Indian River Lagoon Basin Management Action Plan (BMAP) Spatial Watershed Iterative Loading (SWIL) Model Update Meeting

Via Webinar
April 30, 2024
10:30 AM

Webinar Registration Link:
https://attendee.gotowebinar.com/register/1883444065154635609

Agenda

- Welcome
- SWIL Model WQ Calibration Update
- Next Steps

Please note the FTP site for documents pertaining to the various BMAPs:
http://publicfiles.dep.state.fl.us/DEAR/BMAP/
For more information, contact: Diana Turner, 850-245-8825, Diana.M.Turner@FloridaDEP.gov

WEBINAR HOUSEKEEPING

Attendee Participation

Open your control panel.

Join audio:

- Choose Computer Audio **or**
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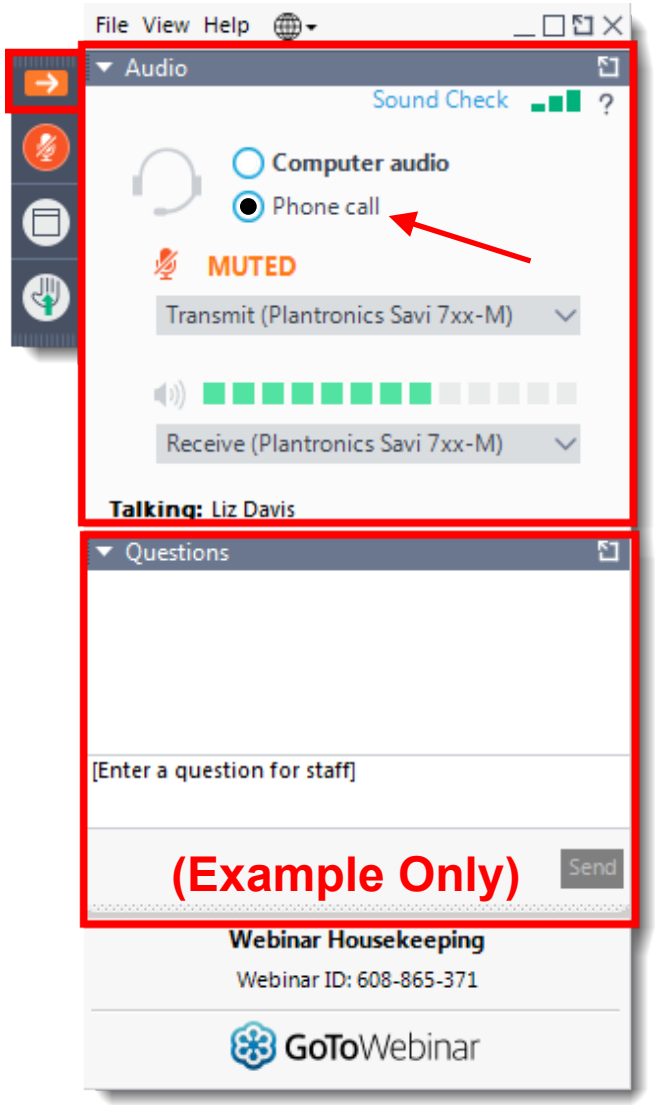
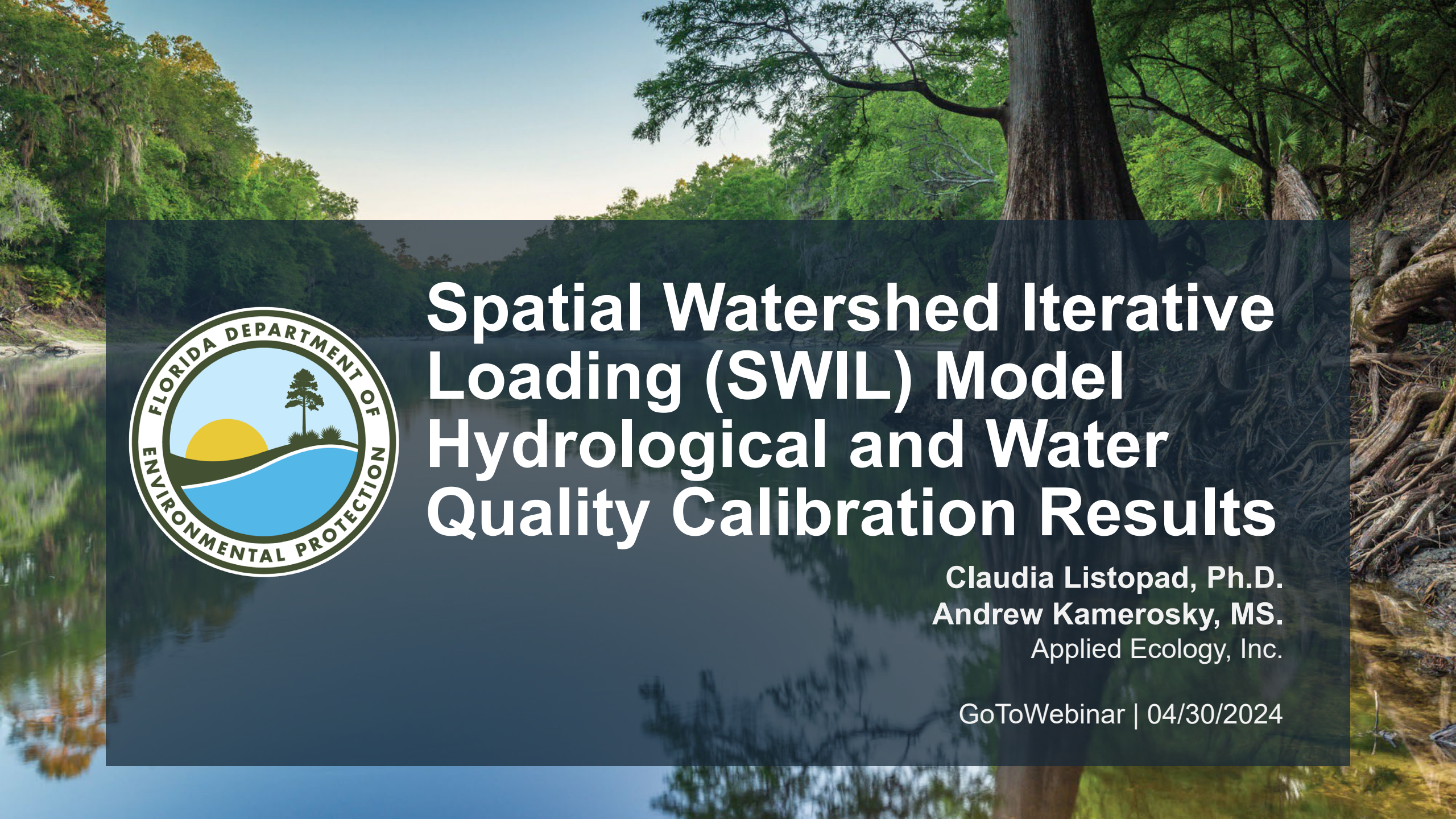
Attendee audio will automatically be muted.

Submit questions and comments via the **Questions** panel.

If viewing this webinar as a group, please provide a list of attendees via the **Questions** panel.

Note: Today's presentation is being recorded and will be provided on the file transfer protocol (FTP) site after the webinar.





Spatial Watershed Iterative Loading (SWIL) Model Hydrological and Water Quality Calibration Results

Claudia Listopad, Ph.D.
Andrew Kamerosky, MS.
Applied Ecology, Inc.

