Appendix A

Modeling Report

Owen Creek (WBID 1933)

and

Myakka River (WBID 1981B)

Dissolved Oxygen and Nutrients

March 2013

Region4 serving the southeast

Table of Contents

Table of Figures

Table of Tables

1. Watershed Description

The Myakka River watershed is less developed than other watersheds of its size, particularly in the middle portion where large areas of conservation lands are located (Figure 1). The Myakka River was designated as a “Florida Wild and Scenic River” by the Florida Legislature in 1985, allowing for the creation of Myakka River State Park in Sarasota County to preserve and protect it. As the Myakka River winds its way through this park, it flows through two successive impoundments associated with Upper and Lower Myakka Lakes. Tidal influence extends upstream to a water control structure (Down’s Dam), located below Lower Myakka Lake. This location is often used to divide the Myakka River into upper and lower subbasins, with the upper portion non-tidal freshwater, and the lower portion brackish and tidal. WBID 1981B is a segment of the Myakka River located between Upper and Lower Myakka Lake.

The upper portion of the watershed is flat and marshy, and does not have much urban or residential development. However, most of the agriculture in the watershed is concentrated in the upper basin (Figure 1). Agricultural uses include pasture, dairies, row crops, citrus and tree crops. The Owen Creek tributary (WBID 1933) joins the Myakka River east of Myakka City.

Error! Reference source not found. and Figure 2 provides the land use areas and percentages for WBID 1933 of Owen Creek, WBID 1981B of the Myakka River, and the entire Myakka River watershed. Considering the basin as a whole, both agriculture and urban/residential uses are significant, comprising 25 and 19 percent of the area, respectively. Wetland (22 percent), forest (16 percent), and non-forested uplands (13 percent) are also prevalent.

For the area draining to the Owen Creek (WBID 1933) tributary, the predominant landuse is agriculture (60 percent), followed by wetlands (16 percent) and forest (15 percent**Error! Reference source not found.**). Owen Creek also receives discharges from two dairy farms that are permitted to operate in the watershed: the Farren Dakin Dairy (FLA182966) and the Cameron Dakin Dairy (FLA182699). The distribution of landuse in WBID 1933 is illustrated in Figure 3.

Wetlands and non-forested uplands such as shrub and brushland comprise the vast majority of the area within WBID 1981B of the Myakka River (Figure 4). However, this section of the river receives drainage from the developed and agricultural uses in the upper watershed.

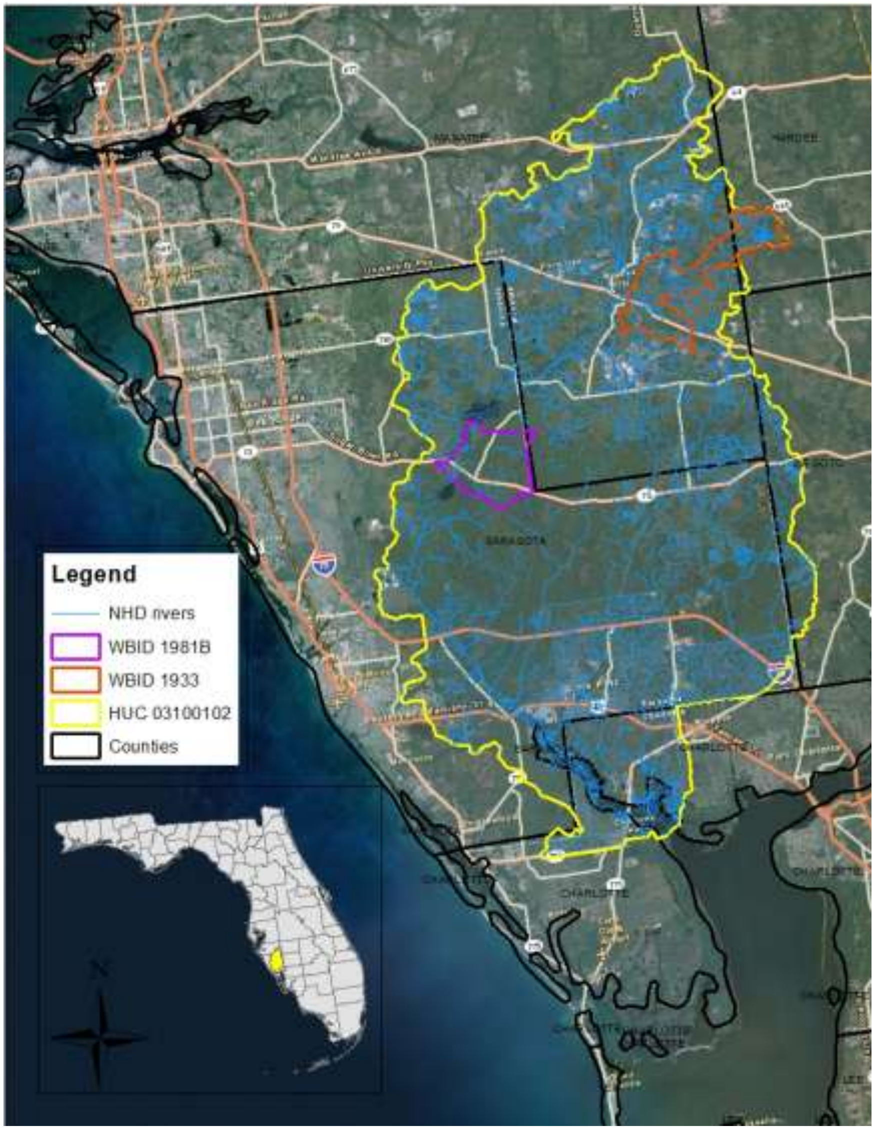

Figure 1 Location of WBIDs 1981B and 1933 in the Myakka River Basin

Table 1 Landuse in WBID 1933, WBID 1981B, and the Myakka River Watershed

Level 1 FLUCCs Landuse Category[1]	WBID 1933[2]		WBID 1981B[3]		Myakka Watershed[4]	
	Percent of Area:	Square Miles	Percent of Area:	Square Miles	Percent of Area:	Square Miles
Urban & Residential	1.0%	0.19	0.6%	0.08	19%	116
Agriculture	60.6%	11.64	2.2%	0.30	25%	151
Upland Nonforested	7.8%	1.50	47.0%	6.45	13%	78
Upland Forest	14.6%	2.81	3.0%	0.41	16%	98
Water	0%	0.09	1.0%	0.13	3%	18
Wetlands	16%	2.98	46%	6.34	22%	135
Barren Land	0%	0.00	0.0%	0.00	0.1%	0
Transportation & Utilities	0%	0.00	0.1%	0.01	0.7%	4
Total	**100%**	**19.21**	**100%**	**13.72**	**100%**	**602**

Notes:

1. Land use data are based on 2009 SWFWMD land cover features categorized according to the Florida Land Use and Cover Classification System (FLUCCS). The features were photointerpreted at 1:8,000 using 2009 one-foot and six-inch color infrared digital aerial photographs.
2. Percent and area of Level 1 FLUCCs landuse classifications within WBID 1933.
3. Percent and area of Level 1 FLUCCs landuse classifications within WBID 1981B.
4. Percent and area of Level 1 FLUCCs landuse classifications within the Myakka River Watershed (HUC 03100102).
5. The urban/residential and built-up category includes commercial, industrial and extractive uses.
6. The upland nonforested category includes rangeland, shrub and brushland.

