Appendix A:

Modeling Report

Little Manatee

WBID: 1790

Nutrients and Dissolved Oxygen

September 30, 2009

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1. Watershed Description

Little Manatee River lies in the southeast corner of Hillsborough County and the northeast corner of Manatee County in the Tampa Bay tributary basin.. WBID 1790 was listed as not attaining its designated uses on Florida's 1998 303(d) list for Nutrients and Dissolved Oxygen. Figure 1 provides the location of Little Manatee River.

Figure 1 Location Map for Little Manatee River

The landuse distribution for the Little Manatee River and watershed is presented in Table 1.

Table 1 Landuse Distribution in Little Manatee Watershed

Land Use Name	Area (ac)	Portion of Watershed (%)
AGRICULTURE	48984.9	87.74
BARREN LAND	403.5	0.72
RANGELAND	809	1.45
TRANSPORTATION, COMMUNICATION AND UTILITIES	329.5	0.59
UPLAND FORESTS	3256.1	5.83
URBAN AND BUILT-UP	593	1.06
WATER	552.4	0.99
WETLANDS	20706	37.09
Totals	**55827.5**	**100**

2. TMDL Targets

The TMDL target to be evaluated in this modeling report is to meet the Little Manatee 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 Little Manatee River 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. *Little Manatee 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 upstream watersheds flowing into the Little Manatee River. 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.   Little Manatee Watershed Delineation and Landuse

The surrounding watershed that drains directly to the Little Manatee is presented in Figure 2. This WBID was delineated into 5 LSPC sub basins to simulate the runoff and pollutant loads.
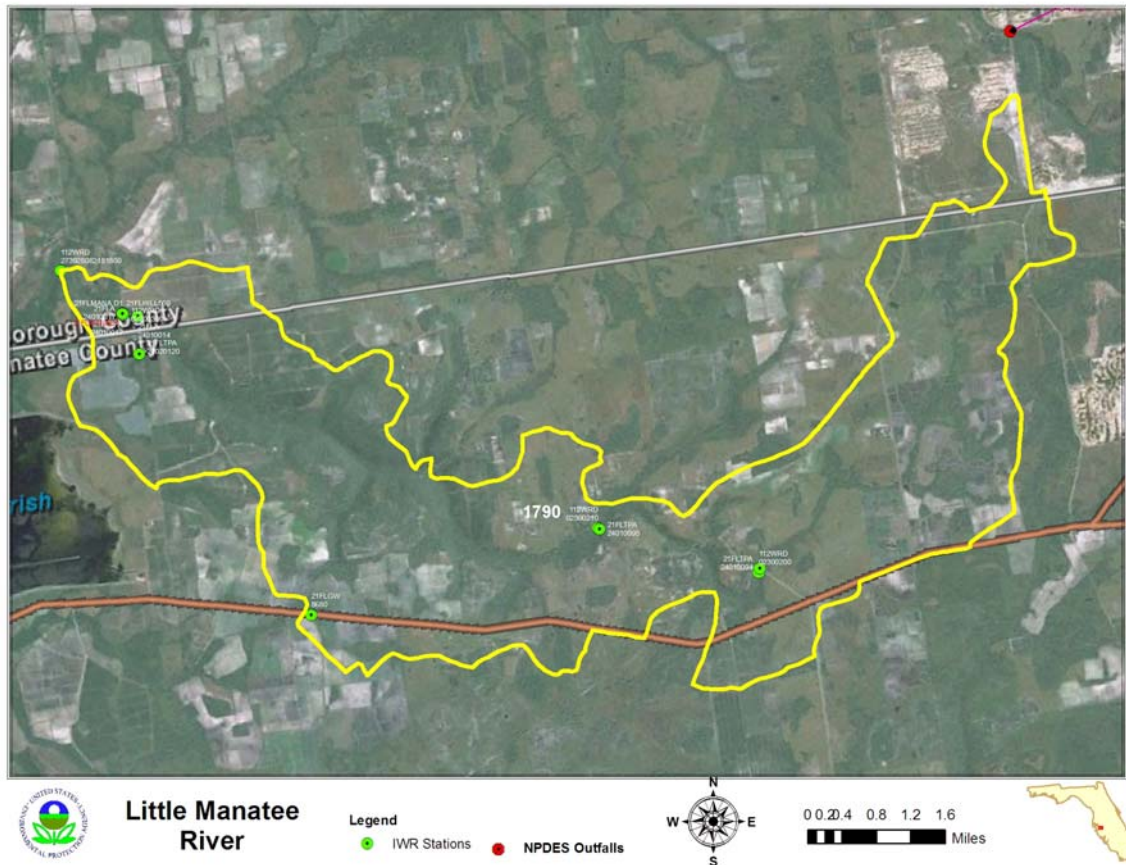
Figure 2 Little Manatee River Watershed

