Modeling Report

WBID 3001 Little Econlockhatchee River – Middle St. Johns River Basin Nutrients and Dissolved Oxygen

WBID 2991A Econlockhatchee River – Middle St. Johns River Basin Nutrients and Dissolved Oxygen

March 11, 2013

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Watershed Description

The Econlockhatchee and the Little Econlockhatchee River are located in the north-central part of Orange County and in southern Seminole County. The Little Econlockhatchee River is a major tributary of the Econlockhatchee River. It originates in the relatively high lands of central Orange County, on the eastern edge of the Orlando metropolitan area. It flows primarily in a north direction in Orange County and in a northeasterly direction in Seminole County into the Econlockhatchee River. Unlike the largely unaltered Econlockhatchee River proper, the Little Econlockhatchee River is hydrologically altered extensively, with substantial portions of the river channel canalized and interrupted by control structures. A number of canals draining various parts of the Orlando area flow into the Little Econlockhatchee River. The watershed of the Little Econlockhatchee River is highly urbanized by residential land use.

WBID 2991A and WBID 3001 were listed as not attaining their designated uses on Florida's 1998 303(d) list for Nutrients and Dissolved Oxygen. Figure 1 provides the location of Econlockhatchee and Little Econlockhatchee Rivers.

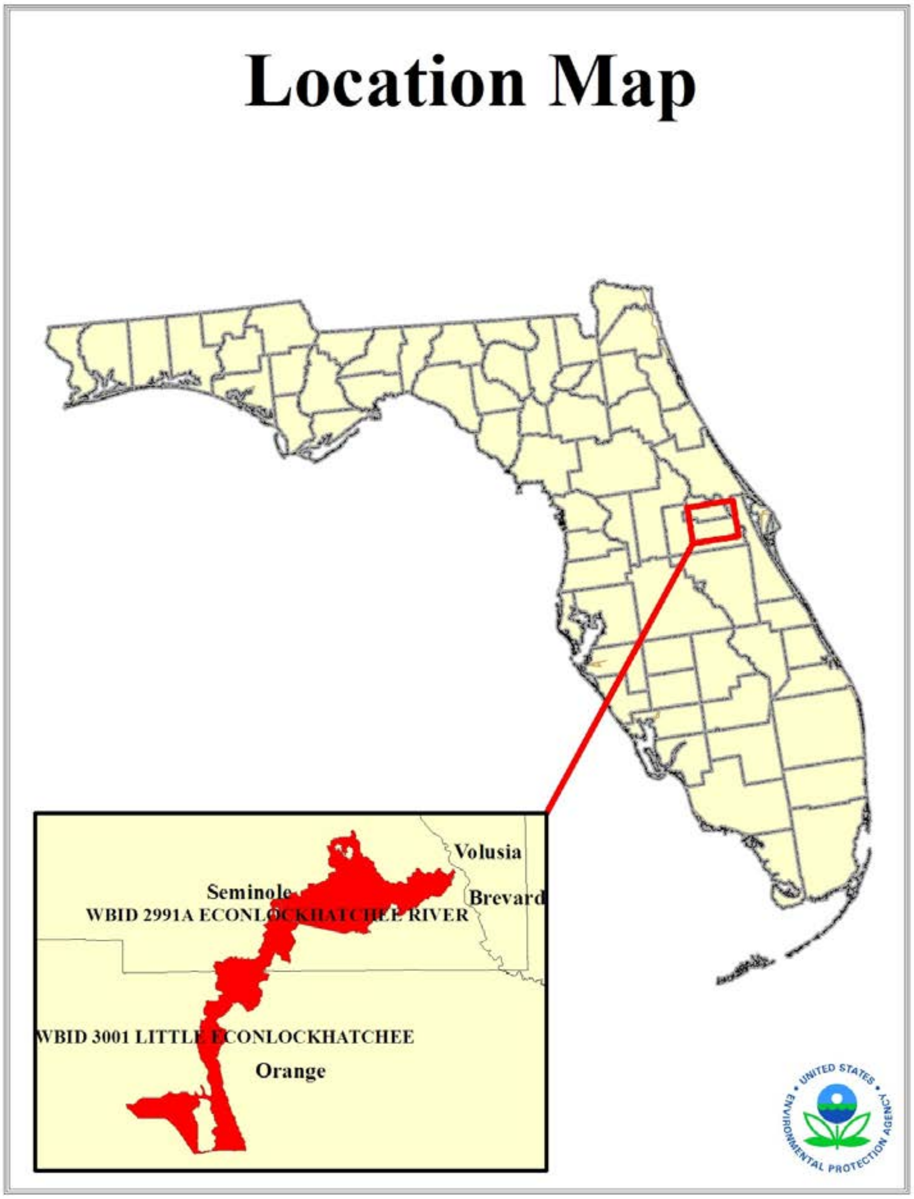


Figure 1 Location of Econlockhatchee and Little Econlockhatchee Watersheds and WBIDs

The landuse distribution for the Econlockhatchee and Little Econlockhatchee Rivers is presented in Figure 2.

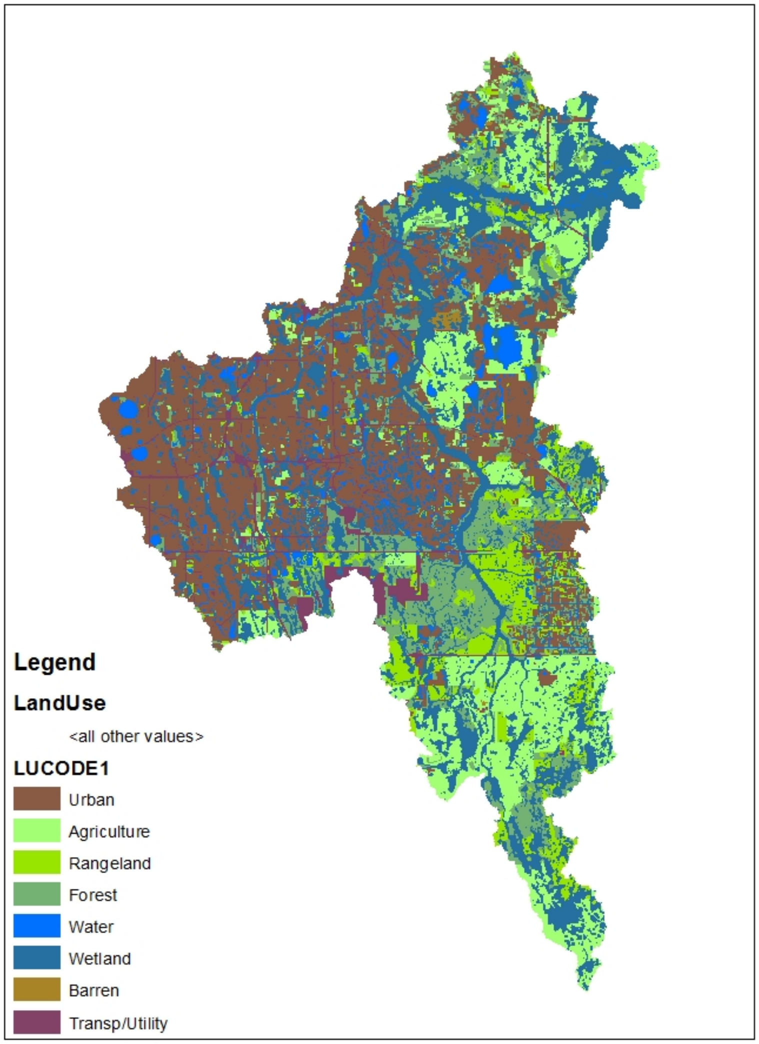


Figure 2 Landuse Distribution for Econlockhatchee and Little Econlockhatchee Watersheds

TMDL Targets

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

The waterbodies in these WBIDs are Class III Freshwater with a designated use of Recreation, Propagation and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife.

Designated use classifications are described in Florida's water quality standards. See Section 62-302.400, F.A.C. Water quality criteria for protection of all classes of waters are established in Section 62-302.530, F.A.C. Individual criteria should be considered in conjunction with other provisions in water quality standards, including Section 62-302.500 F.A.C., which established minimum criteria that apply to all waters unless alternative criteria are specified. Section 62-302.530, F.A.C. Several of the WBIDs addressed in this report were listed due to elevated concentrations of chlorophyll *a*. While FDEP does not have a streams water quality standard specifically for chlorophyll *a*, elevated levels of chlorophyll *a* are frequently associated with a violation of the narrative nutrient standard, which is described below.

Nutrients

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

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

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

Narrative Nutrient Criteria

Florida's narrative nutrient criteria provide:

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

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

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

Florida's adopted numeric nutrient criteria for streams

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

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

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

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

Table 1 Inland Numeric Nutrient Criteria

Nutrient Watershed Region	Total Phosphorus Nutrient Threshold	Total Nitrogen Nutrient Threshold
Panhandle West	0.06 mg/L	0.67 mg/L
Panhandle East	0.18 mg/L	1.03 mg/L
North Central	0.30 mg/L	1.87 mg/L

Peninsular	0.12 mg/L	1.54 mg/L
West Central	0.49 mg/L	1.65 mg/L
South Florida	No numeric nutrient threshold. The narrative criterion in paragraph 62-302.530(47)(b), F.A.C., applies.	No numeric nutrient threshold. The narrative criterion in paragraph 62-302.530(47)(b), F.A.C., applies.

Dissolved Oxygen Criteria

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

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

Natural Conditions

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

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

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

Florida's water quality standards also provide that:

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

Biochemical Oxygen Demand Criteria

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

Modeling Approach

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

LSPC Watershed Model

The Loading Simulation Program C++ (LSPC) as the watershed model. LSPC is the Loading Simulation Program in C++, a watershed modeling system that includes streamlined Hydrologic Simulation Program Fortran (HSPF) algorithms for simulating hydrology, sediment, and general water quality on land as well as a simplified stream fate and transport model. LSPC is derived from the Mining Data Analysis System (MDAS), which was originally developed by EPA Region 3 (under contract with Tetra Tech) and has been widely used for TMDLs. In 2003, the U.S. Environmental Protection Agency (EPA) Region 4 contracted with Tetra Tech to refine, streamline, and produce user documentation for the model for public distribution. LSPC was developed to serve as the primary watershed model for the EPA TMDL Modeling Toolbox.

WASP Water Quality Model

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

The WASP model integrates the predicted flows and loads from the LSPC model to simulate water quality responses in: nitrogen, phosphorus, chlorophyll a and dissolved oxygen. Both LSPC and WASP will be calibrated to current conditions, a natural condition. The WASP model will be used to determine the percent reduction in loadings that would be needed to meet water quality standards.

LSPC Application to Little Econlockhatchee and Econlockhatchee Watersheds

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

Watershed Delineation and Landuse

The surrounding watershed that drains directly to the Little Econlockhatchee and Econlockhatchee WBIDs was included in the watershed model. This encompasses land areas outside the delineated WBIDs. The watershed was delineated into1 sub basins (Figure 3). The LSPC model will predict flow and loads coming from each of these sub basins into the WBIDs (Subwatersheds 130050, 130051, 130052 into WBID 3001 and all others into WBID 2991A).

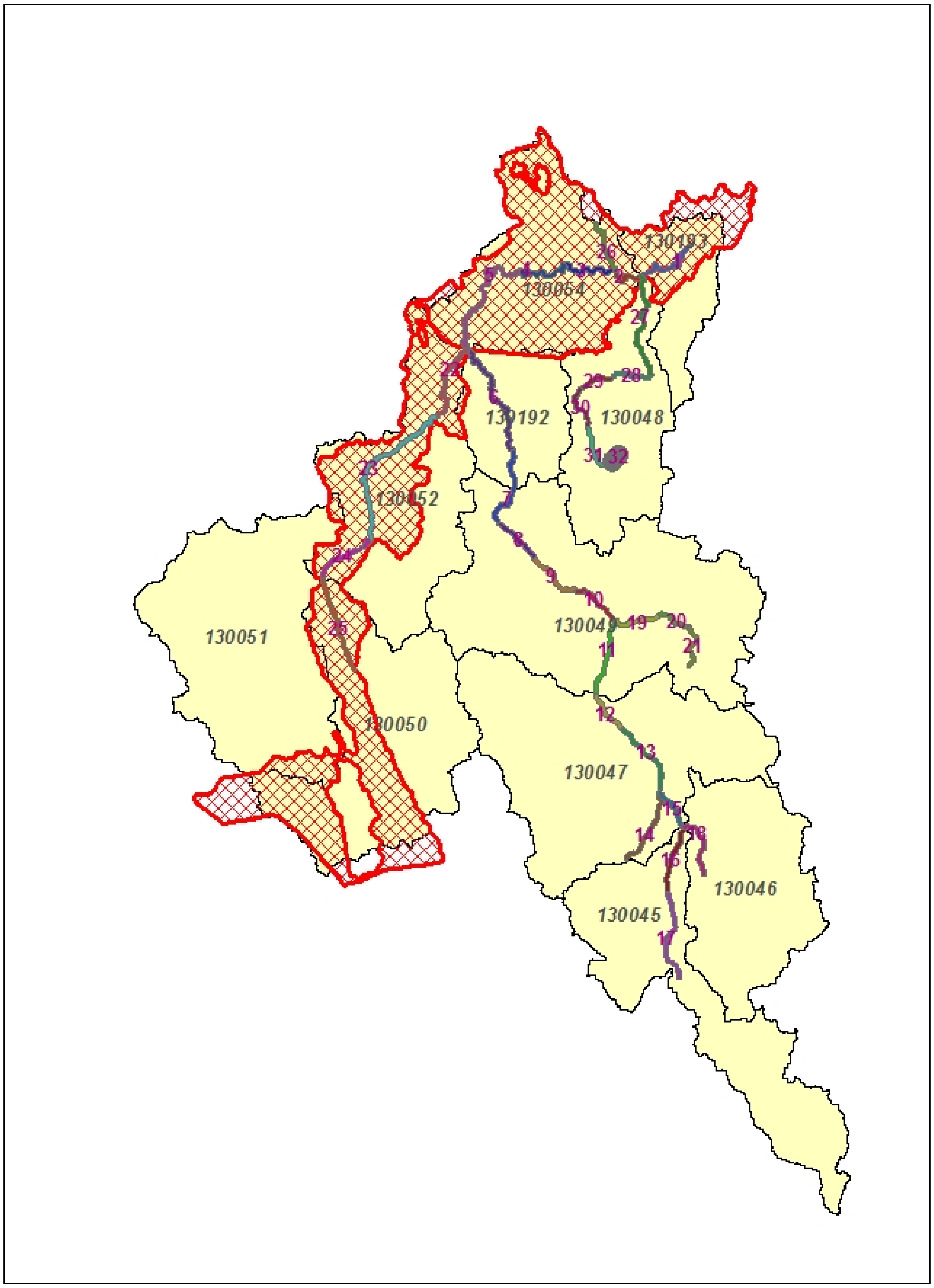


Figure 3 Little Econlockhatchee and Econlockhatchee Watershed Delineation

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

Landuse coverage was obtained from the St. Johns River Water Management District (Florida Landuse Classification Code) coverage developed from 2004. Table 2 provides the landuse distribution for each of the sub basins modeled, and Figure 4 and Figure 5 provide pie chart summaries.

