Goat Creek and two stations located in the IRL lagoon proper that are close to the mouth of Goat Creek. The goal of this analysis is to explore possible similarities of nutrient related parameters among these stations, so that a general understanding can be achieved on whether the ChlaC elevation was caused by increased watershed nutrient loads or was mainly a receiving water phenomenon.

5.1.1 Historic Rainfall Pattern and Dynamics of ChlaC Concentration

Daily rainfall data were retrieved from the Southeast Regional Climate Center (SERCC)'s Climate Information Management and Operational Decision (CLIMOD) system (http://climod.meas.ncsu.edu/). The rainfall data used for this analysis were collected at a weather station located at the Melbourne International Airport, which is about 9 miles from the Goat Creek watershed. **Table 5.1** shows the monthly rainfall and annual rainfall for a 10-year period from 2001 through 2010.

Table 5.1. Monthly and Annual Rainfall (Inch/Year) at the Melbourne International Airport (2001 – 2010)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Rainfall
2001		1.1	3.6	0.64	5.51	4.9	11.33	6.08	9.66	4.68	5.18	0.71	53.39
2002	2.12	2.81	0.56	2.62	1.46	8.7	3.42	6.97	1.65	5.14	1.94	10.29	47.68
2003	0.77	1.69	3.06	1.51	1.79	10.7	5.33	8.08	4.47	0.91	2.08	2.73	43.12
2004	2.13	2.56	1.05	1.03	0.99	10.59	2.48	10.56	7.11	4.89	1.21	3.01	47.61
2005	1.67	3.5	4.13	2.25	4.09	11.37	2.35	7.17	8	11.85	1.2	2.23	59.81
2006	0.54	2.15	0.3	1.15	1.73	7.06	8.19	6.92	5.98	1.02	3.67	1.32	40.03
2007	2.01	1.76	0.52	1.46	1.36	9.49	11.47	1.17	8.95	4.14	0.94	0.69	43.96
2008	2.97	2.21	2.7	2.18	0.46	6.33	11.01	21.06	3.31	9.07	2.43	0.76	64.49
2009	0.93	1.06	0.86	2.16	9.28	3.97	7.61	3.49	8.99	0.74	0.37	5.52	44.98
2010	0.94	2.57	8.74	2.13	0.29	2.9	1.23	5.59	5.94	0.00	3.43	1.95	35.71
Mean	**1.56**	**2.14**	**2.55**	**1.71**	**2.70**	**7.60**	**6.44**	**7.71**	**6.41**	**4.24**	**2.25**	**2.92**	**48.08**

As shown in **Table 5.1**, the long-term average annual rainfall at the Melbourne International Airport for the 10-year period from 2001 through 2010 was about 48.1 inches/year. Annual rainfalls in 2009 and 2010 were both lower than the long-term average annual rainfall. In fact, a cumulative frequency analysis on the annual rainfall indicated that, during the 10-year period, 2009 rainfall ranked about 40^{th} percentile, while the 2010 rainfall was the lowest annual rainfall in the 10-year period.

Examining **Table 5.1** in a more detailed fashion found that, in 2009, monthly rainfalls in May, September, and December were significantly higher than the long-term average monthly rainfall. The May-2009 monthly rainfall was 9.28 inches, comparing to the long-term average May rainfall of 2.7 inches. The September-2009 rainfall was 8.99 inches, comparing to the long-term average September rainfall of 6.44 inches. The December-2009 rainfall was 5.52 inches, comparing to the long-term average December rainfall of 2.92 inches. In 2010, only the monthly rainfall of March (8.74 inches) significantly exceeded long-term average March rainfall of 2.55 inches. The monthly rainfalls of all the other months in 2009 and 2010 were either very close to the long-term average monthly rainfall or lower.

The annual rainfall in 2008 was also examined because this was the year that, although the annual ChlaC concentration did not exceeded the historic minimum by more than 50%, the annual ChlaC was significantly higher than the ChlaC of previous years. The annual rainfall in 2008 was about 64.5 inches/year, which was the highest during the 10-year period. The highest monthly rainfalls were observed in August (21.1 inches), mainly due to the tropical storm Fay. High monthly rainfalls were also observed in July (11.0 inches) and October (9.1 inches).

Could the elevated ChlaC in 2009 and 2010 be caused by the nutrient loads brought into the marine segment of Goat Creek during the several high rainfall months in these two years as well as in 2008 and those nutrient loads supported the phytoplankton growth in low rainfall months when the water residence time becomes longer?

To answer this question, ChlaC data collected from a station located at the marine segment of the creek (21FLSJWMIRLGUS, **Figure 5.1**) were compared to the rainfall data. Data from this station were chosen because this station has the longest period of record among stations located in the impaired marine creek segment. Data from this station represent the vast majority of the data used in the listing process to verify the nutrient impairment of the marine creek segment. **Figure 5.2** shows the dynamics of monthly total rainfall and ChlaC collected in each month in the 10-year period from 2001 through 2010. As shown in the figure, ChlaC concentration in the marine segment of the Goat Creek did not appear to be stimulated by the rainfall. In most cases before 2008, ChlaC of the Goat Creek marine segment was in the range between 1 to 3 ug/L. In 2001, ChlaC concentration reached about 5 µg/L before the rainy season started. The rainy season appeared to be associated with ChlaC concentrations that were lower than 1 µg/L. The ChlaC concentration recovered to about the level before the rainy season at the end of the year when rainfall became low. The similar pattern was observed in 2002. Again, ChlaC concentration reached above 5 µg/L before the rainy season started. The rainy season, once again, was associated with the reduced the ChlaC concentration and kept it below 3 µg/L for most of the rest of the year. In 2003, ChlaC almost showed no response to the rainfall variation. Peak rainfalls appeared in June and August in 2004. Again, before the June peak, ChlaC concentrations higher than 5 µg/L already existed. After the June rainfall peak, there was a ChlaC concentration peak that reached as high as 15 µg/L. But, the August rain peak reduced the ChlaC concentration and made it close to method detection limit for the rest of the year. During the period from early 2005 to late 2007, the monthly ChlaC concentration

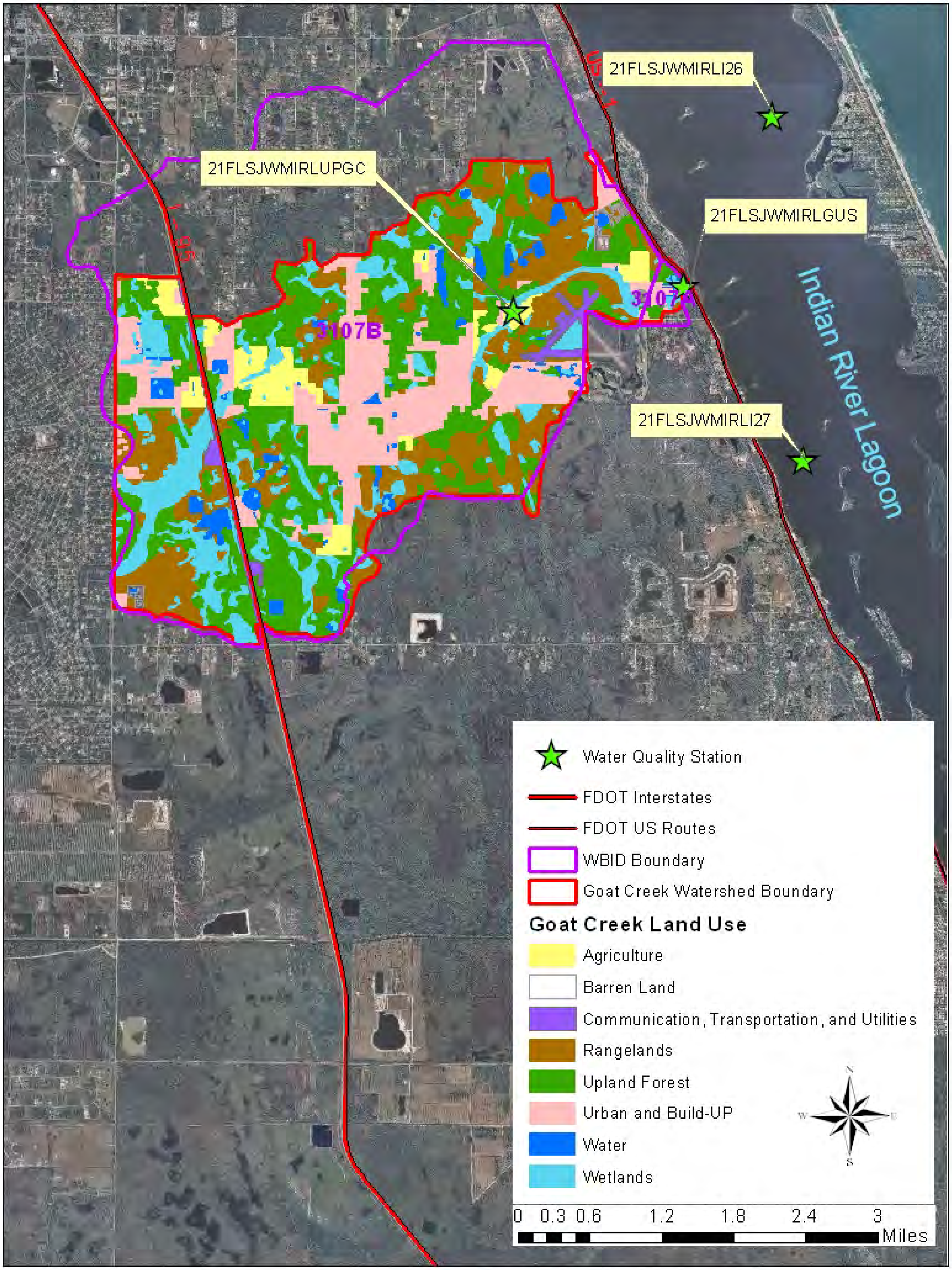

Figure 5.1. Location of Water Quality Stations in Goat Creek and IRL Mainstem Used for Trend Analyses

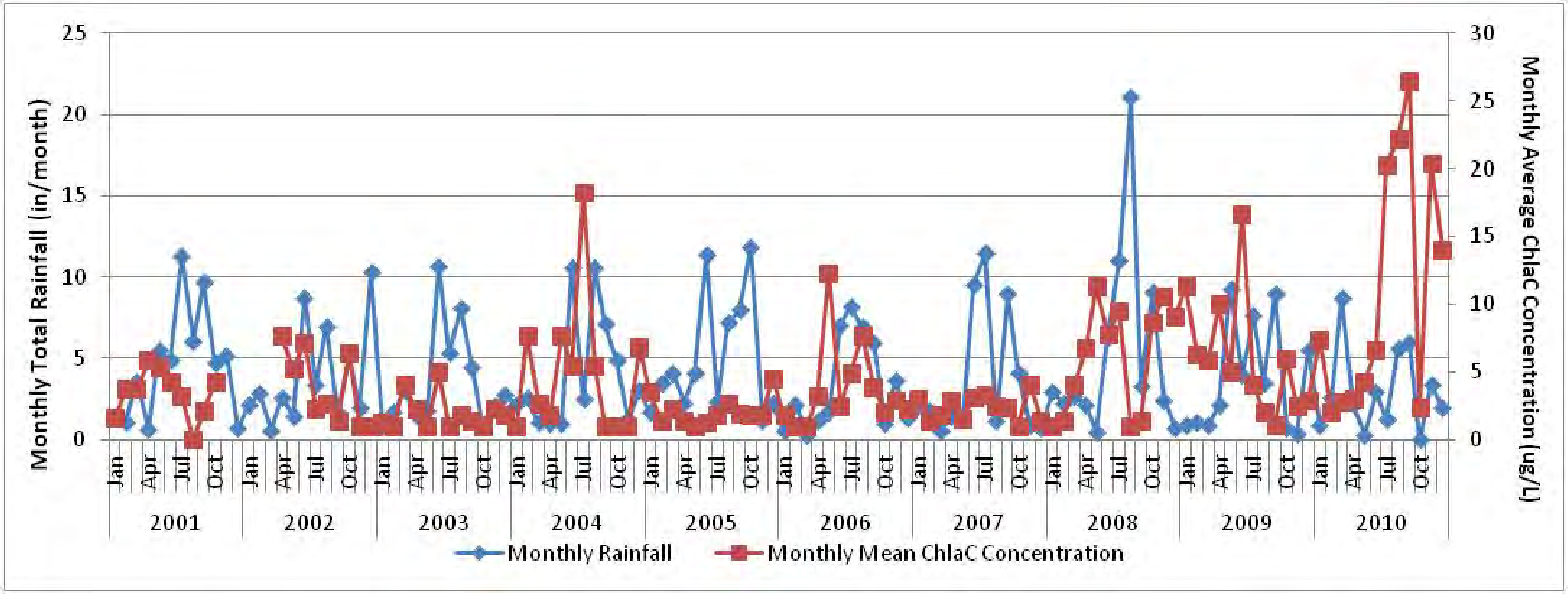

Figure 5.2. Monthly Rainfall and Monthly Average ChlaC Concentration in the 10-Year Period from 2001 through 2010

