Active Water Management within the Lake Mattamuskeet Watershed: One Year Later

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Presenting Today

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- Project Manager | Project Engineering Design | Wetland Siting and Capacity Analysis | Consultation and Oversight | Stakeholder Engagement

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Other Team Members:

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- Coastal Protection Engineering
- Watershed-Scale H&H Model

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- Geosyntec
- Assistant Project Manager | Project Engineering Design | Stakeholder Engagement

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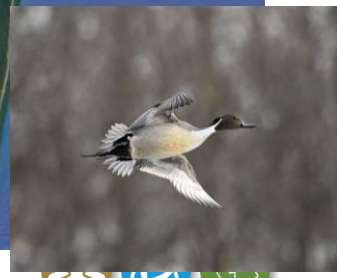
- Geosyntec
- Project Director

Introduction to Lake Mattamuskeet

- North Carolina's largest lake (40,000 acres; once 110,000 ac)
- Low relief: max 9 ft MSL in watershed
- Extensive hydrologic modifications (ditches/drains in area)
- 4 major canals cut to drain lake from 1800's –1930's
- Value of the lake

Lake Mattamuskeet Watershed Restoration Plan

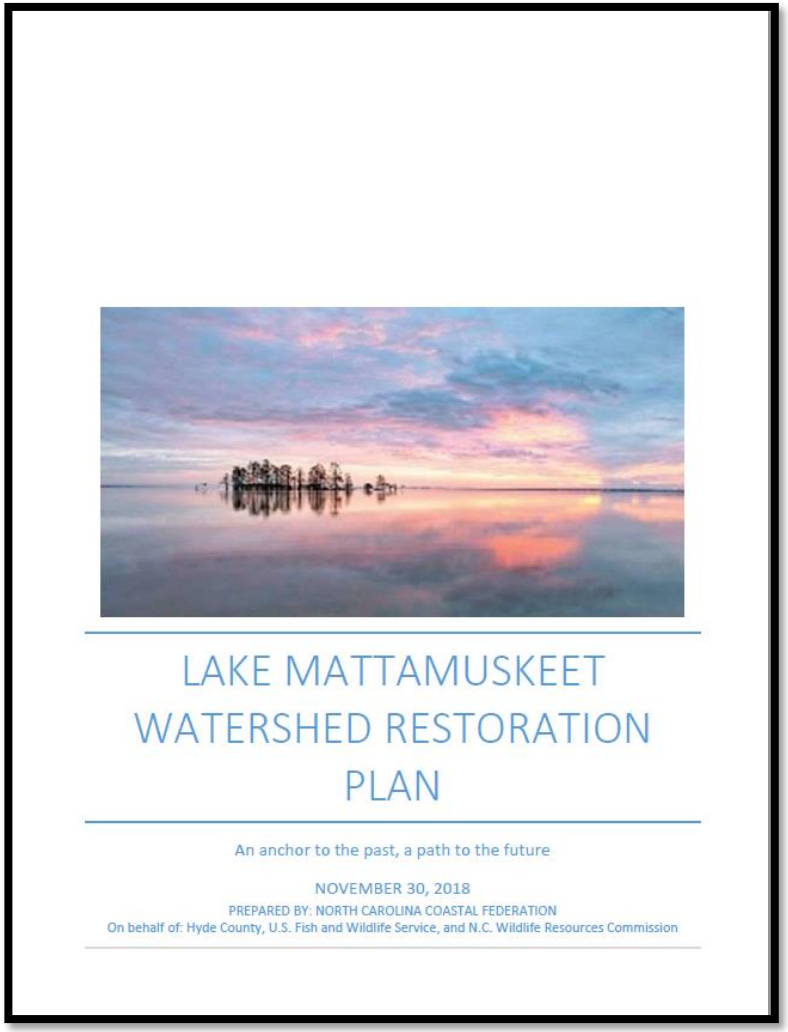


Present-Day Concerns for the Lake

- Lake not actively managed – gravity/tide gate-controlled canal drainage system limited by encroaching sea levels
- Chronic flooding in residential and agricultural areas
- Oligotrophic, sandy bottom ➔ hyper-eutrophic, silty bottom
- Flora transition: submerged aquatic vegetation ➔ algae
  - Decreased light penetration, increased sedimentation and nutrients
  - Cyanobacteria
- Faunal changes: migratory waterfowl habitat affected
  - Lack of SAV and invasive carp contributing to water quality concerns
- All effects exacerbated by sea level rise
- 2016 state Clean Water Act 303(d) listing for pH and chlorophyll-α

Science & Engineering to the Rescue!

- Partnership for Watershed Restoration Plan (WRP):
  - Hyde County
  - NC Wildlife Resources Commission
  - U.S. Fish & Wildlife Service
- Developed by NC Coastal Federation for NCDEQ 319 approval
- 3 goals:
  - Protect Hyde Co. way of life
  - Actively manage lake water level
  - Restore water quality and clarity

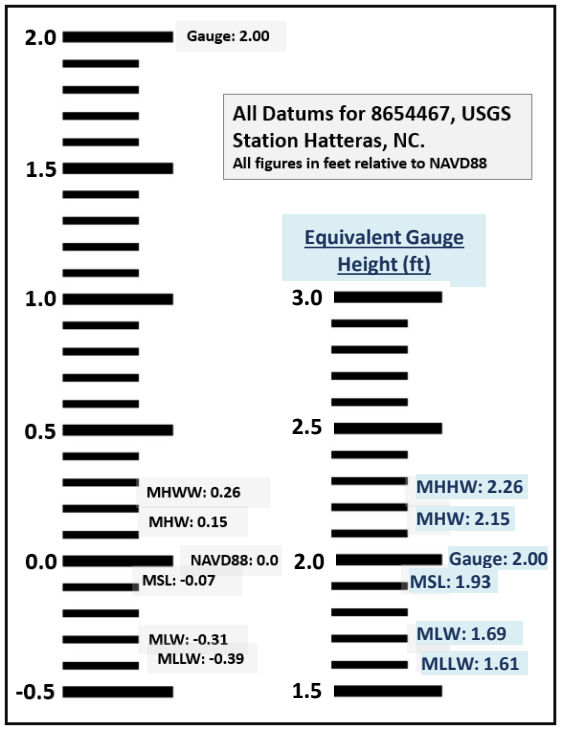


Implementing the Plan

- Hyde County contracting with NC Coastal Federation
- Funding:
  - Clean Water Management Trust Fund
  - NC Office of State Budget and Management
- Step #1: establishment of active water management capabilities
- NC Coastal Federation contracted with Geosyntec and CPE

Priority Active Water Management Design Goals

- Reduce the time watershed is flooded after storms
- Utilize storage where available
- Increase drainage capacity
- Provide functionality to seasonally lower and raise lake water level
- Resilient to sea level rise



Active Water Management: Task at Hand

- Develop watershed-scale H&H model
- Calibrate to Hurricanes Matthew and Joaquin
- Evaluate storage needs and wetland siting and capacity analysis

Presented at NCBIWA 2020 Fall Meeting

- Simulate calibrated model under various design storm scenarios in existing and future sea level rise
- Evaluate engineered options to actively manage lake levels during 10-year design storms
- Evaluate two alternatives for all design storms under existing and future sea level rise
- Progress one preferred alternative to permit-level plans
- Proposed service district boundary

