# Modeling Report

WBID 2351 Julington Creek/WBID 2356 Big Davis Creek for Nutrients and Dissolved Oxygen
Lower St. Johns River Basin

November 2012

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

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# Watershed Description

The Julington Creek Planning Unit is located east of the St. Johns River and covers approximately 104 square miles. Julington and Big Davis Creek lie in the southern portion of Duval County where Interstates 95 and 295 intersect, southeast of the City of Jacksonville.

WBIDs 2351 and 2356 were 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 Julington and Big Davis Creeks.

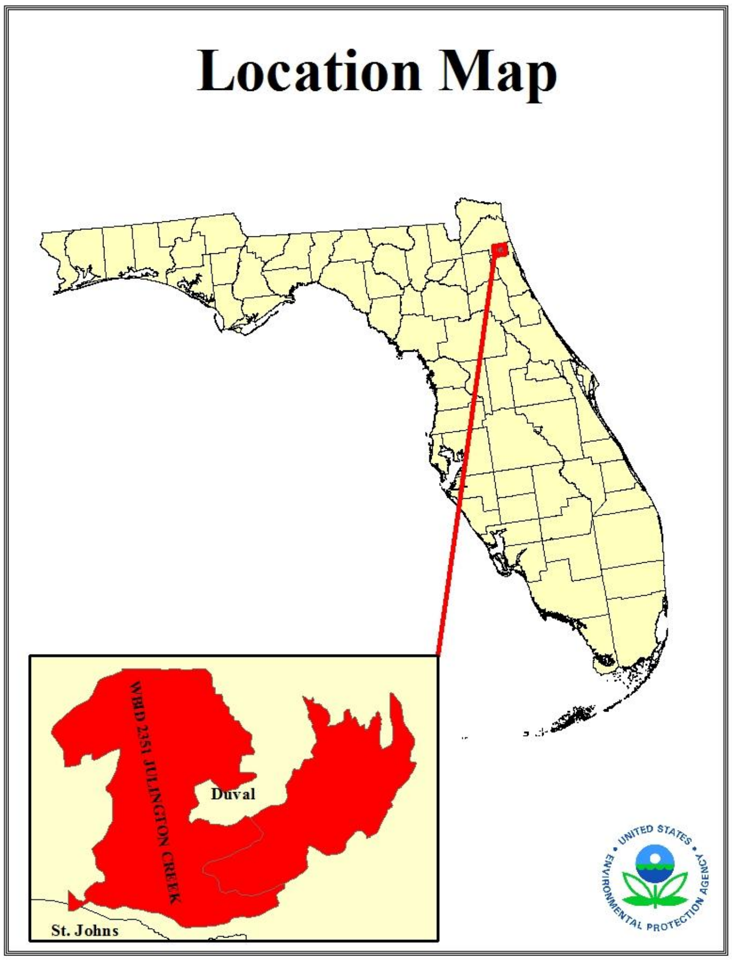



**Figure 1 Location of Julington and Big Davis Creeks Watershed**

The landuse distributions for the Julington/Big Davis watershed is presented in Figure 2. Urban development (Urban and Built-Up) consists of approximately 23 percent of the total area.

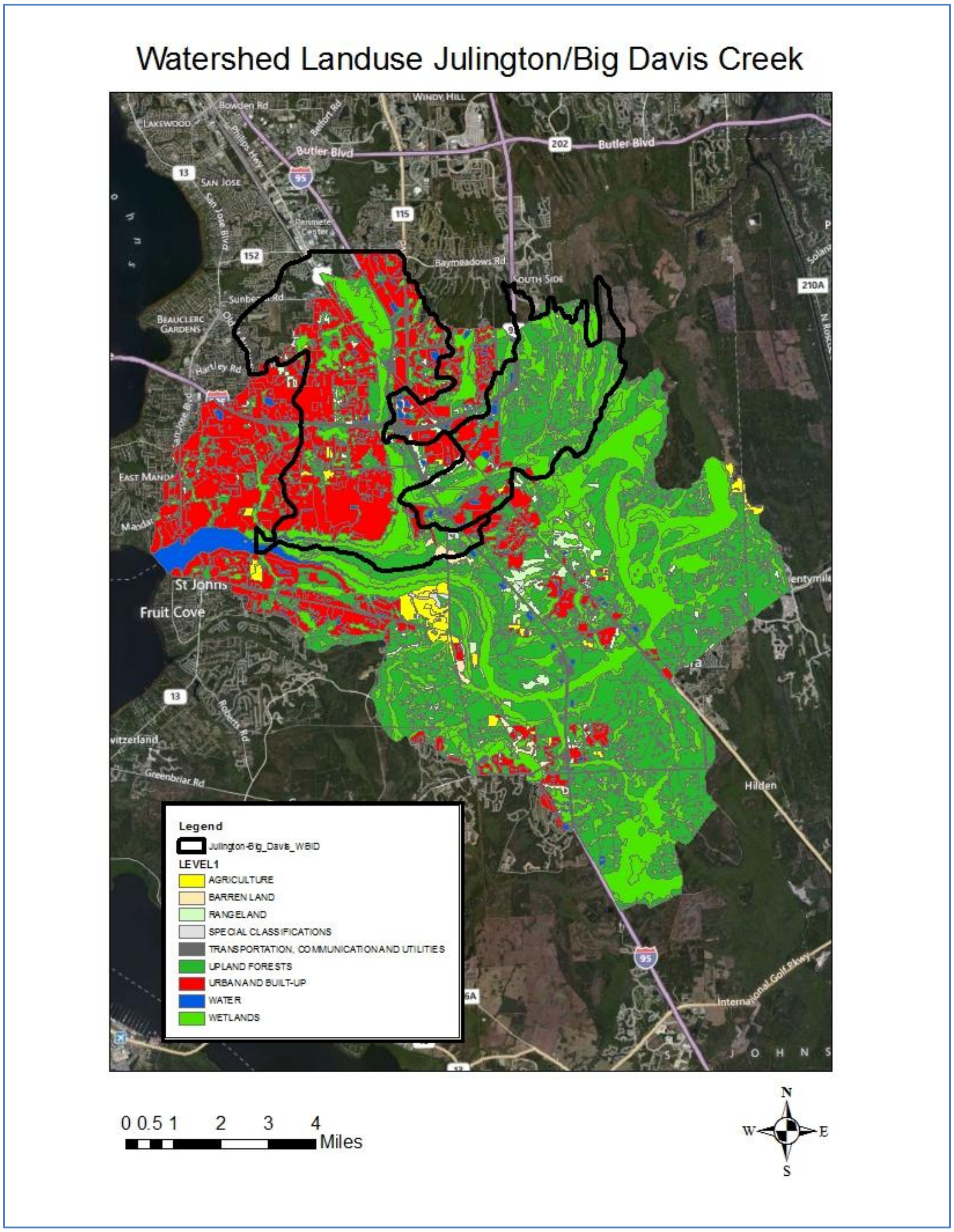



Figure 2 Landuse Distribution for Julington and Big Davis Creeks Watershed

# TMDL Targets

The TMDL reduction scenarios will be done to achieve a Florida's dissolved oxygen concentration of 5 mg/L and insure balanced flora and fauna within Julington/Big Davis Creek or establish the TMDL to be consistent with a natural condition if the dissolved oxygen standard cannot be achieved.

The waterbodies in the Julington/Big Davis WBIDs are Class III Freshwater with a designated use of Recreation, Propagation and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife. Designated use classifications are described in Florida's water quality standards. See Section 62-302.400, F.A.C. Water quality criteria for protection of all classes of waters are established in Section 62-302.530, F.A.C. Individual criteria should be considered in conjunction with other provisions in water quality standards, including Section 62-302.500 F.A.C., which established minimum criteria that apply to all waters unless alternative criteria are specified. Section 62-302.530, F.A.C. While FDEP does not have a streams water quality standard specifically for chlorophyll *a*, elevated levels of chlorophyll *a* are frequently associated with a violation of the narrative nutrient standard, which is described below.

## Nutrients

The designated use of Class III waters is recreation, propagation and maintenance of a healthy, well-balanced population of fish and wildlife. In 1979, FDEP adopted a narrative criterion for nutrients. FDEP recently adopted numeric nutrient criteria for many Class III waters in the state, including streams, which numerically interprets part of the state narrative criterion for nutrients. While those criteria have been submitted to EPA for review pursuant to section 303(c) of the CWA, EPA has not completed that review. Therefore, for streams in Florida, the applicable nutrient water quality standard for CWA purposes remains the Class III narrative criterion.

As set out more fully below, should any new or revised state criteria for nutrients in streams in Florida become applicable for CWA purposes before this proposed TMDL is established, EPA will consider the impact of such criteria on the target selected for this TMDL.

Also, in November 2010, EPA promulgated numeric nutrient criteria for Class III inland waters in Florida, including streams. On February 18, 2012, the streams criteria were invalidated by the U.S. District Court for the Northern District of Florida and remanded back to EPA. Should a federally promulgated criterion become effective for CWA purposes before this proposed TMDL is established, EPA will consider the impact of such criteria on the target selected for this TMDL.

### Narrative Nutrient Criteria

Florida's narrative nutrient criteria provide:

The discharge of nutrients shall continue to be limited as needed to prevent violations of other standards contained in this chapter. Man induced nutrient enrichment (total nitrogen and total phosphorus) shall be considered degradation in relation to the provisions of Sections 62-302.300, 62-302.700, and 62-4.242. Section 62-302.530(48)(a), F.A.C.

In no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations of aquatic flora or fauna. Section 62-302.530(48)(b), F.A.C.

Chlorophyll and dissolved oxygen (DO) levels are often used to indicate whether nutrients are present in excessive amounts. The target for this TMDL is based on levels of nutrients necessary to prevent violations of Florida's DO criterion, set out below.

### Florida's adopted numeric nutrient criteria for streams

Florida's recently adopted numeric nutrient criteria interprets the narrative water quality criterion for nutrients in paragraph 62-302.530(48)(b), F.A.C. See section 62-302.531(2). The Florida rule provides that the narrative water quality criteria for nutrients in paragraph 62-302.530(47)(a), F.A.C., continues to apply to all Class III waters. See section 62-302.531(1).

Florida's recently adopted rule applies to streams, including WBIDs 2351 and 2356. For streams that do not have a site specific criteria, Florida's rule provides for biological information to be considered together with nutrient thresholds to determine whether a waterbody is attaining 62-302.531(2)(c), F.A.C. The rule provides that the nutrient criteria are attained in a stream segment where information on chlorophyll a levels, algal mats or blooms, nuisance macrophyte growth, and changes in algal species composition indicates there are no imbalances in flora and either the average score of at least two temporally independent SCIs performed at representative locations and times is 40 or higher, with neither of the two most recent SCI scores less than 35, or the nutrient thresholds set forth in Table 1 below are achieved. See section 62-302.531(2)(c).

Florida's rule provides that numeric nutrient criteria are expressed as a geometric mean, and concentrations are not to be exceeded more than once in any three calendar year period. Section 62-302.200 (25)(e), F.A.C.

Should FDEP's numeric nutrient criteria for streams become an applicable water quality standard for CWA purposes before this TMDL is established, EPA will consider the nutrient target necessary to attain section 62-302.531(2)(c), F.A.C. EPA will compare that target with the target necessary to attain paragraph 62-302.530(47)(a), F.A.C., to determine which target is more stringent.

