FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

Division of Environmental Assessment and Restoration, Bureau of Watershed Restoration

NORTHEAST DISTRICT • LOWER ST. JOHNS BASIN

FINAL TMDL Report

Dissolved Oxygen TMDL for Sixteen Mile Creek (WBID 2589)

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2008 305(b) Report

http://www.dep.state.fl.us/water/docs/2008_Integrated_Report.pdf

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Basin Status Report for the Lower St. Johns Basin

http://www.dep.state.fl.us/water/basin411/sj_lower/status.htm

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U.S. Environmental Protection Agency, National STORET Program

Region 4: Total Maximum Daily Loads in Florida

http://www.epa.gov/region4/water/tmdl/florida/

National STORET Program

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Chapter 1: INTRODUCTION

1.1 Purpose of Report

This report presents the Total Maximum Daily Load (TMDL) for dissolved oxygen (DO) for Sixteen Mile Creek in the Deep Creek Planning Unit of the Lower St. Johns Basin. The creek was verified as impaired for DO, and was included on the Cycle 1 Verified List of impaired waters for the Lower St. Johns Basin that was adopted by Secretarial Order in May 2004. The impairment was confirmed during the Cycle 2 assessment that was completed in May 2009. In the Cycle 1 assessment, the DO impairment was associated with elevated algal biomass in 2002. This TMDL establishes the allowable loadings to Sixteen Mile Creek that would restore the waterbody so that it meets its applicable water quality criterion for DO.

1.2 Identification of Waterbody

Sixteen Mile Creek is located in the southern portion of St. Johns County and the northern portion of Flagler County east of Hastings (**Figure 1.1**). Sixteen Mile Creek flows primarily northwest into Deep Creek and drains an area of about 27.2 square miles (**Figure 1.2**). The creek is approximately 6.2 miles long and is a second-order stream. County Road (CR) 13 runs through the watershed.

For assessment purposes, the Florida Department of Environmental Protection (Department) has divided the Lower St. Johns Basin into water assessment polygons with a unique **w**ater**b**ody **id**entification (WBID) number for each watershed or stream reach. This TMDL addresses Sixteen Mile Creek, WBID 2589, for DO.

Sixteen Mile Creek is part of the Deep Creek Planning Unit. Planning units are groups of smaller watersheds (WBIDs) that are part of a larger basin unit, in this case the Lower St. Johns Basin. The Deep Creek Planning Unit consists of 18 WBIDs. **Figure 1.3** shows the locations of these WBIDs and the Sixteen Mile Creek watershed in the planning unit.

1.3 Background

This report was developed as part of the Department's watershed management approach for restoring and protecting state waters and addressing TMDL Program requirements. The watershed approach, which is implemented using a cyclical management process that rotates through the state's 52 river basins over a 5-year cycle, provides a framework for implementing the TMDL Program–related requirements of the 1972 federal Clean Water Act and the 1999 Florida Watershed Restoration Act (FWRA) (Chapter 99-223, Laws of Florida).

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

Figure 1.1. Location of the Sixteen Mile Creek Watershed (WBID 2589) in the Lower St. Johns Basin and Major Hydrologic and Geopolitical Features in the Area

Figure 1.2. Location of the Sixteen Mile Creek Watershed (WBID 2589) in St. Johns and Flagler Counties and Hydrologic Features in the Area

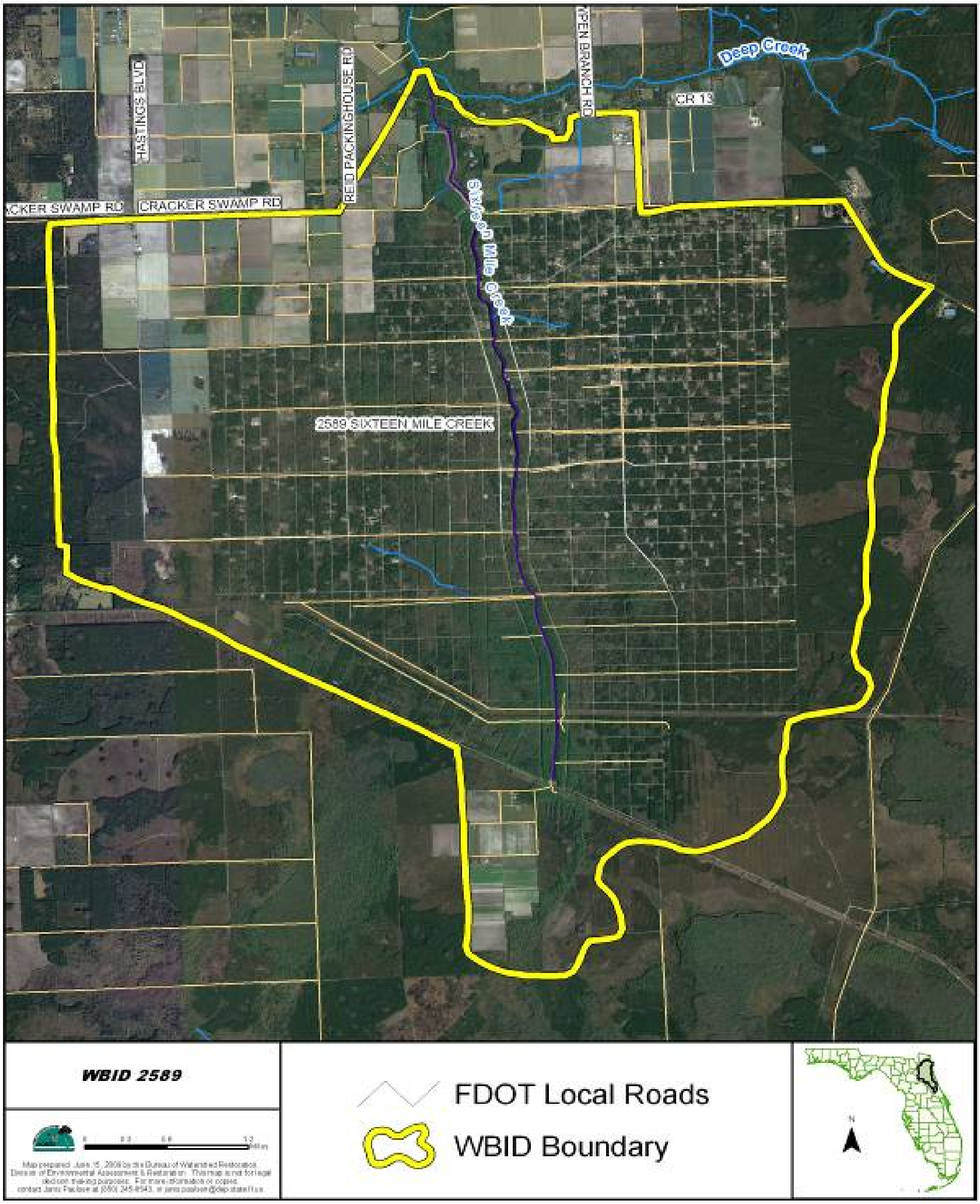
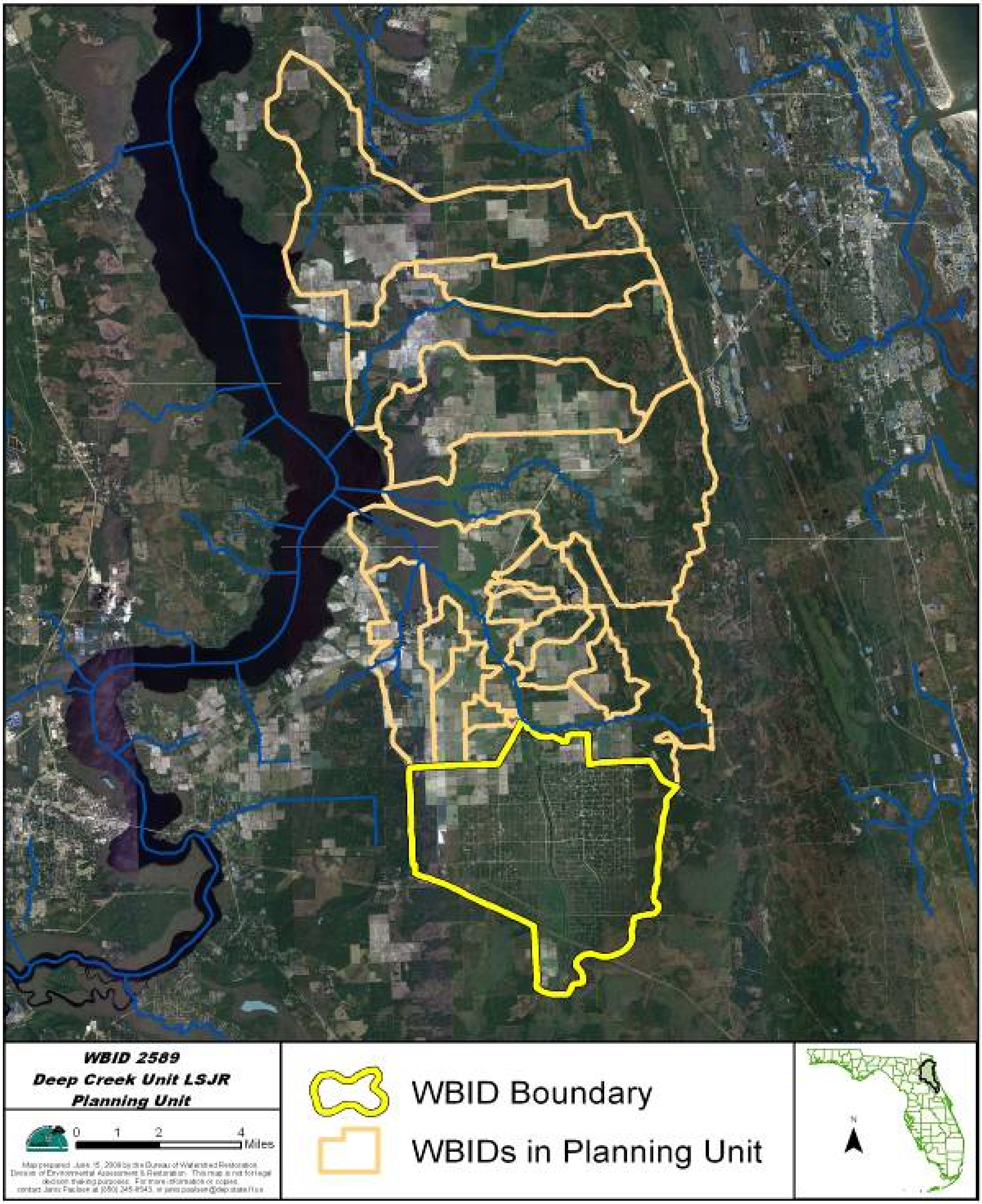


Figure 1.3. WBIDs in the Deep Creek Planning Unit



A nutrient TMDL was adopted in April 2008 for the mainstem of the Lower St. Johns River that required a 30 percent reduction in anthropogenic loadings of nitrogen and phosphorus to the freshwater portion of the Lower St. Johns. A Basin Management Action Plan, or BMAP, was adopted in October 2008 that outlined a number of activities designed to reduce the amount of total nitrogen (TN) and total phosphorus (TP) to the freshwater portion of the Lower St. Johns. These activities will depend heavily on the active participation of the St. Johns River Water Management District (SJRWMD), local governments, businesses, and other stakeholders. The Department will work with these organizations and individuals to undertake or continue reductions in the discharge of pollutants and achieve the established TMDLs for impaired waterbodies, including tributaries to the Lower St. Johns such as Sixteen Mile Creek.

Chapter 2: DESCRIPTION OF WATER QUALITY PROBLEM

2.1 Statutory Requirements and Rulemaking History

Section 303(d) of the federal Clean Water Act requires states to submit to the U.S. Environmental Protection Agency (EPA) lists of surface waters that do not meet applicable water quality standards (impaired waters) and establish a TMDL for each pollutant causing the impairment of listed waters on a schedule. The Department has developed such lists, commonly referred to as 303(d) lists, since 1992. The list of impaired waters in each basin, referred to as the Verified List, is also required by the FWRA (Subsection 403.067[4], Florida Statutes [F.S.]); the state's 303(d) list is amended annually to include basin updates.

Florida's 1998 303(d) list included 55 waterbodies in the Lower St. Johns River Basin. However, the FWRA (Section 403.067, F.S.) stated that all previous Florida 303(d) lists were for planning purposes only and directed the Department to develop, and adopt by rule, a new science-based methodology to identify impaired waters. After a long rulemaking process, the Environmental Regulation Commission adopted the new methodology as Rule 62-303, Florida Administrative Code (F.A.C.) (Identification of Impaired Surface Waters Rule, or IWR), in April 2001; the rule was modified in 2006 and 2007.

2.2 Information on Verified Impairment

The Department used the IWR to assess water quality impairments in the Sixteen Mile Creek watershed and has verified that this waterbody segment is impaired for DO, based on data in the Department's IWR database. **Table 2.1** summarizes the DO data for the verified period, which for Cycle 1, Group 2 waters was January 1, 1996, through June 30, 2003. **Tables 2.2** through **2.4** summarize the Cycle 1 DO data for the verified period by month, season, and year, respectively.

There is a 24.8 percent overall exceedance rate for DO in Sixteen Mile Creek during the verified period (**Table 2.1**). Exceedances did not occur during the winter season. There were no exceedances reported in the months of November, January, February, March, or April (**Tables 2.2** and **2.3**). During the verified period, samples ranged from 0.5 to 13.8 milligrams per liter (mg/L). As DO solubility is influenced by both salinity and water temperature, ranges in DO saturation (DOSAT) were also evaluated. DOSAT ranged from 6.8 to 150.0 percent, averaging 75.4 percent. Fewer than 10 percent of the DOSAT values were less than 32 percent.

When aggregating data by season, the lowest percentage of exceedances occurred in the winter and the highest in summer. Possible relationships between DO and other water quality parameters are further assessed in Chapter 5, using the complete historical dataset.

Table 2.1. Summary of DO Monitoring Data for Sixteen Mile Creek (WBID 2213P) During the Verified Period (January 1, 2001–June 30, 2008)

- = Empty cell
[1] BOD = Biochemical oxygen demand

Waterbody (WBID)	Parameter	DO
Sixteen Mile Creek (2589)	Total number of samples	133
Sixteen Mile Creek (2589)	IWR-required number of exceedances for the Verified List	19
Sixteen Mile Creek (2589)	Number of observed exceedances	33 (24.8%)
Sixteen Mile Creek (2589)	Number of observed nonexceedances	100
Sixteen Mile Creek (2589)	Number of seasons during which samples were collected	4
Sixteen Mile Creek (2589)	Highest observation (mg/L)	13.8
Sixteen Mile Creek (2589)	Lowest observation (mg/L)	0.5
Sixteen Mile Creek (2589)	Median observation (mg/L)	6.7
Sixteen Mile Creek (2589)	Mean observation (mg/L)	6.8
Sixteen Mile Creek (2589)	Median value for 70 BOD observations (mg/L)[1]	1.60
Sixteen Mile Creek (2589)	Median value for 136 TN observations (mg/L)	1.17
Sixteen Mile Creek (2589)	Median value for 139 TP observations (mg/L)	0.15
Sixteen Mile Creek (2589)	Possible causative pollutant by IWR	Algae
-	**FINAL ASSESSMENT:**	**Impaired**

Table 2.2. Summary of DO Data by Month for the Cycle 1 Verified Period (January 1, 1996–June 30, 2003)

DO concentrations are mg/L.

Month	N	Minimum	Maximum	Median	Mean	Number of Exceedances	% Exceedances	Mean Precipitation (inches)
January	10	7.15	13.81	11.13	10.96	0	0.00	2.03
February	9	5.52	12.77	9.88	9.36	0	0.00	3.32
March	15	5.19	12.98	7.14	7.42	0	0.00	4.05
April	12	5.23	11.22	8.03	7.96	0	0.00	1.99
May	10	3.04	8.57	6.97	6.73	2	20.00	1.85
June	9	0.78	10.57	5.80	5.27	4	44.44	9.08
July	11	1.49	9.18	4.05	4.45	7	63.64	7.71
August	11	0.53	7.76	4.83	4.20	7	63.64	5.50
September	11	1.71	5.67	3.78	4.04	7	63.64	8.63
October	10	1.43	8.09	5.11	4.74	5	50.00	3.55
November	13	5.23	9.77	7.70	7.74	0	0.00	1.33
December	12	4.97	11.74	7.97	8.24	1	8.33	3.63

Table 2.3. Summary of DO Data by Season for the Cycle 1 Verified Period (January 1, 1996–June 30, 2003)

DO concentrations are mg/L.

Season	N	Minimum	Maximum	Median	Mean	Number of Exceedances	% Exceedances	Mean Total Precipitation (inches)
Winter	34	5.19	13.81	8.78	8.98	0	0.00	9.40
Spring	31	0.78	11.22	7.30	6.78	6	19.35	12.92
Summer	33	0.53	9.18	4.16	4.23	21	63.64	21.84
Fall	35	1.43	11.74	6.86	7.05	6	17.14	8.51

Table 2.4. Summary of DO Data by Year for the Cycle 1 Verified Period (January 1, 1996–June 30, 2003)

DO concentrations are mg/L.

Year	N	Minimum	Maximum	Median	Mean	Number of Exceedances	% Exceedances	Total Precipitation (inches)
1996	9	1.71	6.67	4.93	4.36	5	55.56	60.63
1997	10	4.22	10.25	6.15	6.75	2	20.00	57.27
1998	12	3.34	8.73	4.99	5.31	6	50.00	56.72
1999	10	1.43	10.13	6.28	6.41	2	20.00	42.44
2000	16	0.78	11.62	6.48	7.15	2	12.50	39.77
2001	33	0.53	13.81	7.65	7.49	7	21.21	49.14
2002	35	1.49	12.98	6.90	6.96	9	25.71	54.72
2003	8	6.14	10.04	8.07	7.78	0	0.00	44.47

Chapter 3. DESCRIPTION OF APPLICABLE WATER QUALITY STANDARDS AND TARGETS

3.1 Classification of the Waterbody and Criteria Applicable to the TMDL

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

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

Sixteen Mile Creek (WBID 2589) is a Class III fresh waterbody, with a designated use of recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlife. The Class III water quality criterion applicable to the impairment addressed by this TMDL is for DO.

3.2 Applicable Water Quality Standards and Numeric Water Quality Target

Numeric criteria for DO are expressed in terms of minimum and daily average concentrations. The water quality criterion for the protection of Class III fresh waterbodies, as established by Rule 62-302, F.A.C., states the following:

> ***Dissolved Oxygen Criteria:***
>
> *Shall not be less than 5.0. Normal daily and seasonal fluctuations above these levels shall be maintained.*

The nutrient criterion in Rule 62-302, F.A.C., is expressed as a narrative:

> ***Nutrients:***
>
> *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 [Note: For Class III waters in the Everglades Protection Area, this criterion has been numerically interpreted for phosphorus in Section 62-302.540, F.A.C.].*

To assess whether this narrative criterion was being exceeded, the IWR provides thresholds for nutrient impairment in estuaries based on annual average chla levels. The following language is found in Rule 62-303, F.A.C.:

62-303.351 Nutrients in Streams.

A stream or stream segment shall be included on the planning list for nutrients if the following biological imbalances are observed:

(1) Algal mats are present in sufficient quantities to pose a nuisance or hinder reproduction of a threatened or endangered species, or

(2) Annual mean chlorophyll a concentrations are greater than 20 micrograms per liter (μg/L) or if data indicate annual mean chlorophyll a values have increased by more than 50% over historical values for at least two consecutive years.

62-303.450 Interpretation of Narrative Nutrient Criteria.

(1) A water shall be placed on the verified list for impairment due to nutrients if there are sufficient data from the last five years preceding the planning list assessment, combined with historical data (if needed to establish historical chlorophyll a levels or historical TSIs), to meet the data sufficiency requirements of subsection 62-303.350(2), FA.C. If there are insufficient data, additional data shall be collected as needed to meet the requirements. Once these additional data are collected, the Department shall determine if there is sufficient information to develop a site-specific threshold that better reflects conditions beyond which an imbalance in flora or fauna occurs in the water segment. If there is sufficient information, the Department shall re-evaluate the data using the site-specific thresholds. If there is insufficient information, the Department shall re-evaluate the data using the thresholds provided in Rules 62-303.351-.353, F.A.C., for streams, lakes, and estuaries, respectively. In any case, the Department shall limit its analysis to the use of data collected during the five years preceding the planning list assessment and the additional data collected in the second phase. If alternative thresholds are used for the analysis, the Department shall provide the thresholds for the record and document how the alternative threshold better represents conditions beyond which an imbalance in flora or fauna is expected to occur.

As noted in Chapter 1, the DO impairment in Cycle 1 was associated with elevated algal biomass in 2002. Subsequent analysis indicated that a corrected chlorophyll *a* (CHLAC) measurement reported as below the method detection limit (MDL) had the incorrect reporting units and resulted in an error in the calculation of the annual CHLAC average for 2002. The corrected annual average was 1.2 μg/L.

Chapter 4: ASSESSMENT OF SOURCES

4.1 Types of Sources

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

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

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

4.2 Potential Sources of Nutrients in the Sixteen Mile Creek Watershed

4.2.1 Point Sources

There are no NPDES wastewater facilities located in the watershed.

Municipal Separate Storm Sewer System Permittees

The Sixteen Mile Creek watershed is located in both St. Johns County, which has a Phase II municipal separate storm sewer system (MS4) permit (FLR04E025), and Flagler County, which does not have a Phase II MS4 permit.

4.2.2 Land Uses and Nonpoint Sources

Nutrient loadings to Sixteen Mile Creek are generated from nonpoint sources in the watershed. These potential sources include loadings from surface runoff, ground water inflow, and septic tanks. Activities in the following districts (called 298 districts because they were created under Chapter 298, F.S.) can also influence nutrient loadings:

- *The Hastings Drainage District was originally created by a 1919 special act by the Florida Legislature (Chapter 7969, Laws of Florida) to provide drainage in a specified area of Putnam and St. Johns Counties. According to Chapter 2005-345, Laws of Florida, the district was created to drain, reclaim, and maintain and protect lands from the effects of waters for agricultural and sanitary purposes, and for the public convenience, utility, welfare, and benefit. The Hastings Drainage District encompasses approximately 11,000 acres, with about 2,946 acres within the Sixteen Mile Creek WBID (**Figure 4.1**).*
- *The Flagler Estates Road and Water Control District was originally named the Sixteen Mile Creek Water Control District when it was created as a public corporation by Final Judgment of the Seventh Judicial Circuit Court, St. Johns County, Florida, on June 4, 1971. The District was authorized to accept and maintain drainage improvements already in existence and to operate pursuant to Chapter 298, F.S. In 1981, the authority was expanded to maintain roads and streets. The Flagler Estates Road and Water Control District covers approximately 7,500 acres and falls within the Sixteen Mile Creek WBID (**Figure 4.1**). The District has 6,181 acres of residential lots (most lots are about 1.13 acres) and had an estimated 1,500 families as of May 2006.*

  Under Chapter 298, F.S., Water Control Districts must develop Water Control Plans. The plans include a description of statutory responsibilities, an environmental or water quality program that the District has implemented or plans to implement, and facilities and services the District plans to provide within 5 years.

Land Uses

The spatial distribution and acreage of different land use categories were identified using the SJRWMD's year 2004 land use coverage (scale 1:51,000) contained in the Department's geographic information system (GIS) library. Land use categories in the watershed were aggregated using the Level 2 land use codes and tabulated in **Table 4.1**. **Figure 4.2** shows the acreage of the principal Level 1 land uses in the watershed.

As shown in **Table 4.1**, the total area of the Sixteen Mile Creek watershed is about 17,431 acres. The dominant land use category is urban and built-up, which accounts for about 47.8 percent of the total watershed area. Upland forest represents 23.7 percent of the total watershed area. Agriculture and rangeland comprise 20.6 percent of the total area. Within the urban and built-up Level 1 land use classification, low-density residential (3,052 acres) and open lands (5,255 acres) are the major land uses.

Figure 4.1. 298 Districts in the Sixteen Mile Creek Watershed (WBID 2589)

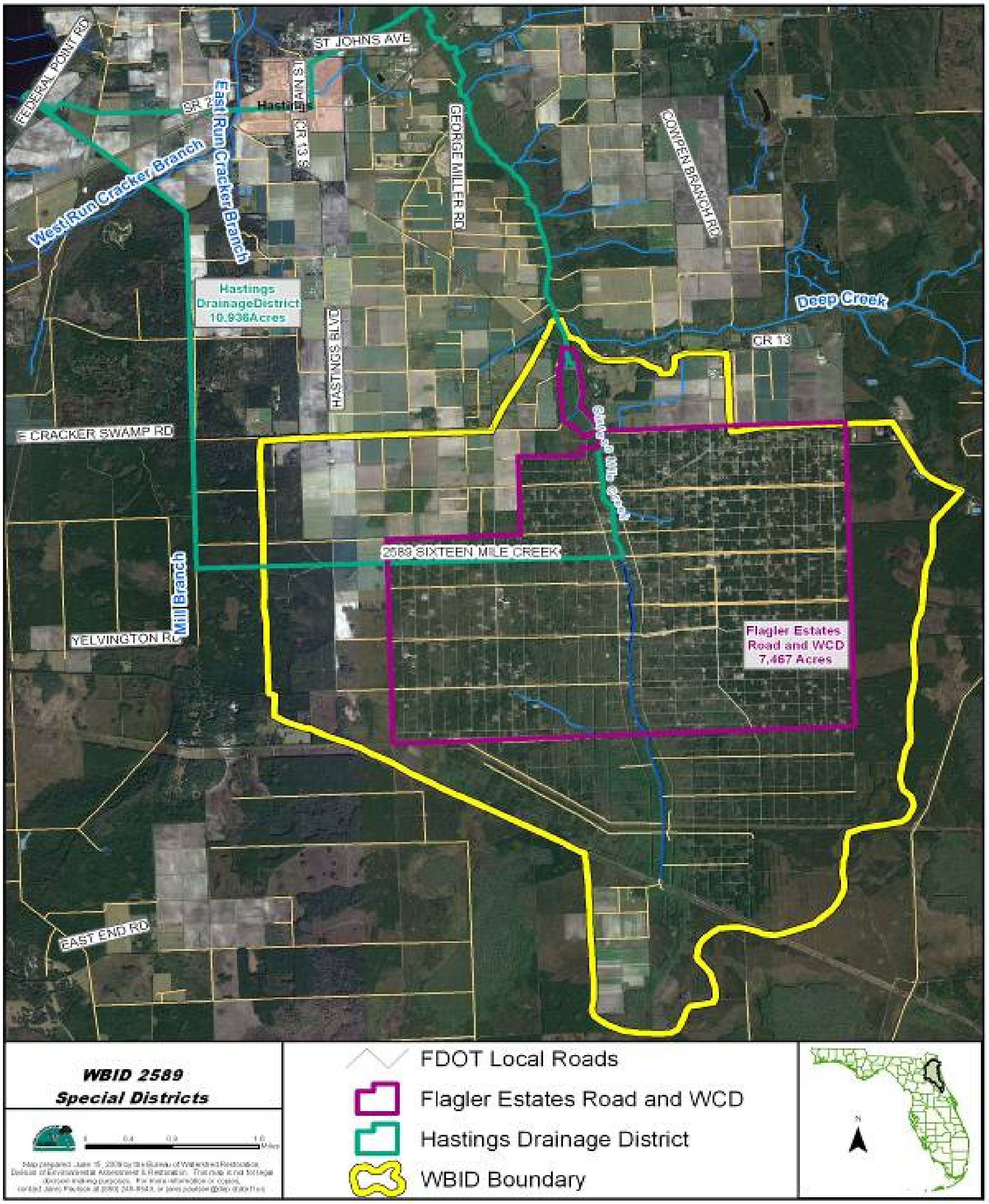
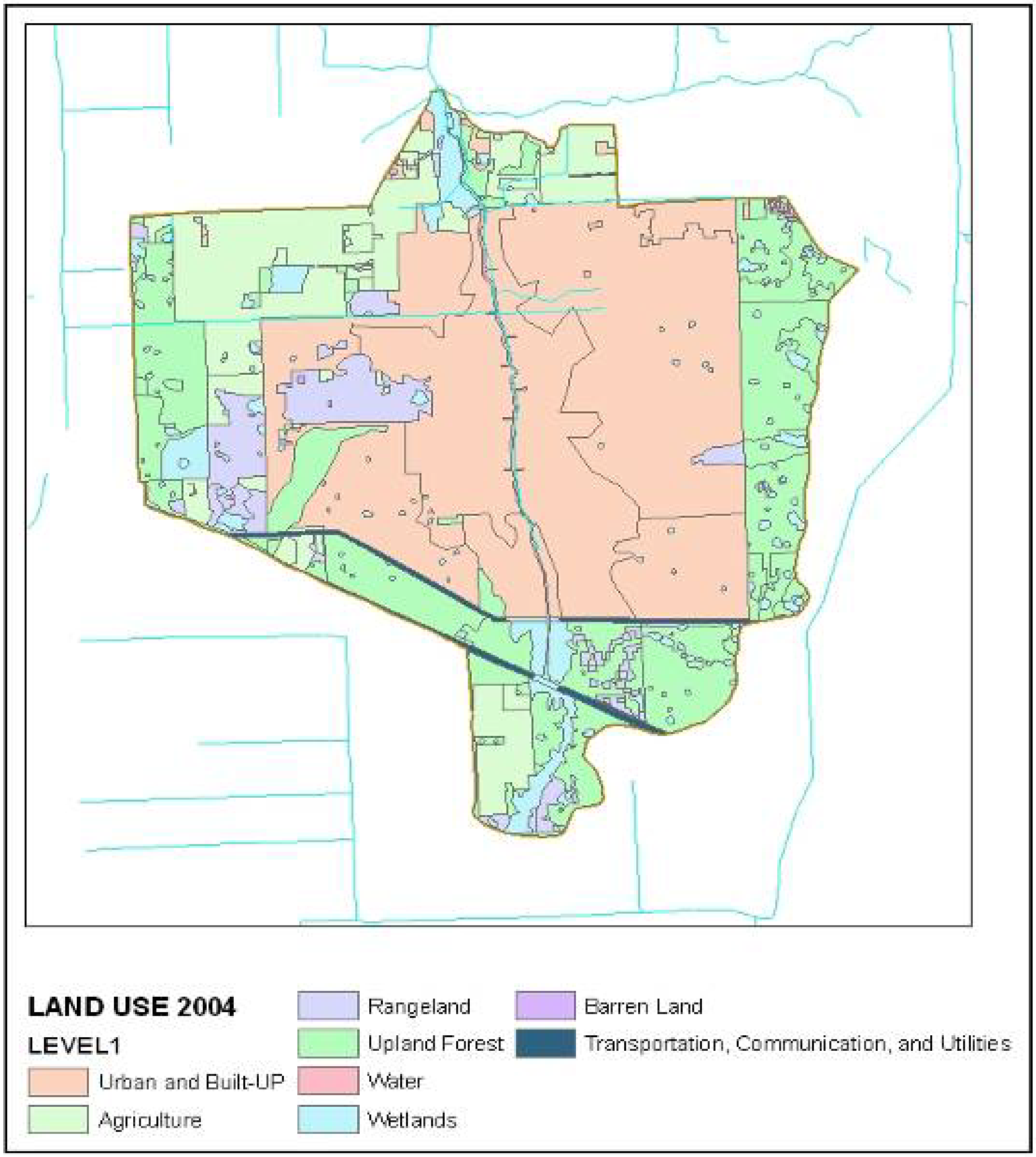


Table 4.1. Classification of Land Use Categories in the Sixteen Mile Creek Watershed (WBID 2589) in 2004

- = Empty cell

Level 2 Land Use Code	Attribute	Acres	% of Total
1100	Residential, low density – less than 2 dwelling units/acre	3,052.29	17.51
1200	Residential, medium density – 2-5 dwelling units/acre	13.29	0.08
1500	Industrial	15.92	0.09
1700	Institutional	4.27	0.02
1900	Open land	5,254.77	30.15
2100	Cropland and pastureland	2,248.58	12.90
2500	Specialty farms	14.21	0.08
2600	Other open lands – rural	295.63	1.70
3100	Herbaceous upland nonforested	61.66	0.35
3200	Shrub and brushland (wax myrtle or saw palmetto, occasionally scrub)	444.57	2.55
3300	Mixed upland nonforested	529.01	3.03
4100	Upland coniferous forests	765.59	4.39
4200	Upland hardwood forests	0.83	0.00
4300	Upland hardwood forests cont.	516.72	2.96
4400	Tree plantations	2,854.3	16.38
5100	Streams and waterways	56.51	0.32
5300	Reservoirs – pits, retention ponds, dams	6.41	0.04
6100	Wetland hardword forests	479.88	2.75
6200	Wetland coniferous forests	159.53	0.92
6300	Wetland forested mixed	244.46	1.40
6400	Vegetated nonforested wetlands	198.34	1.14
7400	Disturbed land	14.35	0.08
8100	Transportation	4.9	0.03
8300	Utilities	194.75	1.12
-	**SUM:**	**17,430.77**	**100.00**

Figure 4.2. Principal Land Uses in the Sixteen Mile Creek Watershed (WBID 2589) in 2004



Soil Characteristics

The Soil Survey Geographic (SSURGO) Database in the Department's GIS database from the SJRWMD was accessed to provide coverage of hydrologic soil groups in the Sixteen Mile Creek watershed (**Figure 4.3**). **Table 4.2** briefly describes the major hydrology soil classes. Soil groups C/D (45.7 percent) and B/D (42.0 percent) are the most common in the watershed, with type D (11.7 percent) found in the lower portion of the watershed along the creek and along the northwestern boundary of the watershed.

Table 4.2. Description of Hydrologic Soil Classes from the SSURGO Database

Hydrology Class	Description
A	High infiltration rates. Soils are deep, well-drained to excessively drained sands and gravels.
A/D	Drained/undrained hydrology class of soils that can be drained and are classified.
B	Moderate infiltration rates. Deep and moderately deep, moderately well- and well-drained soils that have moderately coarse textures.
B/D	Drained/undrained hydrology class of soils that have moderately coarse textures.
C	Slow infiltration rates. Soils with layers impeding downward movement of water, or soils that have moderately fine or fine textures.
C/D	Drained/undrained hydrology class of soils that can be drained and classified.
D	Very slow infiltration rates. Soils are clayey, have a high water table, or are shallow to an impervious layer.

Population

Population and housing unit information from the 2000 census at the block level was obtained from the U.S. Census Bureau. GIS was used to estimate the fraction of each block in the Sixteen Mile Creek watershed and then applied to the block information to estimate the population and number of housing units. Based on **Table 4.3**, the population in the watershed is estimated at 1,756 people living in 611 households.

