

# **TOTAL MAXIMUM DAILY LOAD (TMDL)**

**For**

**Dissolved Oxygen**

**In**

**Hogan Creek (WBID 2252)**

**Lower St. Johns River Basin, Florida**

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Under the authority of Section 303(d) of the Clean Water Act, 33 U.S. Code §1251 et.seq., as amended by the Water Quality Act of 1987 (PL 100-4), the U.S Environmental Protection Agency is hereby establishing a Total Maximum Daily Load (TMDL) for Dissolved Oxygen in Hogan Creek (WBID 2252) located in the Lower St. Johns River Basin. Subsequent actions must be consistent with this TMDL.

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James D. Giattina, Director  
Water Management Division

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Date

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## LIST OF ABBREVIATIONS

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AWT	Advanced Waste Treatment
BMP	Best Management Practices
BOD	Biochemical Oxygen Demand
CBOD	Carbonaceous Biological Oxygen Demand
CBODu	Ultimate Carbonaceous Biological Oxygen Demand
CFS	Cubic Feet per Second
DEM	Digital Elevation Model
DMR	Discharge Monitoring Report
DO	Dissolved Oxygen
EPA	Environmental Protection Agency
F.A.C.	Florida Administrative Code
GIS	Geographic Information System
HUC	Hydrologic Unit Code
JEA	Jacksonville Electrical Authority
LA	Load Allocation
MGD	Million Gallons per Day
MOS	Margin of Safety
MS4	Municipal Separate Storm Sewer Systems
NASS	National Agriculture Statistics Service
NLCD	National Land Cover Data
NPDES	National Pollutant Discharge Elimination System
PLRG	Pollutant Load Reduction Goal
Rf3	Reach File 3
RM	River Mile
SOD	Sediment Oxygen Demand
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
USGS	United States Geological Survey
WBID	Water Body Identification
WLA	Waste Load Allocation
WMP	Water Management Plan
WWTF	Wastewater Treatment Facility

**SUMMARY SHEET**  
**Total Maximum Daily Load (TMDL)**

**1. 303(d) Listed Waterbody Information**

**State:** Florida  
**HUC:** 03080103

**Impaired Waterbody for TMDL (1998 303(d) List):**

WBID	Segment Name and Type	River Basin	County	Constituent(s)
2252	Hogan Creek (freshwater stream)	Lower St. Johns	Duval	Dissolved Oxygen

**2. TMDL Endpoint (i.e., Target):**

The State of Florida water quality criteria for dissolved oxygen (DO) in freshwater streams require in no case shall the concentration be less than 5 mg/L. Therefore, the target for the TMDL is a DO concentration of 5 mg/L. Model simulations indicate reductions in Biochemical Oxygen Demand (BOD) loadings from the watershed result in attainment of the DO criteria.

**3. TMDL Approach**

The Pollutant Load Screening Model (PLSM) was used to estimate seasonal BOD loadings from nonpoint sources in the watershed. BOD loads were converted to Carbonaceous BOD (CBOD) for input to the Water Quality Analysis Simulation Program (WASP) model for simulation of instream DO concentrations. Loadings were reduced until simulated instream DO concentrations were above 5 mg/L at all times.

**4. TMDL Allocation:**

Stream Name / WBID	Parameter	WLA		LA (lb/yr)	TMDL (lb/yr)	Percent Reduction
		Continuous (lb/day)	MS4 (reduction)			
Hogan Creek (2252)	BOD	N/A	35%	38,545	38,545	35%

**5. Endangered Species (yes or blank):** Yes

**6. EPA Lead on TMDL (EPA or blank):** EPA

**7. TMDL Considers Point Source, Nonpoint Source, or both:** Nonpoint

**8. Major NPDES Discharges to surface waters in the watershed:** None

## **TOTAL MAXIMUM DAILY LOAD (TMDL) DISSOLVED OXYGEN IN HOGAN CREEK (WBID 2252)**

### **1. INTRODUCTION**

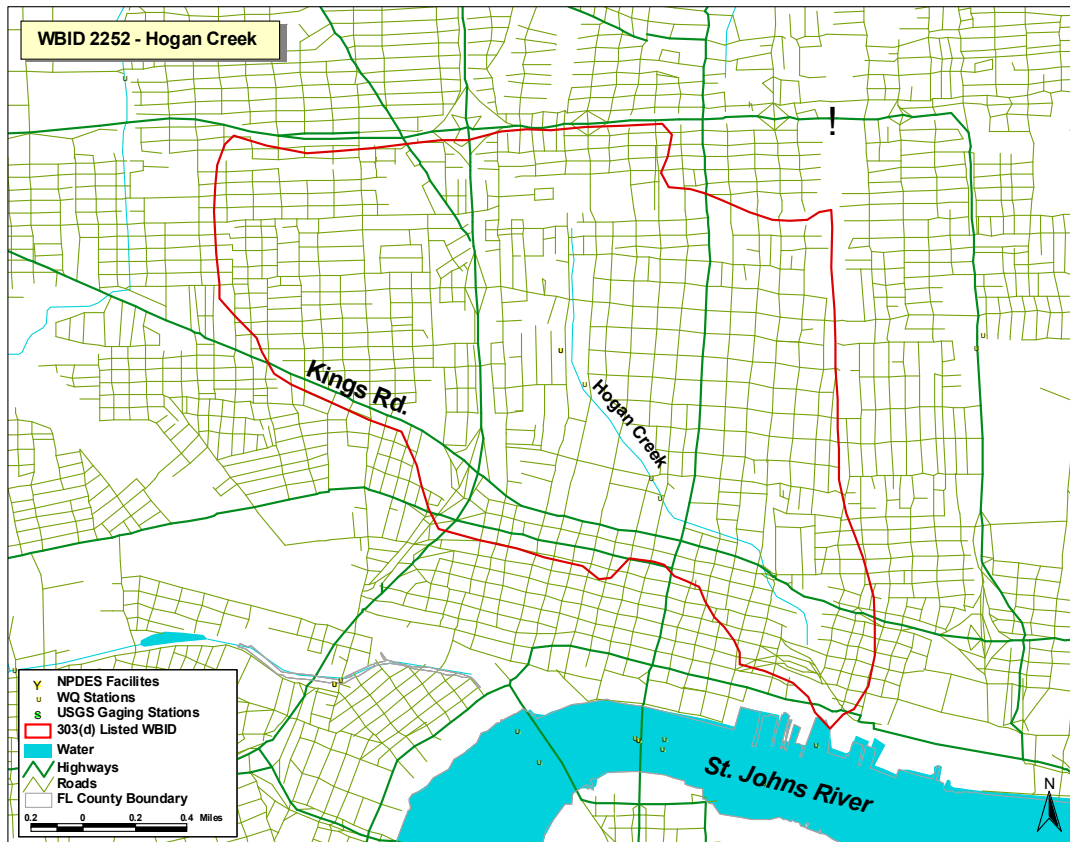
Section 303(d) of the Clean Water Act requires each state to list those waters within its boundaries for which technology based effluent limitations are not stringent enough to protect any water quality standard applicable to such waters. Listed waters are prioritized with respect to designated use classifications and the severity of pollution. In accordance with this prioritization, states are required to develop Total Maximum Daily Loads (TMDLs) for those water bodies that are not meeting water quality standards. The TMDL process establishes the allowable loadings of pollutants or other quantifiable parameters for a waterbody based on the relationship between pollution sources and in-stream water quality conditions, so that states can establish water quality based controls to reduce pollution from both point and non-point sources and restore and maintain the quality of their water resources (USEPA, 1991). This TMDL for dissolved oxygen in Hogan Creek is being established pursuant to EPA commitments in the 1998 Consent Decree in the Florida TMDL lawsuit (Florida Wildlife Federation, et al. v. Carol Browner, et al., Civil Action No. 4: 98CV356-WS, 1998).