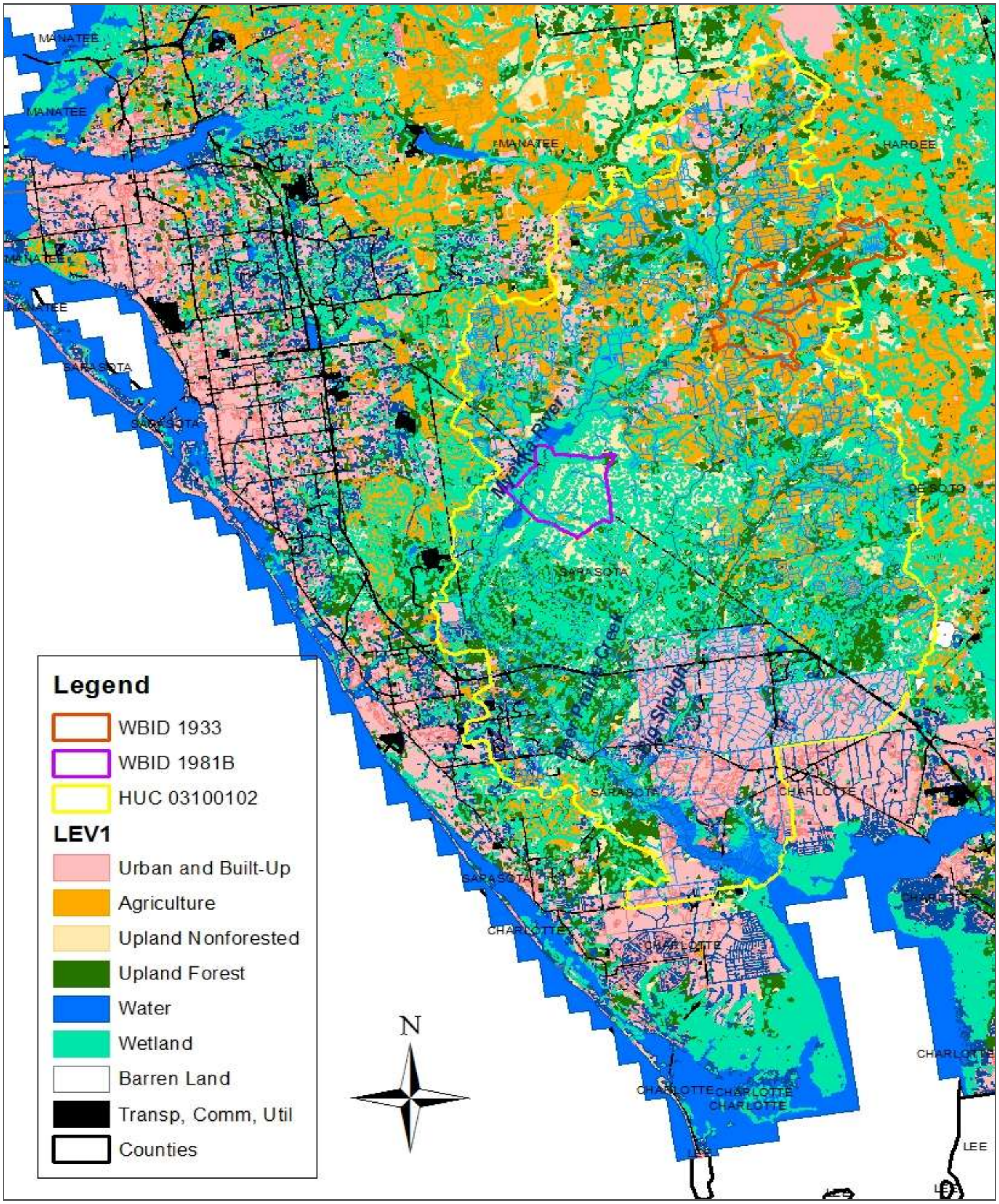

Figure 2 Landuse in the Myakka River Watershed

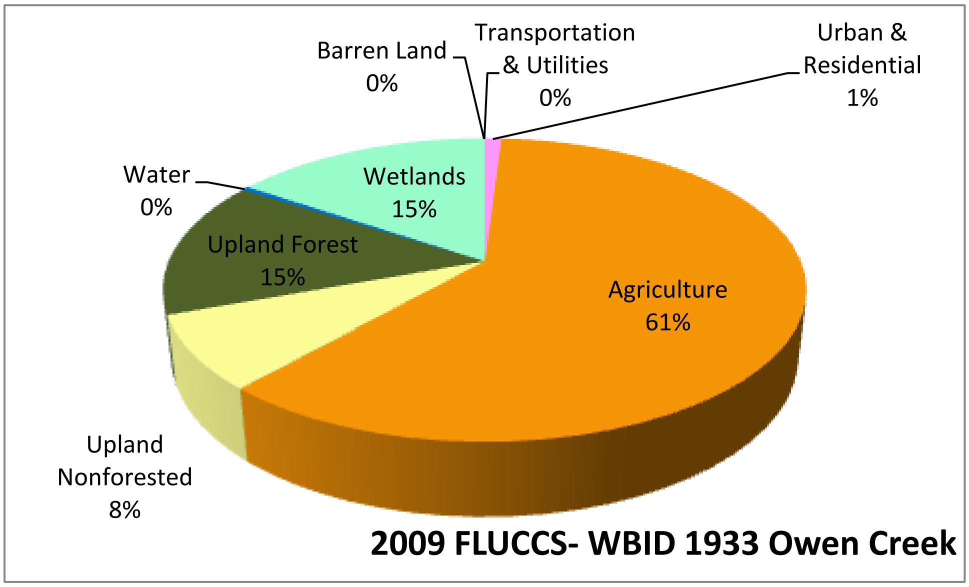

Figure 3 Landuse distribution in Owen Creek WBID 1933

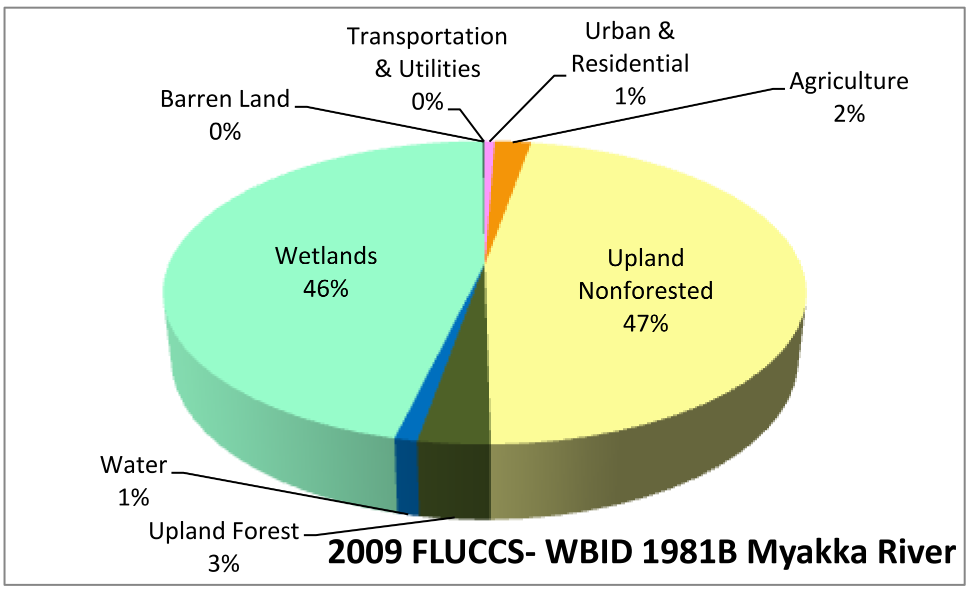

Figure 4 Landuse distribution in the Myakka River WBID 1981B

2. TMDL Targets

The TMDL reduction scenario was done either to achieve a dissolved oxygen concentration of 5 mg/L within the WBIDs or establish the natural condition.

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 (DO) for the time period of 1999 through 2009. The watershed model provides daily runoff, nutrient and BOD loadings from the watershed. The predicted results from the LSPC model served as boundary conditions to the receiving in-stream model Water Quality Analysis Simulation Program (WASP 7.5) (USEPA, 2009). 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 were calibrated to current conditions and used to simulate a natural condition. The WASP model was used to determine the percent reduction in loadings that would be needed to meet water quality standards.