Figure 3 illustrates the Florida Landuse Classification (Level-1) for the Little Manatee surrounding watershed.
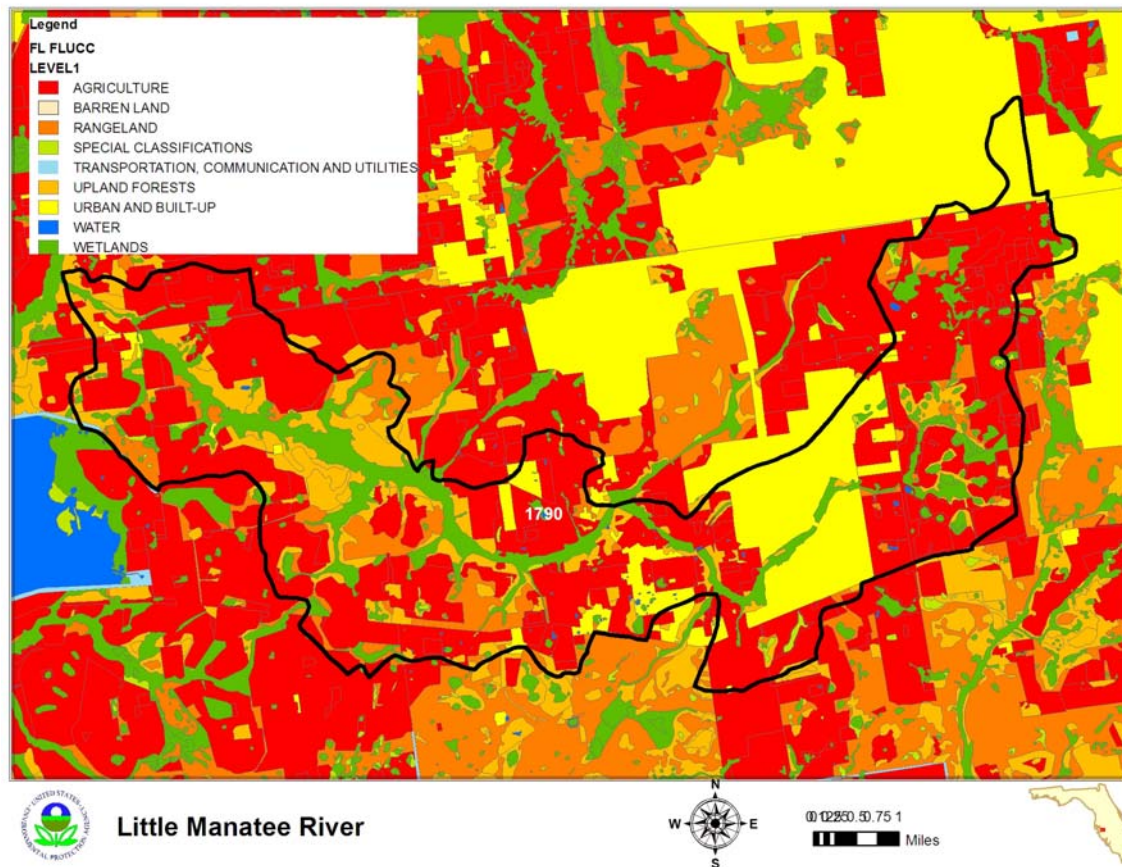
Figure 3 Little Manatee Watershed Landuse Distribution

3.2. Little Manatee 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 12842**:** Tampa International Airport near Tampa, Florida.

Figure 4 provides a time series plot of daily rainfall for the simulation period.
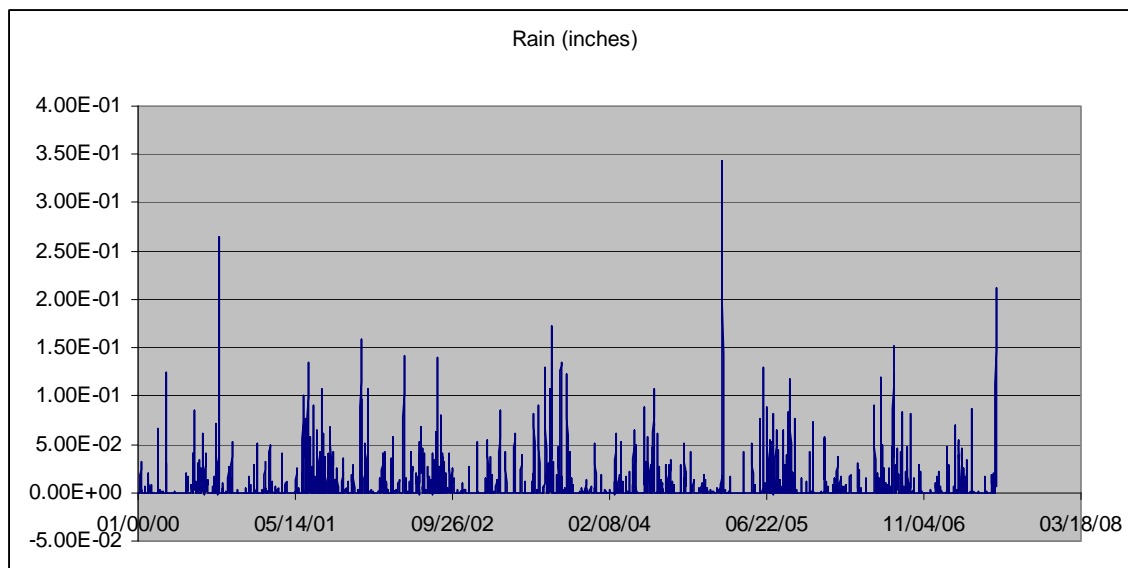
Figure 4 Rainfall for Little Manatee River Watershed