Figure 4.3. Hydrologic Soil Groups Distribution in the Sixteen Mile Creek Watershed (WBID 2589)

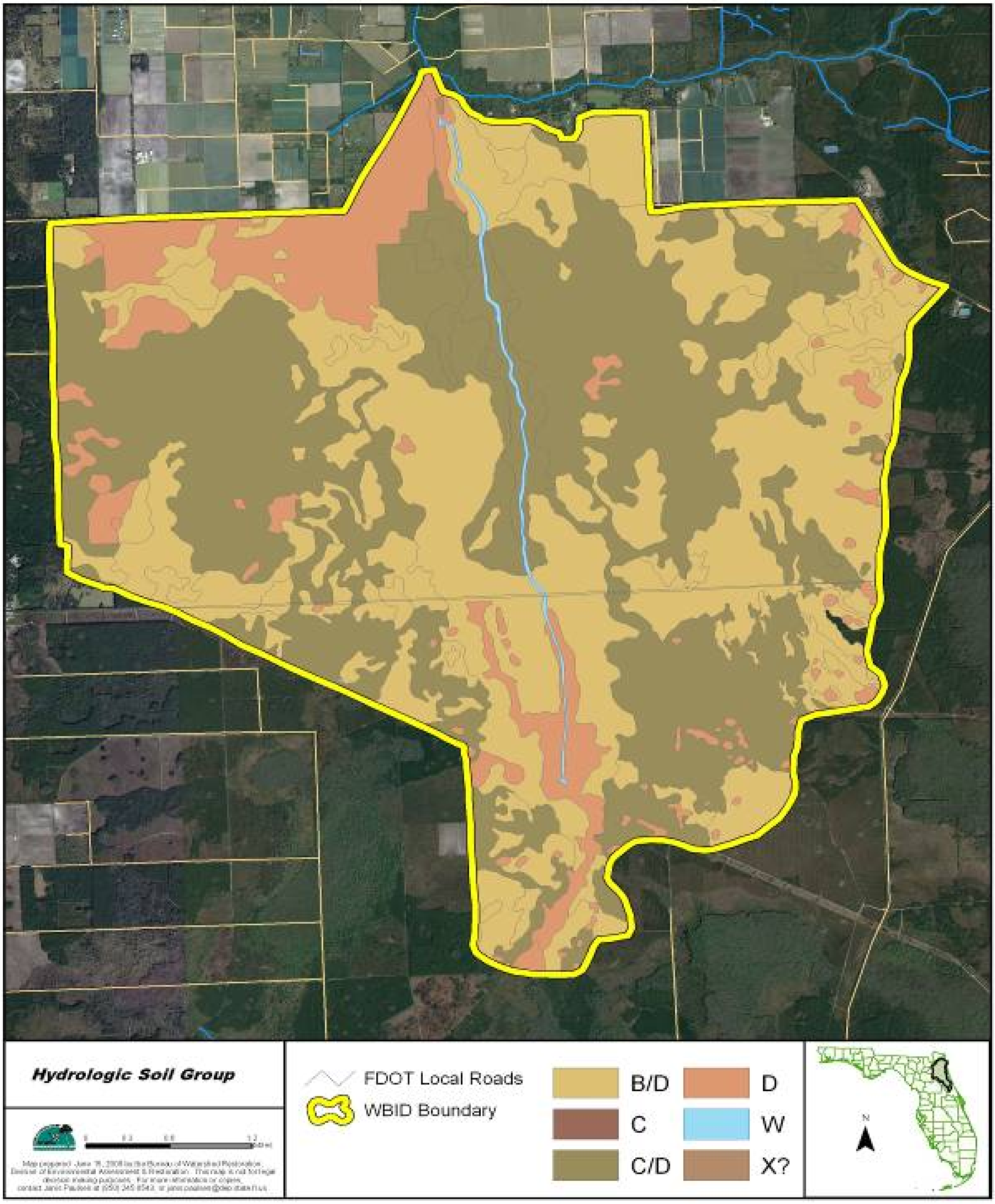


Table 4.3. Estimated Average Household Size in the Sixteen Mile Creek Watershed (WBID 2589)

- = Empty cell
Data from U.S. Census Bureau Website, 2000, based on the St. Johns and Flagler County blocks present in the Sixteen Mile Creek watershed.

Tract	Block Group	Population	Housing Units
211	4	1	0
211	5	1755	611
602.01	1	0	0
-	**Total:**	**1,756**	**611**
		AVERAGE HOUSEHOLD SIZE:	**2.87**

Septic Tanks

Based on the 2000 census estimates and the Florida Department of Health (FDOH) onsite sewage coverage, it was assumed that all 611 residences in the Sixteen Mile Creek watershed are using septic tanks. Using an estimate of 70 gallons/day/person (EPA, 1999), and drainfield TN and TP concentrations of 36 and 15 mg/L, respectively, potential annual ground water loads of TN and TP were calculated. This is a screening level calculation, and soil types, the age of the system, vegetation, proximity to a receiving water, and other factors will influence the degree of attenuation of this load (**Table 4.4**).

Table 4.4. Estimated Nitrogen and Phosphorus Annual Loading from Septic Tanks in the Sixteen Mile Creek Watershed (WBID 2589)

[1] U.S Census Bureau; see **Table 4.3** for more information on this estimate.
[2] EPA, 1999

Estimated Number of Households on Septic	Estimated Number of People per Household[1]	Gallons/ Person/ Day[2]	TN in Drainfield (mg/L)	TP in Drainfield (mg/L)	Estimated Annual TN Load (lbs/yr)	Estimated Annual TP Load (lbs/yr)
611	2.87	70	36	15	13,465	5,610

4.2.3 Summary of Nutrient Loadings to Sixteen Mile Creek from Various Sources

Screening level estimates of annual nitrogen and phosphorus loadings to the watershed were developed based on the 2004 land use and hydrologic soil groups. GIS shapefiles of land use and hydrologic soil groups were used to determine the acreage associated with various Level 2 land uses and soils. Estimates for annual runoff coefficients and event mean concentrations (EMCs) were based on Harper and Baker (2007) and Gao (2006). A screening level estimate of annual runoff was calculated by multiplying the long-term annual average rainfall of 52.44 inches (Jacksonville International Airport, 1955–2007) by the respective runoff coefficient and area. Estimates of annual nitrogen and phosphorus loading were obtained by multiplying the annual runoff by the corresponding EMC. A more detailed loading analysis could be performed based on the development of site-specific runoff coefficients, EMCs, and knowledge of best management practices (BMPs) that have been implemented in the watershed.

Agriculture

In the Level 3 category, eight agricultural land uses were identified in the Sixteen Mile Creek watershed. Row crops were the largest agricultural category and represented approximately 11.5 percent of the watershed area, or 2,004 acres. Fallow cropland was the second largest, representing approximately 1.0 percent of the watershed area, or 174 acres. Improved, unimproved, and woodland pastures represented approximately 1.2 percent of the watershed area. Aggregating land use to Level 1 for the Sixteen Mile Creek watershed yields 2,558 acres in agriculture and 1,035 acres in rangeland. **Table 4.5** summarizes the screening level estimates for nitrogen and phosphorus loads from agricultural sources based on the Level 2 land use classification.

Table 4.5. Estimated Annual Average TN and TP Loads from Agriculture in the Sixteen Mile Creek Watershed (WBID 2589)

- = Empty cell

Land Use Classification	Soil Group	Acres	Annual Runoff Coefficient	Gross Runoff (acre-feet)	Estimated TN Load (lbs)	Estimated TP Load (lbs)
Cropland and pastureland	B/D	835.63	0.09	325.00	2,467.28	381.15
-	C/D	560.26	0.23	553.32	4,200.61	648.91
-	D	852.7	0.23	842.14	6,393.21	987.62
Specialty farms	D	3.86	0.23	3.81	28.94	4.47
-	C/D	10	0.23	9.88	74.98	11.58
-	B/D	0.35	0.09	0.14	1.03	0.16
Other open lands	C/D	112.99	0.23	111.59	847.15	130.87
-	B/D	114.65	0.09	44.59	338.52	52.29
-	D	68	0.23	67.16	509.84	78.76
Herbaceous upland nonforested	D	18.06	0.23	17.84	55.81	2.67
-	B/D	36.59	0.09	14.23	44.53	2.13
-	C/D	7.01	0.23	6.92	21.66	1.04
Shrub and brushland (wax myrtle or saw palmetto, occasionally scrub)	C/D	244.6	0.23	241.57	755.91	36.15
-	D	9.14	0.23	9.03	28.25	1.35
-	B/D	190.81	0.09	74.21	232.22	11.11
Mixed rangeland	B/D	231	0.09	89.84	281.13	13.45
-	C/D	282.35	0.23	278.85	872.58	41.73
-	D	15.67	0.23	15.48	48.43	2.32
-	**SUM:**	**3,593.67**	**-**	**2,705.61**	**17,202.08**	**2,407.76**

Urban Areas

There are 8,340 acres in the Level 1 category of urban and built-up in the watershed and 200 acres in transportation, communication, and utilities. Low-density residential represents approximately a third of the total acreage, while open land represents approximately 63 percent of the total acreage in the urban and built-up category. **Table 4.6** summarizes the screening level estimates for nitrogen and phosphorus loads from Level 2 urban and built-up categories in the watershed.

Forest/Wetland/Water/Open Lands

Table 4.7 summarizes estimates for nitrogen and phosphorus loadings from Level 2 land use classifications for forest, wetland, and water. Wetlands and upland forests (primarily tree plantations) represent 6.2 and 23.7 percent, respectively, of the acreage in the watershed.

Table 4.6. Estimated Urban and Built-up Annual Nitrogen and Phosphorus Loading in the Sixteen Mile Creek Watershed (WBID 2589)

- = Empty cell/no data

Land Use Classification	Soil Group	Acres	Annual Runoff Coefficient	Gross Runoff (acre-feet)	Estimated TN Load (lbs)	Estimated TP Load (lbs)
Residential, low density – less than 2 dwelling units/acre	B/D	1,177.64	0.08	427.14	1,871.23	221.99
-	C	0.06	0.17	0.04	0.19	0.02
-	C/D	1,849.62	0.23	1,826.72	8,002.52	949.37
-	D	24.98	0.23	24.67	108.08	12.82
Residential, medium density – 2-5 dwelling units/acre	D	13.29	0.25	14.64	82.43	13.02
Industrial	B/D	10.25	0.24	10.79	60.80	9.61
-	D	3.49	0.35	5.34	30.07	4.75
-	C/D	2.18	0.35	3.33	18.78	2.97
Institutional	B/D	0.41	0.24	0.43	1.76	0.33
-	D	0.14	0.35	0.21	0.87	0.16
-	C/D	3.72	0.35	5.69	23.22	4.33
Open land	B/D	2,334.06	0.09	907.79	2,840.60	135.85
-	C/D	2,760.02	0.23	2,725.85	8,529.60	407.94
-	D	141.61	0.23	139.86	437.63	20.93
-	W	19.02	0.44	36.16	113.14	5.41
Disturbed lands	C/D	6.89	0.23	6.80	29.62	3.70
-	D	4.31	0.23	4.26	18.53	2.32
-	B/D	3.14	0.29	4.02	17.50	2.19
Transportation	B/D	4.9	0.29	6.27	28.00	3.76
Utilities	D	33.46	0.38	54.83	244.69	32.82
-	B/D	57.07	0.29	73.07	326.08	43.74
-	C/D	104.19	0.38	170.74	761.92	102.21
-	X?	0.01	0.44	0.02	0.08	0.01
-	**SUM:**	**8,554.46**	**-**	**6,448.69**	**2,3547.36**	**1,980.26**

Table 4.7. Estimated Forest/Wetland/Water/Open Lands Annual Nitrogen and Phosphorus Loading in the Sixteen Mile Creek Watershed (WBID 2589)

- = Empty cell/no data

Land Use Classification	Soil Group	Acres	Annual Runoff Coefficient	Gross Runoff (acre-feet)	Estimated TN Load (lbs)	Estimated TP Load (lbs)
Upland coniferous forests	D	19	0.226	18.76	58.72	2.81
-	B/D	322.73	0.089	125.52	392.77	18.78
-	C/D	423.25	0.226	418.01	1,308.02	62.56
-	W	0.59	0.435	1.12	3.51	0.17
-	X?	0.04	0.435	0.08	0.24	0.01
Upland hardwood forests	D	0.83	0.226	0.82	2.57	0.12
Upland hardwood forests cont.	D	72.88	0.226	71.98	225.23	10.77
-	B/D	245.11	0.089	95.33	298.30	14.27
-	C/D	198.13	0.226	195.68	612.30	29.28
-	C	0.54	0.166	0.39	1.23	0.06
Tree plantations	B/D	1,503.02	0.089	584.57	1,829.21	87.48
-	C/D	1,147.59	0.226	1,133.38	3,546.52	169.62
-	D	181.23	0.226	178.99	560.08	26.79
-	X?	20.88	0.435	39.69	124.20	5.94
-	C	1.65	0.166	1.20	3.75	0.18
Streams and waterways	C/D	19.98	0.435	37.98	129.18	11.37
-	B/D	0.84	0.435	1.60	5.43	0.48
-	W	35.66	0.435	67.79	230.56	20.29
Reservoirs – pits, retention ponds, dams	D	2.65	0.435	5.04	17.13	1.51
-	B/D	3.76	0.435	7.15	24.31	2.14
Wetland hardwood forests	B/D	69.03	0.435	131.22	571.29	21.42
-	D	334.7	0.435	636.25	2,769.97	103.87
-	C/D	72.37	0.435	137.57	598.93	22.46
-	W	2.92	0.435	5.55	24.17	0.91
-	X?	0.86	0.435	1.63	7.12	0.27
Wetland coniferous forests	B/D	50.08	0.435	95.20	414.46	15.54
-	C/D	25.32	0.435	48.13	209.55	7.86
-	D	84.11	0.435	159.89	696.09	26.10
Wetland forested mixed	C/D	104.88	0.435	199.37	867.98	32.55
-	D	73.19	0.435	139.13	605.72	22.71
-	B/D	66.12	0.435	125.69	547.21	20.52
-		0.19	0.435	0.36	1.57	0.06
Vegetated nonforested wetlands	C/D	31.6	0.435	60.07	261.52	9.81
	B/D	64.37	0.435	122.36	532.72	19.98

Land Use Classification	Soil Group	Acres	Annual Runoff Coefficient	Gross Runoff (acre-feet)	Estimated TN Load (lbs)	Estimated TP Load (lbs)
-	D	76.27	0.435	144.99	631.21	23.67
-	W	22.71	0.435	43.17	187.95	7.05
-	C	0.05	0.435	0.10	0.41	0.02
-	X?	3.35	0.435	6.37	27.72	1.04
-	**SUM:**	**5,282.48**	**-**	**5,042.12**	**18,328.85**	**800.46**

Source Summary

Table 4.8 summarizes the various estimates from various land uses in the watershed. It is important to note that this is not a complete list and represents estimates of potential loadings. In addition, proximity to the waterbody, site-specific soil characteristics, and rainfall frequency and magnitude are just a few of the factors that could influence and determine the actual loadings from these sources that reach Sixteen Mile Creek. Other factors include the locations of the improved pasture and high-density residential areas relative to Sixteen Mile Creek; whether there is a riparian buffer area between these land uses and the stream; and the types of BMPs, both structural and nonstructural, implemented for specific land uses in the watershed that reduce the actual nutrient loads delivered to Sixteen Mile Creek. Finally, the age and condition of the septic systems and drainage characteristics in the watershed could affect assumptions about the assimilation and/or retention of nutrients.

Table 4.8. Summary of Estimated Potential Annual Nitrogen and Phosphorus Loading from Various Sources in the Sixteen Mile Creek Watershed (WBID 2589)

[1] Potential contribution to ground water

Source	TN (lbs/yr)	TP (lbs/yr)
Septic Tanks[1]	13,465	5,610
Urban and Built-up	23,547.4	1,980.3
Agriculture	1,7202.1	2,407.8
Forest/Wetland/Water/ Open Lands	1,8328.8	800.5

The screening model estimated an annual surface runoff of 14,196.4 acre-feet or 9.8 inches per year based on the watershed area. Dividing the estimated TN load by the surface runoff volume yielded an average TN concentration of 1.53 mg/L. The average and median TN concentrations from the available data were 1.67 and 1.10 mg/L, respectively. Dividing the estimated TP load by the surface runoff volume yielded an average TP concentration of 0.13 mg/L. The average and median TP concentrations from the available data were 0.289 and 0.162 mg/L, respectively. Flow and nutrient contributions from ground water inputs to Sixteen Mile Creek were not included in this screening level calculation and would likely influence in-stream concentrations.

Chapter 5: DETERMINATION OF ASSIMILATIVE CAPACITY

5.1 Determination of Loading Capacity

5.1.1 Data Used in the Determination of the TMDL

Seven sampling stations on Sixteen Mile Creek have historical DO observations (**Figure 5.1**). **Table 5.1** contains summary information on each of the stations. **Table 5.2** provides a statistical summary of DO observations at each station, and **Appendix B** contains historical DO, CHLAC, TN, TP, and BOD5 available observations from sampling sites in WBID 2589. **Figure 5.2** displays the historical observations of DO over time. DO exceedance rates by station range between 3 and 100 percent. A linear regression of DO versus sampling date in **Figure 5.2** was significant at an alpha (α) level of 0.05 (R^2 = 0.0244). **Appendix E** contains plots of DO by season, station, and year.

Figures 5.3 through **5.6** present historical CHLAC, TN, TP, and BOD5 observations, respectively. Linear regressions of each parameter versus sampling date indicate that the regression for BOD was significant at an α level of 0.05. Note that the datasets for CHLAC and BOD are small and sampling has not occurred uniformly over time. **Appendix E** contains additional plots by season, station, and year. **Table 5.3** presents a statistical summary of major water quality parameters from the available data.

Table 5.1. Sampling Station Summary for Sixteen Mile Creek (WBID 2589)

Station	STORET ID	Station Owner	Years With Data	N
Sixteen Creek at Deep Cr Blvd/Ashley St.	21FLA 20030688	Department	2002	10
Sixteen Mile Creek at SR 13	21FLSJWMSXC	SJRWMD	1987–90	23
Deep Creek Headwaters	21FLSJWMDCH	SJRWMD	1993–99	56
Drainage Ditch @ Deep Creek Rd East	21FLSJWMDCRDE	SJRWMD	2000–07	32
Drainage Ditch @ Deep Creek Rd West	21FLSJWMDCRDW	SJRWMD	2000–07	36
16 Mile Creek at Deep Crk Rd W	21FLSJWM16MCRK	SJRWMD	1999–2008	88
SJ2-SS-2043 Sixteen Mile Creek	21FLGW 27945	Department	2005	2

Figure 5.1. Historical Sampling Sites in Sixteen Mile Creek (WBID 2589)

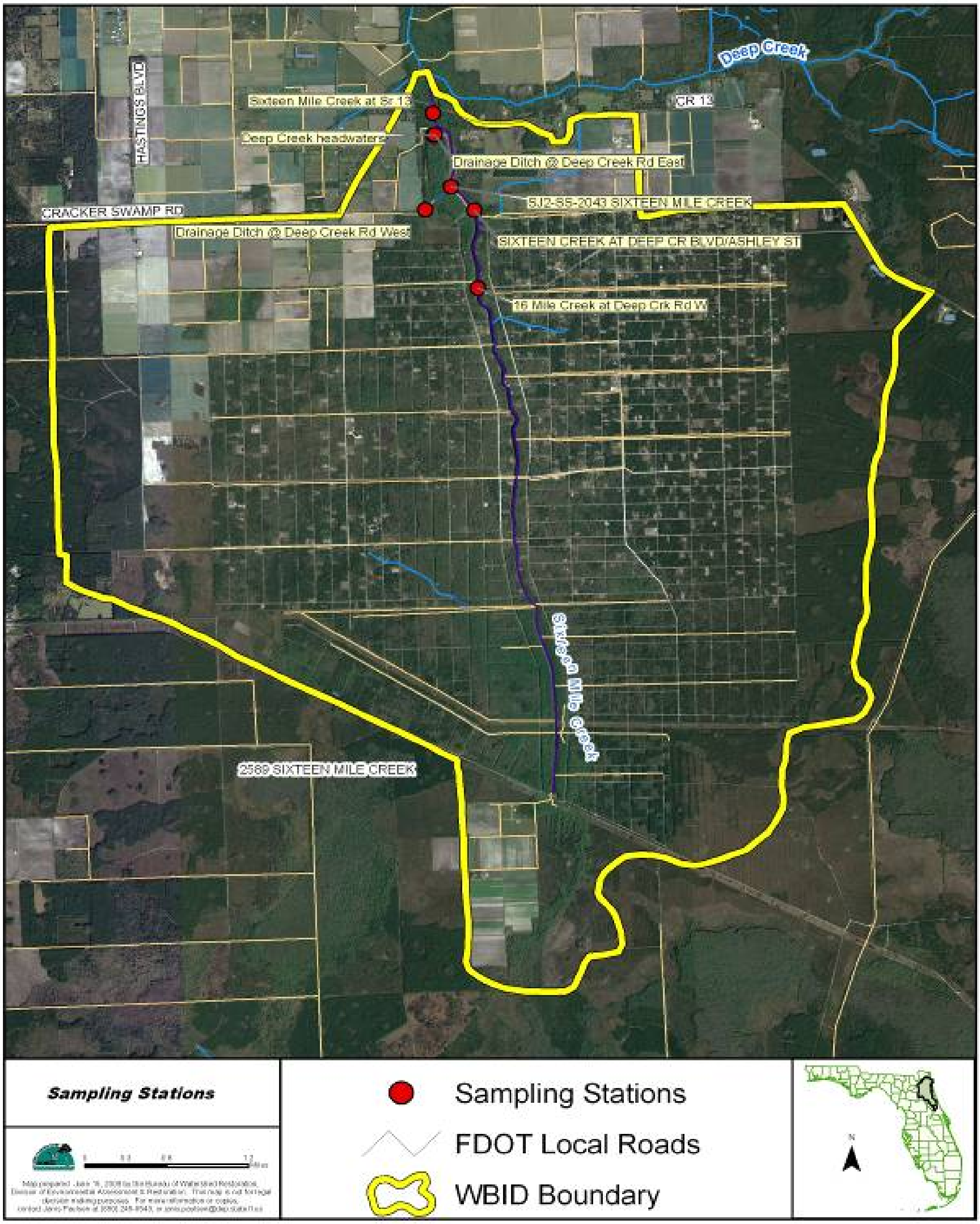


Table 5.2. Statistical Summary of Historical DO Data for Sixteen Mile Creek (WBID 2589)

DO concentrations are mg/L.

Station	N	Minimum	Maximum	Median	Mean	Exceedances	% Exceedances
Sixteen Creek at Deep Cr Blvd/Ashley St.	10	2.2	7.7	5.80	5.31	3	30.00
Sixteen Mile Creek at SR 13	23	0.7	12	5.60	6.10	10	43.48
Deep Creek Headwaters	56	1.71	11	5.34	5.89	23	41.07
Drainage Ditch @ Deep Creek Rd East	32	1.18	12.05	6.72	6.76	11	34.38
Drainage Ditch @ Deep Creek Rd West	36	4.35	12.98	8.16	8.32	1	2.78
16 Mile Creek at Deep Crk Rd W	88	0.53	13.81	7.55	7.05	21	23.86
SJ2-SS-2043 Sixteen Mile Creek	2	4.24	4.29	4.27	4.27	2	100.00

Figure 5.2. Historical DO Observations for Sixteen Mile Creek (WBID 2589)

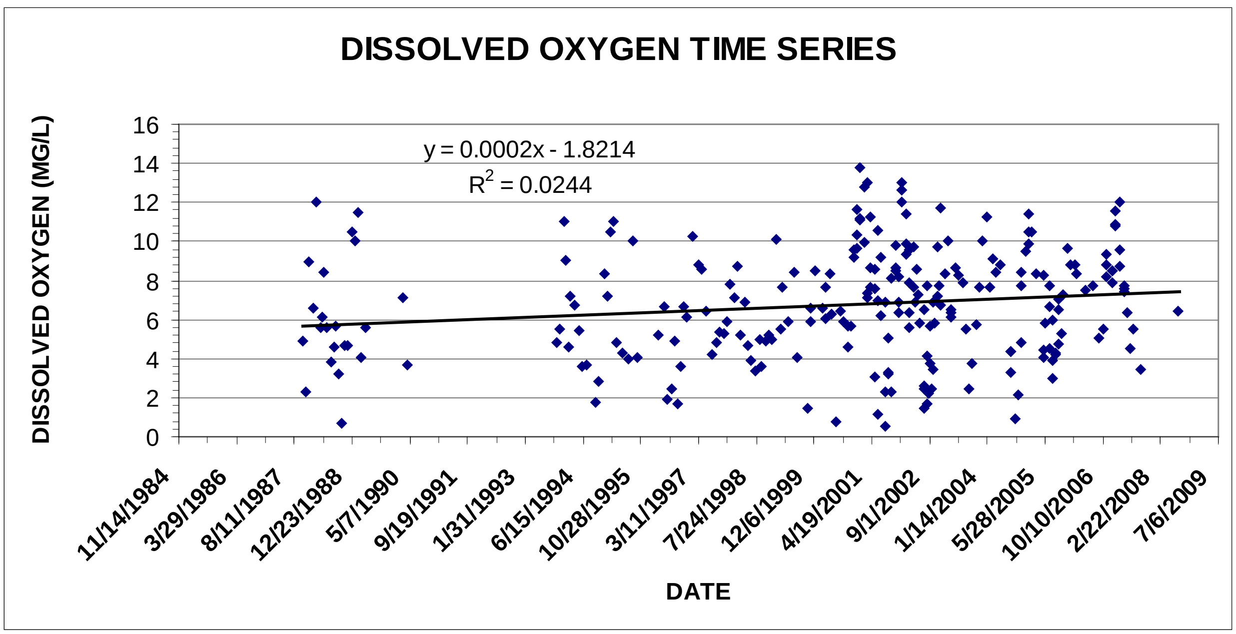


Figure 5.3. Historical CHLAC Observations for Sixteen Mile Creek (WBID 2589)

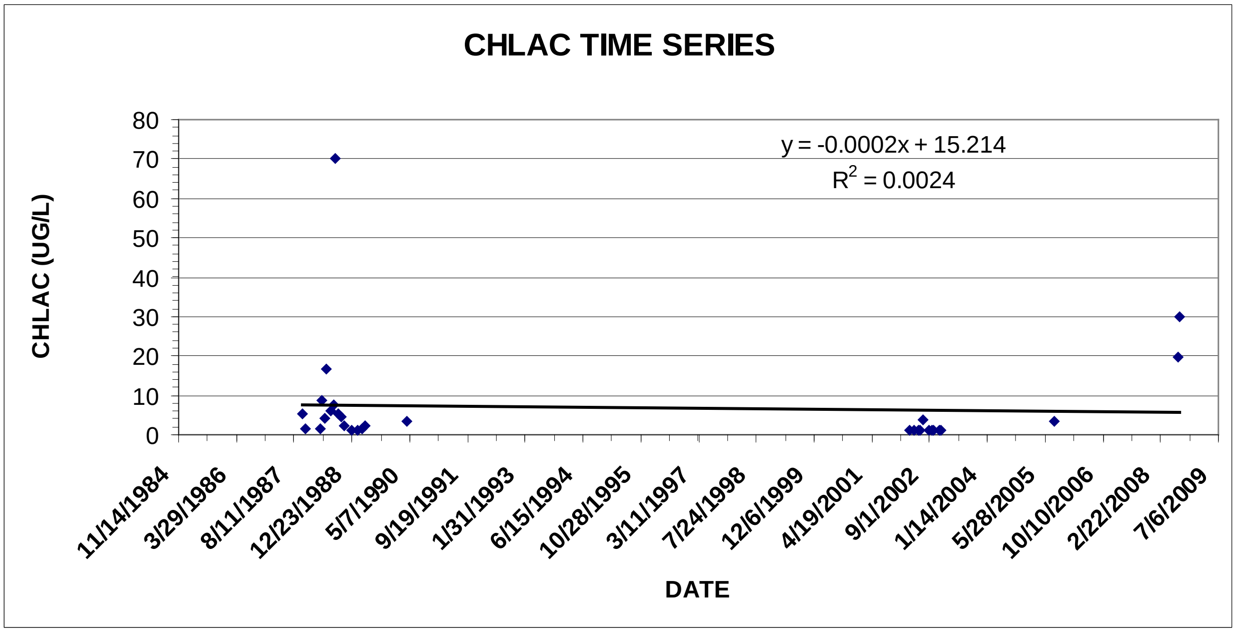


Figure 5.4. Historical TN Observations for Sixteen Mile Creek (WBID 2589)

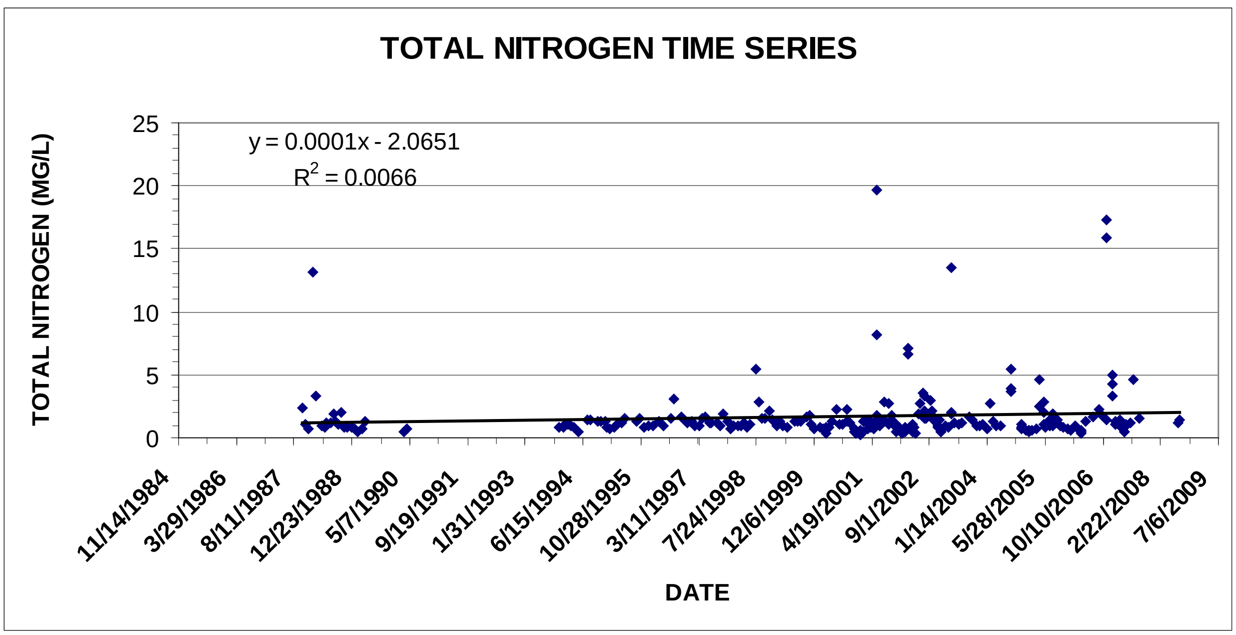


Figure 5.5. Historical TP Observations for Sixteen Mile Creek (WBID 2589)

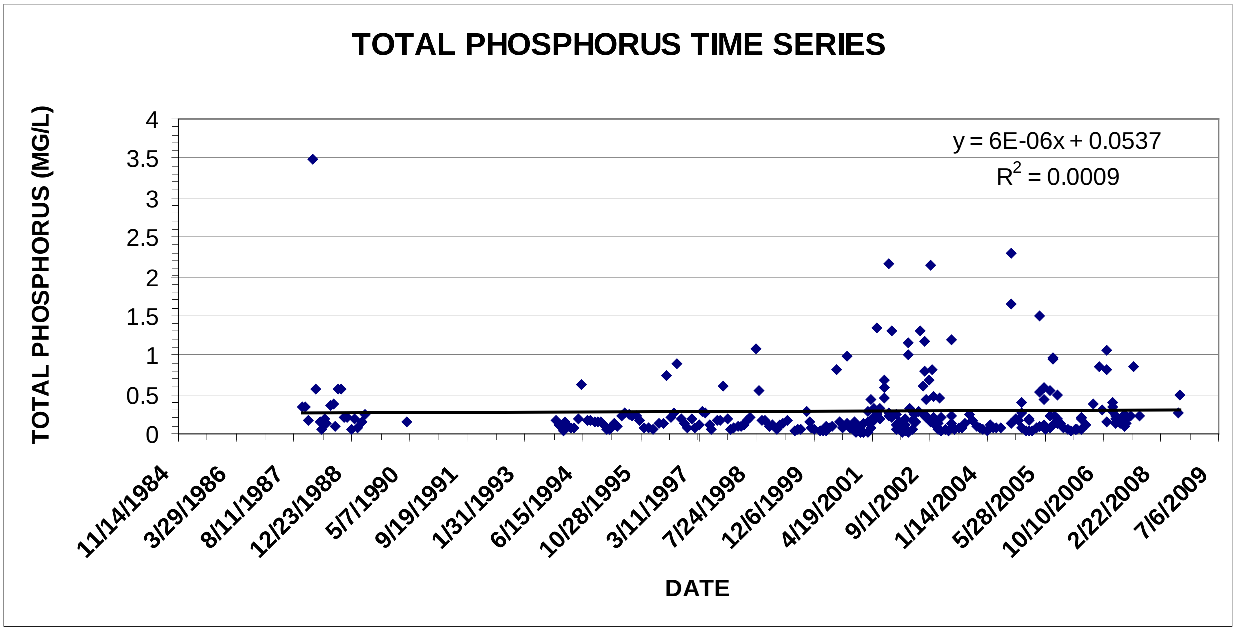


Figure 5.6. Historical BOD5 Observations for Sixteen Mile Creek (WBID 2589)

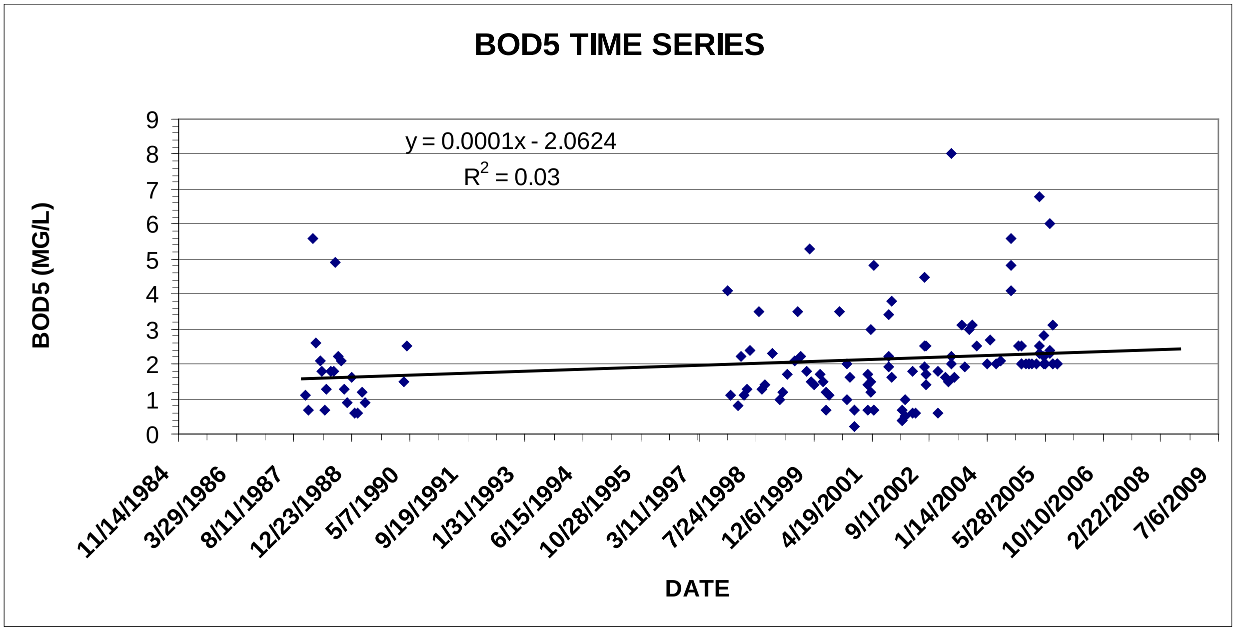


Table 5.3. Summary Statistics for Major Water Quality Parameters Measured in Sixteen Mile Creek (WBID 2589)

PARM	N	MIN	25%	MEDIAN	MEAN	75%	MAX
BOD (mg/L)	129	0.2	1.3	2	2.1	2.4	8
CHLAC µg/L)	30	1	1	2.3	7	5.3	70
CHLORIDE (mg/L)	254	7.4	51.3	102.9	179	292.1	836
COLOR (PCU)	206	10	30	60	123	150	800
COND (µS/cm)	254	87	446	742	1116	1830	3480
DO (mg/L)	247	0.05	4.71	6.64	6.75	8.65	13.81
DOSAT (%)	247	6.83	56.68	77.24	75.57	96.12	149.99
NH4 (mg/L)	256	0.00	0.02	0.04	0.19	0.08	8.35
NO302 (mg/L)	255	0.01	0.02	0.07	0.41	0.24	10.91
PH (su)	253	5.80	7.01	7.36	7.36	7.69	9.01
SO4 (mg/L)	251	2.00	26.87	78.00	173.74	293.48	747.06
TEMP (C)	259	7.2	17.36	22.5	22.05	26.61	35.06
TKN (mg/L)	260	0.19	0.73	1.05	1.27	1.42	14.3
TN (mg/L)	251	0.28	0.82	1.1	1.67	1.56	19.61
TOC (mg/L)	238	1.20	11.59	15.68	17.72	23.59	56.50
TP (mg/L)	263	0.010	0.082	0.162	0.289	0.272	3.497
TSS (mg/L)	249	1	5	7	13	12	270
TURB (NTU)	252	1	4	7	11	10	304

Available DO measurements were also summarized by year (**Table 5.4**) and by season (**Table 5.5**). **Tables 5.6a** through **5.6f** provide a statistical summary of DO, TEMP, TN, TP, BOD5, and CHLAC observations at each station in Sixteen Mile Creek. A nonparametric test (Kruskal-Wallis) was applied to the DO, DOSAT, CHLAC, TN, TP, and BOD5 datasets to determine whether there were significant difference among seasons (**Appendix C**). At an α level of 0.05, differences were significant among seasons for DO and TN. A similar test for differences among months was significant for DO, DOSAT, and TN (**Appendix D**).

