North Carolina Coastal Federation
Working Together for a Healthy Coast

learnnc.org

Lake Mattamuskeet Watershed Restoration Plan

Virtual Public Meeting

April 15, 2021

Housekeeping

- Mics of attendees will be muted throughout the presentations
- Meeting will be recorded and made available for viewing on the project webpage
- Use Q&A feature throughout the meeting
- Question and Comment period at end of meeting
    - Use “Raise Hand” feature to request you mic be unmuted

Zoom Functionality

Please use the chat function if you need technical support.

Zoom Functionality

Please use the Q&A function to type questions or comments during the presentations.

Zoom Functionality

Use the raise hand function if you would like to speak during the question and comment period at the end of the meeting.

Agenda Overview

6:30 p.m.	Welcome
6:35 p.m.	Watershed Restoration Plan Overview
6:40 p.m.	Updates from Technical Working Group
7:00 p.m.	Engineering Active Water Management
7:45 p.m.	Using Undergraduate Engineers & Community Engagement
8:20 p.m.	Question & Comment Period
8:30 p.m.	Adjourn

Welcome

Bill Rich, Hyde County Economic Development

Lake Mattamuskeet Watershed Restoration Plan

Michael Flynn, North Carolina Coastal Federation

In 2017, a partnership was formed

to develop a watershed restoration plan

Plan Goals

Protect the way of life in Hyde County:

Maintain existing land uses and industries in the watershed (residential, farming, fishing and tourism) and enhance and maintain the health of the lake's natural resources (waterfowl and wildlife).

Plan Goals

Actively manage the lake water level:

Minimize flooding of residential, business, and farm properties. Allow for annual drawdowns as appropriate and in compliance with the Refuge's management objectives defined in its Comprehensive Conservation Plan to establish and maintain submerged aquatic vegetation within the lake, and to establish and maintain a zone of emergent vegetation around the lake periphery.

Plan Goals

Restore water quality and clarity:

Reduce nutrients, sediments, and phytoplankton blooms, promote the growth of submerged aquatic vegetation and remove the lake from the NC 303(d) list of impaired waters.

Desired State of the Lake and Watershed

1. Active management of lake level in addition to tide gates
    - Less frequent flooding of residential property
    - Fewer septic system failures & adequate drainage of croplands
2. Clear and mesotrophic water (moderate nutrient levels)
    - Fewer phytoplankton & cyanobacteria blooms
3. Increased SAV abundance along lakebed
4. Increased emergent vegetation
5. Reduced common carp populations
6. Increased game fish and blue crab populations
7. Removal from the NC 303(d) list of impaired waters
    - Chl-*a*, pH, and turbidity within federal and state guidelines

