

Modeling Report

Lake Talquin – Including Ochlockonee River and Little River
Nutrients

May 16, 2017

Revision 8



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Watershed Description

Lake Talquin is located west of Tallahassee, Florida approximately 15 miles south of the Florida-Georgia state line. The Lake Talquin Watershed encompasses over 1,700 square miles and includes portions of the following counties in Georgia: Worth, Mitchell, Colquitt, Decatur, Grady and Thomas, along with Gadsden and Leon Counties in Florida (Figure 1). Lake Talquin receives water from both the Little River and the Ochlockonee River. The following creeks drain to Little River: Quincy Creek, Willacoochee Creek, Attapulugus Creek, and Swamp Creek, along with several smaller and/or unnamed tributaries. The following creeks drain to Ochlockonee River: Turkey Creek, Lees Creek, Barnett's Creek (both east and west branches), Lost Creek, Big Creek, Little Creek, and Bridge Creek, along with several smaller and/or unnamed tributaries. See Figure 2 for an aerial view of the delineated watershed.

Approximately 41% of the watershed is forested or clear-cut and 16% of the watershed is wetlands. Agricultural land uses (crop and pasture) comprise 33% with a greater percentage located in Georgia. About 6% of the watershed is urban land uses (Figure 3).



Figure 1 Location of the Lake Talquin Watershed

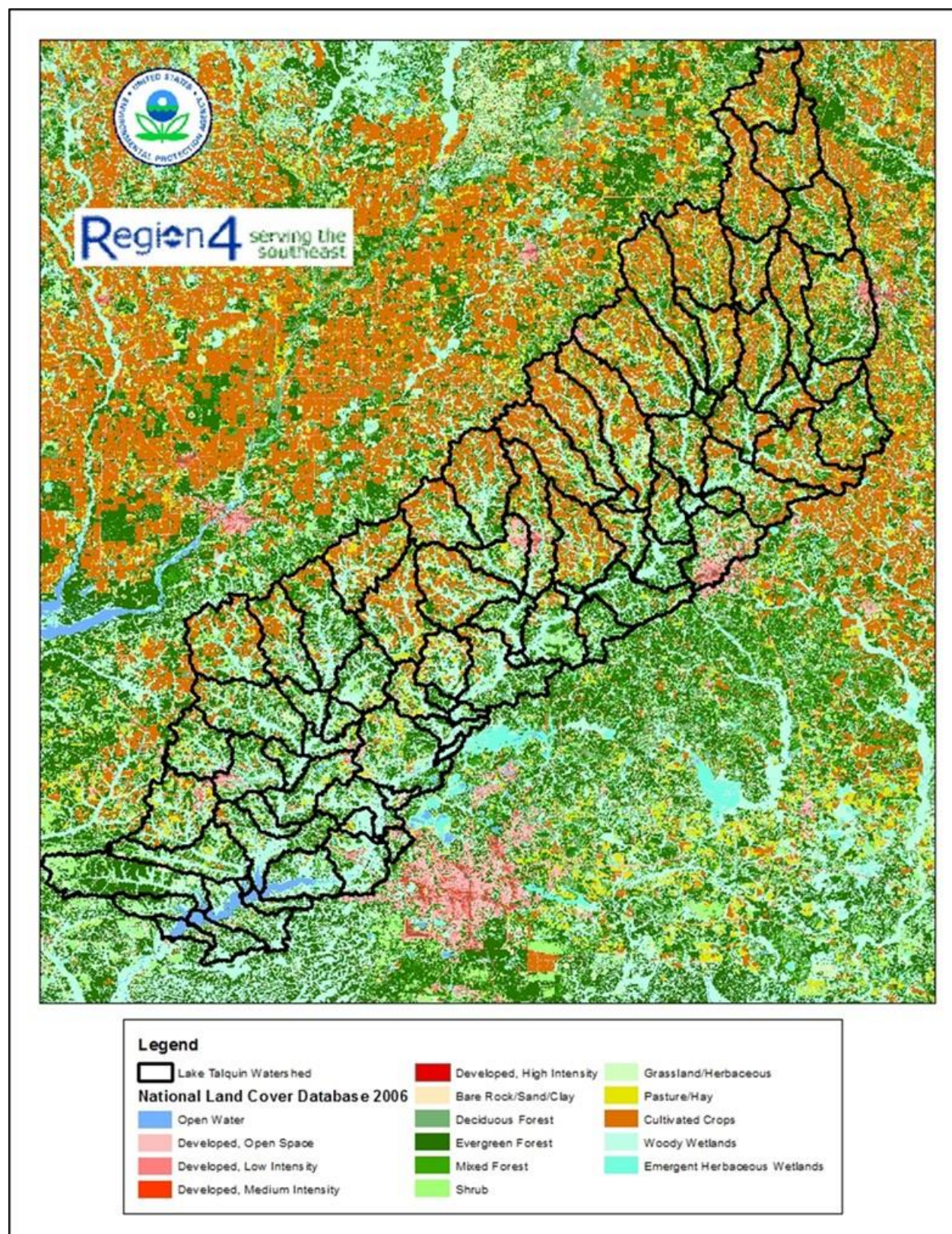


Figure 2 Lake Talquin Watershed Landuse Data

Modeling Approach

The modeling approach that was used for the development of the nutrient model for Lake Talquin (including Little River and Ochlockonee River) considers 17 years of meteorological and flow conditions. The selection of a longer term continuous simulation insures that average, wet and dry conditions are included in the model. 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 17-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 the 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) is 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, 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 7.52) (USEPA, 2014) 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 Advanced Eutrophication Module of WASP was used for Lake Talquin. Figure 3 provides a schematic of the state variables considered by the module.

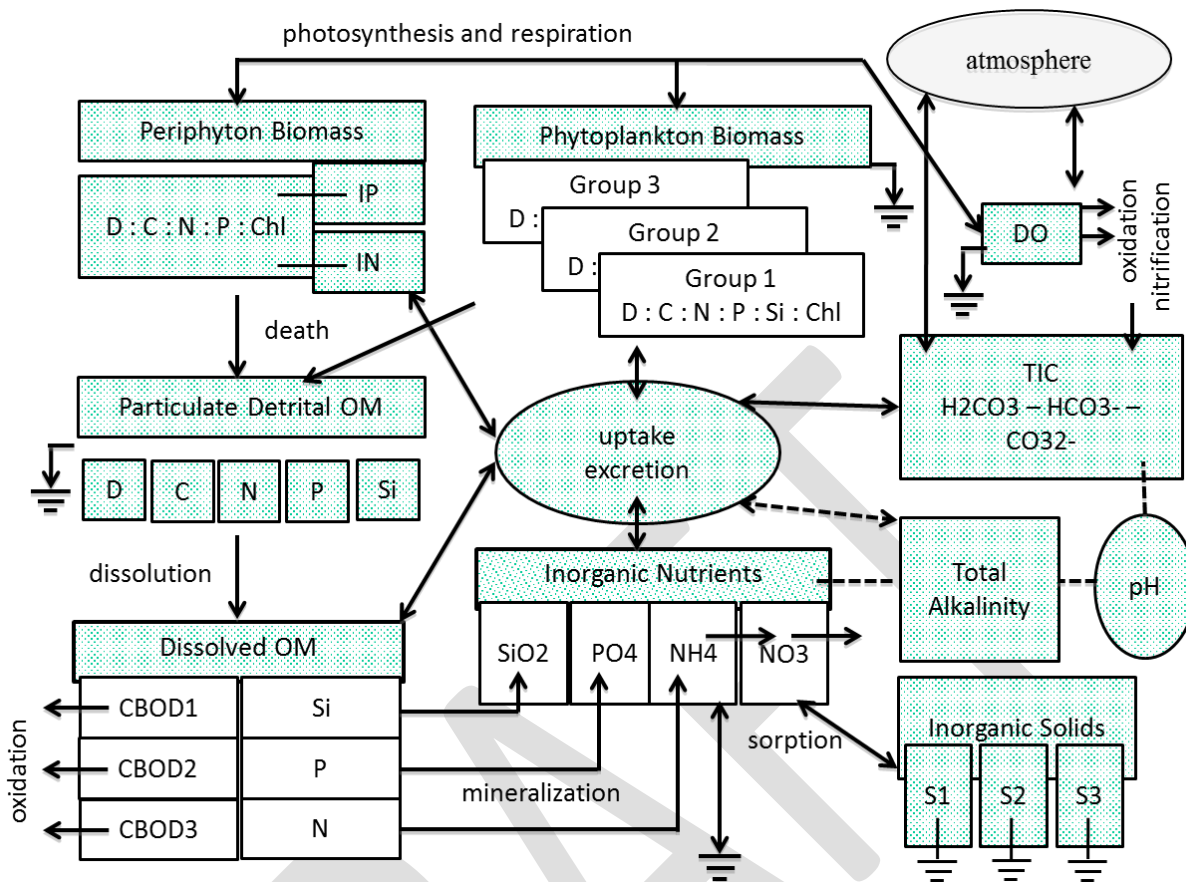


Figure 3 WASP 7.52 Advanced Eutrophication State Variables

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. For this application, WASP is the receiving water quality model for both Lake Talquin and its tributaries.

EFDC Hydrodynamic Model

The Environmental Fluid Dynamics Code (EFDC Hydro) is a state-of-the-art hydrodynamic model that can be used to simulate aquatic systems in one, two, and three dimensions. For this application, a three dimensional EFDC grid was developed for Lake Talquin to provide necessary hydrodynamic inputs to WASP, the advanced receiving water quality model. EFDC uses stretched or sigma vertical coordinates and Cartesian or curvilinear, orthogonal horizontal coordinates to represent the physical characteristics of a waterbody. It solves three-dimensional, vertically hydrostatic, free surface, turbulent averaged equations of motion for a variable-density fluid. Dynamically-coupled transport equations for turbulent kinetic energy, turbulent length scale, salinity and temperature are also solved.

Model Domains

Because of the size and complexity of the watershed and the TMDL/nutrient criteria decision that will be made a set of nested models were developed. Figure 4 depicts the model network for the five models. The green polygons define the areas that were simulated for the Ochlockonee River watershed. Results, both flows and loads are used by all the other models. The red line segments represent the WASP water quality model for the Ochlockonee River. This model incorporates the flows and loads from the watershed model plus the 5 NPDES dischargers for fate and transport to Lake Talquin. The pink line segments represent the WASP water quality model for the Attapulgus River (Georgia)/Little River (Florida). This model incorporates the flows and loads from the watershed model plus the 2 NPDES dischargers for fate and transport to Lake Talquin. The yellow grid represents the hydrodynamic and water quality model for Lake Talquin. The hydrodynamic and water quality model receives flows and loads from the mainstem river WASP models (Ochlockonee and Attapulgus/Little River) and the surrounding watershed model.

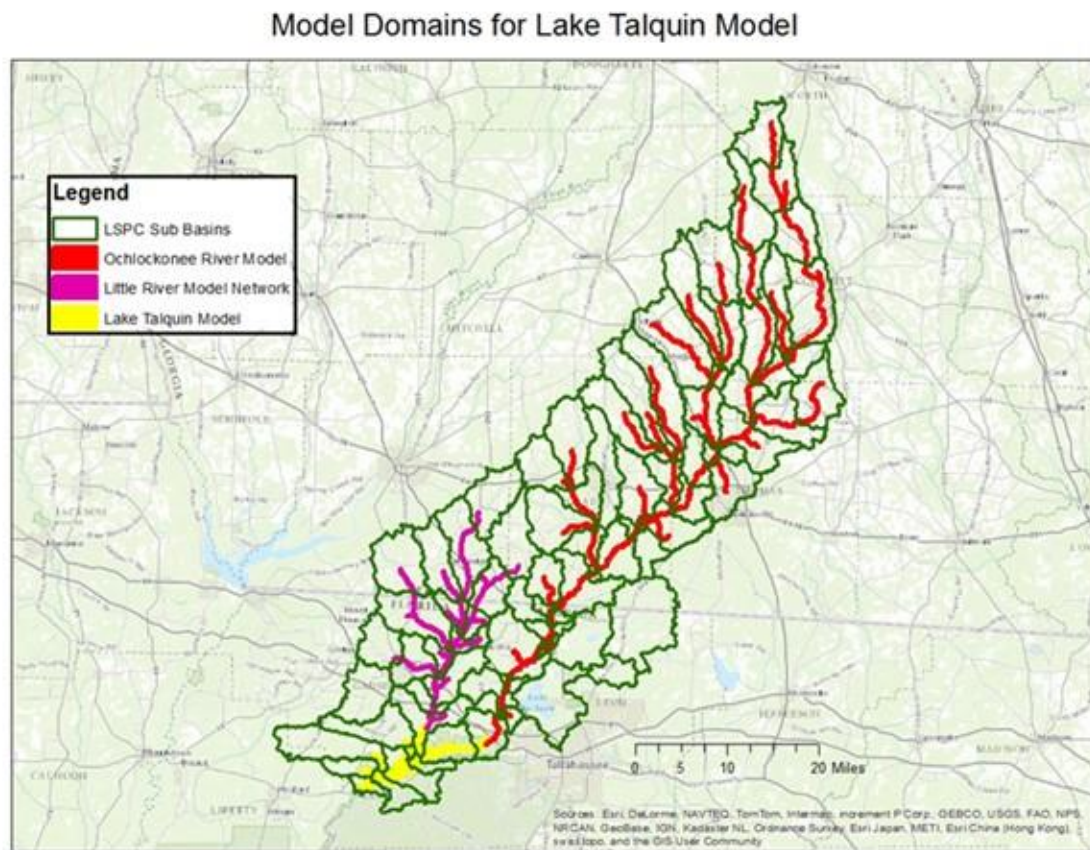


Figure 4 LPSC Watersheds and WASP Segments

Watershed Model Application

The watershed model was applied to the Lake Talquin watershed for the simulation period of 1996 through 2012. The 1996 year was used to equilibrate the initial conditions in the watershed model (soil moisture, buildup and washoff), from 1997 through 2012 was used to predict flows and loads under current conditions that will be passed onto the water quality model.

Watershed Delineation and Landuse

The upstream sections of the watershed that drain ultimately to Lake Talquin, including Little River and Ochlockonee River, were included in the LSPC watershed model. The watershed was delineated into 85 sub basins (Figure 5). Sixteen sub basins drained to the Little River, 57 sub basins drained to Ochlockonee River, and 12 sub basins drained directly to Lake Talquin (Figure 5). The LSPC model predicts flow and loads coming from each of these sub basins into Little River, Ochlockonee River, and eventually into Lake Talquin.

The initial model setup and parameterization for Lake Talquin watershed model was based on EPA's LSPC model used for the purposes of nutrient criteria development and from the Apalachee basin model developed by Tetra-Tech for the State of Georgia (Tetra-Tech, 2011); the initial model was further refined and calibrated to all local data and gages that were available in the watershed.

The watershed model uses land use data as the basis for representing hydrology and nonpoint source loadings. The Georgia Land Use Trends (GLUT), FDEP Level III Florida Land Use, and the National Landuse Coverage Dataset (NLCD) were used to develop the watershed land use representations. The GLUT 2008 was used as the primary coverage in the Georgia portion of the watershed and FDEP and NLCD 2006 data was used complete the land use coverage in Florida where there was no GLUT 2008 data. The coverages utilized a variety of land use classes, and the FDEP coverages were grouped and reclassified into 18 land use categories: beaches/dune/mud, open water, utility swaths, developed open space, developed low intensity, developed medium intensity, developed high intensity, clear-cut/sparse, quarries/strip mines, deciduous forest, evergreen forest, mixed forest, golf courses, pasture, row crop, forested wetland, non-forested wetland (salt/brackish), and non-forested wetland (freshwater). The GLUT and NLCD datasets were then reclassified into the same land use categories. For the LSPC simulation, similar land use classes were grouped together into reduced into 15 modeling categories, i.e., deciduous forest, evergreen forest and mixed forest were grouped together into a unit named forest.

The LSPC model requires division of land uses in each sub-watershed into separate pervious and impervious land units. The GLUT impervious cover was intersected with the GLUT land use-land cover. Any impervious areas associated with utility swaths, developed open space, and developed low intensity, were grouped together and placed into a new category of low intensity developed impervious cover. Impervious areas associated with medium intensity development and high intensity development, were kept separate and placed into two categories of medium intensity

developed impervious and high intensity developed impervious cover, respectively. Finally, any impervious area not already accounted for in the three developed impervious cover categories, were grouped together into a fourth catch all category for remaining impervious areas.

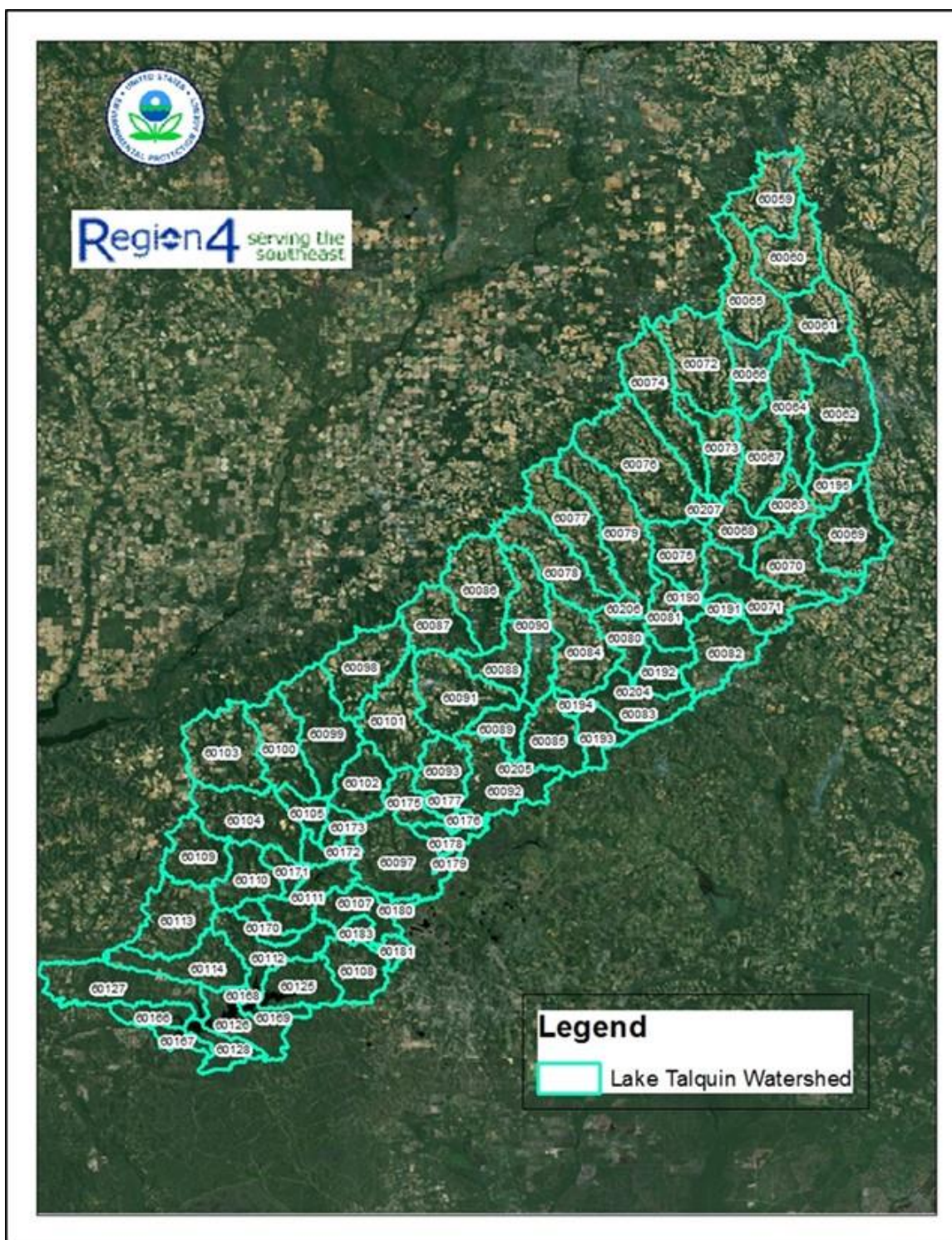


Figure 5 Lake Talquin Watershed Delineation

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 6 depicts the hourly rainfall for the Tallahassee WSO AP (WBAN 088758) meteorological station. The period of record being simulated during this TMDL development contains average, wet and dry years.

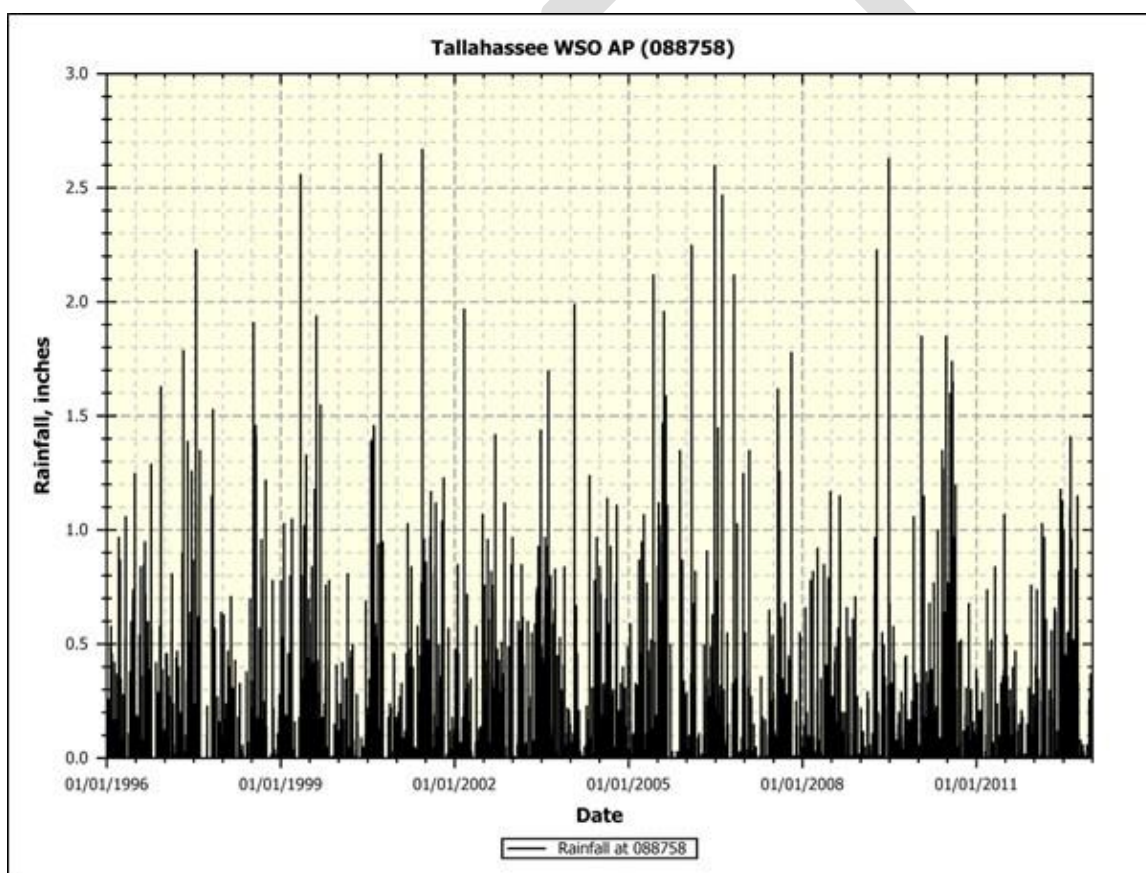


Figure 6 Hourly Rainfall Station 0088758

Table 1 provides the annual rainfall for each of the simulation years.

Table 1 Annual Rainfall for Simulation Period

Year	Quincy (in)	Tallahassee (in)	Bainbridge (in)	Camilla (in)	Moultrie (in)	Cairo (in)	Thomasville (in)
1996	56	53	54	50	49	55	54
1997	74	60	61	56	56	61	69
1998	37	55	57	55	53	51	60
1999	43	48	43	32	35	35	44
2000	45	44	40	41	46	40	55
2001	53	63	46	49	44	55	48
2002	63	55	57	53	59	53	59
2003	57	65	54	64	51	56	58
2004	80	56	51	51	58	57	58
2005	79	68	68	54	65	67	65
2006	46	50	36	47	38	46	45
2007	40	36	34	37	37	37	32
2008	66	51	69	62	53	60	63
2009	63	48	52	58	52	47	50
2010	51	59	43	43	39	44	46
2011	38	35	37	34	38	38	40
2012	45	56	48	35	40	42	44

Figure 7 provides the location of the meteorological stations used in the watershed model.

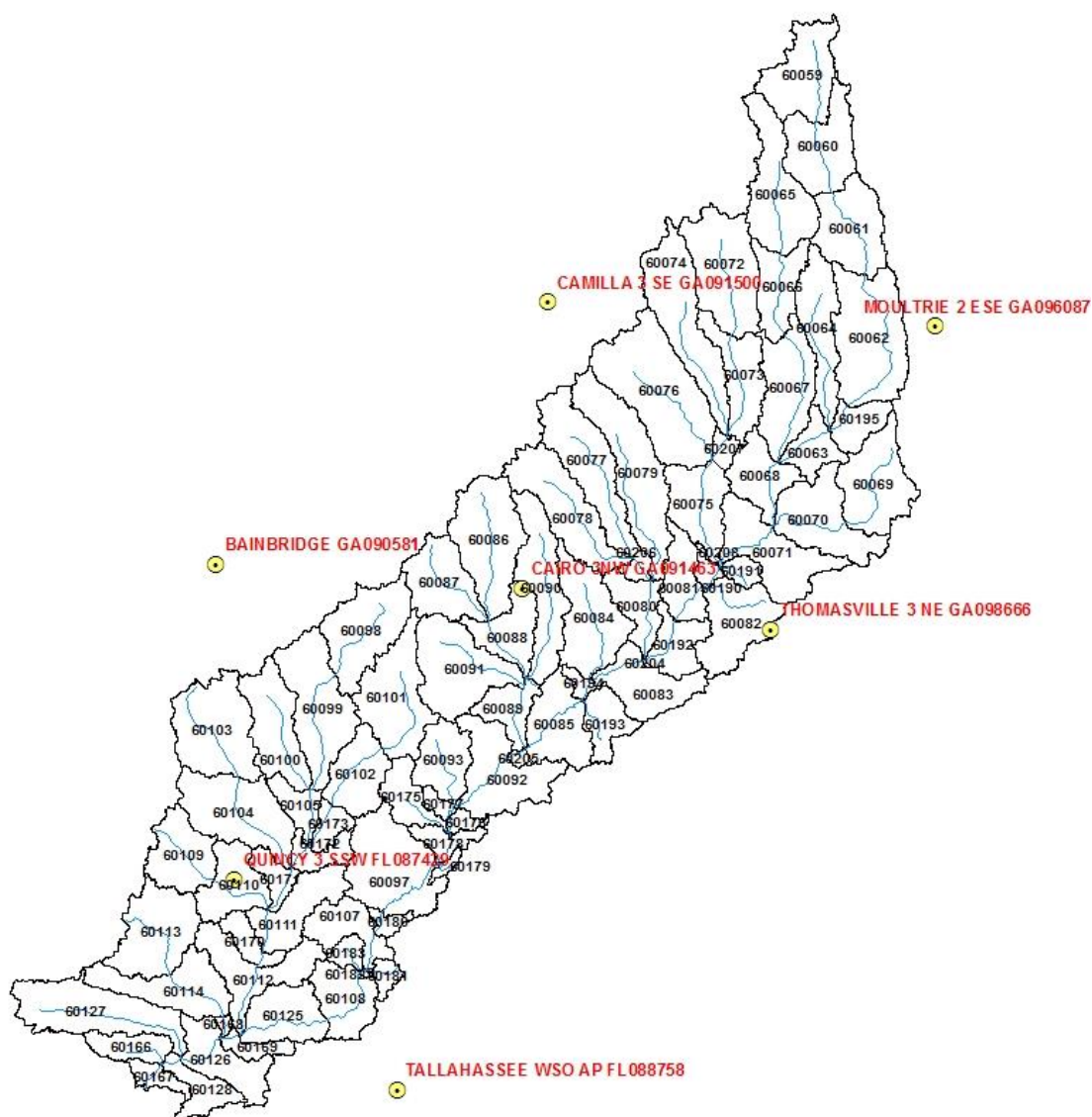


Figure 7 Meteorological Station Locations

Hydraulic Calibration

The watershed and water quality model were calibrated for flow by comparing the predicted flows to several USGS gages located within the watershed. Figure 8 through Figure 10 illustrate both a quantitative and qualitative comparison of the model flow predictions directly compared to measurements at the USGS gages.

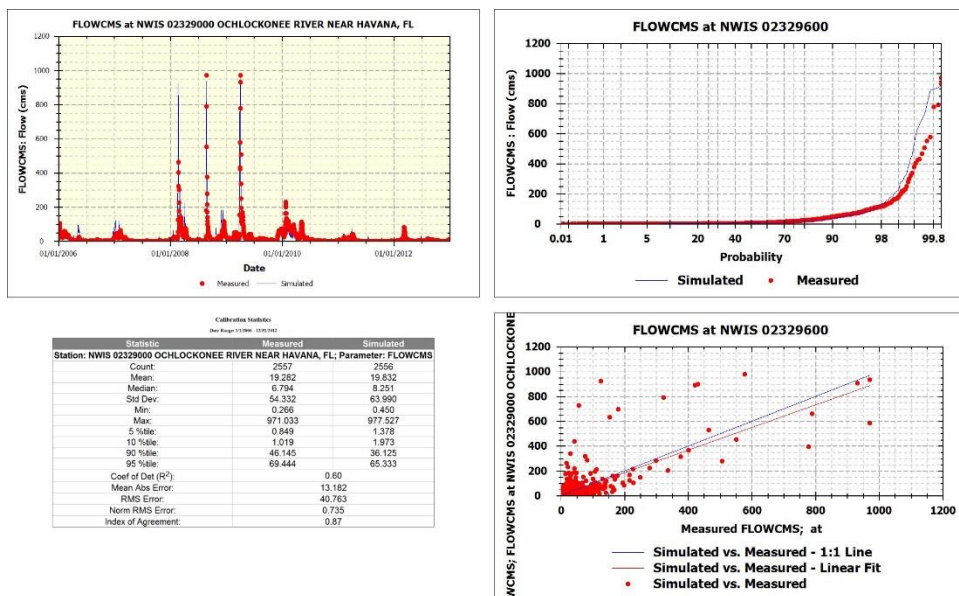


Figure 8 Flow Calibration for Ochlockonee River USGS Gage 02329000

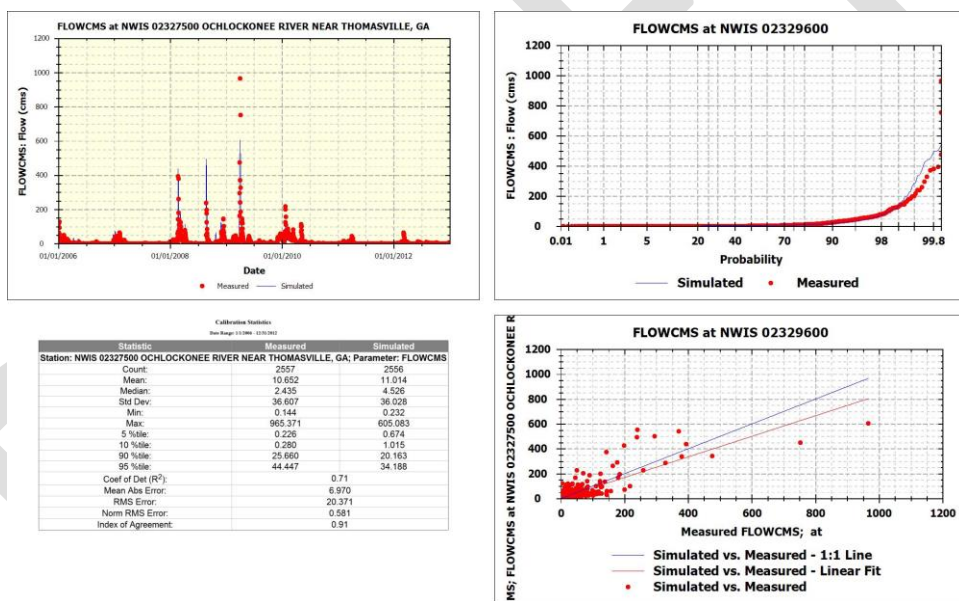


Figure 9 Flow Calibration for Ochlockonee River USGS Gage 02327500

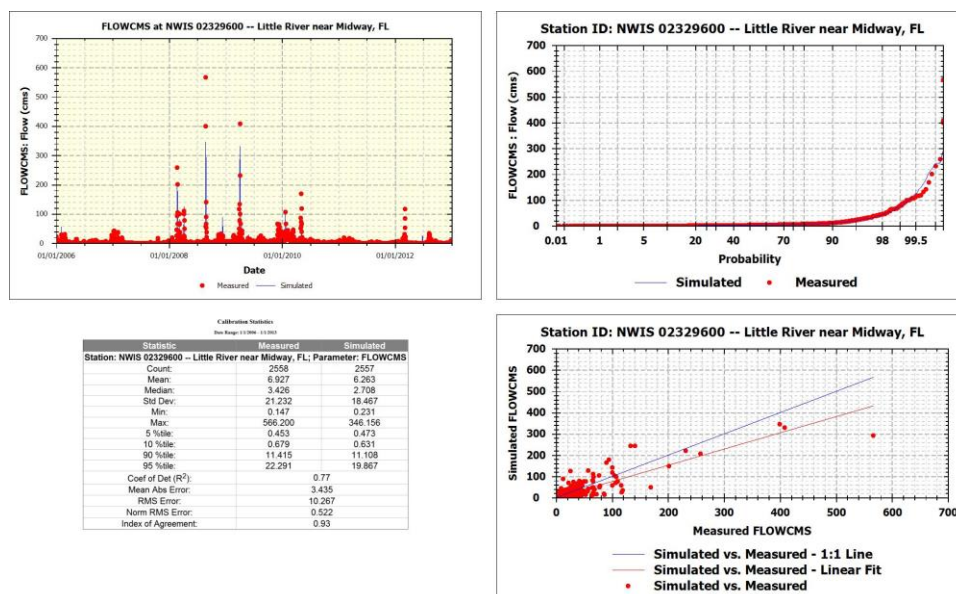


Figure 10 Flow Calibration for Little River USGS Gage 02329600

Nutrient Loadings

Watershed loadings were generated using event mean concentrations for total nitrogen, total phosphorus and BOD (Table 2Table 1). The initial EMC values were derived for each landuse type from a study by Harper and Baker (2007) and then calibrated to all data available for the watershed. Wetland EMCs were derived from the study of Reiss et.al (2009). The study summarizes the available literature on nutrient concentrations and hydrology for wetlands in Florida.

Table 2 Event Mean Concentration (mg/l) for Landuse Classifications

Landuse	TN (mg/L)	TP (mg/L)	BOD ₅ (mg/L)
Beach	2.07	0.41	1.93
Water	1.50	0.10	1.93
LowIntDev-Pervious	2.07	0.41	7.86
LowIntDev-Impervious	1.18	0.19	7.60
MedIntDev-Pervious	2.07	0.41	7.86
MedIntDev-Impervious	2.07	0.41	7.86
HighIntDev-Pervious	2.32	0.52	11.28
HighIntDev-Impervious	2.40	0.35	11.30
Barren	2.07	0.41	1.35
Forest	1.15	0.11	1.35

Golf	3.47	0.62	5.62
Pasture	3.47	0.62	8.24
Crop	2.65	0.85	5.62
WetLand	2.88	0.68	1.93
All Other Impervious	2.07	0.41	7.27

Harper H. H. and D. M. Baker, 2007. *Evaluation of Current Stormwater Design Criteria within the State of Florida*. Final Report submitted to Florida Department of Environmental Protection. Environmental Research & Design, Inc. Orlando, FL.

Reiss, K.C., Evans, J., and M. Brown, 2009. *Summary of Available Literature on Nutrient Concentrations and Hydrology for Florida Isolated Wetlands*. Final Report submitted to Florida Department of Environmental Protection, Tallahassee, FL.

Hydrodynamic Model Application

The Environmental Fluids Dynamic Code (EFDC) was applied to Lake Talquin to predict transport in the lake as a function of watershed flows and meteorological conditions. The Tallahassee Airport station was used to parameterize the meteorological conditions for the lake. The lake was divided up into 212 horizontal segments and consists of two layers (Figure 11).

Hydrodynamic and Water Quality Grid for Lake Talquin

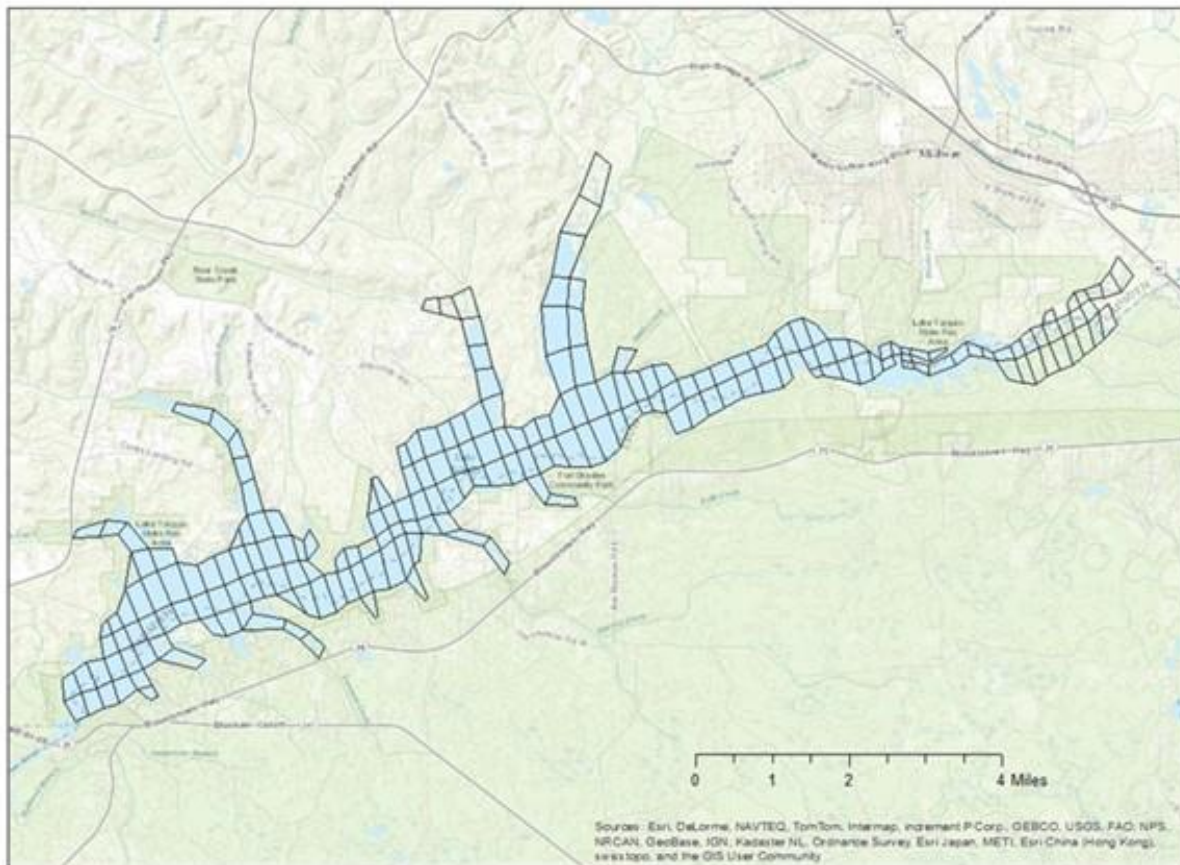


Figure 11 Lake Talquin EFDC Grid

Lake depths were estimated based upon a map that was developed by Gadsden and Leon County from 2007 (Figure 12). Depths were interpolated to the EFDC grid to account for change in depth in the lake.

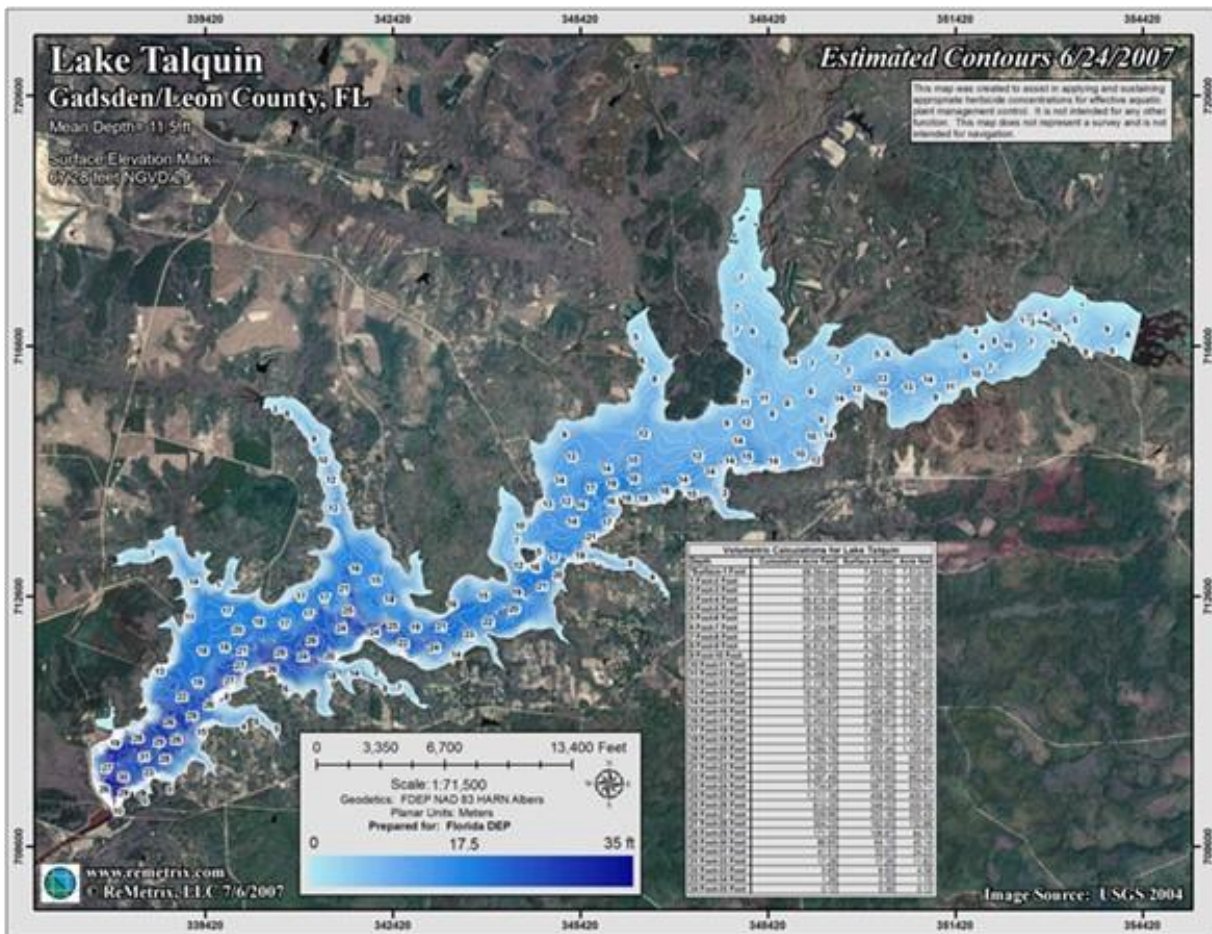


Figure 12 Lake Talquin Depth Profiles

Figure 13 illustrates the calibration of water surface elevation. While the watershed model was executed for 1997 through 2012, the hydrodynamic and water quality model for the lake was executed 2007 through 2012 because of the available water surface elevation data. This data is critical to determine whether the flows are well calibrated.

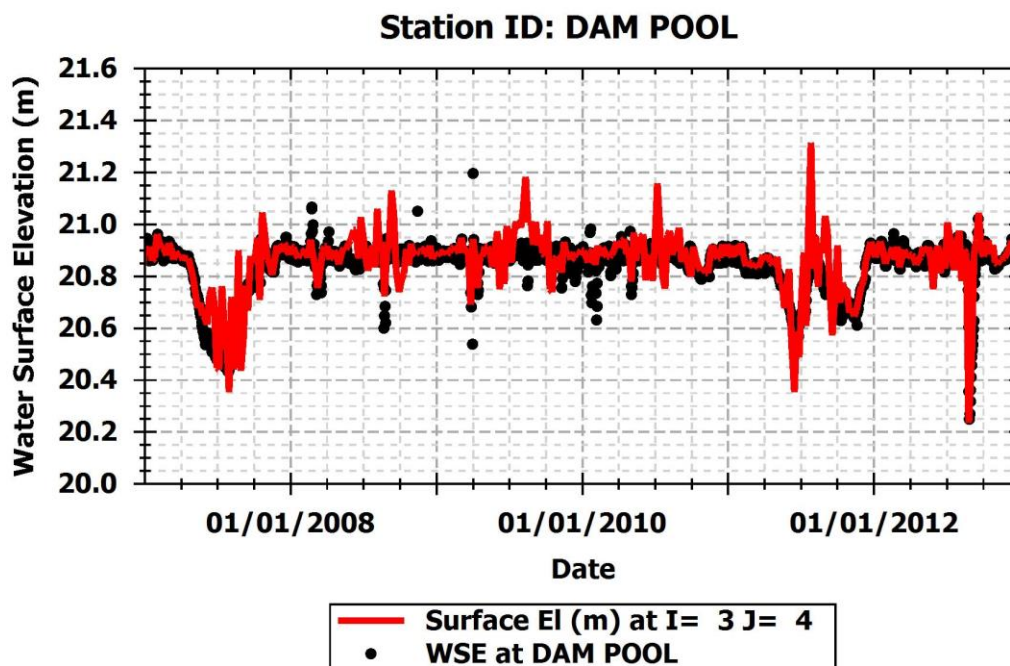


Figure 13 Water Surface Elevation Calibration

Distribution of EFDC Flow Correction

One of the calibration steps in applying EFDC to reservoirs is to adjust inflows and outflows to insure that the predict water surface elevation of the hydrodynamic model matches the measured water surface elevation. This insures that water mass balance is maintained throughout the simulation period. Because it is virtually impossible to define all inflows (tributary, groundwater, sheet flow) and all outflows (dam release, dam seepage, groundwater loss) EFDC includes a flow balancing utility that can adjust inflow/outflow to maintain the measured water surface elevation. The EFDC flow balancing utility has a limitation of only adding and removing flows at two points. Once the adjusted inflow and outflow time series has been estimated, the user must go back and apply the adjusted flows to all of the inflows and outflows. All of corrected outfall was added to the dam discharge time series in the EFDC QSER.INP file. The corrected inflow time series was distributed to all of the inflow time series in the EFDC QSER.INP file. Table 3 below provides the percentage of the inflow correction that would be added to each of the tributary time series.

The step described above was left out of previous versions of the hydrodynamic and water quality model (Version 6). The Section Comparison Version 6 & 8 towards the end of the document provides a graphical comparison between Version 6 of the water quality model to the current Version 7 where of the flow correction was distributed to all of the inflow points.

Table 3 Inflow Correction Distribution

EFDC Inflow	Percent of Flow Correction	Average Flow (cms)
Ochlockonee River	64.67%	17.78
Little River	22.44%	6.17
LSPC Basin 60168	0.21%	0.06
LSPC Basin 60114 (Rocky Creek)	4.02%	1.11
LSPC Basin 60127 (Hammock Creek)	1.58%	0.44
LSPC Basin 60166	0.80%	0.22
LSPC Basin 60128 (Freeman Creek)	0.94%	0.26
LSPC Basin 60126 (Harvey Creek)	1.94%	0.53
LSPC Basin 60169 (Polk Creek)	0.63%	0.17
LSPC Basin 60125	1.97%	0.54
LSPC Basin 60167	0.81%	0.22
Total	100.00%	27.49

Figure 14 illustrates where each of the inflows enter the model grid. Each of these pore points will have additional flow added using the calculated percentages when the EFDC flow correction utility needed to add flow to maintain the measured water surface elevation.

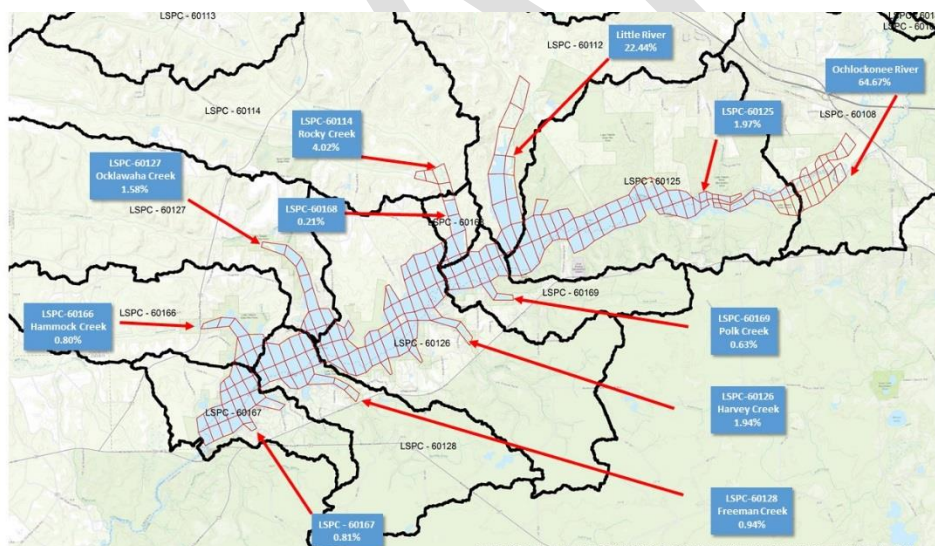


Figure 14 EFDC Inflow Correction Flow Distribution

Hydrodynamic Model Calibration

The following figures illustrate the temperature calibration for Lake Talquin. For all calibration plots for both the hydrodynamic and water quality model will use the same monitoring stations as depicted in Figure 28. For the lake model, all results shown are for the surface layer of the model. Figure 15 through Figure 23 provide a comparison of the model predicted temperature to the measured data.