Activities in Last Year

Hydrologic and Hydraulic Modeling

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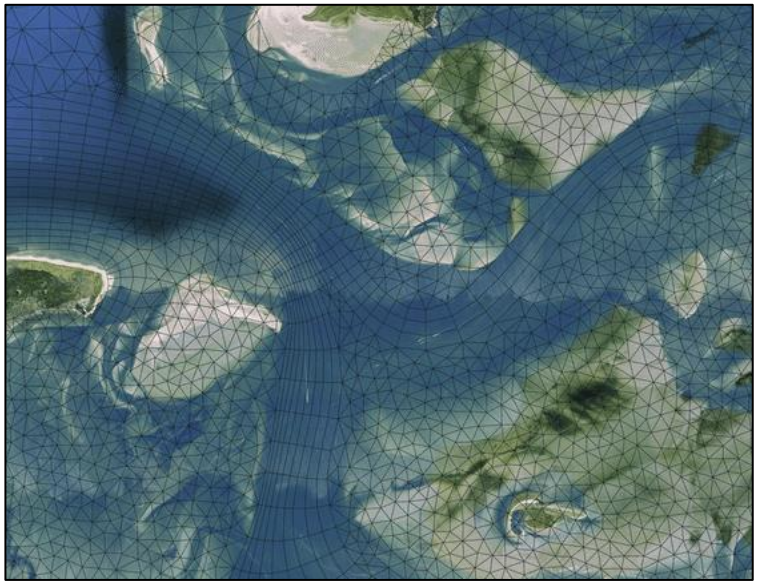
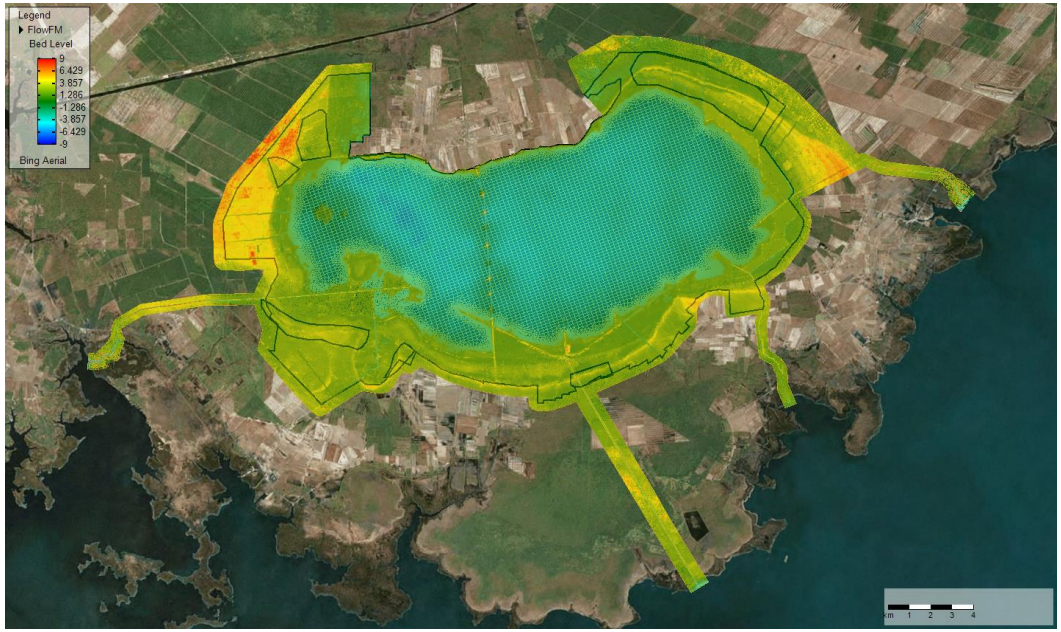
Delft3D Flexible Mesh

- Successor of Delft3D structured and SOBEK from TU Delft/Deltares
- Unstructured 1D-2D-3D grids, widely used in the coast, lakes and rivers
- Allows for the simulation of the interaction of water, sediment, ecology, and water quality in time and space
- Includes coastal hydrodynamics & hydrological processes (precipitation, infiltration and evaporation)
- Allows for implementation of hydrological structures such as weirs, gates, pumps and flow obstacles such as dams
- Greater long-term applicability to the watershed



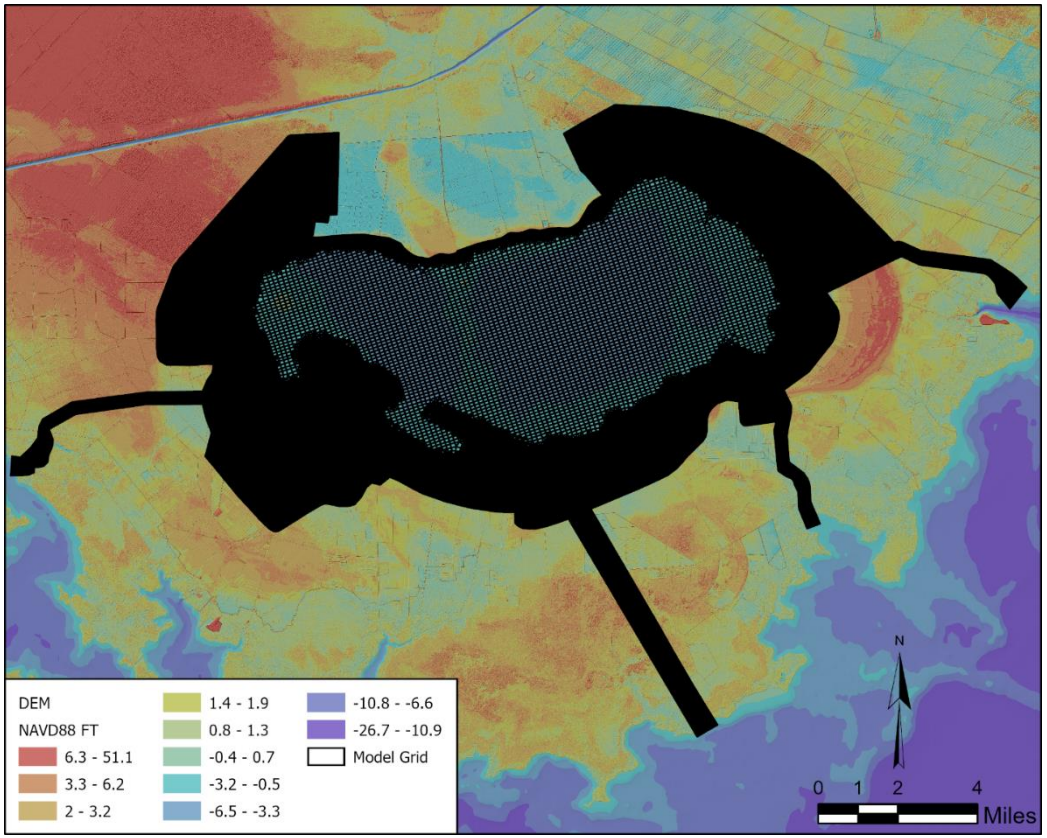
Numerical Modeling Main Objectives

- Determine water levels that result in chronic flooding
- Evaluate sea level rise projections to 2100
- Support definition of a Lake Mattamuskeet service district
- Calibrate to reproduce lake levels during Matthew and Joaquin
- Investigate options for increasing water discharge



