MODELING THE HYDRODYNAMIC AND WATER QUALITY IMPACTS OF PROPOSED TAMIAMI TRAIL BRIDGE CONSTRUCTION USING THE M3ENP NUMERICAL MODEL

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Everglades Management

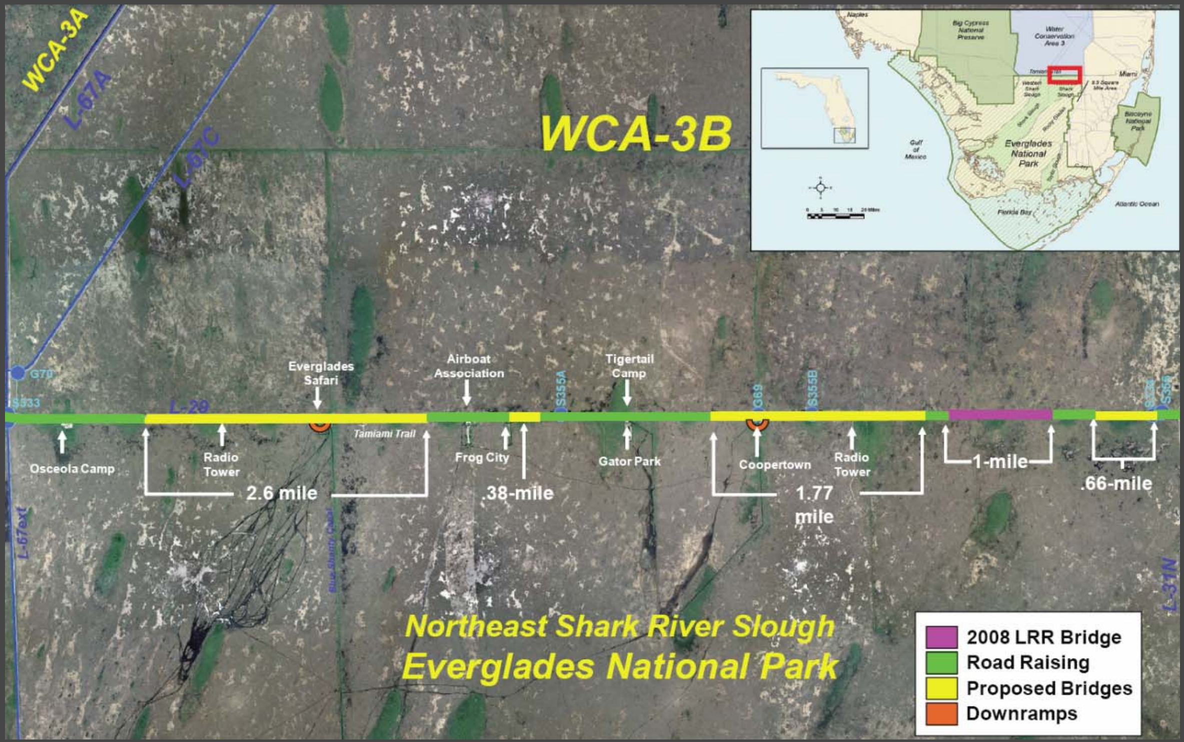
- Changes to the Florida Everglades (drainage, urbanization, and agricultural development) have led to the alteration of hydropatterns and hydroperiods which are critical for maintaining a variety of Everglades ecosystems.

- Water management decisions made now have a direct and measurable impact on Everglades habitat and species diversity.

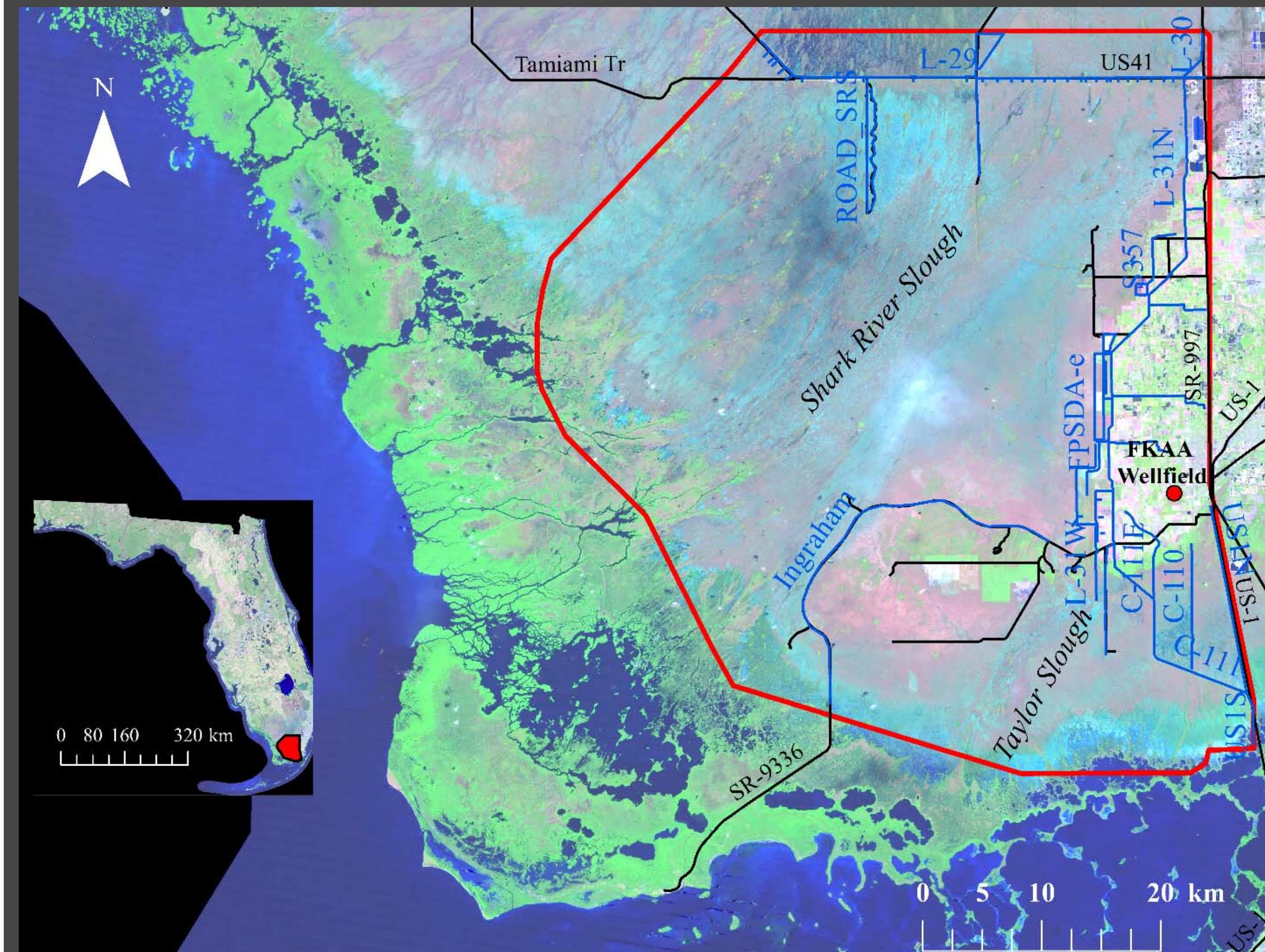
- It is important to quantify the effects of these water management decisions to ensure their effectiveness and limit their negative environmental impacts.