Table 1 Inland Numeric Nutrient Criteria

| Nutrient Watershed Region | Total Phosphorus Nutrient Threshold | Total Nitrogen Nutrient Threshold |
|---|---|---|
| Panhandle West | 0.06 mg/L | 0.67 mg/L |
| Panhandle East | 0.18 mg/L | 1.03 mg/L |
| North Central | 0.30 mg/L | 1.87 mg/L |
| Peninsular | 0.12 mg/L | 1.54 mg/L |
| West Central | 0.49 mg/L | 1.65 mg/L |
| South Florida | No numeric nutrient threshold. The narrative criterion in paragraph 62-302.530(47)(b), F.A.C., applies. | No numeric nutrient threshold. The narrative criterion in paragraph 62-302.530(47)(b), F.A.C., applies. |

## Dissolved Oxygen Criteria

Numeric criteria for DO are expressed in terms of minimum and daily average concentrations. Section 62-302(30), F.A.C., sets out the water quality criterion for the protection of Class III freshwater waters as:

Shall not be less than 5.0 mg/l. Normal daily and seasonal fluctuations above these levels shall be maintained.

## Natural Conditions

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

Florida's water quality standards provide a definition of natural background:

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

Florida's water quality standards also provide that:

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

### Biochemical Oxygen Demand Criteria

Biochemical Oxygen Demand (BOD) shall not be increased to exceed values which would cause dissolved oxygen to be depressed below the limit established for each class and, in no case, shall it be great enough to produce nuisance conditions. [FAC 62-302.530 (11)]

## Modeling Approach

The modeling approach that was used for the development of the nutrient and dissolved oxygen TMDL for Julington/Big Davis considers 13 years of meteorological and flow conditions. The selection of a longer term continuous simulation insures that average, wet and dry conditions are considered in the TMDL determination. The modeling approach uses a dynamic watershed model that predicts surface runoff of pollutants (nitrogen, phosphorus and BOD) and flow as function of landuse and meteorological information. The 13 year simulation of watershed loadings and flow are fed forward to a water quality model that predicts the impacts of the loadings and flow on water quality in waterbody. The water quality model predicts: dissolved oxygen, nitrogen (ammonia, nitrate, and organic nitrogen), phosphorus (orthophosphate, organic phosphorus), chlorophyll a, biochemical oxygen demand as a function of loads and flows provided by the watershed model.

### LSPC Watershed Model

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.

## WASP Water Quality Model

Water Quality Analysis Simulation Program (WASP 7.5) (USEPA, 2011) is a generalized framework for modeling contaminant fate and transport in surface waters. Its flexible, compartmental approach allows it to address problems in one, two, or three dimensions. It is designed to allow easy substitution of user-written routines into the program structure. WASP has been used to answer questions regarding biochemical oxygen demand, dissolved oxygen dynamics, nutrients and eutrophication, bacterial contamination, and organic chemical and heavy metal contamination.

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.

### LSPC Application to Julington/Big Davis Watershed

The watershed model was applied to the Julington/Big Davis watershed model for the simulation period of 1996 through 2009. The 1996 year was used to equilibrate the initial conditions in the watershed model (soil moisture, buildup and washoff), from 1997 through 2009 was used to predict flows and loads under current conditions that will be passed onto the water quality model.

### Watershed Delineation and Landuse

The surrounding watershed that drains directly to the Julington/Big Davis WBIDs was included in the watershed model. This encompasses land areas outside the delineated Julington/Big Davis WBIDs. The watershed was delineated into 6 sub basins (Figure 3). The LSPC model will predict flow and loads coming from each of these sub basins into Julington/Big Davis Creek.

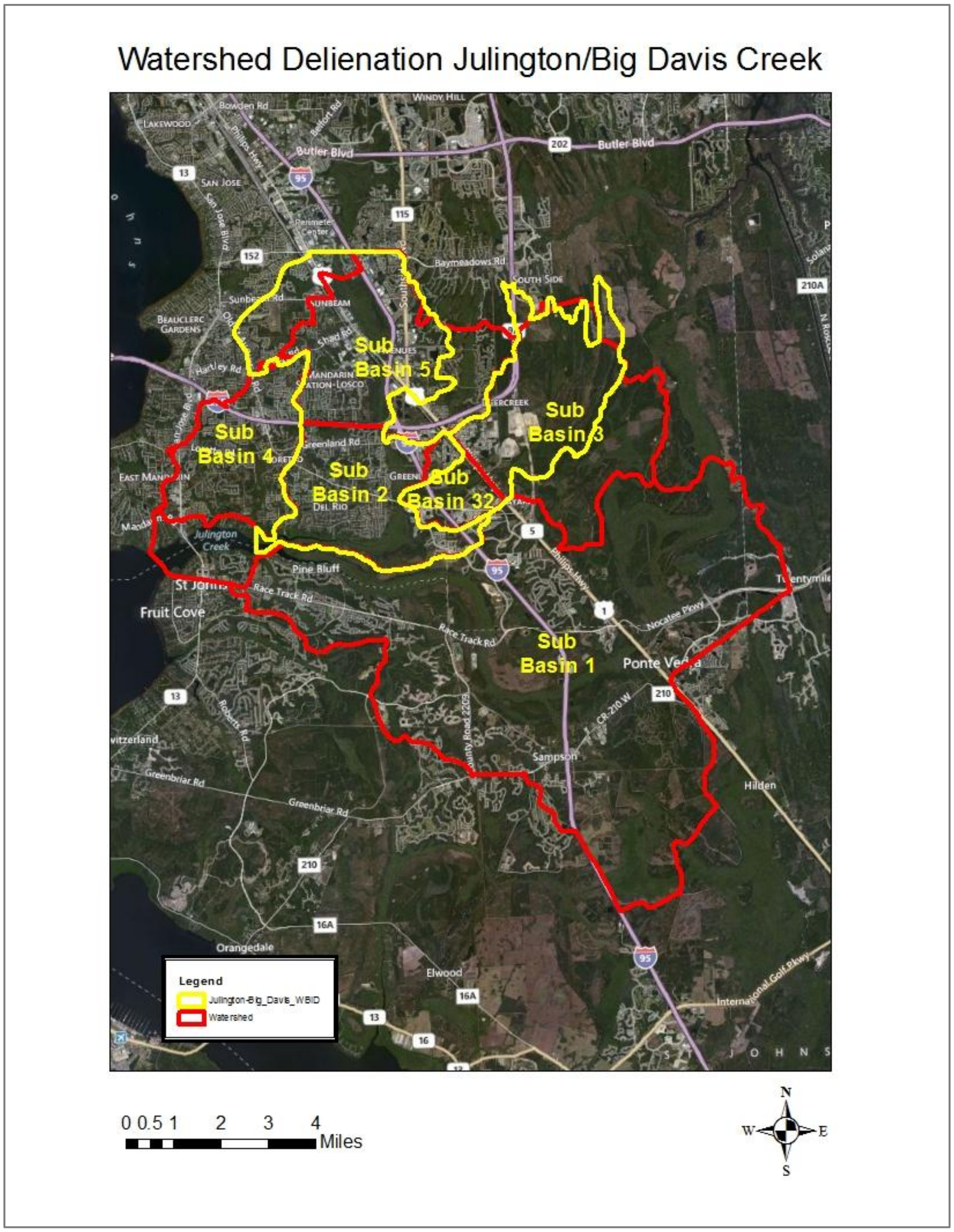



**Figure 3 Julington/Big Davis Watershed Delineation**

The initial model setup for Julington/Big Davis Creek was obtained from EPA's application of LSPC for the purposes of nutrient criteria development; the model was further refined and calibrated to all local data and gages that were available in the watershed.

Landuse coverage was obtained from the St. Johns River Water Management District (Florida Landuse Classification Code) coverage developed from 2004 (See Figure 2). Table 2 provides the landuse distribution for each of the 6 sub basins being modeled.

**Table 2 Landuse Distribution for Sub Basins**

| Subbasin Name | Agriculture | Barren Land | Rangeland | Special Classifications | Transportation, Communication And Utilities | Upland Forests | Urban And Built-Up | Water | Wetlands | Totals |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 826.4 | 230.3 | 715.3 | 208.8 | 748.5 | 14988 | 2959.4 | 518.8 | 11674.9 | 32871 |
| 2 | 70.8 | 62.2 | 59.3 | 45.5 | 166.4 | 844.8 | 3430.9 | 893.5 | 1571.5 | 7144.9 |
| 3 | 23.3 | | 162.7 | 11.8 | 126.1 | 3780.3 | 478.6 | 66 | 3886.1 | 8534.8 |
| 32 | 9.7 | | 85.8 | 10.4 | 157.9 | 324.3 | 487.6 | 67.9 | 429.1 | 1572.6 |
| 4 | 22.2 | 4.2 | 86.8 | 2.5 | 109 | 307.5 | 3525 | 160.1 | 393.8 | 4611.1 |
| 5 | 11.9 | 59.9 | 180.8 | 36.3 | 544.6 | 799.9 | 3678.3 | 373.3 | 1950.9 | 7635.8 |

## Meteorological Information

Non-point source loadings and hydrological conditions are dependent on weather conditions. Hourly data from weather stations within the boundaries of, or in close proximity to the sub-watersheds were applied to the watershed model. An ASCII file (*.air) was generated for each meteorological and precipitation station used for the hydrologic evaluations in LSPC. Each meteorological and precipitation station file contains atmospheric data used for modeling of the hydrologic processes. These data include precipitation, air temperature, dew point temperature, wind speed, cloud cover, evaporation, and solar radiation. These data are used directly, or calculated from the observed data.

Figure 4 depicts the hourly rainfall for the Julington/Big Davis (083137) meteorological station. The period of record being simulated during this TMDL development contains average, wet and dry years.