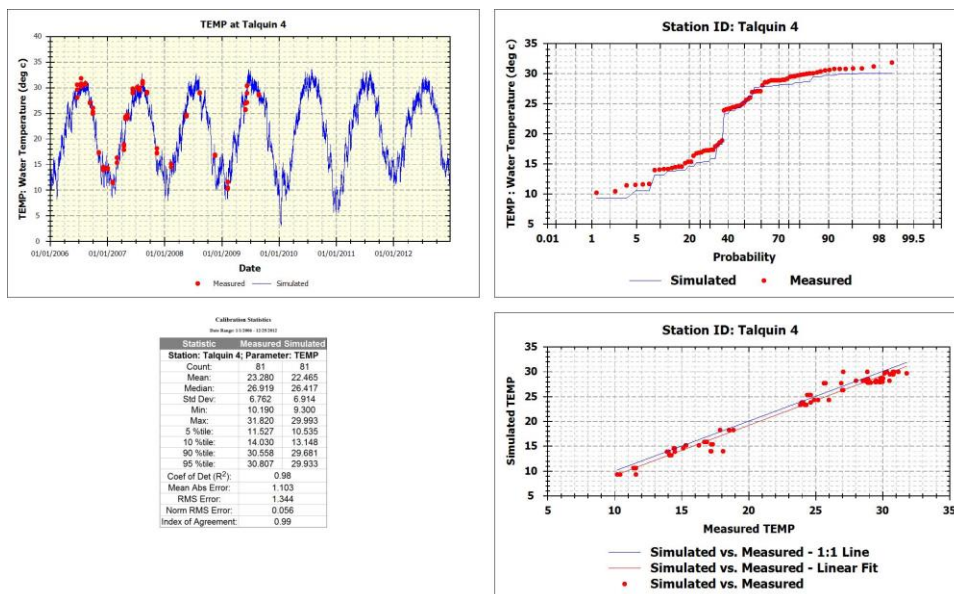


Figure 15 21FLLEONLCT0C3045884492: Talquin 4 for Water Temperature

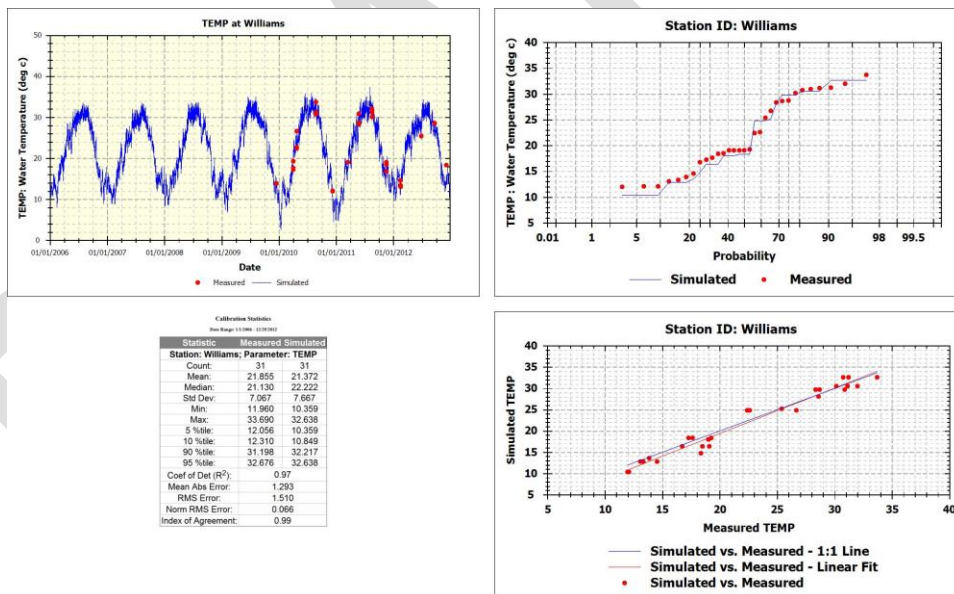


Figure 16 21FLLEONLCT03045184523: Lake Talquin near Williams Landing for Water Temperature

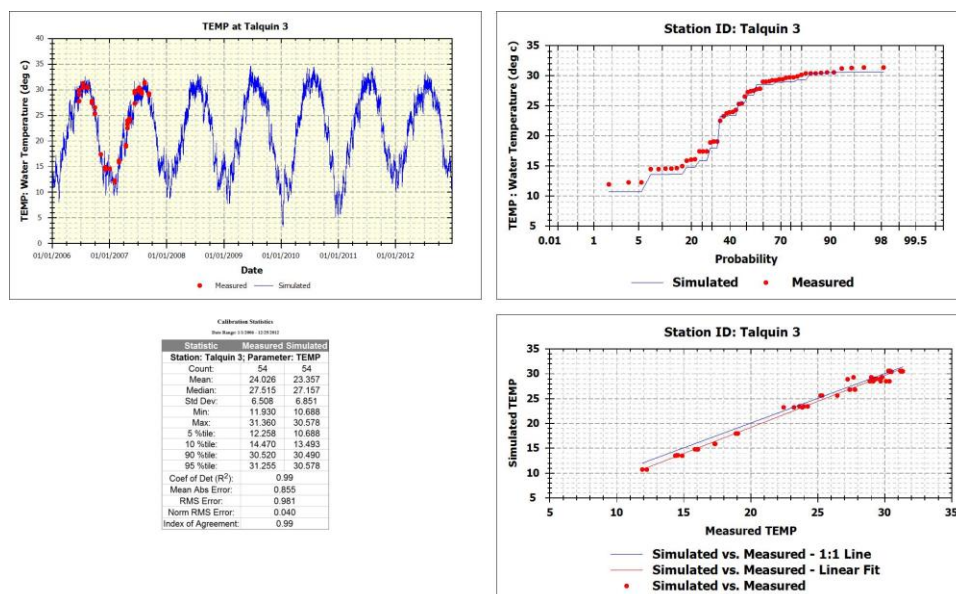


Figure 17 21FLLEONLCT0W3045084521: Talquin 3 for Water Temperature

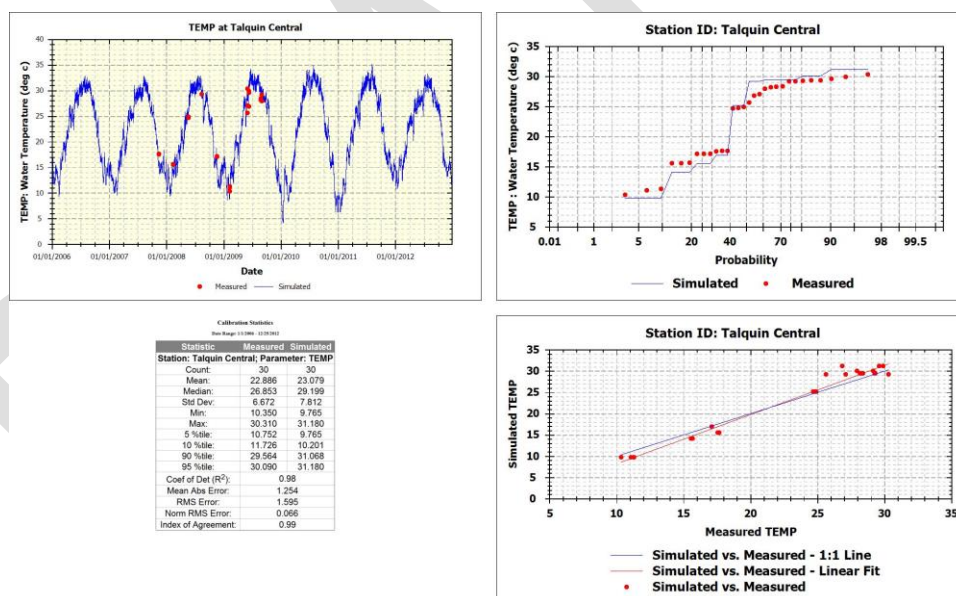


Figure 18 21FLLEONT0E3044084556: Lake Talquin Central for Water Temperature

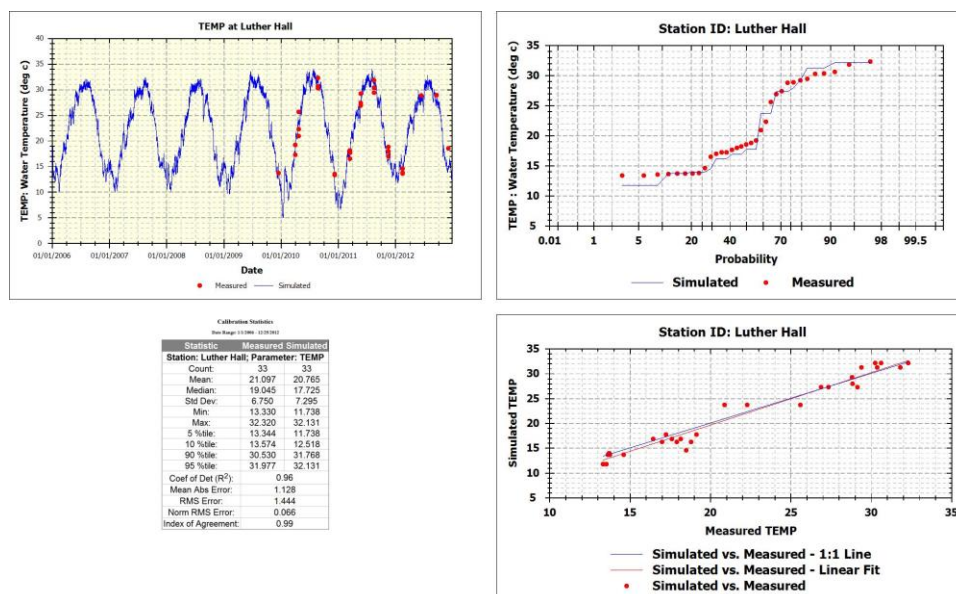


Figure 19 21FLLEONLCT03042384172: Lake Talquin near Luther Hall Landing for Water Temperature

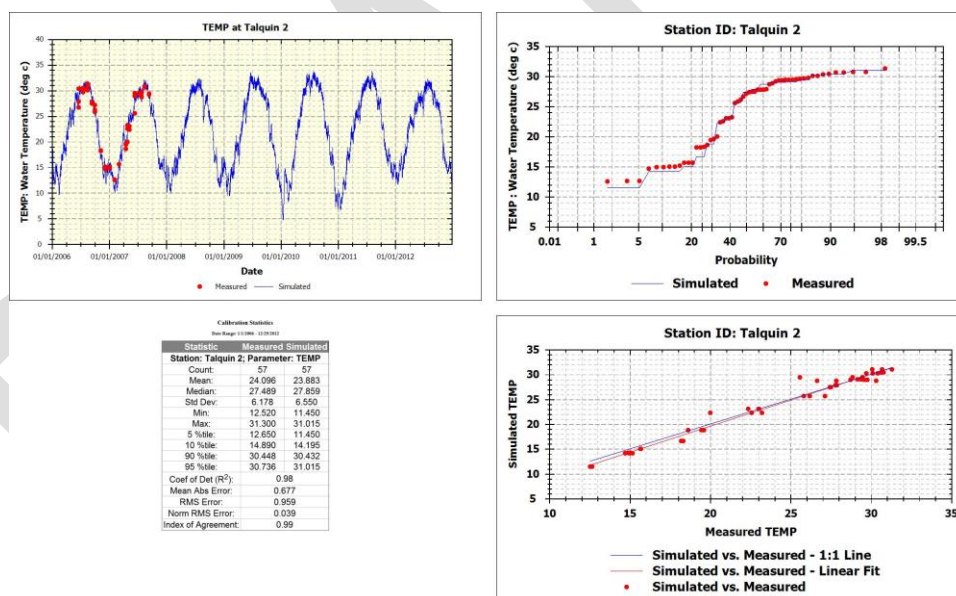


Figure 20 21FLLEONLCT0L3042284573: Talquin 2 for Water Temperature

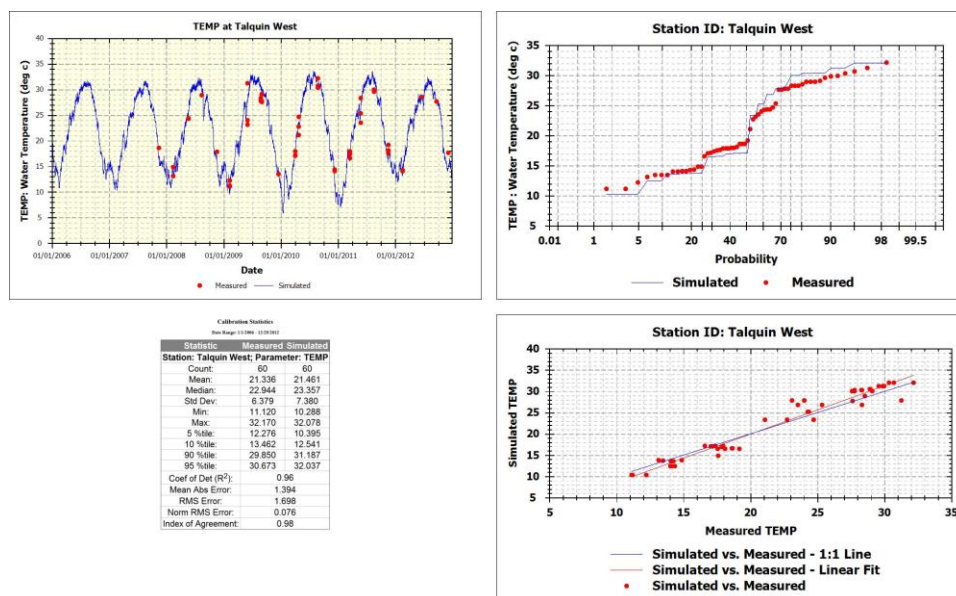


Figure 21 21FLLEONT0D3041488461: Lake Talquin West for Water Temperature

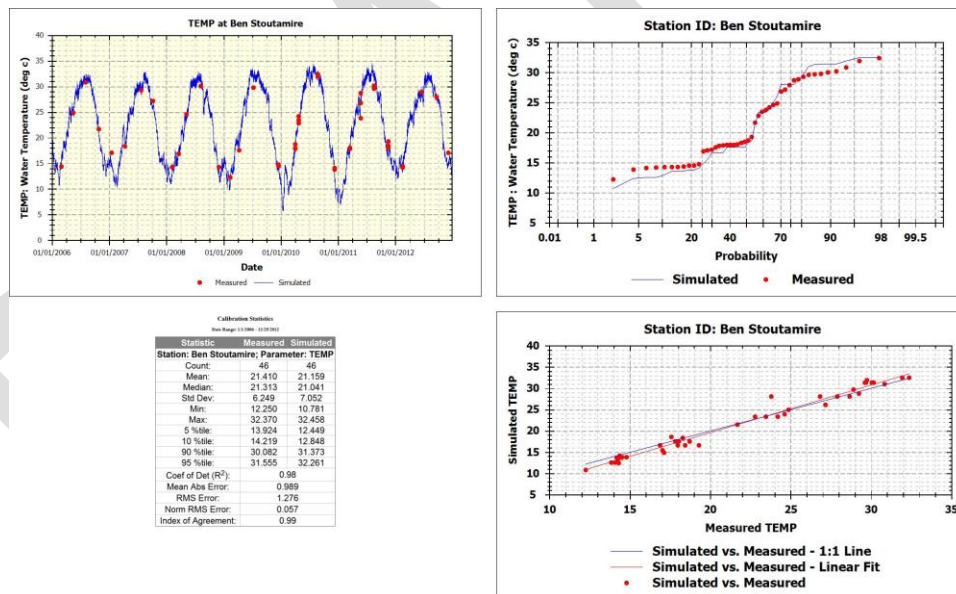


Figure 22 21FLLEONLCOC3040784610: Lake Talquin (Ben Stoutamire Boat Landing) for Water Temperature

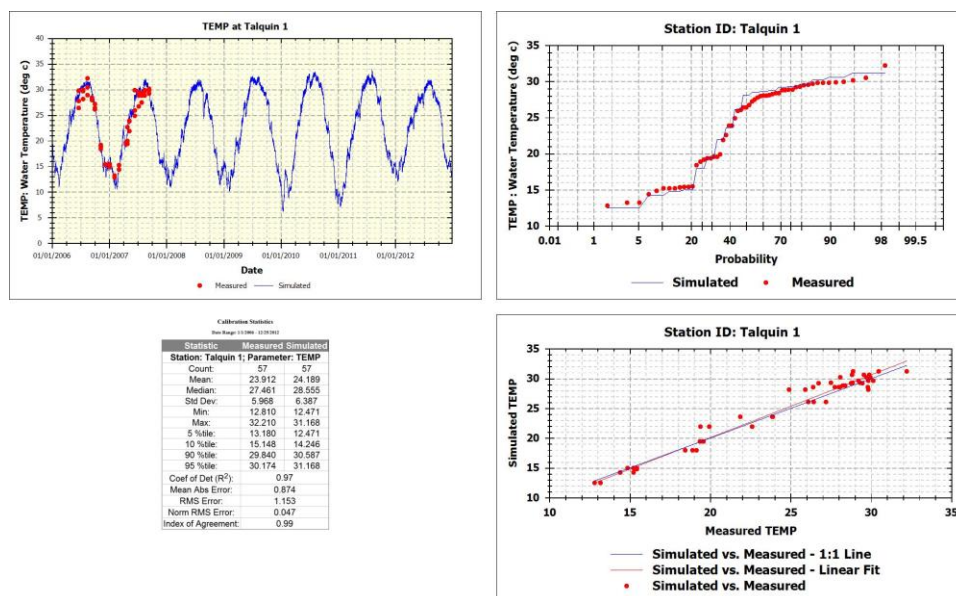


Figure 23 21FLLEONLCT0B3040284630: Talquin 1 for Water Temperature

Water Quality Model Application

The WASP water quality model uses the kinematic wave equation to simulate flow and velocity in Lake Talquin's tributaries, and the advanced eutrophication module to predict dissolved oxygen and Chlorophyll-a responses to BOD, total nitrogen and total phosphorus loadings. The watershed tributary geometry was determined from NHDPlus coverages of the free flowing stream sections.

Model Network

The Lake Talquin WASP model is comprised of 3 separate WASP water quality models, Little River, Ochlockonee River, and Lake Talquin. The output parameters for both Little River and Ochlockonee River tributaries are loaded into the Lake Talquin WASP model. The model segmentation for both of the river models was done based upon the NHDPlus coverage taking into account travel time, pore points for the watershed model and IWR monitoring stations.

Figure 24 illustrates 132 water quality model segments that are simulated for the Little River. The 18 subwatershed LSPC model flows and loads enter the water quality model at 18 different WASP segments. Figure 24 illustrates the 183 water quality model segments that are simulated for the Ochlockonee River. The LSPC model flows and loads enter the water quality model at 55 separate WASP segments.

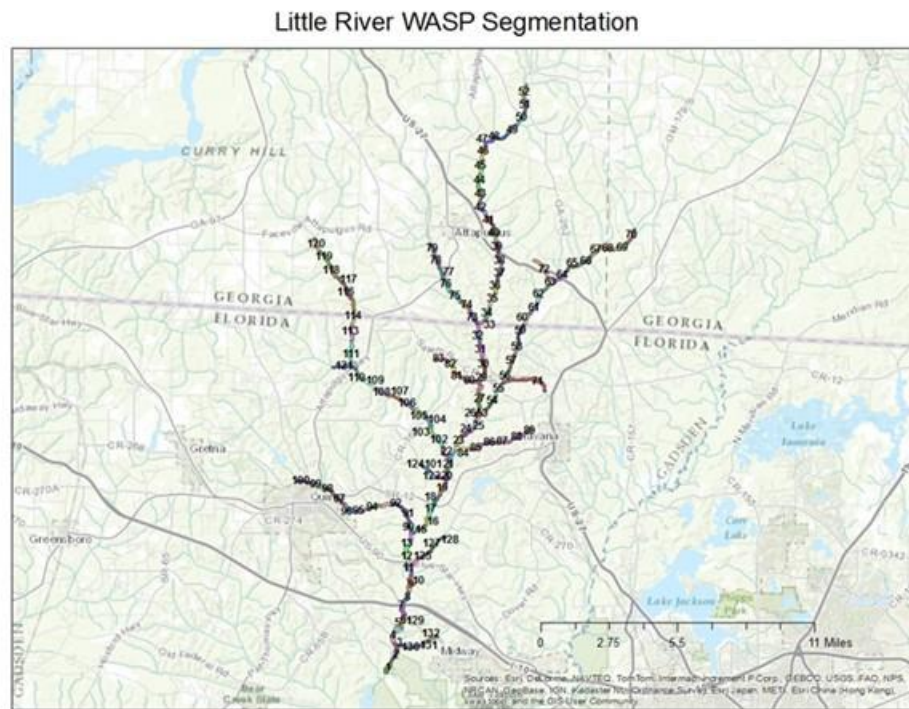


Figure 24 WASP Model Segmentation for Little River

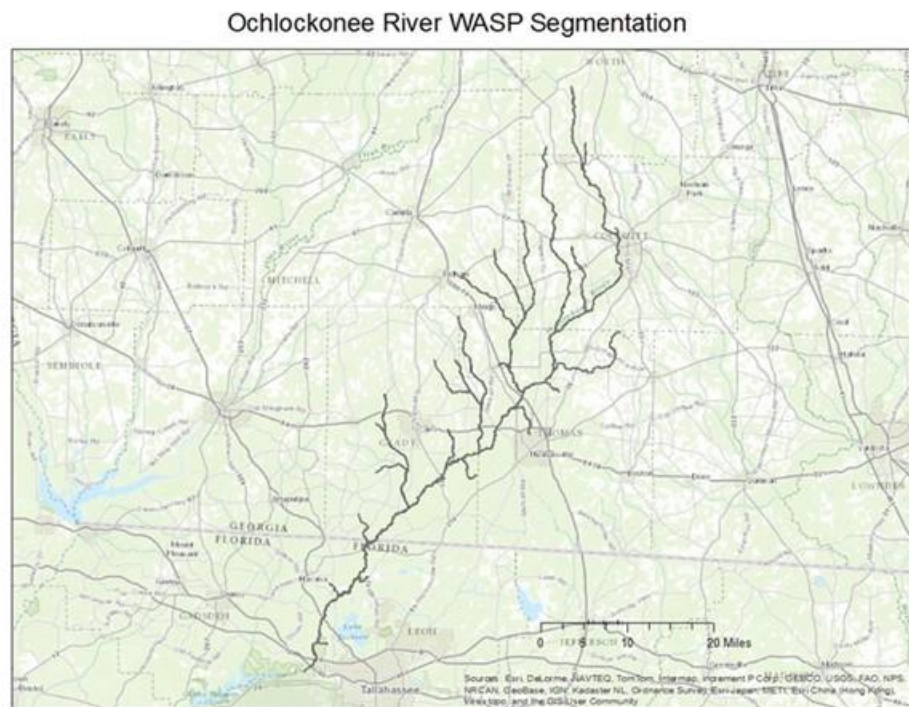


Figure 25 WASP Model Segmentation for Ochlockonee River

An EFDC grid was developed for Lake Talquin which consists of 212 horizontal cells with 2 layers. The model grid includes all the major and minor tributaries to the lake. EFDC and WASP are linked 1 to 1 in space. EFDC supplies updated hydrodynamic information to WASP every 60 EFDC time steps (Figure 11).

Water Quality Model Calibration

The water quality models were calibrated to available data. The fine tuning of the calibration of the models utilized the monitoring station(s) located at the lower end that contained the most monitoring data. For the lake calibration, all model results and measured data are representing the surface layer of the WASP model.

Table 4 - Table 6 list monitoring stations used to calibrate the three WASP models developed for Lake Talquin Watershed. All stations that had nutrient, BOD, dissolved oxygen and chlorophyll-a measurements were used in the calibration process. The stations highlighted in yellow provided the most critical monitoring data and were therefore provided the most influence to the water quality calibration.

Table 4 Monitoring Stations used in Little River Water Quality Model Calibration

WASP Segment	State	Station ID	Station Name
4	FL	21FLBRA 424-A	424 - Little River - far dwnstrm from bridge on SR 268
4	FL	21FLPNS 303043908431244	Little River at SR 268
29	FL	21FLPNS 303946808427477	Attapulgis Creek at SR 159
29	FL	21FLWQA 303946808427477	Attapulgis Creek at SR 159

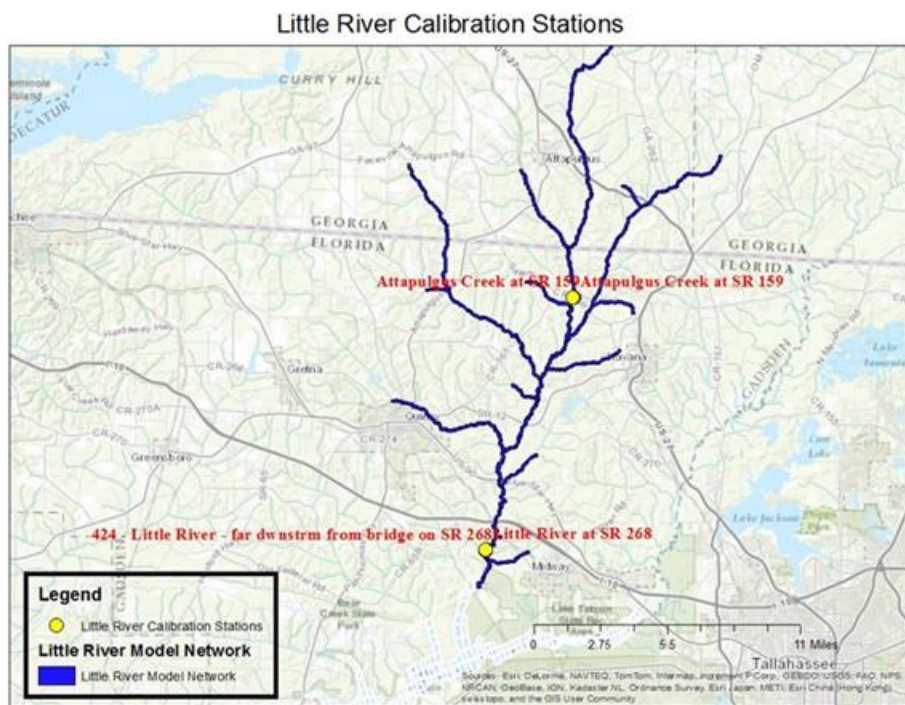


Figure 26 Little River WASP Water Quality Calibration Segments

Table 5 Monitoring Stations used in Ochlockonee River Water Quality Model Calibration

WASP Segment	State	Station ID	Station Name
25	GA	21GAEPD_WQX-1003010102	Ochlockonee River @ Hadley Ferry Rd. nr Calvary, Ga.
25	GA	USGS-02328200	OCHLOCKONEE RIVER NEAR CALVARY, GA
20	FL	21FLGW 3540	Ochlockonee river at SR 12

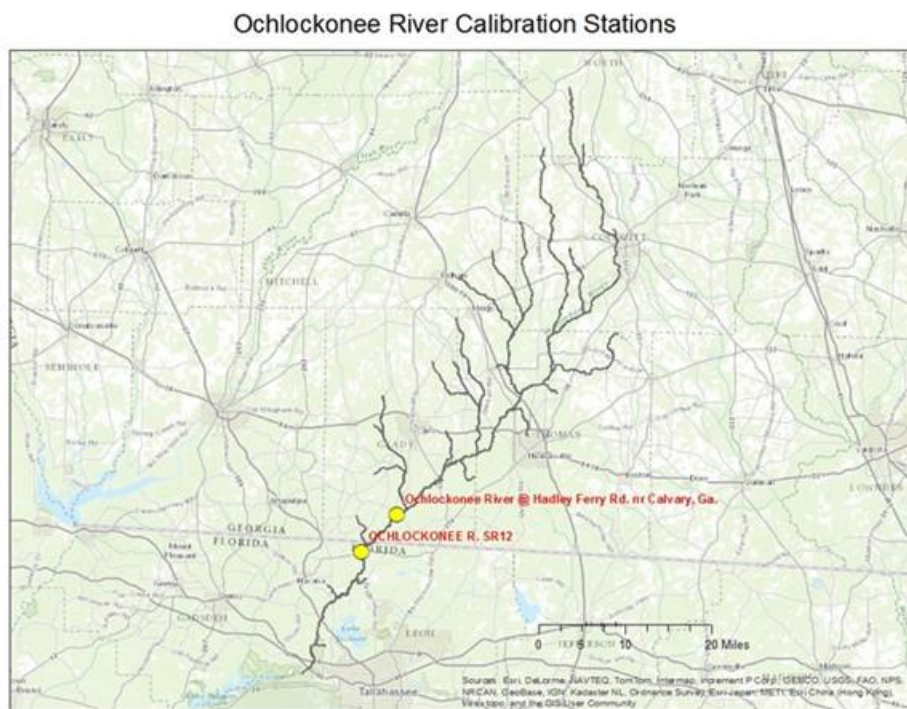


Figure 27 Ochlockonee WASP Water Quality Calibration Segments

Table 6 Monitoring Stations used in Lake Talquin Water Quality Model Calibration

Station	Station Name
21FLLEONLCOC3040784610	Lake Talquin (Ben Stoutamire Boat Landing)
21FLLEONLCT03042384172	Lake Talquin near Luther Hall Landing
21FLLEONLCT03045184523	Lake Talquin near Williams Landing
21FLLEONLCT0B3040284630	Talquin 1
21FLLEONLCT0C3045884492	Talquin 4
21FLLEONLCT0L3042284573	Talquin 2
21FLLEONLCT0W3045084521	Talquin 3
21FLLEONTOD3041488461	Lake Talquin West
21FLLEONT0E3044084556	Lake Talquin Central

Station location

Figure 28 illustrates the location of the water quality stations that were used in the calibration. All of these stations are maintained by Leon County, FL. These stations were chosen because they represent the most complete and long term record of data for Lake Talquin.

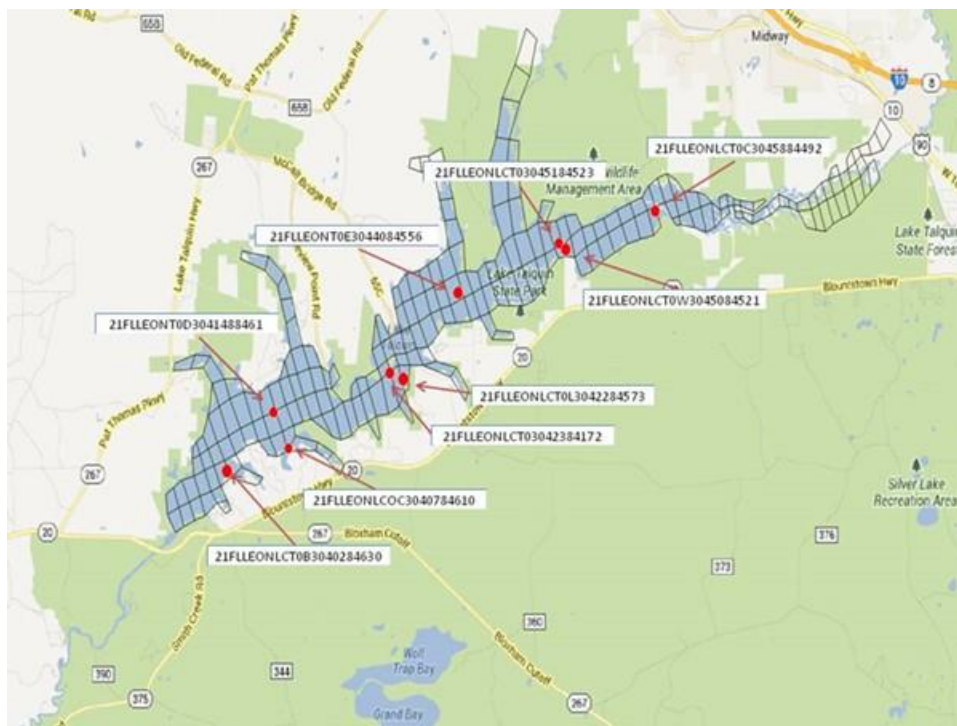


Figure 28 Lake Talquin Calibration Station Location

Little River/Ochlockonee River Water Quality Calibration

Both the Ochlockonee and Little River Models were calibrated against available ambient monitoring data. Stations with the most complete dataset were used. The model calibration focused on getting the loads to Lake Talquin correct.

Water Temperature

The riverine models were configured to simulation water temperature. This step was important because it provides daily water temperatures that are used to influence the degradation of BOD, kinetic transformation (mineralization, dissolution), and algal growth/death rates.

Figure 29 - illustrate both a quantitative and qualitative comparisons of simulated water temperature to direct field measurements.

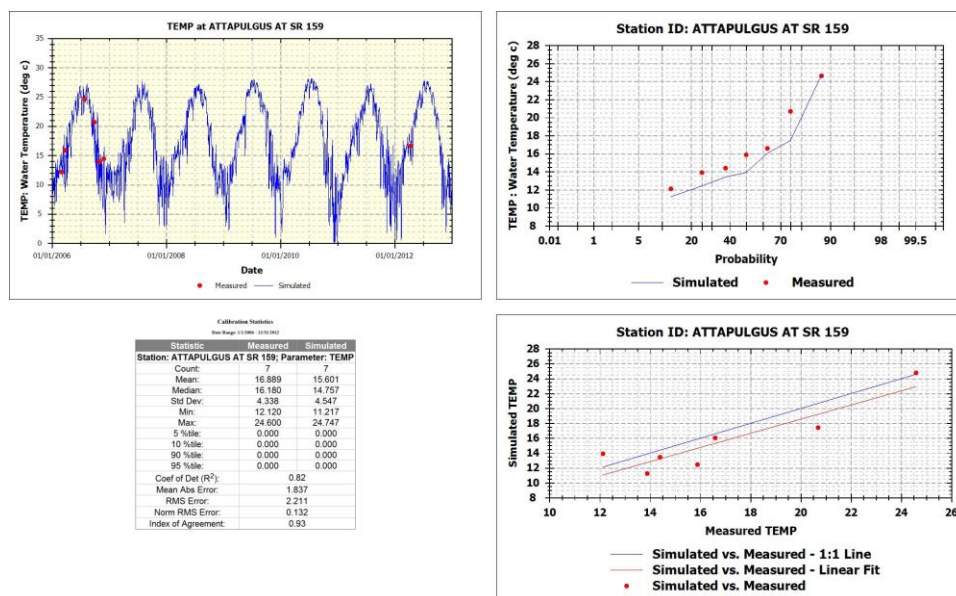


Figure 29 Water Temperature Calibration Attapulcus Creek at SR 159

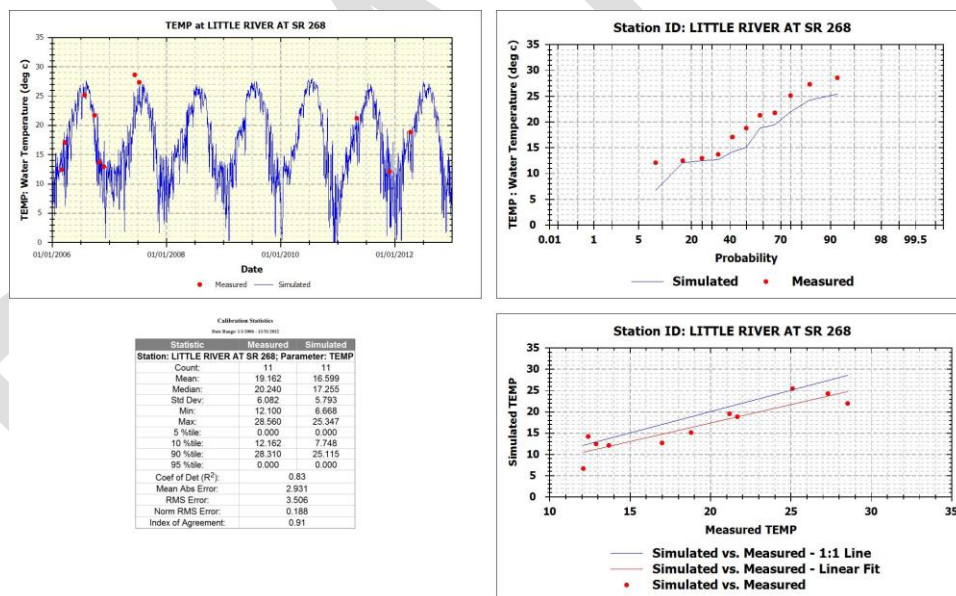


Figure 30 Water Temperature Calibration Little River at SR 268

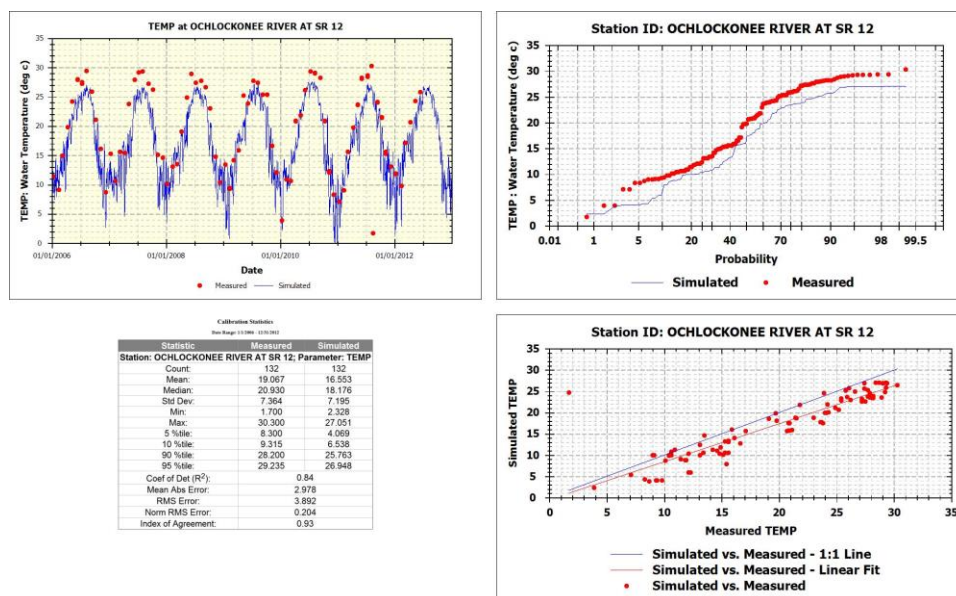


Figure 31 Water Temperature Calibration Ochlockonee River at SR 12

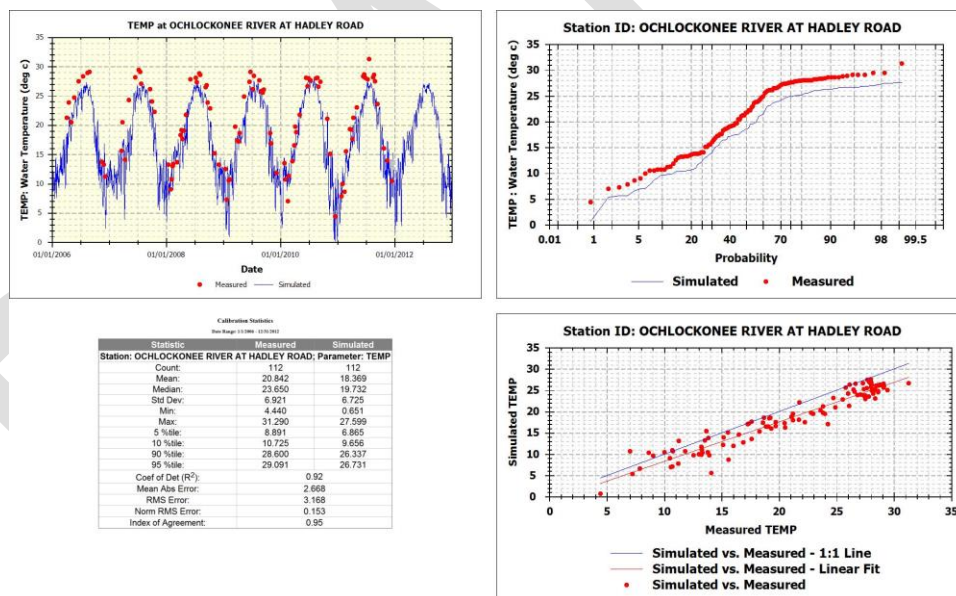


Figure 32 Water Temperature Calibration Ochlockonee River at Hadley Road

Dissolved Oxygen

Figure 33 through Figure 53 illustrates both a quantitative and qualitative comparison of the predicted dissolved oxygen concentrations compared to the direct measurements.

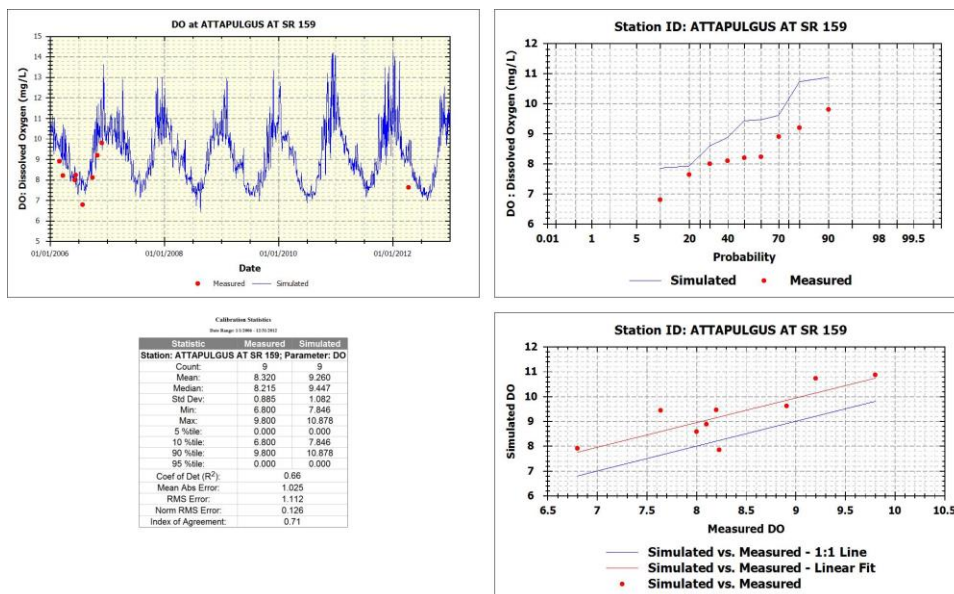


Figure 33 Dissolved Oxygen Calibration Attapulcus Creek at SR 159

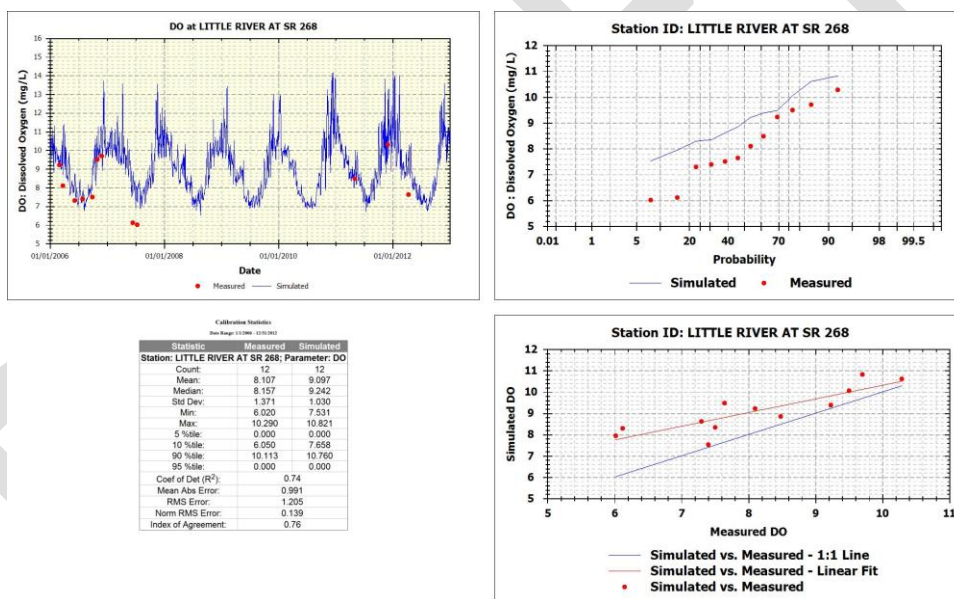


Figure 34 Dissolved Oxygen Calibration Little River at SR 268

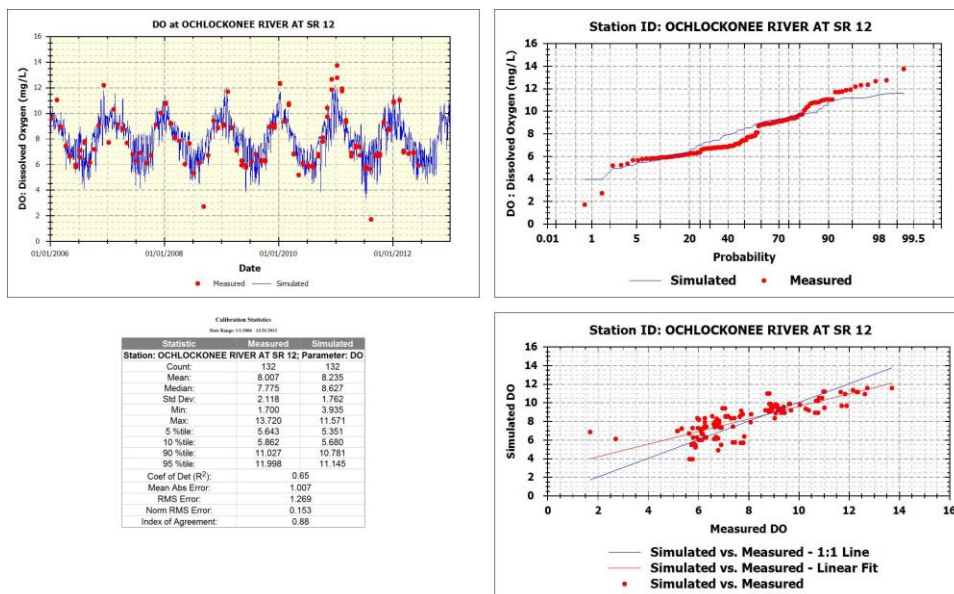


Figure 35 Dissolved Oxygen Calibration Ochlockonee River at SR 12

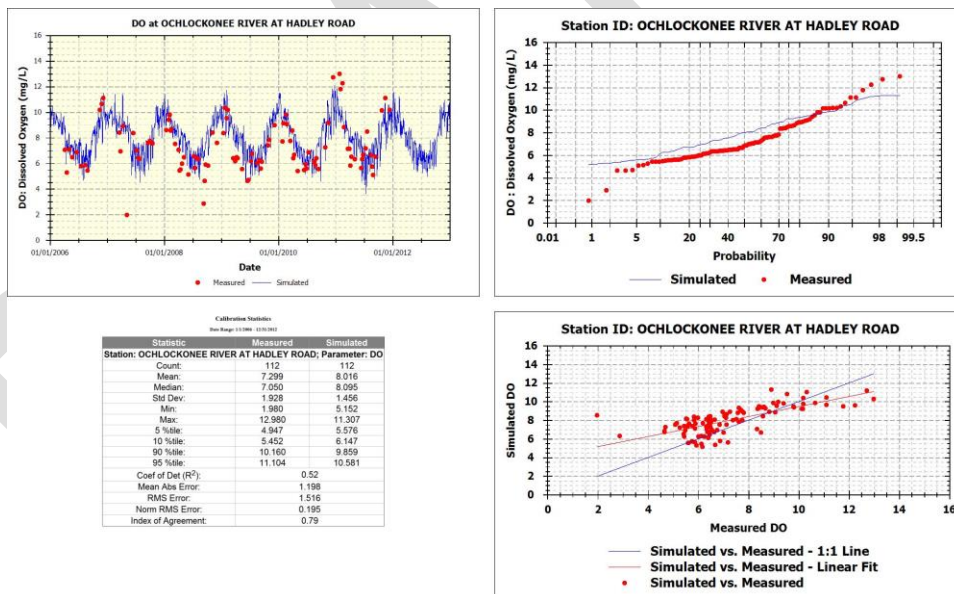


Figure 36 Dissolved Oxygen Calibration Ochlockonee River at Hadley Road

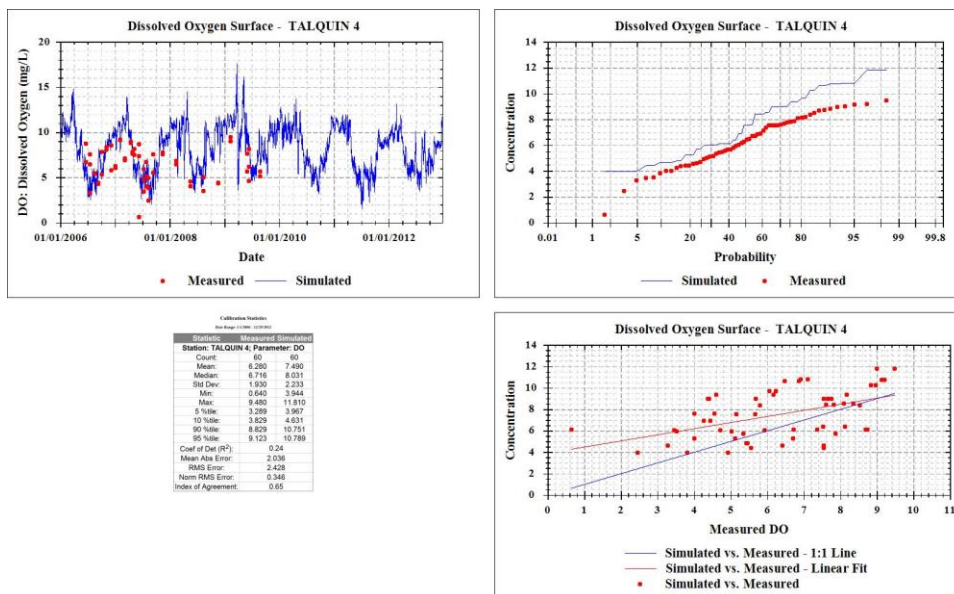


Figure 37 21FLLEONLCT0C3045884492: Talquin 4 for Dissolved Oxygen – Surface Layer

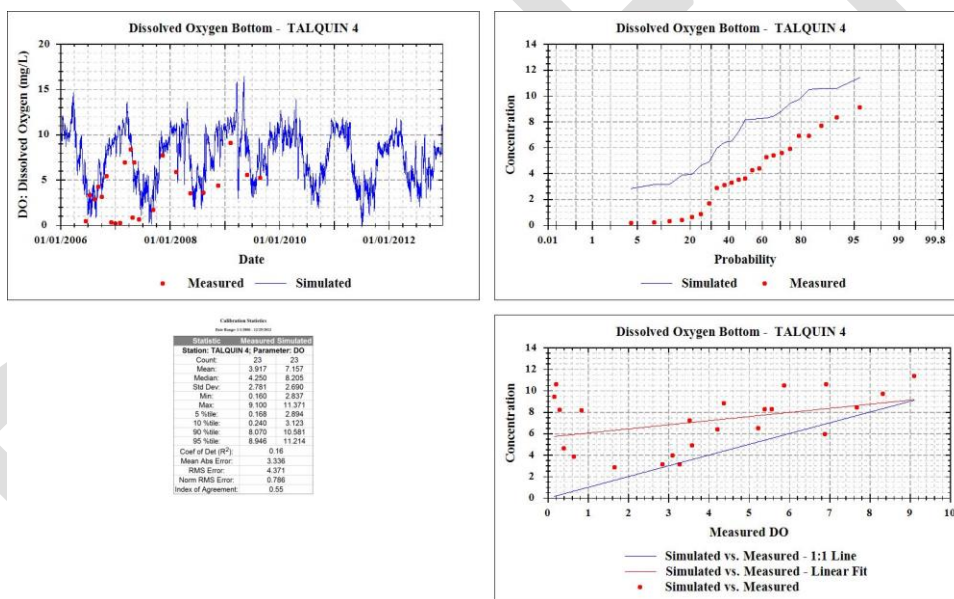


Figure 38 21FLLEONLCT0C3045884492: Talquin 4 for Dissolved Oxygen – Bottom Layer

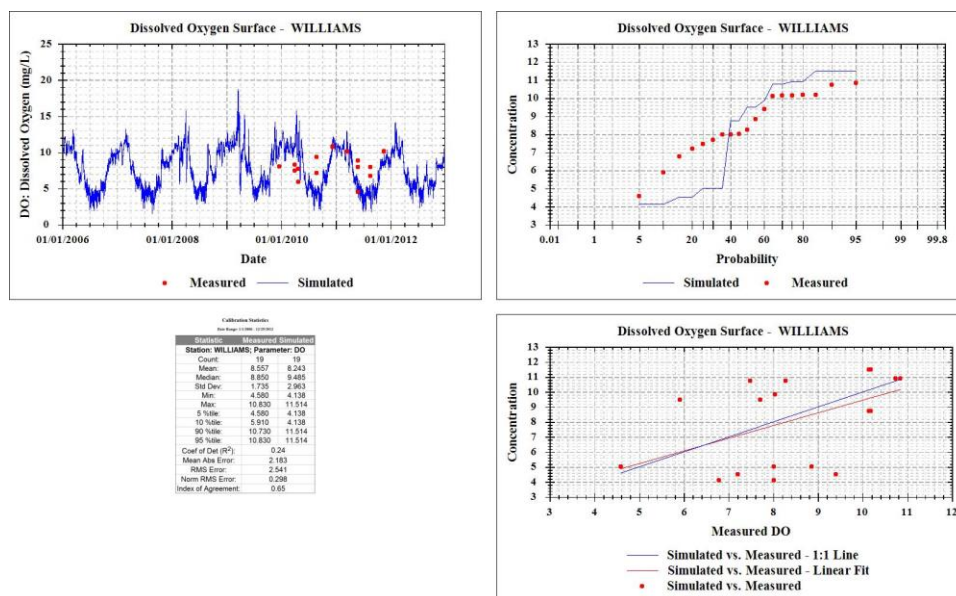


Figure 39 21FLLEONLCT03045184523: Lake Talquin near Williams Landing for Dissolved Oxygen – Surface Layer

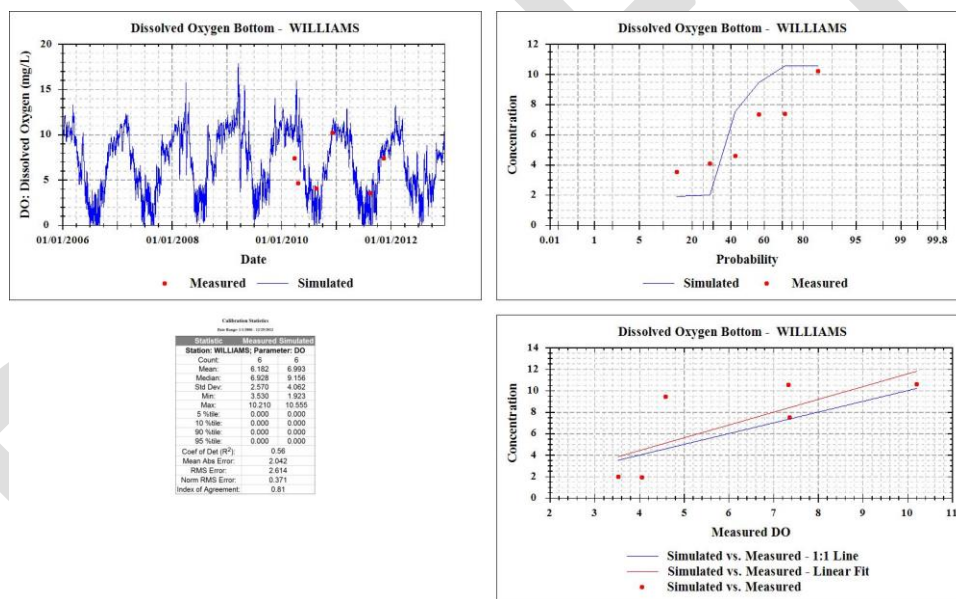


Figure 40 21FLLEONLCT03045184523: Lake Talquin near Williams Landing for Dissolved Oxygen – Bottom Layer

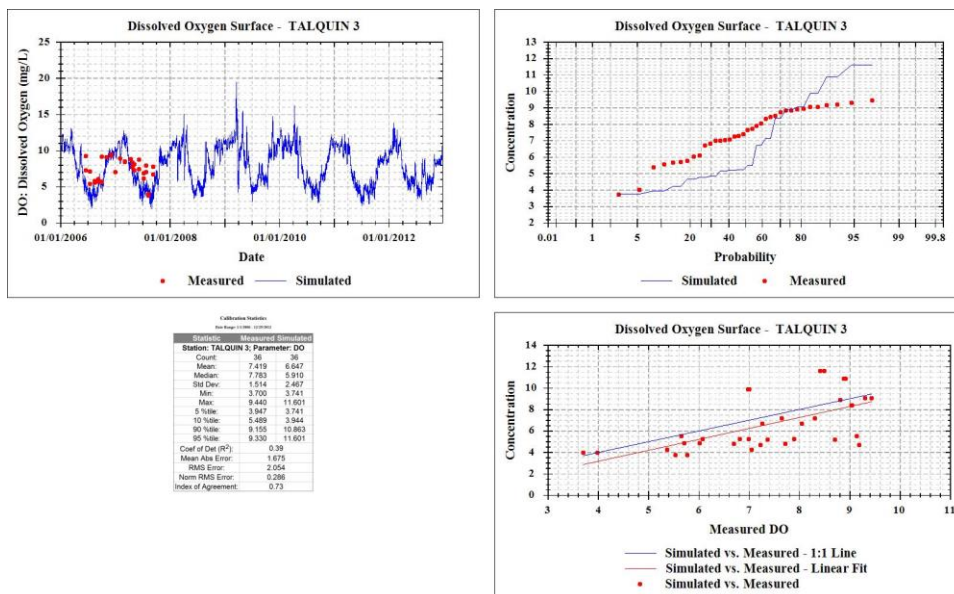


Figure 41 21FLLEONLCT0W3045084521: Talquin 3 for Dissolved Oxygen – Surface Layer

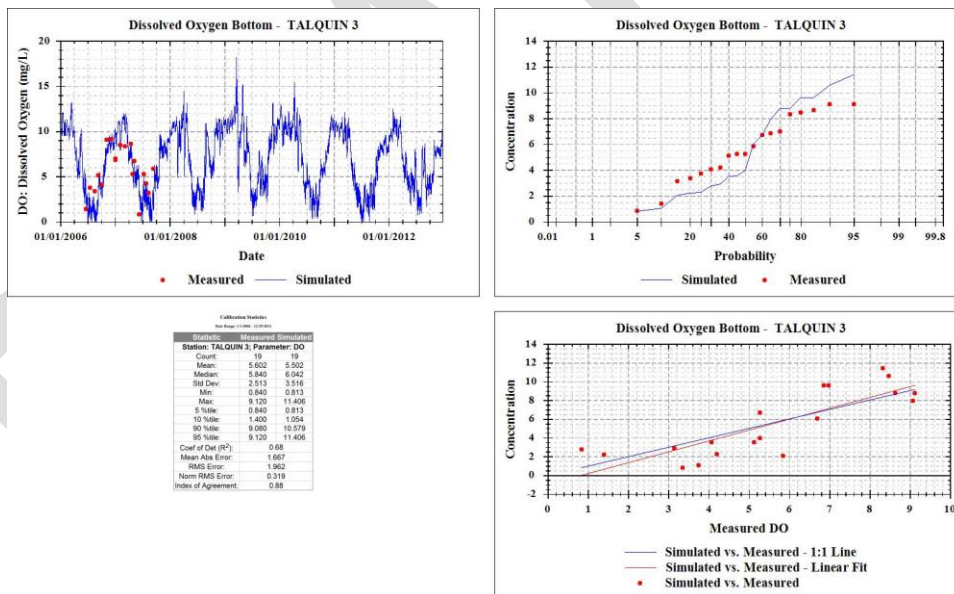


Figure 42 21FLLEONLCT0W3045084521: Talquin 3 for Dissolved Oxygen – Bottom Layer

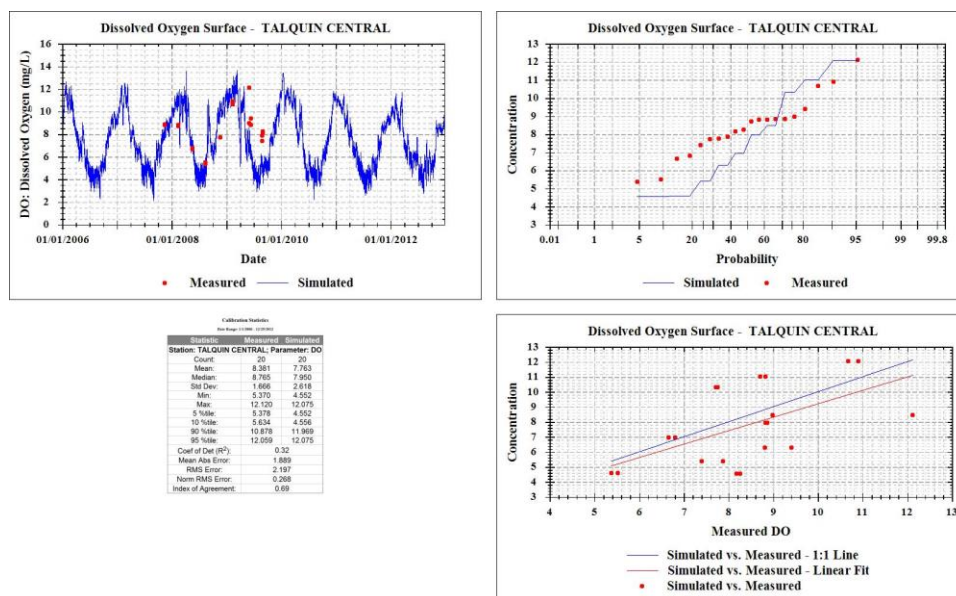


Figure 43 21FLLEONT0E3044084556: Lake Talquin Central for Dissolved Oxygen – Surface Layer

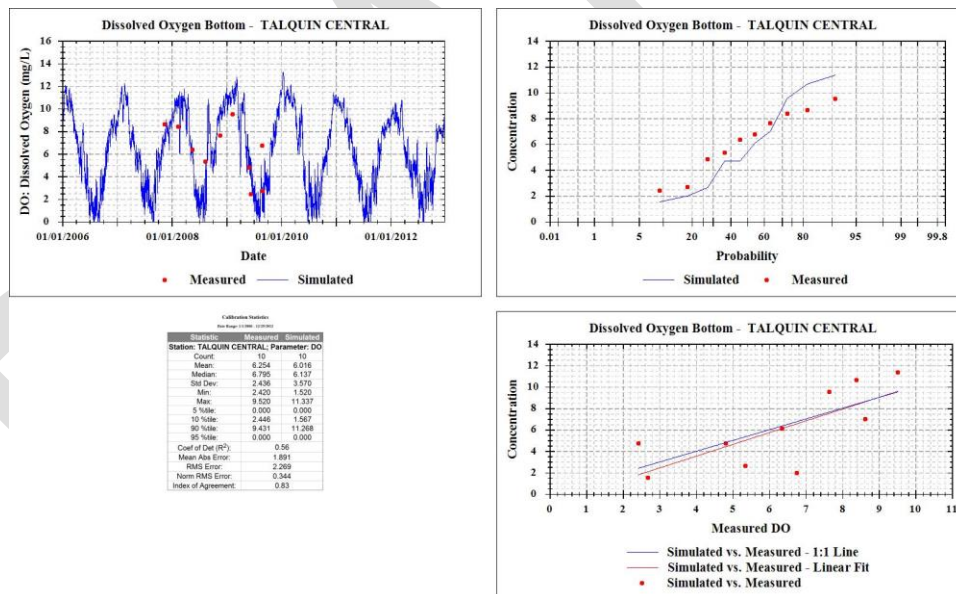


Figure 44 21FLLEONT0E3044084556: Lake Talquin Central for Dissolved Oxygen – Bottom Layer

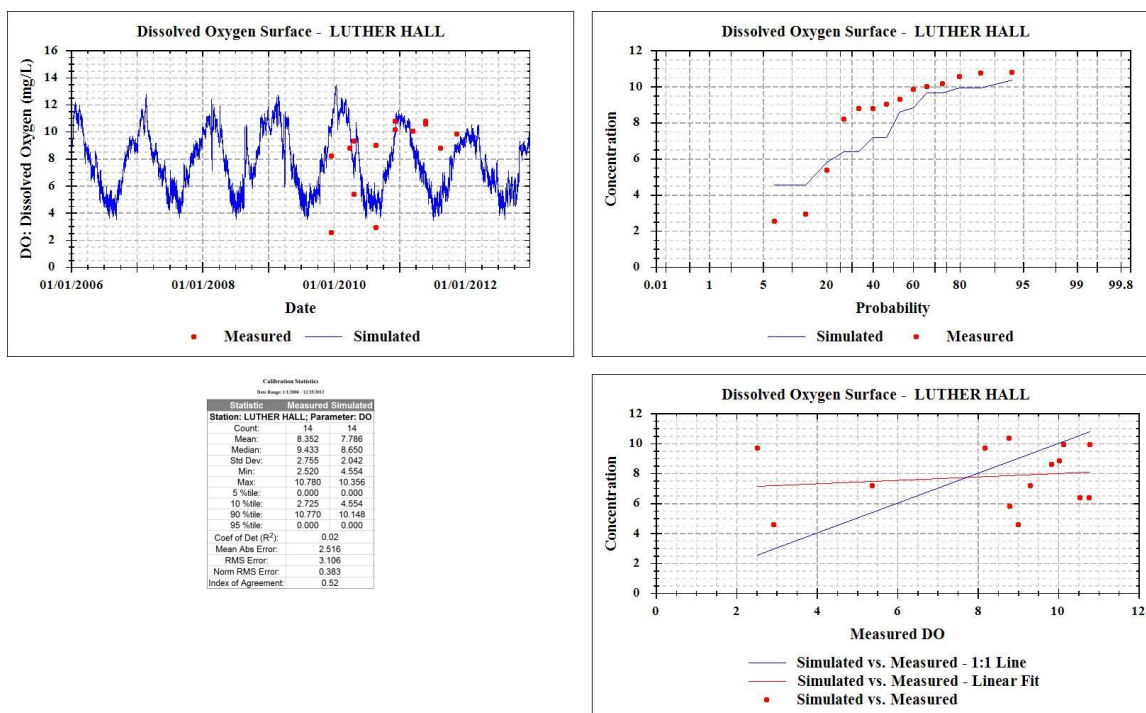


Figure 45 21FLLEONLCT03042384172: Lake Talquin near Luther Hall Landing for Dissolved Oxygen – Surface Layer

