Appendix A:

Modeling Report

Black Creek and Little Black Creek

WBIDs: 2415B & C and 2368

Dissolved Oxygen

September 30, 2009

Region4 serving the southeast

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1. Watershed Description

Black Creek and Little Black Creek lies in southern Brevard County just west of the city of Melbourne. It is an element of the upper St. Johns River, being located upstream of where US Highway 192 crosses the Upper St Johns River.

WBIDs 2415B&C and 2368 were listed as not attaining its designated uses on Florida's 1998 303(d) list for Dissolved Oxygen. Figure 1 provides the location of Black Creek and Little Black Creek.

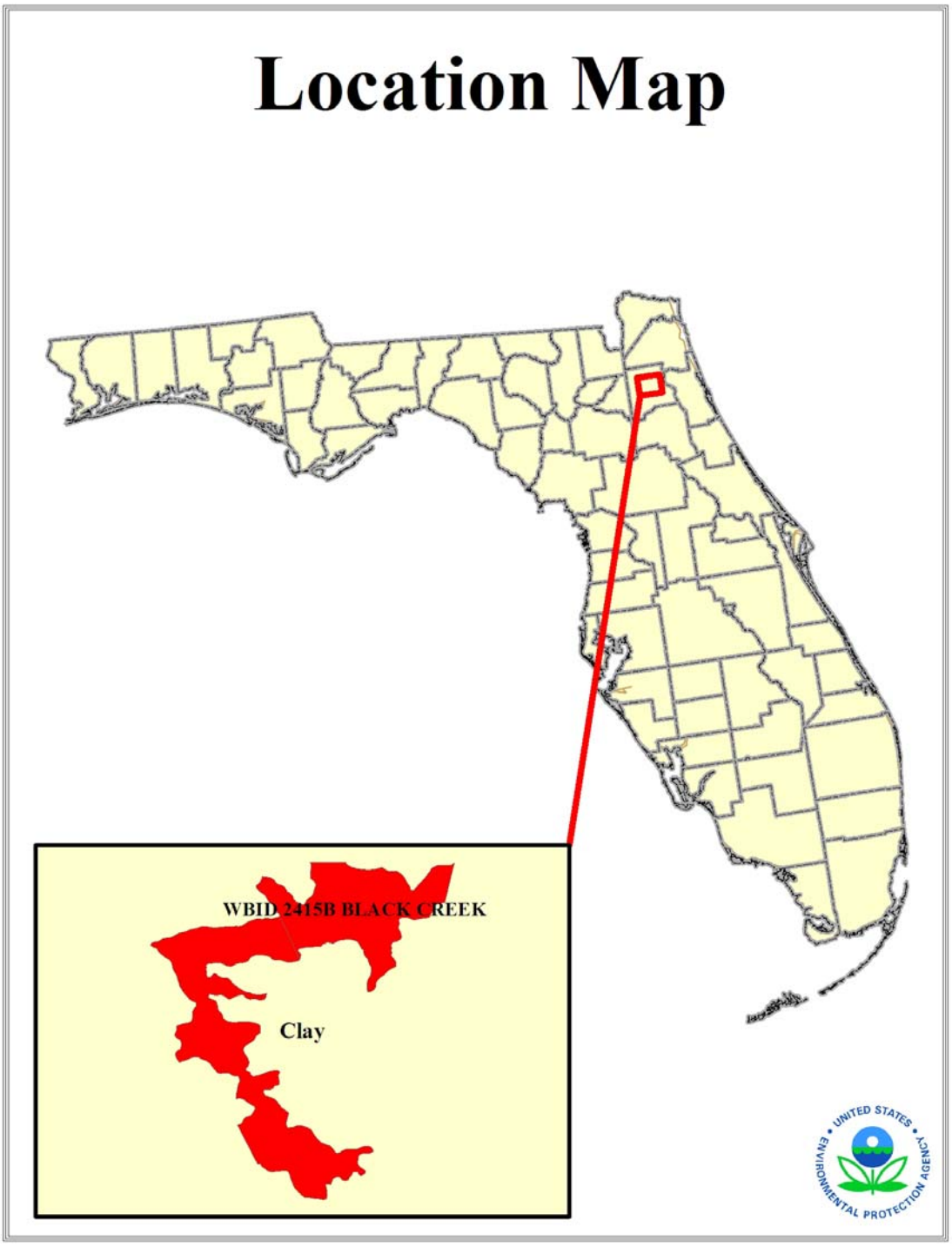

Figure 1 Location Map Black Creek and Little Black Creek

The landuse distribution for the Black Creek and Little Black Creek is presented in Table 1.

Table 1 Landuse Distribution in Black Creek and Little Black Creek Watershed

Land Use Name	Area (ac)	Portion of Watershed (%)
AGRICULTURE	6,876	2.4%
BARREN LAND	4,793	1.7%
RANGELAND	10,472	3.7%
TRANSPORTATION, COMMUNICATION AND UTILITIES	5,106	1.8%
UPLAND FORESTS	152,839	53.7%
URBAN AND BUILT-UP	40,928	14.4%
WATER	3,786	1.3%
WETLANDS	59,955	21.1%
Totals	284,755	100.0%

2. TMDL Targets

The TMDL target to be evaluated in this modeling report is to meet the Black Creek and Little Black Creek dissolved oxygen standard of 5 mg/l.

3. Modeling Approach

A coupled watershed and water quality modeling framework was used to simulate biological oxygen demand (BOD), nutrients (total nitrogen and total phosphorus), and chlorophyll a (Chla) and dissolved oxygen dissolved oxygen for the time period of 2002 through 2008. The watershed model provides daily runoff, nutrient and BOD loadings from the watersheds. The predicted results from the LSPC model are transferred forward to the receiving waterbody model Water Quality Analysis Simulation Program (WASP 7.3) (USEPA, 2007). The WASP model integrates the predicted flows and loads from the LSPC model to simulate water quality responses in: nitrogen, phosphorus, chlorophyll a and dissolved oxygen. Both LSPC and WASP will be calibrated to current conditions, a natural condition. The WASP model will be used to determine the percent reduction in loadings that would be needed to meet water quality standards.