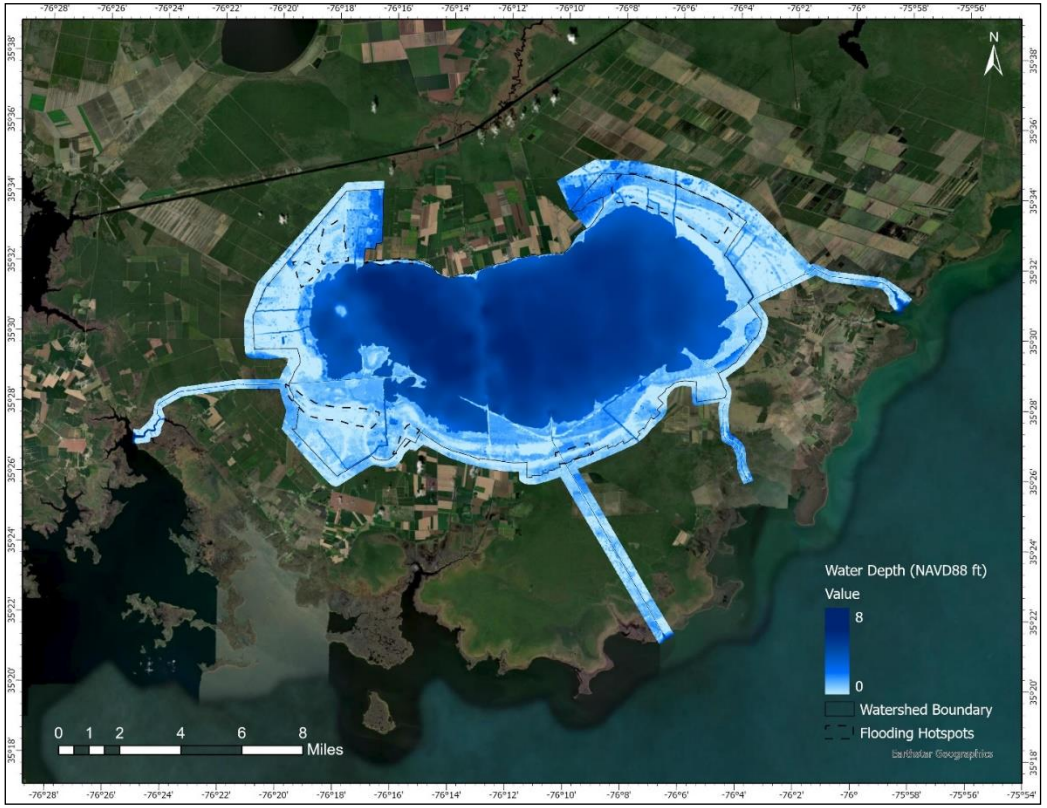
Lake Mattamuskeet Model Setup

- 300k cells; higher resolution in watershed and canals that link to Pamlico Sound
- Water level data: USGS Lake Stations and Bell Island Pier (Pamlico Sound)
- Precipitation and Evaporation data: NOAA - NCEP CFSv2 (hourly)
- Topo Bathy data: Lidar from State Floodplain Mapping Program and locally collected bathy
- Gates resolved as gravity structures (open when lake/sound gradient)