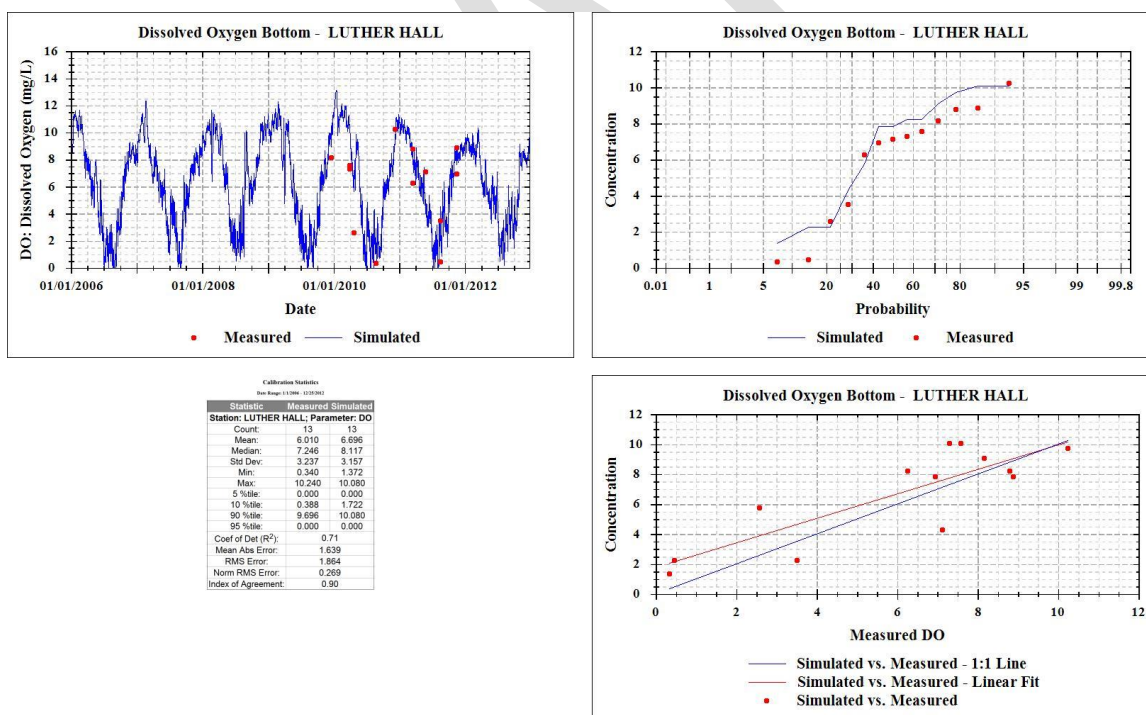


Figure 46 21FLLEONLCT03042384172: Lake Talquin near Luther Hall Landing for Dissolved Oxygen – Bottom Layer

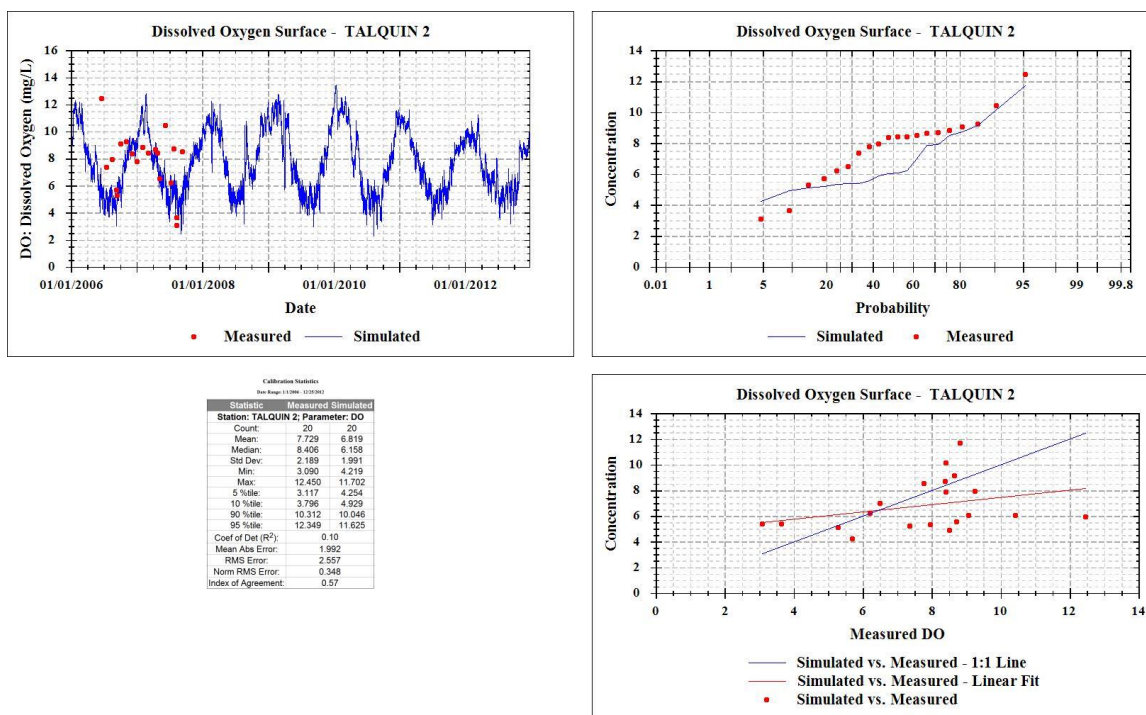


Figure 47 21FLLEONLCT0L3042284573: Talquin 2 for Dissolved Oxygen – Surface Layer

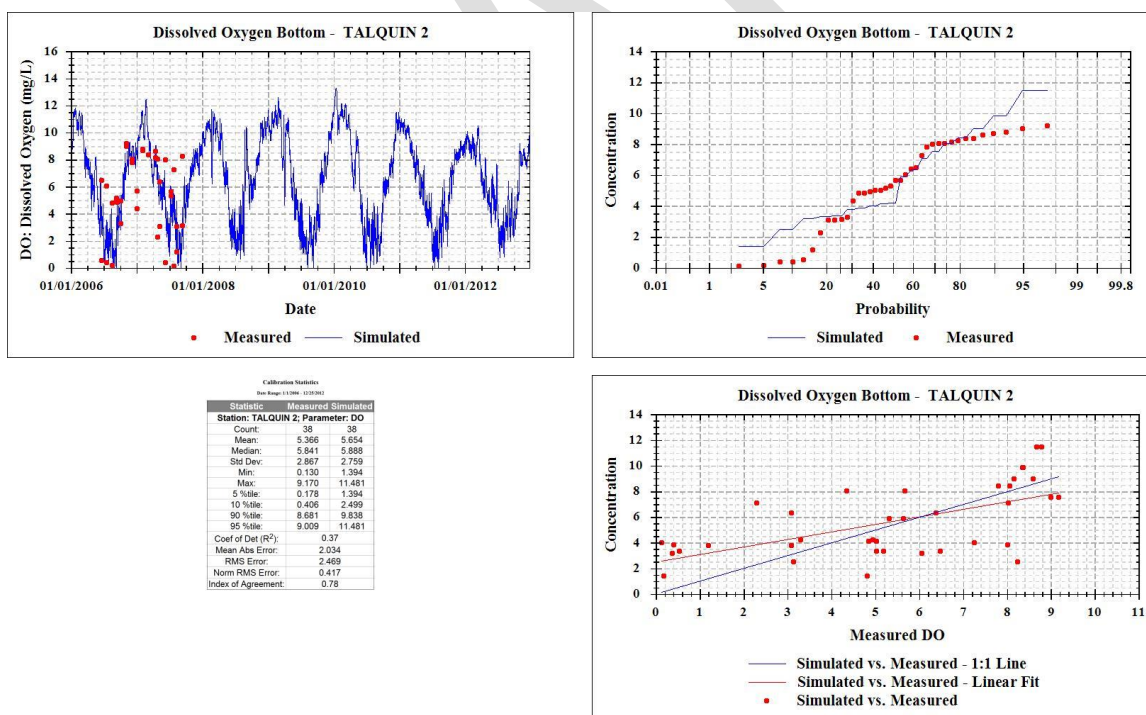


Figure 48 21FLLEONLCT0L3042284573: Talquin 2 for Dissolved Oxygen – Bottom Layer

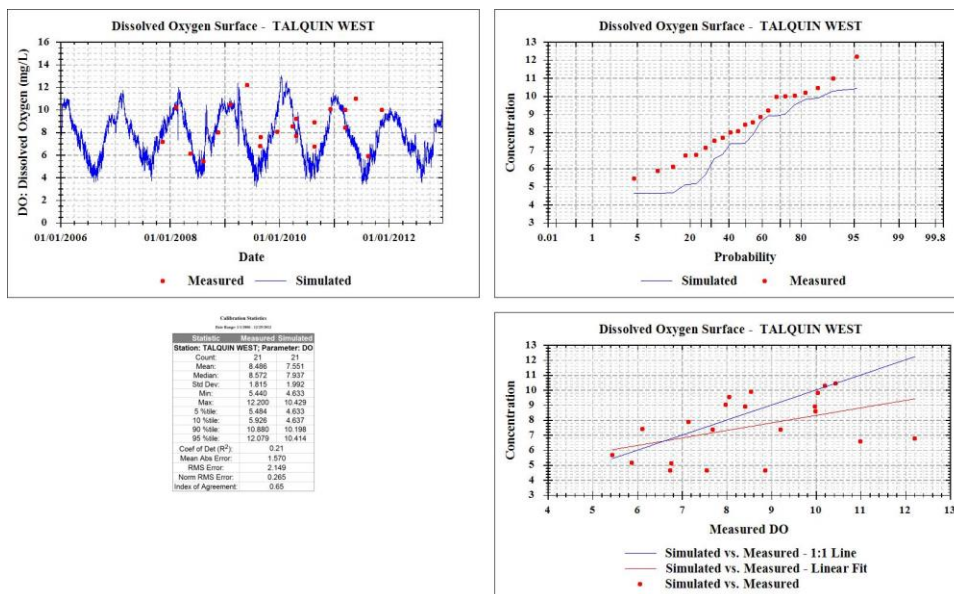


Figure 49 21FLLEONT0D3041488461: Lake Talquin West for Dissolved Oxygen – Surface Layer

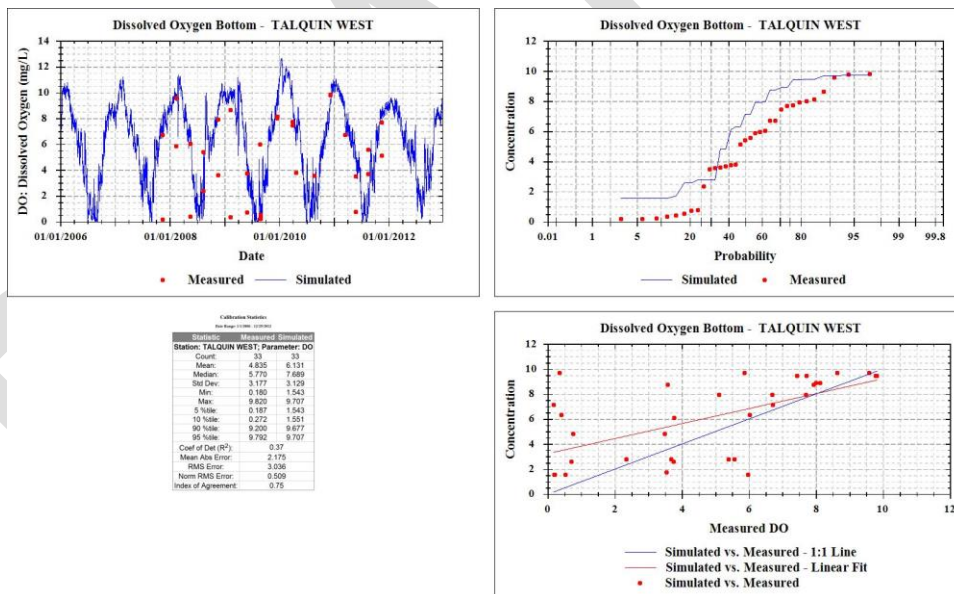


Figure 50 21FLLEONT0D3041488461: Lake Talquin West for Dissolved Oxygen – Bottom Layer

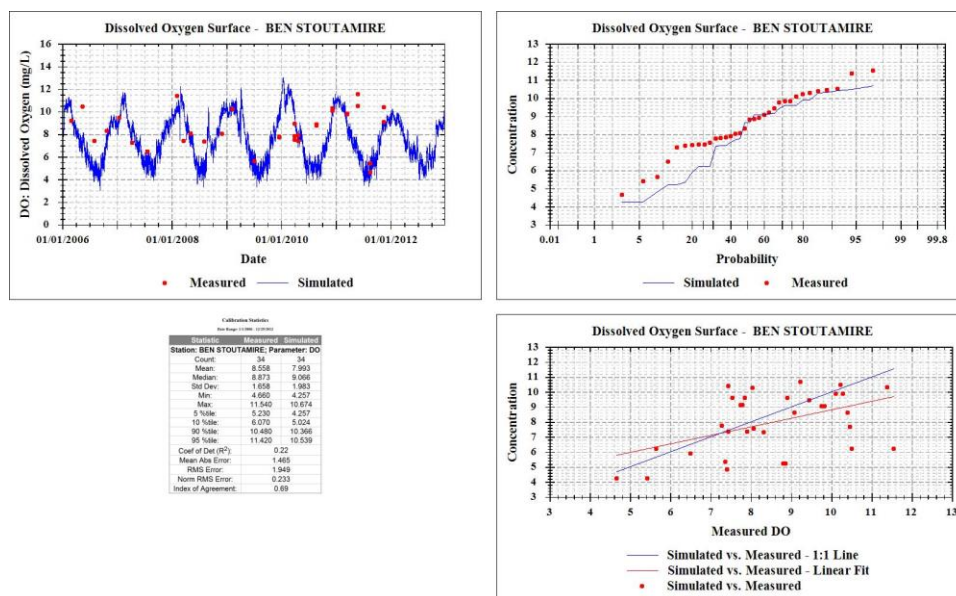


Figure 51 21FLLEONLCOC3040784610: Lake Talquin (Ben Stoutamire Boat Landing) for Dissolved Oxygen – Surface Layer

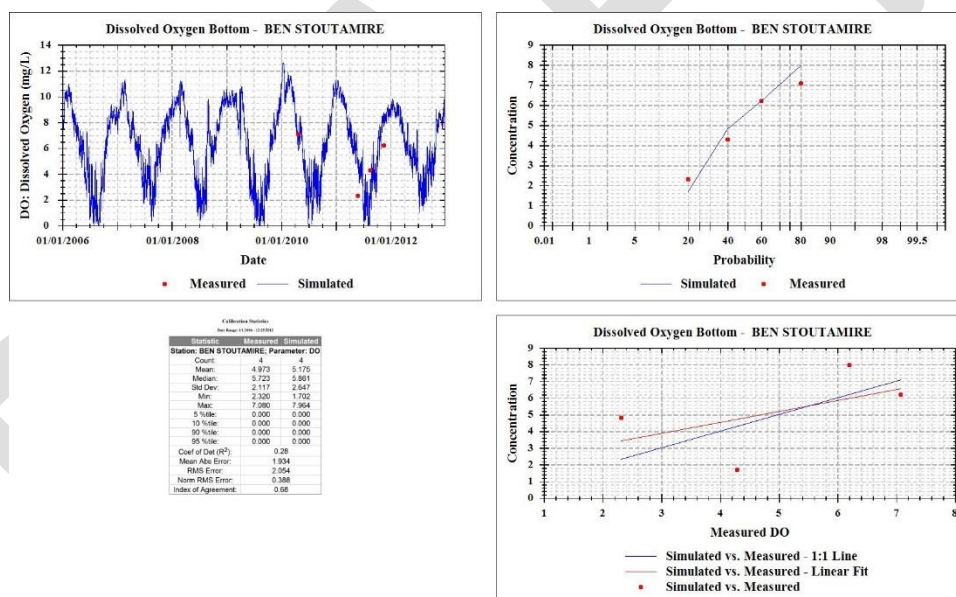


Figure 52 21FLLEONLCOC3040784610: Lake Talquin (Ben Stoutamire Boat Landing) for Dissolved Oxygen – Bottom Layer

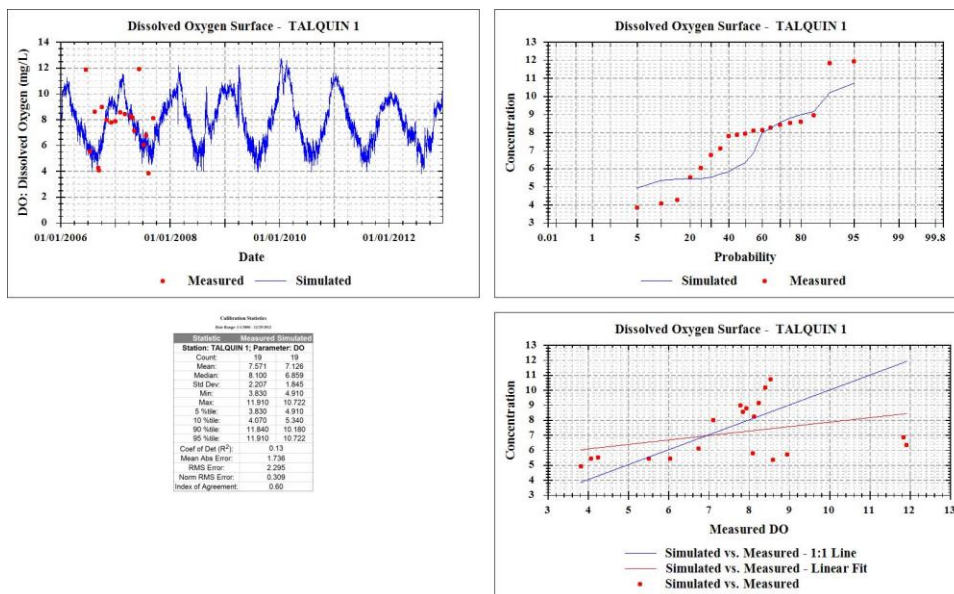


Figure 53 21FLLEONLCT0B3040284630: Talquin 1 for Dissolved Oxygen – Surface Layer

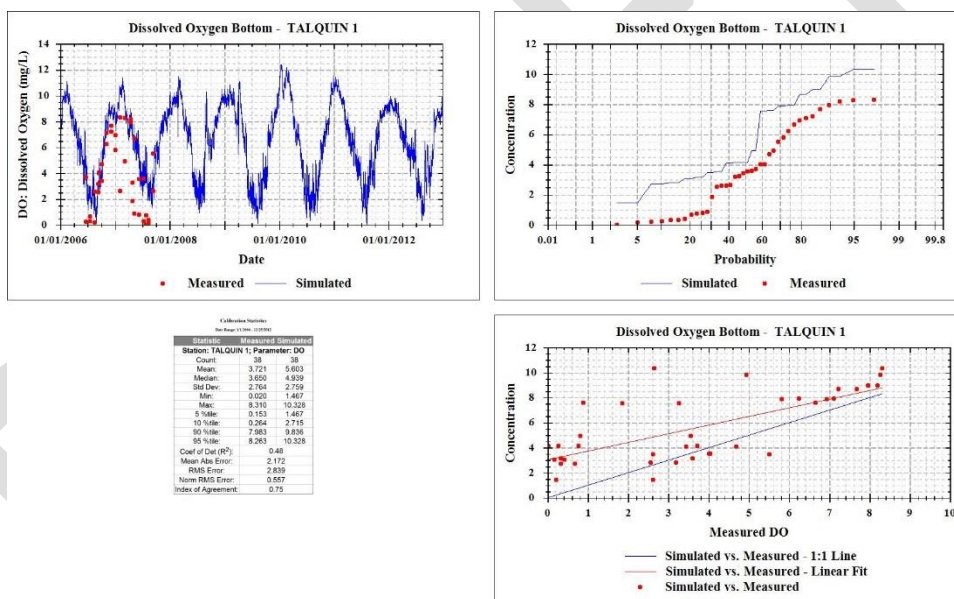


Figure 54 21FLLEONLCT0B3040284630: Talquin 1 for Dissolved Oxygen – Bottom Layer

Chlorophyll a

Figure 55 through Figure 65 illustrate a quantitative and qualitative comparison of the predicted chlorophyll-a concentrations to direct field measurements.

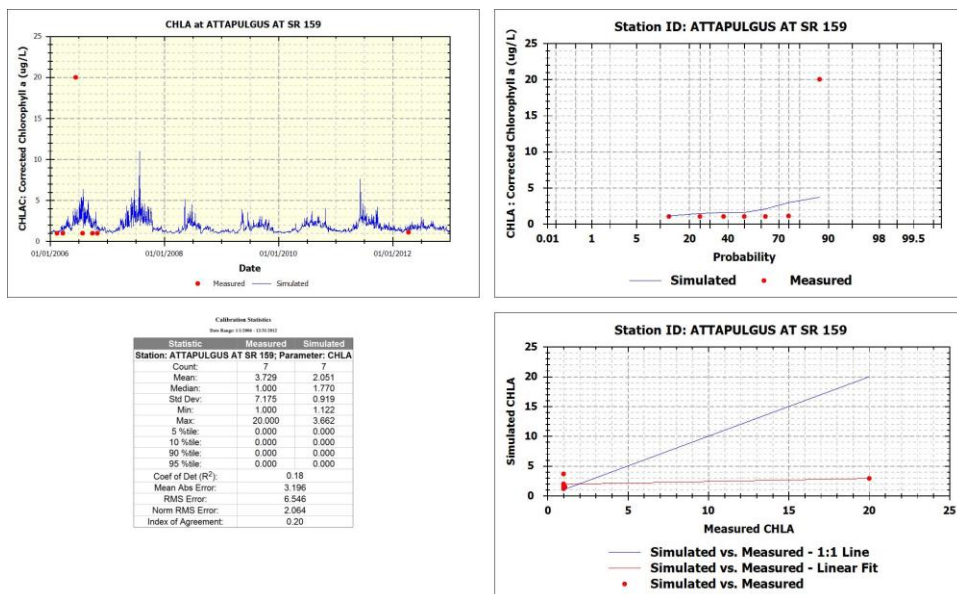


Figure 55 Chlorophyll a Calibration Attapulugus Creek at SR 159

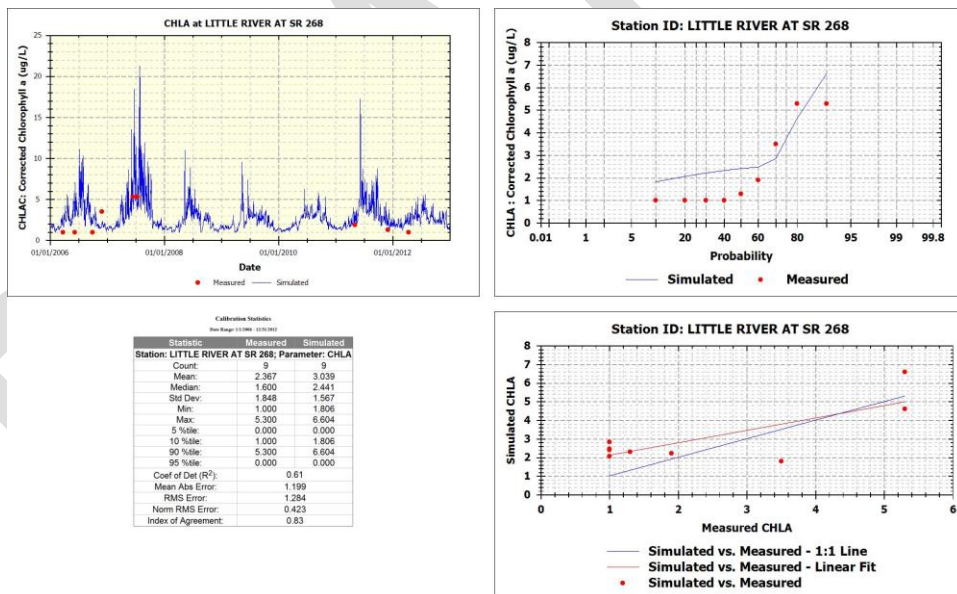


Figure 56 Chlorophyll a Calibration Little River at SR 268

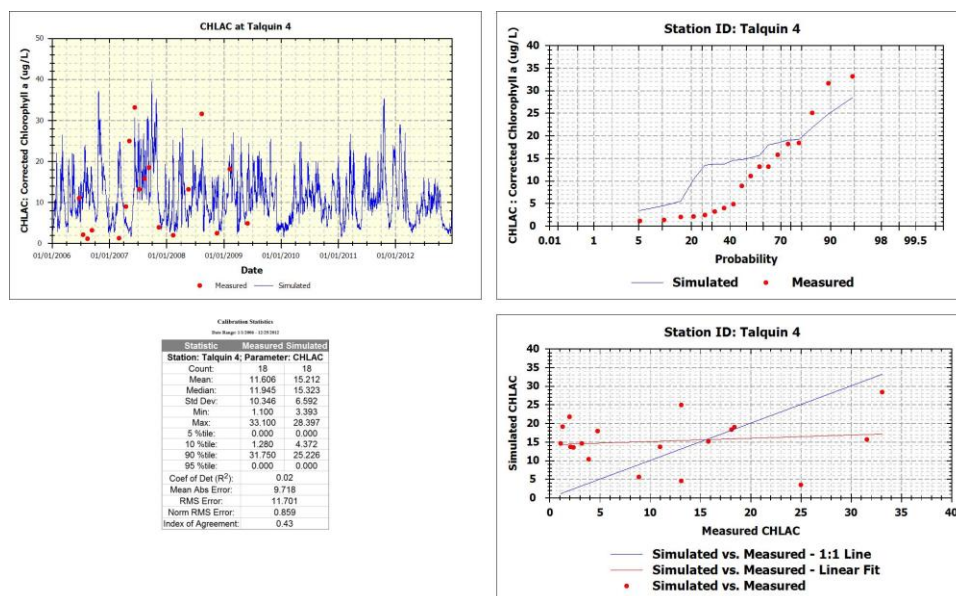


Figure 57 21FLLEONLCT0C3045884492: Talquin 4 for Chlorophyll a

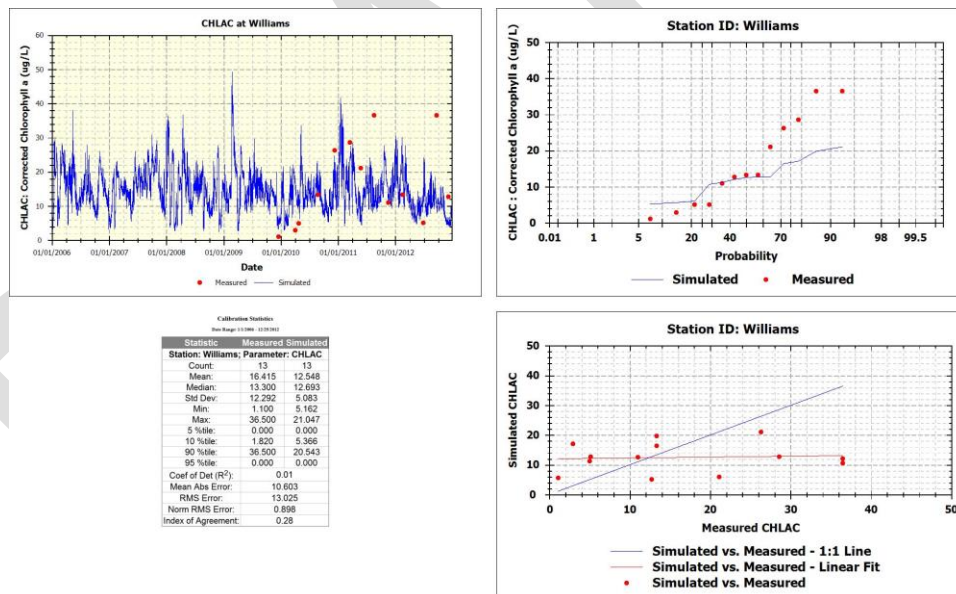


Figure 58 21FLLEONLCT03045184523: Lake Talquin near Williams Landing for Chlorophyll a

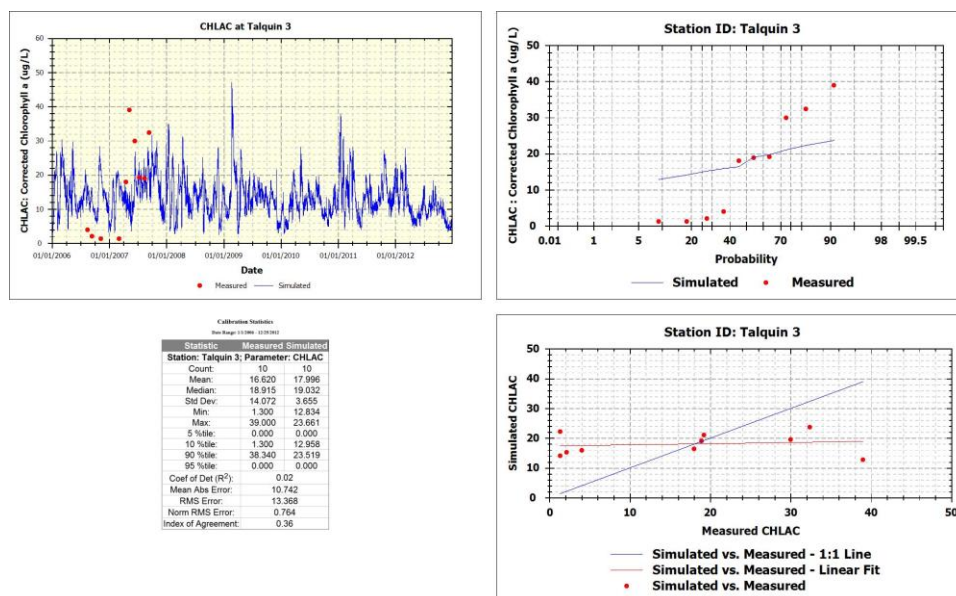


Figure 59 21FLLEONLCT0W3045084521: Talquin 3 for Chlorophyll a

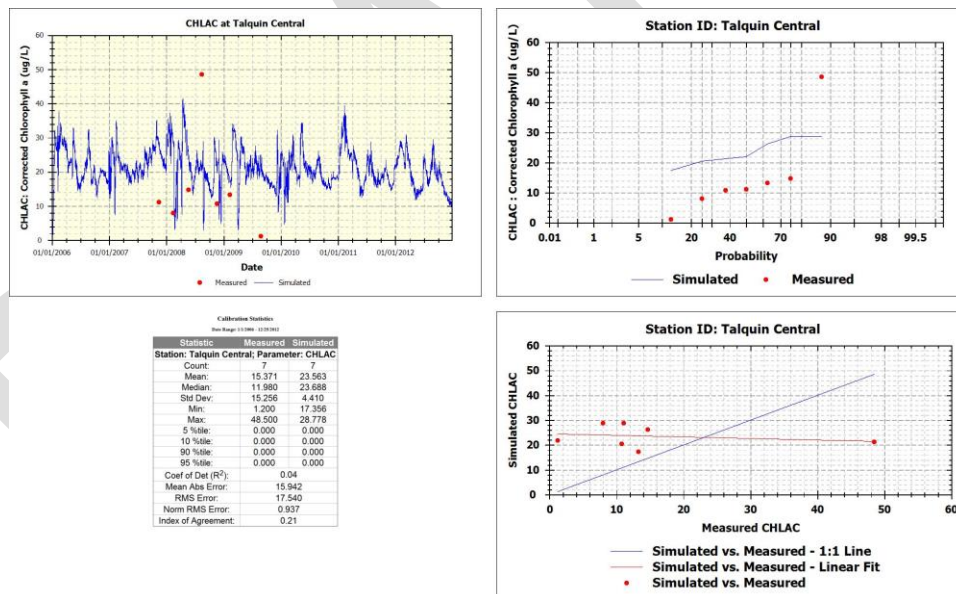


Figure 60 21FLLEONT0E3044084556: Lake Talquin Central for Chlorophyll a

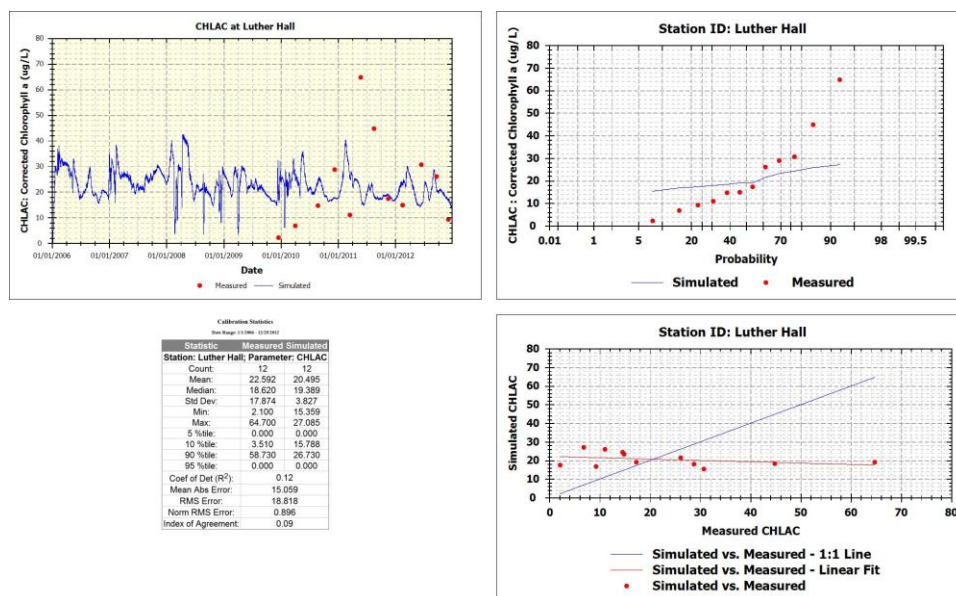


Figure 61 21FLLEONLCT03042384172: Lake Talquin near Luther Hall Landing for Chlorophyll a

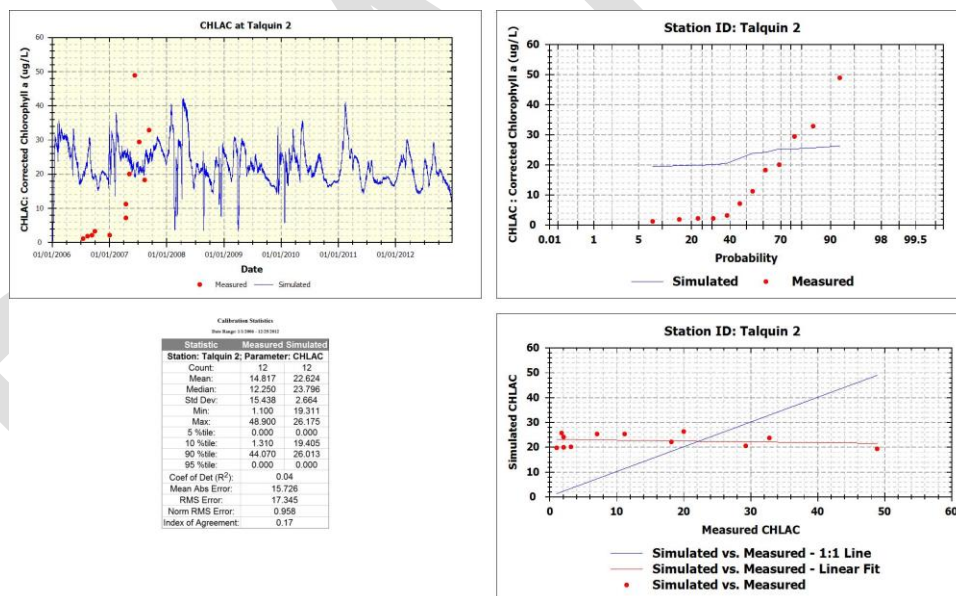


Figure 62 21FLLEONLCT0L3042284573: Talquin 2 for Chlorophyll a

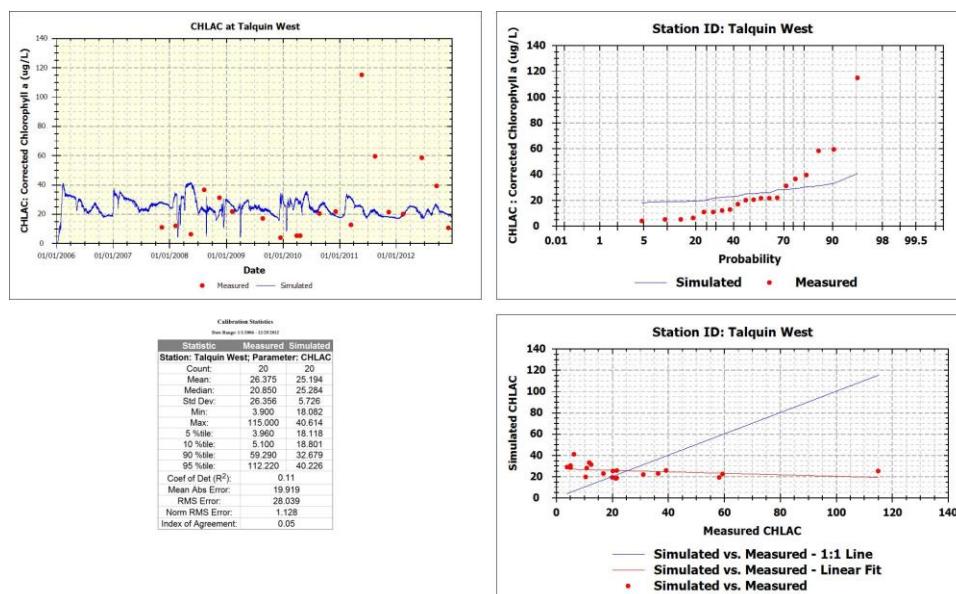


Figure 63 21FLLEONT0D3041488461: Lake Talquin West for Chlorophyll a

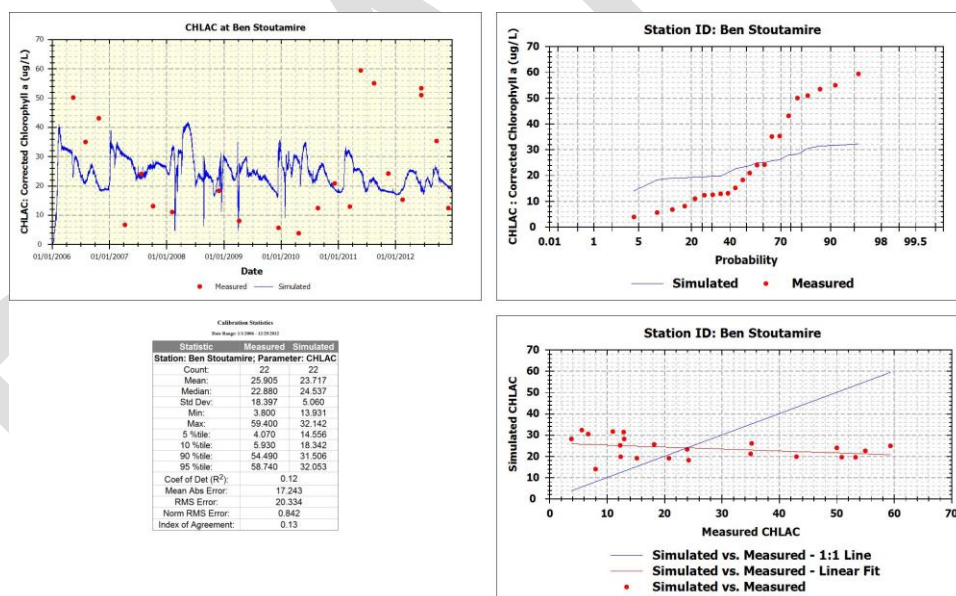


Figure 64 21FLLEONLCOC3040784610: Lake Talquin (Ben Stoutamire Boat Landing) for Chlorophyll a

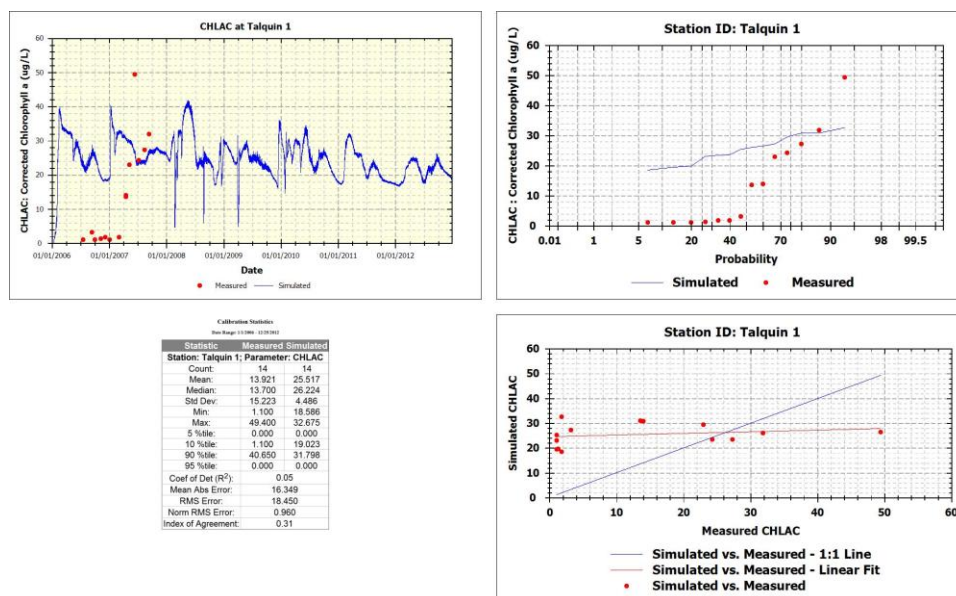


Figure 65 21FLLEONLCT0B3040284630: Talquin 1 for Chlorophyll a

Nitrogen

Figure 66 through Figure 86 illustrate quantitative and qualitative comparisons of the model predictions for total nitrogen, NH_4 , and NO_3O_2 to available direct field measurements.

