Loxahatchee River Watershed Restoration Project

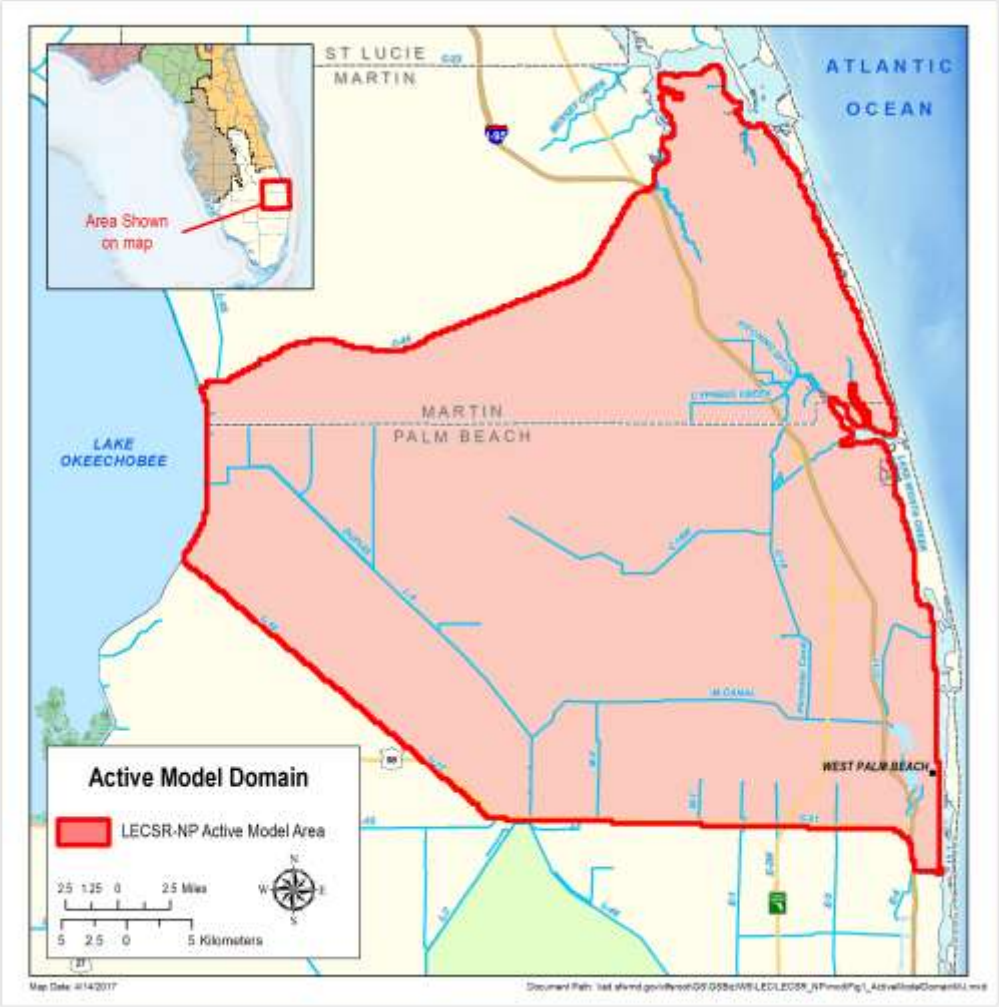
Results of Model Calibration and Verification Runs

South Florida Water Management District
December 13, 2017

Outline

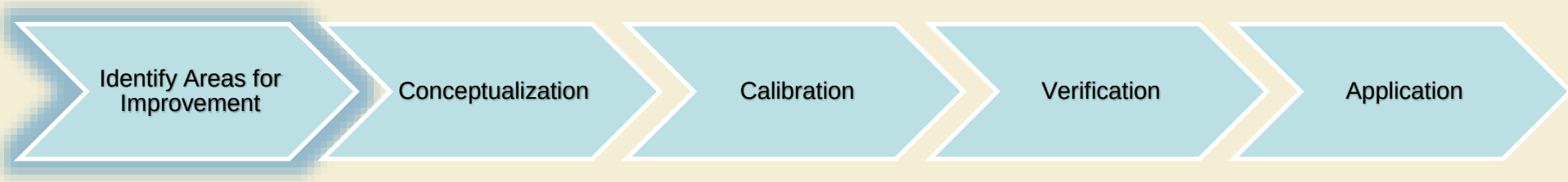
- Model Overview
- Process
- Next Steps

LECsR-NP Model



- Groundwater Model
- MODFLOW
- Model Grid Size – 704 ft by 704 ft
- 3 Layers
- Calibration Period from 2006 to 2014
- Verification Period from 2000 to 2005

Process


Identify Areas for Improvement
Conceptualization
Calibration
Verification
Application

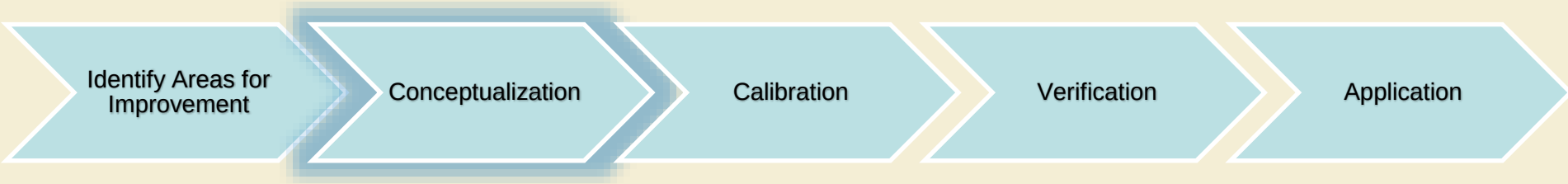
Areas for Improvement

- Structure Flow Statistics – primarily deviation of volume
- Post-processing of runoff in Flow Way 3
- Water levels in key areas such as Loxahatchee Slough and Grassy Waters Preserve
- Calibration points with limited data or that are controlled by a pre-determined stage
- Additional calibration locations were identified
- Updated topography and land use was available

Status

- Multiple agencies concur the model is reasonably calibrated and can be used to compare between alternatives and base conditions during the application phase for the purposes of identifying a Tentatively Selected Plan
  - Florida Department of Environmental Protection
  - Interagency Modeling Center
  - U.S. Army Corps of Engineers
  - South Florida Water Management District
- Model verification runs are complete and awaiting multi-agency team discussions and concurrence

Process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Conceptualization

- **Structure Flow Statistics – primarily deviation of volume**
  - **Solution: ET-Recharge-Runoff Program was updated**
- **Post-processing of runoff in Flow Way 3**
  - **Solution: Flow way 3 is conceptualized so that runoff is internal to the model**
- **Water levels in key areas such as Loxahatchee Slough and Grassy Waters Preserve**
  - **Solution: Calibration statistics improved**

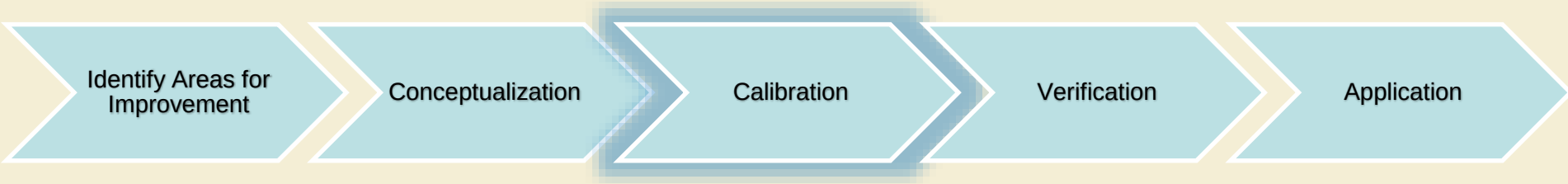
Conceptualization

- Calibration points with limited data or that are controlled by a pre-determined stage
  - Solution: Locations with limited data or with located on a river or general head boundary cell were sequestered
- Additional calibration locations were identified
  - Solution: Additional calibration locations were added to the calibration locations
- Updated topography and land use was available
  - Solution: Updated topography and land use for the model domain was used

Model Conceptualization – Packages Used

Package Name	Description
River (RIV)	Used to simulate rivers and canals that can contribute water or drain water from the groundwater aquifer. Head values are specified in the river package for each cell.
Drain (DRN)	Used to simulate the effects of existing drainage canals and ditches. Removes water from the model when the elevation is above the control elevation for the drain.
Reinjection Drainflow (RDF)	Similar to the Drain package except that it allows water to be redirected to another location in the model instead of being permanently removed from the model
Diversion (DIV)	Simulates the effects of water control structures (e.g., pumping stations, gravity flow drains, weirs) on water levels
Wetland (WTL)	Simulates overland flow in wetlands using the uppermost model layer and barriers to flow.

Process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Calibration

- Quantitative:
  - Structure Flows
  - Groundwater Monitoring Wells
  - Wetland Gages
- Qualitative:
  - WRAP Cells

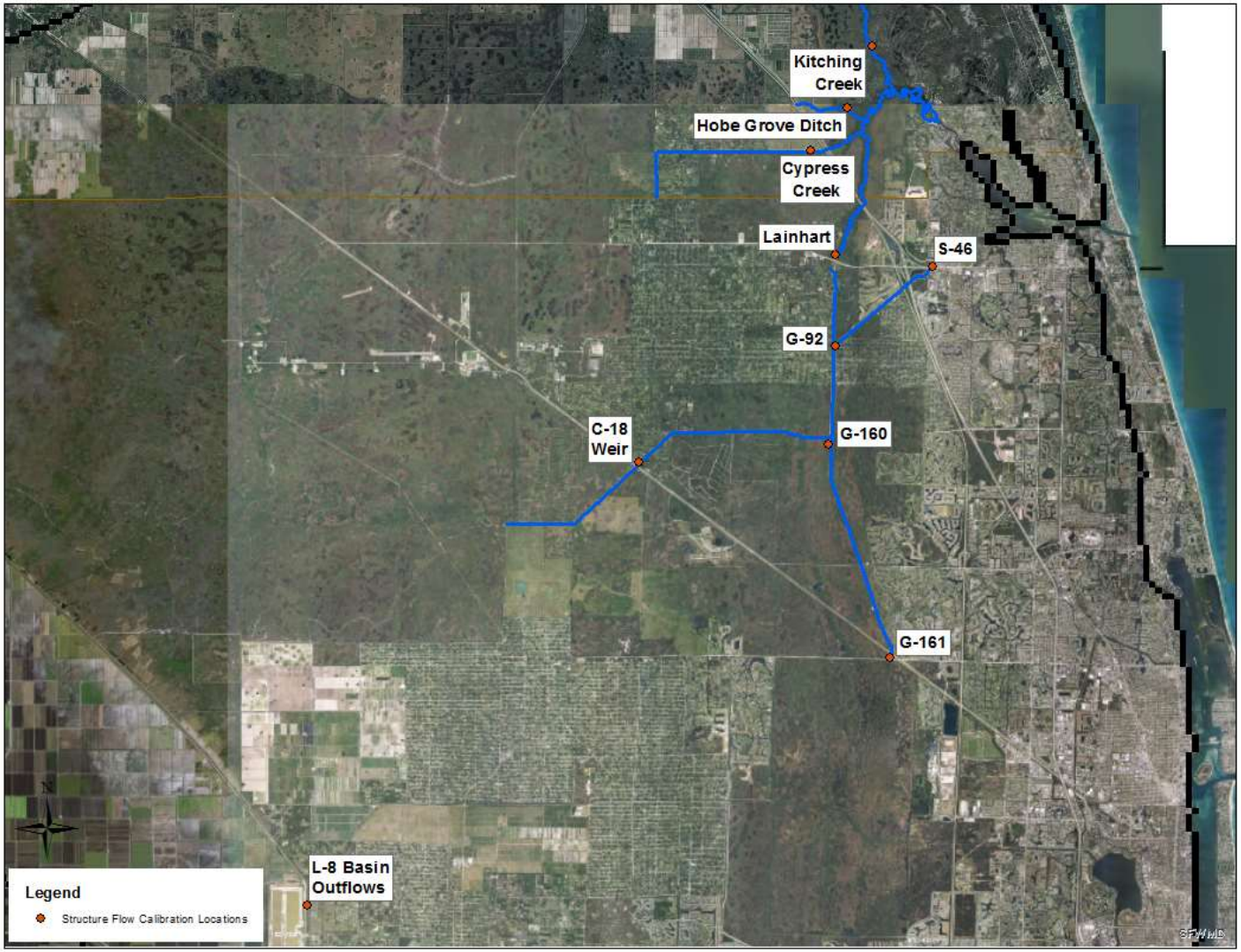
Structure Flow Calibration Criteria

Criteria	Description
Coefficient of Determination (R^2)	Coefficient of determination measures the goodness of fit. The target is an R^2 value greater than 0.4.
Nash-Sutcliffe (NS)	Nash-Sutcliffe is a model efficiency coefficient that indicates the predictive power of models. The target is an NS value greater than 0.4.
Deviation of Volume (DV%)	Deviation of volume measures the difference between historical and simulated flow volumes. Positive values indicate that the model is underpredicting, negative values indicate that the model is overpredicting. The target is a DV within plus/minus 15%.

Water Level Calibration Criteria

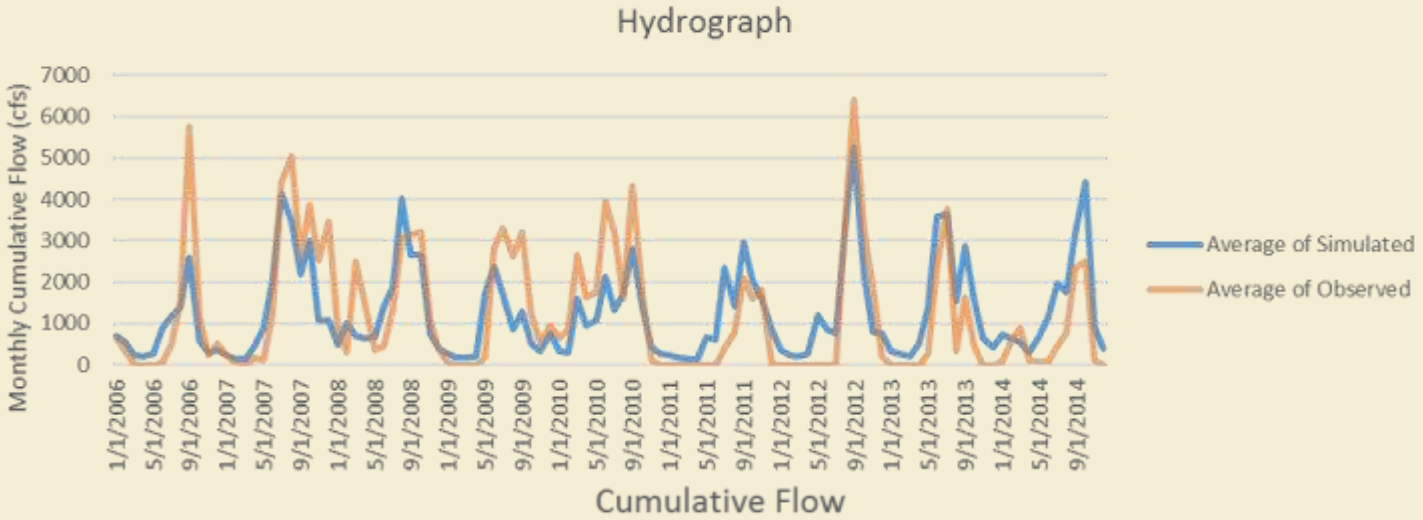
Criteria	Description
±Range Error Target (% of time target met)	Percentage of time that simulated head lies within a plus or minus range error target (feet) of the observed head. Each individual calibration location has its own criteria based on 20% of the absolute difference of minimum and maximum observed values during the calibration period.
Mean Error (feet)	The mean error is the mean difference between measured and simulated heads.
Mean Absolute Error (feet)	The mean absolute error is the mean of the absolute value of the differences in measured and simulated heads.
Root Mean Squared Error (feet)	The root mean squared error is the average of the root of the squared differences in measured and simulated heads.
Satisfy? Y/N	The criteria are met if the calibration location satisfies three out of four calibration targets with the revised criteria. Each location has its own criteria. The acceptance range error target for mean error, mean absolute error, and root mean squared error also are based on the 20% range of the absolute difference of minimum and maximum observed values.