3.1. Watershed Model

The goal of this watershed modeling effort is to estimate runoff (flow), total nitrogen (TN), total phosphorus (TP) and BOD loads and concentrations from contributing areas flowing into Owen Creek and Myakka River (river segment between the upper and lower Myakka lakes). The Loading Simulation Program C++ (LSPC) was used as the watershed model.

LSPC is 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. Watershed Delineation

Figure 5 shows the LSPC model setup. The model includes 23 sub-basins, eight of which drains to Owen Creek (WBID 1933) and two sub-basins drain to Myakka River (WBID 1981B) above Lower Myakka Lake. The model was calibrated using data from the USGS gage 02298608, Myakka River at Myakka City, FL.

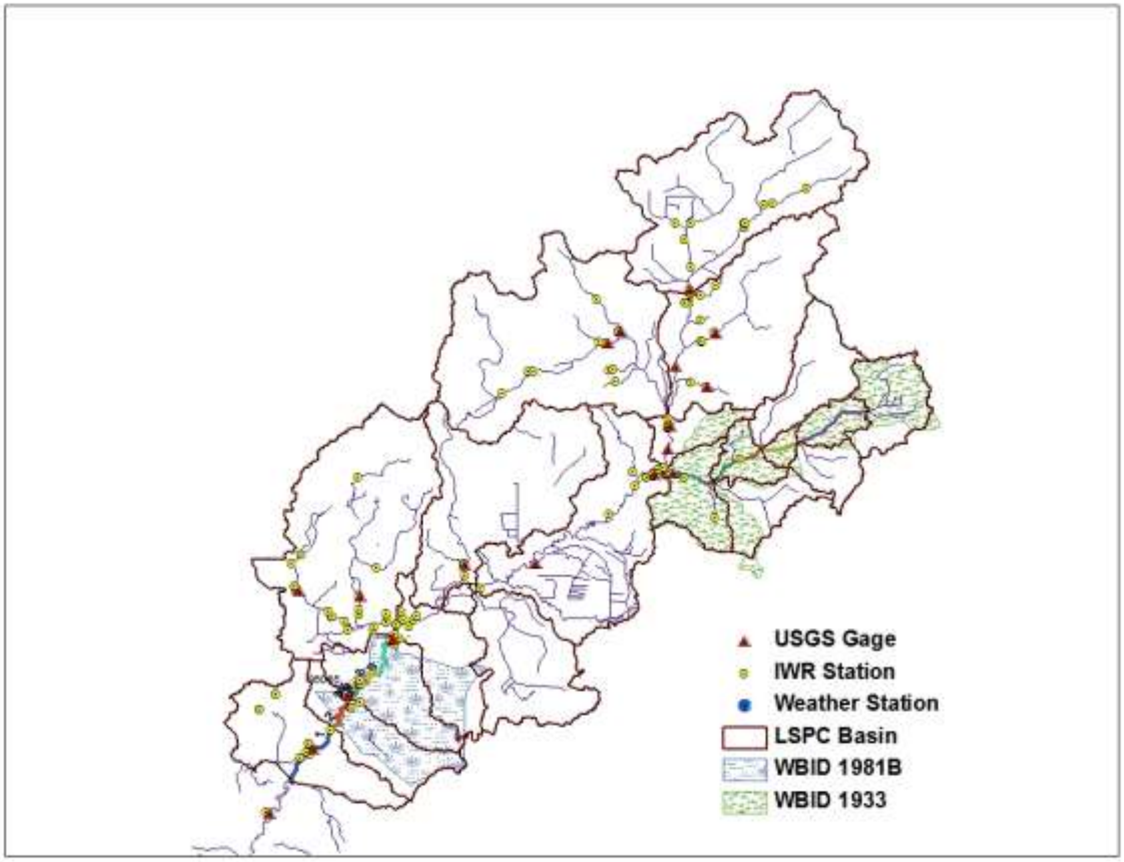

Figure 5 LSPC Watershed Delineation

3.2. Watershed Runoff

The LSPC watershed model was developed to simulate hydrologic runoff and pollutant loadings in response to recorded precipitation events for the current and natural conditions.