3.1. Black Creek and Little Black Creek Watershed Model

The goal of this watershed modeling effort is to estimate runoff (flow), nutrient (total nitrogen & total phosphorus) and BOD loads and concentrations from the J upstream watersheds flowing into Black Creek and Little Black Creek. The Loading Simulation Program C++ (LSPC) as the watershed model.

LSPC is the Loading Simulation Program in C++, a watershed modeling system that includes streamlined Hydrologic Simulation Program Fortran (HSPF) algorithms for simulating hydrology, sediment, and general water quality on land as well as a simplified stream fate and transport model. LSPC is derived from the Mining Data Analysis System (MDAS), which was originally developed by EPA Region 3 (under contract with Tetra Tech) and has been widely used for TMDLs. In 2003, the U.S. Environmental Protection

Agency (EPA) Region 4 contracted with Tetra Tech to refine, streamline, and produce user documentation for the model for public distribution. LSPC was developed to serve as the primary watershed model for the EPA TMDL Modeling Toolbox.

3.1.1. Black Creek and Little Black Creek Watershed Delineation and Landuse

The surrounding watershed that drains directly to the Black Creek and Little Black Creek is presented in Figure 2. This WBID was delineated into 21 LSPC sub basins to simulate the runoff and pollutant loads.

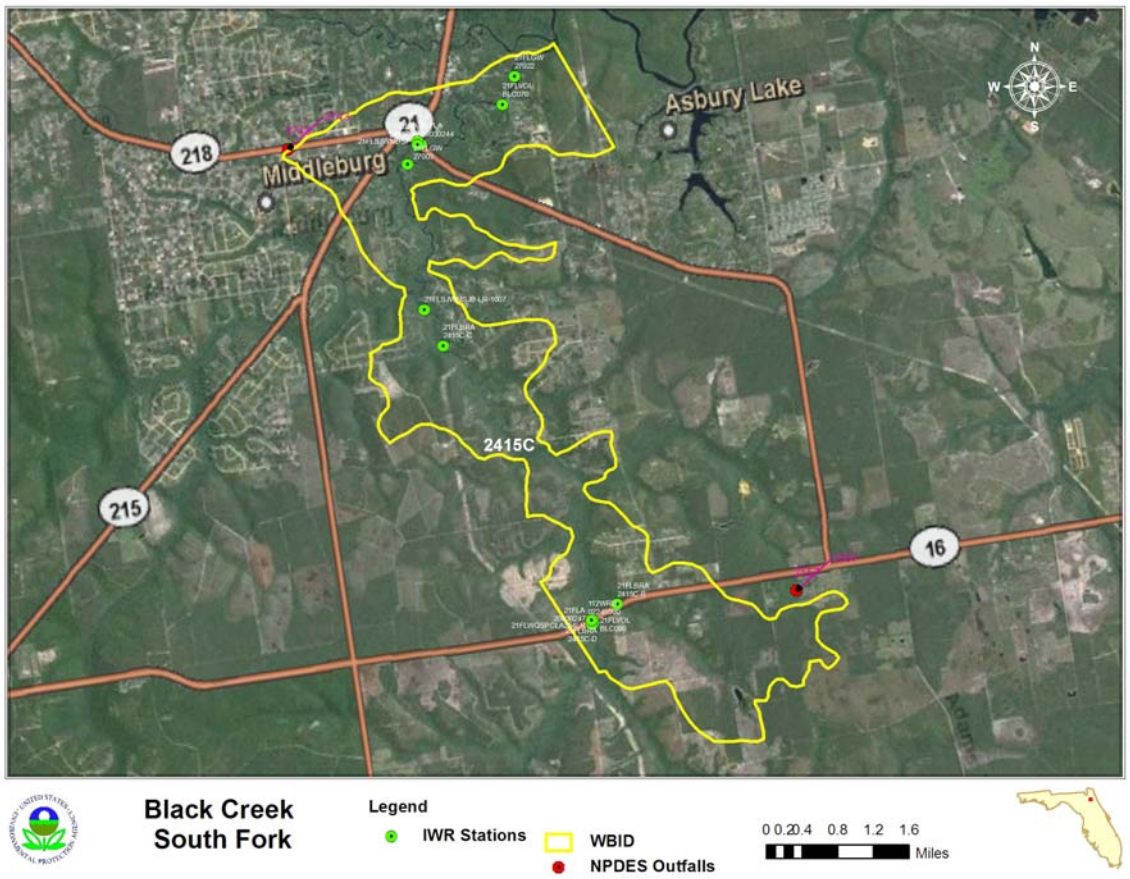

Figure 2 Black Creek and Little Black Creek Watershed

Figure 3 illustrates the Florida Landuse Classification (Level-1) for the Black Creek and Little Black Creek surrounding watershed.