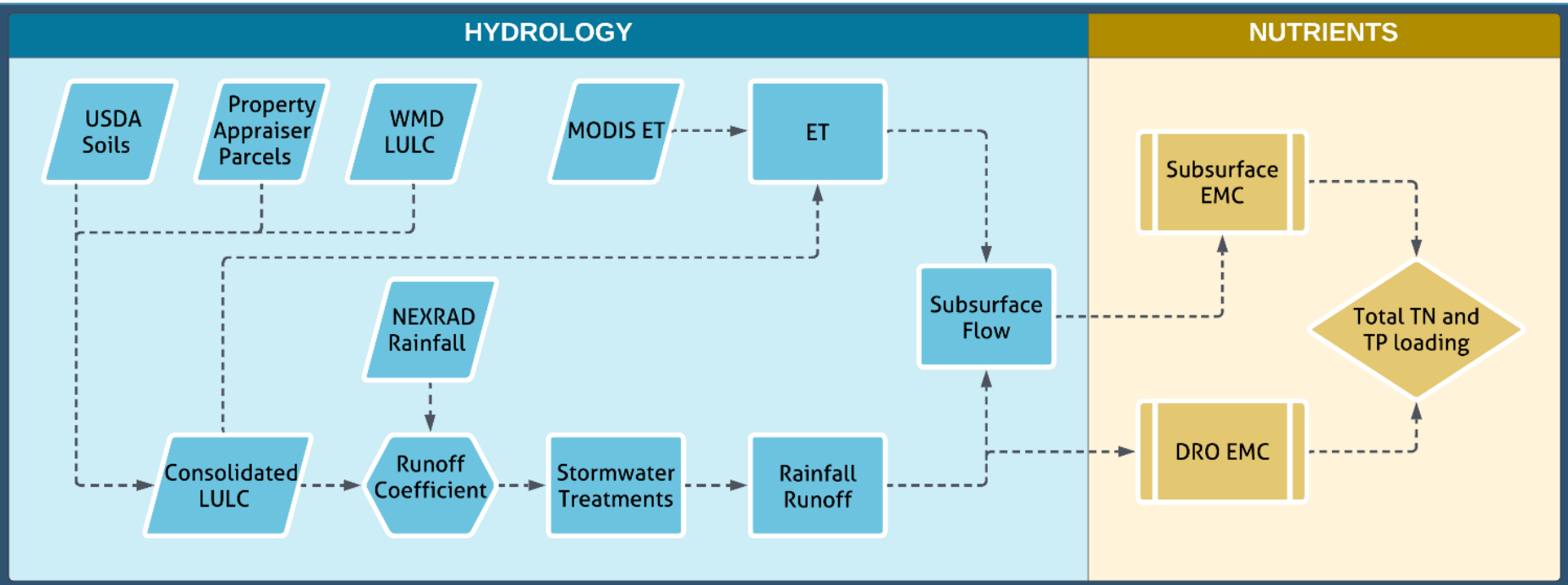
GoToWebinar | 04/30/2024

AGENDA

Presentation Agenda

- SWIL 5.0 Status.
- Calibration Efforts:
  - Hydrology.
  - Water quality.
- Model Performance.
- Next Steps:
  - Calibrated model run.
  - Baseline natural run.
  - LET development.

SWIL
MODEL OVERVIEW



- SWIL model estimates monthly total nitrogen (TN) and total phosphorus (TP) loading of a defined basin for both direct runoff (DRO) and subsurface flow (SSF).
- Volumes of water are estimated using land use land cover (LULC), property appraiser, NEXRAD rainfall, and MODIS evapotranspiration data.
- Event mean concentrations (EMC) were established for both DRO and SSF to convert volume of water to mass of nutrient.

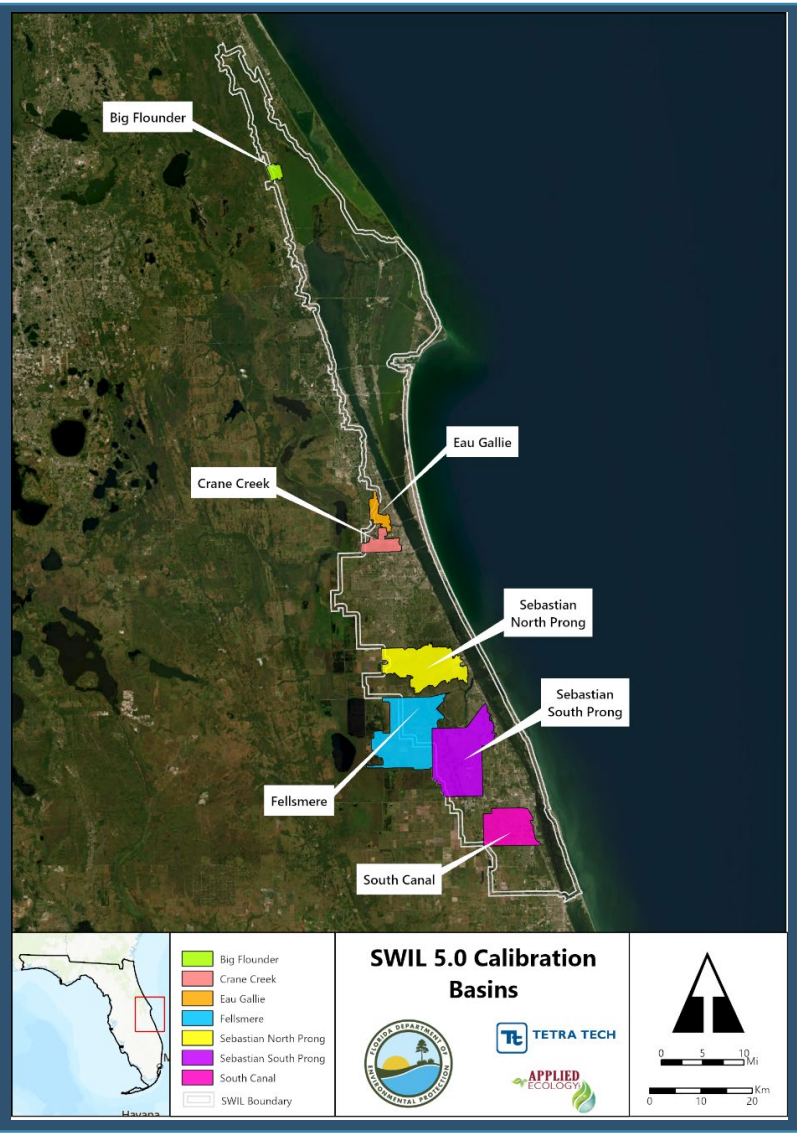
PROJECT TIMELINE

Task Number & Description	Complete	2024								
		Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov
1 - Update Direct Runoff Input Layers	✓									
2 - Update SSF Input Layers	✓									
3 - Incorporate WW treatment in SSF	✓									
4 - Develop Retrofit / BMPs	✓									
5 - SWIL Code Update and Full Execution	✓									
6 - Hydrological Calibration	✓									
7 - Water Quality Calibration	✓									
8 - Allocation Watershed SWIL Run										
9 - Natural Background Condition SWIL Run										
10 - LET (Load Estimation Tool) Automation										
11 – Data/Technical Transfer										

SWIL 5.0 Optimization

SWIL Hydrological and Water Quality Calibration Results

SWIL 5.0
CALIBRATION BASINS



Calibration Basins:

- Big Flounder.
- Eau Gallie.
- Crane Creek.
- Sebastian North Prong.
- Sebastian South Prong.
- Fellsmere.
- South Canal.

Basin Selection: Important that the basins are reflective of the diverse LULC combinations identified across the IRL. Balance of agricultural, developed, and natural LULC.

Characterization of the calibration basins presented to stakeholders on March 23, 2023.

SWIL 5.0 CALIBRATION
OPTIMIZATION PROCESS

Microsoft Excel Solver Add-in:

- Used to identify calibration factors which minimize the error between the model outputs and observed data.
- Evolutionary Solver tests thousands of possible factor combinations to determine the global optimal combination.
- Constraints were applied based on DEP input and available literature.
- Primary performance goals vary between components.

Percent Bias (PBIAS): Measures the average tendency of the simulated data to be larger or smaller than the observed values.

- PBIAS goal: -25% to +25%.

Nash-Sutcliffe Efficiency (NSE): Measure of the predictive skill of models to estimate values by indicating how well the plot of observed versus simulated data fits.

- NSE goal: > 0.50.