Florida Department of Environmental Protection (FDEP) developed a statewide, watershed-based approach to water resource management. Under the watershed management approach, water resources are managed on the basis of natural boundaries, such as river basins, rather than political boundaries. The state's 52 basins are divided into 5 groups. Water quality is assessed in each group on a rotating five-year cycle. Hogan Creek is in the group 3 basin and was first assessed in 2002 with plans to revisit water management issues in 2007. FDEP established five water management districts (WMD) responsible for managing ground and surface water supplies in the counties encompassing the districts. Hogan Creek is in the Lower St. Johns River basin and is managed through the St. Johns Water Management District (SJRWMD).

For the purpose of planning and management, the WMDs divided the district into planning units defined as either an individual primary tributary basin or a group of adjacent primary tributary basins with similar characteristics. Williamson Creek is in the Ortega River Planning Unit. These planning units contain smaller, hydrological based units called drainage basins, which are further divided into "water segments"; each assigned a unique Waterbody Identification (WBID) number. A water segment usually contains only one unique waterbody type (stream, lake, channel, etc.).

### **2. PROBLEM DEFINITION**

Florida's 1998 Section 303(d) list identified Hogan Creek (WBID 2252) in the Lower St. Johns River basin as impaired for dissolved oxygen (DO). Hogan Creek is located in Duval County within the urban areas of the City of Jacksonville (see Figure 1). Hogan Creek is also listed for fecal and total coliforms. EPA developed TMDLs for these parameters as separate reports (EPA, 2006 and 2005).



**Figure 1. Location of Hogan Creek (WBID 2252)**

### **3. WATERSHED DESCRIPTION**

The St. Johns River is a large river system flowing from south to north just inland from the eastern coast of central and northern Florida and drains a watershed covering approximately 9500 square miles before discharging into the Atlantic Ocean east of the City of Jacksonville. The St. Johns River has been divided into three subwatersheds commonly referred to as the Upper, Middle and Lower St. Johns River. Hogan Creek (WBID 2252) is located within the Lower St. Johns River Basin in the North Mainstem Planning Unit. The following description of the watershed is from the Lower St. Johns Basin Status Report (FDEP, 2003). This document should be consulted for additional details.

Hogan Creek (WBID 2252) is approximately 3.4 square miles in area and originates from the Springfield community and flowing south for about a mile and a half, emptying into the St. Johns River. This segment has been assigned a Class 3 Freshwater designation. Sewage problems from local septic tanks have adversely affected the creek over the years and industrial land use activities have also occurred near the mouth, where a shipyard used to exist. A Preliminary Restoration Plan is being developed for Hogan's Creek which would review and develop recommendations for water quality problems associated with the creek and for the creation of a greenway and littoral areas alongside the creek. Land cover within the WBID is shown in Table 1. A large portion of the watershed is dominated by urban land classifications, much of which is impervious.

**Table 1 Land use distribution in Hogan Creek (WBID 2252)**

Description	Hogan Creek	
	Area (acres)	Percentage of Total Area
Residential	1192	62.3
Commercial, Industrial, & Public	572	29.9
Agriculture	0	0
Rangeland	0	0
Forest	0	0
Water	6	0.3
Wetlands	12	0.6
Barren & Extractive	4	0.2
Transportation & Utilities	127	6.6
Total	1914	100%

#### 4. WATER QUALITY STANDARD AND TARGET IDENTIFICATION

Hogan Creek is designated as a Class III freshwater. The designated use of Class III waters is recreation, propagation and maintenance of a healthy, well-balanced population of fish and wildlife. Class III waters are further categorized based on fresh or marine waters. The water quality criteria for protection of Class III waters are established by the State of Florida in the Florida Administrative Code (F.A.C.), Section 62-302.530. The individual criteria should be considered in conjunction with other provisions in water quality standards, including Section 62-302.500 F.A.C. [Surface Waters: Minimum Criteria, General Criteria] that apply to all waters unless alternative or more stringent criteria are specified in F.A.C. Section 62-302.530.

##### Dissolved Oxygen Target

The State of Florida has numeric water quality criteria for DO requiring in no case shall concentrations be less than 5 mg/L. The target for the TMDL is reduction in sources contributing to low DO such that a DO of 5 mg/L is achieved in the stream. Dissolved oxygen is not a pollutant; therefore, the TMDL targets pollutants causing low dissolved oxygen. The causative pollutant for the TMDL is Biochemical Oxygen Demand (BOD).

#### 5. WATER QUALITY ASSESSMENT AND DEVIATION FROM TARGET

FDEP maintains ambient monitoring stations throughout the basin. There are three water quality monitoring station within the WBID (see Table 2). Limited nutrient and BOD data have been collected in the WBID; therefore, data collected between 1995 and 2002 were used in the analysis. Table 3 provides a statistical summary of water quality data collected in the WBID. Data used to calculate these statistics is provided in Appendix A. A comparison of DO samples collected at the monitoring stations with respect to the water quality criteria is shown in Table 4. The distribution of DO measurements over the listing period is shown in Figure 2.

There was one chlorophyll-a measurement collected in the WBID and only four samples were analyzed for BOD and nutrients. Chlorophyll-a data are often used as a screening parameter to assess nutrient impairment in the stream. Of the DO measurements recorded in Hogan Creek about half of the samples violate the water quality criteria (i.e., measurements less than 5 mg/L). Most of the DO exceedances were observed in 2002, which was an above average wet year. Low DO concentrations are often attributed to BOD and/or nutrients. Insufficient data are available to correlate DO to BOD or nutrients. Data are not available to evaluate improvements in water quality resulting from implementations of stormwater Best Management Practices (BMPs).

**Table 2. Monitoring stations in Hogan Creek (WBID 2252)**

Station ID	Station Name	Sampling Period	Number of Observations
21FLA20030692	Hogan Creek at 1 <sup>st</sup> Street (RM 1.3)	5/27/2002 – 12/12/2002	36
21FLA 20030729	Hogan Creek at Broad Street (RM 1.8)	5/25/2000 – 10/8/2002	59
21FLJXWQHC3	Hogan Creek at First Street (RM 1.2)	2/19/1991 – 12/4/2002	507

**Table 3. Summary of Water Quality Monitoring Data (1995 – 2002)**

Parameter	No. of Samples	Minimum	Maximum	Average	Median
BOD (mg/L)	4	1.00	2.600	1.775	1.75
Chlorophyll-a (µg/L)	1	1.00			
DO (mg/L)	57	0.4	10.6	1.112	4.5
Ammonia (mg/L)	4	0.02	0.484	0.211	0.169
Nitrate-Nitrite (mg/L)	4	0.2	0.56	0.3325	0.285
Total Kjeldahl Nitrogen (mg/L)	4	0.59	0.99	0.745	0.7
Total Phosphorus (mg/L)	4	0.07	0.19	0.12	0.11
Total Nitrogen (mg/L)	4	0.92	1.3	1.078	1.045
TN:TP Ratio	4	4.84	13.43	10.15	