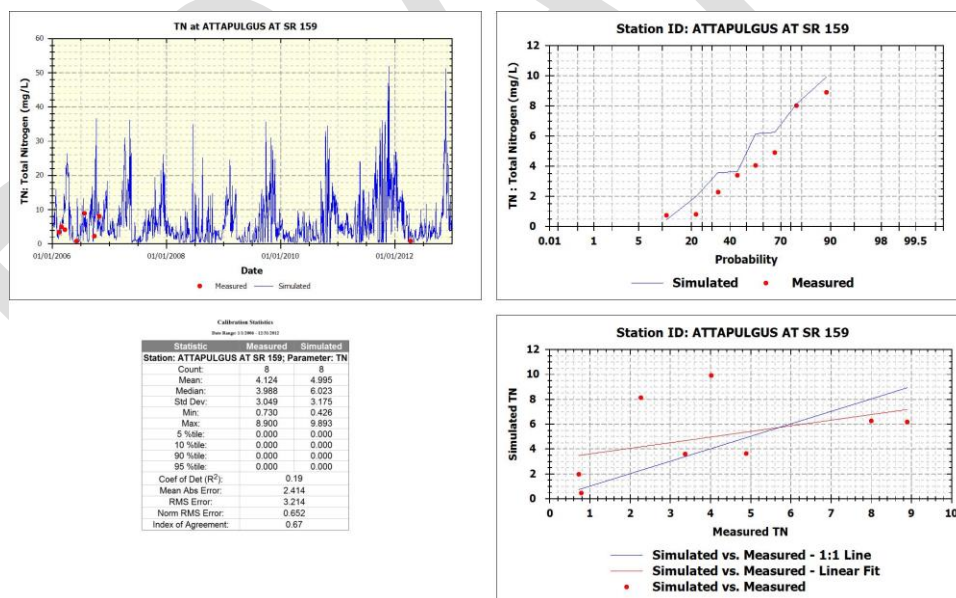


Figure 66 Total Nitrogen Calibration Attapulugus Creek at SR 159

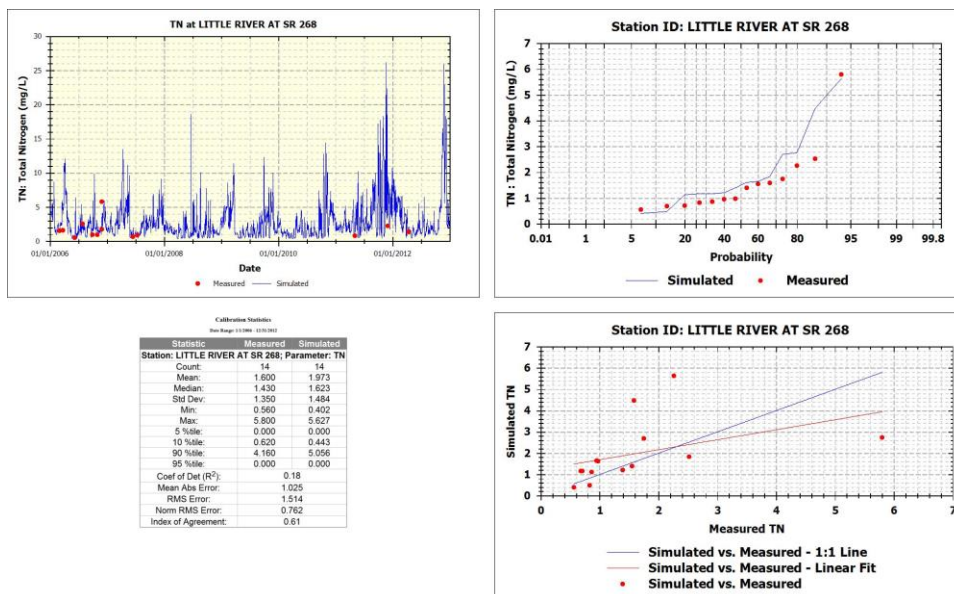


Figure 67 Total Nitrogen Calibration Little River at SR 268

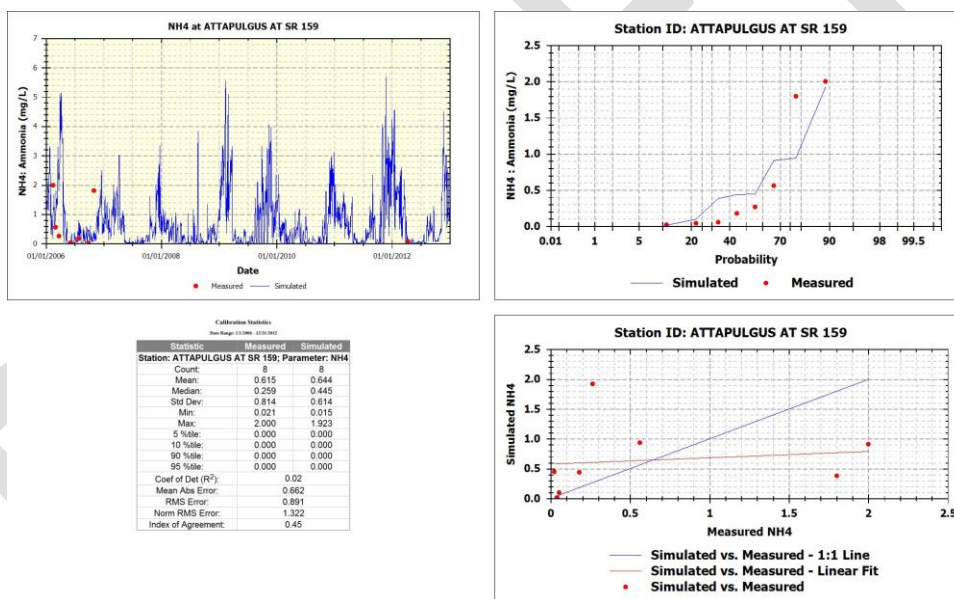


Figure 68 NH4 Calibration Attapulcus Creek at SR 159

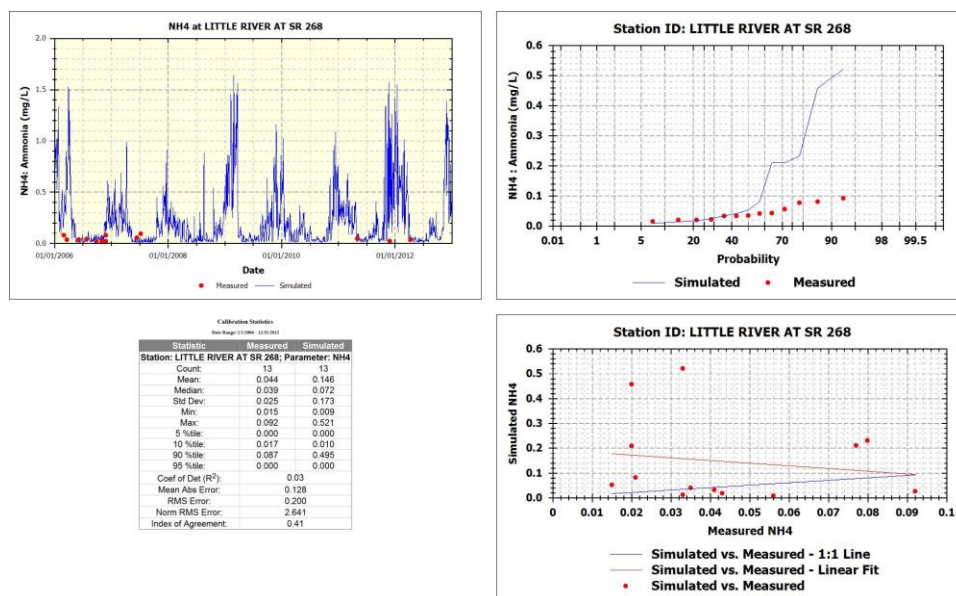


Figure 69 NH4 Calibration Little River at SR 268

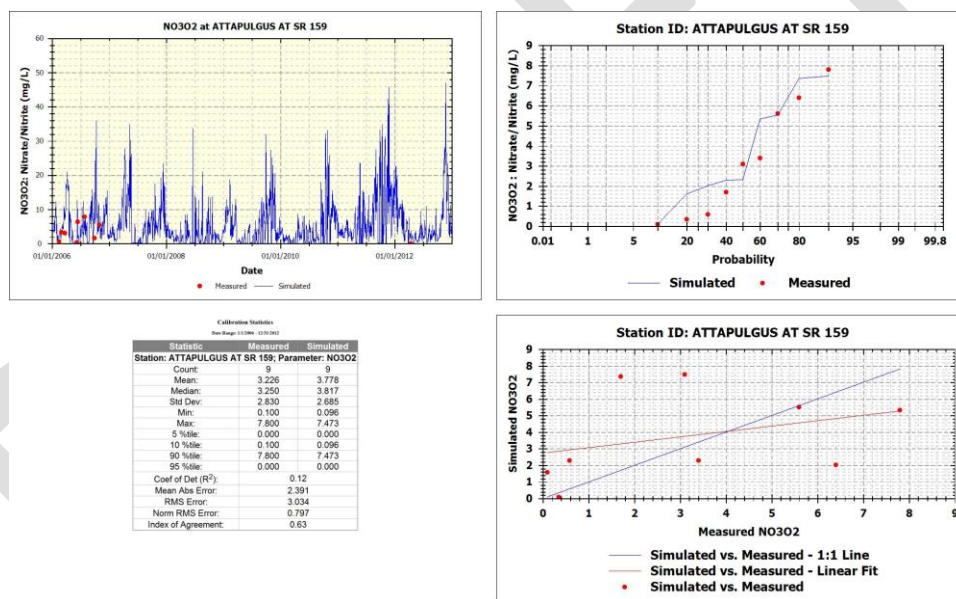


Figure 70 Nitrate/Nitrite Calibration Attapulgus Creek at SR 159

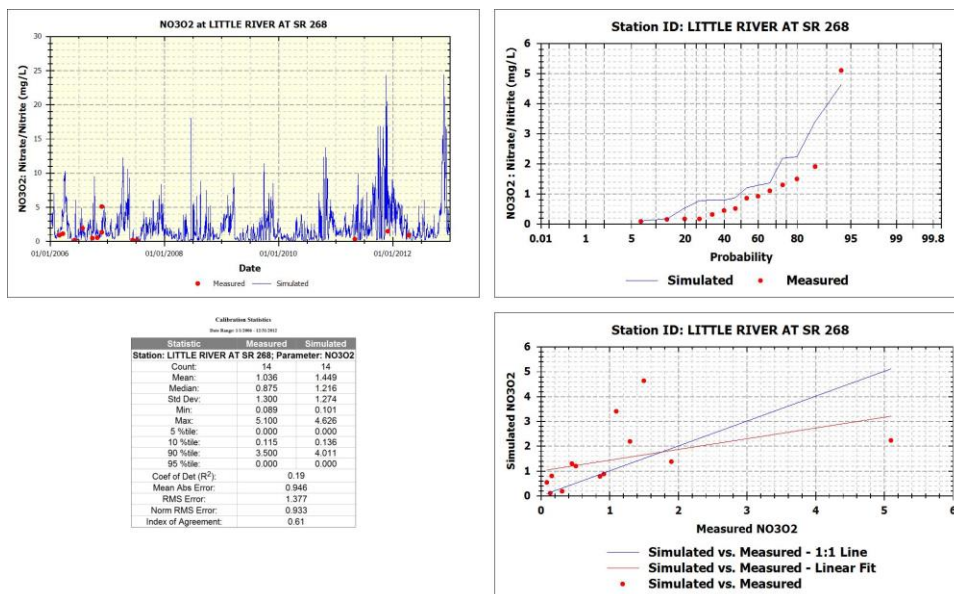


Figure 71 Nitrate/Nitrite Calibration Little River at SR 268

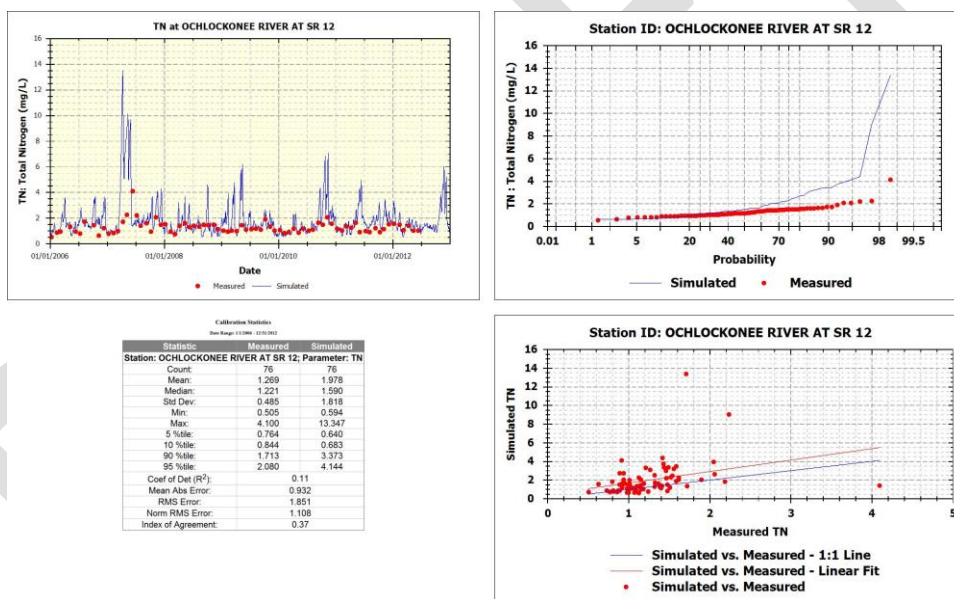


Figure 72 Total Nitrogen Calibration Ochlockonee River at SR 12

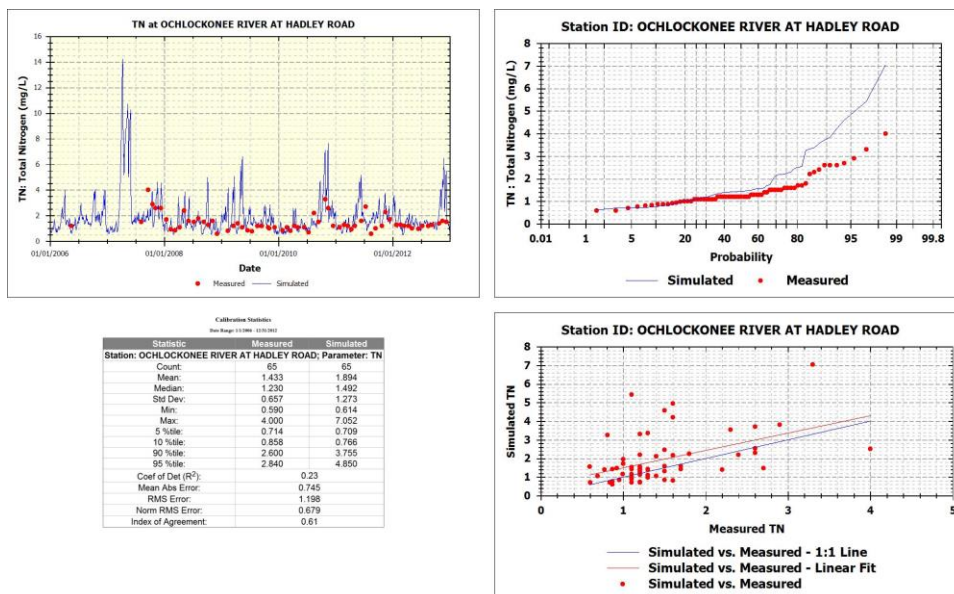


Figure 73 Total Nitrogen Calibration Ochlockonee River Near Hadley Road

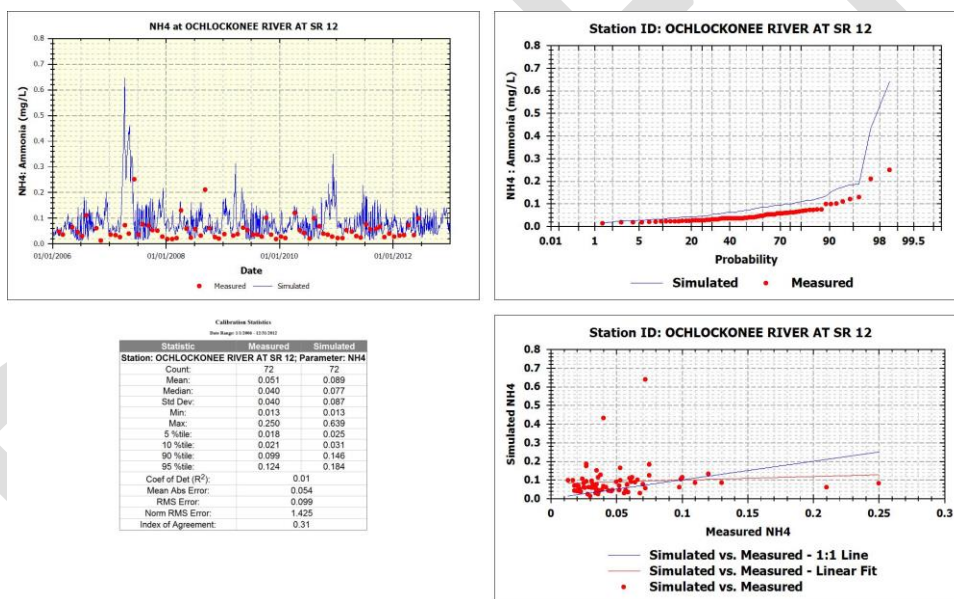


Figure 74 Ammonia Calibration Ochlockonee River at SR 12

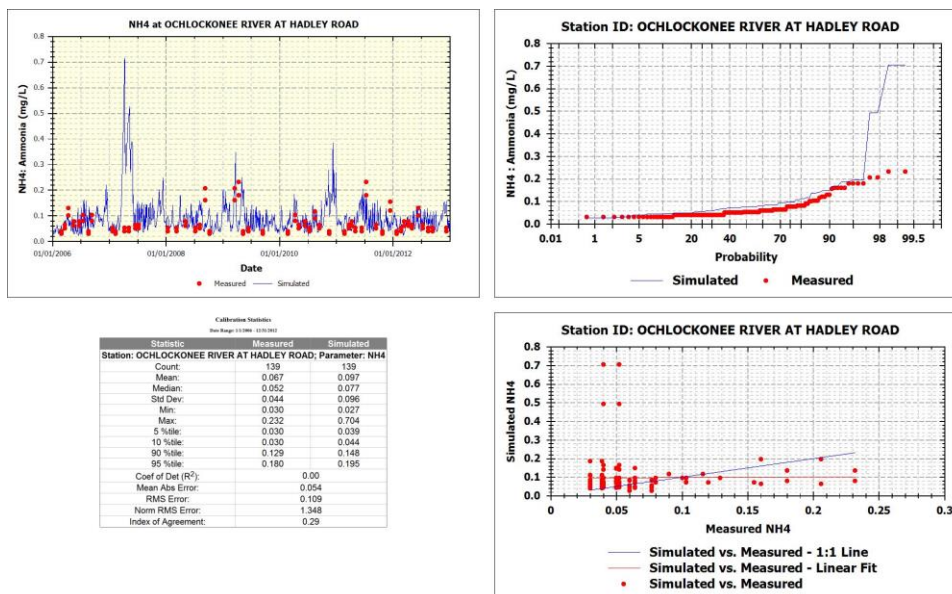


Figure 75 Ammonia Calibration Ochlockonee River Near Hadley Road

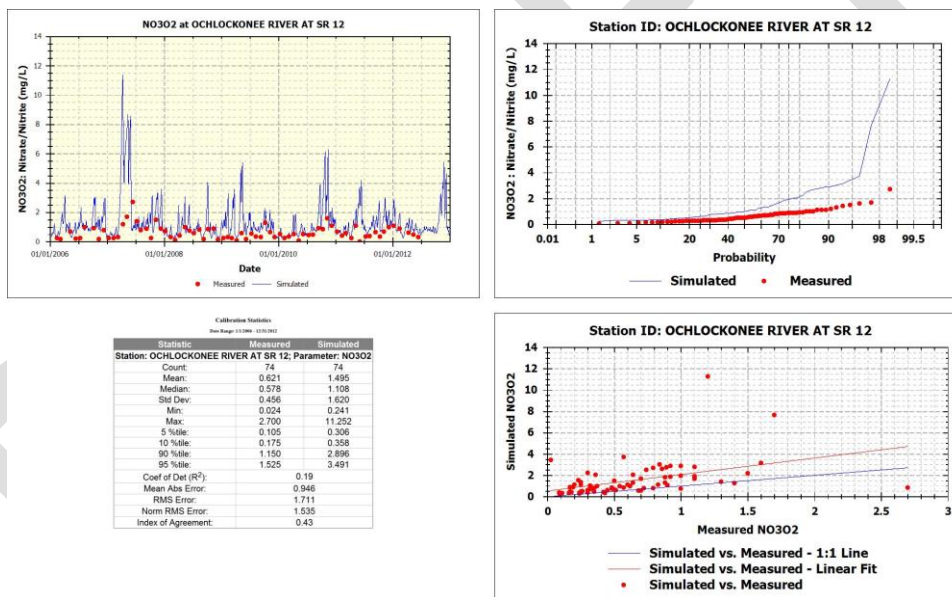


Figure 76 Nitrate Calibration Ochlockonee River at SR 12

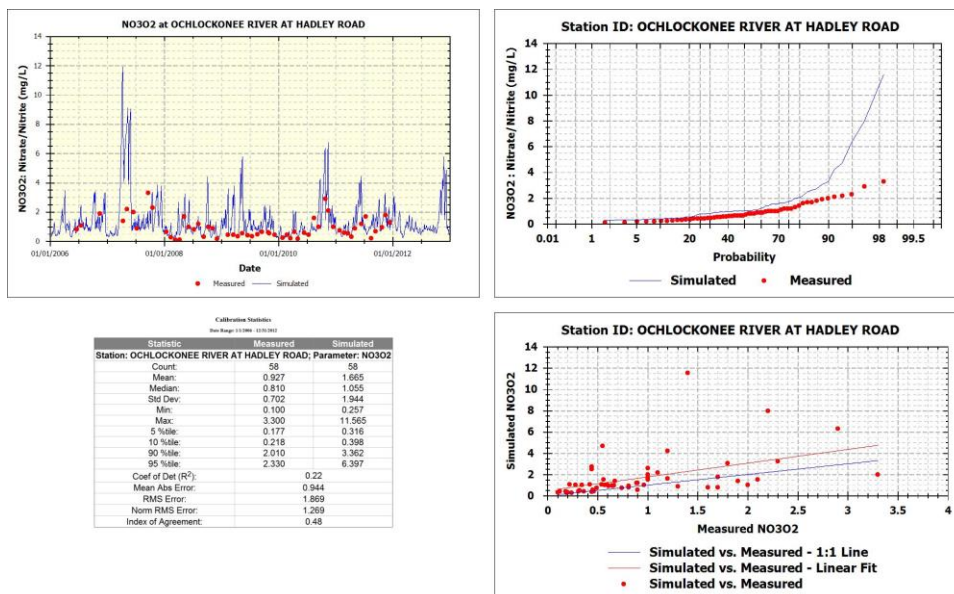


Figure 77 Nitrate/Nitrite Calibration Ochlockonee River Near Hadley Road

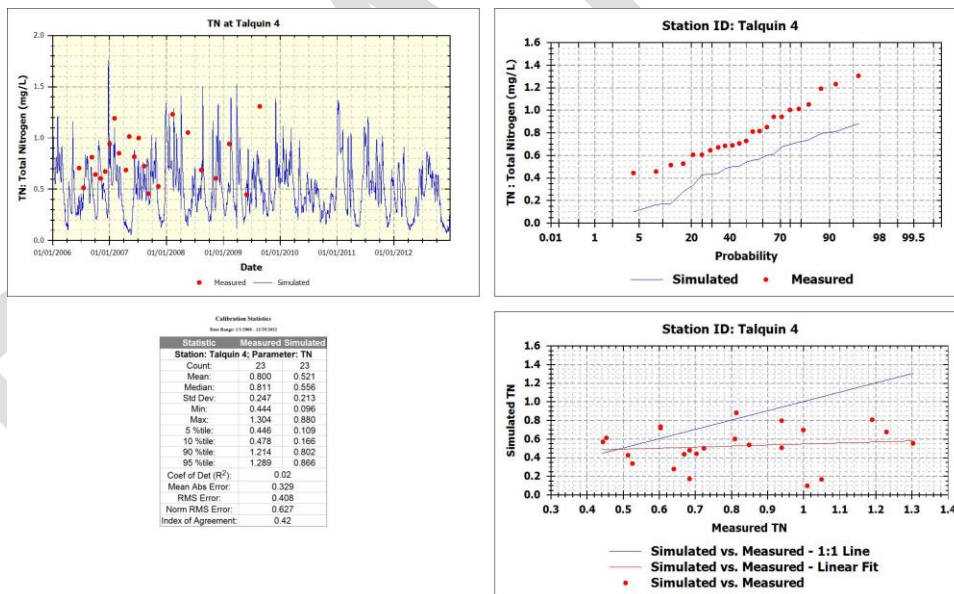


Figure 78 21FLLEONLCT0C3045884492: Talquin 4 for Total Nitrogen

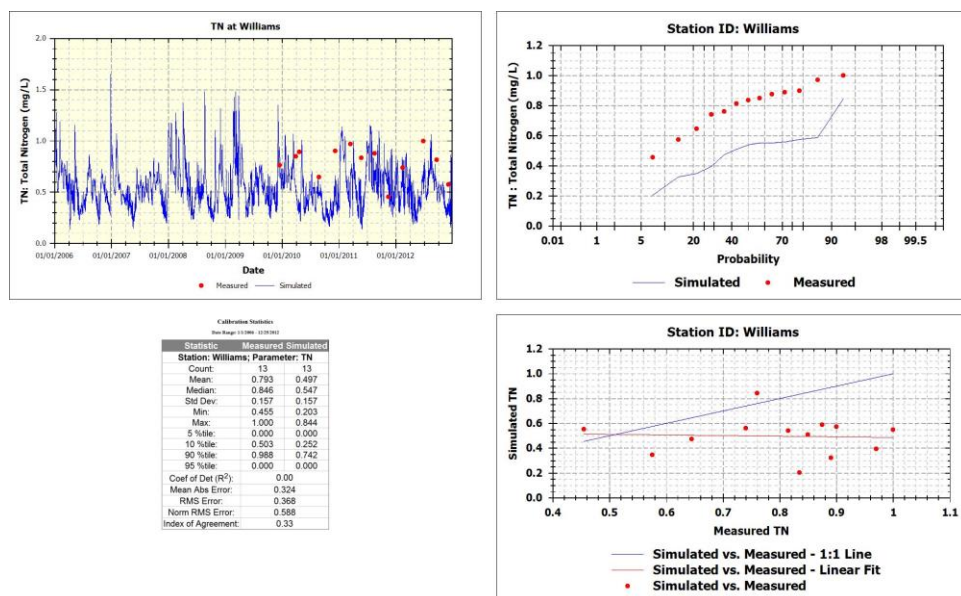


Figure 79 21FLLEONLCT03045184523: Lake Talquin near Williams Landing for Total Nitrogen

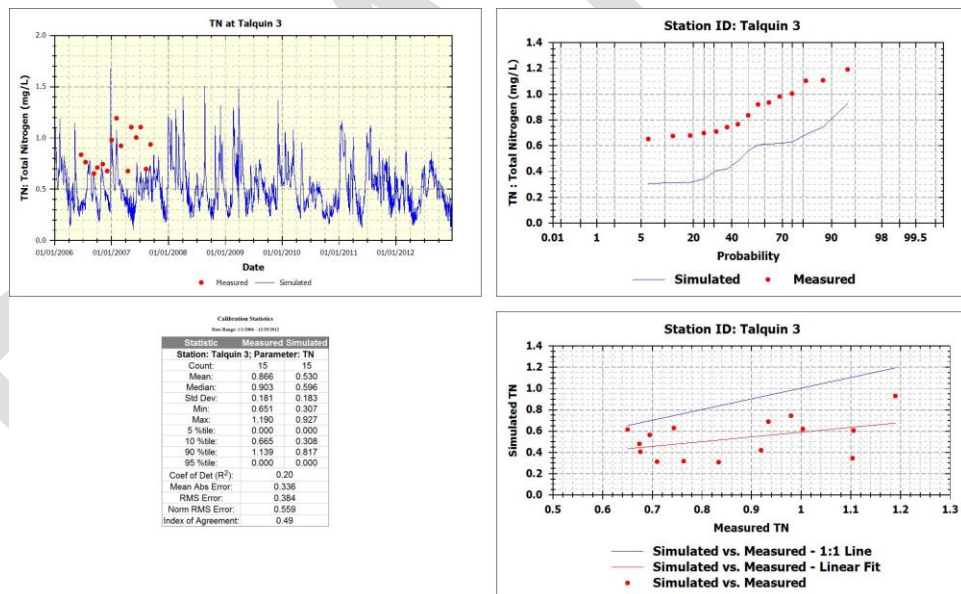


Figure 80 21FLLEONLCT0W3045084521: Talquin 3 for Total Nitrogen

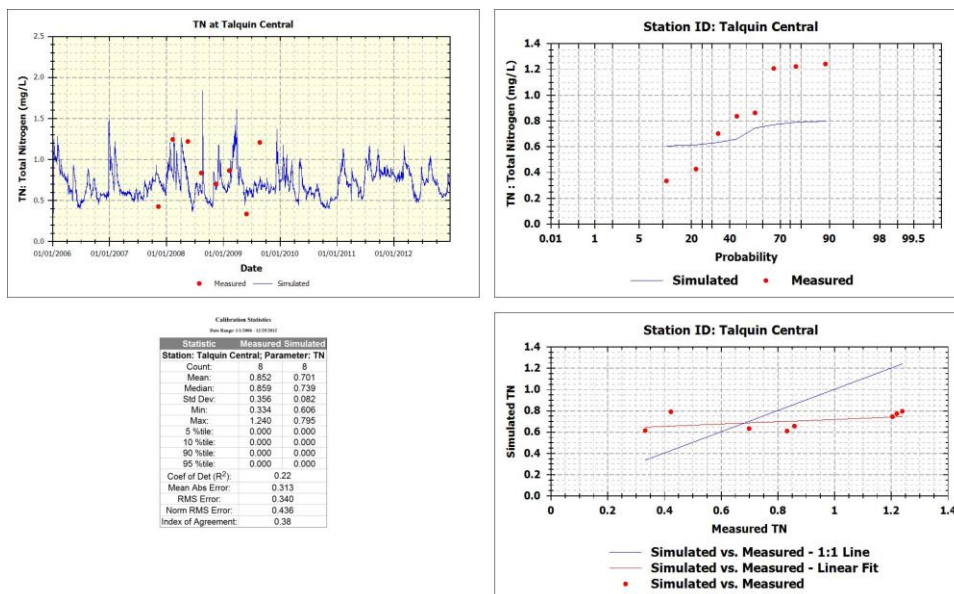


Figure 81 21FLLEONT0E3044084556: Lake Talquin Central for Total Nitrogen

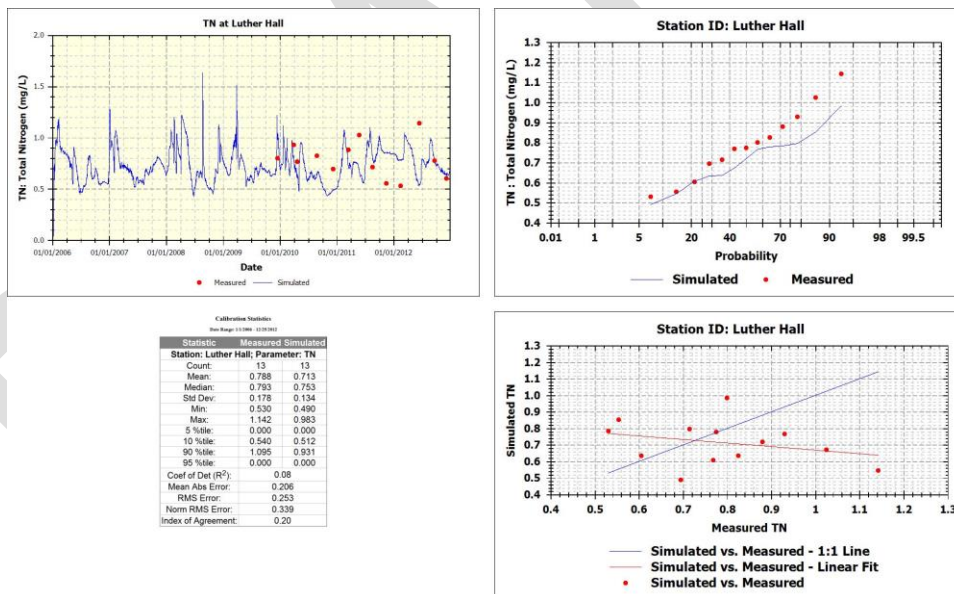


Figure 82 21FLLEONLCT03042384172: Lake Talquin near Luther Hall Landing for Total Nitrogen

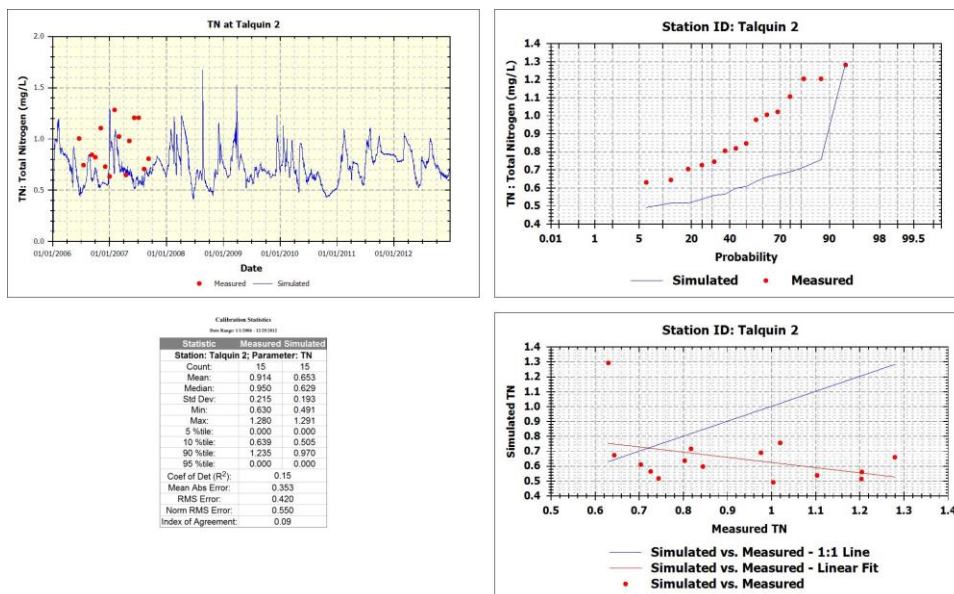


Figure 83 21FLLEONLCT0L3042284573: Talquin 2 for Total Nitrogen

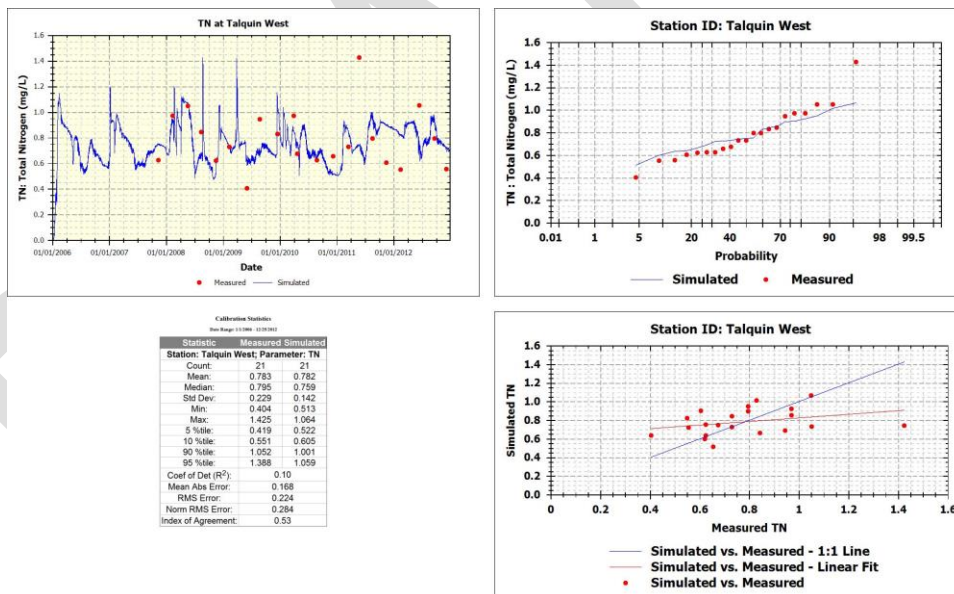


Figure 84 21FLLEONT0D3041488461: Lake Talquin West for Total Nitrogen

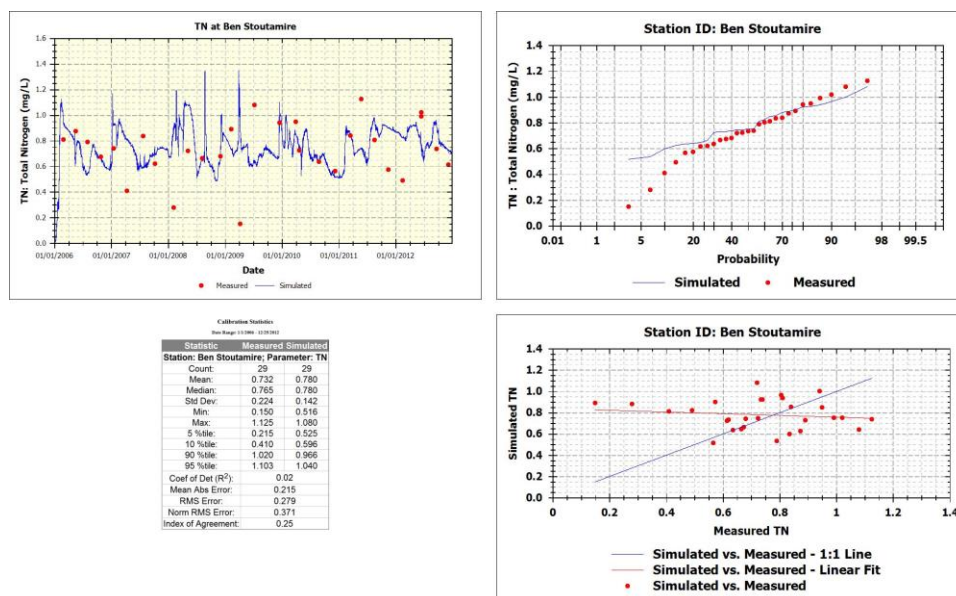


Figure 85 21FLLEONLCOC3040784610: Lake Talquin (Ben Stoutamire Boat Landing) for Total Nitrogen

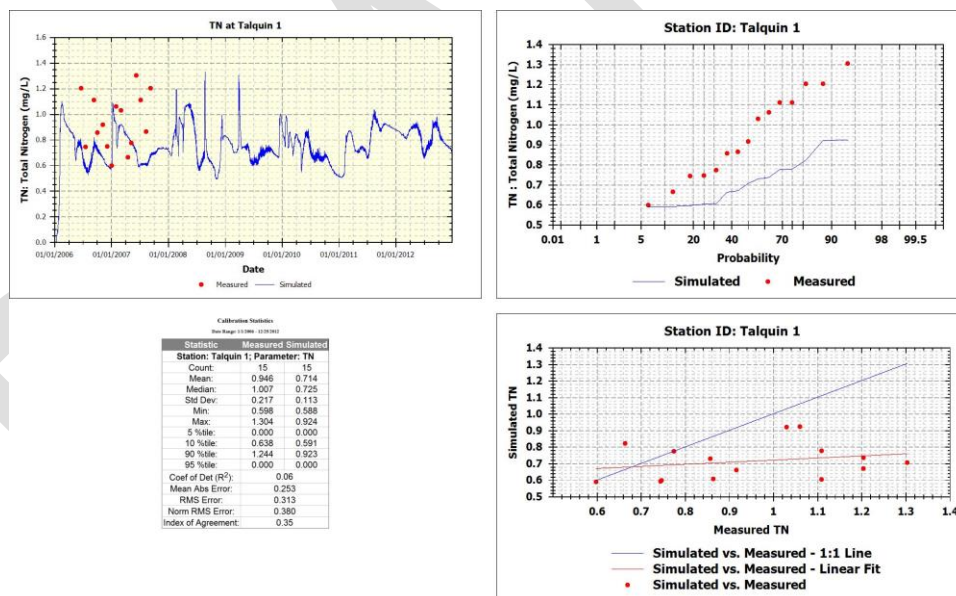


Figure 86 21FLLEONLCT0B3040284630: Talquin 1 for Total Nitrogen

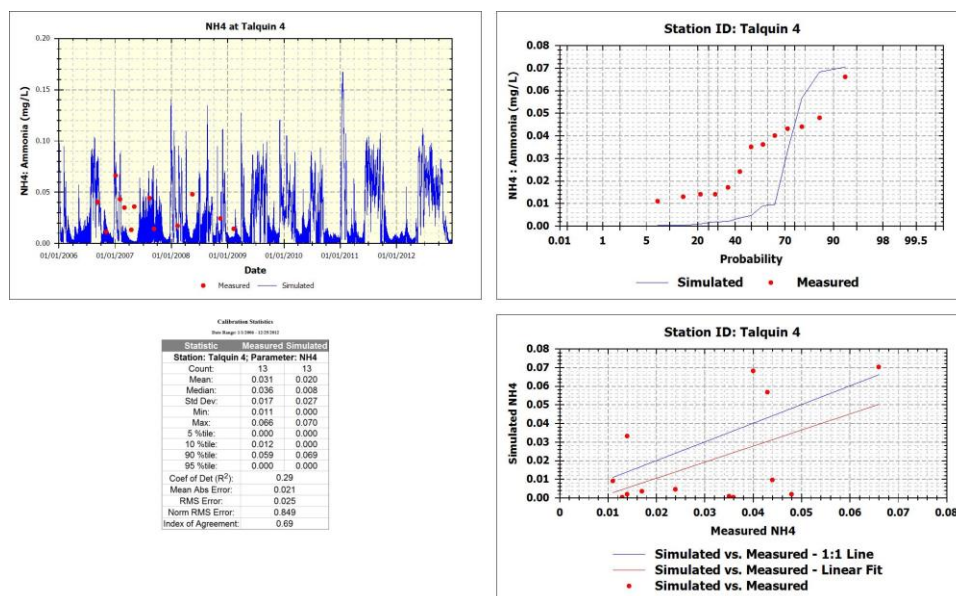


Figure 87 21FLLEONLCT0C3045884492: Talquin 4 for Ammonia

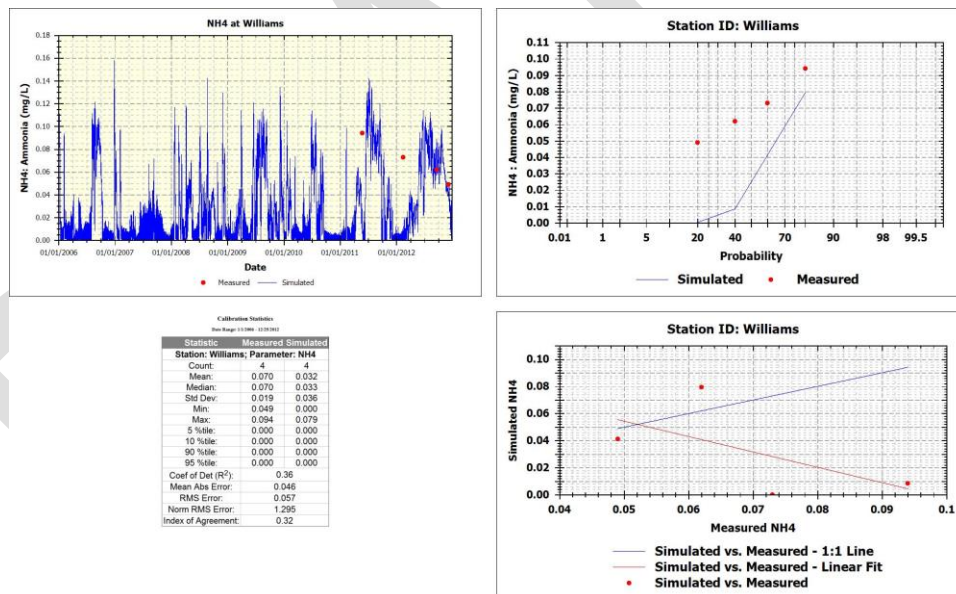


Figure 88 21FLLEONLCT03045184523: Lake Talquin near Williams Landing for Ammonia

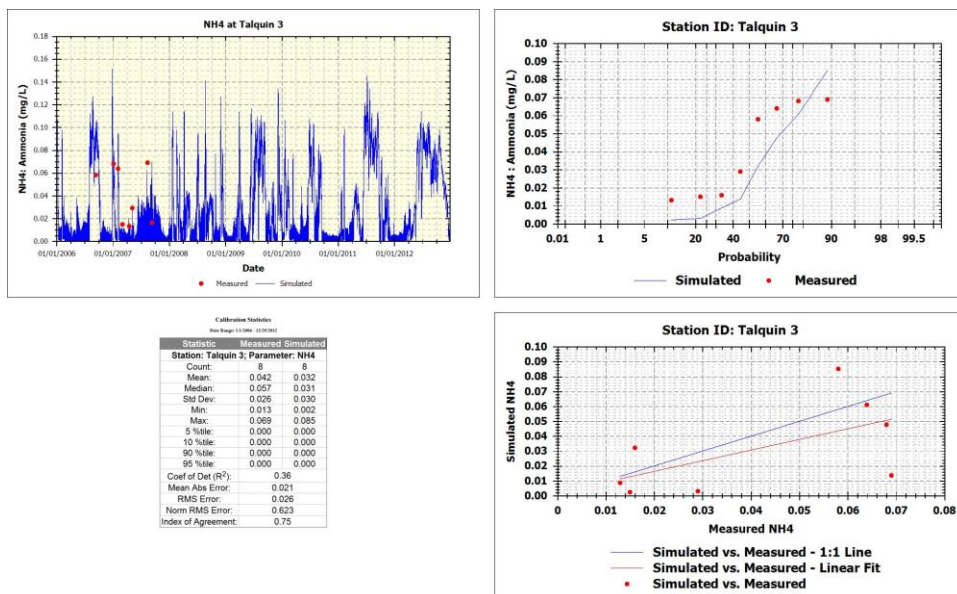


Figure 89 21FLLEONLCT0W3045084521: Talquin 3 for Ammonia

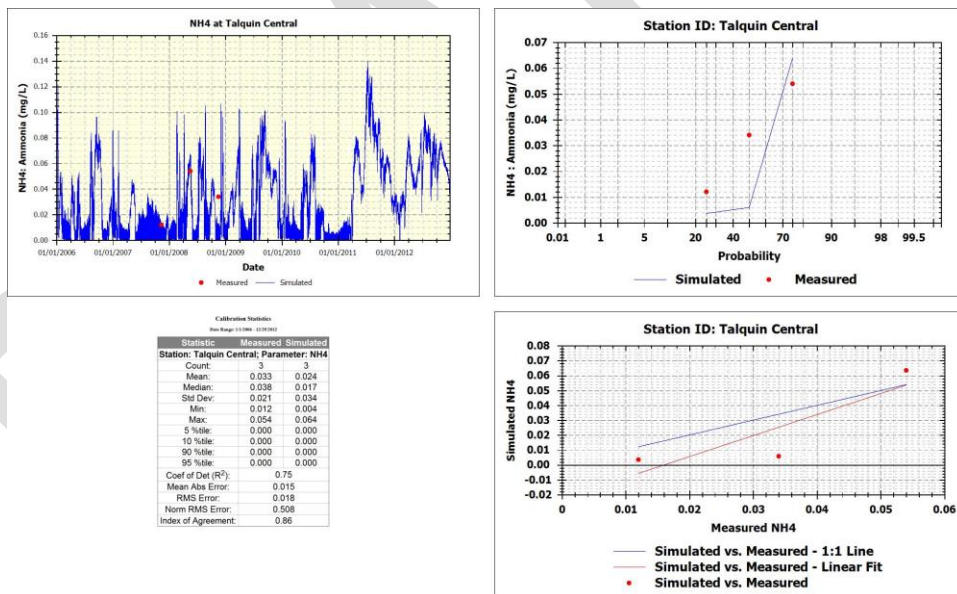


Figure 90 21FLLEONT0E3044084556: Lake Talquin Central for Ammonia

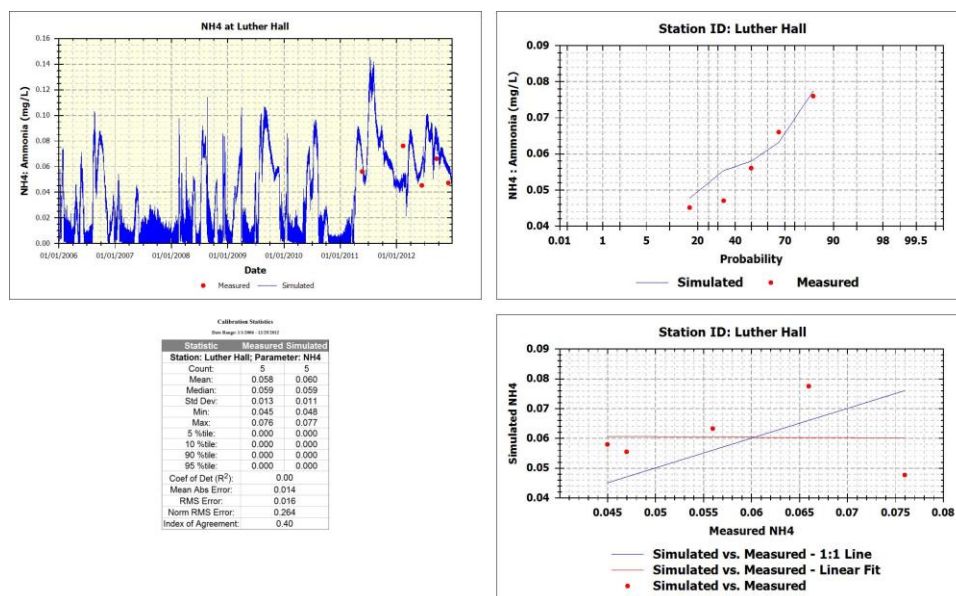


Figure 91 21FLLEONLCT03042384172: Lake Talquin near Luther Hall Landing for Ammonia

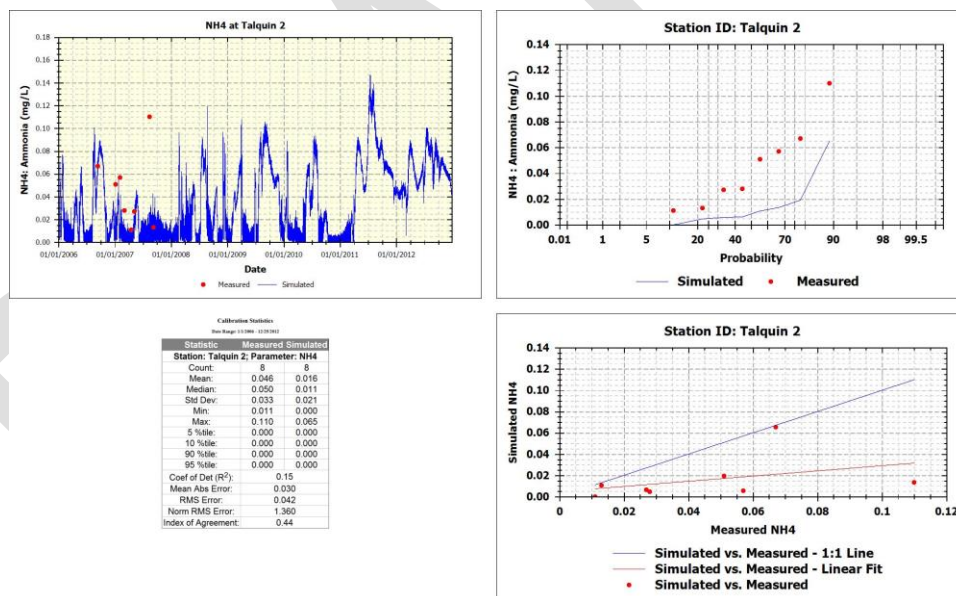


Figure 92 21FLLEONLCT0L3042284573: Talquin 2 for Ammonia

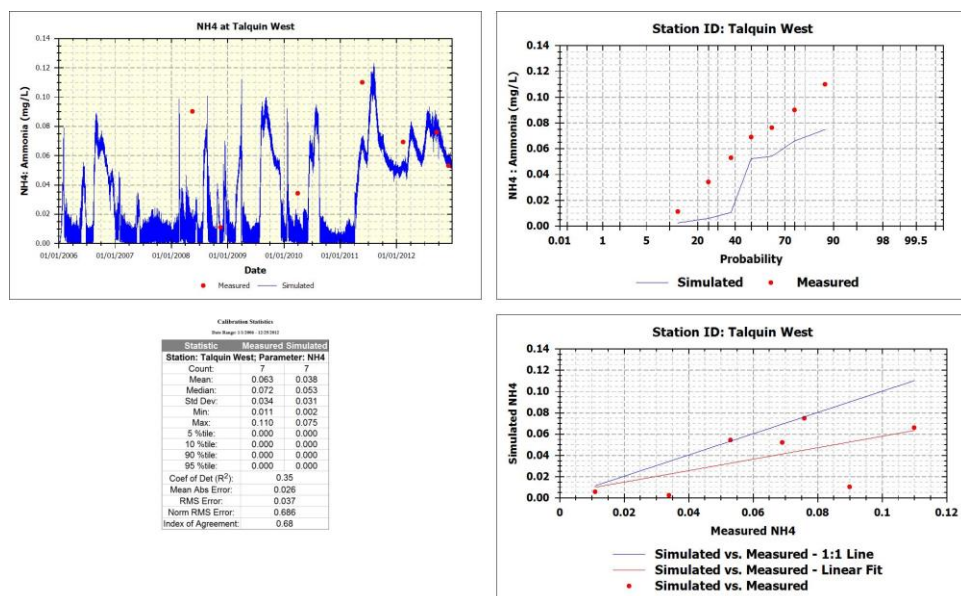


Figure 93 21FLLEONT0D3041488461: Lake Talquin West for Ammonia

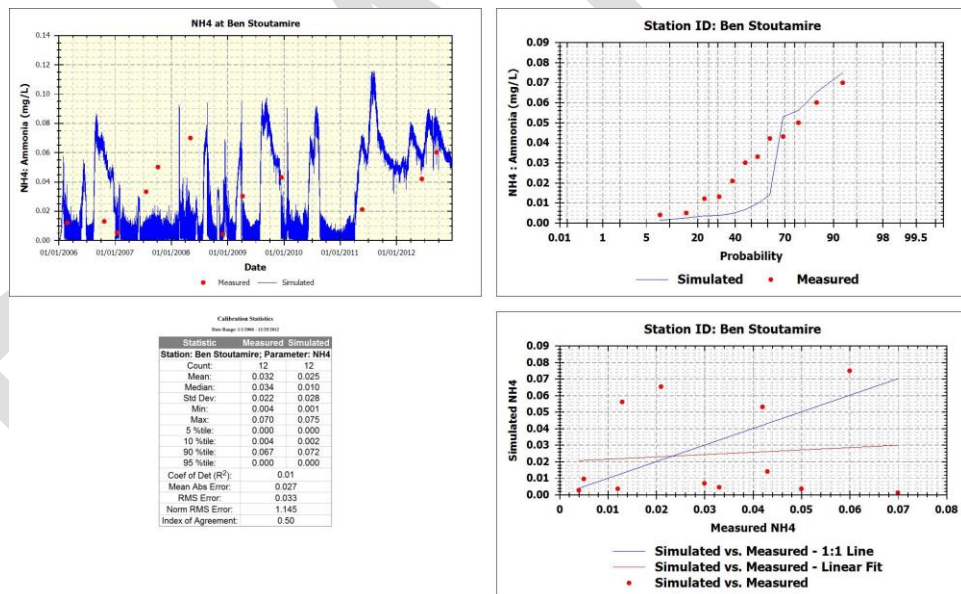


Figure 94 21FLLEONLCOC3040784610: Lake Talquin (Ben Stoutamire Boat Landing) for Ammonia

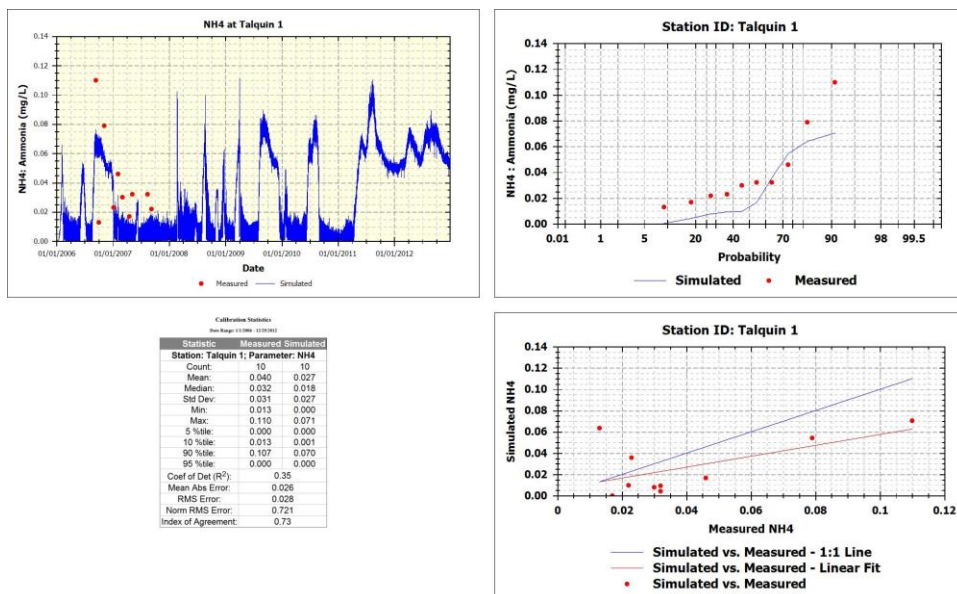


Figure 95 21FLLEONLCT0B3040284630: Talquin 1 for Ammonia

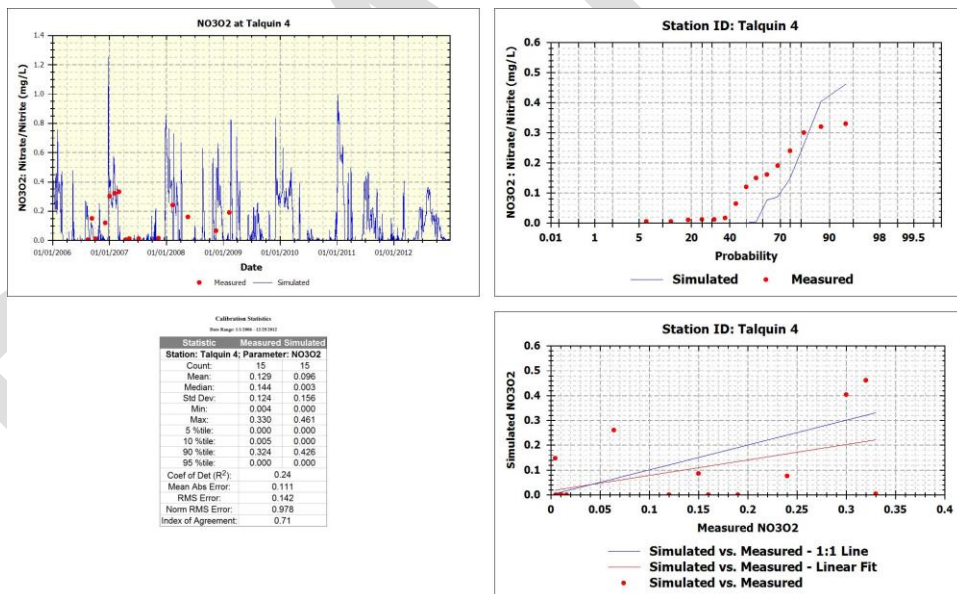


Figure 96 21FLLEONLCT0C3045884492: Talquin 4 for Nitrate

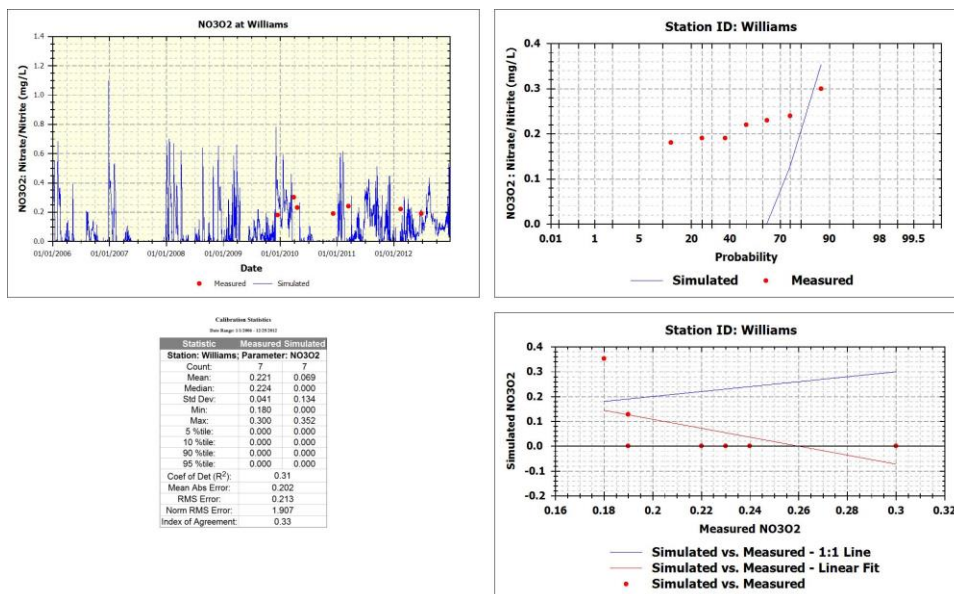


Figure 97 21FLLEONLCT03045184523: Lake Talquin near Williams Landing for Nitrate

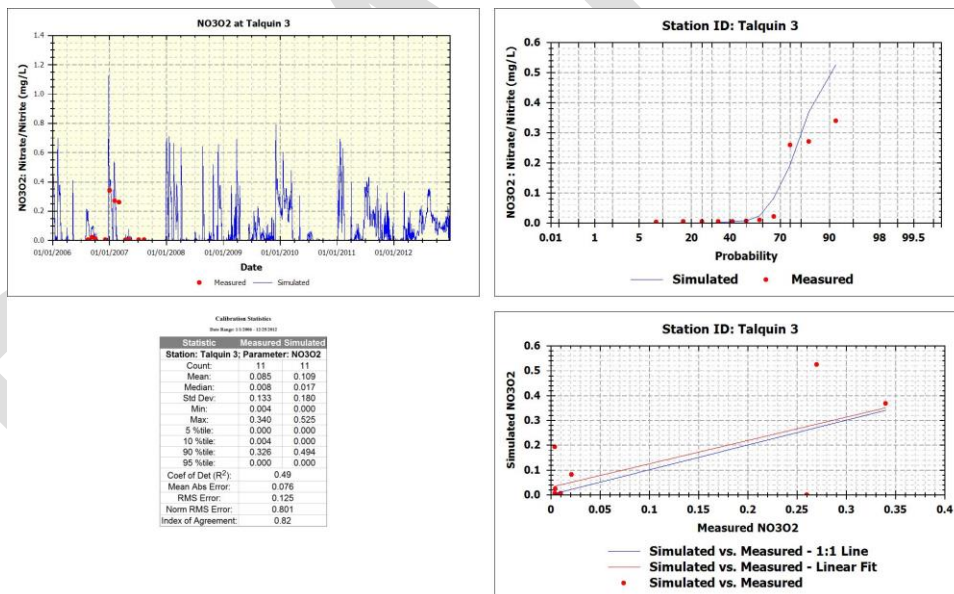


Figure 98 21FLLEONLCT0W3045084521: Talquin 3 for Nitrate

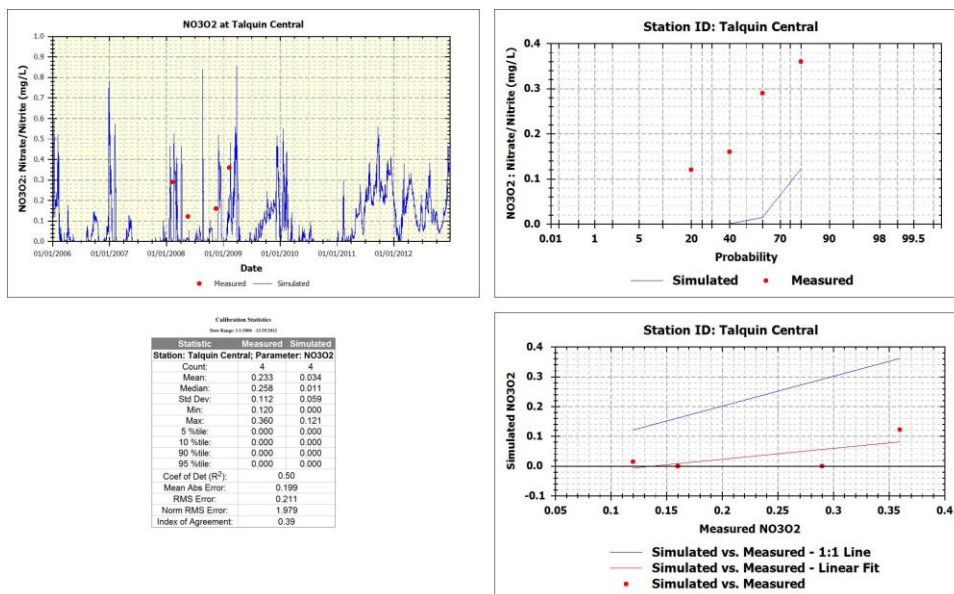


Figure 99 21FLLEONT0E3044084556: Lake Talquin Central for Nitrate

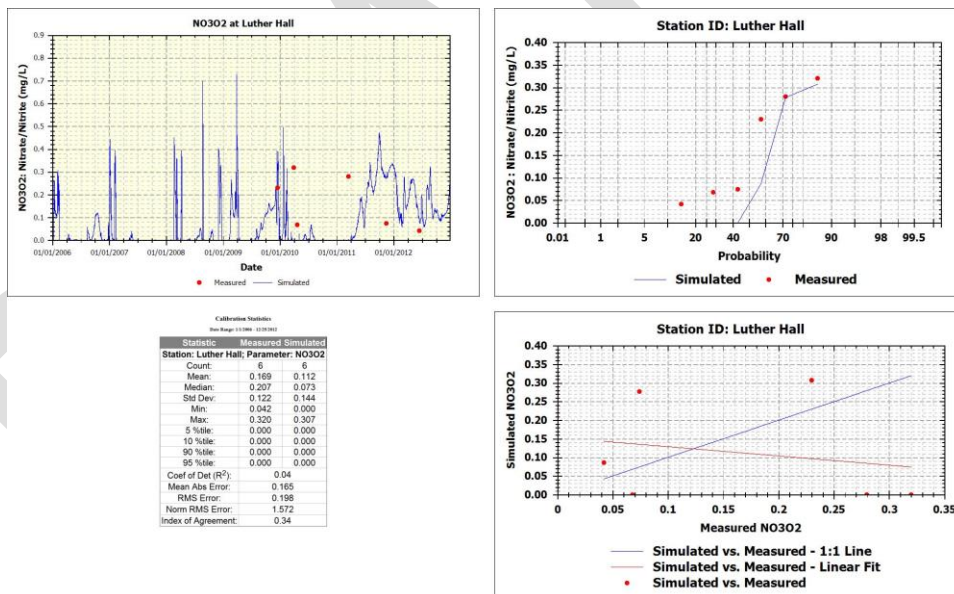


Figure 100 21FLLEONLCT03042384172: Lake Talquin near Luther Hall Landing for Nitrate

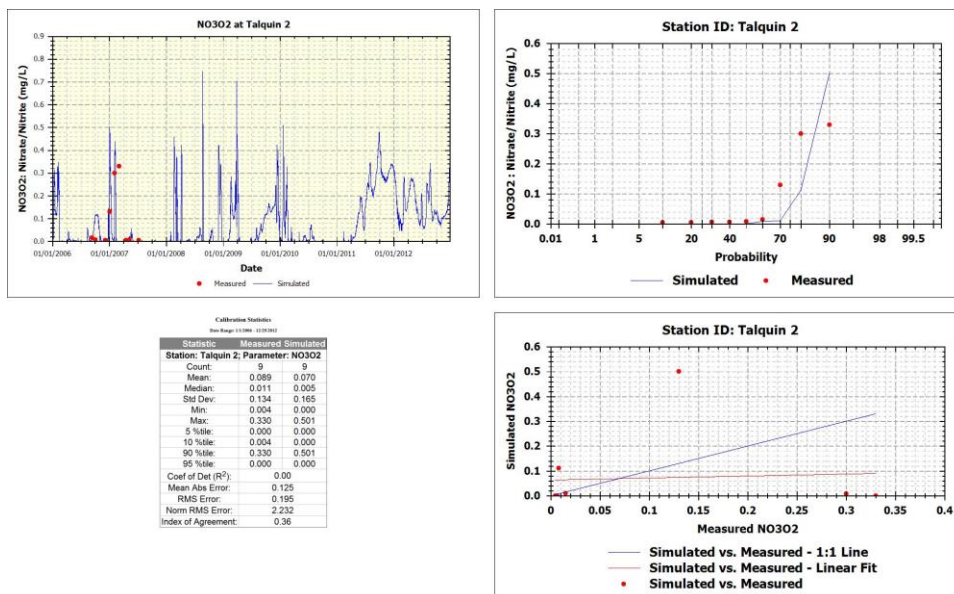


Figure 101 21FLLEONLCT0L3042284573: Talquin 2 for Nitrate

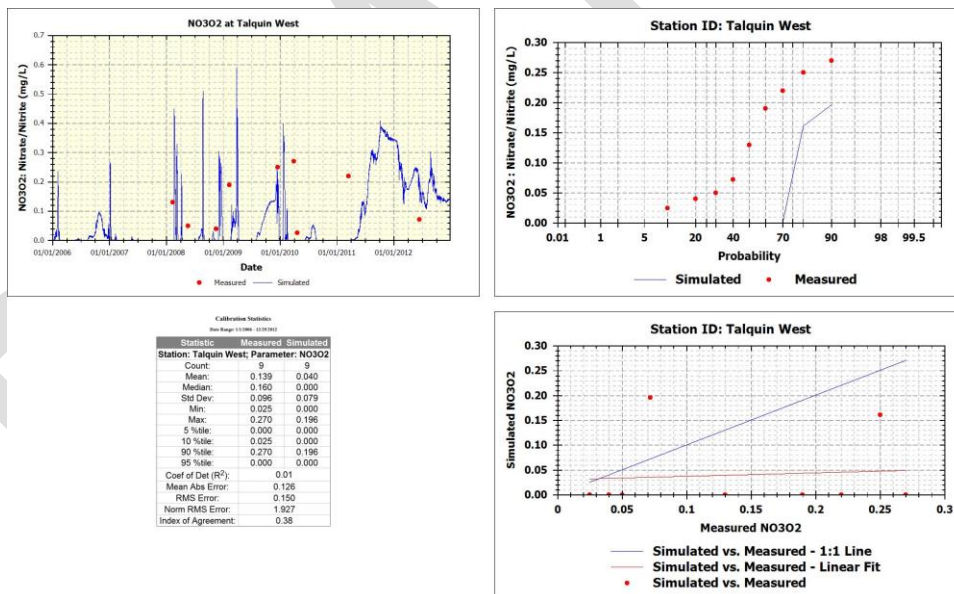


Figure 102 21FLLEONT0D3041488461: Lake Talquin West for Nitrate

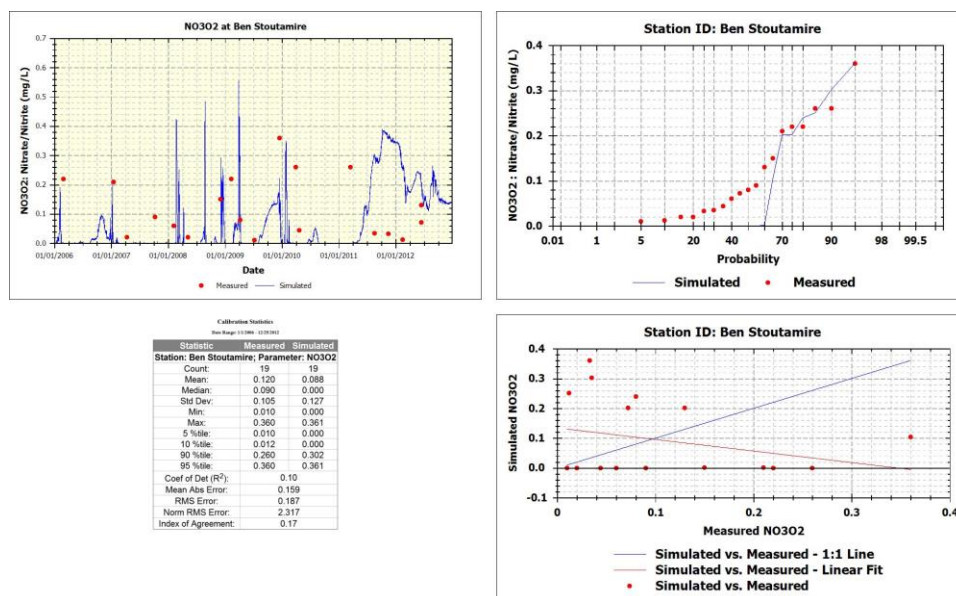


Figure 103 21FLLEONLCOC3040784610: Lake Talquin (Ben Stoutamire Boat Landing) for Nitrate

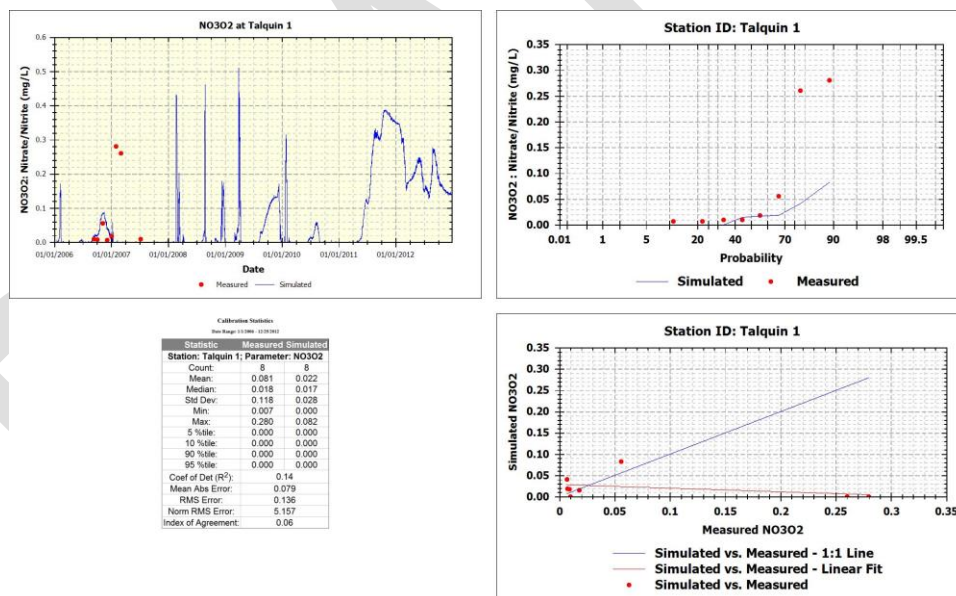


Figure 104 21FLLEONLCT0B3040284630: Talquin 1 for Nitrate

Phosphorus

Figure 105 through Figure 119 illustrate quantitative and qualitative comparison of the model predictions for total phosphorus and ortho-phosphate to direct field measurements.