Proposed Restoration Efforts

- The Tamiami Trail and L-29 Canal impede the flow of water to Northeast Shark River Slough
- Several restoration scenarios have been proposed:
  - A 1-mile bridge has been constructed
  - A 2.6-mile bridge has been approved for design
  - An increase in L-29 canal water levels to provide a greater head difference, intended to promote the flow of water into NESS



MIKE Marsh Model of Everglades National Park (M3ENP)



- MIKE SHE/11 software
  - Coupled surface/ sub surface hydrological model
- 2,720 sq km
- 400 m resolution
- Includes portions of:
  - ENP
  - WCA 3a/3b
  - Agricultural areas

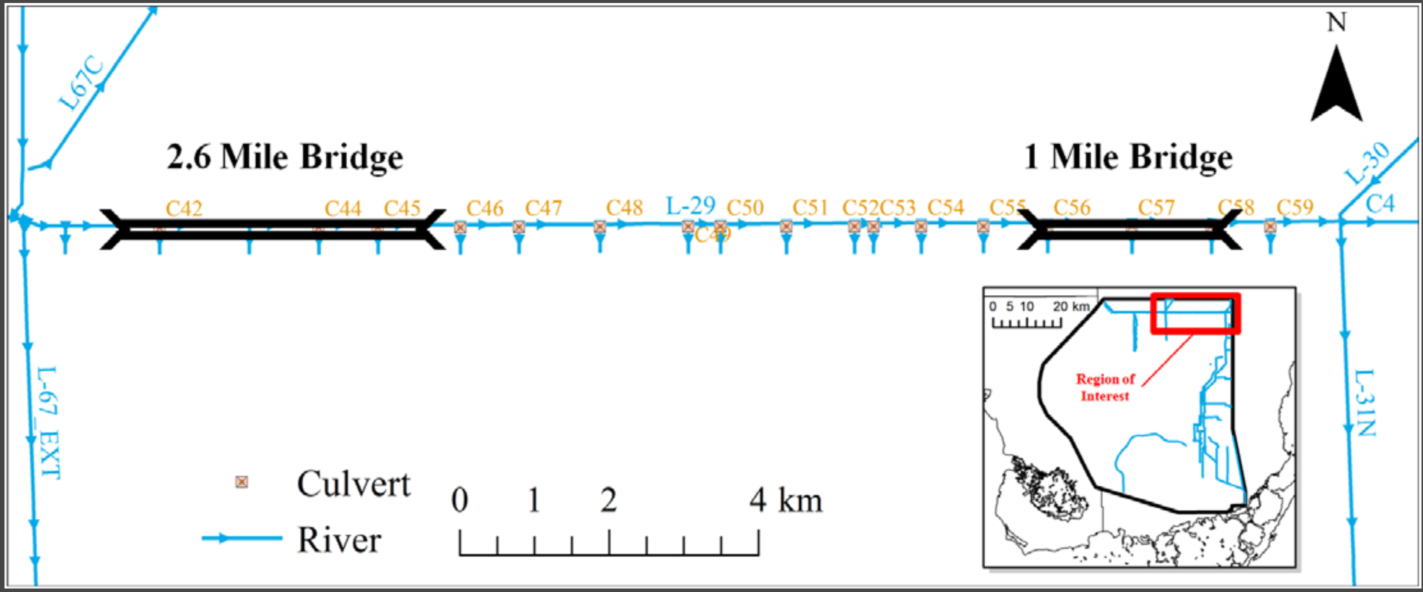
M3ENP Inputs

- Climate
  - Precipitation: gridded daily from SFWMM
  - PET: uniform daily
- Land Use
  - Vegetation: USGS GAP survey
- Channel Flow
  - 73 canals, 13 weirs, 19 culverts, and 65 gates
- Overland Flow
  - Topography
  - Manning's roughness
- Unsaturated Zone Flow
  - Soil types and parameters: NRCS and USGS
  - Marl, Gandy Peat, Everglades Peat, Mangrove Peat, and Rockdale
- Saturated Zone Flow
  - Hydrogeology simplified into a 2-layer subsurface
  - Miami Oolite – up to 6m deep
  - Biscayne Aquifer – up to 70m deep