Table 2 Landuse Distribution for Sub Basins (acres)

Subbasin Name	Water	Low Intensity Develop	Low Intensity Development (Impervious)	Medium Intensity Development	Medium Intensity Development (Impervious)	High Intensity Development (Pervious)	High Intensity Development (Impervious)	Barren	Forest	Golf	Pasture	Crop	Wetland	All Other Imperviou s	Total
130044	48.3	-	-	-	-	-	-	-	-	-	3.3	-	1,263.2	-	1,314.8
130045	8.0	53.7	0.6	-	-	22.0	-	834.8	500.2	-	7,080.7	198.0	5,537.4	10.5	14,245.9
130046	92.5	313.9	15.0	-	-	69.8	7.8	1,657.5	920.2	-	5,297.0	8.9	3,521.7	65.4	11,969.7
130047	720.1	1,042.4	56.7	383.9	195.2	1,465.5	343.5	6,680.1	3,805.8	245.1	1,549.0	32.7	4,277.0	283.0	21,079.9
130048	1,334.8	1,369.3	80.0	767.6	74.3	93.3	27.5	514.1	1,303.4	-	1,503.0	1,025.8	1,997.9	71.7	10,162.8
130049	940.0	2,003.2	114.0	2,389.7	503.9	2,435.4	1,127.4	3,242.5	2,399.0	144.6	3,079.8	243.6	4,983.0	529.7	24,135.6
130054	506.0	690.5	25.9	443.5	66.7	136.7	52.5	934.1	3,302.1	1.3	2,007.1	193.0	4,390.5	134.5	12,884.2
130192	219.1	543.3	23.1	564.8	217.6	395.7	134.3	143.3	1,102.9	91.6	670.6	2.2	2,223.0	97.1	6,428.5
130193	81.7	111.6	0.0	-	-	70.7	0.0	204.0	675.7	-	1,305.9	47.1	2,564.4	11.9	5,073.0
Total Big Econ	3,950.4	6,127.8	315.4	4,549.5	1,057.8	4,689.1	1,693.0	14,210.4	14,009.3	482.5	22,496.4	1,751.2	30,758.1	1,203.7	107,294.6
130050	813.6	689.3	65.5	1,335.7	510.6	3,441.3	1,249.0	1,312.4	1,685.6	-	1,357.2	35.4	3,708.1	427.7	16,631.4
130051	1,118.1	903.1	131.5	4,265.2	1,527.9	4,304.5	2,501.2	465.0	765.5	327.4	87.3	11.6	1,896.4	421.0	18,725.6
130052	763.1	863.2	96.0	2,650.2	856.5	2,909.3	1,683.4	294.8	1,450.0	65.7	331.7	31.6	2,639.6	410.2	15,045.2
Total Little Econ	2,694.7	2,455.6	293.0	8,251.2	2,895.0	10,655.2	5,433.5	2,072.1	3,901.1	393.1	1,776.1	78.6	8,244.1	1,258.8	50,402.2
Total	6,645.2	8,583.4	608.4	12,800.6	3,952.8	15,344.3	7,126.5	16,282.5	17,910.5	875.6	24,272.5	1,829.8	39,002.2	2,462.5	157,696.8

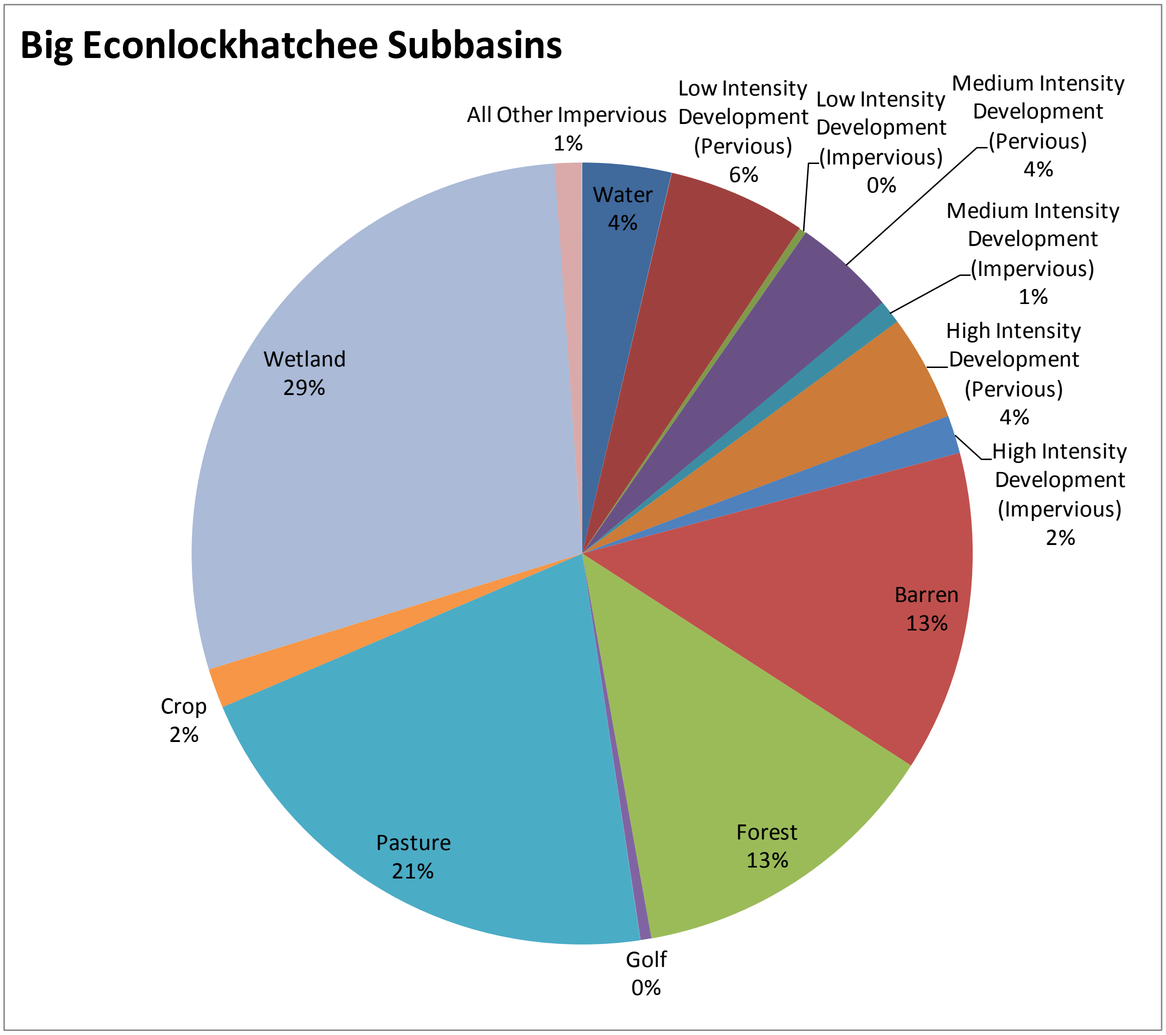


Figure 4 – Big Econlockhatchee Sub Basin Landuses

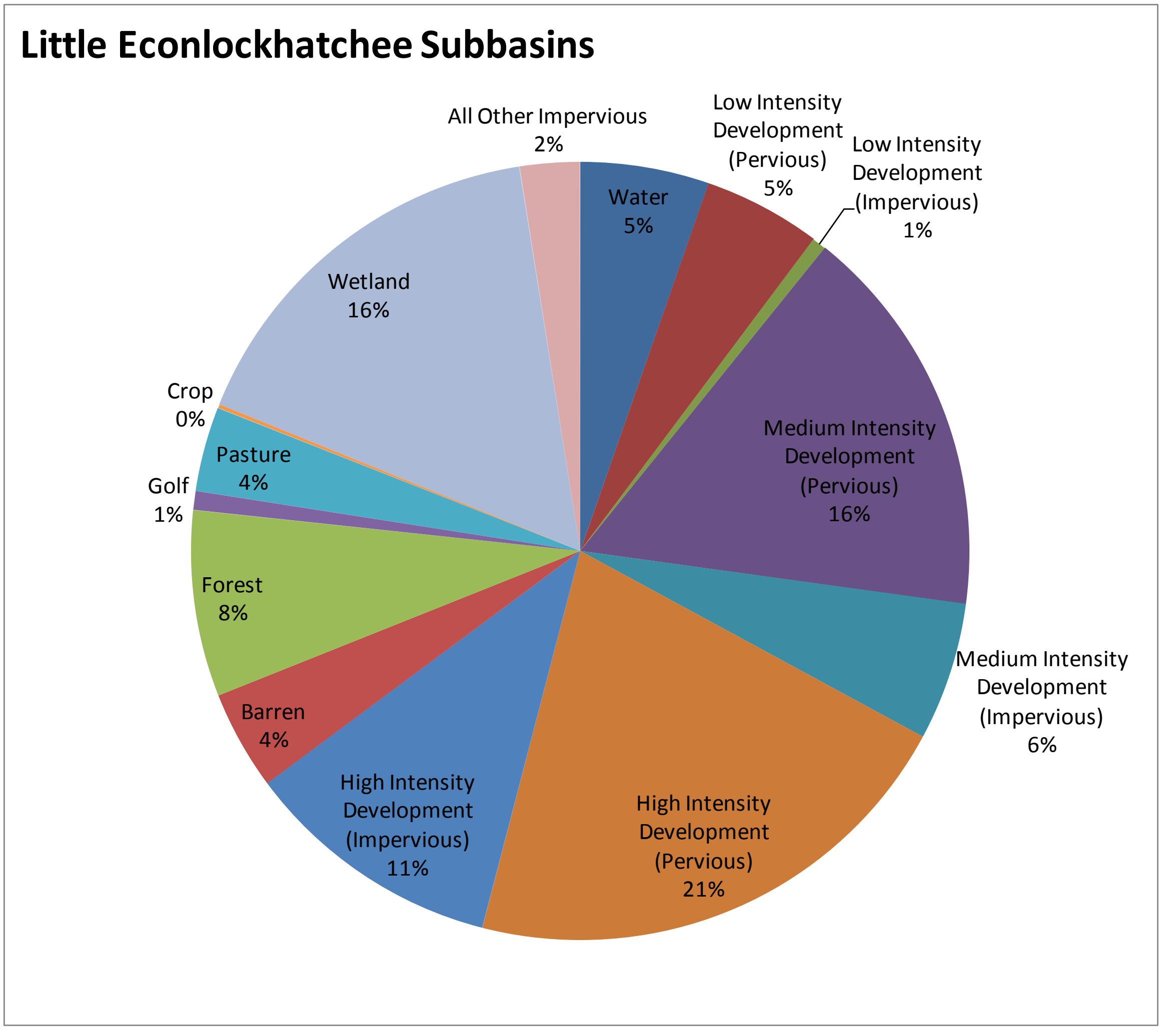


Figure 5 – Little Econlockhatchee Sub Basin Landuses

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.

The period of record being simulated during this TMDL development contains average, wet and dry years. Table 3 provides the annual rainfall for each of the simulation years.

Table 3 – Annual Rainfall at Sanford Meteorological Station for LSPC simulation period

Year	Rainfall (inches)
1996	62.8
1997	54.1
1998	49.0
1999	47.0
2000	32.8
2001	52.7
2002	69.3
2003	52.8
2004	69.6
2005	61.5
2006	39.1
2007	49.2
2008	67.7
2009	49.0

Hydraulic Calibration

The watershed and water quality model were calibrated for flow by comparing the predicted flows to three USGS gages within the simulated watersheds: 02233500, 02233484 and 02233475 (Figure 6).

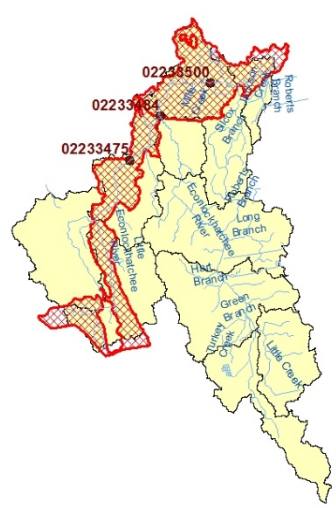
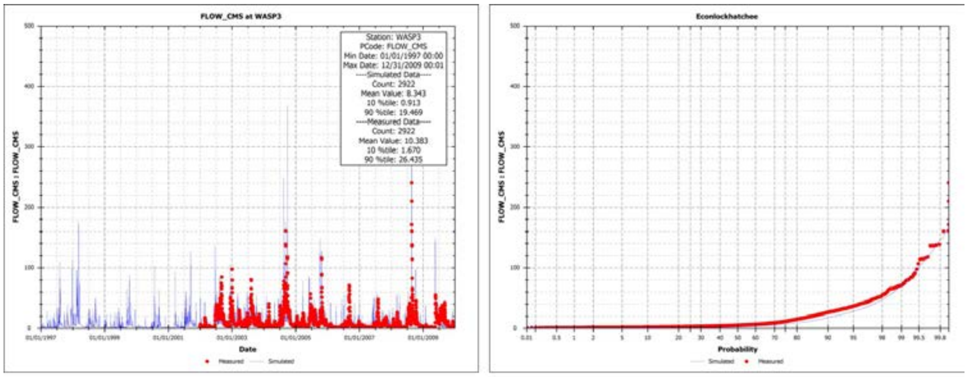


Figure 6 – Econlockhatchee (02233500 and 02233484) and Little Econlockhatchee (02233475) USGS Flow Gage Stations

Figures 7 through 9 illustrate quantitative and qualitative comparison of the model flow predictions to the measurements at the USGS gages.



Calibration Statistics

Station: WASP3; Parameter: FLOW_CMS

Statistic	Measured	Simulated
Count:	2922	2921
Mean:	10.383	8.346
Std Dev:	15.856	20.419
Min:	0.764	0.432
Max:	240.550	445.698
5 %tile:	1.302	0.694
10 %tile:	1.670	0.885
90 %tile:	26.435	19.664
95 %tile:	36.790	31.510
Corr (R^2):	0.21	
Mean Abs Error:	8.439	
RMS Error:	19.407	
Norm RMS Error:	1.267	
Index of Agreement:	0.63	

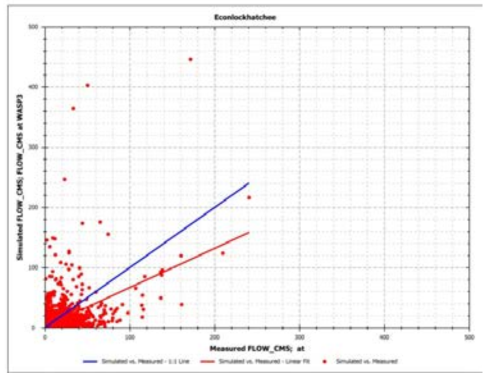
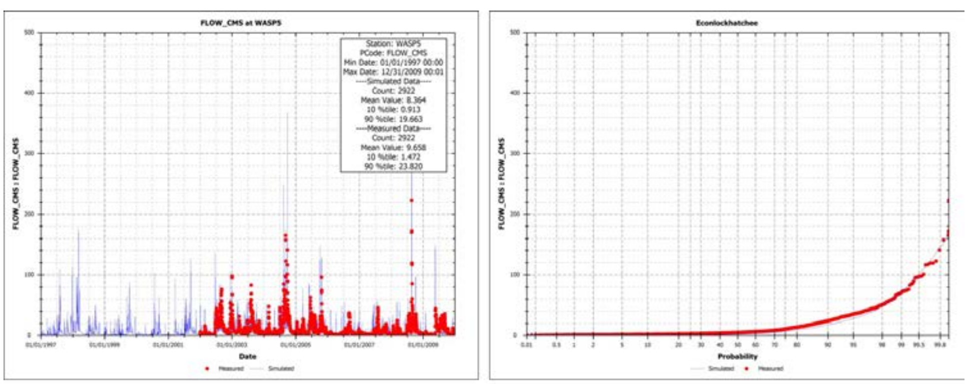


Figure 7 – Flow Calibration at USGS 02233500



Calibration Statistics

Station: WASP5; Parameter: FLOW_CMS

Statistic	Measured	Simulated
Count:	2922	2921
Mean:	9.658	8.346
Std Dev:	14.887	20.429
Min:	0.509	0.433
Max:	223.004	445.518
5 %tile:	1.132	0.695
10 %tile:	1.472	0.887
90 %tile:	23.820	19.643
95 %tile:	35.375	31.544
Corr (R^2):	0.24	
Mean Abs Error:	7.748	
RMS Error:	18.454	
Norm RMS Error:	1.215	
Index of Agreement:	0.65	

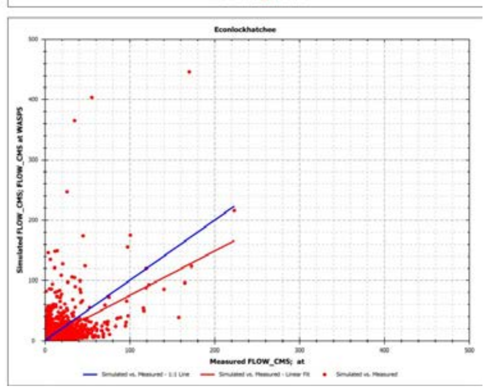
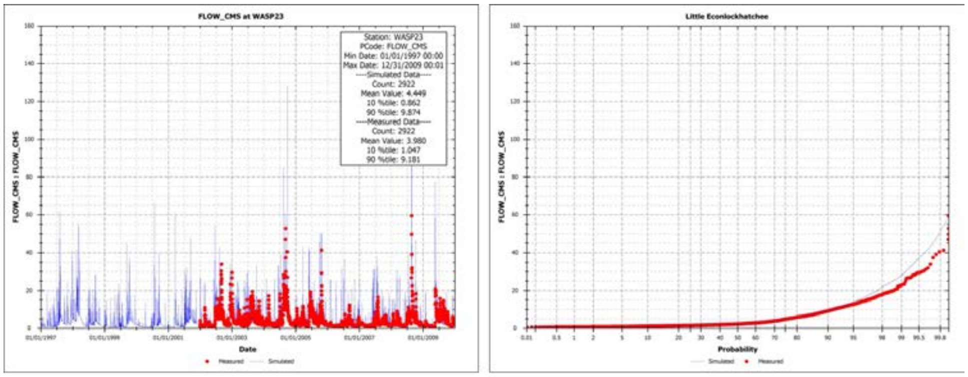


Figure 8 – Flow Calibration at USGS 02233484



Calibration Statistics

Station: WASP23; Parameter: FLOW_CMS

Statistic	Measured	Simulated
Count:	2922	2921
Mean:	3.980	4.442
Std Dev:	4.725	7.348
Min:	0.509	0.432
Max:	59.430	142.103
5 %tile:	0.849	0.674
10 %tile:	1.047	0.857
90 %tile:	9.181	9.965
95 %tile:	12.642	15.871
Corr (R^2):	0.23	
Mean Abs Error:	2.725	
RMS Error:	6.548	
Norm RMS Error:	1.115	
Index of Agreement:	0.63	

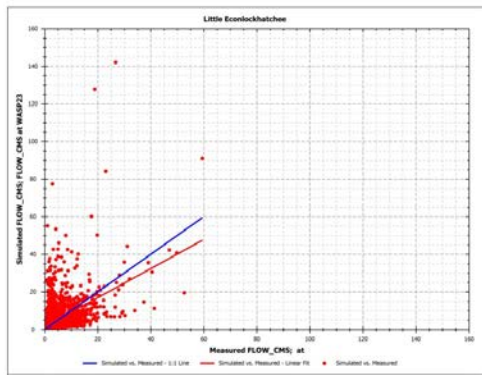


Figure 9 – Flow Calibration at USGS 02233475

Water Quality Model Application

The WASP water quality model uses the kinematic wave equation to simulate flow and velocity and the basic eutrophication module to predict dissolved oxygen and Chlorophyll a responses to the BOD, total nitrogen and total phosphorus loadings. The waterbody geometry was determined from NHDPlus coverages of the free flowing stream sections.

Model Network

The Econlockhatchee waterbodies were broken into segments for the water quality model. The model segmentation was done based upon the NHDPlus coverage taking into account travel time, pore points for the watershed model and IWR monitoring stations.