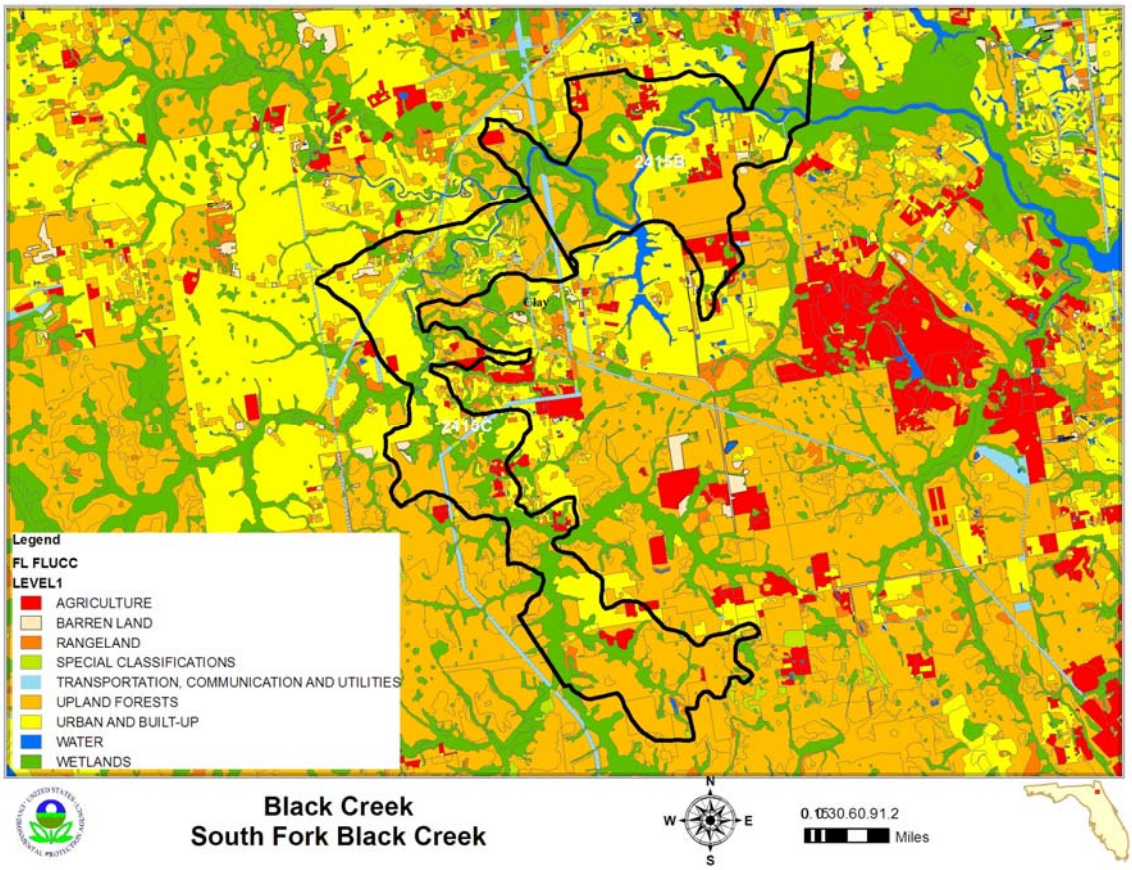

Figure 3 Black Creek and Little Black Creek Watershed Landuse Distribution

3.2. Black Creek and Little Black Creek Watershed Runoff

The LSPC watershed model was developed to simulate hydrologic runoff and pollutant loadings in response to recorded precipitation events.

3.2.1. Meteorological

Rainfall and other pertinent meteorological data was obtained from the National Weather Service (NWS) WBAN station number: 53860 near Jacksonville, Florida.

Figure 4 provides a time series plot of daily rainfall for the simulation period.

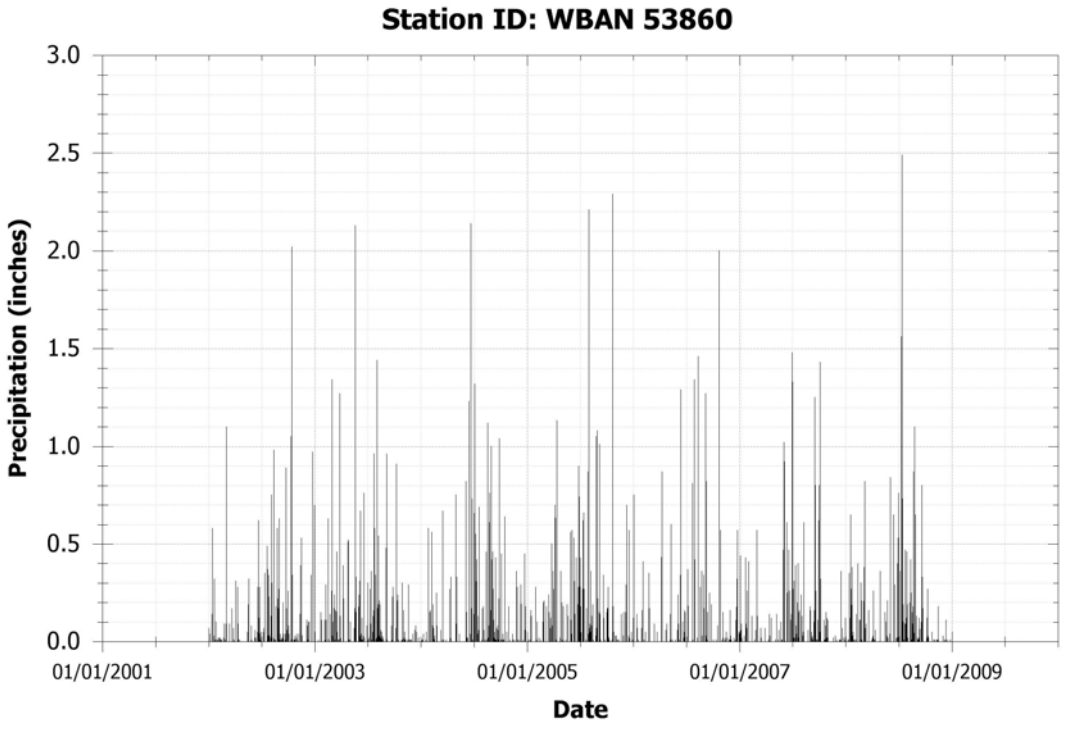

Figure 4 Rainfall for Black Creek and Little Black Creek

Table 2 shows the annual average rainfall for each of the years simulated.

Table 2 Annual Rainfall

Year	Rainfall (Inches)
2002	50
2003	42
2004	47
2005	55
2006	32
2007	49
2008	47

3.2.2. Flow

Flows were simulated for the Black Creek and Little Black Creek watershed using the watershed model and compared to the Black Creek and Little Black Creek USGS gage (USGS 02246025). Flows in the Black Creek and Little Black Creek watersheds were determined by the hydrology component of the LSPC watershed model. The hydrological values used to parameterize LSPC were taken from a previous application of the Hydrologic Simulation Program (FORTRAN) (HSPF) that was previously applied and calibrated for the Upper St. Johns River Basin. (CDM 2007).