Model Calibration performed with over 100 wetland observation locations; more than 40 gates, pumps, and culverts; surface and subsurface discharge; canal stage

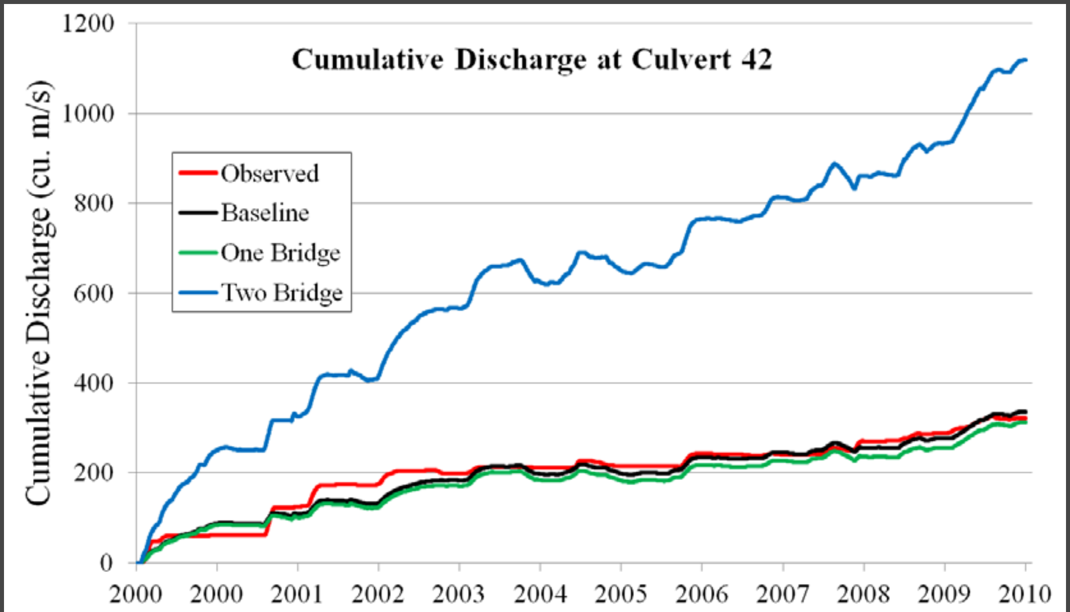
Model Scenarios

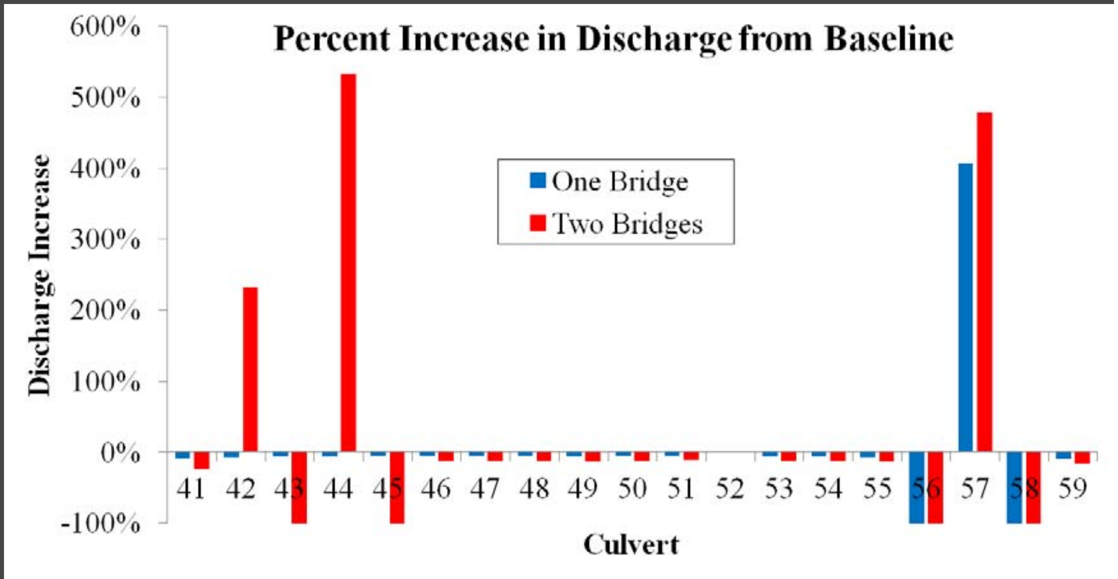
- **Baseline** – calibrated model (no bridges)
- **One Bridge** – Addition of the 1 mile bridge
- **Two Bridges** – Addition of the 1 and 2.6 mile bridges