**Table 4. Comparison of DO samples collected in WBID with respect to water quality criteria**

Station	No. of Observations	No. Samples Exceeding DO Criteria	Percent Samples Exceeding DO Criteria
21FLA20030692	8	7	87.5%
21FLA 20030729	8	5	62.5%
21FLJXWQHC3	41	18	43.9%
All Location	57	30	52.6%

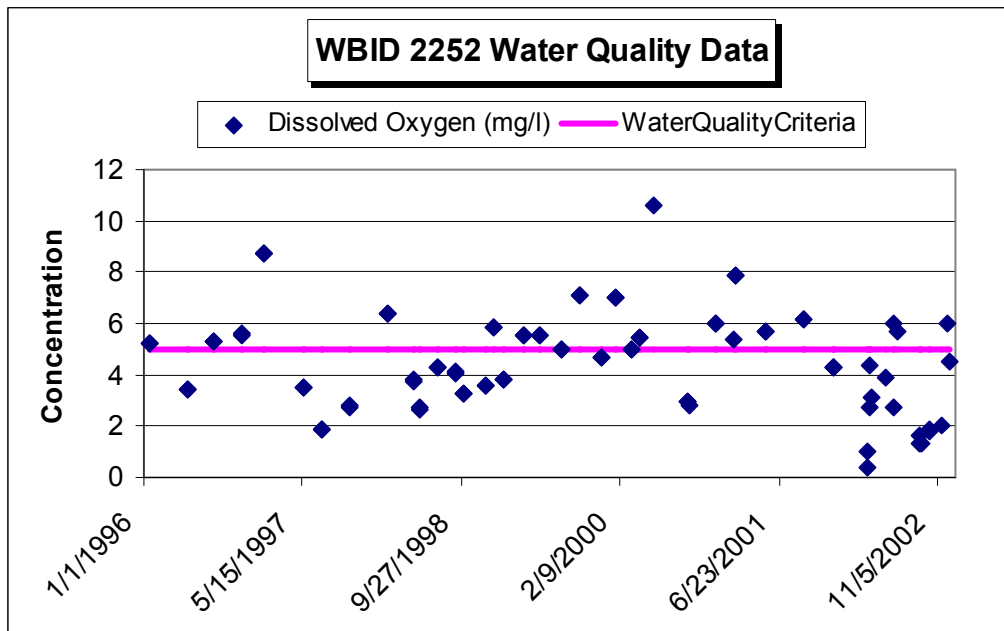


Figure 2. Dissolved Oxygen measurements collected in Hogan Creek

## 6. SOURCE ASSESSMENT

An important part of the TMDL analysis is the identification of source categories, source subcategories, or individual sources of nutrients in the watershed and the amount of pollutant loading contributed by each. Sources are broadly classified as either point or non-point sources. A point source is defined as a discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. Point source discharges of industrial wastewater and treated sanitary wastewater must be authorized by National Pollutant Discharge Elimination System (NPDES) permits.

Non-point sources of pollution are diffuse sources that cannot be identified as entering a waterbody through a discrete conveyance at a single location. Land cover within the WBID can be used as an indication of potential sources. Nonpoint sources addressed in this study primarily include loadings from surface runoff and base flow from the surficial aquifer (including the septic tank). The majority of the pollutants impacting the DO concentration in the stream are likely generated from urban development.

In DO-impaired waters source assessments often target nutrients. The limiting nutrient, generally nitrogen or phosphorus, is defined as the nutrient that limits plant growth when it is not available in sufficient quantities. The ratio of nitrogen to phosphorus is used as a first cut to determine the limiting nutrient. An N:P ratio less than 10 implies nitrogen is the limiting nutrient, a ratio greater than 30 implies phosphorus is the limiting nutrient, and a ratio between 10 and 30 implies both nitrogen and phosphorus are co-limiting nutrients. The limiting nutrient in Hogan Creek is nitrogen as the available data indicates the N: P ratio is on average less than 10 (see Table 3). This implies sources of nitrogen contribute to water quality impairment.

## 6.1 Point Sources

There are no facilities permitted to discharge treated effluent into the Hogan Creek watershed. Municipal Separate Storm Sewer Systems (MS4s) may also discharge pollutants to waterbodies in response to storm events. Currently, large and medium MS4s serving populations greater than 100,000 people are required to obtain a NPDES storm water permit. In March 2003, small MS4s serving urbanized areas were required to obtain a permit under the Phase II storm water regulations. An urbanized area is defined as an entity with a residential population of at least 50,000 people and an overall population density of 1,000 people per square mile.

The municipal area of the City of Jacksonville (FLS000012) includes the Hogan Creek basin and is covered under the Phase I MS4 permit. A requirement of the MS4 permit is the development of a Master Stormwater Management Plan. Implementation of this plan addresses water quality and flooding problems according to a priority list. Water quality in Hogan Creek was considered a priority issue in this plan.

In 1997 the city of Jacksonville's Department of Public Utilities Water and Sewer Operations merged with the Jacksonville Electric Authority (JEA), which now provides more than 80 percent of water and sewer service to residents of Duval County. JEA monitors water quality in Hogan Creek as part of the MS4 requirements for the City. JEA anticipates better management of stormwater runoff and capital improvement plans to address flooding issues will result in improved water quality in the Jacksonville area.

The WLA for the MS4 is expressed in terms of percent reduction. Given the available data, it is not possible to estimate loadings in units of pounds per day (lb/day) coming exclusively from the MS4 area. Although the aggregate wasteload allocation for storm water discharges is expressed in numeric form, percent reduction, based on the information available today, it is infeasible to calculate numeric WLAs for individual storm water outfalls because discharges from these sources can be highly intermittent, are usually characterized by very high flows occurring over relatively short time intervals, and carry a variety of pollutants whose nature and extent varies according to geography and local land use. Water quality impacts, in turn, also depend on a wide range of factors, including the magnitude and duration of rainfall events, the time period between events, soil conditions, fraction of land that is impervious to rainfall, other land use activities, and the ratio of storm water discharge to receiving water flow.

This TMDL assumes for the reasons stated above that it is infeasible to calculate numeric water quality-based effluent limitations for BOD from storm water discharges. Therefore, in the absence of information presented to the permitting authority showing otherwise, the WLA for the City of Jacksonville is expressed in narrative form (e.g., as best management practices), provided that (1) the permitting authority explains in the permit fact sheet the reasons it expects the chosen BMPs to achieve the aggregate wasteload allocation for these stormwater discharges; and (2) the state will perform ambient water quality monitoring for nutrients for the purpose of determining whether the BMPs in fact are achieving such aggregate wasteload allocation.

The percent reduction calculated for nonpoint sources is assigned to the MS4 as violations from both sources typically occur in response to storm events. Permitted MS4s will be responsible for reducing only the loads associated with stormwater outfalls which it owns, manages, or otherwise has responsible control. MS4s are not responsible for reducing other nonpoint source loads within

its jurisdiction. All future MS4s permitted in the area are automatically prescribed a WLA equivalent to the percent reduction assigned to the LA.

## 6.2 Non-point Sources

Land development influences the delivery of water quality constituents to surface waters in two fundamental ways. Through fertilization, lawn maintenance, manure spreading, septic tank operation, vehicular use, etc., nutrients and other pollutants are added to the land surface or to shallow groundwater in excess of natural land cover conditions (i.e., native forest, wetland). Unlike the situation that tends to predominate on developed lands, natural land covers are highly conservative of essential growth nutrients, and thus labile nutrient forms tend to be retained within these terrestrial ecosystems. In addition, the creation of impervious surfaces, drainage development, and the destruction of near stream wetlands increases the amount of rainfall that ultimately ends up as runoff, thus increasing the pollutant exporting capability in developed landscapes. Thus, the process of nonpoint source pollution has both chemical and hydrologic components (Hendrickson, 2002).

