REFINING FLOW RESTORATION TO WORK WITH THE LANDSCAPE

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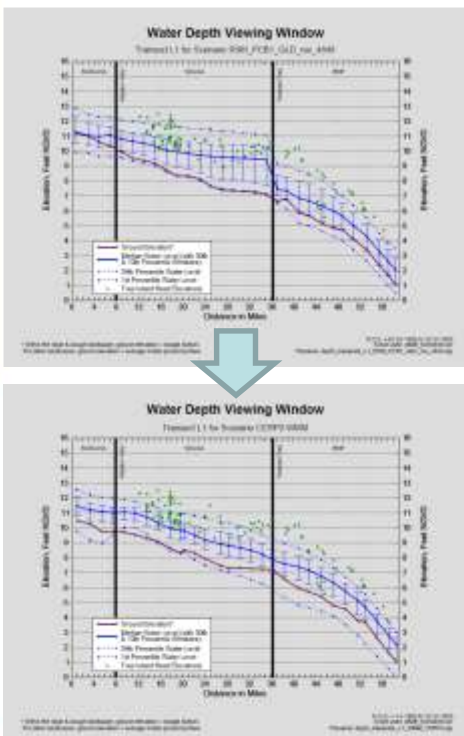
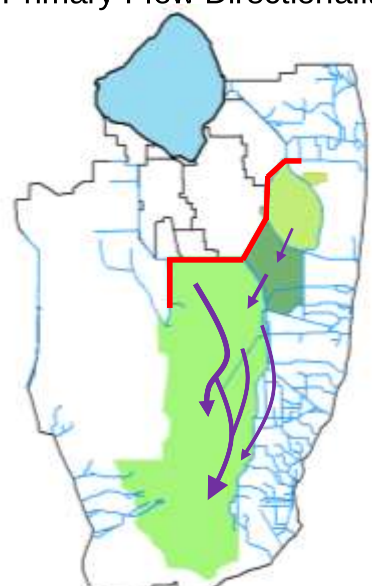
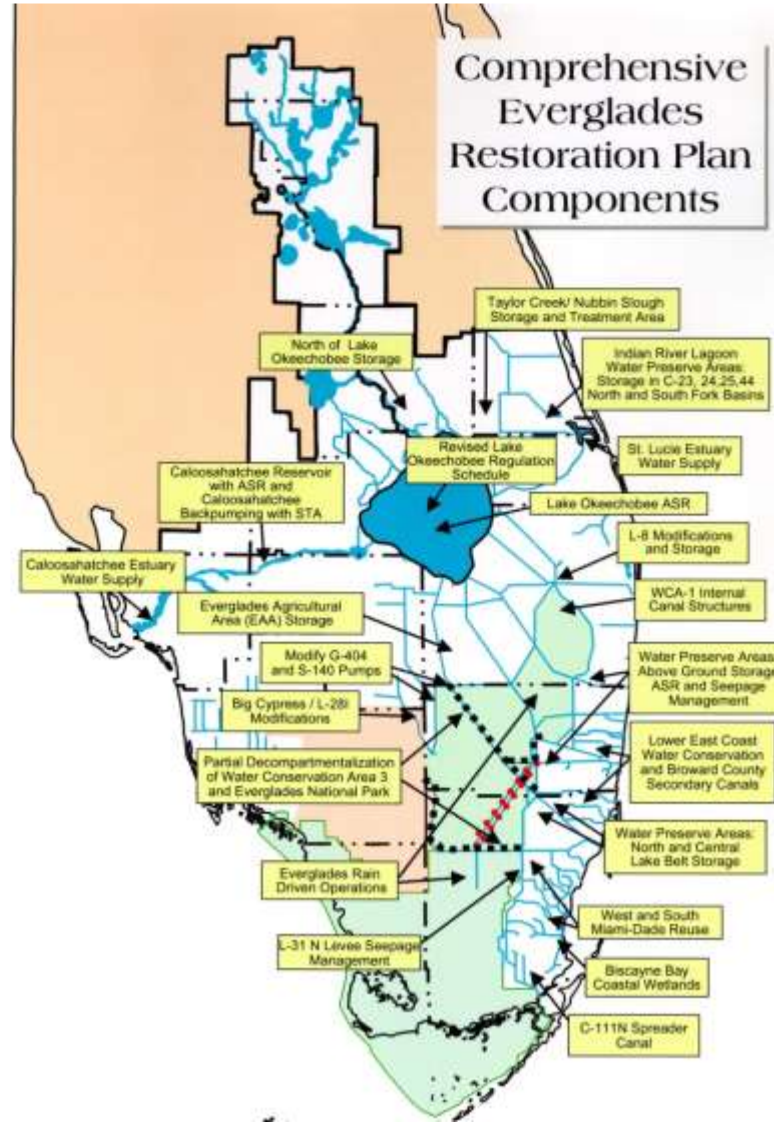
Comprehensive Everglades Restoration Plan (CERP)

- Storage/STAs/ASR
- Canals/Structure modifications
- System Operations
- Decompartmentalization
- Seepage Management