Figure 10 illustrates 32 of the 35 (2 minor segments were added to convey point source discharges, and an additional segment was added to account for the Little Econlockhatchee canal within the western portion of subwatershed 130051 external to the impaired WBID) water quality model segments that are simulated. The LSPC model flows and loads enter the water quality model at appropriate headwater segments within each simulated subwatershed.

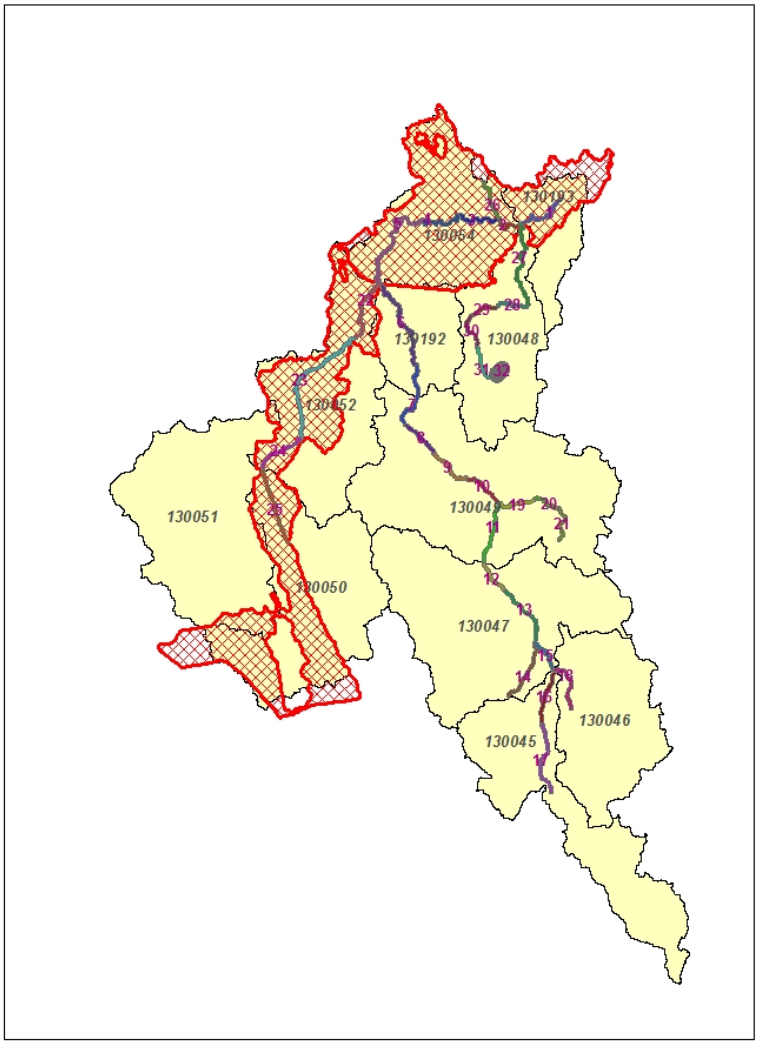


Figure 10 – WASP Model Segments for Econlockhatchee Model

Water Quality Model Calibration

The water quality model was calibrated to all available and feasible data. Some water quality data was omitted due to its location directly upstream of the major wastewater discharge to the Little Econlockhatchee River (Iron Bridge WRF FL0037966). WASP instantly mixes discharges across entire segments and thus this receiving segment containing the discharge (WASP 24) is calibrated to water quality data collected downstream of the fully mixed effluent within this segment.

Table 4 provides a listing of the IWR stations that were used to calibrate the WASP model. All stations that had nutrient, BOD, dissolved oxygen and chlorophyll a measurements were used in the calibration process.

Table 4 Impaired Waters Rule Database Stations used in Water Quality Model Calibration

IWR 44 Station	Station Name	First Date	Last Date	WASP Calibration Segment #
21FLCEN 20010300	Big Econ at Snow Hill Road	10/19/2010 9:51	10/19/2010 9:51	3
21FLORANBEE	Big Econ E (Seminole Co.(Snowhill)	2/14/2005 9:45	4/15/2008 10:30	3
21FLSEM SNO	Econlochatchee River at Snow Hill Rd	9/30/2003 13:35	3/3/2011 9:40	3
21FLSJWMECH	Econ River at Snowhill Road (SR 426)	7/15/2003 8:00	3/17/2011 14:15	3
21FLCEN 20010130	Econ River @ CR 419 bridge	3/20/2007 10:11	10/23/2007 10:54	5
21FLCEN 20011004	Econ River @ 1000M downstream of CR 419 Bridge	3/20/2007 9:34	8/8/2007 9:28	5
21FLCEN 20011005	Econ River @ 750M downstream of CR 419 bridge	3/20/2007 9:43	8/8/2007 9:52	5
21FLCEN 20011006	Econ River @ 5000M downstream of CR 419 bridge	3/20/2007 9:54	10/23/2007 10:42	5
21FLCEN 20011007	Econ River @ 250M downstream of CR 419 bridge	3/20/2007 10:02	10/23/2007 10:47	5
21FLORANBED	Big Econ D (Seminole Co., Hwy 419)	2/7/2005 10:40	4/15/2008 9:35	5
21FLSEM BECO	Big Econlockhatchee River at CR 419	9/30/2003 13:10	3/14/2011 11:20	5
21FLCEN 20010041	Little Econ River @just upstream of confluence w/ Econ River	3/20/2007 10:26	10/23/2007 11:03	22
21FLORANLES	Little Econ at Lockwood Blvd. (Seminole Co.)	9/30/2003 8:45	4/29/2010 9:30	22
21FLSJWMLER-LBB	Little Econ at Lockwood Blvd Bridge	7/15/2003 9:30	3/17/2011 15:45	22
21FLCEN 20010665	Little Econ River @ Alafaya Blvd	3/20/2007 11:52	10/23/2007 12:47	23
21FLORANLEZAF	Little Econ AF (Iron Bridge, Seminole Co.)	6/29/2006 11:20	4/29/2010 9:00	23
21FLORANLEZI	Little Econ at Iron Bridge (Seminole Co.)	6/1/2005 11:40	10/12/2006 10:00	23
21FLGW 3569	LITTLE ECONLOCKHATCHEE NEAR UNION PARK, FLA	7/1/2003 12:25	4/5/2011 13:27	25
21FLORANLEH	Little Econ H (Hwy. 50 - Union Park)	4/14/2005 11:40	4/7/2010 9:30	25
21FLORANLET	Little Econ T (Berry Dease Rd.)	8/13/2003 13:10	4/7/2010 11:11	25

Econlockhatchee River Stations

Little Econlockhatchee River Stations

Station 21FLSJWMER-ULER (Econ River - Upstream of Little Econ) was used to calibrate WASP Segment 6 but is external to the impaired receiving WBID (2991A)

Table 5 and 6 provide comparisons of predicted annual average concentrations versus the annual average concentrations of the measured data within each impaired WBID. While it is important to capture seasonal variation, duration and frequency of water quality, it is very critical to approximate average conditions in the system. It is during these periods of times that nutrients are expressed.

Table 5 Predicted vs. Observed Annual Average Concentrations WBID 3001 (Little Econlockhatchee)

Constituent	Simulated	Observed	RelError
BOD5 (mg/L)	1.44	1.14	-0.30
Chlorophyll a (ug/L)	1.50	0.84	-0.66
DO (mg/L)	6.38	5.79	-0.59
Total Nitrogen (mg/L)	0.71	0.84	0.13
Total Phosphorus (mg/L)	0.08	0.11	0.03

Table 6 Predicted vs. Observed Annual Average Concentrations WBID 2991A (Econlockhatchee)

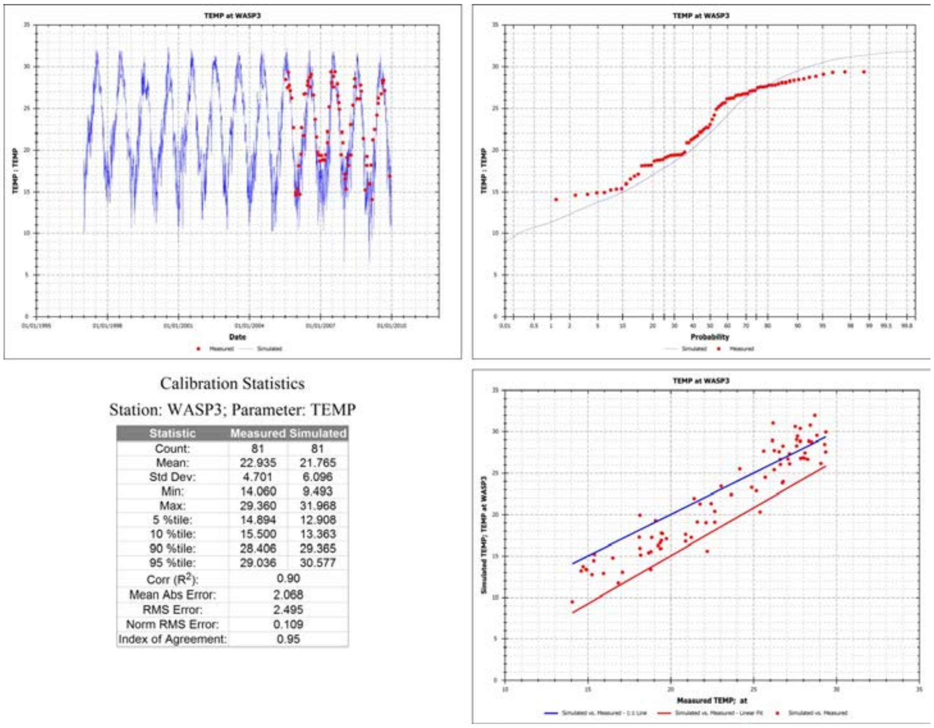
Constituent	Simulated	Observed	RelError
BOD5 (mg/L)	1.35	1.54	0.19
Chlorophyll a (ug/L)	1.38	0.89	-0.49
DO (mg/L)	6.59	6.63	0.04
Total Nitrogen (mg/L)	0.73	0.89	0.16
Total Phosphorus (mg/L)	0.08	0.10	0.02

Figure 11 through Figure 23 provide calibration comparisons for all of the major water quality constituents in which data are available.

Water Temperature

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

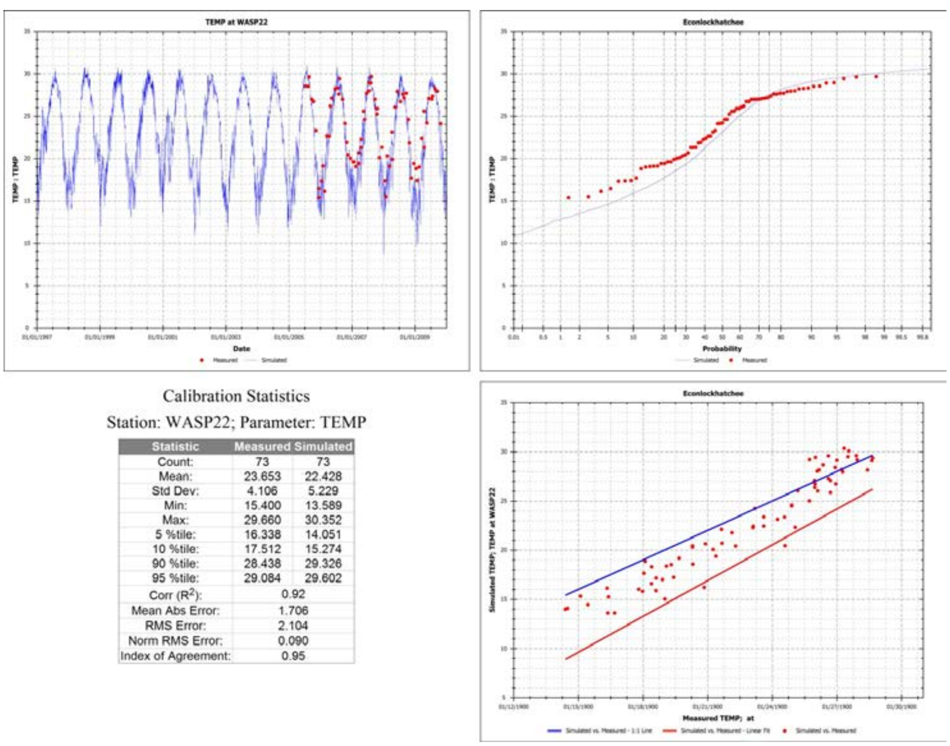
The following figures illustrate both a quantitative and qualitative comparison of the simulated water temperature compared to the direct measurements. Figure 11 demonstrates calibration in WBID 2991A at a location with significant measured data (WASP Segment 3). Likewise, Figure 12 demonstrates calibration at the pour point of WBID 3001 (WASP Segment 22). Additional calibration locations are included in the appendix.



Calibration Statistics
Station: WASP3; Parameter: TEMP

Statistic	Measured	Simulated
Count:	81	81
Mean:	22.935	21.765
Std Dev:	4.701	6.096
Min:	14.060	9.493
Max:	29.360	31.968
5 %tile:	14.894	12.908
10 %tile:	15.500	13.363
90 %tile:	28.406	29.365
95 %tile:	29.036	30.577
Corr (R^2):	0.90	
Mean Abs Error:	2.068	
RMS Error:	2.495	
Norm RMS Error:	0.109	
Index of Agreement:	0.95	

Figure 11 - Water Temperature Calibration at WASP3 (Most Downstream Econlockhatchee WASP segment with Ambient Water Quality Data)



Calibration Statistics
Station: WASP22; Parameter: TEMP

Statistic	Measured	Simulated
Count:	73	73
Mean:	23.653	22.428
Std Dev:	4.106	5.229
Min:	15.400	13.589
Max:	29.660	30.352
5 %tile:	16.338	14.051
10 %tile:	17.512	15.274
90 %tile:	28.438	29.326
95 %tile:	29.084	29.602
Corr (R^2):	0.92	
Mean Abs Error:	1.706	
RMS Error:	2.104	
Norm RMS Error:	0.090	
Index of Agreement:	0.95	

Figure 12 – Water Temperature Calibration at WASP22 (Pour Point of Little Econlockhatchee River)

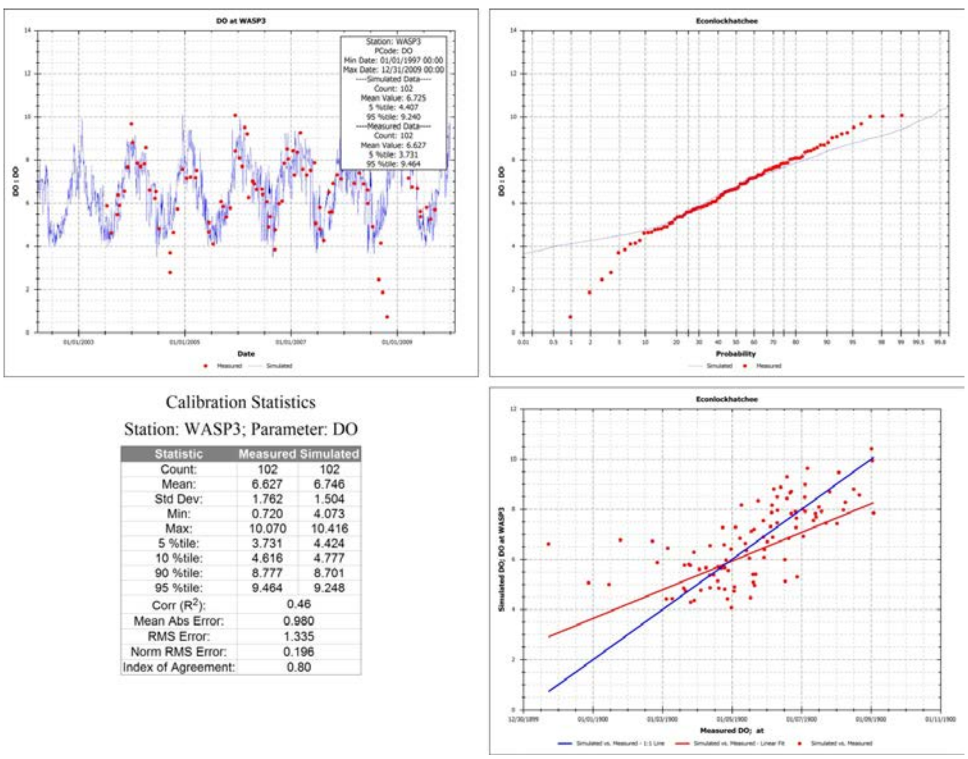
Sediment Oxygen Demand

Sediment Oxygen Demand (SOD, expressed in g/m^2/day) can play an important role in determining dissolved oxygen concentrations in surface waters. For WASP model calibration to the existing conditions, a constant value of 2.0 g/m^2/day was applied to all segments.

Dissolved Oxygen

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

Figure 13 and Figure 14 illustrate both a quantitative and qualitative comparison of the predicted dissolved oxygen concentrations compared to the direct measurements at key locations within the impaired WBIDs. Additional calibration locations are included in the appendix.