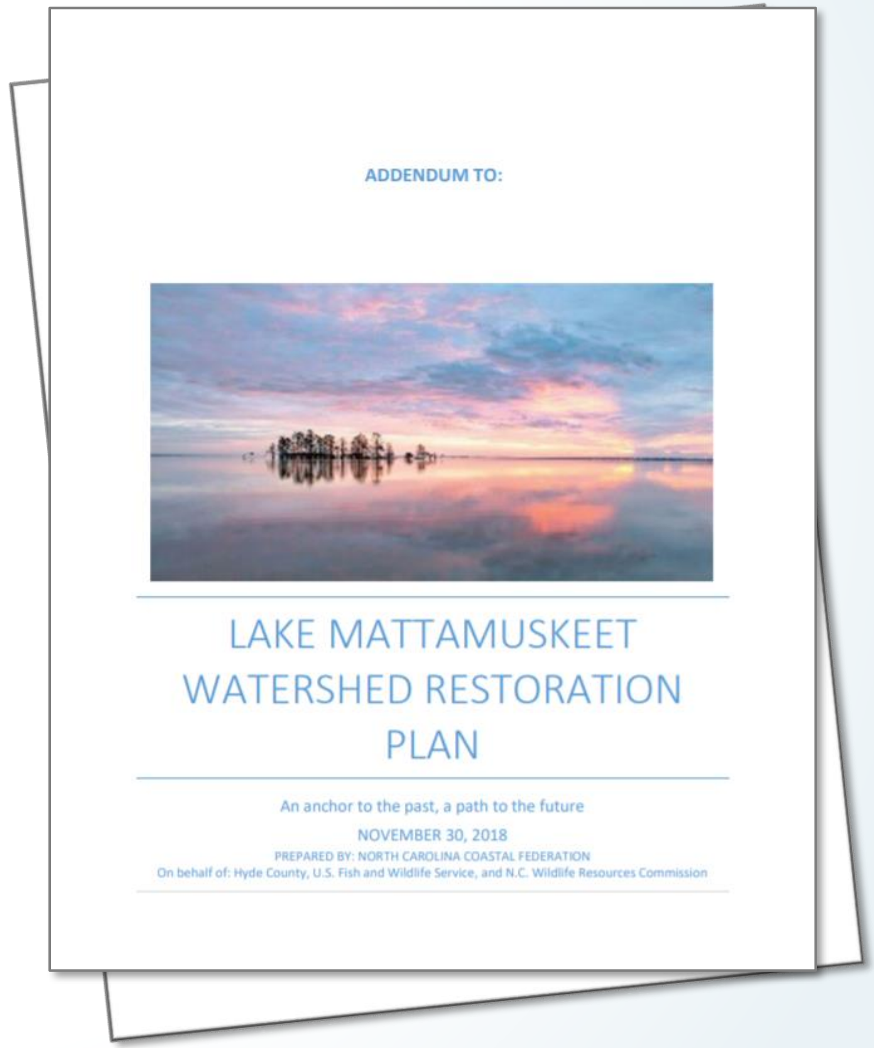
Priority Actions

- Create a formal body that provides managing authority for active water management within the watershed in close coordination with the Refuge, which would be excluded as party to the formal body since USFWS cannot cede management authority.
- Perform hydrologic study of the watershed.
- Design engineered plans for active water management within the lake watershed
  - Infrastructure Improvements
  - Additional Outlet Evaluation
  - Potential Sheet Flow Sites

Implementing the Watershed Restoration Plan

- Pursuing funding to implement the priority management actions has been the focus of partners over the past year.

- **Funding awarded from:**
  - Clean Water Management Trust Fund
  - N.C. General Assembly
  - National Science Foundation


ADDENDUM TO:

LAKE MATTAMUSKEET WATERSHED RESTORATION PLAN

An anchor to the past, a path to the future

NOVEMBER 30, 2018

PREPARED BY: NORTH CAROLINA COASTAL FEDERATION

On behalf of: Hyde County, U.S. Fish and Wildlife Service, and N.C. Wildlife Resources Commission

North Carolina Coastal Federation

Working Together for a Healthy Coast


North Carolina
Coastal Federation
Working Together for a Healthy Coast

REQUEST FOR QUALIFICATIONS:

ENGINEERING ACTIVE WATER MANAGEMENT WITHIN THE LAKE MATTAMUSKEET WATERSHED

HYDE COUNTY, NORTH CAROLINA

Issued by the

NORTH CAROLINA COASTAL FEDERATION

in partnership with

HYDE COUNTY

and

EAST CAROLINA UNIVERSITY

APRIL 15, 2020

ECU

Geosyntec Consultants

and

Coastal Protection Engineering (CPE)