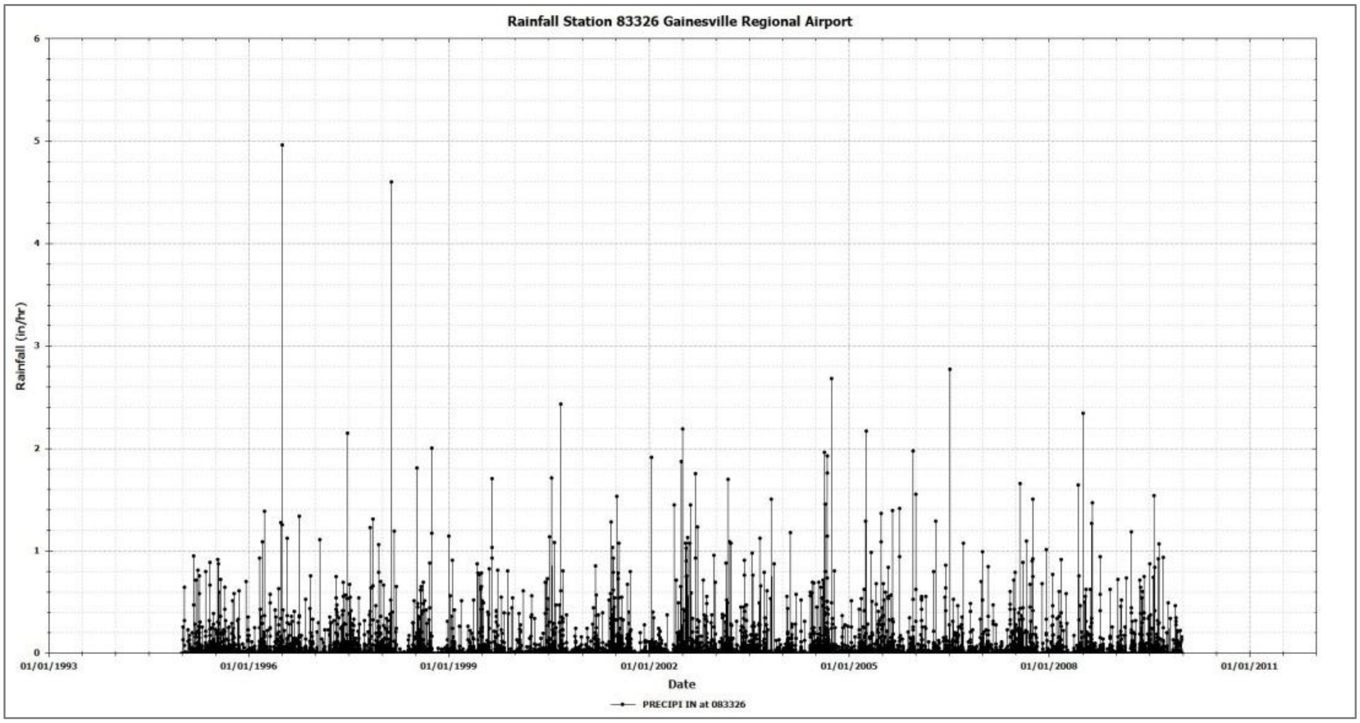



**Figure 4 Hourly Rainfall Station 083137**

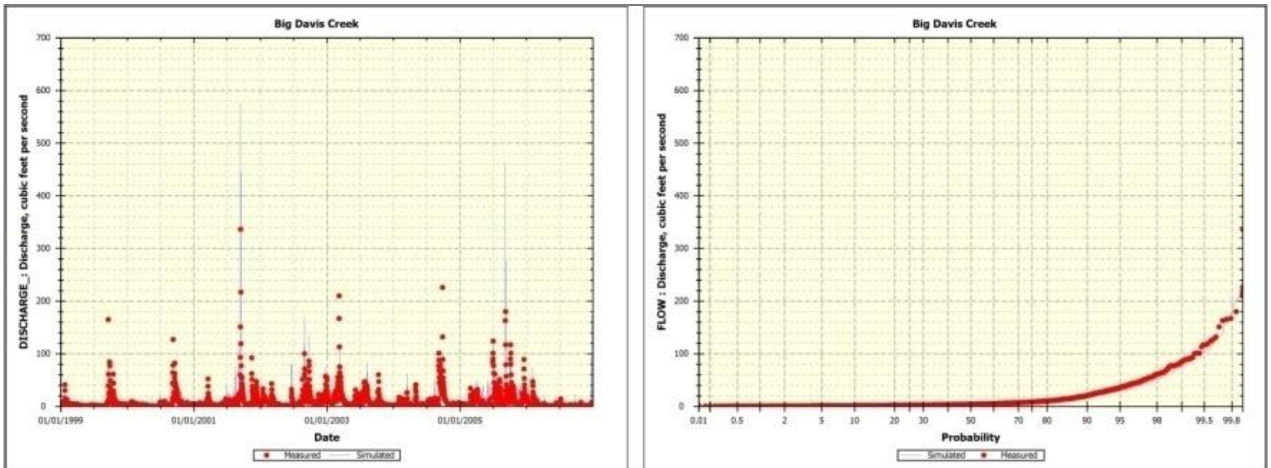
Table 3 provides the annual rainfall for each of the simulation years.

**Table 3 Annual Rainfall for Simulation Period**

| Year | Annual Rainfall |
|---|---|
| 1996 | 51 |
| 1997 | 55 |
| 1998 | 58 |
| 1999 | 46 |
| 2000 | 38 |
| 2001 | 34 |
| 2002 | 42 |
| 2003 | 55 |
| 2004 | 47 |
| 2005 | 58 |
| 2006 | 50 |
| 2007 | 35 |
| 2008 | 46 |
| 2009 | 40 |
| 2010 | 47 |

## Hydraulic Calibration

The watershed and water quality model were calibrated for flow by comparing the predict flows to the USGS gage Big Davis at USGS02246150. Figure 5 illustrates both a quantitative and qualitative comparison of the model flow predictions directly compared to the measurements at the USGS gage.




Calibration Statistics

Station: USGS02246150; Parameter: FLOW

| Statistic | Measured | Simulated |
|---|---|---|
| Count: | 2922 | 2921 |
| Mean: | 9.163 | 9.102 |
| Std Dev: | 17.656 | 20.255 |
| Min: | 0.460 | 0.340 |
| Max: | 336.000 | 575.610 |
| 5 %tile: | 0.970 | 0.702 |
| 10 %tile: | 1.300 | 1.054 |
| 90 %tile: | 20.000 | 17.489 |
| 95 %tile: | 35.000 | 29.043 |
| Corr ($R^2$): | 0.55 | |
| Mean Abs Error: | 5.413 | |
| RMS Error: | 13.803 | |
| Norm RMS Error: | 0.739 | |
| Index of Agreement: | 0.85 | |

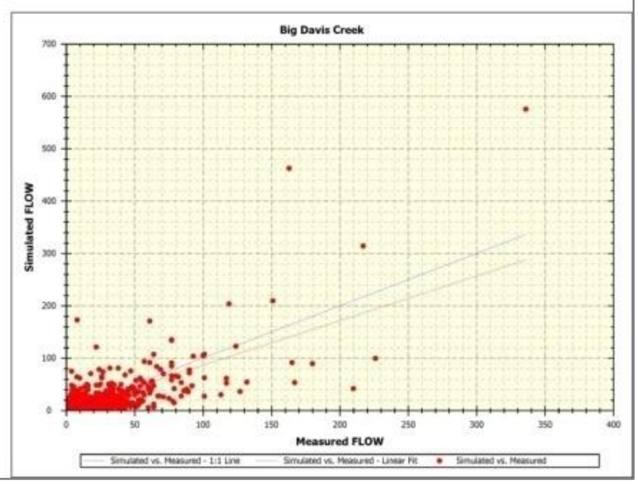



**Figure 5 Flow Calibration for Julington/Big Davis Watershed**

## Water Quality Model Application

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. The waterbody geometry was determined from NHDPlus coverages of the free flowing stream sections.

## Model Network

The Julington/Big Davis waterbody was broken into segments for the water quality model. The model segmentation was done based upon the NHDPlus coverage taking into account travel time, pore points for the watershed model and IWR monitoring stations.

Figure 6 illustrates the 8 water quality model segments that are simulated. The LSPC model flows and loads enter the water quality model at segments 2, 4, and 8.

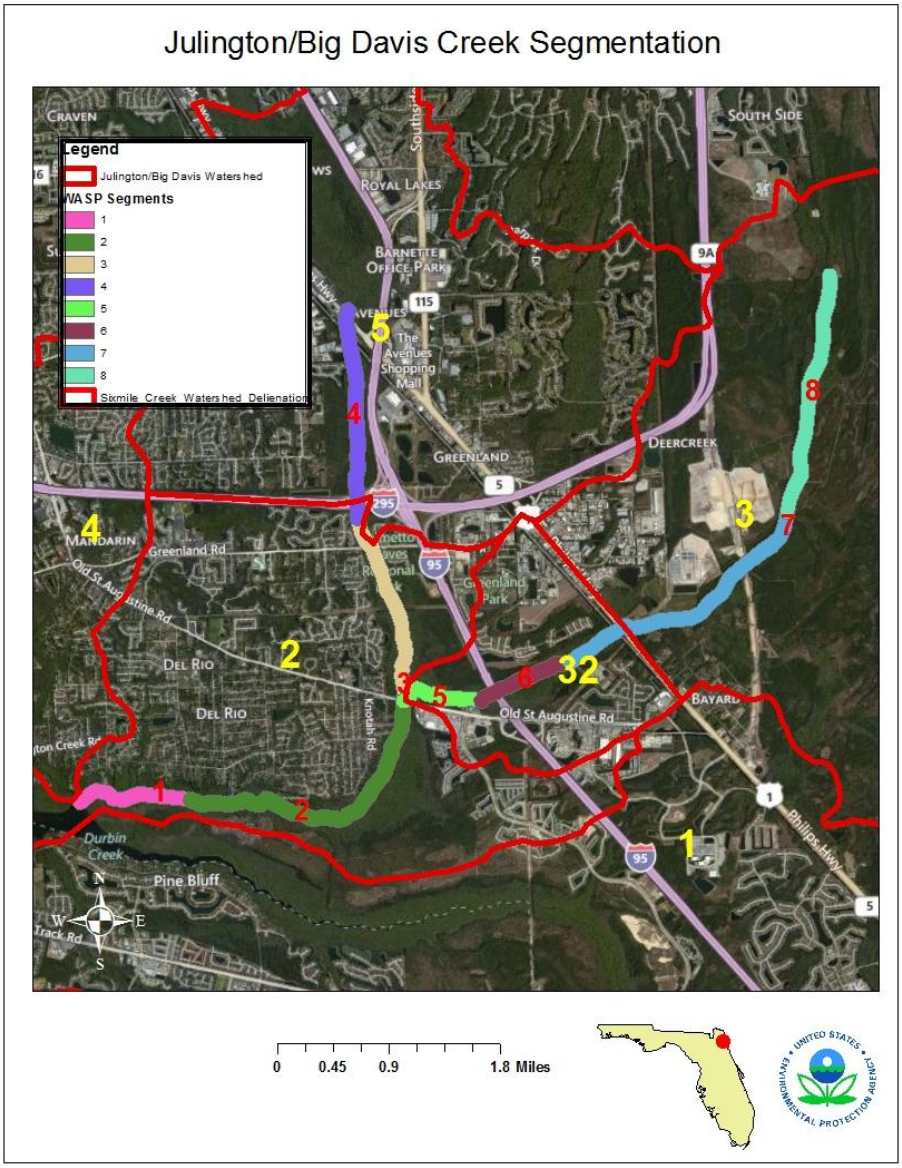



**Figure 6 WASP Model Segmentation**

## Water Quality Model Calibration

The water quality model was calibrated to all available data. The fine tuning of the calibration of the model utilized the IWR station located at the lower end of the WBID that most of the monitoring data.

Table 4 provides a listing of the IWR stations that were used to calibrate the WASP model. All stations that had nutrient, BOD, dissolved oxygen and chlorophyll a measurements were used in the calibration process. The station highlighted in yellow was used for the water quality.