3.2.3. BOD and Nutrient Loadings

The pollutagraph was generated using event mean concentrations for total nitrogen, total phosphorus and BOD (Table 3). The initial EMC values were derived for each landuse type from Harpers Report (Harper, 1994) and Sarasota County modeling report (JEA 2005). Baseflow concentrations were derived from the USJR HSPF report (CDM 2007) and review of the Black Creek and Little Black Creek data.

Table 3 Event Mean Concentration for Landuse Classifications

Landuse	Total Nitrogen (mg/l)	Total Phosphorus (mg/l)	BOD (mg/l)
Agriculture	4	1.1	10
Barren Land	4	1.1	10
Rangeland	2.2	0.34	10
Special Classification	2.2	0.3	10
Transporation	2.2	0.3	10
Upland Forest	1.02	0.1	3
Urban Area	1.9	0.2	10
Water	1.02	0.1	3
Wetlands	1.02	0.1	3

BOD and nutrient watershed runoff were determined using EMCs for surface water runoff and interflow runoff and baseflow concentrations for groundwater flow. Table 4 provides the annual average total nitrogen, total phosphorus and BOD loads for the period of record 2002 thru 2008.

Table 4 Black Creek and Little Black Creek Nutrient Loads (2002-2008)

Subbasin	Total Nitrogen Load (kg/yr)	Total Phosphorus Load (kg/yr)	BOD Load (kg/yr)
Little Black Creek Watershed	37,825	4,169	156,188
Black Creek and Little Black Creek Watershed	370,444	40,201	1,377,151
Total of Black Creek and Little Black Creek Watershed	408,269	44,370	1,533,339

3.3. Point Source Dischargers

There are two significant oxygen demanding wastewater direct dischargers in the BASIN according to the PCS database. Spencer WTF, FL0173371 (sub basin 10) and Clay County Ridaught WTF, FL0039721 (sub basin 15), both located in the upper portions of the Black Creek Watershed.

Point Source	Flow (mgd)	Total Nitrogen (mg/l)	Total Phosphorus (mg/l)	BOD (mg/l)
Spencer WTF, FL017	0.5	3	1	5
Clay County Ridaught WTF, FL0039721	1.3	3	1	5

Note the point source dischargers have little to no impact on the water quality data that resulted in the impaired listing. These two dischargers will be included in the WASP water quality model at their advance wastewater treatment permits limits.

3.4. Black Creek and Little Black Creek Water Quality Model

The Black Creek and Little Black Creek WASP water quality model integrates the predicted flows and loads from the LSPC model to simulate water quality responses in: nitrogen, phosphorus, chlorophyll a and dissolved oxygen. A 43 segment WASP water quality model was setup to include the 21 Black Creek and Little Black Creek sub basins.

3.4.1. WASP Model

The WASP water quality model uses the kinematic wave equation to simulate flow and velocity and the basic eutrophication module to predict dissolved oxygen responses to the BOD, total nitrogen and total phosphorus loadings. Table 5 provides the basic kinetic rates used in the model.

Table 5 WASP Kinetic Rates

WASP Kinetic Parameters	Value
Global Reaeration Rate Constant @ 20 °C (per day)	Covar
Sediment Oxygen Demand (g/m2/day)	1.5 to 2.5 for stream segments
Phytoplankton Maximum Growth Rate Constant @20 °C (per day)	2
Phytoplankton Carbon to Chlorophyll Ratio	80
BOD (1) Decay Rate Constant @20 °C (per day)	0.06
Ammonia, nitrate, phosphorus rates @20 °C (per day)	0.05 to 0.1

The Black Creek and Little Black Creek WASP model predictions were compared to Black Creek and Little Black Creek water quality data stations 21FLSJWMBLC and 21FLSJWMBSF.

Table 6 provides the annual average calibration summary of the comparison between the WASP Black Creek and Little Black Creek segment and the Black Creek and Little Black Creek Station for total nitrogen, total phosphorus and dissolved oxygen along with flow at the USGS gage. Figures 5 to 11 illustrates the comparisons of model results and data at these locations.

Table 6 Model Calibration Summary

Black Creek and Little Black Creek 21FLSJWMBLC	**2002–2008 Data Average**	**2002-2008 Model Average**
Total Nitrogen (mg/l)	0.71	0.78
Total Phosphorus (mg/l)	0.09	0.1
DO (mg/l)	5.8	6.1
Flow (cms)	12.8	13.2
21FLSJWMBSF	**2002–2005 Data Average**	**2002-2008 Model Average**
Total Nitrogen (mg/l)	0.6	0.8
Total Phosphorus (mg/l)	0.14	0.12
DO (mg/l)	6.6	6.3