The Hogan Creek watershed is predominately urban. Debris carrying nutrients and other pollutants washes off roads and other impervious surfaces and discharges into the stream during storm events. Potential pollutant sources contributing to impairment include: animal waste, fertilizer application to lawns, golf courses, and other grassed areas, and malfunctioning septic tank systems.

Jacksonville Electrical Authority (JEA) funded a project, known as the Tributary Pollution Assessment Project (TPAP) to develop a standard manual for conducting sanitary surveys. The manual will be used to assess the health of a watershed and potential sources of pollution. This information will be used by JEA to concentrate repair efforts and to identify areas of failing septic tanks. The Hogan Creek watershed is considered a priority watershed in this study.

Stormwater runoff from urban areas can be a significant source of pollutants to a stream. 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 outlined in Chapter 403 Florida Statutes (F.S.), was established as a technology-based program that relies upon 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.

Florida's stormwater program is unique in having a performance standard for older stormwater systems that were built before the implementation of the Stormwater Rule in 1982. This rule states: "the pollutant loading from older stormwater management systems shall be reduced as needed to restore or maintain the beneficial uses of water" (Section 62-4-.432 (5) (c), F.A.C.).

Nonstructural and structural BMPs are an integral part of the State's stormwater programs. Nonstructural BMPs, often referred to as "source controls", are those that can be used to prevent the generation of NPS pollutants or to limit their transport off-site. Typical nonstructural BMPs include public education, land use management, preservation of wetlands and floodplains, and minimizing impervious surfaces. Technology-based structural BMPs are used to mitigate the increased stormwater peak discharge rate, volume, and pollutant loadings that accompany urbanization.

## 7. ANALYTICAL APPROACH

The SJRWMD Pollutant Load Screening Model (PLSM) was used to calculate the concentration and load of BOD entering Hogan Creek from nonpoint sources (Mundy and Bergman, 1998). The U.S. EPA Water Quality Analysis Simulation Program version 7 (WASP7) was applied as the water quality model (Wool, et. al., 2001). The eutrophication component of WASP was used to simulate the complex nutrient transport and cycling in the river, as well as determining the DO sag within river. The purpose of the modeling exercise was to determine what reductions in BOD loads to the river would have to occur to protect the water body's designated use and achieve dissolved oxygen water quality standards.

### 7.1 PLSM Model

PLSM utilizes a computer-driven geographic information system framework to calculate constituent loads as the product of water quality concentration associated with certain land use practices, and runoff water volume associated with those same practices. The computational approach of the PLSM is similar to that of the Surface Water Management Model (SWMM) screening level tool (Hendrickson, 2002). The model's nonpoint source pollutant concentrations are specific to one of 20 different land use classes. Water quantity is determined through a hybrid of the SCS curve number method, and is the product of rain volumes and a coefficient (referred to as the runoff coefficient, or RC, with values ranging from 0 to 0.9) relating the propensity of various land use and soil hydrologic group combinations to generate runoff. Each land use category is assumed to transport a characteristic mass load of pollutant from one unit of area from one unit of effective rain. Figure 3 displays the computational framework of PLSM.

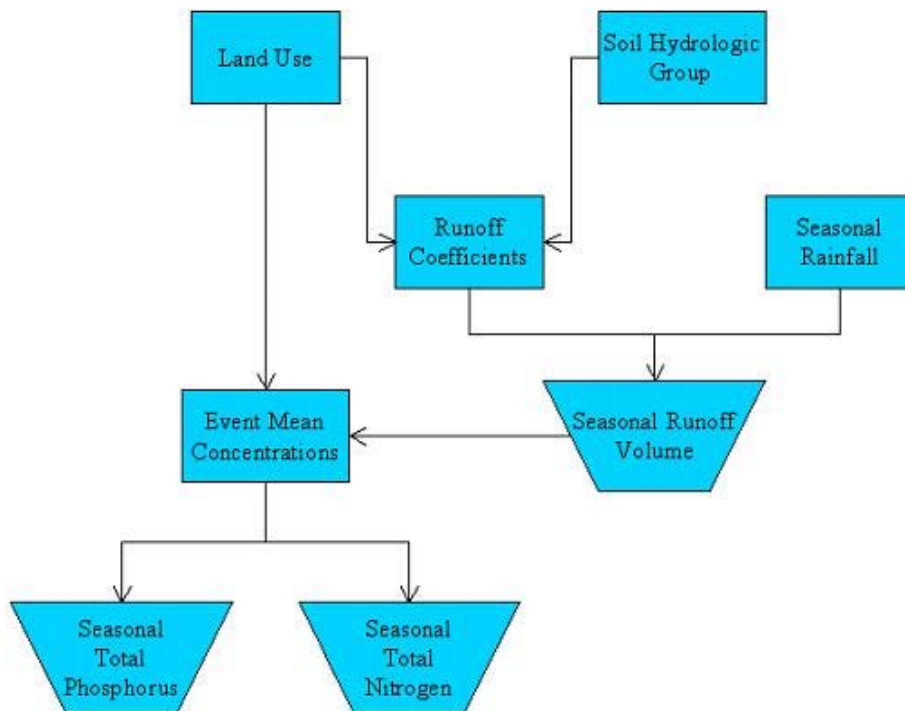


Figure 3. PLSM Conceptual Framework

### 7.1.1 PLSM Setup

In this application of PLSM, the model was run within Microsoft Excel and it first calculated seasonal area-weighted runoff coefficients and flow-weighted concentrations for nutrients (nitrogen and phosphorus) and BOD based upon the area within the WBID of unique land use and soil hydrologic group combinations. This was accomplished by following the procedure outlined in Hendrickson and Konwinski (1998). The inputs required to administer PLSM are provided here. PLSM is calibrated by matching simulated pollutant loads and total discharge volumes to observed values.

#### Land Use

Data from the standard 2000 Florida Land Use, Cover and Forms Classification System (FLUCCS) code was obtained from SJRWMD and the South Florida Water Management District (SFWMD). This data was then aggregated into 20 distinct categories as defined in Table 5.

**Table 5. Land use Categories**

Category ID	Category Label	Category Description
1	LDR	Low Density Residential
2	MDR	Medium Density Residential
3	HDR	High Density Residential
4	LC	Commercial, Low
5	HC	Commercial, High
6	I	Industrial
7	M	Mining
8	RO	Range/Open Land
9	AGGEN	General, Agricultural
10	NAGEN	General, Non-Agricultural
91	PAST	Pasture
92	CROPS	Crops
93	CITRUS	Citrus
94	AGMISC	Agricultural, Miscellaneous
95	ANIM	Animal
101	FOR	Forested
102	SILV	Silviculture
103	WATER	Water
104	WETLDS	Wetlands
105	BARREN	Barren

#### Soils

The Soil Survey Geographic Database (SSURGO), developed by the Natural Resource Conservation Service, was used in PLSM and was obtained from SJRWMD and SFWMD. Soils in PLSM are classified based specifically on their hydrologic group rating of A, B, C and D. Additional soil groups found within the SJRWMD dataset were group U (urban), which allows relatively average drainage, and Group X soils, for which drainage characteristics were unknown. Group U soils were ultimately handled as group C soils. Further, for this process, soils identified in the dataset as B/D and C/D soils were considered as B and C hydrologic group ratings, respectively. Land use and soils data was then cross-referenced to provide the total area of each specific land use-soils combination within each TMDL segment. These values were then applied directly to the model.