Discharge from canals

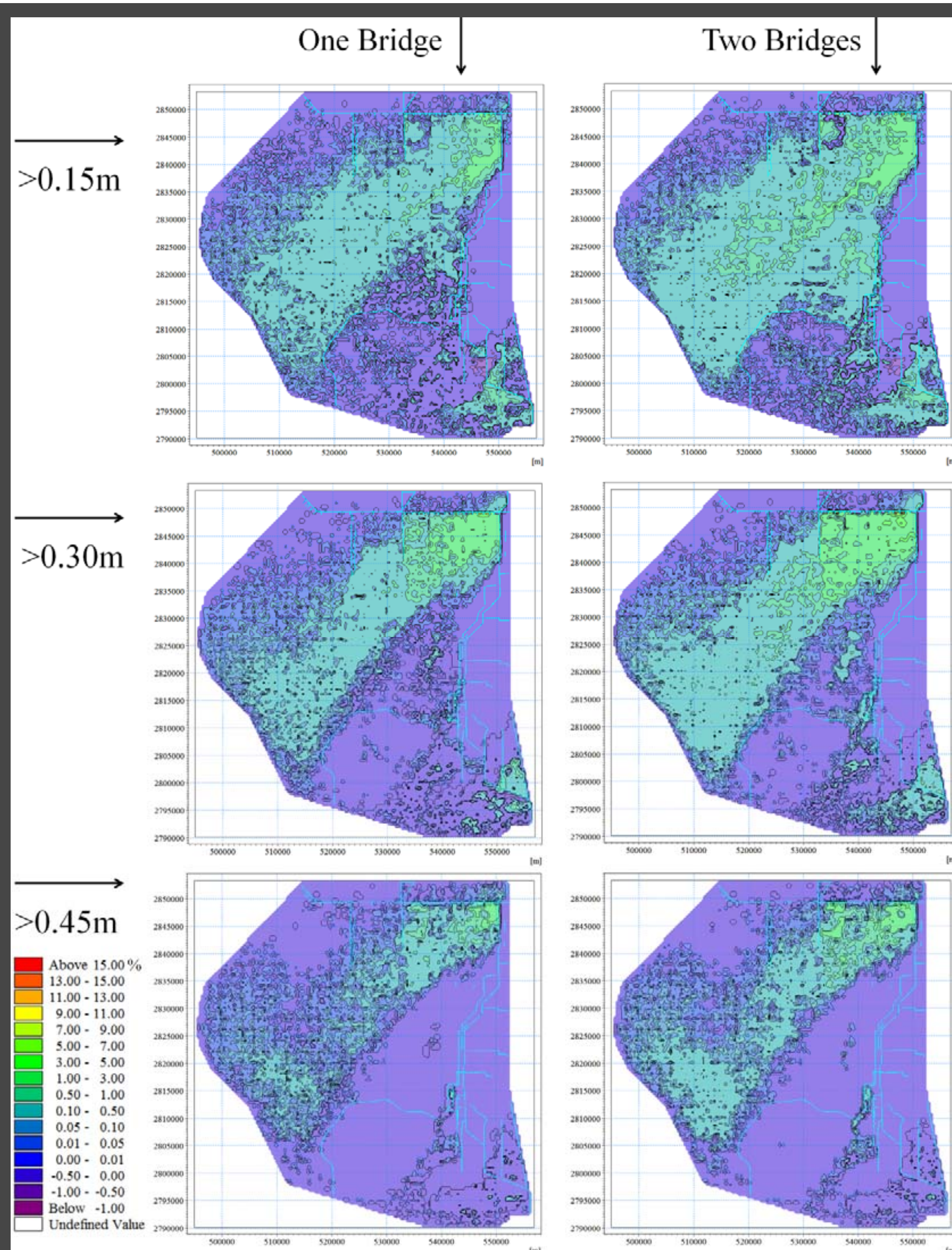
- One Bridge Scenario:
  - Discharge to NESS increased by 5.59%
  - 35,800 kAF of water enters the park annually
- Two Bridge Scenario
  - Discharge to NESS increased by 10.36%
  - 66,400 kAF of water enters the park annually





Probability Exceedence

- Probability exceedence is the percent probability that the cell will experience water levels above a specified value in the simulation period
- One Bridge and Two Bridge exceedences were subtracted from that of the Baseline
- Largest increase in water depth exceedence occurs in NESS, Shark Slough, and in some areas of Taylor Slough for the Two Bridge Scenario