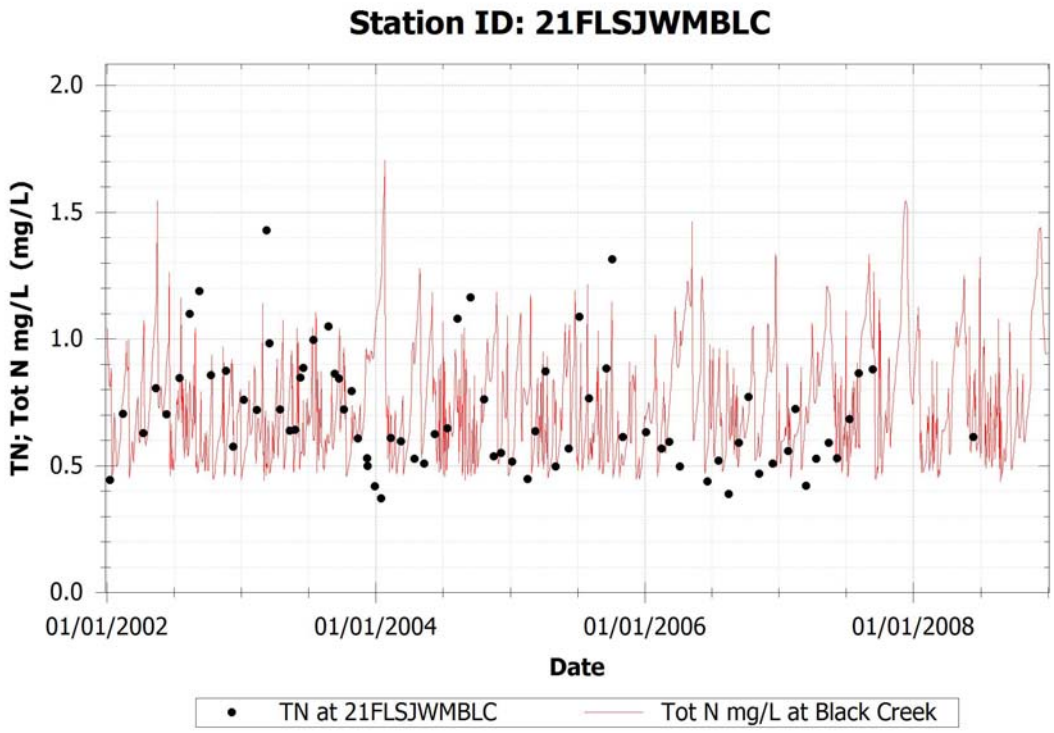

Figure 5 WASP Calibration for Total Nitrogen in Black Creek and Little Black Creek

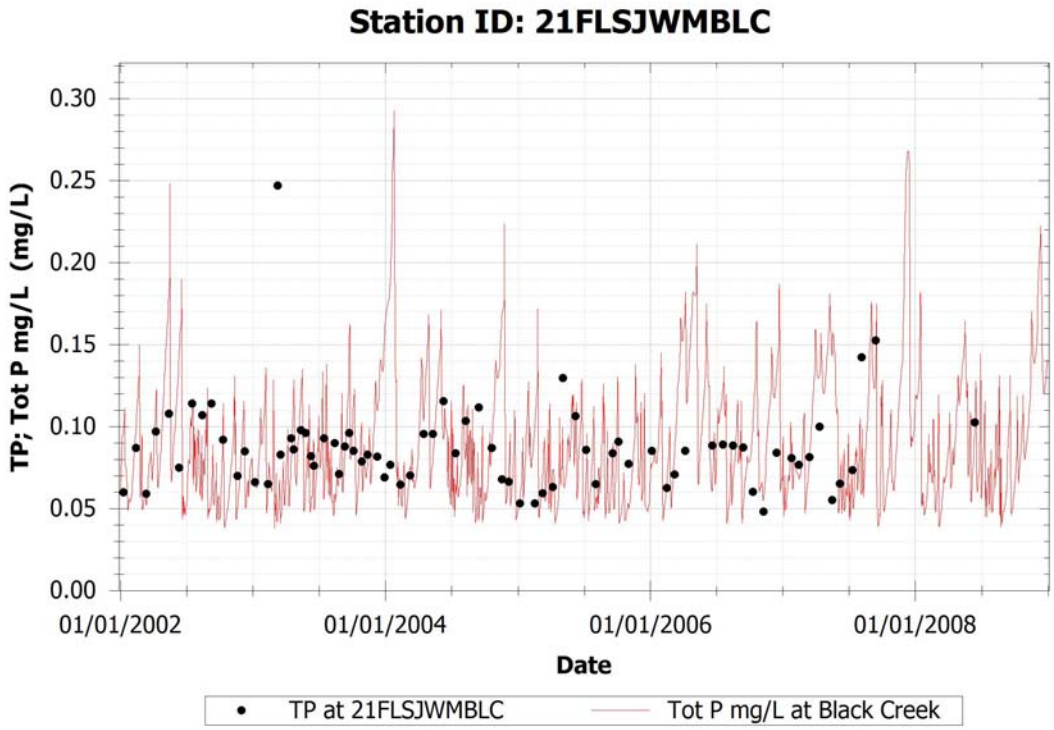

Figure 6 WASP Calibration for Total Phosphorus in Black Creek and Little Black Creek

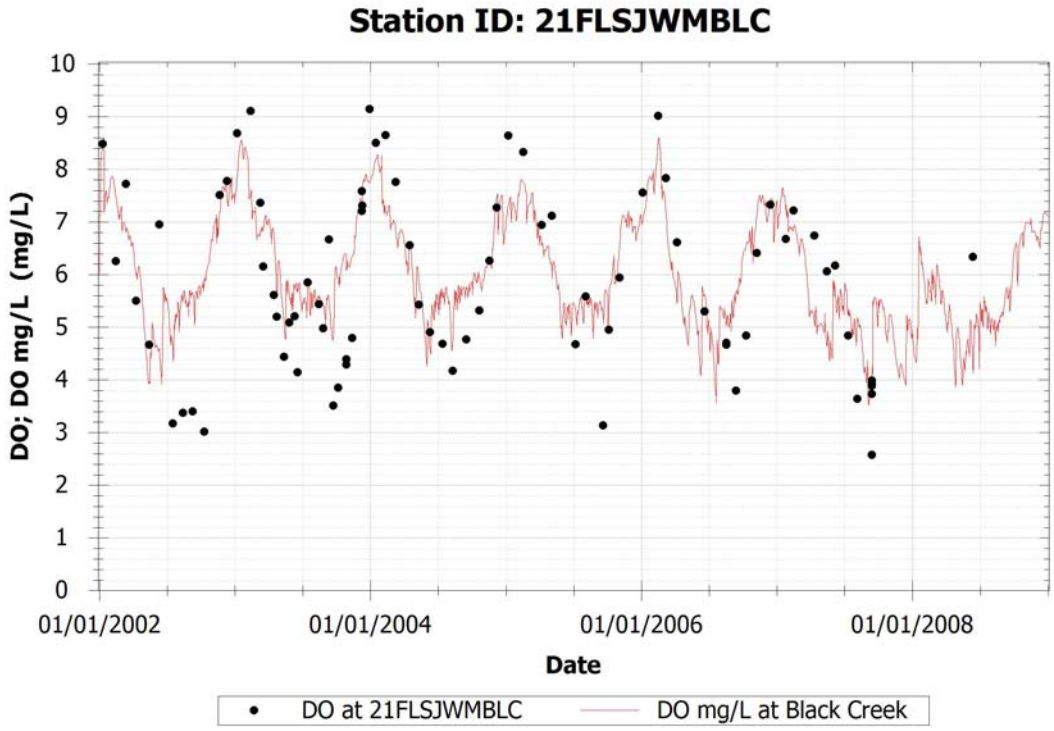

Figure 7 WASP Calibration for Dissolved Oxygen in Black Creek and Little Black Creek