3.2.1. Meteorological

Rainfall and other pertinent meteorological data was obtained from the National Weather Service (NWS) WBAN station 086065 at Myakka River State Park, FL.

3.2.2. BOD and Nutrient Loadings

Watershed loadings were generated using event mean concentrations for total nitrogen, total phosphorus and BOD (Table 2). The initial EMC values were derived for each land use type from a study by Harper and Baker (2003, 2007) and then calibrated to all data available for the watershed. The calibrated EMCs are within the upper 90th confidence limit of the mean of Harper and Baker (2003, 2007) data. Wetland EMCs were derived from the study of Reiss et al. (2009). The study of Reiss et al. (2009) summarizes the available literature on nutrient concentrations and hydrology for wetlands in Florida. The calibrated wetland EMCs are within the 75th percentile of the Reiss et al. (2009) dataset.

Table 2 Event Mean Concentration for Landuse Classifications

Landuse	Total Nitrogen	Total Phosphorus	BOD
Agriculture	3.3	0.90	4.3
Rangeland/Forest/Undeveloped	1.3	0.09	1.4
Transportation	1.6	0.22	5.2
Pasture	2.8	0.84	5.8
Urban Area	2.3	0.52	11.3
Water	1.8	0.09	1.8
Wetlands	2.0	0.43	3.0

Table 3 provides the annual average simulated total nitrogen, total phosphorus and BOD loads for the period of record 1999 through 2009. It is these loadings that the TMDL load reduction was calculated from.

Table 3 Existing Condition Nutrient Loads (1999-2009)

	WBID 1933		WBID 1981B	
Constituent	WLA (kg/yr)	LA (kg/yr)	WLA (kg/yr)	LA (kg/yr)
BOD	NA	24690	NA	66720
Total Nitrogen	NA	11745	NA	26569
Total Phosphorus	NA	3088	NA	4733

3.3. Water Quality Model

The 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. An eight and nine segment WASP water quality model was setup for Owen Creek and Myakka River, respectively.

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 BOD, total nitrogen and total phosphorus loadings. For WBID 1933 (Owen Creek), the WASP model was setup using the tributary flows and concentrations predicted by the LSPC model as boundary conditions. For WBID 1981B

(Myakka River), the WASP model was setup using the Upper Myakka Lake as the upper boundary. Since flows from lake were not simulated with the LSPC model, the upstream boundary flows for the WASP model were taken from the predicted flows of a calibrated MikeShe/Mike11 model developed by the Southwest Florida Water Management District (Interflow Engineering, 2008). Watershed loadings were generated using event mean concentrations for total nitrogen, total phosphorus and BOD (Table 2). The initial EMC values were derived for each land use type from a study by Harper and Baker (2003, 2007) and then calibrated to all data available for the watershed. The calibrated EMCs are within the upper 90^{th} confidence limit of the mean of Harper and Baker (2003, 2007) data. Wetland EMCs were derived from the study of Reiss et al. (2009). The study of Reiss et al. (2009) summarizes the available literature on nutrient concentrations and hydrology for wetlands in Florida. The calibrated wetland EMCs are within the 75^{th} percentile of the Reiss et al. (2009) dataset.

Table 2Table 4 provides the basic kinetic rates used in the WASP models.

Table 4 WASP Kinetic Rates

WASP Kinetic Parameters	Value
Global Reaeration Rate Constant @ 20 °C (per day)	Covar Method
Sediment Oxygen Demand (g/m2/day)	2 for stream segments
Phytoplankton Maximum Growth Rate Constant @20 °C (per day)	3
Phytoplankton Carbon to Chlorophyll Ratio	60
BOD (1) Decay Rate Constant @20 °C (per day)	0.2
Ammonia, nitrate, phosphorus rates @20 °C (per day)	0.05 to 0.1

Table 5 provides a comparison of predicted average concentrations versus the average concentrations of the measured data at the IWR station 21FLSWFD26046 for WBID 1981B (Myakka River) and station 21FLTPA272038708208508 for WBID 1933 (Owen Creek).

Table 5 Existing Condition Observed and Predicted Average Concentrations

	WBID 1933		WBID 1981B	
Constituent	Observed	Predicted[2]	Observed	Predicted[2]
Total Nitrogen (mg/l)	1.456	1.377	1.211	1.240
Total Phosphorus (mg/l)	0.400	0.346	0.364	0.281
DO (mg/l)	7.4	7.9	4.7	4.7
BOD (mg/l)[1]	No data		5.5	5.6
Chlorophyll a (ug/l)	1.2	1.1	9.62	9.58
Avg Daily Flow (cms)[3]	Obs=4.52		Pred=4.69	

[1]BOD data for 2003, 2004, 2009 for WBID 1981B
[2]difference in observed and simulated values are not statistically significant (p-values > 0.01)
[3]USGS gage 02298608

Figure 6 through Figure 10 shows the calibration plots for WBID 1981B which compare the observed data versus the predicted concentrations.

Figure 11 through Figure 14 shows the calibration plots for WBID 1933 which compare the observed data versus the predicted concentrations.

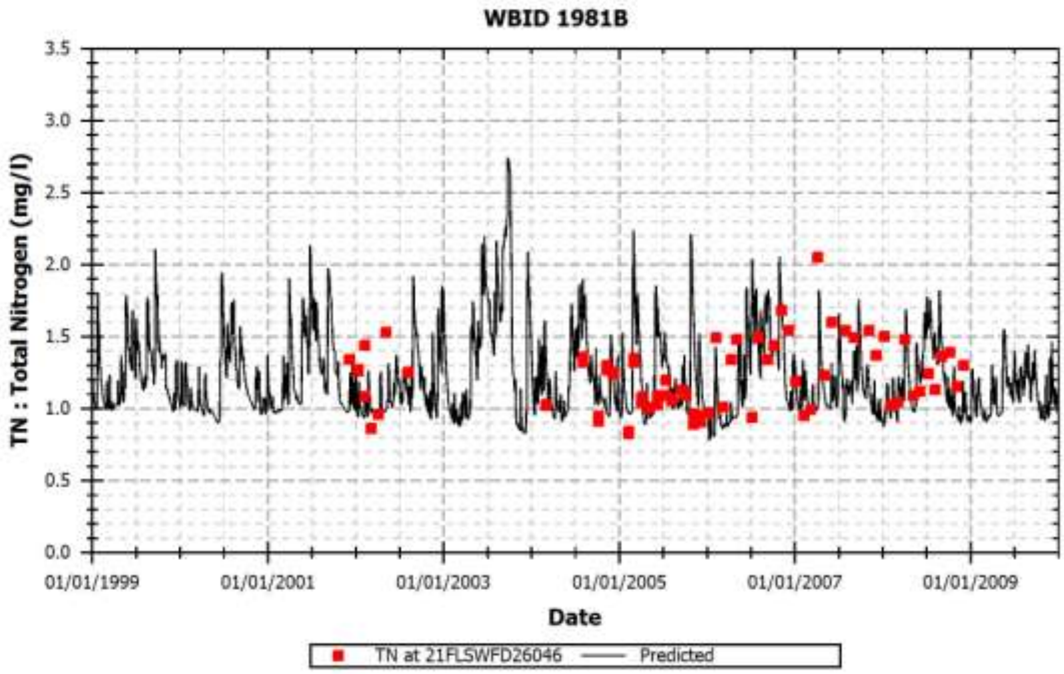

Figure 6 WASP Calibration for Total Nitrogen (WBID 1981B)