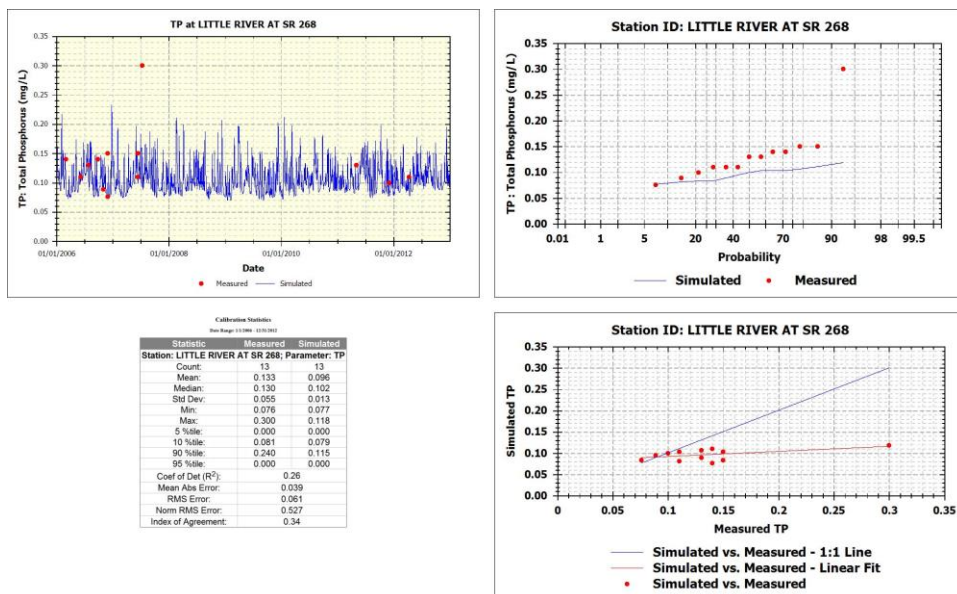


Figure 105 Total Phosphorus Calibration Little River @ SR268

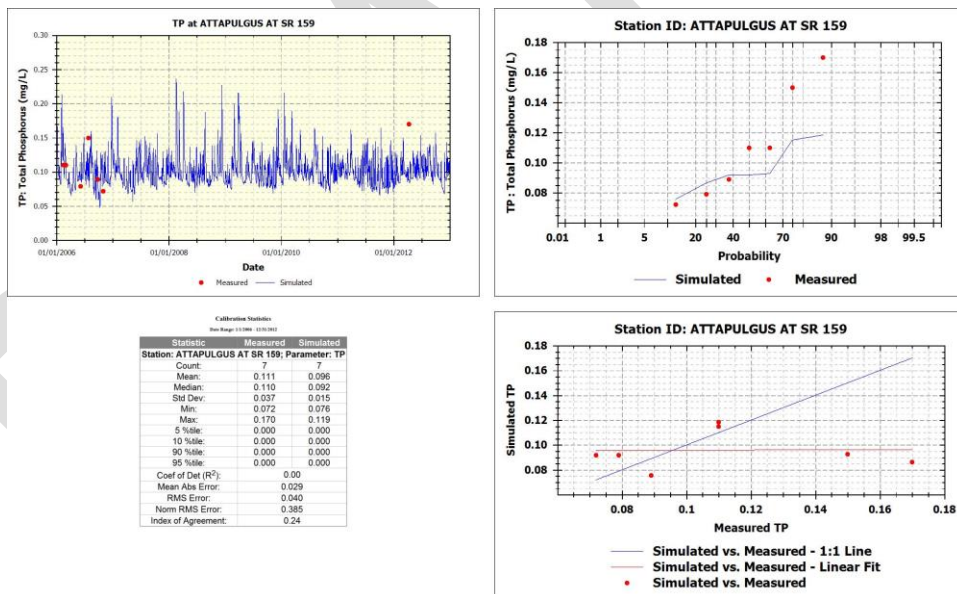


Figure 106 Total Phosphorus Calibration Attapulugus Creek at SR 159

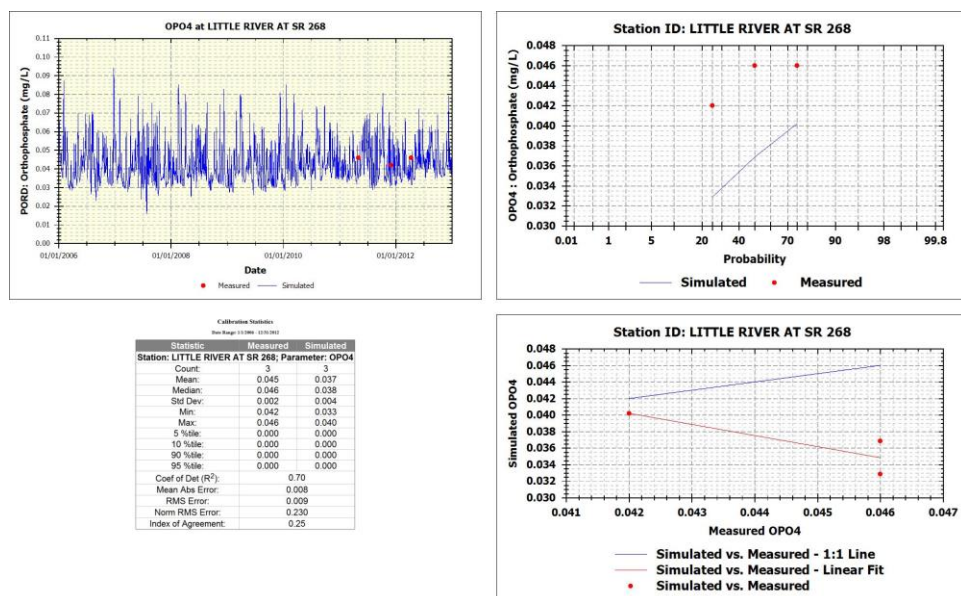


Figure 107 Ortho-Phosphate Calibration Little River @ SR268

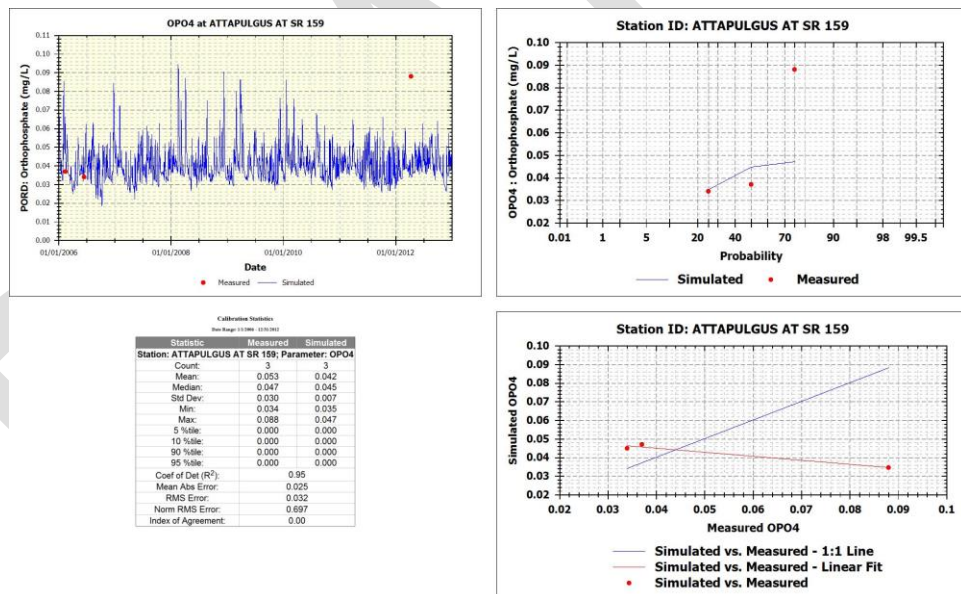


Figure 108 Ortho-Phosphate Calibration Attapulugus Creek at SR 159

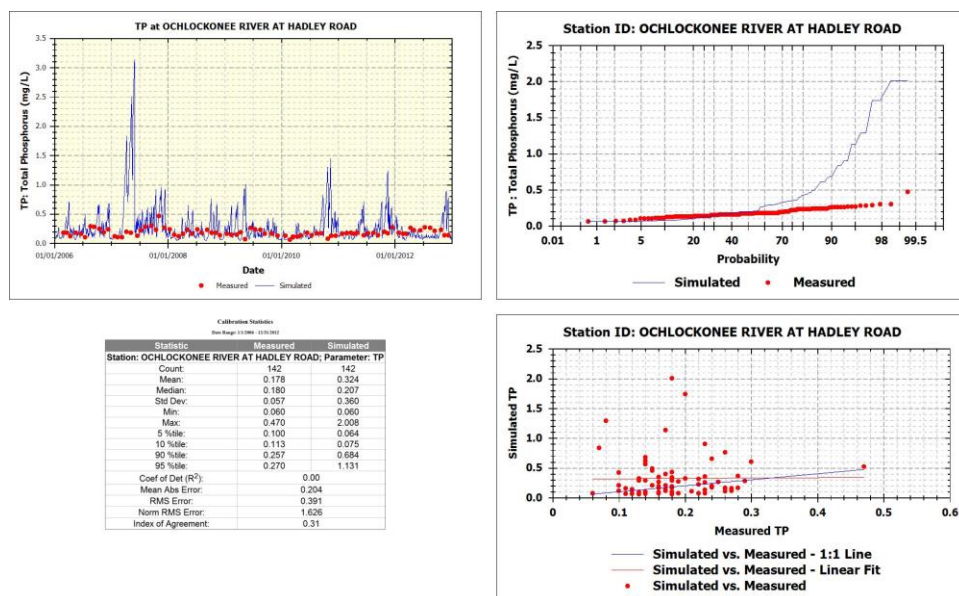


Figure 109 Total Phosphorus Calibration Ochlockonee River near Hadley Road

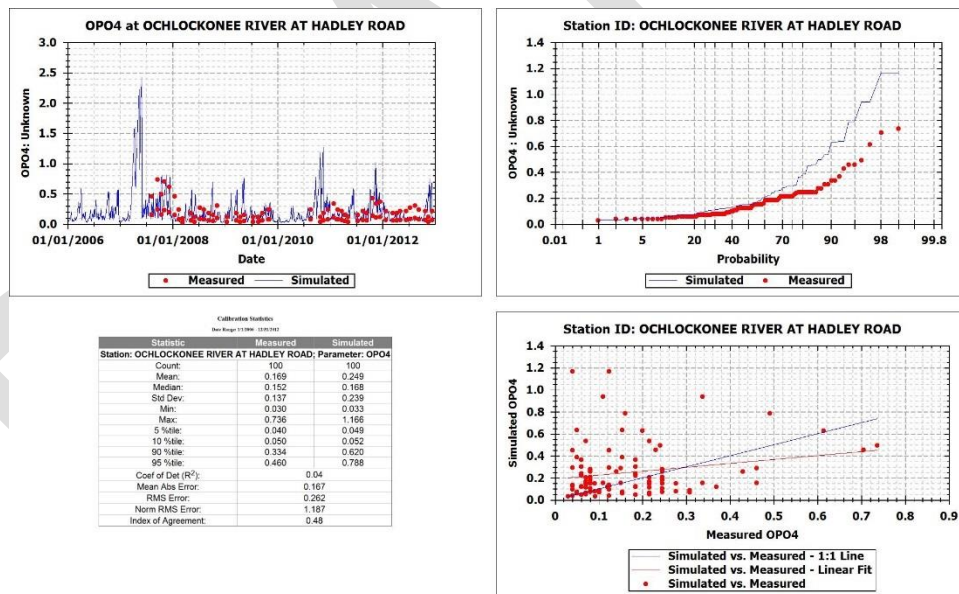


Figure 110 Orthophosphate Calibration Ochlockonee River near Hadley Road

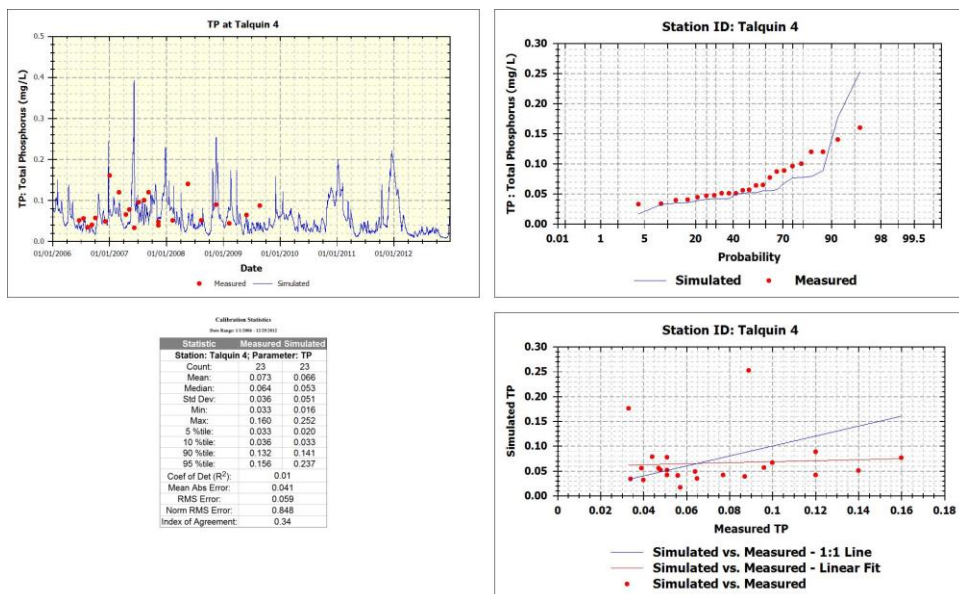


Figure 111 21FLLEONLCT0C3045884492: Talquin 4 for Total Phosphorus

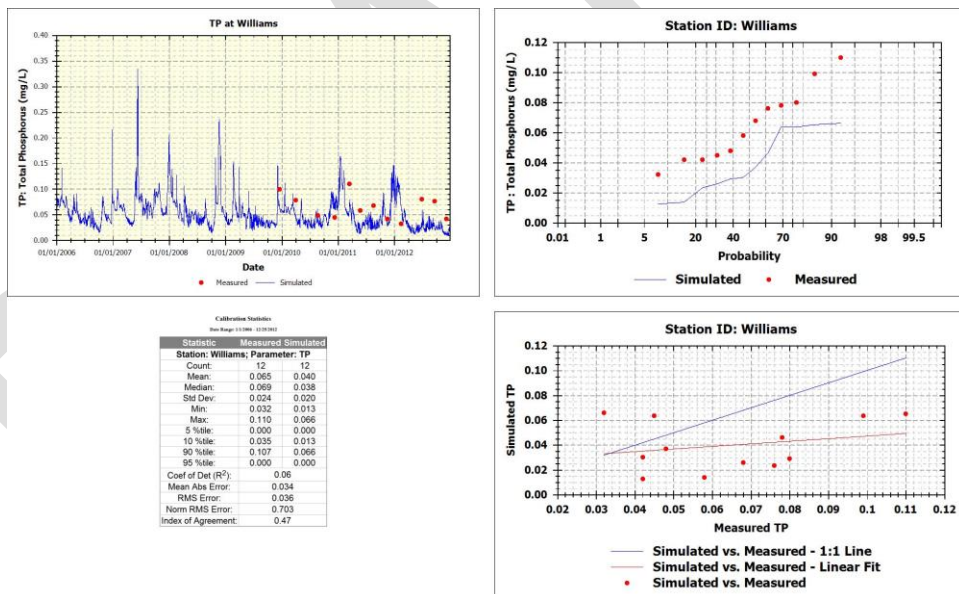


Figure 112 21FLLEONLCT03045184523: Lake Talquin near Williams Landing for Total Phosphorus

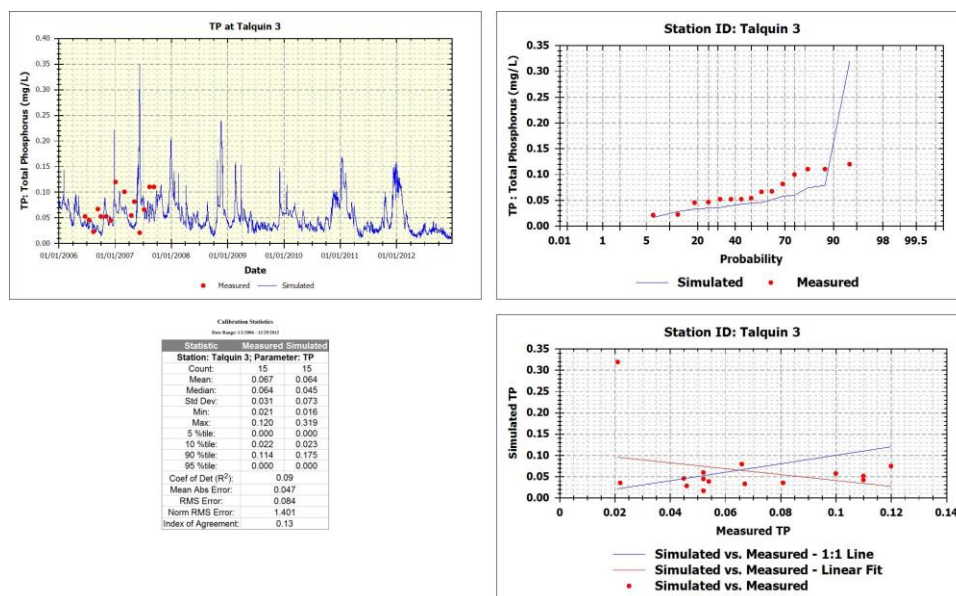


Figure 113 21FLLEONLCT0W3045084521: Talquin 3 for Total Phosphorus

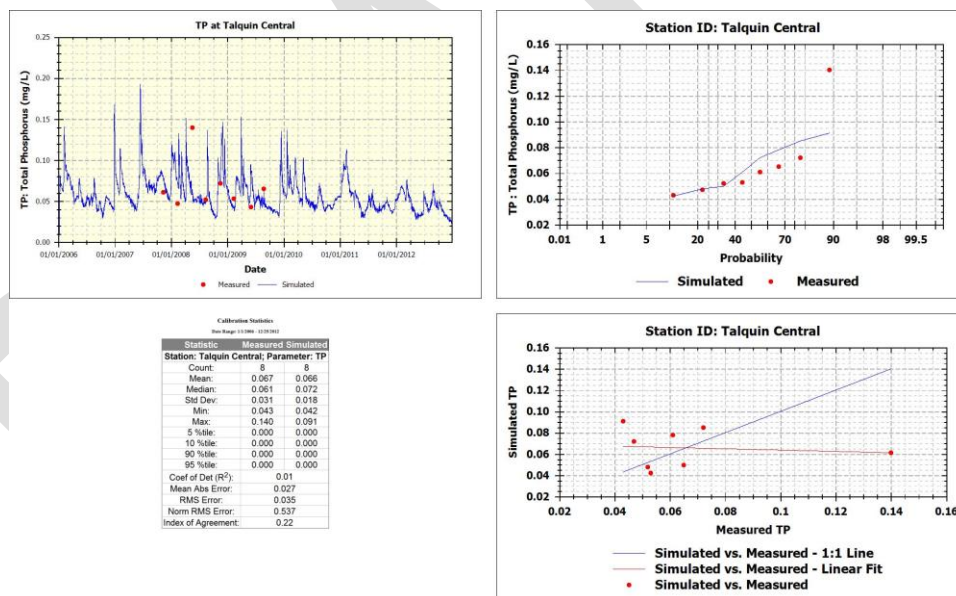


Figure 114 21FLLEONT0E3044084556: Lake Talquin Central for Total Phosphorus

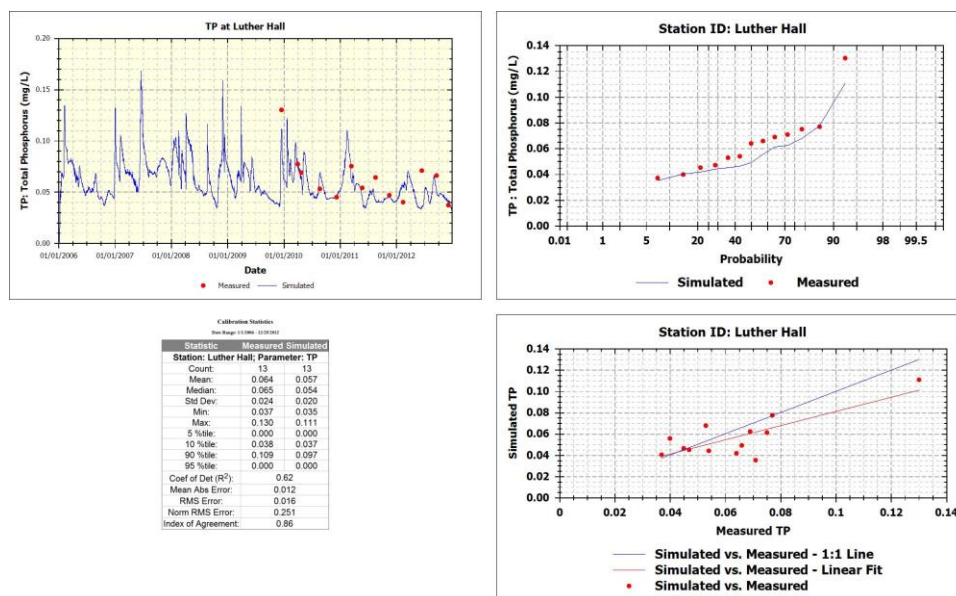


Figure 115 21FLLEONLCT03042384172: Lake Talquin near Luther Hall Landing for Total Phosphorus

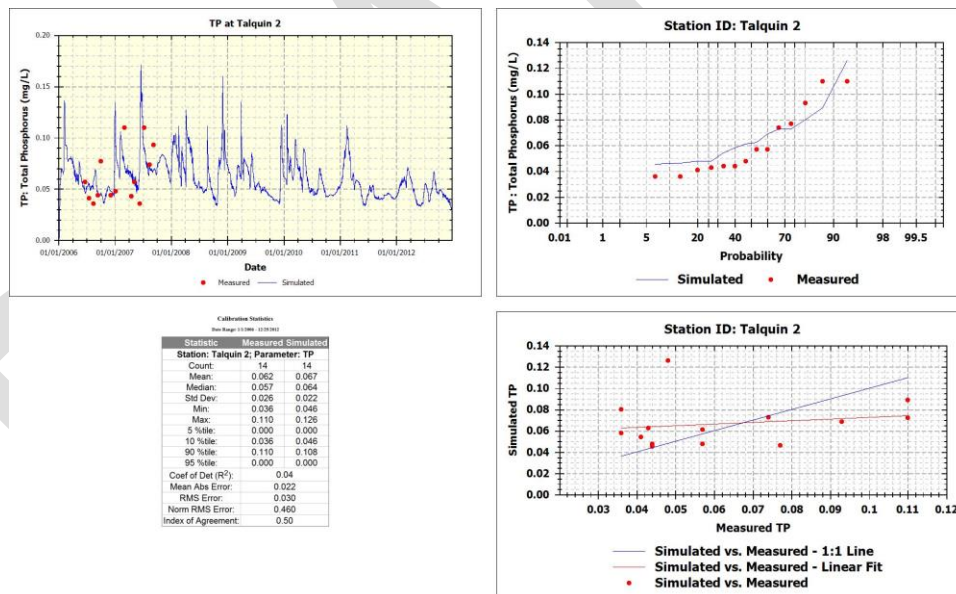


Figure 116 21FLLEONLCT0L3042284573: Talquin 2 for Total Phosphorus

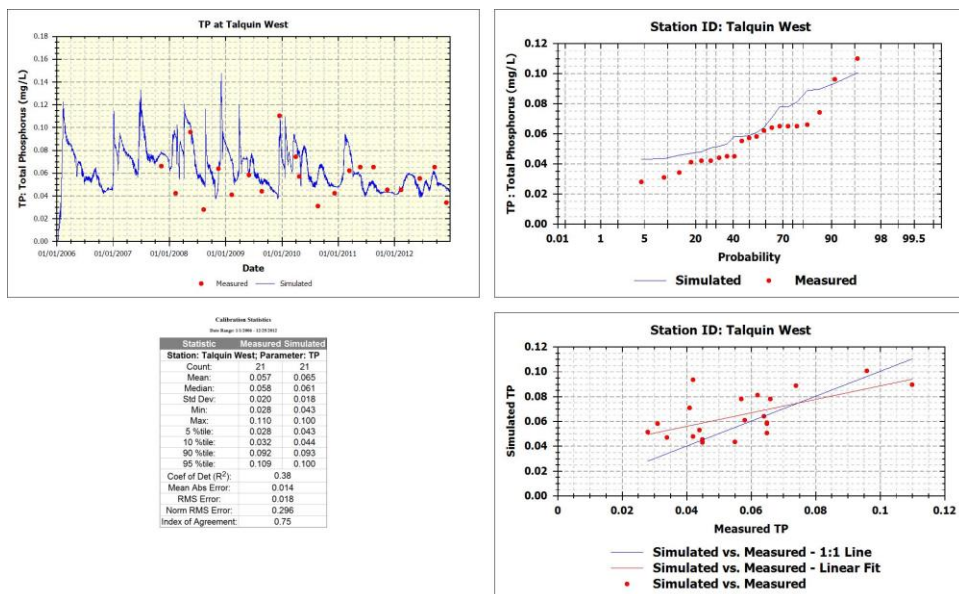


Figure 117 21FLLEONT0D3041488461: Lake Talquin West for Total Phosphorus

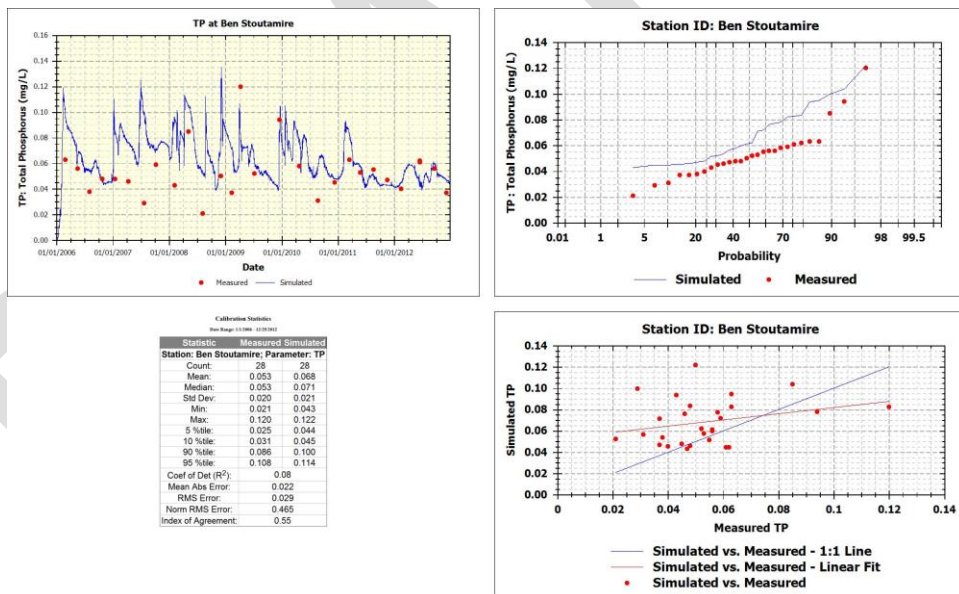


Figure 118 21FLLEONLCOC3040784610: Lake Talquin (Ben Stoutamire Boat Landing) for Total Phosphorus

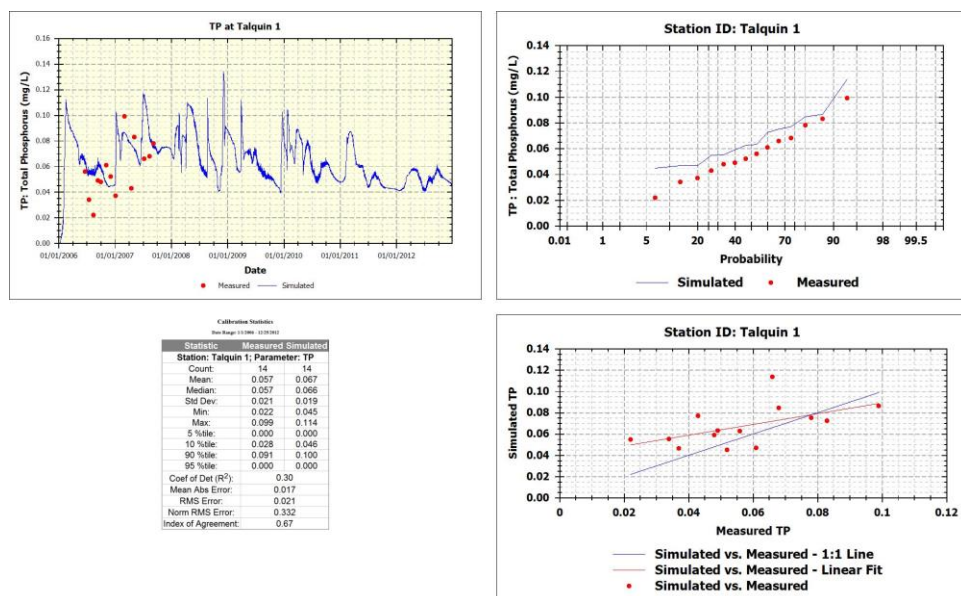


Figure 119 21FLLEONLCT0B3040284630: Talquin 1 for Total Phosphorus

Total Suspended Solids

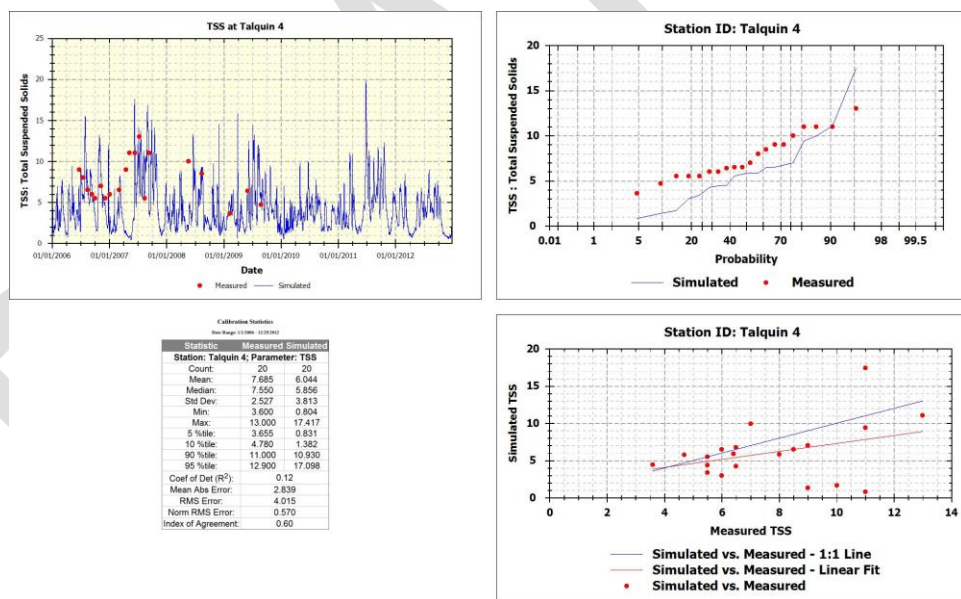


Figure 120 121 21FLLEONLCT0C3045884492: Talquin 4 for Total Suspended Solids

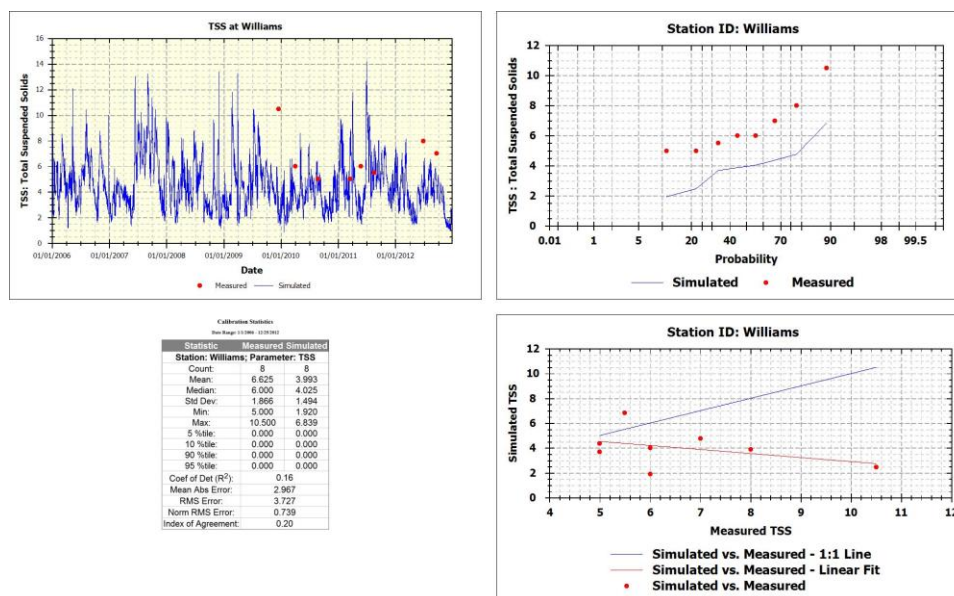


Figure 122 21FLLEONLCT03045184523: Lake Talquin near Williams Landing for Total Suspended Solids

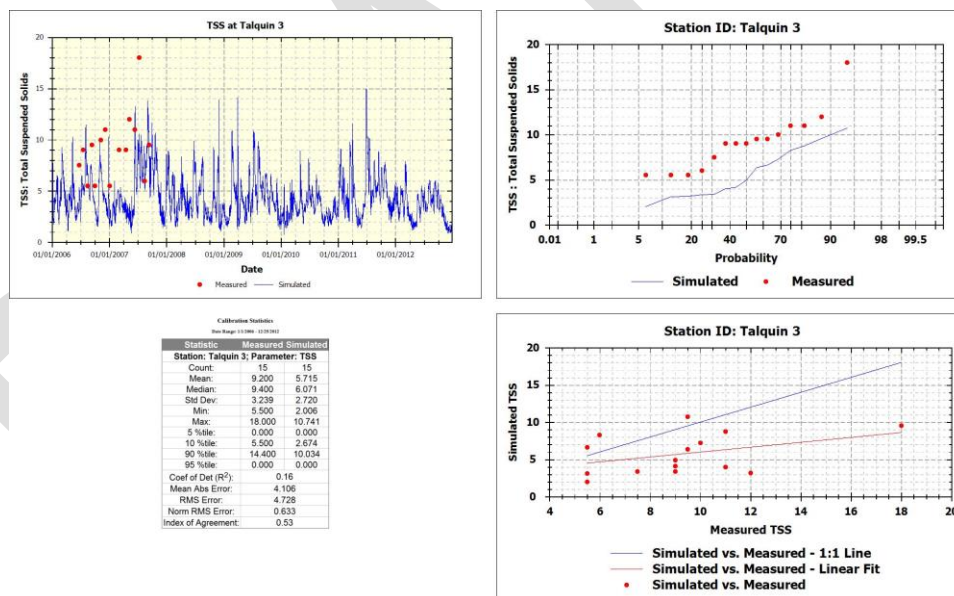


Figure 123 21FLLEONLCT0W3045084521: Talquin 3 for Total Suspended Solids

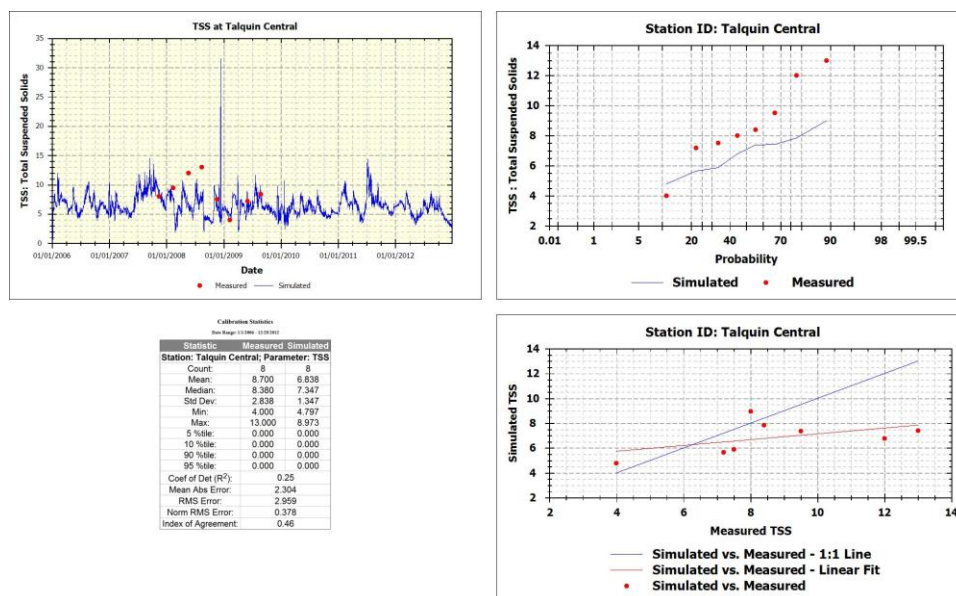


Figure 124 125 21FLLEONT0E3044084556: Lake Talquin Central for Total Suspended Solids

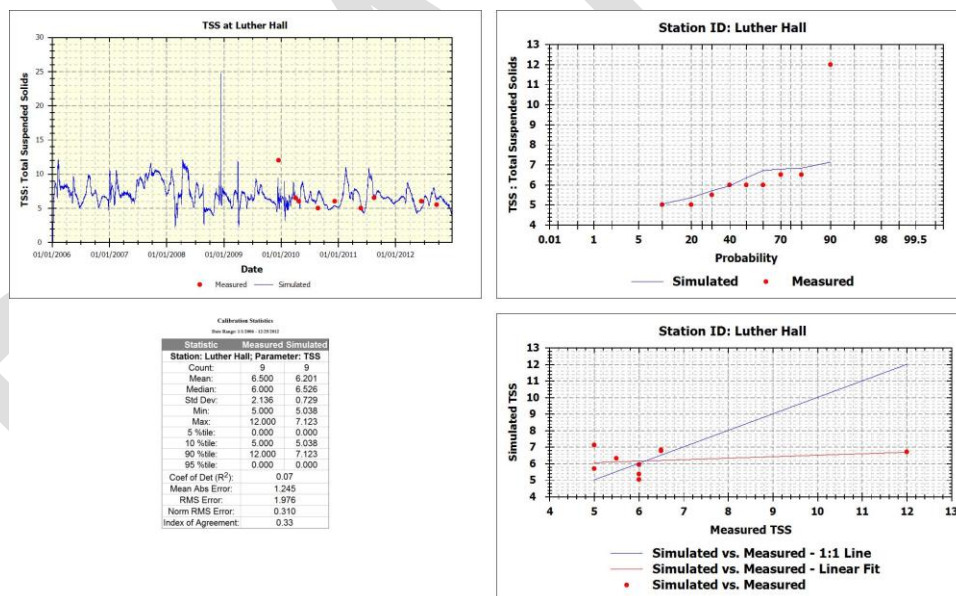


Figure 126 127 21FLLEONLCT03042384172: Lake Talquin near Luther Hall Landing for Total Suspended Solids

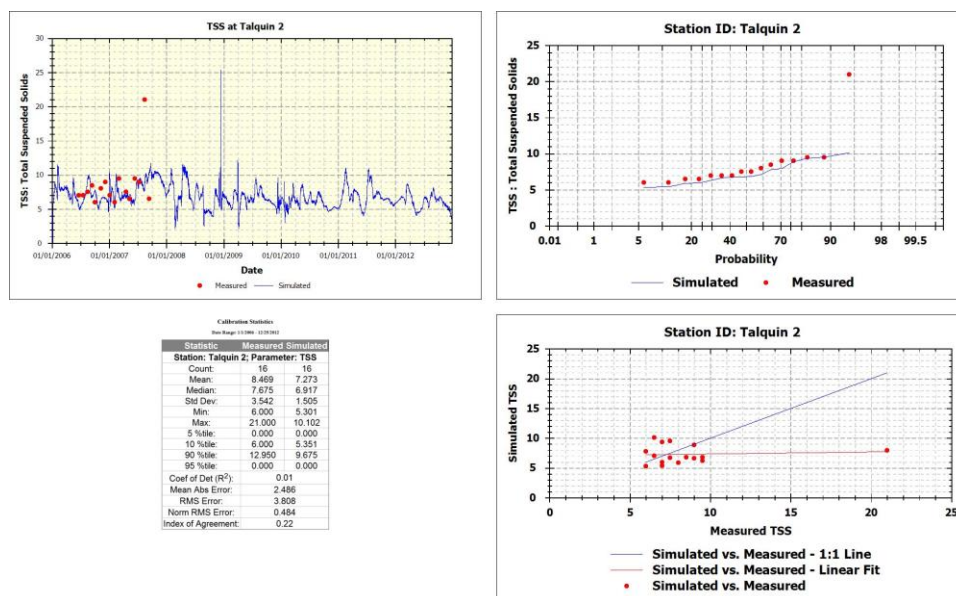


Figure 128 129 21FLLEONLCT0L3042284573: Talquin 2 for Total

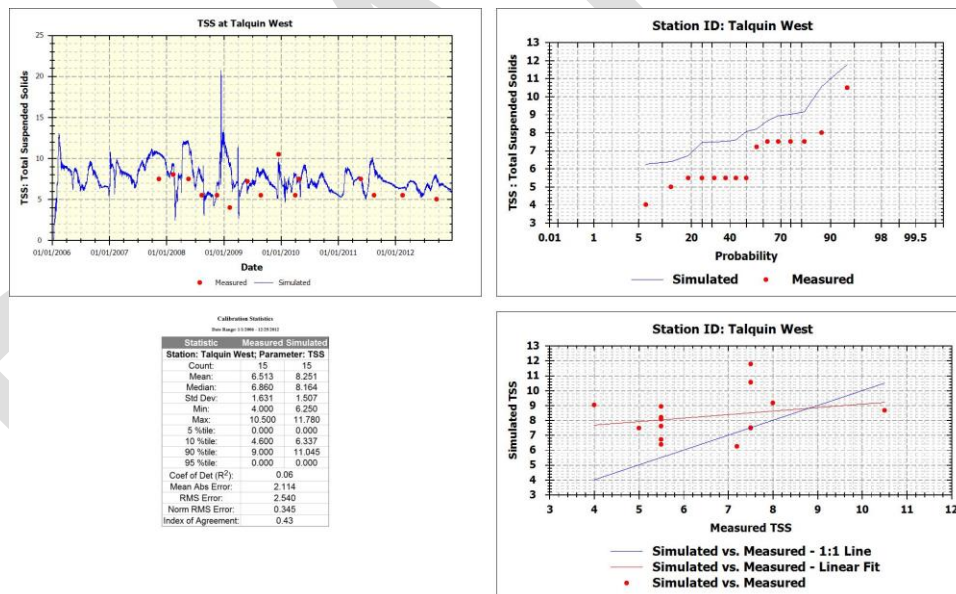


Figure 130 21FLLEONT0D3041488461: Lake Talquin West for Total Suspended Solids

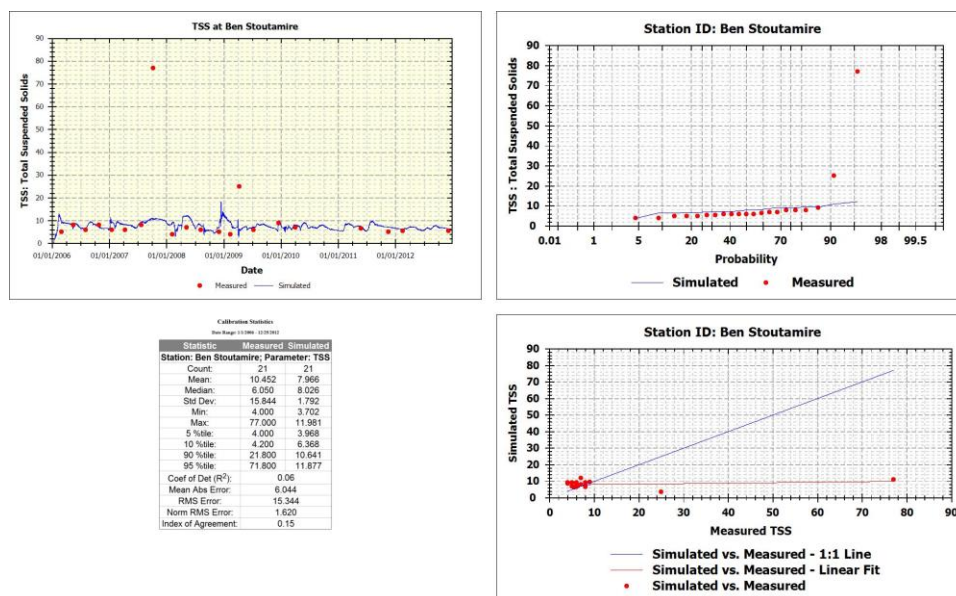


Figure 131 21FLLEONLCOC3040784610: Lake Talquin (Ben Stoutamire Boat Landing) for Total Suspended Solids

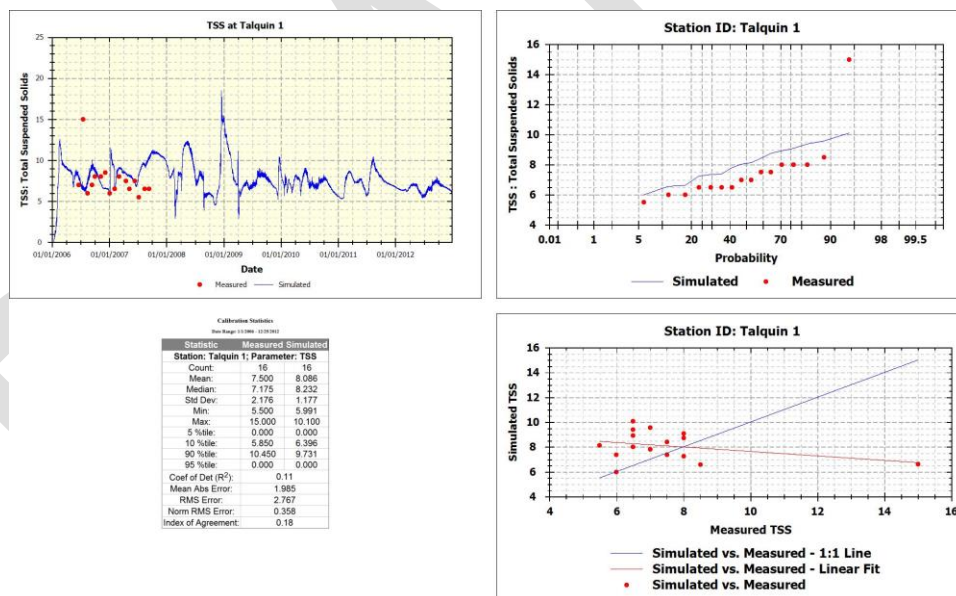


Figure 132 21FLLEONLCT0B3040284630: Talquin 1 for Total Suspended Solids

Longitudinal Profile

Figure 133 through Figure 138 compare the annual average predicted concentrations with the annual average measured concentrations. This provides a good comparison of the nutrient dynamics and algal growth as the watershed loads moves through Lake Talquin.

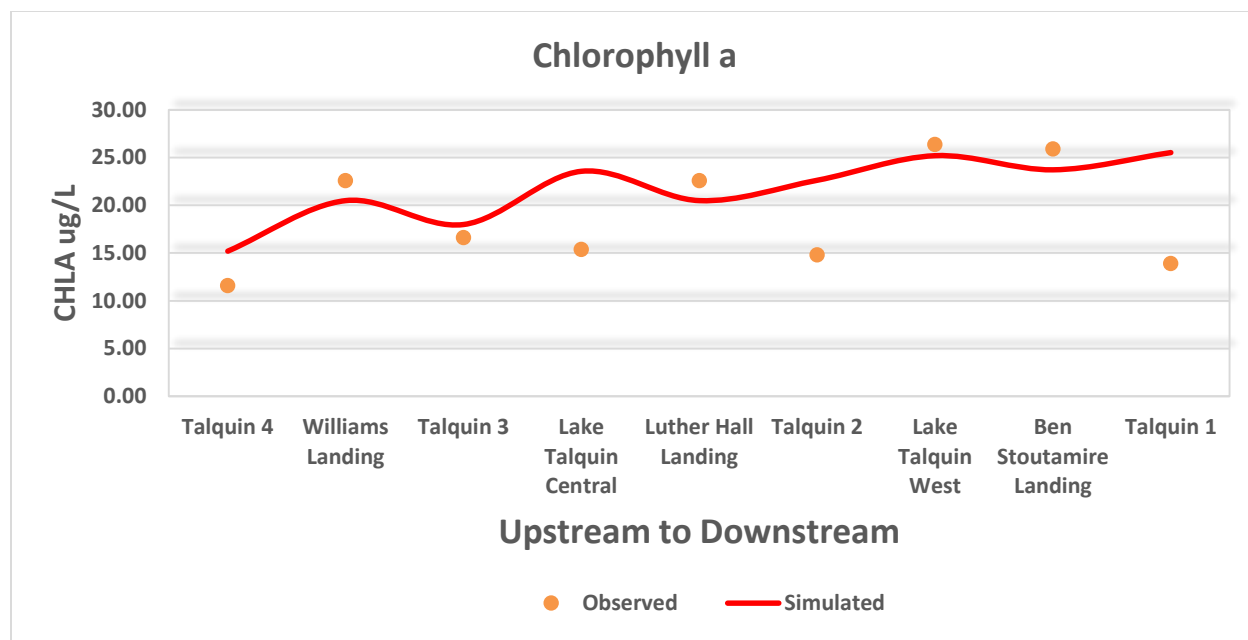


Figure 133 Longitudinal Profile -- Chlorophyll a

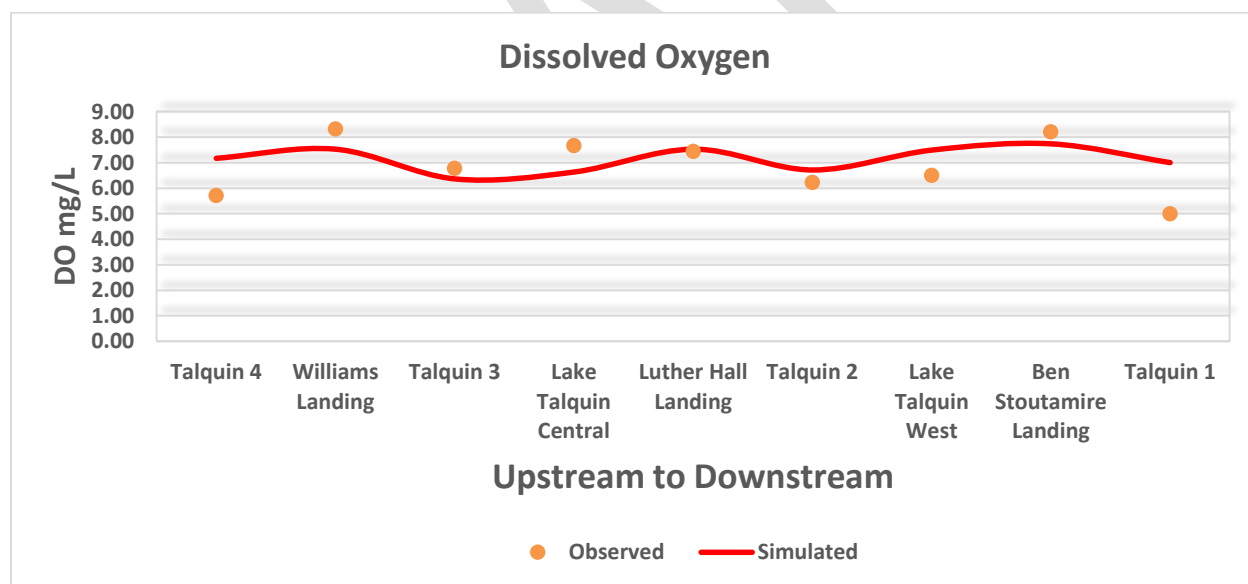


Figure 134 Longitudinal Profile -- Dissolved Oxygen

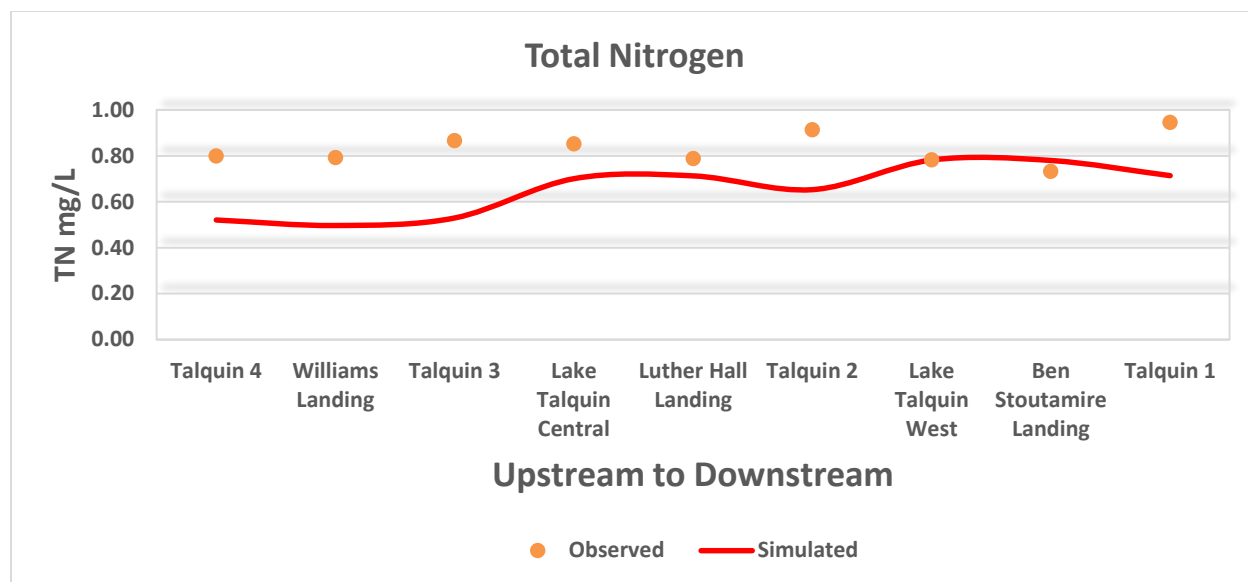


Figure 135 Longitudinal Profile -- Total Nitrogen

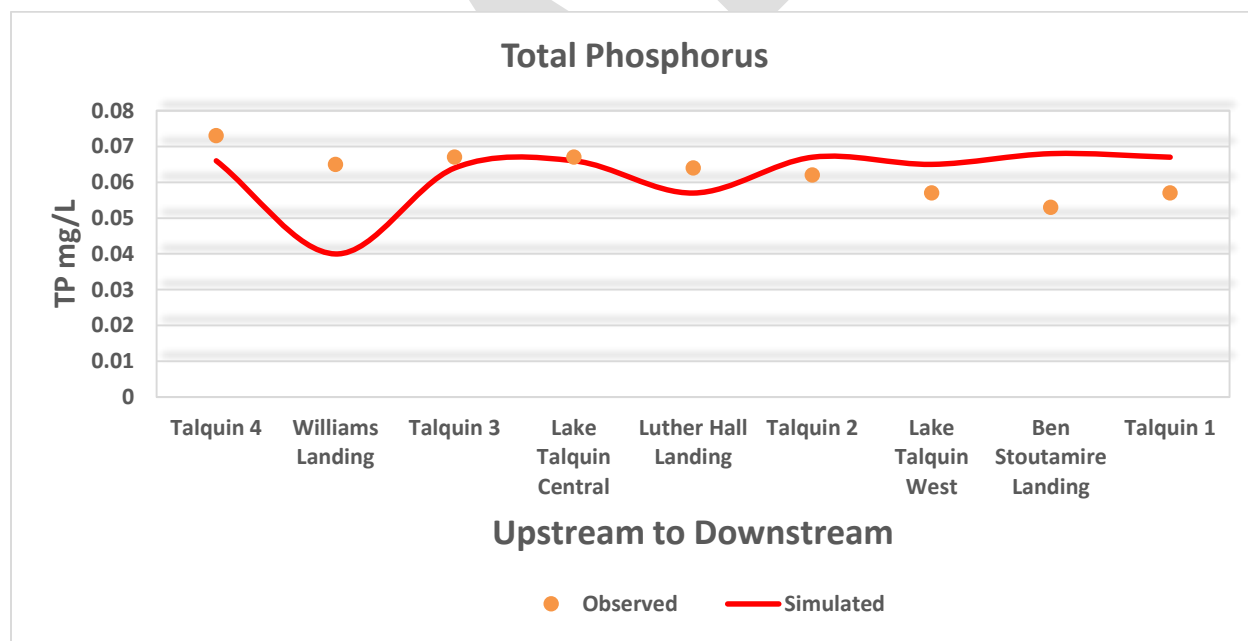


Figure 136 Longitudinal Profile -- Total Phosphorus

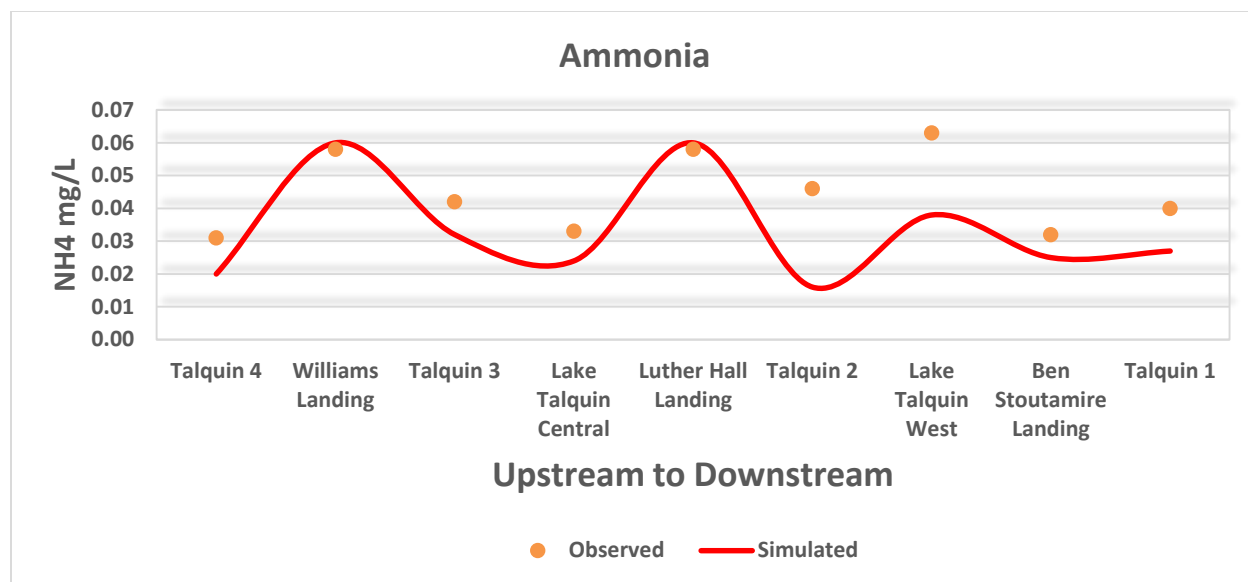


Figure 137 Longitudinal Profile -- Ammonia

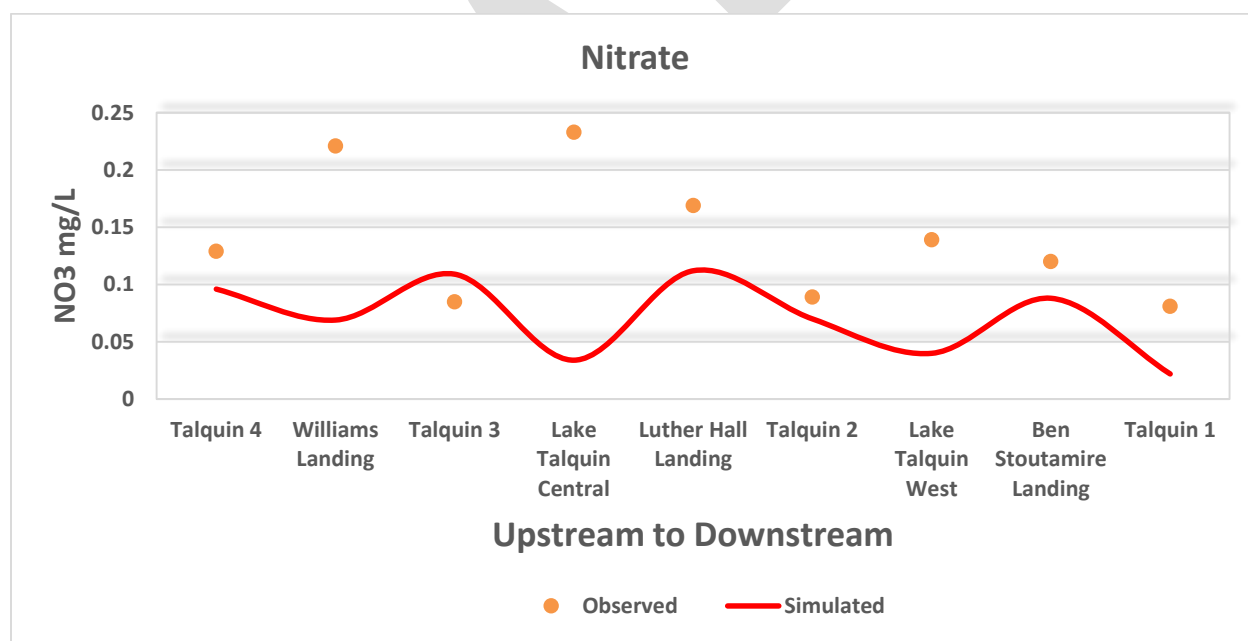


Figure 138 Longitudinal Profile -- Nitrate

Distribution Analysis

The distribution analysis illustrates the range and distribution of the model results over the simulation period using a box and whisker plot. The blue box provides the 75th and 25th quartile, the solid blue line in the box represents the median model prediction, the diamond represents the mean of the model prediction, the green circle represents the average of the observed data, red dots

indicate the individual observed data points, the black dots represents the individual data points from the model prediction. These plots provide a good comparison of observed vs. predicted over the simulation period and are a good way to see any model biases. Distribution plots are provided for the two calibration stations in the Little River and Ochlockonee River and for all stations used in Lake Talquin.