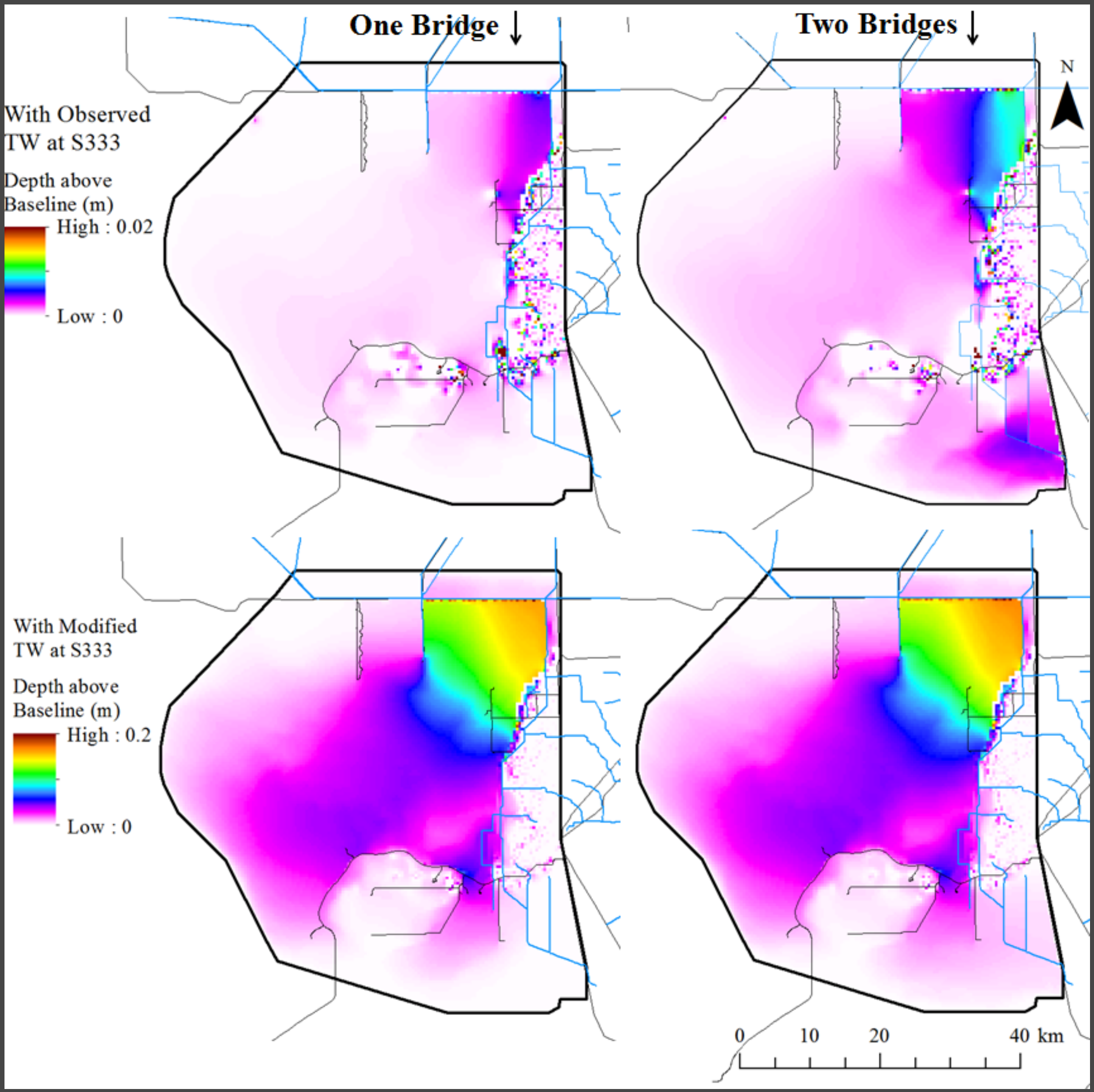


Probability Exceedence (cont.)

Exceedance Threshold	Scenario	Area inundated for 1 day annually more than baseline (sq km)	Area inundated for 2 days annually more than baseline (sq km)
>0.15 m	One Bridge	325	107
	Two Bridges	755	284
>0.30 m	One Bridge	295	166
	Two Bridges	531	261
>0.45 m	One Bridge	97	38
	Two Bridges	177	92

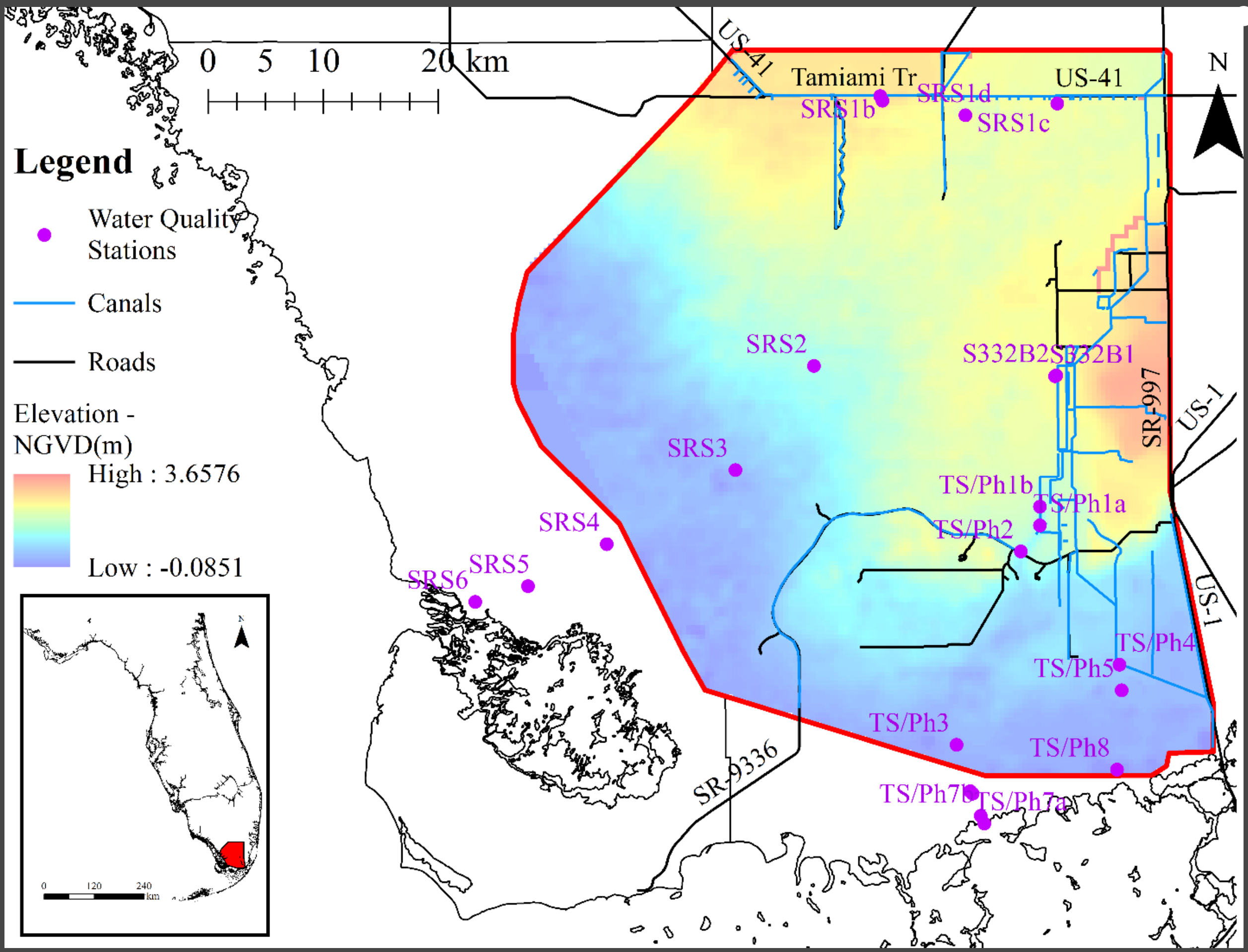
- 284 sq km (110 sq mi) of ENP will flood for an additional 2 days annually at a depth of 0.15m (0.5 ft) with the construction of the 1-mile and 2.6-mile bridges

Effects of Canal Water Level Increases



The modified tailwaters at S333 produced a gradient in the One Bridge and Two Bridge Scenarios which increased surface water levels (up to 21 cm) and hydroperiods more than bridge construction alone.

