TOTAL MAXIMUM DAILY LOAD (TMDL)

For

Nutrients, Biochemical Oxygen Demand and

Dissolved Oxygen

In the

Dade City Canal

(WBID 1399)

Prepared by:

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United States Environmental Protection Agency

Region 4 serving the southeast

In compliance with the provisions of the Federal Clean Water Act, 33 U.S.C §1251 et. seq., as amended by the Water Quality Act of 1987, P.L. 400-4, the U.S. Environmental Protection Agency is hereby establishing these Total Maximum Daily Loads (TMDLs) for nutrients, biochemical oxygen demand and dissolved oxygen in the Dade City Canal (WBID 1399). Subsequent actions must be consistent with this TMDL.

/s/ 3/5/2007

James D. Giattina, Director — Date

Water Management Division

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LIST OF ABBREVIATIONS

AWT	Advanced Waste Treatment
BMP	Best Management Practices
BPJ	Best Professional Judgment
CFS	Cubic Feet per Second
CFU	Colony Forming Units
DEM	Digital Elevation Model
DMR	Discharge Monitoring Report
EPA	Environmental Protection Agency
FAC	Florida Administrative Code
GIS	Geographic Information System
HUC	Hydrologic Unit Code
LA	Load Allocation
MGD	Million Gallons per Day
MOS	Margin of Safety
MPN	Most Probable Number
MS4	Municipal Separate Storm Sewer Systems
NASS	National Agriculture Statistics Service
NLCD	National Land Cover Data
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
OSTD	Onsite Sewer Treatment and Disposal Systems
PLRG	Pollutant Load Reduction Goal
Rf3	Reach File 3
RM	River Mile
STORET	STORage RETrieval database
TBN	Total Bioavailable Nitrogen
TBP	Total Bioavailable Phosphorus
TMDL	Total Maximum Daily Load
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WBID	Water Body Identification
WCS	Watershed Characterization System
WLA	Waste Load Allocation
WMP	Water Management Plan

SUMMARY SHEET
Total Maximum Daily Load (TMDL)

1. 303(d) Listed Waterbody Information

State: Florida

Major River Basin: Withlacoochee River, South (HUC 03100208)

1998 303(d) Listed Waterbodies for TMDLs addressed in this report:

WBID	Segment Name and Type	County	Constituents(s)
1399	Dade City Canal (freshwater)	Pasco	Dissolved Oxygen (D.O.), Nutrients, Biochemical Oxygen Demand (BOD)

2. TMDL Endpoints (i.e., Targets) and Approach

The State of Florida has narrative criteria for nutrients stating that in no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations of aquatic flora or fauna. Biochemical Oxygen Demand (BOD) shall not be increased to exceed values which would cause dissolved oxygen to be depressed below the limit established for each class and, in no case, shall it be great enough to produce nuisance conditions.

TMDLs for nutrients, BOD, and low D.O. in WBID 1399 were addressed by analyzing the effects of BOD, total nitrogen (TN), and total phosphorus (TP) loads on dissolved oxygen concentrations using a steady state WASP model. The target for D.O. is based on the State of Florida's water quality criteria for D.O., which requires that in no case should the concentration of dissolved oxygen be less than 5 mg/L in freshwater streams. Current point and nonpoint source loads of BOD, TN and TP were estimated, and these loads reduced until model simulations indicated the D.O. criterion was attained.

3. Allocations for D.O./BOD and Nutrient TMDLs in WBID 1399 (Dade City Canal).

Parameter	TMDL[1] kg/day	WLA[2]		LA kg/day	MOS kg/day	Percent [3] Reduction
		NPDES kg/day	MS4[3] %			
Total Nitrogen	6.99	3.1	70%	3.15	0.5	70%
Total Phosphorus	1.22	0.7	70%	0.42	0.1	70%
Biochemical Oxygen Demand (BOD)	14.9	6.1	70%	7.34	0.9	70%

Notes:
1. Please refer to Section 5.4, which discusses the TMDL components in greater detail.
2. The WLA is separated into an allocation for continuous NPDES facilities and an allocation for the MS4. WBID 1399 may be affected by Phase I MS4 permit #FLS00032, which is held by the City of Dade City, Pasco County, and other co-permittees. The WLA for facilities is based on the point source continuing to meet its daily minimum D.O. limitation.
3. Percent reduction in total BOD, TN, and TP loading from current conditions to achieve the D.O. standard.

4. Endangered Species (yes or blank): Yes

5. EPA Lead on TMDL (EPA or blank): EPA

6. **TMDL Considers Point Source, Nonpoint Source, or both:** Both

7. **Major NPDES Discharges to surface waters addressed in EPA TMDL:** FL000485

TOTAL MAXIMUM DAILY LOAD (TMDL) FOR NUTRIENTS, BIOCHEMICAL OXYGEN DEMAND AND DISSOLVED OXYGEN in THE DADE CITY CANAL (WBID 1399)

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).

The State of Florida Department of Environmental Protection (FDEP) has developed 303(d) lists since 1992. The process by which Florida implements section 303(d) requirements is set forth in the Florida Watershed Restoration Act (FWRA) of 1999 (s. 403.067, Florida Statutes). The FDEP list of impaired waters in each basin, referred to as the “Verified List”, is also adopted pursuant to the FWRA (Subsection 403.067[4], Florida Statutes). However, the FWRA also states 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-rule-making process, the Florida Environmental Regulation Commission adopted the new methodology as Chapter 62-303, Florida Administrative Code (Identification of Impaired Surface Waters Rule, or IWR), in April 2001. The TMDLs developed in this report are for impaired waters that are on the 1998 303(d) list but not the verified list. They are being proposed 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).

FDEP developed a statewide, watershed-based approach to water resource management. Following this approach, water resources are managed on the basis of natural boundaries, such as river basins, rather than political boundaries. The watershed management approach is the framework DEP uses for implementing TMDLs. The state’s 52 basins are divided into 5 groups. Water quality is assessed in each group on a rotating five-year cycle. The Group 4 basin includes waters in the basins of the Withlacochee River, Pensacola Bay, Nassau-St. Marys, Kissimmee River, Fisheating Creek, and Southeast Coast/Biscayne Bay. Group 4 waters were first assessed in 2003 with plans to revisit water management issues in 2008. FDEP established five water management districts (WMD) responsible for managing ground and surface water supplies in the counties encompassing the districts. The Dade City Canal is located in the Southwest Florida Water Management District (SWFWMD).

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. These planning units contain smaller, hydrological based units called drainage basins, which are further divided into “water segments”. A water segment usually contains only one unique waterbody type (stream, lake, cannel, etc.) and is about 5 square miles. Unique numbers or waterbody identification (WBIDs) numbers are assigned to each water segment.

2. PROBLEM DEFINITION

Florida's final 1998 Section 303(d) list identified WBIDs in the South Withlacoochee River Basin as potentially not supporting water quality standards (WQS). This document addresses the nutrient, biochemical oxygen demand (B.O.D.) and dissolved oxygen (D.O.) listings for WBID 1399, Dade City Canal (Table 1). The geographic location of this WBID is shown in Figure 1.

Table 1. TMDLs Developed by EPA for Dade City Canal.

WBID	Name	Planning Unit	Parameter of Concern
1399	Dade City Canal	Upper Withlacoochee	D.O./BOD and Nutrients/Chlorophyll-a

The format of the remainder of this report is as follows: Chapter 3 is a general description of the impaired watershed; Chapter 4 describes the water quality standard and target criteria for the TMDL; and Chapter 5 describes the development of the TMDL, including the source assessment, data assessment, and analytical approach.

3. WATERSHED DESCRIPTION

Located in northern Pasco County near Dade City, Florida, WBID 1399 is within USGS Hydrologic Unit Code (HUC) 03100208 (Figure 1). Dade City Canal joins with Larkin Canal to flow north toward the Withlacoochee River. These man-made canals were dredged through historic swamplands, and remain hydrologically connected to the Withlacoochee River through wetlands and a small lake (FDER, 1992 and FDEP, 2005). Figure 2 and Figure 3 are images of a canal in WBID 1399.

The Dade City and Larkin canals are surrounded by wetlands. In fact, many waters in the Withlacoochee Basin experience periods of low dissolved oxygen (D.O.) during high flows due to the influence of drainage from nearby wetlands (FDEP, 2005). Much of the remaining area of WBID 1399 is used for silviculture and citrus groves. Agricultural uses comprise approximately 42% of the landuse, with residential uses making up about 15.5%. The local groundwater is known to be high in nitrate, which is assumed to have originated from past agricultural practices (FDEP, 2005). Forest and wetlands are approximately 16% and 14%, respectively, while commercial, industrial, and public lands comprise approximately 10% of the WBID. This land cover distribution is summarized in Table 2. Between May 1987 and January 1997, the Dade City Wastewater Treatment Plant discharged to Dade City Canal. Lykes Pasco, an industrial discharger that produces citrus beverages, maintains a current NPDES permit (FL0000485) to discharge to Larkin Canal. Additional details about these sources are discussed in Chapter 5.

Table 2. Land Cover Distribution (acres) in WBID 1399.

Units[1]	Residential	Com,Ind, Public[2]	Agriculture	Rangeland[3]	Forest	Water	Wetland	Barren & extractive	Transp & utilities	Total
acres	1447.1	941.6	3934.3	3.9	1473.3	102.3	1302.7	44.0	94.2	9343
%	15.5%	10.1%	42.1%	0.0%	15.8%	1.1%	13.9%	0.5%	1.0%	100%

Notes:

1. Acreage represents the land use distribution in the WBID and not the entire drainage area.
2. Com= commercial; Ind= industrial. Public lands include urban and recreational areas.

3. Rangeland includes shrubland, grassland, and herbaceous land covers.
4. Data were derived from IR DOQ photointerpretations of 1999 coverage using FLUCCS.

Dade City Canal
WBID 1399

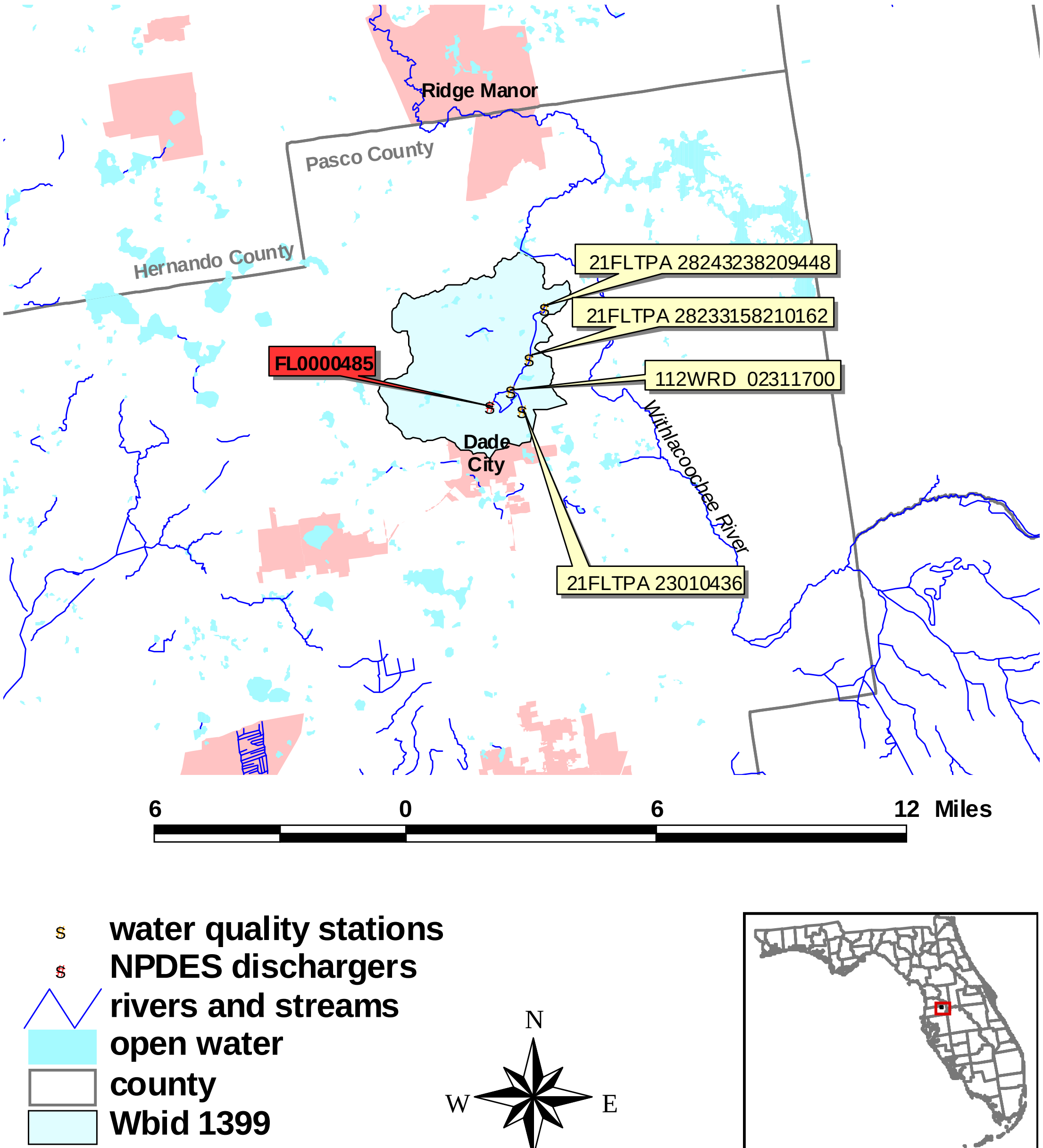

Figure 1. Location of Dade City Canal (WBID 1399).