mostly stayed between 2 and 3 µg/L despite of the variation of the rainfall. Variation of rainfall in these three years did not produce much change in the ChlaC concentration. Several high ChlaC concentrations that caused the 2008 annual mean ChlaC to become elevated appeared before the Tropical Storm Fay. The tropical storm in August was associated with a drop of ChlaC concentration in August and September. Unlike in other years, the ChlaC did not stay below 3 µg/L for the rest of the year. Instead, the ChlaC concentration increased to about 9 µg/L in October and stayed above 5 µg/L until the start of the rainy season in 2009. These high ChlaC values were what caused the 2009 annual mean ChlaC concentration to exceed the historic minimum by more than 50%. The onset of the 2009 rainy season once again was associated with the depressed ChlaC concentration and kept the monthly ChlaC concentration below 4 µg/L for most of the months between August of 2009 and April of 2010. The ChlaC started to soar after July of 2010. Except in October of 2010, the ChlaC concentrations in rest of 2010, starting from July, were all above 20 µg/L. Monthly rainfalls for the entire 2010 were below the long-term average.

The rainfall-ChlaC pattern shown in **Figure 5.2** suggested that one of the possible major effects of rainfall to the ChlaC concentration in the marine segment of Goat Creek was dilution due to flushing. But growth stimulation due to the nutrient loads being brought into the system has not been observed. When ChlaC concentrations became very low, like those appeared in 2005, 2006, and 2007, ChlaC concentrations showed no response to the change of rainfall, likely because the ChlaC concentrations were very close to the detection limit. This appeared to be a typical pattern before 2008. Based on this pattern, it is very unlikely that the elevated ChlaC concentration after 2008 were caused by the large rainfall produced by Tropical Storm Fay. The elevated ChlaC concentrations in 2009, before the rainy season and after July in 2010, were all observed under low monthly rainfall conditions, suggesting that the observed elevation in ChlaC concentrations in 2009 and 2010 was not related to elevated nutrient loadings from the watershed.

Interpretation of the rainfall-ChlaC pattern shown in **Figure 5.2** may be influenced by possible time lag between the phytoplankton biomass increase and nutrient being brought into the system, or the observed dilution of ChlaC by rainfall was caused by the seasonality of algal growth. To indicate that this was not the case, the relationship between annual total rainfall and annual average ChlaC concentration was explored. Analyzing the relationship at the annual time scale avoids the time lag issue because one year provides long enough time for phytoplankton to respond to the nutrient brought into the system. In addition, examining the ChlaC concentration at the annual time scale also avoids the interference from the possible seasonal effects. **Figure 5.3** shows the relationship between the annual total rainfall and annual average ChlaC concentration in the marine segment of Goat Creek. The figure clearly shows that, except in 2008 (marked as a red-color data point), there is a general pattern of decrease in annual average ChlaC concentration with the increase in annual total rainfall ($P = 0.037$). The likely reason for the reverse relationship between ChlaC concentration and rainfall is the short water residence time for the marine segment of the creek. The increase of algal biomass due to the increase of nutrient being brought into the creek by increased runoff may not be high enough to counterbalance the dilution effect of the increased flow.

In summary, the historic data analyses showed that the elevated ChlaC concentration observed in 2009 and 2010 might not have been caused by the elevated nutrient loads brought into the tidal segment of the creek from the Goat Creek watershed. This conclusion was reached because (1) 2009 and 2010 were two dry years compared to the long-term average rainfall. Nutrients entering the impaired segment should be reduced in those two years, and (2) the overall response of the ChlaC concentration to rainfall appeared to be dilution, instead of a growth stimulation. This dilution effect is not only shown on the monthly time scale, it is also shown on the annual time scale. Therefore, the interference of lagged response of algal biomass to nutrient loads and algal growth seasonality can be excluded.

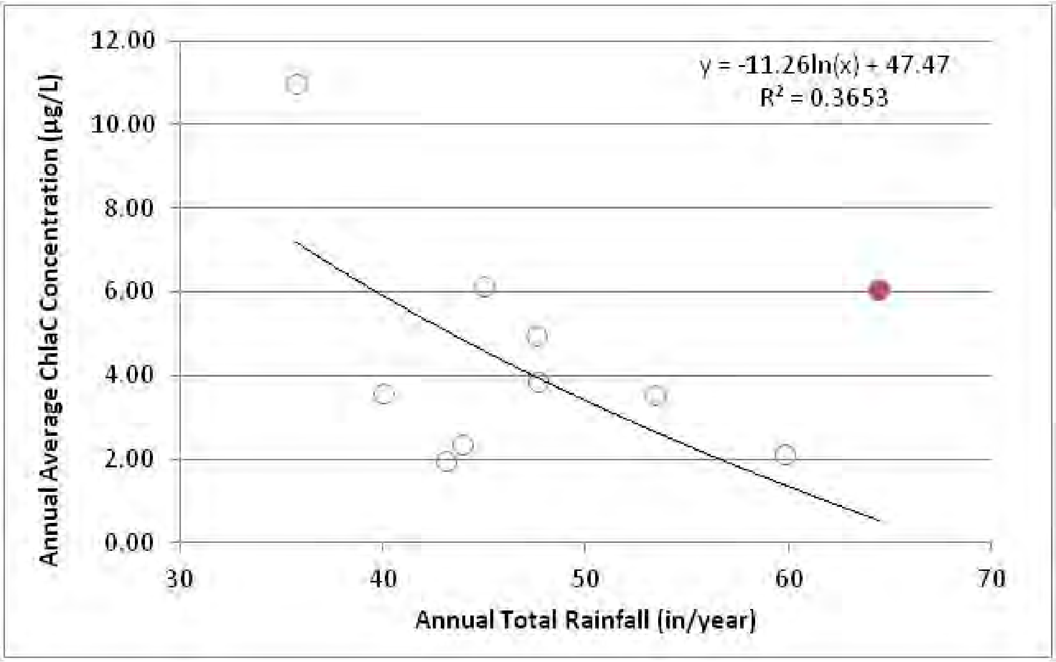

Figure 5.3. Relationship between the Annual Average ChlaC Concentration and Annual Total Rainfall

5.1.2 Examining the Nutrient Related Parameters at Upstream Station, Impaired Water Stations, and Two Stations in the Lagoon Proper

Examining the water quality data collected from stations nearby the impaired water segment is another way to find out whether the elevated ChlaC concentration in the impaired segment was due to the elevated nutrient loading from the watershed. For this analysis, nutrient related parameters, including TN, TP, and ChlaC collected from four water quality stations were used for the comparison. These four stations, all maintained by SJRWMD, include a station located in the Goat Creek segment upstream of the impaired marine segment (21FLSJWMIRLUPGC, a station located where Gradick Road crosses Goat Creek), a station located in the impaired marine creek segment (21FLSJWMIRLGUS, a station located where US-1 crosses Goat Creek), and two stations located in the central IRL lagoon proper (21FLSJWMIRLI26, a station located in the center of Indian River Lagoon that is about 2500 meters northeast to the mouth of Goat Creek, and 21FLSJWMIRLI27, a station located in the lagoon proper that is about 2800 meters south of the mouth of Goat Creek). These stations all have long-term data that allow for the long-term trend comparison. Locations of these stations are shown in **Figure 5.1**. **Figures 5.4-A** and **5.4-B**, **5.5-A** and **5.5-B**, **5.6-A** and **5.6-B**, **5.7-A** and **5.7-B**, show the trend comparison and statistical comparison of TN, TP, ratio between orthophosphate (PO4) and TP, and ChlaC, respectively, at the four water quality stations. In these figures, 3107A represents Station 21FLSJWMIRLGUS; 3107B represents Station 21FLSJWMIRLUPGC; IRLI26 represents Station 21FLSJWMIRLI26; IRLI27 represents Station 21FLSJWMIRLI27.

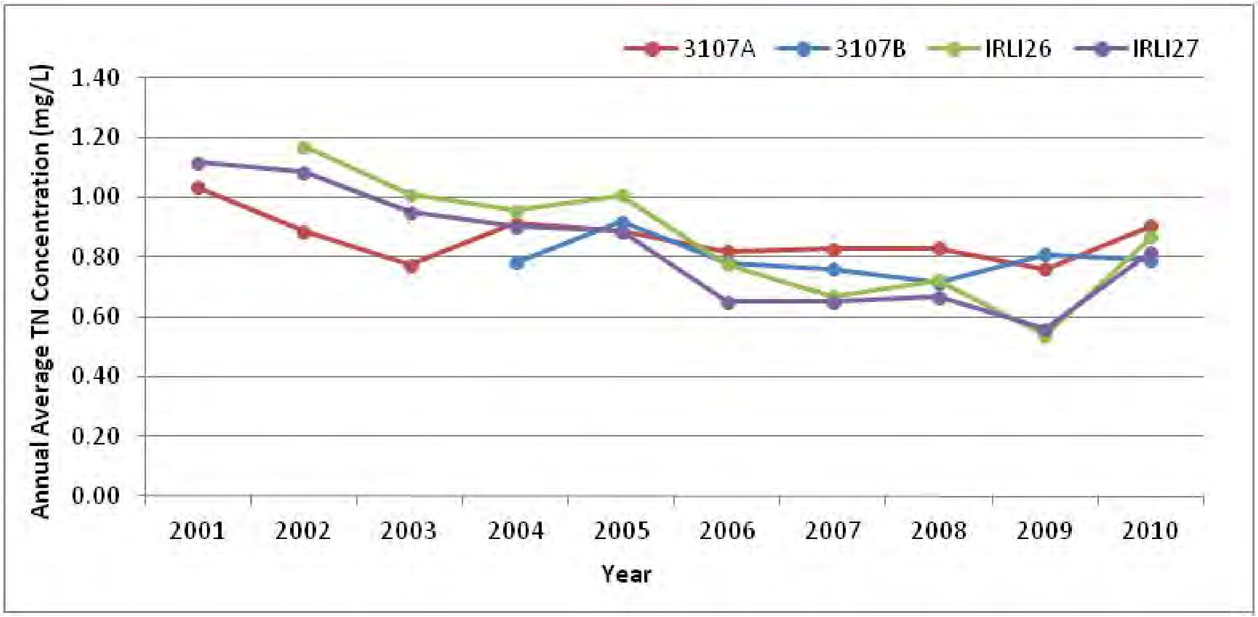

Figure 5.4-A. Trend Comparison of Annual Average TN Concentrations at the Four Water Quality Stations