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

Table 2 Annual Rainfall

Year	Rainfall (Inches)
2001	38
2002	61
2003	51
2004	59
2005	39
2006	57
2007	42
2008	23

3.2.2.   Flow

Flows were simulated for the Little Manatee watershed using the watershed model and calibrated to the USGS gages 02300210 and 02300300 on the Little Manatee River. Flows in the Little Manatee 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 Sarasota County.

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 Little Manatee data.

Table 3 Event Mean Concentration for Landuse Classifications

Landuse	Total Nitrogen (mg/l)	Total Phosphorus (mg/l)	BOD (mg/l)
Agriculture	4	1.5	10
Barren Land	4	1.5	10
Rangeland	4	1.5	10
Special Classification	4	1.5	10
Transporation	4	1.5	10
Upland Forest	1.02	0.16	3
Urban Area	4	1.5	10
Water	1.02	0.1	3
Wetlands	1.02	0.16	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 Little Manatee Nutrient Loads (2002-2008)

Subbasin	Total Nitrogen Load (kg/yr)	Total Phosphorus Load (kg/yr)	BOD Load (kg/yr)
Little Manatee Watershed	97,704	30,640	250,503

3.3. Little Manatee Water Quality Model

The Little Manatee 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 23 segment WASP water quality model was setup to include the 11 Little Manatee sub basins.

3.3.1. 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 and Chlorophyll a responses to the BOD, total nitrogen and total phosphorus loadings. Widths were taken from satellite imagery and depths from the measured water quality data. 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)	1.0
Sediment Oxygen Demand (g/m2/day)	2 for stream segments
Phytoplankton Maximum Growth Rate Constant @20 °C (per day)	2
Phytoplankton Carbon to Chlorophyll Ratio	75
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 Little Manatee WASP model predictions were compared to Little Manatee water quality data stations 21FLMANAD1 and 112WRD02300300.

Table 6 provides the annual average calibration summary of the comparison between the WASP Little Manatee segment and the Little Manatee Station for total nitrogen, total phosphorus, chlorophyll a and dissolved oxygen.   Figures 5 to 12 illustrates the comparisons of model results and data at the same location.