Figure 2. WBID 1399 (Dade City Canal) near Dade City, Florida.

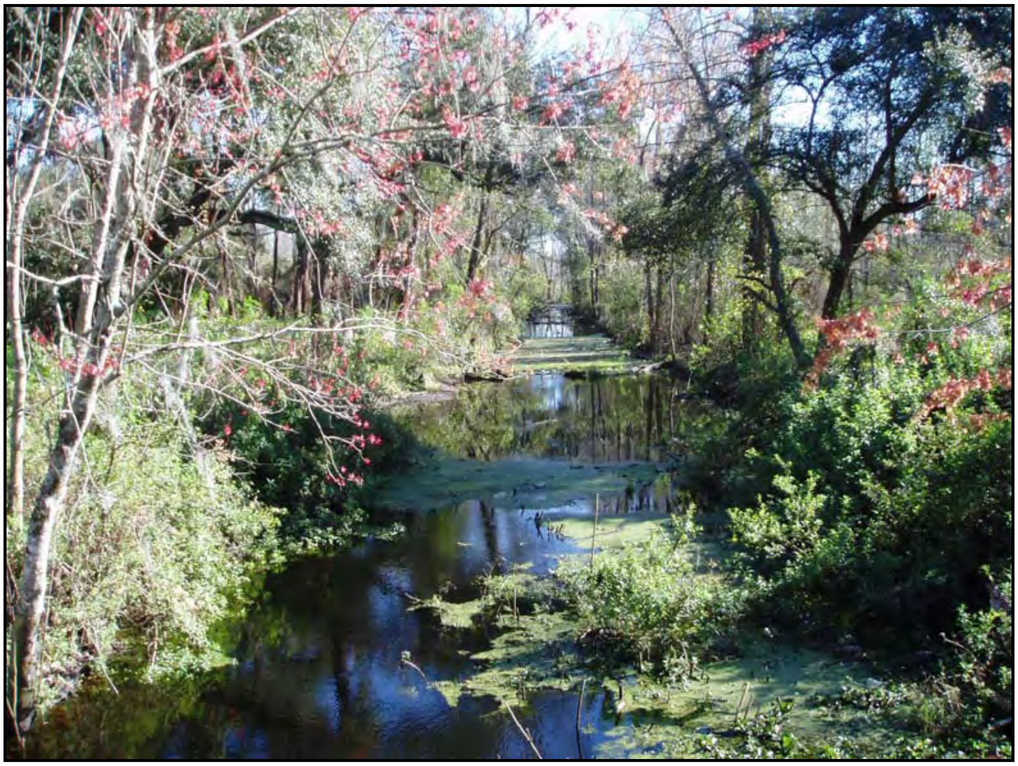

Figure 3. Algae visible in WBID 1399 (Dade City Canal).

4. WATER QUALITY STANDARDS AND TARGET IDENTIFICATION

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)

Waterbodies in WBID 1399 are classified as Class III freshwaters, with a designated use of recreation, propagation and maintenance of a healthy, well-balanced population of fish and wildlife. 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 criteria are specified in F.A.C. Section 62-302.530. In addition, unless otherwise stated, all criteria express the maximum not to be exceeded at any time. While the State of Florida does not have numeric criteria for nutrients, a narrative criterion exists as described below. The specific criteria that apply to WBID 1399 are:

4.1 Nutrients (Freshwater)

The discharge of nutrients shall continue to be limited as needed to prevent violations of other standards contained in this chapter [Section 62.302 F.A.C.]. In no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations of aquatic flora and fauna [Section 62.302.530 F.A.C.]

Because the State of Florida does not have numeric criteria for nutrients, chlorophyll and D.O. levels are used to indicate whether nutrients are present in excessive amounts.

4.2 Dissolved Oxygen

Freshwater: Dissolved Oxygen (D.O.) shall not be less than 5.0 (milligrams/liter). Normal daily and seasonal fluctuations above these levels shall be maintained.

4.3 Biochemical Oxygen Demand (Freshwater)

Biochemical Oxygen Demand (B.O.D.) shall not be increased to exceed values which would cause dissolved oxygen to be depressed below the limit established for each class and, in no case, shall it be great enough to produce nuisance conditions.

4.4 Natural Conditions

In addition to the standards for nutrients, D.O. and B.O.D. described above, Florida's standards include provisions that address waterbodies which do not meet the standards due to "natural background" conditions.

"'Natural Background' shall mean the condition of waters in the absence of man-induced alterations based on the best scientific information available to the Department. The establishment of natural background for an altered waterbody may be based upon a similar unaltered waterbody or on historical pre-alteration data." [Section 62-302.200(15) FAC].

Florida standards also state at 62-302.300(15) FAC that "Pollution which causes or contributes to new violations of water quality standards or to continuation of existing violations is harmful to the waters of this State and shall not be allowed. Waters having water quality below the criteria established for them shall be protected and enhanced. However, the Department shall not strive to abate natural conditions."

4.5 TMDL targets

The TMDL targets were determined by analyzing the effects of biochemical oxygen demand (BOD), total nitrogen (TN), and total phosphorus (TP) loads on dissolved oxygen (D.O.) concentrations in WBID 1399. A steady state WASP model was used to evaluate in-stream impacts of loads from both point and nonpoint sources. The target D.O. concentration is the State of Florida's water quality criteria for D.O., which requires that in no case should the concentration of dissolved oxygen be less than 5 mg/L in freshwater streams. Current point and nonpoint source loads of BOD, TN and TP were estimated, and these loads reduced until model simulations indicated the D.O. criterion was attained. The TMDL targets are the TN, TP, and BOD loads that achieve the D.O. standard of 5 mg/l.

5. NUTRIENT/D.O. TMDL

This section of the report describes the development of the nutrient, BOD, and D.O. TMDLs for Dade City Canal (WBID 1399). First, a discussion of potential sources is presented, followed by an assessment of the available water quality data.

5.1 Source Assessment

An important part of the TMDL analysis is the identification of source categories, source subcategories, or individual sources of pollutants in the watershed and the amount of loading contributed by each of these sources. Sources are broadly classified as either point or non-point sources. Nutrients enter surface waters from both point and 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. NPDES permitted facilities, including certain urban stormwater discharges such as municipal separate stormwater systems (MS4 areas), certain industrial facilities, and construction sites over one acre, are storm-water driven sources considered “point sources” in this report.

Non-point sources of pollution are diffuse sources that cannot be identified as entering a waterbody through a discrete conveyance at a single location. These include nutrient runoff of agricultural fields, golf courses, and lawns, septic tanks, and residential developments outside of MS4 areas. These sources generally, but not always, involve accumulation of nutrients on land surfaces and wash off as a result of storm events.

5.1.1 Point Sources

The only current NPDES discharger in WBID 1399 is Pasco Beverage (also known as Lykes Pasco Packing Inc.), a beverage processing facility that packages concentrated and not-from-concentrate fruit juices and beverages. Their discharge is generated primarily from cleaning of processing equipment (holding tanks, pasteurizers, etc). An on-site activated sludge wastewater treatment plant treats industrial wastewater and domestic waste (via an on-site package plant). Non-contact cooling water and stormwater are collected into a mixing pond before combining with the treated effluent from the wastewater treatment plant prior to discharge at the headwaters of Larkin Canal (FDEP, 2000).

Larkin Canal is a tributary that joins Dade City Canal near station 02311700 (see Figure 1). Pasco Beverage’s last permit application (from March 2004) states that the long-term average flow is 3.3 MGD (5.106 cfs), and the maximum daily flow is 8.8 MGD (13.6 cfs). However, these flow values appear to be for the outlet of the mixing pond, and so would account for the combined flows from stormwater, cooling water, and processed wastewater.

The current permit for Pasco Beverage includes limits for D.O. and BOD. D.O. must be maintained at a daily minimum of 6 mg/l, and BOD must be maintained at a monthly average of no more than 9.5 mg/l, and a maximum daily limit of 19.0 mg/l (Table 3). The permit also includes monitoring and reporting requirements for nutrients (total nitrogen, ammonia nitrogen and total phosphorus) and flow. Other permit limits include temperature, TSS, fecal coliform, pH, specific conductance, unionized ammonia, and total residual chlorine. A summary of the reported 30-day averages for discharge monitoring data is provided in Table 4.

Table 3. Current Discharge Limitations for FL0000485 (Lykes Pasco Beverage).

Discharge Limits[1]	Monthly Average	Daily Maximum	Daily Minimum
WATER TEMPERATURE (Fahrenheit)	report	90.0	-
DISSOLVED OXYGEN (mg/l)	report	-	6.0
BOD, 5-DAY (20 deg. C; mg/l)	9.5	19.0	-
PH (standard units)	-	8.5	6.0
TOTAL SUSPENDED SOLIDS (lbs/day)	735[2]	1470	-
NITROGEN, TOTAL (AS N; mg/l)	report	report	-
NITROGEN, AMMONIA TOTAL (AS N; mg/l)	-	report	-
AMMONIA, UNIONIZED (mg/l)	report	0.02	-
PHOSPHORUS, TOTAL (AS P; mg/l)	report	report	-
FLOW (MGD)	report	report	-

NOTES:

1. The table does not include the limits/monitoring requirements for Whole Effluent Toxicity, Fecal Coliforms, and Specific Conductance
2. Annual average.

The current permit for Pasco Beverage was issued in March 2004 and expires in March 2009. However, the facility recently applied for permit modification. According to Cindy Zhang-Torres, a permit supervisor in Industrial Wastewater Permitting for FDEP's Southwest District, Pasco Beverage has experienced some changes in recent years that have led to their processing at a much smaller scale. This is apparent from the flow data (Figure 4). Their intention is to start applying their industrial waste to a sprayfield in the near future. The outfall would then be used for non-process stormwater and non-contact cooling water, which may have to be permitted together (with a revised NPDES permit) because the flows are currently joined before the outfall.

Table 4. Summary of 30-day average discharge monitoring data for FL0000485.

Summary of 30-day averages	Time Period		count	min	max	average	stdev	median
	first date	last date						
Water Temperature (Fahrenheit)	1/31/2000	3/31/2006	75	63	80.8	73.0	4.6	72.9
Ultimate Oxygen Demand (lbs/day)	1/31/2000	4/30/2004	52	39.4	770.9	257.8	178.6	208.05
Dissolved Oxygen (mg/l)	1/31/2000	3/31/2006	75	5.4	8.2	7.2	0.7	7.4
BOD, 5-DAY (20 deg. C; mg/l)	1/31/2000	3/31/2006	75	0.52	22	4.3	3.3	3.5
PH (standard units)	1/31/2000	2/28/2006	74	7.1	8.5	7.9	0.2	7.9
Total Suspended Solids (lbs/day)	1/31/2000	3/31/2006	73	25.8	373.9	156.8	85.5	143.7
Nitrogen, Total (as N; mg/l)	1/31/2000	3/31/2006	74	0.30	3.48	1.71	0.64	1.67

	Time Period							
Nitrogen, Ammonia Total (as N; mg/l)	1/31/2000	3/31/2006	50	0.012	0.394	0.107	0.068	0.089
Ammonia, Unionized (mg/l)	1/31/2000	3/31/2006	73	0.000	0.400	0.010	0.046	0.004
Total Kjeldahl Nit. (as N)	1/31/2000	4/30/2004	48	0.02	2.10	0.75	0.50	0.73
Phosphorus, Total (as P; mg/l)	1/31/2000	3/31/2006	72	0.000	3.700	0.377	0.492	0.290
Flow (MGD)	1/31/2000	3/31/2006	75	0.07	4.30	2.44	1.04	2.60

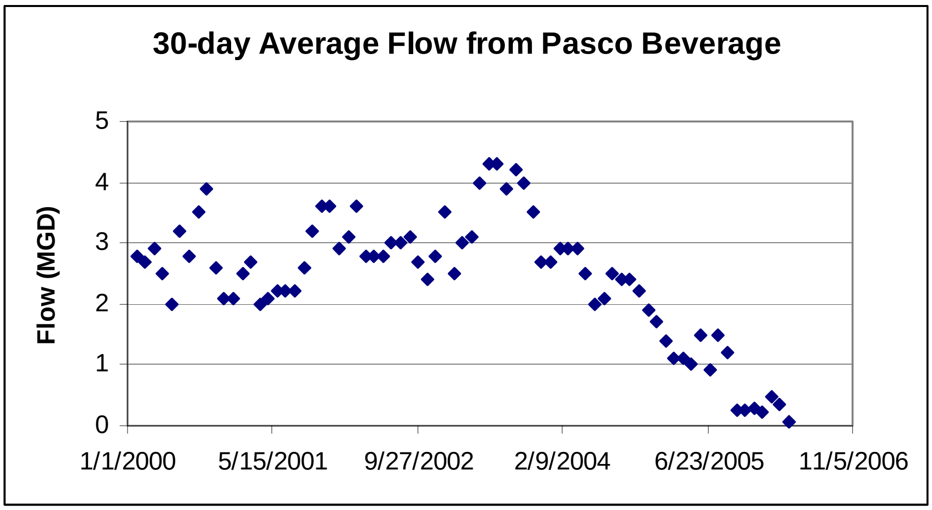

Figure 4. 30-day average flow from Pasco Beverage discharge monitoring data.