selected as the engineering firm

Stakeholder Team

Bill Rich - Hyde County Economic Development

Daniel Brinn - Hyde County Water and Flood Control

Rebekah Martin – U.S. Fish and Wildlife Service

John Stanton – U.S. Fish and Wildlife Service

Kendall Smith - U.S. Fish and Wildlife Service

Wendy Stanton – U.S. Fish and Wildlife Service

Doug Howell - N.C. Wildlife Resources Commission

Michael “Slim” Cahoon - Farming Community

Wilson Daughtry – Mattamuskeet Association

Andrea Gibbs – NC Cooperative Extension

Art Keeney - Residential Community

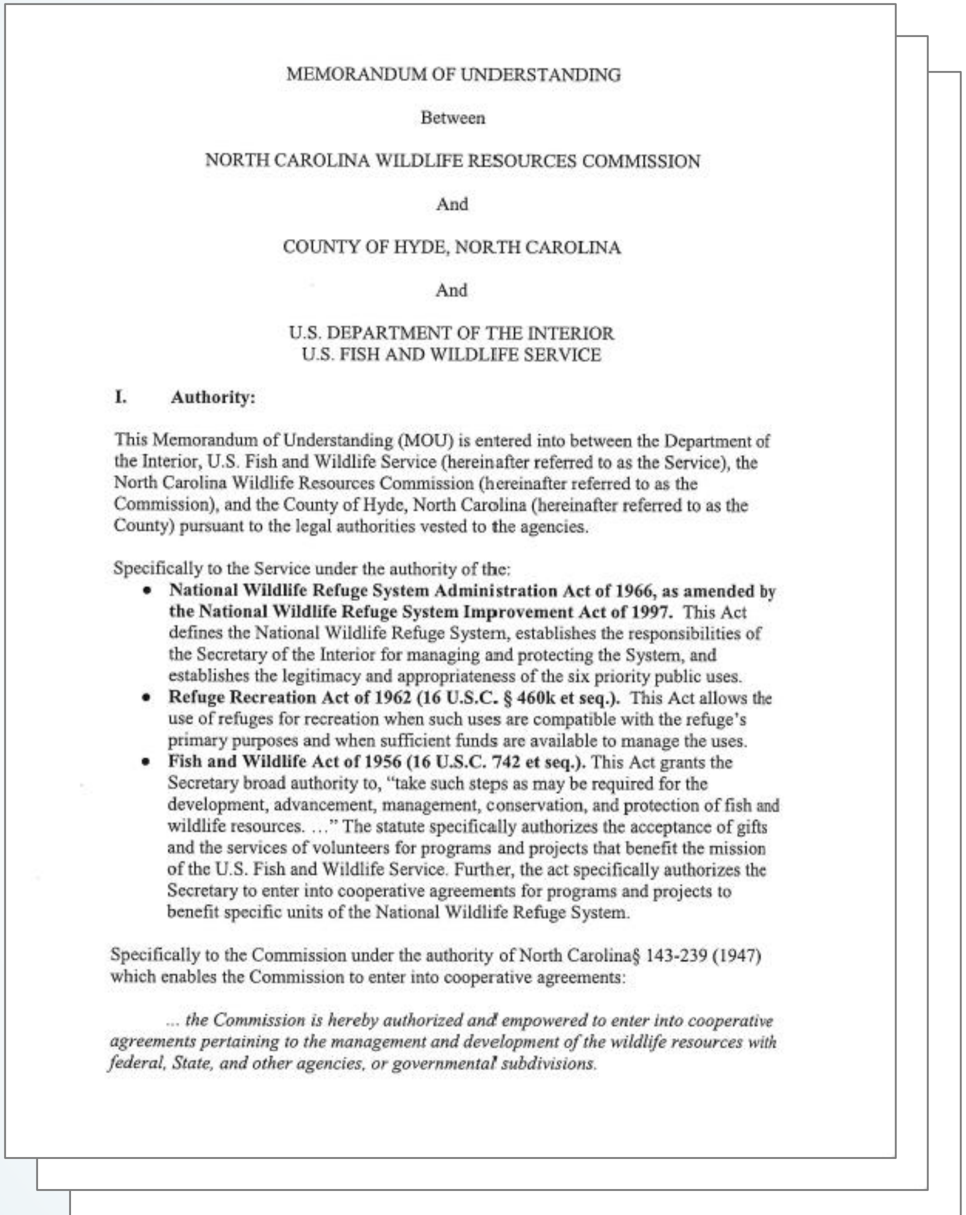
Ben Simmons - Farming Community/Fairfield Drainage

Pat Simmons - Hospitality Industry

J.W. Spencer - Hyde County Soil and Water Board

James “Booboo” Topping - Residential Community

Joey Ben Williams - Impoundments



MEMORANDUM OF UNDERSTANDING

Between

NORTH CAROLINA WILDLIFE RESOURCES COMMISSION

And

COUNTY OF HYDE, NORTH CAROLINA

And

U.S. DEPARTMENT OF THE INTERIOR
U.S. FISH AND WILDLIFE SERVICE

I. Authority:

This Memorandum of Understanding (MOU) is entered into between the Department of the Interior, U.S. Fish and Wildlife Service (hereinafter referred to as the Service), the North Carolina Wildlife Resources Commission (hereinafter referred to as the Commission), and the County of Hyde, North Carolina (hereinafter referred to as the County) pursuant to the legal authorities vested to the agencies.

Specifically to the Service under the authority of the:

- **National Wildlife Refuge System Administration Act of 1966, as amended by the National Wildlife Refuge System Improvement Act of 1997.** This Act defines the National Wildlife Refuge System, establishes the responsibilities of the Secretary of the Interior for managing and protecting the System, and establishes the legitimacy and appropriateness of the six priority public uses.
- **Refuge Recreation Act of 1962 (16 U.S.C. § 460k et seq.).** This Act allows the use of refuges for recreation when such uses are compatible with the refuge's primary purposes and when sufficient funds are available to manage the uses.
- **Fish and Wildlife Act of 1956 (16 U.S.C. 742 et seq.).** This Act grants the Secretary broad authority to, "take such steps as may be required for the development, advancement, management, conservation, and protection of fish and wildlife resources. …" The statute specifically authorizes the acceptance of gifts and the services of volunteers for programs and projects that benefit the mission of the U.S. Fish and Wildlife Service. Further, the act specifically authorizes the Secretary to enter into cooperative agreements for programs and projects to benefit specific units of the National Wildlife Refuge System.