Table 5.4. Statistical Summary of Historical DO Data by Year for Sixteen Mile Creek (WBID 2589)

DO concentrations are mg/L.
- = Empty cell/no data

Year	N	Minimum	Maximum	Median	Mean	Exceedances	% Exceedances
1987	3	2.3	8.95	4.90	5.38	2	66.67
1988	14	0.7	12	5.60	5.87	6	42.86
1989	4	4.05	11.5	7.80	7.79	1	25.00
1990	2	3.7	7.1	5.40	5.40	1	50.00
1993	3	4.8	11	5.50	7.10	1	33.33
1994	10	1.79	9	5.00	5.33	5	50.00
1995	8	4	11	6.03	6.98	4	50.00
1996	9	1.71	6.67	4.93	4.36	5	55.56
1997	10	4.22	10.25	6.15	6.75	2	20.00
1998	12	3.34	8.73	4.99	5.31	6	50.00
1999	10	1.43	10.13	6.28	6.41	2	20.00
2000	16	0.78	11.62	6.48	7.15	2	12.50
2001	33	0.53	13.81	7.65	7.49	7	21.21
2002	35	1.49	12.98	6.90	6.96	9	25.71
2003	14	2.43	10.04	7.09	6.95	2	14.29
2004	14	0.95	11.28	7.72	6.49	6	42.86
2005	23	2.95	11.41	6.51	6.69	8	34.78
2006	10	5.08	9.35	8.25	7.81	0	0.00
2007	16	3.41	12.05	8.22	8.19	2	12.50
2008	1	6.4	6.4	-	6.40	0	0.00

Table 5.5. Statistical Summary of Historical DO Data by Season for Sixteen Mile Creek (WBID 2589)

DO concentrations are mg/L.

Season	N	Minimum	Maximum	Median	Mean	Exceedances	% Exceedances
Winter	68	4.05	13.81	8.83	8.99	2	2.94
Spring	53	0.78	11.22	6.90	6.46	14	26.42
Summer	65	0.53	10.03	4.29	4.44	41	63.08
Fall	61	1.43	11.74	6.92	6.98	14	22.95

Table 5.6a. Seasonal Summary Statistics for DO for Sixteen Mile Creek (WBID 2589)

DO concentrations are mg/L.

Season	N	Minimum	5%	25%	Median	Mean	75%	Maximum
Winter	68	4.05	5.49	7.18	8.83	8.99	10.82	13.81
Spring	53	0.78	2.06	4.81	6.90	6.46	8.28	11.22
Summer	65	0.53	1.36	3.22	4.29	4.44	5.68	10.03
Fall	61	1.43	2.29	5.27	6.92	6.98	8.82	11.74

Table 5.6b. Seasonal Summary Statistics for TEMP for Sixteen Mile Creek (WBID 2589)

TEMP is ° C.

Season	N	Minimum	5%	25%	Median	Mean	75%	Maximum
Winter	69	7.20	10.45	14.49	16.65	16.73	19.33	24.51
Spring	60	16.48	17.16	21.06	23.71	23.99	27.33	32.20
Summer	67	21.61	24.70	26.28	27.34	27.82	29.35	35.06
Fall	63	9.00	11.41	17.00	20.63	19.90	23.15	27.49

Table 5.6c. Seasonal Summary Statistics for TN for Sixteen Mile Creek (WBID 2589)

TN concentrations are mg/L.

Season	N	Minimum	5%	25%	Median	Mean	75%	Maximum
Winter	71	0.28	0.33	0.66	0.90	1.58	1.20	13.55
Spring	58	0.34	0.42	0.84	1.08	1.65	1.35	19.61
Summer	60	0.91	0.99	1.24	1.53	1.91	2.16	5.44
Fall	62	0.35	0.49	0.76	1.01	1.58	1.43	17.28

Table 5.6d. Seasonal Summary Statistics for TP for Sixteen Mile Creek (WBID 2589)

TP concentrations are mg/L.

Season	N	Minimum	5%	25%	Median	Mean	75%	Maximum
Winter	71	0.010	0.016	0.055	0.096	0.210	0.163	3.497
Spring	61	0.045	0.049	0.103	0.176	0.270	0.260	1.507
Summer	67	0.058	0.067	0.176	0.244	0.478	0.598	2.286
Fall	64	0.016	0.037	0.075	0.140	0.198	0.206	1.300

Table 5.6e. Seasonal Summary Statistics for BOD5 for Sixteen Mile Creek (WBID 2589)

BOD5 concentrations are mg/L.

Season	N	Minimum	5%	25%	Median	Mean	75%	Maximum
Winter	36	0.4	0.4	0.8	1.5	1.7	2.0	8.0
Spring	32	0.6	0.6	1.2	1.8	2.0	2.4	6.8
Summer	35	1.0	1.3	2.0	2.2	2.8	3.5	6.0
Fall	26	0.2	0.5	1.1	1.6	1.9	2.3	5.3

Table 5.6f. Seasonal Summary Statistics for CHLAC for Sixteen Mile Creek (WBID 2589)

CHLAC concentrations are µg/L.

Season	N	Minimum	5%	25%	Median	Mean	75%	Maximum
Winter	4	1.0	1.0	1.0	1.2	1.2	1.5	1.6
Spring	9	1.0	1.0	1.0	3.5	4.9	6.6	16.8
Summer	10	1.0	1.0	3.6	4.9	14.6	19.6	70.0
Fall	7	1.0	1.0	1.0	1.0	1.9	2.1	5.3

5.1.2 TMDL Development Process

A Spearman correlation matrix was used to assess potential relationships between DO and other water quality parameters (**Appendix G**). At an alpha (α) level of 0.05, correlations between DO and SO_4, and water temperature (TEMP) were significant. A simple linear regression of DO versus TEMP explained 55 percent of the variance in DO (**Appendix H**).

In order to determine the influence of nutrients on DO without the confounding effects of water temperature on all these variables, the general linear model (GLM) was used to develop an expression that included TEMP, TN, and TP. Based on 232 cases with DO, TN, TP, and TEMP observations, the following expression was significant at an α level of 0.05 and explained 44 percent of the variance in DO:

DO = 13.418 – 0.267*TEMP – 4.796*TP + 0.395*TN + 0.115*TP*TEMP + 0.189*TN*TP - 0.024*TN*TEMP

Since DO is influenced by water temperature and the Kruskal-Wallis test indicated significant differences among seasons for both DO and TN, the TMDL was developed using the summer average TN, TP, and TEMP values (**Tables 5.6b** through **5.6d**).

Since the adopted nutrient TMDL for the Lower St. Johns River requires a 30 percent reduction in anthropogenic nitrogen and phosphorus loads to the freshwater portion of the river, the GLM model for DO was used to estimate the DO concentration under the average summer TEMP following a 30 percent reduction in TN and TP. At the summer average TEMP of 27.82 ^oC, a reduction of TN from 1.91 to 1.34 mg/L and a reduction in TP from 0.478 to 0.335 mg/L resulted in a predicted DO concentration of 5.20 mg/L compared with the historical summer average of 4.44 mg/L. Under the 30 percent reduction of TN and TP, the predicted minimum summer DO improved from 0.53 to 2.83 mg/L. Similarly, the 25th percentile for summer DO was predicted to increase from 3.26 to 4.80 mg/L (**Figure 5.7**).

The GLM was also applied to a subset of observations that had paired TEMP, TN, and TP observations (243 cases). The cumulative frequency plot of predicted DO concentrations following a 30 percent reduction in the paired TN and TP observations indicated a significant improvement in DO (**Figure 5.8**). Less than 10 percent of the DO concentrations were predicted to be below 5.0 mg/L compared with nearly 30 percent under existing conditions.

Although the DO GLM predicted that the minimum DO would be below the Class III freshwater criterion of 5.0 mg/L at times, reductions in BOD will have indirect benefits to DO levels such as reducing the sediment oxygen demand. A simple linear regression between BOD and DO explained 10 percent of the variance in DO (p=0.000). Reductions in TN and TP also reduce BOD. A GLM using TN and TP explained 53 percent of the variance in BOD (p=0.000), and reductions in both TN and TP would lower the BOD. In addition, over 30 percent of the watershed area consists of natural land use categories (forests, water, and wetlands). Finally, there was a positive trend in DO observations based on the period of record (**Figure 5.2**). These TMDLs are not expected to cause an imbalance in the natural populations of flora and fauna nor cause nuisance conditions that depress DO below natural levels.

5.1.3 Critical Conditions/Seasonality

A nonparametric test (Kruskal-Wallis) was applied to the DO, DOSAT, CHLAC, TN, and TP datasets to determine whether there were significant differences among months or seasons. At an alpha (α) level of 0.05, there were significant differences among seasons or months for DO, DOSAT, TN, TP, and TP (**Appendices C** and **D**). As seen in **Table 5.6a**, the lowest DO concentrations occurred during the summer season. The highest CHLAC levels were also observed during the summer season (**Table 5.6f**). Consequently, the TMDL evaluated the DO response to TN and TP reductions under the average TEMP and nutrient concentrations reported during the summer period. Reductions in TN and TP concentrations were predicted to also improve DO concentrations throughout the rest of the year.

Figure 5.7. Cumulative Frequency Plot of Historical Summer DO Observations for Sixteen Mile Creek versus GLM-Predicted Concentrations with a 30 Percent Reduction in TN and TP

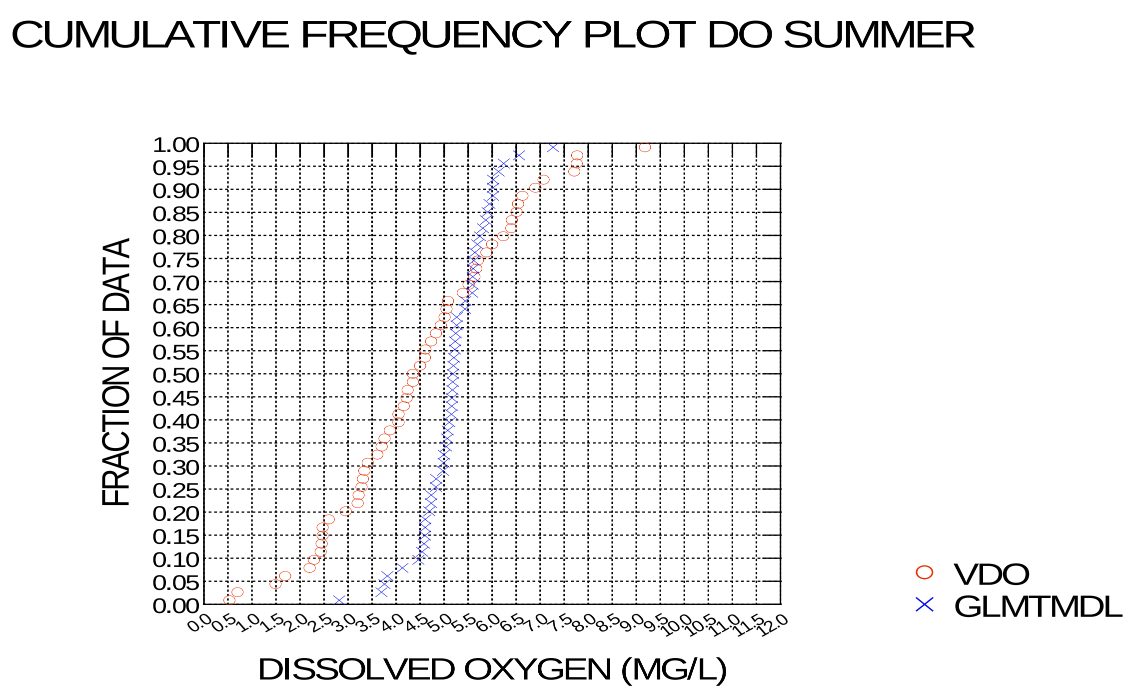


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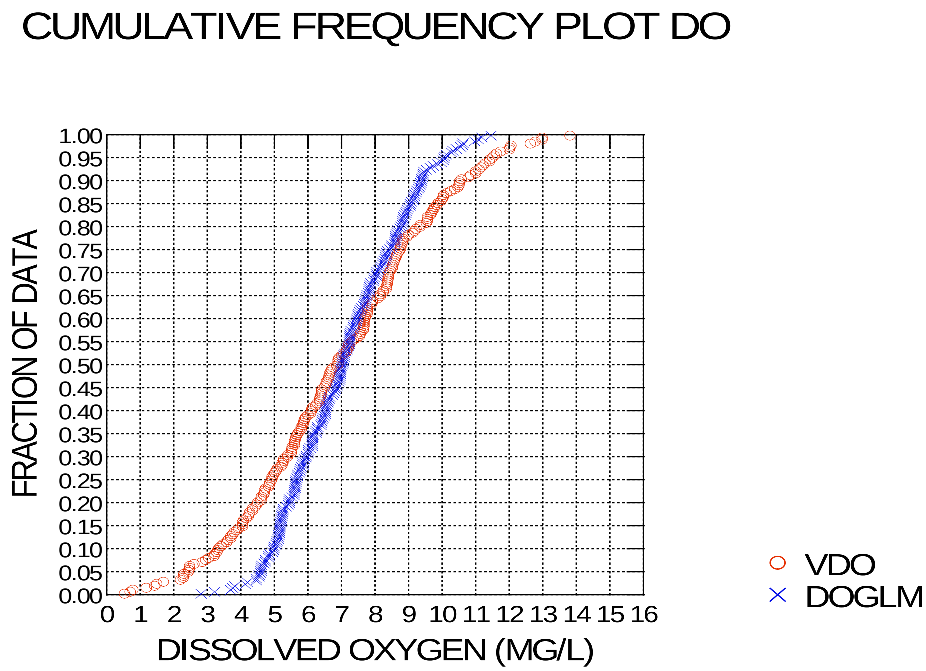
Figure 5.8. Cumulative Frequency Plot of Historical DO Observations for Sixteen Mile Creek versus GLM-Predicted Concentrations with a 30 Percent Reduction in TN and TP



Chapter 6: DETERMINATION OF THE TMDL

6.1 Expression and Allocation of the TMDL

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

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

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

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

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

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

This approach is consistent with federal regulations (40 CFR § 130.2[I]), which state that TMDLs can be expressed in terms of mass per time (e.g., pounds per day), toxicity, or **other appropriate measure**. The TMDLs for Sixteen Mile Creek are expressed in terms of a percent reduction in TN and TP, to meet both the DO and nutrient criteria (**Table 6.1**).

Table 6.1. TMDL Components for Sixteen Mile Creek (WBID 2589)

- = Empty cell/no data
NA = Not applicable
[1] As the TMDL represents a percent reduction, it also complies with EPA requirements to express the TMDL on a daily basis.

WBID	Parameter	TMDL (mg/L)	WLA for Wastewater (mg/L)	WLA for NPDES Stormwater (% reduction)[1]	LA (% reduction)[1]	MOS
2589	TN	-	NA	30%	30%	Implicit
2589	TP	-	NA	30%	30%	Implicit

6.2 Load Allocation

TN and TP reductions of 30 percent are required from nonpoint sources. It should be noted that the load allocation includes loading from stormwater discharges that are not part of the NPDES Stormwater Program.

6.3 Wasteload Allocation

6.3.1 NPDES Wastewater Discharges

There are currently no permitted NPDES discharges in the Sixteen Mile Creek watershed; however, any future discharge permits issued in the watershed will also be required to meet the state's Class III criterion for DO and contain appropriate discharge limitations on nitrogen and phosphorus that will comply with the TMDL.

6.3.2 NPDES Stormwater Discharges

St. Johns County (FLR04E025) has a Phase II MS4 permit that may include portions of the Sixteen Mile Creek watershed and would be responsible for a 30 percent reduction in current anthropogenic TN and TP loading. It should be noted that any MS4 permittee is only responsible for reducing the loads associated with stormwater outfalls that it owns or otherwise has responsible control over, and it is not responsible for reducing other nonpoint source loads in its jurisdiction.

6.4 Margin of Safety

Consistent with the recommendations of the Allocation Technical Advisory Committee (Department, 2001), an implicit MOS was used in the development of this TMDL by applying the average summer TEMP (27.82 ^{o}C) and nutrient concentrations (TN = 1.91 mg/L; TP = 0.478 mg/L), rather than the average TEMP (22.05 ^{o}C) and nutrient concentrations (TN = 1.67 mg/L; TP = 0.289 mg/L). The DO GLM was also applied to the historical dataset to predict improvements in the overall DO distribution.

Chapter 7: NEXT STEPS: IMPLEMENTATION PLAN DEVELOPMENT AND BEYOND

7.1 Basin Management Action Plan

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

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

- *Water quality goals (based directly on the TMDL);*
- *Refined source identification;*
- *Load reduction requirements for stakeholders (quantitative detailed allocations, if technically feasible);*
- *A description of the load reduction activities to be undertaken, including structural projects, nonstructural BMPs, and public education and outreach;*
- *A description of further research, data collection, or source identification needed in order to achieve the TMDL;*
- *Timetables for implementation;*
- *Implementation funding mechanisms;*
- *An evaluation of future increases in pollutant loading due to population growth;*
- *Implementation milestones, project tracking, water quality monitoring, and adaptive management procedures; and*
- *Stakeholder statements of commitment (typically a local government resolution).*

BMAPs are updated through annual meetings and may be officially revised every five years. Completed BMAPs in the state have improved communication and cooperation among local stakeholders and state agencies; improved internal communication within local governments;

applied high-quality science and local information in managing water resources; clarified the obligations of wastewater point source, MS4, and non-MS4 stakeholders in TMDL implementation; enhanced transparency in the Department's decision making; and built strong relationships between the Department and local stakeholders that have benefited other program areas.

7.2 Other TMDL Implementation Tools

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

A multitude of assessment tools is available to assist local governments and interested stakeholders in this detective work. The tools range from the simple (such as Walk the WBIDs and GIS mapping) to the complex (such as bacteria source tracking). Department staff will provide technical assistance, guidance, and oversight of local efforts to identify and minimize fecal coliform sources of pollution. Based on work in the Lower St Johns River tributaries and the Hillsborough Basin, the Department and local stakeholders have developed a logical process and tools to serve as a foundation for this detective work. In the near future, the Department will be releasing these tools to assist local stakeholders with the development of local implementation plans to address fecal coliform impairments. In such cases, the Department will rely on these local initiatives as a more cost-effective and simplified approach to identify the actions needed to put in place a road map for restoration activities, while still meeting the requirements of Subsection 403.067(7), F.S.

Earlier in the document, reference was made to the BMAP adopted in October 2008 that outlined implementation activities in the freshwater portion of the Lower St. Johns River to achieve the nutrient TMDL. Since Sixteen Mile Creek represents a contributing watershed to the Lower St. Johns, applicable activities undertaken in the Sixteen Mile Creek watershed as part of the Lower St. Johns River BMAP should be sufficient to address the DO and nutrient impairment in Sixteen Mile Creek.

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Appendices

Appendix A: Background Information on Federal and State Stormwater Programs

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

Rule 62-40, F.A.C., also requires the state's water management districts to establish stormwater Pollutant Load Reduction Goals (PLRGs) and adopt them as part of a Surface Water Improvement and Management (SWIM) plan, other watershed plan, or rule. Stormwater PLRGs are a major component of the load allocation part of a TMDL. To date, stormwater PLRGs have been established for Tampa Bay, Lake Thonotosassa, the Winter Haven Chain of Lakes, the Everglades, Lake Okeechobee, and Lake Apopka.

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

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

Appendix B: Historical DO, CHLAC, BOD5, TN, and TP Observations in Sixteen Mile Creek (WBID 2589), 1992–2008

- = Empty cell/no data

Station	Sample Date	DO (mg/L)	CHLAC (µg/L)	BOD5 (mg/L)	TN (mg/L)	TP (mg/L)
FLSJWMSXC	10/22/1987	4.9	5.34	-	2.315	0.333
FLSJWMSXC	11/17/1987	2.3	1.39	1.1	1.106	0.333
FLSJWMSXC	12/17/1987	8.95	-	0.7	0.711	0.176
FLSJWMSXC	1/21/1988	6.6	-	5.6	13.094	3.497
FLSJWMSXC	2/17/1988	12	-	2.6	3.321	0.578
FLSJWMSXC	3/22/1988	5.6	1.33	2.1	-	0.145
FLSJWMSXC	4/4/1988	6.1	8.82	1.8	0.95	0.048
FLSJWMSXC	4/26/1988	8.4	4.15	0.7	0.813	0.189
FLSJWMSXC	5/18/1988	5.6	16.83	1.3	1.159	0.141
FLSJWMSXC	6/29/1988	3.8	5.88	1.8	1.24	0.357
FLSJWMSXC	7/18/1988	4.6	7.48	1.8	1.943	0.374
FLSJWMSXC	8/4/1988	5.7	70.03	4.9	1.255	0.098
FLSJWMSXC	8/23/1988	3.2	5.34	2.2	1.012	0.576
FLSJWMSXC	9/19/1988	0.7	4.54	2.1	1.981	0.568
FLSJWMSXC	10/20/1988	4.7	2.4	1.3	0.822	0.202
FLSJWMSXC	11/14/1988	4.7	-	0.9	0.788	0.217
FLSJWMSXC	12/19/1988	10.5	1	1.6	0.796	0.058
FLSJWMSXC	1/18/1989	10	-	0.6	0.665	0.183
FLSJWMSXC	2/13/1989	11.5	1	0.6	0.515	0.078
FLSJWMSXC	3/15/1989	4.05	1.6	1.2	0.735	0.152
FLSJWMSXC	4/19/1989	5.6	2.13	0.9	1.351	0.239
FLSJWMSXC	3/13/1990	7.1	-	1.5	0.432	-
FLSJWMSXC	4/11/1990	3.7	3.47	2.5	0.752	0.152
FLSJWMDCH	10/26/1993	4.8	-	-	-	0.168
FLSJWMDCH	11/23/1993	5.5	-	-	0.849	0.108
FLSJWMDCH	12/28/1993	11	-	-	0.875	0.042
FLSJWMDCH	1/11/1994	9	-	-	1.05	0.154
FLSJWMDCH	2/8/1994	4.6	-	-	1.045	0.096
FLSJWMDCH	3/1/1994	7.2	-	-	0.975	0.082
FLSJWMDCH	3/29/1994	6.75	-	-	0.833	0.081
FLSJWMDCH	5/10/1994	5.4	-	-	0.512	0.186
FLSJWMDCH	6/7/1994	3.6	-	-	-	0.62
FLSJWMDCH	7/21/1994	3.7	-	-	1.41	0.18
FLSJWMDCH	8/18/1994	-	-	-	1.468	0.18
FLSJWMDCH	9/30/1994	1.79	-	-	-	0.156
FLSJWMDCH	10/26/1994	2.85	-	-	1.323	0.144
FLSJWMDCH	11/22/1994	-	-	-	1.253	0.146
FLSJWMDCH	12/21/1994	8.36	-	-	1.305	0.101
FLSJWMDCH	1/10/1995	7.21	-	-	0.775	0.065
FLSJWMDCH	2/7/1995	10.47	-	-	0.703	0.055
FLSJWMDCH	3/7/1995	11	-	-	0.856	0.133

Station	Sample Date	DO (mg/L)	CHLAC (μg/L)	BOD5 (mg/L)	TN (mg/L)	TP (mg/L)
FLSJWMDCH	4/5/1995	4.85	-	-	1.065	0.1
FLSJWMDCH	5/16/1995	4.26	-	-	1.232	0.219
FLSJWMDCH	6/13/1995	-	-	-	1.59	0.26
FLSJWMDCH	7/18/1995	4	-	-	-	0.244
FLSJWMDCH	8/15/1995	10.03	-	-	-	0.234
FLSJWMDCH	9/26/1995	4.05	-	-	1.344	0.229
FLSJWMDCH	10/24/1995	-	-	-	1.497	0.177
FLSJWMDCH	11/21/1995	-	-	-	0.873	0.075
FLSJWMDCH	1/9/1996	-	-	-	0.996	0.073
FLSJWMDCH	2/6/1996	-	-	-	0.967	0.054
FLSJWMDCH	4/2/1996	5.23	-	-	1.335	0.135
FLSJWMDCH	5/14/1996	6.64	-	-	0.918	0.142
FLSJWMDCH	6/11/1996	1.89	-	-	-	0.732
FLSJWMDCH	7/16/1996	2.47	-	-	1.539	0.209
FLSJWMDCH	8/13/1996	4.93	-	-	3.09	0.273
FLSJWMDCH	9/10/1996	1.71	-	-	-	0.883
FLSJWMDCH	10/9/1996	3.58	-	-	1.611	0.188
FLSJWMDCH	11/5/1996	6.67	-	-	1.372	0.124
FLSJWMDCH	12/3/1996	6.11	-	-	1.2	0.079
FLSJWMDCH	1/14/1997	10.25	-	-	1.251	0.182
FLSJWMDCH	2/11/1997	-	-	-	0.987	0.072
FLSJWMDCH	3/11/1997	8.83	-	-	0.944	0.107
FLSJWMDCH	4/8/1997	8.6	-	-	1.564	0.288
FLSJWMDCH	5/14/1997	6.4	-	-	1.643	0.261
FLSJWMDCH	6/10/1997	-	-	-	1.188	0.114
FLSJWMDCH	7/1/1997	4.22	-	-	1.196	0.058
FLSJWMDCH	8/19/1997	4.83	-	-	1.221	0.177
FLSJWMDCH	9/9/1997	5.39	-	-	0.909	0.172
FLSJWMDCH	10/14/1997	5.28	-	-	1.908	0.601
FLSJWMDCH	11/14/1997	5.9	-	4.1	1.296	0.181
FLSJWMDCH	12/9/1997	7.78	-	1.1	0.662	0.053
FLSJWMDCH	1/13/1998	7.15	-	-	1.007	0.085
FLSJWMDCH	2/10/1998	8.73	-	0.8	1.004	0.096
FLSJWMDCH	3/10/1998	5.19	-	2.2	0.944	0.094
FLSJWMDCH	4/14/1998	6.9	-	1.1	1.163	0.108
FLSJWMDCH	5/11/1998	4.68	-	1.3	0.842	0.176
FLSJWMDCH	6/1/1998	3.93	-	2.4	1.009	0.205
FLSJWMDCH	7/17/1998	3.34	-	-	5.441	1.085
FLSJWMDCH	8/21/1998	5.01	-	3.5	2.899	0.545
FLSJWMDCH	9/9/1998	3.61	-	1.3	1.514	0.165
FLSJWMDCH	10/13/1998	4.93	-	1.4	1.538	0.17
FLSJWMDCH	11/11/1998	5.23	-	-	2.186	0.098
FLSJWMDCH	12/8/1998	4.97	-	2.3	1.415	0.105
FLSJWMDCH	1/13/1999	10.13	-	-	0.925	0.066
FLSJWMDCH	2/15/1999	5.52	-	1	1.249	0.119
FLSJWMDCH	3/10/1999	7.67	-	1.2	1.002	0.132

Station	Sample Date	DO (mg/L)	CHLAC (µg/L)	BOD5 (mg/L)	TN (mg/L)	TP (mg/L)
FLSJWMDCH	4/23/1999	5.93	-	1.7	0.821	0.175
FLSJWM16MCRK	6/22/1999	8.39	-	2.1	1.327	0.045
FLSJWM16MCRK	7/16/1999	4.05	-	3.5	1.307	0.064
FLSJWM16MCRK	8/11/1999	-	-	2.2	1.257	0.066
FLSJWM16MCRK	10/5/1999	1.43	-	1.8	1.633	0.285
FLSJWM16MCRK	11/1/1999	5.87	-	5.3	1.788	0.161
FLSJWM16MCRK	11/9/1999	6.62	-	1.5	1.101	0.081
FLSJWM16MCRK	12/13/1999	8.46	-	1.4	0.755	0.051
FLSJWM16MCRK	1/21/2000	-	-	1.7	0.8	0.045
FLSJWM16MCRK	2/17/2000	6.55	-	1.5	0.66	0.03
FLSJWM16MCRK	3/13/2000	6.08	-	1.2	0.873	0.042
FLSJWMDCRDW	3/13/2000	7.67	-	0.7	0.395	0.102
FLSJWM16MCRK	4/17/2000	8.38	-	1.1	0.813	0.081
FLSJWM16MCRK	5/10/2000	6.27	-	-	1.285	0.091
FLSJWM16MCRK	6/19/2000	0.78	-	-	2.235	0.813
FLSJWM16MCRK	7/17/2000	6.41	-	3.5	1.09	0.145
FLSJWM16MCRK	8/14/2000	5.88	-	-	1.085	0.067
FLSJWM16MCRK	9/20/2000	5.67	-	1	1.352	0.125
FLSJWMDCRDE	9/20/2000	4.61	-	2	2.277	0.983
FLSJWM16MCRK	10/16/2000	5.64	-	1.6	1.176	0.074
FLSJWM16MCRK	11/20/2000	9.22	-	0.7	0.716	0.03
FLSJWMDCRDE	11/20/2000	9.56	-	0.2	0.505	0.154
FLSJWM16MCRK	12/7/2000	11.62	-	-	0.624	0.016
FLSJWMDCRDE	12/7/2000	9.68	-	-	0.351	0.092
FLSJWMDCRDW	12/7/2000	10.37	-	-	0.383	0.114
FLSJWM16MCRK	1/11/2001	13.81	-	-	0.568	0.01
FLSJWMDCRDE	1/11/2001	11.16	-	-	0.326	0.096
FLSJWMDCRDW	1/11/2001	11.1	-	-	0.278	0.059
FLSJWM16MCRK	2/8/2001	12.77	-	-	0.527	0.016
FLSJWMDCRDW	2/8/2001	9.96	-	-	1.289	0.128
FLSJWM16MCRK	3/15/2001	12.98	-	0.7	0.707	0.01
FLSJWMDCRDE	3/15/2001	7.14	-	1.7	1.4	0.289
FLSJWMDCRDW	3/15/2001	7.35	-	1.4	1.018	0.16
FLSJWM16MCRK	4/4/2001	11.22	-	1.2	1.057	0.072
FLSJWMDCRDE	4/4/2001	7.65	-	3	1.357	0.435
FLSJWMDCRDW	4/4/2001	8.63	-	1.5	0.835	0.175
FLSJWM16MCRK	5/10/2001	3.04	-	4.8	1.217	0.318
FLSJWMDCRDE	5/10/2001	7.58	-	0.7	0.86	0.213
FLSJWMDCRDW	5/10/2001	8.56	-	0.7	0.725	0.162
FLSJWM16MCRK	6/4/2001	10.57	-	-	1.777	0.26
FLSJWMDCRDE	6/4/2001	1.18	-	-	19.61	1.35
FLSJWMDCRDW	6/4/2001	7	-	-	8.149	0.251
FLSJWM16MCRK	7/2/2001	9.18	-	-	1.007	0.195
FLSJWMDCRDE	7/2/2001	6.23	-	-	1.56	0.313
FLSJWM16MCRK	8/9/2001	0.53	-	-	1.307	0.462

Station	Sample Date	DO (mg/L)	CHLAC (μg/L)	BOD5 (mg/L)	TN (mg/L)	TP (mg/L)
FLSJWMDCRDE	8/9/2001	2.29	-	-	1.396	0.676
FLSJWMDCRDW	8/9/2001	6.9	-	-	2.82	0.59
FLSJWM16MCRK	9/6/2001	3.22	-	2.2	1.186	0.256
FLSJWMDCRDE	9/6/2001	3.28	-	1.9	1.03	0.231
FLSJWMDCRDW	9/6/2001	5.05	-	3.4	2.727	2.16
FLSJWM16MCRK	10/2/2001	2.28	-	1.6	1.75	0.209
FLSJWMDCRDW	10/2/2001	8.09	-	3.8	1.387	1.3
FLSJWM16MCRK	11/12/2001	8.68	-	-	1.053	0.054
FLSJWMDCRDE	11/12/2001	8.53	-	-	0.839	0.245
FLSJWMDCRDW	11/12/2001	9.77	-	-	0.524	0.117
FLSJWM16MCRK	12/10/2001	6.36	-	-	0.886	0.054
FLSJWMDCRDE	12/10/2001	6.92	-	-	0.656	0.161
FLSJWMDCRDW	12/10/2001	8.16	-	-	0.633	0.153
FLSJWM16MCRK	1/9/2002	12.63	-	0.7	0.54	0.01
FLSJWMDCRDE	1/9/2002	12.02	-	0.4	0.326	0.074
FLSJWMDCRDW	1/9/2002	12.98	-	0.4	0.319	0.047
FLSJWM16MCRK	2/6/2002	9.88	-	1	0.825	0.044
FLSJWMDCRDE	2/6/2002	9.34	-	0.5	0.523	0.188
FLSJWMDCRDW	2/6/2002	11.42	-	0.5	0.623	0.12
FLSJWM16MCRK	3/4/2002	7.92	-	-	0.768	0.024
FLSJWMDCRDE	3/4/2002	6.35	-	-	6.608	1.009
FLSJWMDCRDW	3/4/2002	9.56	-	-	7.062	1.161
FLA 20030688	3/13/2002	5.6	1	-	0.87	0.32
FLSJWM16MCRK	4/10/2002	9.75	-	1.8	1.05	0.057
FLSJWMDCRDW	4/10/2002	7.67	-	0.6	0.425	0.169
FLA 20030688	4/23/2002	6.9	1		0.84	0.24
FLSJWMDCRDW	5/8/2002	8.57	-	0.6	0.366	0.148
FLA 20030688	5/23/2002	7.3	1	-	-	-
FLA 20030688	5/23/2002	-	-	-	1.86	0.29
FLA 20030688	6/11/2002	-	1	-	-	-
FLA 20030688	6/11/2002	5.8	-	-	2.72	1.3
FLA 20030688	7/10/2002	2.6	3.7	-	3.5	0.6
FLSJWM16MCRK	7/15/2002	1.49	-	1.9	1.576	0.231
FLSJWMDCRDE	7/15/2002	2.45	-	2.5	2.174	0.796
FLSJWMDCRDW	7/15/2002	6.54	-	4.5	3.286	1.184
FLSJWM16MCRK	8/5/2002	1.69	-	1.7	1.591	0.225
FLSJWMDCRDE	8/5/2002	4.16	-	2.5	1.824	0.434
FLSJWMDCRDW	8/5/2002	7.76	-	1.4	1.767	0.209
FLA 20030688	8/21/2002	-	1	-	-	-
FLA 20030688	8/21/2002	2.2	-	-	1.86	0.69
FLSJWM16MCRK	9/5/2002	3.78	-	-	-	0.143
FLSJWMDCRDW	9/5/2002	5.63	-	-	2.9748	2.134
FLA 20030688	9/19/2002	2.47	1	-	2.14	0.82
FLSJWM16MCRK	10/3/2002	3.47	-	-	1.368	0.133