**Rainfall**

Rainfall data required to calculate runoff volumes and thus loads in PLSM was obtained from data collected at the Jacksonville International Airport (JAX). Rainfall measurements were available from this station from 1949 to the present and were processed to obtain overall seasonal averages. The seasons used were not the Julian seasons but modified seasons corresponding to hydrologic and meteorological patterns within Florida, and were comprised of a cool, moderately wet winter season from December through March characterized by regular frontal storm events; a hot, dry spring/summer from April through July; and a hot, wet summer/fall from August through November characterized by afternoon convective thunderstorms and tropical systems.

**7.1.2 PLSM Calculations****Area-Weighted Runoff Coefficients**

PLSM provides runoff coefficients based on the combination of soil type and land use inputs provided. Runoff coefficients are then multiplied by seasonal rainfall to determine a seasonal runoff volume from each particular combination of land use and soil type. Runoff coefficients indicate the fraction of loads originating from the catchment that actually reach the stream. A value of 1 means the full load reaches the stream.

**Event Mean Concentrations**

The event mean concentration (EMC) reflects the average concentration of a parameter that would be found in surface water running off from an area of land with a consistent soil and land use. PLSM generates event mean concentrations for Total Nitrogen (TN), Total Phosphorus (TP), BOD, Total Inorganic Nitrogen (TIN), Phosphate (PO<sub>4</sub>), Labile Total Organic Carbon (LTOC), and Refractory Total Organic Carbon (RTOC) based on calibrations as conducted in Hendrickson and Konwinski (1998) and the varying land use-soils combinations that were provided. Event mean concentrations are then applied to the seasonal runoff volume to calculate average seasonal nutrient and BOD loads for each land use-soil combination. Total seasonal loads were calculated as the sum of all loads within a drainage basin.

**7.1.3 PLSM Results**

BOD loads for Hogan Creek were calculated for the existing land use conditions in the WBID for three seasons: season 1 (December through March); season 2 (April through July) and season 3 (August through November). Table 6 provides total daily and seasonal BOD loads obtained from PLSM.

**Table 6. Existing BOD loads obtained from PLSM for Hogan Creek**

Season 1			Season 2			Season 3		
Conc. (mg/L)	Daily Load (lb/day)	Seasonal Load (lb/season)	Conc. (mg/L)	Daily Load (lb/season)	Seasonal Load (lb/season)	Conc. (mg/L)	Daily Load (lb/day)	Seasonal Load (lb/season)
3.5	133.76	16,452	3.52	120.13	14,656	3.46	231.09	28,193

The total annual load is the sum of the seasonal loads or 59,300 lb/yr. Expressed as an average seasonal load, the existing BOD load for Hogan Creek is 162 lb/day.

## 7.2 WASP Model

Hogan Creek was initially divided into 17 segments for the WASP model corresponding to monitoring stations and tributaries branching from the main stem. In the calibrated model, segments 2 through 5 were combined as they represented small drainage areas and the combined segment provided added model stability. Model segmentation was based on the Grid Based Mercury Model (GBMM). The GBMM is a GIS environment extension that aids in defining the segmentation and boundary conditions for the WASP7 model input file. The GBMM extension utilizes the National Hydrography Dataset (NHD) and the National Elevation Dataset (NED) along with various other coverages, including watershed boundary, weather data and soils. GBMM was used to predict inflows to the WASP model where there are no continuous flow gages. GBMM predicts runoff as a function of land use (pervious/impervious area), slope, soil type, infiltration and evaporation. When the GBMM was executed, two ASCII files were produced for use in building the WASP7 application for Hogan Creek. Those were the segment.txt and the flow.txt files. The segment.txt file contained the following information for each segment:

- Segment Name,
- Segment Number,
- Length (m),
- Width (m),
- Depth Multiplier,
- Velocity Multiplier,
- Slope (m/m), and
- Mannings Roughness.

The flow.txt file contains two important pieces of information, 1) how the segments were connected to one another, and 2) a time series of flow for each individual segment drainage area.

### 7.2.1 WASP Input

WASP requires BOD to be input as carbonaceous BOD (CBOD). To determine the loading of CBOD to each segment, the load for the entire WBID was area-weighted to the segment drainage area. The units were then converted from (lb/d) to (kg/d) by dividing (lb/d) by 2.2046. The CBOD estimates were converted to ultimate CBOD (CBOD<sub>u</sub>) by multiplying the CBOD load by an f-ratio of 3.0. This procedure was done for each season. A time-series of CBOD<sub>u</sub> load was then created for each segment and input into WASP7 (see Table 7).

**Table 7. CBOD<sub>u</sub> Loadings for WASP Segmentation of Hogan Creek**

Segment	Segment Drainage Area (m <sup>2</sup> )	Area-Weight Factor	Season 1 Load (kg/day)	Season 2 Load (kg/day)	Season 3 Load (kg/day)
1	277,200	0.0311	5.663	5.086	9.784
6 (includes segments 2-5)	412,200	0.0463	8.421	7.563	14.548
7	38,700	0.0043	0.791	0.710	1.366
8	54,900	0.0062	1.122	1.007	1.938
9	2,359,800	0.2649	48.207	43.297	83.287
10	580,500	0.0652	11.859	10.651	20.488

Segment	Segment Drainage Area (m <sup>2</sup> )	Area-Weight Factor	Season 1 Load (kg/day)	Season 2 Load (kg/day)	Season 3 Load (kg/day)
11	43,200	0.0048	0.882	0.793	1.525
12	27,000	0.0030	0.552	0.495	0.953
13	406,800	0.0457	8.310	7.464	14.358
14	59,400	0.0067	1.213	1.090	2.096
15	29,700	0.0033	0.607	0.545	1.048
16	9,000	0.0010	0.184	0.165	0.318
17	197,100	0.0221	4.026	3.616	6.956

WASP7 was setup to simulate modified Streeter-Phelps equations for DO and CBODu and Sediment Oxygen Demand (SOD). SOD is defined as the rate of oxygen consumption exerted by bottom sediments on overlying water. Constants for DO and CBODu were selected based on literature values and experience modeling in Florida and are presented in Table 8. Constants used to simulate DO are related to reaeration and a stoichiometric ratio. The constants for CBODu describe the decay rate and half saturation limit.

**Table 8. Constants used in WASP7 model for simulating DO and CBODu**

Parameter Simulated	Constant	Value
DO	Minimum Reaeration Rate (per day)	0.00005
	Theta—Reaeration Temperature Correction	1.0477
	Oxygen to Carbon Stoichiometric Ratio	2.67
CBOD1 (ultimate)	BOD (1) Decay Rate Constant @ 20 <sup>o</sup> C (per day)	0.20
	BOD(1) Decay Rate Temperature Correction Coefficient	1.04
	BOD(1) Half Saturation Oxygen Limit (mg O/L)	0.5