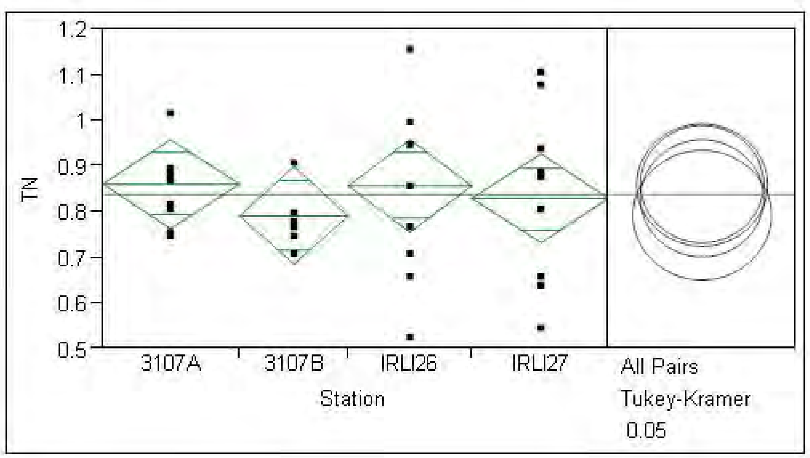

Figure 5.4-B. Statistical Comparison of Annual Average TN Concentrations at the Four Water Quality Stations

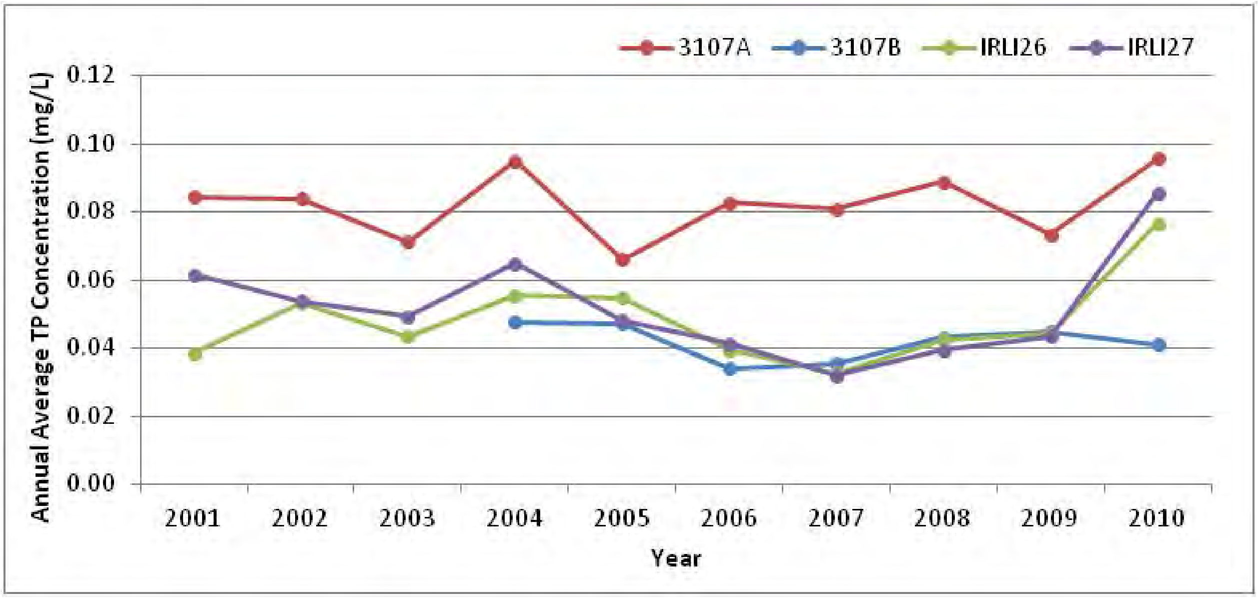

Figure 5.5-A. Trend Comparison of Annual Average TP Concentrations at the Four Water Quality Stations

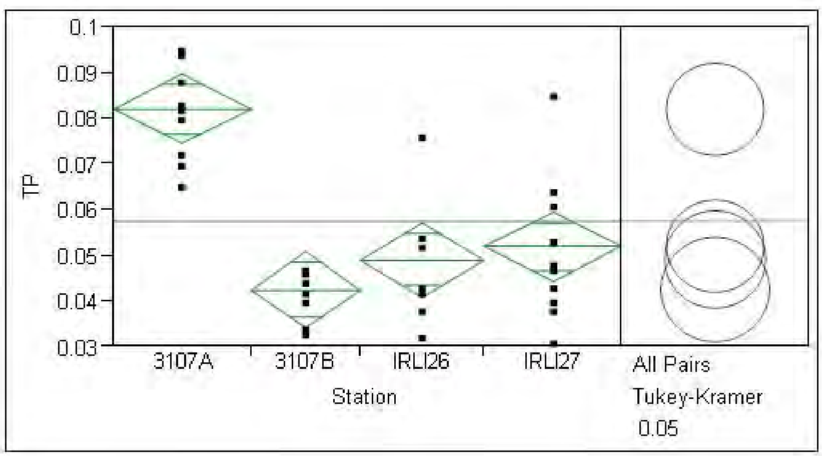

Figure 5.5-B. Statistical Comparison of Annual Average TP Concentrations at the Four Water Quality Stations

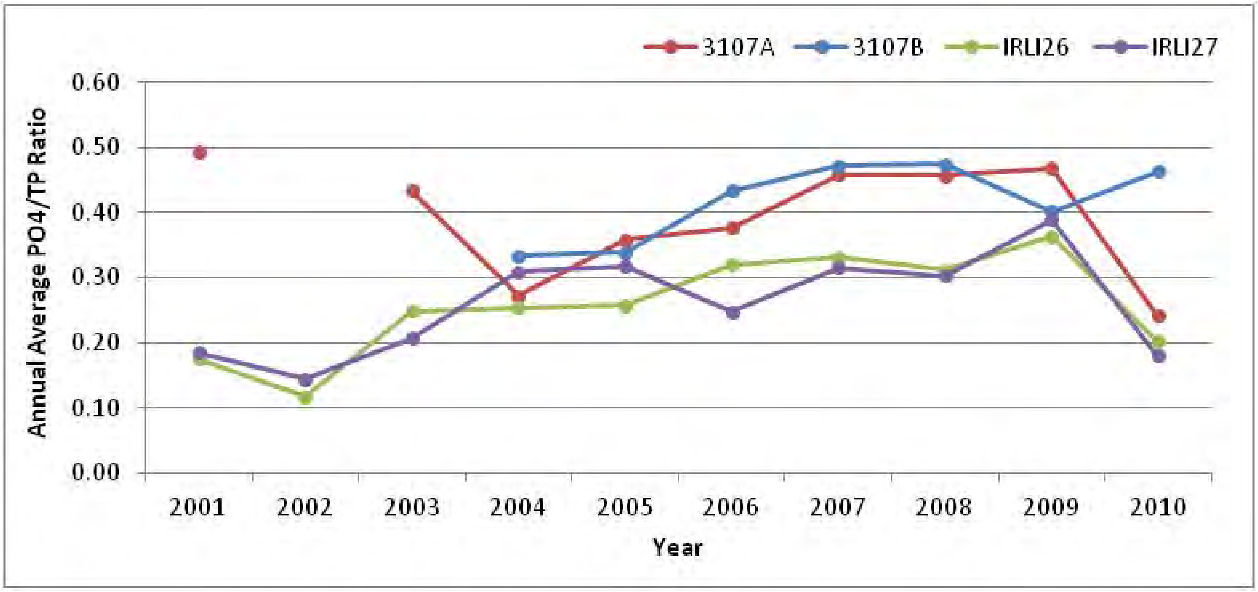

Figure 5.6-A. Trend Comparison of Annual Average PO4/TP Ratio at the Four Water Quality Stations

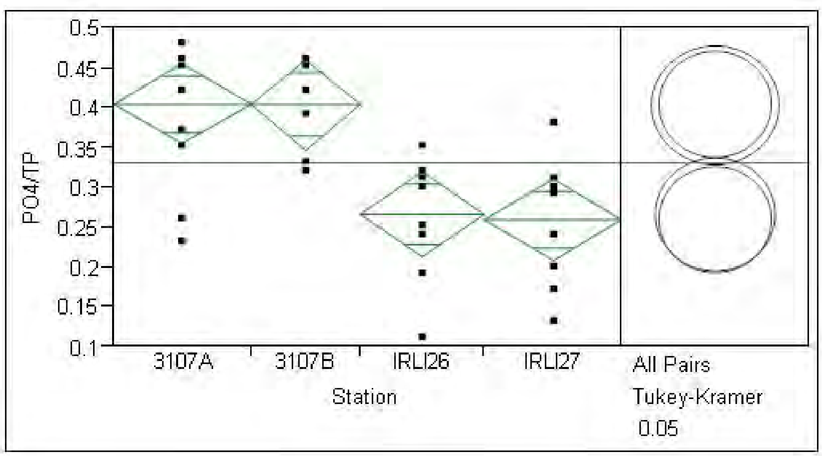

Figure 5.6-B. Statistical Comparison of Annual Average PO4/TP Ratio at the Four Water Quality Stations

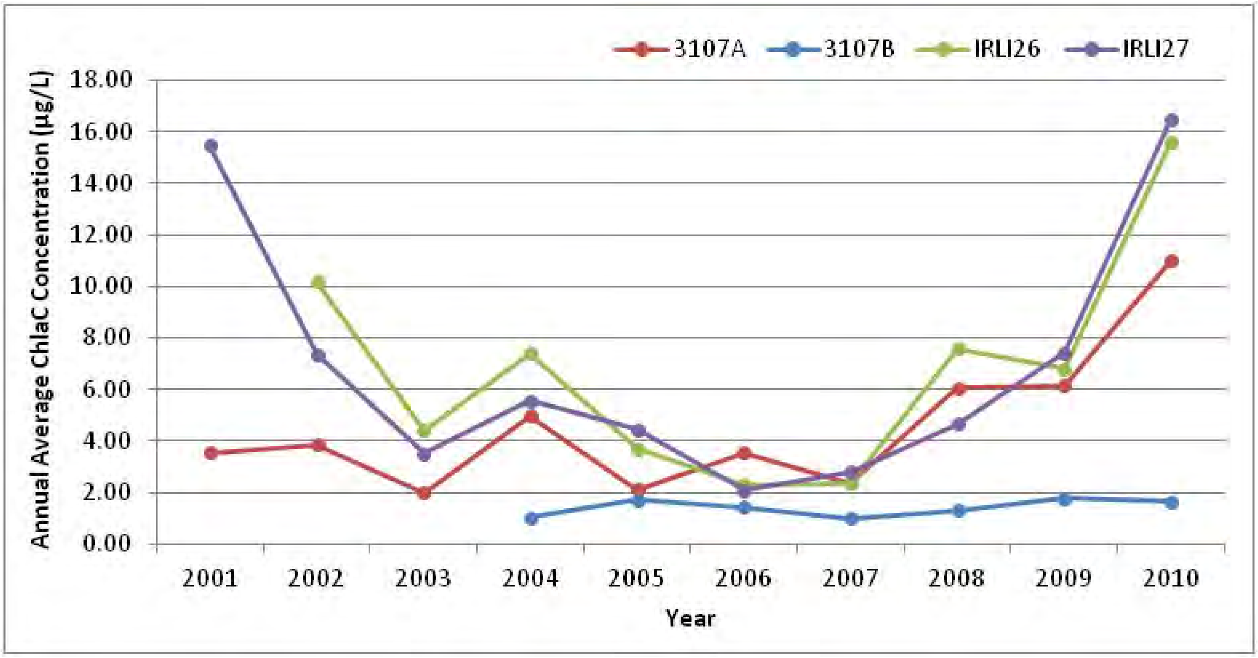

Figure 5.7-A. Trend Comparison of Annual Average ChlaC Concentrations at The Four Water Quality Stations