Little River Distribution Analysis

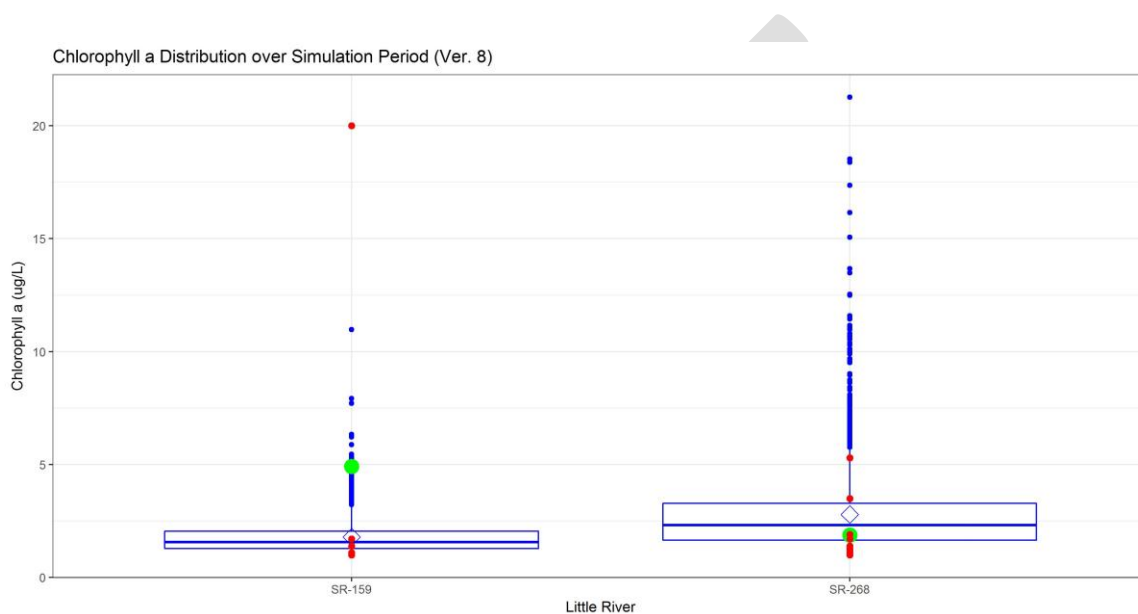


Figure 139 Little River Chlorophyll a Distribution over Simulation Period

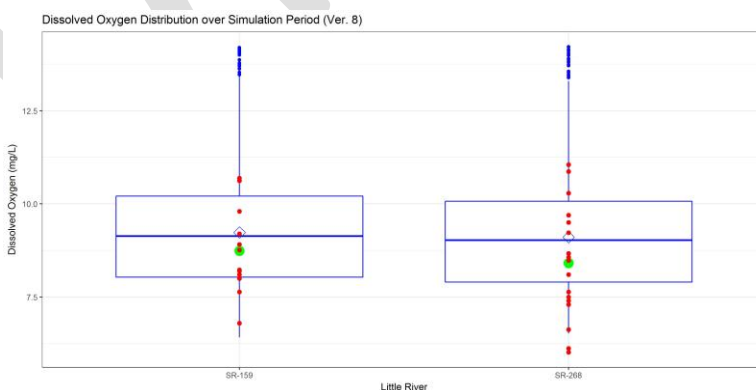


Figure 140 Little River Dissolved Oxygen Distribution over Simulation Period

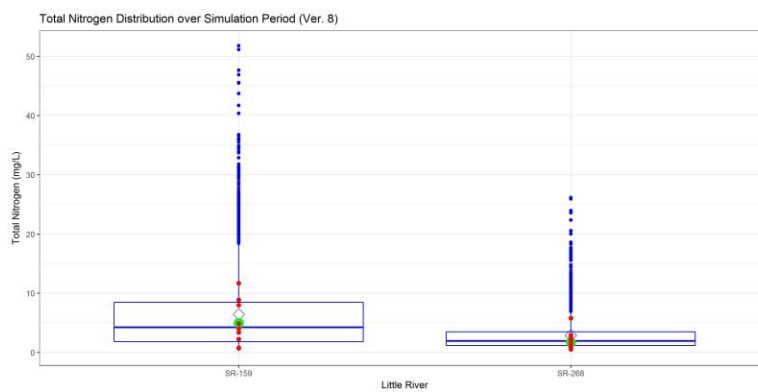


Figure 141 Little River Total Nitrogen Distribution over Simulation Period

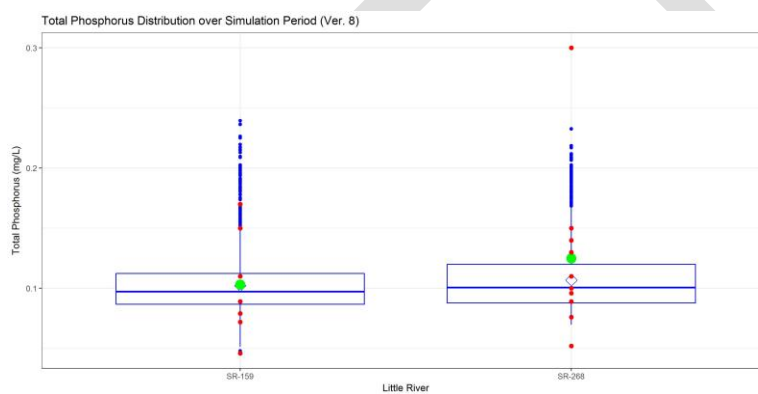


Figure 142 Little River Total Phosphorus Distribution over Simulation Period

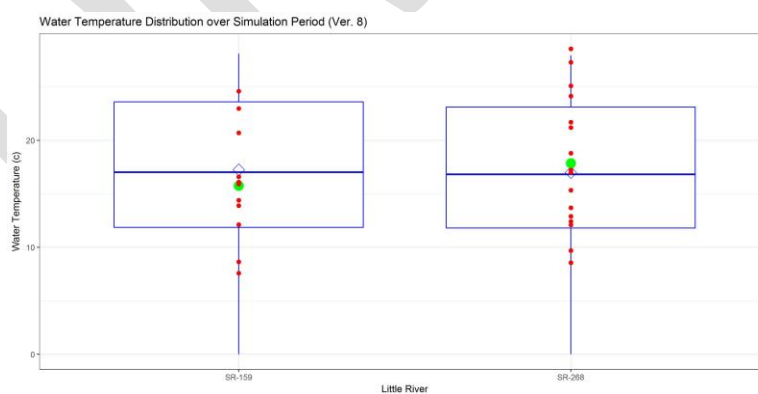


Figure 143 Little River Water Temperature Distribution over Simulation Period

Ochlockonee River Distribution Analysis

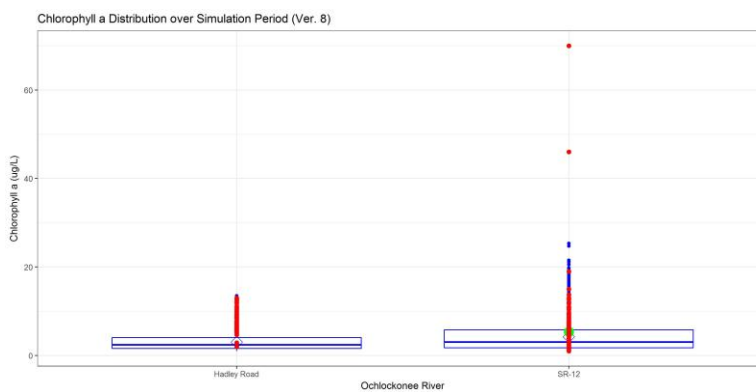


Figure 144 Ochlockonee River Chlorophyll a Distribution over Simulation Period

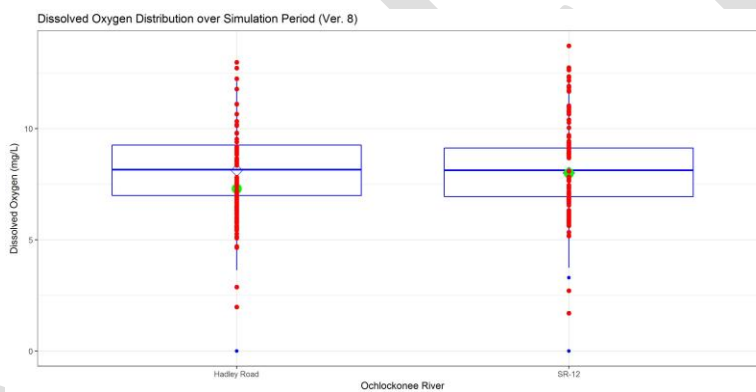


Figure 145 Ochlockonee River Dissolved Oxygen Distribution over Simulation Period

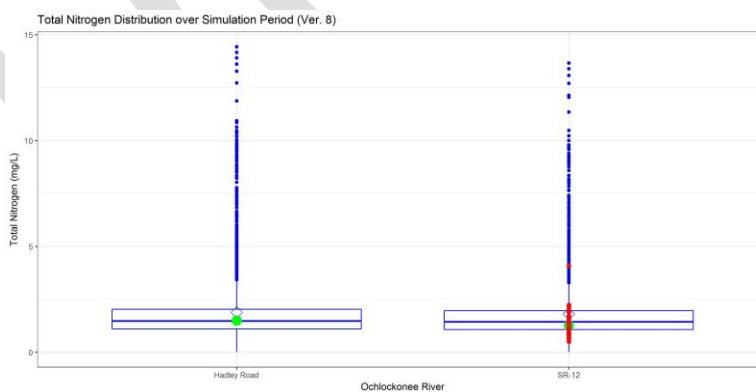


Figure 146 Ochlockonee River Total Nitrogen Distribution over Simulation Period

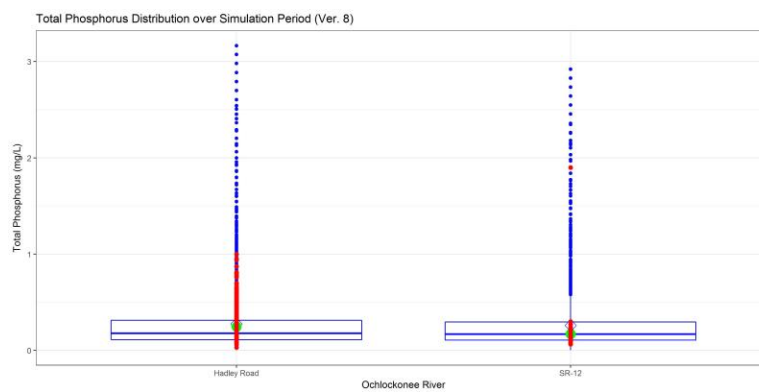


Figure 147 Ochlockonee River Total Phosphorus Distribution over Simulation Period

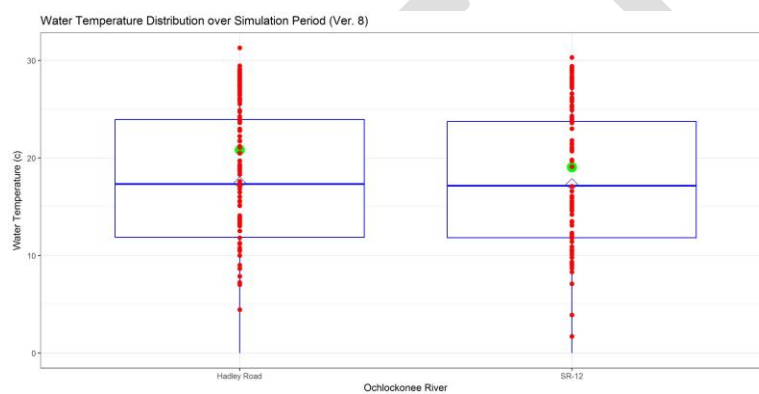


Figure 148 Ochlockonee River Water Temperature Distribution over Simulation Period

Lake Talquin Distribution Analysis

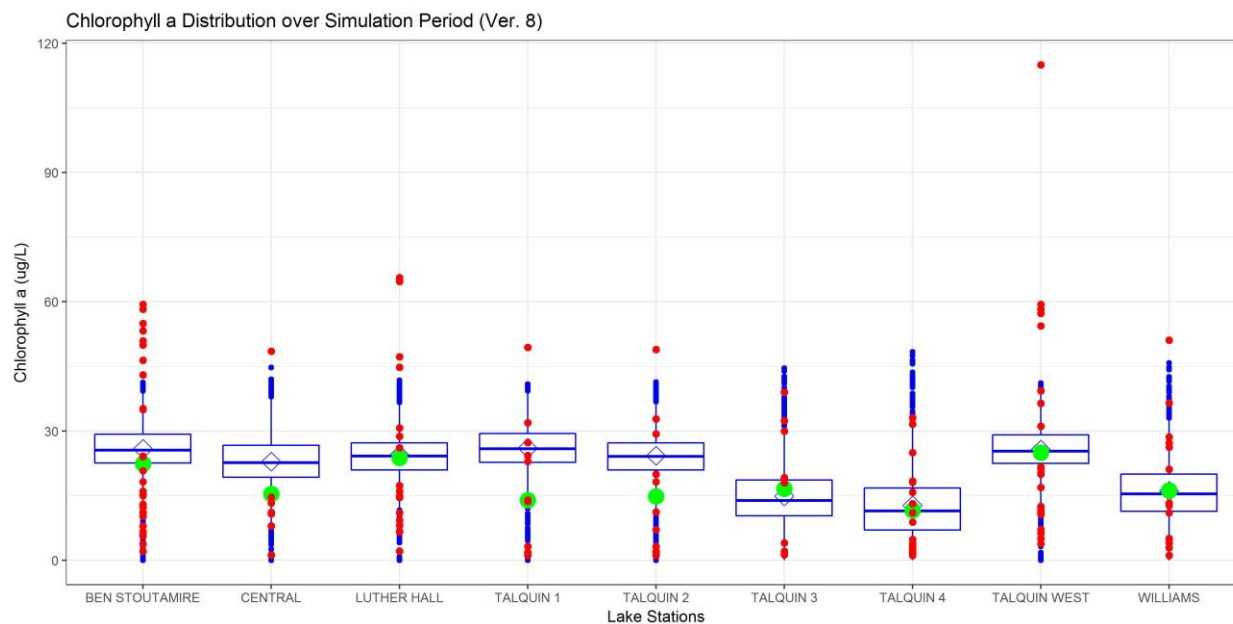


Figure 149 Lake Talquin Chlorophyll a Distribution over Simulation Period

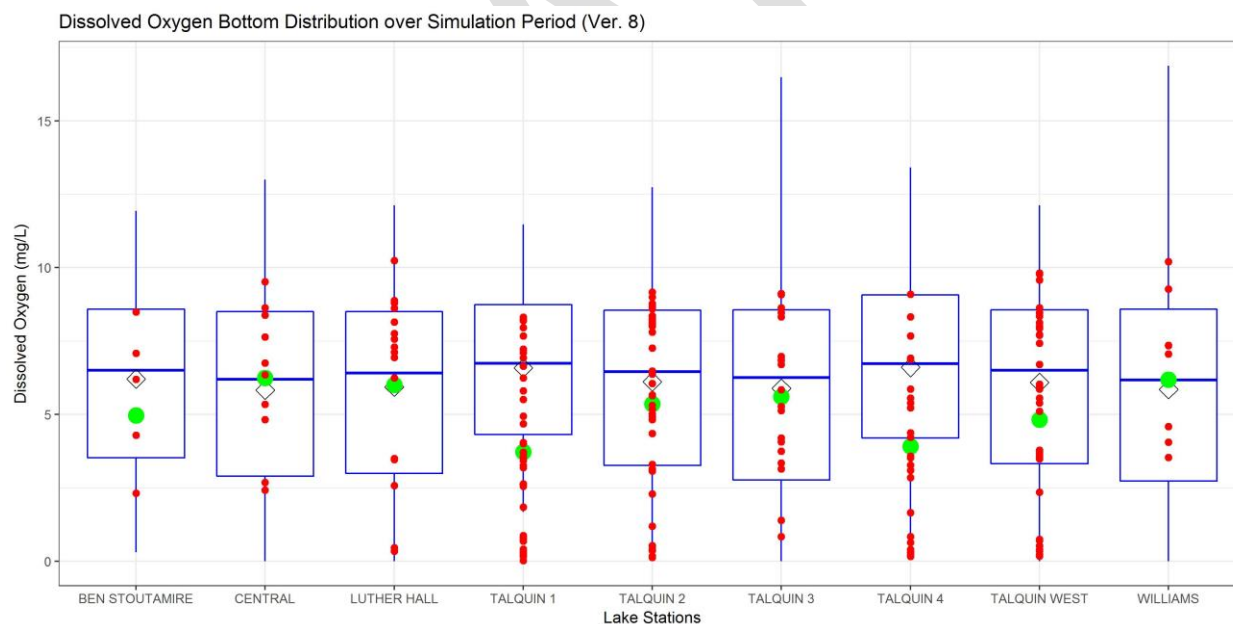


Figure 150 Lake Talquin Dissolved Oxygen Bottom Distribution over Simulation Period

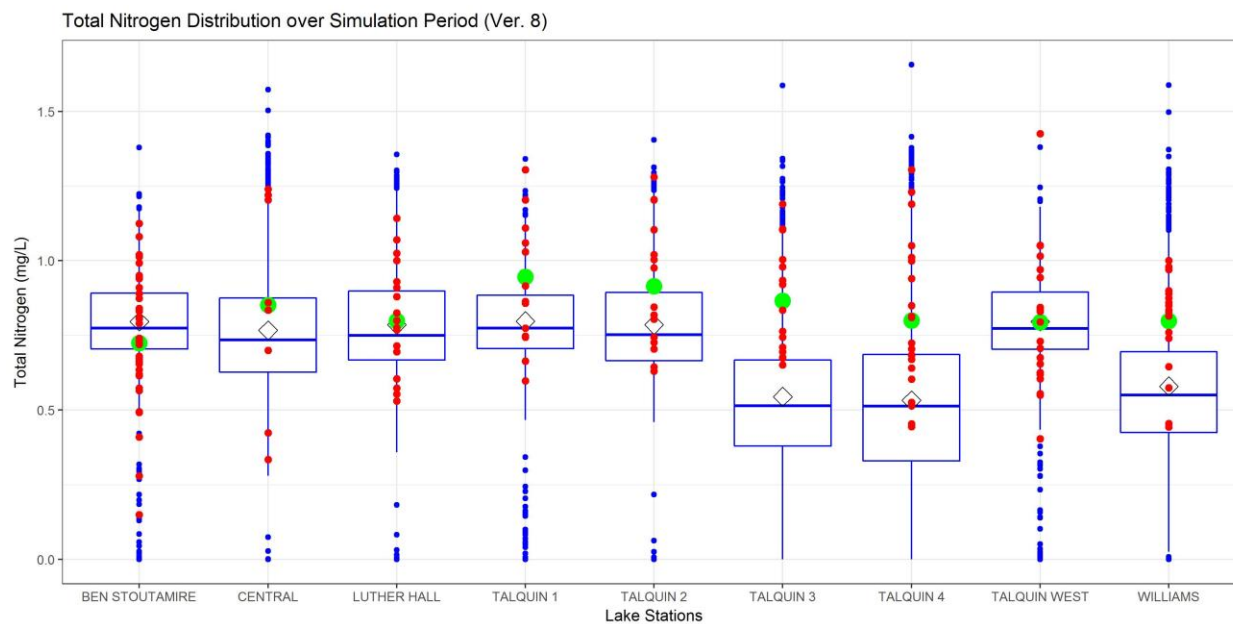


Figure 151 Lake Talquin Total Nitrogen Distribution over Simulation Period

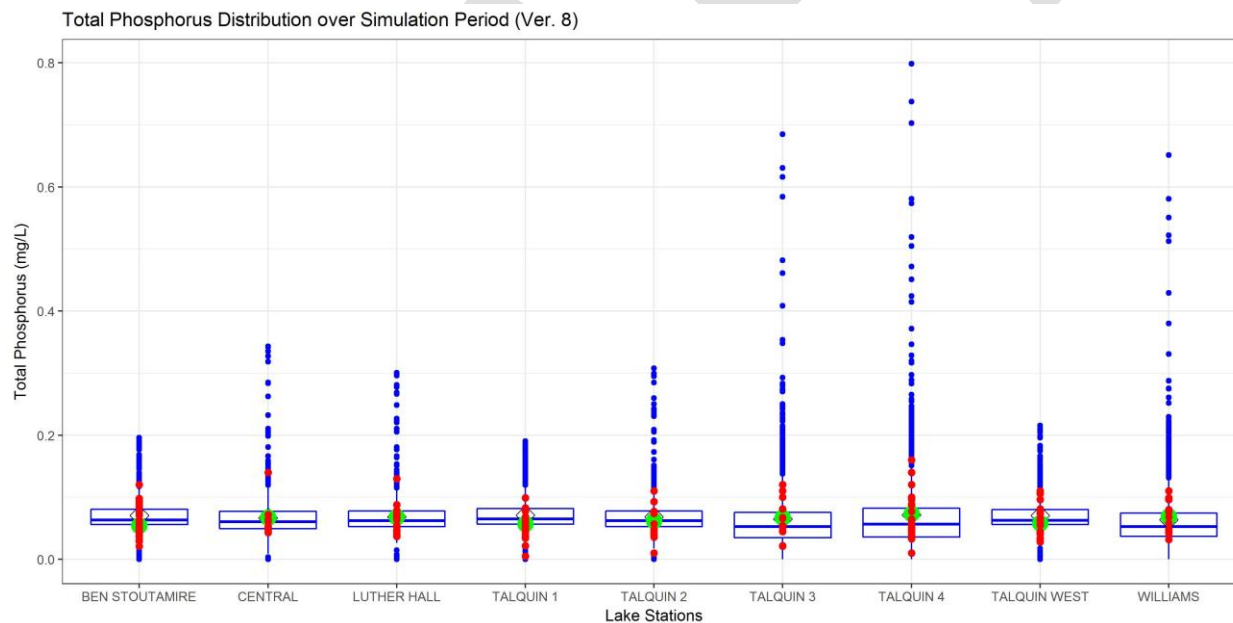


Figure 152 Lake Talquin Total Phosphorus Distribution over Simulation Period

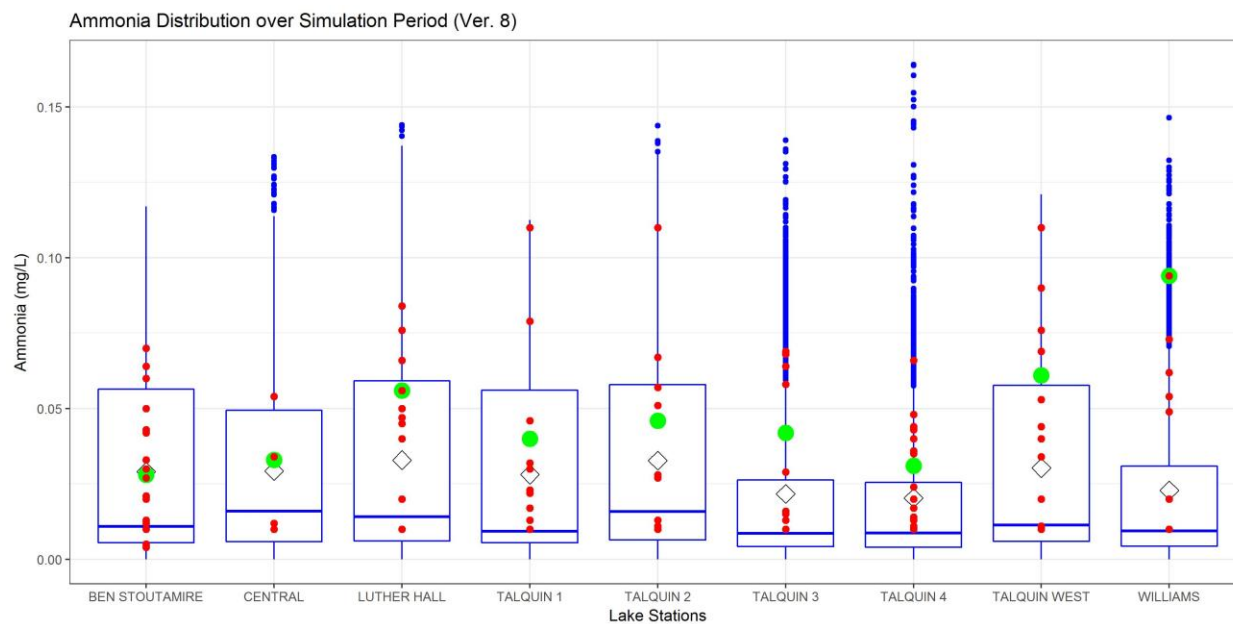


Figure 153 Lake Talquin Ammonia Distribution over Simulation Period

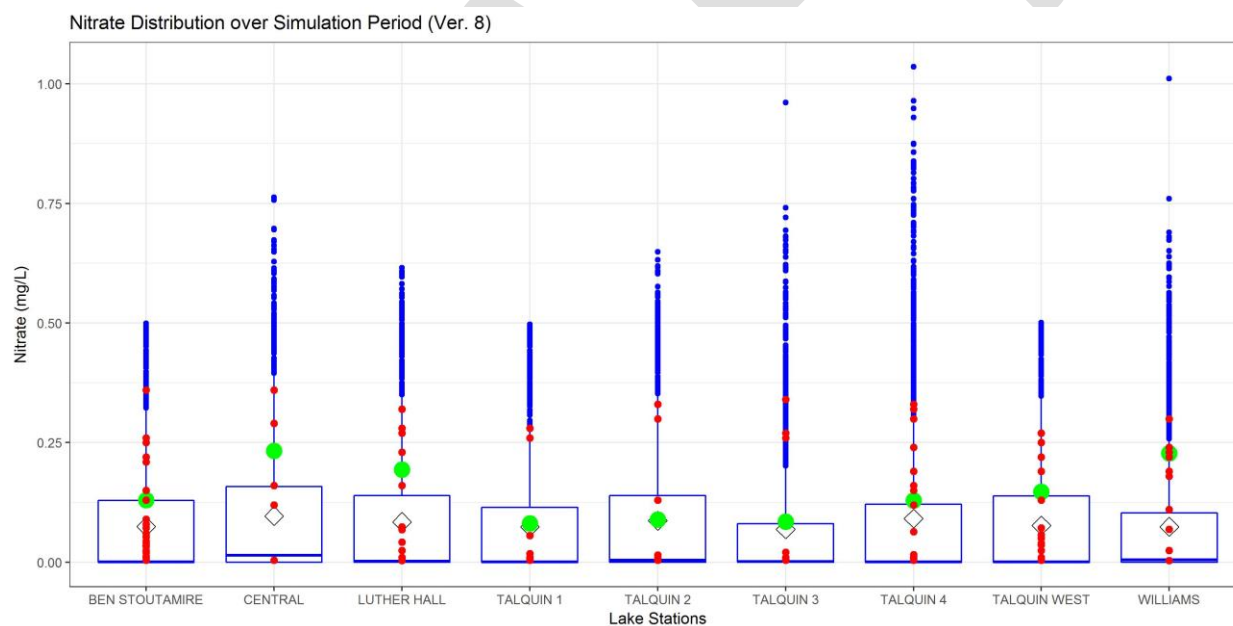


Figure 154 Lake Talquin Nitrate Distribution over Simulation Period

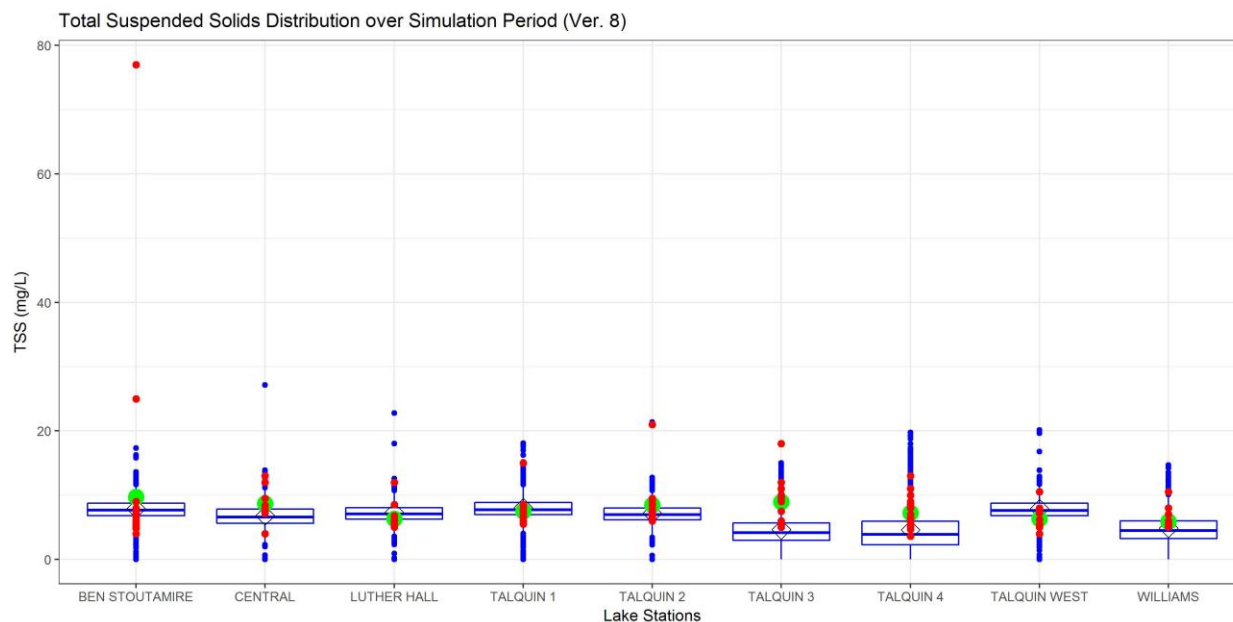


Figure 155 Lake Talquin Total Suspended Solids Distribution over Simulation Period

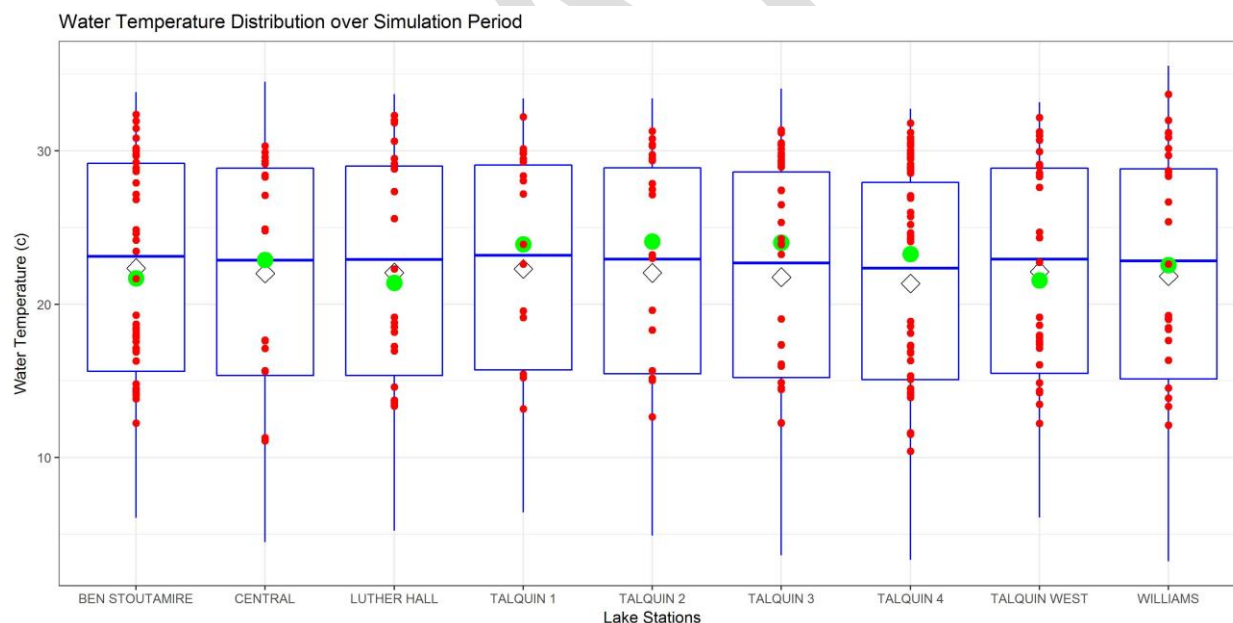


Figure 156 Lake Talquin Temperature Distribution over Simulation Period

Lake Talquin Load Analysis

Using the predicted time series of flows and loads from the Ochlockonee and Little River water quality models a load analysis was conducted. Loads were calculated from daily flows and

concentrations from the terminal model segments (inlets to the Lake model). Load analysis was conducted at the segments that correspond to the Georgia/Florida state line.

Figure 157 provides a comparison of the percentage of the watershed land area that is in each state. With 73% of the watershed area in Georgia it is expected that most of the loading to Lake Talquin will come from Georgia.

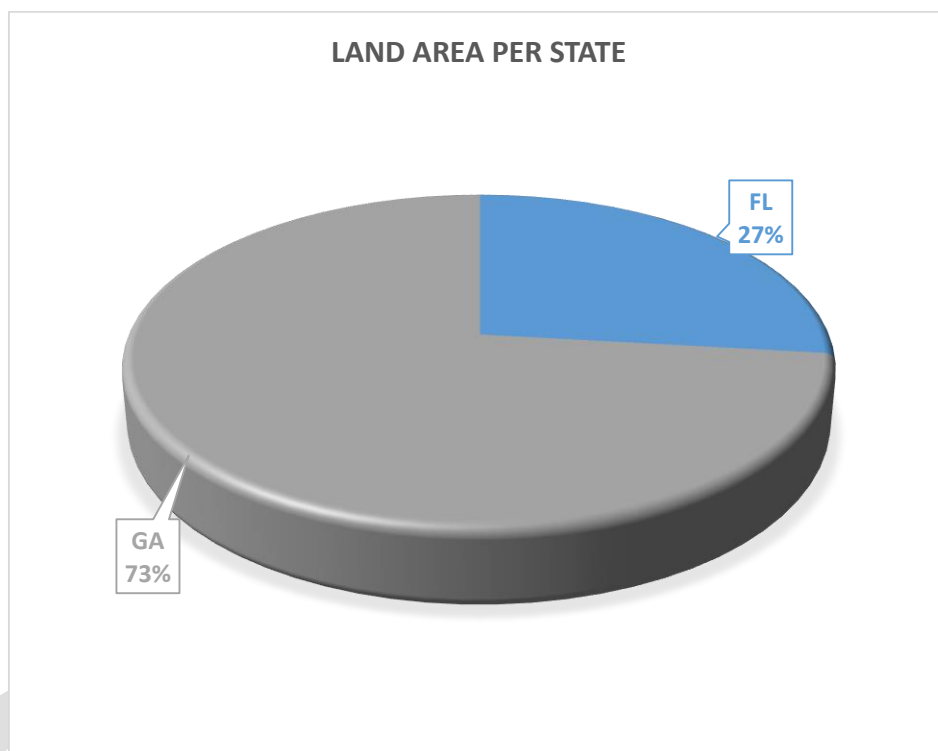


Figure 157 Percent Land Area for Watershed by State

Flows

Figure 158 illustrates the predicted annual average daily flows at the inlet of Lake Talquin from the Ochlockonee and Little Rivers. The figure shows the simulation period considers a wide range of hydraulic conditions. This simulation period provides a wide range of flow and loading conditions.

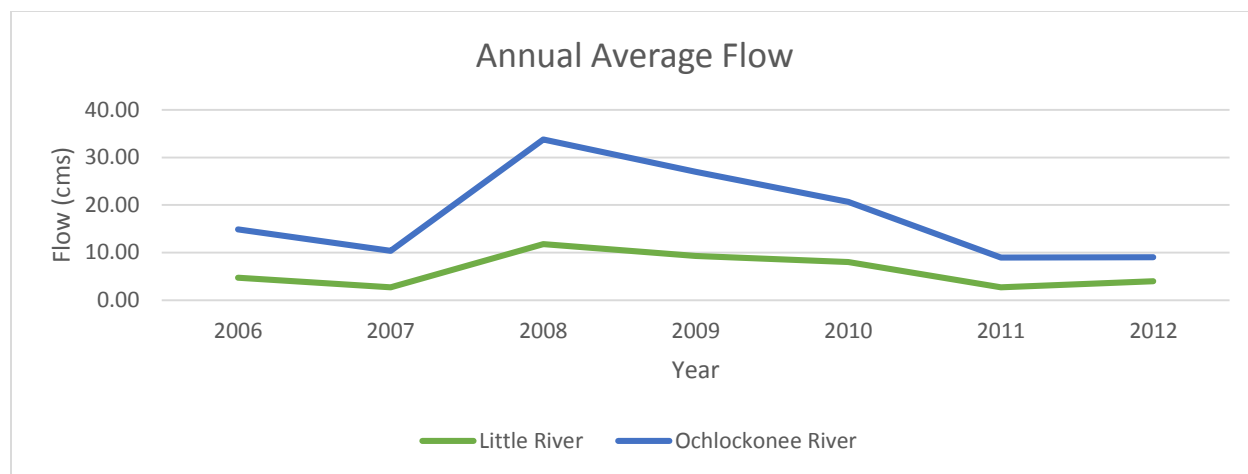


Figure 158 Annual Daily Average Flow at Lake Talquin Inlet

Lake Talquin Nutrient Load Analysis

The following provides an analysis of the nutrient loadings to Lake Talquin. The loadings were calculated using the predicted flows and concentrations predicted by the river water quality models. Therefore, these loads do account for nutrient cycling in the watershed. Table 7 provides the nutrient loads to Lake Talquin by year and river basin.

Table 7 Annual Nutrient Loadings to Lake Talquin

Year	Little River		Ochlockonee River		Direct Load	
	TN	TP	TN	TP	TN	TP
2006	293000	23244	568545	51794	118317	11498
2007	218814	16673	516348	51986	99482	9287
2008	624414	72491	1482480	116816	228552	26554
2009	501430	49544	1140927	86622	187727	21358
2010	357174	34910	651036	57321	157909	16563
2011	252672	14750	458565	39110	90178	8263
2012	279946	17700	385873	28313	109196	9449

Figure 159 shows an analysis of the percentage of the total nitrogen load coming from the Ochlockonee and Little River basins.

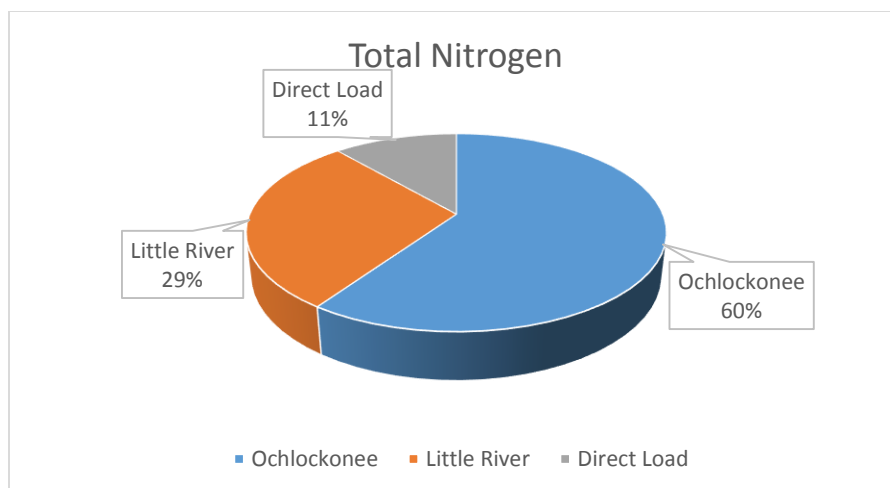


Figure 159 Total Nitrogen Loading to Lake Talquin from Ochlockonee and Little River

Figure 160 shows an analysis of the percentage of the total phosphorus load coming from the Ochlockonee and Little River basins.

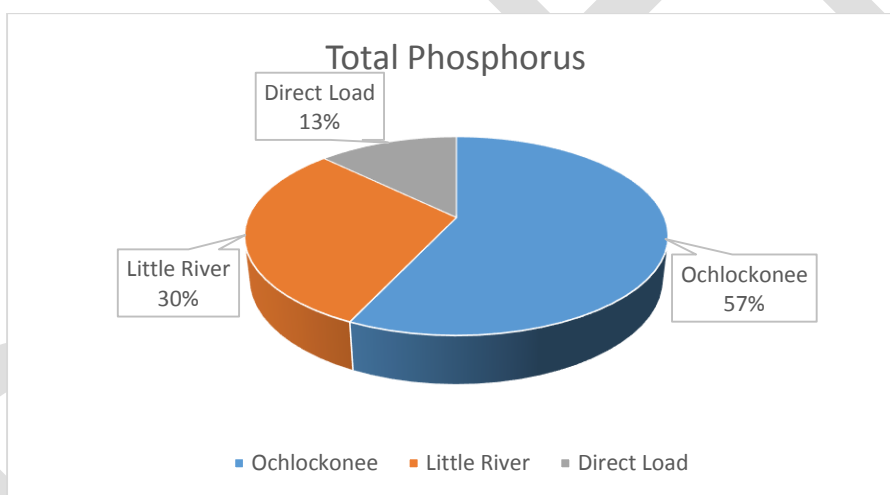


Figure 160 Total Phosphorus Loading to Lake Talquin from Ochlockonee and Little River

Point and Non-Point Source Analysis

Model simulations were conducted with and without the permitted discharges to determine their contribution to the nutrient loads to Lake Talquin. provides the annual loads of nutrients attributed to the point sources in each river basin.

State Loadings

A loading analysis was conducted to determine the amount of nutrient loads coming from both states in Lake Talquin. The State of Georgia's nutrient loadings to Lake Talquin were calculate by using the simulated daily flows and concentrations corresponding to the segments at the

Georgia/Florida Stateline. Florida's nutrient contribution was calculated by taking the current loading to Lake Talquin minus the Georgia loadings at the Stateline.

Year	Little River (kg/yr)				Ochlockonee River (kg/yr)			
	Total Nitrogen		Total Phosphorus		Total Nitrogen		Total Phosphorus	
	FL	GA	FL	GA	FL	GA	FL	GA
2006	58552	234448	7614	15630	83359	485189	7595	44204
2007	51549	167265	6118	10555	70553	445789	7102	44873
2008	215814	408600	31572	40919	144586	1337811	11401	105490
2009	171901	329529	24666	24878	176481	964463	13387	73161
2010	85405	271769	11382	23528	95402	555647	8399	48918
2011	54736	197935	6535	8215	52110	406470	4445	34671
2012	32956	246990	3320	14380	54417	331459	3992	24313
Average	95845	265219	13030	19729	96701	646690	8046	53662

Figure 161 and Figure 162 illustrate the annual total nutrient load by state for Little River over the simulation period.

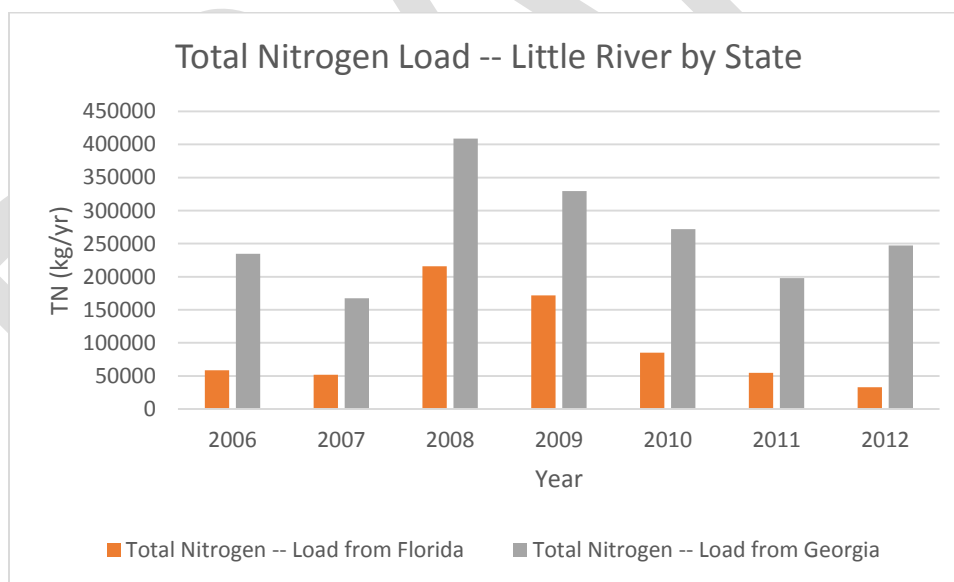


Figure 161 Annual Total Nitrogen Loads by State for Little River

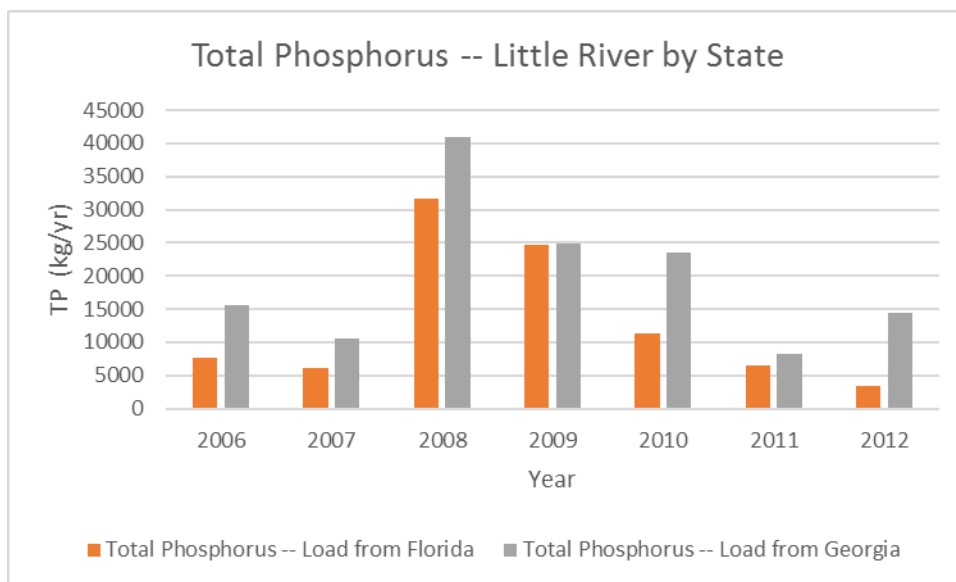


Figure 162 Annual Total Phosphorus Loads by State for Little River

Figure 163 and Figure 164 illustrate the annual total nutrient load by state for Ochlockonee River over the simulation period.

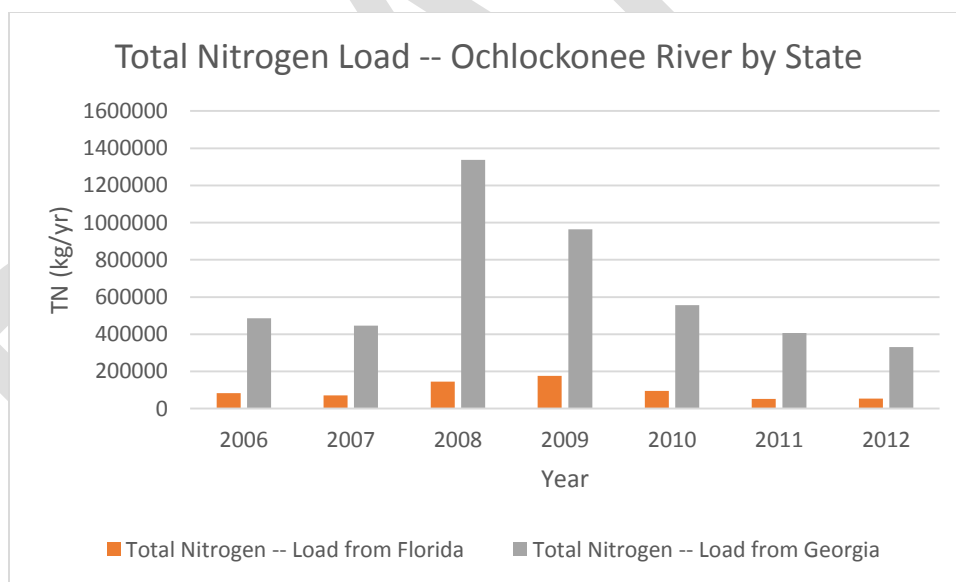


Figure 163 Annual Total Nitrogen Loads by State for Ochlockonee River

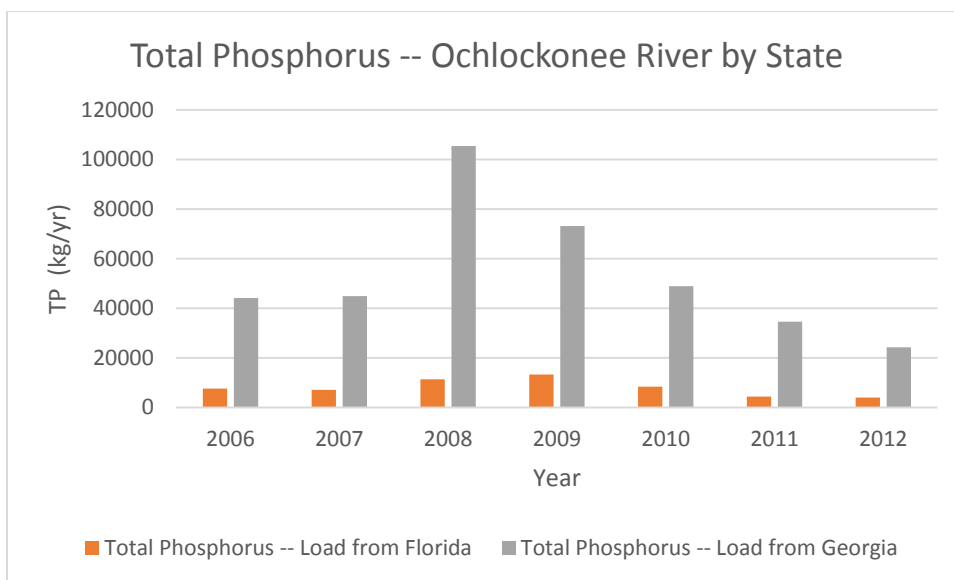


Figure 164 Annual Total Phosphorus Loads by State for Ochlockonee River

Figure 165 and Figure 166 illustrates the percentages of total nitrogen and total phosphorus coming from each state that enters Lake Talquin.

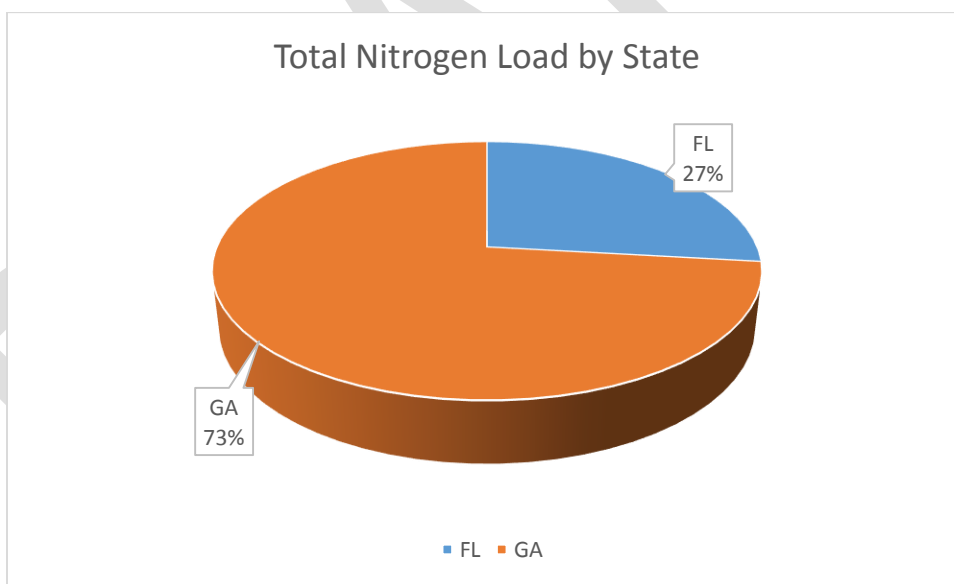


Figure 165 Percentage of Total Nitrogen Load to Lake Talquin by State

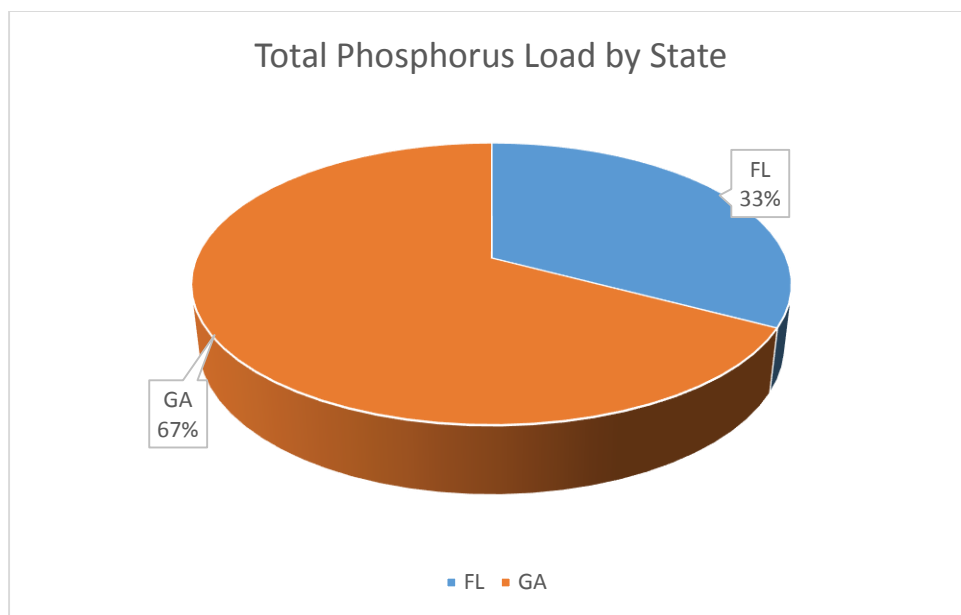


Figure 166 Percentage of Total Phosphorus Load to Lake Talquin by State

Ochlockonee River Nutrient Contribution Analysis

When reviewing the time series plots of the model predicted phosphorus concentration with the measured data it could be concluded that the models are over predicting the phosphorus load. Several analyses were conducted to determine when the model is over predicting phosphorous compared to the observed data as well as an annual loading analysis. Figure 167 and Figure 168 illustrates the predicted total phosphorus and concentrations versus flow. This figure shows that the over prediction of total phosphorus occurs during the lowest flow periods where the river is dominated by waste water treatment plants. Because the over predictions are at the very lowest flows the overall load to the lake is minimal.