A wasteload allocation (WLA) is only given to NPDES facilities discharging to surface waters and to permitted Municipal Separate Storm Sewer Systems (MS4s). It should be noted that wastewater facilities permits authorize a discharge only if the applicant provides reasonable assurance that the discharge will not cause or contribute to violations of the water quality criteria.

Municipal Separate Storm Sewer Systems (MS4s) may also discharge nutrients to waterbodies in response to storm events. Large and medium MS4s serving populations greater than 100,000 people are required to obtain a NPDES storm water permit under the Phase I storm water regulations. After March 2003, small MS4s serving urbanized areas are 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. WBID 1399 may be affected by Phase I MS4 permit #FLS00032, which is held by the City of Dade City, Pasco County, and other co-permittees and located near the headwaters of Dade and Larkin Canals. Each permittee covered in the permit is ultimately responsible for the MS4 discharges resulting from their jurisdiction, including TMDLs and WLAs. Since no MS4 water quality data was available, the MS4 pollutant loads were not specifically analyzed. The MS4 loads were indirectly included in the TMDL analysis through the use of landuse GIS coverages, landuse loading rates for urban areas and the observed in-stream water quality data.

5.1.2 Non-point Sources

Nonpoint sources that ultimately contribute to depletion of in-stream dissolved oxygen include sources of nutrients such as animal waste, waste-lagoon sludge, fertilizer application to agricultural fields, lawns, and golf courses, and malfunctioning onsite sewage treatment and disposal systems or septic tank systems. Most non-point source pollutant loads were included in the TMDL analysis indirectly through the use of landuse GIS coverages, landuse loading rates, and the observed instream water quality data. Landcover acreages and percentages for WBID 1399 were provided in Table 2.

5.1.2.1 Wildlife

Wildlife deposit bacteria deposit their feces onto land surfaces where it can be transported during storm events to nearby streams. Generally, the nutrient load from wildlife is assumed to be background, as the contribution from this source is small relative to the load from urban and agricultural areas in most watersheds. In addition, any strategy employed to control this source would probably have a negligible impact on obtaining water quality standards.

5.1.2.2 Agricultural Uses

Agricultural activities, including runoff of fertilizers and animal wastes from pasture and cropland, can impact water quality. Agricultural runoff is presumed to be an important pollutant source in WBID 1399, since agricultural uses, including citrus groves and silviculture, comprise over 40% of the WBID. Farm data from the 2002 Census of Agriculture indicate that there were 168,716 acres of farmland in 1222 farms in Pasco County (NASS, 2002).

5.1.2.3 Onsite Sewerage Treatment and Disposal Systems (Septic Tanks)

Onsite sewage treatment and disposal systems (OSTDs) including septic tanks are commonly used where providing central sewer is not cost effective or practical. Most septic tanks are used for individual households of small commercial establishments that are in rural or remote areas, or in urban areas not served by a domestic wastewater facility. Water from septic tanks is generally released to the ground through a subsurface drain field after natural biological treatment. Most of the effluent is released to the subsurface through on-site subsurface drain fields or boreholes that allow the water from the tank to percolate into the ground (usually into the surficial aquifers) and either transpire to the atmosphere through surface vegetation or add to the flow of shallow ground water.

When properly sited, designed, constructed, maintained, and operated, OSTDs are a safe means of disposing of domestic waste. The effluent from a well-functioning OSTD is comparable to secondarily treated wastewater from a sewage treatment plant. When not functioning properly, OSTDs can be a source of nutrients (nitrogen and phosphorus), BOD, pathogens, and other pollutants to both ground and surface water.

The State of Florida Department of Health (DOH) publishes statistics regarding septic tanks on a county basis (see: http://www.doh.state.fl.us/environment/OSTDS/statistics/ostdsstatistics.htm). Table 5 summarizes the number of septic systems installed since the 1970 census and the total number of repair permits issued between 1997 and 2004. The data in Table 5 do not account for septic tanks removed from service.

Table 5. Estimates of Septic Tanks and Repair Permits for Pasco County (FDOH, 2005).

County	Number of Septic Tanks (2004)	Number of Repair Permits Issued (1997 – 2004)
Pasco	68,069	4,958

5.1.2.4 Urban and Commercial Development

Nutrient loading from urban and commercial areas is attributable to multiple sources including storm water runoff, leaks and overflows from sanitary sewer systems, illicit discharges of sanitary waste, runoff from improper disposal of waste materials, leaking septic systems, and domestic animals. Urban and commercial development is an important nonpoint source in WBID 1399 (Dade City Canal). Residential uses comprise about 15% of WBID 1399, while commercial, industrial, and public lands account for 10%. Currently, stormwater runoff from the Lykes Pasco facility contributes to the discharge outfall at Larkin Canal.

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.

5.2 Water Quality Data Assessment

5.2.1 Water Quality Data and Sampling Stations

Excessive nutrients in a waterbody can lead to overgrowth of algae and other aquatic plants such as phytoplankton, periphyton and macrophytes. This process can deplete oxygen in the water, adversely affecting aquatic life and potentially restricting recreational uses such as fishing and boating.

While the State of Florida does not have numeric criteria for nutrients, a narrative criterion exists as described in the Water Quality Standards section of this report. Chlorophyll and dissolved oxygen are used to indicate whether nutrients are present in excessive amounts. For Class III fresh waters, the dissolved oxygen should not be less than 5.0 mg/l.

Table 6 provides a list of the monitoring stations in WBID 1399. Each station is identified, and the time period of record for the individual stations is provided. Data collected at these monitoring stations during the Group 4 listing cycle (i.e. January 1998 through December 2004) or after are considered in the data assessment and TMDL analysis. However, when no recent data are available for a particular parameter, data collected prior to 1997 are considered. The original data are included in the Administrative Record for this report, and are also available upon request. Explanations of data remark codes are provided in Appendix A.

Table 6. Water Quality Stations in WBID 1399.

WBID	STATION	STATION NAME	DATES	
			FIRST	LAST
1399	21FLTPA 23010436	TP92-Dade City Canal	01/27/1998	06/28/2005
1399	112WRD 02311700	Dade City Canal Near Dade City	03/04/1998[1]	07/31/2003
1399	21FLTPA 28233158210162	TP255-Dade City Canal	03/15/2004	10/11/2004
1399	21FLTPA 28243238209448	TP256-Dade City Canal	03/15/2004	04/29/2005

Note:

The entire available record of flow data, which extends back to 02/05/1993, was used to construct a flow duration curve and determine a critical low flow condition for the canal.

Table 7 provides summary statistics for water quality data collected in WBID 1399 (Dade City Canal) between January 1998 up to the most recent data collected in June 2005.

Table 7. Water Quality Data for WBID 1399 (Dade City Canal).

Parameter	Obs	Min	Max	Mean	StDev	Median
BOD, carbonaceous 5-day (mg/l)	14	0.48	10	2.76	2.48	2
Chlorophyll A, corrected (μg/l)	12	1	76	19.7	24.9	12.5
Color (PCU)	13	50	152	100	36	100
Conductance (mohm)	51	106	820	429	169	453
Dissolved Oxygen (mg/l)	51	0.37	8.99	3.57	2.56	2.88
Flow (cfs)	37	0	50	10.0	10.2	7.3
Nitrogen Ammonia as N (mg/l)	12	0.01	0.47	0.21	0.18	0.16
Nitrate Nitrite (mg/l)	12	0.00	0.57	0.11	0.17	0.05
pH (su)	51	6.2	8.3	7.1	0.6	7.1
Diss. Orthophosphate as P (mg/l)	12	0.074	0.310	0.196	0.086	0.215
Water Temperature (Celsius)	51	14.4	31.2	23.5	4.0	23.9
Nitrogen Kjeldahl as N (mg/l)	12	0.88	2.30	1.60	0.40	1.65
Nitrogen, Total as N (mg/l)	12	0.90	2.30	1.71	0.38	1.77
Total Organic Carbon (mg/l)	12	8.7	26.0	15.7	5.6	15.5
Phosphorus Total as P (mg/l)	12	0.07	0.50	0.32	0.14	0.37
Total Suspended Solids (TSS;mg/l)	13	2	18	6	4	5
Turbidity (NTU)	14	1.2	6.7	3.2	1.7	3.2
Saturation D.O. (mg/l)	51	7.40	10.22	8.54	0.67	8.43
D.O. Saturation (%)	51	3.7	101.1	42.3	30.4	31.9
D.O. Deficit from Saturation (mg/l)	51	-0.09	9.64	4.98	2.75	6.15

NOTES:

1. Obs= number of observations; Max= maximum value; Min= mininum value; Mean= average value; StDev= standard deviation; Median= median value.
2. Some values contributing to these statistics are below the practical quantification or reporting limit; in those instances the value was left as the reported limit. Please see original data for associated remark codes.

5.2.2 Biology

A biological assessment of the Dade City WWTP, a former NPDES discharger in WBID 1399, was performed in June 1992 (FDER, 1992). The Dade City WWTP began operating in May 1987 and its permit (FL0020273) was inactivated in January 1997. The study noted very elevated concentrations of bioavailable nutrients and high algal growth potentials in the test site influenced by the discharge. Although chlorophyll concentrations remained relatively low at the test site, they were much higher than chlorophyll concentrations at the control site, and the assessment concluded that water quality in the canal was dominated by the WWTP discharge, creating a high potential for algal blooms further downstream. The Dade City WWTP will not be considered in the Waste Load Allocation (WLA), since they are not a current discharger. However, it is important to know that this discharge was present when interpreting historical water quality data. Most of the data considered in the TMDL assessment and analysis was collected after the WWTP ceased to discharge to the canal.

At least four bioassays of the Lykes Pasco discharge have been performed, most recently in July 2000 (e.g. FDEP, 2000). Bioassays are performed to determine whether a particular effluent is acutely toxic to organisms. The most recent bioassays found no toxicity in the effluent from Lykes Pasco, but the limited scope of these studies offer little insight into other, non-toxic effects of the discharge, such as its potential to cause algal blooms or suppress dissolved oxygen in the receiving water.

5.2.3 Nutrients and Chlorophyll

Chlorophyll is the green pigment in plants that allows them to create energy from light. In a water sample, chlorophyll is indicative of the presence of algae, and chlorophyll-*a* is simply a measure of the active portion of total chlorophyll. Corrected chlorophyll refers to chlorophyll-*a* measurements that are corrected for the presence of pheophytin, a natural degradation product of chlorophyll that can interfere with analysis because it has an absorption peak in the same spectral region. Corrected chlorophyll-*a* was measured in Dade City Canal in March and April 2004, July 2004, and October 2004. Station 23010436, located at the headwaters of the canal, was sampled again in June 2005. The corrected chlorophyll-*a* concentrations in these 12 samples have a fairly high range, from as low as 1 to as high as 76 μg/l (Table 7). The mean value is 19.7 μg/l (+- 24.9 μg/l) and the median is 12.5 μg/l. The two highest corrected chlorophyll-*a* measurements were both made in October 2004 at stations 28243238209448, and 28233158210162, which are located the furthest downstream. Corrected chlorophyll-a measured at station 23010436 on the same day in October 2004, was low (3.6 μg/l). Although the chlorophyll data are somewhat limited, having been collected mostly in one year (2004), they suggest that algal concentrations are low in late winter and early spring, but that they gradually increase over the spring and into summer, potentially blooming in the downstream half of the canal by fall (Figure 5).