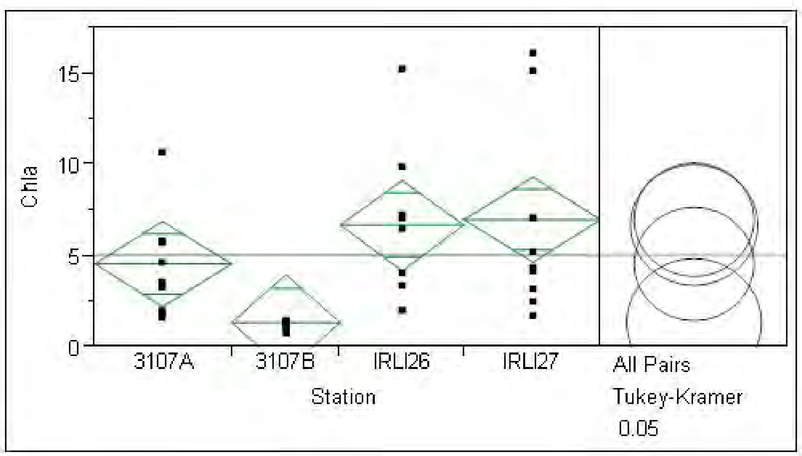

Figure 5.7-B. Statistical Comparison of Annual Average ChlaC Concentrations at The Four Water Quality Stations

The annual average TN concentrations of the four water quality stations show very similar long-term patters. In most years during the 2001 through 2010 period, the variance of the annual average TN concentration across the four sites was less than 0.2 mg/L. Except that the upstream site showed a relatively flat long-term TN trend, there is a general decreasing trend of TN concentration in this period for other stations, from between 1.00 and 1.20 mg/L in 2001, to between 0.8 to 1.0 mg/L in 2003 through 2005, to between 0.6 and 0.8 mg/L in 2006 through 2009. There was a slight increase of TN from all the four stations above 0.8 mg/L in 2010. No single one dataset was distinctively different from the other datasets. The long-term trend comparison results were supported by the statistical comparison results. None of the four datasets are significantly different from the other (**Figures 5.4-A and 5.4-B**).

In contrast to the annual average TN concentrations, TP concentration at the site located in the impaired marine creek segment of the creek (i.e., 21FLSJWMIRLGUS located at the mouth of Goat Creek) were significantly higher than TP concentrations from all the other three stations. While annual average TP concentrations from the other three stations mostly ranged from 0.03 mg/L to 0.06 mg/L, the TP concentration at Station 21FLSJWMIRLGUS ranged from 0.07 mg/L to 0.09 mg/L. This general trend was confirmed by the statistical comparison, which shows that the TP concentration at the Station 21FLSJWMIRLGUS was significantly different from the TP concentrations from the other stations. However, there was an exception. In 2010, annual average TP concentrations of the two lagoon proper stations, including 21FLSJWMIRLI26 and 21FLSJWMIRLI27, showed a significant increase from about 0.04 mg/L to about 0.08 mg/L. However, TP concentration at Station 21FLSJWMIRLGUS did not show a significant increase. This caused the TP concentration at the Station 21FLSJWMIRLGUS to become similar to those two lagoon stations. The annual average TP concentration at Station 21FLSJWMIRLUPGC, which is the station located in upstream freshwater segment of Goat Creek, did not change in 2009 – 2010, still staying at the 0.04 mg/L level (**Figures 5.5-A** and **5.5-B**). As shown in **Figure 5.1**, the Station 21FLSJWMIRLUPGC is located in the freshwater segment of Goat Creek at a location that drains the majority of the Goat Creek watershed. The impact on this upstream site by the lagoon water was low based on a long-term average salinity of 0.74 ppt at this station compared to the long-term average salinity of 25 ppt at the two lagoon stations (the long-term average salinity at the impaired marine station is 17 ppt, indicating a significant impact from the lagoon water). The fact that the TP concentration did not change in 2009 and 2010 at the upstream station, which receives drainage from the majority of the watershed and received insignificant impact from the lagoon water, suggests that the nutrient loads from the watershed did not increase in 2009 and 2010. Meanwhile, the fact that the TP concentration increased in 2009 and 2010 at the station located in the impaired marine segment of the creek that receives only slightly more discharge from the Goat Creek watershed than the upstream stream, but receives much greater impact from the lagoon water, suggests that the observed elevation in TP concentration in 2009 and 2010 might be due to the internal nutrient loadings or recycling instead of the elevated nutrient loads from the watershed.

Another way to show that the elevated TP at the impaired segment station was due to the receiving water process instead of the elevated nutrient loadings from the watershed is to look at the characteristics of the TP composition. In this case, the Department examined the variation of the ratio between the orthophosphate (PO4) and TP. As shown in **Figure 5.6-A**, in the 10-year period from 2001 through 2010, there was a trend that the PO4/TP ratios of the two creek stations were similar to each other while the PO4/TP ratios of the two lagoon stations were similar to each other. The difference in PO4/TP ratios between these two pair of stations is also confirmed with the statistical comparison shown in **Figure 5.6-B**. The PO4/TP ratio difference was most obvious in the period from 2006 through 2008, when about 45% of the TP at the two creek stations was in the form of PO4, while only about 30% of the TP at the two lagoon stations was PO4. In 2009 and 2010, the PO4/TP ratio of the two lagoon stations dropped to about 20%, suggesting that more phosphate was converted into organic phosphorus due to the uptake of phosphate by increased algal biomass. The station located in the impaired marine segment of the creek also showed a drop of the PO4/TP ratio from about 45% to about 20% in 2009 and 2010, which became similar to the ratio of the lagoon stations. At the same time in 2009 and 2010, at the upstream creek station, which receives insignificant influence from the lagoon water, the PO4/TP ratio did not change and remained at about 45% level. These observations are consistent with the hypothesis that the observed elevation of TP at the impaired marine creek segment was due to receiving water processes instead of the elevated nutrient loadings from the watershed.

The ChlaC concentration dynamics shown in **Figures 5.7-A** and **5.7-B**, also suggest that what happened at the impaired marine creek segment was due to the receiving water influence. As shown in these figures, the ChlaC concentration at the upstream creek station was consistently lower than the ChlaC concentrations observed at the other three stations, mostly staying below 2.0 µg/L in the period of record. This might be due to the short water residence time and low nutrient concentrations in the creek. ChlaC concentrations at the two lagoon stations, in the same time period, varied between 2.0 µg/L and 16.0 µg/L, with a mean value of about 7.0 µg/L. The ChlaC concentration at the impaired marine creek segment, which, in most cases in the period of records, had a TP concentrations 2 times of the TP concentrations observed at the other three stations, fluctuated in the 3.0 to 4.0 µg/L range before 2008, which are lower than the ChlaC concentrations observed at the two lagoon stations. The ChlaC concentrations at the two lagoon stations increased from about 2.0 µg/L to about 16 µg/L in 2008, 2009, and 2010. At the same time, ChlaC concentration at the upstream creek station did not change, still remaining below 2.0 µg/L. The ChlaC concentration at the impaired marine segment station, increased with the increase of the ChlaC concentrations at the two lagoon stations, from about 2.3 µg/L in 2007 to about 11.0 µg/L in 2010. The ChlaC concentration increased about 378% in this period. While the TP concentration at the impaired marine segment station also increased at the same time period from 0.08 mg/L to 0.10 mg/L, the TP only increased by about 25%. Compared to the 378% increase in ChlaC concentration at this station, the increase in TP, by itself, was small and cannot explain the increase in ChlaC concentration. This is especially true considering that, during the same period, the PO4 component of the TP even decreased, which provides even less amount of biologically available TP to stimulate the elevated growth of phytoplankton at the impaired marine creek segment. The only processes that may explain the dramatic increase of ChlaC concentration with the minor increase in TP and decrease in biologically available phosphorus component in the impaired marine creek segment are extended water residence time due to the drought condition, change of phytoplankton species to those that have higher chlorophyll content, or receiving of elevated algal biomass from the nearby lagoon segment. All these processes are receiving water processes instead of a stimulation of phytoplankton growth by the elevated watershed nutrient loadings.

5.1.3 Conclusions

Based on analyses described above, the Department decided that the observed elevation of ChlaC concentrations in 2009 and 2010 were not caused by the elevated nutrient loading from the watershed. This conclusion was reached because the watershed nutrient loads should be low in 2009 and 2010 due to the low rainfall condition in those years (**Table 5.1**). Although 2008 was a wet year, and while several months in 2009 and 2010 showed higher than average monthly rainfall, the relative monthly rainfall and ChlaC concentration dynamic pattern (**Figure**

5.2) and the general inverse relationship between the annual total rainfall and annual average ChlaC concentration (**Figure 5.3**) suggests that the elevated rainfall condition primarily diluted out the ChlaC concentration in the impaired marine creek segment instead of stimulating the growth and biomass accumulation of phytoplankton in the creek segment.

That elevated ChlaC concentration in the Goat Creek marine segment in 2009 and 2010 was not caused by elevated watershed nutrient loadings was further confirmed with the comparisons of nutrient related parameters among two Goat Creek water quality stations, including the upstream Station 21FLSJWMIRLUPGC and impaired segment Station 21FLSJWMIRLGUS, and two nearby lagoon stations, including a station located north of the Goat Creek mouth (21FLSJWMIRLI26) and a station located south of the Goat Creek mouth (21FLSJWMIRLI27). These comparisons showed that: (1) The upstream station (21FLSJWMIRLUPGC), which receives the majority of the discharge from the Goat Creek watershed, maintains a TP concentration about 0.04 mg/L or lower and a ChlaC concentration generally lower than 2.0 µg/L. During the period of record of the station, the long-term mean annual average TN concentration was about 0.79 mg/L. This suggests that the land use pattern in the Goat Creek basin does not produce very high nutrient loads in the first place.

(2) The long-term mean annual average TN concentration for the impaired marine creek segment was about 0.88 mg/L, only slightly higher than the TN at the upstream station. The TP concentration at the impaired marine creek station was about 0.08 mg/L, which was two times of the TP concentration at the upstream station. It is not clear what causes the large difference in TP concentration between the upstream and downstream stations considering that the general land use patterns in upstream and downstream of the watershed are fairly similar, especially when the equally low TN concentration at the downstream station did not show any signs of elevated fertilizer use in the downstream watershed. There are several borrow pits that discharge into the downstream segment of the creek. The Department hypothesized that these pits may be so deep as to cut into the phosphorus rich Hawthorn formation and discharge high TP concentration water into the creek. During the development of this TMDL, the Department contacted Brevard County (Ms. Virginia Barker and Mr. John Royal). The county immediately sampled several pits that discharge into the marine segment of Goat Creek. The sampling results showed that the TP concentrations of these borrowed pits were not higher than the TP concentrations in the marine segment of the creek, suggesting that these borrow pits are not sources of TP to the creek. The Department also hypothesized that the high TP concentration of the downstream segment of the creek might be caused by high sediment nutrient release rates. At the time this TMDL was developed, there were no sediment nutrient release data available to the Department. However, if the high TP was mainly caused by the sediment nutrient release, the majority of released phosphorus should be in the form of phosphate. Therefore, the downstream segment should show a significantly higher PO4/TP ratio than the upstream station. However, as it was discussed previously, the PO4/TP ratio at the impaired marine creek segment was not significantly different from that of the upstream station. So far, it remains unclear what is the source of TP that result in the high TP concentration in the impaired downstream segment.

One important finding from the cross-station water quality comparison was that, while the TP concentration at the downstream marine segment is high, the observed ChlaC concentration at the station, in most cases of the 10-year period of record, was relatively low, around 4.0 µg/L. This ChlaC concentration was lower than the ChlaC concentrations observed at the two lagoon stations. The ChlaC concentration at the two lagoon stations ranged between 2 µg/L and 16 µg/L with a mean long-term annual average ChlaC concentration of 7 µg/L, suggesting that, for some reason, the phosphorus availability at the downstream creek station were not fully used, most likely due to the short water residence time. But, this also suggests a possibility that nutrients are not the limiting factor for phytoplankton biomass accumulation at the impaired marine creek segment, which further suggests that the observed elevation of ChlaC concentration in 2009 and 2010 were not caused by elevated nutrient loads from the watershed.