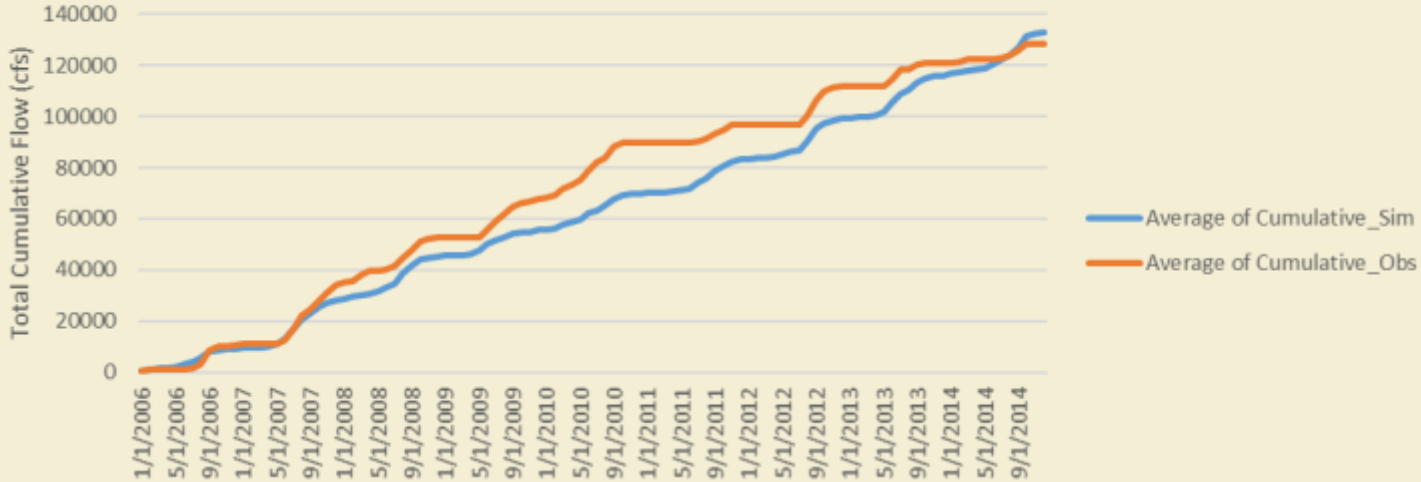
Structure Flow Calibration Locations



Structure Flow Statistics – C-18 Weir

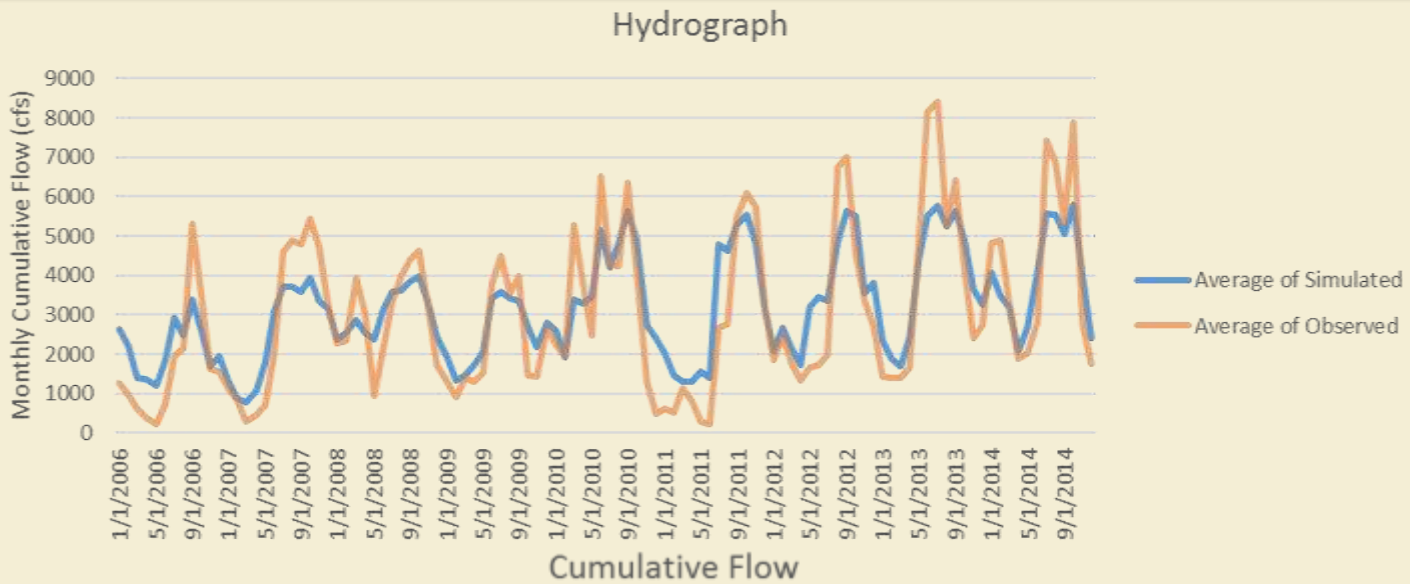
Criteria	Calibration
R^2	0.62
DV (%)	-3
NS	0.61

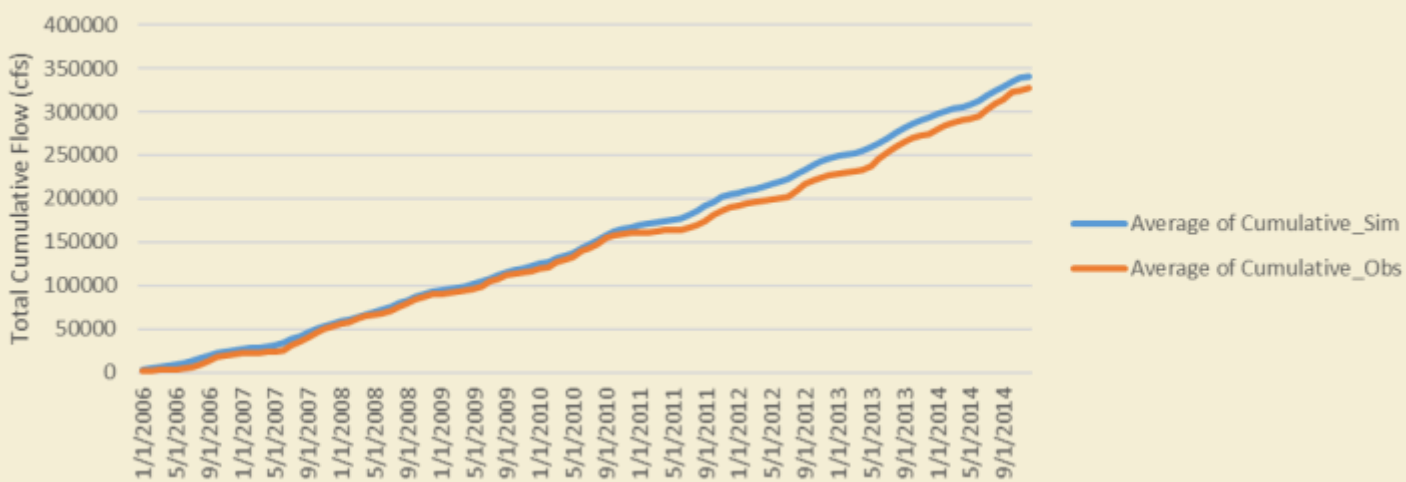




Structure Flow Statistics – Lainhart Dam

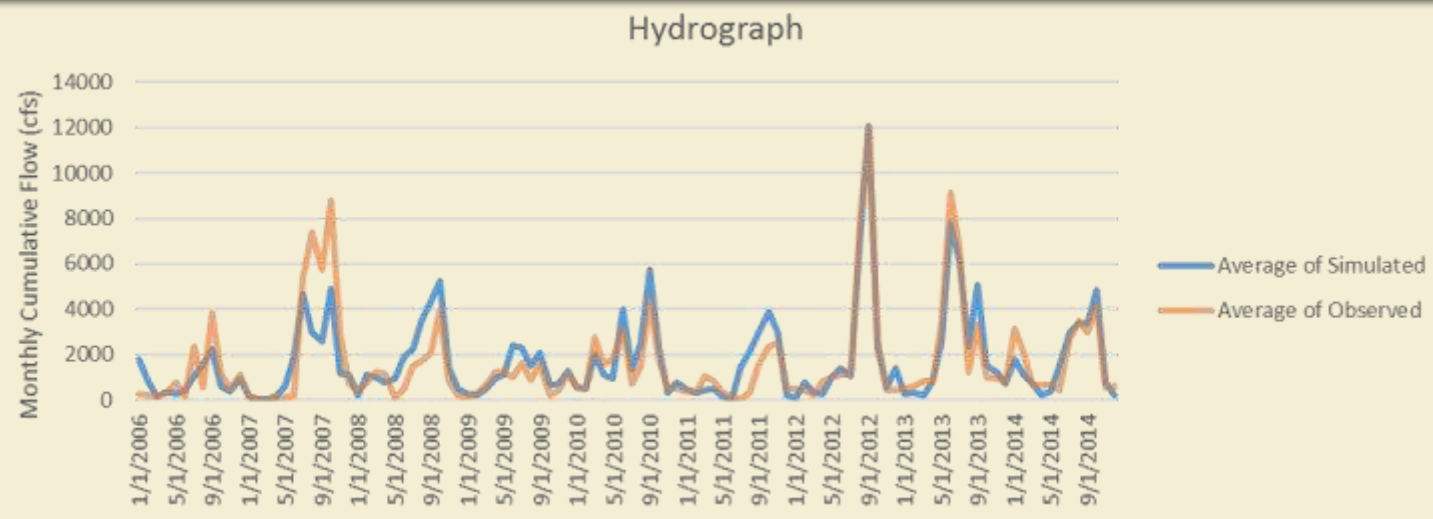
Criteria	Calibration
R^2	0.80
DV (%)	-4
NS	0.74

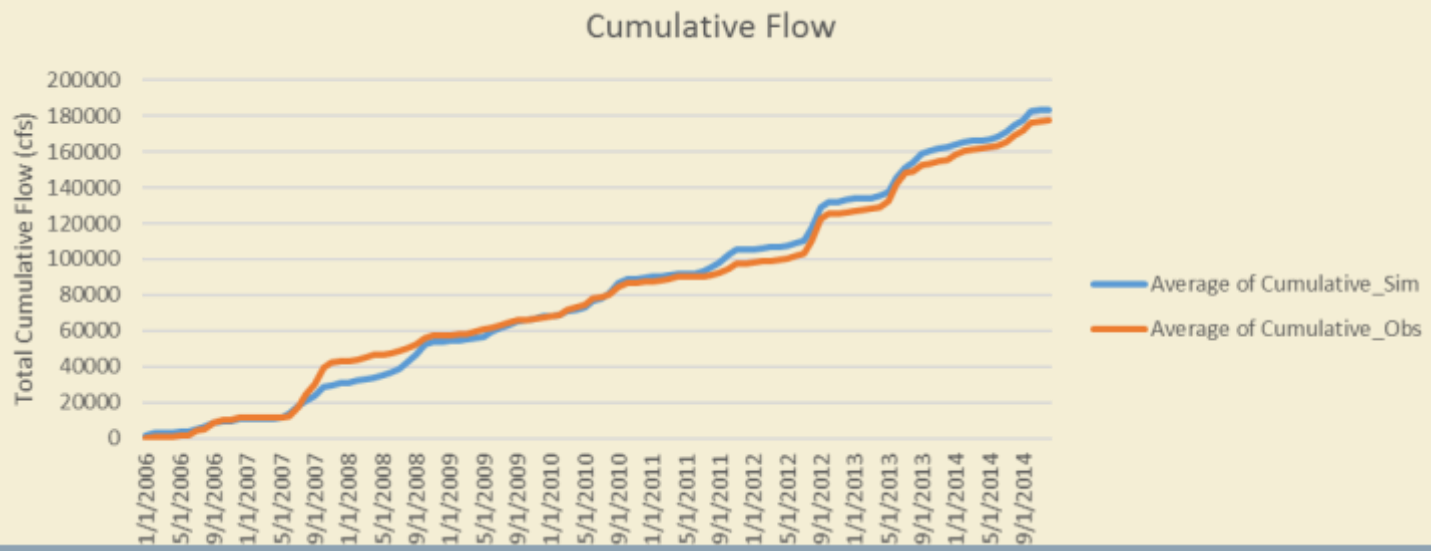




Structure Flow Statistics – G-160

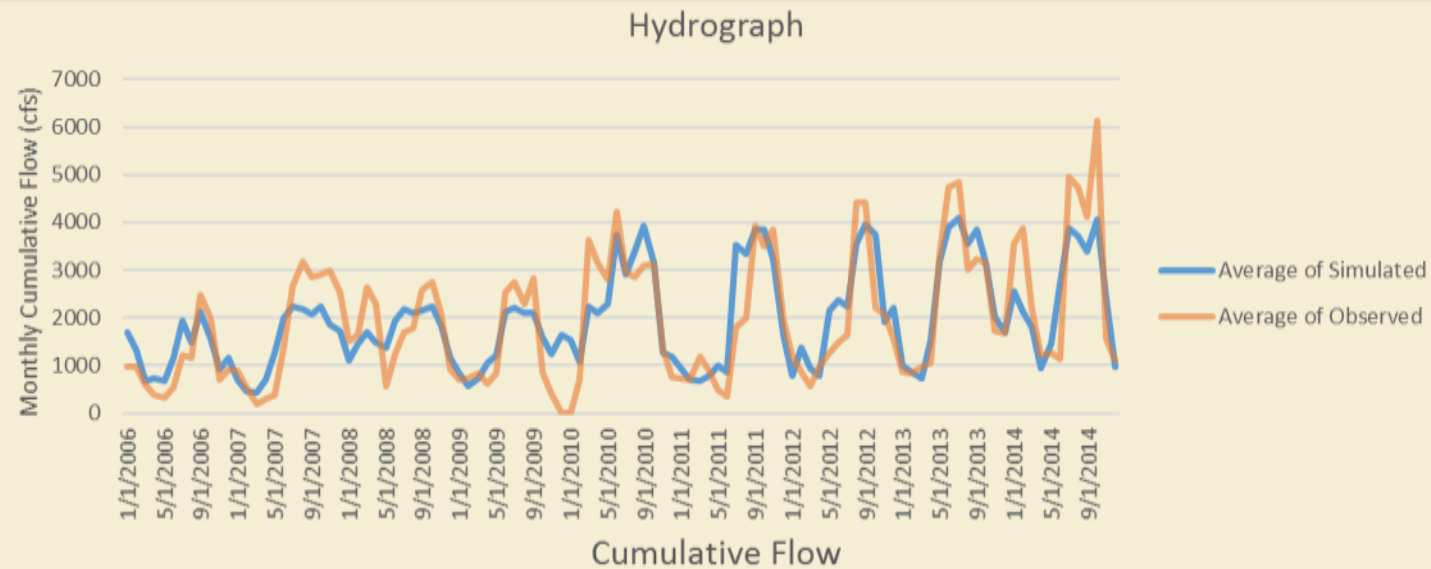
Criteria	Calibration
R^2	0.77
DV (%)	-4
NS	0.77

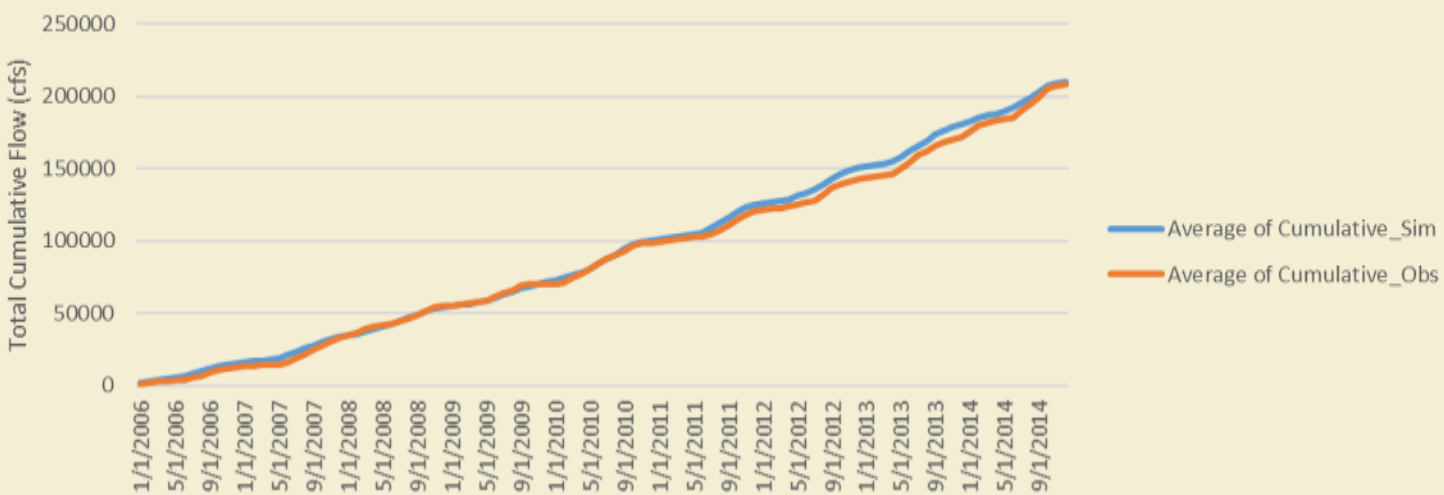




Structure Flow Statistics – G-92

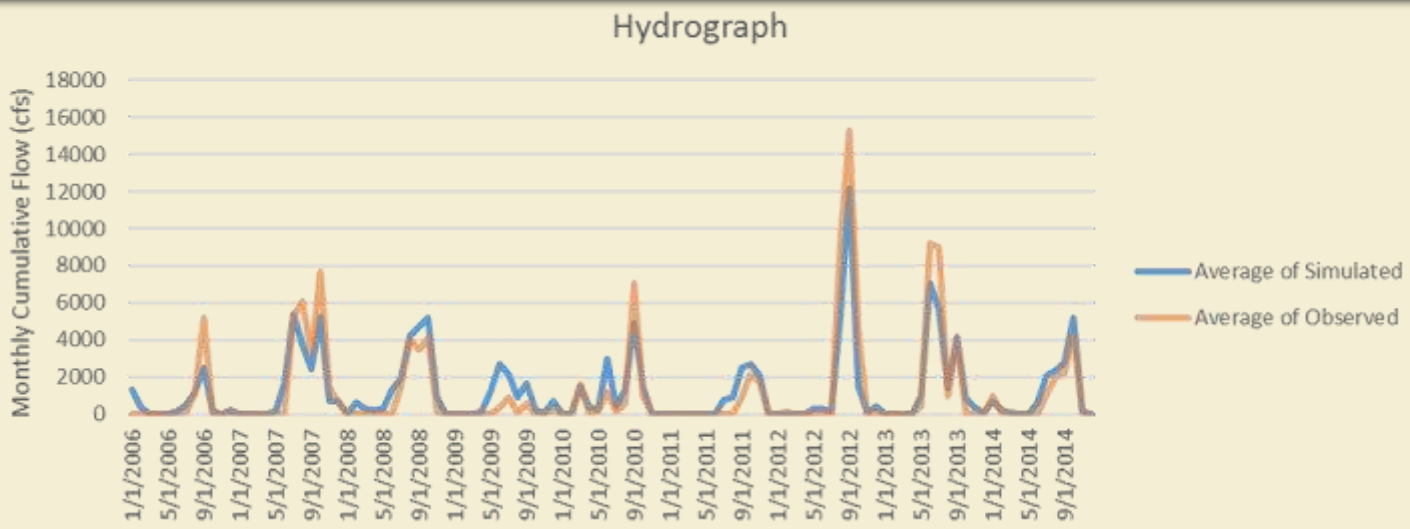
Criteria	Calibration
R^2	0.72
DV (%)	-1
NS	0.71