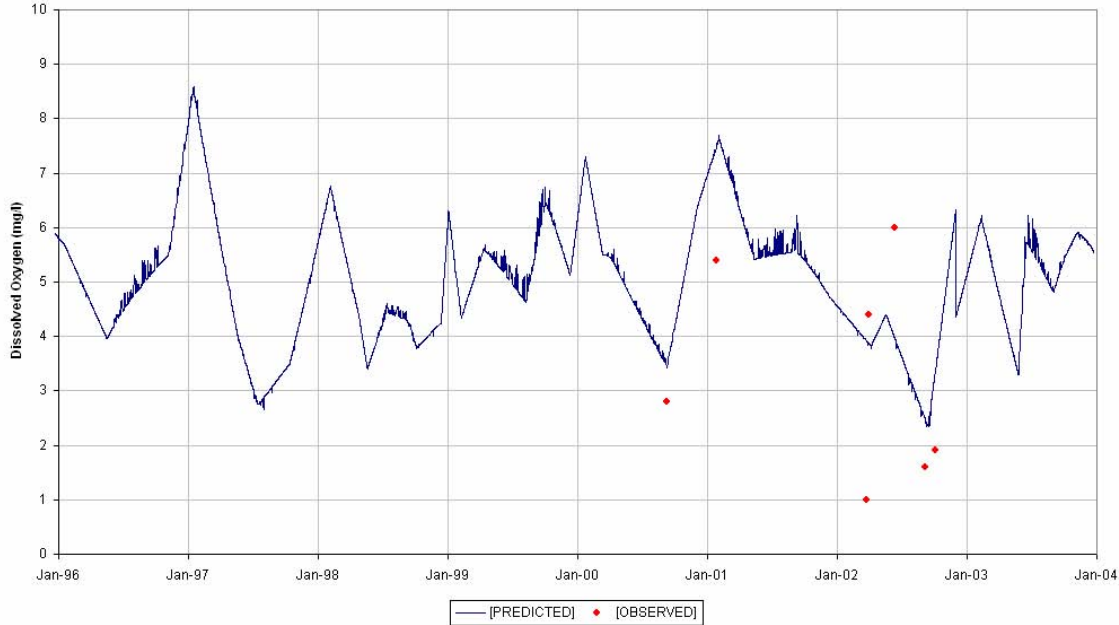
### 7.2.2 WASP Calibration

The only available water quality data to characterize the Hogan Creek WBID were observed from the three observation stations: 21FLJXWQHC3 (RM 1.2); 21FLA 20030692 (RM 1.3); and 21FLA20030729 (RM 1.8). Thus, choices were limited while trying to develop model forcing time series. In addition, observations at Stations 21FLA 20030692 and 21AFL 20030729 were infrequent and only spanned from May 2000 through December 2002. Therefore, these stations were used to parameterize the condition of the water entering the WASP7 network.

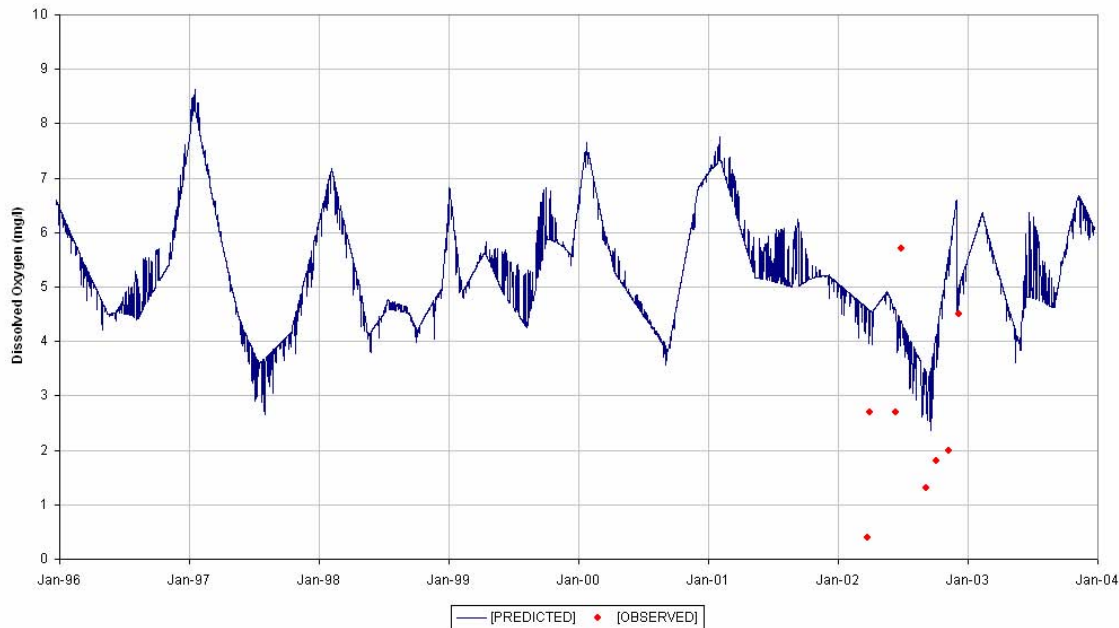
SOD is a major component of the Hogan Creek WASP model. SOD data are not available in the WBID, thus model parameters were based on literature values. During initial model set-up, SOD was set using a value of 1.0 g/m<sup>2</sup>/d. After the iterative calibration process, SOD was set to 3.0 g/m<sup>2</sup>/d for all segments.

Once model input forcings and parameters were developed, model calibration was an iterative process. During the calibration process it was determined that the dominant parameter was SOD. Therefore, calibration of the Hogan Creek model was performed by adjusting SOD until the simulated dissolved oxygen values were close to the measured values.

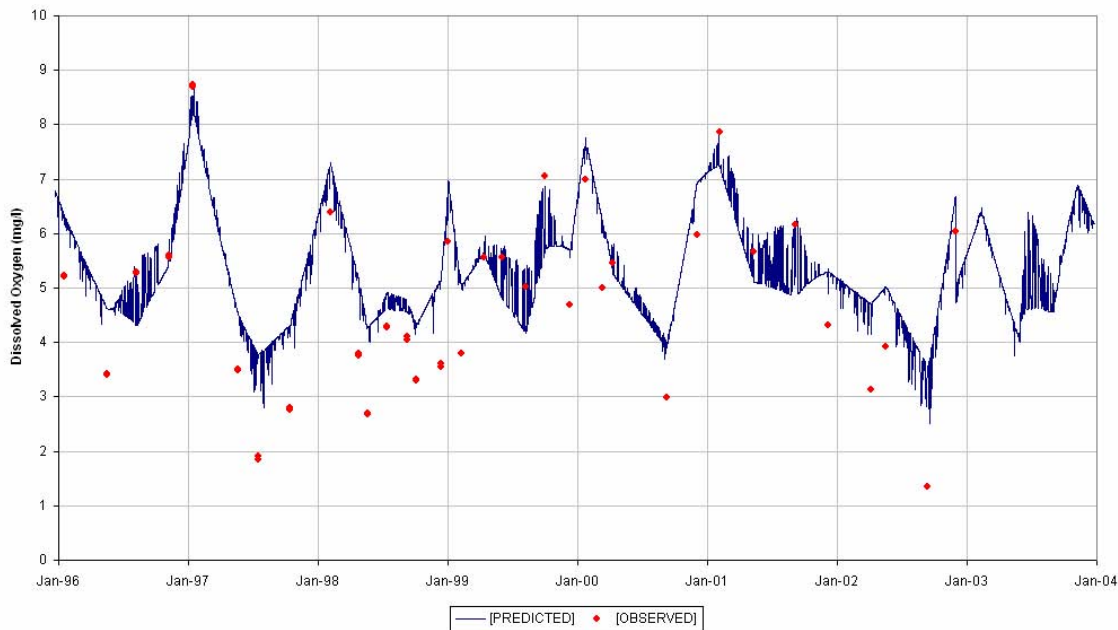
Model runs were compared to the observed data for the period of 1996-2003. The critical period for the simulations was selected as 1999-2000 as rainfall for these two years was significantly lower than the annual average. Time series comparisons were developed for Segment 6 (RM 1.8), Segment 9 (RM 1.3), and Segment 10 (RM 1.2) as shown in Figure 4 through Figure 6, respectively. The comparisons at river miles 1.2 and 1.8 are reasonable. Simulation comparisons at river mile 1.3 show more variation of simulated versus observed data. In consideration of the uncertainty in model forcing information and assumptions, the model simulations are considered reasonable.