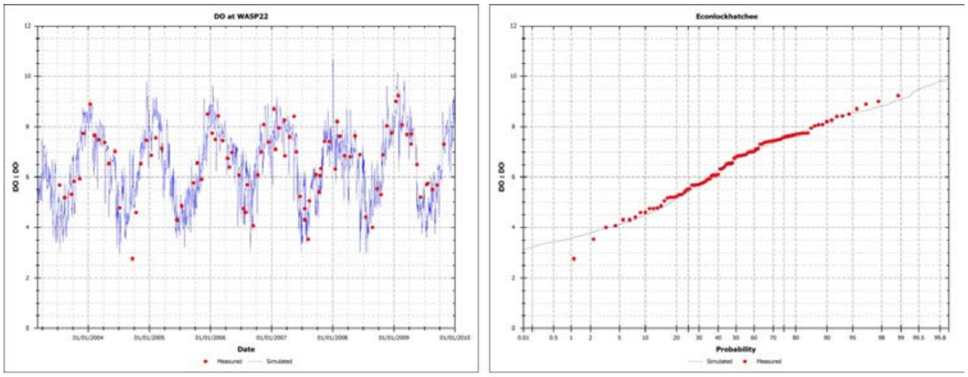


Calibration Statistics

Station: WASP3; Parameter: DO

Statistic	Measured	Simulated
Count:	102	102
Mean:	6.627	6.746
Std Dev:	1.762	1.504
Min:	0.720	4.073
Max:	10.070	10.416
5 %tile:	3.731	4.424
10 %tile:	4.616	4.777
90 %tile:	8.777	8.701
95 %tile:	9.464	9.248
Corr (R^2):	0.46	
Mean Abs Error:	0.980	
RMS Error:	1.335	
Norm RMS Error:	0.196	
Index of Agreement:	0.80	

Figure 13 Dissolved Oxygen Calibration at WASP3 (Most Downstream Econlockhatchee WASP segment with Ambient Water Quality Data)



Calibration Statistics

Station: WASP22; Parameter: DO

Statistic	Measured	Simulated
Count:	89	89
Mean:	6.523	6.486
Std Dev:	1.366	1.581
Min:	2.760	3.112
Max:	9.240	9.523
5 %tile:	4.185	3.811
10 %tile:	4.600	4.371
90 %tile:	8.200	8.408
95 %tile:	8.600	8.626
Corr (R^2):	0.57	
Mean Abs Error:	0.777	
RMS Error:	1.043	
Norm RMS Error:	0.157	
Index of Agreement:	0.86	

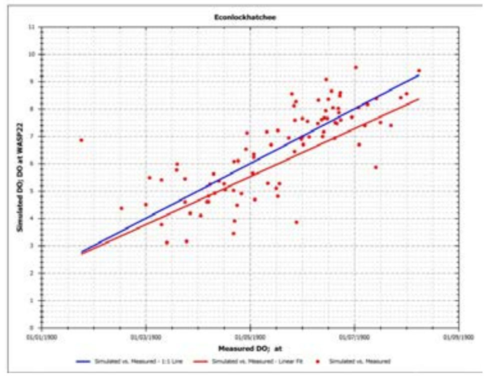


Figure 14 Dissolved Oxygen Calibration at WASP22 (Pour Point of Little Econlockhatchee River)

Biochemical Oxygen Demand

Biochemical Oxygen Demand (BOD) is calibrated at key locations within the model network. WASP simulates ultimate BOD (BODu) whereas available field samples measure 5-day BOD (BOD5). For this simulation an F-ratio of 2.5 was assumed, meaning it is reasonable to convert simulated BODu to BOD5 for comparison with field measurements. This assumption introduces inherent error but is conventional and necessary due to the lack of BODu field data.

Figure 15 through Figure 17 illustrate both a quantitative and qualitative comparison of the predicted BOD5 concentrations compared to the direct measurements.

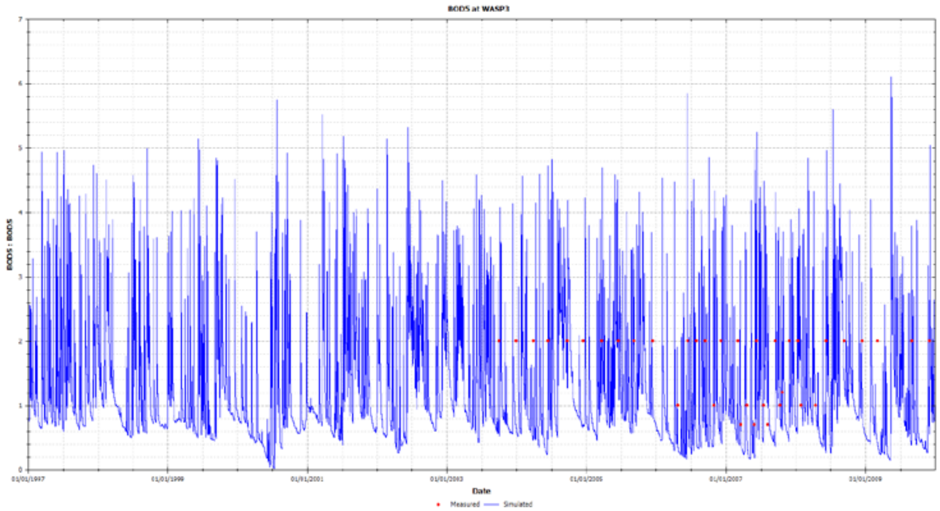


Figure 15 – BOD5 Calibration at WASP3

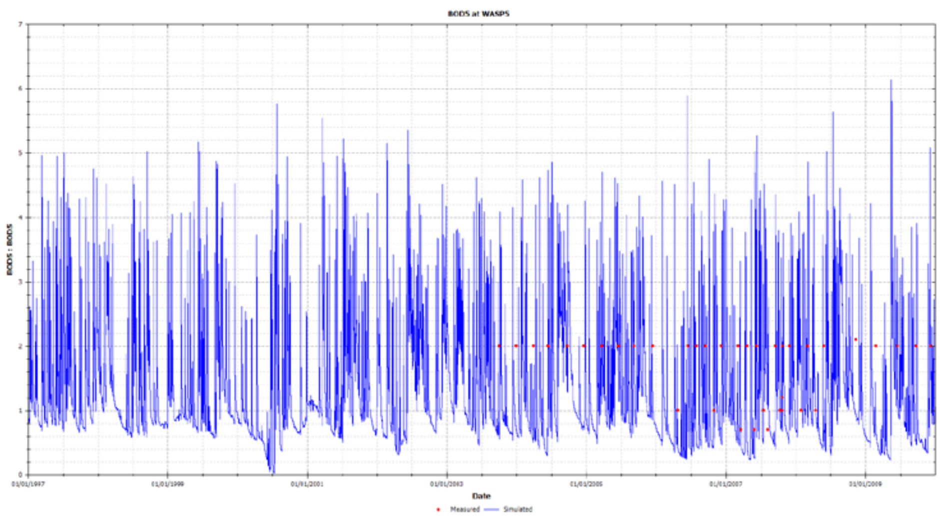


Figure 16 – BOD5 Calibration at WASP5

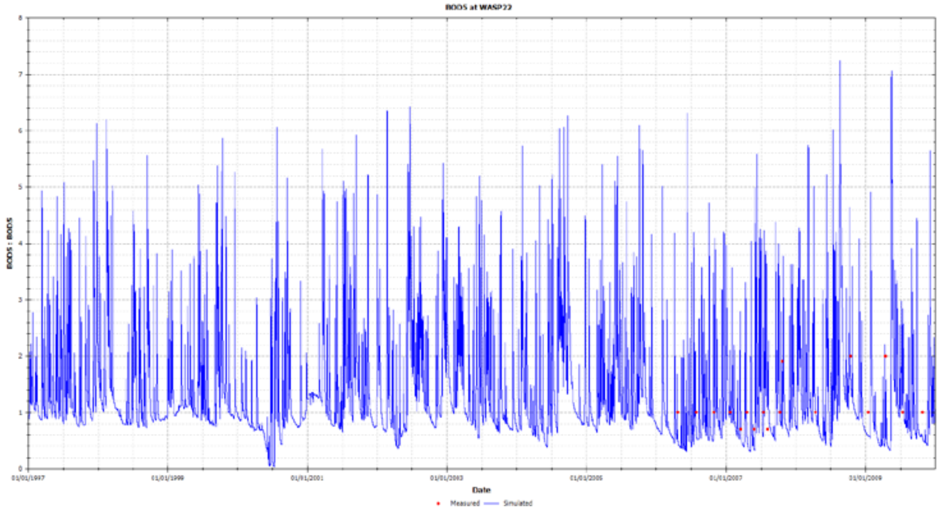
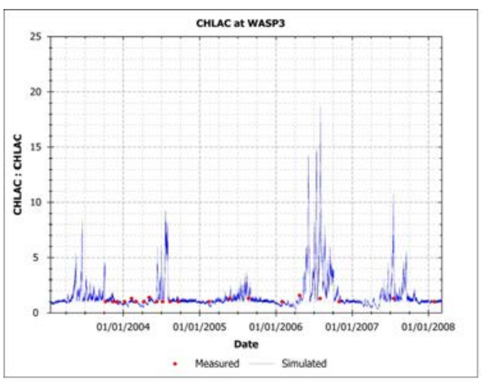


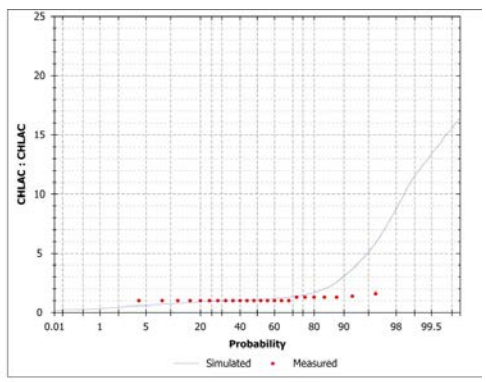
Figure 17 – BOD5 Calibration at WASP22

Chlorophyll a

Chlorophyll-a represents a response variable to nutrient loading and is a key calibration parameter.

Figure 18 and Figure 19 illustrate both a quantitative and qualitative comparison of the predicted chlorophyll-a concentration compared to the direct measurements. Additional calibration locations are included in the appendix.





Calibration Statistics

Station: WASP3; Parameter: CHLAC

Statistic	Measured	Simulated
Count:	24	24
Mean:	1.104	1.718
Std Dev:	0.176	1.778
Min:	1.000	0.613
Max:	1.600	8.620
5 %tile:	1.000	0.626
10 %tile:	1.000	0.668
90 %tile:	1.350	4.030
95 %tile:	1.550	7.883
Corr (R^2):	0.11	
Mean Abs Error:	0.787	
RMS Error:	1.799	
Norm RMS Error:	1.273	
Index of Agreement:	0.29	

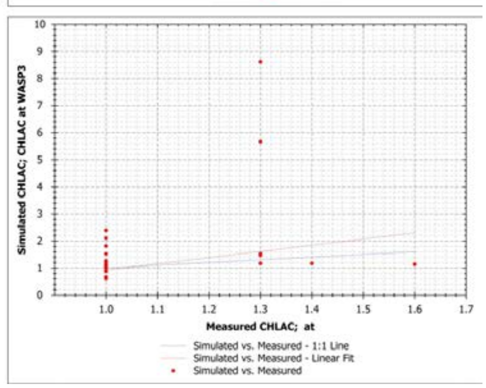
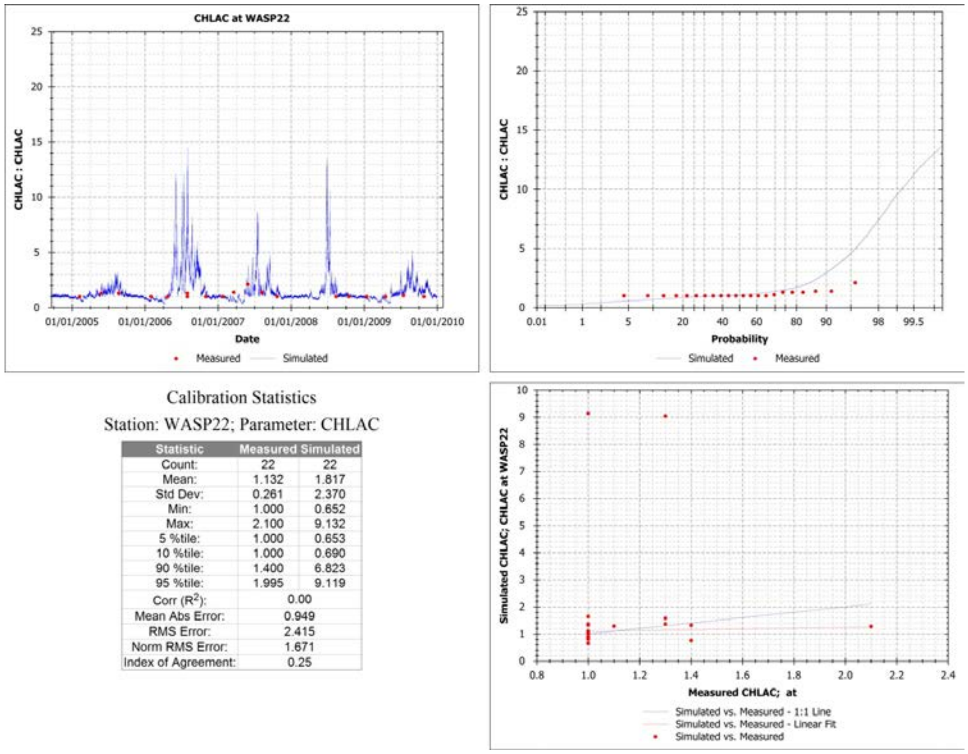


Figure 18 Chl-a Calibration at WASP3



Calibration Statistics

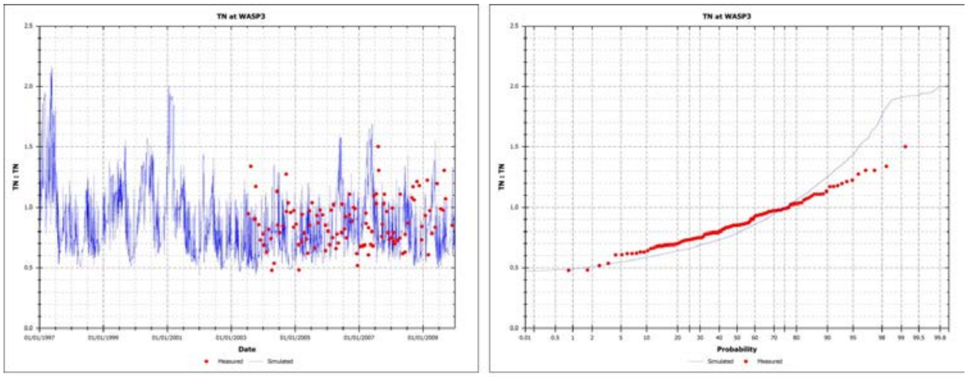
Station: WASP22; Parameter: CHLAC

Statistic	Measured	Simulated
Count:	22	22
Mean:	1.132	1.817
Std Dev:	0.261	2.370
Min:	1.000	0.652
Max:	2.100	9.132
5 %tile:	1.000	0.653
10 %tile:	1.000	0.690
90 %tile:	1.400	6.823
95 %tile:	1.995	9.119
Corr (R^2):	0.00	
Mean Abs Error:	0.949	
RMS Error:	2.415	
Norm RMS Error:	1.671	
Index of Agreement:	0.25	

Figure 19 – Chl-a Calibration at WASP22

Nitrogen

Figure 20 and Figure 21 illustrate both a quantitative and qualitative comparison of the model predictions for total nitrogen to direct measurements. Additional calibration locations are included in the appendix.



Calibration Statistics

Station: WASP3; Parameter: TN

Statistic	Measured	Simulated
Count:	116	116
Mean:	0.875	0.807
Std Dev:	0.195	0.204
Min:	0.478	0.453
Max:	1.500	1.637
5 %tile:	0.607	0.565
10 %tile:	0.638	0.589
90 %tile:	1.143	1.086
95 %tile:	1.232	1.226
Corr (R^2):	0.03	
Mean Abs Error:	0.248	
RMS Error:	0.312	
Norm RMS Error:	0.373	
Index of Agreement:	0.24	

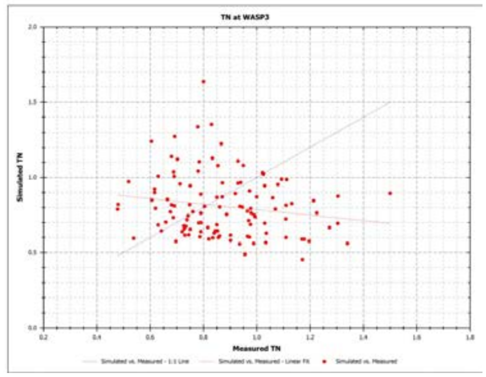
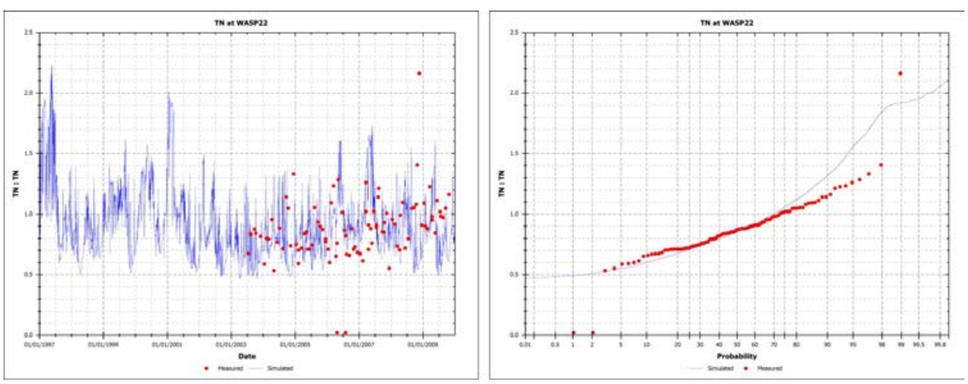


Figure 20 - Total Nitrogen Calibration at WASP3



Calibration Statistics

Station: WASP22; Parameter: TN

Statistic	Measured	Simulated
Count:	96	96
Mean:	0.879	0.873
Std Dev:	0.258	0.246
Min:	0.020	0.489
Max:	2.161	1.703
5 %tile:	0.581	0.557
10 %tile:	0.658	0.584
90 %tile:	1.147	1.218
95 %tile:	1.264	1.377
Corr (R^2):	0.02	
Mean Abs Error:	0.279	
RMS Error:	0.381	
Norm RMS Error:	0.437	
Index of Agreement:	0.22	