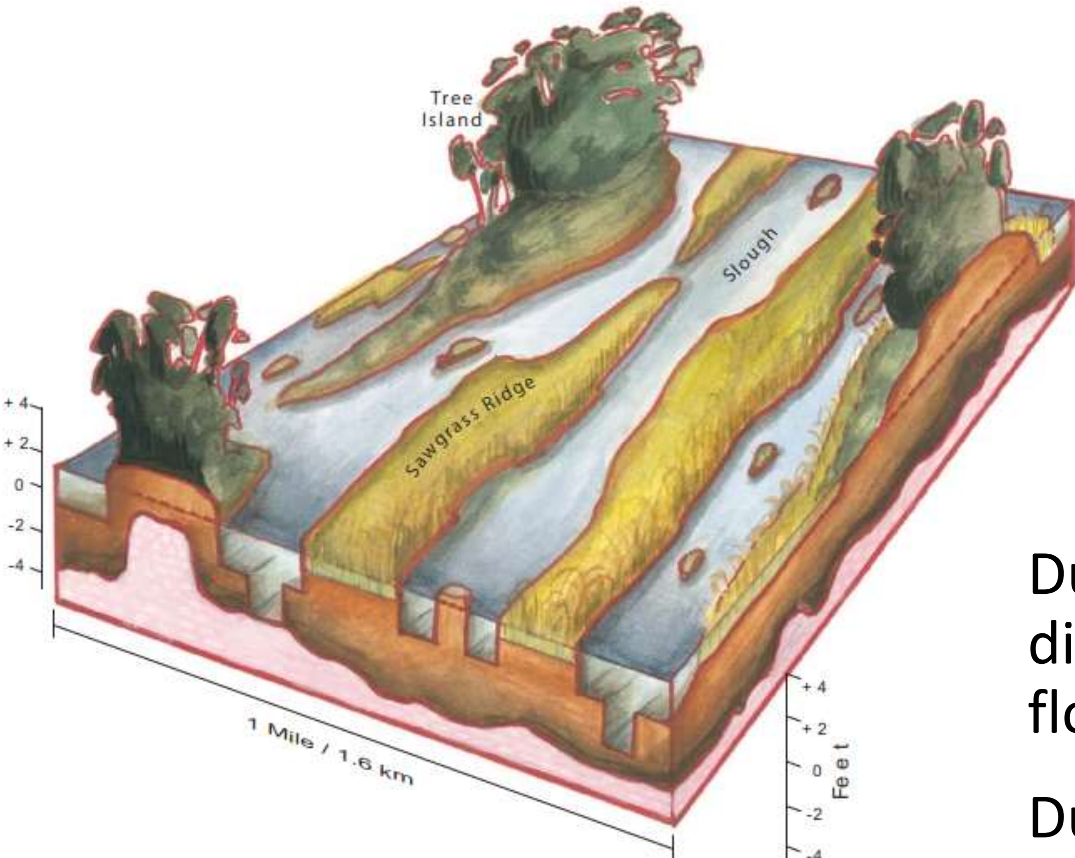
System Configuration & Primary Flow Directionality





The Unique Everglades Ridge & Slough Landscape

Pre-Drainage Ridge & Slough Landscape Pattern (~50% Slough)



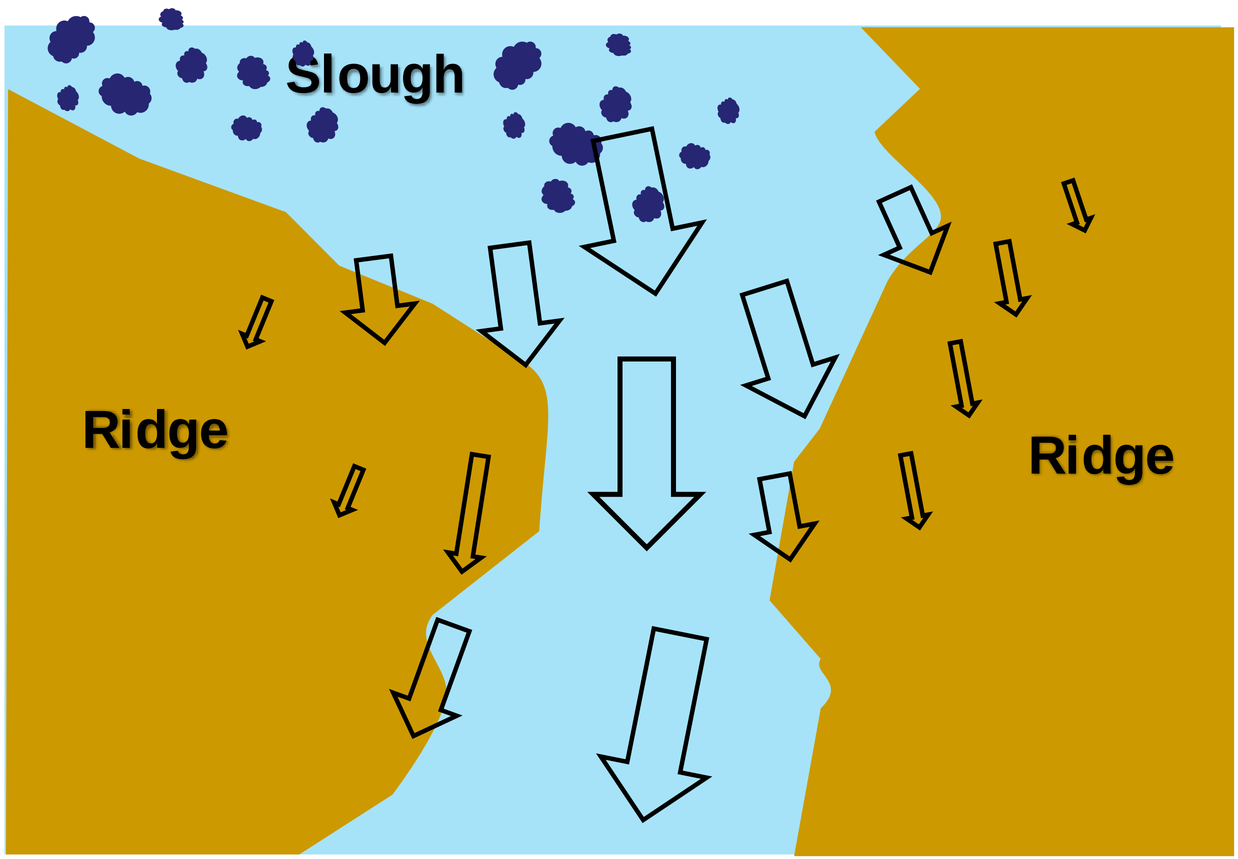
During the wet season, flows distribute nutrients, food and floc (Everglades “topsoil”)