**Figure 4. Dissolved Oxygen calibration at Station 21FLA 20030729 (RM 1.8)**



**Figure 5. Dissolved Oxygen calibration at Station 21FLA 20030692 (RM 1.3)**



**Figure 6. Dissolved Oxygen calibration at Station 21FLJXWQHC3 (RM 1.2)**

### 7.2.3. WASP Results

After calibration, allocation scenarios were evaluated at segments 6, 9, and 10 corresponding to monitoring stations at RM 1.8, RM 1.3, and RM 1.2, respectively. Model SOD values were reduced until DO standards were achieved at all times. Acceptable DO levels were achieved with an SOD value of 1.9 g/m<sup>2</sup>/day. Since load allocations cannot be made for SOD, a relationship between CBOD<sub>u</sub> and SOD was needed. Hence, the goal was to determine what reduction in the watershed CBOD<sub>u</sub> load would result in an SOD value of 1.9 g/m<sup>2</sup>/day.

WASP7 does not have a sediment diagenesis algorithm to predict SOD based on instream loads of CBOD. The SOD spreadsheet model developed by Quantitative Environmental Analysis (QEA) and modified by Dr. James Martin at Mississippi State University (MSU) was implemented to determine the relative change in SOD by reducing the watershed load of CBOD<sub>u</sub> (Martin, 2002). The SOD spreadsheet model was run on segments 6, 9, and 10. The downstream segment, Segment 10, was used to determine the watershed load reduction. Results of the SOD spreadsheet model for CBOD reductions of 10, 25, 50, 75 and 90% at model segment 10 are shown in Figure 7. Model results indicate a 35 percent reduction in existing loads of BOD from the watershed is needed for Hogan Creek to attain standards.

As discussed in Section 7.1.3, the existing average annual load is estimated at 59,300 lb/yr. To achieve the DO criteria a 35 percent reduction in BOD load is required resulting in a TMDL of 38,545 lb/yr.

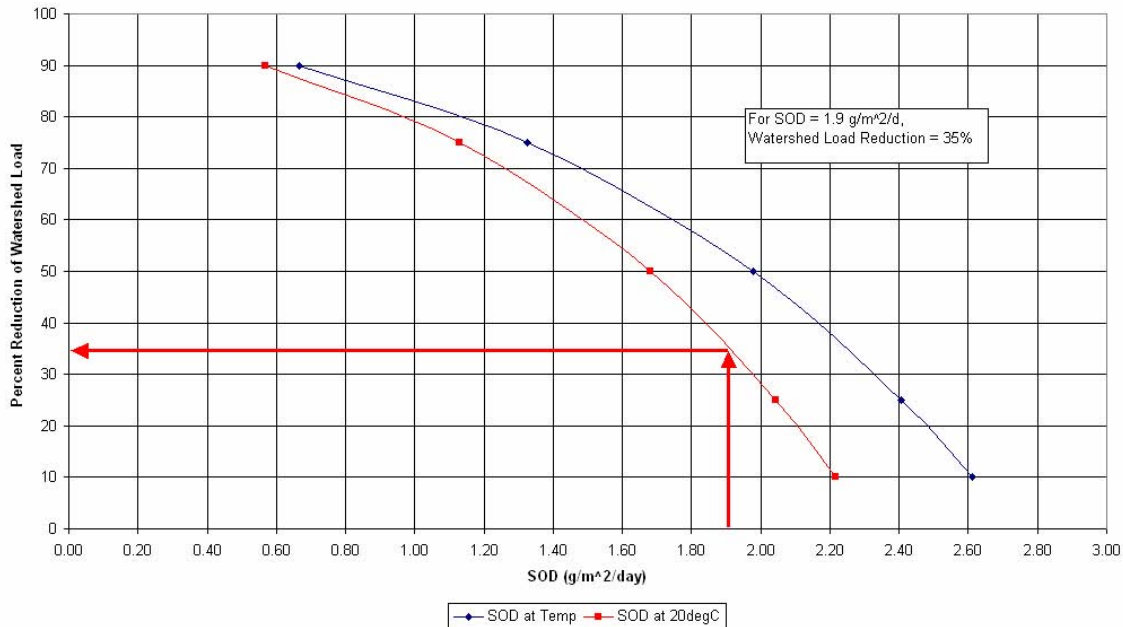


Figure 7. SOD Spreadsheet model results at WASP Segment 10 (RM 1.2)

## 8. DETERMINATION OF TMDL

The TMDL process quantifies the amount of a pollutant that can be assimilated in a waterbody, identifies the sources of the pollutant, and recommends regulatory or other actions to be taken to achieve compliance with applicable water quality standards based on the relationship between pollution sources and in-stream water quality conditions. A TMDL can be expressed as the sum of all point source loads (Waste Load Allocations), non-point source loads (Load Allocations), and an appropriate margin of safety (MOS), which takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

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

The objective of a TMDL is to allocate loads among all of the known pollutant sources throughout a watershed so that appropriate control measures can be implemented and water quality standards achieved. 40 CFR §130.2 (i) states that TMDLs can be expressed in terms of mass per time (e.g. pounds per day), toxicity, or other appropriate measure. The TMDL for Hogan Creek is expressed as an annual BOD load that achieves an instream DO concentration of 5 mg/L.

### 8.1 Critical Conditions

The critical conditions can be defined as the environmental conditions requiring the largest reduction to meet standards. By achieving the reduction for critical conditions, water quality standards should be achieved during all other times.

A single critical condition could not be considered due to the limited amount of monitoring data. The modeling approach used in this TMDL takes into account the accumulative loading over a seven

year period. In addition, the location and time period during which dissolved oxygen concentrations were lowest in Hogan Creek were identified, and the TMDL loads were set to ensure that standards were met during that and all other times.

## 8.2 Existing Conditions

Existing conditions are based on modeling simulations of DO at three monitoring stations within the WBID over a seven year time period. This period of time was selected because of monitoring data available to calibrate the water quality model.

## 8.3 Margin of Safety

There are two methods for incorporating a MOS in the analysis: a) implicitly incorporate the MOS using conservative model assumptions to develop allocations; or b) explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations. An implicit MOS was incorporated in the TMDL through the use of conservative modeling assumptions. These assumptions include a conservative estimate of the F ratio resulting in greater BOD load than what would have been calculated using a smaller F ratio.

## 8.4 Determination of TMDL, LA and WLA

The TMDL for Hogan Creek is expressed as the average annual daily loading of BOD that achieves the dissolved oxygen concentration of 5 mg/L. By achieving the 35% reduction in the sources contributing to low levels of DO, attainment of the designated use of the stream should be attained. There are no point sources, with the exception of the MS4, discharging effluent in the WBID; therefore, a value for the waste load allocation (WLA) assigned to non-stormwater NPDES facilities is not applicable. The MS4 and load allocation values are assigned a percent reduction equivalent to the TMDL, or 35 percent. TMDL components are summarized in Table 9.