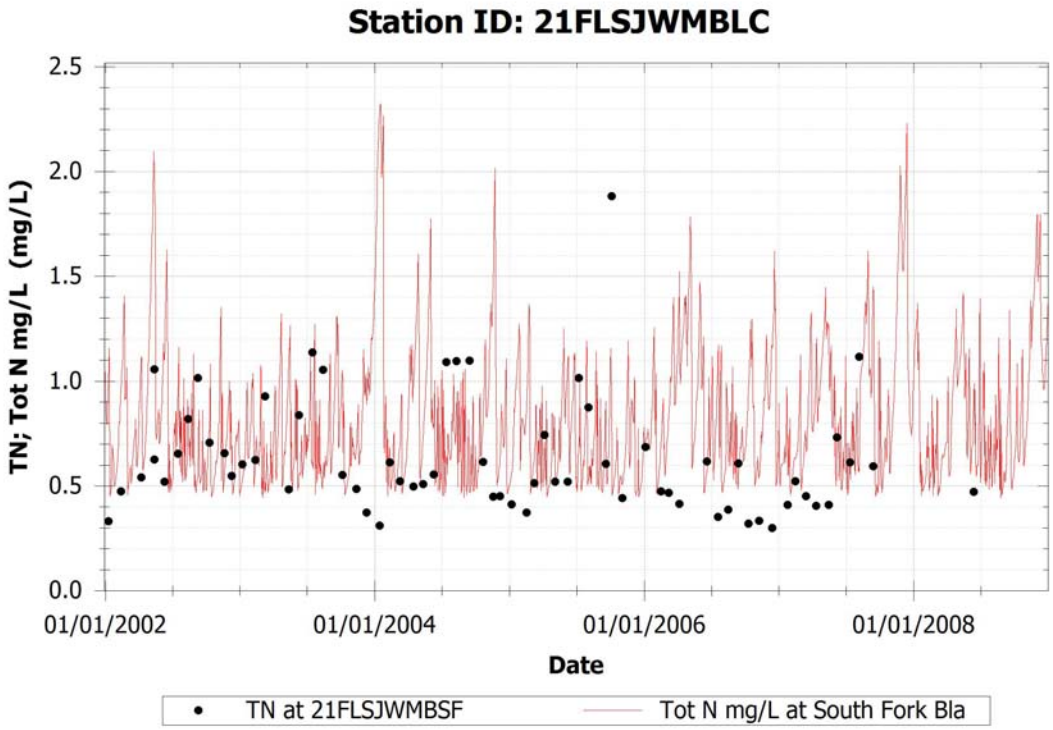

Figure 8 WASP Calibration for Total Nitrogen in Black Creek

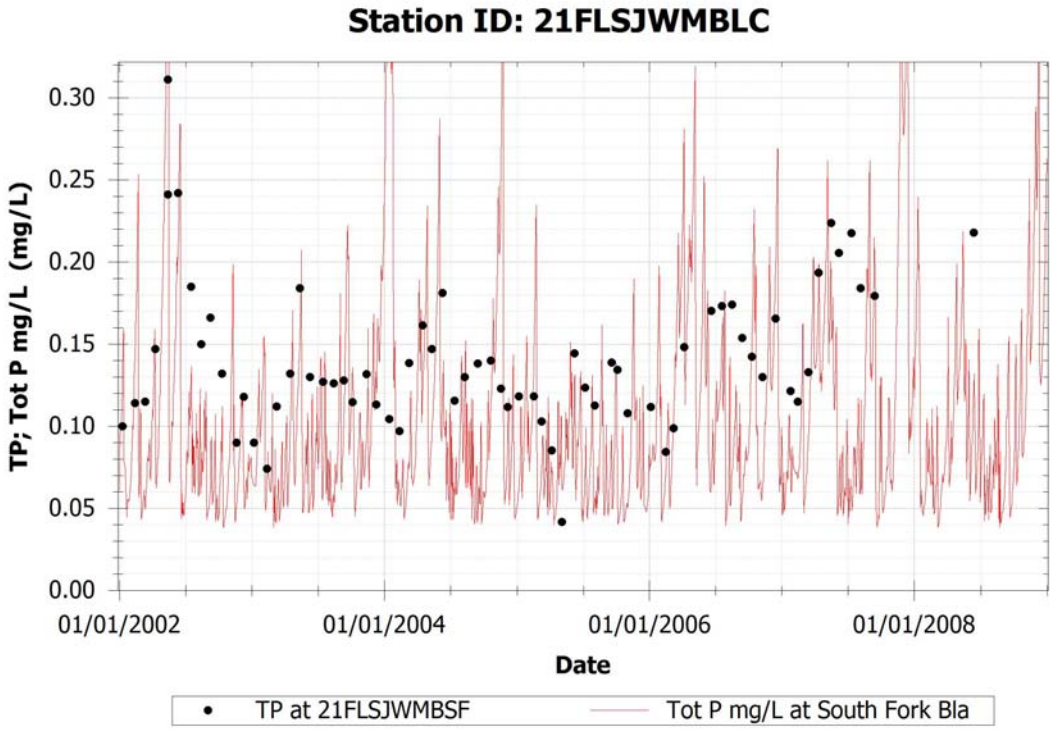

Figure 9 WASP Calibration for Total Phosphorus in Black Creek

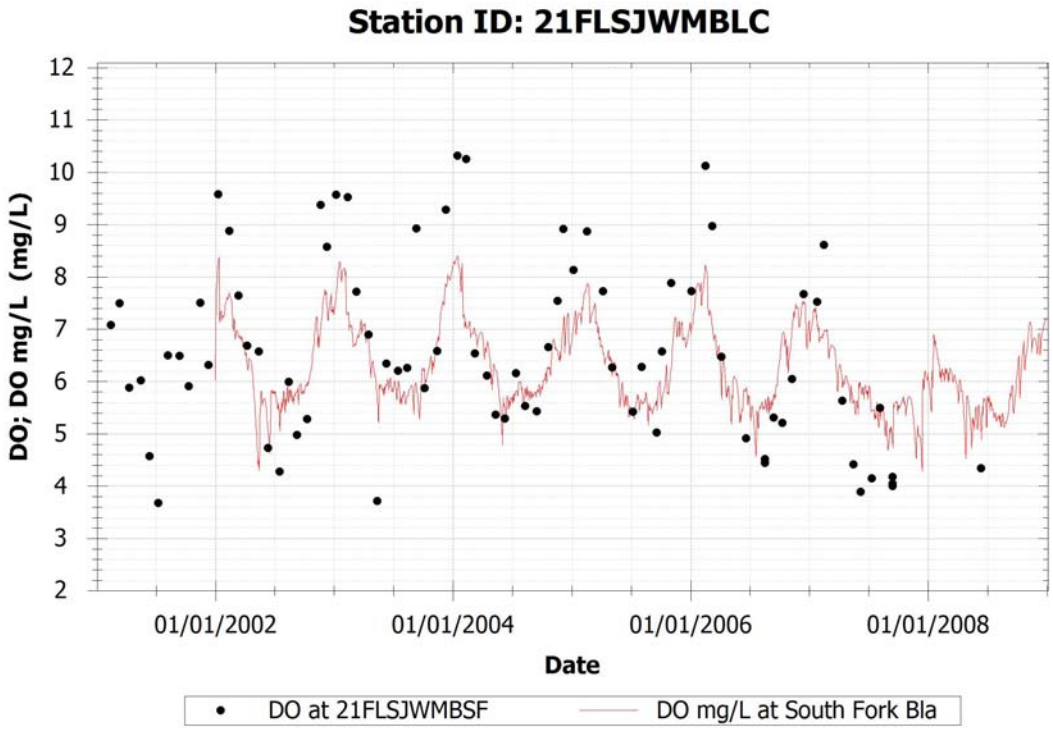