During the dry season, wading birds feed in the sloughs and nest in the tree islands

Why Do We Care About Flow and Velocities?

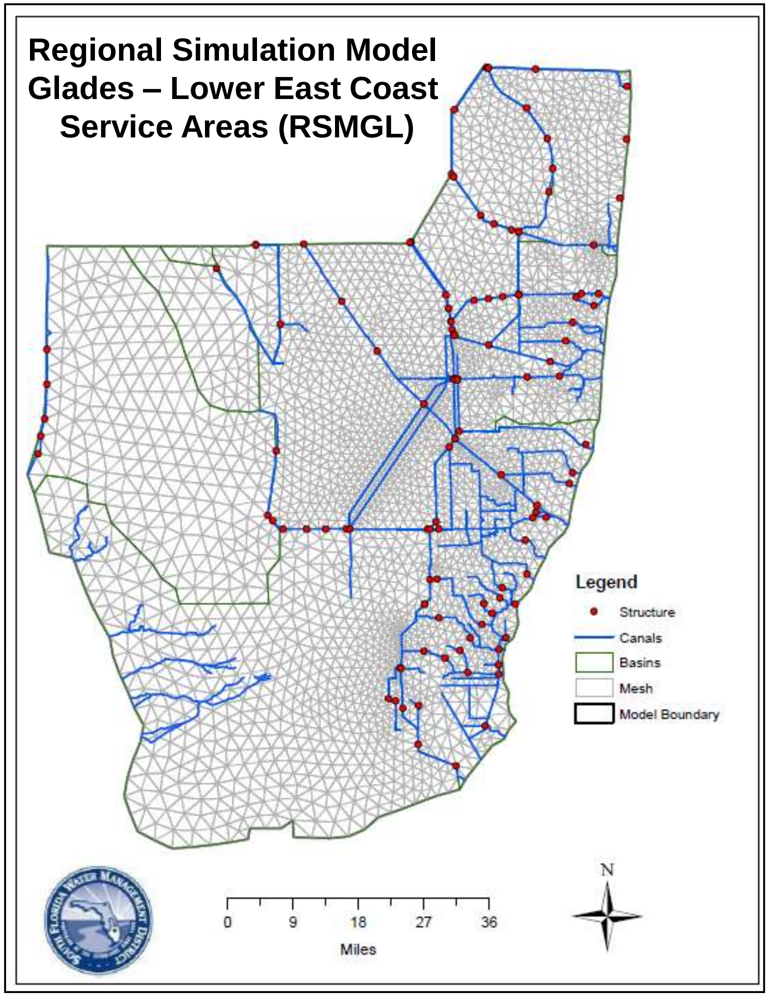
Among Other Reasons…

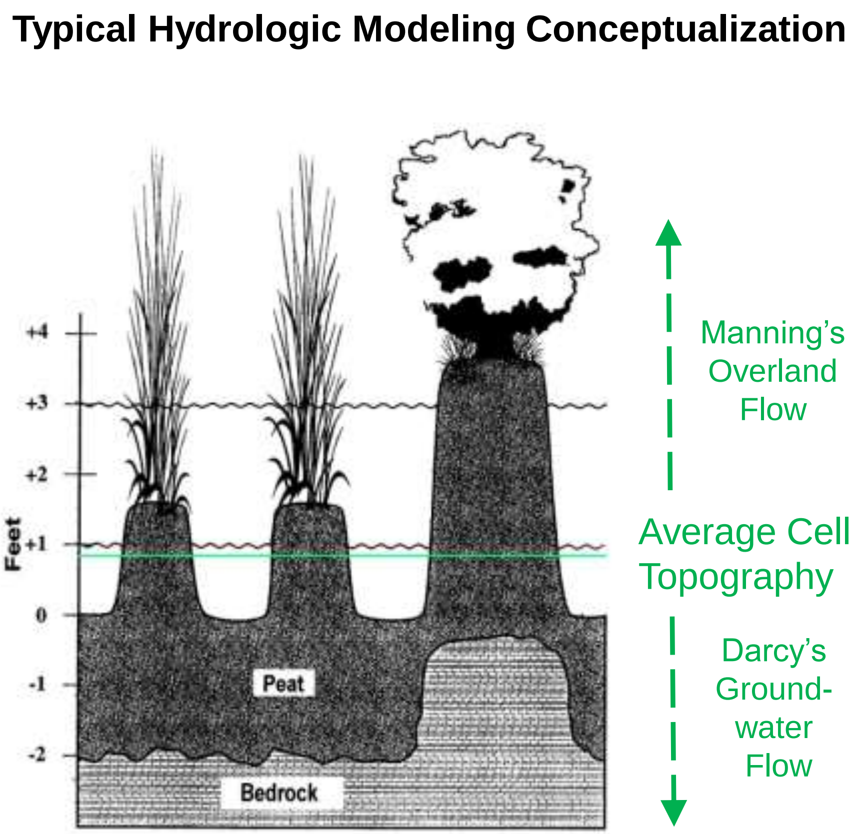
- Restoration flows are needed to rebuild ridge and slough topography.
- Sustained flows increase slough velocities and sediment transport.
- Surface water flows are not following the historic ridge and slough flow-paths.