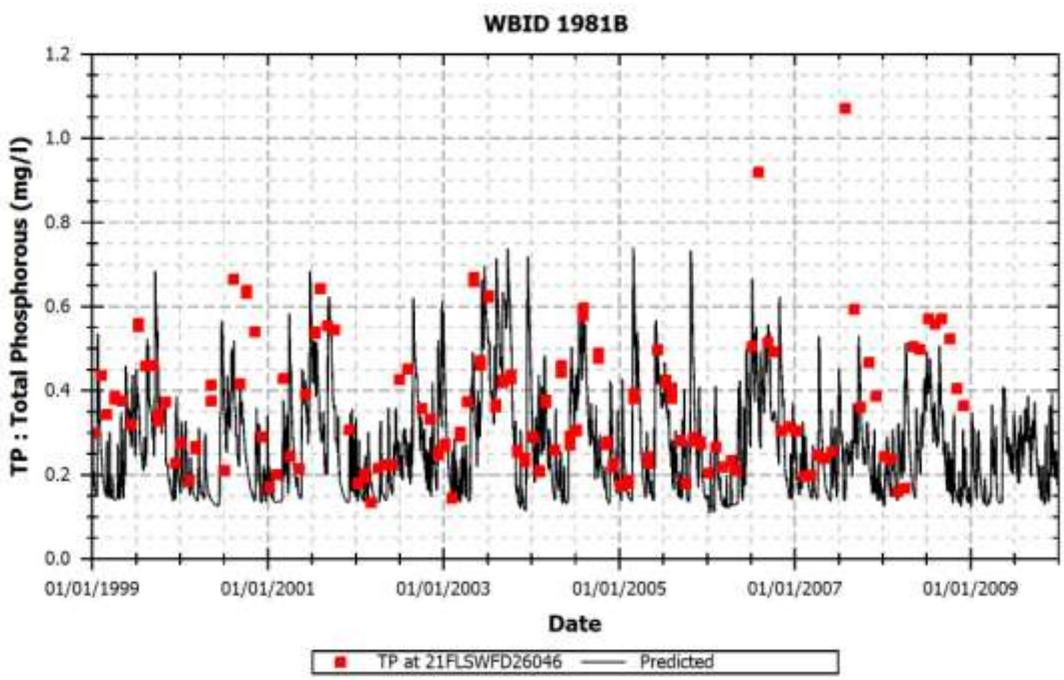

Figure 7 WASP Calibration for Total Phosphorous (WBID 1981B)

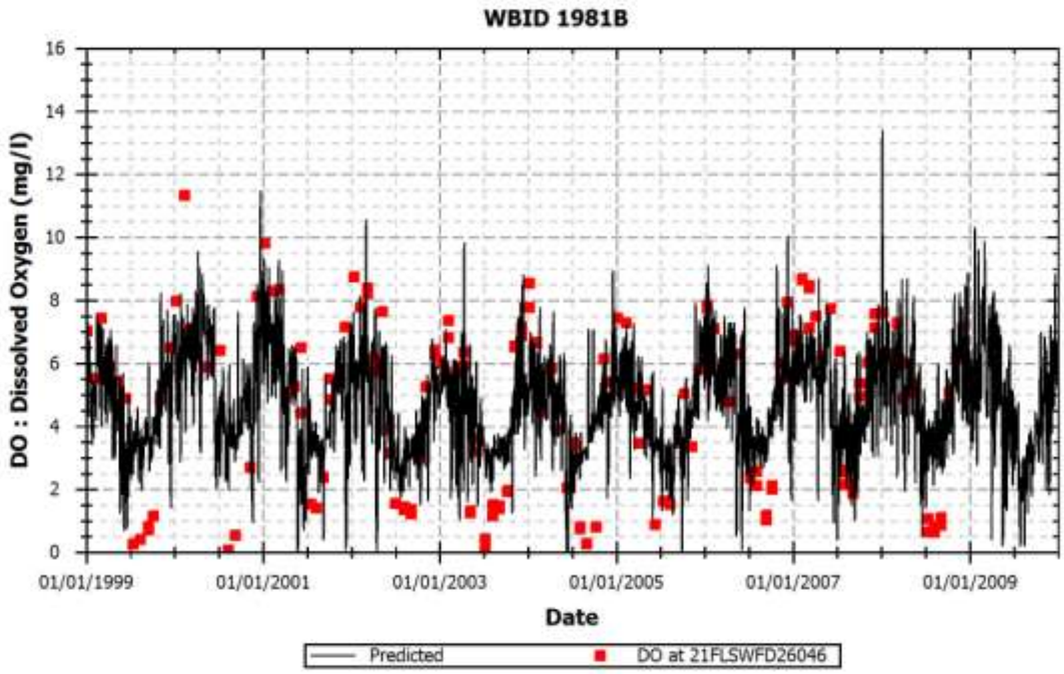

Figure 8 WASP Calibration for Dissolved Oxygen (WBID 1981B)