(3) The PO4/TP ratio at both creek stations showed very similar value ranges and trends and are significantly different from the ratio observed at the two lagoon stations. This is especially true for the 2006 to 2008 period. However, the PO4/TP ratio at the downstream marine creek station dropped dramatically from about 45% to about 20% in 2009 and 2010 period, which became very similar to the PO4/TP ratio at the two lagoon stations. At the same time, the PO4/TP ratio at the upstream creek station showed no change in 2009 and 2010, suggesting that the TP concentration change at the downstream marine segment was influenced more by the lagoon processes instead of by the watershed processes.

The long-term ChlaC concentration variation at the downstream station also confirmed this hypothesis. While the ChlaC concentration at the impaired marine station were mostly ranged from 3.0 to 4.0 µg/L in the 10-year period, it increased by about 378% in 2009 and 2010. At the same time, the TP concentration at this site only increased by about 25%. This 25% increase was not due to the increase of biologically more available phosphate concentration. In fact, the ratio of PO4/TP dropped from around 45% to about 20%. This indicates that the dramatic elevation of ChlaC concentration in 2009 and 2010 were not caused by the elevation of watershed nutrient loads. Most likely, it was caused by receiving water processes such as increased water residence time in dry years, switch of phytoplankton species to those with higher chlorophyll content, and receiving phytoplankton biomass coming from the lagoon proper through tidal activities.

One possible reason why the downstream marine segment is not very responsive to the change of nutrient loading may be because of the short water residence time. Using the 2007 DOQQ aerial photos from the Federal Geographic Data Committee (FGDC) shown in **Figure 5.8**, the length of the Goat Creek downstream segment was measured as about 1300 meters. A 10-point stream cross-section measurement showed that the average stream width at this part of the creek is about 20 meters. Using the stream depth data downloaded from the SJRWMD's water quality database (http://webapub.sjrwmd.com/agws10/edqt/), it was found that the average stream depth at the Station 21FLSJWMIRLGUS for the 10-year period from 2001 through 2010 was about 0.99 meters. Assuming that this depth applies to the entire marine segment of the creek, the total volume of the downstream segment would be 1300 x 20 x 0.99 = 25,740 m^3. Using the SJRWMD's PLRG model for the Goat Creek watershed (48.3 inches of 30-year long-term annual rainfall and year 2000 land use coverage), the annual total runoff from the Goat Creek watershed was about $1.35x10^7$ m^3/year. The water residence for the marine segment of Goat Creek was calculated as the volume of the creek divided by the total annual runoff, which equals to 25,740 m^3 / $1.35x10^7$ m^3/year = 0.0019 year = 0.69 days. This is a very short water residence time.

Of course, with the tidal influence, the water residence time at the marine creek segment may increase. Water residence time may also increase under the dry weather condition. However, considering that the upstream ChlaC input is always low (less than 2 µg/L) and most of these

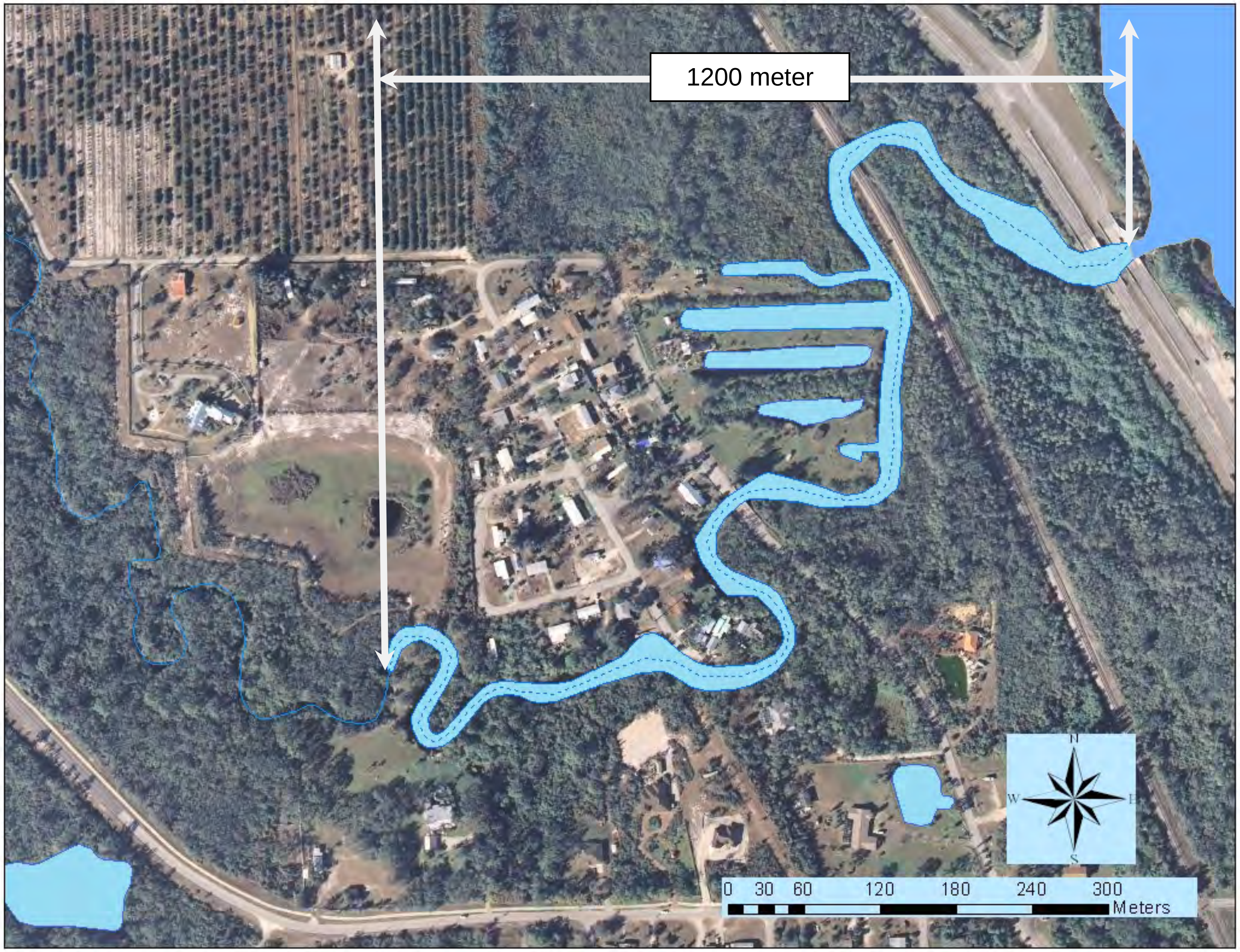

Figure 5.8. Dimension of the Downstream Marine Segment of Goat Creek. The segment is about 1,200 meters. A 10-points cross-section analysis showed that the average stream width is about 20 meters.

are freshwater algae and will die when enter the marine environment, the starting algal concentration in the downstream creek segment could be very low. Also consider that, under the ambient condition, with the zooplankton grazing and other factors that cause phytoplankton death, the general phytoplankton doubling time is in an order of weeks. Comparing the water residence time of days and algal biomass doubling time of weeks, the chance that a significant accumulation of algal biomass will happen due solely to the algal growth within the segment is very low. This is consistent with the hypothesis that the observed elevation of the ChlaC concentration in the marine segment of Goat Creek in 2009 and 2010 were not caused by the elevated nutrient loadings from the watershed. It is caused by processes happened in the receiving waters, most likely in the lagoon proper and was brought into the Goat Creek marine segment due to the tidal activity.

Increased ChlaC concentrations in 2009 and 2010, which worsened in 2011 and extended into 2012, were observed across the Indian River Lagoon and Banana River Lagoon. Until now, no conclusion has been reached on exactly what happened in the lagoon that caused the ChlaC concentration to elevate. One possible explanation is that the historically low temperature in the winter between 2009 and 2010 caused a large scale loss of macro-algae in the lagoon. The nutrients fixed in the macro-algal biomass were released into the water column as macro-algae died and provide more nutrient sources to phytoplankton. In the meantime, lower winter temperature also depressed the population of zooplankton and benthic filter feeders. So when temperature increased in the spring of 2010, phytoplankton in the lagoon had a very favorable growth environment with higher nutrient availability and lower grazing pressure. In addition, with much organic nutrient being released into the water column, the growth of picoplanktonic green algae and blue-green algae were favored. These algae typically have higher cellular chlorophyll content then *Pyrodinium* and diatoms, which usually dominate the lagoon system. All these factors combine might have caused the elevated ChlaC concentration in late 2010 that extended into 2011 (Dr. Edward Phlips from the University of Florida, and Mr. Joel Steward and Mr. Whit Green from SJRWMD, personal communication). One possible cause that resulted in elevated ChlaC concentration in late 2008 and early 2009 might be the larger amount of nutrient brought into the lagoon system by Tropical Storm Fay. These nutrients took effect in late 2008 and early 2009 when the weather became drier and water residence time became longer, especially in the southern part of the Indian River Lagoon. Because the tidal influence of the lagoon on tributaries that discharge into the lagoon, the elevated algal biomass might have been brought into these tributaries, including the marine segment of Goat Creek, causing the observed ChlaC concentration in the creek that usually is not very responsive to the change of nutrients loadings due to the short water residence time.

In summary, the Department believes that the elevated ChlaC concentration in the marine segment of Goat Creek was not caused by the elevated nutrient loadings to the lagoon in 2009 and 2010. Instead, the weather condition caused receiving water processes might be the major cause. Therefore, with this TMDL, the Department will not request further nutrient reductions from the Goat Creek watershed beyond those already being requested by the Indian River Lagoon main stem seagrass nutrient TMDLs (FDEP 2009).

5.2. Areal Nutrient Loading Targets for the Seagrass Restoration in The Indian River lagoon and Banana River Lagoon

In 2009, the Department adopted a set of nutrient TMDLs for mainstem water segments of the IRL and BRL. These TMDLs were developed based on the Pollutant Load Reduction Goals

(PLRGs) created by SJRWMD to restore the seagrass distribution in IRL and BRL segments. These PLRGs were established based on seagrass distribution targets, which were represented by the seagrass depth-limit in different lagoon segments. Different seagrass depth-limit targets were established for 15 lagoon segments, including four segments for the BRL sublagoon, six segments for the North IRL sublagoon, and five for the Central IRL sublagoon, through analyzing the seagrass mapping results created in 1943, 1986, 1989, 1992, 1994, 1996, and 1999 and the lagoon bathymetry established by Coastal Planning and Engineering, Inc., in 1996 (Steward et al. 2005). **Figure 5.9** shows the segmentation of the IRL and BRL system used by the mainstem seagrass nutrient TMDLs. **Table 5.2** shows the range of the median values of maximum achievable seagrass depth-limit targets for each sublagoon. The final TMDL depth-limit targets were established by allowing a 10 percent departure (shallower) from the maximum achievable depth-limit targets because the State Surface Water Quality Standard (Chapter 62-302, F.A.C.) allows a decrease of depth of the compensation point by no more than 10 percent from the natural background condition.