Water Quality Concerns



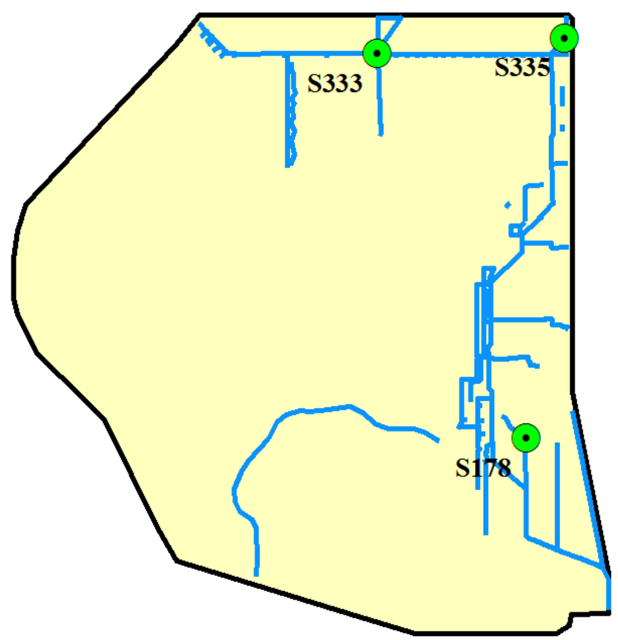
Phosphorus data monitoring sites (FCE-LTER)

- Everglades ecosystems are adapted to low P concs.
  - How will the implementation of bridges and raised canal elevations impact P levels in ENP?

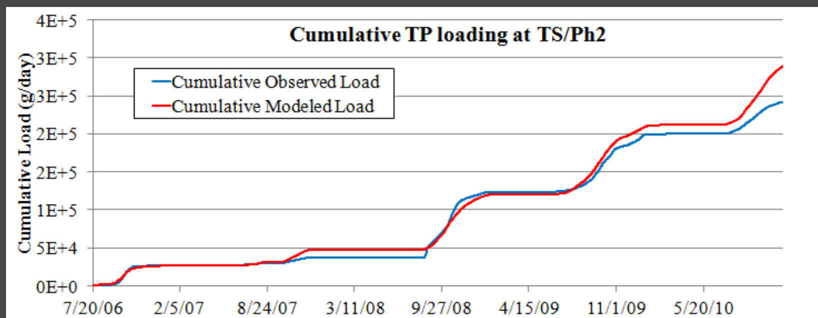
M3ENP-AD Model Development

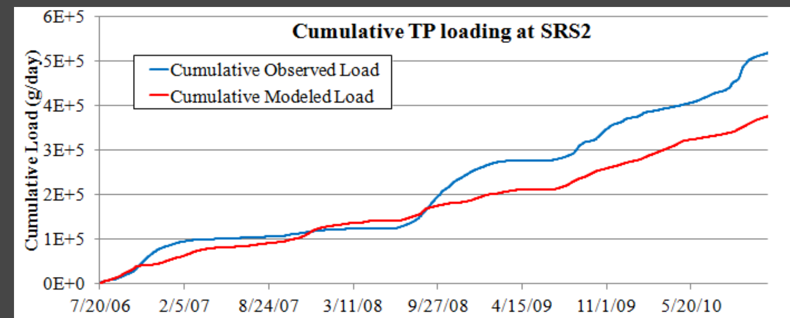
- Advection-Dispersion-Reaction Equation
- Phosphorus inputs from two sources:
  - Canal Boundary conc at stations S333, S335, and S178
  - Atmospheric Deposition

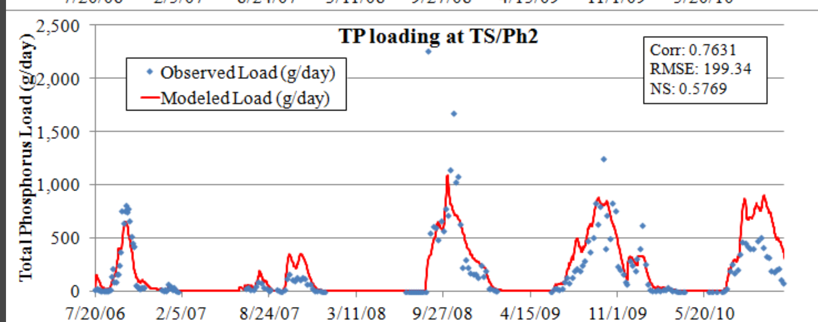
Parameter	Units	Value
Canal Dispersivity, a	m^2/s	15.0
OL Longitudinal Dispersion Coefficient, D_L	m^2/s	0.0001
OL Transverse Dispersion Coefficient, D_T	m^2/s	10^{-5}
Linear Sorption Coefficient, k_D	m^3/g	0.007 – 0.07
Wet Atmospheric Deposition, TP_{rain}	mg/L	0.0017
Dry Atmospheric Deposition, TP_{drydep}	g/day	13.2