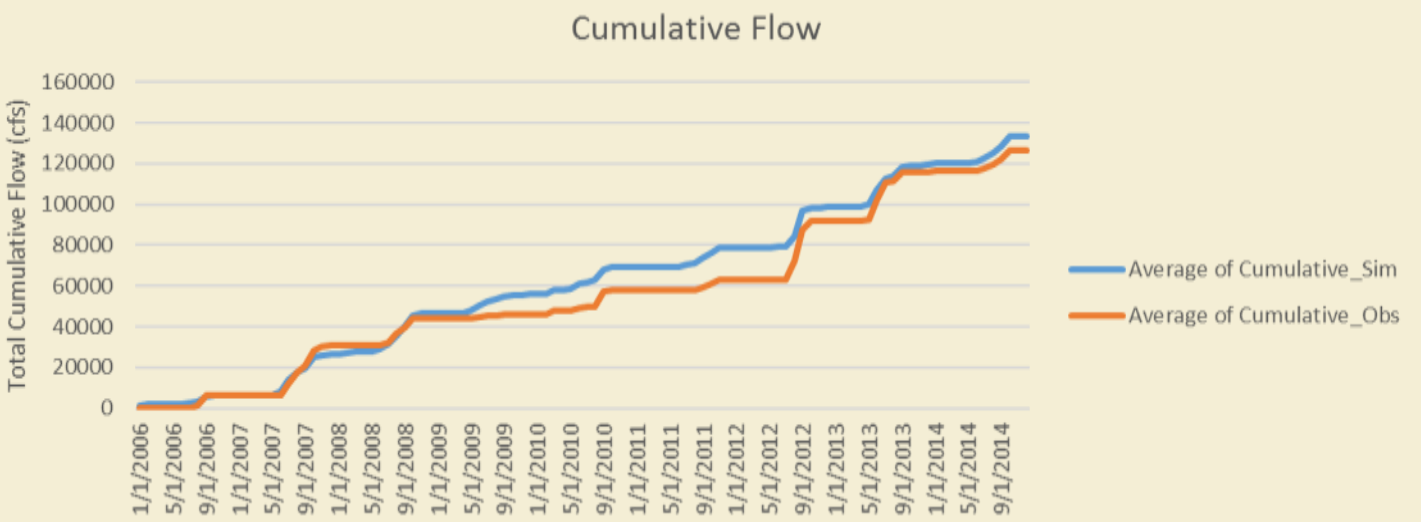




Structure Flow Statistics – S-46

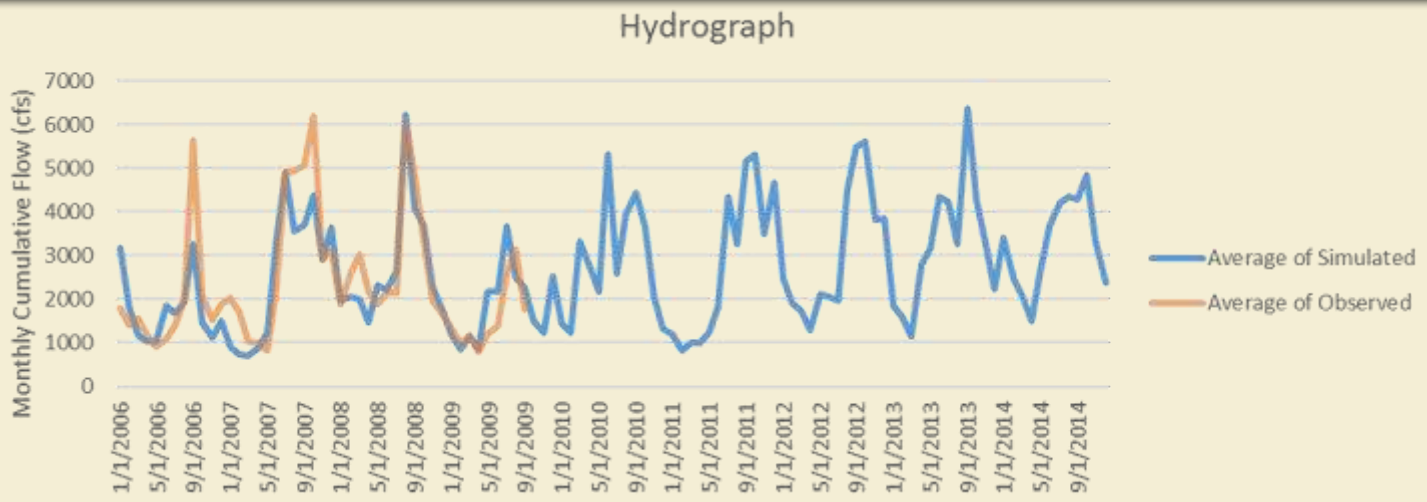
Criteria	Calibration
R^2	0.87
DV (%)	-6
NS	0.84

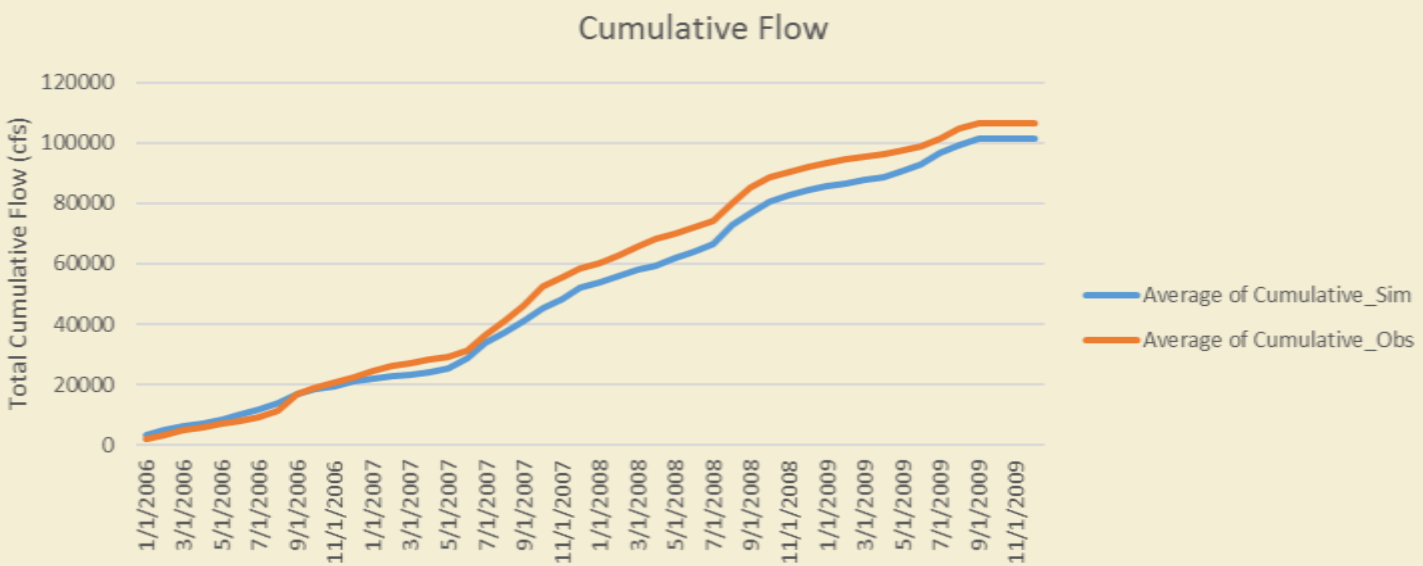




Structure Flow Statistics – Cypress Creek and Hobe Grove Ditch

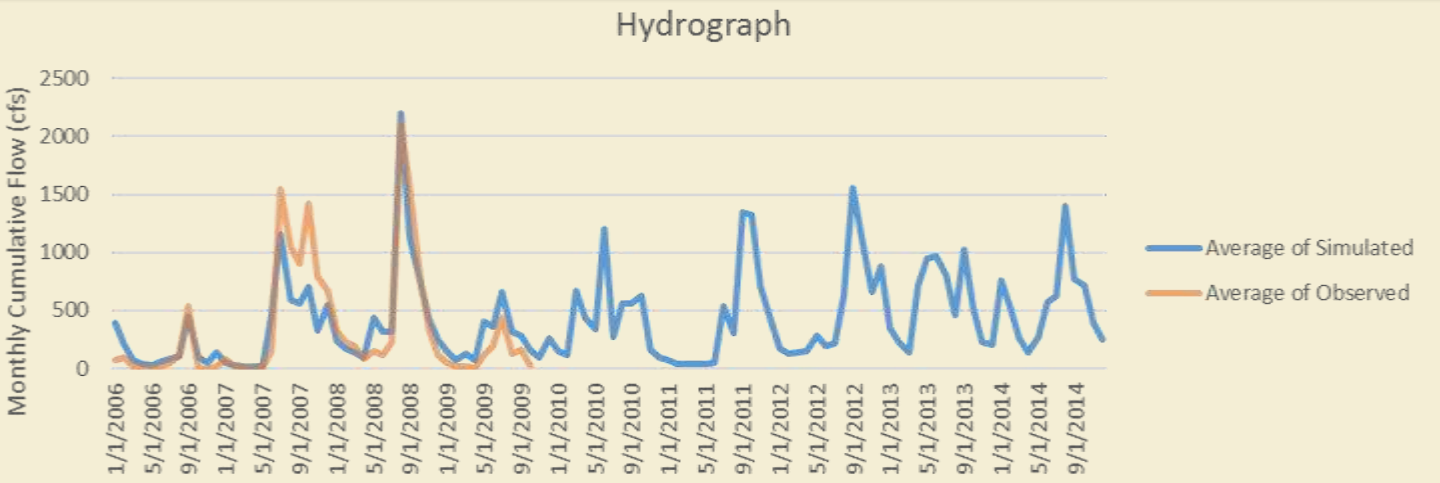
Criteria	Calibration
R^2	0.72
DV (%)	5
NS	0.72

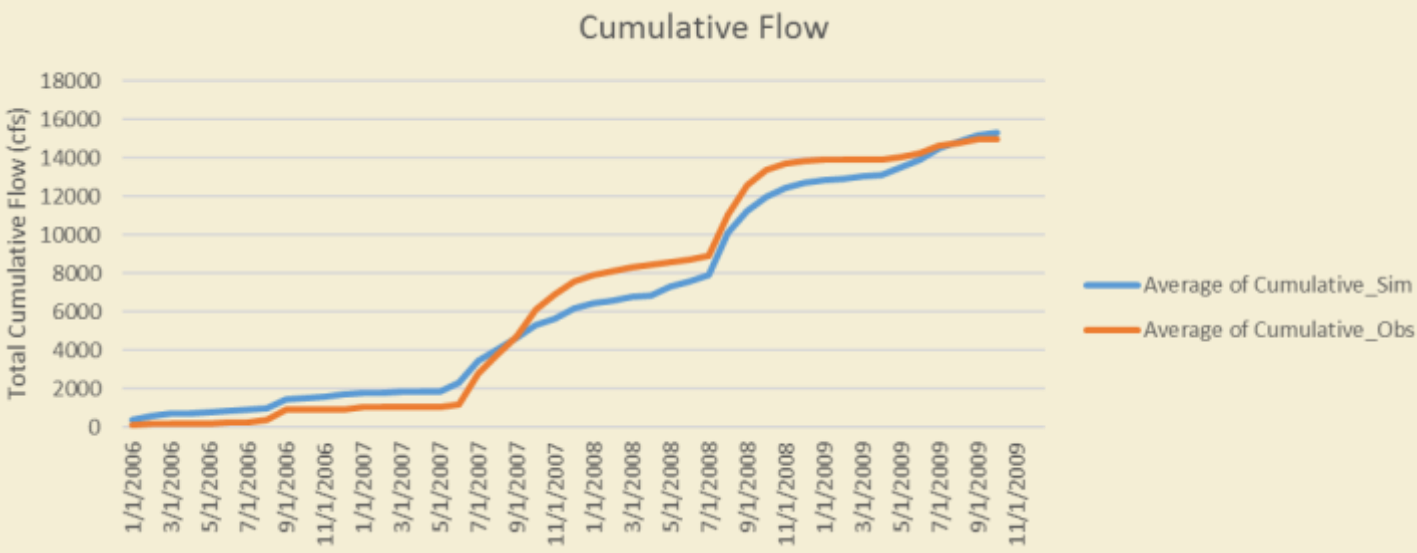




Structure Flow Statistics – Kitching Creek

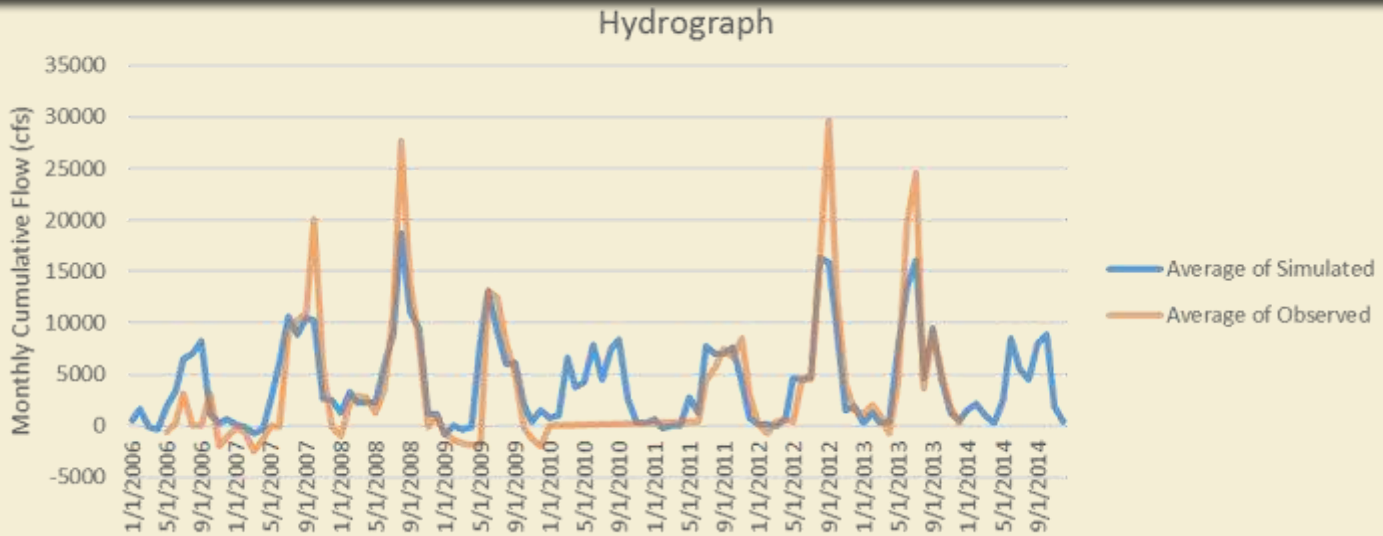
Criteria	Calibration
R^2	0.82
DV (%)	-2
NS	0.81

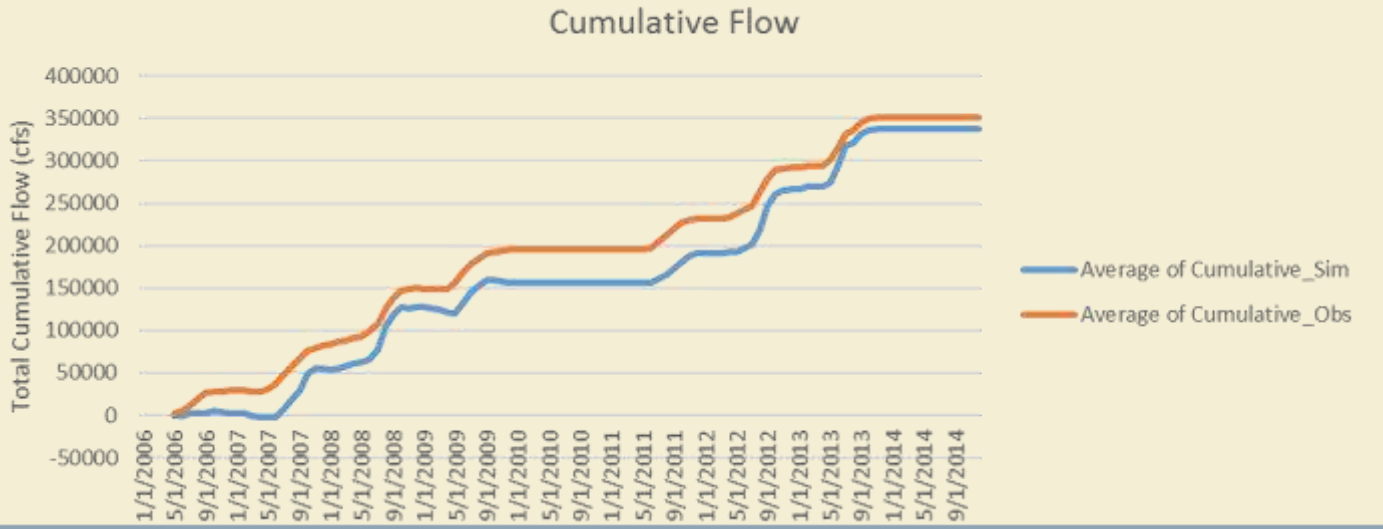




Structure Flow Statistics – L-8 Outflows

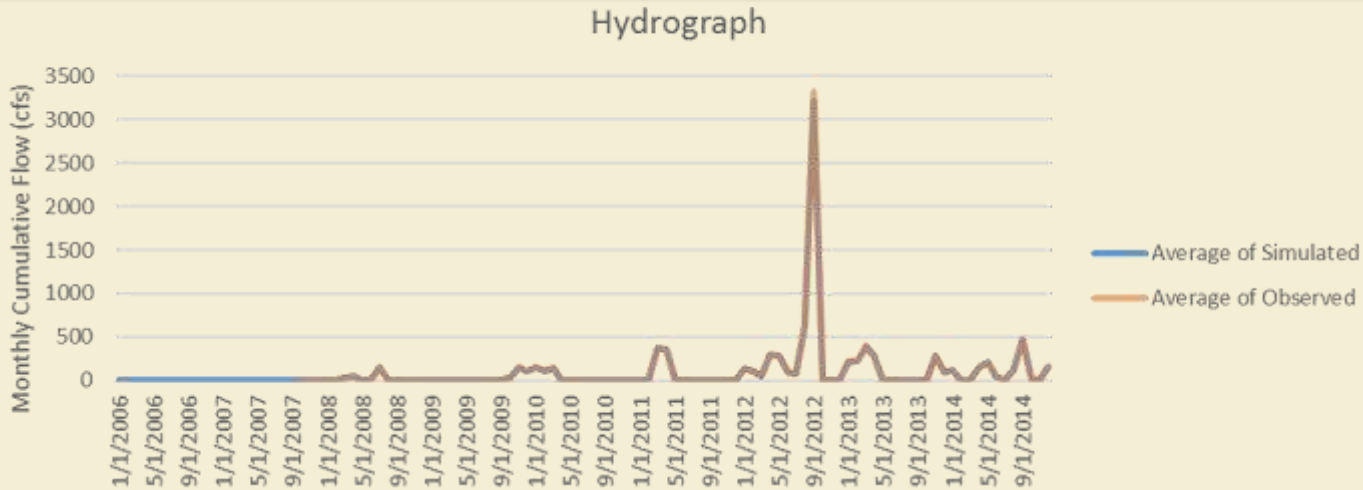
Criteria	Calibration
R^2	0.78
DV (%)	-4
NS	0.73