Table 5.2. Range of Seagrass Median Maximum Achievable Depth-Limit Targets for the Three Sublagoons

Sublagoon	Median Maximum Achievable Seagrass Depth-Limit Target (meters)
North IRL	1.5 – 1.8
Central IRL	1.2 – 1.7
Banana River Lagoon	1.4 – 1.8

In order to derive nutrient targets from the seagrass depth-limit targets, relationships between watershed nutrient loadings and seagrass depth-limits were established for the three sub-lagoons by SJRWMD (Steward and Green 2006 and 2007). Nutrient loadings from lagoon segments' drainage basins were estimated for years that both land use information and seagrass depth-limit measurements were available using either the Pollutant Loading Screening Model (PLSM) or Hydrologic Simulation Program – Fortran (HSPF). The estimation of total nutrient loads discharged into each lagoon segment took into consideration of the nutrient loads from point source dischargers, nonpoint source human land use areas and nutrient removal effects from the best management practices (BMPs) associated with the constructions built after 1984 when the state stormwater rule was implemented. Areal nutrient loadings into each lagoon segments were calculated by dividing the drainage basin loadings by the drainage basin area. Areal nutrient loadings for different years were then log-transformed and regressed against the percent deviation of seagrass depth-limit from the nutrient loadings were estimated. The final TMDL nutrient target loadings for each sub-lagoon were then derived as the nutrient loadings that resulted in ten percent (10%) deviation (shallower) of the seagrass depth-limit from the maximum achievable seagrass depth- maximum achievable targets in different lagoon segments in each sub-lagoon for the years for which the areal limit target. **Table 5.3** lists the per acre TN and TP nutrient loading targets for all the three sub-lagoons.

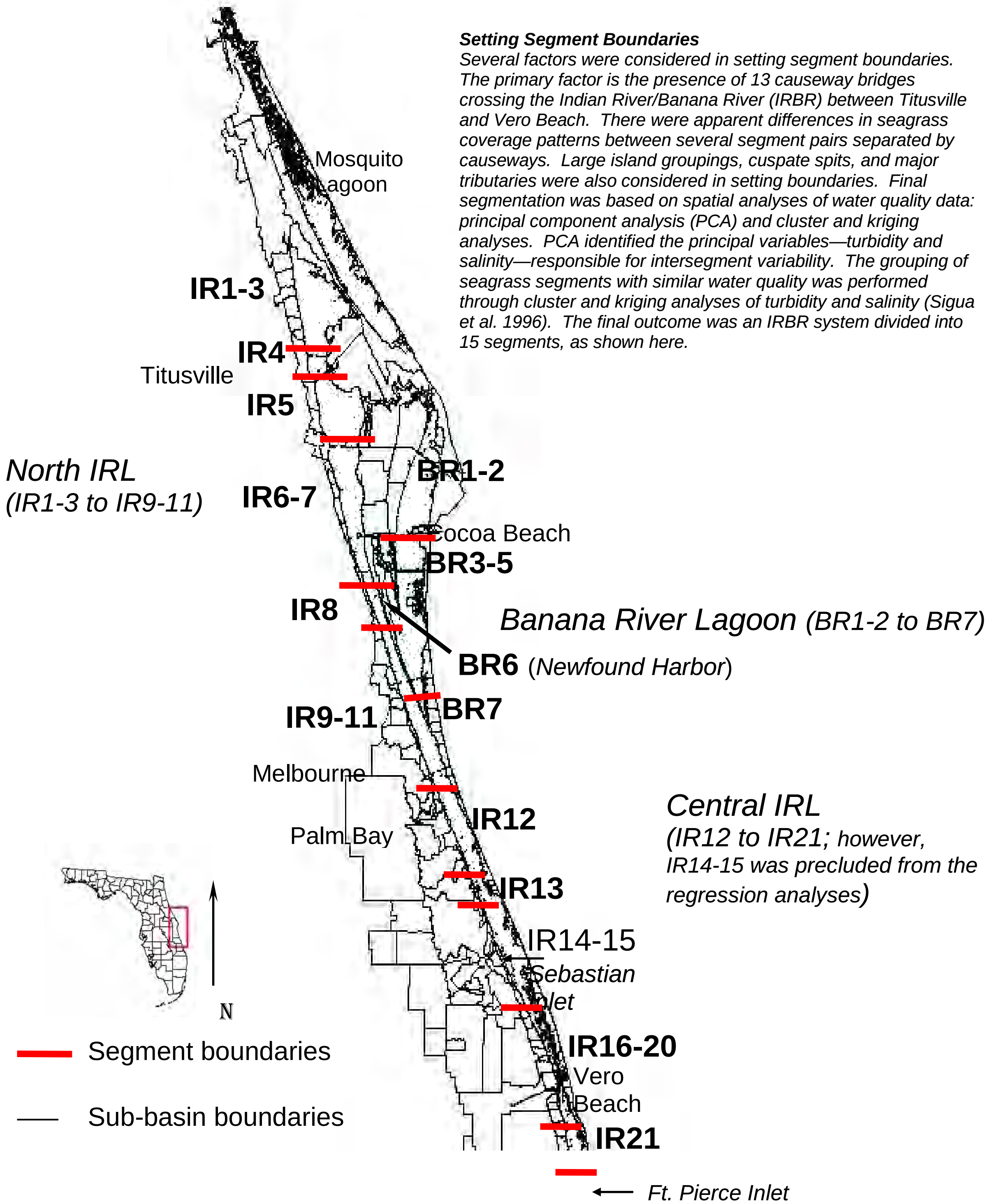

Figure 5.9. Location of the North IRL, Central IRL, and BRL, and Further Segmentation of the IRL and Banana River Lagoon Systems (Steward and Green 2006)

Table 5.3. Nutrient Loading Targets for Surface Water Nonpoint and Point Sources Lagoonwide, and for the Three Sublagoon Systems (Steward and Green 2006)

Lagoonwide - (IRL and Banana River Lagoon combined; excludes Sebastian Segment IR14-15)

PLSM Regressions	TN target loading (pounds per acre per year [lbs/ac/yr])	TP target loading (lbs/ac/yr)
Years included in the analyses: 1943, 1996, 1999, and 2001 data	3.34 $R^2 = 0.49$, $p < 0.001$	0.546 $R^2 = 0.53$, $p < 0.001$

North IRL

PLSM Regressions	TN target loading (lbs/ac/yr)	TP target loading (lbs/ac/yr)
Years included in the analyses: 1943, 1996, and 1999 data	2.88 $R^2 = 0.43$, $p = 0.006$	
HSPF Regressions		
Years included in the analyses: 1943, 1996, and 1999 data		0.368 $R^2 = 0.47$, $p = 0.003$

Central IRL - (excludes Sebastian Segment IR14-15)

PLSM Regressions	TN target loading (lbs/ac/yr)	TP target loading (lbs/ac/yr)
Years included in the analyses: 1996, 1999, and 2001 data	2.90 $R^2 = 0.87$, $p<0.001$	0.574 $R^2 = 0.65$, $p = 0.001$

Banana River Lagoon

PLSM Regressions	TN target loading (lbs/ac/yr)	TP target loading (lbs/ac/yr)
Years included in the analyses: 1943, 1996, and 1999 data	2.18 $R^2 = 0.74$, $p = 0.001$	0.374 $R^2 = 0.72$, $p = 0.001$

As the Goat Creek watershed is located in the Central Indian River Lagoon basin, the TN and TP areal targets established for the Central Indian River Lagoon also apply to the Goat Creek watershed. In SJRWMD model, Goat Creek watershed is located in the part of the Central Indian River Lagoon that discharges to the mainstem Segment IR-13. Based on the PLSM model simulation results, the existing TN and TP loads from the drainage basin discharging to IR-13 are 62,789 lbs/year of TN and 7,743 lbs/year of TP (FDEP, 2009). Using the areal TN and TP load targets, the target TN and TP loads for the basin areas discharging to IR-13 are 27,896 lbs/year and 4,010 lbs/year, respectively. These target nutrient loads represent 56% reduction of TN and 48% reduction of TP from the existing watershed nutrient loads. These are average TN and TP load reduction required for the drainage areas discharging to Segment IR-13. As the Goat Creek watershed is part of the Segment IR-13 drainage area, theoretically, these required percent reductions can also be applied to the Goat Creek watershed. However, as the Goat Creek watershed includes large amount of natural lands, and it is not the Department's intention to request any load reduction from natural land areas, it is desirable to calculate a required percent reduction that takes into consideration of the natural land loads.

Following steps were taken to estimate the needed percent reduction for the Goat Creek watershed:

(1) Sub-lagoon average allowable per acre TN and TP loads for human land were first calculated. These human land per acre allowable loads were later used to calculate the total human land allowable loads for the Goat Creek watershed based on the human

land acreage of the Goat Creek watershed. The reason why these human land per acre allowable loads were calculated on the sub-lagoon scale was because the areal TN and TP targets were established at the sub-lagoon spatial scale.

SJRWMD's PLSM divided the Central IRL into several segments that are distinct in hydrodynamics and chemistry. These segments include IR-12, IR-13, IR-14-15, IR-16-20, and IR-21. **Table 5.4** tabulated target TN loads with direct atmospheric deposition, atmospheric deposition loads, and point source loads for each of these lagoon segments cited from the seagrass TMDLs developed for the Central IRL (FDEP 2009). The table also listed calculated nonpoint source TN loads from the watershed of each lagoon segment and the total nonpoint source TN loads from the entire sub-lagoon drainage areas.

Table 5.4. Parameters Used to Calculate the Target Per Acre Human Land Allowable Loads for TN

Items	Target Load With Atmospheric	Atmospheric	Point Source Loading	Target Drainage Basin Loading
IR-12 Load (lbs/year)	261,412	35,051	355	226,006
IR-13 Load (lbs/year)	42,811	14,915		27,896
IR-14-15 Load (lbs/year)	380,491	56,734	476	323,281
IR-16-20 Load (lbs/year)	262,384	24,591	25,391	212,402
IR-21 load (lbs/year)	15,890	10,415		5,475
Total Central IRL Sub-Lagoon load (lbs/year)	962,988	141,706	26,222	795,060
Natural Land Loads (lbs/year)				151,554
Human Lands Loads (lbs/year)				643,506
Human Land Acre				209,186
Areal Human Land Loads (lbs/acre/year)				**3.08**

Based on **Table 5.4**, the total target nonpoint source TN loads from the entire Central IRL sub-lagoon drainage basin is about 795,060 lbs/year. Using the PLSM model (SJRWMD's year 2000 land use, NRCS' 1990 soil coverage, and a long-term average annual rainfall of 48.3 inches/year) , the TN loads from the natural land areas, including upland forest, water, and wetland areas, are about 151,554 lbs/year under the existing condition. As the load reduction will only be requested from human land use areas, including urban and build-up, agriculture, rangelands, barren lands, and transport, communication, and utility land areas, the target human land TN loads equals to the total nonpoint watershed TN loads minus the natural land loads. In other words, the total TN loads allowable from the human land areas in the Central IRL sub-lagoon basin equal to 795,060 lbs/year minus 151,554 lbs/year = 643,506 lbs/year. The total human land areas occupy about 209,186 acres of land in the Central IRL sub-lagoon basin.

Therefore, the per acre human land allowable loads equals to 643,506 lbs/year divided by the 209,186 acres of human lands, which is **3.08** lbs/acre/year.

Table 5.5 tabulated target TP loads with direct atmospheric deposition, atmospheric deposition loads, and point source loads for each of these lagoon segments cited from the seagrass TMDLs developed for the Central IRL (FDEP 2009). The table also listed calculated nonpoint source TP loads from the watershed of each lagoon segment and the total nonpoint source TP loads from the entire sub-lagoon drainage areas.