SWIL 5.0 CALIBRATION
HYDROLOGY OPTIMIZATION

Hydrological Components:

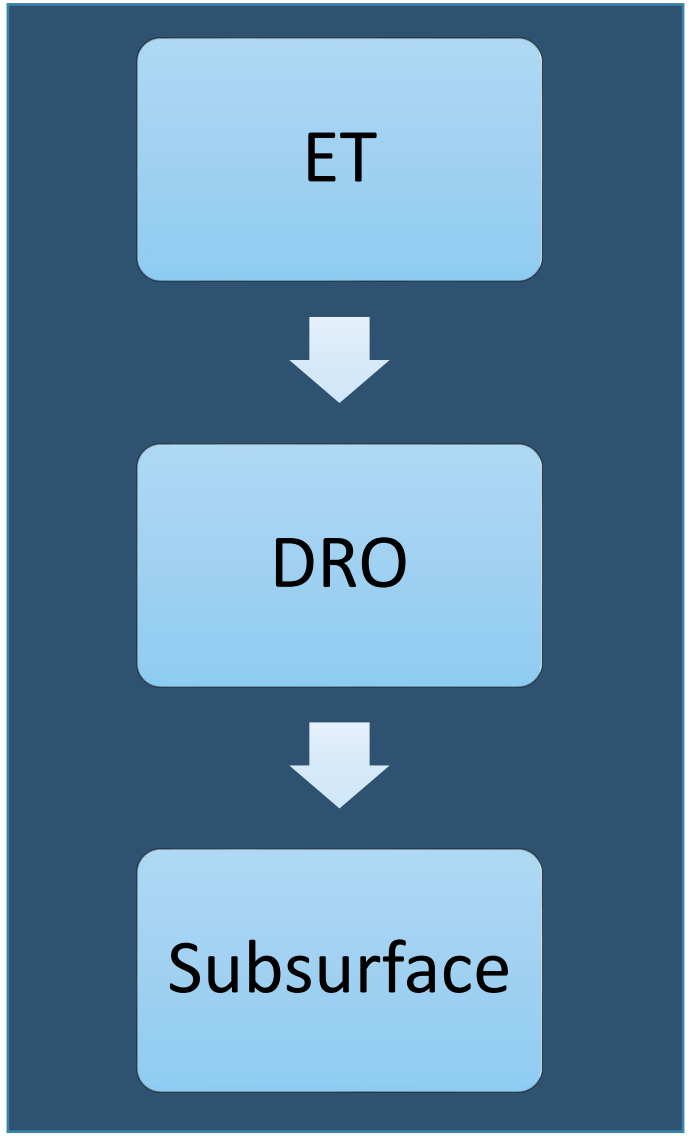
- Evapotranspiration (ET).
- DRO.
- SSF.

ET: ET is estimated by the MODIS satellite ET, NEXRAD rainfall, and LULC:

- Undeveloped pervious.
- Developed pervious.
- Developed impervious.

DRO: DRO is estimated by NEXRAD rainfall and runoff coefficients determined by LULC and soil hydrology. Also includes stormwater treatment systems.

SSF: SSF is estimated as a product of ET and DRO. Lag factor used to determine the storage capacity and release of groundwater.



SWIL 5.0 CALIBRATION

ET OPTIMIZATION – STATISTICS

Basin	Monthly Volume	
	SWIL 5.0u	SWIL 5.0c
Eau Gallie	23.6%	1.1%
Crane Creek	18.3%	1.0%
Sebastian North Prong	61.1%	16.5%
Sebastian South Prong	20.0%	-8.1%
Fellsmere	30.4%	-3.2%
South Canal	33.9%	9.5%
Avg. PBIAS	**31.2%**	**2.8%**
Avg. Abs. PBIAS	**31.2%**	**6.5%**

SWIL 5.0 CALIBRATION

DRO OPTIMIZATION – SETUP

DRO Optimization Rules:

- Wetland and Upland LULC cannot have a final ROC value of 0.
- Wetland and Upland LULC must have final ROC values less than all other LULC.
- Rangeland, Agriculture, and Tree Crop LULC must have final ROC values less than Industrial and Commercial LULC.
- Mid Modified must have final ROC values greater than Low Modified.
- Industrial and Commercial must have greater final ROC values than Mid Modified.
- Low Density Residential must have final ROC values greater than Medium to High Density Residential.

SWIL 5.0 CALIBRATION

DRO OPTIMIZATION – GROUPS

An initial optimization run for all 30 LULC identified which LULC types had similar factor values and could be grouped together.

The reduction in the number of LULC types being calibrated from 30 to 10 reduced the runtime and increased the stability of each model run.

DRO Group	Calibration Factor
Pasture	2.5
Crops	1.0
Tree Crops	1.5
Low Modified	0.3
Mid Modified	0.4
Low Density Residential	0.8
Medium to High Density Residential	1.2
Commercial and Industrial	1.5
Upland	0.2
Wetland	0.2

SWIL 5.0 CALIBRATION

DRO OPTIMIZATION – STATISTICS

Basin	Monthly NSE		Monthly PBIAS	
	SWIL 5.0u	SWIL 5.0c	SWIL 5.0u	SWIL 5.0c
Eau Gallie	0.69	0.71	-11.9%	-5.5%
Crane Creek	0.72	0.69	17.3%	6.4%
Sebastian North Prong	0.63	0.63	33.8%	2.7%
Sebastian South Prong	0.66	0.67	-8.2%	-3.9%
Fellsmere	0.74	0.72	-9.8%	2.5%
South Canal	0.73	0.78	-9.7%	4.0%
Average	**0.70**	**0.70**	**1.9%**	**1.0%**
		Avg. Abs. PBIAS	**15.1%**	**4.2%**

SWIL 5.0 CALIBRATION

SSF OPTIMIZATION – STATISTICS

Station	Monthly Volume NSE		PBIAS	
	SWIL 5.0u	SWIL 5.0c	SWIL 5.0u	SWIL 5.0c
Eau Gallie	0.28	0.44	31.3%	-6.2%
Crane Creek	0.7	0.67	7.8%	-11.3%
Sebastian North Prong	0.39	0.64	52.3%	3.2%
Sebastian South Prong	0.65	0.63	23.6%	-18.8%
Fellsmere	-0.37	0.42	42.6%	-10.8%
South Canal	0.34	0.71	41.4%	-1.6%
Average	0.33	0.59	33.2%	-7.6%
		Average Abs. PBIAS	33.2%	8.7%