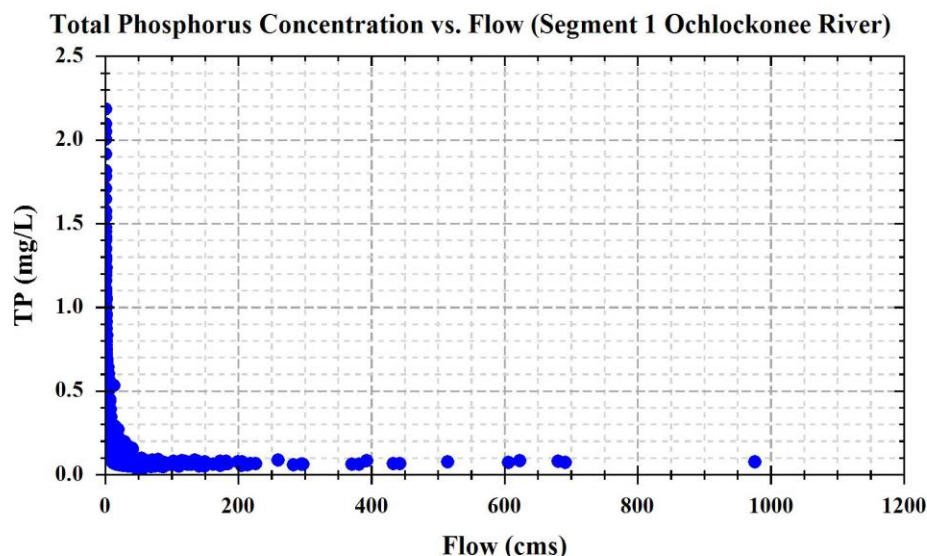


Figure 167 Ochlockonee River: Total Phosphorus vs. Flow

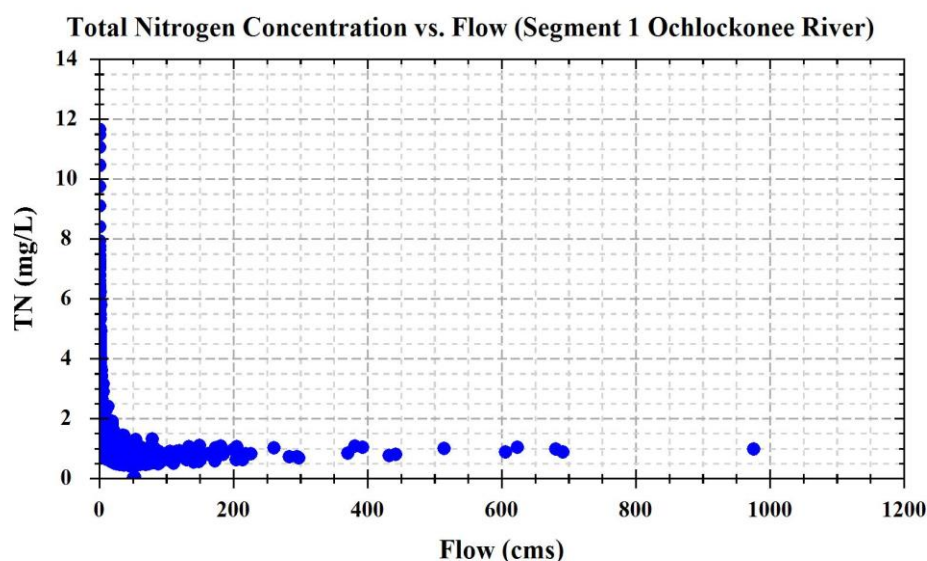


Figure 168 Ochlockonee River: Total Nitrogen vs. Flow

Table 8 compares the annual loads of nitrogen and phosphorus as calculated from the model predictions and using the USGS's LOADEST method for the Ochlockonee River. USGS LOADEST uses paired observations of flow and total nitrogen/phosphorus concentrations and applies statistical methods to calculate annual loads. The analysis indicates that the models are under predicting (red values) total nutrient loads.

Table 8 Total Phosphorus and Nitrogen Loading Analysis for Ochlockonee River

Average Daily Load , lb/d						
	WASP		LOADEST		Difference	
Year	TN	TP	TN	TP	TN	TP
2006	2041.77	215.85	2173.91	275.42	132.14	59.56
2007	1641.77	209.78	1449.04	177.85	192.73	31.94
2008	4396.93	387.93	6515.72	767.87	2118.79	379.94
2009	3932.85	328.19	6419.67	763.90	2486.81	435.71
2010	2460.84	242.10	4981.35	603.43	2520.52	361.33
2011	1406.00	158.99	1147.73	146.25	258.27	12.74
2012	1359.90	118.47	1346.34	176.47	13.55	58.00
Avg	2462.87	237.33	3433.40	415.88	970.53	178.55

Little River Nutrient Contribution Analysis

Table 9 compares the annual loads of nitrogen as calculated from the model predictions and using the USGS's LOADEST method for the Little River. While there are limited measured total nitrogen values, the analysis shows the model is over predicting by approximately 16%. The results of the comparison are statistical the same at the 95 percentile.

Table 9 Total Nitrogen Loading Analysis for Little River

Average Daily Load TN (Lb/Day)			
Date	WASP	LOADEST	Difference
1/1/2006 0:00	3984	3651	333
2/1/2006 0:00	5132	5506	374
3/1/2006 0:00	2018	1620	398
4/1/2006 0:00	1093	563.64	529
5/1/2006 0:00	1177	763	414
6/1/2006 0:00	739	246.61	493
7/1/2006 0:00	919	217.9	701
8/1/2006 0:00	1382	738	644
9/1/2006 0:00	1093	1137	44
10/1/2006 0:00	839	718	121
11/1/2006 0:00	902	1097	195
12/1/2006 0:00	2955	2927	28

Point Sources Data Inputs

Point sources discharging into the Ochlockonee River and the Little River were input into the corresponding WASP model. Descriptions of the included point sources, the utilized data sources, and the methods used to calculate unavailable data are provided in the sections below. No significant point sources discharge directly to Lake Talquin or its immediate watersheds (those not

simulated in the Ochlockonee and Little Rivers). The distributed models and model inputs include spreadsheets that were used to characterize the point sources.

Ochlockonee River

The Ochlockonee River WASP model includes four municipal wastewater treatment plants (WWTP) and one food processing facility as point sources for BOD, and TN. TP is also included for the WWTPs. All parameters associated with the point sources were added into the Ochlockonee River WASP model as concentration boundary inputs with separate surface flow functions. (Figure 169)

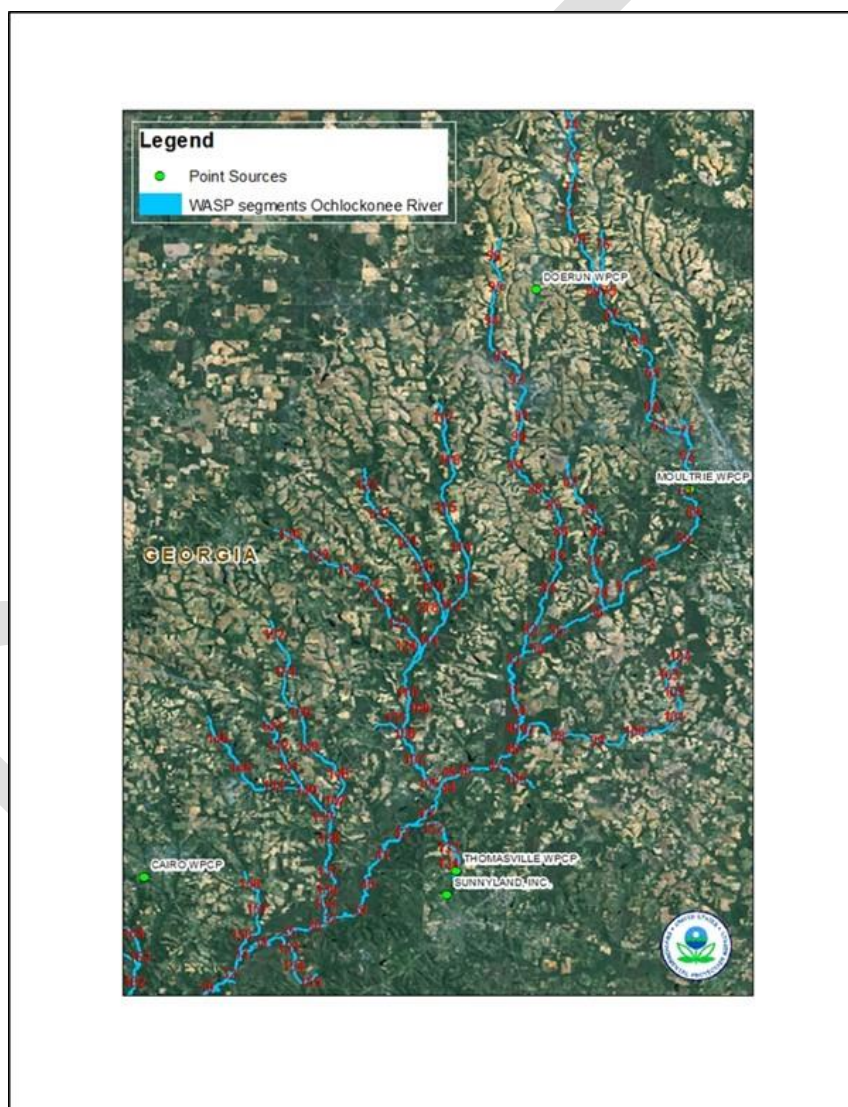


Figure 169 Location of Point Sources along the Ochlockonee River

The total annual loads, along with the Chlorophyll-a concentrations at the outflow of the Ochlockonee River WASP model, are depicted below in Figure 170- Figure 173.

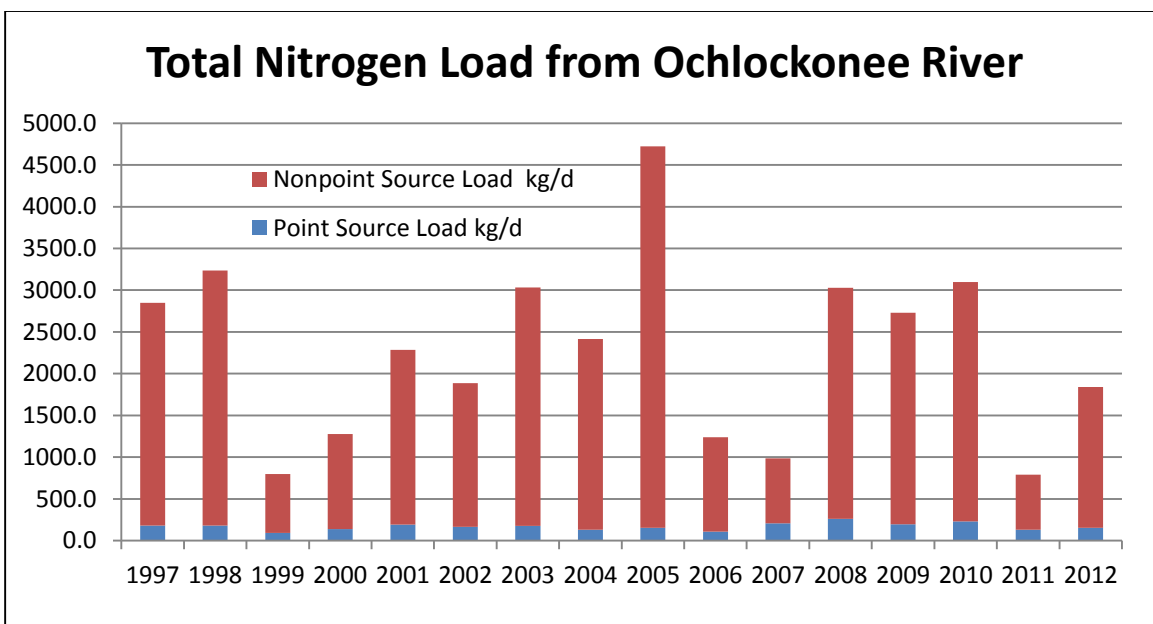


Figure 170 Total Nitrogen Load from Point Sources in Ochlockonee River

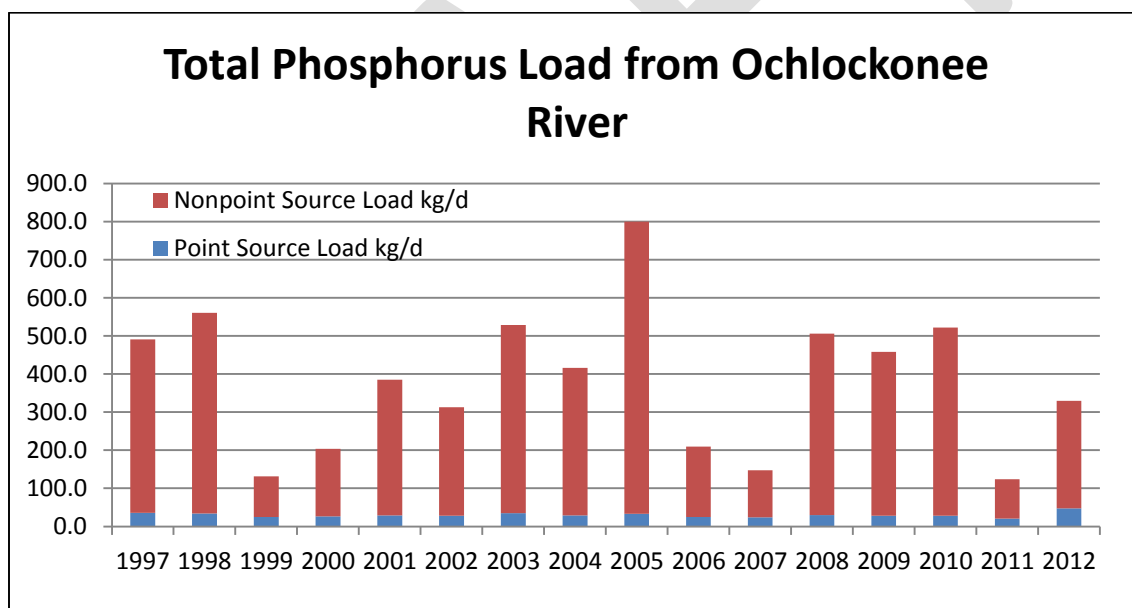


Figure 171 Total Phosphorus Load from Point Sources in Ochlockonee River

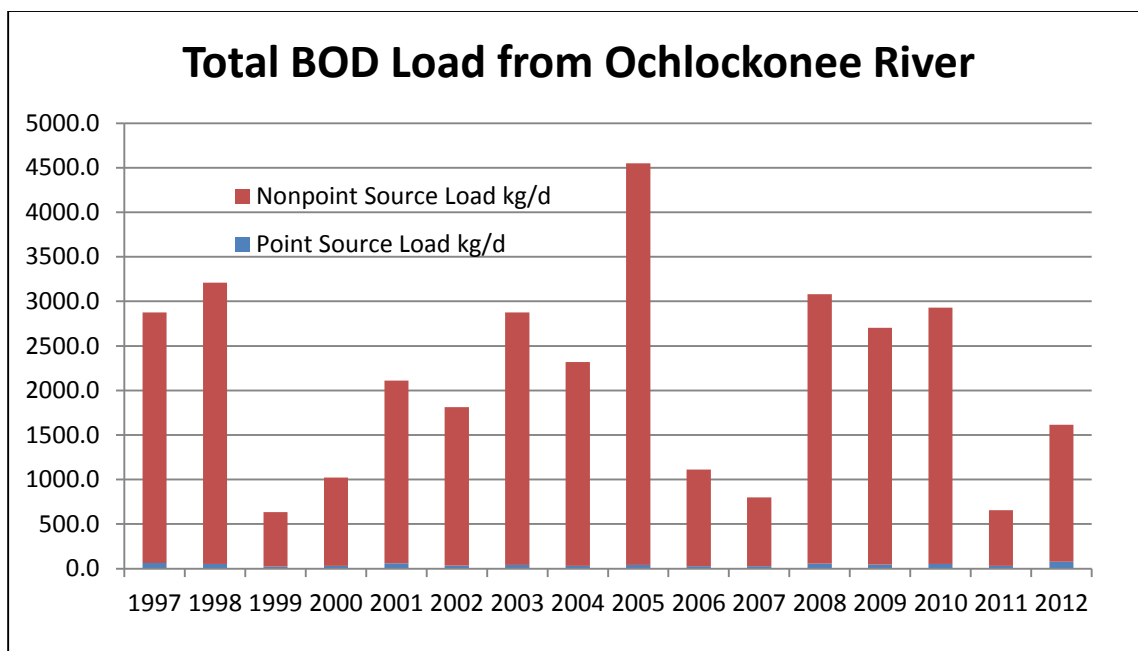


Figure 172 BOD Load from Point Sources in Ochlockonee River

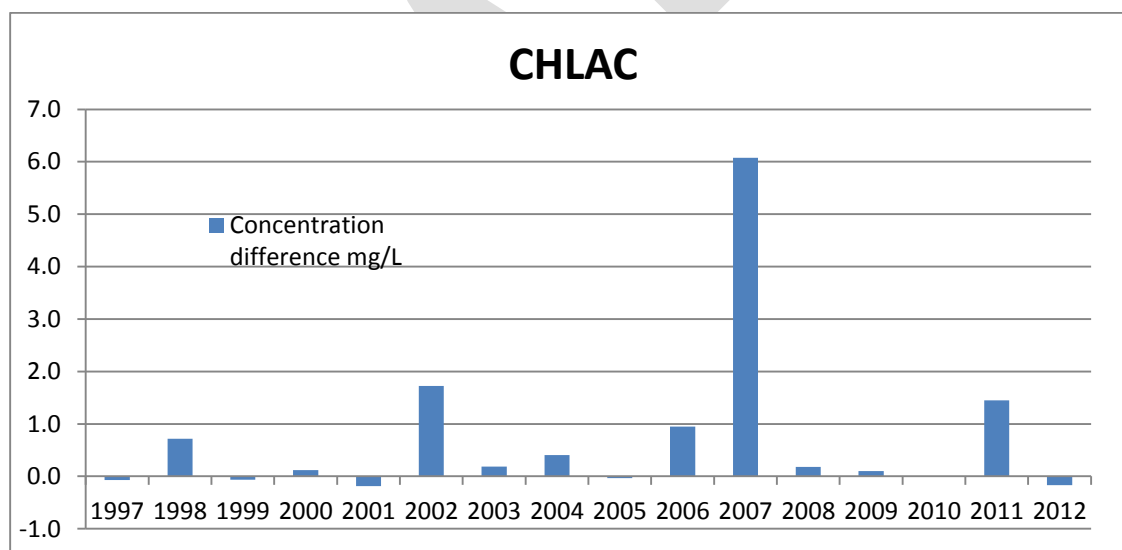


Figure 173 CHLAC Concentration Change Due to Point Sources in Ochlockonee River

The following paragraphs discuss each point source individually.

Thomasville WPCP – Permit #GA0024082

DMR data stored on PCS and ICIS was used for the BOD, flow, and ammonia monthly input values. However, no data was identified in PCS or ICIS for TP (PO₄ and Organic P) or NO_x and Organic N (Table 10). All of these parameters are needed in order to run the WASP model. A review of EPA's file for this facility located two permit applications and some limited TKN sampling data from 2012. This data was used to calculate an average ratio for Ammonia/TN,

NO_x/TN, and Organic N/TN. These ratios were used to calculate NO_x and Organic N based on the Ammonia concentrations provided in DMR. Due to spikes in NO_x concentrations when ammonia concentrations were high, a maximum TN target of 20.60 (the maximum of the two TN values presented in the permits applications) was added to the model. The average TP value was also calculated by using the permit applications. Due to no additional data available, a percentage allotment of 70% PO₄ and 30% Organic P was assumed.

Table 10 Thomasville DMR Data

Parameter	# of Obs	Start Date	End Date	Mean	Min	Max
Ammonia	192	1/1/1997	12/7/2012	0.338	0.010	2.000
Nitrate	84	1/1/2006	12/7/2012	17.927	8.430	35.000
DON	84	1/2/2006	12/7/2012	1.042	0.200	4.920
DIP	84	1/2/2006	12/7/2012	1.902	1.000	7.000
DOP	84	1/2/2006	12/7/2012	0.862	0.000	15.800
BOD	192	1/1/1997	12/7/2012	5.424	2.000	17.500
DO	127	6/30/2002	12/31/2012	6.554	5.200	7.600
Flow	192	1/1/1997	12/7/2012	0.171	0.000	0.453

Moultrie WPCP – Permit # GA0024660

DMR data stored on PCS and ICIS was used for the BOD, flow, and ammonia monthly input values. However, no data was identified in PCS or ICIS for TP (PO₄ and Organic P) or NO_x and Organic N (Table 11). All of these parameters are needed in order to run the WASP model. A review of EPA's file for this facility located two permit applications. This data was used to calculate an average ratio for Ammonia/TN, NO_x/TN, and Organic N/TN. These ratios were used to calculate NO_x and Organic N based on the Ammonia concentrations provided in DMR. Due to spikes in NO_x concentrations when ammonia concentrations were high, a maximum TN target of 22.7 (the maximum of the two TN values presented in the permits applications) was added to the model. The average TP value was also calculated by using the permit applications. Due to no additional data available, a percentage allotment of 70% PO₄ and 30% Organic P was assumed.

Table 11 Moultrie DMR Data

Parameter	# of Obs	Start Date	End Date	Mean	Min	Max
Ammonia	192	1/1/1997	12/7/2012	0.562	0.000	7.000
Nitrate	84	1/2/2006	12/7/2012	16.660	1.560	26.500
DON	84	1/2/2006	12/7/2012	9.200	0.000	68.000
DIP	84	1/2/2006	12/7/2012	4.523	1.400	9.000
DOP	84	1/2/2006	12/7/2012	0.351	0.000	1.500
BOD	192	1/1/1997	12/7/2012	4.091	1.000	24.000
DO	192	1/31/1997	12/31/2012	7.352	3.300	9.300

Flow	192	1/1/1997	12/7/2012	0.133	0.068	0.296
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Cairo WPCP – Permit # GA0025771

DMR data stored on PCS and ICIS was used for the BOD, flow, and ammonia monthly input values (Table 12). However, Cairo was not discharging to a stream during from 1998 until 2006. Cairo was operating under a land application permit at that time. For this model, a zero discharge (i.e. load) was assumed during those years. GAEPD provided the BOD, flow and ammonia monthly values for 2006. However, no data was identified in PCS or ICIS, or available from GAEPD, for NO_x and Organic N. These parameters are needed in order to run the WASP model. A review of EPA's file for this facility located a permit application. This data was used to calculate an average ratio for Ammonia/TN, NO_x/TN, and Organic N/TN. GAEPD provided the TP and Ortho P data for the years 2006 through 2012. This data was used as the monthly input values for phosphorus. Since no data was available for 1997-98, the average TP value was used for those years.

Table 12 Cairo DMR Data

Parameter	# of Obs	Start Date	End Date	Mean	Min	Max
Ammonia	99	1/1/1997	12/4/2012	0.900	0.000	4.710
Nitrate	84	1/1/2006	12/4/2012	3.326	0.160	8.180
DON	84	1/1/2006	12/4/2012	1.573	0.080	3.870
DIP	84	1/1/2006	12/4/2012	0.185	0.000	0.990
DOP	84	1/1/2006	12/4/2012	0.323	0.000	0.790
BOD	99	1/1/1997	12/4/2012	5.500	0.000	12.000
DO	72	1/31/2007	12/31/2012	7.358	6.000	10.000
Flow	99	1/1/1997	12/4/2012	0.060	0.000	0.148

Doerun WPCP – Permit # GA0021717

This facility is a minor wastewater treatment plant and therefore, no DMR data was available. A review of EPA's file for this facility located a permit application. The permit application contained sampling results for ammonia, NO_x, TKN and phosphorus. Since this was the only data available it was used as the monthly data inputs in the WASP model. Additionally, the permit provided permit limits for BOD and flow. These limits were used in the model.

Sunnyland (aka Genesis Project/Affinity) Permit # GA001279

This facility is a frozen food plant. The DMR data stored on PCS and ICIS was used for the monthly BOD, flow and ammonia input values (Table 13). Several gaps in data were present on the in the databases. A search of the PCS website indicated that the gaps in data occurred whenever there was no discharge from the facility. Therefore, in the WASP model, whenever no flow was listed a zero flow and concentration was assumed for that time period. No data was found

regarding phosphorus in PCS, ICIS or during a file review. Therefore, a phosphorus load was not added to the model for this point source.

Table 13 Sunnyland DMR Data

Parameter	# of Obs	Start Date	End Date	Mean	Min	Max
Ammonia	192	1/1/1997	12/7/2012	0.147	0.000	8.500
Nitrate	84	1/2/2006	12/7/2012	0.033	0.000	0.426
DON	2	1/1/2006	12/31/2012	0.000	0.000	0.000
DIP	84	1/2/2006	12/7/2012	0.471	0.000	5.900
DOP	84	1/2/2006	12/7/2012	0.075	0.000	0.840
BOD	192	1/1/1997	12/7/2012	3.300	0.000	115.500
DO	124	9/30/2002	12/31/2012	1.031	0.000	10.800
Flow	192	1/1/1997	12/7/2012	0.005	0.000	0.237

Facilities Not Included in the Model

The following permitted facilities were not included in this model:

- Pelham WPCP – Permit # GA0025518 – This facility was a minor wastewater treatment plant. According to GAEPD, the facility closed out their permit in the 1990s. Therefore, it was not included in the WASP model.
- W.B. Roddenbery Company – Permit # GA0001660 – According to the PCS data, this facility was first permitted in 1997. A review of the EPA’s files on this facility determined all production ceased on July 2002. Since the facility was only active for five years, TN and TP were not regulated by the permit, and it was only a minor permitted facility, it was not included in the WASP model.
- The remaining permits are for mining facilities (Permits # GA0047503, GA0047511, GA0047520, and GA0032409) and three of the four permits are no longer active. Additionally none of the mining permits have limits for TN or TP. For these reasons, the mining permits were not included in the WASP model.

Little River

The Little River model includes two significant point sources: Quincy WPCP and BASF Attapulugus Plant (Figure 174). Quincy is a major domestic wastewater treatment plant while BASF is a major industrial discharger.

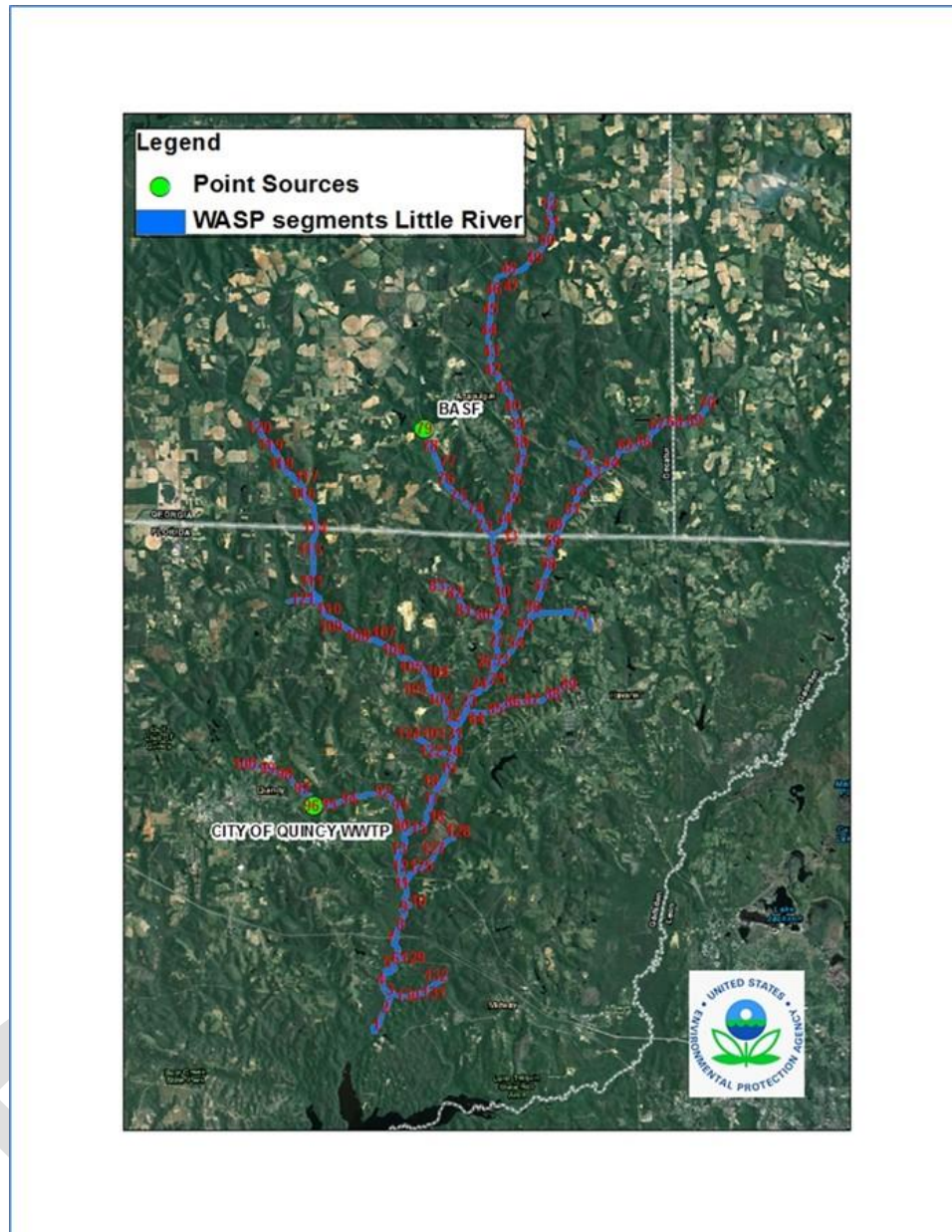


Figure 174 – Little River Simulated NPDES Dischargers

The total annual nutrient loads at the outflow of the Little River WASP model, are depicted below in Figure 175 and Figure 176.

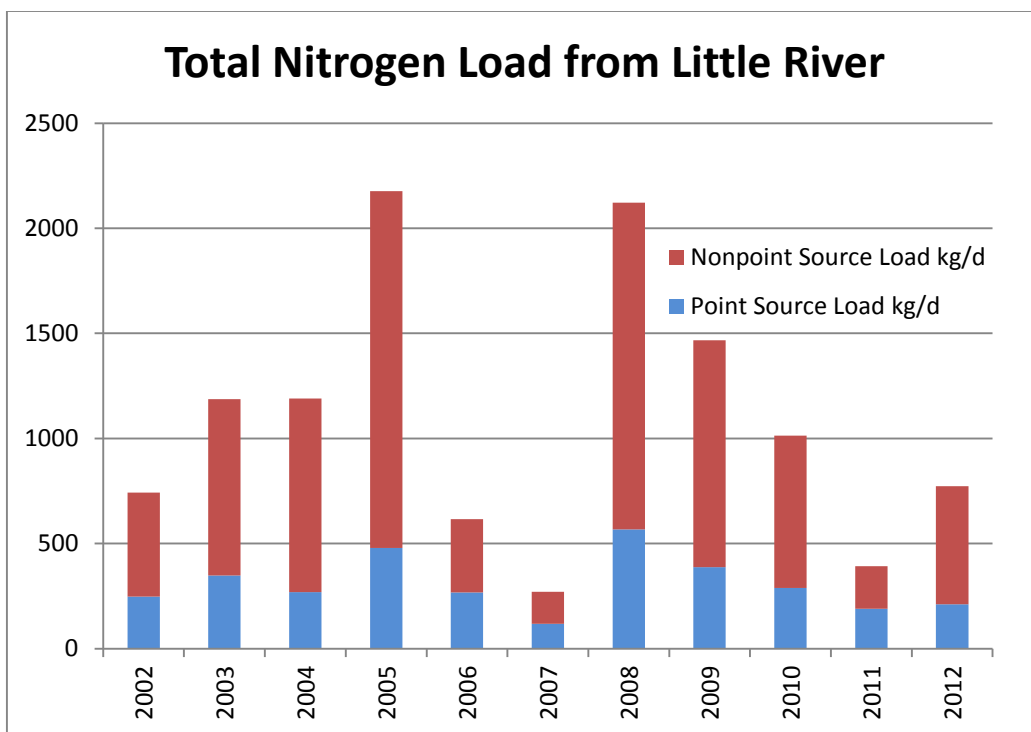


Figure 175 Total Nitrogen Load from Point Sources in Little River (Daily Average)

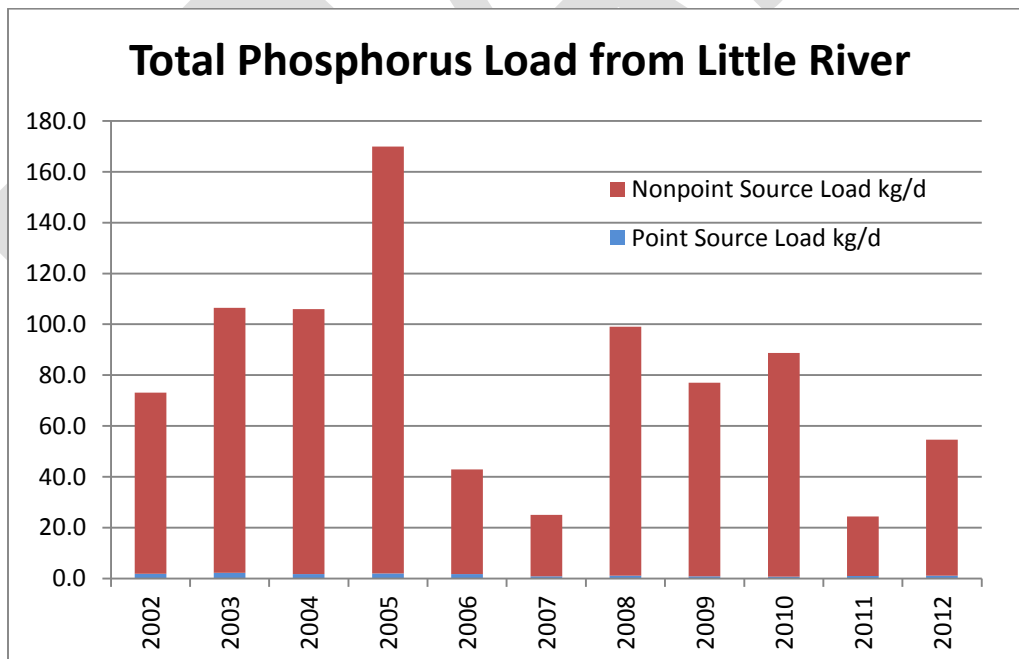


Figure 176 Total Phosphorus Load from Point Sources in Little River

The following paragraphs discuss each point source.

Quincy WPCP – Permit # FL0029033

This facility discharges out of a single outfall (001)(Table 14). Monthly DMR data retrieved from ICIS and PCS are used to load effluent flows and pollutant concentrations for total nitrogen, total phosphorus and BOD5. Data for the period 1996 through 2012 are available. For individual nutrient speciation, limited PO₄, TKN and NH₃ data from the facility's most recent permit application is used to estimate nutrient fractions. These values compare reasonably well with ambient and observed nutrient fractions such that the ambient speciation applied to LSPC output was also used for this facilitate for efficiency (3% NH₃, 23% NO₃NO₂, 74% Org N, 40% PO₄, 60% Org P). Reported monthly dissolved oxygen concentrations are put directly into the model. Stepwise interpolations are used in the model to emulate the DMR monthly values.

Table 14 Quincy DMR Data

Parameter	# of Obs	Start Date	End Date	Mean	Min	Max
Ammonia	30	5/11/2006	8/27/2012	9.271	0.200	29.600
Nitrate	30	5/11/2006	8/27/2012	37.507	0.800	180.000
DON	2	1/1/2006	12/31/2012	0.000	0.000	0.000
DIP	2	1/1/2006	12/31/2012	0.000	0.000	0.000
DOP	2	1/1/2006	12/31/2012	0.000	0.000	0.000
BOD	2	1/1/2006	12/31/2012	0.000	0.000	0.000
DO	2	1/1/2006	12/31/2012	7.000	7.000	7.000
Flow	2557	1/1/2006	12/31/2012	0.005	0.000	0.200

BASF Attapulugus Plant – Permit # GA0001678

The BASF facility maintains two permitted outfalls (001 and 002)(Table 15 & Table 16). Monthly DMR data was processed to parameterize the inputs to the model. A summary of the data is provided in the tables below for each of the outfalls.

Table 15 BASF001 DMR

Parameter	# of Obs	Start Date	End Date	Mean	Min	Max
Ammonia	883	1/2/2006	12/31/2012	32.874	0.042	108.000
Nitrate	885	1/2/2006	12/31/2012	170.194	3.820	408.000
DON	2	1/1/2006	12/31/2012	0.000	0.000	0.000
DIP	2	1/1/2006	12/31/2012	0.000	0.000	0.000
DOP	2	1/1/2006	12/31/2012	0.000	0.000	0.000
BOD	2	1/1/2006	12/31/2012	0.000	0.000	0.000
DO	2	1/1/2006	12/31/2012	7.000	7.000	7.000
Flow	2557	1/1/2006	12/31/2012	0.026	0.000	0.214

Table 16 BASF002 DMR

Parameter	# of Obs	Start Date	End Date	Mean	Min	Max
Ammonia	30	5/11/2006	8/27/2012	9.271	0.200	29.600
Nitrate	30	5/11/2006	8/27/2012	37.507	0.800	180.000
DON	2	1/1/2006	12/31/2012	0.000	0.000	0.000
DIP	2	1/1/2006	12/31/2012	0.000	0.000	0.000
DOP	2	1/1/2006	12/31/2012	0.000	0.000	0.000
BOD	2	1/1/2006	12/31/2012	0.000	0.000	0.000
DO	2	1/1/2006	12/31/2012	7.000	7.000	7.000
Flow	2557	1/1/2006	12/31/2012	0.005	0.000	0.200

Natural Condition Scenarios

Two sets of natural conditions scenarios were developed (FDEP and GAEPD) that used different methodologies for characterizing a non-anthropogenic Ochlockonee watershed. This methodology converted all anthropogenic landuses (developed, agriculture, etc.) to upland forest and wetlands. All point sources loads and flows were removed. The watershed model scenarios (FDEP & GAEPD) executed and fed forward into the calibrated Ochlockonee and Little River WASP models. The river models and the directly connected watershed model results were fed forward into the calibrated Lake Talquin WASP model. Because the two natural condition scenarios yield virtually the same result, the FDEP methodology is compared with the current condition.

Ochlockonee River

Figure 177 - Figure 183 illustrate the difference between the current conditions and the natural condition scenarios for flow, total nitrogen and total phosphorus for the Ochlockonee River.

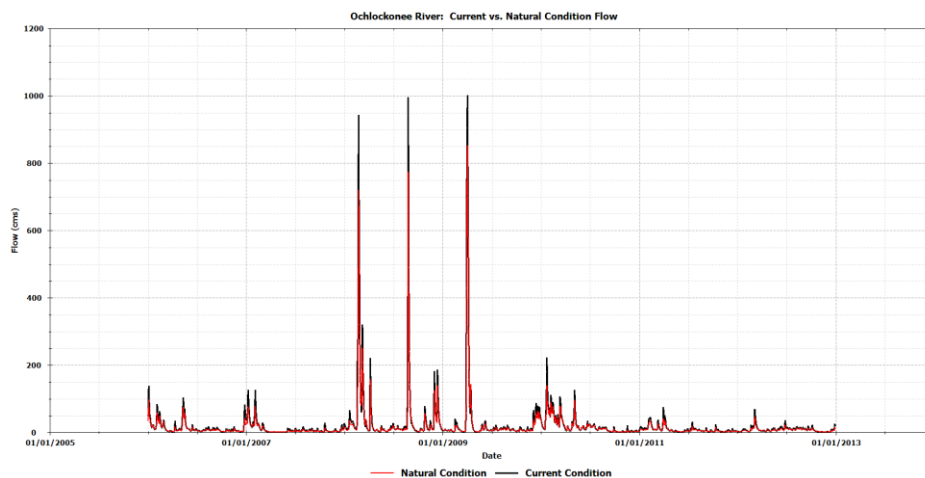


Figure 177 Ochlockonee River Predicted Flow: Current vs. Natural Conditions

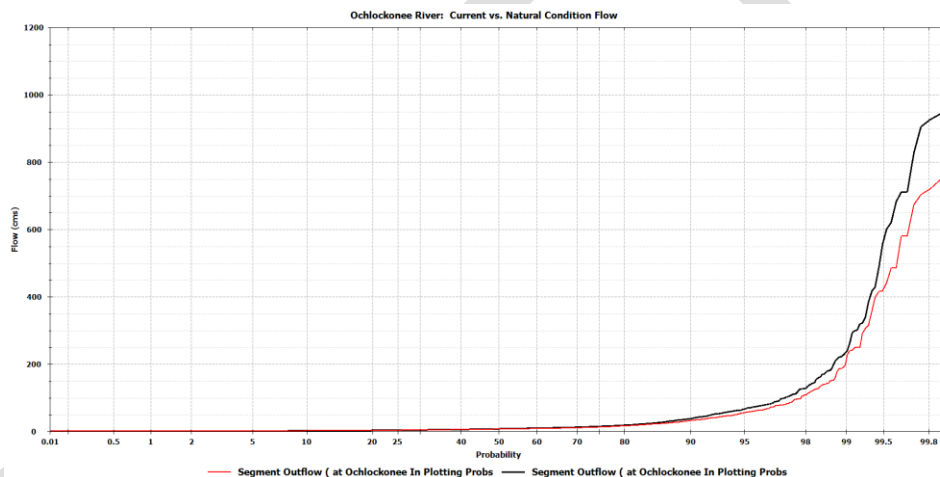


Figure 178 Ochlockonee River Probability Plot for Flow: Current vs. Natural Conditions

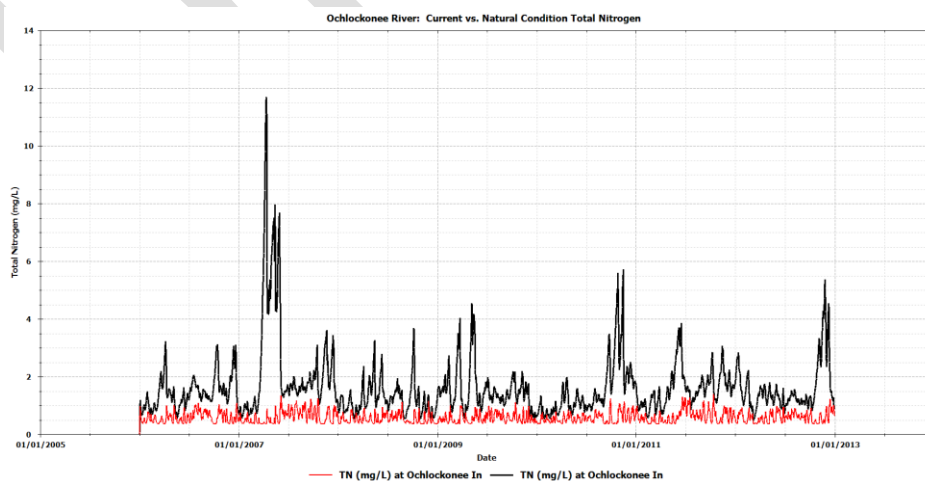


Figure 179 Ochlockonee River Predicted Total Nitrogen: Current vs. Natural Conditions

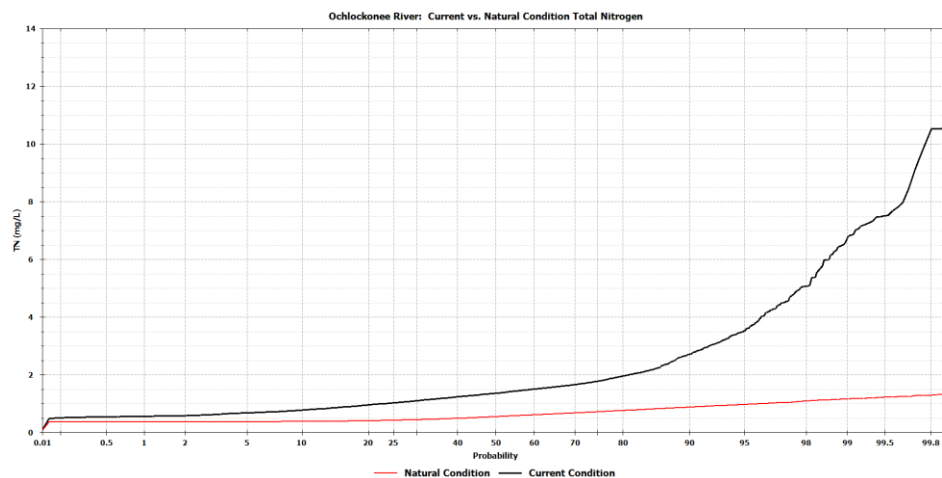


Figure 180 Ochlockonee River Probability Plot for Total Nitrogen: Current vs. Natural Conditions

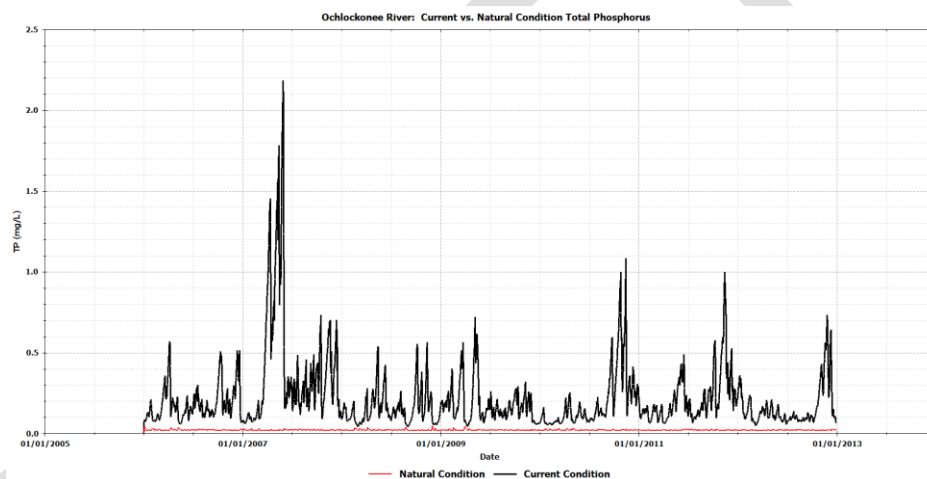


Figure 181 Ochlockonee River Predicted Total Phosphorus: Current vs. Natural Conditions

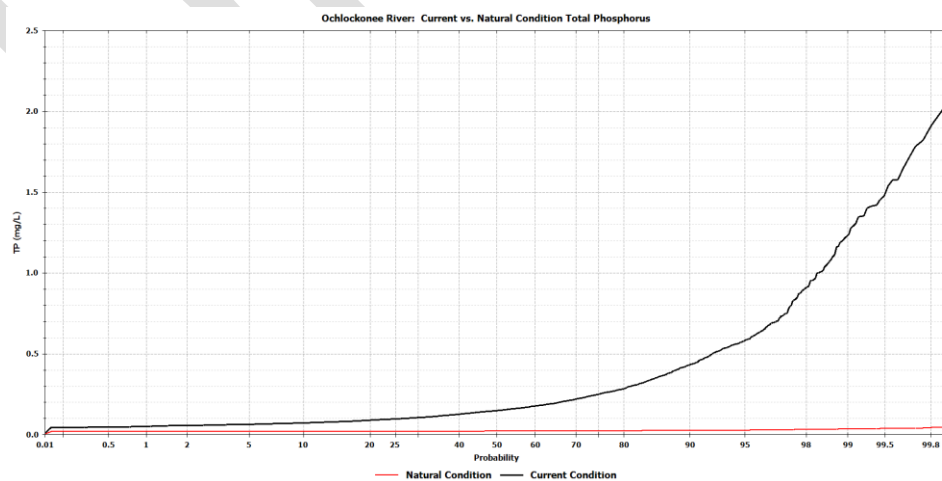


Figure 182 Ochlockonee River Probability Plot for Total Phosphorus: Current vs. Natural Conditions

Little River

Figure 183 - Figure 188 illustrate the difference between the current conditions and the natural condition scenarios for flow, total nitrogen and total phosphorus for the Little River.

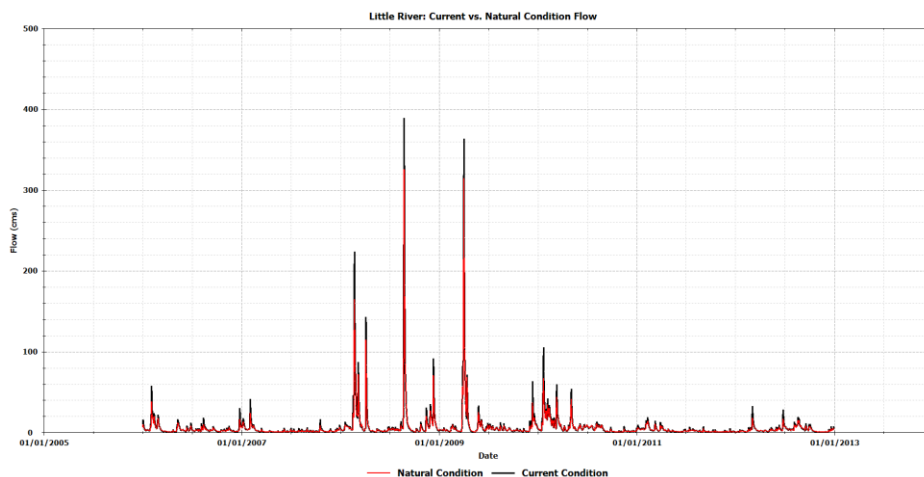


Figure 183 Little River Predicted Flow: Current vs. Natural Conditions

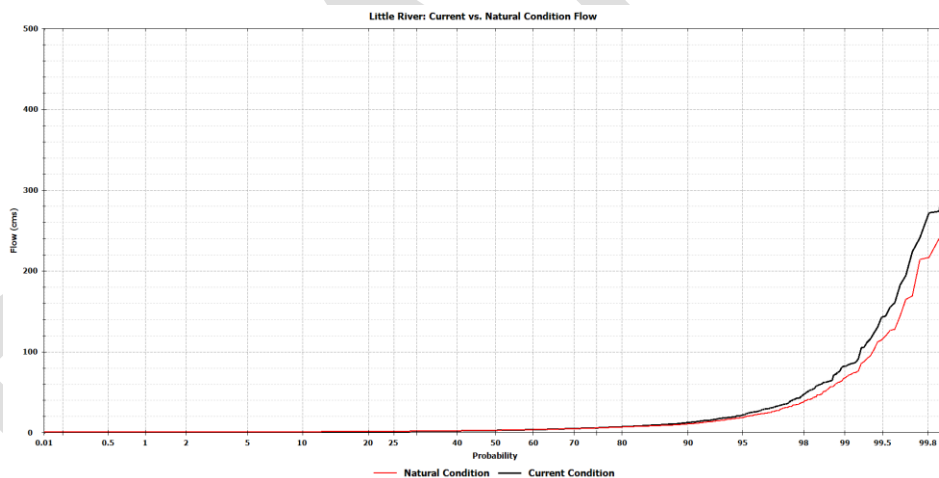


Figure 184 Little River Probability Plot for Flow: Current vs. Natural Conditions

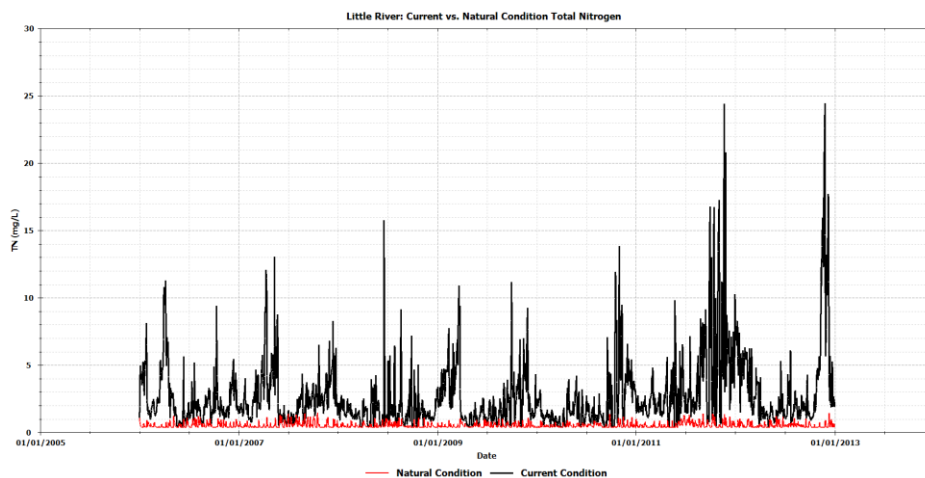


Figure 185 Little River Predicted Total Nitrogen: Current vs. Natural Conditions

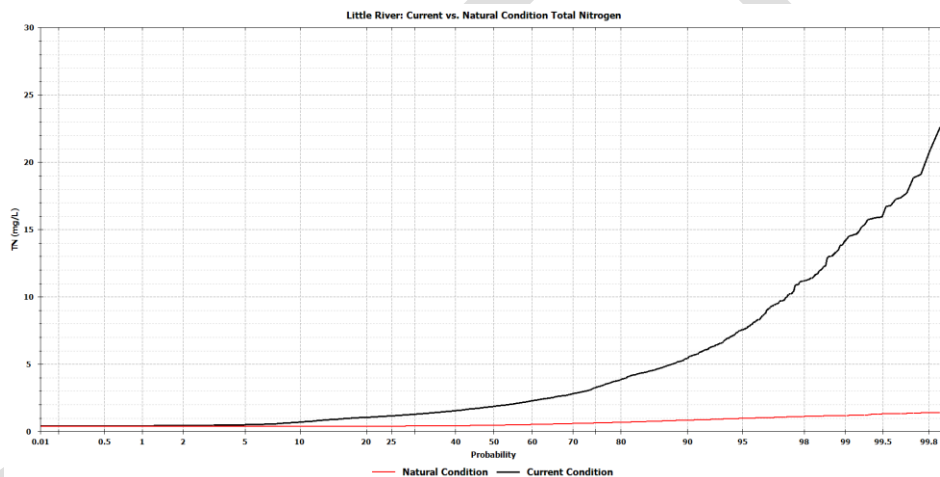


Figure 186 Little River Probability Plot for Total Nitrogen: Current vs. Natural Conditions

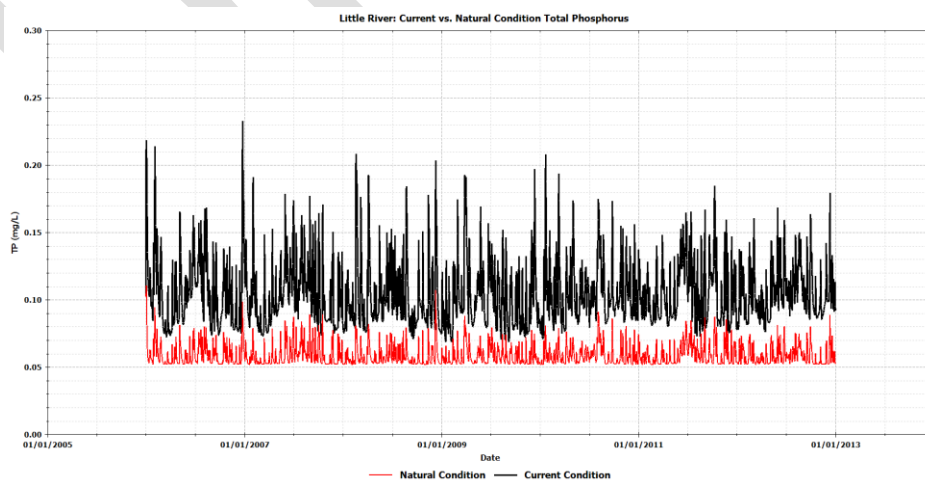


Figure 187 Little River Predicted Total Phosphorus: Current vs. Natural Conditions

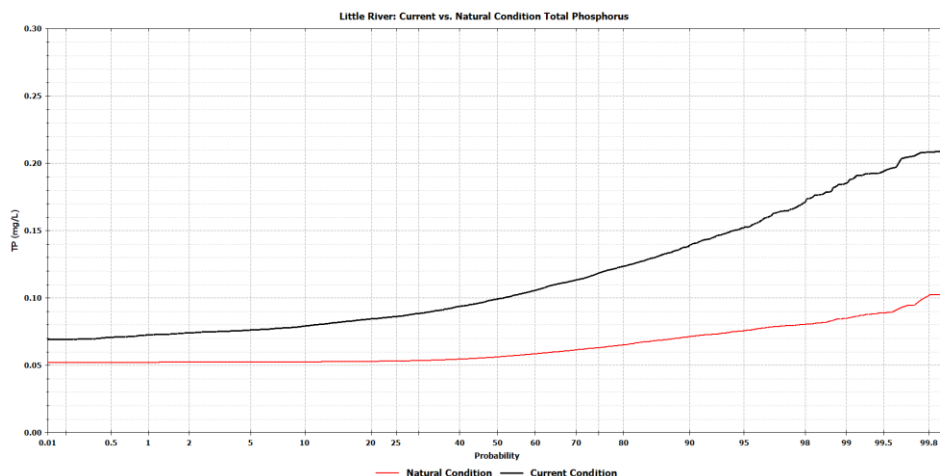


Figure 188 Little River Probability Plot for Total Phosphorus: Current vs. Natural Conditions

Lake Talquin Modeling Scenarios

The results of the natural conditions scenarios for Ochlockonee and Little River we processed forward into the calibrated Lake Talquin hydrodynamic and water quality. The EFDC model was executed using the new inflows from the scenarios. The calibrated Lake Talquin water quality model was executed using the new flows (from EFDC) and loads from (LSPC directly connected to the lake) and the WASP Ochlockonee and Little River WASP models.