Table 5.5. Parameters Used to Calculate the Target Per Acre Human Land Allowable Loads for TP

Items	Target Load With Atmospheric	Atmospheric	Point Source Loading	Target Drainage Basin Loading
IR-12 Load (lbs/year)	43,170	794	44	42,332
IR-13 Load (lbs/year)	4,348	338		4,010
IR-14-15 Load (lbs/year)	64,076	1,285	78	62,713
IR-16-20 Load (lbs/year)	52,141	557	1,949	49,635
IR-21 load (lbs/year)	1,458	236		1,222
Total Central IRL Sub-Lagoon load (lbs/year)	165,193	3,210		159,912
Natural Land Loads (lbs/year)				19,978
Human Lands Loads (lbs/year)				139,934
Human Land Acre				209,186
Areal Human Land Load (lbs/acre)				**0.669**

Based on **Table 5.5**, the total target nonpoint source TP loads from the entire Central IRL sub-lagoon drainage basin is about 159,912 lbs/year. Using the PLSM model (SJRWMD's year 2000 land use, NRCS' 1990 soil coverage, and a long-term average annual rainfall of 48.3 inches/year), the TP loads from the natural land areas, including upland forest, water, and wetland areas, are about 19,978 lbs/year under the existing condition. As the load reduction will only be requested from human land use areas, including urban and build-up, agriculture, rangelands, barren lands, and transport, communication, and utility land areas, the target human land TP loads equals to the total nonpoint watershed TP loads minus the natural land loads. In other words, the total TP loads allowable from the human land areas in the Central IRL sub-lagoon basin equal to 159,912 lbs/year minus 19,978 lbs/year = 139,934 lbs/year. The total human land areas occupy about 209,186 acres of land in the Central IRL sub-lagoon basin. Therefore, the per acre human land allowable loads equals to 139,934 lbs/year divided by the 209,186 acres of human lands, which is **0.669** lbs/acre/year.

(2) The target nutrient loads for the Goat Creek watershed were then estimated by keeping the existing condition natural land loads unchanged, and estimating the target human land loading by multiplying the per acre allowable human land loads estimated in (1) by the total acreage of human land use areas in the Goat Creek watershed. The existing

condition natural land loads of the Goat Creek watershed, including nutrients loads for areas of upland forests, waters, and wetlands, were estimated using the PLSM model (SJRWMD's year 2000 land use, NRCS' 1990 soil coverage, and a long-term average annual rainfall of 48.3 inches/year). The natural land nutrient loads estimated this way are 7,797 lbs/year of TN and 1,072 lbs/year of TP. The total human land acreage, include acreages of urban and build-up, agriculture, rangeland, barren land, and transportation, communication, and utility lands, are 3,444 acres. Multiplying this acreage by the 3.08 lbs/acre/year of allowable human land TN target and 0.669 lbs/acre/year of allowable human TP target gives total allowable TN and TP loads for human lands of 10,609 lbs/year and 2,304 lbs/year, respectively. The target TN and TP loads were then calculated as the sum of the natural land TN and TP loads and human lands allowable TN and TP loads. For the Goat Creek watershed, the total allowable TN loads are 7,797 lbs/year (natural land loads) + 10,609 lbs/year (human land allowable loads) = **18,405 lbs/year**. The total allowable TN loads represent a **36%** reduction from the existing 28,723 lbs/year. The total allowable TP loads are 1,072 lbs/year (natural land loads) + 2,304 lbs/year (human land allowable loads) = **3,376 lbs/year**. Compared to the existing TP loads of 3,356 lbs/year, the allowable TP loads are even higher. Therefore, **no TP reduction is needed from the Goat Creek watershed**.

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 (wasteload 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:

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

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

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

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 Goat Creek are expressed in terms of lbs/yr, lbs/day, and percent reduction of TN and TP, and represent the long-term average TN and TP loadings that the creek can assimilate and maintain balanced aquatic flora and fauna.

According to the analysis conducted in **Chapter 4** and **Chapter 5** of this report, the total existing loads of TN and TP from the Goat Creek watershed are 28,723 lbs/year of TN and 3,352 lbs/year of TP. The allowable TN and TP loading targets were established for the Goat Creek based on the mainstem seagrass to restore the seagrass distribution in Indian River Lagoon. The allowable nutrient loads for the Goat Creek watershed are 18,405 lbs/year of TN and 3,376 lbs/year of TP. The allowable TN loads represent a 36% reduction from the existing loading of 28,723 lbs/year of TN. The allowable TP loads, however, are higher than the existing loads, which means that no reduction in TP is needed (**Table 6.1**).

Based on an EPA memorandum (2006), daily loads of TN and TP from point and nonpoint sources were also calculated. These daily loads were calculated by dividing the annual loads by 365 days/yr and were about 50.4 lbs/day of TN and 9.2 lbs/day of TP. These daily loading numbers are only provided in this report for informational purposes. The implementation of the TMDLs covered in this TMDL report should be carried out using an annual time scale.

Table 6.1. Nutrient TMDL Components for the Goat Creek Marine Segment

WBID	Parameter	TMDL (lbs/yr)	WLA NPDES wastewater (lbs/yr)	WLA NPDES Stormwater *	LA (lbs/yr)	MOS
3107A	TN	18,405	N/A	N/A	36%	Implicit
3107A	TP	3,376	N/A	N/A	0%	Implicit

N/A – Not applicable.

It should be pointed out that, the TMDL established for the Goat Creek marine segment is the for the nutrient loads from the watershed of the creek be controlled in such a way to restore the seagrass distribution in the Indian River Lagoon proper. These targets were established based on the nutrient TMDLs adopted by the Department in 2009 for the mainstem of Indian River Lagoon (FDEP, 2009). The analyses done in Chapter 5 showed that the observed elevation of ChlaC concentration in 2009 and 2010 in the marine segment of Goat Creek were not caused by elevated nutrient loadings from the Goat Creek watershed in those years. The marine segment of the creek is not very responsive to watershed nutrient loads because of the short water residence of the creek. The observed elevation in ChlaC concentration in the marine segment in 2009 and 2010 are likely to be caused by processes taking place in the lagoon proper. ChlaC concentration elevation in Indian River Lagoon in 2009 and 2010, and extended into 2011, is a cross the whole lagoon phenomenon. It could be caused by weather induced loss of macro-algae, which release nutrient into the water column and causing phytoplankton growth to be stimulated. Tropical Storm Fay might also have played some roles in bringing more nutrient into the lagoon system and supported more phytoplankton growth. In summary, the Department believes that, reducing the nutrient loads from the lagoon drainage areas into the lagoon is still very important to control the lagoon nutrient condition and restore the seagrass distribution in the lagoon. However, it is the Department's understanding that the elevated ChlaC concentration observed in the marine segment of Goat Creek was not caused by the elevated nutrient loads into the creek segment. Therefore, the Department decided not to request any further nutrient reductions beyond those already being requested to protect the mainstem seagrass communities.

The mainstem seagrass target, based on which this TMDL was developed, was established based on the seagrass depth-limit target. Considering that nutrients are not the only factor affecting seagrass distribution in the Indian River Lagoon, if, when the seagrass depth-limit target is achieved, the nutrient load reduction targets have not been reached, the seagrass depth-limit target should be the primary consideration to determine whether additional nutrient reduction is needed.

6.2 Load Allocation

As discussed in **Section 6.1**, the total existing loads of TN and TP from the Goat Creek watershed are 28,723 lbs/year of TN and 3,352 lbs/year of TP. The allowable TN and TP loading targets were established for the Goat Creek based on the mainstem TMDL goals set to restore the seagrass distribution in Indian River Lagoon. The allowable nutrient loads for the Goat Creek watershed are 18,405 lbs/year of TN and 3,376 lbs/year of TP. The allowable TN loads represent a 36% reduction from the existing loading of 28,723 lbs/year of TN. The allowable TP loads, however, are higher than the existing loads, which mean that no reduction in TP is needed.

6.3 Wasteload Allocation

6.3.1 NPDES Wastewater Discharges

There were no NPDES permitted facilities located in the Goat Creek watershed. Therefore, no WLA was assigned to any wastewater facilities.

6.3.2 NPDES Stormwater Discharges

As discussed in **Chapter 4**, although the Goat Creek watershed is located within the boundary of Brevard County, which has a Phase II MS4 permit (FLR04E052), the watershed of the creek is not located in any urban areas as defined by year 2000 census (http://www.dep.state.fl.us/water/stormwater/npdes/docs/census/UA_PalmBay_Melbourne_roads.pdf). Therefore, the Brevard County Phase II MS4 permit does not apply to the Goat Creek watershed. No WLA was assigned by this TMDL to any MS4 permitee.

6.4 Margin of Safety

As discussed in previous chapters, ChlaC concentration of the marine segment of Goat Creek, based on historic data analyses, is not very responsive to the change of nutrients. This is likely due to the short water residence of the creek segment and die-out of freshwater algal that enter the marine segment. This TMDL still requests nutrient reduction from the Goat Creek watershed to protect the mainstem seagrass distribution. This will further reduce the possibility that high algal growth will take place in the marine segment of the creek when water residence becomes long under extreme weather conditions. This implicitly adds to the margin of safety to control the ChlaC concentration in the marine segment of the creek.

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Chapter 7: NEXT STEPS: IMPLEMENTATION PLAN DEVELOPMENT AND BEYOND

7.1 Basin Management Action Plan

Following the adoption of this TMDL by rule, the Department will determine the best course of action regarding its implementation. Depending upon the pollutant(s) causing the waterbody impairment and the significance of the waterbody, the Department will select the best course of action leading to the development of a plan to restore the waterbody. Often this will be accomplished cooperatively with stakeholders by creating a Basin Management Action Plan, referred to as the BMAP. Basin Management Action Plans are the primary mechanism through which TMDLs are implemented in Florida [see Subsection 403.067(7) F.S.]. A single BMAP may provide the conceptual plan for the restoration of one or many impaired waterbodies.

If the Department determines a BMAP is needed to support the implementation of this TMDL, a BMAP will be developed through a transparent stakeholder-driven process intended to result in a plan that is cost-effective, technically feasible, and meets the restoration needs of the applicable waterbodies. Once adopted by order of the Department Secretary, BMAPs are enforceable through wastewater and municipal stormwater permits for point sources and through BMP implementation for nonpoint sources. Among other components, BMAPs typically include the following:

- *Water quality goals (based directly on the TMDL);*
- *Refined source identification;*
- *Load reduction requirements for stakeholders (quantitative detailed allocations, if technically feasible);*
- *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;*
- *Implementation funding mechanisms;*
- *An evaluation of future increases in pollutant loading due to population growth;*
- *Implementation milestones, project tracking, water quality monitoring, and adaptive management procedures; and*
- *Stakeholder statements of commitment (typically a local government resolution).*

BMAPs are updated through annual meetings and may be officially revised every five years. Completed BMAPs in the state have improved communication and cooperation among local stakeholders and state agencies; improved internal communication within local governments; applied high-quality science and local information in managing water resources; clarified obligations of wastewater point source, MS4, and non-MS4 stakeholders in TMDL implementation; enhanced transparency in Department decision making; and built strong relationships between the Department and local stakeholders that have benefited other program areas.

Nutrient TMDLs were previously developed by the Department for mainstem segments of Indian River Lagoon (IRL). These TMDLs have been adopted into Chapter 62-304.520, Florida Administrative Code. The Department is now working closely with the SJRWMD, counties, cities, and other local stakeholders to develop Basin Management Action Plans to implement these TMDLs. As the proposed Goat Creek TMDL targets are the same as those established for their mainstem drainage basin areas in the central IRL basin, the implementation strategies of these newly proposed TMDLs should be consistent with those being adopted for the central IRL basins. The Goat Creek watershed is part of the larger central IRL mainstem drainage basin and is already included in the developing BMAPs. If the receiving segments of the central IRL mainstem meet the previously adopted TMDLs, Goat Creek will have met its targets as well and the Department will not request that the target percent reductions of nutrient be applied specifically to Goat Creek watershed.

7.2 Other TMDL Implementation Tools

However, in some basins, and for some parameters, particularly those with fecal coliform impairments, the development of a BMAP using the process described above will not be the most efficient way to restore a waterbody, such that it meets its designated uses. This is because fecal coliform impairments result from the cumulative effects of a multitude of potential sources, both natural and anthropogenic. Addressing these problems requires good old-fashioned detective work that is best done by those in the area.

Many assessment tools are available to assist local governments and interested stakeholders in this work. The tools range from the simple (such as Walk the WBIDs and GIS mapping) to the complex (such as bacteria source tracking). Department staff will provide technical assistance, guidance, and oversight of local efforts to identify and minimize fecal coliform sources of pollution. Based on work in the Lower St Johns River Tributaries and Hillsborough Basins, the Department and local stakeholders have developed a logical process and tools to serve as a foundation for this detective work.