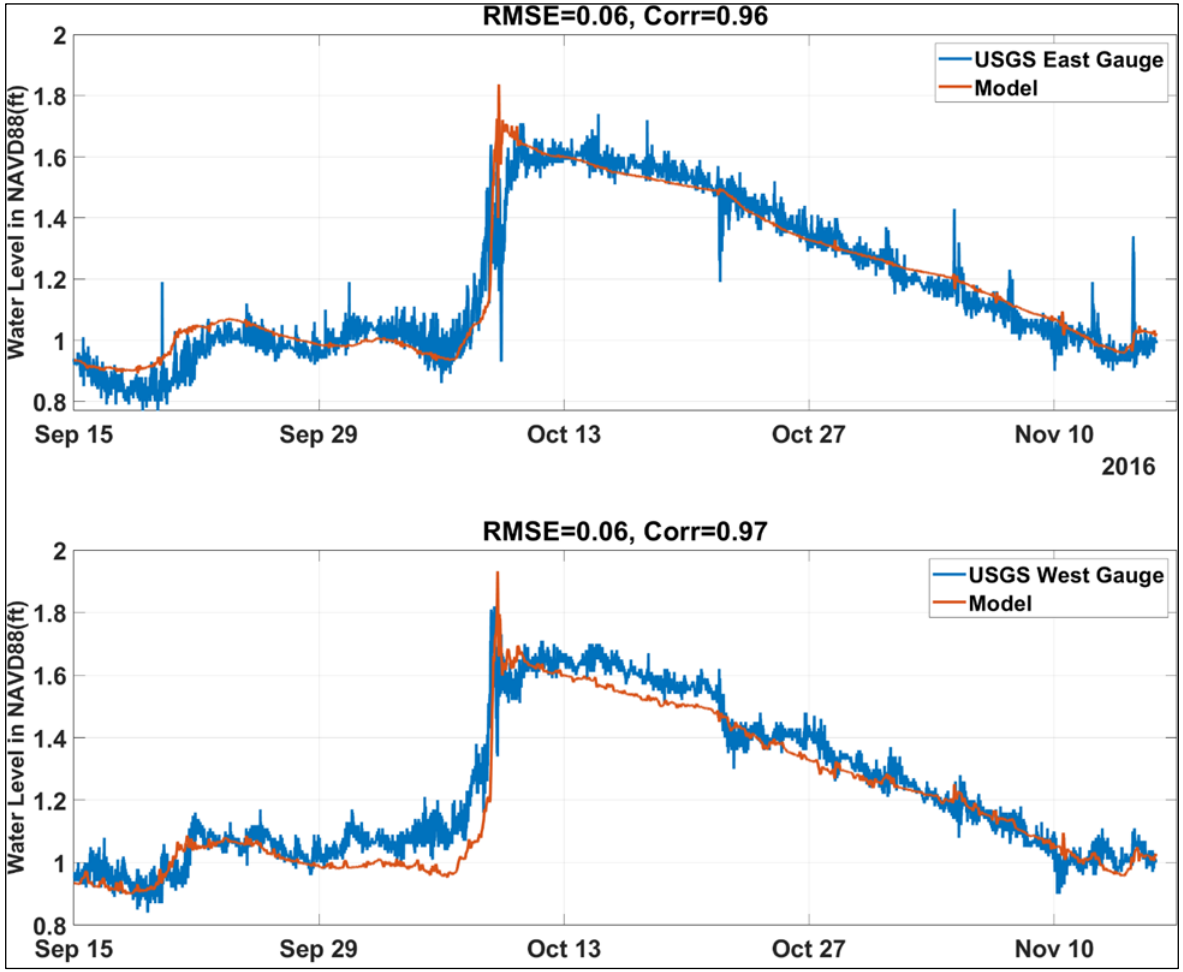


Existing Conditions Model: One Year Later

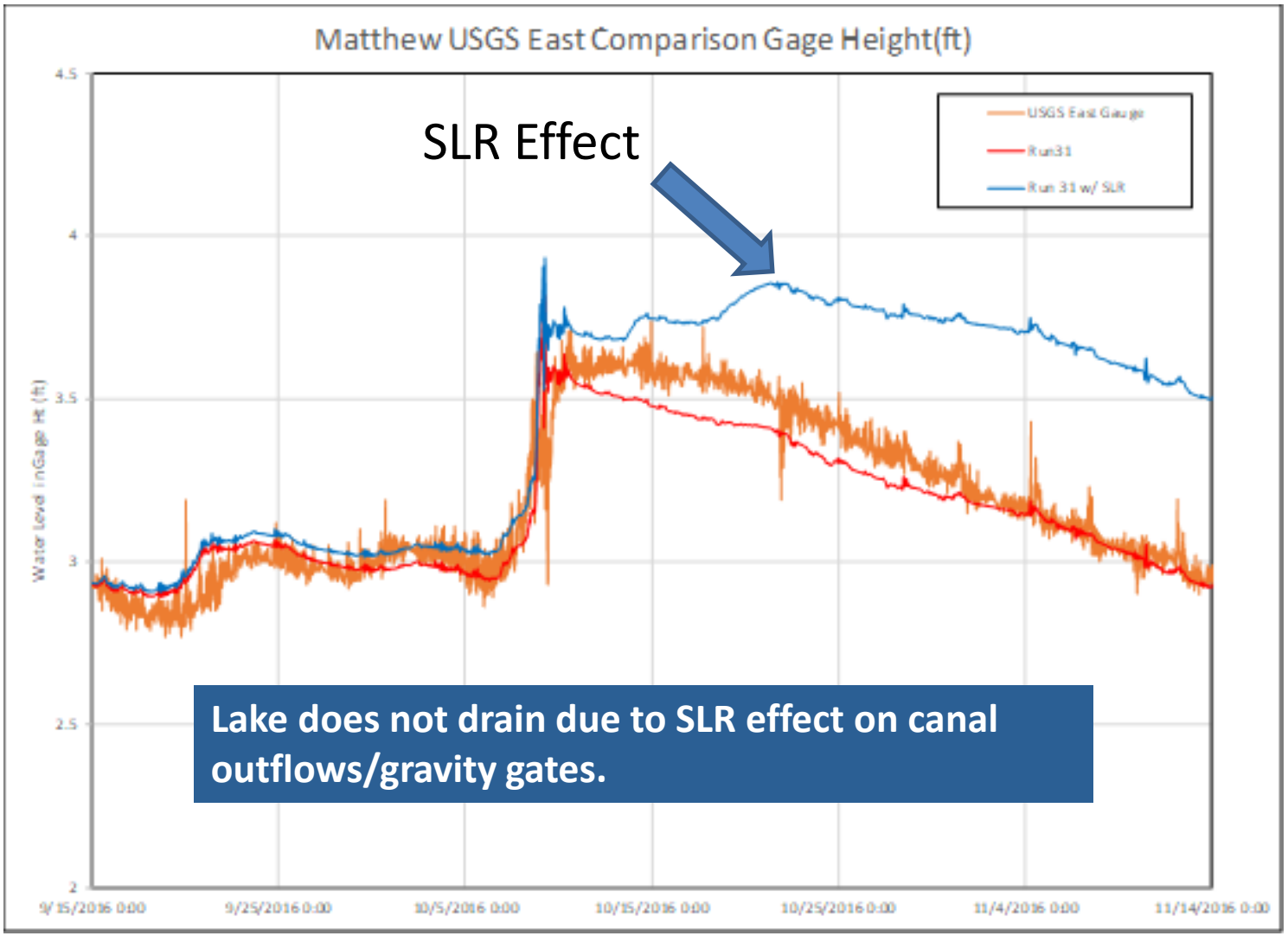
- Calibration Improvements
- Design storm simulations
- Existing and Future Sea Level Rise



Calibration Improvements

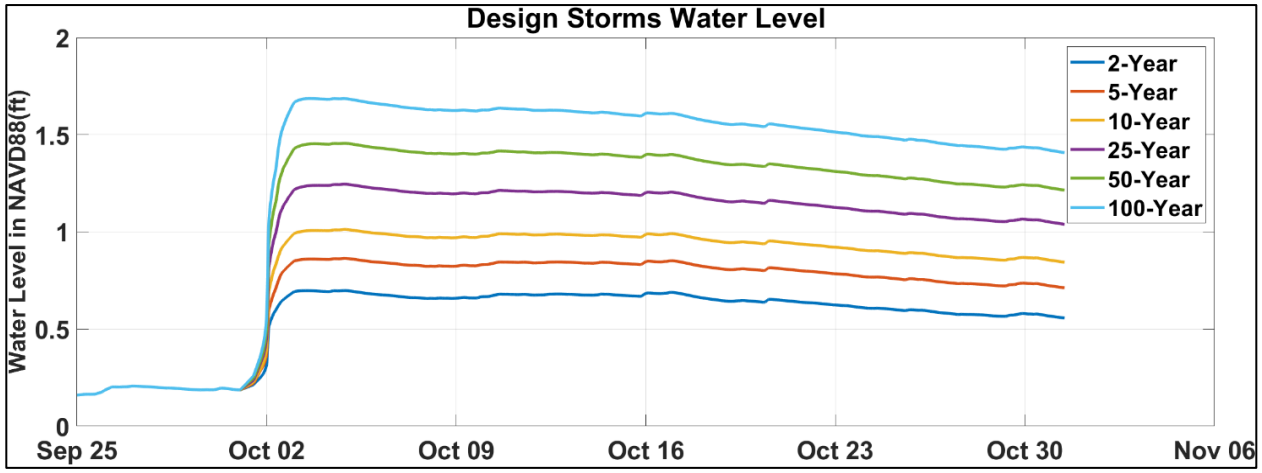


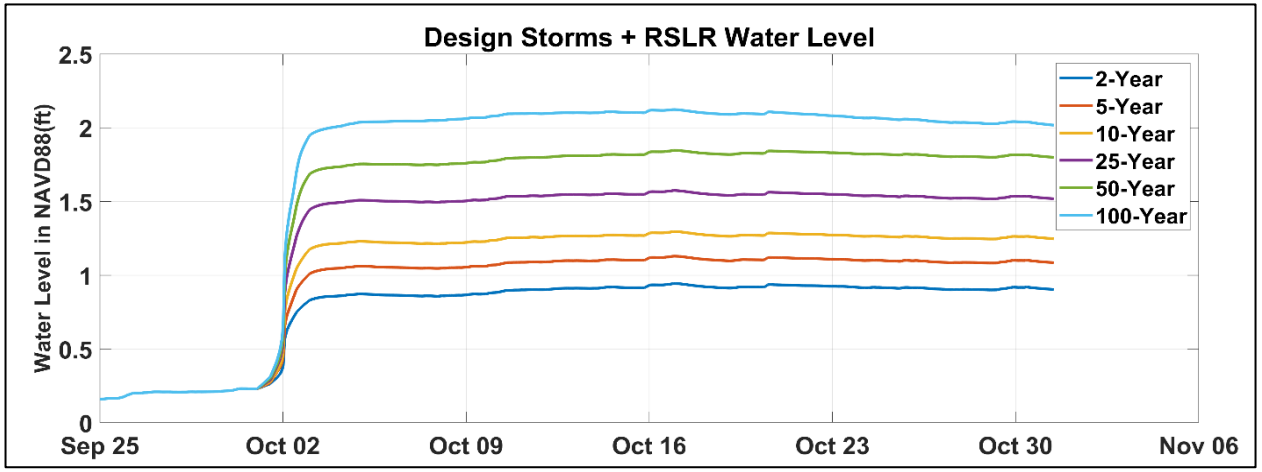
Effect of Sea Level Rise



Lake does not drain due to SLR effect on canal outflows/gravity gates.

Design Storm Scenarios: Existing Sea Level & Future Sea Level Rise





Engineered Alternatives Analysis

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10-Year Design Storm Screening Scenario

- Simulate each alternative with 10-year design storm
  - Starting water level of 2.17 ft (October average)
  - Soundside boundary condition corresponding to Hurricane Matthew record with storm surge
- Evaluate performance metrics including:
  - Peak water level
  - No. of days pumping if option includes pumping
  - No. of days to return to starting water level OR final lake level at end of simulation
- Select two alternatives to perform more detailed simulations

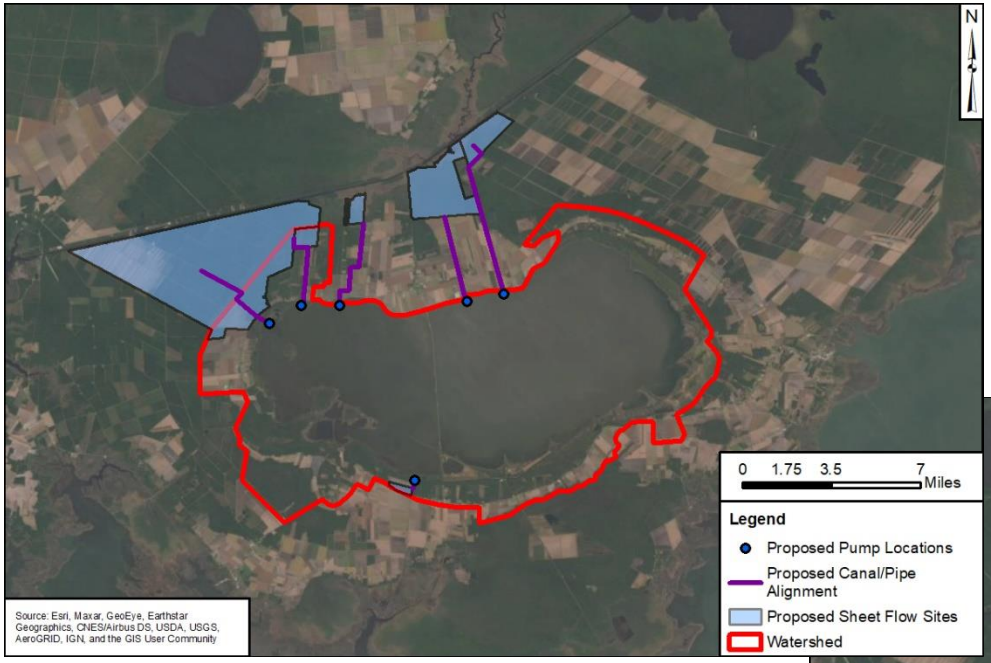
List of Potential Engineered Alternatives