Table 6 Model Calibration Summary

Little Manatee 21FLMANAD1	2002–2008 Data Average	2002-2008 Model Average
Total Nitrogen (mg/l)	1.1	0.96
Total Phosphorus (mg/l)	0.32	0.33
DO (mg/l)	7.6	7.5
Flow (cms)	1.35	1.37
Little Manatee 112WRD02300300		
Total Nitrogen (mg/l)	1.1	0.95
Total Phosphorus (mg/l)	0.4	0.35
DO (mg/l)	6.8	6.6
Flow (cms)	0.86	0.74
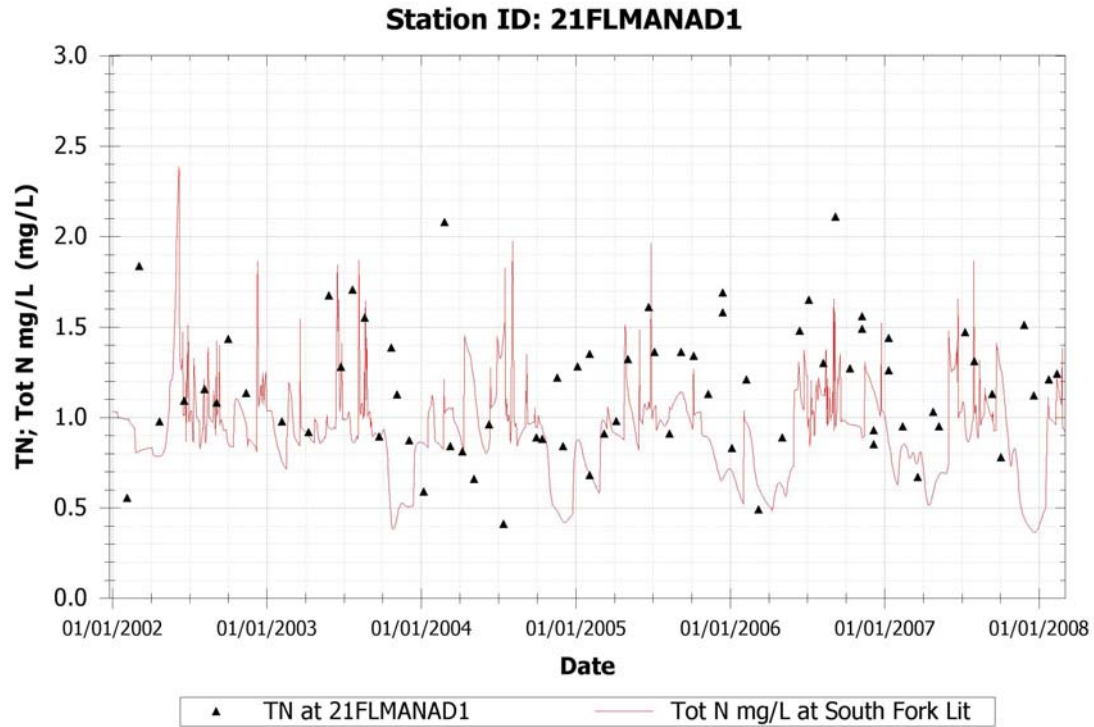
Figure 5 WASP Calibration for Total Nitrogen in Little Manatee
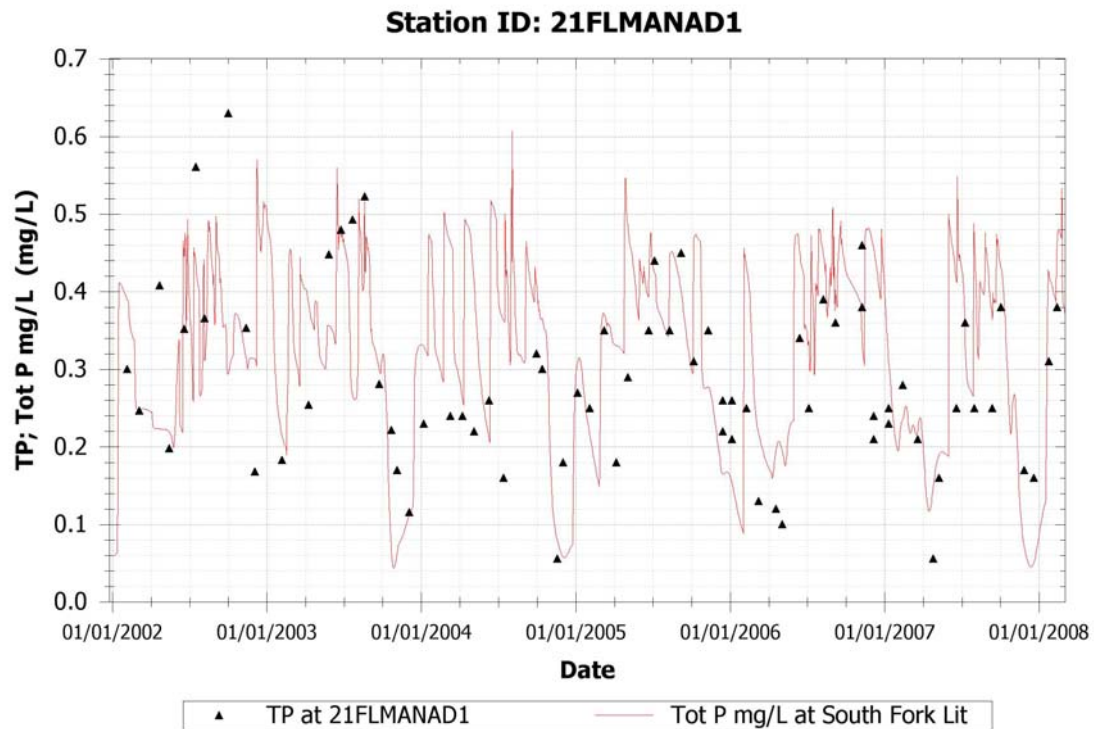
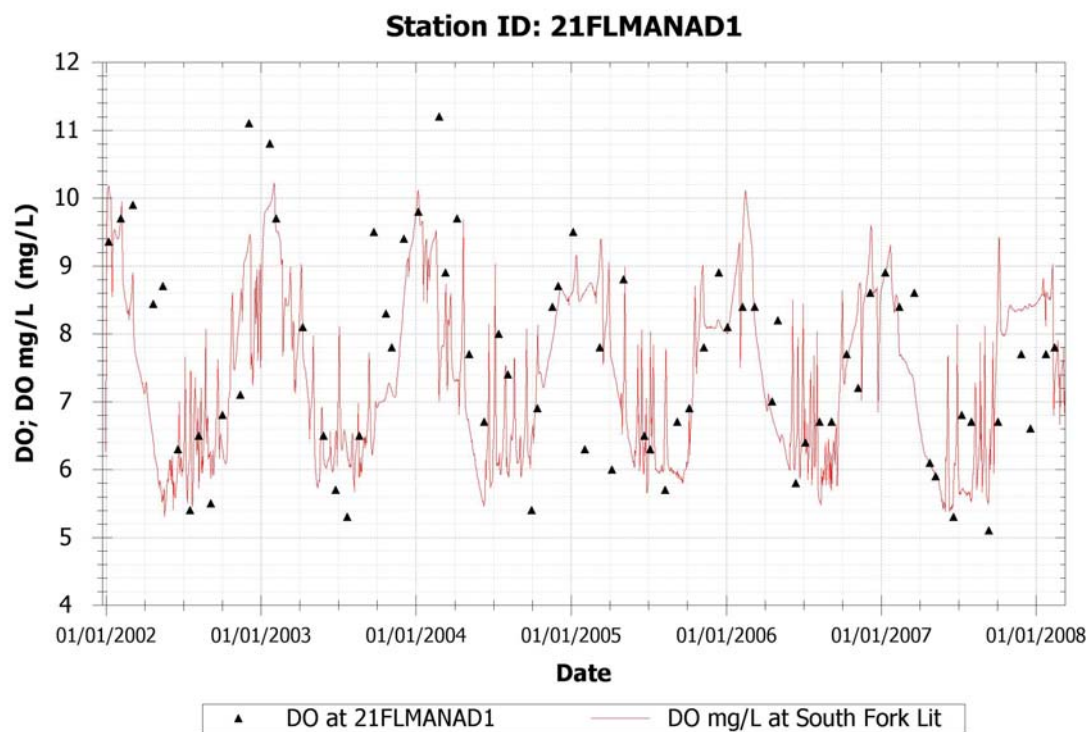**Figure 6 WASP Calibration for Total Phosphorus in Little Manatee**