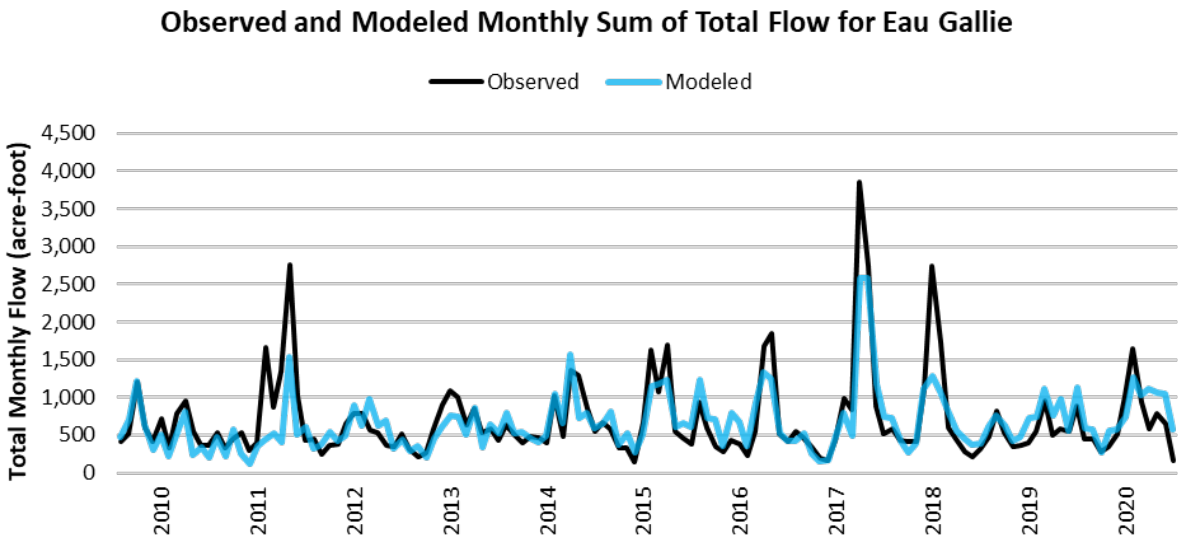
SWIL 5.0 CALIBRATION

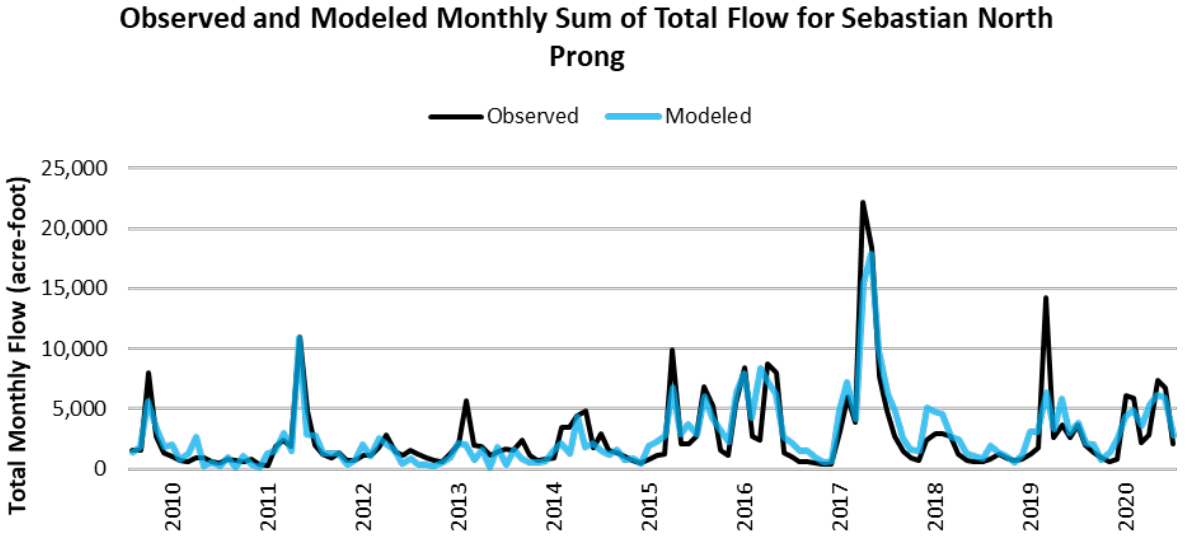
TOTAL FLOW – STATISTICS

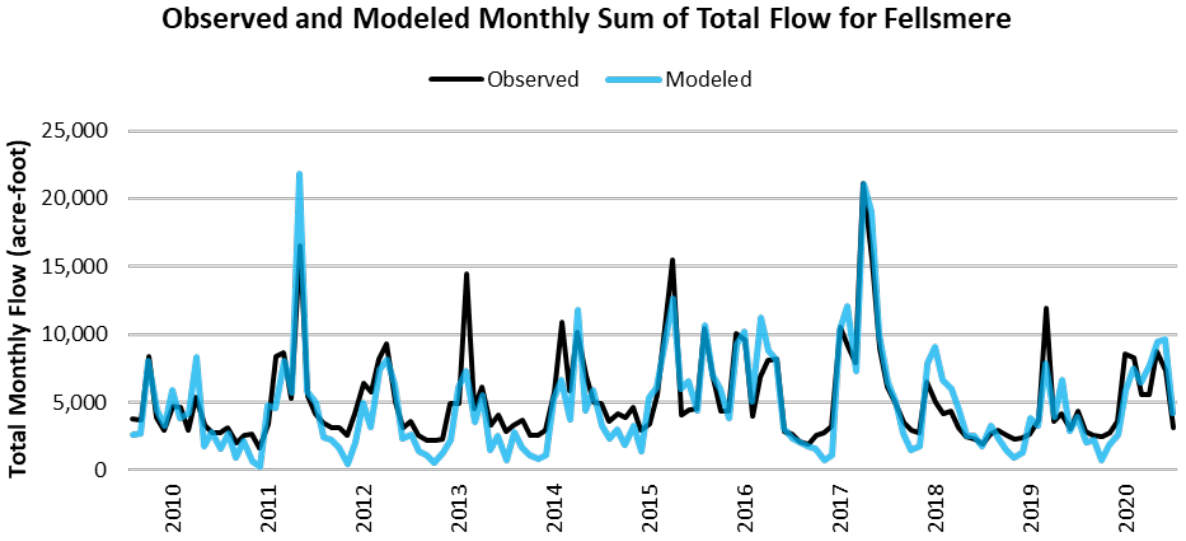
Station	Monthly NSE		Monthly PBIAS	
	SWIL 5.0u	SWIL 5.0c	SWIL 5.0u	SWIL 5.0c
Eau Gallie	0.47	0.52	19.5%	-3.4%
Crane Creek	0.64	0.67	14.9%	-3.2%
Sebastian North Prong	0.36	0.66	53.6%	6.0%
Sebastian South Prong	0.66	0.66	16.2%	-12.5%
Fellsmere	0.42	0.64	26.0%	-7.3%
South Canal	0.66	0.79	27.2%	2.5%
Average	0.53	0.53	26.2%	-2.9%
		Average Abs. PBIAS	26.2%	5.8%

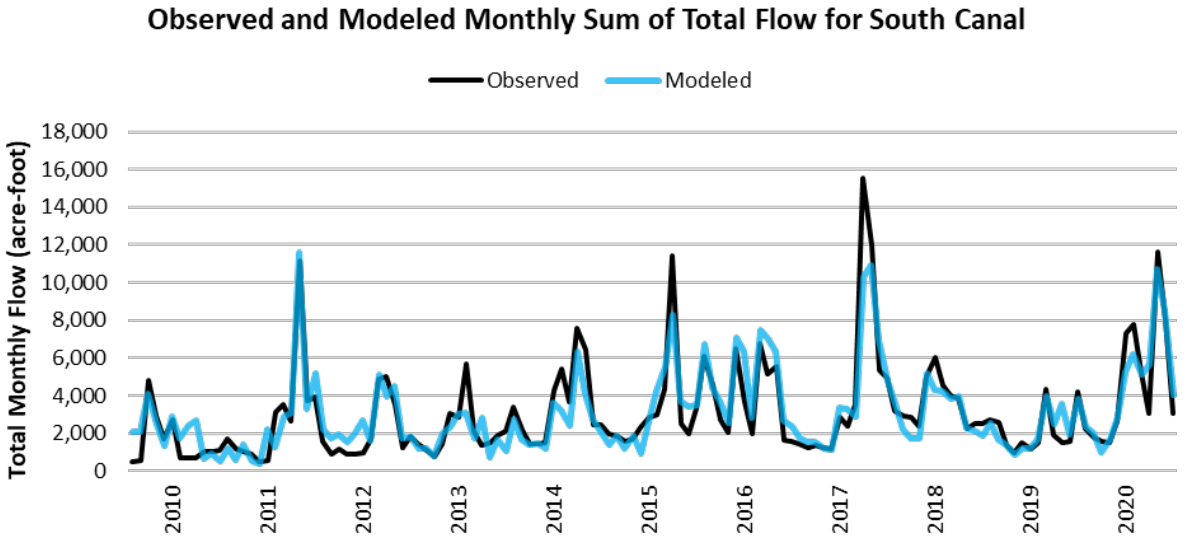
SWIL 5.0 CALIBRATION

TOTAL FLOW – GRAPHS









SWIL 5.0 CALIBRATION
WATER QUALITY OPTIMIZATION

SJRWMD WQM — Acquire SJRWMD monthly surface water sampling data.

USGS Hydrology — Acquire the corresponding USGS gauge monthly total discharge data.

Mass of TN & TP — Estimate the mass of TN and TP loading with the SJRWMD and USGS monthly data.

Segregate DRO and SSF — Using the WHAT DRO and SSF estimations, identify SJRWMD sampling events that correspond with each state.

Calibrate Subsurface — Calibrate the SSF TN and TP loadings based on percent of flow as SSF.

Calibrate DRO/Total — Calibrate DRO TN and TP loadings based on percent flow as DRO.

SWIL 5.0 CALIBRATION

SSF WATER QUALITY OPTIMIZATION – GROUPS

The optimal SSF EMC calibration factors were identified based on grouping LULC types into 4 groups.

The nutrient contribution from each LULC group was determined by the percent area of each group per basin.