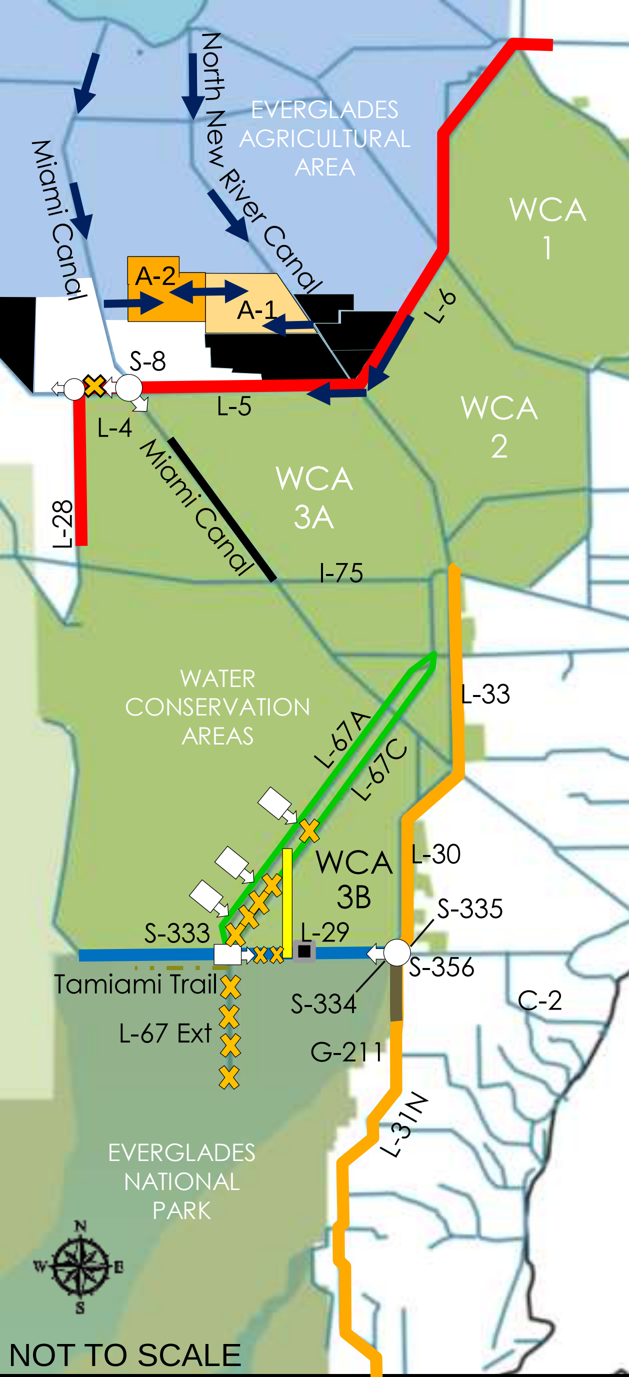


Current CERP Hydrologic Modeling Approaches

Currently, CERP hydrologic planning models typically have one average topographical elevation for each model cell.







CENTRAL EVERGLADES SELECTED PLAN

STORAGE AND TREATMENT

- Construct A-2 FEB and integrate with A-1 FEB operations
- Lake Okeechobee operation refinements within LORS

DISTRIBUTION/CONVEYANCE

- Diversion of L-6 flows, Infrastructure and L-5 canal improvements
- Remove western ~2.9 miles of L-4 levee (west of S-8 3,000 cfs capacity)
- Construct 360 cfs pump station at western terminus of L-4 levee removal
- Backfill Miami Canal and Spoil Mound Removal ~1.5 miles south of S-8 to I-75

DISTRIBUTION/CONVEYANCE

- Increase S-333 capacity to 2,500 cfs
- Two 500 cfs gated structures in L-67A, 0.5 mile spoil removal west of L-67A canal north and south of structures
- Construct ~8.5 mile levee in WCA 3B, connecting L-67A to L-29
- Remove ~8 miles of L-67C levee in Blue Shanty flowway (no canal back fill)
- One 500 cfs gated structure north of Blue Shanty levee and 6,000-ft gap in L-67C levee
- Remove ~4.3 miles of L-29 levee in Blue Shanty flowway, divide structure east of Blue Shanty levee at terminus of western bridge
- Tamiami Trail western 2.6 mile bridge and L-29 canal max stage at 9.7 ft (FUTURE WORK BY OTHERS)
- Remove entire 5.5 miles L-67 Extension levee, backfill L-67 Extension canal
- Remove ~6 mile Old Tamiami Trail road (from L-67 Ext to Tram Rd)