Specifically to the Commission under the authority of North Carolina§ 143-239 (1947) which enables the Commission to enter into cooperative agreements:

… the Commission is hereby authorized and empowered to enter into cooperative agreements pertaining to the management and development of the wildlife resources with federal, State, and other agencies, or governmental subdivisions.

Purpose

The Service, the Commission, and the County individually and collectively have major responsibilities for management and protection of the watershed surrounding Lake Mattamuskeet.

In consideration of the mutual benefits to be derived, the agencies agree to cooperate and collaborate to achieve mutual and individual agency goals and objectives identified in the Lake Mattamuskeet Watershed Restoration Plan.

Review the Plan and Addendum

Lake Mattamuskeet Watershed Restoration Plan

Lake Mattamuskeet, the largest lake in North Carolina, is a vital part of Hyde County's amazing natural and cultural heritage. Coastal residents and visitors alike value this national treasure.

However, declining water quality and elevated water levels are threatening the future of this natural wonder. In 2017, Hyde County, N.C. Wildlife Resources Commission, and the U.S. Fish and Wildlife Service formed a partnership and contracted the Coastal Federation to develop a watershed restoration plan. This plan aims to address both poor water quality within the Lake as well as chronic and persistent flooding on the surrounding landscape.

The partners embarked on an 18-month planning process that involved stakeholder and public engagement, and on August 7, 2019 the Lake Mattamuskeet Watershed Restoration Plan was officially approved by the N.C. Department of Environmental Quality. Since then the partners transitioned from developing the plan, to implementing the plan. In 2020, three grants were awarded from state and national funders to advance the implementation of the Lake Mattamuskeet Watershed Restoration Plan.

The goals of the plan are to:

- Protect the way of life in Hyde County;
- Actively manage the lake water level; and
- Restore water quality and clarity.

The grant awards allow the partners to advance several of the priority management actions for the watershed. Throughout 2020 and 2021, the partners will host a series of public meetings and seek input on different implementation ideas.

Upcoming Events

Next Public Meeting – April 15, 2021

Register Here

Resources

- Lake Mattamuskeet Watershed Restoration Plan
- Addendum
- Timeline of changes to the lake

Meeting Agendas and Presentations

- Meeting Agenda – Apr. 15, 2021
- Meeting Agenda – Aug. 26, 2020
- Meeting Presentation – Aug. 26, 2020
- Meeting Recording – Aug. 26, 2020

North Carolina Coastal Federation

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nccoast.org/lakemattamuskeet

Subscribe for Updates/Submit Comments Online

Lake Mattamuskeet Watershed Restoration Plan

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Click on the link below to receive meeting announcements and ongoing updates regarding the watershed restoration plan.

CLICK HERE TO SUBSCRIBE FOR UPDATES/SUBMIT COMMENTS

Protect Water Quality

You can protect and restore water for fishing, swimming and working.

Support Clean Water

Upcoming Events

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In The News

- **Lake's Health Requires Ridding It of Carp:** https://www.coastalreview.org/2020/10/lakes-health-requires-ridding-it-of-carp/
- **Lake Mattamuskeet Finalizes Restoration Plan:** https://www.publicradioeast.org/post/lake-mattamuskeet-finalizes-restoration-plan
- "Restoring Lake Mattamuskeet In North Carolina" — June 29, 2017. U.S. Fish and Wildlife Service.
- "Secrets of Lake Mattamuskeet" — NC Science Now | UNC-TV

Updates from Mattamuskeet Technical Working Group

Wendy Stanton, U.S. Fish and Wildlife Service
Doug Howell, N.C. Wildlife Resources Commission