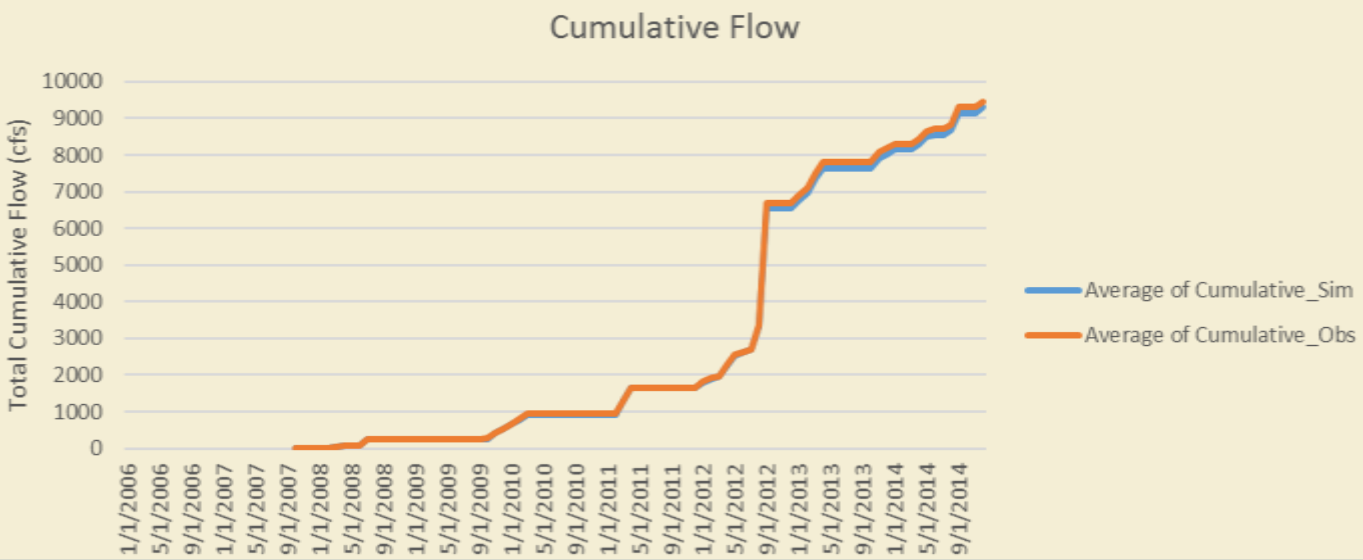




Structure Flow Statistics – G-161

Criteria	Calibration
R^2	1.00
DV (%)	2
NS	1.00





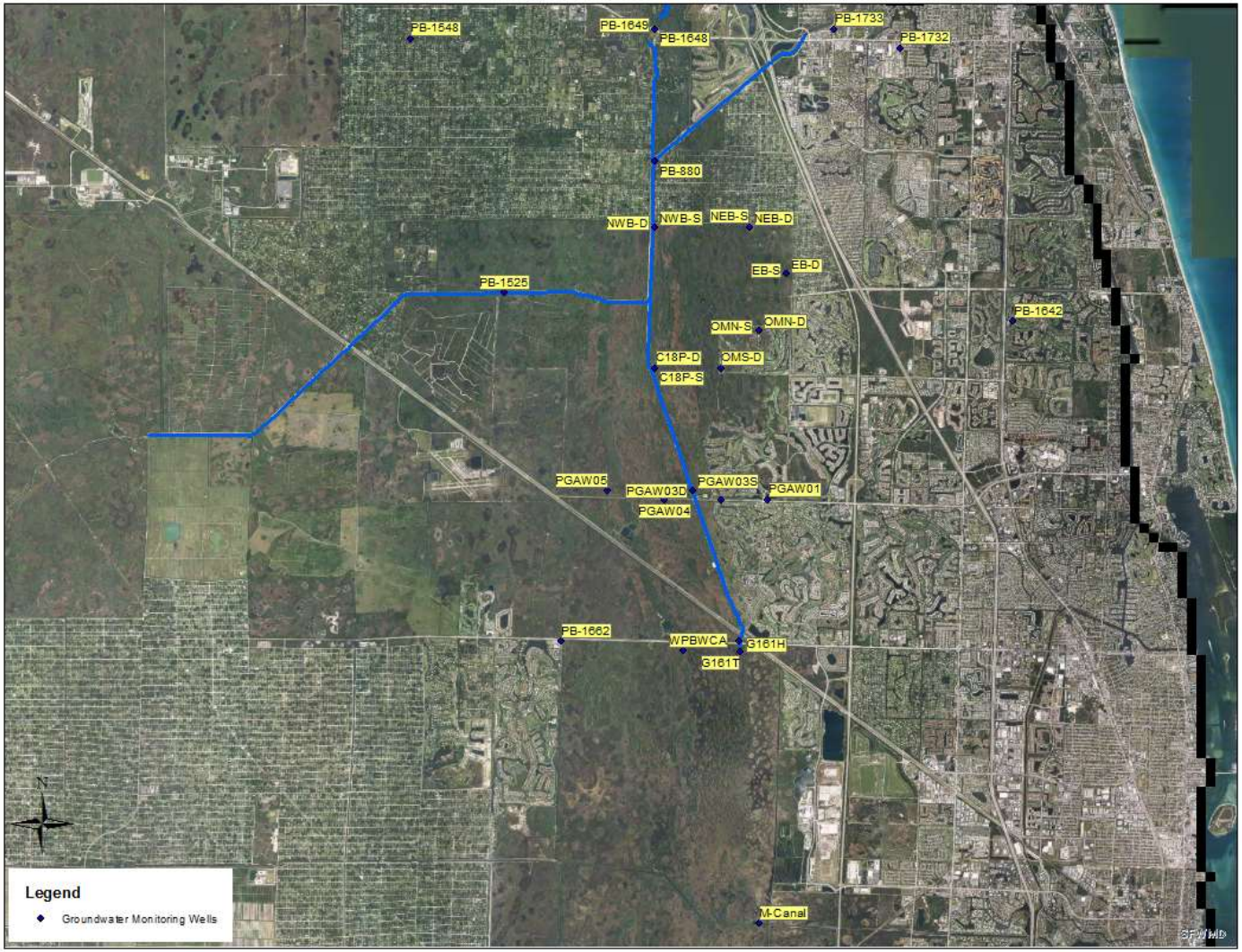
*G-161 flows are prescribed

Structure Flow Calibration

	C-18/C-14 Watersheds						Tributaries to Lox River		L-8 Basin
	C-18W Weir	G-161*	G-160	S-46	G-92	Lainhart	Cypress Creek and Hobe Grove	Kitching Creek	Outflow
Number of months	108	87	108	108	108	108	45	46	76
R^2	0.62	1.00	0.77	0.87	0.72	0.80	0.72	0.82	0.78
NS	0.61	1.00	0.77	0.84	0.71	0.74	0.72	0.81	0.73
DV (%)	-3	2	-4	-6	-1	-4	5	-2	-4