SEEPAGE MANAGEMENT

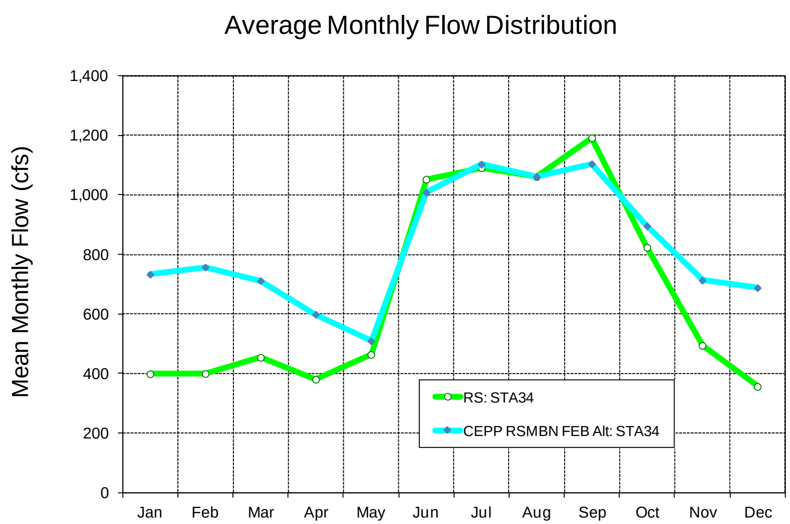
- Increase S-356 pump station to ~1,000 cfs
- Partial depth seepage barrier south of Tamiami Trail (along L-31N)
- G-211 operational refinements; use coastal canals to convey seepage

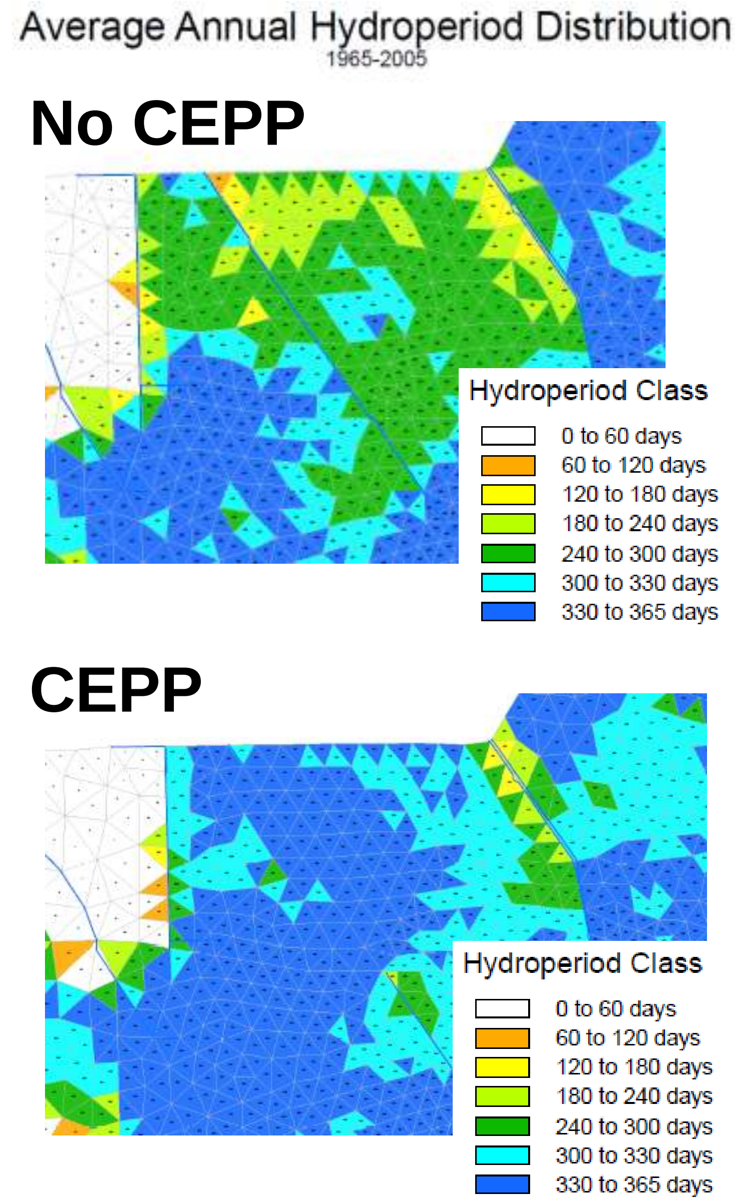
Note: System wide operational changes and adaptive management considerations will be included in project

FEB | STA | Pump | Old Tamiami Trail Removal
Backfill | Levee Removal | Gated Structure
Seepage Barrier | Divide | Levee

Restoration Progress: Central Everglades (CEPP) Outcomes

- **Central Everglades provides ~ 200 kac-ft of additional flow to the Everglades over a long-term period of simulation**
- **Most CEPP restoration flow is provided in the dry season; these flows help to extend hydroperiods and avoid soil oxidation and muck fires**
- **Next steps in Everglades restoration will need to establish sustained flows that provide adequate velocities for desired landscape - scale processes**