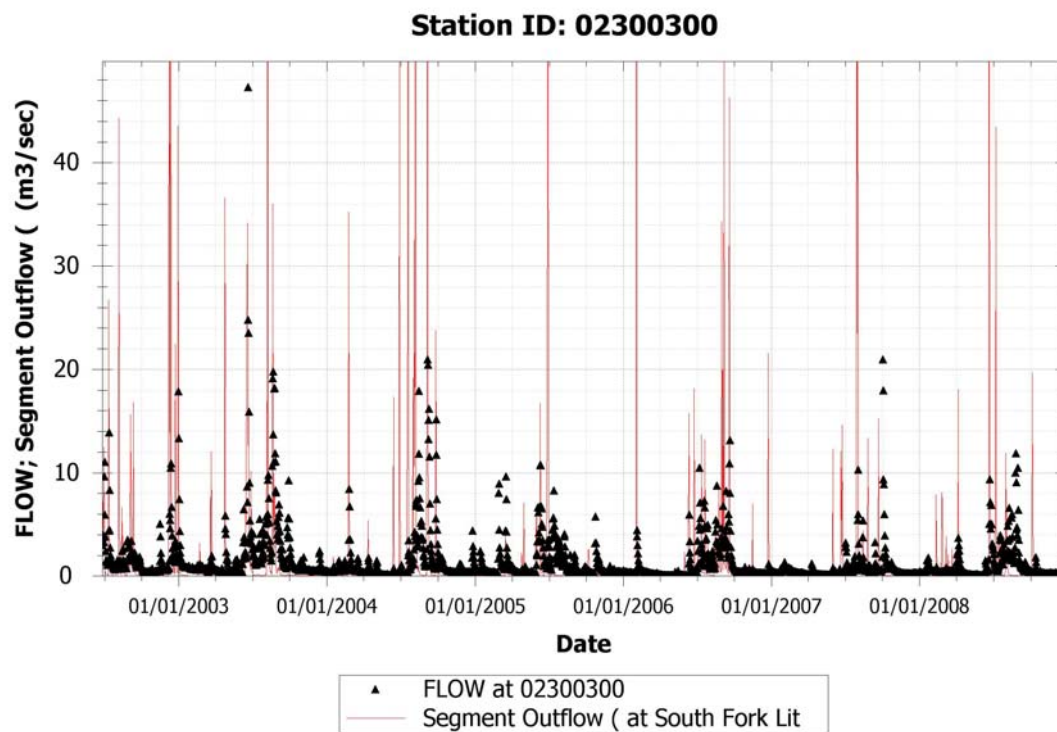**Figure 7 WASP Calibration for Dissolved Oxygen in Little Manatee**