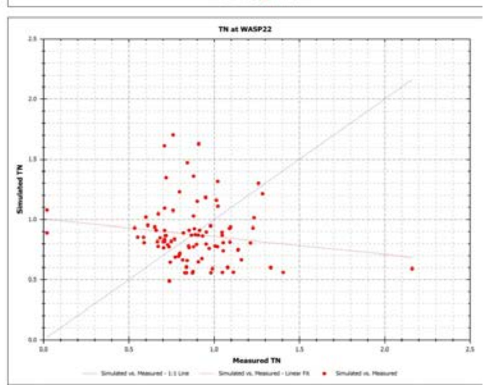
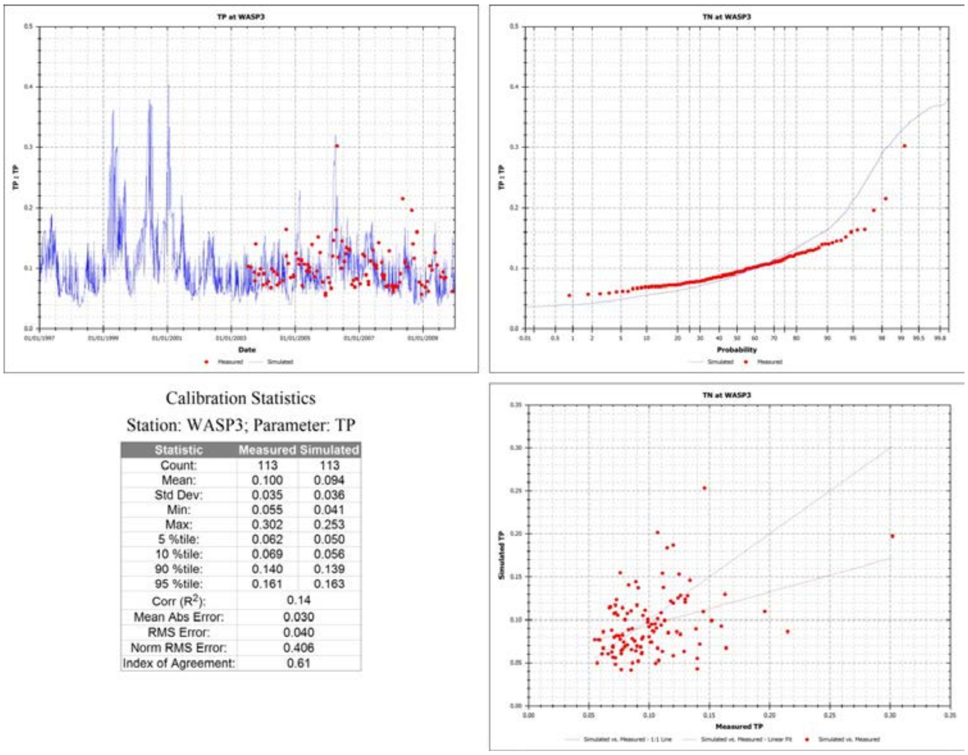


Figure 21 – Total Nitrogen Calibration at WASP22

Phosphorus

Figure 22 and Figure 23 illustrate both a quantitative and qualitative comparison of the model predictions for total phosphorus to direct measurements. Additional calibration locations are included in the appendix.

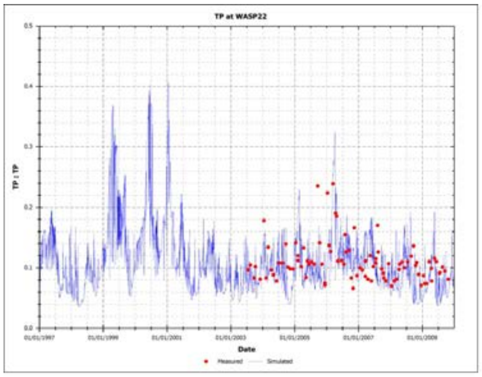


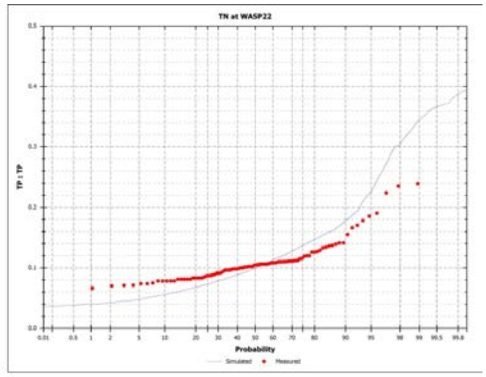
Calibration Statistics

Station: WASP3; Parameter: TP

Statistic	Measured	Simulated
Count:	113	113
Mean:	0.100	0.094
Std Dev:	0.035	0.036
Min:	0.055	0.041
Max:	0.302	0.253
5 %tile:	0.062	0.050
10 %tile:	0.069	0.056
90 %tile:	0.140	0.139
95 %tile:	0.161	0.163
Corr (R^2):	0.14	
Mean Abs Error:	0.030	
RMS Error:	0.040	
Norm RMS Error:	0.406	
Index of Agreement:	0.61	

Figure 22 - Total Phosphorus Calibration at WASP3





Calibration Statistics

Station: WASP22; Parameter: TP

Statistic	Measured	Simulated
Count:	94	94
Mean:	0.110	0.103
Std Dev:	0.034	0.042
Min:	0.066	0.041
Max:	0.239	0.251
5 %tile:	0.073	0.048
10 %tile:	0.078	0.053
90 %tile:	0.148	0.158
95 %tile:	0.186	0.183
Corr (R^2):	0.17	
Mean Abs Error:	0.033	
RMS Error:	0.042	
Norm RMS Error:	0.385	
Index of Agreement:	0.63	

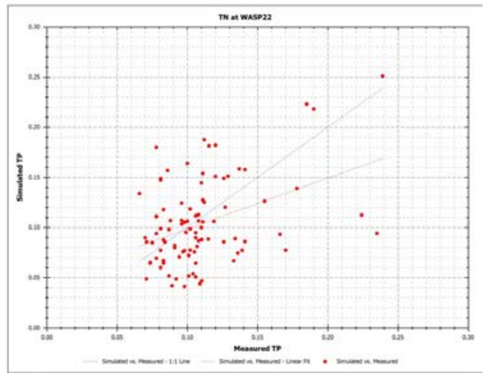


Figure 23 – Total Phosphorus Calibration at WASP22

Current Loads

Table 7 and Table 8 provides the annual average total nitrogen, total phosphorus and BOD loads for the simulated period of 1997 through 2009. It is these loadings that the TMDL load reduction will be calculated from. Note that the current wasteload allocation is based on permissible loading under the existing NPDES permits, as opposed to actual reported point source loadings.

Econlockhatchee River (WBID 2991A)		
	Current Condition	
Constituent	WLA (kg/yr)	LA (kg/yr)
BOD5	166,028	1,256,462
Total Nitrogen	119,412	290,413
Total Phosphorus	36,453	32,061

Table 7 - WBID 2991A: Econlockhatchee River Existing Annual Average Pollutant Loading

Little Econlockhatchee River (WBID 3001)		
	Current Condition	
Constituent	WLA (kg/yr)	LA (kg/yr)
BOD5	166,028	638,593
Total Nitrogen	119,412	122,010
Total Phosphorus	36,453	14,609

Table 8 - WBID 3001: Little Econlockhatchee River Existing Annual Average Pollutant Loading

Modeling Scenarios

Using the calibrated watershed and water quality models, up to two potential modeling scenarios will be developed. The first scenario will be to predict water quality conditions under a natural condition (remove point sources and returning landuses back to upland forests and wetlands). A second scenario will be developed if water quality standards can be met under natural conditions (balanced flora and fauna, dissolved oxygen greater than 5 mg/L); loads would be reduced from the current conditions until standards are met (balanced flora and fauna, dissolved oxygen greater than 5 mg/L)

Natural Condition Analysis

The natural condition scenario is developed to estimate what water quality conditions would exist if there were little to no impact from anthropogenic sources. The simulated point source discharges have been removed for this scenario. For the purpose of this analysis any landuse that is associated with man induced activities (urban, agriculture, transportation, barren lands and rangeland) is converted to upland forests and wetlands (50/50 split) and the associated event mean concentration for nitrogen, phosphorus and BOD are used. These natural condition loadings from the watershed model are passed onto the water quality model where natural water quality conditions are predicted. The natural condition water quality predictions are presented in Table 9 and Table 10. The natural condition scenario makes the following assumptions:

1. All man induced landuses in the watershed model are transformed back to wetlands and upland forest (50:50 ratio).
2. New hydrology is predicted under natural landuse assumption.
3. All point sources are removed.
4. Water quality is predicted using the new flows and loads from the natural condition run from the watershed model.
5. Sediment oxygen demand is reduced based upon the percent reduction in nutrient loads (constant value of 0.8 g/m^2/day assumed for all segments).

WBID 2991A: Natural Condition	
Constituent	**Natural**
BOD5 (mg/L)	0.67
Chlorophyll a (ug/L)	2.45
DO (mg/L)	7.46
Total Nitrogen (mg/L)	0.53
Total Phosphorus (mg/L)	0.05

Table 9 - WBID 2991A (Econlockhatchee River) Simulated Natural Conditions Annual Average Parameters (2002-2009)

WBID 3001: Natural Condition	
Constituent	**Natural**
BOD5 (mg/L)	0.68
Chlorophyll a (ug/L)	2.61
DO (mg/L)	7.40
Total Nitrogen (mg/L)	0.54
Total Phosphorus (mg/L)	0.05

Table 10 - WBID 3001 (Little Econlockhatchee River) Simulated Natural Conditions Annual Average Parameters (2002-2009)

The purpose of the natural conditions scenario is to determine whether water quality standards can be achieved without abating the naturally occurring loads from the watershed.

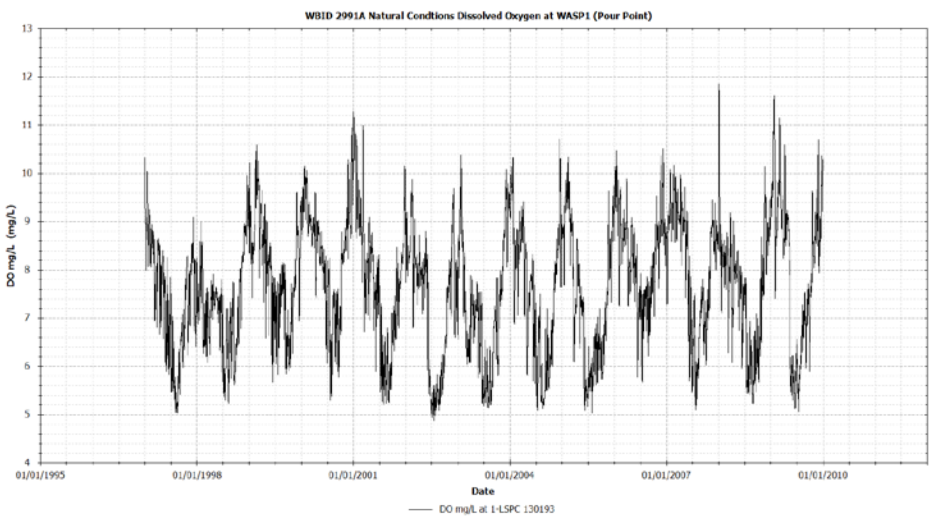


Figure 24 Natural Conditions Predicted Dissolved Oxygen Concentrations (Econlockhatchee)

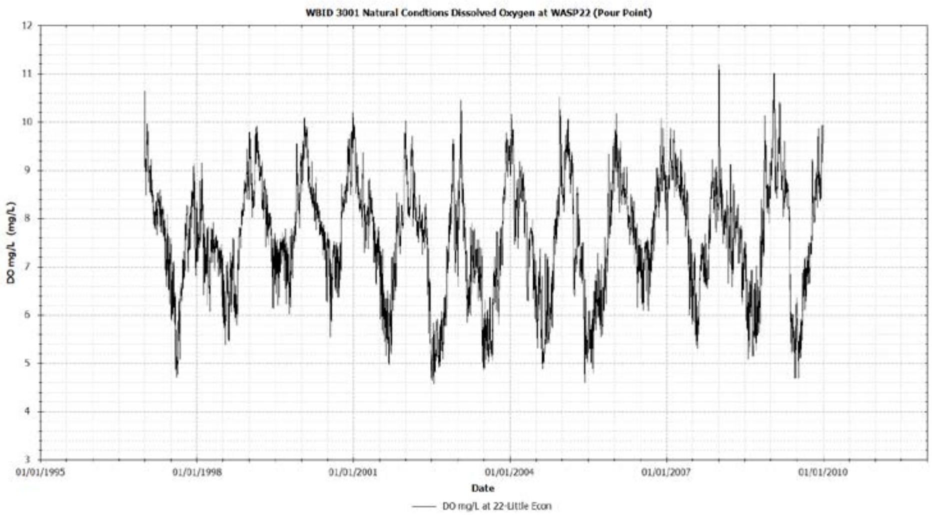


Figure 25 Natural Conditions Predicted Dissolved Oxygen Concentrations (Little Econlockhatchee)

As demonstrated by Figure 24 and Figure 25, the DO standard is not achievable under natural conditions at the pour points of either WBID. The minimum dissolved oxygen criterion of 5 mg/l is exceeded briefly during warm, low-flow conditions during July 2002 in the Econlockhatchee River and on numerous occasions in the Little Econlockhatchee River.

Table 11 and Table 12 provide the natural condition's annual average load predictions for total nitrogen, total phosphorus, and BOD.

Econlockhatchee River (WBID 2991A)		
	Natural Condition	
Constituent	WLA (kg/yr)	LA (kg/yr)
BOD5	NA	326,962
Total Nitrogen	NA	134,043
Total Phosphorus	NA	12,639

Table 11 - WBID 2991A: Econlockhatchee River Natural Conditions Annual Average Pollutant Loading

Little Econlockhatchee River (WBID 3001)		
	Natural Condition	
Constituent	WLA (kg/yr)	LA (kg/yr)
BOD5	NA	114,775
Total Nitrogen	NA	48,592
Total Phosphorus	NA	4,497

Table 12 - WBID 3001: Little Econlockhatchee River Natural Conditions Annual Average Pollutant Loading

Figure 26 provides a cumulative distribution function of the DO concentrations under natural conditions for the simulated pour point segments of each WBID.

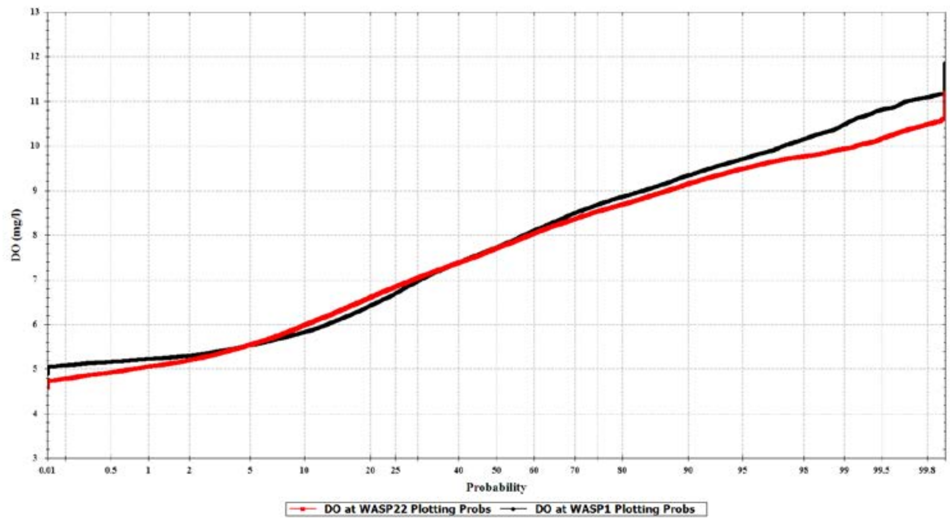


Figure 26 - Probability Plot of Simulated Natural Conditions Dissolved Oxygen at Modeled Pour Points

TMDL Load Reductions

Because water quality standards for dissolved oxygen cannot be met under natural conditions, the TMDL will be set to the natural conditions.

TMDL Determination

The TMDL load reduction was determined by reducing the current conditions to the natural conditions. The annual average loadings are given in Table 13 along with the prescribed load reductions.