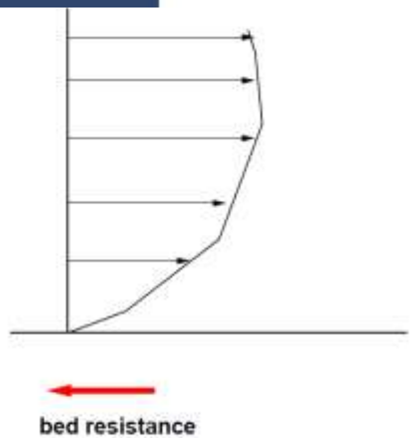
The Complexities of Modeling Flow Mechanics…

Current RSMGL Overland Flow Formulation:

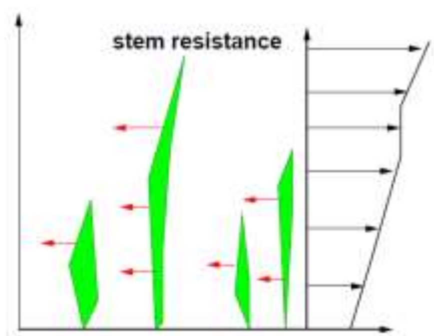
$$Q = \frac{L}{n} d^{\frac{5}{3}} \sqrt{S}$$

where

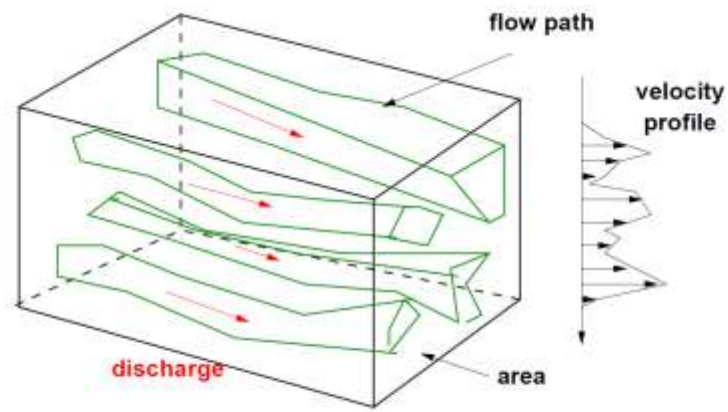
Q	=	volumetric flow rate,	d	=	ponded depth, and
n	=	Manning's roughness coefficient,	S	=	water surface slope.
L	=	width of flow,			



(a) Velocity profile for Manning's equation



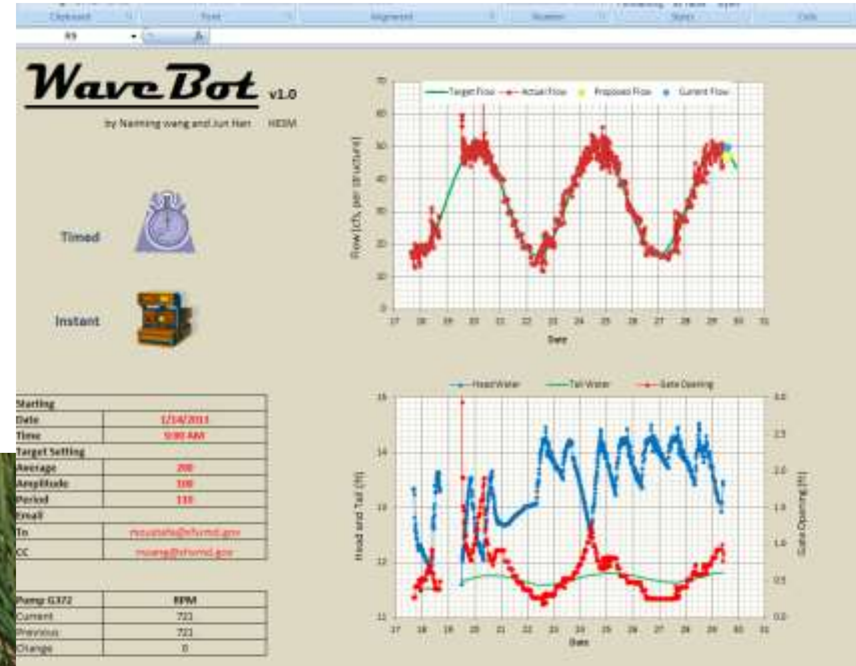
(b) Velocity profile for flow resisted by stem drag