Station	Sample Date	DO (mg/L)	CHLAC (µg/L)	BOD5 (mg/L)	TN (mg/L)	TP (mg/L)
FLSJWMDCRDW	10/3/2002	6.86	-	-	1.55	0.202
FLA 20030688	10/9/2002	5.8	1	-	1.6	0.48
FLSJWM16MCRK	11/7/2002	7.22	-	1.8	0.895	0.063
FLSJWMDCRDW	11/7/2002	9.71	-	0.6	0.794	0.124
FLA 20030688	11/19/2002	7.7	1	-	1.48	0.45
FLSJWM16MCRK	12/4/2002	11.74	-	-	0.532	0.031
FLA 20030688	12/5/2002	6.7	1	-	0.477	0.21
FLSJWM16MCRK	1/14/2003	8.37	-	1.6	0.971	0.053
FLSJWM16MCRK	2/11/2003	10.04	-	1.5	0.783	0.041
FLSJWM16MCRK	3/5/2003	6.14	-	2	1.89	0.136
FLSJWMDCRDE	3/5/2003	6.49	-	2.2	1.987	0.22
FLSJWMDCRDW	3/5/2003	6.38	-	8	13.549	1.196
FLSJWM16MCRK	4/7/2003	8.65	-	1.6	1.15	0.06
FLSJWM16MCRK	5/6/2003	8.25	-	-	1.045	0.081
FLSJWM16MCRK	6/12/2003	7.89	-	3.1	1.223	0.077
FLSJWM16MCRK	7/9/2003	5.5	-	1.9	-	0.132
FLSJWM16MCRK	8/6/2003	2.43	-	3	1.659	0.253
FLSJWM16MCRK	9/4/2003	3.76	-	3.1	1.373	0.176
FLSJWM16MCRK	10/13/2003	5.75	-	2.5	1.00177	0.09035
FLSJWM16MCRK	11/5/2003	7.68	-	-	0.94142	0.07082
FLSJWM16MCRK	12/3/2003	10.03	-	-	1.05152	0.05936
FLSJWM16MCRK	1/8/2004	11.28	-	2	0.70935	0.03811
FLSJWM16MCRK	2/3/2004	7.66	-	2.7	2.69688	0.11857
FLSJWM16MCRK	3/2/2004	9.12	-	-	1.27844	0.06858
FLSJWM16MCRK	4/1/2004	8.42	-	2	0.93407	0.07336
FLSJWM16MCRK	5/5/2004	8.81	-	2.1	0.93634	0.07522
FLSJWM16MCRK	8/4/2004	4.35	-	4.1	3.63086	0.12464
FLSJWMDCRDE	8/4/2004	3.31	-	4.8	3.90236	1.64766
FLSJWMDCRDW	8/4/2004	4.35	-	5.6	5.4018	2.28647
FLSJWM16MCRK	9/14/2004	0.95	-	-	-	0.18696
FLSJWM16MCRK	10/5/2004	2.12		2.5	-	0.17309
FLSJWMDCRDE	10/5/2004	-	-	-	-	-
FLSJWMDCRDW	10/5/2004	-	-	-	-	-
FLSJWM16MCRK	11/4/2004	7.77	-	2.5	1.02594	0.08208
FLSJWMDCRDE	11/4/2004	4.86	-	2	0.78429	0.39692
FLSJWMDCRDW	11/4/2004	8.39	-	2	0.72221	0.27304
FLSJWM16MCRK	12/8/2004	9.53	-	2	0.64146	0.03961
FLSJWMDCRDE	12/8/2004	-	-	-	-	-
FLSJWMDCRDW	12/8/2004	-	-	-	-	-
FLSJWM16MCRK	1/4/2005	10.51	-	2	0.53066	0.03083
FLSJWMDCRDE	1/4/2005	9.84	-	2	0.55783	0.18275
FLSJWMDCRDW	1/4/2005	11.41	-	2	0.62798	0.16364
FLSJWM16MCRK	2/1/2005	10.52	-	2	0.58493	0.03784
FLSJWMDCRDE	2/1/2005	-	-	-	-	-

Station	Sample Date	DO (mg/L)	CHLAC (µg/L)	BOD5 (mg/L)	TN (mg/L)	TP (mg/L)
FLSJWMDCRDW	2/1/2005	-	-	-	-	-
FLSJWM16MCRK	3/9/2005	8.34	-	2	0.75216	0.0718
FLSJWM16MCRK	4/4/2005	-	-	2.3	-	0.10368
FLSJWMDCRDE	4/4/2005	-	-	2.5	2.46056	0.5275
FLSJWMDCRDW	4/4/2005	-	-	6.8	4.65531	1.50651
FLSJWM16MCRK	5/12/2005	4.43	-	2	1.08668	0.11017
FLSJWMDCRDE	5/12/2005	4.07	-	2.8	2.01201	0.58373
FLSJWMDCRDW	5/12/2005	8.24	-	2.2	2.79432	0.44399
FLSJWM16MCRK	6/2/2005	5.84	-	2	0.88544	0.04762
FLSJWMDCRDE	6/3/2005	-	-	-	-	-
FLSJWMDCRDW	6/3/2005	-	-	-	-	-
FLSJWM16MCRK	7/5/2005	6.63	-	2.3	0.97766	0.08356
FLSJWMDCRDE	7/5/2005	4.5	-	2.4	1.38277	0.55279
FLSJWMDCRDW	7/5/2005	7.71	-	6	1.10109	0.23639
FLSJWM16MCRK	8/1/2005	3.87	-	3.1	0.91318	0.10793
FLSJWMDCRDE	8/1/2005	2.95	-	2	1.87866	0.94747
FLSJWMDCRDW	8/1/2005	6	-	2	1.86054	0.96752
FLGW 27945	8/22/2005	4.24	3.6	-	1.209	0.22
FLGW 27945	8/22/2005	4.29	-	-	-	-
FLSJWM16MCRK	9/15/2005	4.73	-	2	1.18564	0.13601
FLSJWMDCRDE	9/16/2005	6.51	-	2	1.42158	0.48567
FLSJWMDCRDW	9/16/2005	7.07	-	2	1.45615	0.18626
FLSJWM16MCRK	10/12/2005	5.28	-	-	0.97276	0.136
FLSJWMDCRDE	10/12/2005	-	-	-	-	-
FLSJWMDCRDW	10/12/2005	-	-	-	-	-
FLSJWM16MCRK	11/2/2005	7.3	-	-	0.79728	0.07116
FLSJWM16MCRK	12/6/2005	9.65	-	-	0.70356	0.05221
FLSJWM16MCRK	1/5/2006	8.83	-	-	0.65097	0.04489
FLSJWM16MCRK	2/9/2006	8.77	-	-	0.96947	0.06203
FLSJWM16MCRK	3/1/2006	8.34	-	-	0.87079	0.05575
FLSJWM16MCRK	4/3/2006	-	-	-	0.5961	0.05049
FLSJWMDCRDE	4/3/2006	-	-	-	0.41479	0.20821
FLSJWMDCRDW	4/3/2006	-	-	-	0.33947	0.19824
FLSJWM16MCRK	5/9/2006	7.54	-	-	1.2616	0.1143
FLSJWM16MCRK	7/11/2006	7.77	-	-	1.63503	0.37282
FLSJWM16MCRK	9/11/2006	5.08	-	-	2.28768	0.8442
FLSJWM16MCRK	10/9/2006	5.53	-	-	1.80287	0.30329
FLSJWM16MCRK	11/8/2006	9.35	-		1.43227	0.14387
FLSJWMDCRDE	11/8/2006	8.77	-	-	17.27519	1.05957
FLSJWMDCRDW	11/8/2006	8.16	-	-	15.86466	0.8244
FLSJWM16MCRK	1/4/2007	8.51	-	-	3.32286	0.29278
FLSJWMDCRDE	1/4/2007	7.92	-	-	4.25119	0.33264
FLSJWMDCRDW	1/4/2007	8.52	-	-	5.02849	0.40254
FLSJWM16MCRK	2/1/2007	10.85	-	-	1.02405	0.12586

Station	Sample Date	DO (mg/L)	CHLAC (µg/L)	BOD5 (mg/L)	TN (mg/L)	TP (mg/L)
FLSJWMDCRDE	2/1/2007	11.55	-	-	1.05248	0.18802
FLSJWMDCRDW	2/1/2007	10.78	-	-	1.28296	0.23492
FLSJWM16MCRK	3/12/2007	8.76	-	-	1.39153	0.12945
FLSJWMDCRDE	3/12/2007	12.05	-	-	0.90433	0.16186
FLSJWMDCRDW	3/12/2007	9.56	-	-	0.90129	0.16246
FLSJWM16MCRK	4/10/2007	7.56	-	-	0.83378	0.10066
FLSJWMDCRDE	4/10/2007	7.77	-	-	0.49415	0.17949
FLSJWMDCRDW	4/10/2007	7.46	-	-	0.46653	0.23883
FLSJWM16MCRK	5/3/2007	6.35	-	-	1.03529	0.13935
FLSJWM16MCRK	6/7/2007	4.48	-	-	1.21038	0.22942
FLSJWMDCRDE	7/2/2007	5.51	-	-	4.57465	0.85342
FLSJWMDCRDW	7/2/2007	-	-	-	-	-
FLSJWM16MCRK	8/28/2007	3.41	-	-	1.58632	0.22182
FLSJWM16MCRK	7/21/2008	6.4	19.6245	-	1.2291	0.27
FLSJWM16MCRK	8/4/2008	-	30.1265	-	1.4637	0.4997

Appendix C: Kruskal–Wallis Analysis of DO, DOSAT, CHLAC, TN, TP, and BOD5 Observations versus Season in Sixteen Mile Creek (WBID 2589)

Kruskal-Wallis One-Way Analysis of Variance for 247 cases
Dependent variable is VDO
Grouping variable is SEASON$

Group	Count	Rank Sum
FALL	61	8010.500
SPRING	53	6264.500
SUMMER	65	4128.000
WINTER	68	12225.000

Kruskal-Wallis Test Statistic = 89.034
Probability is 0.000 assuming Chi-square distribution with 3 df

Kruskal-Wallis One-Way Analysis of Variance for 247 cases
Dependent variable is DOSAT
Grouping variable is SEASON$

Group	Count	Rank Sum
FALL	61	7534.000
SPRING	53	6797.000
SUMMER	65	4876.000
WINTER	68	11421.000

Kruskal-Wallis Test Statistic = 56.482
Probability is 0.000 assuming Chi-square distribution with 3 df

Kruskal-Wallis One-Way Analysis of Variance for 30 cases
Dependent variable is VCHLAC
Grouping variable is SEASON$

Group	Count	Rank Sum
FALL	7	75.500
SPRING	9	147.000
SUMMER	10	204.500
WINTER	4	38.000

Kruskal-Wallis Test Statistic = 7.475
Probability is 0.058 assuming Chi-square distribution with 3 df

Kruskal-Wallis One-Way Analysis of Variance for 251 cases
Dependent variable is VTN
Grouping variable is SEASON$

Group	Count	Rank Sum
FALL	62	6994.500
SPRING	58	7007.500
SUMMER	60	10806.000
WINTER	71	6818.000

Kruskal-Wallis Test Statistic = 47.757
Probability is 0.000 assuming Chi-square distribution with 3 df

Kruskal-Wallis One-Way Analysis of Variance for 263 cases
Dependent variable is VTP
Grouping variable is SEASON$

Group	Count	Rank Sum
FALL	64	7342.000
SPRING	61	8592.000
SUMMER	67	12125.500
WINTER	71	6656.500

Kruskal-Wallis Test Statistic = 49.858
Probability is 0.000 assuming Chi-square distribution with 3 df

Kruskal-Wallis One-Way Analysis of Variance for 129 cases
Dependent variable is VBOD
Grouping variable is SEASON$

Group	Count	Rank Sum
FALL	26	1500.500
SPRING	32	1994.500
SUMMER	35	3099.500
WINTER	36	1790.500

Kruskal-Wallis Test Statistic = 21.140
Probability is 0.000 assuming Chi-square distribution with 3 df

Appendix D: Kruskal–Wallis Analysis of DO, DOSAT, CHLAC, TN, TP, and BOD5 Observations versus Month in Sixteen Mile Creek (WBID 2589)

Kruskal-Wallis One-Way Analysis of Variance for 247 cases
Dependent variable is VDO
Grouping variable is MONTH

Group	Count	Rank Sum
1	22	4469.500
2	19	3722.000
3	27	4033.500
4	21	3002.500
5	19	2187.000
6	13	1075.000
7	21	1635.500
8	24	1457.000
9	20	1035.500
10	18	1198.500
11	24	3417.500
12	19	3394.500

Kruskal-Wallis Test Statistic = 128.135
Probability is 0.000 assuming Chi-square distribution with 11 df

Kruskal-Wallis One-Way Analysis of Variance for 247 cases
Dependent variable is DOSAT
Grouping variable is MONTH

Group	Count	Rank Sum
1	22	4157.000
2	19	3429.000
3	27	3835.000
4	21	3059.000
5	19	2469.000
6	13	1269.000
7	21	2036.000
8	24	1703.000
9	20	1137.000
10	18	1187.000
11	24	3279.000
12	19	3068.000

Kruskal-Wallis Test Statistic = 87.376
Probability is 0.000 assuming Chi-square distribution with 11 df

Kruskal-Wallis One-Way Analysis of Variance for 30 cases
Dependent variable is VCHLAC
Grouping variable is MONTH

Group	Count	Rank Sum
2	1	6.000
3	3	32.000
4	5	84.000
5	2	33.000
6	2	30.000
7	3	72.000
8	5	105.500
9	2	27.000
10	3	44.500
11	2	19.000
12	2	12.000

Kruskal-Wallis Test Statistic = 10.947
Probability is 0.362 assuming Chi-square distribution with 10 df

Kruskal-Wallis One-Way Analysis of Variance for 251 cases
Dependent variable is VTN
Grouping variable is MONTH

Group	Count	Rank Sum
1	24	1976.000
2	21	1953.500
3	26	2888.500
4	26	2459.500
5	19	2305.000
6	13	2243.000
7	19	3378.000
8	25	4602.000
9	16	2826.000
10	17	2869.000
11	26	2971.500
12	19	1154.000

Kruskal-Wallis Test Statistic = 79.771
Probability is 0.000 assuming Chi-square distribution with 11 df

Kruskal-Wallis One-Way Analysis of Variance for 263 cases
Dependent variable is VTP
Grouping variable is MONTH

Group	Count	Rank Sum
1	24	2098.500
2	21	1638.000
3	26	2920.000
4	27	3371.000
5	19	2666.500
6	15	2554.500
7	21	3681.500
8	26	4757.500
9	20	3686.500
10	19	3002.500
11	26	3157.500
12	19	1182.000

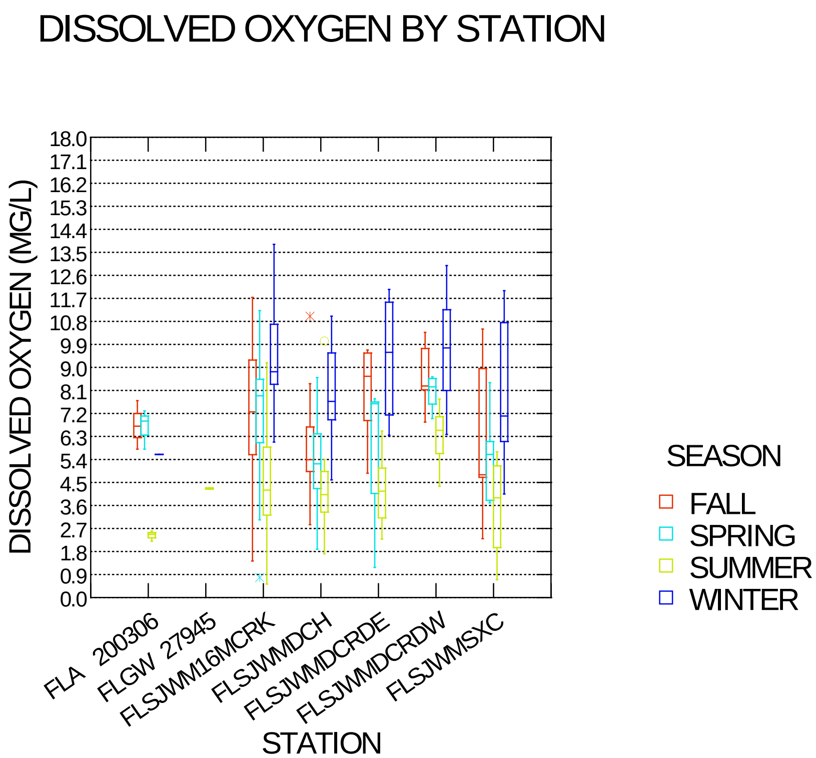
Kruskal-Wallis Test Statistic = 71.504
Probability is 0.000 assuming Chi-square distribution with 11 df

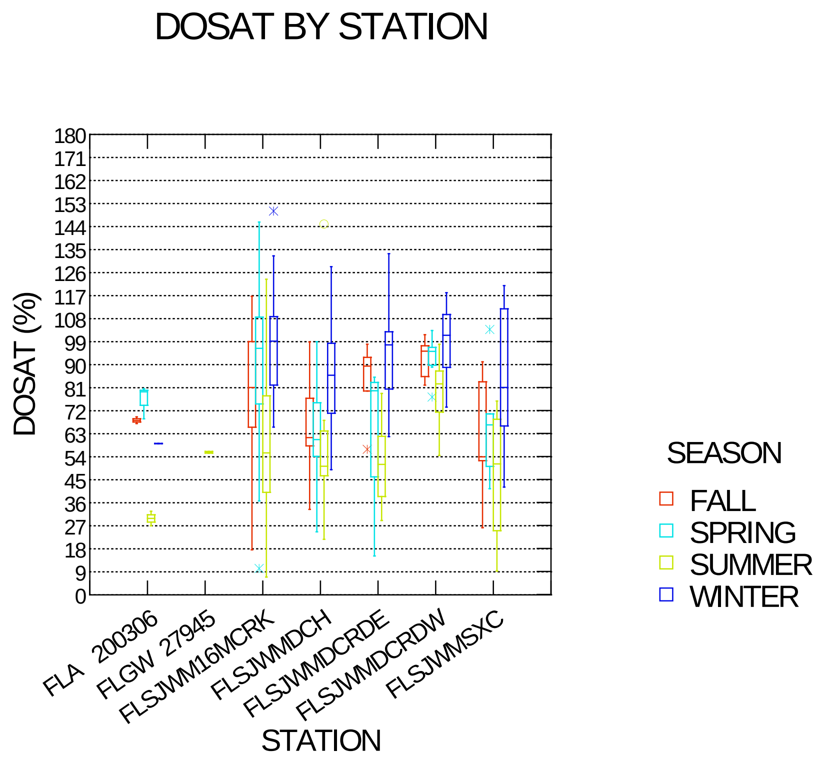
Kruskal-Wallis One-Way Analysis of Variance for 129 cases
Dependent variable is VBOD
Grouping variable is MONTH

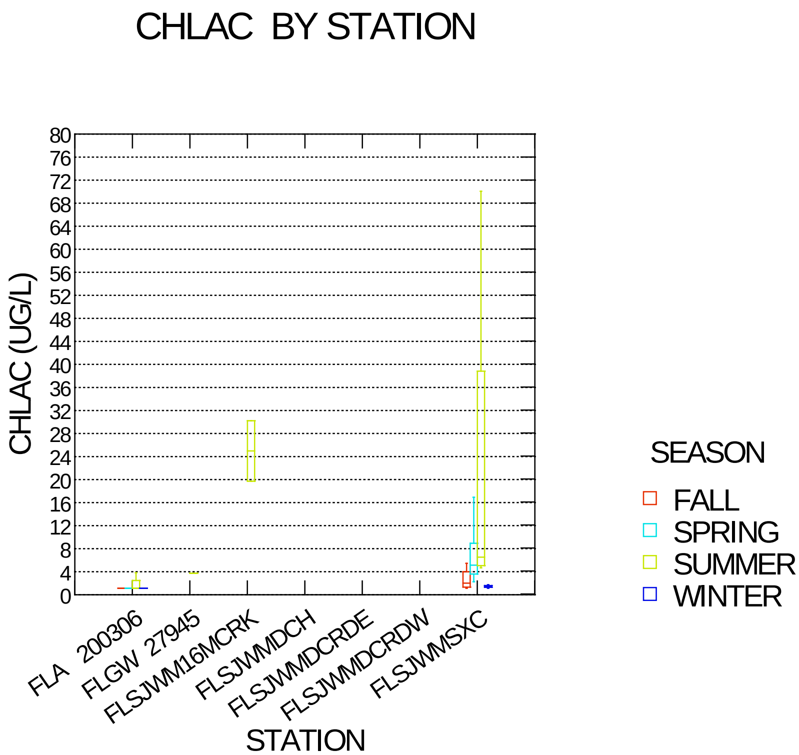
Group	Count	Rank Sum
1	11	545.500
2	11	452.000
3	14	793.000
4	17	990.500
5	10	581.500
6	5	422.500
7	10	950.000
8	14	1340.000
9	11	809.500
10	8	545.500
11	12	660.500
12	6	294.500

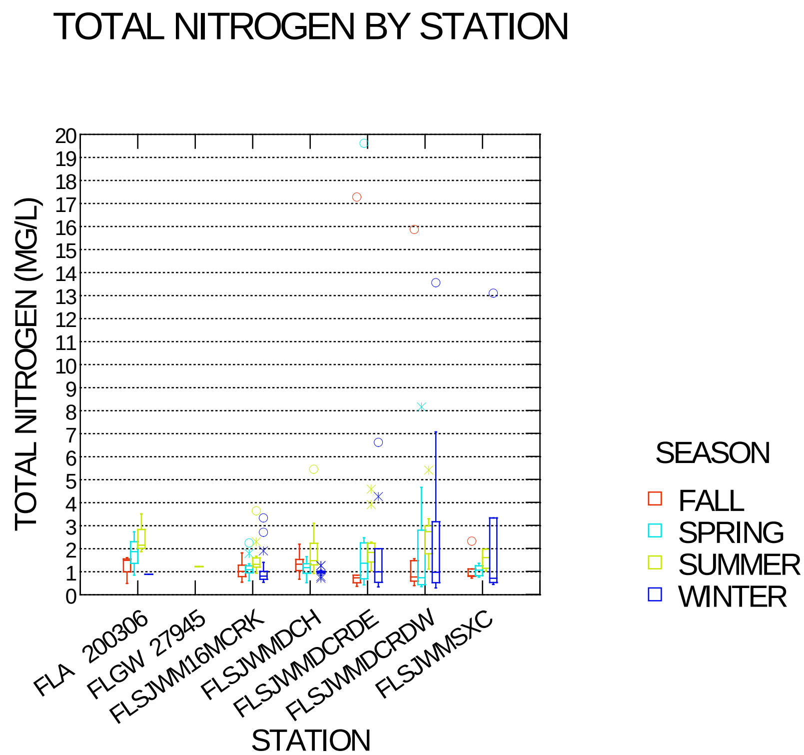
Kruskal-Wallis Test Statistic = 27.902
Probability is 0.003 assuming Chi-square distribution with 11 df

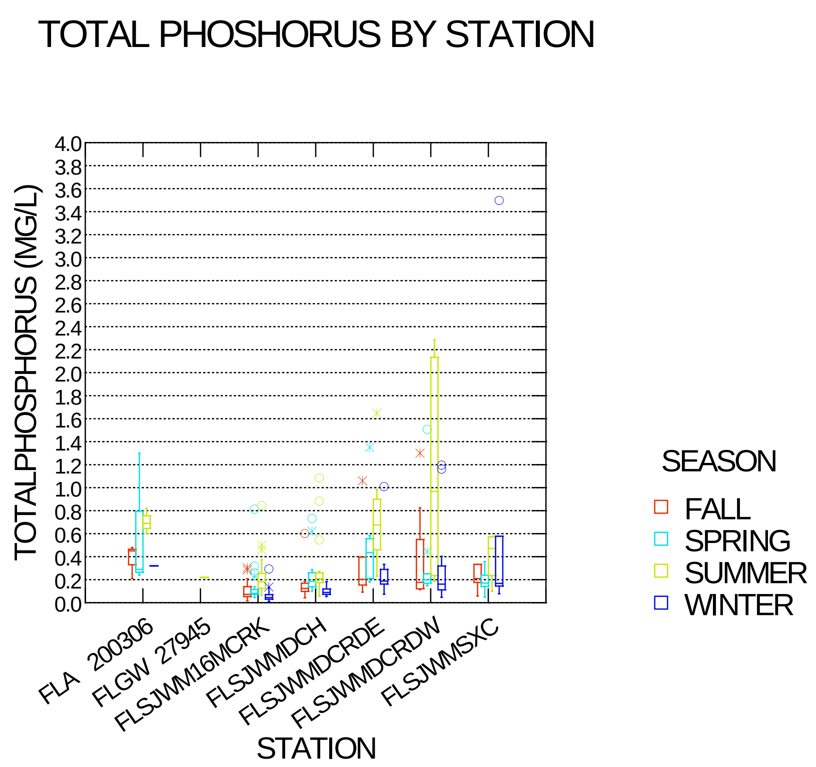
Appendix E: Chart of DO, DOSAT, CHLAC, TN, and TP Observations by Season, Station, and Year in Sixteen Mile Creek (WBID 2589)

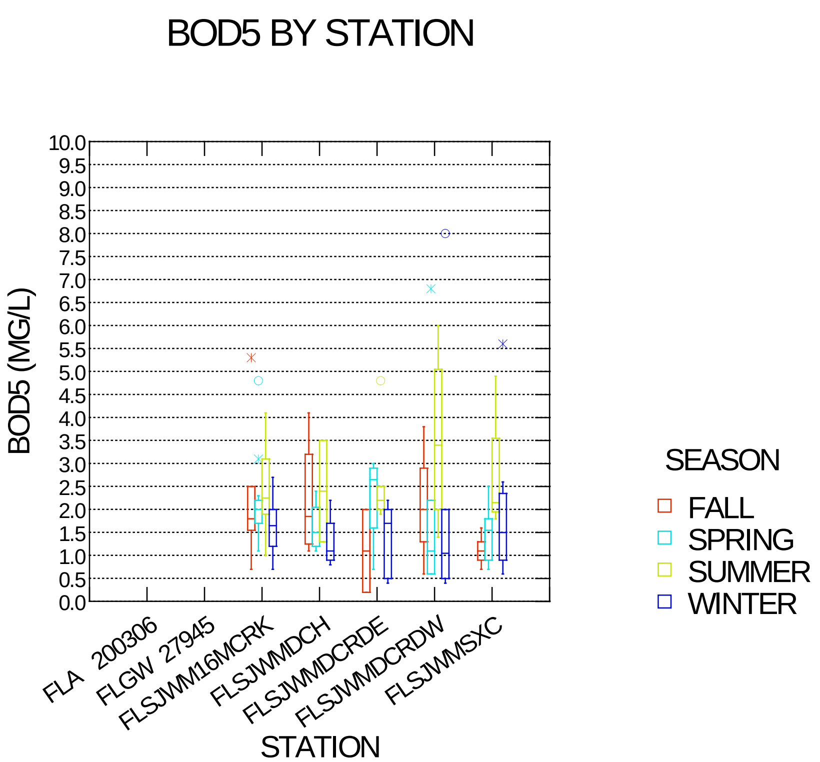


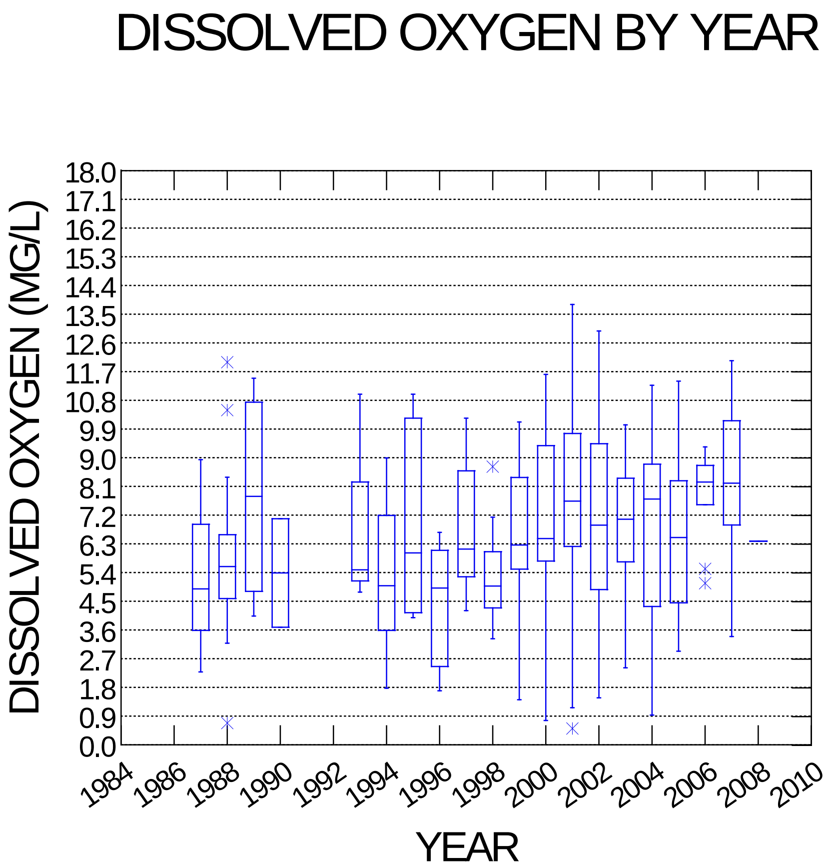

DOSAT BY STATION
DOSAT (%)
180
171
162
153
144
135
126
117
108
99
90
81
72
63
54
45
36
27
18
9
0
FLA 200306
FLGW 27945
FLSJWM16MCRK
FLSJWMDCH
FLSJWMDCRDE
FLSJWMDCRDW
FLSJWMSXC
STATION
SEASON
FALL
SPRING
SUMMER
WINTER

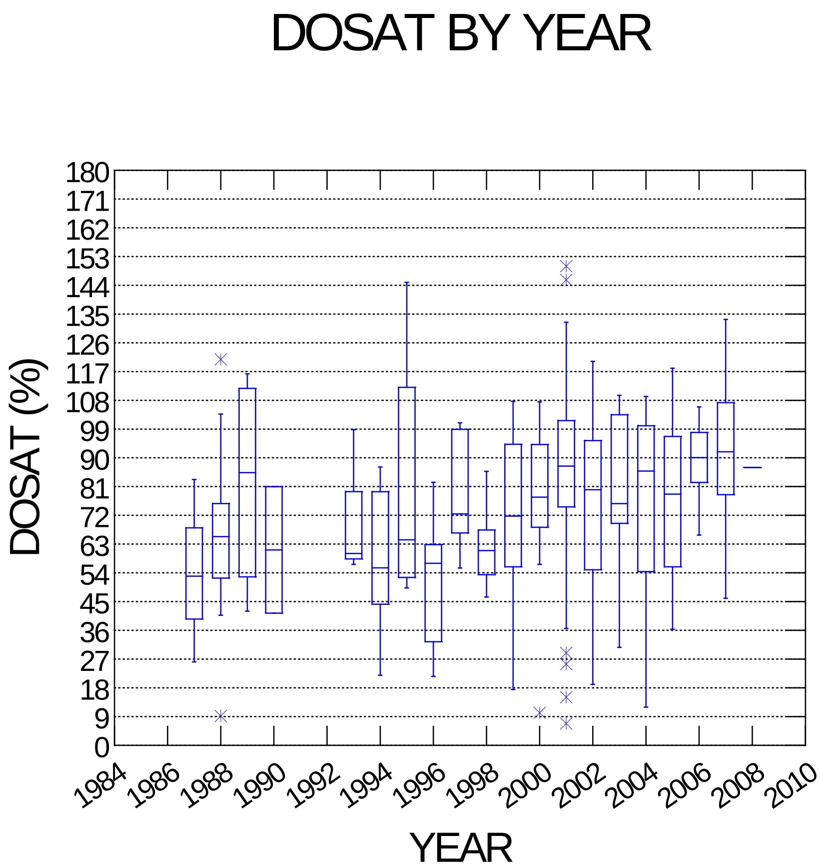

CHLAC BY STATION
CHLAC (UG/L)
80
76
72
68
64
60
56
52
48
44
40
36
32
28
24
20
16
12
8
4
0
FLA 200306
FLGW 27945
FLSJWM16MCRK
FLSJWMDCH
FLSJWMDCRDE
FLSJWMDCRDW
FLSJWMSXC
STATION
SEASON
FALL
SPRING
SUMMER
WINTER

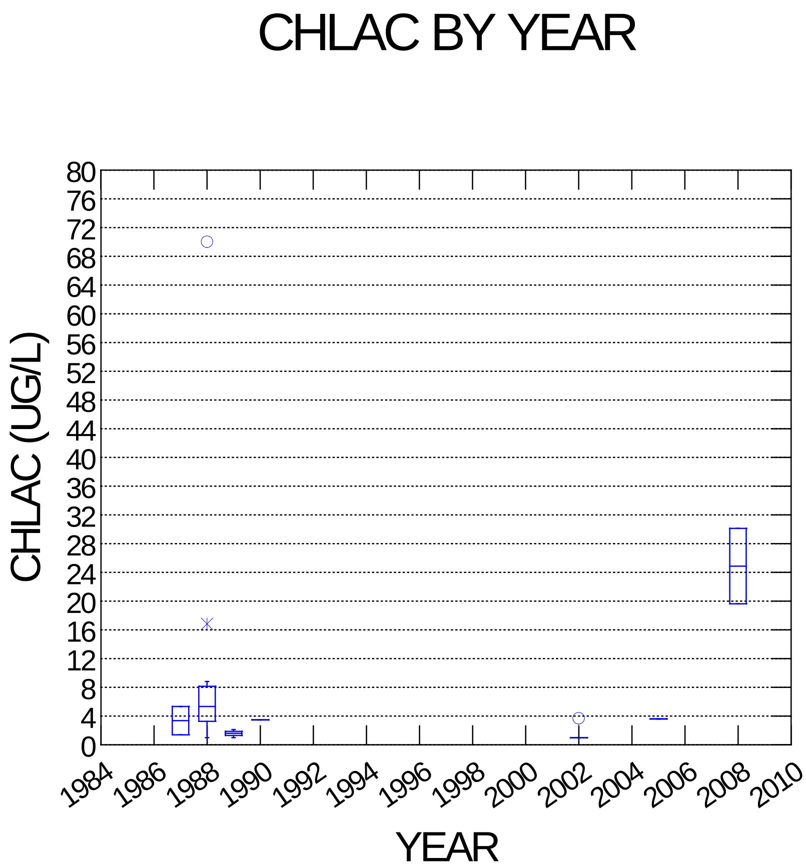

TOTAL NITROGEN BY STATION
TOTAL NITROGEN (MG/L)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
FLA 200306
FLGW 27945
FLSJWM16MCRK
FLSJWMDCH
FLSJWMDCRDE
FLSJWMDCRDW
FLSJWMSXC
STATION
SEASON
FALL
SPRING
SUMMER
WINTER

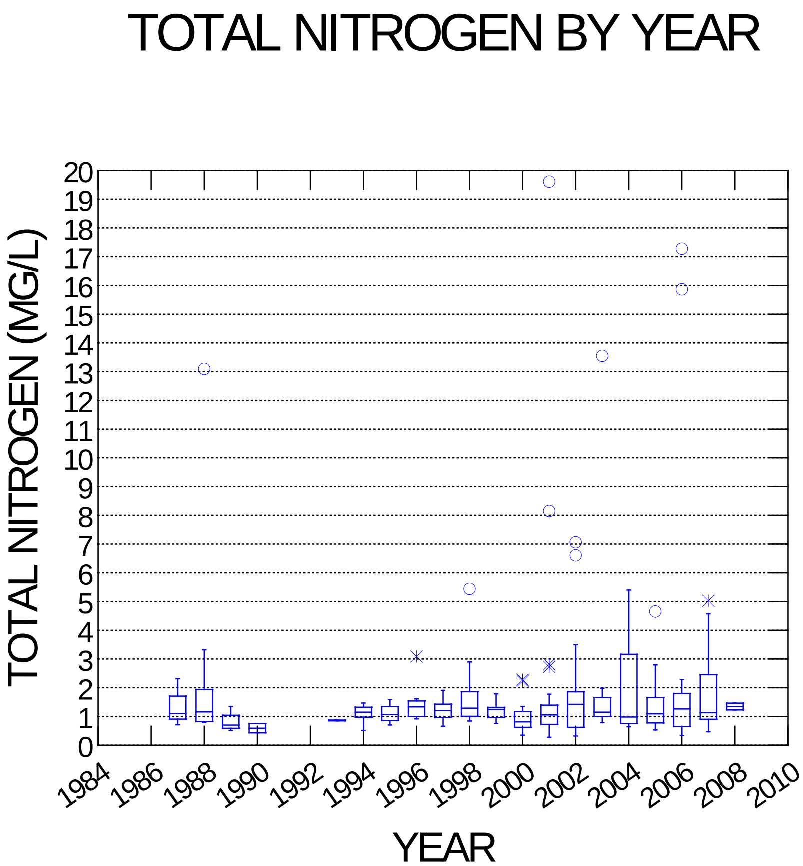

TOTAL PHOSHORUS BY STATION
TOTALPHOSPHORUS (MG/L)
4.0
3.8
3.6
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
FLA 200306
FLGW 27945
FLSJWM16MCRK
FLSJWMDCH
FLSJWMDCRDE
FLSJWMDCRDW
FLSJWMSXC
STATION
SEASON
FALL
SPRING
SUMMER
WINTER