**Table 4 Impaired Waters Rule Database Stations used in Water Quality Model Calibration Julington/Big Davis Creek**

| Station | Station Name | First Date | Last Date | No. Obs |
|---|---|---|---|---|
| 21FLA 20030355 | LITTLE DAVIS CR E US1 @ AVENUES SPORTS BAR DRIVEWAY | 1/11/2007 | 12/6/2007 | 44 |
| 21FLA 20030356 | BIG DAVIS CR E OF US 1 S OF GOLF DRIVING RANGE | 1/11/2007 | 1/26/2012 | 41 |
| 21FLA 20030516 | JULINGTON CR 1/2 MI S OF ST AUGUSTINE RD | 2/9/2012 | 5/7/2012 | 20 |
| 21FLA 20030517 | JULINGTON CREEK AT ST AUGUSTINE RD | 8/11/2004 | 9/17/2007 | 8 |
| 21FLA 20030597 | JULINGTON CREEK AT 50 M ABOVE US 1 | 8/11/2004 | 2/25/2008 | 16 |
| 21FLA 20030598 | JULINGTON CREEK AT GREENLAND RD | 8/11/2004 | 11/20/2007 | 14 |
| 21FLA 20030606 | BIG DAVIS CR @ RR TRACKS W OF US 1 | 1/11/2007 | 12/6/2007 | 38 |
| 21FLBRA 2356-A | 2356 - Big Daivs Creek - Bridge on Hwy 1 | 4/21/2008 | 5/1/2008 | 2 |
| 21FLGW 27862 | SJ2-SS-2009 UNNAMED SMALL STREAM | 8/16/2005 | 8/16/2005 | 5 |
| 21FLJXWQJC3 | JULINGTON CREEK AT GREENLAND RD | 2/22/2005 | 12/1/2011 | 31 |
| 21FLJXWQJC339 | Julington Creek at US 1 | 8/10/2004 | 12/1/2011 | 51 |
| 21FLJXWQJC440 | JULINGTON CREEK AT OLD ST. AUGUSTINE RD | 7/7/2004 | 12/1/2011 | 36 |
| 21FLJXWQJC441 | BIG DAVIS CREEK AT U.S. 1 | 7/7/2004 | 12/1/2011 | 57 |
| 21FLSJWMD-JCGR | Julington Creek at Greenland Rd; DET-37 | 7/14/2004 | 9/21/2005 | 67 |
| 21FLSJWMJC339N | Julington Creek at Philips Highway, Usptream side | 4/13/2005 | 9/27/2005 | 4 |
| 21FLSJWMJC339S | Un-named branch to Julington Creek at Philips Hwy Upstr side | 4/13/2005 | 4/13/2005 | 1 |
| 21FLSJWMLSJ099 | BIG DAVIS CREEK AT US1 | 8/10/2004 | 3/14/2012 | 127 |

Table 5 provides a comparison of predicted annual average concentrations versus the annual average concentrations of the measured data. While it is important to capture seasonal variation, duration and frequency of water quality, it is very critical to approximate average conditions in the system. It is during these periods of times that nutrients are expressed.

**Table 5 Predicted vs. Observed Annual Average Concentrations**

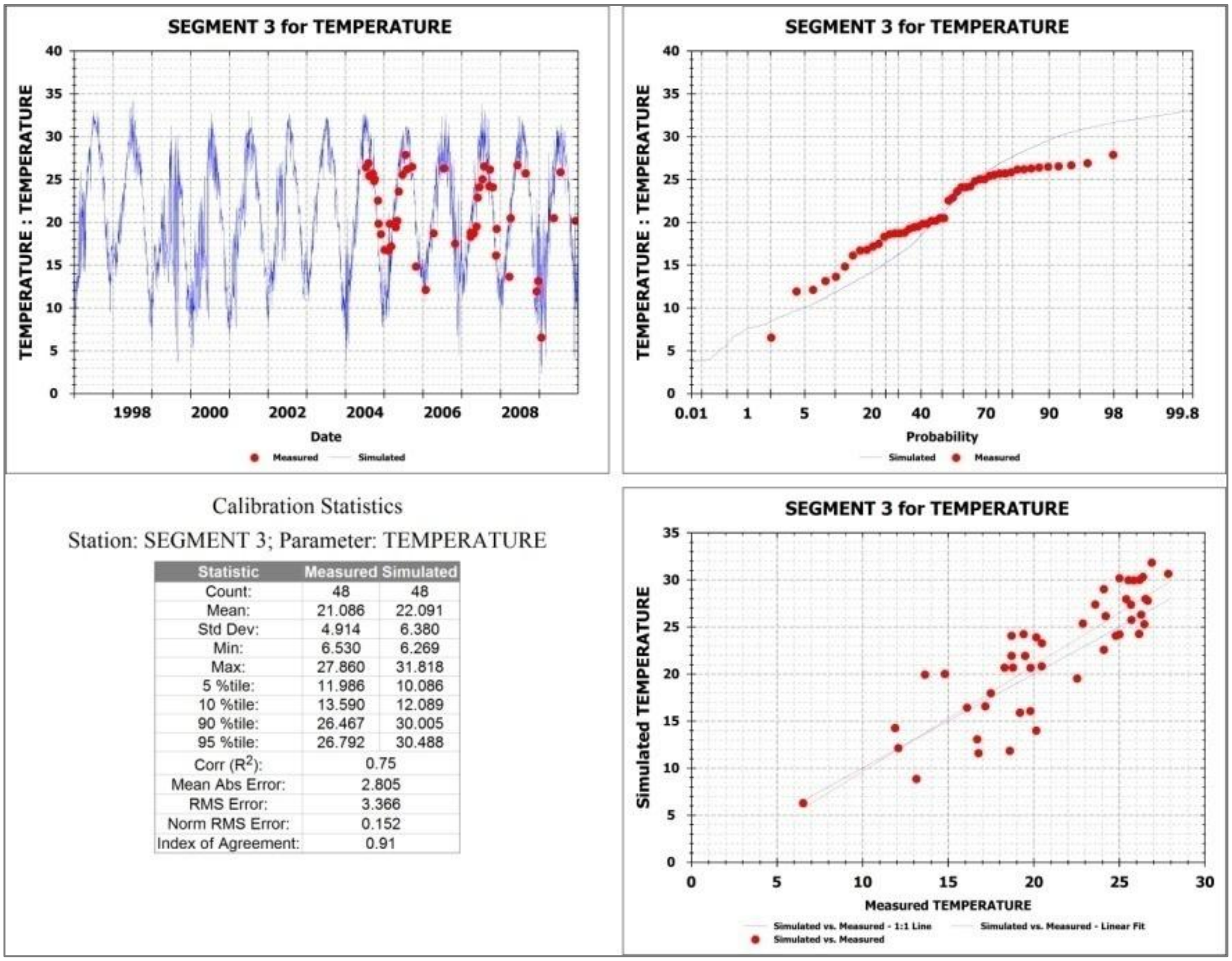
| Constituent | Simulated | Observed |
|---|---|---|
| BOD (mg/L) | 2.03 | 1.89 |
| Chlorophyll a (ug/L) | 1.11 | 3.97 |
| DO (mg/L) | 5.81 | 5.40 |
| Total Nitrogen (mg/L) | 0.85 | 0.87 |
| Total Phosphorus (mg/L) | 0.10 | 0.11 |

Figure 7 through **Error! Reference source not found.** provide calibration comparison for all of the major water quality constituents in which data is available.

## Water Temperature

Water temperature is simulated in the water quality because of its influence on degradation, kinetic transformation, algal growth and decay rates. Because several modeling scenarios will be simulated, such as a natural condition, an estimate of water temperature under this condition could be important.

Figure 7 through Figure 9 illustrates both a quantitative and qualitative comparison of the simulated water temperature compared to the direct measurements.

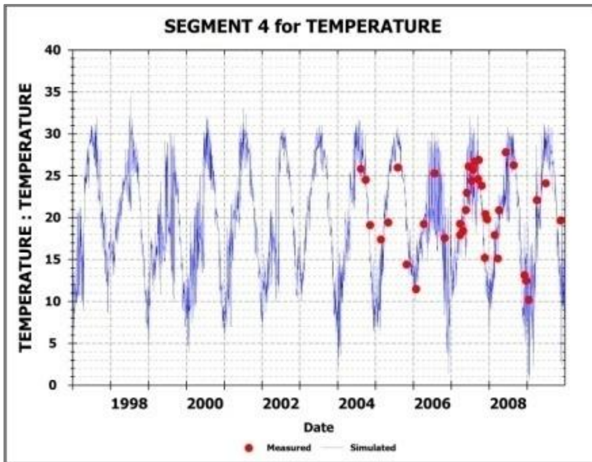


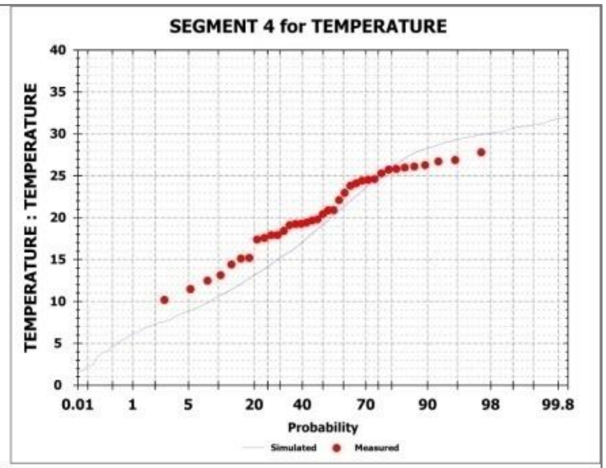

Calibration Statistics

Station: SEGMENT 3; Parameter: TEMPERATURE

| Statistic | Measured | Simulated |
|---|---|---|
| Count: | 48 | 48 |
| Mean: | 21.086 | 22.091 |
| Std Dev: | 4.914 | 6.380 |
| Min: | 6.530 | 6.269 |
| Max: | 27.860 | 31.818 |
| 5 %tile: | 11.986 | 10.086 |
| 10 %tile: | 13.590 | 12.089 |
| 90 %tile: | 26.467 | 30.005 |
| 95 %tile: | 26.792 | 30.488 |
| Corr ($R^2$): | 0.75 | |
| Mean Abs Error: | 2.805 | |
| RMS Error: | 3.366 | |
| Norm RMS Error: | 0.152 | |
| Index of Agreement: | 0.91 | |

**Figure 7 Water Temperature Calibration Segment 3**




Calibration Statistics

Station: SEGMENT 4; Parameter: TEMPERATURE

| Statistic | Measured | Simulated |
|---|---|---|
| Count: | 37 | 37 |
| Mean: | 20.610 | 19.109 |
| Std Dev: | 4.800 | 6.147 |
| Min: | 10.180 | 2.611 |
| Max: | 27.790 | 29.384 |
| 5 %tile: | 11.332 | 5.800 |
| 10 %tile: | 13.000 | 11.132 |
| 90 %tile: | 26.348 | 26.378 |
| 95 %tile: | 26.953 | 28.803 |
| Corr ($R^2$): | 0.65 | |
| Mean Abs Error: | 3.061 | |
| RMS Error: | 3.873 | |
| Norm RMS Error: | 0.190 | |
| Index of Agreement: | 0.87 | |

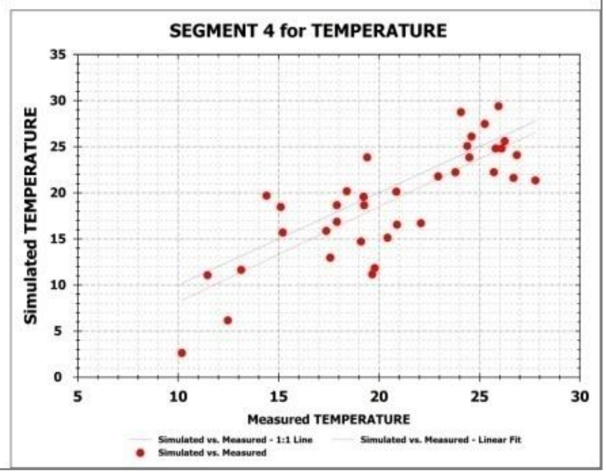
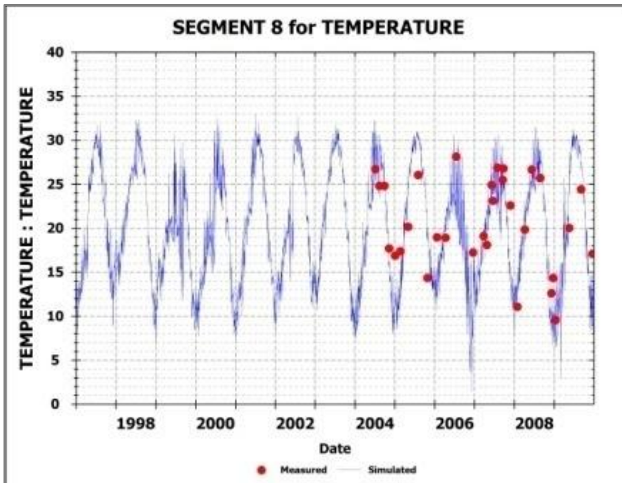
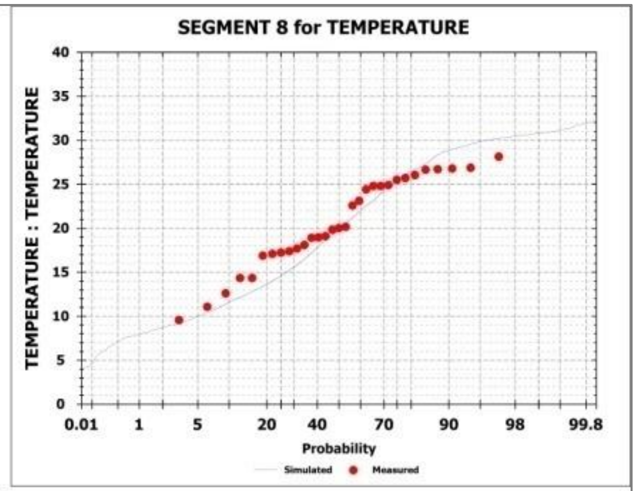