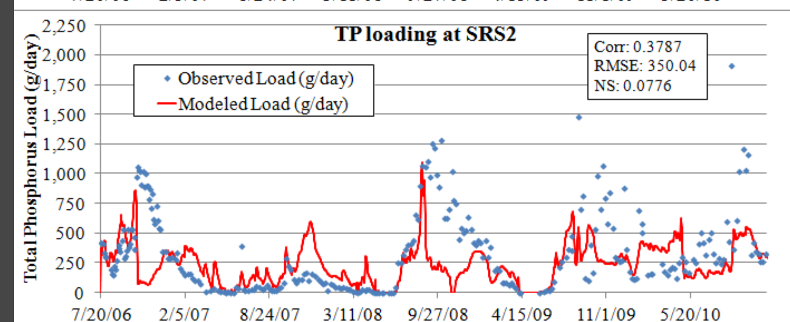


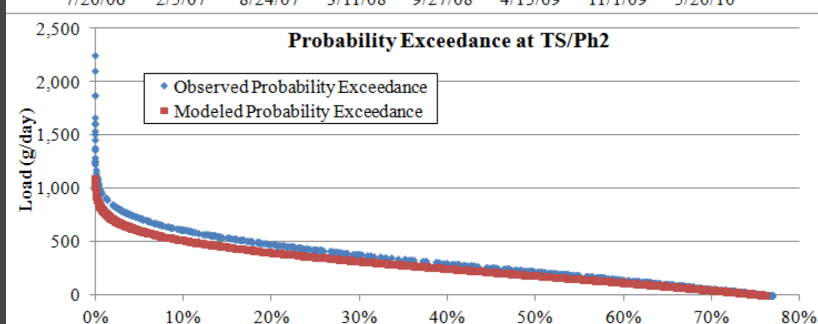
Model Calibration

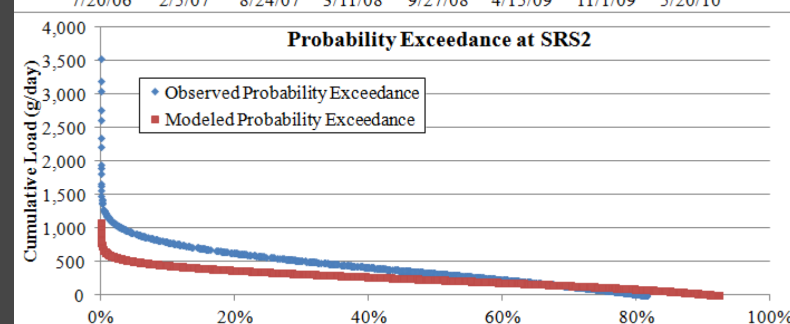






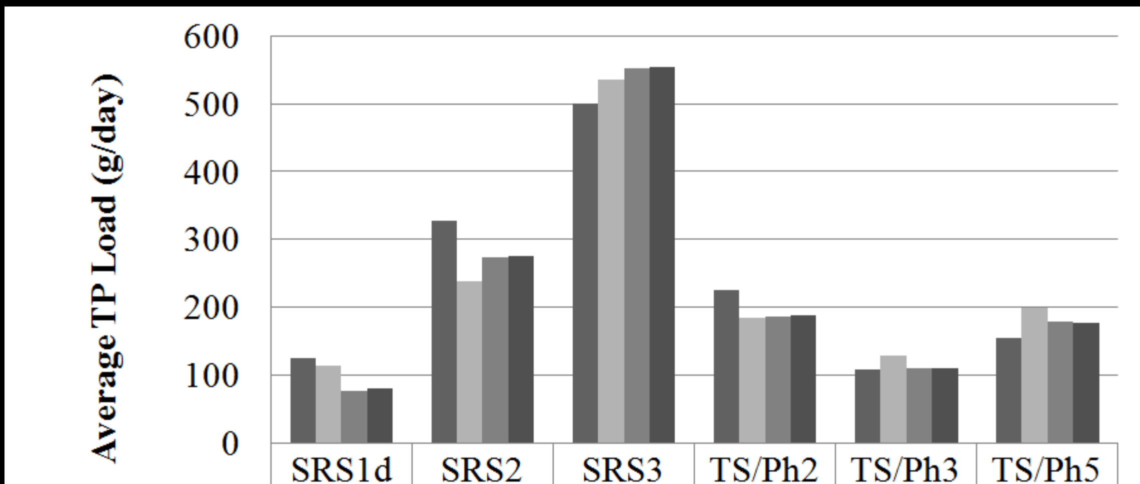






Results

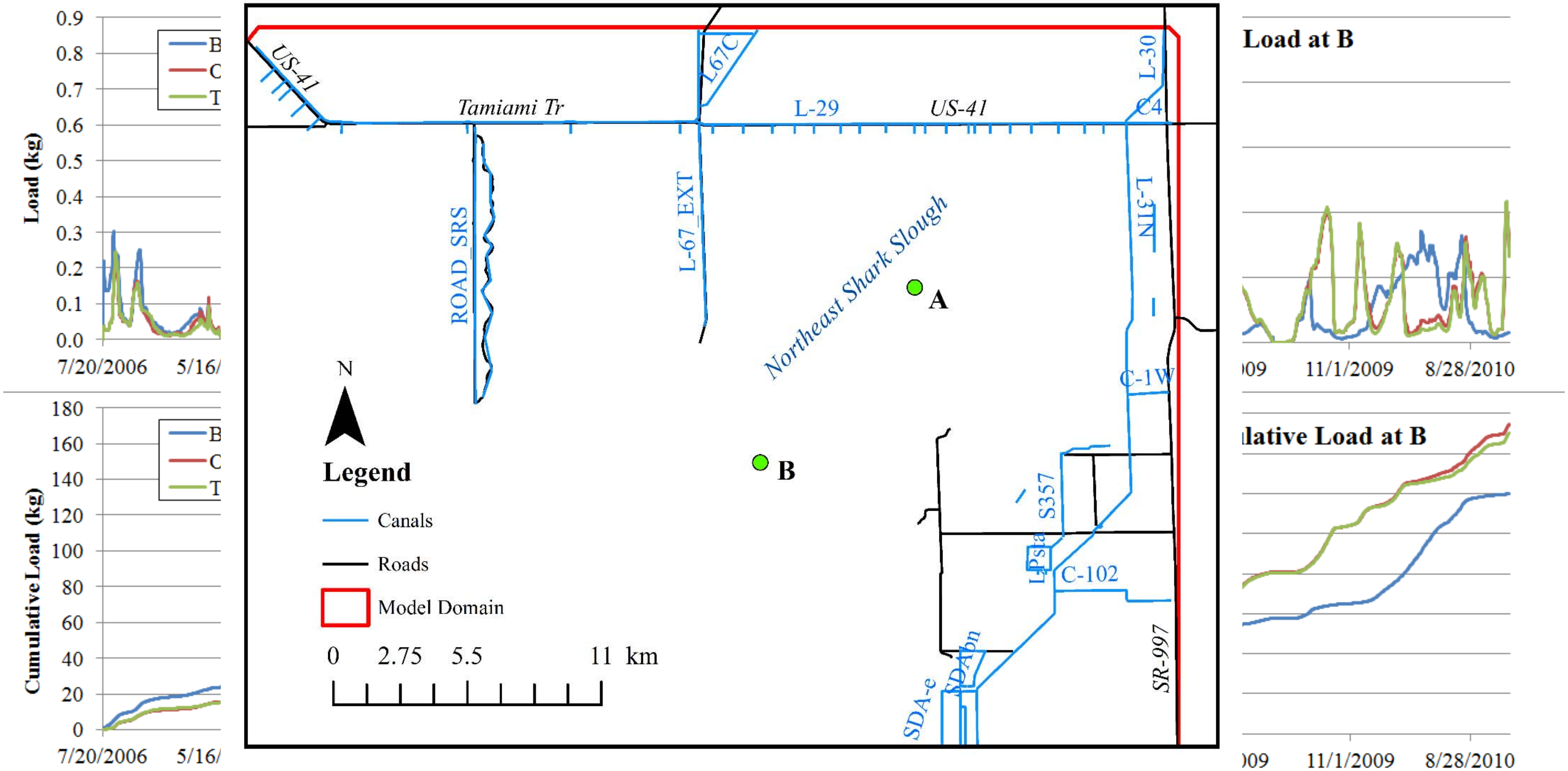
	Overland Concentration (mg/L)		Overland Mass (g/m^2)	
	One Bridge	Two Bridges	One Bridge	Two Bridges
Total Change	-4.62%	-3.95%	-14.35%	-14.80%
Avg. Dry Season	-3.59%	-2.76%	-11.20%	-11.75%
Avg. Wet Season	-4.58%	-4.10%	-13.59%	-14.11%



	SRS1d	SRS2	SRS3	TS/Ph2	TS/Ph3	TS/Ph5
Observed	125.45	326.57	500.70	226.13	107.82	155.05
Baseline	114.31	237.62	535.53	183.69	128.26	198.55
One Bridge	76.54	273.53	551.49	186.34	110.97	178.79
Two Bridges	80.32	275.67	553.59	187.23	110.99	176.12

- Over the whole model domain
  - Decrease in concentration and loading
- For WQ monitoring sites
  - Decrease in TP load near canals
  - Increase in TP load toward the interior

Results (cont.)



Conclusions

- The M3ENP model was used to determine changes in flow to ENP with the construction of bridges.
  - Bridge scenarios showed an increase in discharge to NESS and increased hydroperiods in large areas of the Park.
  - Increasing L-29 canal water levels by up to a foot increased interior surface water levels. This strategy showed a greater increase in surface water levels than with bridge construction alone.

- The M3ENP-AD model was used to determine how changes in flow with the introduction of bridges and increased L-29 water levels may impact TP loading to ENP.
  - M3ENP-AD showed that proposed bridges and canal stage increases will decrease TP conc and mass per area over the entire model domain.