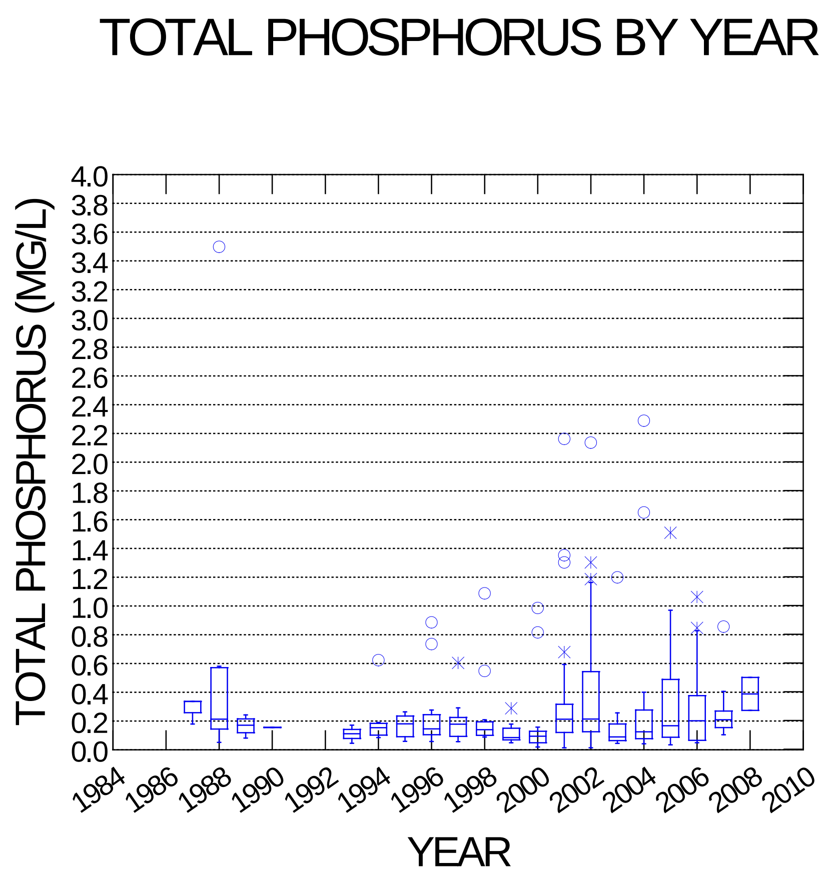

BOD5 BY STATION
BOD5 (MG/L)
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
FLA 200306
FLGW 27945
FLSJWM16MCRK
FLSJWMDCH
FLSJWMDCRDE
FLSJWMDCRDW
FLSJWMSXC
STATION
SEASON
FALL
SPRING
SUMMER
WINTER

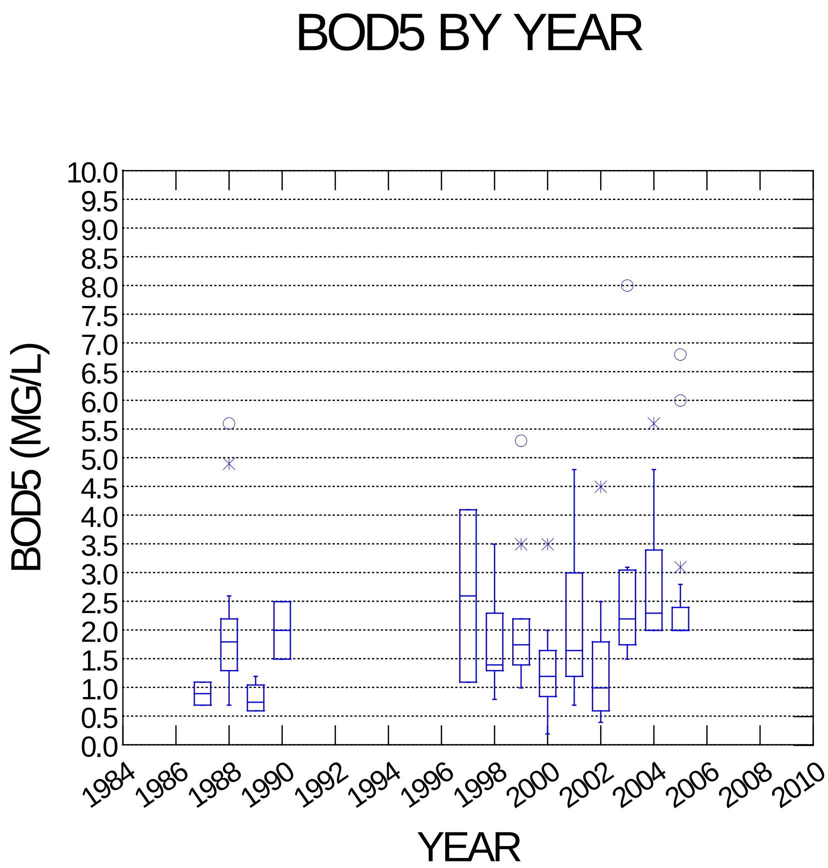

DISSOLVED OXYGEN BY YEAR
DISSOLVED OXYGEN (MG/L)
18.0
17.1
16.2
15.3
14.4
13.5
12.6
11.7
10.8
9.9
9.0
8.1
7.2
6.3
5.4
4.5
3.6
2.7
1.8
0.9
0.0
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
YEAR

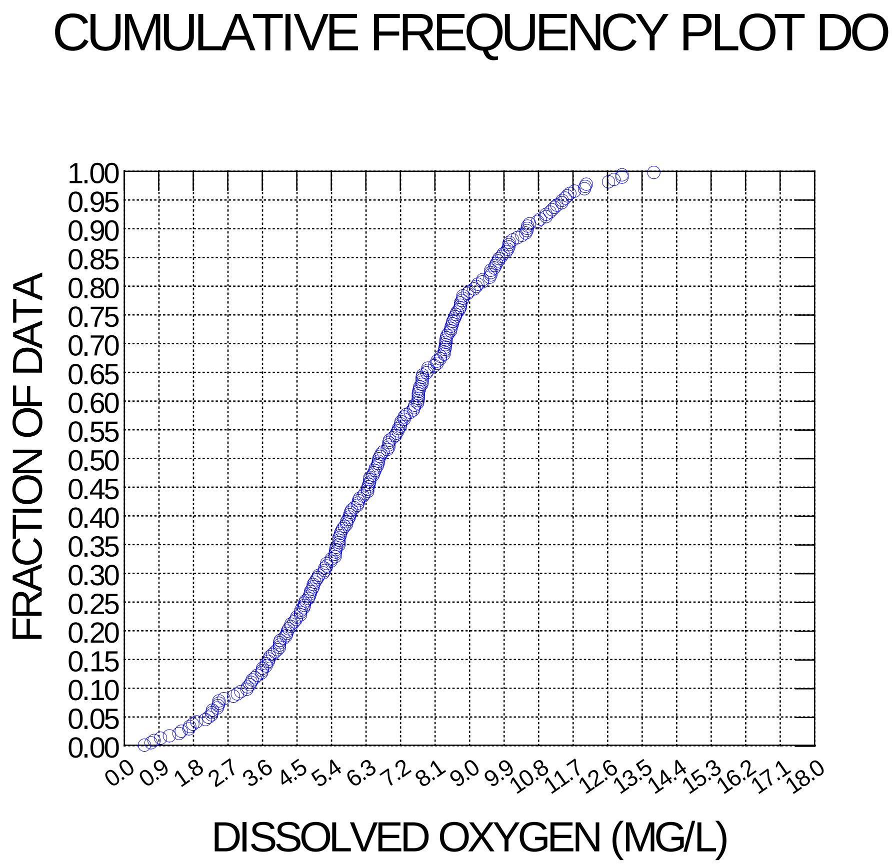

DOSAT BY YEAR
DOSAT (%)
180
171
162
153
144
135
126
117
108
99
90
81
72
63
54
45
36
27
18
9
0
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
YEAR

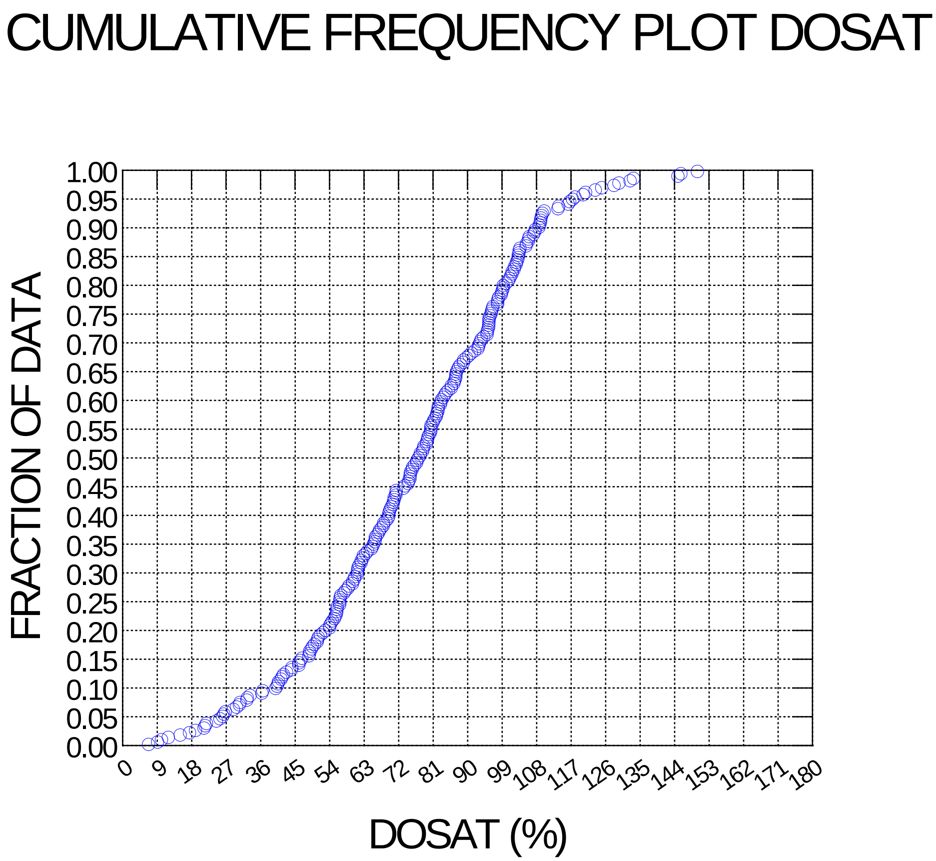

CHLAC BY YEAR
CHLAC (UG/L)
80
76
72
68
64
60
56
52
48
44
40
36
32
28
24
20
16
12
8
4
0
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
YEAR


TOTAL NITROGEN BY YEAR
TOTAL NITROGEN (MG/L)
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
YEAR

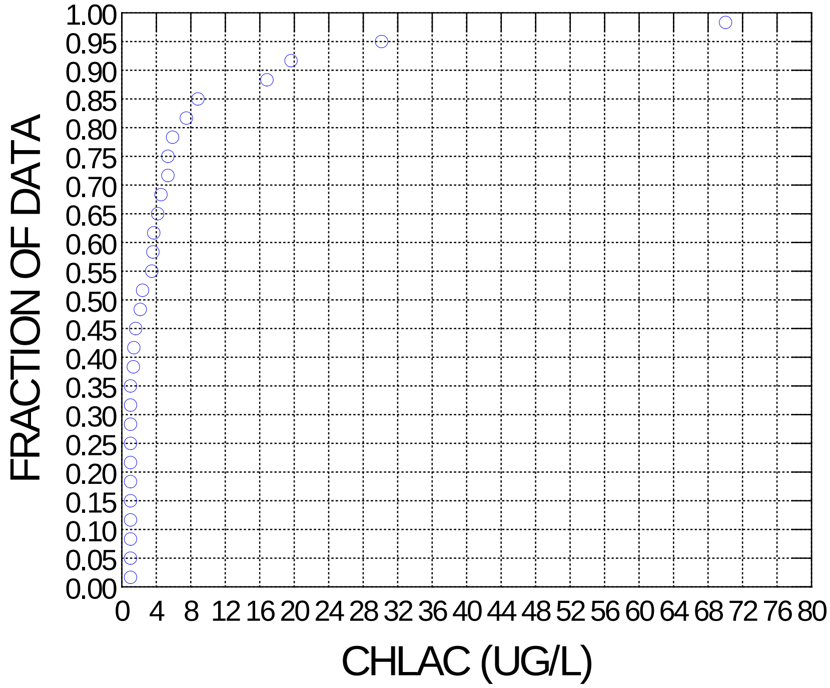

TOTAL PHOSPHORUS BY YEAR
TOTAL PHOSPHORUS (MG/L)
4.0
3.8
3.6
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
YEAR

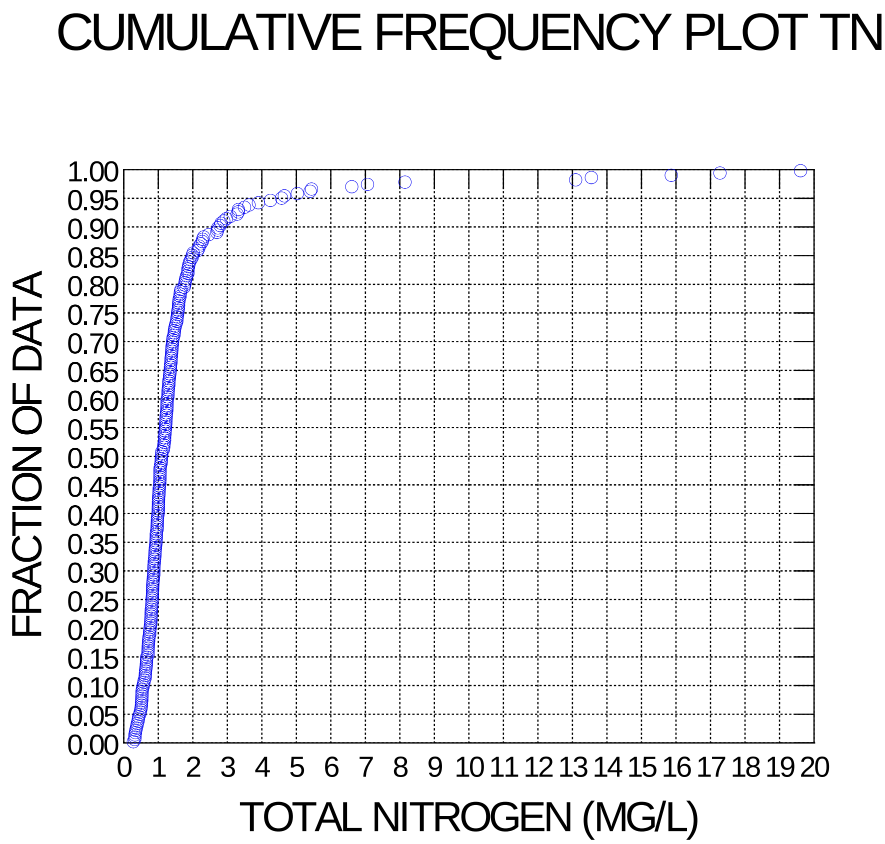

BOD5 BY YEAR
BOD5 (MG/L)
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
YEAR

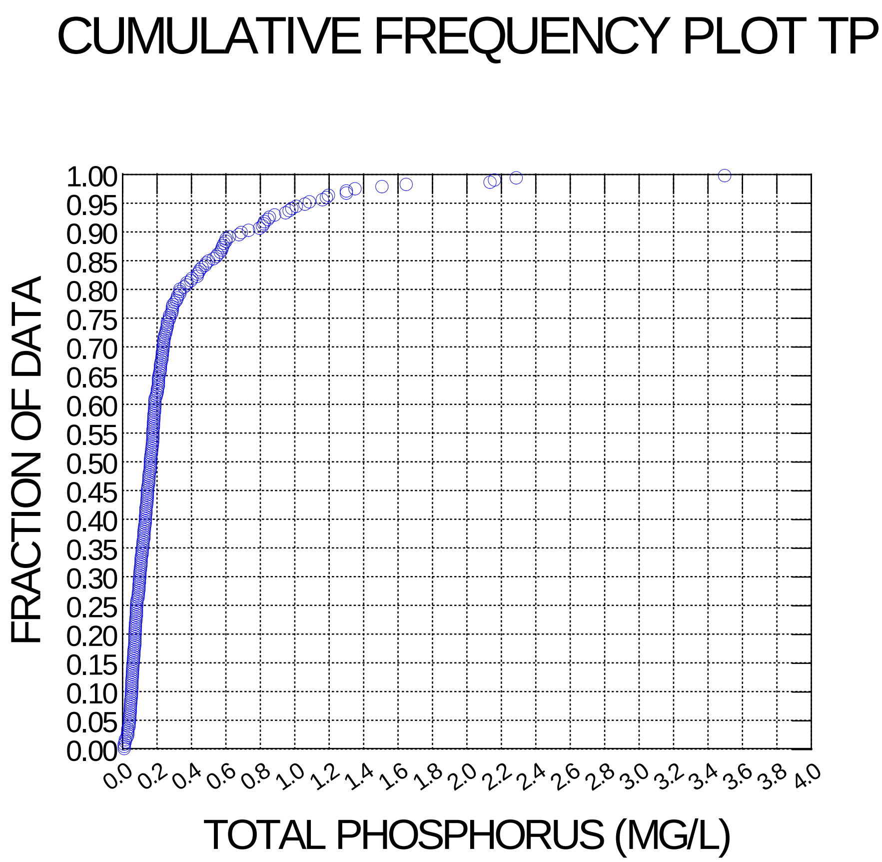

CUMULATIVE FREQUENCY PLOT DO
FRACTION OF DATA
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.0
0.9
1.8
2.7
3.6
4.5
5.4
6.3
7.2
8.1
9.0
9.9
10.8
11.7
12.6
13.5
14.4
15.3
16.2
17.1
18.0
DISSOLVED OXYGEN (MG/L)

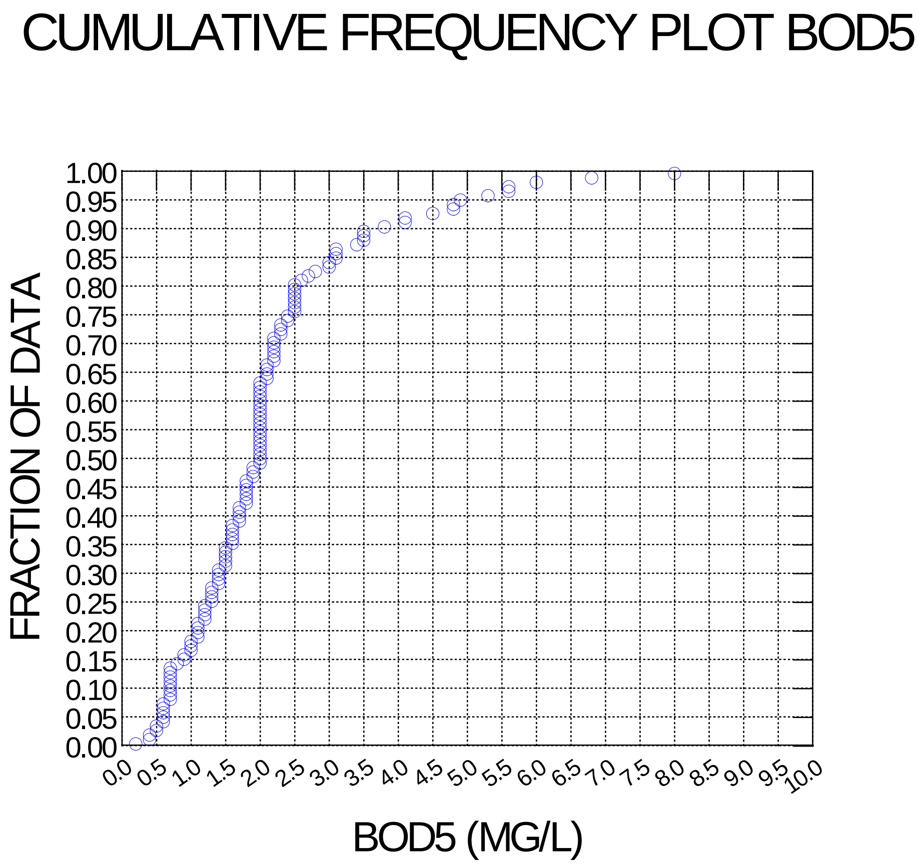

CUMULATIVE FREQUENCY PLOT DOSAT
FRACTION OF DATA
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0
9
18
27
36
45
54
63
72
81
90
99
108
117
126
135
144
153
162
171
180
DOSAT (%)

CUMULATIVE FREQUENCY PLOT CHLAC

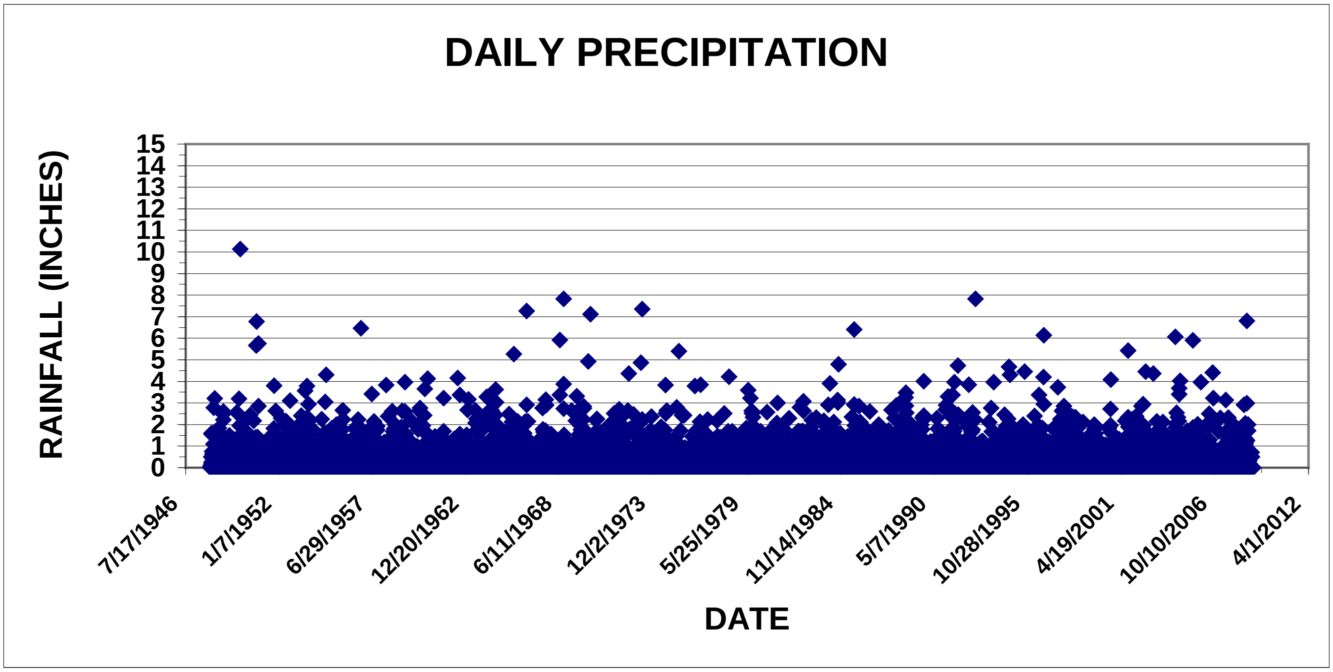



CUMULATIVE FREQUENCY PLOT TN
FRACTION OF DATA
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
TOTAL NITROGEN (MG/L)


CUMULATIVE FREQUENCY PLOT TP
FRACTION OF DATA
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0
3.2
3.4
3.6
3.8
4.0
TOTAL PHOSPHORUS (MG/L)


CUMULATIVE FREQUENCY PLOT BOD5
FRACTION OF DATA
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0
BOD5 (MG/L)

Appendix F: Chart of Rainfall for JIA, 1948–2008



Appendix G: Spearman Correlation Matrix Analysis for Water Quality Parameters in Sixteen Mile Creek (WBID 2589)

Spearman correlation matrix

PARM	PRECIP	PRECIP3DAY	PRECIP7DAY	PRECIP14DAY	JULIANDATE
PRECIP	1				
PRECIP3DAY	0.573	1			
PRECIP7DAY	0.375	0.738	1		
PRECIP14DAY	0.197	0.507	0.71	1	
JULIANDATE	0.017	0.072	0.057	0.148	1
VBOD	0.224	0.371	0.398	0.366	0.325
VCHLAC	-0.265	0.044	0.237	0.134	-0.341
VCHLOR	0.012	-0.107	-0.185	-0.197	0.058
VCOLOR	0.066	0.234	0.319	0.366	-0.004
VCOND	0.05	-0.057	-0.156	-0.165	0.077
VDO	-0.145	-0.291	-0.336	-0.328	0.167
DOSAT	-0.131	-0.28	-0.307	-0.284	0.217
VNH4	0.117	0.295	0.313	0.402	0.118
VNO3O2	0.174	0.262	0.199	0.263	0.141
VPH	-0.126	-0.164	-0.204	-0.273	0.336
VSO4	0.01	-0.078	-0.172	-0.172	0.034
VTEMP	0.109	0.193	0.304	0.321	0.031
VTKN	0.088	0.353	0.396	0.403	0.003
VTN	0.108	0.368	0.412	0.436	0.073
VTOC	-0.001	0.174	0.252	0.33	-0.108
VTORTH	0.171	0.296	0.315	0.378	-0.067
VTP	0.194	0.305	0.276	0.345	0.079
VTSS	0.088	0.189	0.135	0.039	0.089
VTURB	0.055	0.216	0.234	0.194	0.23

Spearman correlation matrix (cont.)

PARM	VBOD	VCHLAC	VCHLOR	VCOLOR	VCOND
VBOD	1				
VCHLAC	0.473	1			
VCHLOR	-0.229	-0.129	1		
VCOLOR	0.314	0.107	-0.776	1	
VCOND	-0.229	-0.474	0.9	-0.785	1
VDO	-0.419	-0.307	0.309	-0.525	0.291
DOSAT	-0.339	-0.108	0.325	-0.515	0.284
VNH4	0.254	-0.054	0.083	0.216	0.13
VNO3O2	0.247	-0.367	0.342	-0.025	0.4
VPH	-0.306	-0.34	0.315	-0.557	0.279
VSO4	-0.186	-0.085	0.959	-0.71	0.889
VTEMP	0.406	0.744	-0.137	0.303	-0.174
VTKN	0.627	0.452	-0.287	0.539	-0.241
VTN	0.638	0.316	-0.159	0.442	-0.109
VTOC	0.33	0.785	-0.781	0.882	-0.725
VTORTH	0.253	0.081	0.242	0.196	0.237
VTP	0.378	0.003	0.301	0.096	0.297
VTSS	0.256	0.62	0.095	-0.094	0.091
VTURB	0.455	0.215	0.022	0.05	0.006

PARM	VDO	DOSAT	VNH4	VNO3O2	VPH
VDO	1				
DOSAT	0.962	1			
VNH4	-0.402	-0.42	1		
VNO3O2	-0.113	-0.154	0.631	1	
VPH	0.585	0.609	-0.46	-0.304	1
VSO4	0.282	0.285	0.184	0.463	0.205
VTEMP	-0.619	-0.406	0.144	-0.077	-0.199
VTKN	-0.551	-0.478	0.475	0.22	-0.383
VTN	-0.508	-0.434	0.609	0.431	-0.392
VTOC	-0.478	-0.461	0.158	-0.174	-0.473
VTORTH	-0.554	-0.532	0.623	0.58	-0.486
VTP	-0.487	-0.443	0.607	0.566	-0.39
VTSS	-0.051	0.005	0.056	0.04	0.056
VTURB	-0.089	-0.055	0.25	0.285	-0.073

Spearman correlation matrix (cont.)

PARM	VSO4	VTEMP	VTKN	VTN	VTOC
VSO4	1				
VTEMP	-0.161	1			
VTKN	-0.216	0.495	1		
VTN	-0.081	0.457	0.948	1	
VTOC	-0.732	0.295	0.549	0.439	1
VTORTH	0.306	0.357	0.47	0.55	0.119
VTP	0.356	0.38	0.577	0.659	0.043
VTSS	0.102	0.237	0.265	0.268	-0.07
VTURB	0.057	0.133	0.361	0.383	-0.007

PARM	VTORTH	VTP	VTSS	VTURB
VTORTH	1			
VTP	0.937	1		
VTSS	0.07	0.217	1	
VTURB	0.201	0.308	0.629	1

Pairwise frequency table

PARM	PRECIP	PRECIP3DAY	PRECIP7DAY	PRECIP14DAY	JULIANDATE
PRECIP	279				
PRECIP3DAY	279	279			
PRECIP7DAY	279	279	279		
PRECIP14DAY	279	279	279	279	
JULIANDATE	279	279	279	279	279
VBOD	129	129	129	129	129
VCHLAC	30	30	30	30	30
VCHLOR	254	254	254	254	254
VCOLOR	206	206	206	206	206
VCOND	254	254	254	254	254
VDO	247	247	247	247	247
DOSAT	247	247	247	247	247
VNH4	256	256	256	256	256
VNO3O2	255	255	255	255	255
VPH	253	253	253	253	253
VSO4	251	251	251	251	251
VTEMP	259	259	259	259	259
VTKN	260	260	260	260	260
VTN	251	251	251	251	251
VTOC	238	238	238	238	238
VTORTH	216	216	216	216	216
VTP	263	263	263	263	263
VTSS	249	249	249	249	249
VTURB	252	252	252	252	252

PARM	VBOD	VCHLAC	VCHLOR	VCOLOR	VCOND
VBOD	129				
VCHLAC	16	30			
VCHLOR	129	19	254		
VCOLOR	126	18	205	206	
VCOND	127	27	242	200	254
VDO	124	27	235	196	246
DOSAT	124	27	235	196	246
VNH4	126	27	245	202	244
VNO3O2	127	27	244	203	242
VPH	124	27	241	200	249
VSO4	128	19	251	203	239
VTEMP	127	28	247	203	253
VTKN	127	26	249	201	247
VTN	125	26	240	199	238
VTOC	109	9	229	184	226
VTORTH	128	17	216	169	208
VTP	128	27	252	204	250
VTSS	128	19	249	202	237
VTURB	128	20	251	205	240

Pairwise frequency table (cont.)

PARM	VDO	DOSAT	VNH4	VNO3O2	VPH
VDO	247				
DOSAT	247	247			
VNH4	238	238	256		
VNO3O2	237	237	247	255	
VPH	243	243	244	242	253
VSO4	233	233	243	242	239
VTEMP	247	247	250	248	253
VTKN	241	241	252	251	247
VTN	233	233	243	251	238
VTOC	220	220	230	229	227
VTORTH	202	202	208	209	204
VTP	244	244	255	254	250
VTSS	232	232	241	240	237
VTURB	234	234	244	243	240

PARM	VSO4	VTEMP	VTKN	VTN	VTOC
VSO4	251				
VTEMP	245	259			
VTKN	247	253	260		
VTN	238	244	251	251	
VTOC	227	231	236	227	238
VTORTH	214	210	212	205	192
VTP	250	256	259	250	237
VTSS	247	243	245	236	225
VTURB	250	246	248	239	227

PARM	VTORTH	VTP	VTSS	VTURB
VTORTH	216			
VTP	215	263		
VTSS	212	249	249	
VTURB	214	251	248	252

Appendix H: Linear Regression Analysis of DO and CHLAC Observations versus Nutrients and BOD in Sixteen Mile Creek (WBID 2589)

Dep Var: VDO N: 124 Multiple R: 0.328 Squared multiple R: 0.107

Adjusted squared multiple R: 0.100 Standard error of estimate: 2.601

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	8.103	0.440	0.000	.	18.411	0.000
VBOD	-0.698	0.182	-0.328	1.000	-3.832	0.000

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	99.346	1	99.346	14.684	0.000
Residual	825.378	122	6.765		

*** WARNING ***
Case 188 has large leverage (Leverage = 0.182)
Case 225 has large leverage (Leverage = 0.119)

Durbin-Watson D Statistic 1.297
First Order Autocorrelation 0.336

Dep Var: VDO N: 233 Multiple R: 0.165 Squared multiple R: 0.027

Adjusted squared multiple R: 0.023 Standard error of estimate: 2.709

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	7.234	0.218	0.000	.	33.216	0.000
VTN	-0.189	0.074	-0.165	1.000	-2.539	0.012

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	47.313	1	47.313	6.447	0.012
Residual	1695.324	231	7.339		

*** WARNING ***
Case 4 has large leverage (Leverage = 0.102)
Case 128 has large leverage (Leverage = 0.246)
Case 188 has large leverage (Leverage = 0.110)
Case 259 has large leverage (Leverage = 0.187)
Case 260 has large leverage (Leverage = 0.155)

Durbin-Watson D Statistic 0.999
First Order Autocorrelation 0.499

Dep Var: VDO N: 244 Multiple R: 0.287 Squared multiple R: 0.082

Adjusted squared multiple R: 0.078 Standard error of estimate: 2.699

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	7.335	0.212	0.000	.	34.526	0.000
VTP	-1.964	0.422	-0.287	1.000	-4.652	0.000

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	157.708	1	157.708	21.642	0.000
Residual	1763.452	242	7.287		

*** WARNING ***
Case 4 has large leverage (Leverage = 0.255)
Case 137 has large leverage (Leverage = 0.089)
Case 174 has large leverage (Leverage = 0.087)
Case 205 has large leverage (Leverage = 0.101)

Durbin-Watson D Statistic 1.105
First Order Autocorrelation 0.446

Dep Var: VDO N: 244 Multiple R: 0.646 Squared multiple R: 0.417

Adjusted squared multiple R: 0.410 Standard error of estimate: 2.160

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	13.243	0.664	0.000	.	19.933	0.000
VTP	0.174	1.748	0.025	0.037	0.099	0.921
VTEMP	-0.277	0.030	-0.562	0.652	-9.199	0.000
VTEMP*VTP	-0.058 0.074	-0.207 0.035	-0.786 0.433			

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	801.288	3	267.096	57.241	0.000
Residual	1119.872	240	4.666		

*** WARNING ***
Case 4 has large leverage (Leverage = 0.492)
Case 79 has large leverage (Leverage = 0.112)
Case 137 has large leverage (Leverage = 0.130)
Case 139 has large leverage (Leverage = 0.091)
Case 153 has large leverage (Leverage = 0.095)
Case 154 has large leverage (Leverage = 0.141)
Case 174 has large leverage (Leverage = 0.159)
Case 205 has large leverage (Leverage = 0.159)
Case 225 has large leverage (Leverage = 0.127)

Durbin-Watson D Statistic 1.692
First Order Autocorrelation 0.148

Dep Var: VDO N: 232 Multiple R: 0.665 Squared multiple R: 0.442

Adjusted squared multiple R: 0.428 Standard error of estimate: 2.078

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	13.418	0.689	0.000	.	19.486	0.000
VTP	-4.796	3.068	-0.728	0.01	-1.563	0.119
VTEMP	-0.267	0.032	-0.550	0.582	-8.431	0.000
VTN	0.395	0.420	0.345	0.018	0.940	0.348
VTEMP*VTP	0.115	0.118	0.422	0.013	0.975	0.331
VTN*VTEMP	-0.024	0.019	-0.488	0.017	-1.285	0.200
VTP*VTN	0.189	0.093	0.280	0.130	2.030	0.043

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	771.009	6	128.501	29.758	0.000
Residual	971.593	225	4.318		

*** WARNING ***
Case 4 has large leverage (Leverage = 0.886)
Case 79 has large leverage (Leverage = 0.133)
Case 128 has large leverage (Leverage = 0.684)
Case 129 has large leverage (Leverage = 0.201)
Case 137 has large leverage (Leverage = 0.173)
Case 139 has large leverage (Leverage = 0.341)
Case 153 has large leverage (Leverage = 0.151)
Case 154 has large leverage (Leverage = 0.200)
Case 174 has large leverage (Leverage = 0.204)
Case 188 has large leverage (Leverage = 0.118)
Case 205 has large leverage (Leverage = 0.179)
Case 225 has large leverage (Leverage = 0.252)
Case 259 has large leverage (Leverage = 0.277)
Case 260 has large leverage (Leverage = 0.450)

Durbin-Watson D Statistic 1.738
First Order Autocorrelation 0.125

Dep Var: VDO N: 233 Multiple R: 0.641 Squared multiple R: 0.411

Adjusted squared multiple R: 0.404 Standard error of estimate: 2.116

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	13.428	0.683	0.000	.	19.660	0.000
VTEMP	-0.290	0.031	-0.596	0.627	-9.314	0.000
VTN	0.096	0.291	0.084	0.040	0.329	0.742
VTN*VTEMP	-0.009	0.013	-0.183	0.038	-0.700	0.485