*G-161 flows are prescribed

Groundwater Well Calibration Locations

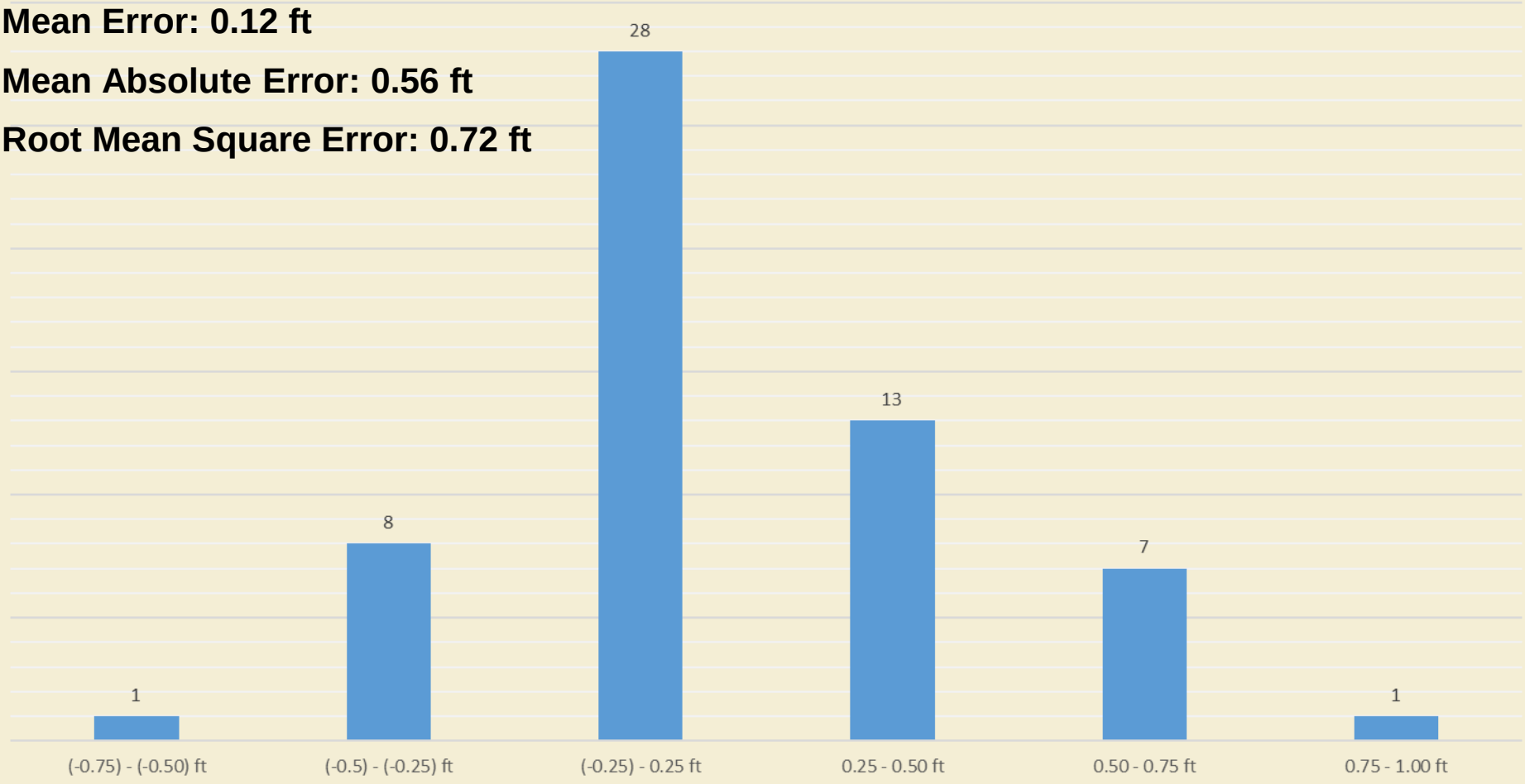


Groundwater Well Calibration

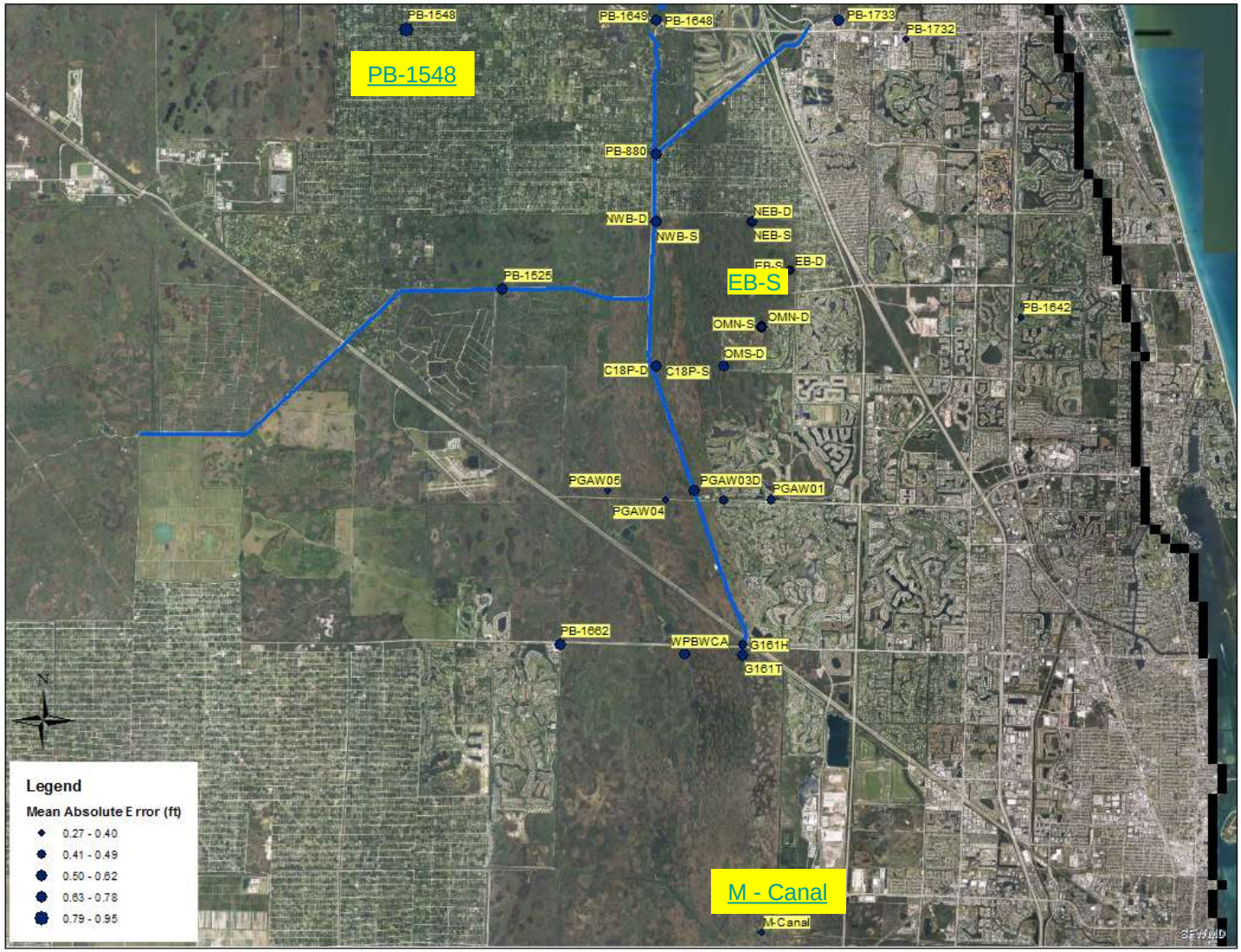
Mean Error: 0.12 ft

Mean Absolute Error: 0.56 ft

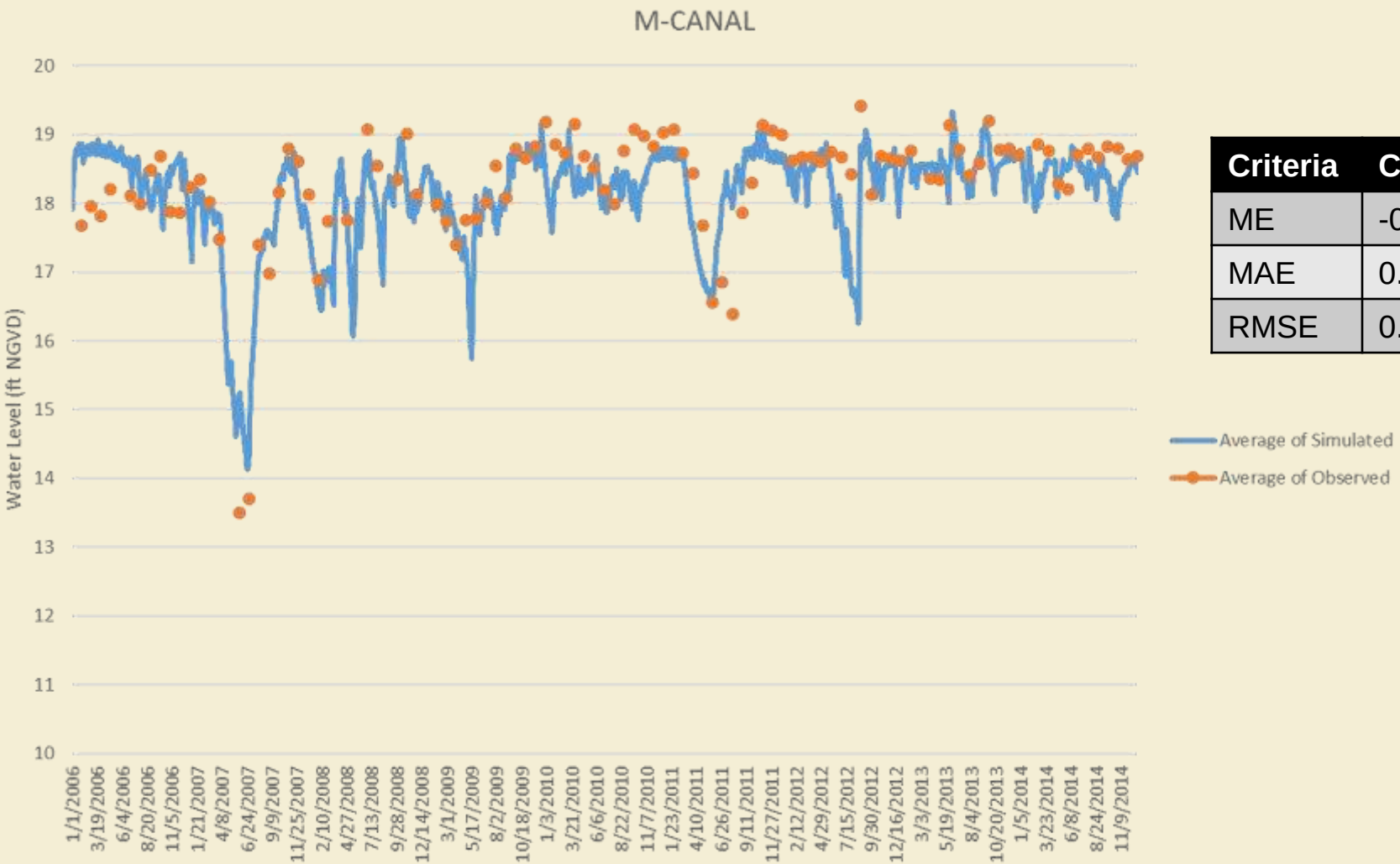
Root Mean Square Error: 0.72 ft



Groundwater Well Mean Absolute Error



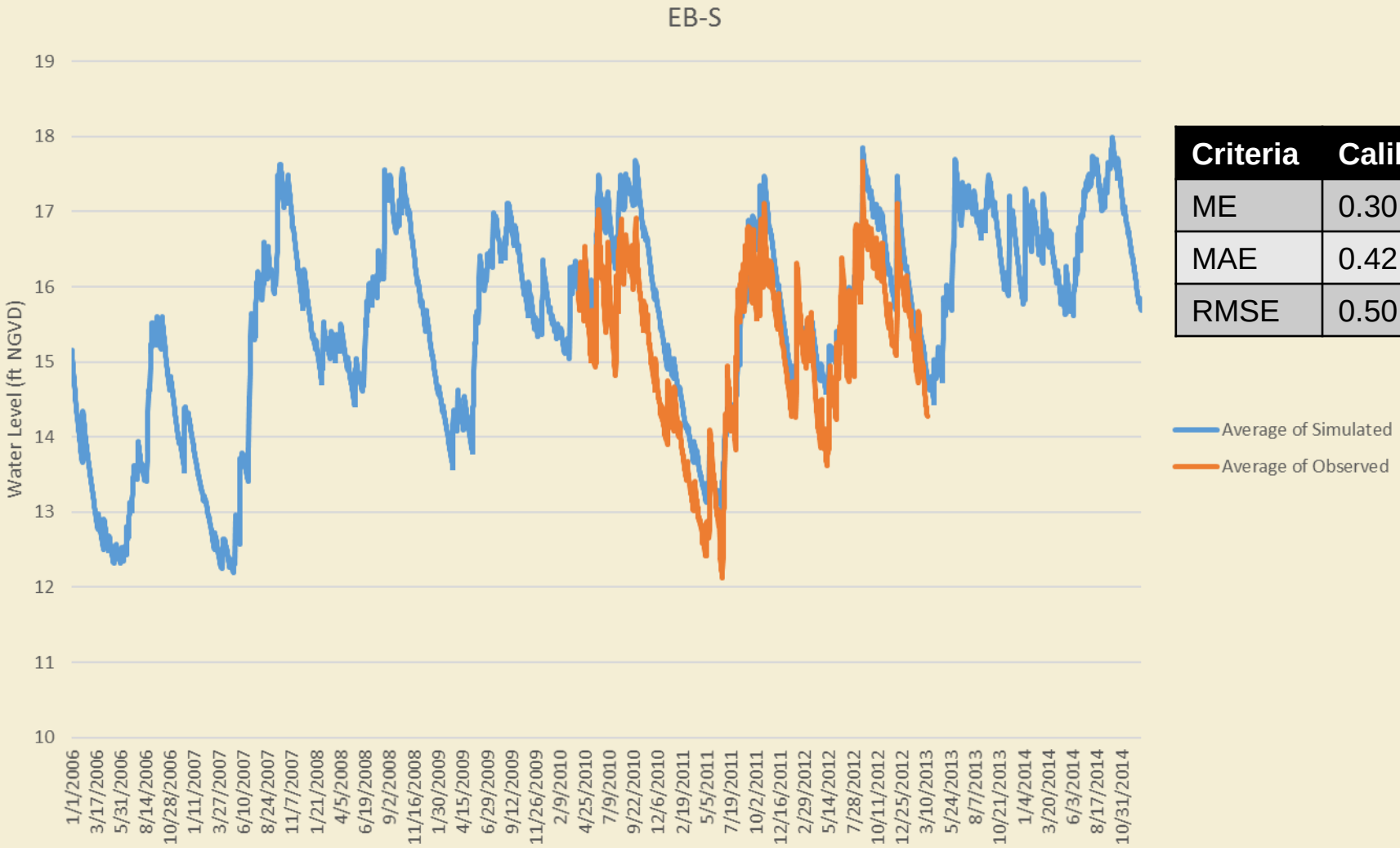
M-Canal



Criteria	Calibration
ME	-0.08
MAE	0.39
RMSE	0.51

map

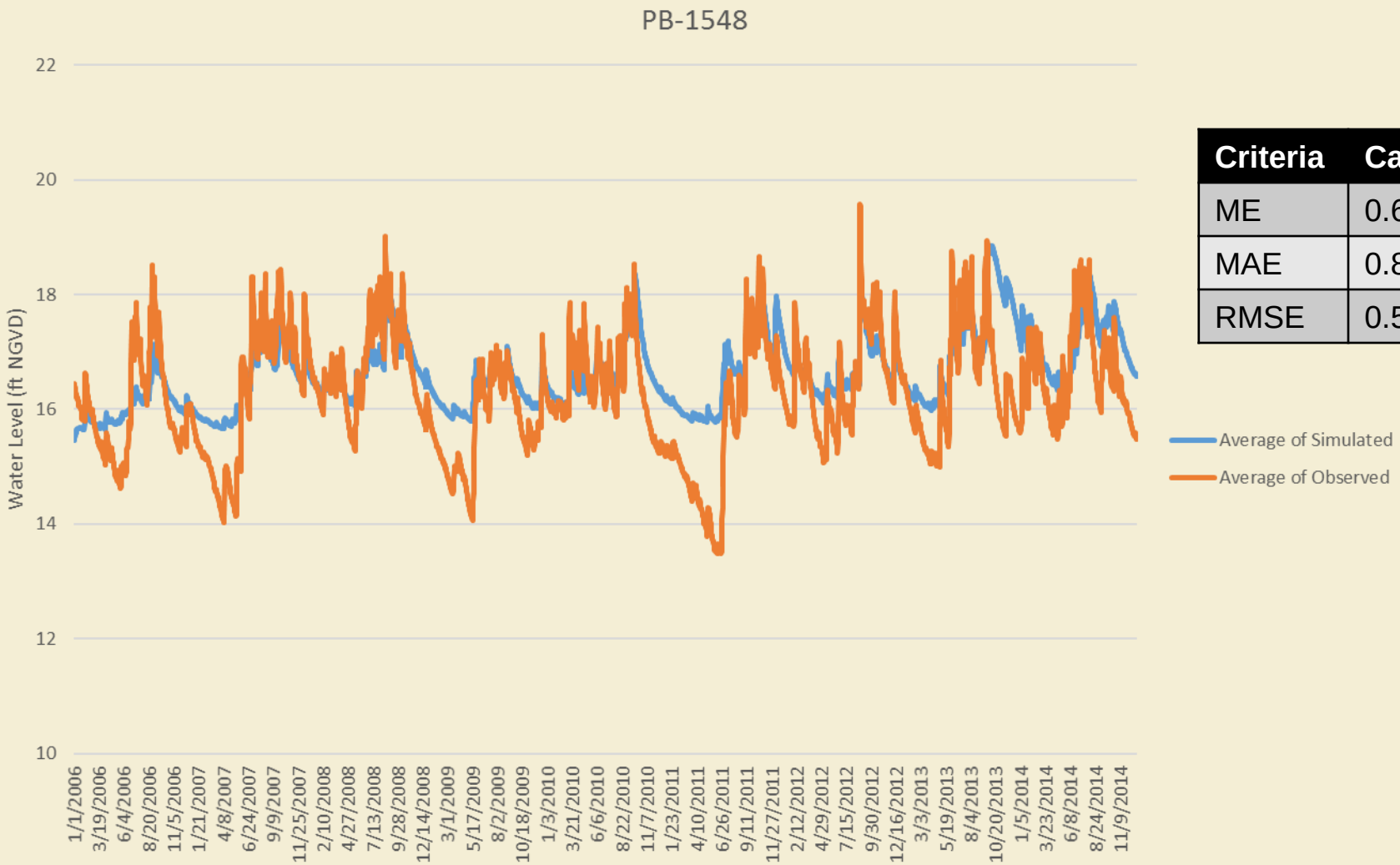
Loxahatchee Slough



Criteria	Calibration
ME	0.30
MAE	0.42
RMSE	0.50

map

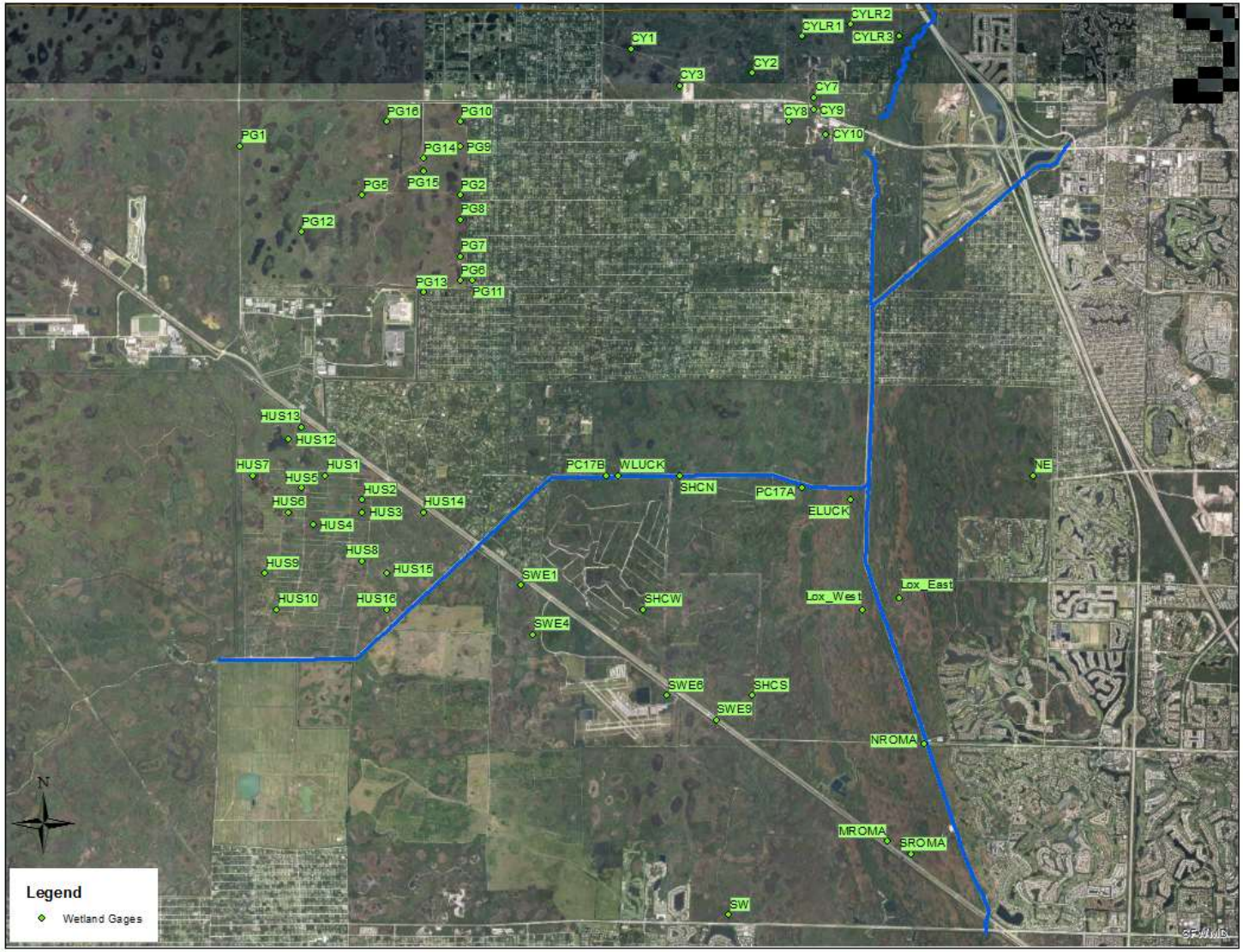
Jupiter Farms



Criteria	Calibration
ME	0.63
MAE	0.86
RMSE	0.56

map

Wetland Gage Calibration Locations

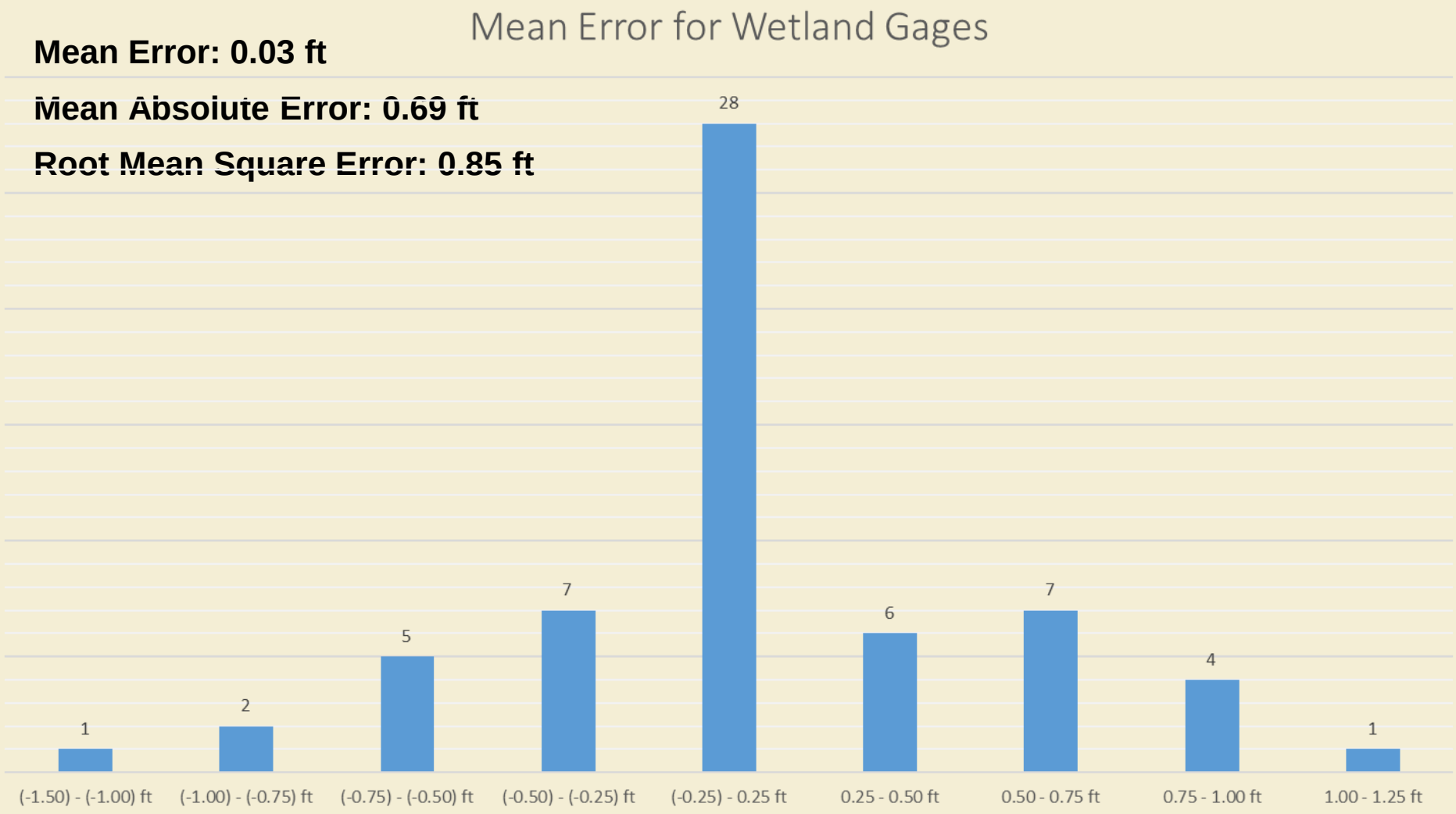


Wetland Water Level Calibration

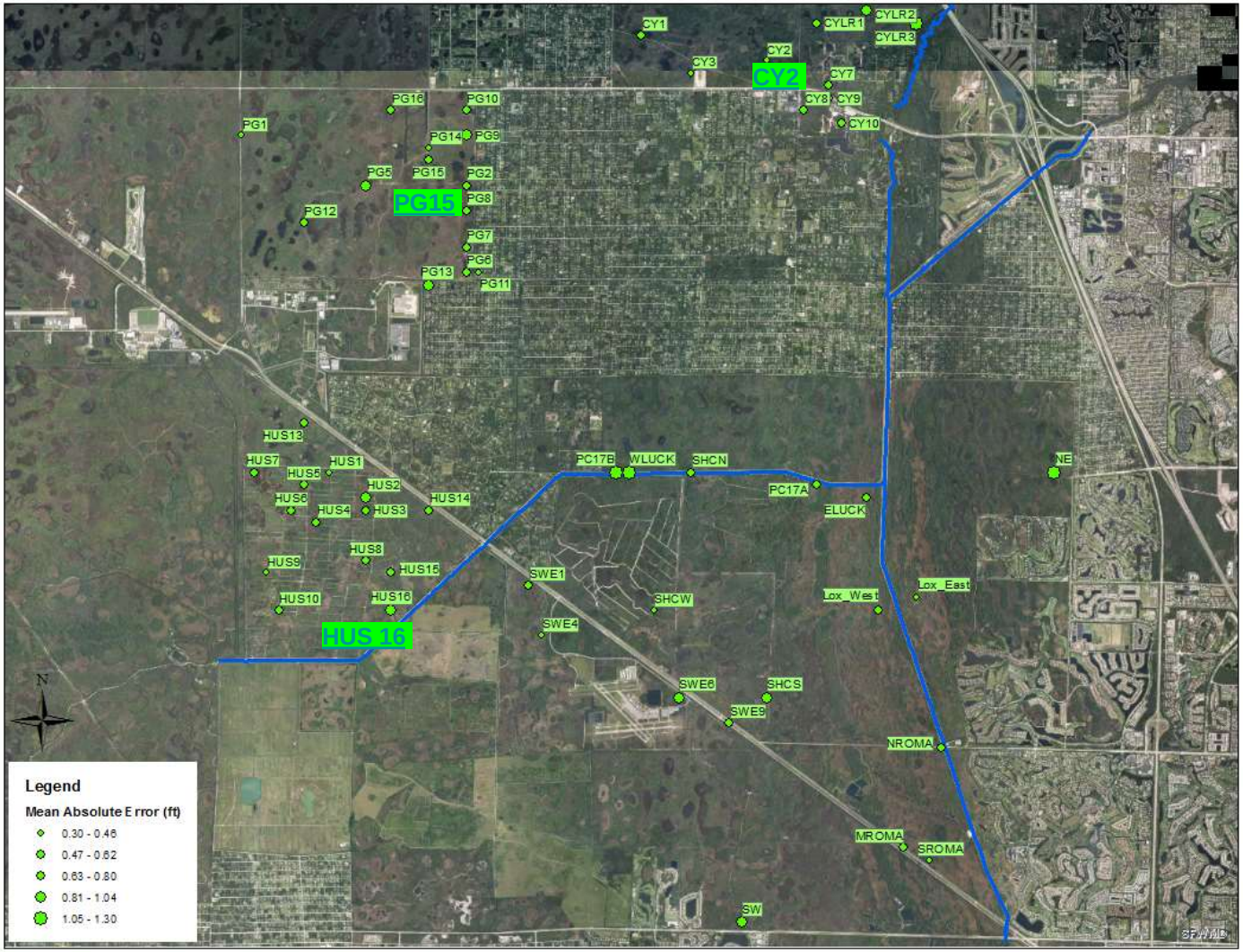
Mean Error: 0.03 ft

Mean Absolute Error: 0.69 ft

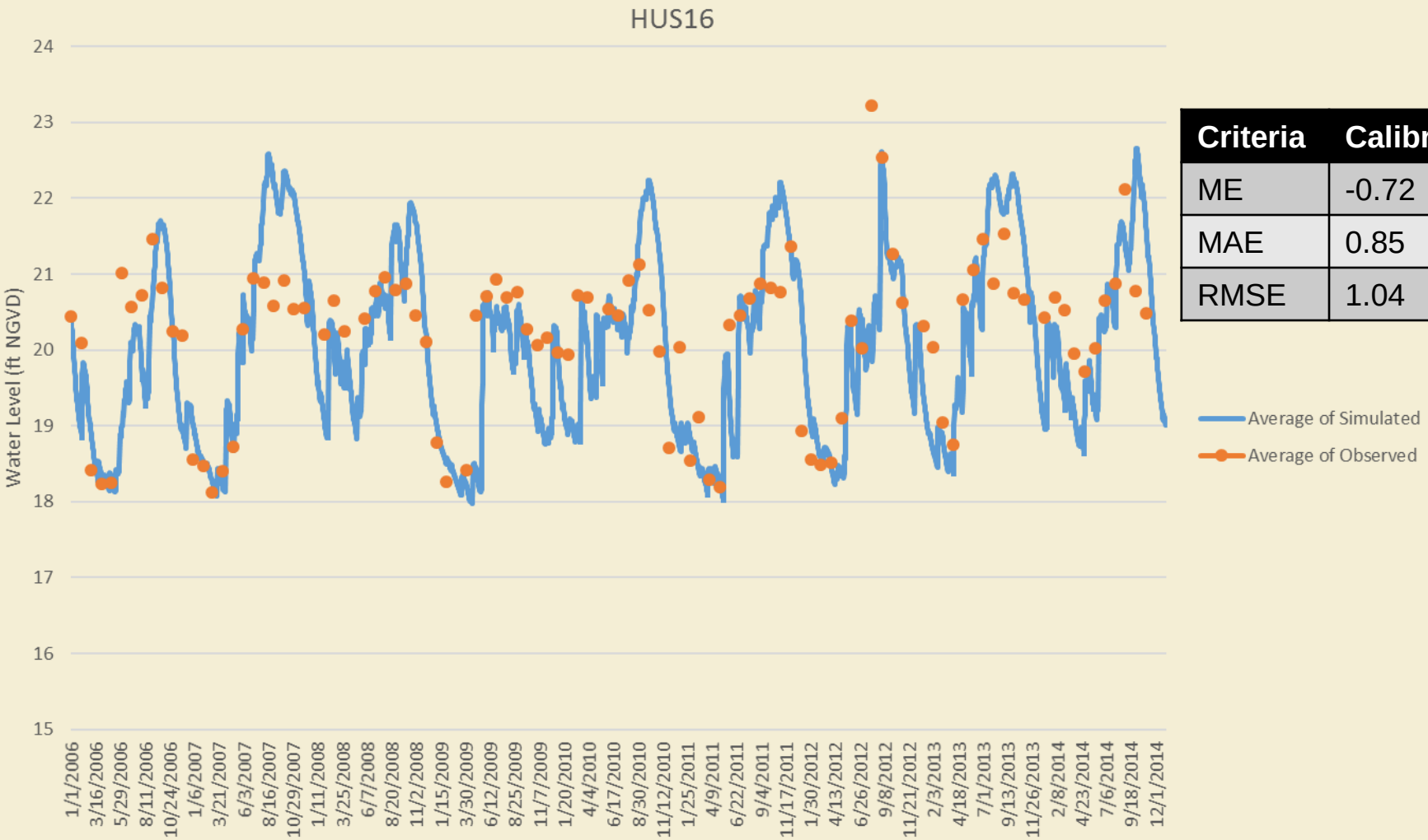
Root Mean Square Error: 0.85 ft



Wetland Mean Absolute Error Map



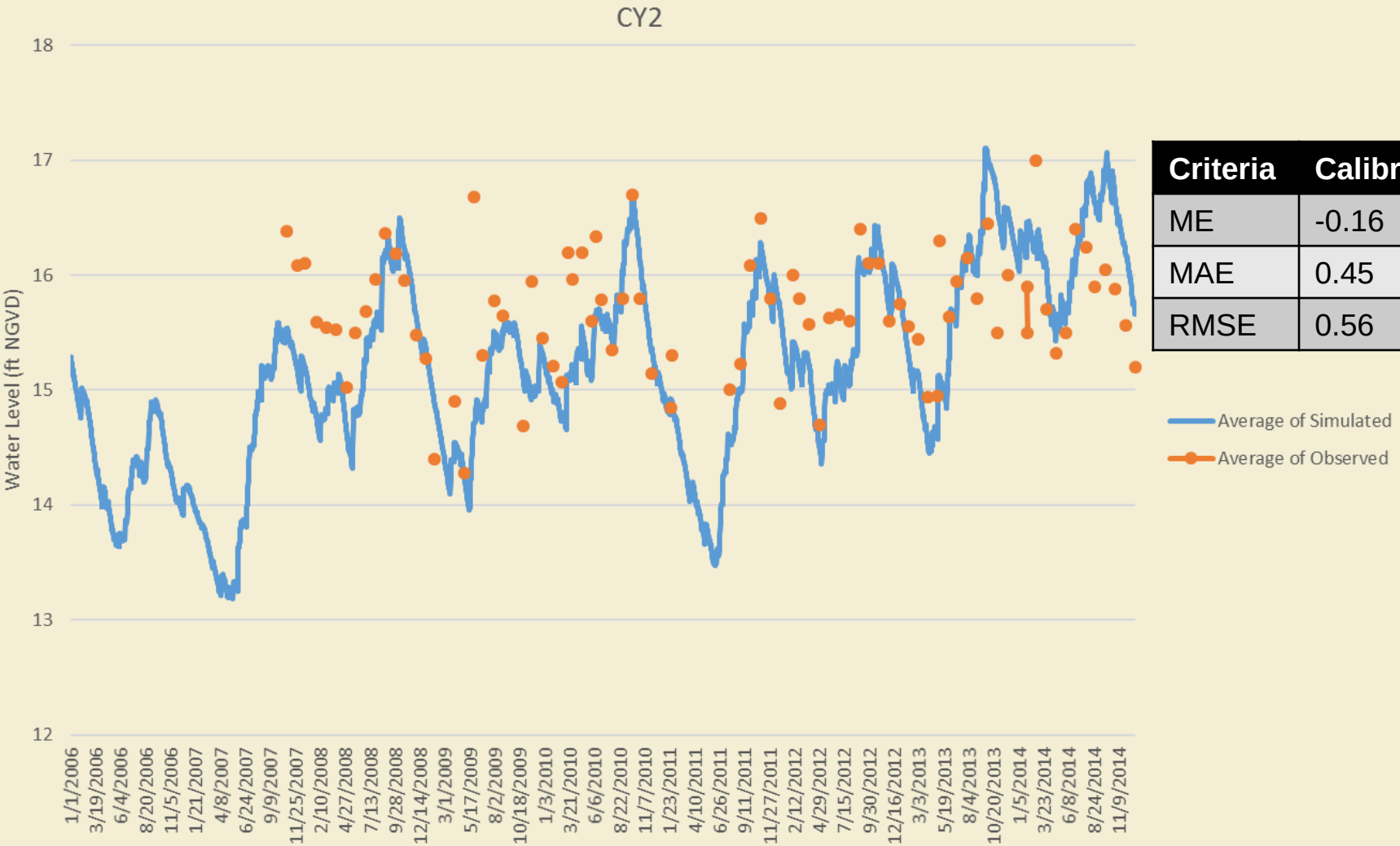
Hungryland Slough



Criteria	Calibration
ME	-0.72
MAE	0.85
RMSE	1.04

map

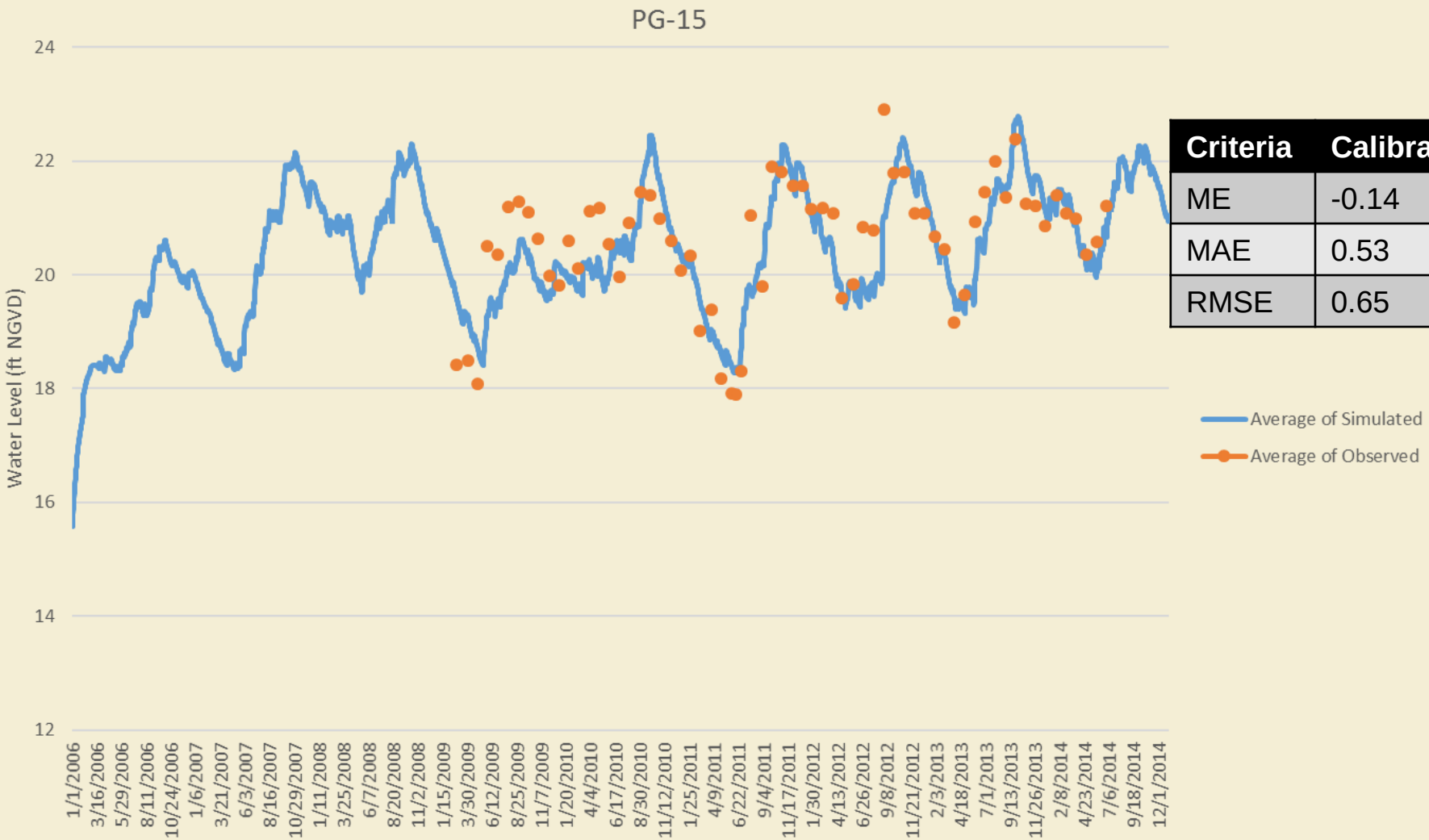
Cypress



Criteria	Calibration
ME	-0.16
MAE	0.45