  - NESS experienced an increase in cumulative TP load of about 30%
  - M3ENP-AD model provides a tool which can simulate the transport of a key nutrient in the Everglades system and provide insight toward the effects of future restoration efforts

Publications

- Cook, A., 2012. Development of an integrated surface and subsurface model of Everglades National Park. FIU Electronic Theses and Dissertations. Paper 634. URL: http://digitalcommons.fiu.edu/etd/634
- Long, S., 2014. Simulating Everglades National Park hydrology and phosphorus transport under existing and future scenarios using numerical modeling. FIU Electronic Theses and Dissertations. Paper 1543. URL: http://digitalcommons.fiu.edu/etd/1543
- Long, S.A., Cook, A.M., Tachiev, G.I., Villamizar, V., Fennema, R., Kotun, K., Miralles-Wilhelm, F., Submitted to Journal of Hydraulic Engineering. Analysis of bridge construction as a hydrological restoration technique for Everglades National Park, FL, USA using hydrological numerical modeling.
- Long, Stephanie A., Georgio I. Tachiev, Robert Fennema, Amy M. Cook, Michael C. Sukop, Fernando Miralles-Wilhelm. Modeling the impact of restoration efforts on phosphorus loading and transport through Everglades National Park, FL, USA. Science of The Total Environment. Volume 520. http://dx.doi.org/10.1016/j.scitotenv.2015.01.094
- GEER Poster #18 – Georgio Tachiev et. al.

Acknowledgements

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FIU Applied Research Center

NASA WaterSCAPES

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