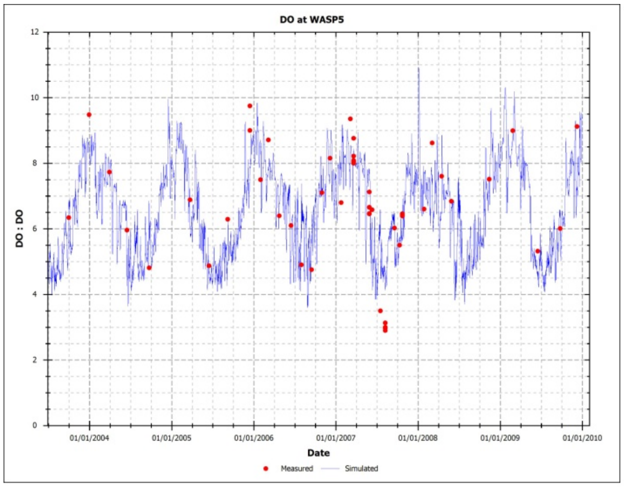
WBID 2991A - Econlockhatchee River	Current Condition		TMDL Condition		MS4	LA	WLA
Constituent	WLA (kg/yr)	LA (kg/yr)	WLA (kg/yr)	LA (kg/yr)	% Reduction	% Reduction	% Reduction
BOD5	166,028	1,256,462	166,028	326,962	74%	74%	0%
Total Nitrogen	119,412	290,413	119,412	134,043	54%	54%	0%
Total Phosphorus	36,453	32,061	36,453	12,639	61%	61%	0%
WBID 3001 - Little Econlockhatchee	Current Condition		TMDL Condition		MS4	LA	WLA
Constituent	WLA (kg/yr)	LA (kg/yr)	WLA (kg/yr)	LA (kg/yr)	% Reduction	% Reduction	% Reduction
BOD5	166,028	638,593	166,028	114,775	82%	82%	0%
Total Nitrogen	119,412	122,010	119,412	48,592	60%	60%	0%
Total Phosphorus	36,453	14,609	36,453	4,497	69%	69%	0%

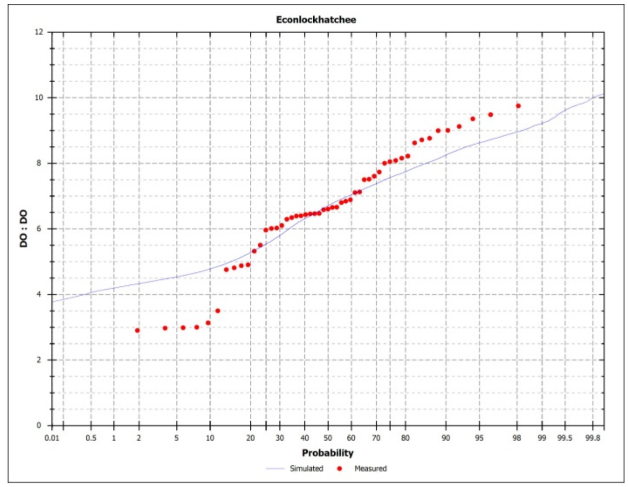
Table 13 - TMDL Allocations for WBID 2991A (Econlockhatchee River) and WBID 3001 (Little Econlockhatchee River)

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

APPENDIX

Additional Calibration Plots

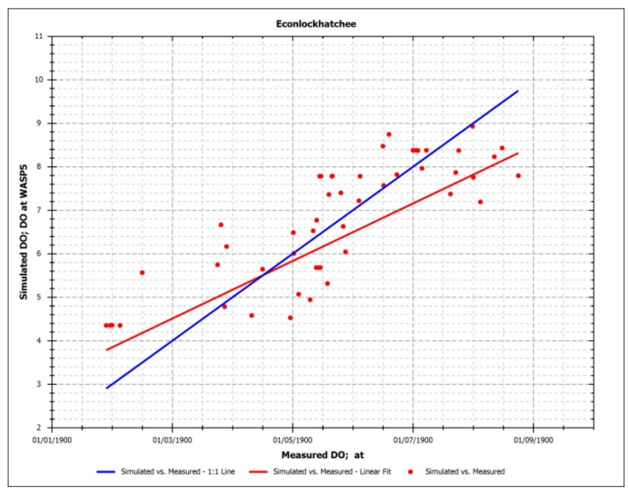


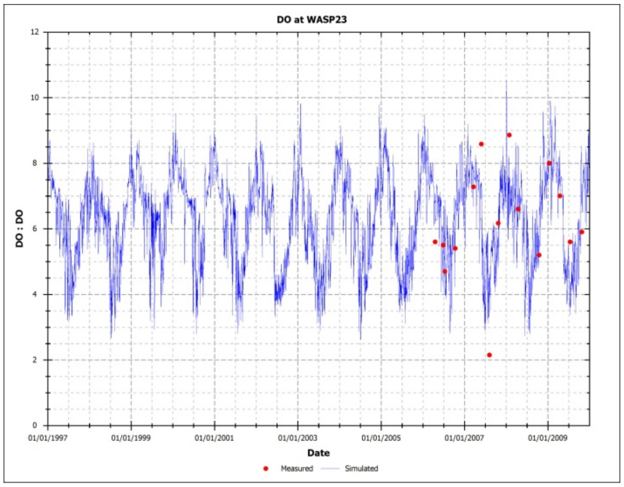


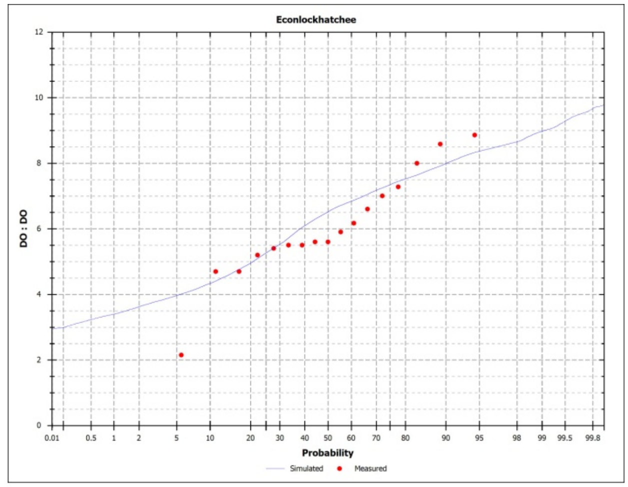
Calibration Statistics

Station: WASP5; Parameter: DO

Statistic	Measured	Simulated
Count:	51	51
Mean:	6.624	6.728
Std Dev:	1.813	1.431
Min:	2.900	4.350
Max:	9.750	8.931
5 %tile:	2.976	4.351
10 %tile:	3.204	4.391
90 %tile:	8.998	8.375
95 %tile:	9.402	8.581
Corr (R^2):	0.68	
Mean Abs Error:	0.859	
RMS Error:	1.024	
Norm RMS Error:	0.150	
Index of Agreement:	0.89	



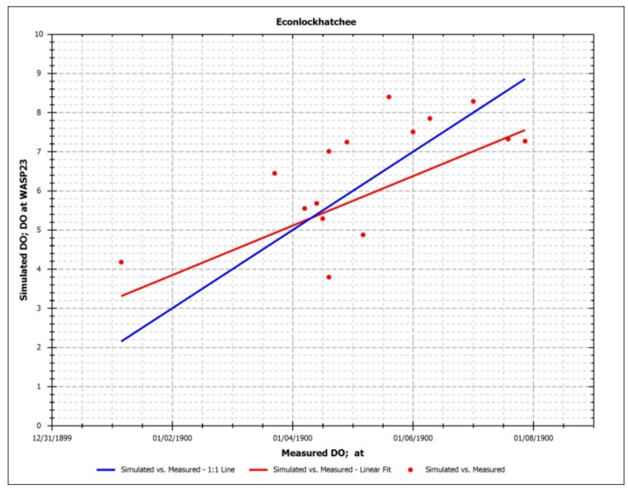


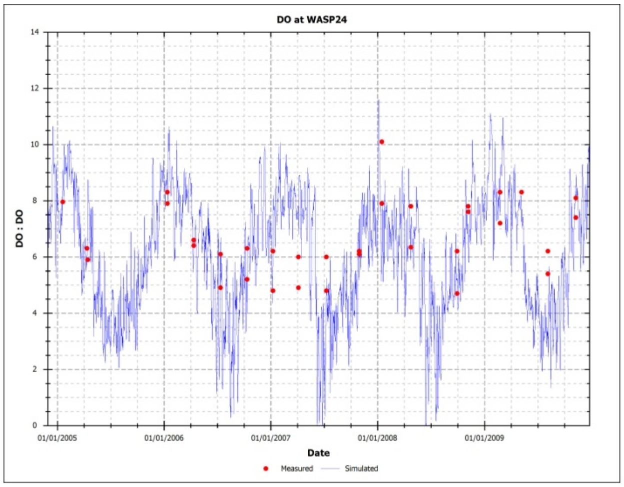


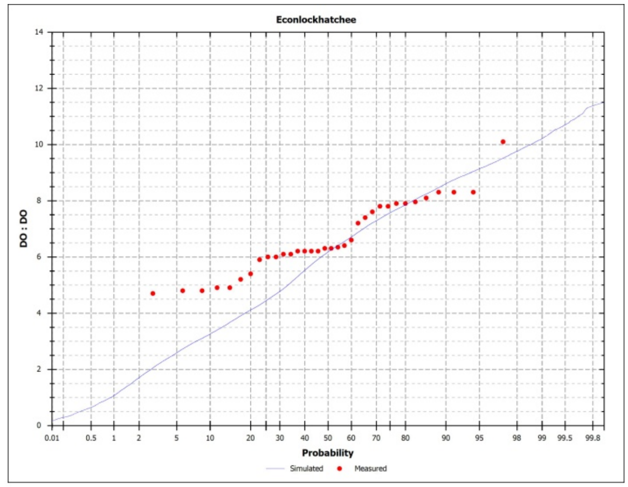
Calibration Statistics

Station: WASP23; Parameter: DO

Statistic	Measured	Simulated
Count:	17	17
Mean:	6.044	6.378
Std Dev:	1.618	1.399
Min:	2.150	3.796
Max:	8.860	8.398
5 %tile:	0.000	0.000
10 %tile:	4.190	4.102
90 %tile:	8.636	8.306
95 %tile:	0.000	0.000
Corr (R^2):	0.44	
Mean Abs Error:	1.084	
RMS Error:	1.266	
Norm RMS Error:	0.200	
Index of Agreement:	0.79	



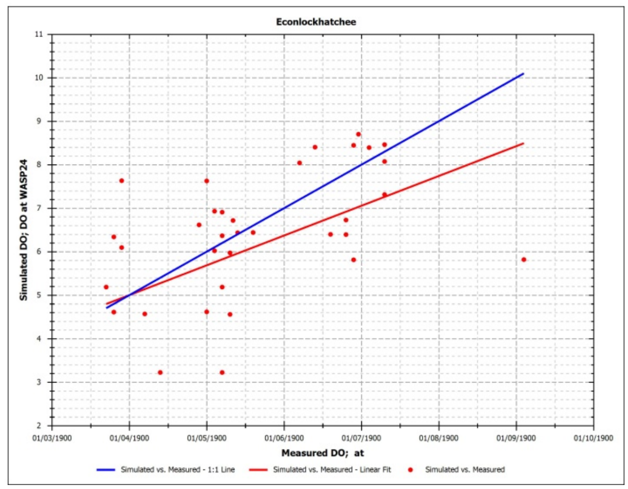


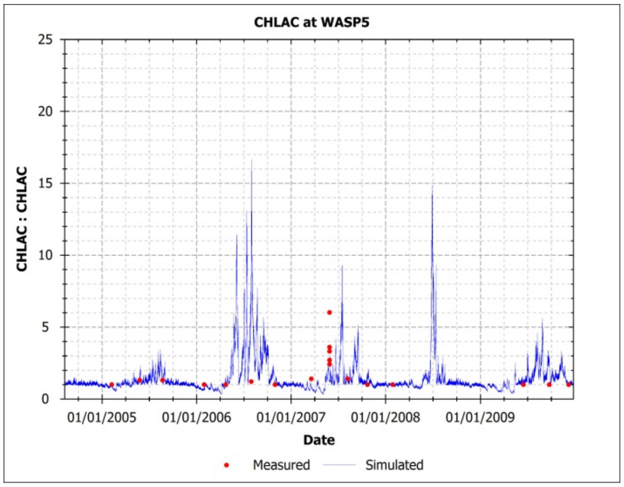


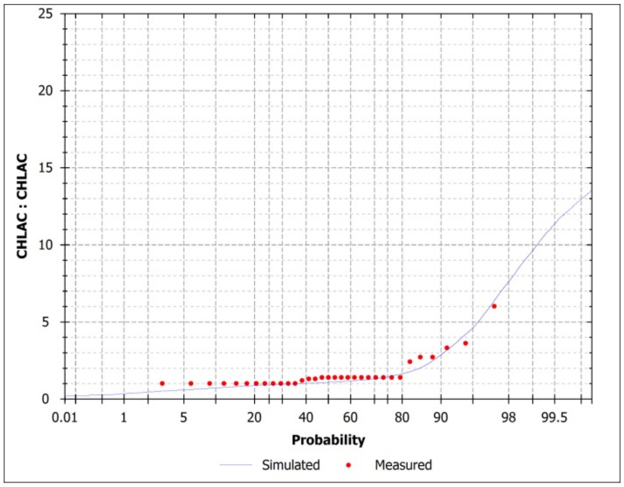
Calibration Statistics

Station: WASP24; Parameter: DO

Statistic	Measured	Simulated
Count:	34	34
Mean:	6.653	6.419
Std Dev:	1.292	1.448
Min:	4.700	3.222
Max:	10.100	8.700
5 %tile:	4.775	3.225
10 %tile:	4.850	4.562
90 %tile:	8.300	8.424
95 %tile:	8.750	8.519
Corr (R^2):	0.23	
Mean Abs Error:	1.057	
RMS Error:	1.405	
Norm RMS Error:	0.213	
Index of Agreement:	0.68	



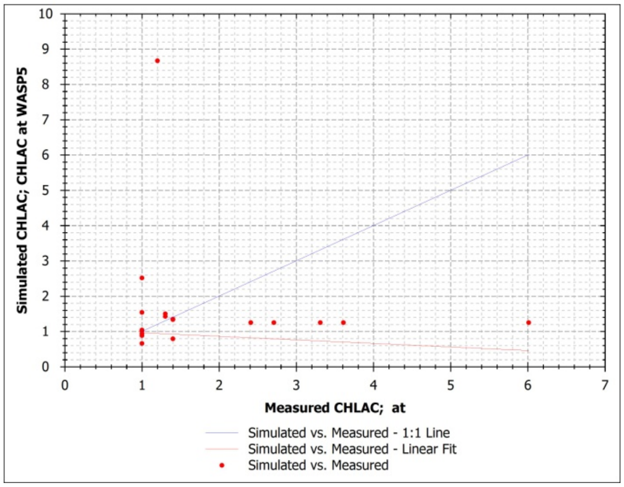


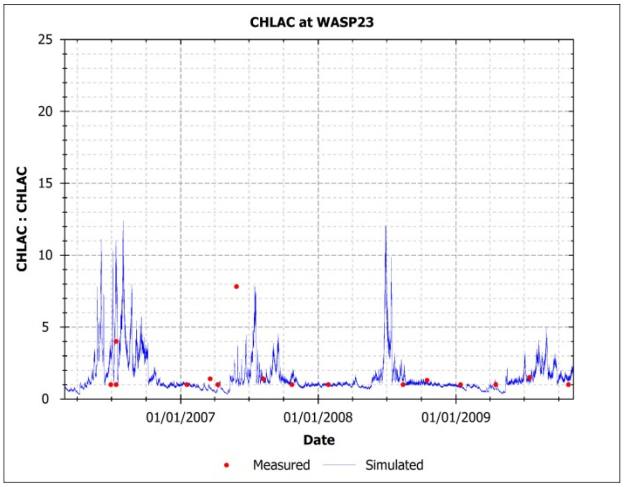


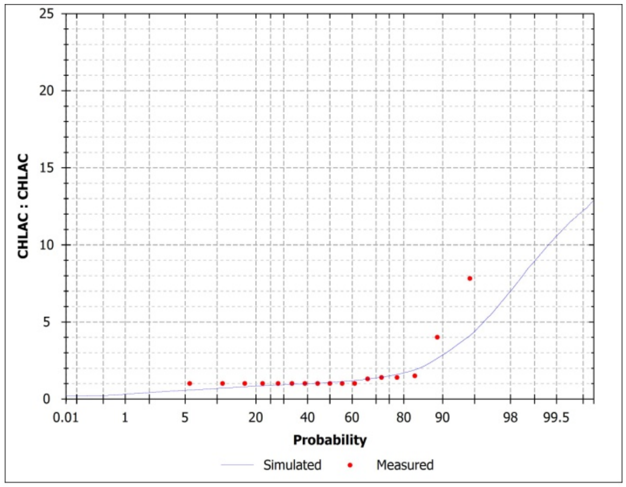
Calibration Statistics

Station: WASP5; Parameter: CHLAC

Statistic	Measured	Simulated
Count:	33	33
Mean:	1.617	1.430
Std Dev:	1.041	1.347
Min:	1.000	0.660
Max:	6.010	8.667
5 %tile:	1.000	0.755
10 %tile:	1.000	0.795
90 %tile:	3.070	1.542
95 %tile:	4.330	4.362
Corr (R^2):	0.00	
Mean Abs Error:	0.887	
RMS Error:	1.738	
Norm RMS Error:	1.165	
Index of Agreement:	0.06	