Lake Mattamuskeet
Technical Working Group Update
April 15, 2021

Mattamuskeet National Wildlife Refuge Purpose

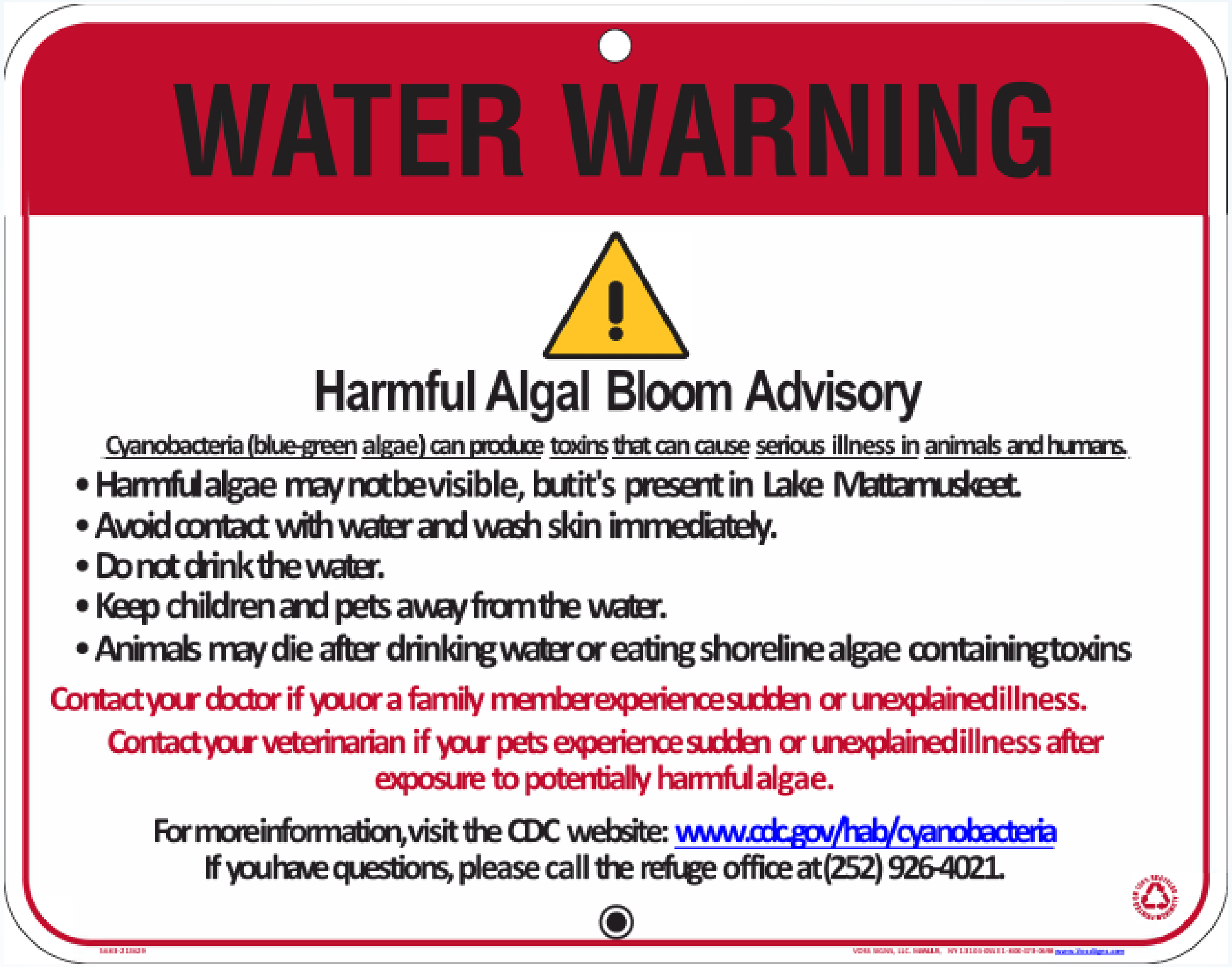
is to protect and conserve migratory birds and other wildlife resources through the protection of wetlands

The state of Lake Mattamuskeet has shifted: Water quality and clarity has declined (eutrophic), SAV has disappeared, and cyanobacteria is abundant which is negatively affecting waterfowl habitat