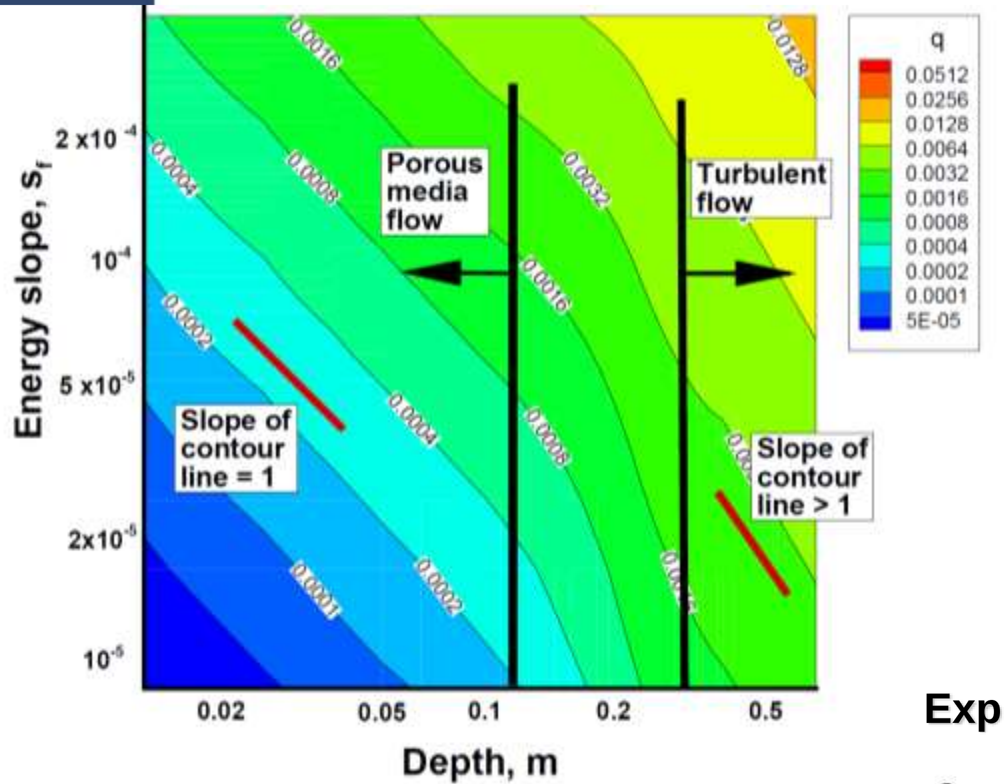
bulk velocity = total discharge / area

This is Closer to Reality – How Do We Get Here?

Field Tests Using Structured "Waves" in Everglades Stormwater Treatment Areas (STAs)



Improving Flow Algorithms Using Outcomes of STA Vegetation Field Tests



- **Improved surface-water flow equations can be conceptualized as depth-dependent power functions (Lal, et al.)**
- **Builds upon work by Kadlec, Nepf and others to benchmark performance and better capture the dynamics of flow in vegetated landscapes like the Everglades**

Expressed as a multi-zone power function:

$$Q_0 = 900 \text{ cfs}, \; d \approx 0.41 \text{ m:} \quad Q = B\frac{1}{0.995}d^{0.856}s_f^{0.49}$$

$$Q_0 = 650 \text{ cfs}, \; d \approx 0.26 \text{ m:} \quad Q = B\frac{1}{0.192}d^{1.426}s_f^{0.58}$$

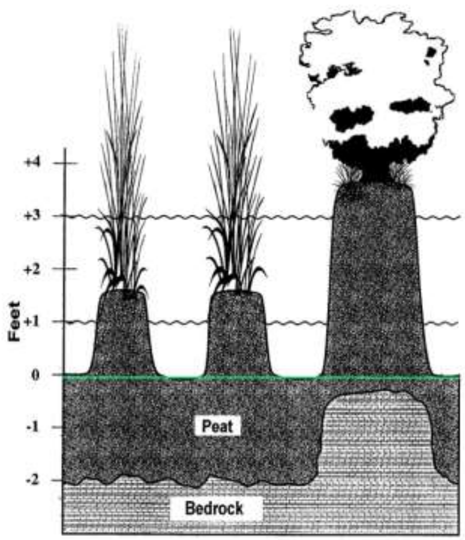
$$Q_0 = 200 \text{ cfs}, \; d \approx 0.10 \text{ m:} \quad Q = B\frac{1}{0.026}d^{0.951}s_f^{0.88}$$

If you want only one equation:

$$Q = B\frac{1}{0.3887}d^{0.95052}s_0^{0.58388}$$

Additional Improvements: Accounting for Micro-Topography

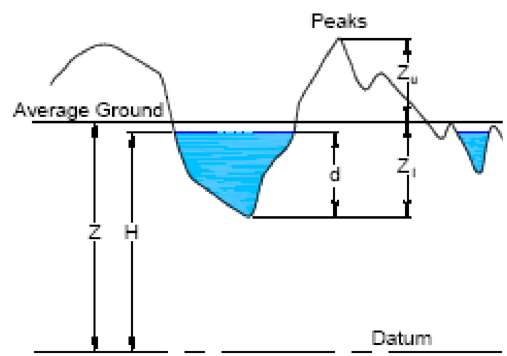
In addition to improved flow algorithms, techniques for capturing the volume / depth effects of micro-topography have already been explored in the development of the Natural System RSM model (Said and Brown)

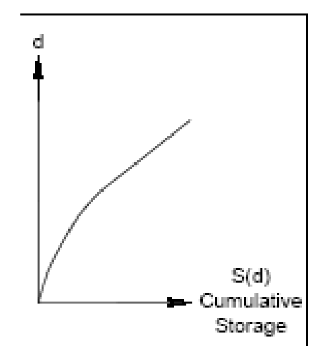


Depth Referenced at Slough Bottom, not Average Cell Topography

Location	Elevation	Percentage
Slough	0.0	46%
Ridge	1.5 - 1.75	46%
Bay Head	3.0 - 3.5	3%
Tree Island	3.0 - 3.5	5%