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	716.856	3	238.952	53.345	0.000

Residual	1025.780	229	4.479

*** WARNING ***
Case 4 has large leverage (Leverage = 0.160)
Case 79 has large leverage (Leverage = 0.097)
Case 128 has large leverage (Leverage = 0.624)
Case 153 has large leverage (Leverage = 0.104)
Case 154 has large leverage (Leverage = 0.132)
Case 188 has large leverage (Leverage = 0.112)
Case 259 has large leverage (Leverage = 0.215)
Case 260 has large leverage (Leverage = 0.299)

Durbin-Watson D Statistic 1.614
First Order Autocorrelation 0.186

Dep Var: VDO N: 247 Multiple R: 0.624 Squared multiple R: 0.389

Adjusted squared multiple R: 0.387 Standard error of estimate: 2.192

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	13.558	0.562	0.000	.	24.128	0.000
VTEMP	-0.308	0.025	-0.624	1.000	-12.500	0.000

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	750.618	1	750.618	156.241	0.000
Residual	1177.041	245	4.804		

Durbin-Watson D Statistic 1.641
First Order Autocorrelation 0.174

Dep Var: VBOD N: 124 Multiple R: 0.731 Squared multiple R: 0.534

Adjusted squared multiple R: 0.523 Standard error of estimate: 0.936

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	0.888	0.149	0.000	.	5.972	0.000
VTN	0.710	0.098	0.908	0.246	7.240	0.000
VTP	1.127	0.309	0.404	0.316	3.647	0.000
VTP*VTN	-0.186	0.044	-0.622	0.182	-4.265	0.000

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	120.773	3	40.258	45.902	0.000
Residual	105.243	120	0.877		

*** WARNING ***
Case 4 has large leverage (Leverage = 0.940)
Case 128 has large leverage (Leverage = 1.568)

Case	129 has large leverage	(Leverage =	0.461)
Case	137 has large leverage	(Leverage =	0.246)
Case	174 has large leverage	(Leverage =	0.226)
Case	188 has large leverage	(Leverage =	0.698)
Case	205 has large leverage	(Leverage =	0.163)
Case	234 is an outlier	(Studentized Residual =	4.797)
Case	259 has large leverage	(Leverage =	1.382)
Case	260 has large leverage	(Leverage =	1.341)

Durbin-Watson D Statistic 1.765
First Order Autocorrelation 0.114

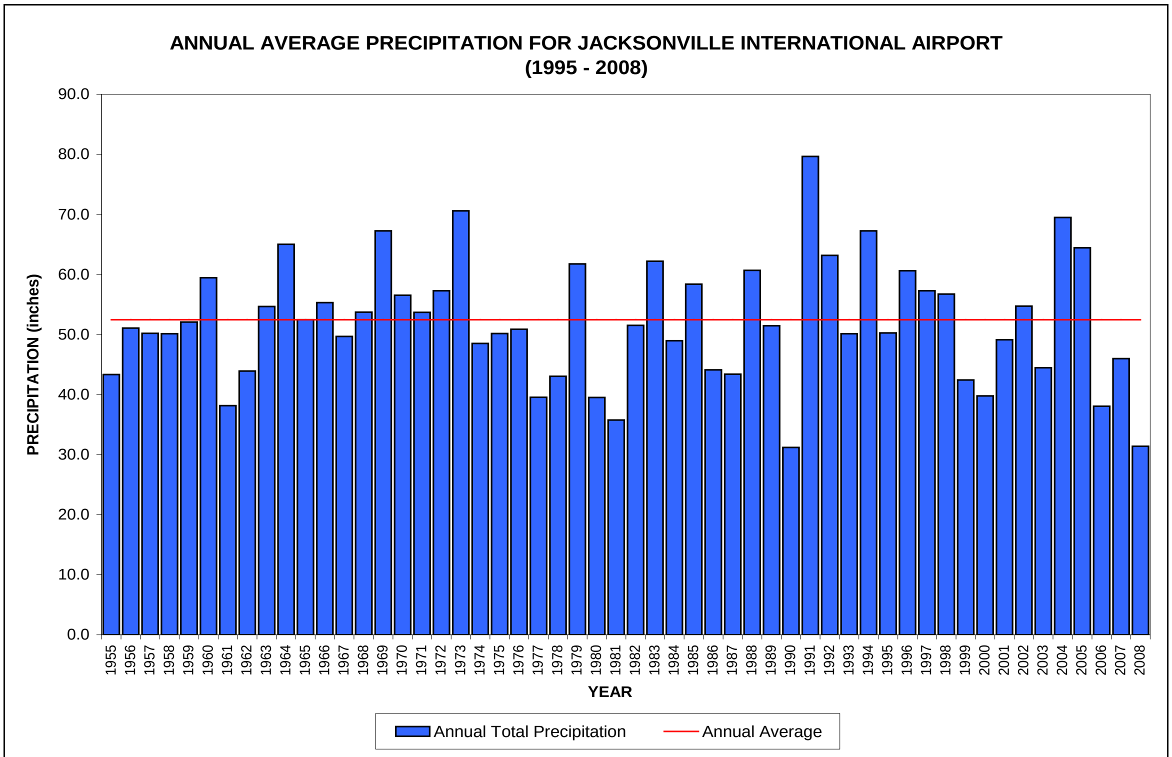
Appendix I: Monthly and Annual Precipitation at JIA, 1955–2008

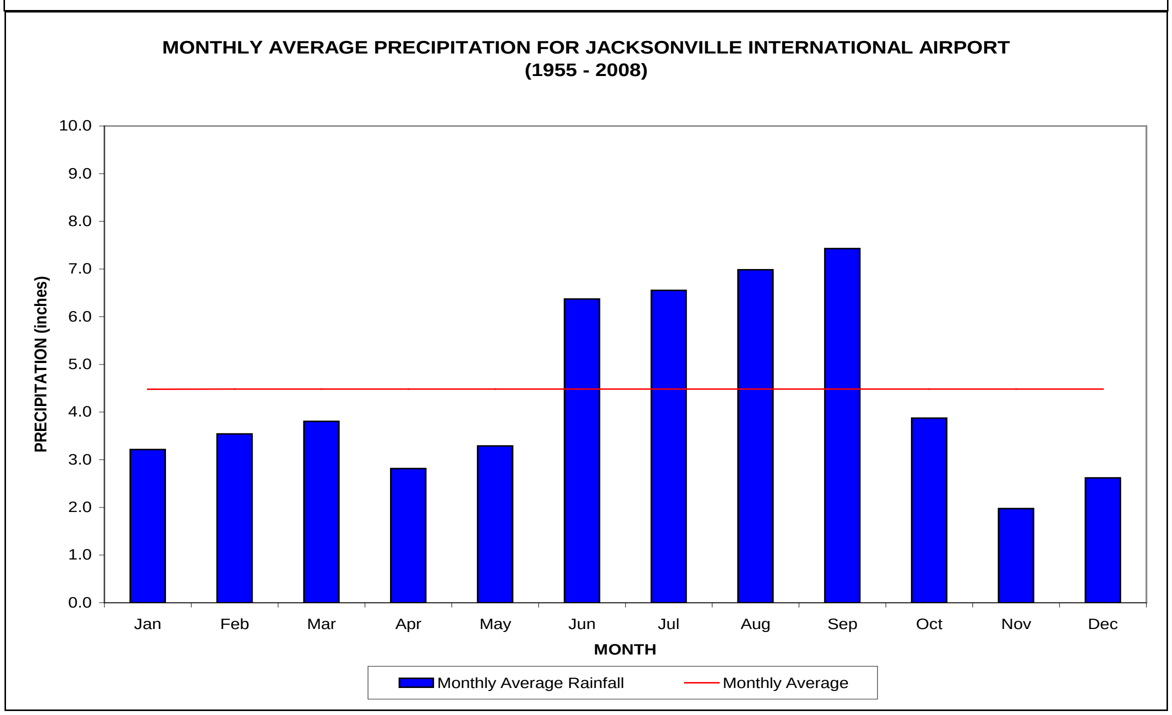
Rainfall is in inches, and represents data from JIA.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1955	3.1	2.46	1.66	1.5	4.51	2.7	5.53	3.85	10.6	5.36	1.9	0.2	**43.33**
1956	2.9	2.94	0.81	2.33	3.98	7.87	8.25	5.24	2.89	13.4	0.4	0	**51.08**
1957	0.3	1.69	3.87	1.61	5.25	7.1	12.3	3.3	8.33	3.5	1.6	1.3	**50.18**
1958	3.4	3.74	3.38	8.24	3.79	3.96	4.37	4.67	4.75	5.07	2	2.8	**50.14**
1959	3	5.22	9.75	2.65	9.2	2.94	4.51	2.86	5.67	3.12	2.2	1	**52.08**
1960	2.1	5.17	6.94	3.54	1.18	4.7	16.2	6.5	8.57	2.95	0.1	1.5	**59.45**
1961	2.9	4.85	1.17	4.16	3.06	5.27	3.48	10.6	1.02	0.27	0.9	0.5	**38.15**
1962	2.2	0.52	3.1	2.36	1.12	8.22	6.31	10.1	4.37	1.13	2.1	2.5	**43.9**
1963	5.4	6.93	2.23	1.75	1.74	12.5	6.47	4.95	4.88	1.53	2.7	3.6	**54.66**
1964	7.3	6.55	1.76	4.65	4.8	4.67	6.12	5.63	10.3	5.09	3.3	4.8	**65.03**
1965	0.7	5.5	3.91	0.95	0.94	9.79	2.71	9.58	11	1.75	1.9	3.8	**52.47**
1966	4.6	5.97	0.71	2.25	10.4	7.74	11.1	3.88	5.94	1.38	0.2	1.1	**55.3**
1967	3.1	4.35	0.81	2	1.18	12.9	5.22	12.3	1.8	1.13	0.2	4.7	**49.68**
1968	0.8	3.05	1.2	0.99	2.17	12.3	6.84	16.2	2.68	5.09	1.3	1.1	**53.72**
1969	0.8	3.39	4.23	0.34	3.78	5.12	5.89	15.1	10.3	9.81	4.6	3.9	**67.26**
1970	4.2	8.85	9.98	1.77	1.84	2.65	7.6	11	3.2	3.95	0	1.6	**56.55**
1971	2	2.55	2.41	4.07	1.9	5.52	5.07	12.8	4.17	6.46	0.8	5.9	**53.69**
1972	5.8	3.48	4.43	2.98	8.26	6.75	3.15	9.76	2.6	4.46	4.2	1.4	**57.29**
1973	4.6	5.07	10.2	11.6	5.33	4.1	5.45	7.49	7.86	4.08	0.4	4.3	**70.57**
1974	0.3	1.28	3.47	1.53	4.14	5.53	9.83	11.2	8.13	0.34	1	1.7	**48.52**
1975	3.5	2.58	2.46	5.78	7	5.21	6.36	6.23	5.24	3.63	0.4	1.8	**50.15**
1976	2.3	1.05	3.41	0.63	10	4.26	5.41	6.37	8.56	1.63	2.4	4.8	**50.87**
1977	3	3.24	1.03	1.76	3.07	2.65	1.97	7.26	7.45	1.68	3.1	3.4	**39.56**
1978	4.6	4.17	2.83	2.24	9.18	2.62	6.67	2.39	4.4	1.26	0.8	1.8	**43.04**
1979	6.3	3.75	1	4.18	7.54	5.91	4.67	4.78	17.8	0.25	3.6	2	**61.76**
1980	2.6	1.06	6.83	3.91	3.02	4.59	5.29	3.97	3.03	2.69	2.3	0.2	**39.53**
1981	0.9	4.53	5.41	0.32	1.48	3.31	2.46	6.47	1.22	1.35	4.9	3.4	**35.77**
1982	3	1.67	4.26	3.6	3.55	8.06	3.81	6.93	9.32	3.37	1.9	2	**51.52**
1983	7.2	4.27	8.46	4.65	1.38	6.86	6.11	4.63	4.61	4.29	3.3	6.4	**62.19**
1984	2.1	4.67	5.77	3.14	1.46	4.76	6.01	3.78	12.3	1.53	3.3	0.1	**48.96**
1985	1.1	1.45	1.26	2.76	2.08	3.71	6.33	8.93	16.8	8.34	2.1	3.6	**58.39**
1986	4.2	4.72	5.44	0.93	2.13	2.53	3.27	9.6	1.99	1.8	2.9	4.7	**44.1**
1987	4.1	6.47	6.27	0.14	0.75	4.18	4.4	4.48	7.13	0.3	5	0.2	**43.39**
1988	6.4	6.08	2.65	3.44	1.35	3.71	4.5	8.48	16.4	2.35	4.3	1.1	**60.68**
1989	1.7	1.77	2.14	2.79	1.55	3.66	8.98	9.16	14.4	1.39	0.5	3.4	**51.45**
1990	1.8	4.07	1.59	1.34	0.18	1.59	6.53	3.81	2.6	4.54	1.2	1.9	**31.2**
1991	10	1.52	7.33	6.31	9.35	11.7	15.9	3.48	6.2	6.36	0.7	0.6	**79.63**
1992	5.8	2.64	4.09	5.33	5.97	7.04	3.32	10.8	7.33	8.34	1.9	0.7	**63.18**
1993	3.9	2.89	5.98	0.85	1.6	2.52	7.54	2.96	7.6	8.84	3.6	1.9	**50.12**
1994	6.6	0.92	2.14	1.51	3.15	14	8.26	3.29	9.79	10.2	3.5	3.9	**67.26**
1995	1.9	2.07	3.67	1.77	1.77	5.35	9.45	9.93	5.41	3.53	3.2	2.2	**50.25**

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1996	1.1	1.11	6.83	2.85	0.72	11.4	4.2	7.83	8.49	11.5	1.4	3.2	**60.63**
1997	2.9	1.28	1.84	4.56	3.43	6.33	7.69	8.24	3.97	4.84	2.4	9.8	**57.27**
1998	3.5	11.1	2.64	4.71	0.96	2.95	7.29	10.1	7.65	3.01	2.4	0.4	**56.72**
1999	4.6	1.7	0.4	1.92	1.02	7.75	3.56	3.51	13	3.24	0.8	0.9	**42.44**
2000	2.8	1.17	1.79	2.6	1.15	2.43	5.69	7.38	11.6	0.23	1.6	1.4	**39.77**
2001	0.9	0.68	5.48	0.62	2.56	5.59	8.31	3.58	16	0.81	1.4	3.1	**49.14**
2002	4.5	0.82	4.38	2.41	0.47	6.24	7.8	8.14	9.31	2.58	2.7	5.4	**54.72**
2003	0.1	4.66	10.7	2.63	2.54	6.75	7.33	1.83	3.04	2.98	0.7	1.2	**44.47**
2004	1.6	4.47	1.36	2.02	1.24	17.2	8.6	9.85	16.3	1.32	2.9	2.7	**69.47**
2005	1.9	3.56	3.67	4.53	3.51	14.8	7.37	4.43	5.76	6.49	1.1	7.4	**64.44**
2006	2.30	3.91	0.68	1.22	2.01	7.25	3.97	7.08	4.55	1.81	0.39	2.90	**38.07**
2007	2.29	2.40	2.22	1.02	1.12	6.68	9.48	3.57	5.44	8.85	0.17	2.74	**45.98**
2008	2.63	5.22	3.50	2.34	0.66	8.21	8.73	16.83	5.84	1.62	1.01	0.59	**46.01**
AVG	**3.21**	**3.54**	**3.81**	**2.82**	**3.29**	**6.37**	**6.55**	**6.99**	**7.43**	**3.87**	**1.98**	**2.62**	**52.32**

Appendix J: Annual and Monthly Average Precipitation at JIA





Appendix K: Response to Comments

August 6, 2009

H.P. Tompkins, Jr , County Engineer
St. Johns County Board of County Commissioners
Public Works I Engineering Division
2740 Industry Center Road
St. Augustine, FL 32084

RE: Draft TMDLs for Sixteen Mile Creek (WBID 2589) and Mill Creek (WBID 2460)
Released June 2009

Dear Mr. Tompkins:

Thank you for taking the time to compile your insightful comments and questions regarding the draft Total Maximum Daily Load reports we presented at the public workshop on July 9th. To aid you in reviewing our responses, we have included your comment (in blue), followed by a response to each, in the order in which they were presented.

St. Johns County appreciates the opportunity to comment on the draft TMDLs released on June 19, 2009 for the Lower St. Johns River Basin. We are providing FDEP with both general comments regarding the TMDL and BMAP processes and specific comments concerning three of the proposed TMDLs:

Dissolved oxygen TMDL for Sixteen Mile Creek, WBID 2589
Dissolved Oxygen and Nutrient TMDLs for Mill Creek, WBID 2460
Fecal Coliform TMDL for Mill Creek, WBID 2460

Based on these comments, we request that FDEP extend the adoption date of the referenced TMDLs by 90 days.

GENERAL COMMENTS:

FINANCIAL IMPLICATIONS/TIMELINE

For the TMDL and the following BMAP to be successfully implemented, it is critical that all stakeholders have the chance to make sure that the methodologies, data, and science used in support the TMDL are valid. Given the potential financial burden that the proposed TMDLs will place on the County and its citizen, 30 days is not sufficient time to allow stakeholders to conduct a thorough review of technical information used in developing the TMDLs presented on July 9, 2009.

Department Response: We appreciate the difficulty in conducting a thorough review of the technical information used in developing the TMDLs that were presented in July within a 30-day period. The nutrient reductions proposed for Sixteen Mile Creek and Mill Creek, however, are consistent with reductions required under the Lower St. Johns River nutrient TMDL that was adopted in 2008. Development of the mainstem St. Johns River involved review by an Executive Committee consisting of stakeholders representing a number of entities in the basin. The Basin Management Action Plan that was adopted to implement the Lower St. Johns River nutrient TMDL in the fall of 2008 was also a stakeholder-driven process that allocated reductions to both point and nonpoint sources in the watershed.

H.P. Tompkins, Jr , County Engineer
St. Johns County Board of County Commissioners
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TMDL DEVELOPMENT PROCESS

The TMDL framework established in the "Impaired Waters Rule," Chapter 62-303, is meant to include all stakeholders in the regulatory process. We do not feel there has been adequate communication in the TMDL development process to allow for interested stakeholders to understand the draft TMDLs. We propose that for future TMDLs the FDEP provide more collaboration during the data analysis and model development stages of the TMDL.

Department Response: The Department will continue to make every effort to provide more collaboration during the data analysis and TMDL development processes. As described under the Department's watershed-based approach, individual basin assessments are performed on a five-year cycle. The Lower St. Johns Basin was first assessed and a Verified List of impaired waters adopted in 2004, following a series of public meetings. Both Sixteen Mile Creek and Mill Creek were part of the 1998 list submitted to EPA which became part of a Consent Decree between EPA and Earthjustice that included a schedule for TMDL development. As part of the second cycle, public meetings on draft lists of impaired waters in the Lower St. Johns Basin were held on November 24, 2008, and April 2, 2009. The Cycle 2 Verified List of impaired waters was adopted on May 19, 2009. As the DO impairments were "re-verified" in the second cycle, the Department needed to develop and adopt these TMDLs and submit them to EPA prior to September 30, 2009. Under the Consent Decree that EPA has with Earthjustice, if the state does not establish a TMDL by that time, EPA will have to propose these TMDLs no later than September 30, 2009.

STAKEHOLDER RESP0NSIBILITY

As stated in the TMDLs, the County can only be held responsible for reducing the loads that are included within its MS4 coverage. It will be critical for FDEP to identify all parties responsible for contributing loads to the impaired water bodies.

Department Response: As noted, our TMDL report states: "It should be noted that any MS4 permittee is only responsible for reducing the loads associated with stormwater outfalls that it owns or otherwise has responsible control over, and it is not responsible for reducing other nonpoint source loads in its jurisdiction." The TMDL also has a load allocation (LA) component that represents nonpoint sources outside MS4 areas. Depending upon the activities and responsible parties represented by the LA component, the County may have some obligations under the LA. All responsible parties will be identified prior to specific allocations being formally established in the Basin Management Action Plan.

IMPLEMENTATION SCHEDULE

The County cannot be expected to implement load-reduction projects until FDEP adopts all intermediate TMDLs between the tributaries and the main stem of the LSJR. For instance, Sixteen Mile Creek discharges to impaired waterbody Deep Creek (WBID 2549), which flows into the LSJR. The TMDL for Deep Creek has not been adopted by FDEP while the LSJR has an adopted BMAP and a draft TMDL for Sixteen Mile Creek is being proposed. Without a complete understanding of the pollutants of concern and the load reductions required in Deep Creek, it is not possible for the County to determine the optimal location or cost effectiveness of water quality improvement that could affect all three water bodies.

H.P. Tompkins, Jr , County Engineer
St. Johns County Board of County Commissioners
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Department Response: As noted in the comment, a TMDL for Deep Creek has not been adopted by FDEP at this time for the DO (TP identified as causative pollutant) and nutrient impairments. As Sixteen Mile Creek flows into Deep Creek, water quality improvements made to Sixteen Mile Creek would benefit Deep Creek, and credit for improvements in the Sixteen Mile Creek watershed may reduce the burden on what must be done to restore Deep Creek. As noted in a previous response, Deep Creek, Sixteen Mile Creek, and Mill Creek were all part of contributing watersheds to the mainstem Lower St. Johns River addressed by the nutrient TMDL and BMAP.

SPECIFIC COMMENTS

DISSOLVED OXYGEN TMDL FOR SIXTEEN MILE CREEK, WBID 2589

It is not clear how the waterbody is exceeding the nutrient criterion expressed in Rule 62-302, FAC. Only two data points are provided in the period of record that indicate chlorophyll-a concentrations greater than the average annual threshold of 20 ug/L. In addition, the seasonal means provided in Table 5.6 do not exceed 20 ug/L.

Department Response: As noted in the document, in Cycle 1 Sixteen Mile Creek was verified impaired for nutrients based on an annual average chlorophyll concentration above 20 μg/L. Subsequently, an error in the reported detection limits units associated with a measurement in 2002 was corrected and the recalculated annual average chlorophyll was below 20 μg/L. Although there were two observations of chlorophyll above 20 μg/L over the period of record, there were insufficient measurements during those years to calculate an annual average under the IWR methodology. Consequently, the TMDL addressed only the dissolved oxygen impairment.

The importance of dissolved oxygen's relationship with sulfate seems to be ignored in the analysis of impairment cause. If algae (chlorophyll-a) is not present above the threshold criteria as stated above, there may be another oxygen consumption mechanism driving the DO impairment. It is plausible that the impairment could be more related to sulfate loading and sediment oxygen demands instead of the traditional algal and limiting nutrient (TP and TN) causes. While the potential sources of TN, TP, and sulfates are common (fertilizers), the identification of the pollutant and the mechanism causing the impairment is critical to the TMDL and its ultimate implementation.

Department Response: In the sulfur cycle, under anaerobic conditions, sulfate is reduced to sulfide by sulfate-reducing bacteria, and in aerobic conditions sulfide is oxidized to sulfate by sulfur bacteria. Observed dissolved oxygen concentrations in Sixteen Mile Creek ranged between 0.53 and 13.81 mg/L, with less than 1 percent of the observations equaling less than 0.8 mg/L. Sulfate observations ranged between 2 and 747 mg/L (25^{th} percentile, 26.8 mg/L; and 75^{th} percentile, 293.4 mg/L). The following graphs illustrate the time series of sulfate and the relationship between sulfate and DO. Based upon the available information, it does not appear that sulfate reduction is a significant process in Sixteen Mile Creek or that it explains the DO impairment. With respect to sediment oxygen demands (SOD), the Department is unaware of any measurements of SOD in Sixteen Mile Creek.

H.P. Tompkins, Jr., County Engineer
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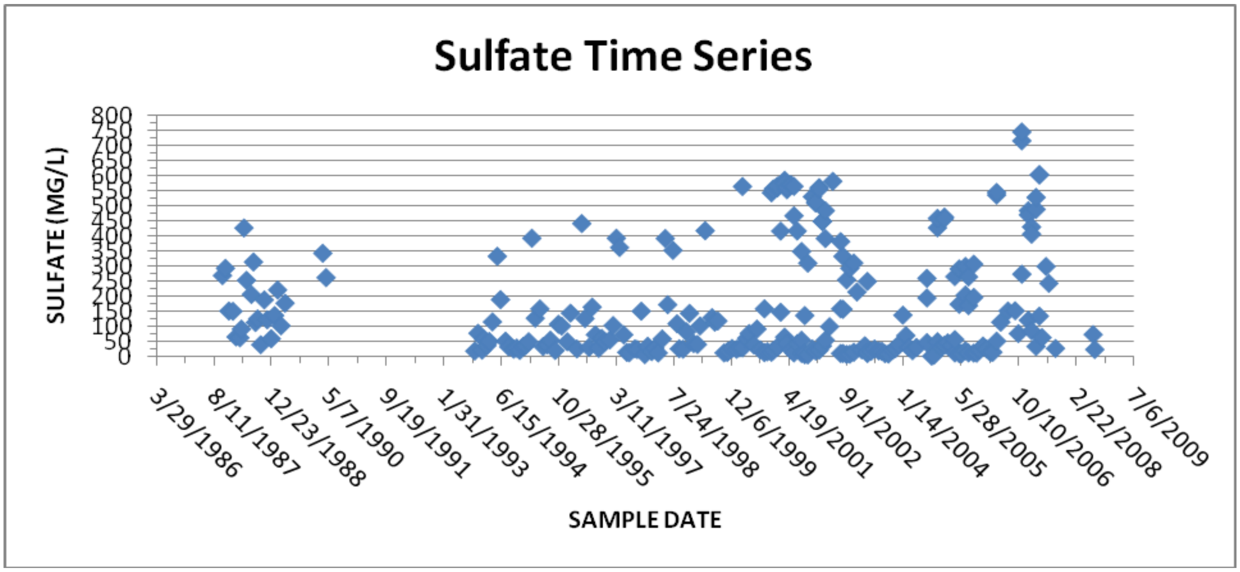

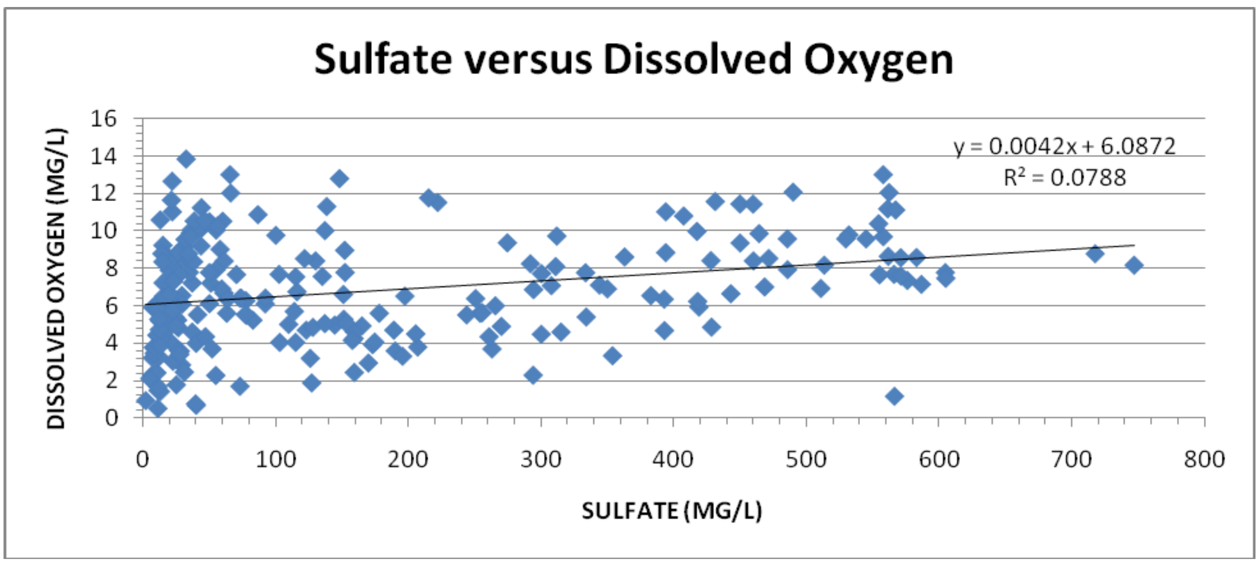

The Sixteen Mile Creek WBID covers an area of about 17,400 acres as described in the TMDL. Approximately 80% of the WBID is under the control of other entities, including Flagler County, the Flagler Estates Road and Water Control District, and the Hastings Drainage District. Both districts are Chapter 298 jurisdictions. We request that this be acknowledged in the TMDL.

Department Response: The document will be revised to acknowledge the two 298 districts. We have asked Mr. Mike Kelter, representing the Flagler Estates Road and Water Control District, for a figure that illustrates the jurisdictional boundaries of the 298 districts. If the county can provide additional information regarding jurisdictional boundaries of the county and the 298 districts in this area we would appreciate it.

H.P. Tompkins, Jr , County Engineer

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The runoff coefficients and EMCs used to the calculate the loads for Sixteen Mile Creek were based on Gao (2006) and Harper and Baker (2007), which vary significantly from those used in the Pollution Load Screening Model applied to calculate loads for the LSJR. Consistency between the main stem and its tributaries would seem preferable to achieve fair allocations.

Department Response: The load/concentration estimates described in Chapter 4 were provided to indicate the relative importance of various sources of nutrients in the watershed and represented potential loads. Estimates were based on a long-term average rainfall, EMCs based on land use activities, and runoff coefficients based on soil types and land use activity. The TMDL reductions were not based on model-estimated loads and/or concentrations. As discussed in Chapter 5, the assimilative capacity was based on relationships developed between water quality measurements taken in the Sixteen Mile Creek WBID. In the mainstem nutrient TMDL, the Pollution Load Screening Model was used to provide daily watershed loads to the St. Johns River. Seasonal coefficients were used for various land use and soil type combinations, and water quality coefficients were derived from a multiple regression analysis of monitored watersheds. As pointed out in Appendix M of the Lower St. Johns Nutrient TMDL document, in-stream processes such as sedimentation, denitrification, and assimilation reduce nutrient loads from the watershed, which are then delivered to the St. Johns River.

DISSOLVED OXYGEN AND NUTRIENT TMDLS FOR MILL CREEK, WBID 2460

It is not clear how the waterbody is exceeding the nutrient criterion expressed in Rule 62-302, FAC. The seasonal means for chlorophyll-a provided in Table 5.6 do not exceed the annual average threshold of 20 ug/L.

Department Response: In Cycle 1, Mill Creek was verified for a nutrient impairment based on an annual average chlorophyll concentration greater than 20 μg/L in 2002, and nitrogen was identified as the limiting nutrient. Subsequently, an error in the MDL units for a reported observation was identified that resulted in a recalculated annual average below 20 μg/L. Dissolved oxygen (DO) was also verified impaired based on the number of exceedances of the Class III criterion. In Cycle 2, DO was still impaired based on the number of exceedances and TN was identified as the causative pollutant. Since elevated TN was associated with the DO impairment, nutrients were still considered impaired.

As with the Sixteen Mile Creek Draft TMDL, the importance of dissolved oxygen's relationship with sulfate seems to be ignored in the analysis of impairment cause. Is it assumed that the sulfate reduction that could be occurring within these streams is included in the BOD component of the TMDL?

Department Response: As noted in the response to a similar question raised in the Sixteen Mile Creek TMDL, under anaerobic conditions, sulfate is reduced to sulfide by sulfate-reducing bacteria, and in aerobic conditions sulfide is oxidized to sulfate by sulfur bacteria. The observed dissolved oxygen concentration in Mill Creek ranged between 2.40 and 8.50 mg/L. Sulfate observations ranged between 8 and 196 mg/L (25^{th} percentile, 28.5 mg/L; and 75^{th} percentile, 57.5 mg/L). The following graphs illustrate the time series of sulfate, the relationship between sulfate and DO, and the relationship between sulfate and BOD. Based on the available information, it does not appear that sulfate reduction is a significant process in Sixteen Mile Creek or that it explains the DO impairment.

H.P. Tompkins, Jr , County Engineer
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August 6, 2009
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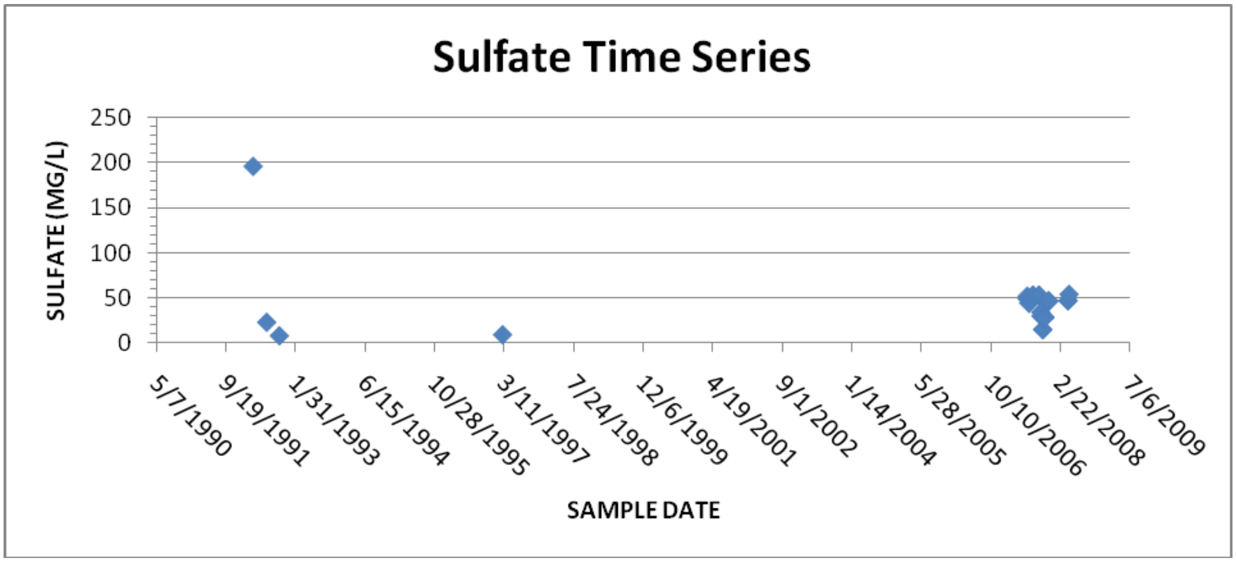

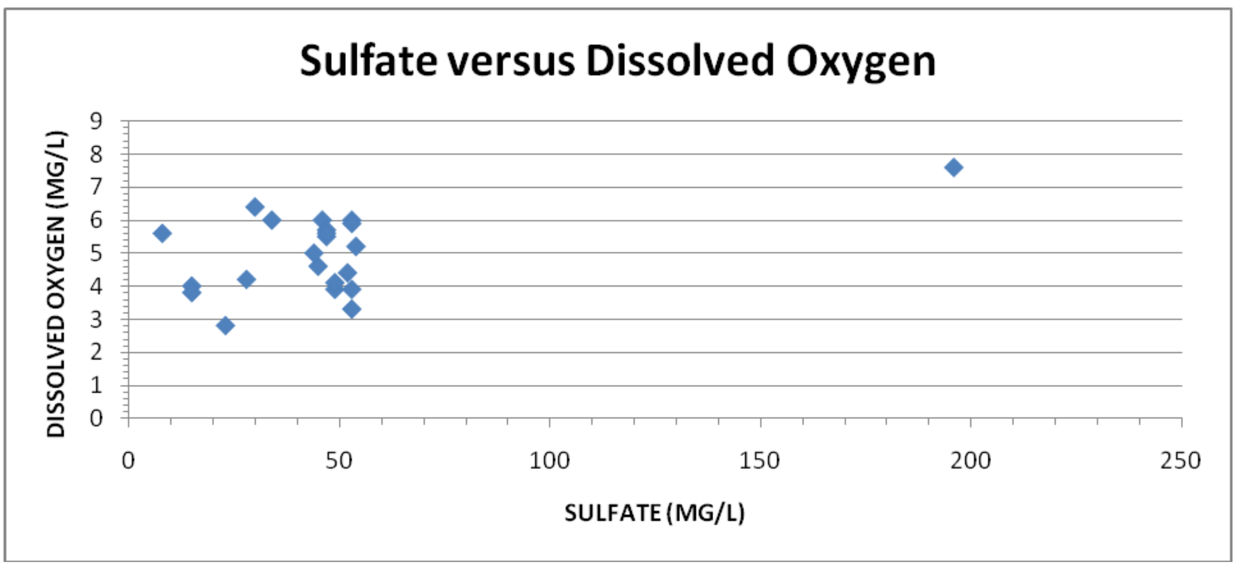

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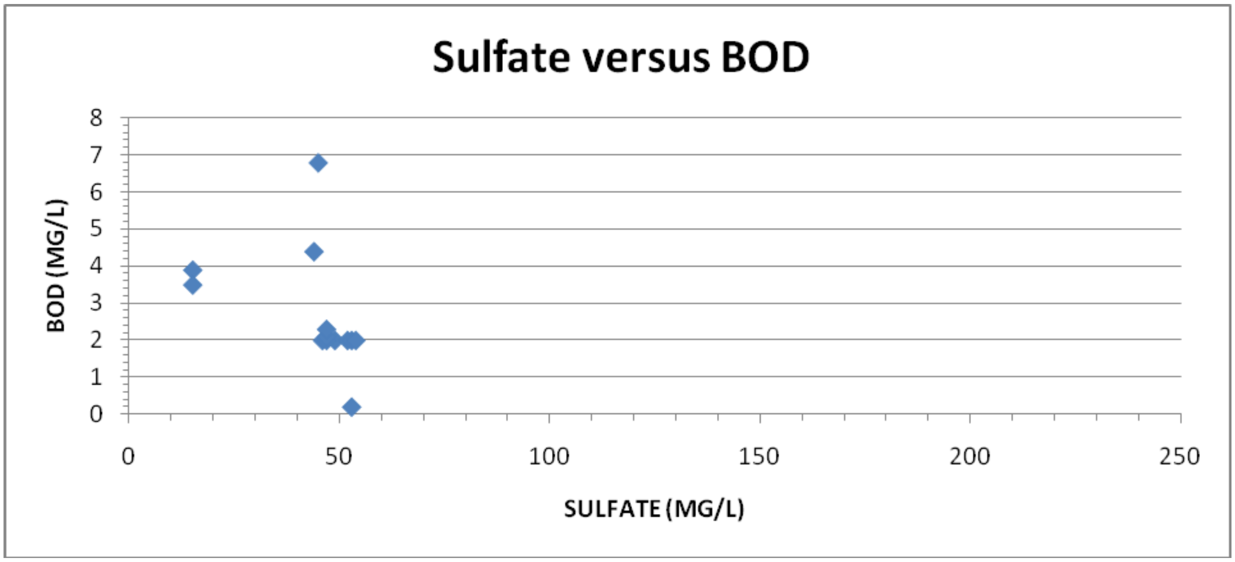

The 2004 SJRWMD land use data used to calculate the potential nitrogen and phosphorus loadings requires updates in several areas based on 2008 aerial photography. Most notably, there is an approximately 600-acre area south of SR 16 which is predominantly residential, but which is classified as agriculture in Figure 4.1 of the draft TMDL.