Current state: Turbid waters dominated by cyanobacteria lacking SAV

Desired state: Heathy SAV community with clear water

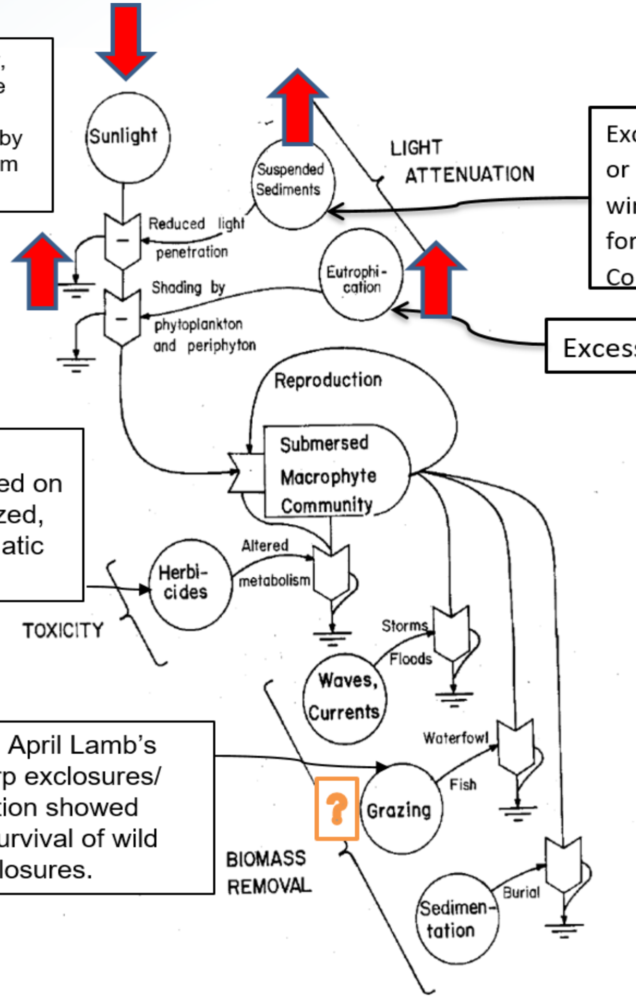
***SAV is the indicator for water quality in Lake Mattamuskeet**



Water warning signs are posted at public use areas around the refuge.

SAV Conceptual Model

Light attenuation, toxicity, and biomass removal are three general stressors which can be influenced by other specific factors (from Davis and Brinson 1980)



Excess sediment input, or re-suspension from wind, erosion, benthic foraging (Invasive Common Carp

Excess N and P

Results from Dr. Michael Piehler, Suzanne Thompson, Matthew Waters study:

- **Light available to submerged aquatic vegetation (SAV) in the lake is below the conventional thresholds for rooted plant growth.**

-Total suspended solids (turbidity) is the best predictor of the low light conditions.

-Algae are co-limited by both N and P.

-Wild celery plantings in the east and west basins persisted for 7 months when protected from grazing, but no plantings persisted for a year.

Results from Anna Alicea's study – Based on the herbicides analyzed, little to no risk to aquatic plants.

Results from April Lamb's study on Carp exclosures/ SAV restoration showed successful survival of wild celery in exclosures.

Model of submerged aquatic vegetation productivity (Davis and Brinson, 1980). Arrows indicate the trend of parameters that have been monitored and analyzed.

Monitoring parameters for water quality include:

USGS Continual Water Quality Stations (e & w sides of lake):

Water depth
pH,
Specific conductance
Temperature (^{o}C)
DO
Turbidity
*USGS weather station on Hwy 94

Water samples (taken at CWQS): Many thanks to NCDWR for conducting analysis!

Total nitrogen (mg/L)
Total phosphorous (mg/L)
Phytoplankton
Secchi disk (water clarity) (decimeters)
Total suspended solids (mg/L)
Chlorophyll a (*u*g/L)
Cyanotoxin samples
Light attenuation

Canal water quality parameters:

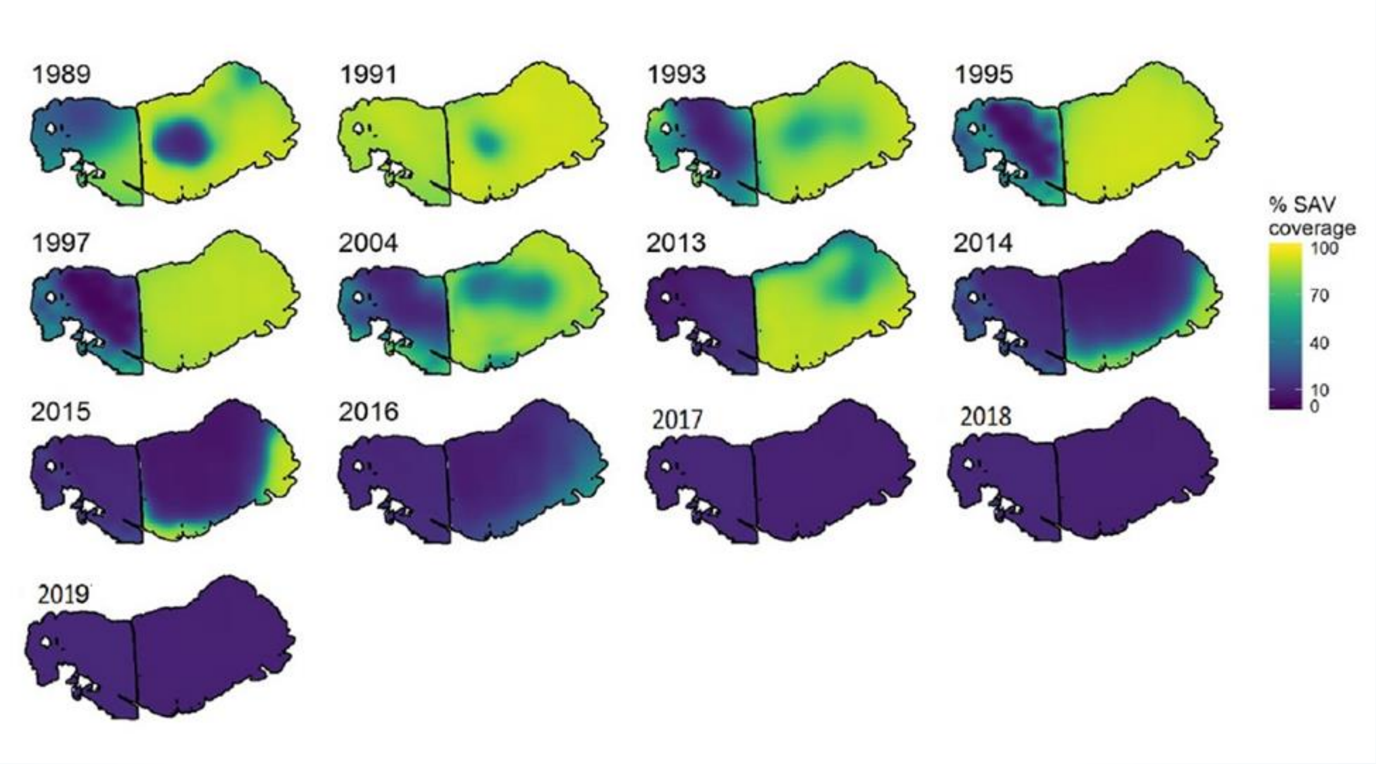
Water depth (ft)
Temperature (^{o}C)
Secchi disk (water clarity)
Specific conductance
Salinity (ppt)
pH, DO

Continuous Tide gauge at Bell Island Pier (Pamlico Sound)

Water depth (ft) (NC Flood Inundation Mapping and Alert Network)

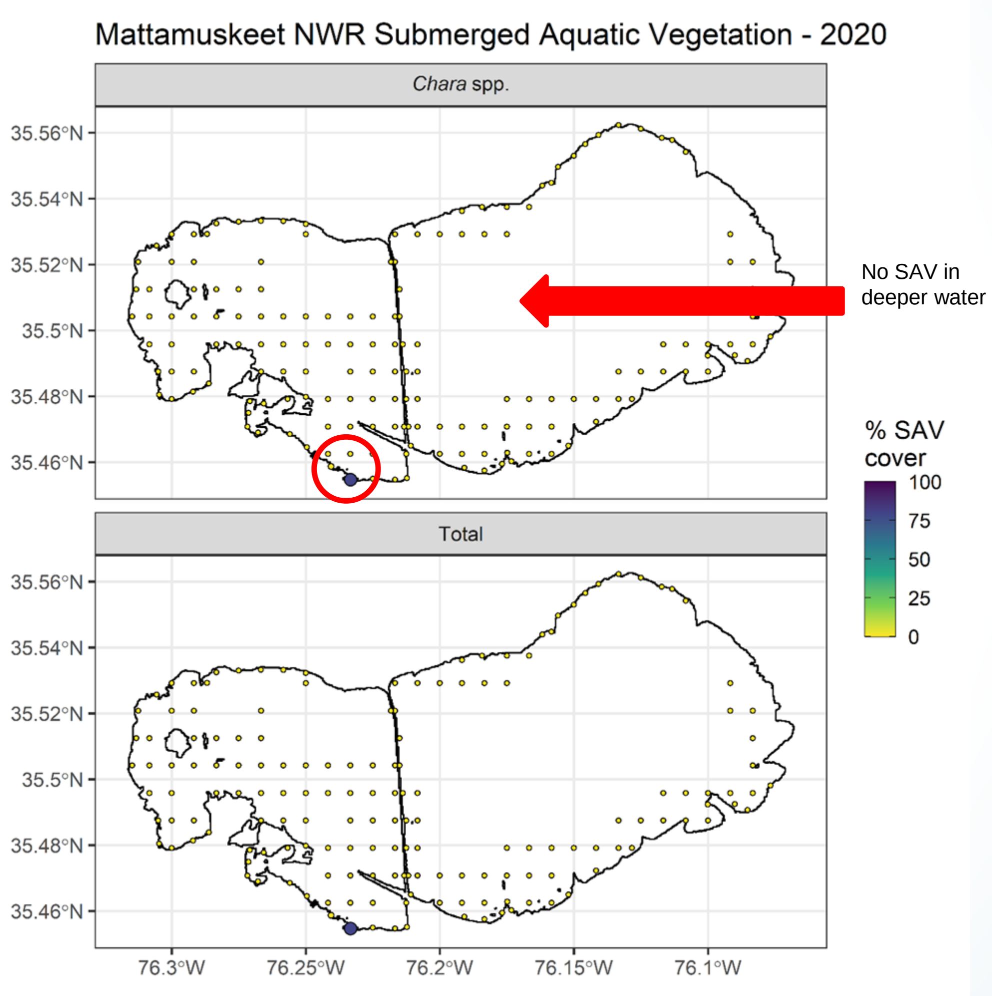
*Annual SAV surveys in the lake
Ground and aerial waterfowl surveys from November – March
Annual fish monitoring by NCWRC