**Figure 8 Water Temperature Calibration Segment 4**




Calibration Statistics

Station: SEGMENT 8; Parameter: TEMPERATURE

| Statistic | Measured | Simulated |
|---|---|---|
| Count: | 31 | 31 |
| Mean: | 20.649 | 19.808 |
| Std Dev: | 5.141 | 6.745 |
| Min: | 9.550 | 7.281 |
| Max: | 28.140 | 30.364 |
| 5 %tile: | 10.456 | 7.342 |
| 10 %tile: | 12.938 | 8.556 |
| 90 %tile: | 26.754 | 27.281 |
| 95 %tile: | 27.366 | 29.300 |
| Corr ($R^2$): | 0.67 | |
| Mean Abs Error: | 3.233 | |
| RMS Error: | 3.941 | |
| Norm RMS Error: | 0.189 | |
| Index of Agreement: | 0.88 | |

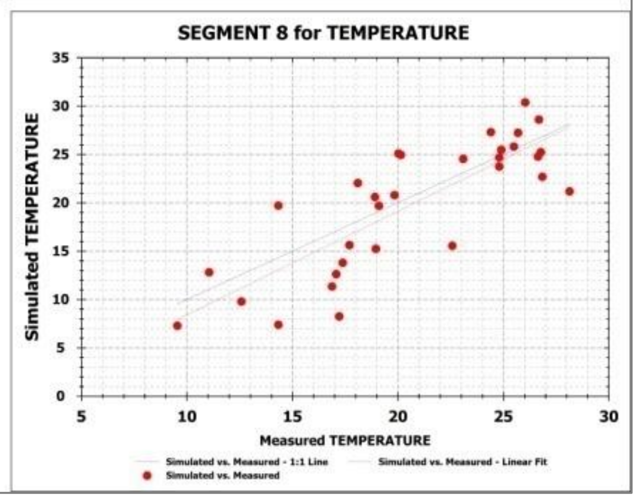
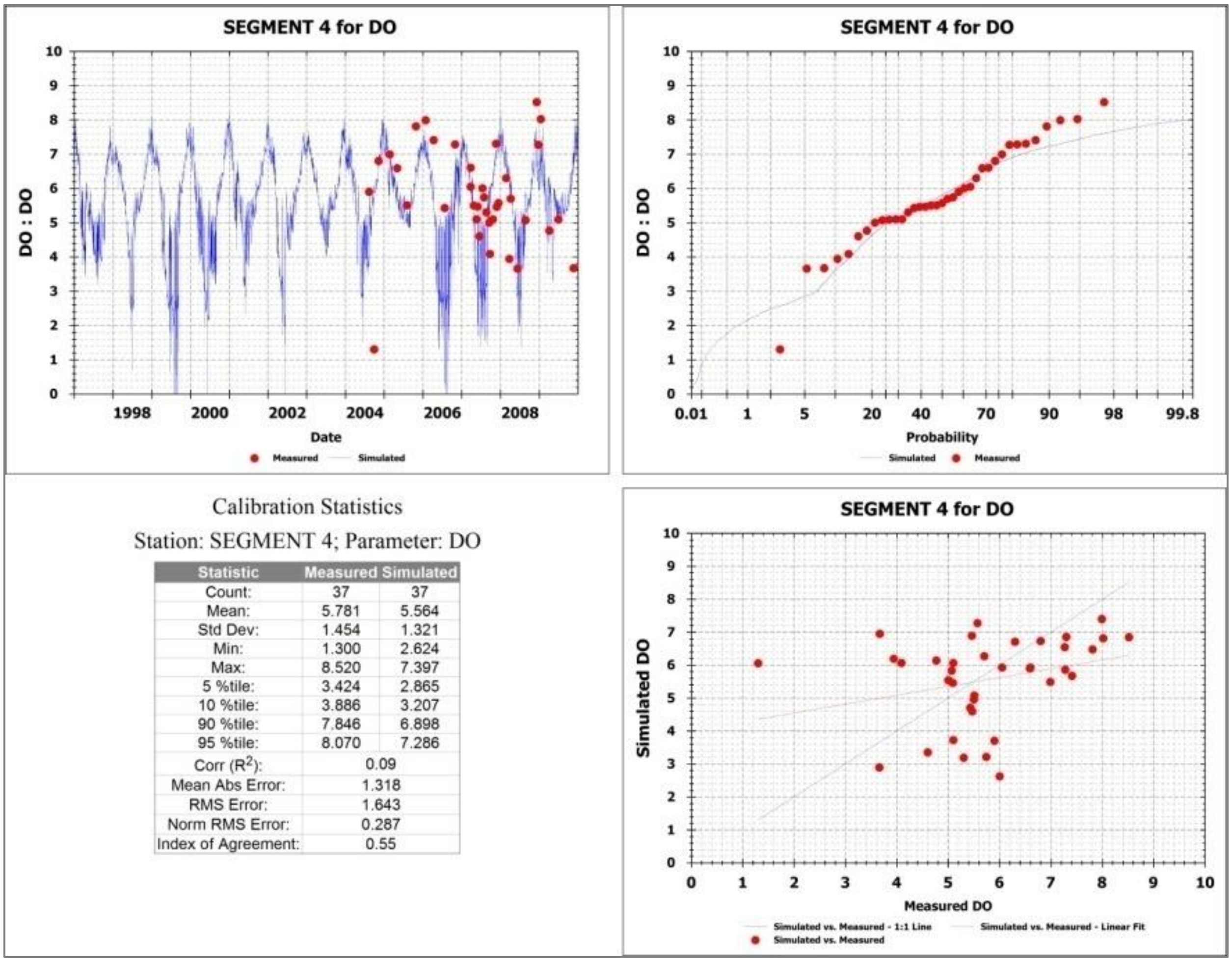



**Figure 9 Water Temperature Calibration Segment 8**

## Dissolved Oxygen

The dissolved oxygen calibration will be important in the development of this TMDL because it will be the primary response variable to determine the reductions.

Figure 10 illustrates both a quantitative and qualitative comparison of the predicted dissolved oxygen concentrations compared to the direct measurements.




Calibration Statistics

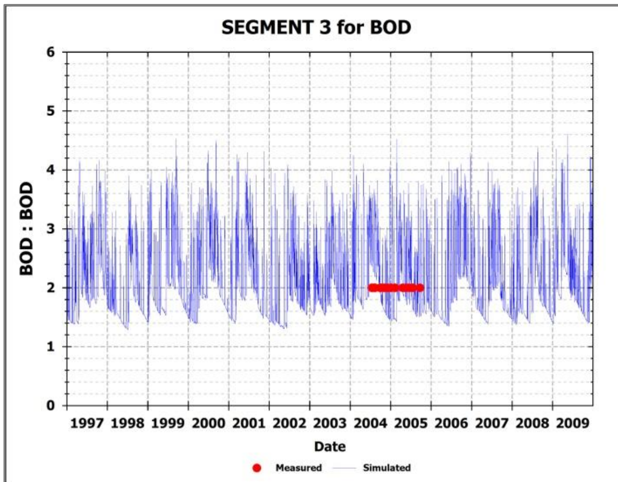
Station: SEGMENT 4; Parameter: DO

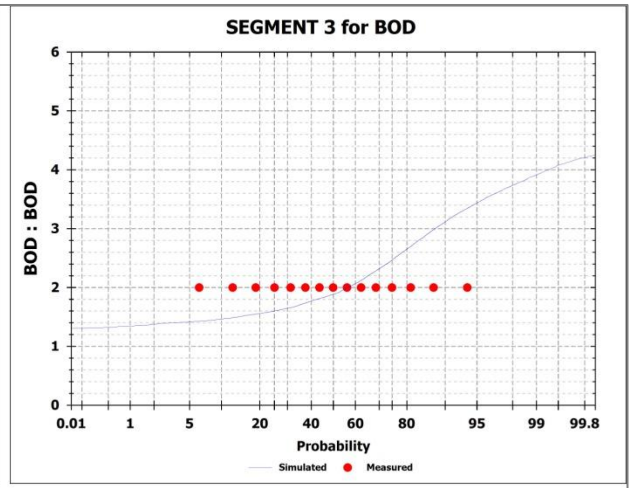
| Statistic | Measured | Simulated |
|---|---|---|
| Count: | 37 | 37 |
| Mean: | 5.781 | 5.564 |
| Std Dev: | 1.454 | 1.321 |
| Min: | 1.300 | 2.624 |
| Max: | 8.520 | 7.397 |
| 5 %tile: | 3.424 | 2.865 |
| 10 %tile: | 3.886 | 3.207 |
| 90 %tile: | 7.846 | 6.898 |
| 95 %tile: | 8.070 | 7.286 |
| Corr ($R^2$): | 0.09 | |
| Mean Abs Error: | 1.318 | |
| RMS Error: | 1.643 | |
| Norm RMS Error: | 0.287 | |
| Index of Agreement: | 0.55 | |

**Figure 10 Dissolved Oxygen Calibration**

## Biochemical Oxygen Demand

There is very little BOD data available for the Julington/Big Davis WBIDs. Figure 11 through Figure 12 illustrate both a quantitative and qualitative comparison of the predicted dissolved oxygen concentrations compared to the direct measurements.