- Mid-sized pump station to drainage districts
- Large pump station to ICW
- Pump station with optimized pumping rate to ICW
- Sheet flow sites
- Dredge existing outlet canals
- Optimized outlet structures
- Dredge canals + optimized outlet structures
- Gravity-drained canals to drainage districts

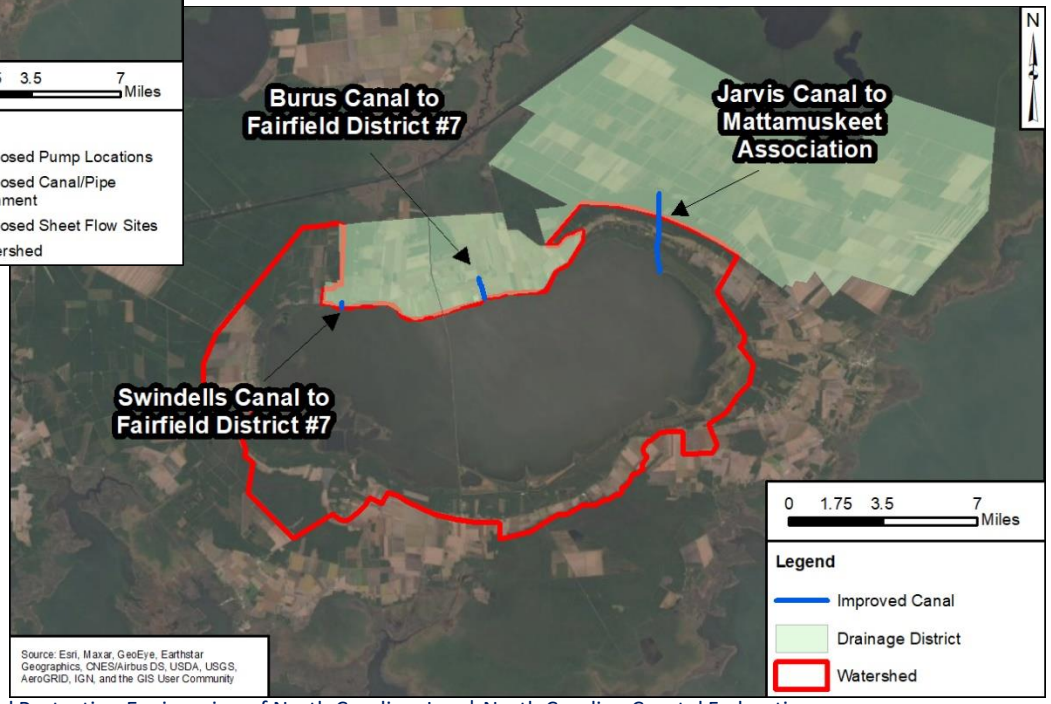
Selected by Hyde County BOC at May 2021 meeting