The model results were processed for each of the 4 zones for the 7 years as described in the potential end point analysis.

Table 17 Little River – Annual Loadings for Total Nitrogen and Total Phosphorus for each Scenario

Year	Total Nitrogen (kg/year)						Total Phosphorus (kg/year)					
	Current	Natural	TMDL	% Reduction	Anthropogenic	%	Current	Natural	TMDL	% Reduction	Anthropogenic	%
2006	293000	104395	169940	42%	188605	64%	23244	11792	16851	28%	11453	49%
2007	218814	88890	126912	42%	129924	59%	16673	8669	12088	27%	8004	48%
2008	624414	294506	362159	42%	329908	53%	72491	33969	52551	28%	38522	53%
2009	501430	210839	290827	42%	290591	58%	49544	24104	35919	28%	25440	51%
2010	357174	146843	207159	42%	210331	59%	34910	17409	25310	27%	17501	50%
2011	252672	82515	146550	42%	170157	67%	14750	8138	10694	27%	6612	45%
2012	279946	83758	162369	42%	196188	70%	17700	9125	12833	27%	8575	48%
Average	361064	144535	209417		216529		32759	16172	23749		16587	

Table 18 Ochlockonee River– Annual Loadings for Total Nitrogen and Total Phosphorus for each Scenario

Year	Total Nitrogen (kg/year)						Total Phosphorus (kg/year)					
	Current	Natural	TMDL	% Reduction	Anthropogenic	%	Current	Natural	TMDL	% Reduction	Anthropogenic	%
2006	568545	358489	436642	23%	210056	37%	51794	10705	31077	40%	41089	79%
2007	516348	331322	396557	23%	185026	36%	51986	8178	31191	40%	43808	84%
2008	1482480	1074168	1138539	23%	408312	28%	116816	39942	70083	40%	76874	66%
2009	1140927	786915	876235	23%	354012	31%	86622	28477	51972	40%	58145	67%
2010	651036	406387	499998	23%	244649	38%	57321	13165	34390	40%	44156	77%
2011	458565	289810	352179	23%	168755	37%	39110	6299	23466	40%	32811	84%
2012	385873	223342	296352	23%	162530	42%	28313	5054	16986	40%	23259	82%
Average	743396	495776	570929		247620		61709	15974	37024		45735	

Table 19 LSPC 60114 – Annual Loadings for Total Nitrogen and Total Phosphorus for each Scenario

Year	Total Nitrogen (kg/year)						Total Phosphorus (kg/year)					
	Current	Natural	TMDL	% Reduction	Anthropogenic	%	Current	Natural	TMDL	% Reduction	Anthropogenic	%
2006	20232	14560	15842	22%	5672	28%	3223	1805	2369	26%	1418	44%
2007	19000	13339	14877	22%	5661	30%	2889	1480	2124	27%	1409	49%
2008	73624	49754	57648	22%	23870	32%	11786	5642	8663	27%	6144	52%
2009	55374	37766	43357	22%	17608	32%	8887	4345	6531	27%	4542	51%
2010	32534	22801	25474	22%	9733	30%	5188	2804	3813	27%	2384	46%
2011	17719	11999	13874	22%	5720	32%	2655	1395	1952	26%	1260	47%
2012	14065	9825	11013	22%	4240	30%	2115	1162	1554	27%	953	45%
Average	33221	22864	26012		10358		5249	2662	3858		2587	

Table 20 LSPC 60125 – Annual Loadings for Total Nitrogen and Total Phosphorus for each Scenario

Year	Total Nitrogen (kg/year)						Total Phosphorus (kg/year)					
	Current	Natural	TMDL	% Reduction	Anthropogenic	%	Current	Natural	TMDL	% Reduction	Anthropogenic	%
2006	24916	23812	24293	3%	1104	4%	1942	1642	1810	7%	300	15%
2007	19846	19445	19350	3%	401	2%	1486	1354	1385	7%	133	9%
2008	29701	28597	28958	3%	1104	4%	2339	2026	2180	7%	313	13%
2009	26325	25353	25666	3%	972	4%	2062	1791	1921	7%	271	13%
2010	30584	29032	29820	2%	1552	5%	2511	2114	2341	7%	398	16%
2011	17097	16848	16669	3%	248	1%	1244	1162	1159	7%	82	7%
2012	25846	24971	25200	2%	875	3%	1923	1710	1792	7%	213	11%
Average	24902	24008	24279		894		1929	1686	1798		244	

Table 21 LSPC 60126 – Annual Loadings for Total Nitrogen and Total Phosphorus for each Scenario

Year	Total Nitrogen (kg/year)						Total Phosphorus (kg/year)					
	Current	Natural	TMDL	% Reduction	Anthropogenic	%	Current	Natural	TMDL	% Reduction	Anthropogenic	%
2006	25417	23860	24568	3%	1557	6%	2044	1619	1858	9%	425	21%
2007	19975	19490	19308	3%	485	2%	1518	1345	1380	9%	173	11%
2008	30030	28561	29027	3%	1469	5%	2418	1993	2198	9%	425	18%
2009	26651	25333	25761	3%	1318	5%	2136	1762	1941	9%	374	17%
2010	31003	28851	29968	3%	2153	7%	2617	2060	2379	9%	557	21%
2011	17188	16908	16614	3%	279	2%	1260	1158	1145	9%	102	8%
2012	26092	24903	25221	3%	1189	5%	1971	1684	1792	9%	287	15%
Average	25194	23987	24352		1207		1995	1660	1813		335	

Table 22 LSPC 60127 – Annual Loadings for Total Nitrogen and Total Phosphorus for each Scenario

Year	Total Nitrogen (kg/year)						Total Phosphorus (kg/year)					
	Current	Natural	TMDL	% Reduction	Anthropogenic	%	Current	Natural	TMDL	% Reduction	Anthropogenic	%
2006	10581	9428	9523	10%	1153	11%	1296	1053	1105	15%	243	19%
2007	9143	8290	8228	10%	853	9%	1011	804	862	15%	207	20%
2008	35985	30164	32386	10%	5820	16%	4695	3198	4005	15%	1497	32%
2009	27966	23051	25170	10%	4915	18%	3697	2457	3154	15%	1240	34%
2010	17210	14823	15489	10%	2387	14%	2224	1687	1897	15%	536	24%
2011	8797	8014	7918	10%	783	9%	970	798	827	15%	172	18%
2012	7349	6629	6614	10%	719	10%	805	664	687	15%	141	18%
Average	16719	14343	15047		2376		2100	1523	1791		577	

Table 23 LSPC 60128 – Annual Loadings for Total Nitrogen and Total Phosphorus for each Scenario

Year	Total Nitrogen (kg/year)						Total Phosphorus (kg/year)					
	Current	Natural	TMDL	% Reduction	Anthropogenic	%	Current	Natural	TMDL	% Reduction	Anthropogenic	%
2006	12140	11072	11515	5%	1069	9%	1018	769	910	11%	249	24%
2007	9518	9086	9028	5%	433	5%	738	642	660	11%	96	13%
2008	14263	13249	13528	5%	1014	7%	1181	954	1056	11%	227	19%
2009	12871	11820	12209	5%	1051	8%	1082	847	967	11%	235	22%
2010	15133	13613	14353	5%	1519	10%	1356	1006	1212	11%	349	26%
2011	8048	7807	7634	5%	241	3%	594	544	531	11%	51	9%
2012	12221	11365	11592	5%	856	7%	943	786	843	11%	157	17%
Average	12028	11144	11409		883		987	792	883		195	

Table 24 LSPC 60166 – Annual Loadings for Total Nitrogen and Total Phosphorus for each Scenario

Year	Total Nitrogen (kg/year)						Total Phosphorus (kg/year)					
	Current	Natural	TMDL	% Reduction	Anthropogenic	%	Current	Natural	TMDL	% Reduction	Anthropogenic	%
2006	4302	3927	3928	9%	376	9%	468	389	400	14%	79	17%
2007	4083	3835	3728	9%	248	6%	392	334	335	14%	58	15%
2008	12695	10783	11590	9%	1911	15%	1547	1042	1324	14%	505	33%
2009	10121	8430	9241	9%	1691	17%	1256	823	1075	14%	432	34%
2010	6750	5895	6163	9%	855	13%	775	585	663	14%	190	24%
2011	4282	3978	3910	9%	305	7%	393	337	336	14%	56	14%
2012	3617	3329	3302	9%	288	8%	330	281	282	14%	49	15%
Average	6550	5739	5980		811		737	542	631		195	

Table 25 LSPC 60167 – Annual Loadings for Total Nitrogen and Total Phosphorus for each Scenario

Year	Total Nitrogen (kg/year)						Total Phosphorus (kg/year)					
	Current	Natural	TMDL	% Reduction	Anthropogenic	%	Current	Natural	TMDL	% Reduction	Anthropogenic	%
2006	9648	9412	9368	3%	237	2%	672	609	614	9%	63	9%
2007	8876	8772	8618	3%	104	1%	607	564	555	9%	43	7%
2008	17777	16632	17259	3%	1144	6%	1487	1132	1359	9%	354	24%
2009	15602	14524	15148	3%	1079	7%	1276	974	1166	9%	302	24%
2010	11492	10886	11157	3%	606	5%	859	725	785	9%	133	16%
2011	8868	8767	8610	3%	102	1%	585	549	534	9%	36	6%
2012	8853	8731	8596	3%	122	1%	571	534	522	9%	36	6%
Average	11588	11103	11251		485		865	727	791		138	

Table 26 LSPC 60168 – Annual Loadings for Total Nitrogen and Total Phosphorus for each Scenario

Year	Total Nitrogen (kg/year)						Total Phosphorus (kg/year)					
	Current	Natural	TMDL	% Reduction	Anthropogenic	%	Current	Natural	TMDL	% Reduction	Anthropogenic	%
2006	2744	2718	2713	1%	26	1%	173	169	168	3%	3	2%
2007	2524	2514	2496	1%	10	0%	158	157	154	3%	1	1%
2008	4660	4545	4608	1%	115	2%	321	293	313	3%	28	9%
2009	4138	4031	4091	1%	107	3%	281	257	274	3%	24	9%
2010	3158	3096	3122	1%	61	2%	205	195	199	3%	10	5%
2011	2535	2519	2507	1%	17	1%	154	153	150	3%	1	1%
2012	2577	2556	2548	1%	21	1%	153	152	149	3%	1	1%
Average	3191	3140	3155		51		206	197	201		10	

Table 27 LSPC 60169 – Annual Loadings for Total Nitrogen and Total Phosphorus for each Scenario

Year	Total Nitrogen (kg/year)						Total Phosphorus (kg/year)					
	Current	Natural	TMDL	% Reduction	Anthropogenic	%	Current	Natural	TMDL	% Reduction	Anthropogenic	%
2006	8337	7903	8127	3%	433	5%	662	531	607	8%	132	20%
2007	6516	6446	6352	3%	70	1%	488	440	447	8%	47	10%
2008	9817	9458	9570	3%	359	4%	780	649	715	8%	131	17%
2009	8679	8377	8460	3%	301	3%	682	575	624	8%	107	16%
2010	10045	9460	9792	3%	586	6%	829	664	759	8%	165	20%
2011	5642	5608	5500	3%	34	1%	407	381	373	8%	26	6%
2012	8577	8277	8361	3%	300	3%	638	554	585	8%	85	13%
Average	8230	7933	8023		298		641	542	587		99	

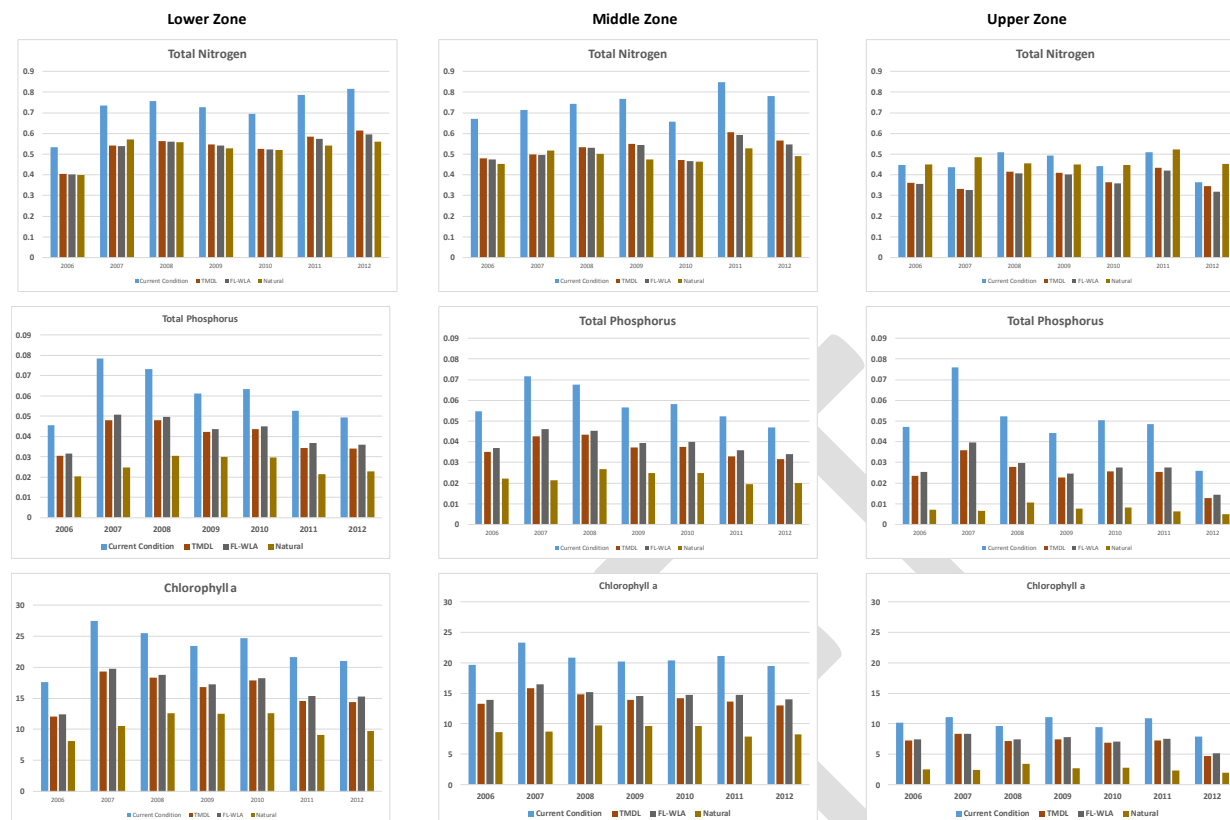


Figure 189 Calculated Annual Geometric Means for each scenario

Comparison Version 6 & 8

The following figures show a direct comparison between the Version 6 and Version 8 calibrated models at current conditions. The difference can be attributed to how the EFDC flow correction is applied to the water quality model as well patching to the LSPC rainfall files. Slight modifications were made to the model constants for Version 8, these changes were made because of changes in retention time (due to flow correction modification). Maximum algal growth rate was reduced from 3.0 to 2.5 per day. Organic nitrogen mineralization rates were increased to better match the inorganic nitrogen concentrations.

Figure 190 through Figure 203 provides a direct comparison of the predicted time series to CBOD, NH₃, NO₃, Chlorophyll a, Total Nitrogen, Total Phosphorus, Total Suspended Solids for the entire simulation period. Probability plot comparisons are made as well to show the difference in central tendency and the high and low percentiles.

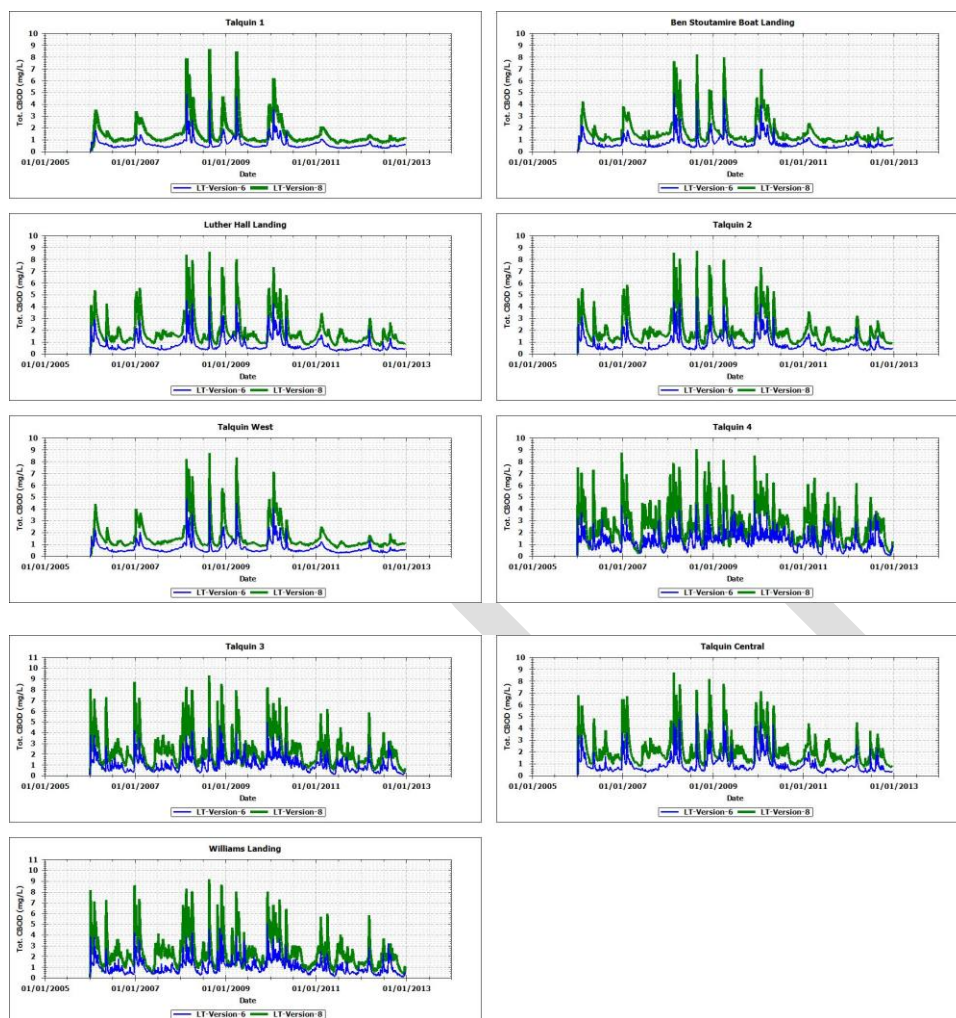


Figure 190 Comparison of CBOD Time Series Version 6 vs. 8

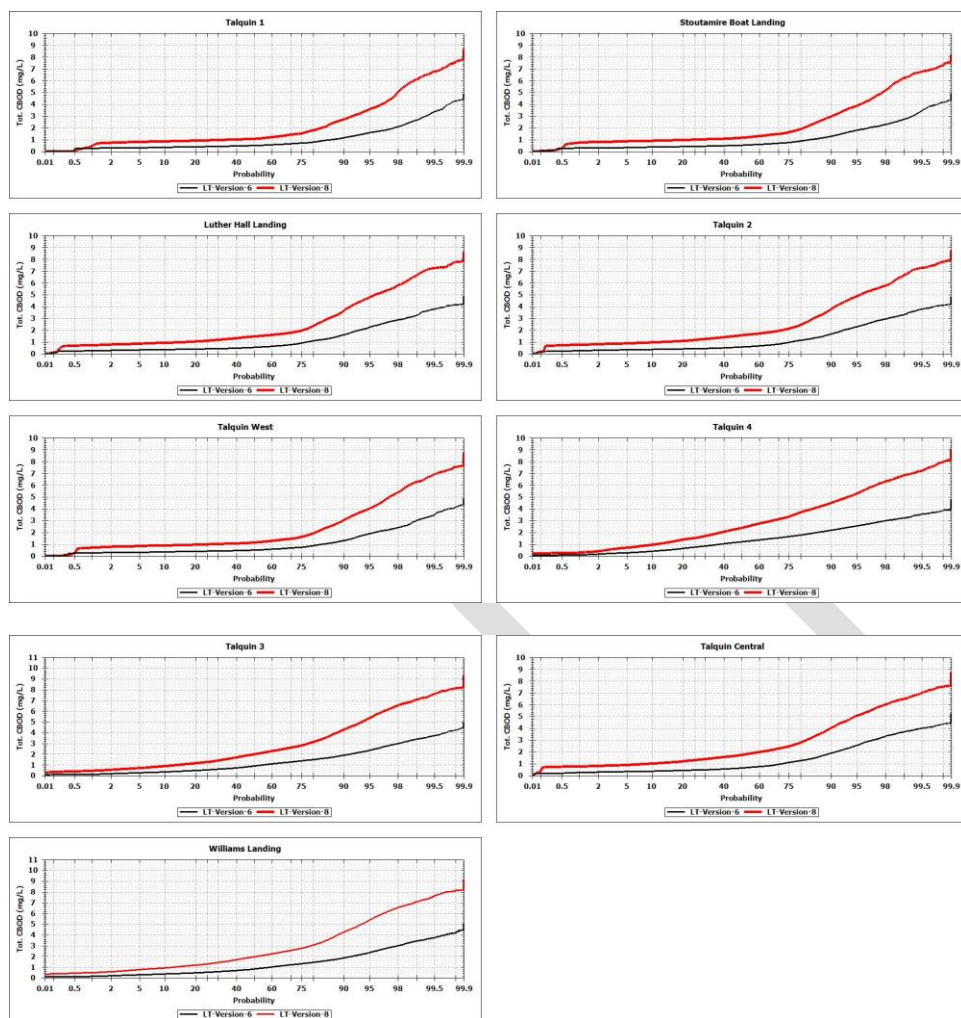


Figure 191 Comparison of CBOD Probability Plot Version 6 vs. 8

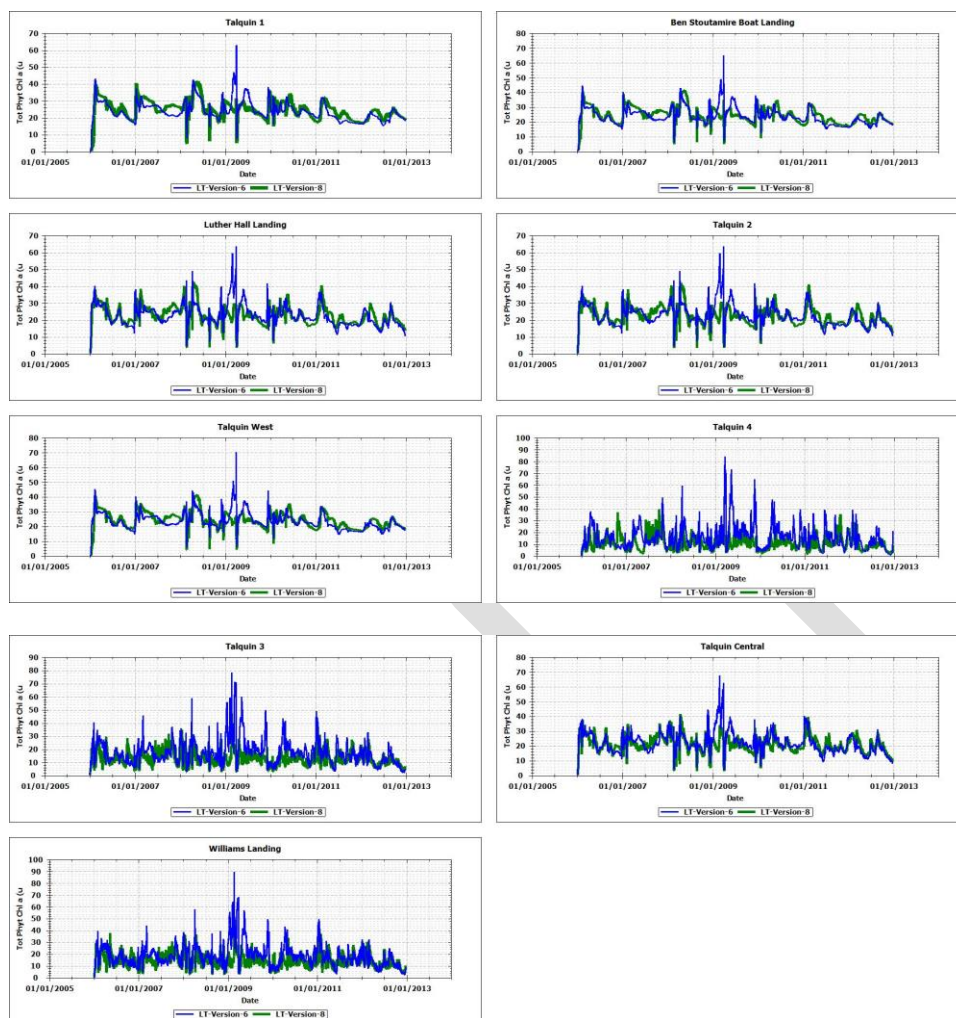


Figure 192 Comparison of Chlorophyll a Time Series Version 6 vs. 8

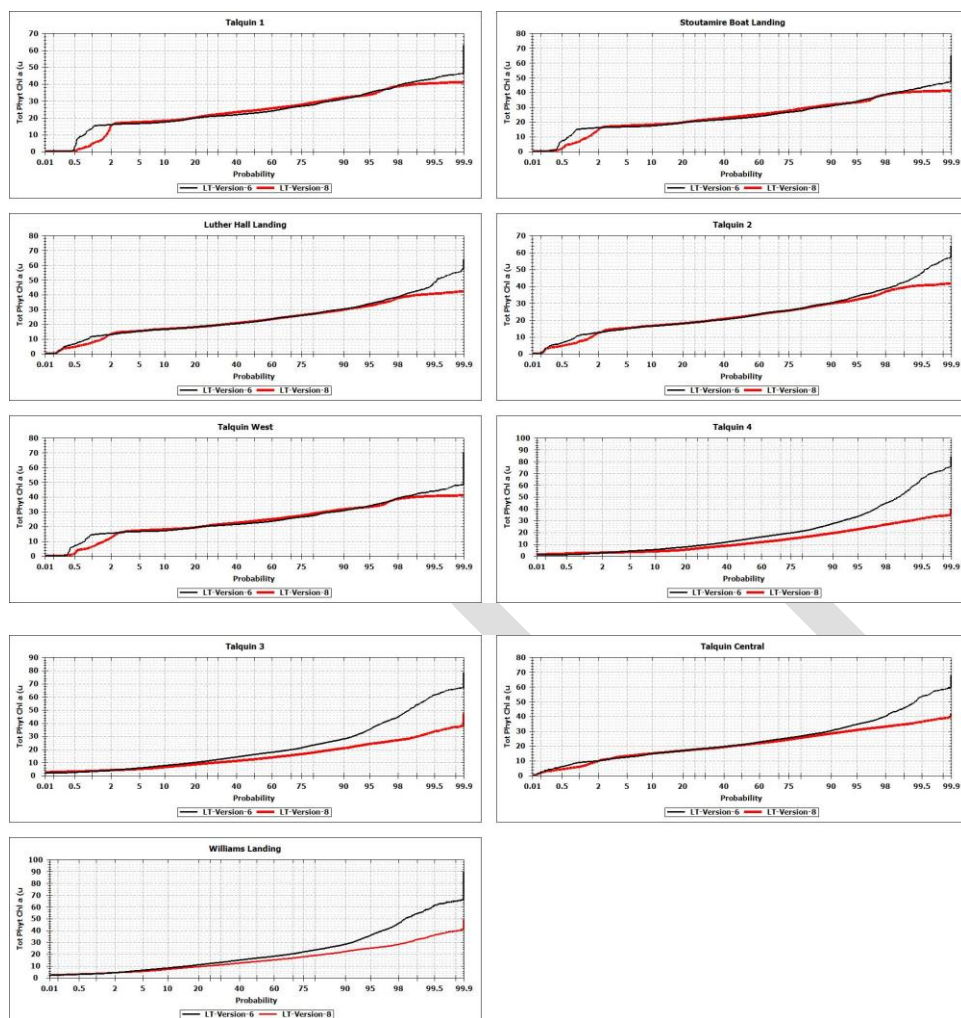


Figure 193 Comparison of Chlorophyll a Probability Plot Version 6 vs. 8



Figure 194 Comparison of Ammonia Time Series Version 6 vs. 8

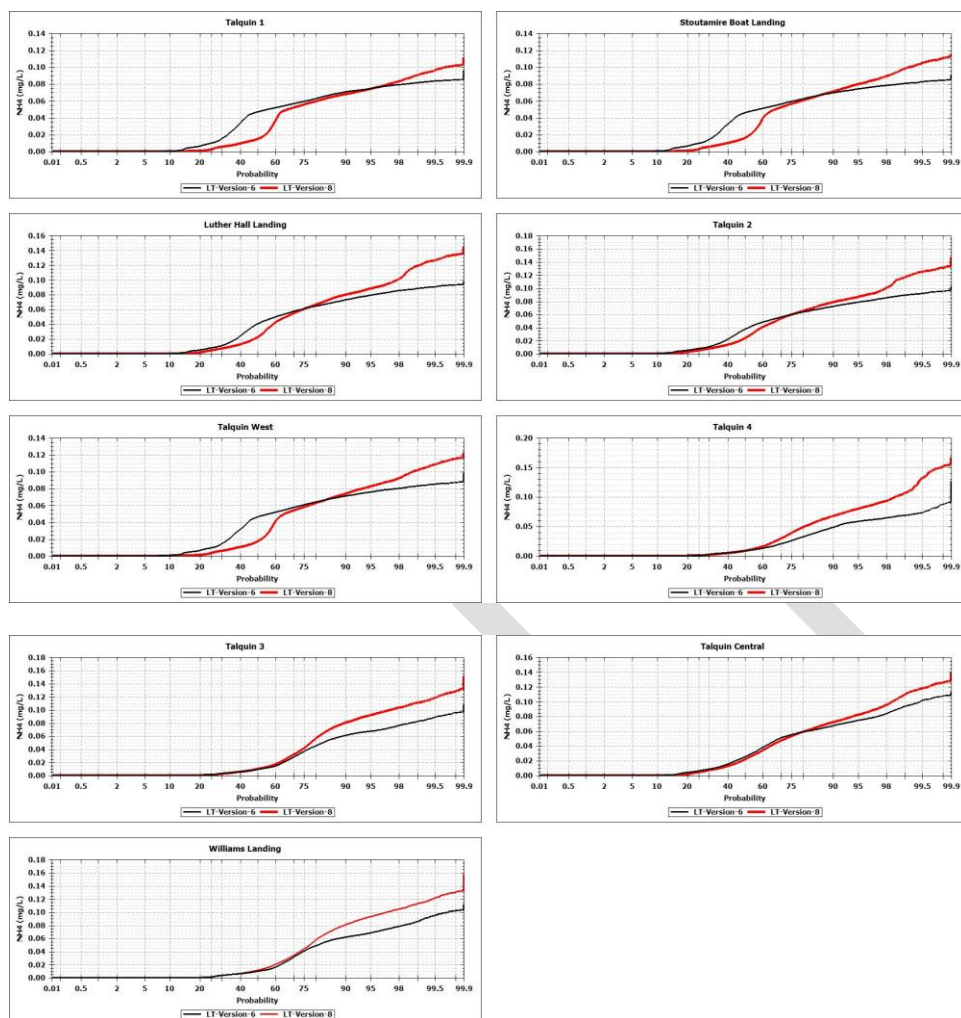


Figure 195 Comparison of Ammonia Probability Plot Version 6 vs. 8

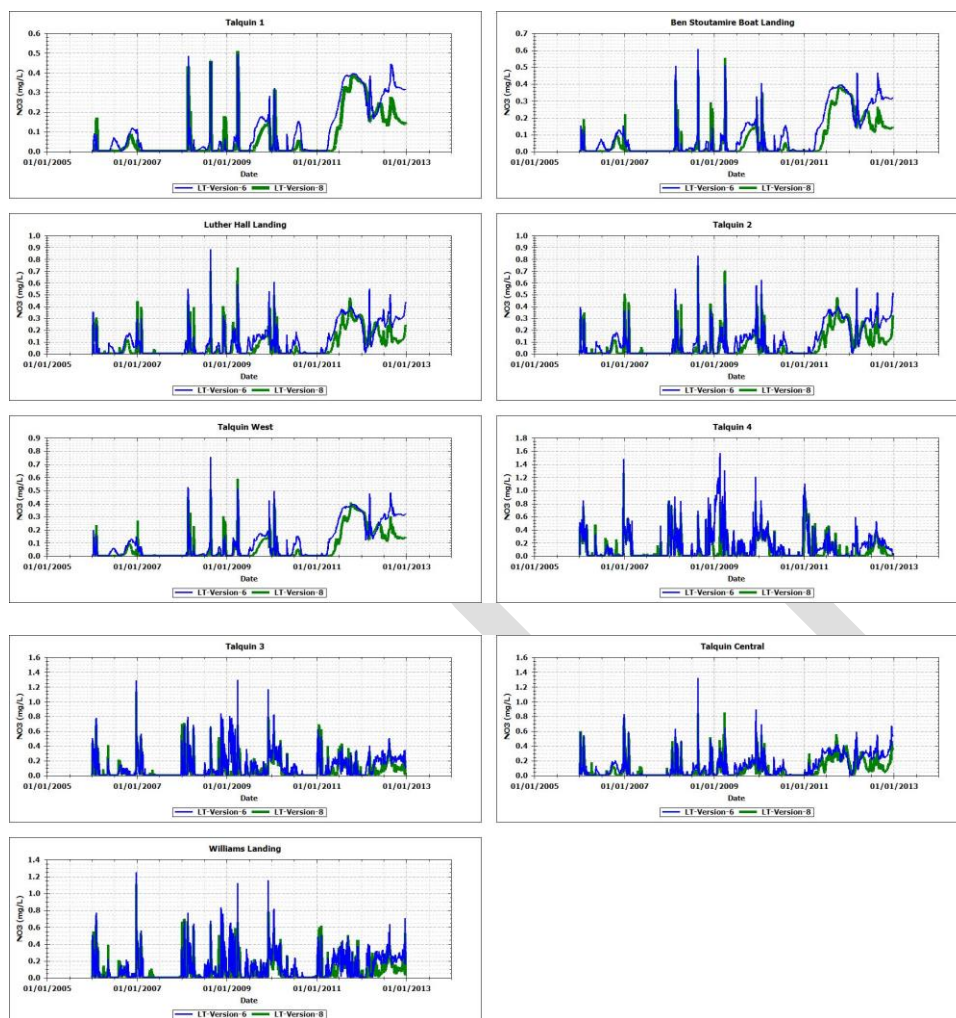


Figure 196 Comparison of Nitrate Time Series Version 6 vs. 8

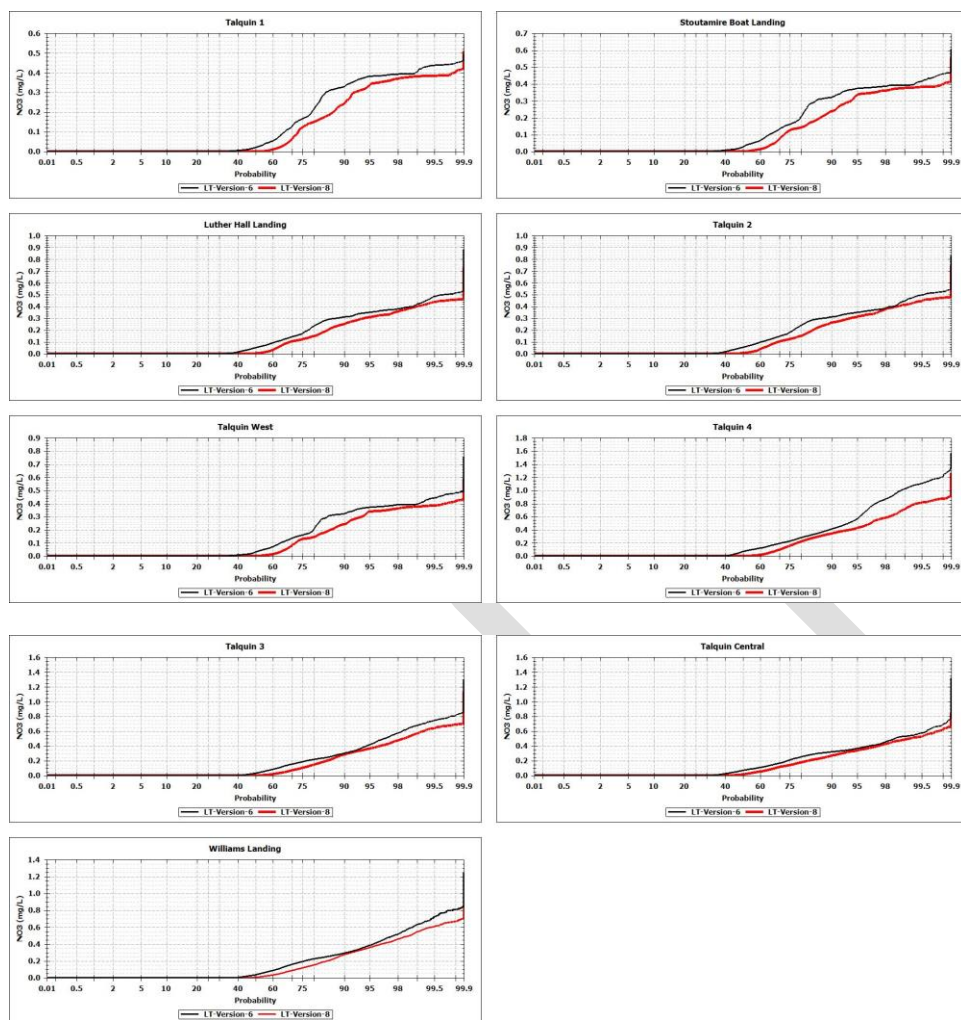


Figure 197 Comparison of Nitrate Probability Plot Version 6 vs. 8

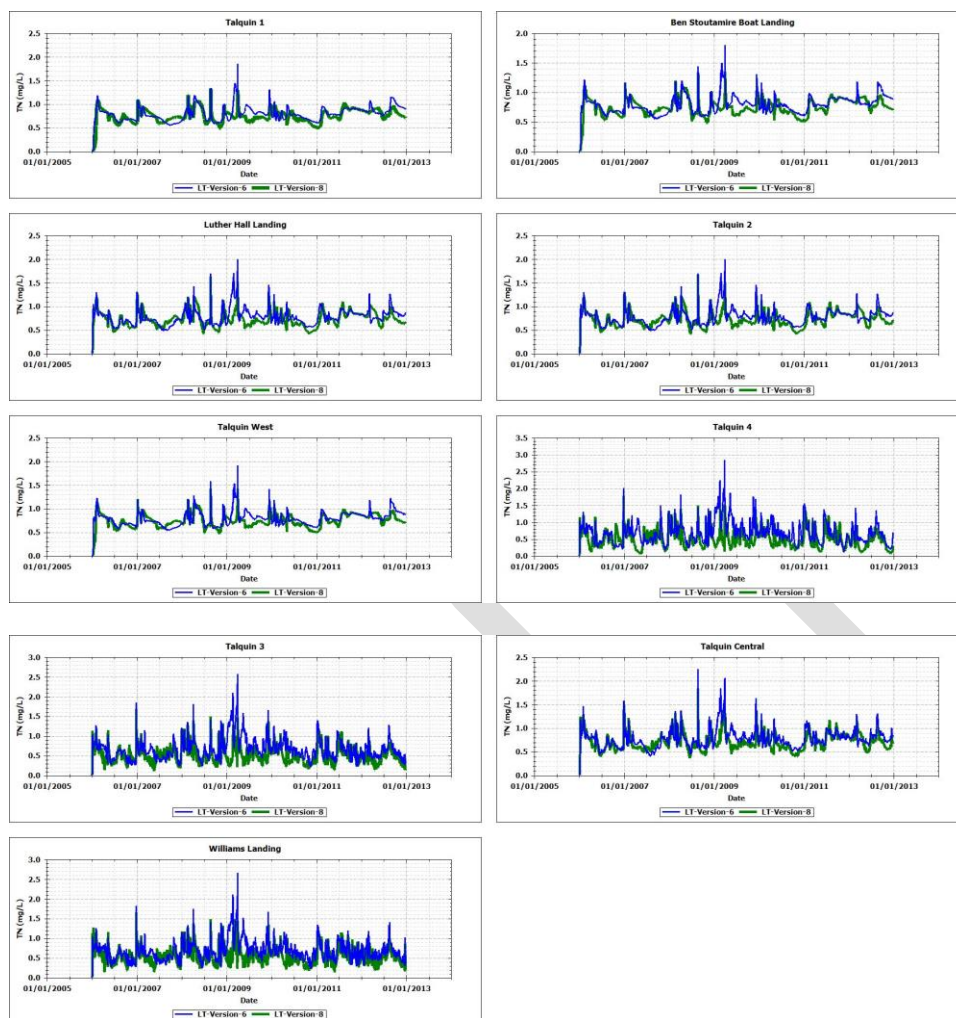


Figure 198 Comparison of Total Nitrogen Time Series Version 6 vs. 8

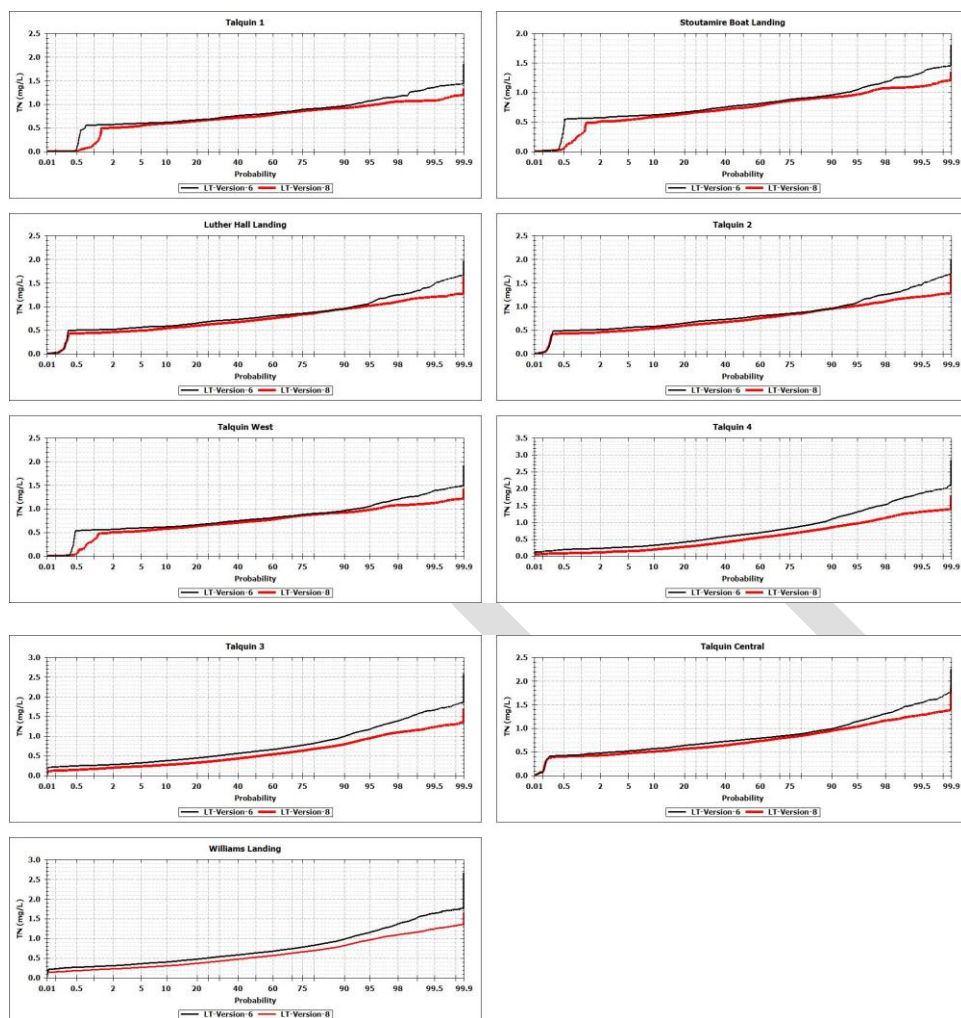


Figure 199 Comparison of Total Nitrogen Probability Plot Version 6 vs. 8

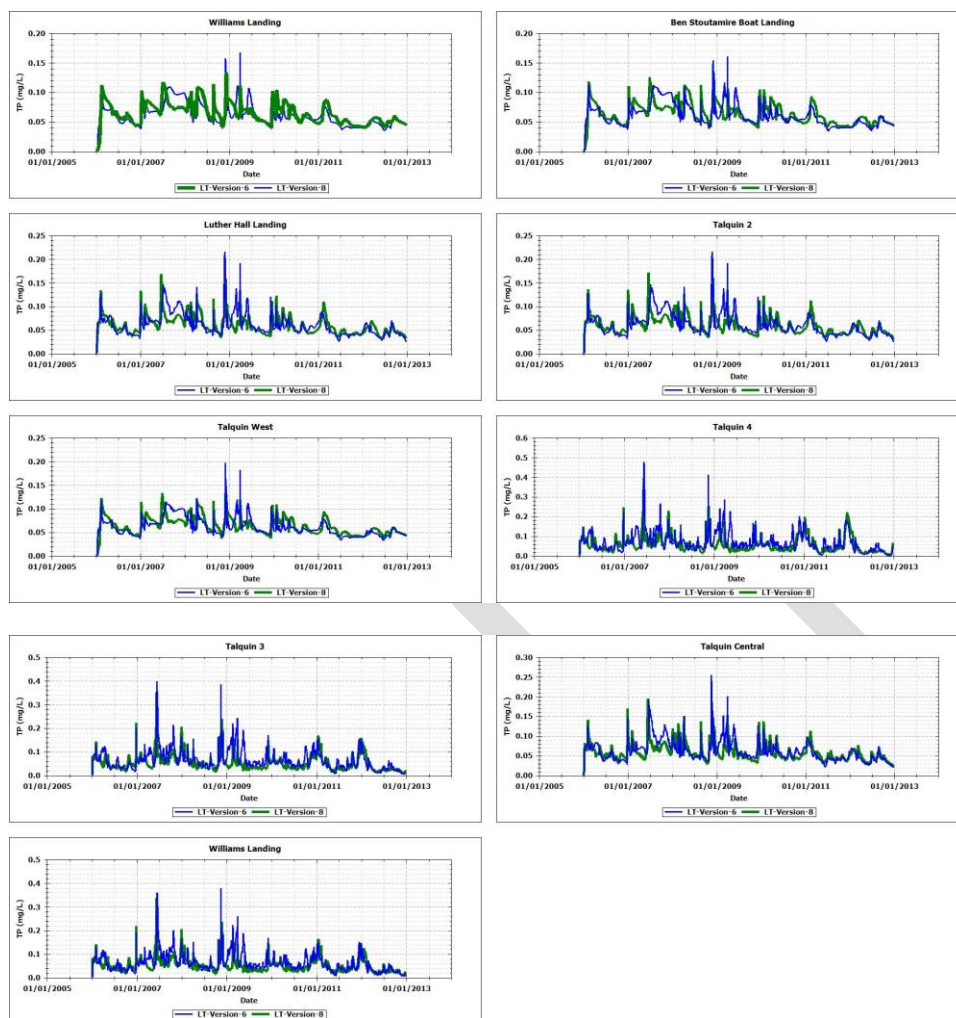


Figure 200 Comparison of Total Phosphorus Time Series Version 6 vs. 8

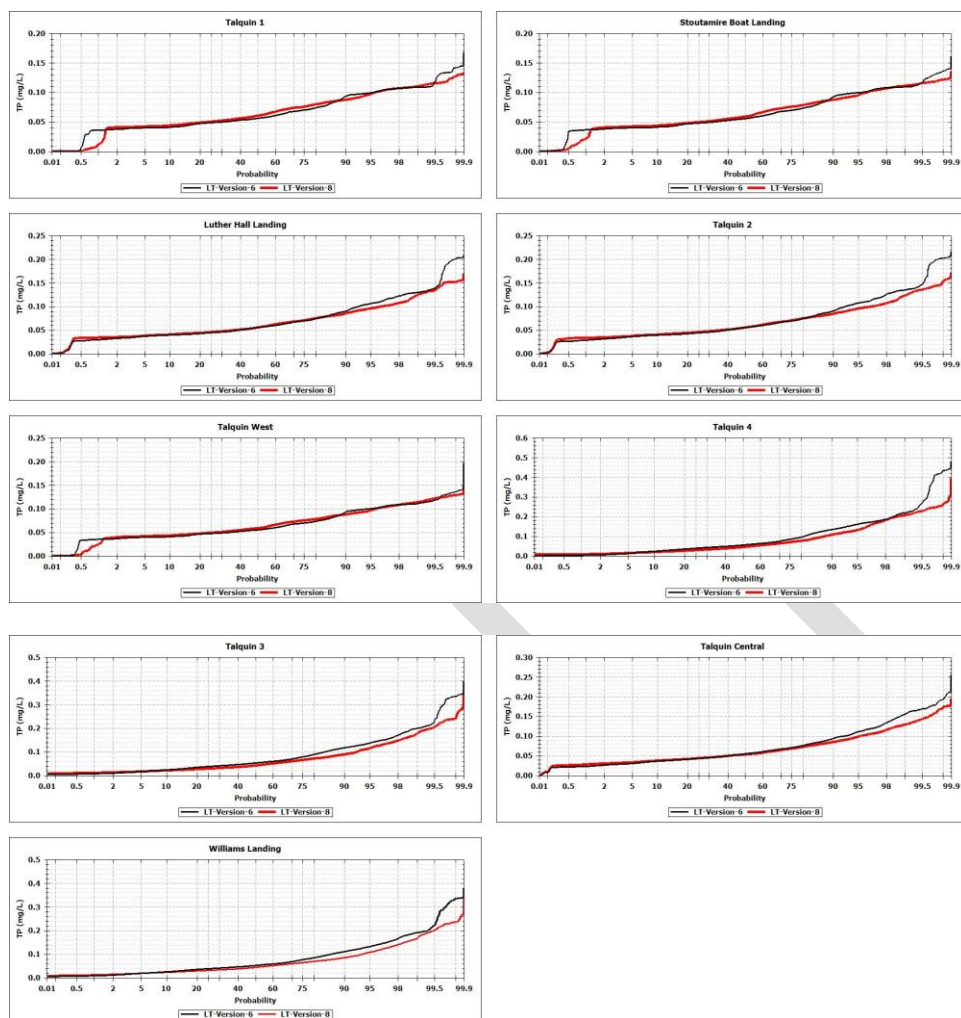


Figure 201 Comparison of Total Phosphorus Probability Plot Version 6 vs. 8

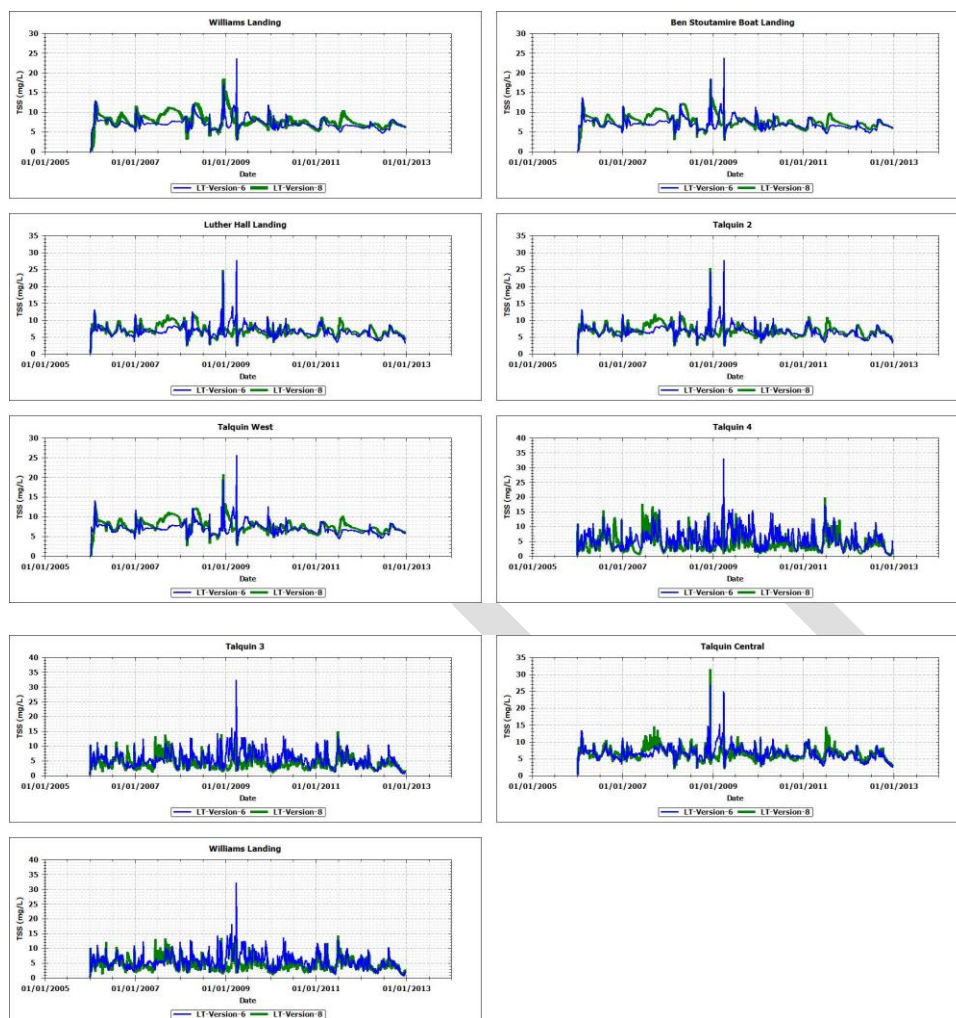


Figure 202 Comparison of Total Suspended Solids Time Series Version 6 vs. 8

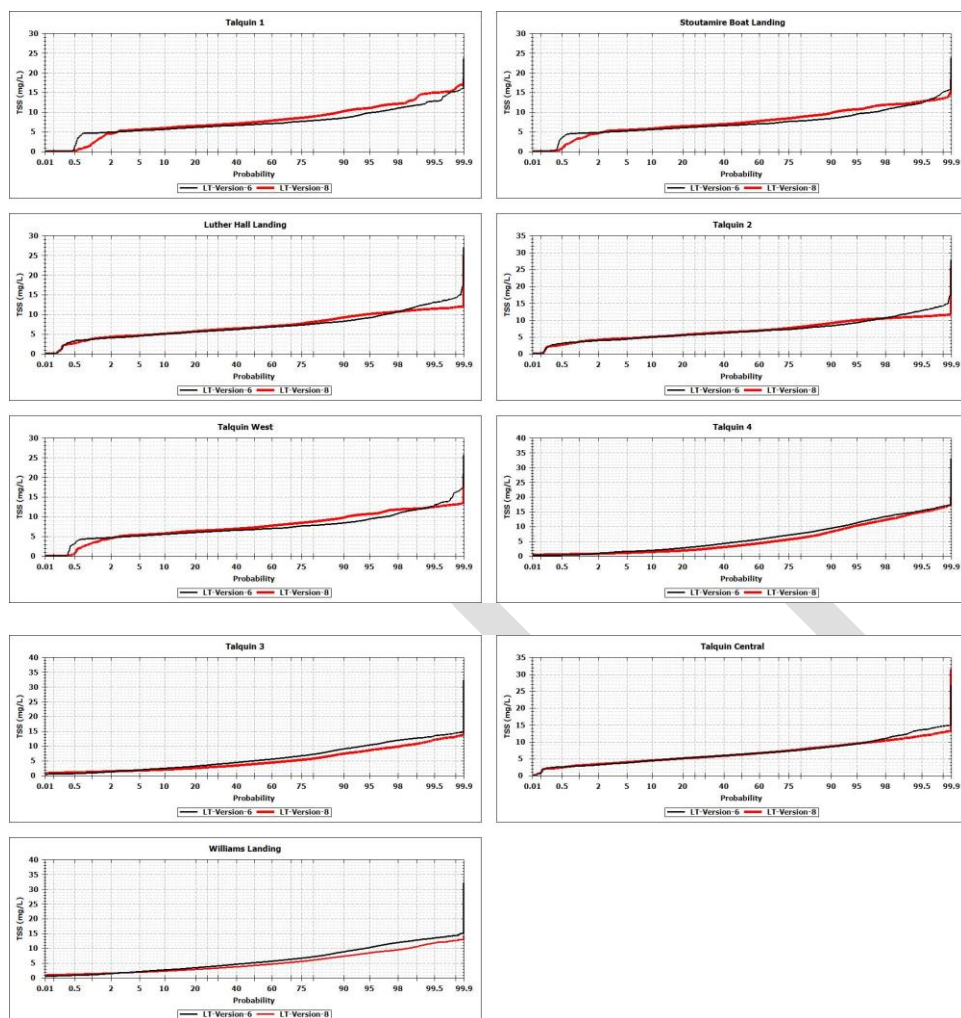


Figure 203 Comparison of Total Suspended Solids Probability Plot Version 6 vs. 8