Calibration Statistics

Station: SEGMENT 3; Parameter: BOD

| Statistic | Measured | Simulated |
|---|---|---|
| Count: | 15 | 15 |
| Mean: | 2.000 | 1.959 |
| Std Dev: | 0.000 | 0.525 |
| Min: | 2.000 | 1.459 |
| Max: | 2.000 | 3.135 |
| 5 %tile: | 0.000 | 0.000 |
| 10 %tile: | 2.000 | 1.459 |
| 90 %tile: | 2.000 | 3.058 |
| 95 %tile: | 0.000 | 0.000 |
| Corr ($R^2$): | 0.00 | |
| Mean Abs Error: | 0.000 | |
| RMS Error: | 0.000 | |
| Norm RMS Error: | 0.000 | |
| Index of Agreement: | 0.00 | |

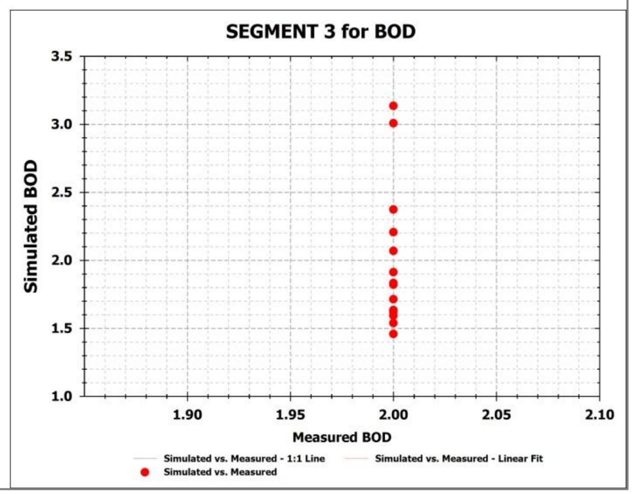
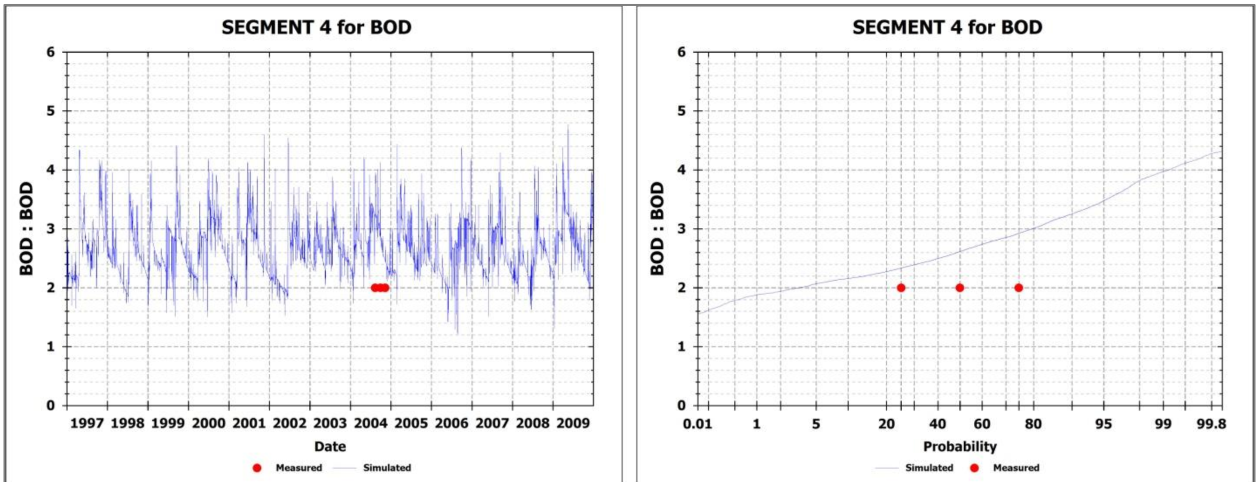



**Figure 11 BOD Calibration Segment 3**




Calibration Statistics

Station: SEGMENT 4; Parameter: BOD

| Statistic | Measured | Simulated |
|---|---|---|
| Count: | 3 | 3 |
| Mean: | 2.000 | 2.880 |
| Std Dev: | 0.000 | 0.390 |
| Min: | 2.000 | 2.463 |
| Max: | 2.000 | 3.234 |
| 5 %tile: | 0.000 | 0.000 |
| 10 %tile: | 0.000 | 0.000 |
| 90 %tile: | 0.000 | 0.000 |
| 95 %tile: | 0.000 | 0.000 |
| Corr ($R^2$): | 0.00 | |
| Mean Abs Error: | 0.000 | |
| RMS Error: | 0.000 | |
| Norm RMS Error: | 0.000 | |
| Index of Agreement: | 0.00 | |

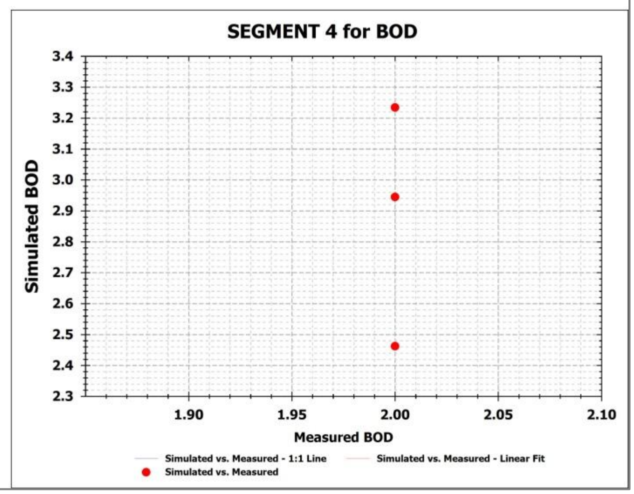
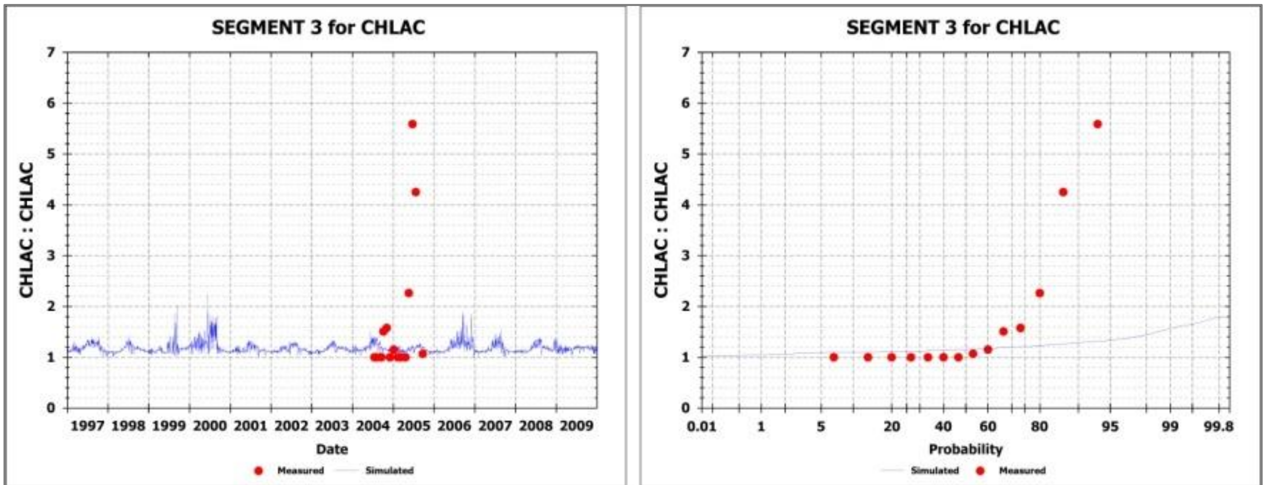



Figure 12 BOD Calibration Segment 4

## Chlorophyll a

Figure 13 illustrates both a quantitative and qualitative comparison of the predicted chlorophyll a concentrations compared to the direct measurements.




Calibration Statistics

Station: SEGMENT 3; Parameter: CHLAC

| Statistic | Measured | Simulated |
|---|---|---|
| Count: | 14 | 14 |
| Mean: | 1.742 | 1.177 |
| Std Dev: | 1.416 | 0.062 |
| Min: | 1.000 | 1.100 |
| Max: | 5.586 | 1.329 |
| 5 %tile: | 0.000 | 0.000 |
| 10 %tile: | 1.000 | 1.112 |
| 90 %tile: | 4.917 | 1.306 |
| 95 %tile: | 0.000 | 0.000 |
| Corr ($R^2$): | 0.00 | |
| Mean Abs Error: | 0.772 | |
| RMS Error: | 1.480 | |
| Norm RMS Error: | 1.034 | |
| Index of Agreement: | 0.01 | |

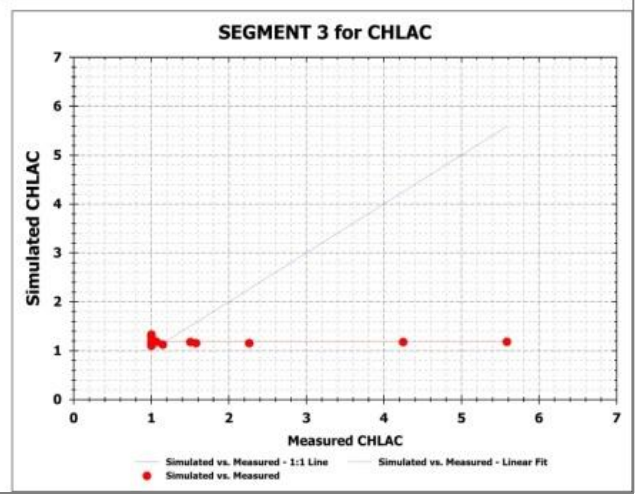
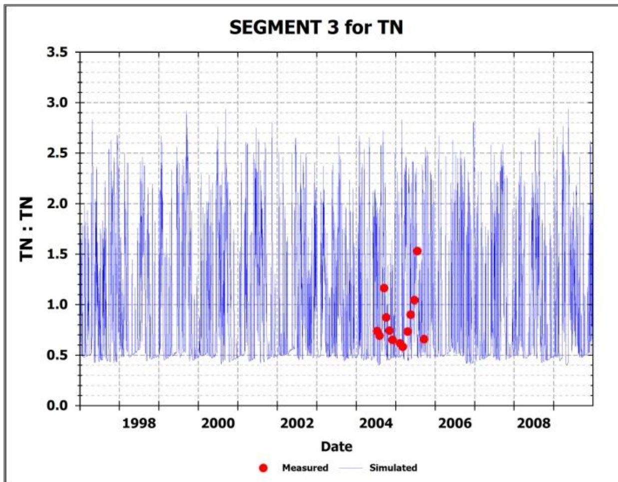
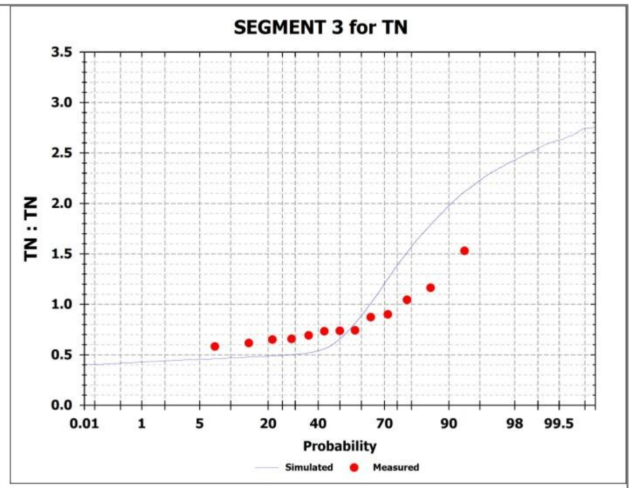



**Figure 13 Chlorophyll a Calibration**

## Nitrogen

Figure 14 through Figure 15 illustrate both a quantitative and qualitative comparison of the model predictions for total nitrogen to direct measurements.