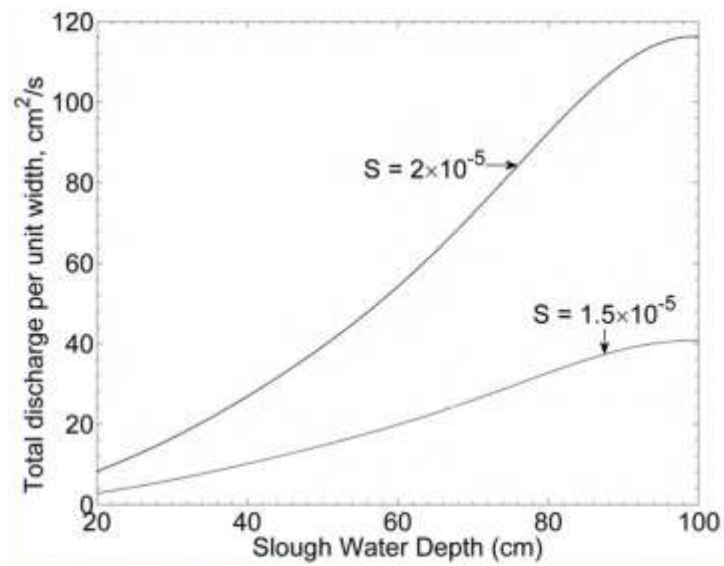
- **Volume of water in a cell below land surface:**
  - **$(H - Z_B)\ S_c$**
- **Volume of water in a cell above land surface:**
  - **$(H - Z) + (Z - Z_B)\ S_c$ where,**
  - **H = head**
  - **Z = land surface**
  - **Z_B = bottom of aquifer**
  - **S_c = storage coefficient**



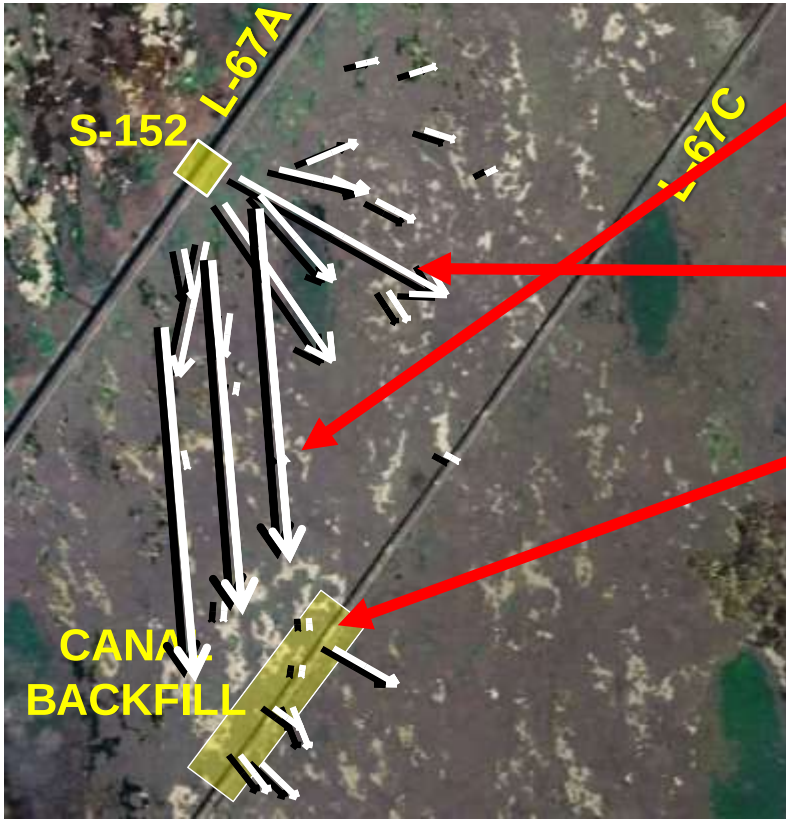


The Importance of Ongoing Research

- As hydrologic modeling algorithms improve, there are increasing opportunities to evolve not just the modeling tools' ability to represent the system, but also to improve the predictive ability of the modeling to inform desired restoration actions.
- Ongoing research, field experimentation and collaboration provide the path forward.
- For example: Larsen and Harvey rate law (example shown) accounts for both flow change and ecological changes (vegetation type, biomass, and frontal area).
- Curve such as these could provide "soft" calibration targets for modeling as well as a means to translate hydrologic outputs into meaningful performance measures.



Understanding Flow Behavior: DECOMP Physical Model



- Flows did not follow the ecologically preferred pattern
- Velocities across the pocket ranged from 2 -10 cm/sec
- High flows were detected in the gap in the L-67C

Summary and Next Steps

- Current CERP progress and planning have been informed by hydrologic modeling tools that somewhat simplify flow dynamics associated with the complex Everglades ridge and slough landscape.
- Due to the nature of restoration efforts to date (focused on hydroperiod extension and dry season flows), these completed plans (e.g. CEPP) are robust and well informed by the existing modeling tools.
- To inform ongoing restoration efforts which will seek to establish sustained flows and higher velocities needed to restore ridge and slough landscape, CERP modeling tools must evolve.
- A variety of efforts will be leveraged to improve model algorithms and benchmark behavior based on the outcomes of ongoing research efforts (e.g. USGS efforts and the CERP DECOMP Physical Model project).

In the Future…

Hopefully – this will not be the only performance graphic informing CERP's path forward…