Group	TN EMC		TP EMC	
	Uncalibrated	Calibrated	Uncalibrated	Calibrated
Agriculture	0.35	1.36	0.13	0.29
Heavy Development	1.09	1.17	0.14	0.2
Light Development	0.35	1.24	0.13	0.17
Undeveloped	0.35	0.7	0.13	0.03
Average Concentration	0.53	1.12	0.13	0.17

SWIL 5.0 CALIBRATION

SSF WATER QUALITY OPTIMIZATION – STATISTICS

Basin	Monthly TN PBIAS	
	SWIL 5.0u	SWIL 5.0c
Eau Gallie	0.6%	-0.8%
Crane Creek	-10.5%	3.1%
Sebastian North Prong	-35.4%	-5.1%
Sebastian South Prong	-25.0%	7.0%
Fellsmere	-44.0%	0.7%
South Canal	-18.4%	0.0%
Average	**-22.1%**	**0.8%**

Basin	Monthly TP PBIAS	
	SWIL 5.0u	SWIL 5.0c
Eau Gallie	-14.6%	-27.0%
Crane Creek	47.0%	28.5%
Sebastian North Prong	95.8%	-12.2%
Sebastian South Prong	20.2%	-18.6%
Fellsmere	11.3%	4.6%
South Canal	21.6%	8.3%
Average	**30.2%**	**-2.7%**

SWIL 5.0 CALIBRATION

DRO OPTIMIZATION

DRO Optimization Rules:

- Upland and Wetland final TN and TP EMCs cannot be 0.
- Upland and Wetland final TN and TP EMCs must be lower than all other LULC.
- Low Density Residential final TN and TP EMCs must be lower than Medium to High Density Residential.

SWIL 5.0 CALIBRATION

DRO WATER QUALITY OPTIMIZATION – STATISTICS

Basin	Monthly TN PBIAS	
	SWIL 5.0u	SWIL 5.0c
Eau Gallie	23.3%	3.4%
Crane Creek	91.2%	5.4%
Sebastian North Prong	124.8%	-7.0%
Sebastian South Prong	86.6%	7.9%
Fellsmere	85.1%	-0.5%
South Canal	25.5%	-9.8%
Average	**72.7%**	**-0.1%**

Basin	Monthly TP PBIAS	
	SWIL 5.0u	SWIL 5.0c
Eau Gallie	-4.1%	-28.2%
Crane Creek	143.4%	23.8%
Sebastian North Prong	39.2%	13.2%
Sebastian South Prong	4.8%	-19.1%
Fellsmere	10.5%	-6.4%
South Canal	11.2%	-18.8%
Average	**34.2%**	**-5.9%**

SWIL 5.0 CALIBRATION

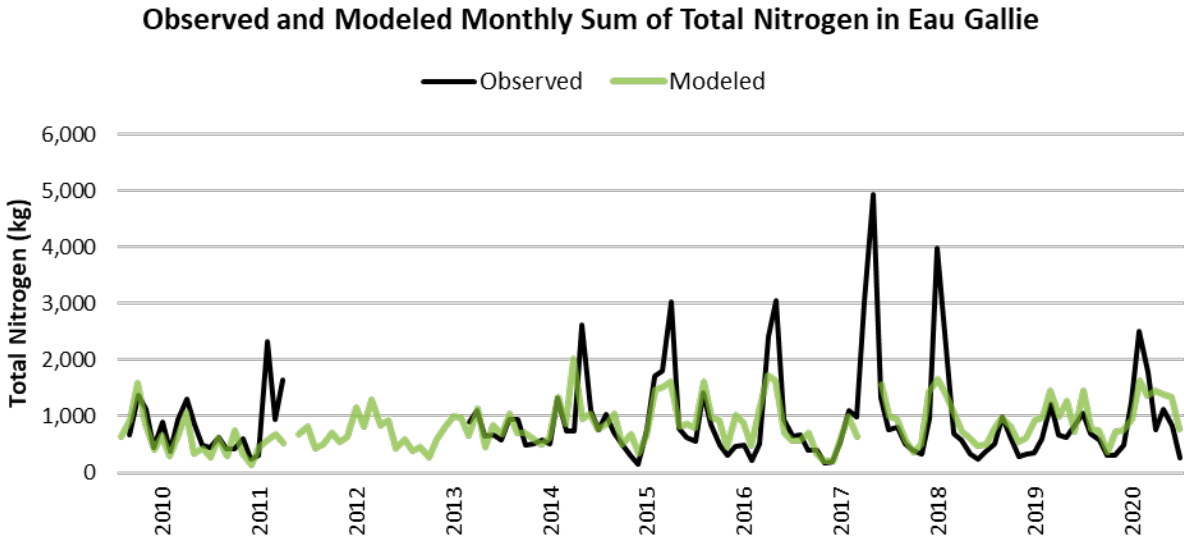
TOTAL FLOW WATER QUALITY OPTIMIZATION – STATISTICS

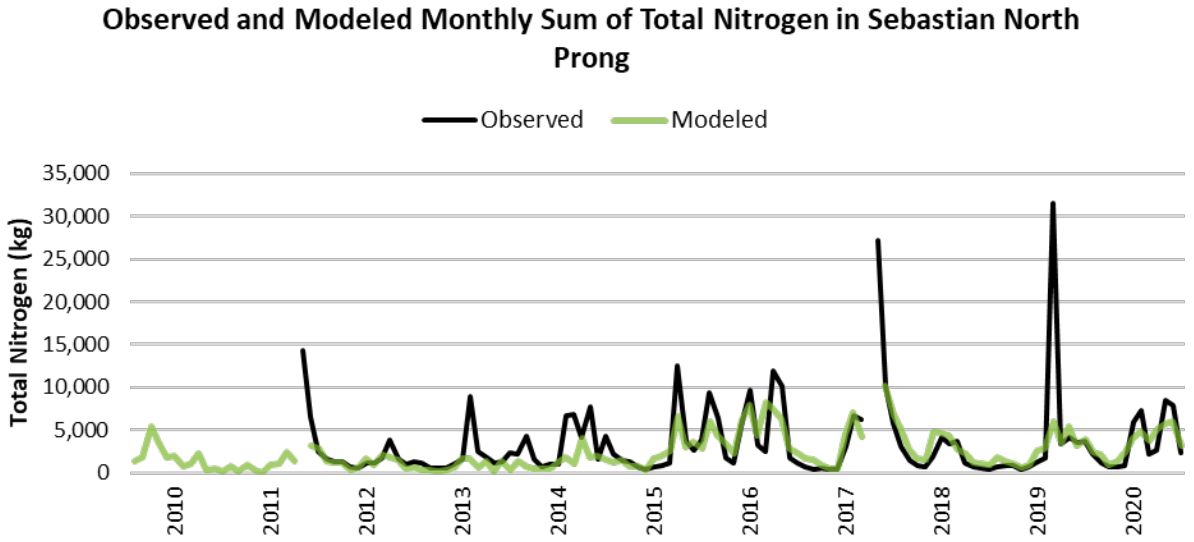
Basin	Monthly TN PBIAS	
	SWIL 5.0u	SWIL 5.0c
Eau Gallie	8.2%	0.5%
Crane Creek	13.7%	5.9%
Sebastian North Prong	12.4%	1.2%
Sebastian South Prong	9.7%	9.8%
Fellsmere	-1.2%	7.4%
South Canal	-0.3%	1.1%
Average	**7.1%**	**4.3%**

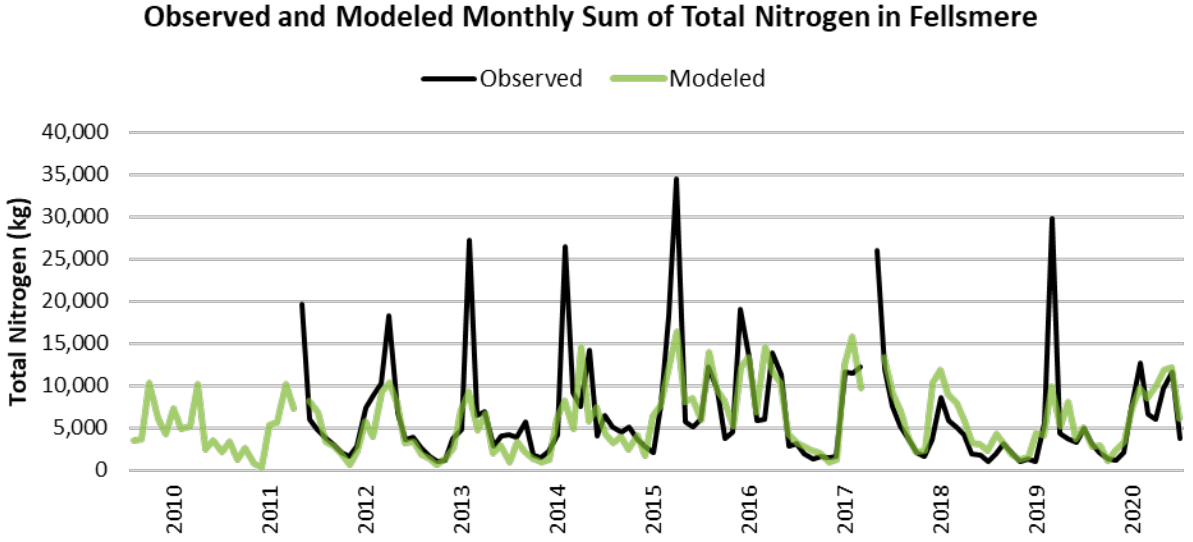
Basin	Monthly TP PBIAS	
	SWIL 5.0u	SWIL 5.0c
Eau Gallie	-13.4%	-29.4%
Crane Creek	65.5%	25.7%
Sebastian North Prong	104.1%	3.2%
Sebastian South Prong	28.5%	-12.3%
Fellsmere	35.9%	21.8%
South Canal	28.8%	7.9%
Average	**41.6%**	**2.8%**