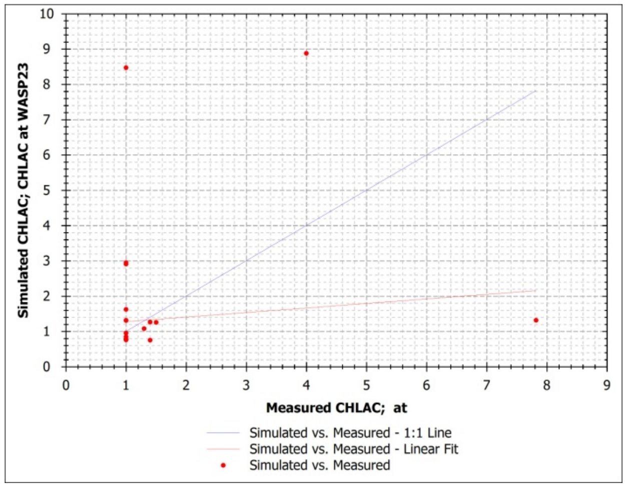


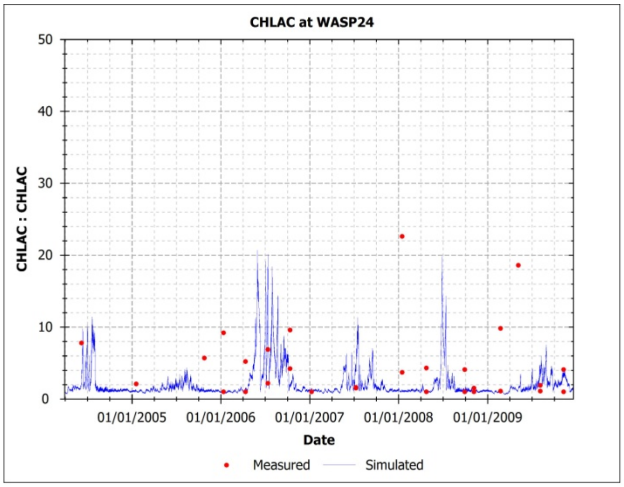


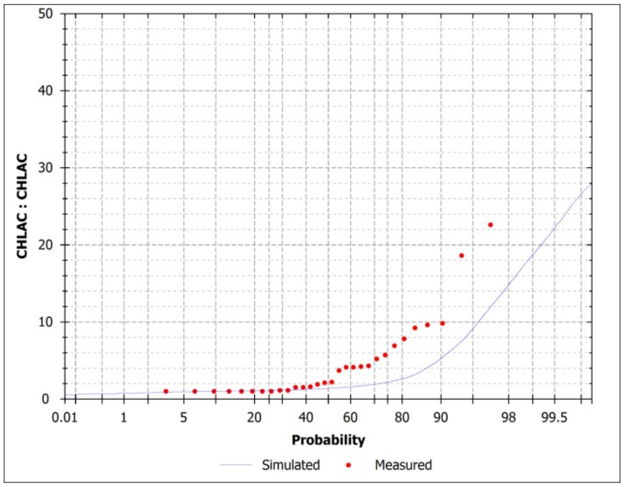
Calibration Statistics

Station: WASP23; Parameter: CHLAC

Statistic	Measured	Simulated
Count:	17	17
Mean:	1.672	2.192
Std Dev:	1.741	2.528
Min:	1.000	0.754
Max:	7.820	8.879
5 %tile:	0.000	0.000
10 %tile:	1.000	0.759
90 %tile:	4.764	8.551
95 %tile:	0.000	0.000
Corr (R^2):	0.03	
Mean Abs Error:	1.534	
RMS Error:	2.772	
Norm RMS Error:	1.323	
Index of Agreement:	0.45	



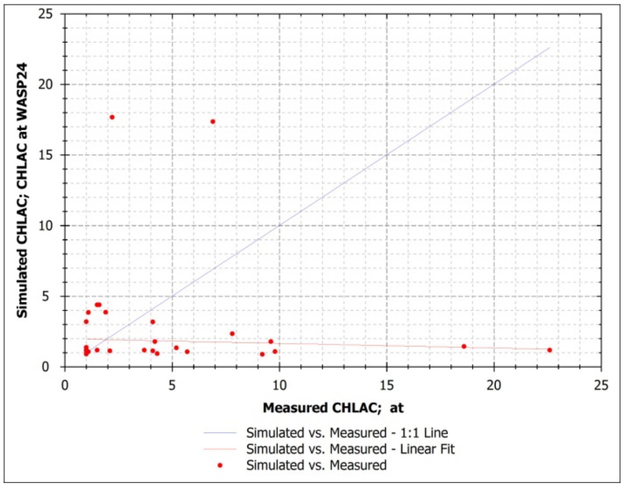


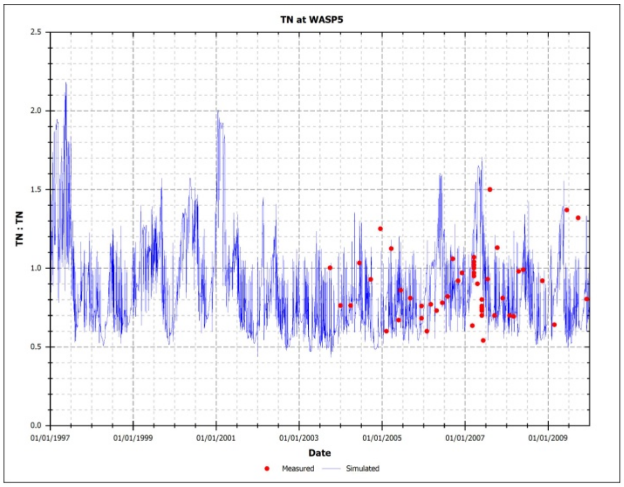


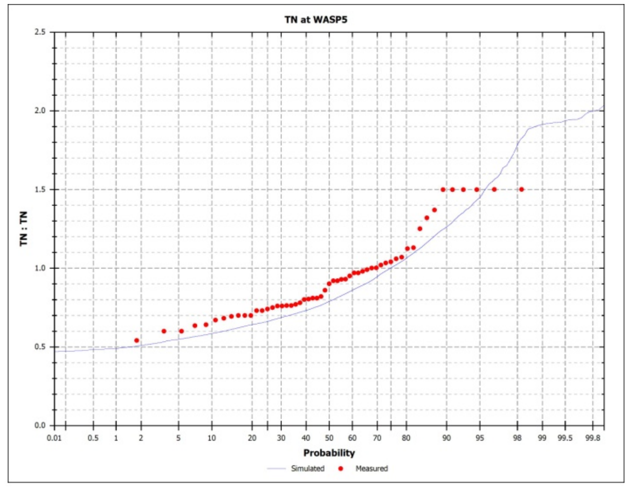
Calibration Statistics

Station: WASP24; Parameter: CHLAC

Statistic	Measured	Simulated
Count:	30	30
Mean:	4.560	2.840
Std Dev:	5.211	4.140
Min:	1.000	0.889
Max:	22.600	17.680
5 %tile:	1.000	0.892
10 %tile:	1.000	0.914
90 %tile:	9.780	4.393
95 %tile:	20.400	17.504
Corr (R^2):	0.00	
Mean Abs Error:	4.357	
RMS Error:	6.932	
Norm RMS Error:	2.017	
Index of Agreement:	0.20	



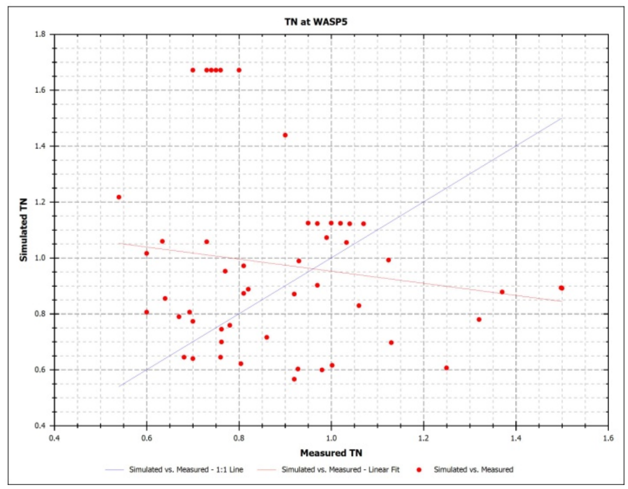


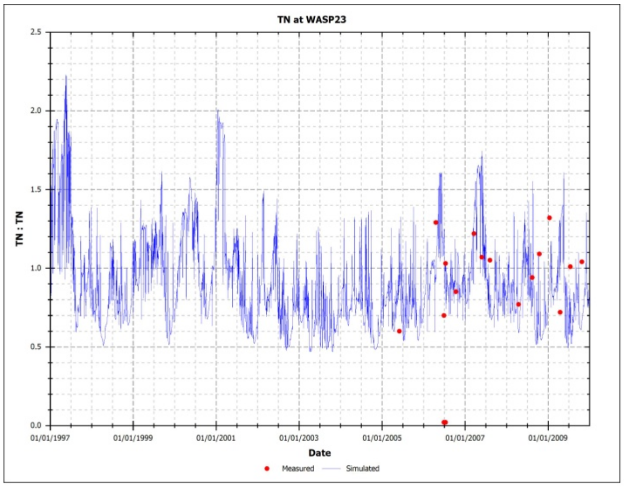


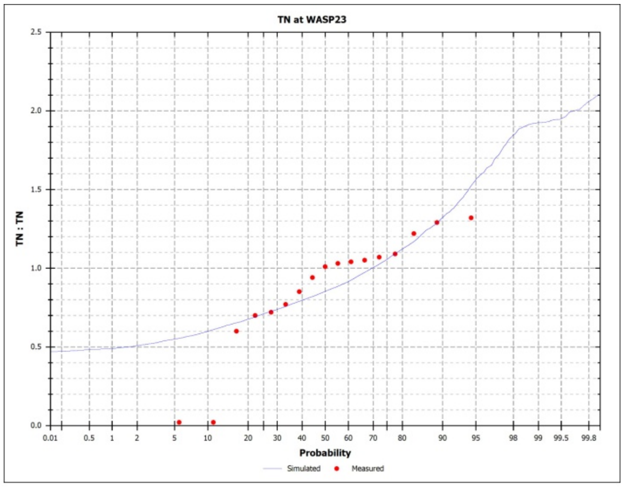
Calibration Statistics

Station: WASP5; Parameter: TN

Statistic	Measured	Simulated
Count:	55	55
Mean:	0.936	0.966
Std Dev:	0.266	0.308
Min:	0.540	0.567
Max:	1.500	1.672
5 %tile:	0.600	0.602
10 %tile:	0.658	0.619
90 %tile:	1.498	1.671
95 %tile:	1.499	1.671
Corr (R^2):	0.03	
Mean Abs Error:	0.333	
RMS Error:	0.440	
Norm RMS Error:	0.467	
Index of Agreement:	0.24	



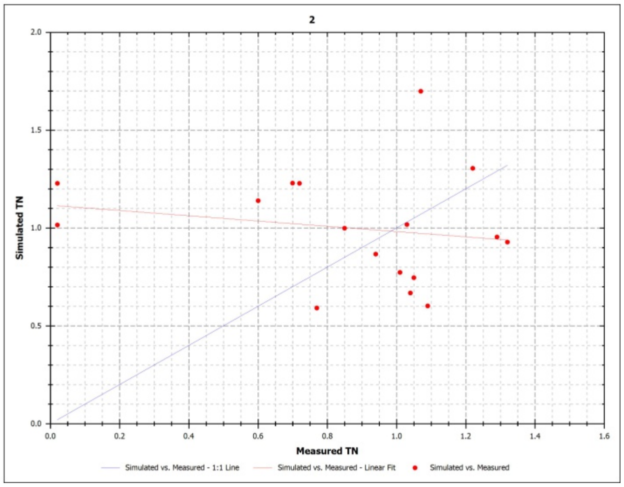


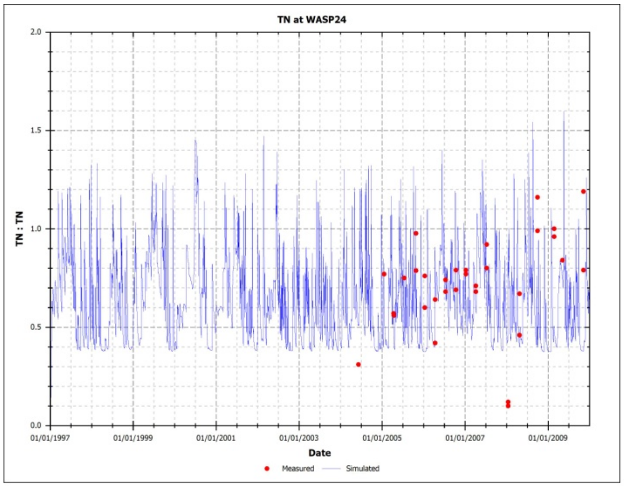


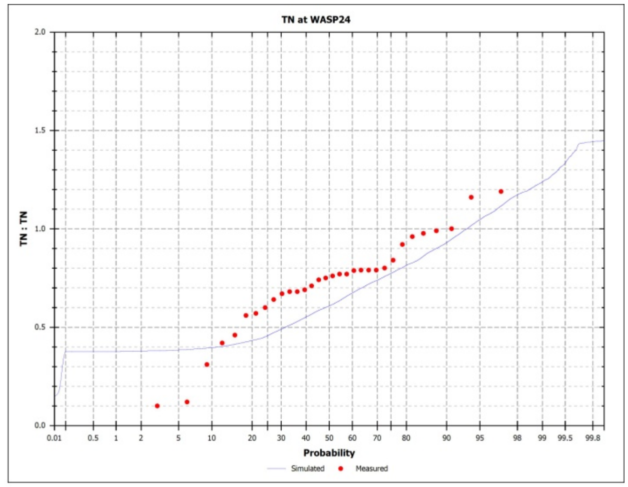
Calibration Statistics

Station: WASP23; Parameter: TN

Statistic	Measured	Simulated
Count:	17	17
Mean:	0.867	0.999
Std Dev:	0.378	0.289
Min:	0.020	0.590
Max:	1.320	1.698
5 %tile:	0.000	0.000
10 %tile:	0.020	0.599
90 %tile:	1.296	1.384
95 %tile:	0.000	0.000
Corr (R^2):	0.03	
Mean Abs Error:	0.414	
RMS Error:	0.516	
Norm RMS Error:	0.561	
Index of Agreement:	0.16	



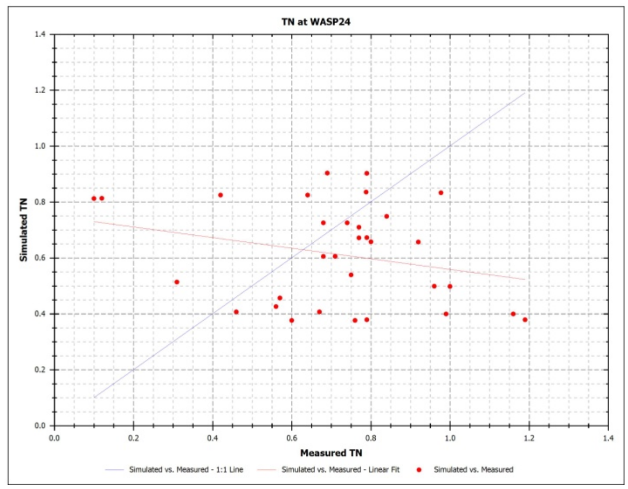


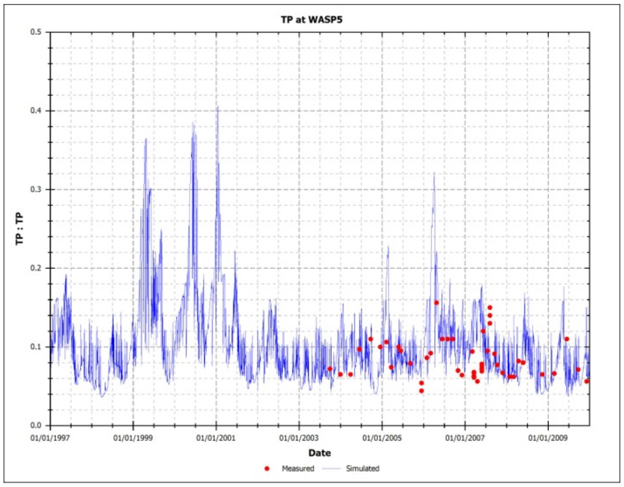


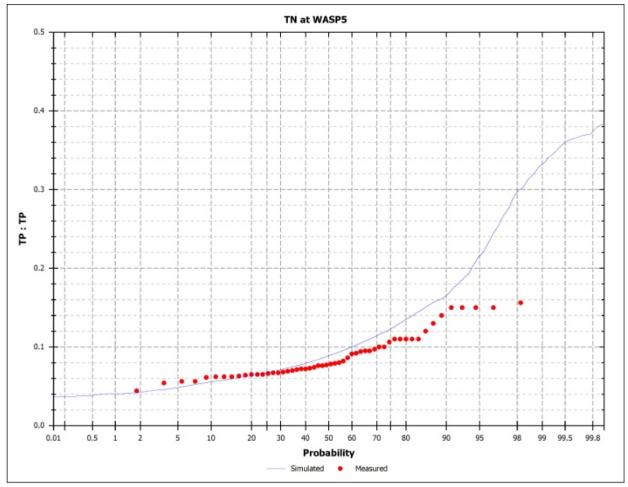
Calibration Statistics

Station: WASP24; Parameter: TN

Statistic	Measured	Simulated
Count:	32	32
Mean:	0.719	0.612
Std Dev:	0.249	0.179
Min:	0.100	0.376
Max:	1.190	0.903
5 %tile:	0.113	0.376
10 %tile:	0.343	0.379
90 %tile:	0.997	0.835
95 %tile:	1.171	0.903
Corr (R^2):	0.07	
Mean Abs Error:	0.270	
RMS Error:	0.354	
Norm RMS Error:	0.541	
Index of Agreement:	0.28	