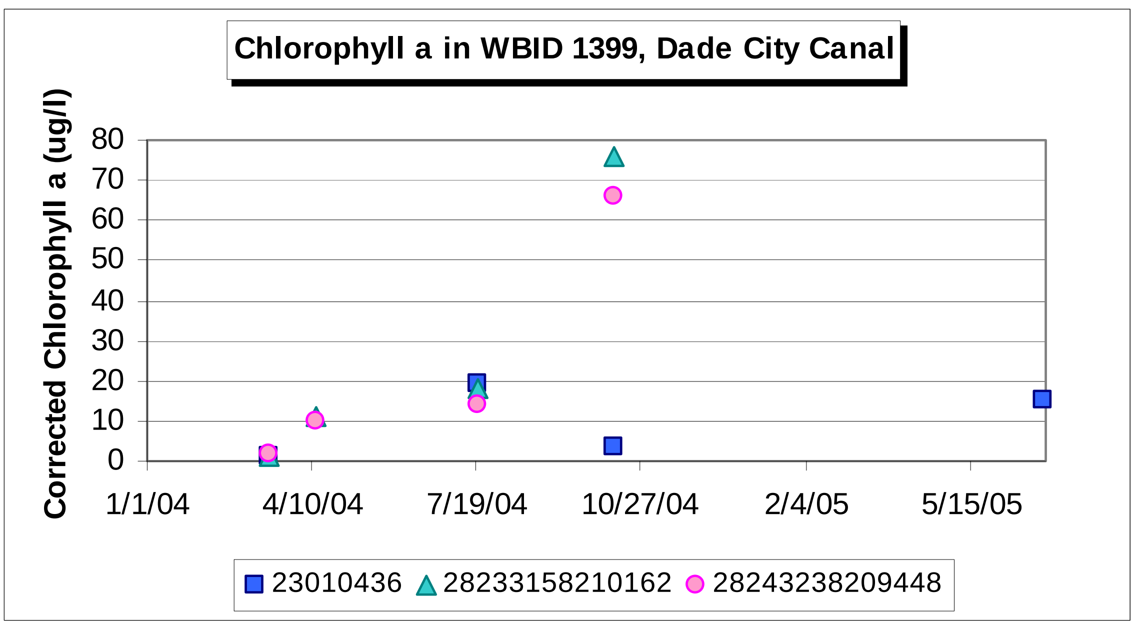

Figure 5. Corrected chlorophyll-*a* in WBID 1399 (Dade City Canal).

When analyzed by location, the downstream sampling stations 21FLPTA 28243238209448 and 21FLPTA 28233158210162 have negative correlations between corrected chlorophyll-*a* and dissolved oxygen (D.O.), meaning that higher algal concentrations are associated with lower dissolved oxygen at those sites (Figure 6). However, it is important to note that D.O. is below the Class III freshwater standard of 5 mg/l even when chlorophyll is low, and an increase of over 50μg/l corrected chlorophyll-*a* correlated to a decrease D.O. concentration of only about 1 mg/l. No relationship was observed at station 21FPTA 23010436, which is located near the headwaters of the canal.

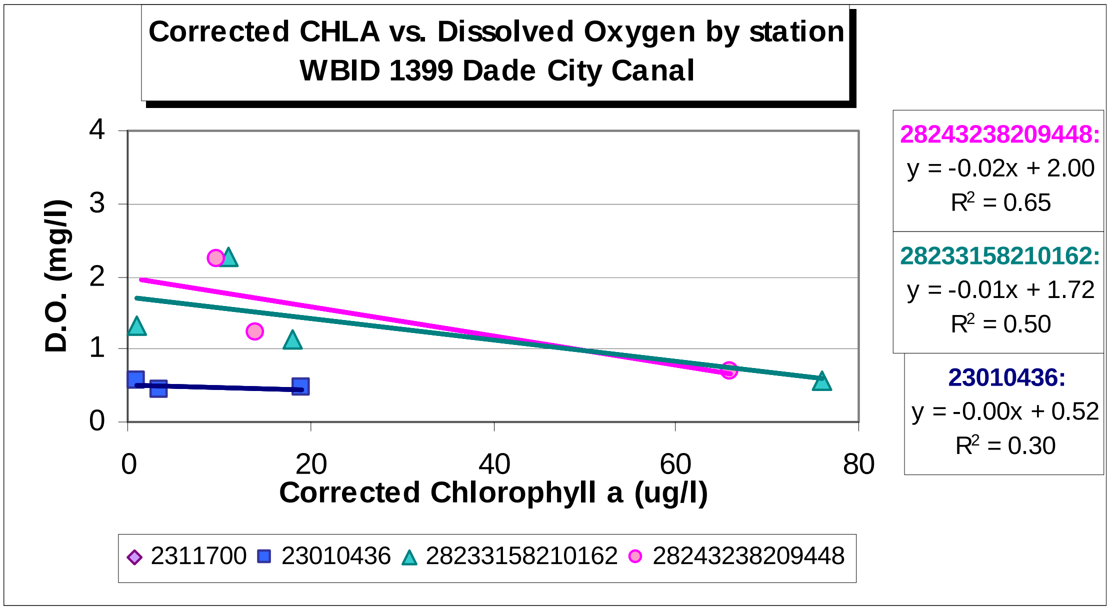

Figure 6. Relationship between D.O. and corrected chlorophyll in WBID 1399.

Although most of the corrected chlorophyll-a measurements are relatively low, both the average total nitrogen (TN) and total phosphorus (TP) exceed FDEP's screening thresholds for streams (1.6 mg/L TN and 0.22 mg/L TP). Total Nitrogen is comprised of nitrate (NO3), nitrite (NO2), organic nitrogen and ammonia nitrogen. TN measurements in Dade City Canal ranged from 0.9 mg/l to 2.3 mg/l, and had an average of 1.71 mg/l, with a median of 1.77 mg/l (Table 7). Most of the TN appears to consist of Total Kjeldahl Nitrogen (TKN), which is the sum of organic nitrogen and ammonia. High concentrations of TKN typically result from the decay of organic matter, such as plant and animal wastes. These organic materials may be natural, or they may result from urban or industrial sources. Fertilizer runoff is another potential source. Nitrification of ammonia to nitrite and then nitrate can use up dissolved oxygen from the water.

Phosphorus is usually the growth-limiting nutrient in freshwaters. Total phosphorus measurements in Dade City Canal ranged from 0.07 mg/l to 0.5 mg/l, and had an average of 0.32 mg/l, with a median of 0.37 mg/l (Table 7). The average TP concentration puts Dade City Canal around the 75th percentile for all streams in Florida. In natural waters, total phosphorus (TP) exists in either in soluble or particulate forms. Dissolved phosphorus includes inorganic and organic forms, while particulate phosphorus is made up of living and dead plankton, and adsorbed, amorphous, and precipitated forms. Inorganic forms of phosphorus include orthophosphate and polyphosphates, though polyphosphates are unstable and convert to orthophosphate over time. Orthophosphate is both stable and reactive, making it the form most used by plants. High levels of TP may result from wastewater and septic system effluent, agriculture (including fertilizers and animal waste), soil erosion, phosphate mining, or industrial sources. Excessive phosphorus can lead to overgrowth of algae and aquatic plants, the decomposition of which uses up oxygen from the water. In turn, low oxygen levels near bottom sediments can free additional phosphorus from the sediments.

The ratio of TN/TP in Dade City Canal ranges between 3.2 to 14.6, with a mean of 6.9 (+- 3.9) and a median of 5.3. A ratio less than 7.2 generally indicates nitrogen limitation, whereas a high ratio indicates that phosphorus is the limiting nutrient. These TN/TP ratios indicate that nitrogen is typically the limiting nutrient, but that Dade City Canal may occasionally be co-limited by both nitrogen and phosphorus.

Although nutrient levels may directly and indirectly affect dissolved oxygen concentrations, neither total nitrogen, total phosphorus, nor any of their constituents show significant correlations with dissolved oxygen levels in Dade City Canal.

5.2.4 Dissolved Oxygen and Biochemical Oxygen Demand

There are several factors that affect the concentration of dissolved oxygen (D.O.) in a waterbody. Oxygen can be introduced by wind, diffusion, photosynthesis, and additions of higher D.O. water (e.g. from tributaries). Dissolved oxygen concentrations are lowered by processes that use up oxygen from the water, such as respiration and decomposition, and by additions of water with lower D.O. (e.g. swamp or groundwater). Natural dissolved oxygen levels are a function of water temperature, water depth and velocity, and relative contributions of groundwater. Warm water holds less oxygen than cool water, and slower-flowing, less turbulent water has less diffusion of atmospheric oxygen into it. Because it is not in contact with air, groundwater naturally has lower concentrations of oxygen dissolved in it. Decomposition of organic matter, such as dead plants and animals, also uses up dissolved oxygen. Biochemical oxygen demand (BOD) is a measure of the amount of oxygen used by bacteria as they stabilize organic matter.

D.O. levels naturally fluctuate over the course of a day. Respiration and decomposition may consume oxygen dissolved in the water. During daylight, submerged aquatic plants take up carbon dioxide and produce oxygen as by-products of photosynthesis. At night, photosynthesis does not occur and so the oxygen-consuming processes dominate. The available data indicate that the D.O. concentrations in Dade City Canal are frequently below the Class III Freshwater Water Quality Criterion of 5.0 mg/L (Figure 7). Dissolved oxygen values measured between January 1998 and June 2005 range from 0.37 to 8.99 mg/l, with an average of 3.6 mg/l and a median of 2.9 mg/l.

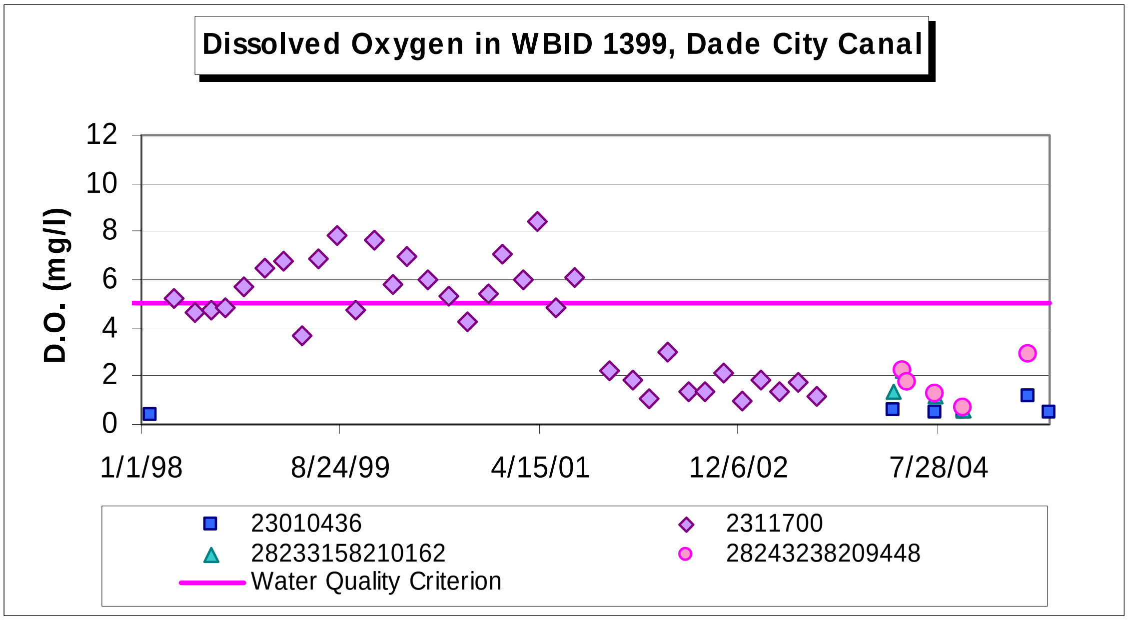

Figure 7. Dissolved Oxygen measurements in WBID 1399 Dade City Canal.

In order to understand the likely cause of low dissolved oxygen in Dade City Canal, the influence of respiration (as indicated by chlorophyll and pH), temperature, flow, nutrients, and degradation of organic matter (as indicated by biochemical oxygen demand and total organic carbon) was considered.

Since there is a longer period of record for pH in Dade City Canal, and more paired measurements of pH and D.O. than of chlorophyll-*a* and D.O., the relationship between pH and dissolved oxygen was also examined. Photosynthesis by algae and other submerged plants is usually associated with an increase in both D.O. and pH, as the plants take up carbon dioxide and release oxygen into the water. Respiration is associated with lower D.O. concentrations and lower pH, as plants use up oxygen and release carbon dioxide back into the water. Carbon dioxide (CO_2) dissociates in water to create carbonic acid, so increasing its concentration tends to make the water more acidic (i.e. have lower pH), while decreasing CO_2 tends to make the water more alkaline (i.e. have a higher pH). In the Dade City Canal, pH is consistently between 6.2 to 8.3 standard units, within the 6.0-8.5 s.u. range of pH allowed for Class III waters. With the exception of the most upstream station (21FLPTA 23010436), all other sampling locations appear to show correlations between D.O. and pH (Figure 8). These results are consistent with the chlorophyll-a data, which showed stronger correlations between chlorophyll and D.O. at the two downstream sampling stations. An increase in pH of 1 standard unit is associated with an increase in D.O. of 2.7 mg/l or more of D.O. at three of the four sites.