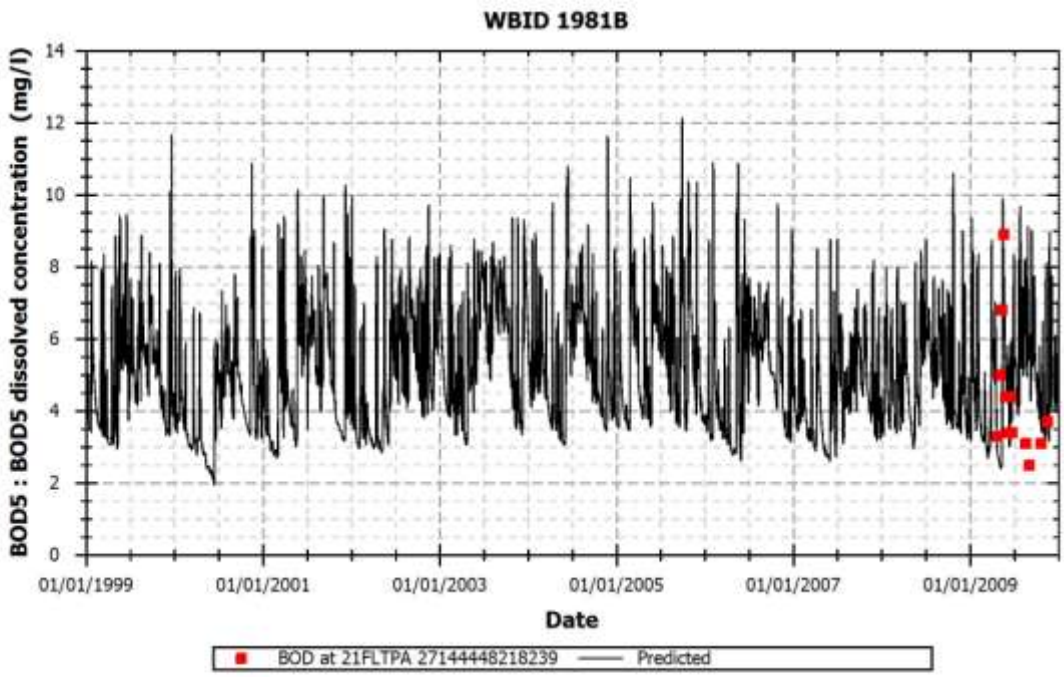

Figure 9 WASP Calibration for BOD (WBID 1981B)

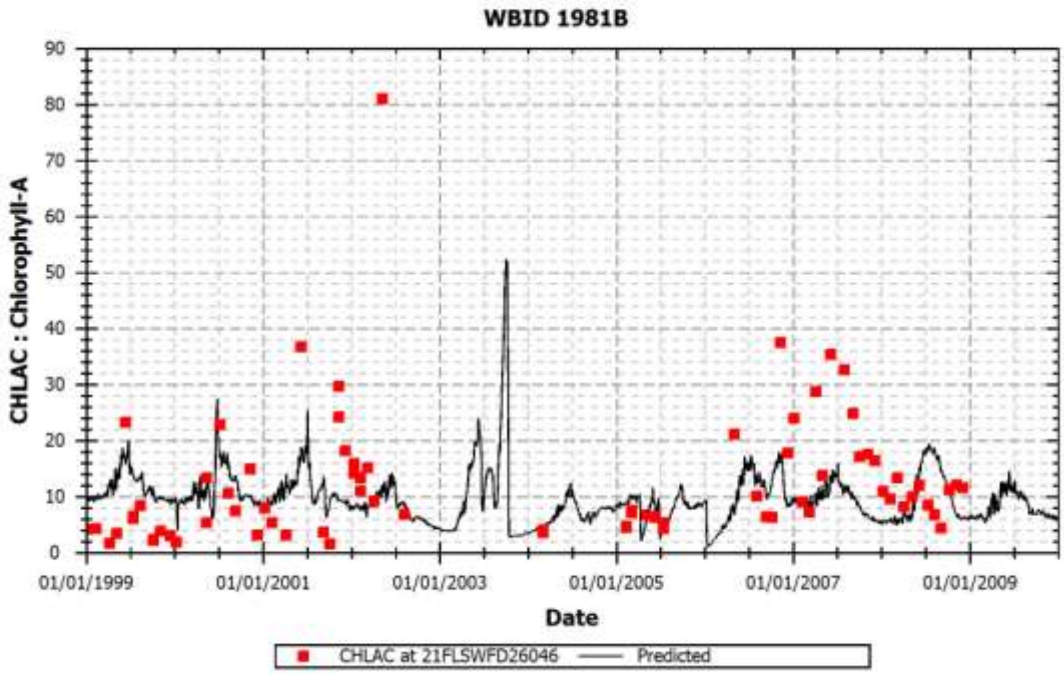

Figure 10 WASP Calibration for Chlorophyll-a (WBID 1981B)

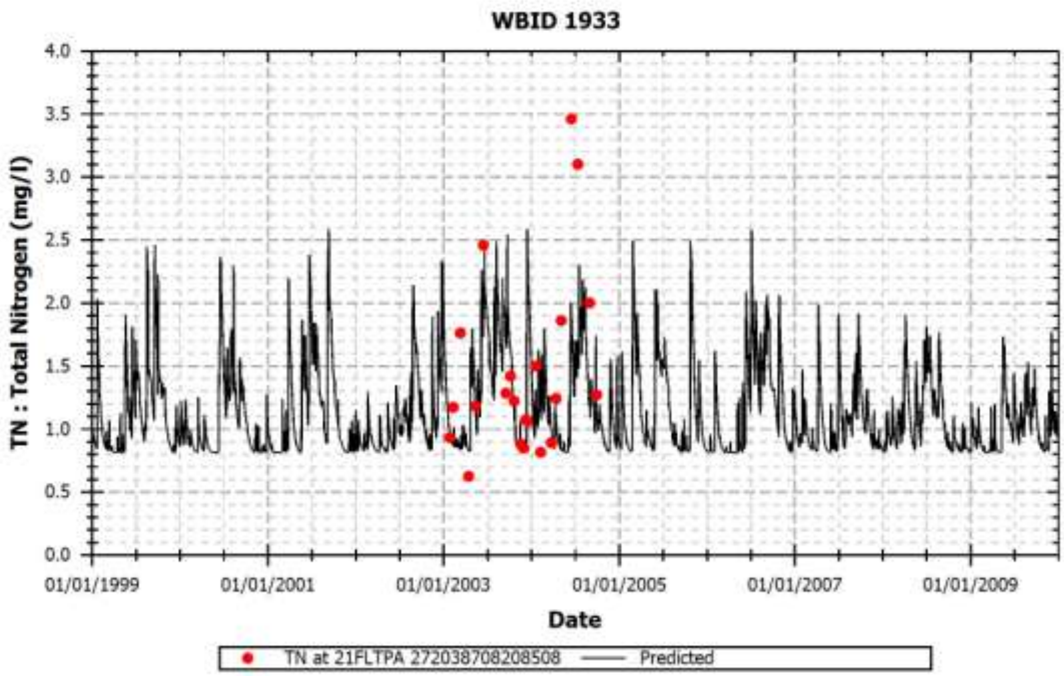

Figure 11 WASP Calibration for Total Nitrogen (WBID 1933)