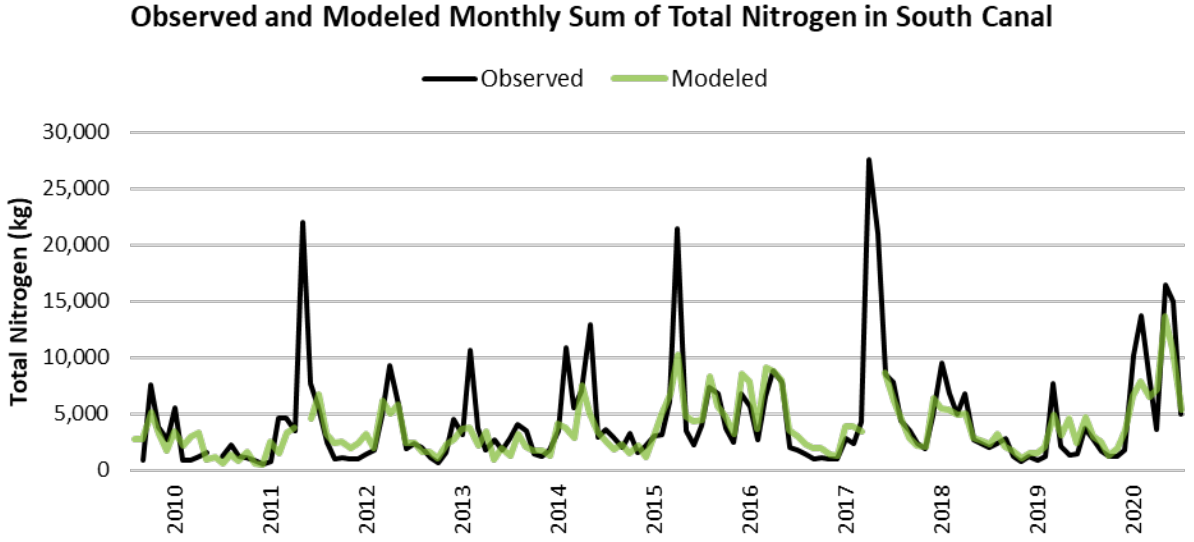
SWIL 5.0 CALIBRATION

TOTAL FLOW WATER QUALITY – TN GRAPHS



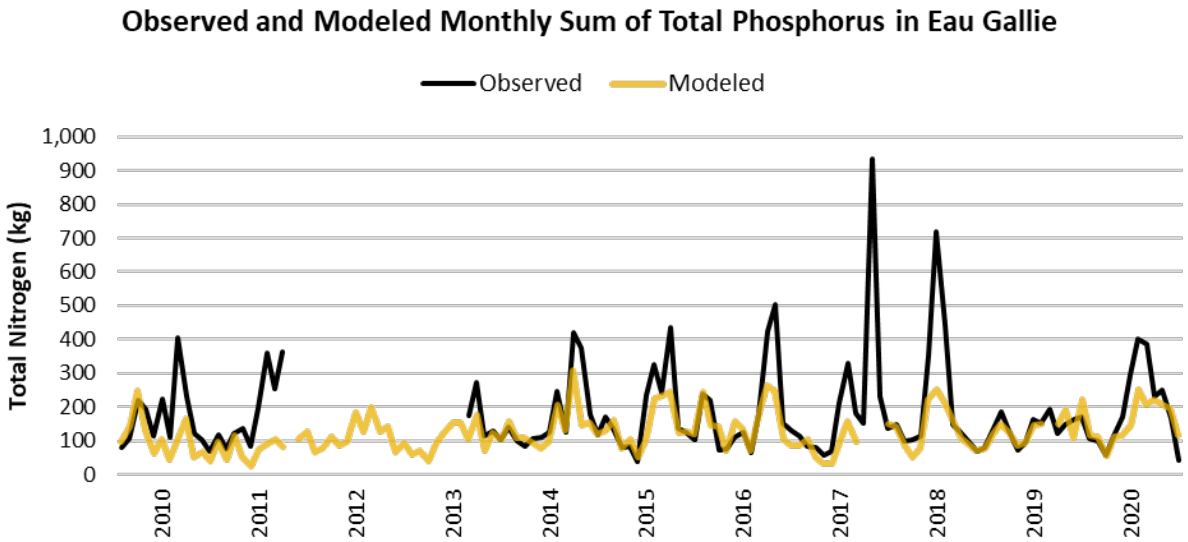


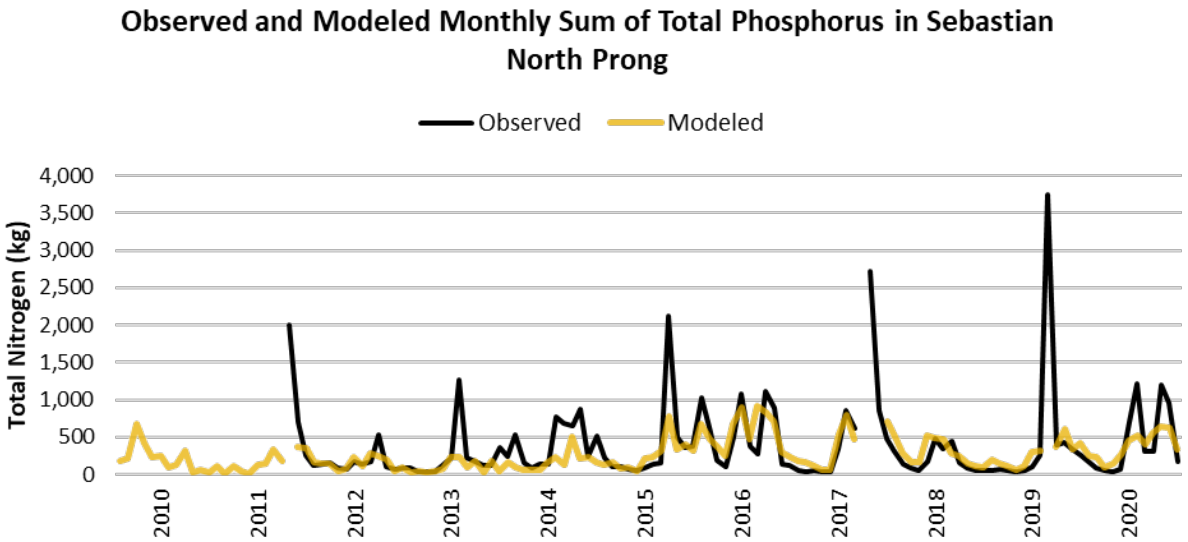


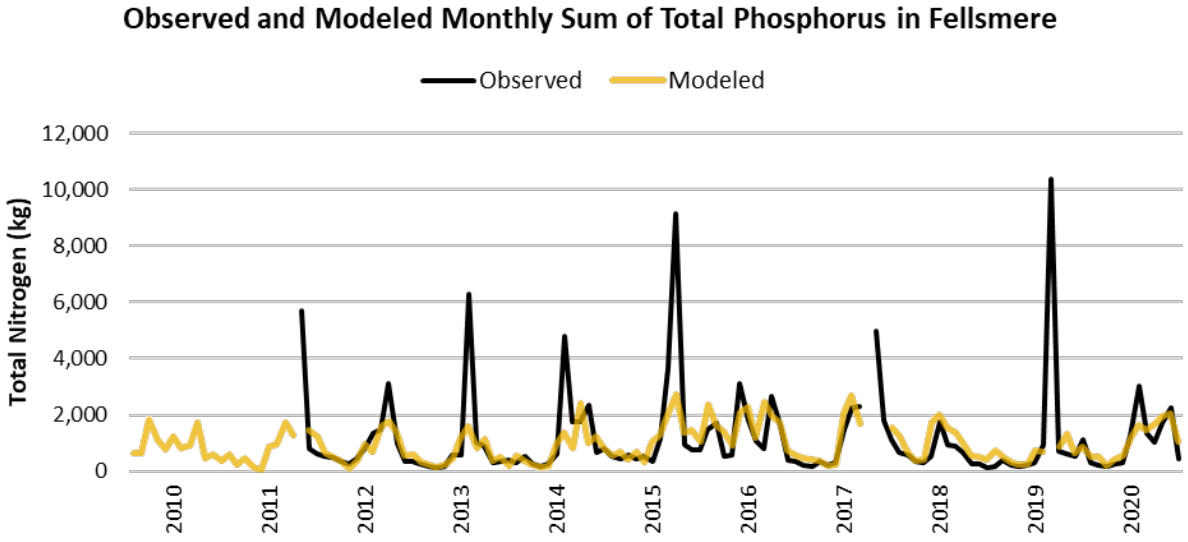


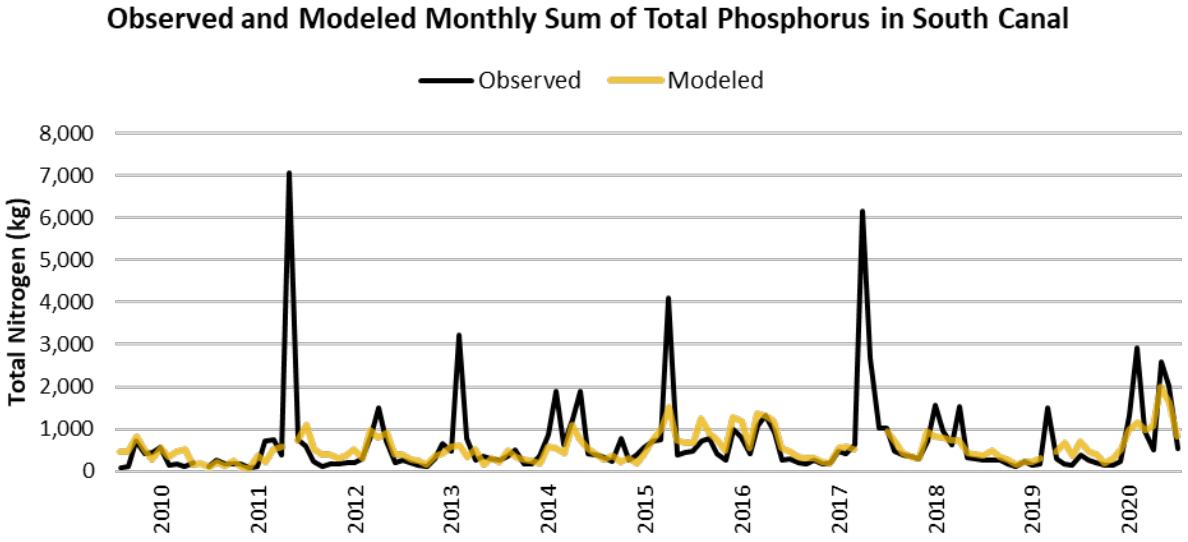
SWIL 5.0 CALIBRATION

TOTAL FLOW WATER QUALITY – TP GRAPHS









SWIL 5.0 CALIBRATION

OPTIMIZATION SUMMARY

Hydrology:

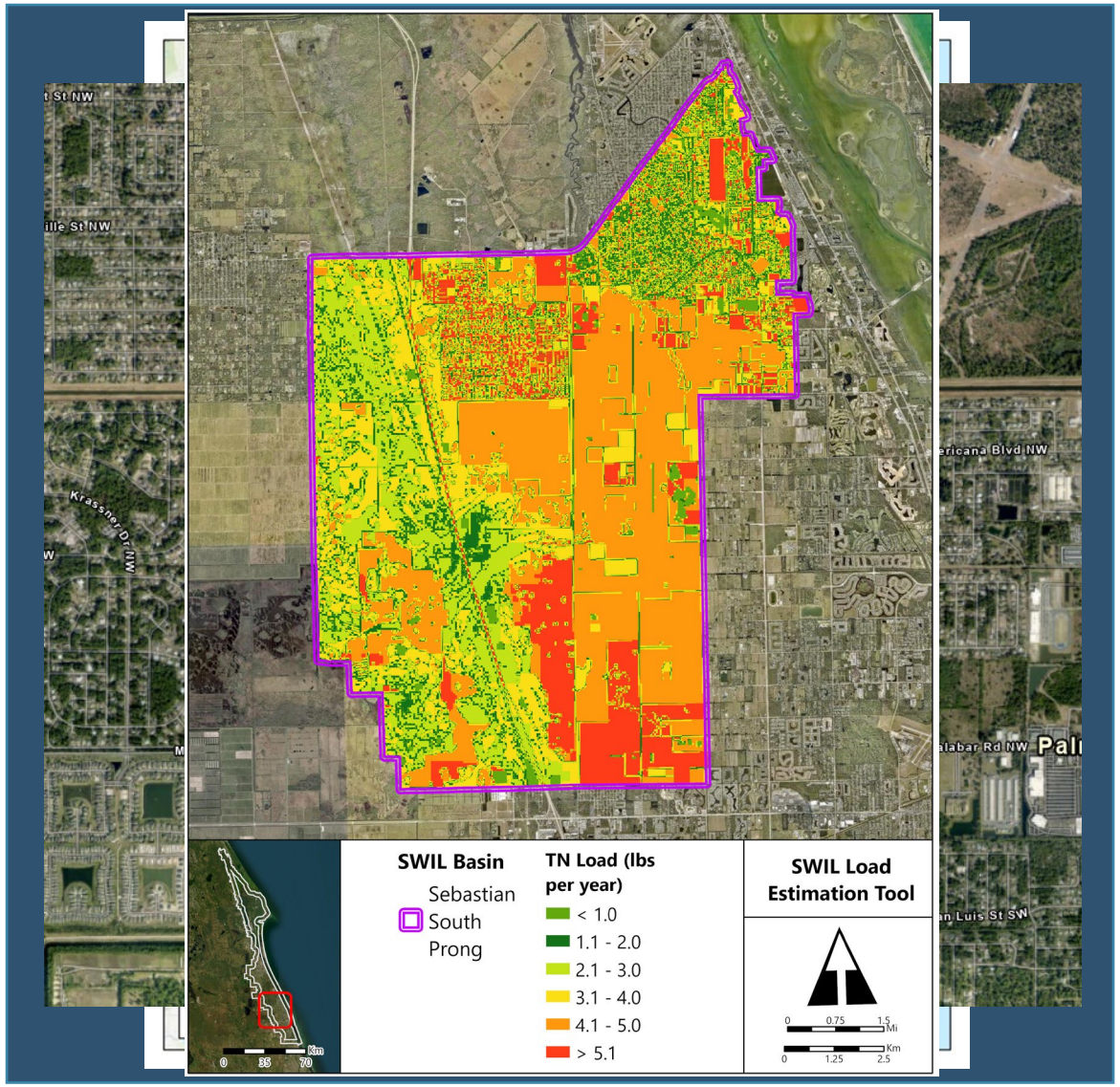
- ET and DRO were within model goal ranges for all basins.
- SSF NSE was slightly below the goal of 0.50 for Eau Gallie and Fellsmere.
- Total flow was within model goal ranges for all basins.

Water Quality:

- SSF.
- DRO.

NEXT STEPS/TASKS

FINAL MODEL DEVELOPMENT



Fully Calibrated Model Run:

- Entire Indian River Lagoon Watershed from 2010 to 2020.

Baseline Natural Model Run:

- 1943 SJRWMD LULC.

SWIL LET:

- 50-meter grid of period of record TN and TP loading.