Department Response: The Department will contact the SJRWMD regarding updates to the 2004 land use data. It would also be informative if the County had any information regarding this residential area and whether this area should have been classified as residential prior to 2004 or has been a conversion from agricultural since 2004.

As with the Sixteen Mile Creek Draft TMDL, the runoff coefficients and EMCs used to calculate the loads for Mill Creek were based on Gao (2006) and Harper and Baker (2007), which vary significantly from those used in the Pollution Load Screening Model applied to calculate loads for the LSJR. Consistency between the main stem and its tributaries would seem preferable to achieve fair allocation.

Department Response: The load/concentration estimates described in Chapter 4 were provided to indicate the relative importance of various sources of nutrients in the watershed and represented potential loads. Estimates were based on a long-term average rainfall, EMCs were based on land use activities, and runoff coefficients were based on soil types and land use activity. The TMDL reductions were not based on model-estimated loads and/or concentrations. As discussed in Chapter 5, the assimilative capacity was based on relationships developed between water quality measurements taken in the Mill Creek WBID. In the mainstem nutrient TMDL, the Pollution Load Screening Model was used to provide daily watershed loads to the St. Johns River. Seasonal coefficients were used for various land use and soil type combinations, and water quality coefficients were derived from a multiple regression analysis of monitored watersheds. As pointed out in Appendix M of the Lower St. Johns Nutrient TMDL document, in-stream processes such as sedimentation, denitrification, and assimilation reduce nutrient loads from the watershed that are delivered to the St. Johns River.

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FECAL COLIFORM TMDL FOR MILL CREEK, WBID 2460

The TMDL discusses the potential sources of fecal coliform. Another recognized source of fecal coliform in Florida is the re-production of fecal coliform in the environment. In these cases, fecal coliform released from its host organism finds conducive environmental conditions (cool temperatures, food sources, and shelter from predation) to reproduce outside a host organism. We request that this potential source be added to the discussion in Section 4 of the draft TMDL.

Department Response: Based on your suggestion, we added text in Chapter 4, as shown below:
In addition, some studies show that fecal coliform can reproduce in the sediments and be re-suspended to surface water when conditions are right. Current methodology cannot quantify fecal coliform coming from each source. Therefore, we were unable to estimate fecal coliform loading from the sediments in this chapter.

It is not clear how the percent reductions were calculated in Table 5.1. The column labeled "fecal coliform exceedances" appears to represent daily values. In this case the water quality criterion for the daily maximum limit of 800 counts per 100 m1 is more appropriate. If the criterion for no more than 400 counts per 100 ml in ten percent of the samples is applicable, then the values in the "fecal coliform exceedances" should be represented by a statistical value rather than a daily result?

Department Response: The state's water quality criterion for fecal coliform has three components. As described in Chapter 2 of the draft report, we determined that the language allowing a 10% exceedance rate over 400 counts/100mL is more consistent with the assessments being made using the Impaired Waters Rule methodology (Chapter 62-303, Florida Administrative Code). Please note, if we used 800 counts/100mL for the TMDL calculation instead of 400 counts/100mL, then the TMDL would be a 64 percent reduction instead of a 72 percent reduction. When we evaluate fecal coliform impairment we use the criterion "no more than 400 counts per 100 ml in 10 percent of the samples," but when we calculate the TMDL, we use any exceedances without consideration of 10 percent, which gives a margin of safety. The reductions are based on using the median of all the exceedances, which allows for a long-term smoothing of the data. However, based on recent litigation results from the federal courts, in addition to the expression of the TMDL in any other meaningful way (e.g., not to exceed 400 counts/100mL by more than 10% for all the data), all TMDLs must also be expressed as being "daily."

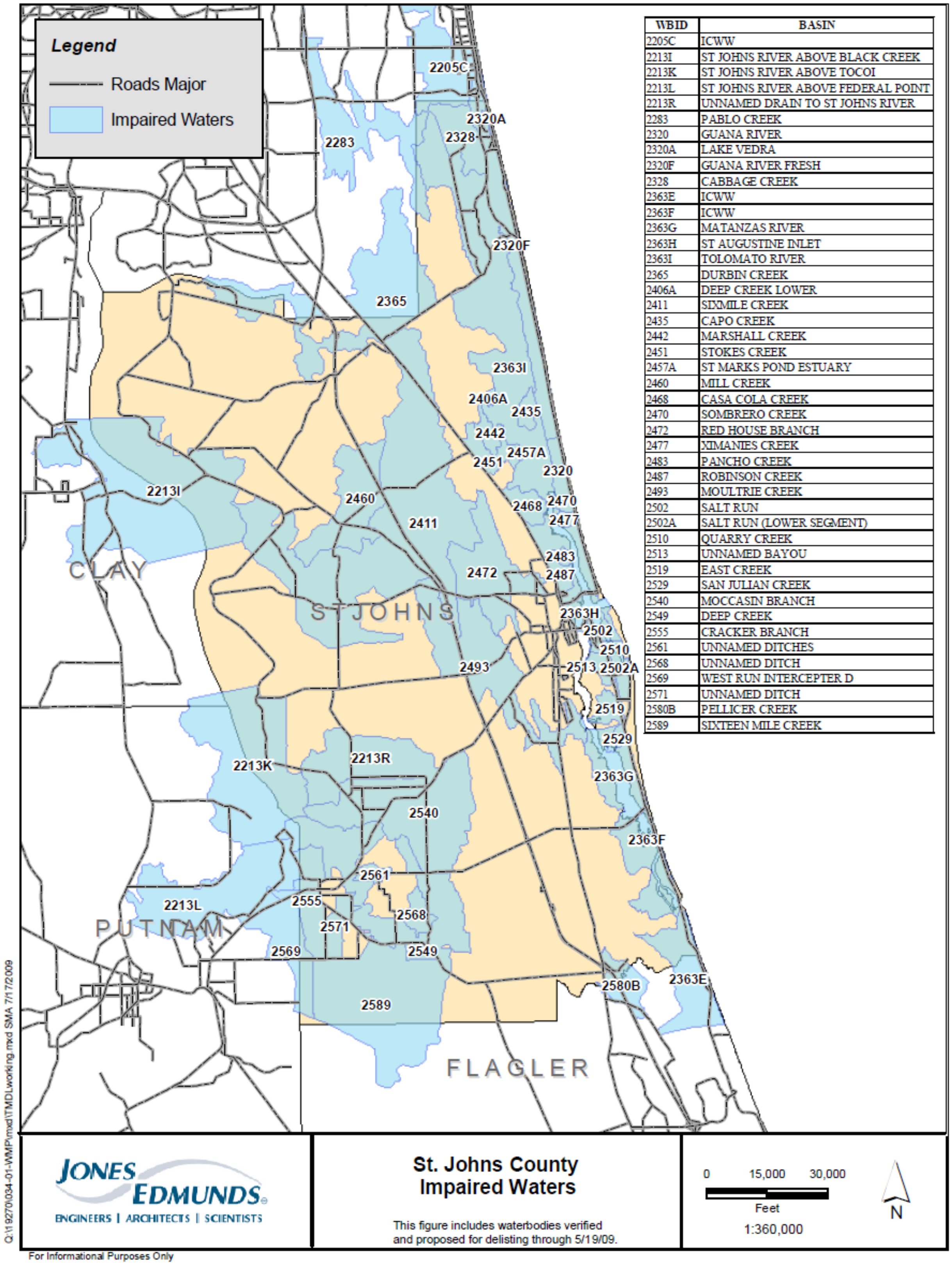
If you have any questions regarding these comments, please contact Dr. Wayne Magley (850/245–8463) for dissolved oxygen and nutrient issues, or Dr. Kyeongsik Rhew at
(850/245–8461) for questions relating to fecal coliform.

Finally, as discussed previously, we do not have the discretion to extend the period for proposing these TMDL rules due to the time constraints imposed by the court-ordered Consent Decree.

Sincerely,

Jan Mandrup-Poulsen, Administrator
Watershed Evaluation and TMDL Section

ec: Jeff Martin



WBID	BASIN
2205C	ICWW
2213I	ST JOHNS RIVER ABOVE BLACK CREEK
2213K	ST JOHNS RIVER ABOVE TOCOI
2213L	ST JOHNS RIVER ABOVE FEDERAL POINT
2213R	UNNAMED DRAIN TO ST JOHNS RIVER
2283	PABLO CREEK
2320	GUANA RIVER
2320A	LAKE VEDRA
2320F	GUANA RIVER FRESH
2328	CABBAGE CREEK
2363E	ICWW
2363F	ICWW
2363G	MATANZAS RIVER
2363H	ST AUGUSTINE INLET
2363I	TOLOMATO RIVER
2365	DURBIN CREEK
2406A	DEEP CREEK LOWER
2411	SIXMILE CREEK
2435	CAPO CREEK
2442	MARSHALL CREEK
2451	STOKES CREEK
2457A	ST MARKS POND ESTUARY
2460	MILL CREEK
2468	CASA COLA CREEK
2470	SOMBRERO CREEK
2472	RED HOUSE BRANCH
2477	XIMANIES CREEK
2483	PANCHO CREEK
2487	ROBINSON CREEK
2493	MOULTRIE CREEK
2502	SALT RUN
2502A	SALT RUN (LOWER SEGMENT)
2510	QUARRY CREEK
2513	UNNAMED BAYOU
2519	EAST CREEK
2529	SAN JULIAN CREEK
2540	MOCCASIN BRANCH
2549	DEEP CREEK
2555	CRACKER BRANCH
2561	UNNAMED DITCHES
2568	UNNAMED DITCH
2569	WEST RUN INTERCEPTER D
2571	UNNAMED DITCH
2580B	PELLICER CREEK
2589	SIXTEEN MILE CREEK

LEGACY CIVIL ENGINEERS, INC

Civil Engineering ✦ Utility Management Consulting ✦ Public Works Assistance

TO: **Jan Mandrup-Poulsen**

FROM: **Mike Kelter, P.E.**

DATE: **July 20, 2009**

RE: **WBID 2589, Comments by Flagler Estates Road & Water Control District regarding Sixteen Mile Creek TMDL : PART 1**

As District Engineer for the Flagler Estates Road & Water Control District (FERWCD), which has title to Sixteen Mile Creek, I have supervised the review of information that was provided in the TMDL report dated June 19, 2009 and in subsequent correspondence received by the office on July 17, 2009.

Because of the compressed timeframe, we will offer our comments in parts. We intend to comment on the reliability of data used in the FDEP TMDL report; on the validity of focusing TMDL efforts in Sixteen Mile Creek on reducing turbidity, TSS and sedimentation; on correcting the area of the WBID to ensure that all stakeholders who drain into Sixteen Mile Creek are afforded equal opportunity to participate; and on protecting the District's right to use Sixteen Mile Creek, which was constructed as a drainage conveyance and treatment system, for its historical intended use.

Part 1 of our comments discusses data reliability and turbidity, TSS and sedimentation. The District offers the following comments on the Department's analysis:

COMMENTS ON TEMPERATURE DATA:

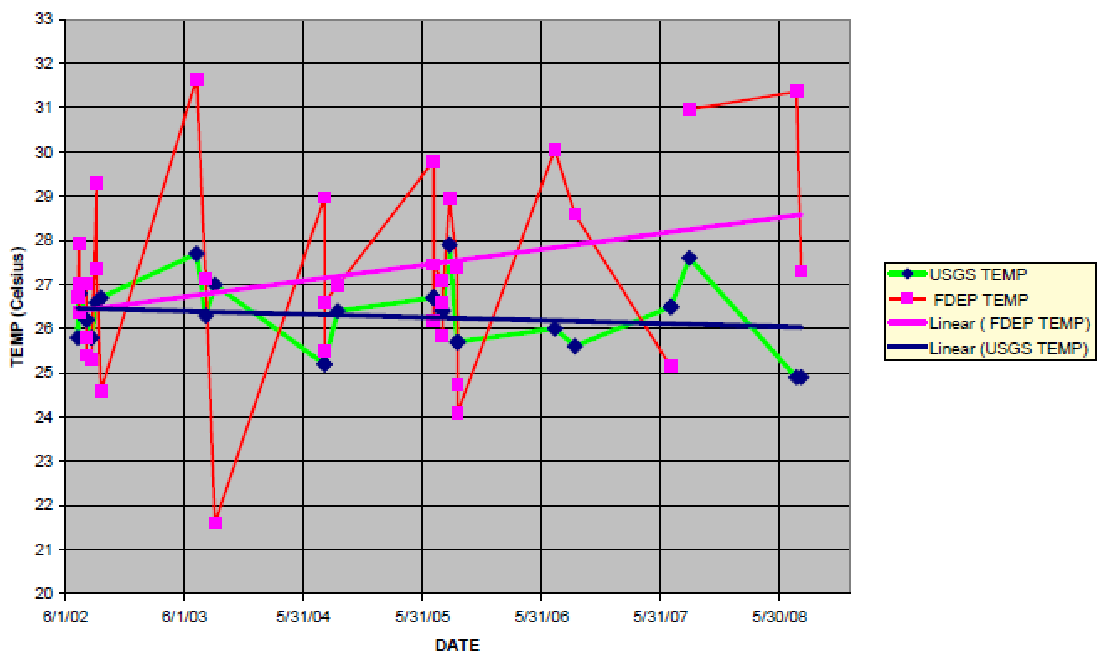
The District is concerned about some of the temperature data corresponding to dissolved oxygen readings throughout the period of analysis. Incorrect temperature data can lead to improper reporting of dissolved oxygen levels and can also lead to inappropriately high margins of safety.

The Department apparently used 67 samples to establish a summer average temperature of 27.82^{o} C for a period ranging from 1988 to 2008. Our initial impression of the data was concern for an apparently very high standard deviation about the mean (about 2.5 standard deviations), which leads to concerns about sampling error. While we expected some variation in the summer water temperatures, the range looked somewhat unbelievable. In addition, the data used by the Department showed a trend of a 2^{o} C increase in average water temperatures between 2002 and 2009, which is not likely considering the cooling trend in ambient air temperatures which have been experienced around Flagler Estates over the past seven years.

We compared the summer data provided by FDEP with other local data to provide some assurance that temperature data was reasonably sound. The USGS stream gauges at Spuds, Florida has been recording water temperature since 2002. The gauge is located approximately 3 miles downstream (north) of the confluence of Sixteen Mile Creek with Deep Creek. Based on observations over the past several years, the peak flows at the Spuds gauge lag the peak flows in Flagler Estates by about 8 – 10 hours. In the USGS database, we found data on 21 days that corresponded to days when temperature was recorded in the FDEP report. This data can be found on the USGS website.

Figure 1 shows the comparison of summer temperatures recorded in Flagler Estates vs the temperatures recorded by USGS.

EXHIBIT 1: USGS vs FDEP TEMPS



It is very clear that the temperatures recorded for the FDEP report are often much higher than the temperatures recorded by USGS. Since Spuds is located downstream from Flagler Estates, it would be reasonable to expect that water temperatures of Deep Creek would increase, due to surface contact with ambient air exceeding 30^{o} C, as stormwater runoff flows northward from Flagler Estates during an 8 - 10 hour period. However, as Figure 1 shows, in most cases, the temperatures recorded at Spuds are actually cooler than those in Flagler Estates. This is not reasonable.

As shown in Figure 1, it is very clear that the USGS temperatures have a smaller distribution about the mean than the FDEP temperature data set for the same days. This suggests more statistical reliability for the USGS data set. We tested this by looking at specific conditions that existed in Sixteen Mile Creek at certain data points. Here is one example:

The FDEP data set includes three samples that were obtained on August 4, 2004, presumably between 12:00 and 12:30 P.M. Grab samples were taken at FLSJWM16MCRK, FLSJWMDCRDE, and FLSJWMDCRDW, in respective order. The recorded temperature range for the three samples was presumably 25.5^{o} C to 28.97^{o} C. The recorded depth of sample was 0.25 to 0.5 feet, presumably. The depth of flow presumably ranged from 0.6 feet to 1.3 feet. The dissolved oxygen recorded at the three sampling points was depressed, ranging presumably from 3.31 mg/L to 4.35 mg/L. We say “presumably” because the FDEP data set that we received just 24 hours ago, have data fields that do not describe units of measurement.

We have good reason to be skeptical of the data, included in the FDEP for this date. The first issue is rainfall that fell during the afternoon of August 3, 2004. On that date, a tight storm cell passed over Flagler Estates and dropped enough rain in a two-hour period to cause the creek levels to rise 4.5 feet—nearly to the top of the headwalls at the Flagler Estates Blvd Crossing at Sixteen Mile Creek. The USGS gauge at Spuds began recording an increase in discharge (measured in cubic feet per second) late on August 3, 2004 from 37 cfs to 167 cfs. The peak discharge of 343 cfs occurred on August 4, 2004. At the same time, the temperature at the gauge recorded a drop from 27.0^{o} C to 25.2^{o} C and a sixfold rise in dissolved oxygen. With the amount of water that was still in Sixteen Mile Creek at the time of sampling on August 4, 2004, there is no reasonable explanation for a temperature of 28.97^{o} C as shown in the FDEP data set.

The second reason that we are skeptical of the data included in the FDEP data set is what appears to be a measurement (presumably in feet) of the depth of water in the creek at the time of measurement (found in the data field nebulously labeled “BOTTM”). At the time of sampling, the data for “BOTTM” was recorded at 1.3, 0.7, and 0.6 for FLSJWM16MCRK, FLSJWMDCRDE, and FLSJWMDCRDW, respectively. These numbers are likely impossible: there was too much stormwater in Sixteen Mile Creek on August 3, 2004 for these recordings of depth to be correct (if in fact they are recordings of depth). You would need supercritical flow to make that to occur, and there is no way that supercritical flow will ever occur in Sixteen Mile Creek.

The third reason that we are skeptical of the data included in the FDEP data set is our knowledge of how long it takes to get around Flagler Estates. According to the map and the data set, grab samples were taken as follows:

- FLSJWM16MCRK (near the Flagler Estates Blvd Crossing) 12:00 p.m.
- FLSJWMDCRDE (Bypass canal north of Ashley Crossing) 12:15 p.m.
- FLSJWMDCRDW (Cracker Swamp & West Deep Creek) 12:30 p.m.

During August 2004, the District was stockpiling road construction materials North of Ashley crossing. To get from FLSJWM16MCRK to FLSJWMCRDE would entail a three minute drive (it might be longer with road flooding), stopping to unlock the gate (I am not sure they have a key to the gate), stopping and unloading the vehicle, walking 2000 feet to the sampling point, taking the grab sample and recording other date, walking back to the vehicle, stopping to lock the gate, and driving another 4 minutes to get to FLSJWMDCRDW. That is not likely to occur in that duration of time.

FDEP finally responded to our request for information just over 24-hours ago, and with only 72 hours remaining until comments must be submitted, we have had scant time to fully evaluate FDEP's analysis. However, in our very brief analysis to date, we believe there are sufficient concerns about the reliability of temperature data being used by FDEP to adopt TMDL rules that will cost the Flagler Estates landowners millions of dollars to implement.

<u>COMMENTS ON TURBIDITY, TSS, AND SEDIMENTATION:</u>

Sixteen Mile Creek and its tributary canals are manmade facilities constructed pursuant to a Court Order filed in the Circuit Court of Florida on June 14, 1971. Since that time the canals and creek were constructed and have been maintained as drainage conveyance and treatment facilities.

Figure 2: erosive hydraulic forces along the Palatka Canal

By all indications, the system was undersized at the time of design and construction. Since construction, numerous unpermitted-construction of open ditches has occurred in lands outside the District boundaries. These unpermitted drainage conveyance systems have overloaded the conveyance capacity of the canals, creek and the associated drainage control structures. This overload has resulted in huge amounts of erosion which manifests itself in high levels of turbidity, Total Suspended Solids (TSS), and sedimentation in the canal and creek bottoms.

We are not talking about a little bit of dirt—we are talking about a lot. In the Annual Engineer's Report to the Flagler Estates landowners (published in June 2009 and posted on the District website at www.ferwcd.org) we reported that 10,290 tons of soils and other materials had eroded in Flagler Estates during 2008/09. This amount of erosion is substantially less than the 13,125 tons of erosion that occurred in 2007/08. The reduction in erosion is the result of substantial investment made by the District Board of Supervisors in permanent erosion protection.The Board of Supervisors believes that permanent erosion control and removal of sediments in the top environmental priority for the District. Clearly you can see in **FIGURE 2** that erosion endangers at least one of the species that inhabit Flagler Estates.

Erosion of soils, as the result of high velocity flows, creates enormous turbidity, TSS and sedimentation issues. We have measured TSS in excess of 687 mg/L coming into Flagler Estates from unpermitted ditches lying outside the District Boundaries. FDEP (Northeast District) has told the District that they are obligated to stop the condition or be fined. SJRWMD has told the District that FERWCD has no authority to stop the condition.
We believe that erosion of soils, and the attendant increases in turbidity, TSS and sedimentation have more bearing on the levels of dissolved oxygen in Sixteen Mile Creek than do issues of Total Nitrogen or algal blankets. First, erosion of 10,290 tons of soil annually is going to go someplace. To the extent that the soil deposits along the canal and creek banks, friendly, submerged aquatic species are smothered and can no longer provide oxygen-generating functions during photosynthesis **(SEE FIGURE 3).**

Figure 3: Sedimentation along Melanie Canal

Second, when eroded soils remain in suspension as TSS, the heat-storing capacity of a water body increases.

Finally, when turbidity increases and water discolors, the ability of light to reach friendly, submerged aquatic plant species is diminished and dissolved oxygen drops.

The Department has asked the District to show that turbidity, TSS and sedimentation are relevant to the Sixteen Mile Creek dissolved oxygen TMDL. Let's talk about this:

For this discussion, we will use data collected at the USGS gauge at Spuds during the summer months of 2002. With all due respect to our friends at the Department, there is more data available and it is, perhaps, more reliable. Drops in dissolved oxygen levels don't occur instantaneously—they occur over time. The data set that Dr. Magley, which are used to establish correlations between TN and DO, and which fail to establish correlations between

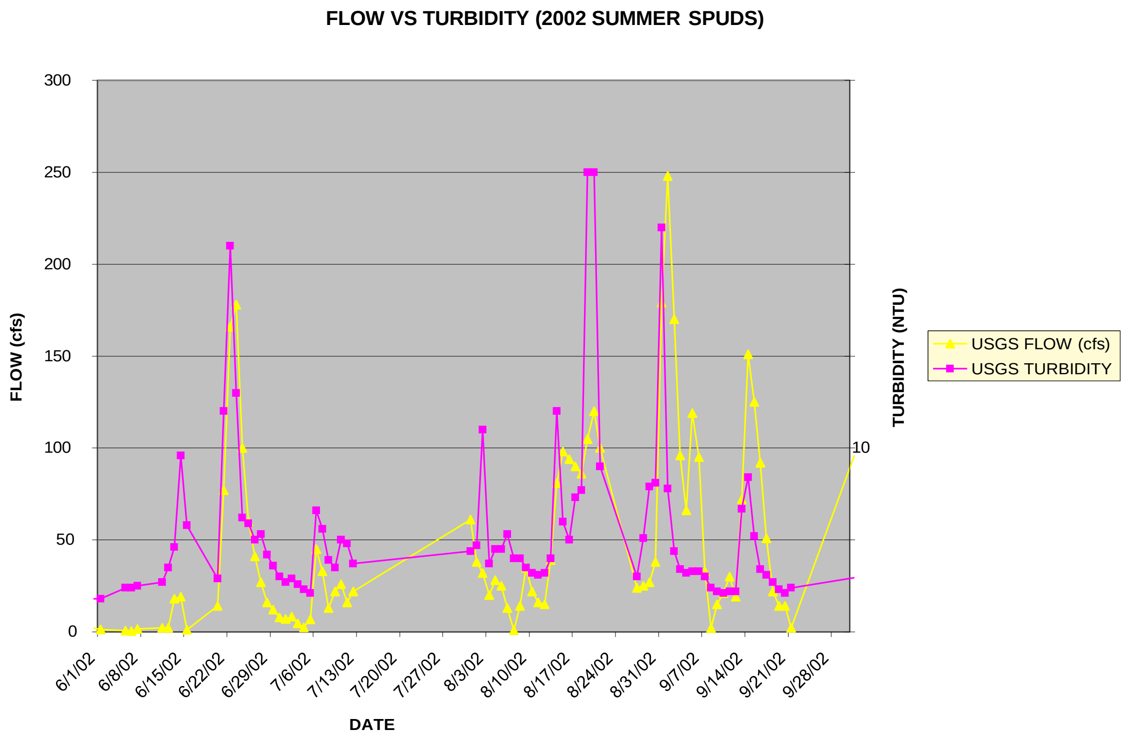


Figure 4: relationship of flow to turbidity during the summer months of 2002, as measured at the USGS station in Spuds, Florida

turbidity and DO, are limited to monthly "snapshots" of stream conditions. In some cases, the data sets are limited to two samplings per year. The data sets do not provide an accurate snapshot of stream conditions over a week of cloudy days or cloudy water.

Continuous gauge readings do show a very clear relationship between turbidity and dissolved oxygen levels.

As shown in **FIGURE 4** there is a very clear relationship between flow and turbidity. In most cases, when flow increases, so does turbidity. In some cases that doesn't happen, especially when there are back-to-back storm events. In those cases, flows may rise without a corresponding rise in turbidity. It is generally accepted that the first-flush of pollution has the heaviest loads. You don't see that in the semi-annual data that is used in the FDEP report.

FIGURE 5 illustrates the relationship between turbidity and dissolved oxygen. Again, this data is from the USGS gauge at Spuds during the summer of

2002. This chart shows that dissolved oxygen increases when turbidity increases. Dissolved oxygen in canals and streams increases when it rains. Turbidity increases when rain runoff causes unacceptable flow velocities. That is why DO and turbidity often increase independently at the same time. When turbidity is high, and it is not raining, **FIGURE 5** suggests that dissolved oxygen decreases, dependent on the turbidity levels.

We are citing turbidity, TSS and sedimentation as the constituents of concern due to the obvious response of dissolved oxygen to high concentrations of those constituents. While the District is sensitive to its responsibilities as good environmental stewards, we don't believe that the Department has made the case nutrient pollution in Sixteen Mile Creek. In the response letter sent by Mr. Mandrup-Poulsen, the Department admitted that there were no threatened or endangered species that could be threatened due to algal mats (Rule 62-303.351 (1)) and admitted that the chlorophyll a levels did not exceed 20 ug/L during the planning list assessment (Rule 62-303.351 (2)). As such, the TMDL in Sixteen Mile Creek needs to address dissolved oxygen. We believe that correcting high turbidity, TSS and sedimentation is the most economical and efficient method of achieving that goal.

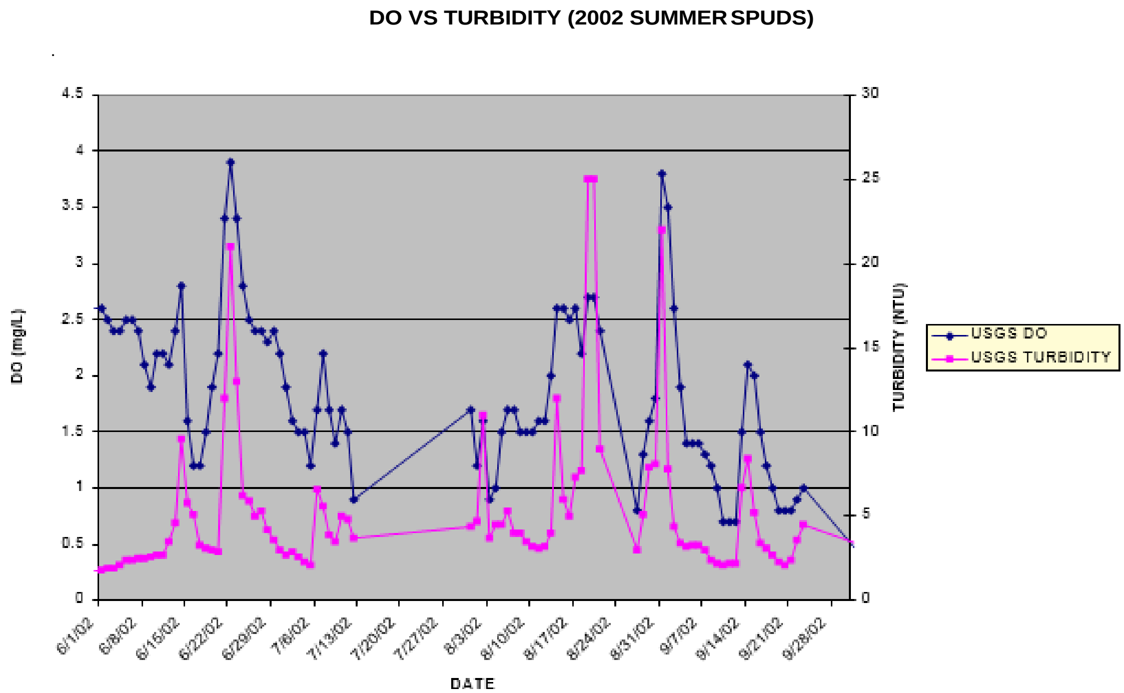


Figure 5: Relationship between Dissolved Oxygen and Turbidity at the USGS gauge, Spuds, Florida

August 7, 2009

Mr. Mike Kelter, P.E.
Legacy Civil Engineers
630 Myrtle Avenue
Green Cove Springs, FL 32043

RE: WBID 2589, Comments by Flagler Estates Road & Water Control District regarding Sixteen Mile Creek TMDL: PART 1

Dear Mr. Kelter:

The Department appreciates the time and effort you and your staff put into reviewing this draft TMDL. We have made any necessary edits to the draft report as a result of your comments. Because of your efforts, the final TMDL will be improved. To aid you in reviewing our responses, we have included your comment, followed by a response to each (in blue), in the order in which they were presented. Some of the images included in the original submittal have been deleted to save space.

As District Engineer for the Flagler Estates Road & Water Control District (FERWCD), which has title to Sixteen Mile Creek, I have supervised the review of information that was provided in the TMDL report dated June 19, 2009 and in subsequent correspondence received by the office on July 17, 2009.

Because of the compressed timeframe, we will offer our comments in parts. We intend to comment on the reliability of data used in the FDEP TMDL report; on the validity of focusing TMDL efforts in Sixteen Mile Creek on reducing turbidity, TSS and sedimentation; on correcting the area of the WBID to ensure that all stakeholders who drain into Sixteen Mile Creek are afforded equal opportunity to participate; and on protecting the District's right to use Sixteen Mile Creek, which was constructed as a drainage conveyance and treatment system, for its historical intended use.

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Mr. Mike Kelter, P.E.
Legacy Civil Engineers
August 10, 2009
Page Two

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Mr. Mike Kelter, P.E.
Legacy Civil Engineers
August 10, 2009
Page Three

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FLSJWMDCRDE (Bypass canal north of Ashley Crossing) 12:15 p.m.
FLSJWMDCRDW (Cracker Swamp & West Deep Creek) 12:30 p.m.

During August 2004, the District was stockpiling road construction materials North of Ashley crossing. To get from FLSJWM16MCRK to FLSJWMCRDE would entail a three minute drive (it might be longer with road flooding), stopping to unlock the gate (I am not sure they have a key to the gate), stopping and unloading the vehicle, walking 2000 feet to the sampling point, taking the grab sample and recording other date, walking back to the vehicle, stopping to lock the gate, and driving another 4 minutes to get to FLSJWMDCRDW. That is not likely to occur in that duration of time.

FDEP finally responded to our request for information just over 24-hours ago, and with only 72 hours remaining until comments must be submitted, we have had scant time to fully evaluate FDEP’s analysis. However, in our very brief analysis to date, we believe there are sufficient concerns about the reliability of temperature data being used by FDEP to adopt TMDL rules that will cost the Flagler Estates landowners millions of dollars to implement.

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Department Response: The water temperature and dissolved oxygen measurements cited in the TMDL document represent discrete measurements in Sixteen Mile Creek. The water temperature measurements presented in Figure 1 reported at the USGS gaging site located in Deep Creek near Spuds (02245260) appear to be the daily average values. Daily minimum and maximum temperatures are available from that gage starting in October 2008. Over the October 1, 2008 – August 6, 2009 period, the average daily temperature difference was 1º C with minimum and maximum differences of 0.2 and 3.5º C, respectively. There are a number of physical and hydrologic factors that can influence water temperature and dissolved oxygen conditions between stream locations. Units for dissolved oxygen in the Excel file previously provided were mg/L. With respect to total water depths and ability to complete measurements at multiple sites in the times reported, the data provider (SJRWMD) should be contacted. The Department often employs multiple sampling teams to conduct sampling surveys.

COMMENTS ON TURBIDITY, TSS, AND SEDIMENTATION:

Sixteen Mile Creek and its tributary canals are manmade facilities constructed pursuant to a Court Order filed in the Circuit Court of Florida on June 14, 1971. Since that time the canals and creek were constructed and have been maintained as drainage conveyance and treatment facilities.

By all indications, the system was undersized at the time of design and construction. Since construction, numerous unpermitted-construction of open ditches has occurred in lands outside the District boundaries. These unpermitted drainage conveyance systems have overloaded the conveyance capacity of the canals, creek and the associated drainage control structures. This overload has resulted in huge amounts of erosion which manifests itself in high levels of turbidity, Total Suspended Solids (TSS), and sedimentation in the canal and creek bottoms.

We are not talking about a little bit of dirt—we are talking about a lot. In the Annual Engineer's Report to the Flagler Estates landowners (published in June 2009 and posted on the District website at www.ferwcd.org) we reported that 10,290 tons of soils and other materials had eroded in Flagler Estates during 2008/09. This amount of erosion is substantially less than the 13,125 tons of erosion that occurred in 2007/08. The reduction in erosion is the result of substantial investment made by the District Board of Supervisors in permanent erosion protection. The Board of Supervisors believes that permanent erosion control and removal of sediments in the top environmental priority for the District. Clearly you can see in **FIGURE 2** that erosion endangers at least one of the species that inhabit Flagler Estates.