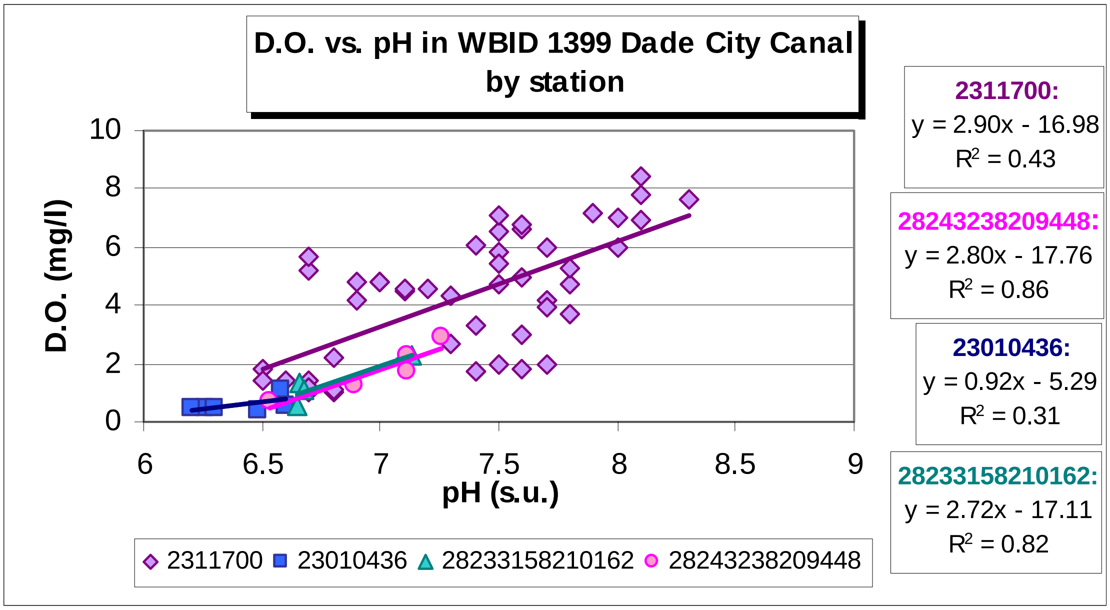

Figure 8. Relationship between D.O. and pH for stations in WBID 1399 Dade City Canal.

Biochemical oxygen demand is a measure of the amount of oxygen consumed by organisms in breaking down organic material. It is difficult to draw firm conclusions about the relationship between biochemical oxygen demand (BOD) and D.O. in Dade City Canal. The BOD dataset consists of only 14 samples collected at three stations and includes some values below the Method Detection Limit. While the overall relationship between BOD and D.O. is negative, so that increasing biochemical oxygen demand is associated with lower D.O., the correlation is weak due to spatial and temporal variability in the limited dataset. The majority of the samples were collected in 2004, with the exception of one sample collected in 1998, and another in 2005. Slightly more than half of the measurements for BOD are below 2 mg/l, but a few of the values are high enough to contribute to suppression of D.O. levels (Figure 9). BOD ranges from 0.48 mg/l (below the Method Detection Limit) to 10 mg/l, with an average of 2.8 mg/l, and a median of 2 mg/l (Table 7). The maximum BOD concentration of 10 mg/l was measured in January 1998 at station 21FLPTA 23010436, located near the headwaters.

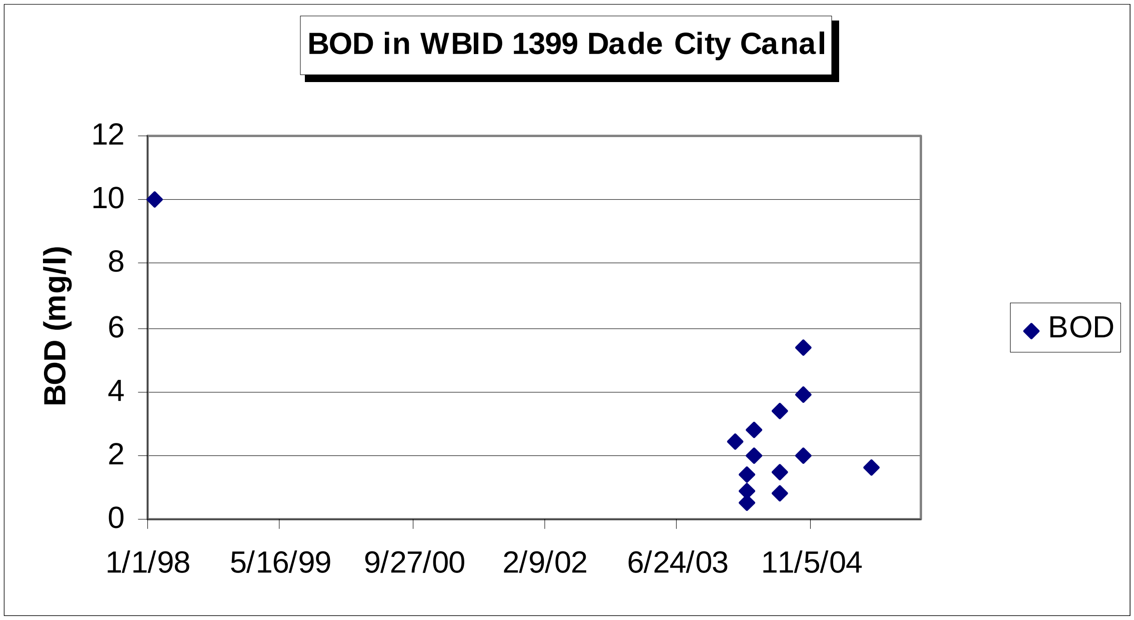

Figure 9. Biochemical Oxygen Demand in WBID 1399 Dade City Canal.

Total Organic Carbon (TOC) is a measure of the organic content of the water. TOC is important because higher carbon/organic contents generally mean that more oxygen will be consumed when this matter is decomposed by microorganisms. Natural vegetation is a source of such organic material, although TOC may also be contributed by wastewater treatment plant discharges, carbon-containing industrial effluents, and agriculture. Total organic carbon (TOC) in Dade City Canal shows some correlation with dissolved oxygen at the two most downstream sampling stations (Figure 10). Data from station 23010436 was not included, because no correlation was observed there. (TOC data are not available for station 02311700.) In the lower portion of Dade City Canal, an increase in organic matter (as indicated by TOC) is associated with a decrease in dissolved oxygen.

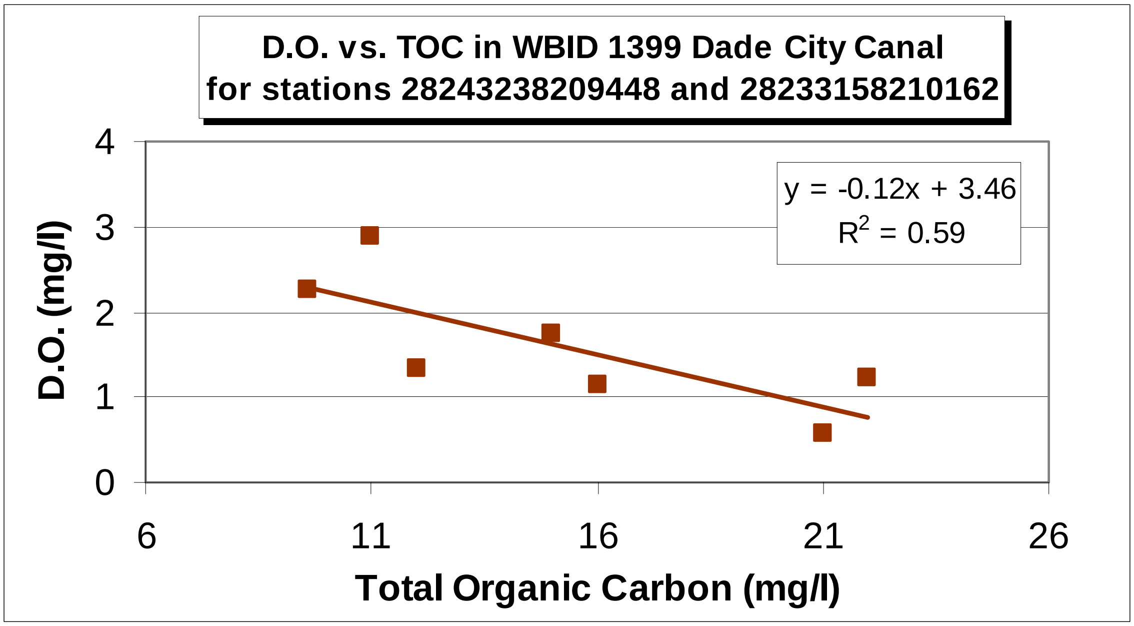

Figure 10. Correlation between Total Organic Carbon and Dissolved Oxygen.

Water temperature in the Dade City Canal averages about 23.5 degrees Celsius, and shows characteristic seasonal variability, with the highest temperatures typically measured in July and the lowest in temperatures in December or January (Figure 11).

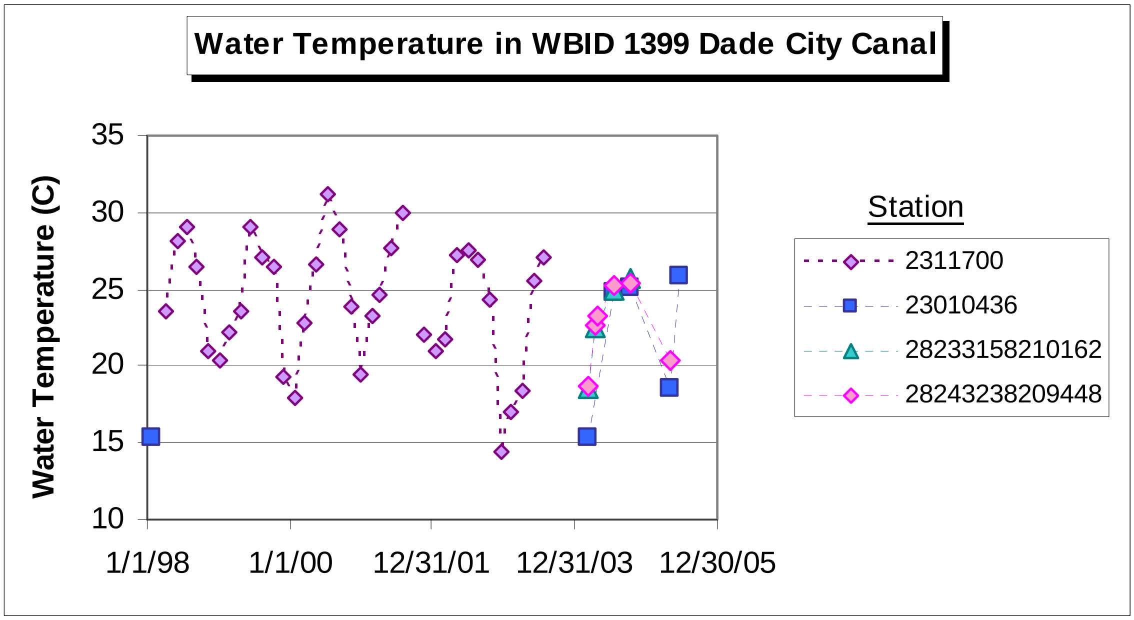

Figure 11. Water temperature in WBID 1399 Dade City Canal.

Water temperature frequently has an influence on D.O. concentrations, since hotter water is not capable of holding as much dissolved oxygen as cooler water. However, in Dade City Canal, the correlations between D.O. and temperature are weak, with the possible exception of the most downstream station (21FLPTA 28243238209448), where increasing temperature correlates with lower D.O. concentrations. A plot of observed D.O. versus saturation D.O. (i.e. the maximum D.O. concentration that would be expected at the measured water temperature) shows that saturated D.O. is calculated to be consistently above about 7.5 mg/l, whereas instream D.O. was measured anywhere between 0-8 mg/l (Figure 12). Note that one datapoint, collected in March 2004, was excluded from the series for station 21FLPTA 28243238209448 because it appears to be an outlier for the station and the season.