Figure 10 WASP Calibration for Dissolved Oxygen

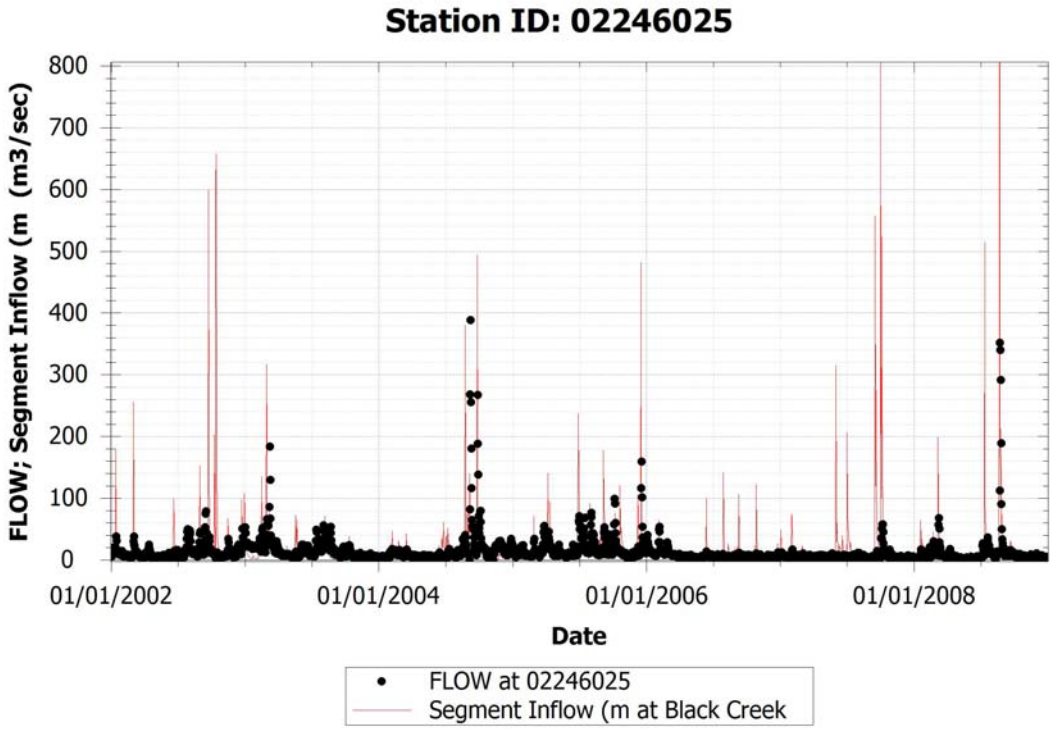

Figure 11 USGS 02243025 Flow Calibration

Table 7 presents the watershed's annual average predictions for BOD, total nitrogen, total phosphorus and dissolved oxygen.