Erosion of soils, as the result of high velocity flows, creates enormous turbidity, TSS and sedimentation issues. We have measured TSS in excess of 687 mg/L coming into Flagler Estates from unpermitted ditches lying outside the District Boundaries. FDEP (Northeast District) has told the District that they are obligated to stop the condition or be fined. SJRWMD has told the District that FERWCD has no authority to stop the condition.

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We believe that erosion of soils, and the attendant increases in turbidity, TSS and sedimentation have more bearing on the levels of dissolved oxygen in Sixteen Mile Creek than do issues of Total Nitrogen or algal blankets. First, erosion of 10,290 tons of soil annually is going to go someplace. To the extent that the soil deposits along the canal and creek banks, friendly, submerged aquatic species are smothered and can no longer provide oxygen-generating functions during photosynthesis **(SEE FIGURE 3).**

Second, when eroded soils remain in suspension as TSS, the heat-storing capacity of a water body increases.

Finally, when turbidity increases and water discolors, the ability of light to reach friendly, submerged aquatic plant species is diminished and dissolved oxygen drops.

The Department has asked the District to show that turbidity, TSS and sedimentation are relevant to the Sixteen Mile Creek dissolved oxygen TMDL. Let's talk about this:

For this discussion, we will use data collected at the USGS gauge at Spuds during the summer months of 2002. With all due respect to our friends at the Department, there is more data available and it is, perhaps, more reliable. Drops in dissolved oxygen levels don't occur instantaneously—they occur over time. The data set that Dr. Magley, which are used to establish correlations between TN and DO, and which fail to establish correlations between turbidity and DO, are limited to monthly "snapshots" of stream conditions. In some cases, the data sets are limited to two samplings per year. The data sets do not provide an accurate snapshot of stream conditions over a week of cloudy days or cloudy water.

Continuous gauge readings do show a very clear relationship between turbidity and dissolved oxygen levels.

As shown in **FIGURE 4** there is a very clear relationship between flow and turbidity. In most cases, when flow increases, so does turbidity. In some cases that doesn't happen, especially when there are back-to-back storm events. In those cases, flows may rise without a corresponding rise in turbidity. It is generally accepted that the first-flush of pollution has the heaviest loads. You don't see that in the semi-annual data that is used in the FDEP report.

FIGURE 5 illustrates the relationship between turbidity and dissolved oxygen. Again, this data is from the USGS gauge at Spuds during the summer of 2002. This chart shows that dissolved oxygen increases when turbidity increases. Dissolved oxygen in canals and streams increases when it rains. Turbidity increases when rain runoff causes unacceptable flow velocities. That is why DO and turbidity often increase independently at the same time. When turbidity is high, and it is not raining, **FIGURE 5** [Figure deleted] suggests that dissolved oxygen decreases, dependent on the turbidity levels.

Figure 5: Relationship between Dissolved Oxygen and Turbidity at the USGS gauge, Spuds, Florida

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We are citing turbidity, TSS and sedimentation as the constituents of concern due to the obvious response of dissolved oxygen to high concentrations of those constituents. While the District is sensitive to its responsibilities as good environmental stewards, we don't believe that the Department has made the case nutrient pollution in Sixteen Mile Creek. In the response letter sent by Mr. Mandrup-Poulsen, the Department admitted that there were no threatened or endangered species that could be threatened due to algal mats (Rule 62-303.351 (1)) and admitted that the chlorophyll a levels did not exceed 20 μg/L during the planning list assessment (Rule 62-303.351 (2)). As such, the TMDL in Sixteen Mile Creek needs to address dissolved oxygen. We believe that correcting high turbidity, TSS and sedimentation is the most economical and efficient method of achieving that goal.

Department Response: Daily mean discharge (CFS), daily mean DO (mg/L), and mean daily unfiltered turbidity (NFU) measurements from the USGS gage at Spuds at summarized below.

- = Empty cell/no data

-	DISCHARGE	TEMPMEAN	DOMEAN	TURBIDITYM
N of cases	2563	2284	2160	2179
Minimum	-60.000	7.300	0.000	0.000
Maximum	3790.000	29.700	8.500	180.000
Mean	82.617	21.266	2.776	2.989
Standard Dev	227.780	4.979	1.668	6.897
1 %	-31.870	10.600	0.200	0.000
5 %	-7.000	12.600	0.600	0.100
10 %	0.448	13.900	0.900	0.200
20 %	7.100	16.100	1.400	0.400
25 %	10.000	17.200	1.500	0.525
30 %	13.000	18.300	1.700	0.700
40 %	18.000	19.900	2.100	1.000
50 %	25.000	21.900	2.500	1.400
60 %	32.000	24.100	2.900	1.800
70 %	45.000	25.500	3.400	2.680
75 %	56.000	25.800	3.600	3.100
80 %	74.900	26.200	4.000	3.700
90 %	163.200	26.900	5.400	6.000
95 %	355.700	27.500	6.100	11.000
99 %	1240.000	28.300	7.500	25.000

The following graphs of daily mean DO versus daily mean discharge as well as daily mean DO versus mean daily unfiltered turbidity are presented.

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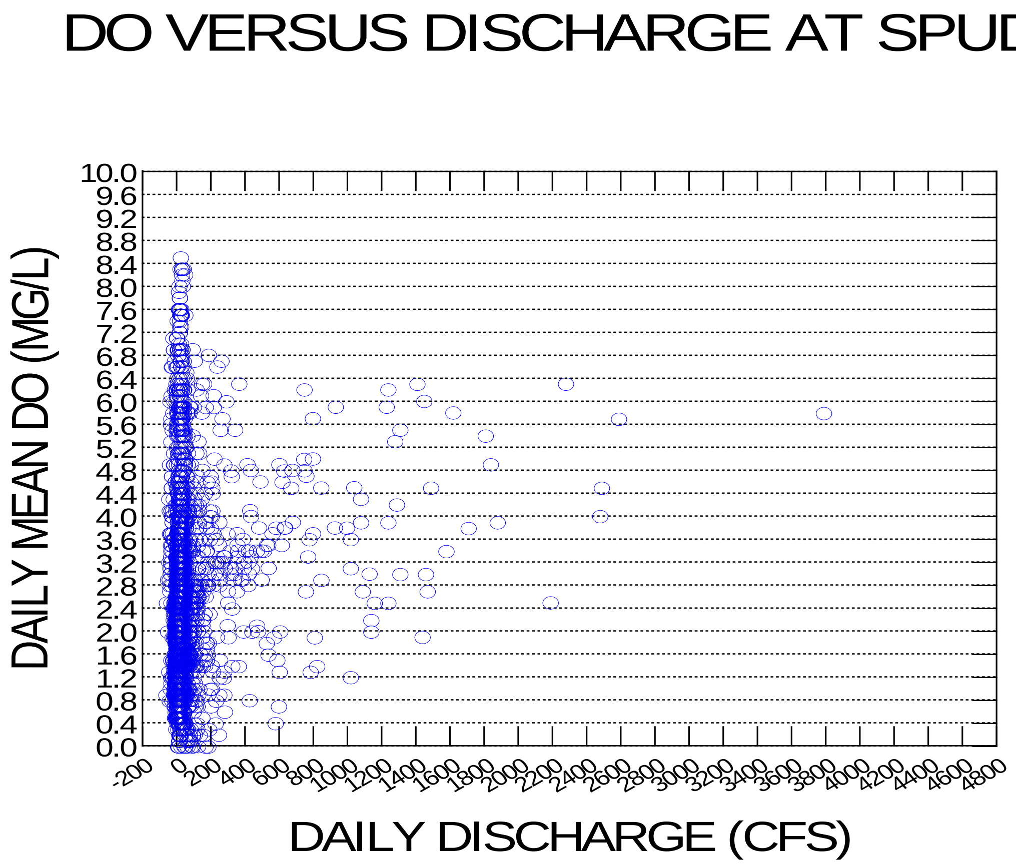

In order to better illustrate possible relationships between do and discharge, the following graph limited discharge measurements to less than 200 CFS.

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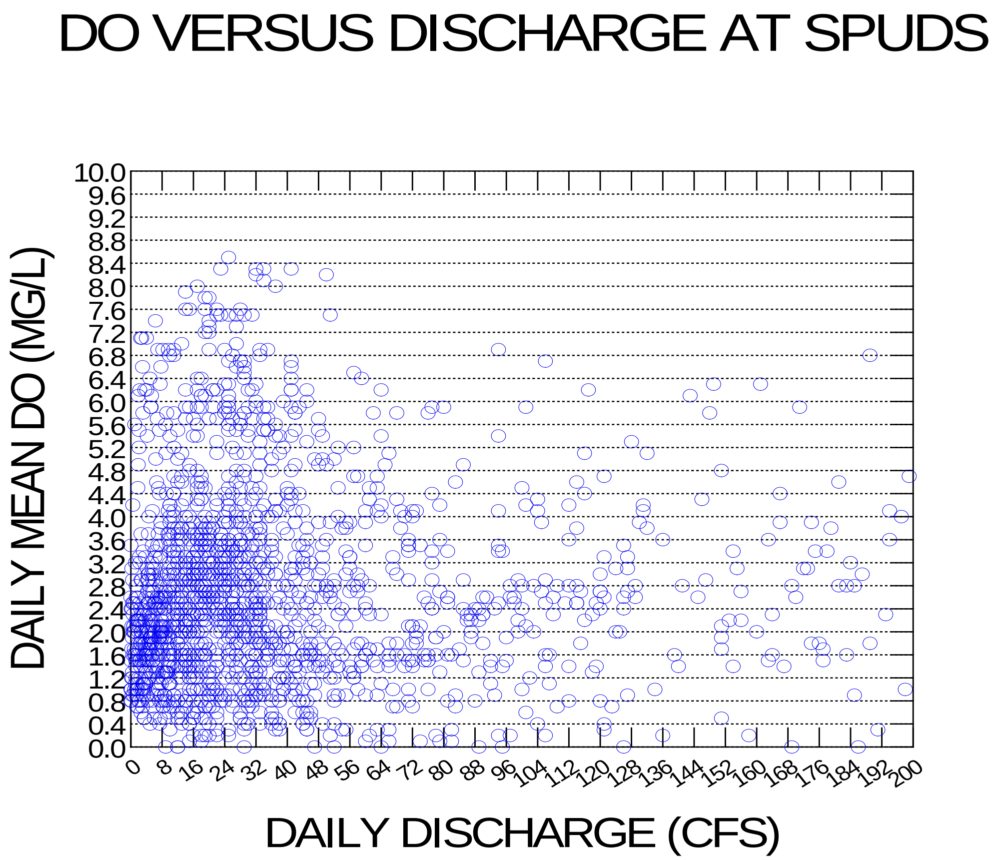

The Department concurs that excessive turbidity and sediment erosion can adversely affect the hydrology and habitat in receiving waters such as Sixteen Mile Creek and support efforts by the Flagler Estates Road & Water Control District to control flows, turbidity, TSS, and sediments in the Sixteen Mile Creek. The Department encourages the District to participate in the BMAP process and help demonstrate the effectiveness of its activities to restore the Sixteen Mile Creek watershed.

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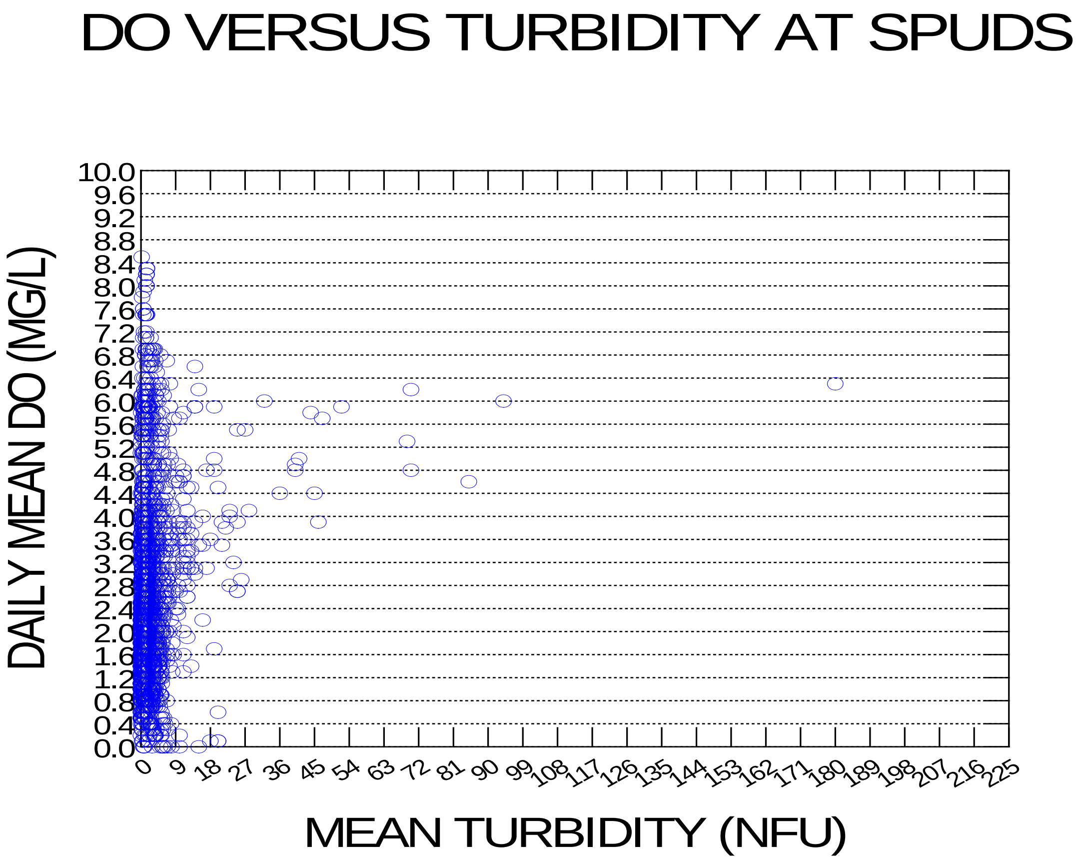

In closing, we appreciate your continuing active interest in the Total Maximum Daily Load program, and look forward to you and your clients helping us to restore the designated uses in the Sixteen Mile watershed.

Please contact me or Dr. Wayne Magley at 850/245-8449 if you have any further questions.

Sincerely,

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

ec: Jeff Martin/DEP
Amy Tracy/DEP

August 7, 2009

Mike Kelter, P.E.
Legacy Civil Engineers
630 Myrtle Avenue
Green Cove Springs, FL 32043

RE: WBID 2589, Comments by Flagler Estates Road & Water Control District regarding Sixteen Mile Creek TMDL: PART 2

Dear Mr. Kelter:

The Department appreciates the time and effort you and your staff put into reviewing this draft TMDL. We have made edits to the draft report as a result of your comments. Because of your efforts, the final TMDL will be improved. To aid you in reviewing our responses, we have included your comment, followed by a response to each (in blue), in the order in which they were presented.

As District Engineer for the Flagler Estates Road & Water Control District (FERWCD), which has title to Sixteen Mile Creek, I have supervised the review of information that was provided in the TMDL report dated June 19, 2009 and in subsequent correspondence received by the office on July 17, 2009.

Because of the compressed timeframe, we will offer our comments in parts. PART 1 comments on the reliability of data used in the FDEP TMDL report and on the validity of focusing TMDL efforts in Sixteen Mile Creek on reducing turbidity, TSS and sedimentation. PART 2 comments on correction of minor errors in the FDEP report and on correcting the area of the WBID to ensure that all stakeholders who drain into Sixteen Mile Creek are afforded equal opportunity to participate. PART 3 comments on concerns regarding use of analytic tools and application of rules designed to protect natural streams and water bodies on Sixteen Mile Creek, which is a man-made drainage conveyance and treatment system.

Part 2 of our comments discusses sources of assessment found in Section 4 of the FDEP TMDL report, and area of the WBID assumed in the report. The District offers the following comments on the Department's analysis:

COMMENTS ON ASSESSMENT OF SOURCES:

We have a number of concerns regarding the calculations and assumptions used in assessing the pollution loads of the Sixteen Mile Creek basin. These concerns range from simple math errors in the FDEP TMDL report to very major, questionable assumptions. Let's look at the simple math errors first. In Table 4.6 gross runoff is calculated by multiplying the acreage for each land-use classification by the annual runoff coefficient times the annual rainfall (in feet). For the Residential, Low Density B/D classification, the Department calculated gross runoff as 427.14 acre-feet. We checked the calculation and came up with gross runoff of 411.70 acre-feet for that calculation. Similarly, we found Open land B/D to have gross runoff of 917.94 acre-feet instead of 907.79 acre-feet; and Open Land C/D to have gross runoff of 2774.09 acre-feet instead of 2725.85 acre-feet. We checked four calculations and found three errors in the little time that we have been given to review the Department's report. We suggest that the Department check all their math prior to adopting any TMDL.

Department Response: We stand by the calculated values we provided in the report. However, by way of explanation, the values in **Table 4.6** were only reported to two decimal places, which would have led to the minor differences you noted. In your first example (for the "Residential, low density B/D" classification), the actual annual runoff coefficient used in the calculation was 0.083 rather than the 0.08

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value in the table. Using 0.083 yields a gross runoff of 427.14 acre-feet. Similarly, for the open land example, the annual runoff coefficient in the calculation was 0.089 rather than 0.09. The tables in the document will be revised to show the annual runoff coefficients to three decimal places.

We have a concern about using the Harper-Baker method for assessing pollution loads. Consistent with the peer reviews of that method, we are concerned that this method makes inappropriate use of annual average runoff based on rainfall data from the Jacksonville International Airport (80 miles to the north) without accounting for the variability of rainfall and runoff amounts.

Department Response: The calculations in Chapter 4 represented estimates of potential nutrient loads assuming a long-term annual average rainfall of 52.44 inches based on records from the Jacksonville International Airport. It was not intended to represent seasonal or annual variations in rainfall or runoff. The following table is based on NOAA rainfall data for sites in the SJRWMD compiled by the SJRWMD. Based upon the table, it does not appear that a long-term average of 52.44 inches is inappropriate.

Location	Period of Record	Long-term Annual Average Rainfall (inches)
Crescent City	1897 - 2006	51.88
Federal Point	1892 - 2006	52.47
Hastings	1944 - 2006	52.65
City of Jacksonville and JIA	1867 - 2006	52.06
Palatka, Hastings, SJRWMD District Headquarters	1923 - 2006	52.06

We have a number of comments on the Land Use Classifications for the basin. The report claims that there are 13.29 acres of medium density residential land in the so-called urban built-up areas, all located on soils group D. For purposes of TN calculations, these lands have apparently been assigned a Harper event mean concentration of 2.07. We have not found the existence of this land classification in the basin. As the Department is well aware, in the Sixteen Mile Creek basin a soils group D is hydric and therefore wetland. Neither the Department nor SJRWMD will allow construction on wetlands without significant mitigation. These areas need to be assigned a Harper event mean concentration of 1.60 for TN just like other mixed forested wetlands in the basin.

Department Response: The land use classifications and associated acreages were based on the 2004 land use coverage provided to the Department from the SJRWMD. Attached is a figure that illustrates the Level 2 land uses. Similarly, the soils information was based on the SSURGO coverage also provided by the SJRWMD. If you can identify specific areas where the land use or soil classifications may be incorrect, please provide that information to the Department and we will work with the SJRWMD to make the necessary corrections.

We're also commenting on the 15.92 acres of industrial land-use classification that the Department's report claims to exist in the basin, some of which is on soils group D. There is no industry in the Sixteen Mile Creek WBID.

Department Response: According to the 2004 land use coverage, the 15.92 acres classified as industrial land use represented food processing. If there are no food processing activities in the Sixteen Mile Creek watershed, please let us know and we will work with the SJRWMD to make the appropriate classification changes.

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We have a major concern about the assumptions and calculations regarding estimated TN and TP loads as a result of septic tanks. The report states that there are 611 septic tanks in the basin, each with a daily hydraulic loading of 200.9 gallons per day with TN and TP concentrations of 36 mg/L and 15 mg/L, respectively. The 1998 EPA WMM User Manual suggests TN and TP maximum loads of 30 mg/L and 4 mg/L, respectively.

Department Response: The TN and TP concentrations were based on materials available on the FDOH Website (such as "Unsaturated Zone Monitoring Below Subsurface Wastewater Systems Serving Individual Homes in Florida" by Anderson, Lewis, and Sherman), literature (such as "Effects of Aeration on Water Quality from Septic System Leachfield," by Potts, Gorres, Nicosia, and Amador), studies conducted in other states (such as "Nitrogen and Phosphorus Loading From Septic Systems in the Broadkill River Watershed in Delaware"; "Statewide GIS/Census Data Assessment of Nitrogen Loadings from Septic Systems in Pennsylvania" by Nizeyimana, Petersen, Anderson, Evans, Hamlett, and Baumer; and "Septic Systems and Nitrate Nitrogen as Indicators of Ground Water Quality Trends in New Jersey" by Fred Bowers), and additional citations from the Annotated Septic System Bibliography.

According to the calculations in the FDEP report, every septic tank in the basin would need to fail and leak every single day in order to discharge 13,465 pounds of TN and 5,610 pounds of TP annually. A failure rate of 100% is highly unrealistic. Studies conducted on the water quality of the Ocklawaha River Basin found that annual frequency of septic tank repairs was about 0.97% (Ocklawaha Basin Status Report 2001). For average annual conditions, it is conservative to assume that septic tank systems failures would be unnoticed or ignored for five years before repair or replacement occurred (WMM User Manual: 1998). Therefore, the septic tank failure rate used in this TMDL should be calculated by multiplying repairing frequency (0.97%) by 5 (years), or about 5%.

Using a 5% failure rate/repair frequency times 30 mg/L for each septic tank yields a Total Nitrogen contribution of 560.83 pounds per year for septic tanks, compared to the 13,465 pound load estimated in the FDEP TMDL report.

Using a 5% failure rate/repair frequency times 4 mg/L for each septic tank yields a Total Phosphorous contribution of 74.77 pounds per year for septic tanks, compared to the 5,610 pound load estimated in the FDEP TMDL report.

Department Response: As you are aware, conventional septic systems consist of two major components, the septic tank and the underground absorption field. Liquid from the septic tank flows through perforated pipes through gravel in the drain field into unsaturated soils and mixes with ground water. This process represents the normal operation of the system. The TMDL document presented the potential TN and TP load from septic systems that would enter the unsaturated soils and mix with ground water. The document also pointed out that a number of factors would influence how much of this potential load might reach Sixteen Mile Creek. Some of these factors included the age of the individual systems, rate of loading of each system, the degree of assimilation or retention of nutrients based on soil types and vegetation, as well to proximity to Sixteen Mile Creek. If there needs to be further clarification of the loading calculations and factors that would reduce this potential load or have additional site-specific information on septic tank contributions, please provide this to the Department and it will be incorporated into the document.

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COMMENTS ON WBID SIZE:

The District believes that the area used by FDEP in calculations for the TMDL report is inaccurate. The TMDL report states that the basin size is 17,431 acres. The District believes this vastly understates the acreage that drains through Sixteen Mile Creek, which is a manmade drainage canal constructed in 1973, pursuant to a Court order filed in the Circuit Court of St. Johns County in June, 1971.

The original drainage calculations performed by JJ Garcia & Associates, based the canal and structure sizes on runoff from approximately 18,600 acres as shown in Exhibit A. Rainfall data was based on a 30-year average rainfall recorded at the Daytona Beach Airport.

Department Response: At this time the Department has not received Exhibit A. If materials are provided that support modifying the WBID boundaries, the appropriate changes will be made to the document and the Department's WBID coverage.

During Tropical Storm Gabrielle, in September 2001, the District noted that the flow characteristics of Sixteen Mile Creek indicated runoff from an area greater than that planned by JJ Garcia and Associates. Based on this observation, the District began to inventory all drainage structures in the District and all connections to the District that were not shown in the approved Plan of Reclamation, filed with the Courts.

In 2004 and 2005, the District found that many water control structures were inexplicably damaged by runoff from relatively small storms. When the District investigated the issue, extensive ditch and canal digging was discovered outside the District boundaries. This excavation of ditches altered the characteristic of off-site runoff from overland flow to open-channel flow. The District reported this to SJRWMD and determined that no permits had been issued for the work. No action has been taken by SJRWMD with respect to this alteration of flows.

Department Response: Unpermitted ditch and canal digging is not within the scope of the TMDL Program. As noted in the comment, the SJRWMD would be the appropriate agency to address this issue.

In 2007 St. Johns County undertook the County-wide drainage study. Concurrent with this effort, the District began its own parallel study to further refine the results of the County-wide study in order to provide locally-relevant drainage information. Throughout the study, the District and the County agreed only to include sub-basin runoff that could be physically verified.

Throughout 2008 and into 2009, the District verified 20,723 acres of land that drain into Sixteen Mile Creek (SEE APPENDIX B). Most of this additional acreage was identified in Flagler County by actual observation of flows, since Flagler County only possesses Digital Elevation Models in 5-foot contour intervals. The 20,723 acres excludes some acreage in St. Johns County, east of WBID eastern boundary which flows west instead of east, depending on the condition of the eastern outfalls. Both St. Johns County and Flagler Estates Road & Water Control District have developed extensive ICPR models for the watershed based on verified connections to Sixteen Mile Creek.

During the May 2009 No-Name Northeaster, the District observed flows from Flagler County that could not be explained by the size of the sub-basin that had been defined in the model. It is apparent from that event that further evaluation of the Flagler County sub-basin needs to be undertaken. The problem with

Mike Kelter, P.E.
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undertaking further evaluation of Flagler County runoff is jurisdiction. These areas lie outside both the County and the District boundaries and both entities are somewhat restrained by law from expending taxpayer or landowner funds outside the boundaries of the respective jurisdictions.

Department Response: At this time the Department has not received Exhibit B. If materials are provided that support modifying the WBID boundaries, the appropriate changes will be made to the document and the Department's WBID coverage.

The District is concerned that the TMDL methodology will be disproportionally weighted against Flagler Estates and St. Johns County, which maintain good records of flow contribution, and in favor of Flagler County which has very few records for this area. It will take years to document flows through Flagler County into Sixteen Mile Creek, especially if patterns of unpermitted drainage construction are allowed to continue.

Department Response: As noted earlier, it seems that the appropriate course of action for the Flagler Estates and St. Johns County is to re-engage the SJRWMD regarding unpermitted drainage construction that enters the Drainage District and influences water quality.

The District does not intend to expend large amounts of resources based on data that may or may not lead to successful accomplishment of TMDL goals. Getting the WBID size right is key to success. Since this will not happen within the short time provided by FDEP, the District requests that FDEP include in the TMDL provisions that allow the District and St. Johns County the ability to re-open discussion of WBID size throughout the BMAP and BMAP implementation process, and reallocate responsibility for removal of pollutants that lead to the low dissolved oxygen conditions that FDEP has found from time to time in Sixteen Mile Creek.

Department Response: The Department will revise Chapter 7 in the document to indicate that further studies are ongoing by St. Johns County and Flagler Estates Road & Water Control District regarding the drainage area for the Sixteen Mile Creek WBID that may influence stakeholders' responsibilities for removal of pollutants in Sixteen Mile Creek in the BMAP and the subsequent implementation process such that designated uses are restored.

In closing, we appreciate your continuing active interest in the Total Maximum Daily Load program, and look forward to you and your clients helping us to restore the designated uses in the Sixteen Mile watershed. If time allows, we would appreciate receiving any additional materials to aid us in this effort, including Attachments A and B, as discussed above.

Please contact me or Dr. Wayne Magley at 850/245-8449 if you have any further questions.

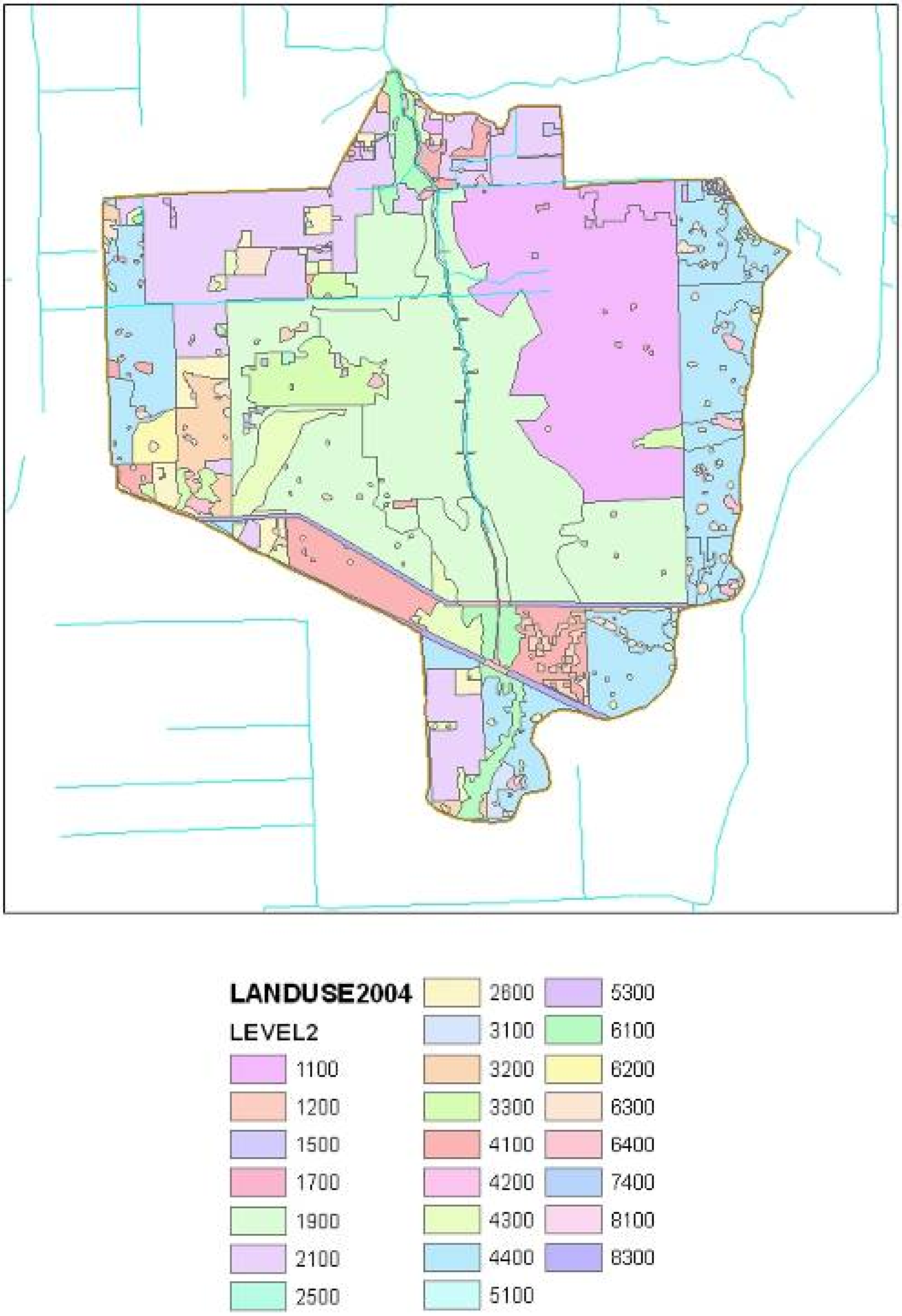
Sincerely,

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

ec: Jeff Martin/DEP
Amy Tracy/DEP

Attachment

SIXTEEN MILE CREEK 2004 LANDUSE



August 10, 2009

Mr. Joshua Boan
Environmental Process/Natural Sciences Manager
Environmental Research Administrator
605 Suwannee Street MS 37
Tallahassee, FL 32399
Ph: 850-414-5266
Email: joshua.boan@dot.state.fl.us

Re: FDOT Comments on Newly Released Draft TMDLs

Dear Mr. Boan,

The Department appreciates the time and effort you and your staff put into reviewing these draft TMDLs. We have made necessary edits to some draft TMDL reports as a result of your comments. Because of your efforts, the final TMDL will be improved. To aid you in reviewing our responses, we have included your comments, followed by a response to each (in blue), in the order in which they were presented. Please contact me at Jan.Mandrup-Poulsen@dep.state.fl.us. if you have any further questions.

Sincerely

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

DISTRICT 2 COMMENTS

GENERAL COMMENTS

The following comments relate to multiple TMDLs where specific comments are provided below for each of the TMDL documents.

1. It appears that the nutrient load assessments for the transportation category (Chapter 4) are based upon values presented in Harper (2007) (i.e., 1.64 mg/l TN and 0.22 mg/l TP). Harper's numbers are determined by averaging the average results from eleven different datasets from studies conducted between 1975 and 2005. Each study was given equal weight in the averaging procedure regardless of the number of events sampled and the methodologies used. Between December 2004 and October 2007 roadway runoff water quality data were collected by Johnson Engineering for FDOT District 1 at four locations within District 1. Ten events were sampled for each of the four locations, with samples collected at both the inflows and outflows of existing stormwater treatment ponds. All collection, transfer, and handling procedures were conducted in accordance with FDEP Standard Operating Procedures, and samples were analyzed by certified labs. Average values for TN and TP ***at the pond inflows*** were determined to be 1.17 mg/l and 0.158 mg/l, respectively. [It is perhaps noteworthy to observe that the highest average TN and TP values were measured at the first site sampled (i.e., samples collected between December 2004 and November 2005) which is also the site with the lowest percentage of impervious area.] Given the changes to roadway management practices that FDOT has undertaken

over the past several years and the rigorous quality control used in these studies compared with the older studies, we believe that the numbers presented by Johnson Engineering are more representative than Harper's numbers of present day TN and TP loading conditions. [This comment applies to all nutrient and DO TMDL documents reviewed. This included WBIDs 2410, 2389, 2203, 2213P, 2265A, 2460, 2589, 2578.]

Department Response: A copy of the Johnson Engineering Study report was not included with the comments we received. If FDOT could provide the report to Mr. Eric Livingston (Bureau Chief for the Bureau of Watershed Restoration), it will be reviewed for incorporation into the stormwater database and use in estimation of transportation event mean concentrations (EMCs).

1. The load reductions determined for the non-point sources, which include the WLA for the stormwater (under the MS4 permit) and the LA, have not been allocated but simply applied evenly between the WLA for Stormwater and the LA. Sufficient studies have not been completed to determine if an even distribution of the load reductions is justified, therefore some language acknowledging this (within the TMDL and ultimately within the Rule) should be put into both the TMDL documents and ultimately the rules to allow the ability to finalize (and therefore change the assigned reductions) under the BMAP. [This comment applies to all TMDLs reviewed in which there was an WLA-MS4 allocation specified.]

   Department Response: In 2001, the Department submitted to the Governor and Legislature a document outlining the intended process for the allocation of loads under the TMDL Program. One key provision of the proposal was to level the "playing field," such that once stakeholders had the opportunity to meet and discuss what steps needed to be taken and to get appropriate credit for those initiatives already completed, the specific allocations will be set by the agreements reached under the Basin Management Action Plan (BMAP). This process has been successfully used in several adopted BMAPs and has demonstrated the flexibility that remains after setting the initial reductions for stormwater-related allocations (LA and WLA_{sw}) at identical levels.

   The laws of Florida form the underlying basis for the initial equal allocations. In particular, Section 403.067(6)(b), Florida Statutes, states in part that:

   "Allocations may also be made to individual basins and sources or as a whole to all basins and sources or categories of sources of inflow to the water body or water body segments. An initial allocation of allowable pollutant loads among point and nonpoint sources may be developed as part of the total maximum daily load. However, in such cases, the detailed allocation to specific point sources and specific categories of nonpoint sources shall be established in the basin management action plan…"

   Additionally, each of the draft TMDL reports contains language in the NPDES Stormwater Discharges section in Chapter 6 of the reports (repeated below) to address the issue of allocation between the WLA for stormwater and the LA portions of the TMDL.

   "It should be noted that any MS4 permittee is only responsible for reducing the anthropogenic loads associated with stormwater outfalls that it owns or otherwise has responsible control over, and it is not responsible for reducing other nonpoint source loads in its jurisdiction."

Florida Department of Environmental Protection
Division of Environmental Assessment and Restoration
Bureau of Watershed Restoration
2600 Blair Stone Road, Mail Station 3565
Tallahassee, Florida 32399-2400