THANK YOU

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Indian River Lagoon (IRL) Basin Management Action Plans (BMAPs)

Spatial Watershed Iterative Loading (SWIL) Model

April 30, 2024, via GoToWebinar

10:30 am – 11:13 am

Attendees

Becky Allenbach, EPA
Carolina Alvarez, Brevard County
Irene Arpayoglou, DEP
Jana Ash, RES
Taufiqul Aziz, DEP
Steven Baker, U.S. Space Force
Lisa Bally, ATM
Peter Barile, Citizen
Virginia Barker, Brevard County
Venetia Barnes, Fort Pierce
Connie Becker, DEP
Anthony Betts, SFWMD
Terri Breeden, Brevard County
Tiffany Busby, Wildwood Consulting
Timothy Carlisle, Cape Canaveral
Stacy Cecil, SJRWMD
Eric Charest, Indian River County
Taryn Chaya, University of Florida
Tessah Christian, Farm 2 Food
Carolin Ciarlariello, DEP
Anne Cox, Citizen
David Cox, Citizen
Derek Cox, SFWMD
Natalie Dahl, Intertek
Dean Dobberfuhl, SJRWMD
Christine Eastwick, U.S. Fish & Wildlife Service
James Einloth, Citizen
Jerry Elsberry, Advanced Biofermentation Services
Yesenia Escribano, FDACS
Julie Espy, SAS
Amanda Exposito-Ferree, Atkins Realis
Chris Fagerstrom, Pond & Company
Jake Fojtik, Florida Farm Bureau
Marcy Frick, Tetra Tech
Felicia Gordian, Sebastian
Raichel Gulde, RES
Samuel Hankinson, DEP
Kenny Hayman, DEP
Laila Hudda, EPA
Dana Hutchinson, Citizen
Danielle Ivey, Audubon
Kelly Jackson, Indian River Pioneer Farms
Chandy John, AECOM
Andrew Kamerosky, Applied Ecology
VJ Karycki, Rockledge
Lisa Krimsky, University of Florida
Tricia Kyzar, University of Florida
James Lappert, St. Lucie County
Ivette Leiva, FDOT
Jack Levy, AECOM
Nicholas Linehan, St. Lucie County
Esteban Lopez, RES
Jonathan Madden, SFWMD
Tom Mayton, SJRWMD
Michael Mccabe, Melbourne Tillman WCD
Bach McClure, Brevard County
Mike McMunigal, SJRWMD
Melissa Meisenburg, Indian River County

Valentina Miele, Florida Oceanographic Society
Gabrielle Milch, St. Johns Riverkeeper
Abigail Morgan, Cocoa
Lori Morris, SJRWMD
Jessica Mostyn, DEP
Natalie Novak, Indian River County
Kevin O'Donnell, DEP
Stacey Ollis, SFWMD
Judy Orcutt, Citizen
Sara Ouly, SFWMD
Josh Papacek, SJRWMD
Ximena Pernett, RES
Jon Perry, ESA
Kimberly Peyton, Rockledge
Nicolas Pisarello, ATM
Elon Poole, Rockledge
Robert Potts, ATM
Erin Preston, SJRWMD
Allyson Reinert, DEP
Sandra Reller, Titusville
Samantha Russo, SJRWMD
Jerome Ryan, SWIG
Jimmy Sellers, Ecological Associates
Kevin Shropshire, Rockledge
Lorae Simpson, SJRWMD
Jennifer Spain, Volusia County
Anita Stine, DEP
Katie Sweetman, Brevard County
Rachel Tennant, Fort Pierce Utilities Authority
Lisa Van Houdt, DEP
Charlie Venuto, Citizen
Rachel Vitek, RES
Shreya Vuttaluru, Tampa Bay Times
Thomas Waite, Citizen
Jessica Wakefield, SFWMD
Michael Walther, Coastal Tech Corp
Benita Whalen, Dispersed Water LLC
Ragan Whitlock, Center for Biological Diversity
Terry Williamson, Brevard County
Laura Yonkers, Indian River County
Kelly Young, Volusia County

SWIL 5.0 Status

There were no questions during this agenda item.

Calibration Efforts & Model Performance

Q: Will a report of the SWIL model be public record associated with the BMAP? The report would help engineers and designers within the BMAP watershed.
A: Yes, this report will be posted, and the prior reports have been posted. The final report on the model will also be posted.

Q: Does the model include the large stormwater and wetland marsh treatments operated by St. Johns River Water Management District (SJRWMD) in the North Fork of the North Prong of the Sebastian River, which would modify flow?
A: The SWIL Model did not account for that. There are a number of water control structures such as the weir on Eau Gallie River. The SWIL estimated loading matched pretty well so those structures did not seem to have significant impact. Adding more information about the structures could be considered for future model development.

Q: How well do the event mean concentrations (EMCs) for subsurface flows in undeveloped land cover/land use match the groundwater well data?
A: When we reviewed the records, we were unable to find enough representative wells to calibrate every land use category. Most of the data were sap les from the Upper and Lower Floridan Aquifer and not surficial groundwater samples. In the Brevard County surficial groundwater data, the natural land cover concentrations matched well with the SWIL output and had low nutrient concentrations. The SWIL Model estimates loading at the mouth of the lagoon, so the upland wells are expected to be representative of the nutrient concentrations at the lagoon. Where we had surficial groundwater samples from areas with natural land uses, the wells matched well with the calibrated data. However, there were a lot of variability in the Brevard County surficial well data associated with developed land uses. For example, some of the areas measured in Brevard County had septic systems and some had sewers. Some areas had wastewater effluent disposal with high nutrient concentrations and some areas had wastewater effluent with lower concentrations. Aggregating those concentrations in developed areas was expected to yield higher concentrations than the modeled concentrations for subsurface concentrations at the lagoon. The purpose of the SWIL Model is not to represent the surficial concentrations at every location in the basin but to capture what the concentration will be when it reaches the lagoon. To date, we haven't put the developed area surficial concentration numbers side-by-side to the subsurface flow concentrations predicted by the SWIL Model because there is attenuation of the loading expected between the developed areas and subsurface water that is discharged to the lagoon. The concentrations were higher than what we ended up as EMCs for subsurface flows into the lagoon. For natural areas, the subsurface concentrations were very close.

Q: What practical level of monitoring is warranted to improve reliability of the SWIL Model as a guide for public policy and total maximum daily loads (TMDLs)?
A: Part of what DEP is achieving with the IRL BMAP updates and the IRL Protection Program is reviewing the monitoring networks and looking at what additional data are needed. If you have feedback for DEP on data needs, please provide that information to Diana Turner. Data are always welcome by modelers when calibrating. However, when modelers use periodic samples (e.g., monthly samples), the data represent one point in time. We are counting on that measurement to represent the conditions for the entire sampling period (i.e., month). More continuous monitoring would be very welcome because then you get a better sense of the variability of the data and how much the periodic samples represent the average conditions. We know that there are spatial differences in the model too that are not always represented by the stations. The estimates are limited by the available data.

Q: The presenter stated golf courses are characterized as "light development." I'm just wondering how that is looked at from a development perspective as they have a high impact on our natural resources. There should be a push for requirements for them to reclaim/reuse their own water on site.

A: DEP can look into that suggestion as we work on the BMAP updates. We are unsure how those requirements would function in the development process. Note that in the SWIL Model, each land use cover has its own EMC, including golf courses. For golf courses, the EMCs for nitrogen and phosphorus are fairly high. The optimization process in the SWIL Model kept the subsurface concentrations of parks and golf courses linked together.

Q: Did you evaluate model calibration performance for total phosphorus (TP) and total nitrogen (TN) using metrics like root mean square error (RMSE), standard error, or other metrics?
A: Keeping in line with prior work by Harvey Harper, we looked at percent bias (PBIAS) to see if the error is within the range of plus or minus 25 percent. We also considered the Nash-Sutcliffe Efficiency (NSE) as described in the presentation. The model creates a month-to-month estimation of flows. More factors could be considered. However, in keeping with prior work, we focused on those two metrics.

Q: Is TP & TN speciation (speciation of pollutants) identified in any studies? Would this information be helpful to understand if biosolids are significant sources?
A: With previous work, we reviewed the literature for EMCs. There were too few studies that provided the details that we would need to speciate the nutrients. In a separate effort, we did a subset of the speciated models, and it was quite difficult. We need more water quality data and more monitoring of EMCs to do that effectively and to calibrate.

Next Steps

Q: Since FDEP is now also looking at loadings to the St. Johns River, is there any consideration to expanding SWIL to the St. Johns Basin?
A: We have not looked at expanding the SWIL Model to the St. Johns Basin, but we could consider that after the next BMAP update and see if that is something we want to do.