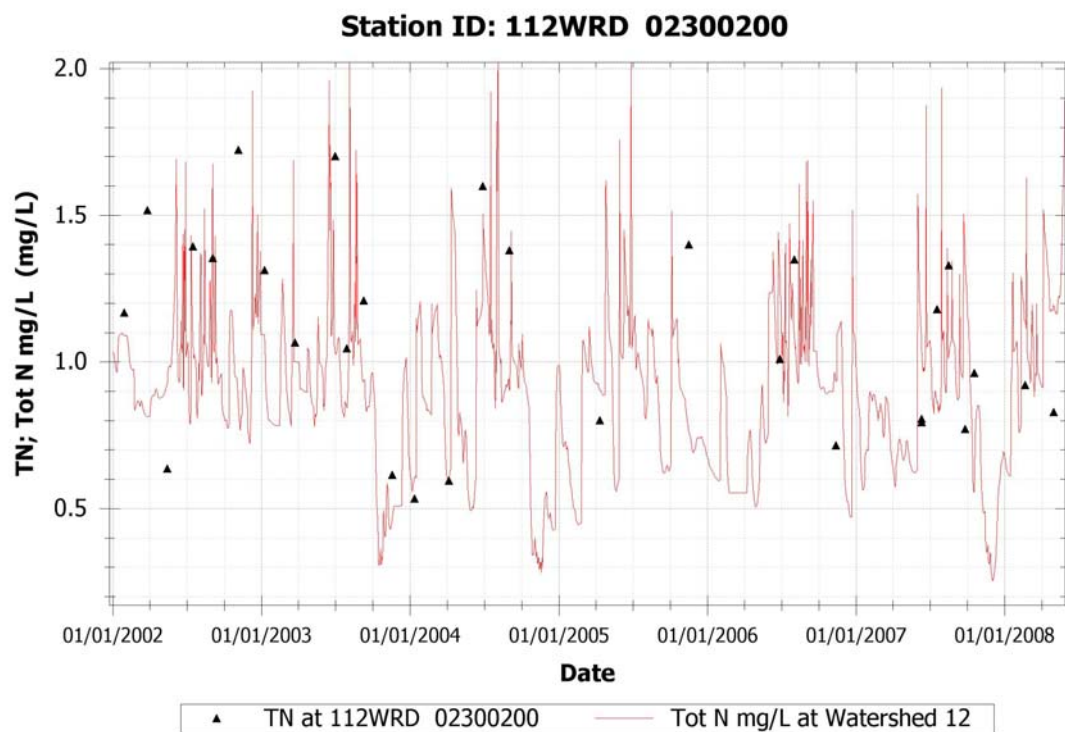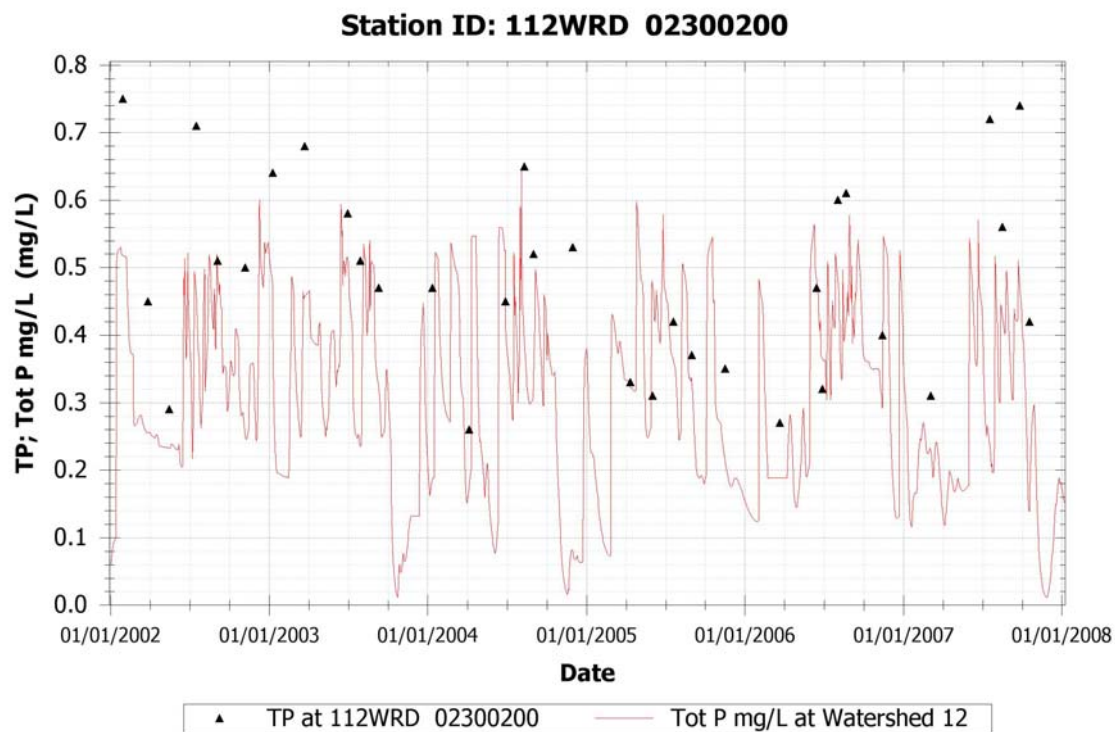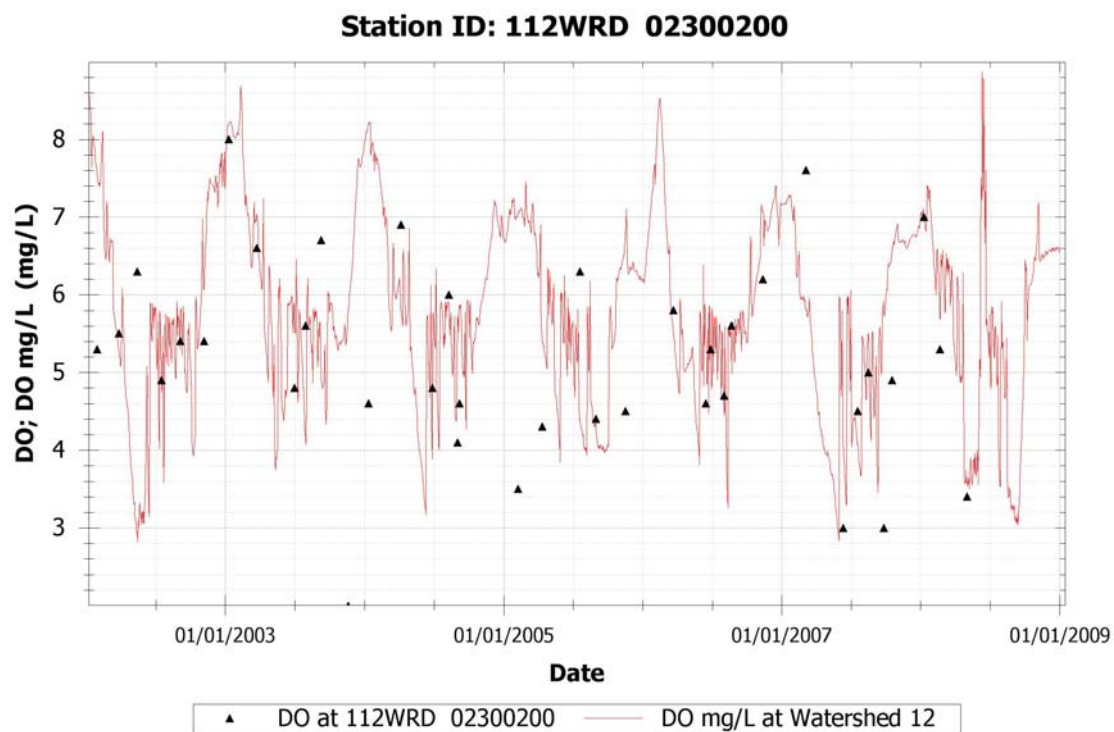