RMSE	0.56

map

Pine Glades



Criteria	Calibration
ME	-0.14
MAE	0.53
RMSE	0.65

map

Water Level Stage Statistics

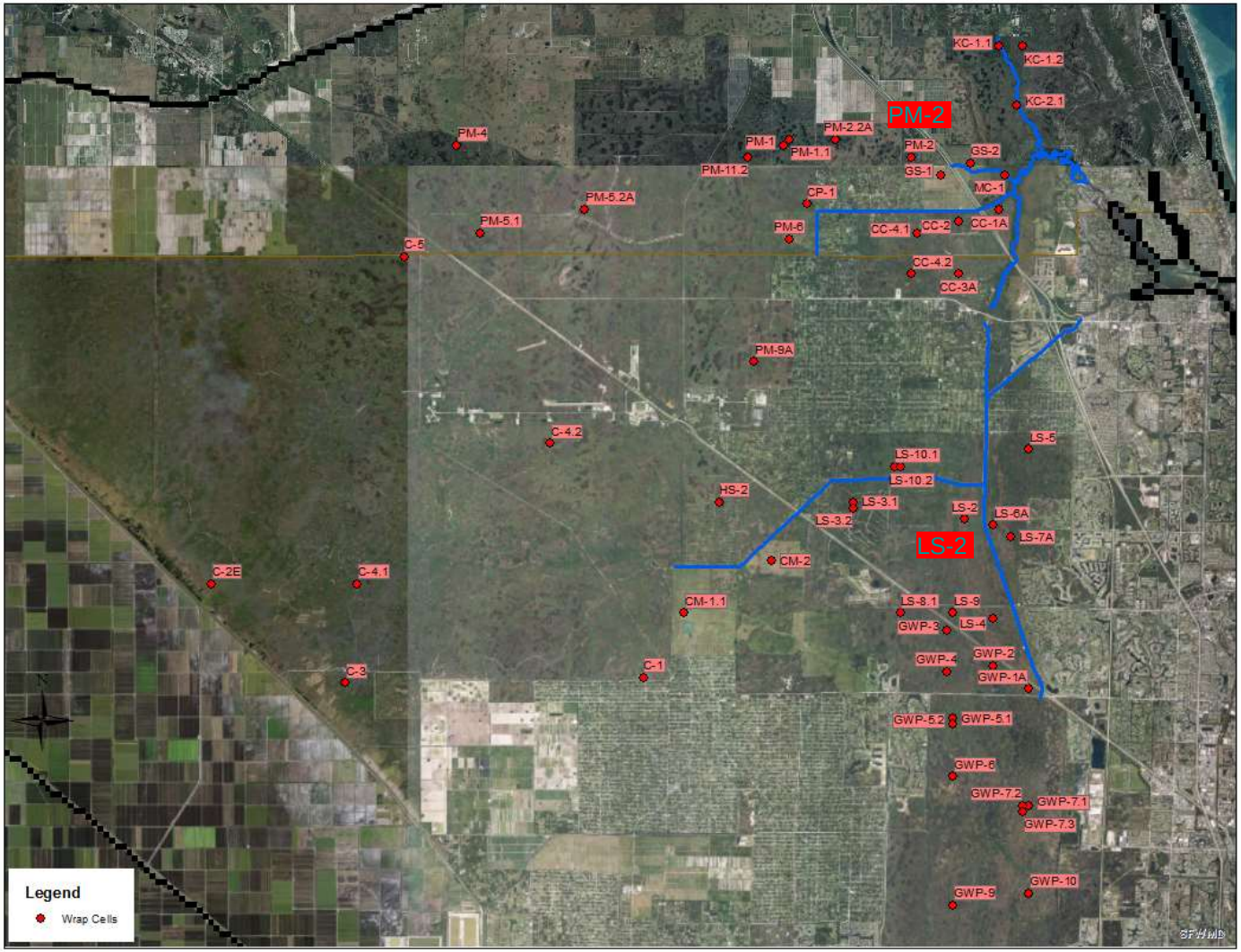
Overall Mean Absolute Error (feet)	Calibration
Groundwater Monitor Wells	0.56
Wetland Gages	0.69

Statistics do not include calibration locations that have been sequestered
Decreasing values indicate less error and a better calibrated model

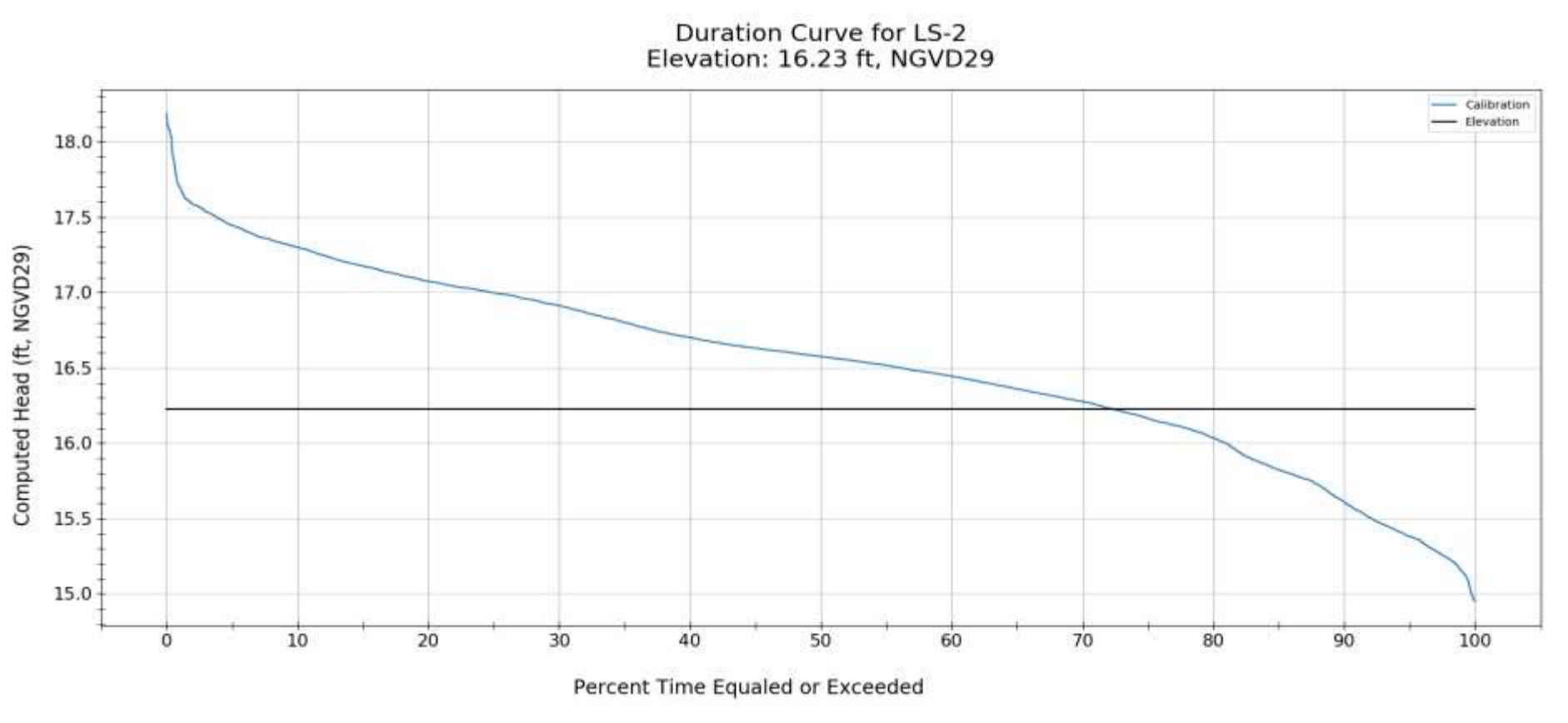
Wetland Rapid Assessment Procedure (WRAP) Cells

- Field assessments were conducted to determine existing wetland hydrology and condition for each indicator region
- Model cells were identified to be representative of each indicator regions
- Topographic information is used by the model to determine inundation
- Performance Measure 4 documents how the WRAP process and modeled hydrologic output will be used to evaluate project performance
- Hydrographs and Stage Duration Curves are used to assess inundation and determine benefits
- Hydrographs and Stage Duration Curves were developed for the calibration
- Ecological Subteam met to review hydrographs and stage duration curves and concluded that the WRAP cells are performing as expected during the calibration