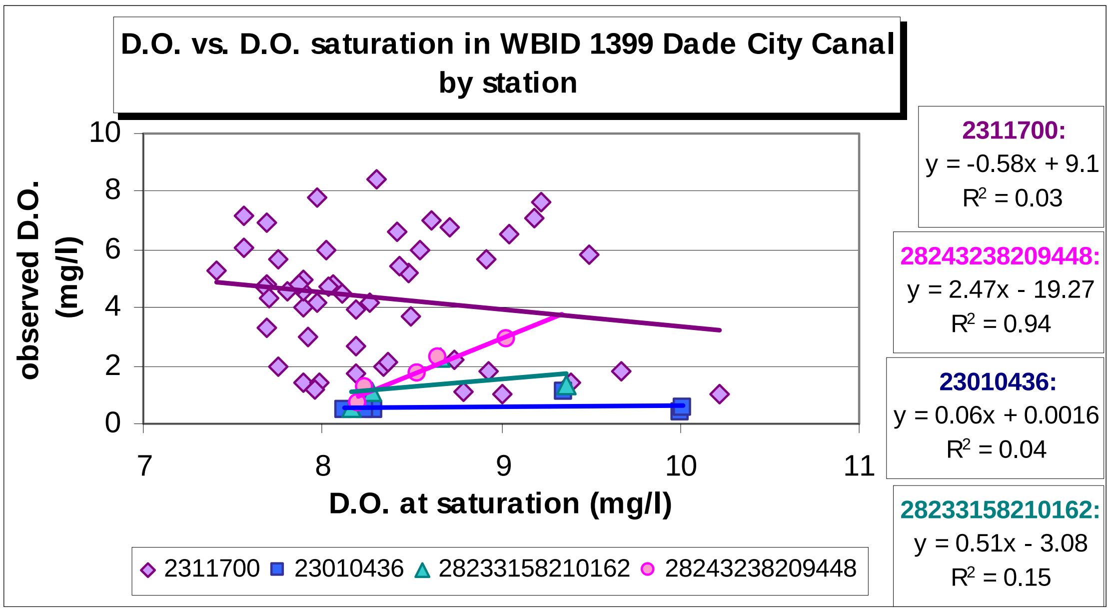

Figure 12. Measured vs. saturated D.O. by station in WBID 1399.

Though measured D.O. did not correlate well with saturated D.O. at three out of the four stations, all stations show potential for large deficits (i.e. the difference between saturated and observed values). Some D.O. deficits are low, and one measurement was even negative (meaning that D.O. was greater than saturation). Up until late 2001, most of the D.O. deficits were between 2 to 6 mg/l below saturation. However, even though saturation D.O. remained about the same, the D.O. deficits went up to greater than 6 mg/l after 2001 (Figure 13).

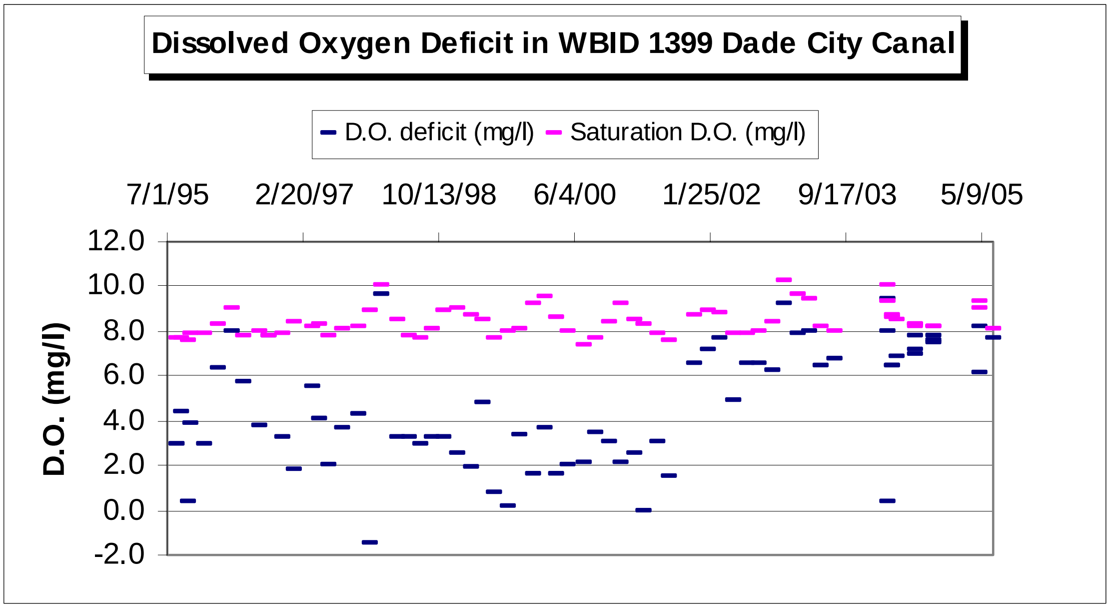

Figure 13. Saturation D.O. and D.O. deficit in Dade City Canal (all data).

Flow conditions are also known to influence D.O. concentrations. Typically, higher flows are associated with higher D.O., since the increased flow leads to greater turbulence and aeration. However, this may not be the case in Dade City Canal, which is influenced by a discharge, and which is surrounded by swampy areas that can introduce lower D.O. water during periods of higher flow. Flow measurements have only been taken at station 112WRD 02311700, located at the confluence of Larkin Canal with Dade City Canal. Flows in Dade City Canal seem to have decreased significantly from the maximum recorded in the spring of 1998, and been consistently lower since June 1998 until the increase measured in July 2003 (Figure 14). There appears to be no consistent relationship between D.O. and flow at this site (Figure 15). The last permit application for the discharger states that the long-term average flow is 3.3 MGD (5.106 cfs), and the maximum daily is 8.8 MGD (13.6 cfs) (these flow values include the discharge and stormwater). Recent discharges have been less than 1 MGD (1.547 cfs).

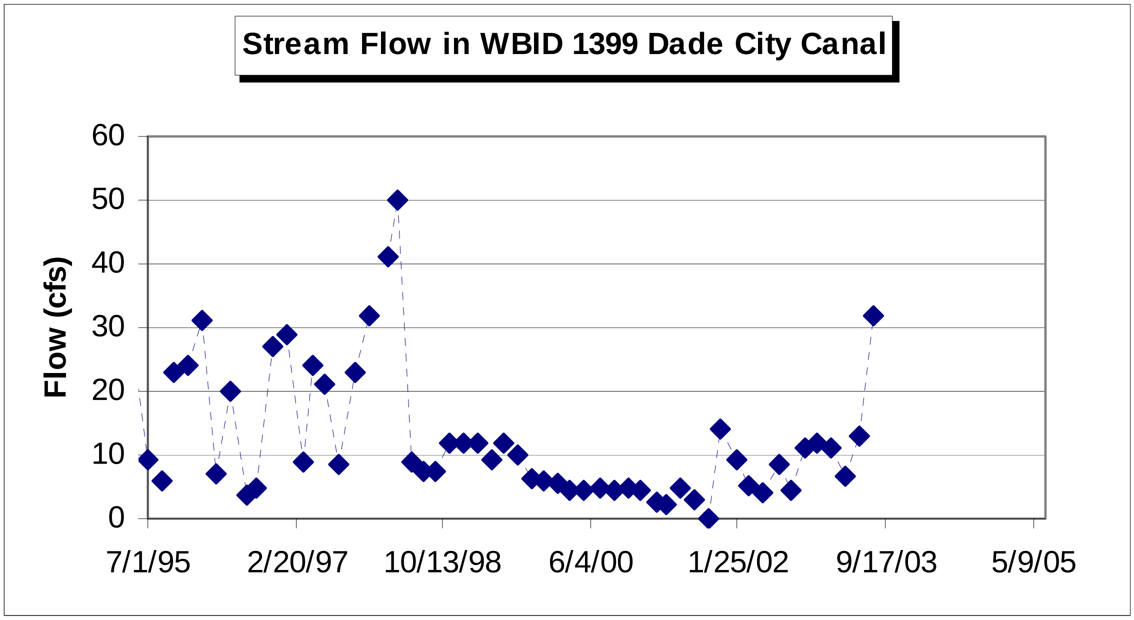

Figure 14. Flow in WBID 1399 Dade City Canal (station 112WRD 02311700).

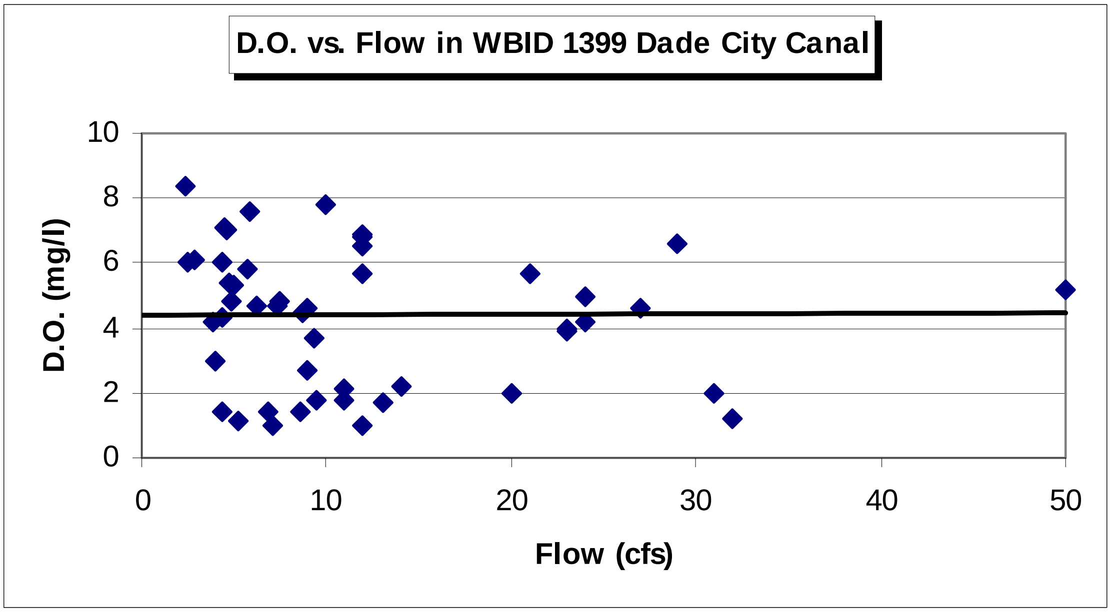

Figure 15. Dissolved oxygen plotted against flow at station 112WRD 02311700.

5.2.5 Summary of Data Assessments

The average concentrations of total nitrogen and total phosphorus from all stations in WBID 1399 are above the 70th percentile of streams in Florida. D.O. concentrations have frequently been below the Class III freshwater criterion of 5 mg/l, and have consistently been below the criterion since late 2001.

The data do not indicate significant algal blooms at the most upstream sampling station, 21FLPTA 23010436, which should not be affected by the discharge from Pasco Beverage. Corrected CHLA has not been above 20 μg/l there, and D.O. is not strongly correlated with pH, chlorophyll-a, or temperature (flow data were not available). However, all of the D.O. concentrations measured at that station have been very low (0.37 mg/l – 1.14 mg/l).

A couple of elevated (corrected) chlorophyll-a measurements, and correlations between D.O. and corrected chlorophyll-*a* and between D.O. and pH suggest that there may be algal blooms in the downstream half of the canal. Based on this information, and the presence of potential point and nonpoint sources of relevant pollutants, TMDLs for BOD and nutrients are being proposed to protect dissolved oxygen concentrations in WBID 1399.

It should be noted that algal blooms are not likely to be the only cause of low D.O., since D.O. is low even when corrected chlorophyll-*a* is low. Drainage from swamps that border the canal for much of its length could be suppressing D.O. naturally. The data, along with the modeling analysis, suggest that WBID 1399 would not be able to sustain a daily average D.O. of 5.0 mg/l at all times, even with little impact from industry and urbanization. For this reason, it is recommended that a site-specific criterion D.O. be developed for the waters WBID 1399. Until a more appropriate criterion is developed the 5.0 mg/l D.O. standard will be targeted for the TMDL analysis.

5.3 Analytical Approach for TMDLs

Dade City Canal (WBID 1399) was listed for impairment due to low dissolved oxygen. Since dissolved oxygen is not a pollutant, the TMDLs need to allocate limitations for pollutants that cause low dissolved oxygen. The causative pollutants targeted for these TMDLs are biochemical oxygen demand (BOD) and the nutrients total nitrogen (TN) and total phosphorus (TP). BOD is a measure of the amount of oxygen used by bacteria as they stabilize organic matter. Carbonaceous Biochemical Oxygen Demand (CBOD) is the carbonaceous portion of that demand that occurs in the first stage of decomposition as organic matter is converted to carbon dioxide.

TMDLs for nutrients, BOD, and low D.O. were determined by analyzing the effects of BOD, total nitrogen (TN), and total phosphorus (TP) loads on dissolved oxygen concentrations in WBID 1399. The U.S. EPA Water Quality Analysis Simulation Program version 7 (WASP7.1) was applied as the instream water quality model (Wool et. al., 2001). The eutrophication component of WASP was used to simulate complex nutrient transport and cycling in the streams, as well as to model any dissolved oxygen sag resulting from a point source discharge. The purpose of the modeling exercise was to determine what reductions in BOD and nutrient loads would have to occur in order to protect the designated use and achieve water quality standards in Dade City Canal. Current point and nonpoint source loads of BOD, TN and TP were estimated, and these loads reduced until model simulations indicated the D.O. criterion of 5 mg/l was attained.