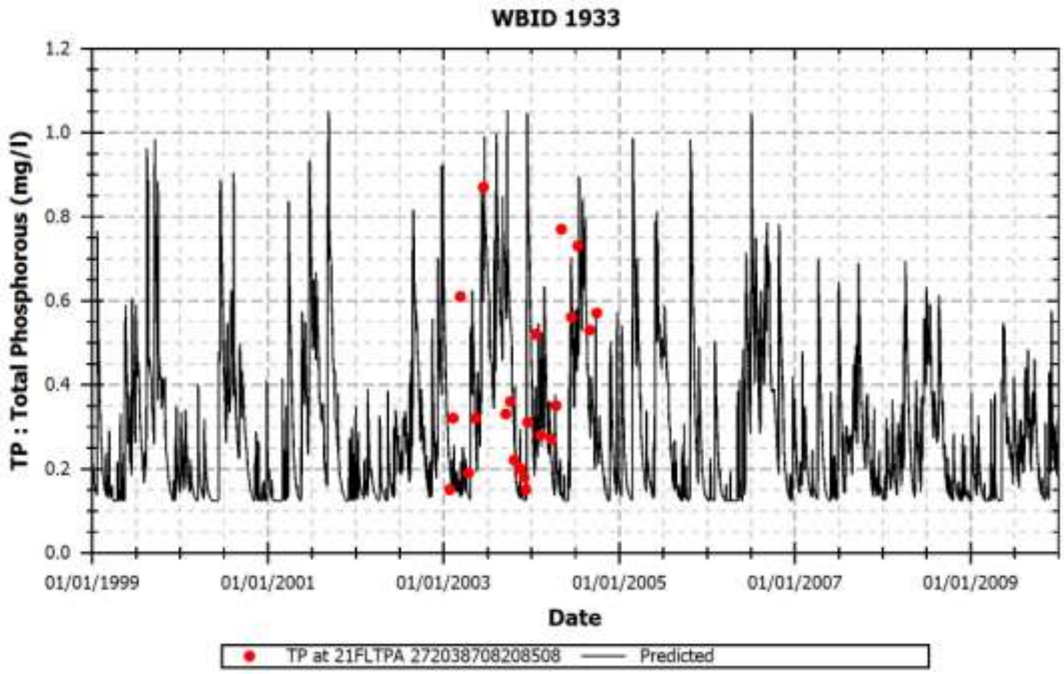

Figure 12 WASP Calibration for Total Phosphorous (WBID 1933)

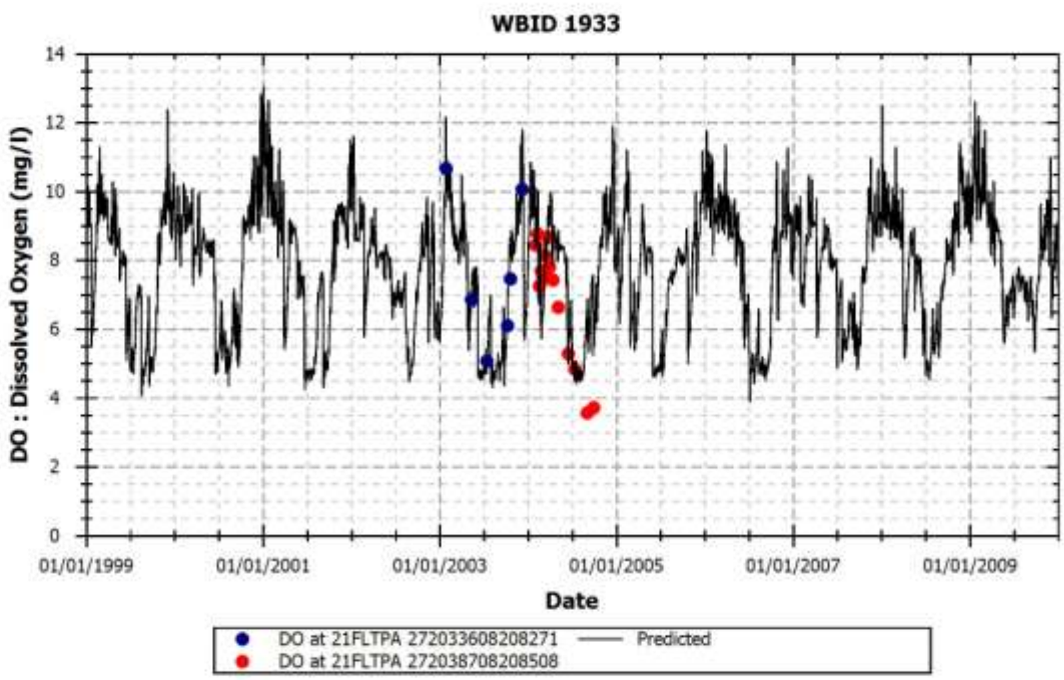

Figure 13 WASP Calibration for Dissolved Oxygen (WBID 1933)

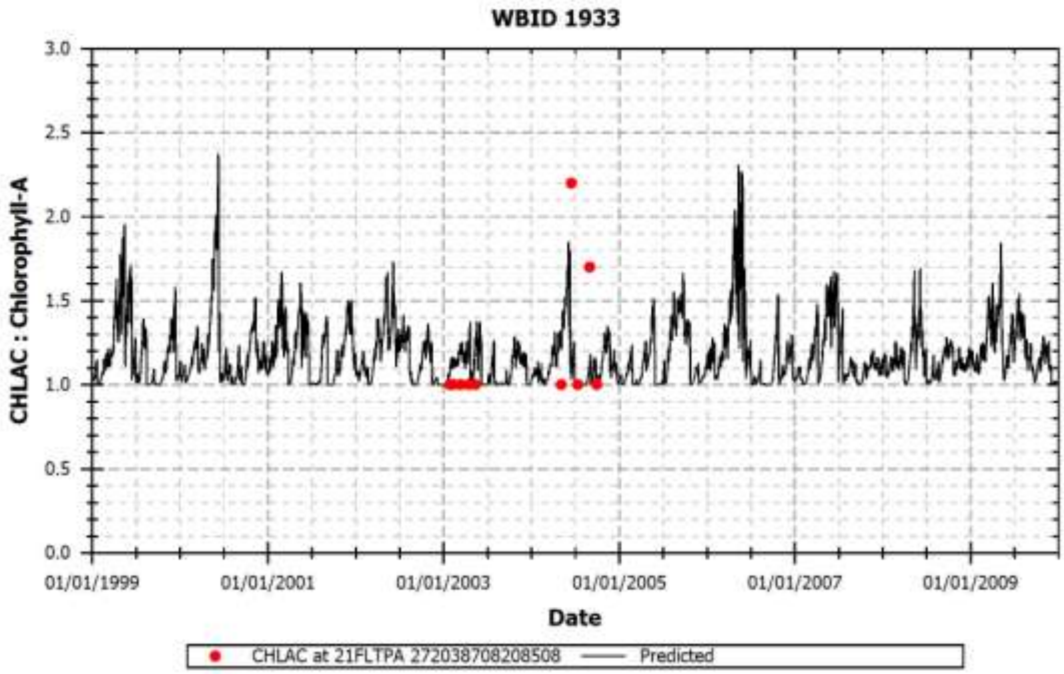

Figure 14 WASP Calibration for Chlorophyll-a (WBID 1933)