Calibration Statistics

Station: SEGMENT 3; Parameter: TN

| Statistic | Measured | Simulated |
|---|---|---|
| Count: | 13 | 13 |
| Mean: | 0.840 | 0.806 |
| Std Dev: | 0.269 | 0.427 |
| Min: | 0.581 | 0.453 |
| Max: | 1.529 | 1.874 |
| 5 %tile: | 0.000 | 0.000 |
| 10 %tile: | 0.595 | 0.453 |
| 90 %tile: | 1.383 | 1.605 |
| 95 %tile: | 0.000 | 0.000 |
| Corr ($R^2$): | 0.03 | |
| Mean Abs Error: | 0.386 | |
| RMS Error: | 0.521 | |
| Norm RMS Error: | 0.641 | |
| Index of Agreement: | 0.26 | |

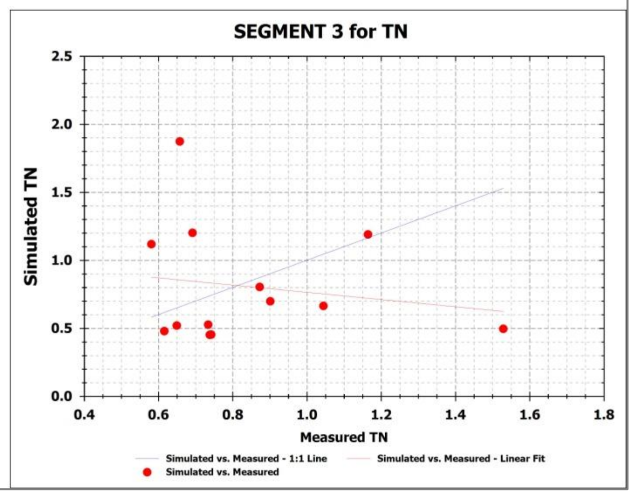
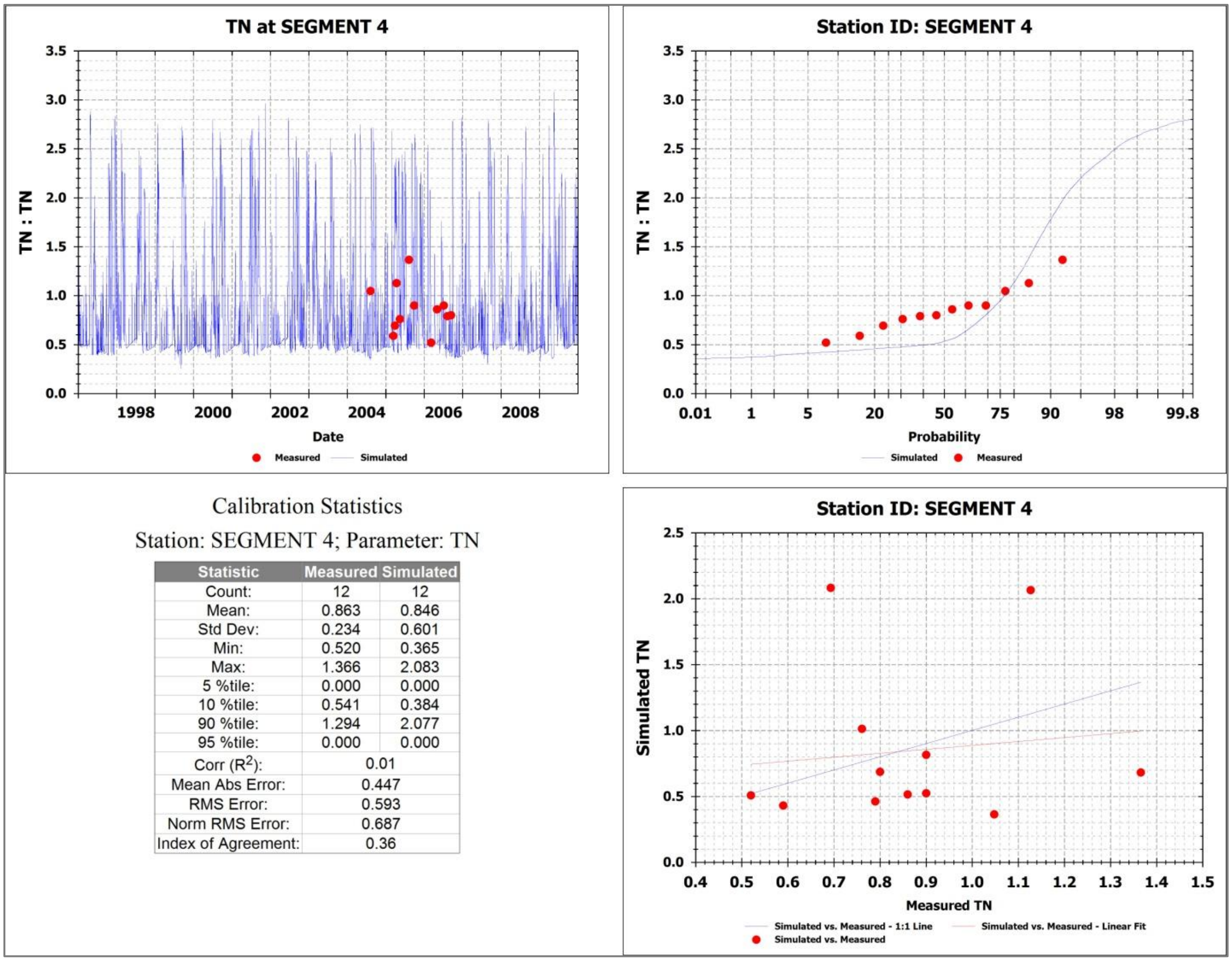



**Figure 14 Total Nitrogen Calibration Segment 3**

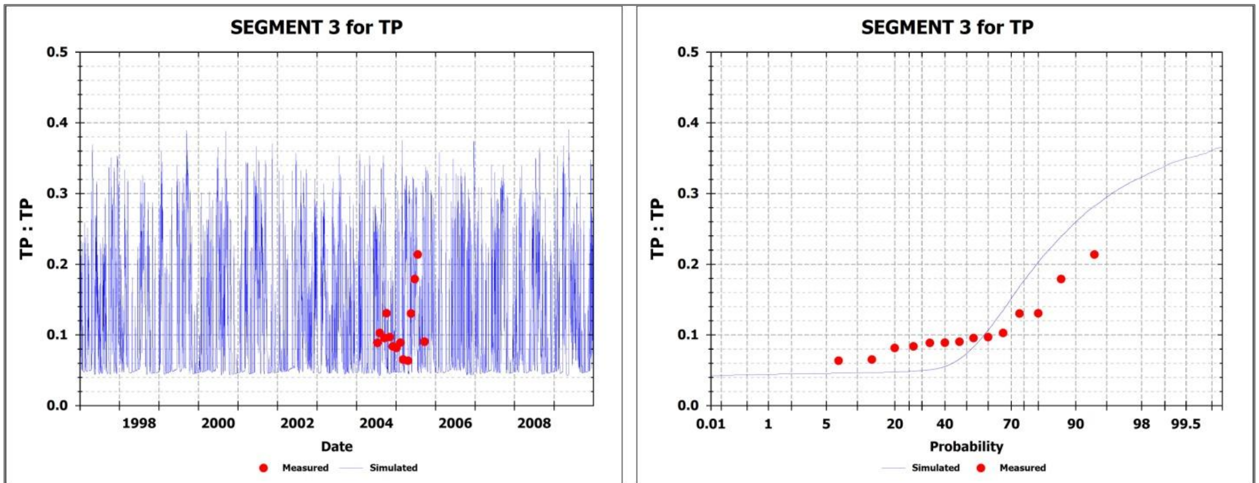



| Statistic | Measured | Simulated |
|---|---|---|
| Count: | 12 | 12 |
| Mean: | 0.863 | 0.846 |
| Std Dev: | 0.234 | 0.601 |
| Min: | 0.520 | 0.365 |
| Max: | 1.366 | 2.083 |
| 5 %tile: | 0.000 | 0.000 |
| 10 %tile: | 0.541 | 0.384 |
| 90 %tile: | 1.294 | 2.077 |
| 95 %tile: | 0.000 | 0.000 |
| Corr ($R^2$): | 0.01 | |
| Mean Abs Error: | 0.447 | |
| RMS Error: | 0.593 | |
| Norm RMS Error: | 0.687 | |
| Index of Agreement: | 0.36 | |

**Figure 15 Total Nitrogen Calibration Segment 4**

## Phosphorus

Figure 16 and 18 illustrate both a quantitative and qualitative comparison of the model predictions for total phosphorus to direct measurements.




Calibration Statistics

Station: SEGMENT 3; Parameter: TP

| Statistic | Measured | Simulated |
|---|---|---|
| Count: | 14 | 14 |
| Mean: | 0.108 | 0.093 |
| Std Dev: | 0.043 | 0.059 |
| Min: | 0.063 | 0.045 |
| Max: | 0.214 | 0.244 |
| 5 %tile: | 0.000 | 0.000 |
| 10 %tile: | 0.064 | 0.046 |
| 90 %tile: | 0.196 | 0.201 |
| 95 %tile: | 0.000 | 0.000 |
| Corr ($R^2$): | 0.03 | |
| Mean Abs Error: | 0.063 | |
| RMS Error: | 0.077 | |
| Norm RMS Error: | 0.788 | |
| Index of Agreement: | 0.13 | |

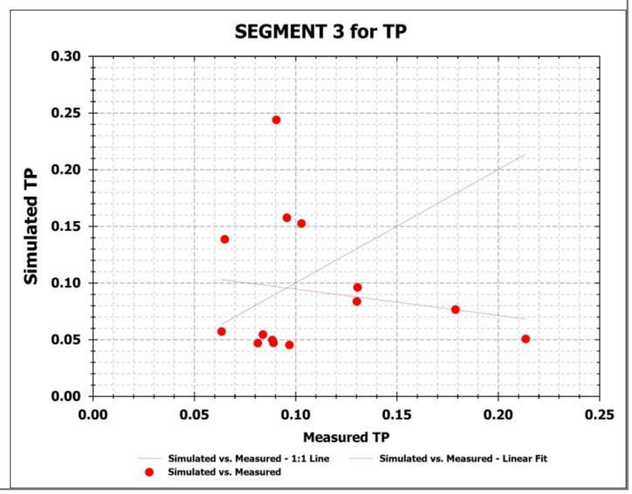
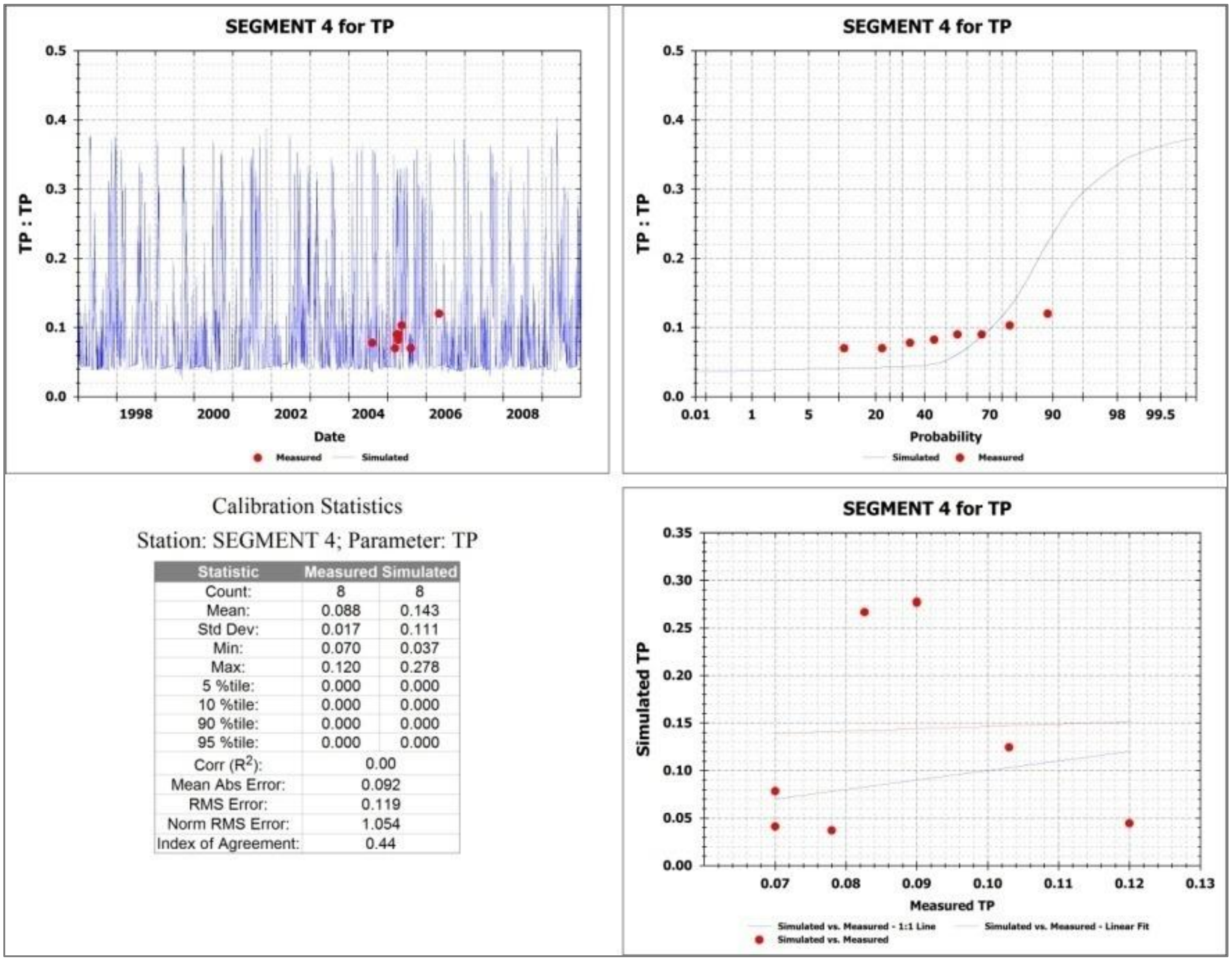