Table 7 Existing Condition Annual Average Model Predictions

Black Creek and Little Black Creek 21FLSJWMBLC	**2002-2008 Model Prediction Annual Average**
BOD (mg/l)	2.6
Total Nitrogen (mg/l)	0.7
Total Phosphorus (mg/l)	0.06
DO avg (mg/l)	6.1
DO min (mg/l)	3.8
21FLSJWMBSF	**2002-2008 Model Prediction Annual Average**
DO avg (mg/l)	6.3
DO minimum (mg/l)	3.8

Table 8 Black Creek and Little Black Creek Nutrient Loads (2002-2008)

Subbasin	**Total Nitrogen Load (kg/yr)**	**Total Phosphorus Load (kg/yr)**	**BOD Load (kg/yr)**
Little Black Creek Watershed	37,825	4,169	156,188
Black Creek and Little Black Creek Watershed	370,444	40,201	1,377,151
Total of Black Creek and Little Black Creek Watershed	408,269	44,370	1,533,339
Point Sources			
Spencer WTF, FL0173371	2,076	692	3,459
Clay County Ridaught WTF, FL0039721	5,396	1,799	8,994
Total	415,741	46,860	1,545,792

4. Modeling Scenarios

Three modeling scenarios were completed to evaluate potential nutrient reduction options. Model years 2002 thru 2008 were used, 2001 was used as model ramp up period. A natural condition analysis was completed to predict what the naturally occurring Black Creek and Little Black Creek dissolved oxygen levels would be if all impacted upstream lands were converted back to upland forest and wetlands. The second

analysis examined the impacts a 30 percent BOD, total nitrogen and total phosphorus reduction. The third analysis examined the impacts 35 percent reduction of BOD, total nitrogen and total phosphorus TMDL scenario.

4.1. Black Creek and Little Black Creek Watershed Natural Condition Analysis

Black Creek and Little Black Creek sub basins and upstream USJR and Jane Creeks' watersheds landuses were changed from impacted lands to upland forest and wetlands landuses. LSPC was then used to simulate the natural condition nutrient loads (Table 8) were inputted in to WASP model. Other than the nutrient load reductions the SOD rate was reduced by 50 percent to reflect the reduced loadings. Table 9 provides the annual average model predictions for total nitrogen, total phosphorus, chlorophyll a, dissolved oxygen.

Table 8 Natural Condition Annual Average Nutrient Loads

Subbasin	Total Nitrogen Load (kg/yr)	Total Phosphorus Load (kg/yr)	BOD Load (kg/yr)
Little Black Creek Watershed	19,825	1,799	55,805
Black Creek and Little Black Creek Watershed	240,171	21,715	674,477
Total of Black Creek and Little Black Creek Watershed	259,995	23,514	730,283

Table 9 presents the predicted annual average concentrations under natural conditions. Without the impacts of anthropogenic sources the dissolved oxygen concentration in the Black Creek and Little Black Creek and would achieve the dissolved oxygen standard of 5 mg/l.

Table 9 Natural Condition Annual Average Model Predictions

Black Creek and Little Black Creek	2002-2008 Model Prediction Annual Average
BOD (mg/l)	1.1
Total Nitrogen (mg/l)	0.4
Total Phosphorus (mg/l)	0.032
DO avg (mg/l)	7.2
DO minimum (mg/l)	5.5

4.2. 30 Percent Reduction Scenario

The thirty percent reduction of BOD, total nitrogen and total phosphorus and corresponding reduction in sediment oxygen demand (SOD). Table 10 provides the annual loads for the 30% reduction.

Table 10 30% Reduction Black Creek Nutrient Loads (2002-2008)

Subbasin	Total Nitrogen Load (kg/yr)	Total Phosphorus Load (kg/yr)	BOD Load (kg/yr)
Little Black Creek Watershed	26,477	2,918	109,331
Black Creek Watershed	259,311	28,140	964,006
Total of Black Creek Watershed	285,788	31,059	1,073,337
Point Sources			
Spencer WTF, FL0173371	2,076	692	3,459
Clay County Ridaught WTF, FL0039721	5,396	1,799	8,994
Total	293,260	33,550	1,085,790

Table 11 shows the resultant predictions for total nitrogen, total phosphorus and dissolved oxygen applying the 30% reduction.

Table 11 30% Reduction Annual Average Nutrient Concentrations

Black Creek and Little Black Creek	2002-2008 Model Prediction Annual Average
BOD (mg/l)	2.2
Total Nitrogen (mg/l)	.6
Total Phosphorus (mg/l)	0.055
DO avg (mg/l)	6.6
DO minimum (mg/l)	4.7

4.3. 35 Percent Reduction Scenario

The third scenarios is a thirty-five percent reduction of BOD, total nitrogen and total phosphorus and corresponding reduction in sediment oxygen demand (SOD). Table 12 presents the calculated loads for the 35% reduction.

Table 12 35% Reduction Black Creek and Little Black Creek Nutrient Loads (2002-2008)

Subbasin	Total Nitrogen Load (kg/yr)	Total Phosphorus	BOD Load (kg/yr)

		Load (kg/yr)	
Little Black Creek Watershed	24,586	2,710	101,522
Black Creek and Little Black Creek Watershed	240,789	26,131	895,148
Total of Black Creek and Little Black Creek Watershed	265,375	28,841	996,670
Point Sources			
Spencer WTF, FL0173371	2,076	692	3,459
Clay County Ridaught WTF, FL0039721	5,396	1,799	8,994
Total	272,847	31,332	1,009,123

Table 13 presents the resultant water quality predictions for the 35% reduction scenario for total nitrogen, total phosphorus and dissolved oxygen.

Table 13 35% Reduction Annual Average Nutrient Concentrations

Black Creek and Little Black Creek	2002-2008 Model Prediction Annual Average
BOD (mg/l)	2
Total Nitrogen (mg/l)	0.55
Total Phosphorus (mg/l)	0.05
DO avg (mg/l)	6.8
DO minimum (mg/l)	5.0

4.4. TMDL Reduction

The TMDL load reduction was set to the 35% watershed load reduction scenario the point source dischargers will be held at their current loads as described in Table 8.

Table 14 TMDL Percent Reduction

Subbasin	Total Nitrogen Load (kg/yr)	Total Phosphorus Load (kg/yr)	BOD Load (kg/yr)
Existing Loads	415,741	46,860	1,545,792
TMDL Loads	272,847	31,332	1,009,123
Percent Reduction	34%	33%	35%

Table 15 NPDES Wasteload Allocation

NPDES Permit	Total Nitrogen Load (kg/yr)	Total Phosphorus Load (kg/yr)	BOD Load (kg/yr)
Spencer WTF, FL0173371	2,076	692	3,459
Clay County Ridaught WTF, FL0039721	5,396	1,799	8,994
Total	272,847	31,332	1,009,123