Preferred Engineering Alternatives

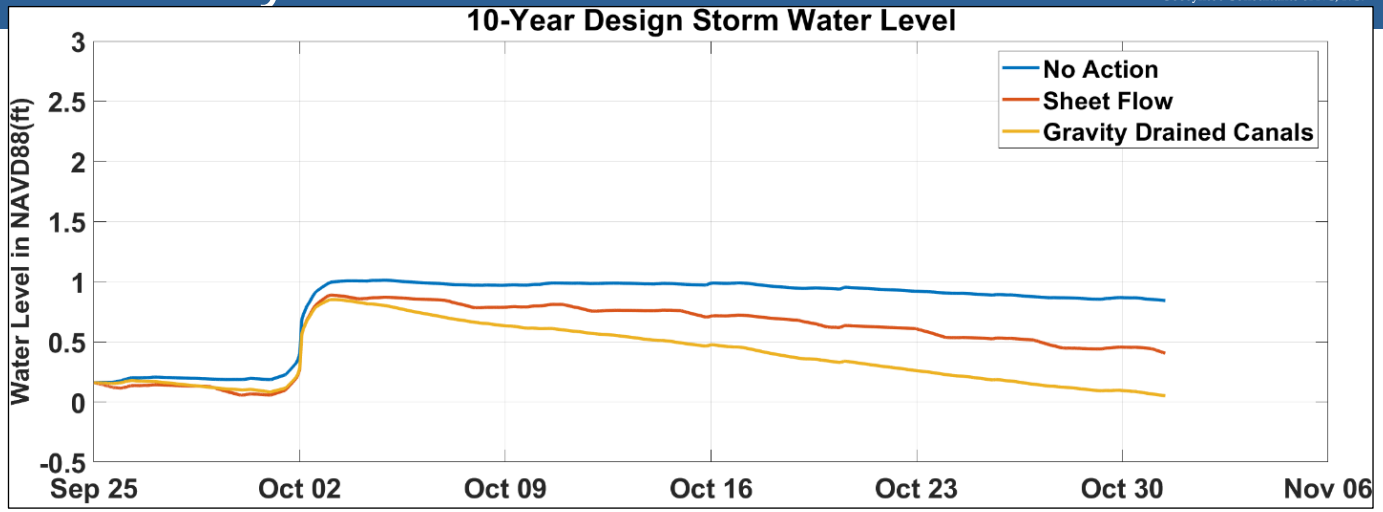
Multiple Sheet Flow Sites



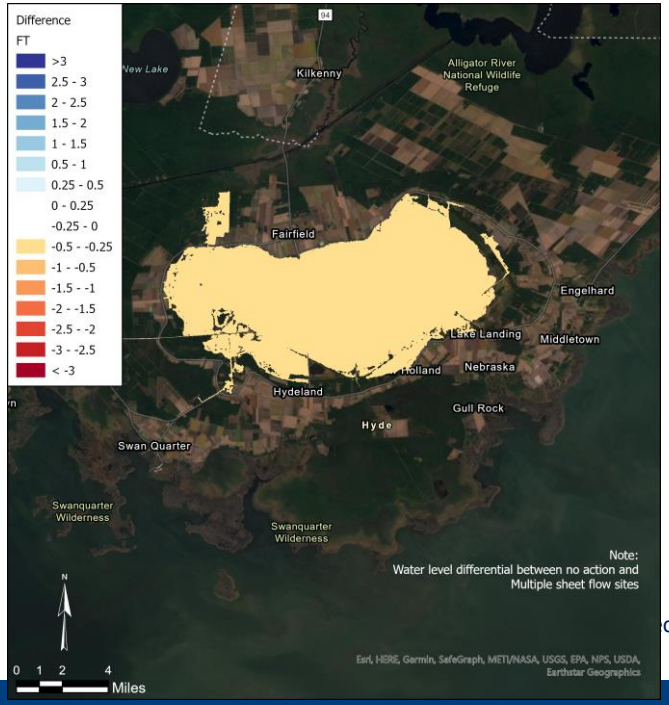
Gravity-drained Canals



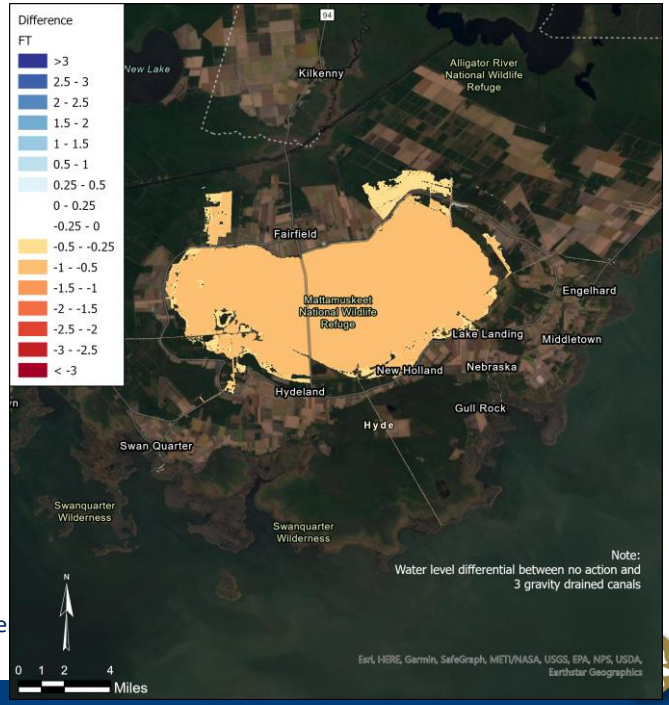
Comparison of Alternative Simulations: 10-year storm



Sheet Flow Sites



Gravity-drained Canals



Conceptual Costs Comparison: 10-year design storm

Parameter	No Action Alternative	Sheet Flow Sites	Gravity-drained Canals (3 canals)
Conceptual Costs with 30% Contingency	-	$13,300,000 to $23,500,000	$5,800,000 to $11,900,000
Peak Water Level	3.01	2.89	2.85
Ending Water Level	2.84	2.49	2.05
Difference in Ending Water Level from No Action	-	0.40	0.80
$/acre/ft of water level drop during 10-year storm	-	$550 - $975	$110 - $220

Additional Design Storm Simulations: 2-year and 100-year Design Storms

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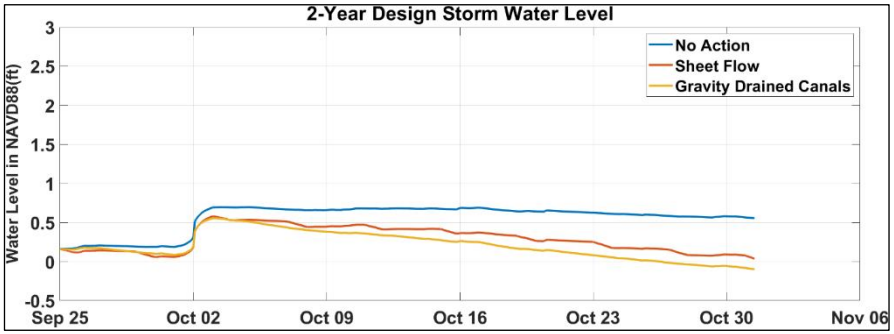
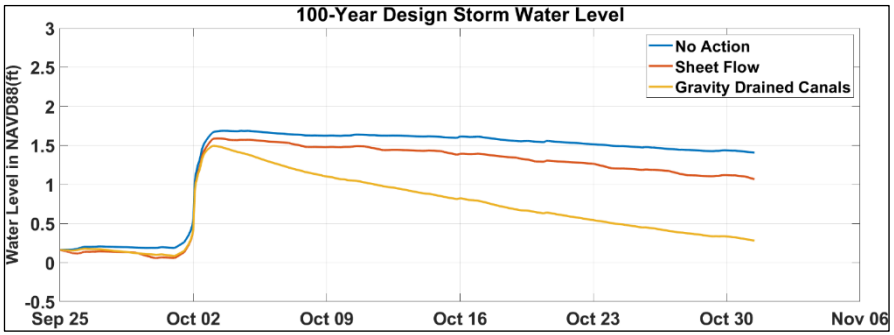
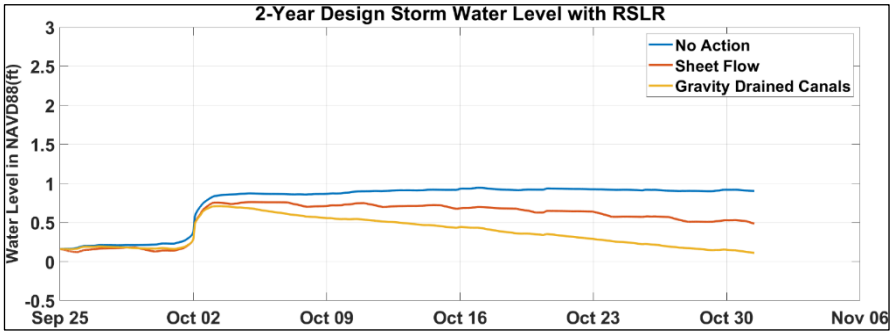
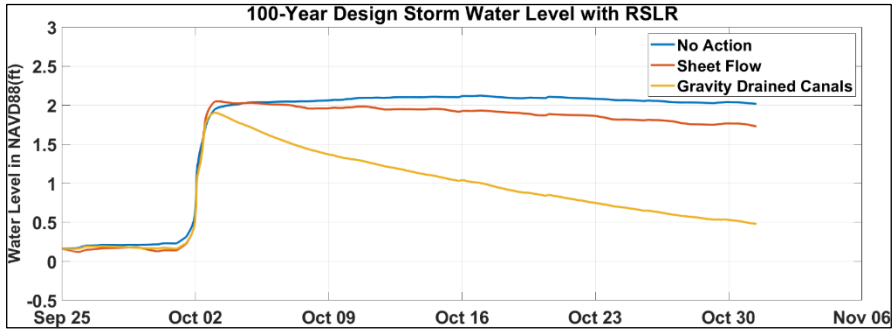
Current Conditions





Relative Sea Level Rise





- Reduction in peak water levels and improved drawdown (current and RLSR)
- Gravity-drained canals resulted in 1.2 to 4.5 times more drawdown sheet flow sites
- Difference in performance more noticeable for larger and more intense storms and RSLR scenario