WRAP Cell locations

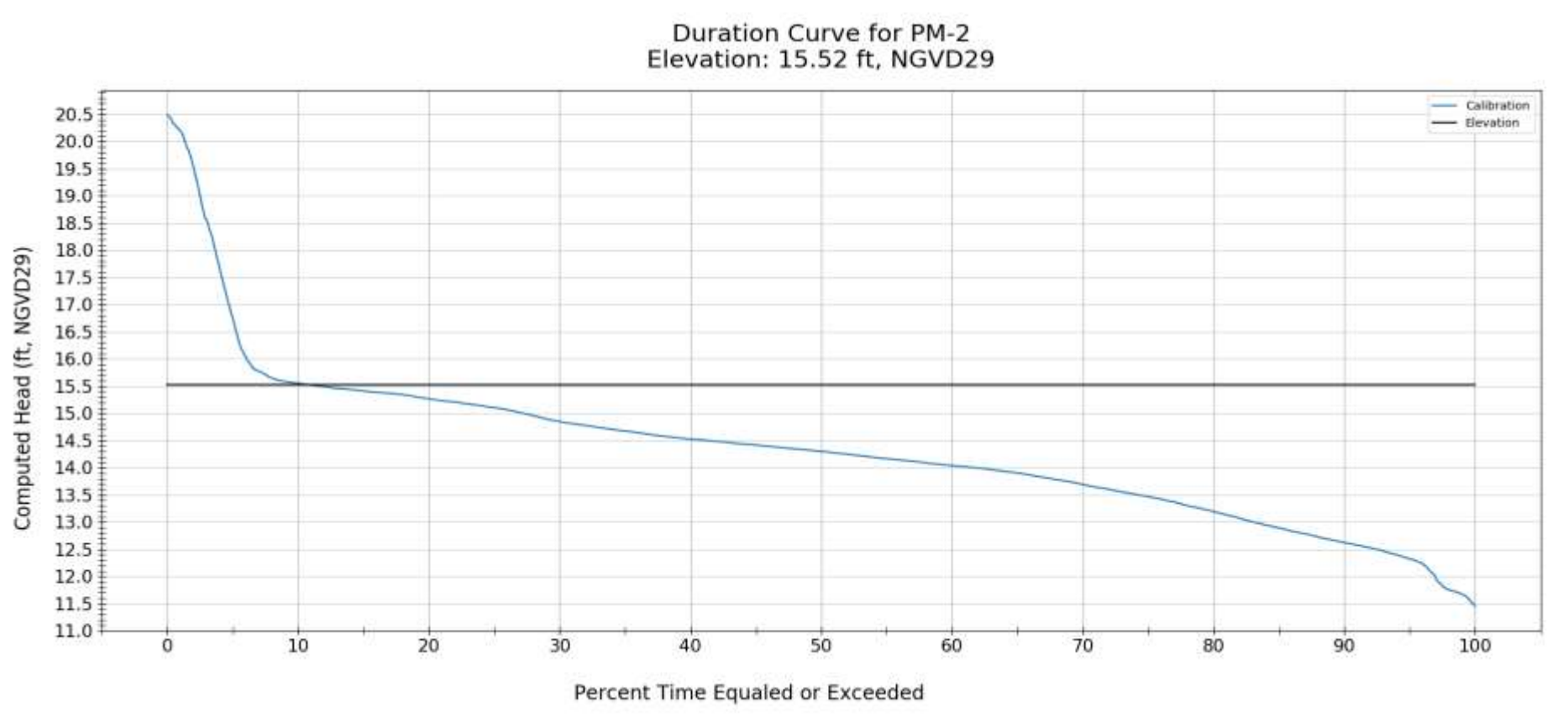


Loxahatchee Slough



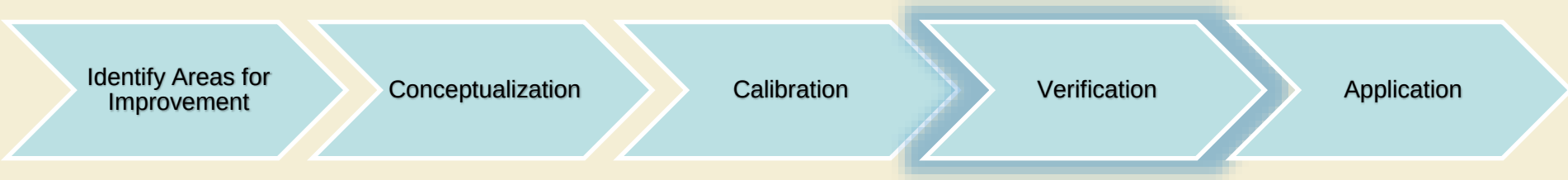
map

Palmar Wetland Area



map

Process


Identify Areas for Improvement
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Verification of Model

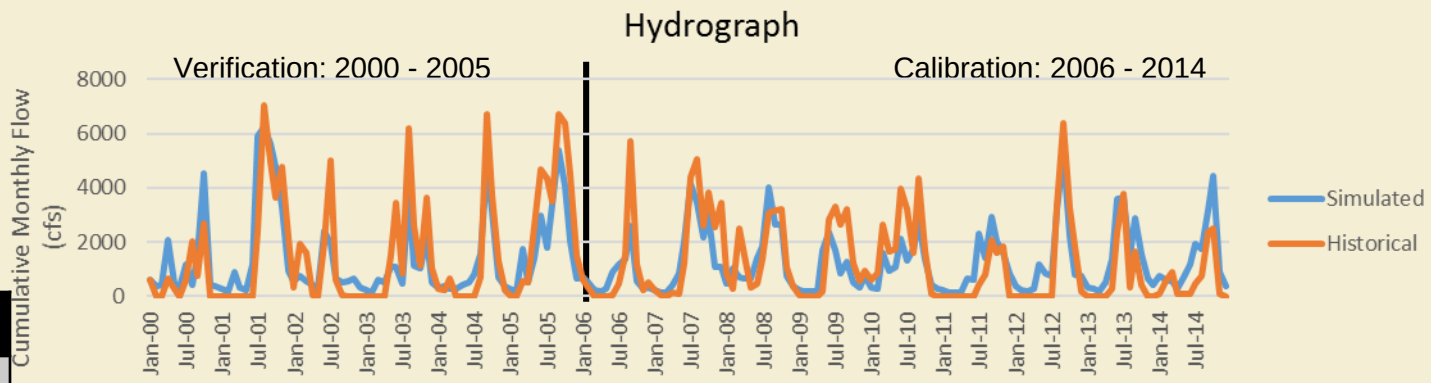
- Model Verification is the process to demonstrate that the calibrated model matches a set of field data independent of what was used to calibrate the model.
- Verification is a modeling “best practice” and is presented herein as a simple test of the model’s capability.

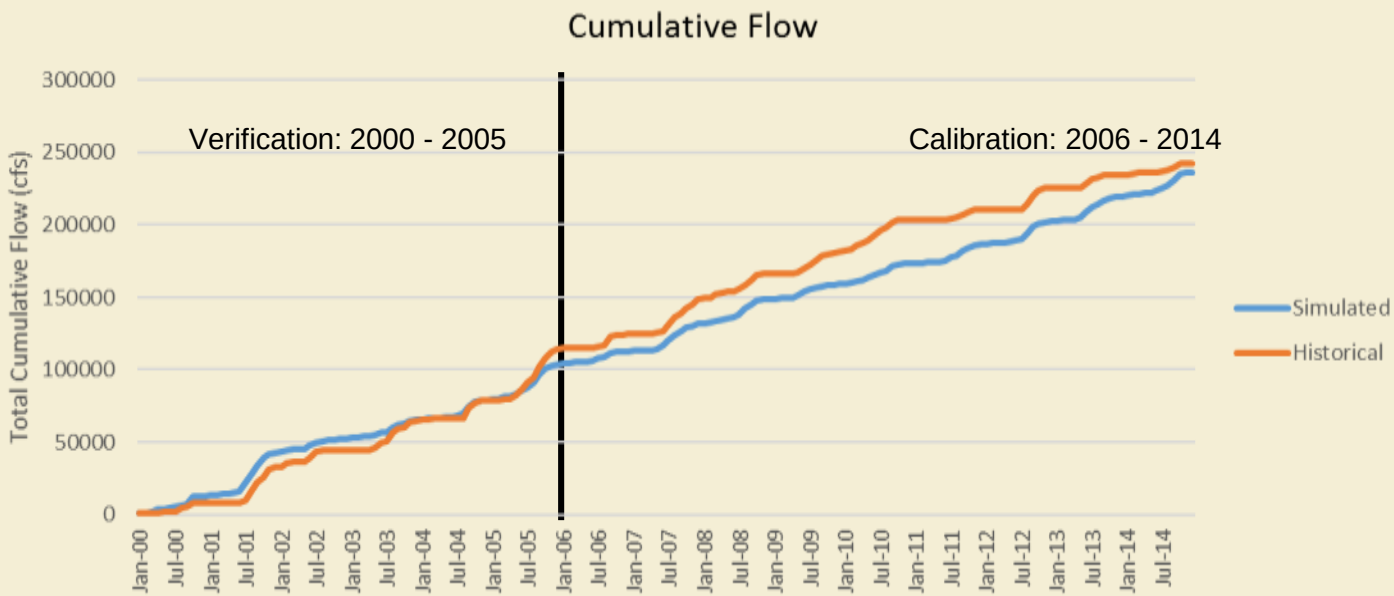
Model Verification

- The model "verification" period was chosen from the year 2000 through the year 2005
- G-160 and G-161 structures were not operational during the verification period
- Significant restoration areas undertaken by Palm Beach County in recent years had not occurred or were just beginning
- Large parcels of State owned lands in the project area had not be acquired or recently acquired during the period and had not undergone significant alterations

Structure Flow Statistics – C-18 Weir

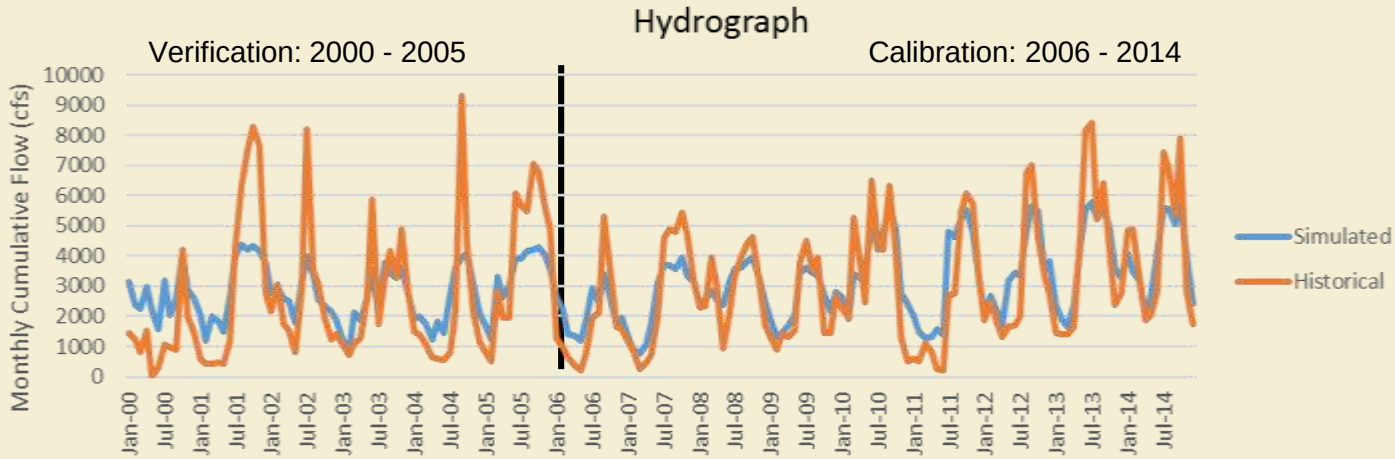
Criteria	2000 - 2014
R^2	0.66
DV (%)	3
NS	0.66

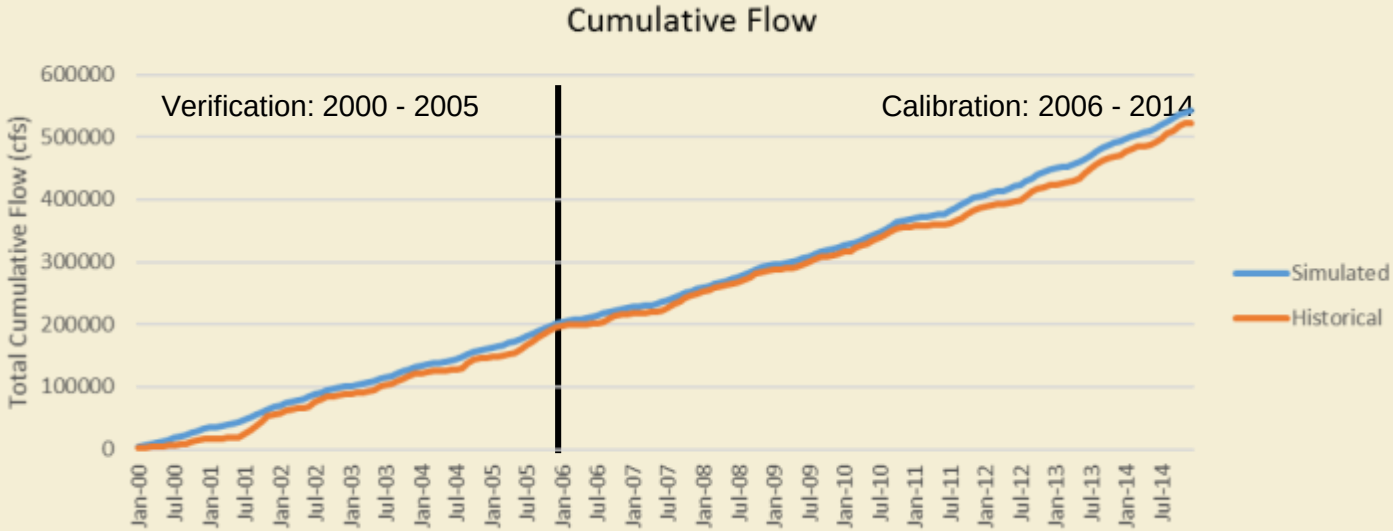




Structure Flow Statistics – Lainhart Dam

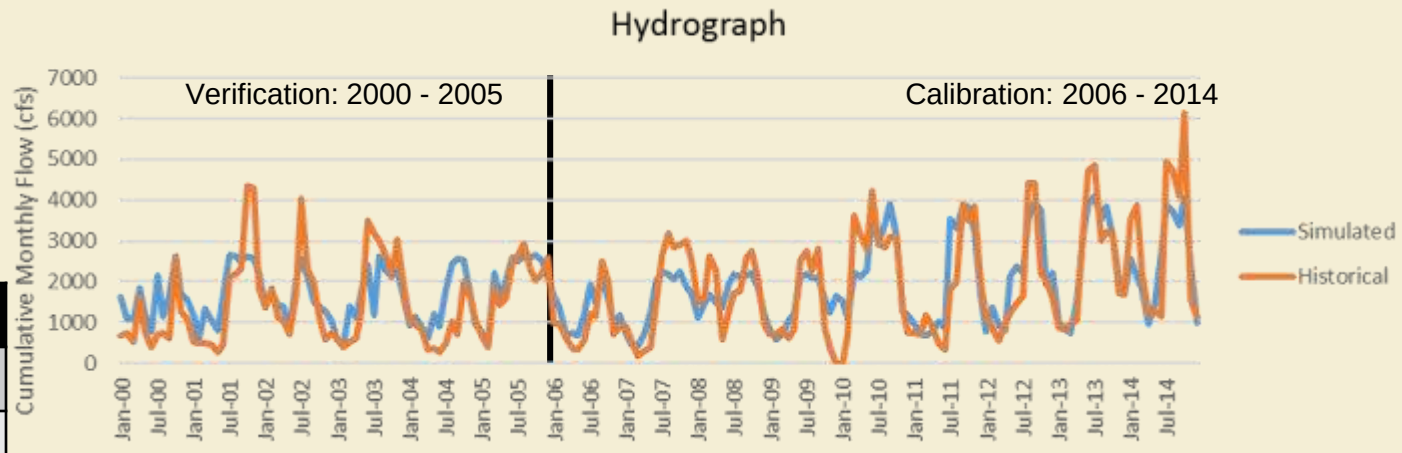
Criteria	2000 - 2014
R^2	0.73
DV (%)	-4
NS	0.64

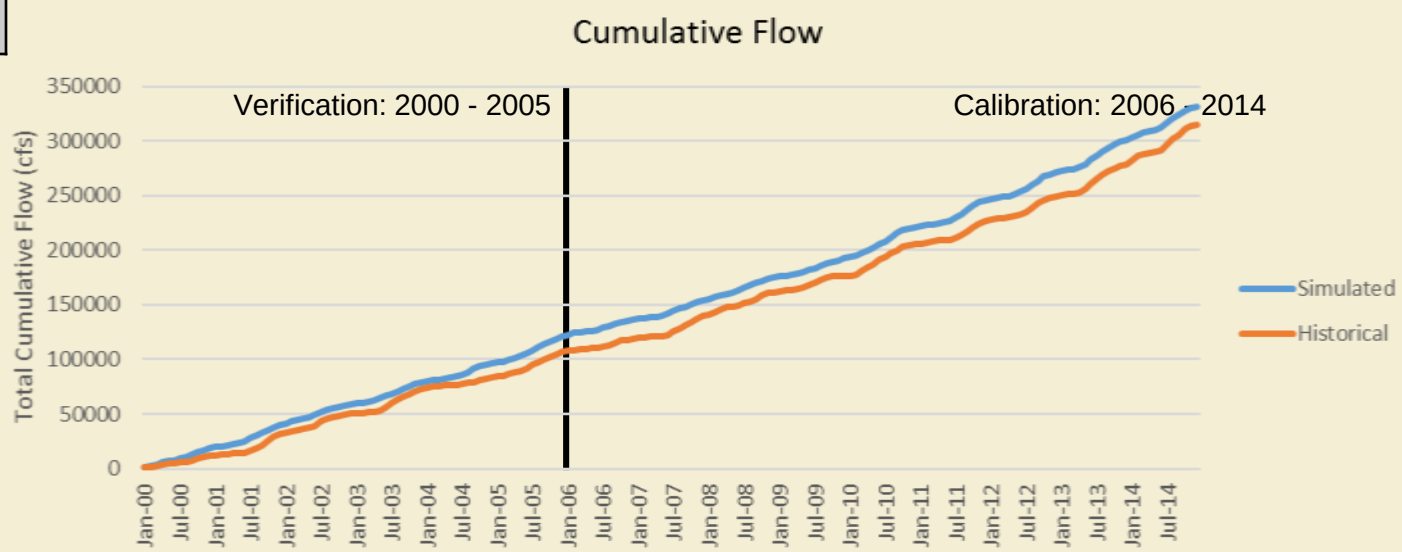




Structure Flow Statistics – G-92

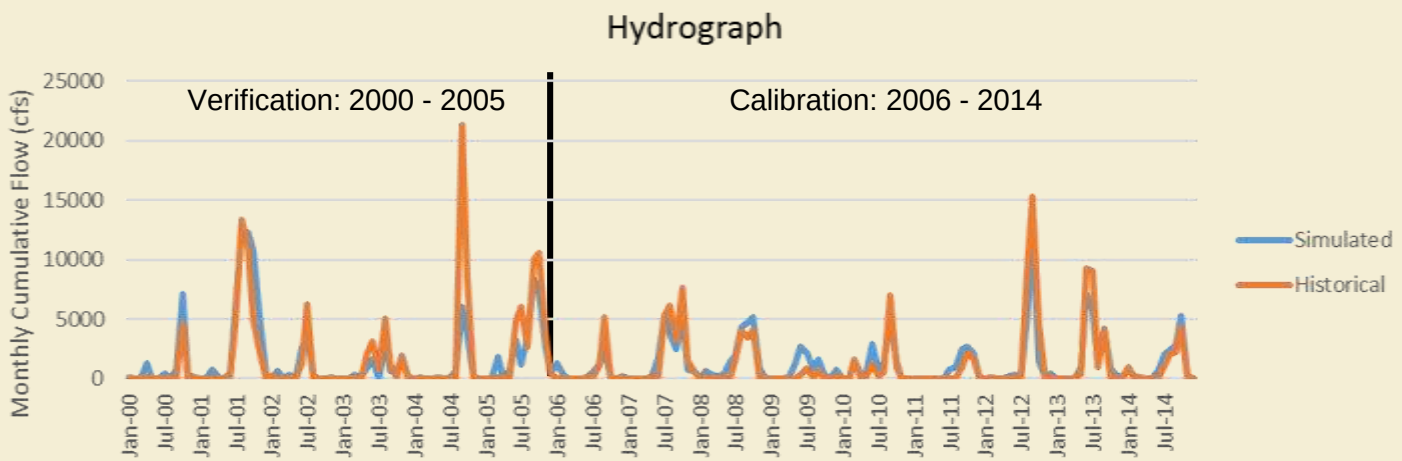
Criteria	2000 - 2014
R^2	0.68
DV (%)	-4
NS	0.67