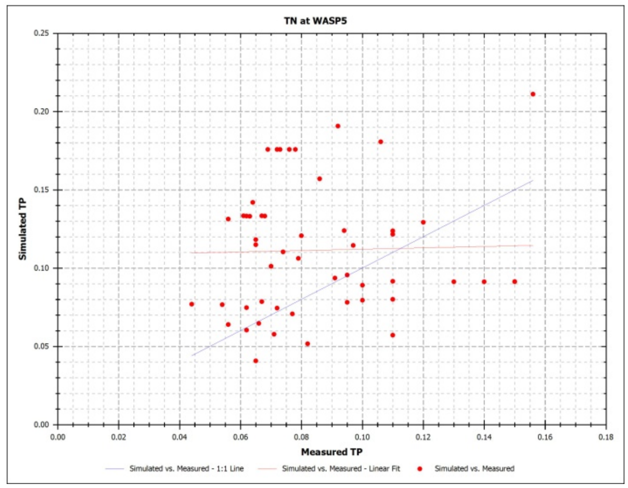


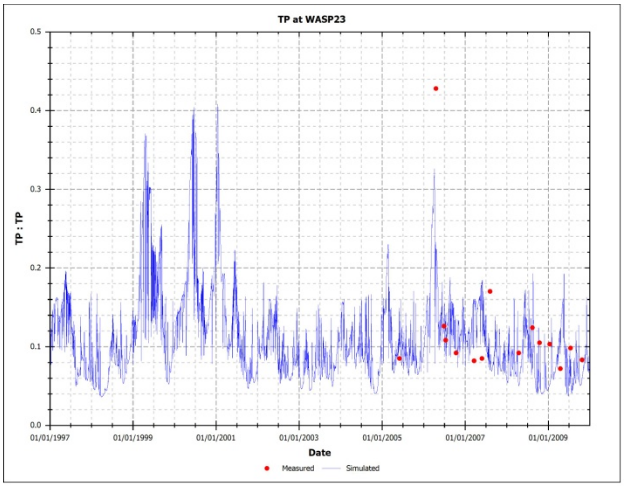


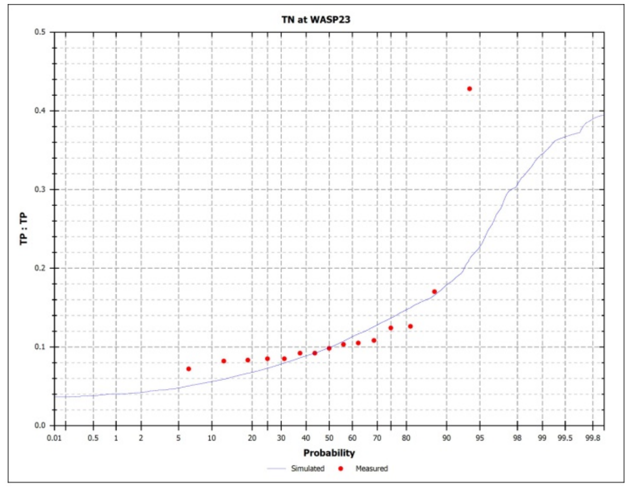
Calibration Statistics

Station: WASP5; Parameter: TP

Statistic	Measured	Simulated
Count:	54	54
Mean:	0.088	0.112
Std Dev:	0.029	0.041
Min:	0.044	0.041
Max:	0.156	0.211
5 %tile:	0.056	0.056
10 %tile:	0.062	0.062
90 %tile:	0.145	0.176
95 %tile:	0.150	0.183
Corr (R^2):	0.00	
Mean Abs Error:	0.044	
RMS Error:	0.054	
Norm RMS Error:	0.547	
Index of Agreement:	0.45	



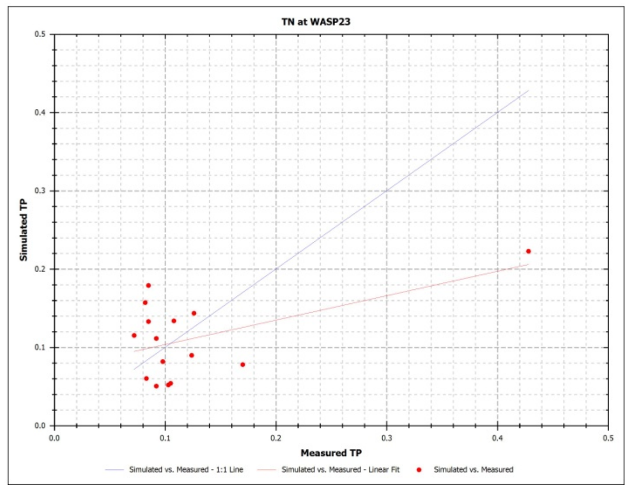


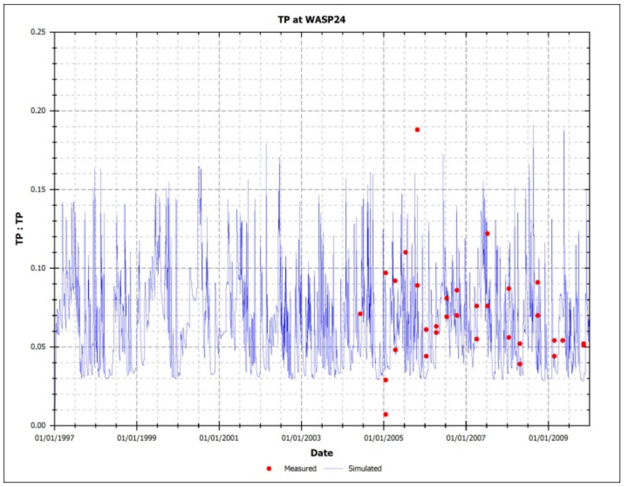


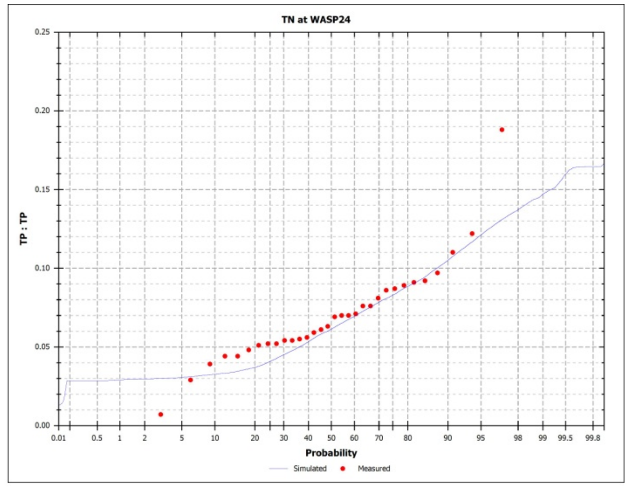
Calibration Statistics

Station: WASP23; Parameter: TP

Statistic	Measured	Simulated
Count:	15	15
Mean:	0.124	0.111
Std Dev:	0.088	0.051
Min:	0.072	0.051
Max:	0.428	0.223
5 %tile:	0.000	0.000
10 %tile:	0.078	0.051
90 %tile:	0.273	0.197
95 %tile:	0.000	0.000
Corr (R^2):	0.29	
Mean Abs Error:	0.056	
RMS Error:	0.073	
Norm RMS Error:	0.577	
Index of Agreement:	0.67	



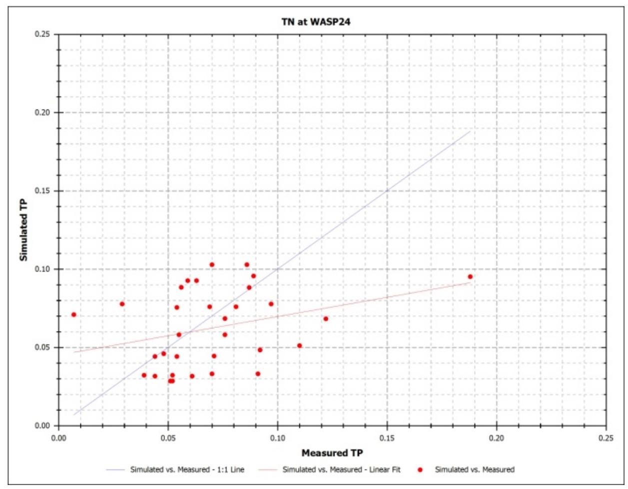


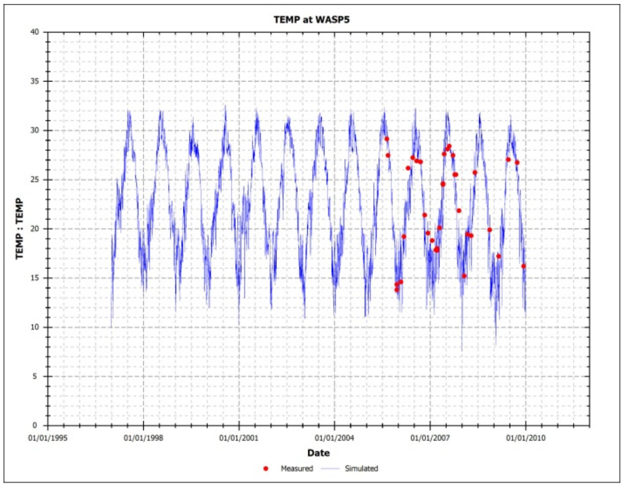


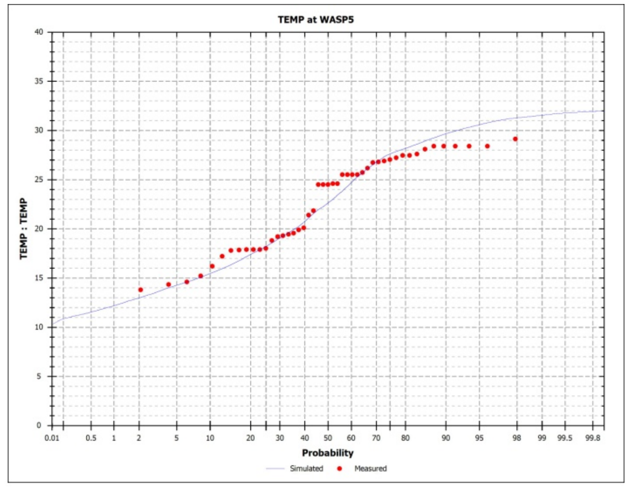
Calibration Statistics

Station: WASP24; Parameter: TP

Statistic	Measured	Simulated
Count:	32	32
Mean:	0.070	0.062
Std Dev:	0.032	0.025
Min:	0.007	0.029
Max:	0.188	0.103
5 %tile:	0.021	0.029
10 %tile:	0.041	0.032
90 %tile:	0.106	0.095
95 %tile:	0.145	0.103
Corr (R^2):	0.10	
Mean Abs Error:	0.026	
RMS Error:	0.034	
Norm RMS Error:	0.502	
Index of Agreement:	0.55	



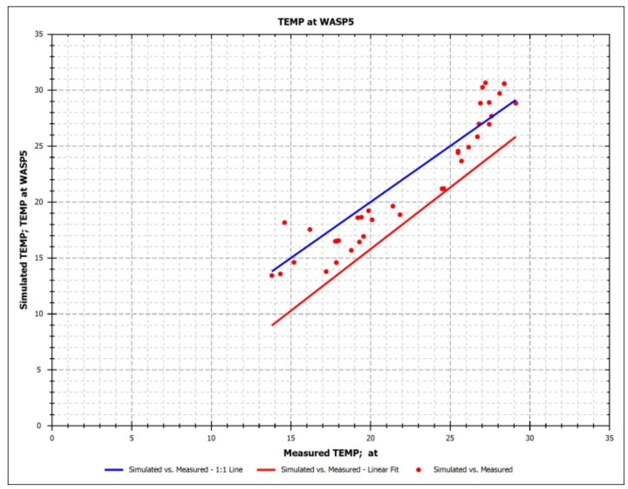


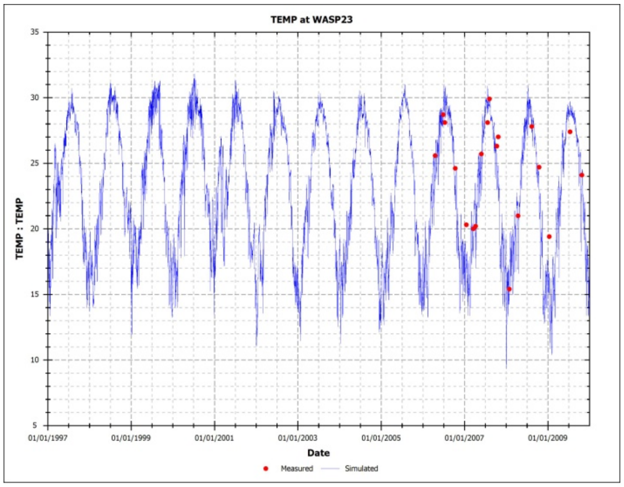


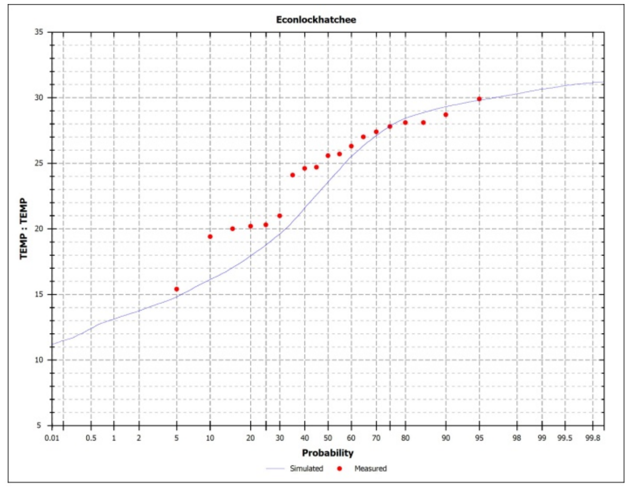
Calibration Statistics

Station: WASP5; Parameter: TEMP

Statistic	Measured	Simulated
Count:	47	47
Mean:	22.792	22.132
Std Dev:	4.708	5.724
Min:	13.800	13.430
Max:	29.120	30.656
5 %tile:	14.444	13.648
10 %tile:	16.000	14.601
90 %tile:	28.400	30.568
95 %tile:	28.400	30.577
Corr (R^2):	0.89	
Mean Abs Error:	1.835	
RMS Error:	2.120	
Norm RMS Error:	0.092	
Index of Agreement:	0.96	



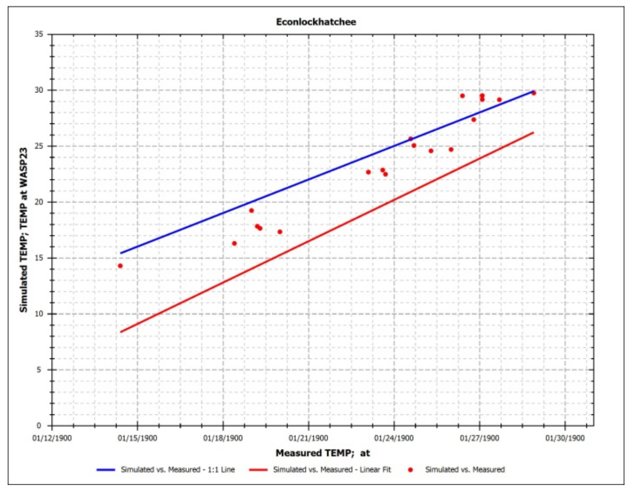


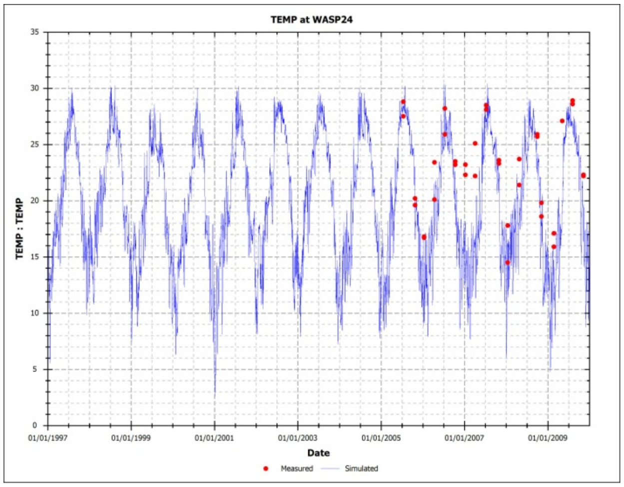


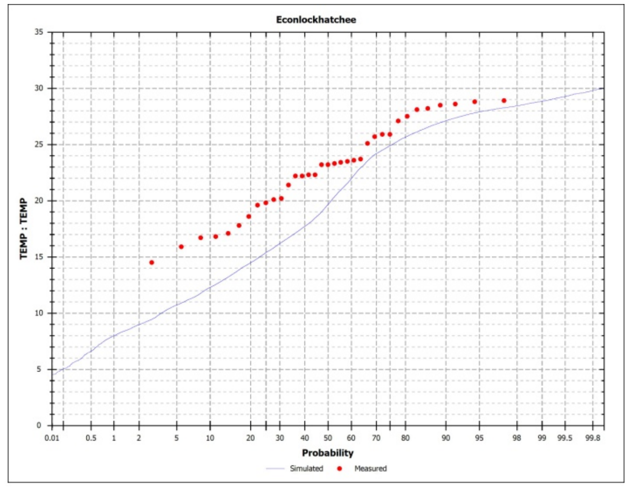
Calibration Statistics

Station: WASP23; Parameter: TEMP

Statistic	Measured	Simulated
Count:	19	19
Mean:	24.436	23.419
Std Dev:	3.956	5.062
Min:	15.400	14.284
Max:	29.900	29.741
5 %tile:	15.400	14.284
10 %tile:	19.400	16.291
90 %tile:	28.700	29.517
95 %tile:	29.900	29.741
Corr (R^2):	0.94	
Mean Abs Error:	1.552	
RMS Error:	1.841	
Norm RMS Error:	0.076	
Index of Agreement:	0.96	







Calibration Statistics

Station: WASP24; Parameter: TEMP

Statistic	Measured	Simulated
Count:	35	35
Mean:	22.849	19.433
Std Dev:	4.109	5.037
Min:	14.500	11.380
Max:	28.900	28.140
5 %tile:	15.620	11.407
10 %tile:	16.760	12.254
90 %tile:	28.540	27.023
95 %tile:	28.820	28.137
Corr (R^2):	0.84	
Mean Abs Error:	3.451	
RMS Error:	3.971	
Norm RMS Error:	0.185	
Index of Agreement:	0.84