Simple Method for Nonpoint Source Loads

Average annual non-point source loads of BOD and nutrients were estimated using a spreadsheet based on EPA's Simple Method formula from the BASINS PLOAD model (EPA, 2001):

$$LP = \Sigma u\ (P * PJ * RVu * Cu * Au * 2.72 / 12)$$

Where: LP = Pollutant load, lbs

P = Precipitation, inches/year
PJ = Ratio of storms producing runoff (default = 0.9)
RVu= Runoff Coefficient for land use type u, inches of runoff/inches of rain
RVu=0.05 + (0.009 * Iu); Iu = percent imperviousness
Cu = Event Mean Concentration for land use type u, milligrams/liter
Au = Area of land use type u, acres

This method calculates nonpoint source loadings for nutrients and BOD as the product of the water quality concentration and runoff water volume associated with certain land use practices. An annual average rainfall of 55 inches was determined for WBID 1399, using a nearby meterological station in Brooksville, Florida. The station is maintained as part of the Florida Automated Weather Network (FAWN). The default ratio of 0.9 for storms producing runoff was used. Landuse data entered into the spreadsheet were based on the SWFWMD 1999 land use/cover features categorized according to the Florida Land Use and Cover Classification System (FLUCCS; see Table 8). The features were photointerpreted from 1:12,000 UGSG color infrared (CIR) digital orthophoto quarter quadrangles (DOQQs). Event Mean Concentrations (EMCs) for each landuse type in Florida were compiled by Harper and Baker (2003), and are provided in Table 9.

Table 8. Landcover data (square meters) by FLUCCS code for WBID 1399.

FLUCCS CODE	WBID 1399 Landcover Data (m^2)
1000	3,974,017
1100	1,926,305
1200	3,763,580
1300	295,421
2000	15,843,457
3000	16,187
4000	5,912,462
5000	404,686
6000	5,277,105
7000	0
8000	380,405

Table 9. EMCs from Evaluation of Alternative Stormwater Regulations for Southwest Florida.

FLUCCS ID	Land Use	BOD (mg/l)	Total N (mg/l)	Total P (mg/l)
4000	Forest/rural open	1.23	1.09	0.046
1000 – (1100+1200+1300)	Urban open	7.4	1.12	0.18
2000	Agriculture	3.8	2.32	0.344
1100	Low-density residential	4.3	1.64	0.191
1200	Medium-density residential	7.4	2.18	0.335
1300	High-density residential	11.0	2.42	0.49
8000	Communication and transportation	6.7	2.23	0.27
3000 + 7000	Rangeland	3.8	2.32	0.344

5000	Water	1.6	1.60	0.067
6000	Wetlands	2.63	1.01	0.09

Average annual nonpoint source loads of TN, TP, and BOD generated from the PLOAD spreadsheet (in lbs/year) were converted to units of kg/day. Then total nitrogen was partitioned into ammonia, nitrate, and organic nitrogen, and total phosphorus was partitioned into orthophosphate and organic phosphorus. The percent assigned to each constituent was determined from its average ratio to TN or TP from all of the available ambient water quality data for the WBID. TN was partitioned as: 6.6% nitrate-nitrite, 12.4% ammonia-nitrogen, and 81.1% organic nitrogen. TP was partitioned as: 61% orthophosphorus and 39% organic phosphorus. BOD5 is a standard way to express biochemical oxygen demand. BOD5 loads, which characterize the oxygen used up by decomposition after 5-days at 20 degrees Celsius, were converted to CBODu using an F-ratio of 3.0. CBODu is the ultimate carbonaceous demand representing complete biochemical oxidation of organic matter. Table 10 contains the average annual nonpoint source loads in units of kg/day that were entered into the WASP model.

Table 10. Average Annual Nonpoint Source Loads estimated for WBID 1399.

Parameter	NPS Load (kg/day)
Ammonia	1.44
Nitrate	0.77
Organic N	9.45
Orthophosphate	0.954
Organic P	0.606
CBODu	81.60

WASP Model

A steady state Water Quality Analysis Simulation Program (WASP) model was set up to simulate the combined effects of total point and non-point source pollutant loads on the dissolved oxygen concentration in the canals of WBID 1399 during critical low flow, high temperature conditions. WASP can aid in interpretation and prediction of water quality responses to natural phenomena and man-made pollution for various pollution management decisions. The eutrophication module of WASP was applied in the development of these TMDLs.

Four segments were created to represent WBID 1399, as described in Table 11 and depicted in Figure 16 (see also Figure 1).

Table 11. Segment parameters for WBID 1399 WASP model.

Segment	Description	Length (m)	Width (m)	Surface Area (m^2)	Depth (m)	X-Sectional area (m^2)	Volume (m^3)
1	Headwaters between station 23010436 to merge at station 02311700	917.3	7	6421	0.5	3.5	3211
2	FL000485 (Pasco) to merge at station 02311700	804.7	7	5633	0.5	3.5	2816
3	Merge at station 02311700 to	1448.4	7	10139	0.5	3.5	5069

	station 28233158210162						
4	Station 28233158210162 to station 28243238209448	2414.0	7	16898	0.5	3.5	8449

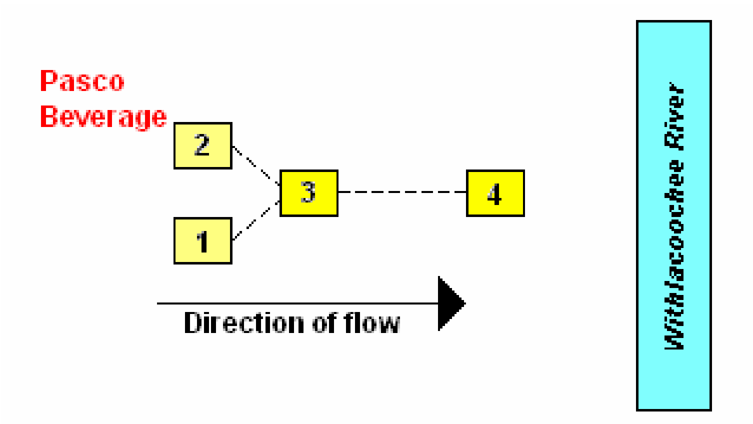

Figure 16. Schematic of Dade City Canal Segments in WASP Model.

In this TMDL analysis, the WASP model was parameterized, and existing pollutant loads simulated so that segments 3 and 4 had low D.O. as reflected in the available water quality data. The nonpoint source watershed loads determined from the PLOAD spreadsheet were entered (in kg/day) directly into segment 3. (Segment 1 is estimated to drain only ~6% of the watershed.) Then the point and non-point source loads were reduced equally until the water quality standard of 5 mg/l D.O. was met in segments 3 and 4. Segments 1 and 2 were not targeted because both are short sections that are dominated by whatever boundary conditions are assigned to them in the steady-state model. Also, for the TMDL scenario, the upper boundary condition for dissolved oxygen at segment 1 was set to 5 mg/l. Given the prevalence of swamp drainage in the basin, it is probably not realistic to assume that the water entering the headwaters of Dade City Canal could meet the D.O. criterion of 5 mg/l, but this was done in order to evaluate oxygen-consuming reactions within the canal resulting from pollutant loads in the watershed. With the boundary condition set to the “existing” D.O. concentration of 0.45 mg/l, segments 3 & 4 could not recover to 5 mg/l dissolved oxygen concentration even with no point or nonpoint source loads in the watershed. As discussed in the data assessment section above, all of the D.O. concentrations measured at the most upstream sampling station (21FLPTA 23010436), which defines the boundary of segment 1, have been very low (0.37 mg/l – 1.14 mg/l). Despite this, there is no indication of algal blooms at that station. Corrected CHLA measurements have been low, and D.O. is not strongly correlated with pH, chlorophyll-a, or temperature.

A depth and width estimate for the canal was taken from the 1992 Bioassessment report for the Dade City WWTP, which no longer discharges to the canal (FDER, 1992). Segment lengths were measured from National Hydrography Data in GIS. Cross-sectional areas were calculated by assuming that each segment of the canal has a rectangular shape and multiplying the depth by the width. The segments were assigned low slopes (0.0001), and a constant water temperature of 31°C. That water temperature was selected to create critical conditions because it is the maximum temperature recorded in the available data. The model was set to calculate reaeration using the Tsvigolou formula with an escape coefficient of 0.11, since the Tsvigolou approach is preferred for shallow stream reaches (<2ft). The model is able to equilibrate quickly, so initial concentrations for the modeled parameters were left at zero.

The time period on which the steady state simulation was based is the month of October 2004. This month (Oct 1, 2004 - Nov 1, 2004) was considered to represent a critical condition because the available water quality data show that chlorophyll-a concentrations were elevated, BOD was high, and D.O. concentrations were low at that time. A time series of hourly solar radiation data for October 2004 was obtained from the Florida Automated Weather Network (FAWN) Brooksville station for use in the model.

The modeled critical conditions include upstream low flow of about 0.06796 cubic meters per second, (2.4 cfs), with the point source continuous discharge of 0.096 cms, (2.2 mgd). Flow was not measured in October 2004, so the steady flow for the canal is based on the lowest flow measured (other than zero). The steady flow used to represent Pasco Beverage is the 30-day average discharge from October 2004.

The water quality concentrations associated with upstream flows were set to observed values measured at water quality station 23010436 in October 2004 (Table 12). The one exception is the TP concentration reported for October 2004. This value was not used because it was low, and its corresponding concentration of orthophosphorus (Ortho-P) was higher. Because Ortho-P is a constituent of total phosphorus, TP cannot be lower than Ortho-P for a given sample. Even if all of the phosphorus in a sample exists as Ortho-P, at most the two can have equal concentration. Since the reported Ortho-P concentration was approximately the same as that measured at the other two sampling stations on the same day, it was assumed that the TP should also have been approximately the same concentration as the other two stations. The average TP from the other two sampling stations was used to represent the boundary, and the organic phosphorus was calculated as the difference between TP and Ortho-P. BOD5 was converted to CBODu using an F-ratio of 3.0.
To define boundary conditions for segment 2, which receives the discharge from Pasco Beverage, Discharge Monitoring data reported by Pasco Beverage for October 2004 were used (Table 12). The maximum 30-day average concentrations were evaluated because the facility does not have permit limits for TN or TP. The daily maximum concentration was used for ammonia, because a 30-day average was not reported. TP was partitioned using the same ratios as the instream data from October 2004. Unfortunately, Total Kjeldahl Nitrogen (TKN) was not reported (and has not been reported since April 2004), so TN was partitioned by first subtracting the ammonia (NH4) from TN, leaving just the organic + nitrate-nitrite fractions. Because no nitrate was measured at the two in-stream stations downstream of the discharge in October 2004, nitrate was set to 0 mg/l, and the remainder of TN was assigned to organic nitrogen. The continuous permit limits for the FL000485 were provided in Table 3, and the reported actual discharge loads (for 2000-2006) were summarized in Table 4.

Table 12. Values used as boundary conditions.

Boundary Parameter	23010436	FL0000485
Ammonia (mg/l)	0.04	0.032
Nitrate (mg/l)	0.02	0
Organic N (mg/l)	0.84	1.368
Orthophosphate (mg/l)	0.18	0.159
Organic P (mg/l)	0.165	0.141
Chlorophyll-a (ug/l)	3.6	0

Dissolved Oxygen (mg/l)	0.45	6.9
CBOD ultimate (mg/l)	6	8.1

Determination of Watershed Load Reductions

The WASP model for Dade City Canal was set up as a steady state, meaning the model stresses such as flows and pollutant loads do not vary over time, allowing the model to reach equilibrium for a particular set of conditions. Only solar radiation was allowed to vary so that diurnal changes could be observed. Two scenarios were modeled: one to represent existing loads of BOD and nutrients from point and nonpoint sources, and another in which these sources were reduced until the water quality standard for dissolved oxygen was met. In both model scenarios, conditions like low flows and high temperatures were imposed to represent an expected critical condition. For the TMDL scenario, all conditions were maintained except that the pollutant loading was reduced and D.O. at the upstream boundary was set to 5 mg/l. As previously explained, this was done in order to evaluate oxygen-consuming reactions within the canal resulting from pollutant loads in the watershed. Another important reason is that the modeling analysis indicates that D.O. in segments 3 & 4 cannot recover to 5 mg/l when the upstream D.O. is set to the existing condition- even with all point and nonpoint source loads removed.

Figure 17 shows the predicted water quality in Dade City Canal under existing loads for BOD and nutrients. Figure 18 shows that the D.O. is improved to meet the 5.0 mg/l water quality standard with a 70 percent reduction in all nutrient and BOD loads from both point and nonpoint sources. D.O. is achieved through the nutrient and BOD TMDLs. Note that it takes the model only 3 to 4 days to reach equilibrium starting from initial conditions of zero for both segments.