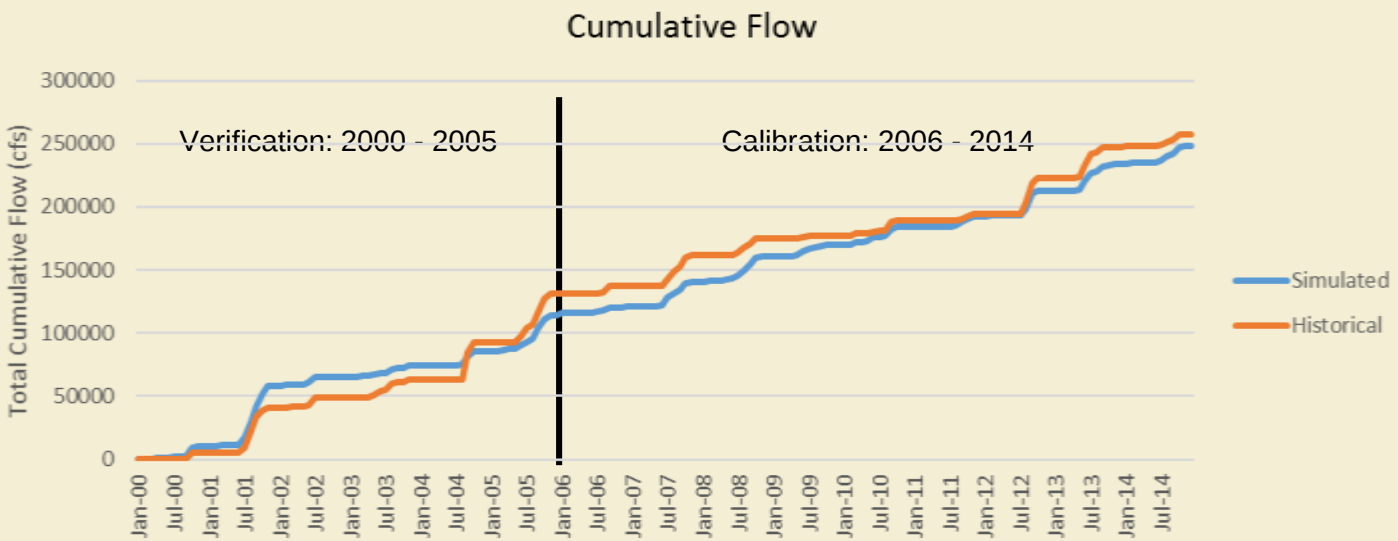




Structure Flow Statistics – S-46

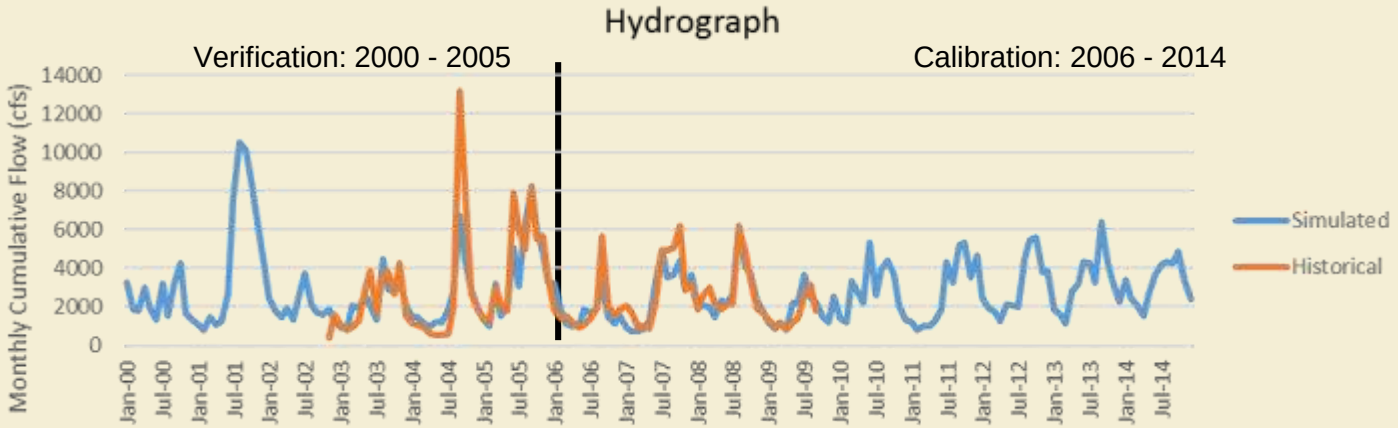
Criteria	2000 - 2014
R^2	0.73
DV (%)	4
NS	0.72

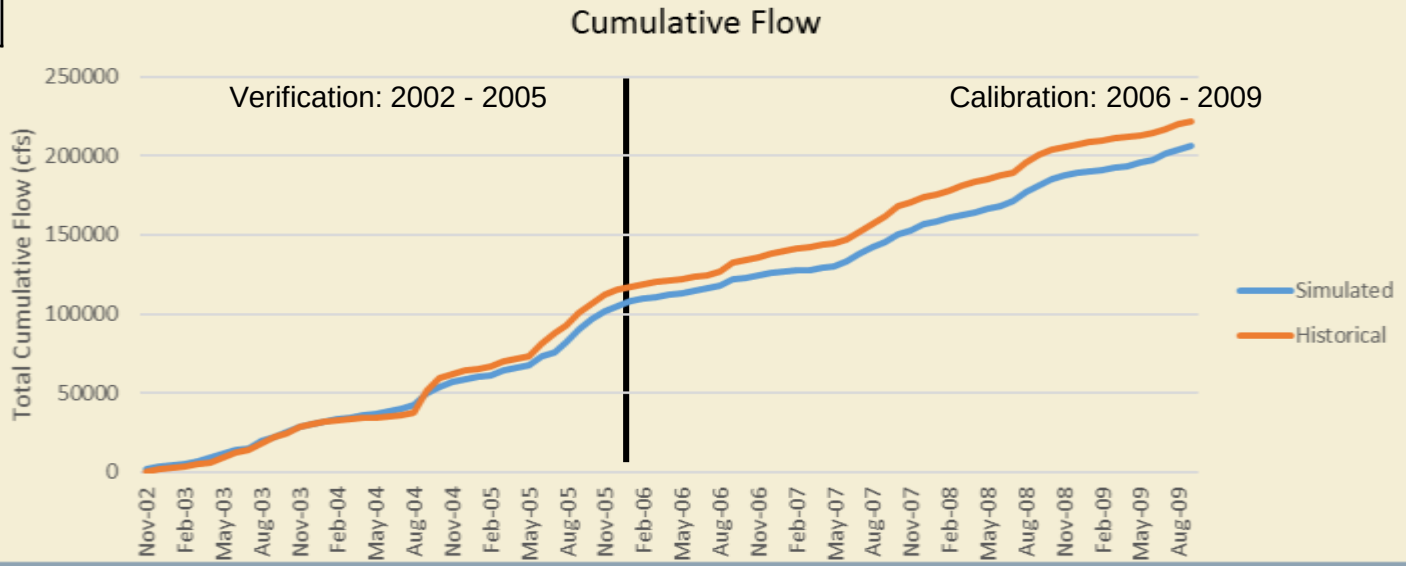




Structure Flow Statistics – Cypress Creek and Hobe Grove Ditch

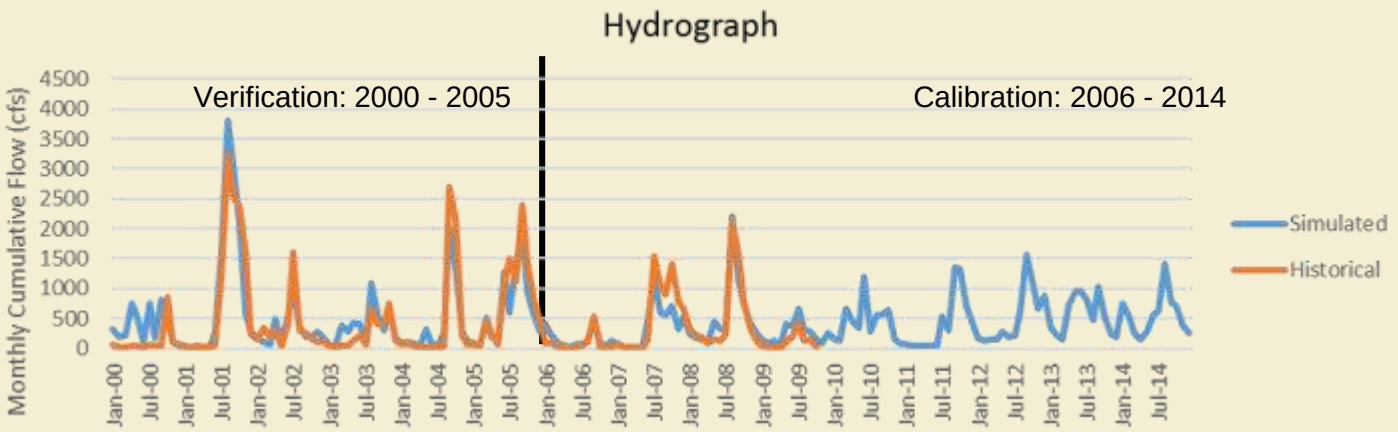
Criteria	2000 - 2014
R^2	0.73
DV (%)	7
NS	0.70

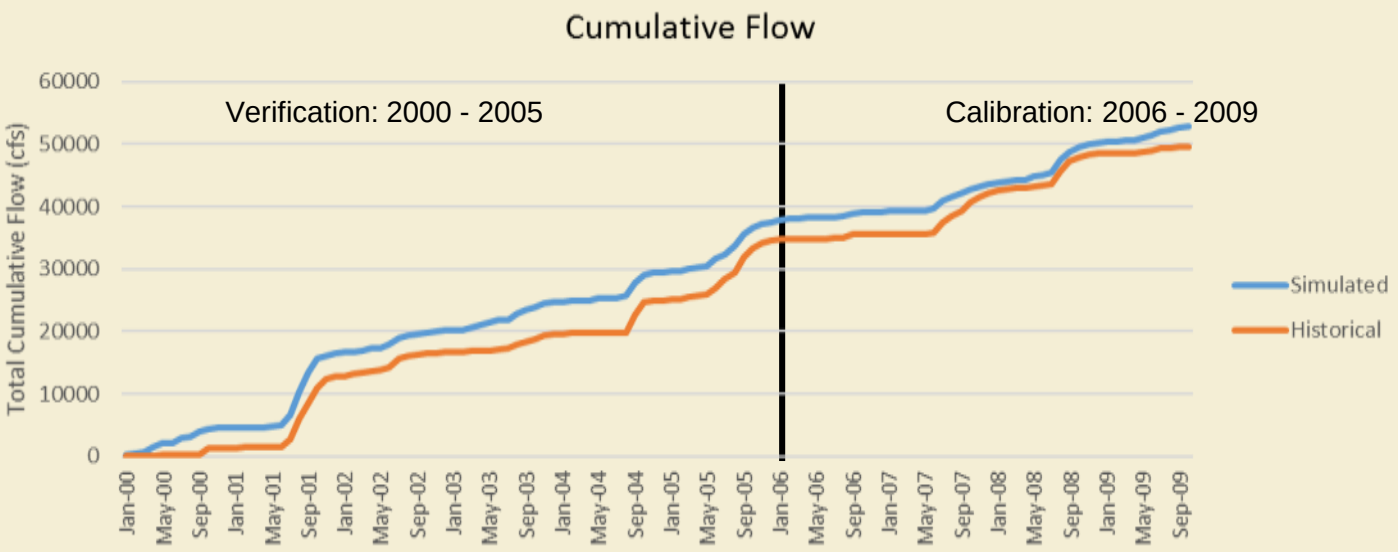




Structure Flow Statistics – Kitching Creek

Criteria	2000 - 2014
R^2	0.81
DV (%)	-6
NS	0.81





Structure Flow Comparison

	Calibration (2006 – 2014)			Calibration & Verification (2000 – 2014)		
Structure	R^2	DV (%)	NS	R^2	DV (%)	NS
C-18 Weir	0.62	-3	0.61	0.66	3	0.66
Lainhart	0.80	-4	0.74	0.73	-4	0.64
G-92	0.72	-1	0.71	0.68	-4	0.67
S-46	0.87	-6	0.84	0.73	4	0.72
Kitching Creek	0.82	-2	0.81	0.81	-6	0.81
Cypress Creek and Hobe Grove Ditch	0.72	5	0.72	0.73	7	0.70

Water Level Verification Summary

Overall Mean Absolute Error (ft)	Calibration (2006 – 2014)	Verification & Calibration (2000 – 2014)
Groundwater Monitor Wells	0.59	0.62
Wetland Gages	0.66	0.66

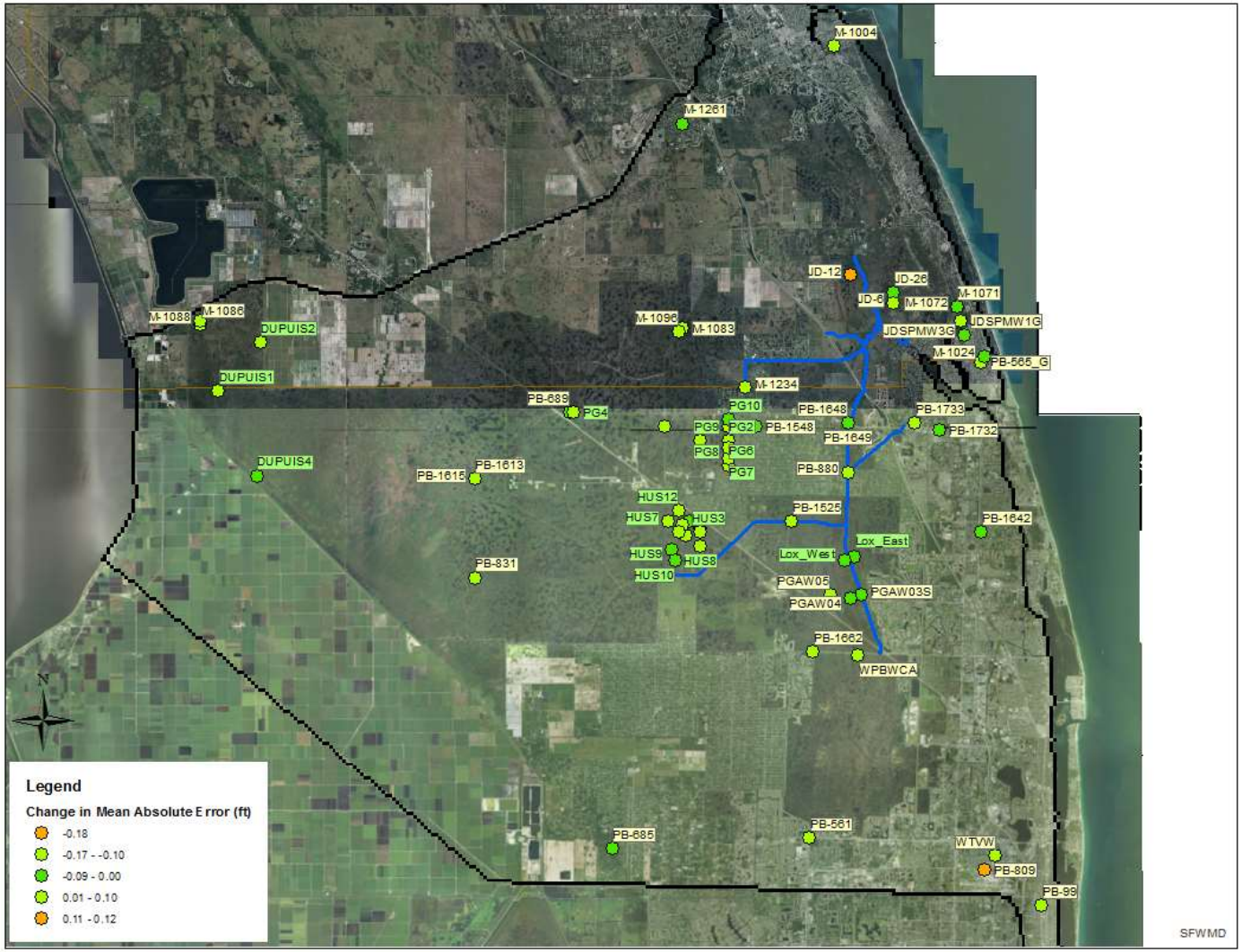
Statistics only include locations used in both calibration and verification

Decreasing values indicate less error and a better calibrated model

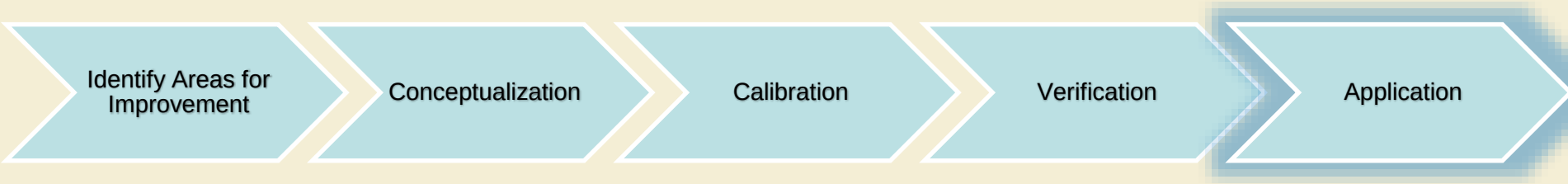
Difference in Mean Absolute Error

Comparison between MAE calculated for calibration period (2006 – 2014), and verification/calibration period (2000 – 2014)

- 25 Wetland Gages
- 41 Groundwater Wells



Process


Identify Areas for Improvement
Conceptualization
Calibration
Verification
Application

Next Steps

- Calibration ✓
- Verification ✓
- Base Case Modeling Assumptions ✓
- Base Case Model Runs
  - Currently working on – expect results to be posted soon
- Alternative Modeling Assumptions
- Alternative Model Runs

Performance Measure Graphics

- 11 categories
  - Indicator Regions
    - 55 locations, 2 types of graphics for each location
  - Other Indicators
    - 55 locations, 2 types of graphics for each location
  - Storage Reservoirs
    - 4 locations, 2 types of graphics for each location
  - Profile Points
    - 31 locations, 2 types of graphics for each location

Performance Measure Graphics

- 11 categories
  - Profiles
    - 24 locations, 3 types of graphics for each location
  - ASR
    - 2 locations, 6 types of graphics
  - Difference Maps
    - 3 days, 3 types of graphics for each day
  - Flow Transects
    - 11 locations, 2 types of graphics for each location

Performance Measure Graphics

- 11 categories
  - Structure Flows
    - 40 locations, 6 types of graphics
  - Water Supply
    - 8 zones, 14 trigger locations, 4 types of graphics
  - Water Budget
    - 8 locations, 3 types of graphics

Questions?