Selected Design and Preliminary Plans

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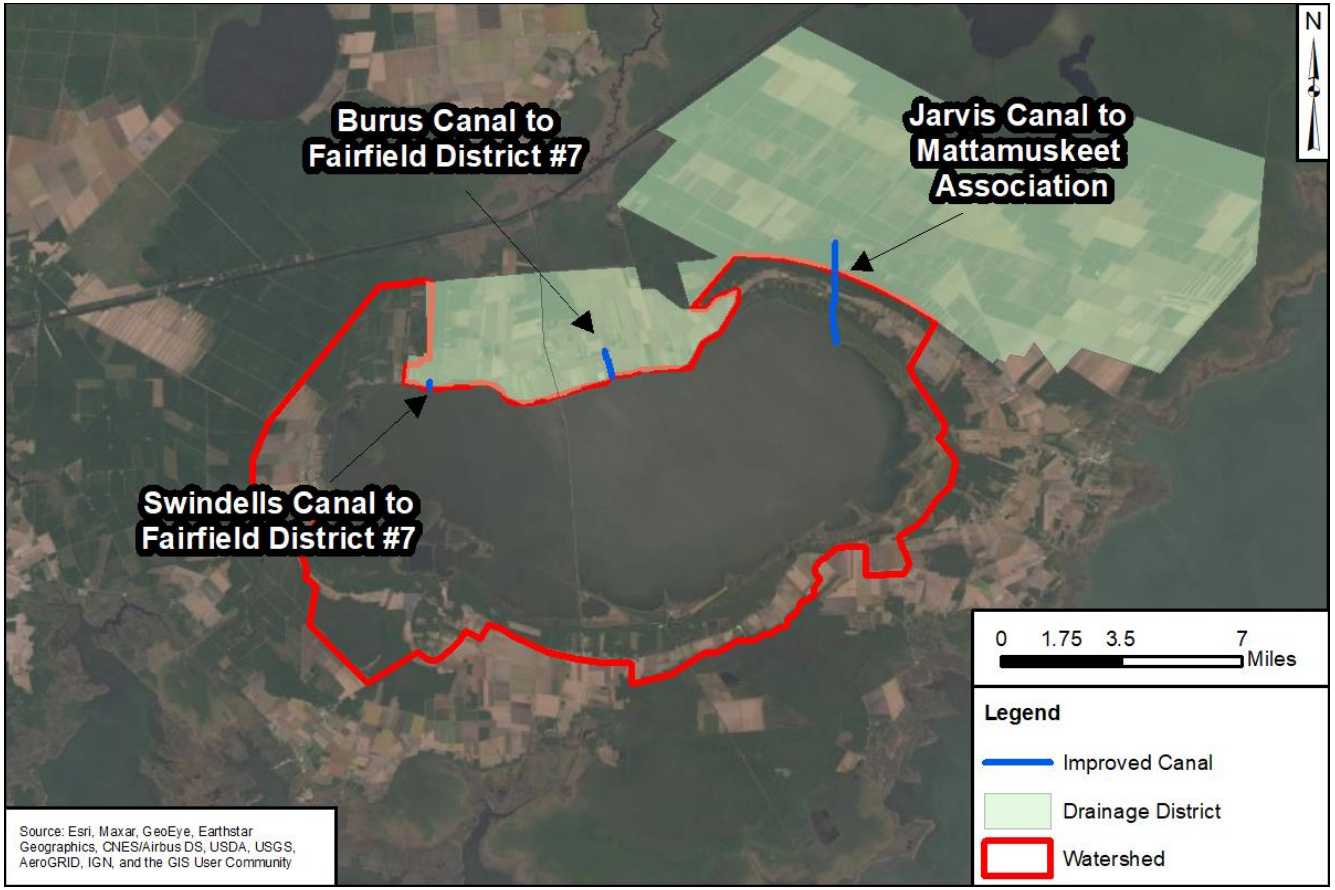
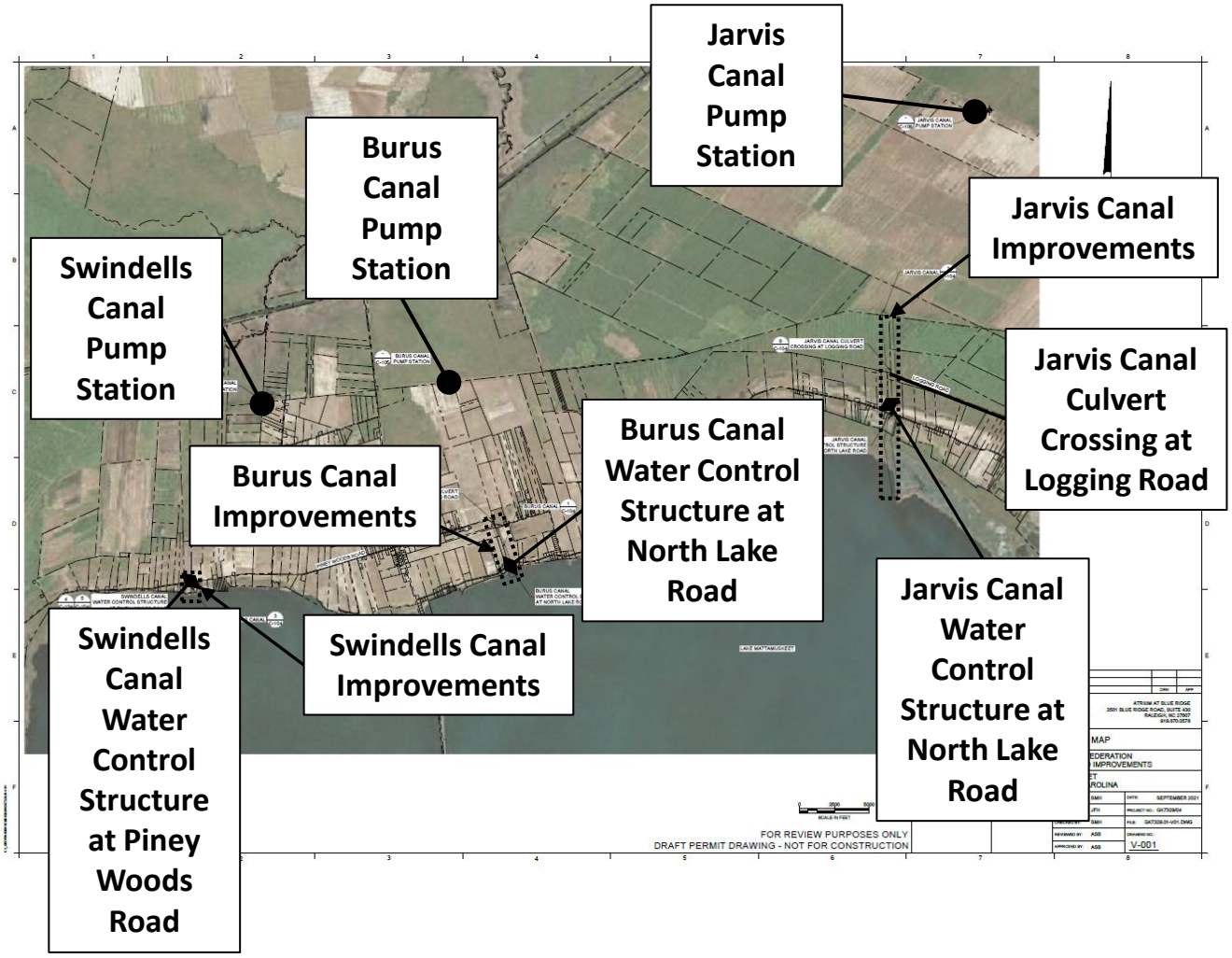
Selected Alternative: Gravity-Drained Canals to Drainage Districts



- Permit-level Plans
- Preliminary Ecological Impact Analysis (EIA)
- Preliminary Water Management Plan

Preliminary Engineering Design: Site Plan



Canal Improvements

- Burus Canal: ~ 3,500 LF
- Jarvis Canal: ~ 13,000 LF
- Swindells Canal: ~ 800 LF