In the near future, the Department will be releasing these tools to assist local stakeholders with the development of local implementation plans to address fecal coliform impairments. In such cases, the Department will rely on these local initiatives as a more cost-effective and simplified approach to identify the actions needed to put in place a road map for restoration activities, while still meeting the requirements of Subsection 403.067(7), F.S.

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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 Surface Water Improvement and Management (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 the master drainage systems of local governments with a population above 100,000, which are better known as 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. EPA authorized the Department to implement the NPDES Stormwater Program (with the exception of Indian lands) in October 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. These revised rules require that these additional activities obtain permits by 2003.

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 reopener clause that allows permit revisions to implement TMDLs when the implementation plan is formally adopted.

Appendix B: Public Comments and FDEP Responses

Comments from Brevard County

BREVARD County
BOARD OF COUNTY COMMISSIONERS
FLORIDA'S SPACE COAST

NATURAL RESOURCES MANAGEMENT OFFICE
2725 Judge Fran Jamieson Way, Building A-219, Viera, FL 32940

October 5, 2012

Jan Mandrup-Poulsen, Environmental Administrator
Watershed Evaluation and TMDL Section
Florida Department of Environmental Protection, MS 3555
2600 Blair Stone Road
Tallahassee, FL 32399-2400

RE: Comments on FDEP's Draft TMDLs for portions of the Indian River Lagoon Basin - Sykes Creek/Barge Canal (WBID 3044B) and Goat Creek Marine Segment (WBID 3107A)

Dear Mr. Mandrup Poulsen:

We appreciate this opportunity to provide comments to FDEP on the proposed TMDLs for WBIDs 3044B and 3107A within the IRL Basin. In reviewing the listing data for these WBIDs and their upstream and downstream counterparts, Brevard County was encouraged to see progress toward lowering TN and TP concentrations over the 1998 to 2008 timeframe. Despite this decade of progress in nutrient concentrations, chlorophyll a impairments were documented in the IRL mainstem and multiple marine segments of IRL tributaries in 2009 and 2010. While we concur and commend FDEP for the technical aspects and logic of their analyses, we disagree with the recommendation that a TMDL is needed and we disagree on how to apply the downstream TMDLs to the upstream WBIDs.

- We concur with FDEP's conclusion that there is no apparent causal linkage between the recent chlorophyl a impairments in these WBIDs and changes in loading from the immediate or upstream drainage areas (as landuse changes, drought, and upstream ambient measurements do not indicate elevated loadings).

- We concur that measured chlorophyl a impairments do appear to be influenced by factors in the hydrologically connected IRL segments located immediately dowustream.

- We concur with FDEP's conclusion that adequate reduction of nutrient loads to the IRL mainstem should reduce total loading to the adjacent marine segments of tributaries and thereby improve the health of these marine segments of tributaries.

- We concur with the Department's recommendation not to request any further nutrient reductions beyond those already being enforced through the TMDLs and BMAPs for the mainstem of the IRL (and Banana) system.

- We disagree with applying the average allowable load per acre for the adjacent IRL segment (assimilative capacity of the IRL) to determine specific load reductions required within the drainage area of the impaired WBID. While we agree this is one way to allocate load reductions required for the IRL and provide a Measure of Safety for the impaired WBID, it will not lead to the most effective siting of load reducing BMPs and may not be feasible to implement. In fact, the TN reduction calculated for Goat Creek using this method exceeds the estimated load from all urbanized land in the Goat Creek watershed. Since the reports state that the WBID watershed loads are not responsible for the impairments, it seems unlikely that further reductions within these WBIDs will result in the water quality standard being achieved within the tributaries. To the contrary, wouldn't BMPs be more effective for both the IRL and the impaired tributaries if sited outside the tributary watershed in an area where the BMPs could intercept more problematic (higher) load concentrations entering the IRL mainstem? Siting BMPs where they are most feasible within the IRL basin is consistent with the draft BMAPs and should minimize the risk of IRL impairments extending from the IRL up the tributaries.

- We disagree with the current TMDLs adopted for the IRL and are currently developing an updated model to provide to FDEP for updating the TMDLs for the IRL. Is it possible to craft the tributary TMDLs in such a way that if the mainstem TMDLs change, the tributary TMDLs will automatically update by reference? Or is it possible to avoid numerical limits for the tributaries and simply state that if the IRL TMDLs (as amended) are met, the tributary TMDLs will also be satisfied?

In addition to the points of agreement and concurrence stated above, we are unsure regarding the measure of success. The draft IRL BMAPs measure success, not by changes in estimates of watershed loading, but in measured performance of the biological indicator that was the basis of the original impairment listing – seagrass. If target seagrass depths are achieved, the BMAP/TMDL is satisfied. It would seem consistent that if the impairment in the tributaries is addressed, then the tributary TMDL would be satisfied, but there is no measure in the proposal other than numerical standards that are derived from old model estimates of watershed load.

Thank you for this opportunity to provide comments on the proposed TMDLs for WBIDs 3044B and 3107A within the IRL Basin. In sum, and consistent with our comments to FDEP at the time of listing, we concur that the standards for chlorophyll a have been exceeded, and that the causative pollutant does not appear to be TN or TP from within the WBID watershed, therefore we maintain that development of nutrient TMDLs for these tributaries does not seem appropriate. More detailed concerns are provided in the staff comments that follow. Nonetheless, Brevard County remains committed to implementing stormwater BMPs to further reduce nutrient loadings to our locally and nationally treasured waters. If you have any questions about our comments, please do not hesitate to call me at 321-633-2016.

Sincerely,

Virginia Barker, Watershed Program Manager
Natural Resources Management Office

Response from the Florida Department of Environmental Protection

March 6, 2013

Ms. Virginia Barker, Watershed Program Manager
Natural Resource Management Office
2725 Judge Fran Jamieson Way, Building A-219,
Viera, FL 32940

Dear Virginia,

Thanks again for your letter dated October 5, 2012, regarding the nutrient TMDLs for Sykes Creek and Goat Creek that the Florida Department of Environmental Protection (FDEP) presented at the August 30, 2012 public workshop. We responded to your comments on October 5, 2012 through an email. As you mentioned in your returning email, our responses addressed most of the concerns from Brevard County regarding these two TMDLs. This letter is provided as our formal response to your comments.

You raised primarily three concerns in your summary comments:

(1) Because the elevated chlorophyll a concentration observed in these two creeks in 2009 and 2010 were not caused by the elevation of nutrient loads in the watershed, and the nutrient targets proposed by the FDEP was to follow the Indian River Lagoon (IRL) and Banana River Lagoon (BRL) mainstem nutrient TMDLs to protect the seagrass communities in the mainstem system, the local stakeholders should have the flexibility to decide where in the IRL and BRL basins nutrient controls and best management practices (BMPs) can be implemented most efficiently. The FDEP should not make it an obligation that local stakeholders have to implement BMPs in the watersheds of Sykes Creek and Goat Creek.
(2) As there are on-going efforts led by Brevard County to refine the IRL mainstem nutrient TMDLs, the FDEP should not use the watershed loading models that the FDEP used previously to develop the mainstem nutrient TMDL.
(3) There is not a specific measure (biological response factor) being established in Sykes Creek and Goat Creek TMDLs to evaluate the implementation success.

Reading through your detailed technical comments, we also realized that you and your staff have another concern. If the FDEP claimed that the elevated chlorophyll a concentrations observed in these two creeks were not caused by the elevation of nutrient loadings from the watershed, why does the FDEP still propose nutrient reductions and have the belief that the nutrient reductions will help the water quality condition of these tributaries?

These are all thoughtful comments and questions. While reports of Sykes Creek and Goat Creek TMDLs indicated that the observed elevation of chlorophyll a concentrations in these waters were not caused by elevated nutrient loadings from watershed of these impaired waters, the results from our analyses support the conclusion that the elevation of chlorophyll a concentration in these impaired segments was related to the lagoon processes that are influenced by nutrients. Therefore, reducing watershed nutrient loadings to the lagoon system will reduce the probability and intensity of the phytoplankton growth in the lagoon system, which will, in turn, benefit the nutrient condition of these impaired tributary segments that are closely related to their corresponding lagoon segments.

While it is only fair that nutrient loadings created anywhere in the drainage basin should be treated equally in order to level the playing field, we understand that, in practice, applying BMPs in different parts of the drainage basin can have different efficiencies in controlling the amount of nutrient eventually reach the lagoon. Therefore, although the nutrient targets were set up for the watershed of these impaired water segments, we agree with you that these targets are in reality set up to protect the lagoon system, which will in turn benefit these two impaired segments. As the watersheds of these impaired water segments are part of the larger lagoon drainage basin, if the nutrient goals set up for the larger drainage basin are achieved, we will not specifically request that nutrient reduction be applied to the watersheds of these impaired tributary segments. In fact, we have already included the following language into Chapter 7 of revised reports of these TMDLs:

> *Nutrient TMDLs were previously developed by the Department for mainstem segments of Indian River Lagoon and Banana River Lagoon basins. These TMDLs have been adopted into Chapter 62-304.520, Florida Administrative Code. The Department is now working closely with the SJRWMD, counties, cities, and other local stakeholders to develop Basin Management Action Plans to implement these TMDLs. As the proposed Sykes Creek and Goat Creek TMDL targets are the same as those established for their corresponding mainstem drainage basin areas in the Indian River Lagoon and Banana River Lagoon basins, the implementation strategies of these newly proposed TMDLs should be consistent with those being adopted for the corresponding mainstem drainage basins. The watersheds of Sykes Creek and Goat Creek are parts of the larger corresponding mainstem drainage basins and are already included in the developing BMAPs. If the receiving segments of the mainstem meet the previously adopted TMDLs, Sykes Creek and Goat Creek will have met their targets as well and the Department will not request that the target percent reductions of nutrient be applied specifically to Sykes Creek and Goat Creek watersheds.*

The FDEP remains committed to work with the County and its consultants as part of the ongoing efforts to refine the water quality targets and loading models that the FDEP used previously to develop the mainstem nutrient TMDLs. In fact, it is FDEP's long-term policy that the adopted TMDLs can be adaptive targets and may be refined or modified when new data and information become available. If the TMDL refinement products from Brevard County and consultants show a significant improvement compared to the mainstem nutrient TMDLs previously adopted for the mainstem segments, revising the mainstem nutrient TMDLs will certainly be considered by the FDEP. At this time, as the SJRWMD's PLSM model (and the associated HSPF model) and the nutrient targets derived from the seagrass depth-limit targets are still the only set of established tools available to us for developing loading targets, the FDEP intends to use these tools until a significantly improved set of tools become established. Doing this makes the potential revision of TMDLs in the future easier because we know the pros and cons of the existing methodology. Should we decide to revise the adopted TMDLs, we only need to address whatever the same set of improvements needed for all nutrient TMDLs adopted in the IRL basin, instead of analyzing many TMDLs developed using many different tools.

Regarding the measurement needed to evaluate the effect of TMDL implementation, because Sykes Creek and Goat Creek were primarily verified for nutrient impairment based on the elevated chlorophyll a concentration in 2009 and 2010, which, based on the analyses conducted by the FDEP, were associated with the receiving water processes taking place in the lagoon mainstem, the FDEP believes that, as long as the water quality condition of the IRL and BRL mainstem segments associated with these two creeks meets the established seagrass depth-limit bench mark, the nutrient condition of these two creeks should be considered meeting the water quality target.

Once again, we appreciate the effort from you to help us improve the quality of our work. We are looking forward to continuously working with you to improve the water quality conditions of the valuable water resources in the Indian River Lagoon basin.

Sincerely,

Jan Mandrup-Poulsen, Environmental Administrator
Watershed Evaluation and TMDL Section
Florida Department of Environmental Protection

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