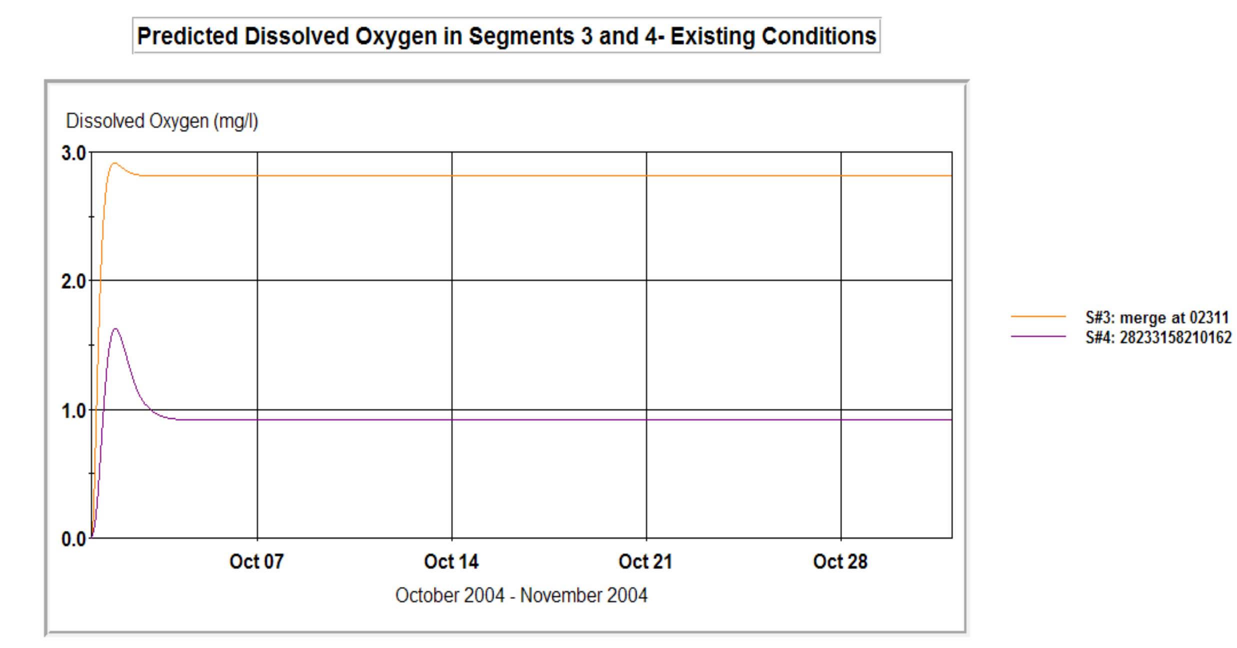

Figure 17. Predicted dissolved oxygen under existing loading conditions.

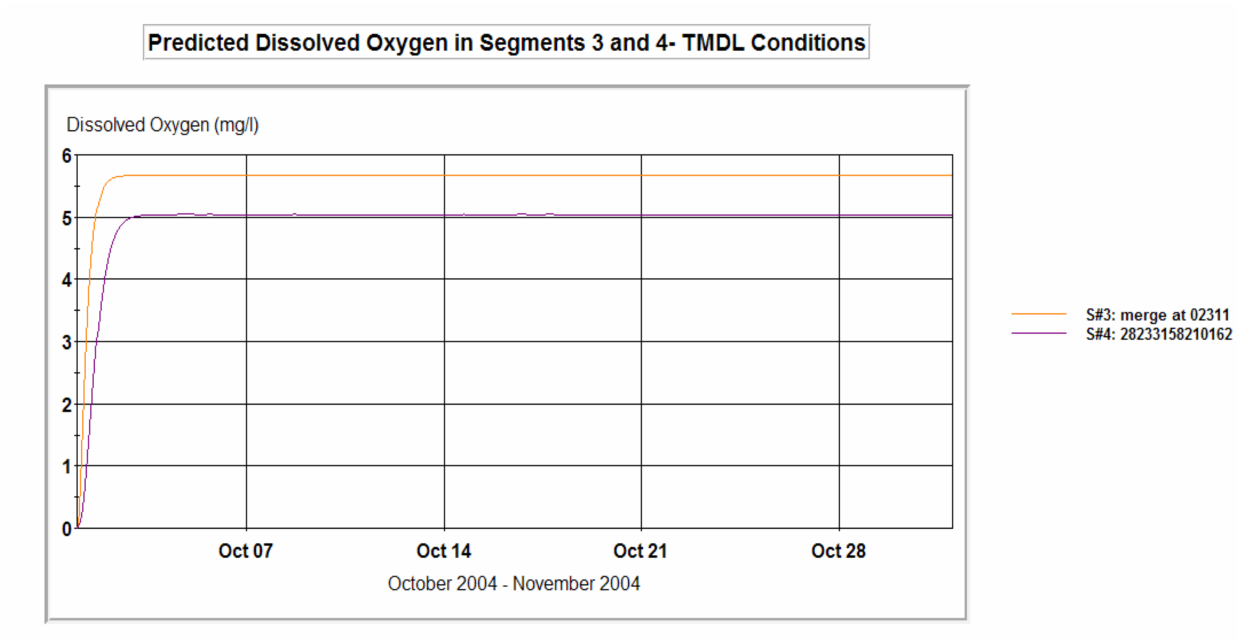

Figure 18. Predicted dissolved oxygen under TMDL conditions.

The TMDL scenario was achieved by imposing equal reductions from all point and nonpoint sources. An explicit 10% margin of safety was reserved from the TMDL, and then subtracted from the Load and Waste Load Allocations in proportion to their relative contributions.

The one point source discharger in the watershed, Pasco Beverage (FL000485), recently applied for permit modification because they have started processing at a much smaller scale. It is likely that these changes will decrease the pollutant load they contribute from their discharge. However, information to quantify these changes in flow and water quality is not currently available, so this TMDL is based on data from the time period selected for simulation. This TMDL may be revised and pollutant loads re-allocated between point and nonpoint sources when additional or more current information becomes available.

Table 13 summarizes the estimates of average annual non-point loads for TN, TP and BOD currently coming from landuses in the WBID. These estimates include both natural and anthropogenic sources.

Table 13. Existing Average Annual Nonpoint Source Loads in WBID 1399.

Parameter	Existing Nonpoint Source Load (kg/day)	Nonpoint Source Load after TMDL Reduction and MOS (kg/day)
Total Nitrogen	11.66	3.15
Total Phosphorus	1.56	0.42
5-day Biochemical Oxygen Demand	27.2	7.34

Table 14 summarizes the existing point source loads of TN, TP and BOD that were used to characterize Pasco Beverage, the only NPDES-permitted facility remaining in the watershed. The existing load is represented in the model by the reported monthly average concentrations and flow (2.2 MGD) from October 2004, because ambient data indicate an impaired condition in the canal during that month.

Table 14. Existing Point Source Load from FL000485.

Parameter	Existing Point* Source Load (kg/day)	Point Source Load after TMDL Reduction and MOS (kg/day)
Total Nitrogen	11.65	3.1
Total Phosphorus	2.50	0.7
5-day Biochemical Oxygen Demand	22.5	6.1

Note: Load estimates are based on monthly average discharge monitoring data.

5.4 Total Maximum Daily Loads

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:

$$TMDL = \Sigma\ WLAs + \Sigma\ LAs + MOS$$

The objective of a TMDL is to allocate loads among 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 <u>other appropriate measure</u>. The TMDLs for WBID 1399 (Dade City Canal) are expressed as the loads of total BOD, TN, and TP loading that are expected to achieve the D.O. standard (Table 15).

Table 15. TMDL components for WBID 1399 (Dade City Canal).

Parameter	TMDL kg/day	WLA[1]		LA kg/day	MOS kg/day	Percent [2] Reduction
		NPDES kg/day	MS4[2] %			
Total Nitrogen	6.99	3.1	70%	3.15	0.7	70%
Total Phosphorus	1.22	0.7	70%	0.42	0.1	70%
Biochemical Oxygen Demand (BOD)	14.9	6.1	70%	7.34	1.5	70%

Notes:

1. The WLA is separated into an allocation for continuous NPDES facilities and an allocation for the MS4. WBID 1399 may be affected by Phase I MS4 permit #FLS00032, which is held by the City of Dade City, Pasco County, and other co-permittees. The WLA for facilities is based on the point source continuing to meet its daily minimum D.O. limitation.

2. Percent reduction in total BOD, TN, and TP loading from current conditions to achieve the D.O. standard.

5.4.1 Waste Load Allocation

Only facilities discharging directly into streams and MS4 areas are assigned a WLA. The WLAs, if applicable, are expressed separately for continuous discharge facilities (e.g., WWTPs) and MS4 areas, as the former discharges during all weather conditions whereas the latter discharges in response to storm events. WBID 1399 has one facility (Pasco Beverage, permit #FL0000485) that maintains an NPDES permit to discharge. WBID 1399 may also be affected by Phase I MS4 permit #FLS00032, which is held by the City of Dade City, Pasco County, and other co-permittees and located near the headwaters of Dade and Larkin Canals. At this time is not possible to isolate the loading discharging exclusively from MS4 areas. The WLA assigned to the MS4 area is expressed in terms of the percent reduction of nutrient and BOD loads required to attain the dissolved oxygen target. Each permittee covered in the permit is ultimately responsible for the MS4 discharges resulting from their jurisdiction, including TMDLs and WLAs.

The WLA for this WBID requires reductions of total nitrogen (TN), total phosphorus (TP) and BOD in order to meet the water quality standard for dissolved oxygen. Allocations are recommended for both nutrients because the TN to TP ratio indicates that Dade City Canal may occasionally be co-limited by both nitrogen and phosphorus. The WLA for facilities is based upon the facility continuing to meet the daily minimum D.O. limitation currently required by their permit.

The impact of a discharge from Pasco Beverage (FL000485) was incorporated into the model as steady state boundary concentrations and flow for segment 2. For nutrients, the primary adverse impact of changing the trophic state occurs over a long time, and so daily loads are not as important as the seasonal or annual loading. Even so, for permit compliance purposes, it is desirable to express point source loads on a shorter time frame. The loads in Table 14 and Table 15 are based on monthly average concentrations.

5.4.2 Load Allocation

The primary mode for transport of nutrients and BOD to streams is during a storm event. Modification of the land surface from a pervious land cover to an impervious surface results in higher peak flow rates that wash nutrient and BOD-enriched water into the stream. The load allocation calls for reductions in average annual BOD and nutrient loadings from nonpoint sources throughout the watershed equal to the percent reductions provided in Table 15. These reductions are expected to allow dissolved oxygen concentrations to recover to a natural condition. The average annual nonpoint source loads used in the TMDL reduction scenario are also summarized in Table 13.

5.4.3 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 explicit 10% MOS was reserved from the TMDL, and subtracted from the Load and Waste Load Allocations in proportion to their relative contributions. An additional, implicit MOS was incorporated in the analyses for WBID 1399 through conservative modeling assumptions. These assumptions include basing the simulation period on a month when available data show that water quality conditions were poorest, as well as using the lowest measured flow for the canal, its highest measured water temperature, and the maximum 30-day discharge from the simulation period.

5.4.4 Critical Conditions and Seasonal Variation

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.

Seasonal variation must also be considered to ensure that water quality standards will be met during all seasons of the year. For Dade City Canal, seasonal variation was considered by analyzing all available water quality data, representing various seasons and incorporating changes in flow and meteorological conditions such as temperature, rainfall, and rainfall intensity. An important component of the steady state TMDL analysis was to identify the time period during which dissolved oxygen concentrations were lowest in the canal.

The critical condition for non-point source loadings is typically an extended dry period followed by a rainfall runoff event. During the dry weather period, pollutants build up on the land surface, and are washed off by rainfall. The critical condition for point source loading occurs during periods of low stream flow when dilution is minimized. Although loading of nonpoint source pollutants contributing to a nutrient impairment may occur during a runoff event, the expression of that nutrient impairment is more likely to occur during warmer months. A high temperature, low flow critical condition was analyzed for the Dade City Canal TMDLs.

5.5 Recommendations

Determining the source of nutrients in waterbodies is the initial step to implementing a nutrient 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

As this TMDL is implemented, the Agency strongly encourages the development of site-specific dissolved oxygen and nutrient criteria for Dade City Canal.

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APPENDIX A WATER QUALITY DATA REMARK CODES

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

Remark Code	Definition
A	Value reported is mean of two or more samples
B	Result based on colony counts outside the acceptable range
E	Extra sample taken in compositing process
I	The value reported is less than the practical quantification limit and greater than or equal to the method detection limit.
K	Off-scale low. Actual value not known, but known to be less than value shown
L	Off-scale high. Actual value not known, but known to be greater than value shown
Q	Sample held beyond normal holding time
T	Value reported is less than the criteria of detection
U	Material was analyzed for but not detected. Value stored is the limit of detection.
<	NAWQA – actual value is known to be less than the value shown