Figure 8 WASP Calibration for Flow in Little Manatee

Figure 9 Total Phosphorus Calibration Little Manatee River

Figure 10 Total Nitrogen Calibration Little Manatee River

Figure 11 Dissolved Oxygen Calibration Little Manatee River

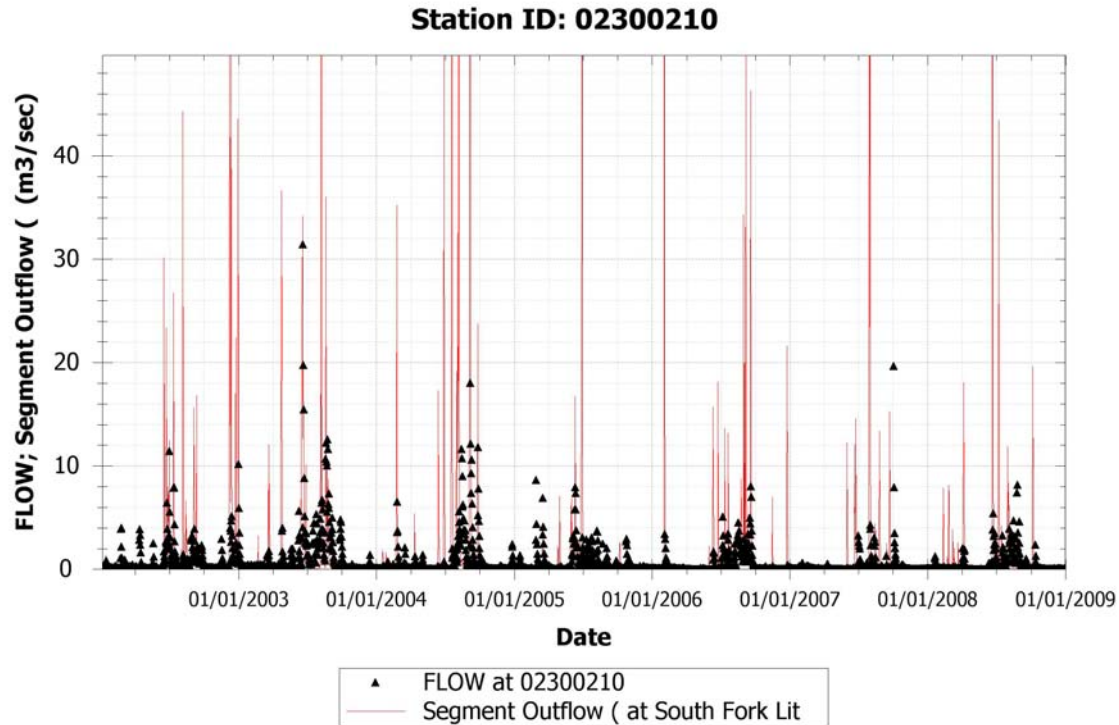**Figure 12 Flow Calibration Little Manatee River**

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

Table 7 Existing Condition Annual Average Model Predictions

Little Manatee	2002-2008 Model Prediction Annual Average
BOD (mg/l)	2
Total Nitrogen (mg/l)	.96
Total Phosphorus (mg/l)	0.26
DO avg (mg/l)	6.0
DO min (mg/l)	3.5

4. Modeling Scenarios

Two modeling scenarios were completed to evaluate potential nutrient reduction options. The model was applied for years 2002 through 2008, the first year of simulation 2001 was used to spin up the model. The first scenario that was modeled was a natural condition. This was completed to predict what typical Little Manatee River chlorophyll a and dissolved oxygen levels would be if all impacted upstream lands were converted back to upland forest and wetlands. The final scenario was a forty percent nutrient

reduction scenario which allows the dissolved oxygen standard of 5.0 mg/l minimum to be met.

4.1. *Little Manatee Watershed Natural Condition Analysis*

Little Manatee sub basins and upstream 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) which were inputted in to WASP model. Other than the nutrient load reductions the SOD rate was reduced to reflect the reduced loadings. Table 8 provides the annual average model predictions for total nitrogen, total phosphorus, and 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 Manatee Watershed	46,883	6,724	134,529

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

Table 9 Natural Condition Annual Average Model Predictions

Little Manatee	2002-2008 Model Prediction Annual Average
BOD (mg/l)	1.0
Total Nitrogen (mg/l)	0.5
Total Phosphorus (mg/l)	0.05
DO avg (mg/l)	7.7
DO minimum (mg/l)	6.0

4.2. *Forty Percent Reduction TMDL*

The TMDL load reduction was set to the forty percent reduction scenario and this allowed the DO standard of 5.0 minimum to be met. Table 10 provides the watershed loads. Table 11 presents the predicted annual average concentrations under the TMDL forty percent reduction scenario and Table 12 is a summary of TMDL Loading Reduction.

Table 10 40% Load Reduction Scenario Annual Average Loads

Subbasin	Total Nitrogen Load (kg/yr)	Total Phosphorus Load (kg/yr)	BOD Load (kg/yr)
Little Manatee Watershed	58,623	18,384	150,302

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Table 11 TMDL Scenario Annual Average Model Predictions

Little Manatee	2002-2008 Model Prediction Annual Average
BOD (mg/l)	1.6
Total Nitrogen (mg/l)	0.7
Total Phosphorus (mg/l)	0.1
DO avg (mg/l)	6.7
DO minimum (mg/l)	5.0

Table 12 TMDL Forty Percent Reduction Summary

Little Manatee Watershed	Total Nitrogen Load (kg/yr)	Total Phosphorus Load (kg/yr)	BOD Load (kg/yr)
Existing Loads	97,704	30,640	250,503
Forty Percent Reduction	58,623	18,384	150,302
Percent Reduction	40%	40%	40%