**Figure 16 Total Phosphorus Calibration Segment 3**




| Statistic | Measured | Simulated |
|---|---|---|
| Count: | 8 | 8 |
| Mean: | 0.088 | 0.143 |
| Std Dev: | 0.017 | 0.111 |
| Min: | 0.070 | 0.037 |
| Max: | 0.120 | 0.278 |
| 5 %tile: | 0.000 | 0.000 |
| 10 %tile: | 0.000 | 0.000 |
| 90 %tile: | 0.000 | 0.000 |
| 95 %tile: | 0.000 | 0.000 |
| Corr ($R^2$): | 0.00 | |
| Mean Abs Error: | 0.092 | |
| RMS Error: | 0.119 | |
| Norm RMS Error: | 1.054 | |
| Index of Agreement: | 0.44 | |

**Figure 17 Total Phosphorus Calibration Segment 4**

## Current Loads

Table 6 provides the annual average total nitrogen, total phosphorus and BOD loads for the period of record 1997 through 2009. It is these loadings that the TMDL load reduction will be calculated from.

**Table 6 Current Loads (1997-2009)**

| | Current Condition | |
|---|---|---|
| Constituent | WLA (Kg/Yr) | LA (Kg/Yr) |
| BOD | NA | 112,929 |
| Total Nitrogen | NA | 74,268 |
| Total Phosphorus | NA | 9,687 |

# Modeling Scenarios

Using the calibrated watershed and water quality models, up to two potential modeling scenarios will be developed. The first scenario will be to predict water quality conditions under a natural condition (remove 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)

## Natural Condition Analysis

The purpose of the natural condition scenario is to determine the water quality in the Julington/Big Davis watershed without the influences of man. Because of Florida's regulation of not allowing abating of a natural condition, this scenario determines the maximum reduction that could be required. The natural condition scenario makes the following assumptions:

1. All man induced landuses in the watershed model are transformed back to wetlands and upland forest (50:50 ratio).
2. New hydrology is predicted under natural landuse assumption.
3. All point sources are removed (if any).
4. Water quality is predicted using the new flows and loads from the natural condition run from the watershed model.
5. Sediment oxygen demand is reduced based upon the percent reduction in nutrient loads.

Table 7 presents the predicted annual average concentrations under natural conditions. Without the impacts of anthropogenic sources the dissolved oxygen concentration in the Julington/Big Davis watershed. It should be noted that under natural conditions the dissolved oxygen standard of 5 mg/l would not be achieved. The natural condition scenario will be used to set the maximum loads for the TMDL.

**Table 7 Natural Condition Annual Average Model Predictions**

| Constituent | Natural |
|---|---|
| BOD (mg/L) | 0.93 |
| Chlorophyll a (ug/L) | 1.13 |
| DO (mg/L) | 6.09 |
| Total Nitrogen (mg/L) | 0.64 |
| Total Phosphorus (mg/L) | 0.05 |

Table 8 provides the annual average model predictions for total nitrogen, total phosphorus, and dissolved oxygen under a natural condition.

Table 8 Annual Average Loadings for Natural Condition

| | Natural Condition | |
|---|---|---|
| Constituent | WLA (kg/yr) | LA (kg/yr) |
| BOD | NA | 22,933 |
| Total Nitrogen | NA | 24,548 |
| Total Phosphorus | NA | 1,391 |

Figure 18 shows the probability distribution for dissolved oxygen concentration in the Julington and Big Davis Creeks under current and the natural condition scenario.

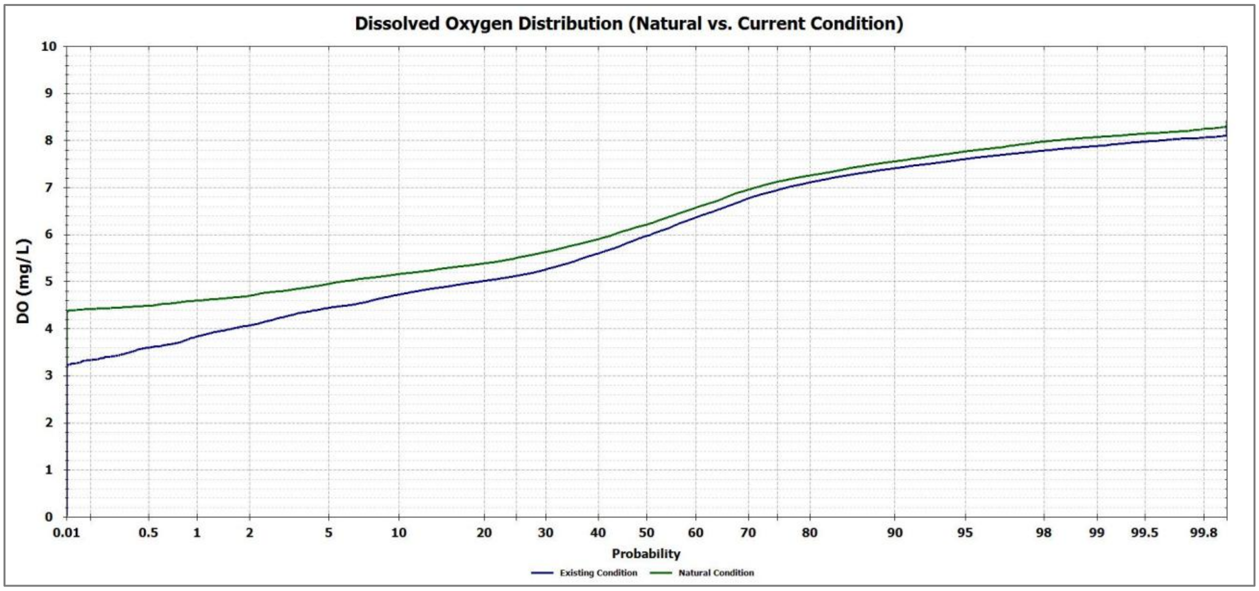



Figure 18 Dissolved Oxygen Concentration Probability Current vs. Natural Condition

Figure 19 shows the time series plot of dissolved oxygen concentration in Julington Creek under the natural condition scenario.

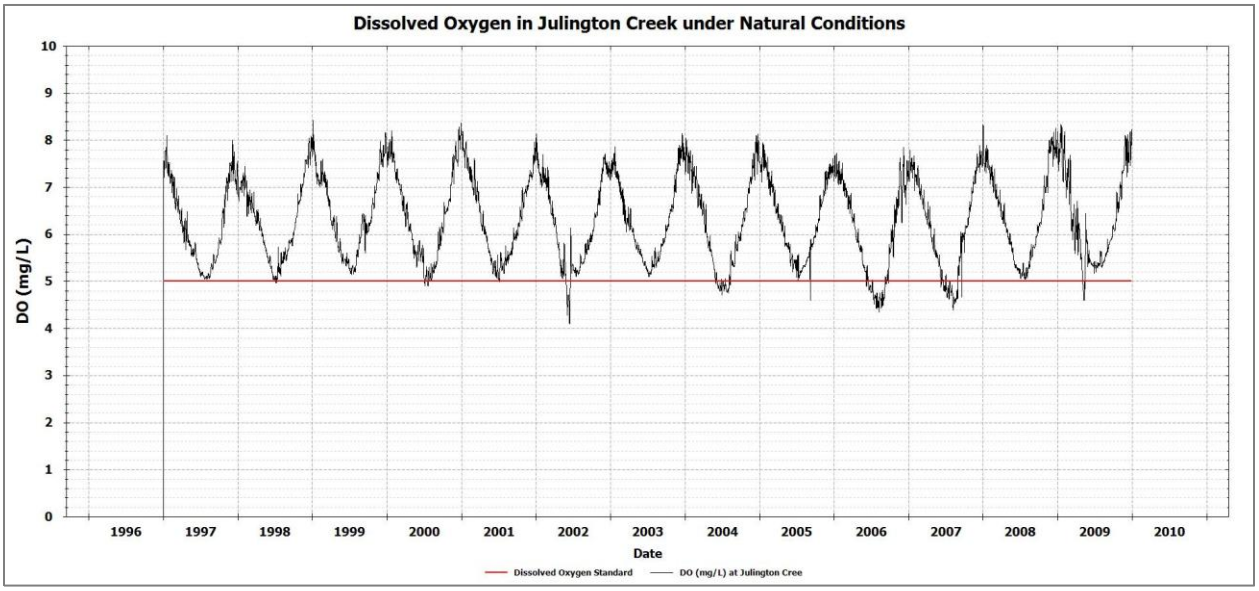



Figure 19 Dissolved Oxygen Concentration under Natural Condition

### TMDL Load Reductions

Because water quality standards cannot be met under natural conditions no other scenarios were conducted. The TMDL will be set to the natural conditions.

## 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 9 along with the prescribed load reductions.

Table 9 TMDL Determination

| | Current Condition | | TMDL Condition | | MS4 | LA |
|---|---|---|---|---|---|---|
| Constituent | WLA (kg/yr) | LA (kg/yr) | WLA (kg/yr) | LA (kg/yr) | % Reduction | % Reduction |
| BOD | NA | 112,929 | NA | 22,933 | 80% | 80% |
| Total Nitrogen | NA | 74,268 | NA | 24,548 | 67% | 67% |
| Total Phosphorus | NA | 9,687 | NA | 1,391 | 86% | 86% |

Note: Both the watershed and water quality models including calibration and scenario input files are available upon request.