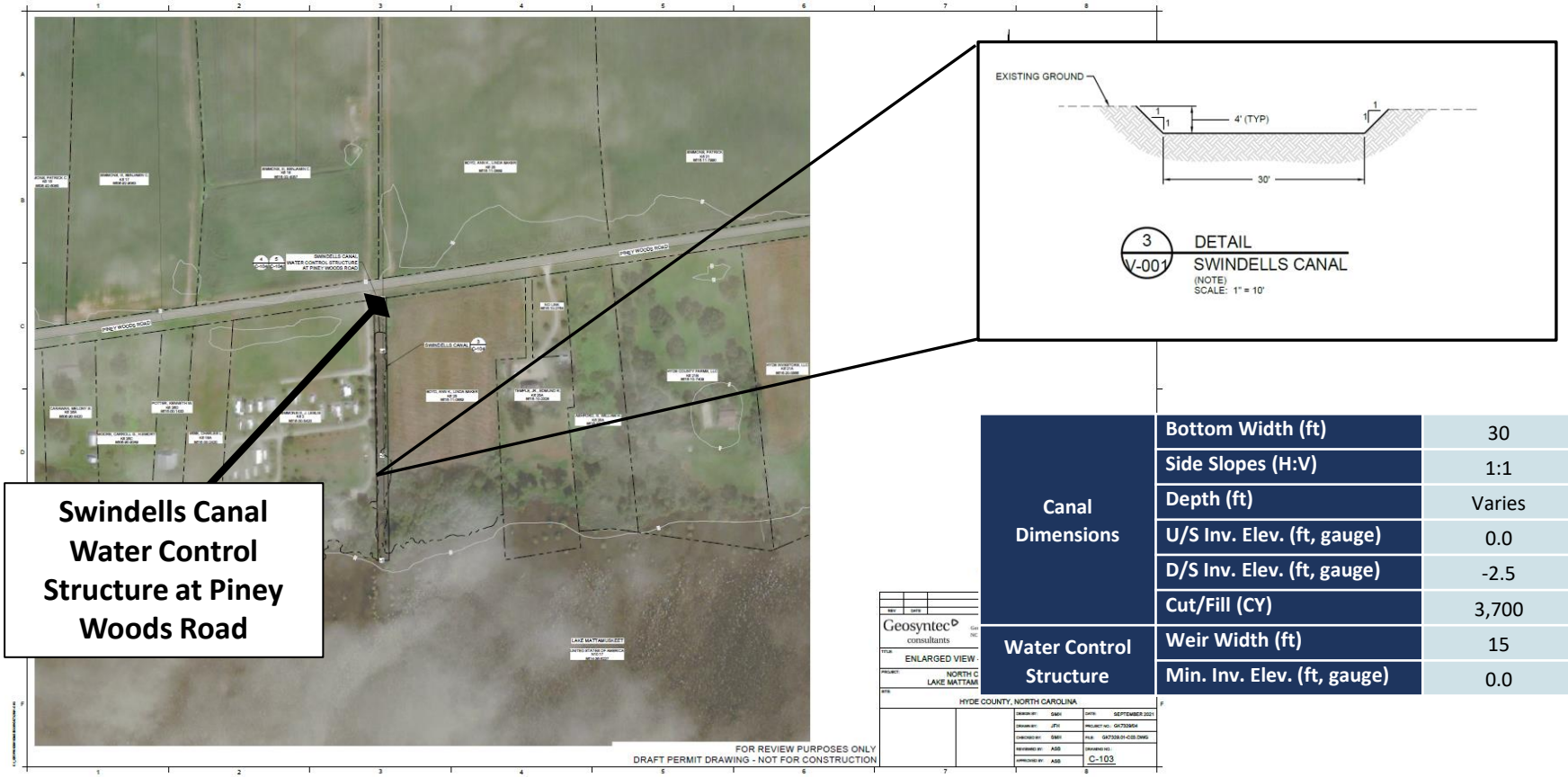
Water Control Structures

- Series of adjustable weir gates, width based on canal

Pump Stations

- Three (3) 48” axial flow pumps at each pump station

Preliminary Engineering Design: Swindells Canal Improvements

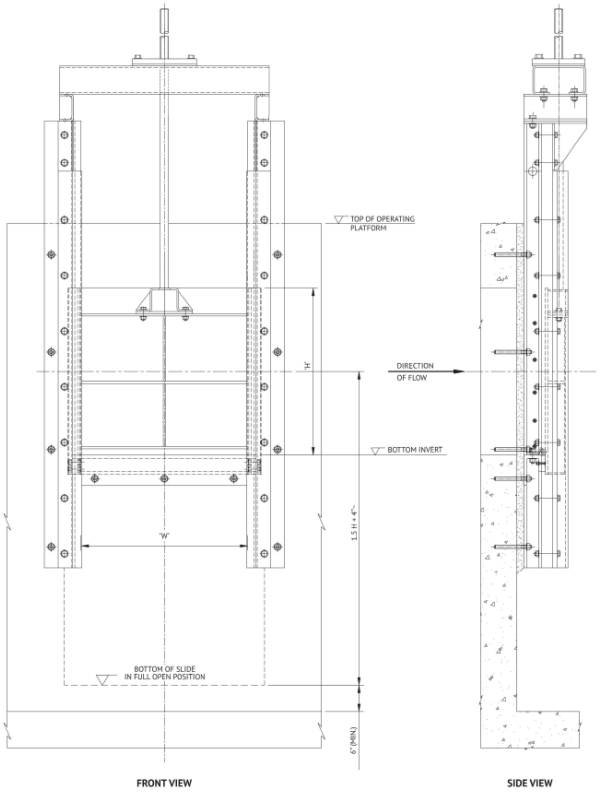


Swindells Canal Water Control Structure at Piney Woods Road

Canal Dimensions	Bottom Width (ft)	30
	Side Slopes (H:V)	1:1
	Depth (ft)	Varies
	U/S Inv. Elev. (ft, gauge)	0.0
	D/S Inv. Elev. (ft, gauge)	-2.5
	Cut/Fill (CY)	3,700
Water Control Structure	Weir Width (ft)	15
	Min. Inv. Elev. (ft, gauge)	0.0

Preliminary Engineering Design: Water Control Structures

- **Adjustable Weir Gate**
  - Slides from bottom down
  - Minimum invert El. of 0.0 ft gauge, but can go up to the top of the operating platform (e.g., up to 5 – 6 ft)
  - Flow measurement using water level loggers
- **Operational Considerations**
  - Conveyance capacity of receiving canal (250,000 gpm+)
  - Pump capacity of downstream pump stations (150,000 gpm – 180,000 gpm if all three pumps operating)
  - Limit head such that it does not exceed the pump capacity



Preliminary Engineering Design: Pump Stations

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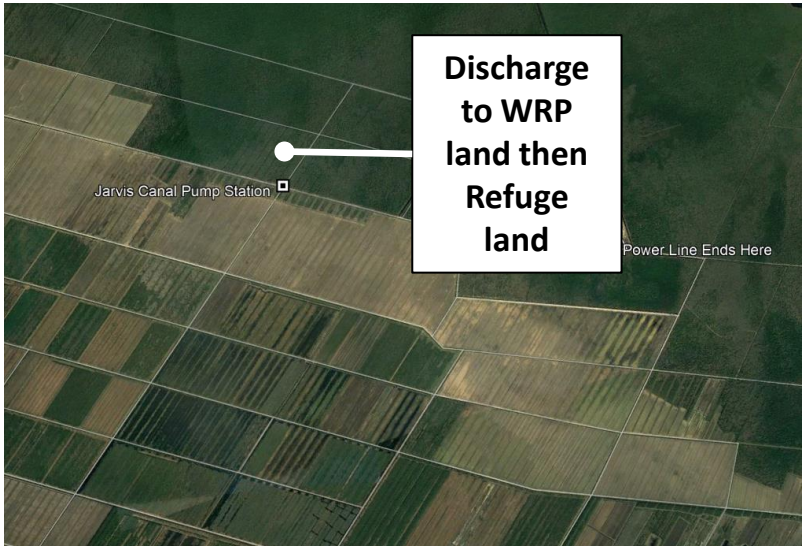
- Pump Station Siting
  - All locations can be either powered by diesel generators or three-phase power (with power line extension ranging from 0.75 miles to 2.75 miles)
  - Discharge locations could utilize surrounding land for sheet flow application
  - Axial flow pump can be configured with electric motor or diesel-powered engines



Next Steps

- Finalize EIA and design narrative
- Potentially collect additional bathymetric data to improve cost estimates for sediment removal in existing outlet canals, pending funding
- Finalization of proposed service district boundary, potentially with additional bathymetric data

Proposed Service District Boundary

Approach: Evaluate change in flood maps of the 10-year storm (and potentially other design storms) for the selected alternative compared to the no action alternative to delineate service district boundary

Questions?

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