4. Modeling Scenarios

Using the calibrated watershed and water quality models, two potential modeling scenarios were developed. The calibrated model was first used to predict water quality conditions under natural condition (without point sources and returning landuses back to upland forests and wetlands). A second scenario will be developed if water quality standards can be met under natural conditions (balanced flora and fauna, dissolved oxygen greater than 5 mg/L); loads would be reduced from the current conditions until standards are met (balanced flora and fauna, dissolved oxygen greater than 5 mg/L).

4.1. Natural Condition Analysis

The land uses in the modeled Owen Creek and Myakka River sub-basins were changed from impacted lands to upland forest and wetlands. LSPC was then used to simulate the natural condition nutrient loads (Table 6) which were inputted in to WASP model. Other than the nutrient load reductions the SOD rate was reduced to reflect the reduced loadings.

Table 6 Annual Average Loadings for Natural Condition

	WBID 1933		WBID 1981B	
Constituent	**WLA (kg/yr)**	**LA (kg/yr)**	**WLA (kg/yr)**	**LA (kg/yr)**
BOD	NA	21000	NA	59666
Total Nitrogen	NA	8992	NA	25492
Total Phosphorus	NA	1207	NA	4155

Table 7 presents the predicted annual average concentrations under natural conditions. Without the impact of anthropogenic sources the dissolved oxygen concentration in WBID 1933 barely meets the dissolved oxygen standard of 5 mg/l. For WBID 1981B, the dissolved oxygen standard is not achievable under natural conditions.

Table 7 Natural Condition Annual Average Model Predictions

Constituent	WBID 1933	WBID 1981B
Total Nitrogen (mg/L)	0.988	1.098
Total Phosphorus (mg/L)	0.164	0.183
BOD (mg/L)	3.7	3.6
DO (mg/L)	8.0	6.6
Chlorophyll a (ug/L)	1.1	8.8

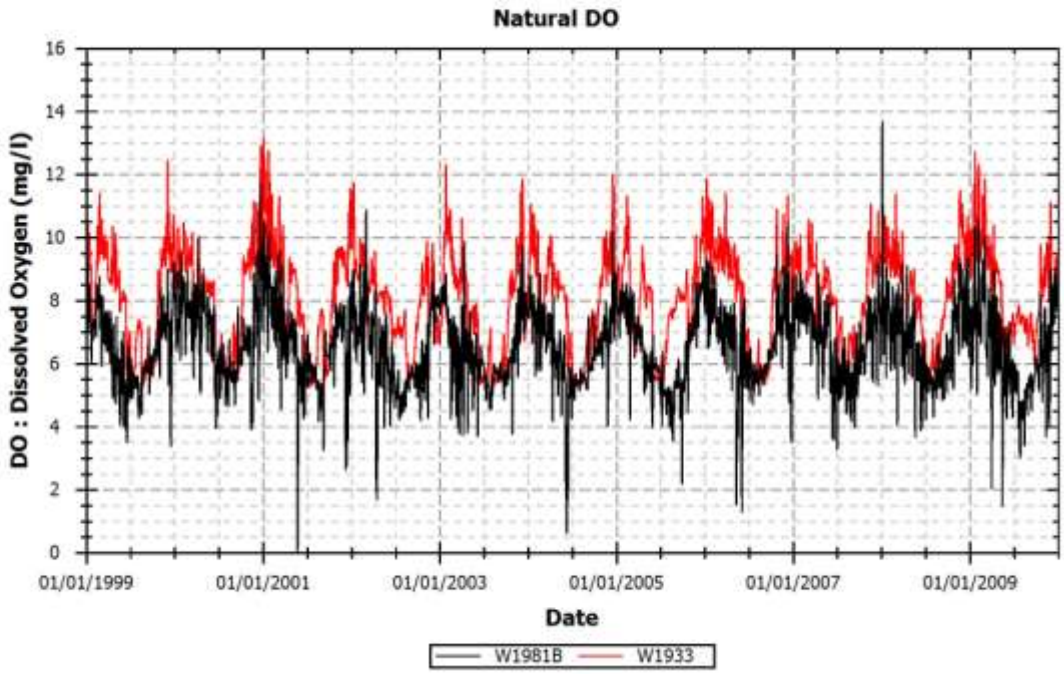

Figure 15 DO Concentration Time Series under Natural Condition

4.2. TMDL Load Reductions

Because water quality standards cannot be met under natural conditions, the TMDL was set to the natural conditions.

5. TMDL Determination

The TMDL load reduction was determined by reducing the current conditions to the natural conditions. The annual average loadings are given in

Table 8 along with the prescribed load reductions.

Table 8 TMDL Determination

	Current Condition		TMDL Condition		MS4	LA
WBID 1933 Owen Creek	**WLA (kg/yr)**	**LA (kg/yr)**	**WLA (kg/yr)**	**LA (kg/yr)**	**% Reduction**	**% Reduction**
BOD	0	24690	0	21000	15	15
TN	0	11745	0	8992	23	23
TP	0	3088	0	1207	61	61
WBID 1981B Myakka River	**WLA (kg/yr)**	**LA (kg/yr)**	**WLA (kg/yr)**	**LA (kg/yr)**	**% Reduction**	**% Reduction**
BOD	NA	66720	NA	59666	11	11
TN	NA	26569	NA	25492	4	4
TP	NA	4733	NA	4155	12	12

6. References

Harper, H. H. and D.M. Baker. 2003. Evaluation of Alternative Stormwater Regulations for Southwest Florida. Environmental Research & Design, Inc. Orlando, FL.

Interflow Engineering. 2008. Myakka River Watershed Initiative: Water Budget Model Developmnent and Calibration. Final Report submitted to the Southwest Florida Water Management District, Brooksville, FL.

Reiss, K. C., J. Evans and M.T. Brown. 2009. Summary of the Available Literature on Nutrient Concentrations and Hydrology for Florida Isolated Wetlands. Howard T. Odum Center for Wetlands, Department of Environmental Engineering Sciences, University of Florida, Water Management District, Gainesville, FL.