**Table 9. Summary of TMDL Components for Hogan Creek (WBID 2252)**

Parameter	WLA		LA (lb/yr)	TMDL (lb/yr)	Percent Reduction
	Continuous	MS4 (reduction)			
BOD	N/A	35%	38,545	38,545	35%

### 8.4.1 Waste Load Allocations

There are no NPDES facilities discharging to Hogan Creek. Only facilities discharging pollutants directly into streams and MS4 areas are assigned a WLA. The WLAs are expressed separately for continuous discharge facilities and MS4 areas as the former discharges during all weather conditions whereas the later discharges in response to storm events. Any future facility permitted to discharge effluent into the Hogan Creek watershed that adversely impact DO will be required to meet end-of-pipe limits that do not cause or contribute to impairment in the stream.

The City of Jacksonville MS4 impacts Hogan Creek. The WLA assigned to the MS4 area is expressed in terms of percent reduction of BOD loads required to attain the target. With the

available water quality data it is not possible to calculate the WLA in terms of load or isolate the loading discharging exclusively from the MS4 areas.

#### **8.4.2 Load Allocations**

The primary mode of transport of BOD to the stream is during a storm event. Nutrient data were collected during storm events in 1991 and 1992 and on select dates in later years. Modification of the land surface from a pervious land cover to an impervious surface results in higher peak flow rates that wash BOD-enriched water into the stream. Nonpoint source pollution and MS4 runoff is responsible for the low DO measurements in the stream. Since there are no NPDES facilities discharging to Hogan Creek, the TMDL load is assigned to nonpoint sources in the Load Allocation. Reductions in BOD loadings of 35 percent throughout the watershed should result in attainment of standards.

#### **8.5 Seasonal Variation**

Seasonal variation was incorporated in the analysis by simulating loads during the various seasons. The entire period of record of data collected in the WBID was used in the analysis. This incorporates changes in water temperature, rainfall, and rainfall intensity.

### **9. RECOMMENDATIONS**

Controlling sources contributing to reduced DO concentrations should be the focus of implementing this TMDL. FDEP employs the Basin Management Action Plan (B-MAP) as the mechanism for developing strategies to accomplish the necessary load reductions. Components of a B-MAP are:

- Allocations among stakeholders
- Listing of specific activities to achieve reductions
- Project initiation and completion timeliness
- Identification of funding opportunities
- Agreements
- Local ordinances
- Local water quality standards and permits
- Follow-up monitoring

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**APPENDIX A WATER QUALITY DATA**

**Table A- 1. Guide to Water Quality Remark Codes (Rcode column in data tables)**

<b>Remark Code</b>	<b>Definition</b>	<b>Use in TMDL</b>
A	Value reported is mean of two or more samples	Data included in analysis as reported
E	Extra sample taken in compositing process	Data included as average
I	The value reported is less than the practical quantification limit and greater than or equal to the method detection limit.	Data included in analysis as reported
J	Estimated. Value shown is not a result of analytical measurement.	Data not included in analysis as reported
K	Off-scale low. Actual value not known, but known to be less than value shown	Data included in analysis as reported
L	Off-scale high. Actual value not known, but known to be greater than value shown	Data included in analysis as reported
Q	Sample held beyond normal holding time	<b>Data used in analysis – samples held on on ice; actual concentration is expected to be at least as high as the value reported.</b>
T	Value reported is less than the criteria of detection	Data included in analysis if the reported value is below criteria; otherwise, reported value is not used in the analysis
U	Material was analyzed for but not detected. Value stored is the limit of detection.	Data not included in analysis
<	NAWQA – actual value is known to be less than the value shown	Data included in analysis

Table A-2. Water quality data collected in Hogan Creek

Parameter	Station	Date	Time	Result	Remark Code
Biochemical Oxygen Demand (mg/L)	21FLJXWQHC3	10/4/1995	1310	1	
	21FLA 20030729	5/25/2000	1540	2.6	
		9/12/2000	1420	1.7	
		2/2/2001	915	1.8	
Chlorophyll-a (µg/L)	21FLA 20030729	9/12/2000	1420	1	U
Dissolved Oxygen (mg/L)	21FLJXWQHC3	1/17/1996	1023	5.2	
		5/19/1996	836	3.4	
		8/7/1996	1349	5.26	
		11/7/1996	1110	5.6	
		1/14/1997	1347	8.74	
		5/24/1997	939	3.5	
		7/19/1997	750	1.85	
		10/13/1997	1029	2.75	
		2/8/1998	955	6.39	
		4/30/1998	924	3.8	
		5/20/1998	1155	2.7	
		7/17/1998	920	4.3	
		9/9/1998	1004	4.1	
		10/8/1998	943	3.31	
		12/17/1998	925	3.55	
		1/4/1999	1020	5.86	
		2/9/1999	1505	3.79	
		4/13/1999	1438	5.56	
		6/3/1999	1414	5.55	
		8/10/1999	1434	5.02	
		10/4/1999	1126	7.06	
		12/16/1999	941	4.69	
		1/25/2000	1120	7	
		3/17/2000	935	5	
		4/12/2000	1413	5.46	
		9/11/2000	1506	2.98	
		12/5/2000	1324	5.98	
		2/6/2001	1432	7.87	
		5/15/2001	1112	5.66	
		9/10/2001	1426	6.16	
		12/11/2001	1036	4.32	
		4/13/2002	759	3.14	
5/25/2002	848	3.92			
9/17/2002	1200	1.34			
12/4/2002	1200	6.03			

Parameter	Station	Date	Time	Result	Remark Code
Dissolved Oxygen (mg/L)	21FLA 20030692	3/27/2002	1000	0.4	
		4/7/2002	950	2.7	
		6/17/2002	1000	2.7	
		7/2/2002	1120	5.7	
		9/12/2002	930	1.3	
		10/11/2002	910	1.8	
		11/17/2002	948	2	
		12/12/2002	1025	4.5	
	21FLA 20030729	5/25/2000	1540	10.6	
		9/12/2000	1420	2.8	
		2/2/2001	915	5.4	
		3/27/2002	1020	1	
		4/4/2002	1000	4.4	
		6/17/2002	1015	6	
9/12/2002		945	1.6		
10/11/2002	930	1.9			
Ammonia (mg/L)	21FLJXWQHC3	10/4/1995	1310	0.02	
	21FLA 20030729	5/25/2000	1540	0.1452	
		9/12/2000	1420	0.484	
		2/2/2001	915	0.1936	
Nitrate-Nitrite (mg/L)	21FLJXWQHC3	10/4/1995	1310	0.26	
	21FLA 20030729	5/25/2000	1540	0.2	
		9/12/2000	1420	0.31	
		2/2/2001	915	0.56	
Total Kjeldahl Nitrogen (mg/L)	21FLJXWQHC3	10/4/1995	1310	0.68	
	21FLA 20030729	5/25/2000	1540	0.72	
		9/12/2000	1420	0.99	
		2/2/2001	915	0.59	
Total Organic Carbon (mg/L)	21FLA 20030729	5/25/2000	1540	7.1	
		9/12/2000	1420	8.3	
		2/2/2001	915	1	U
Total Phosphorus (mg/L)	21FLJXWQHC3	10/4/1995	1310	0.07	
	21FLA 20030729	5/25/2000	1540	0.19	
		9/12/2000	1420	0.12	
		2/2/2001	915	0.1	
Total Nitrogen (mg/L)	21FLJXWQHC3	10/4/1995	1310	0.94	
	21FLA 20030729	5/25/2000	1540	0.92	
		9/12/2000	1420	1.3	
		2/2/2001	915	1.15	