The decline of SAV at Lake Mattamuskeet is concerning

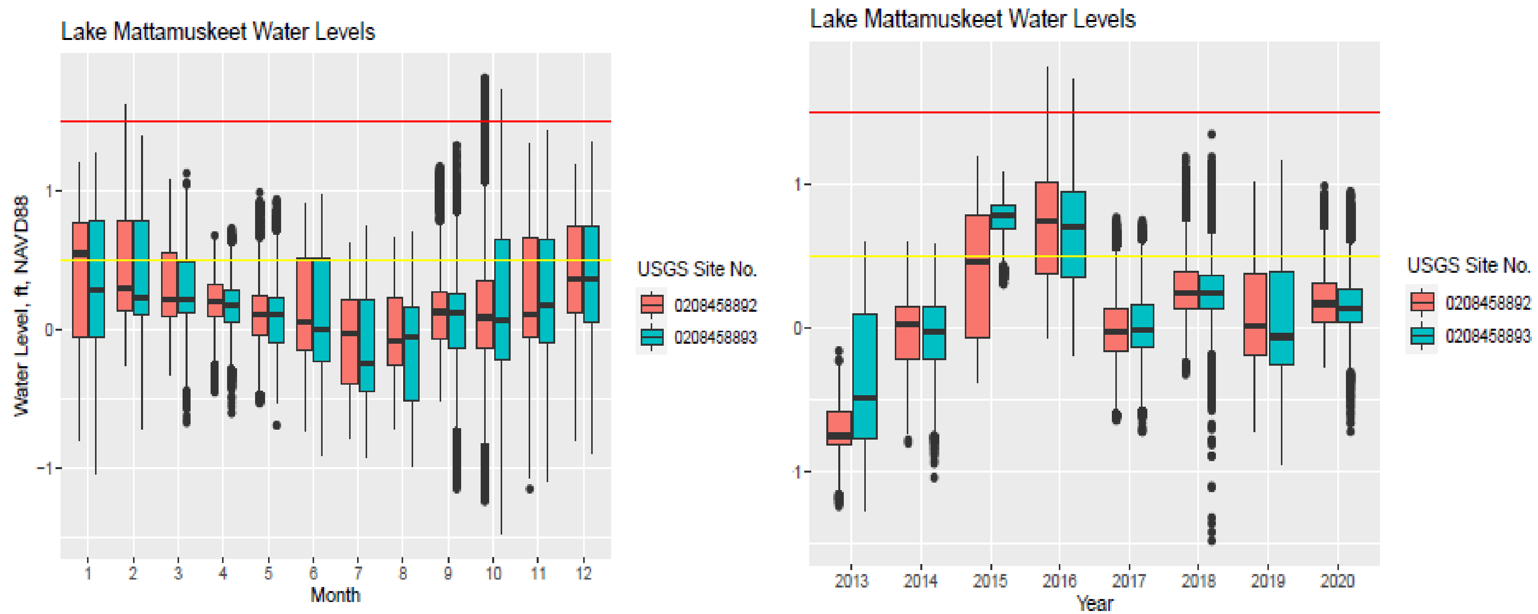


2016 the lake was designated as 303d for impaired waters based on elevated levels chlorophyll a, high pH and more recently high turbidity levels (water clarity).

2020 SAV Survey



USFWS has been monitoring lake levels since 2012

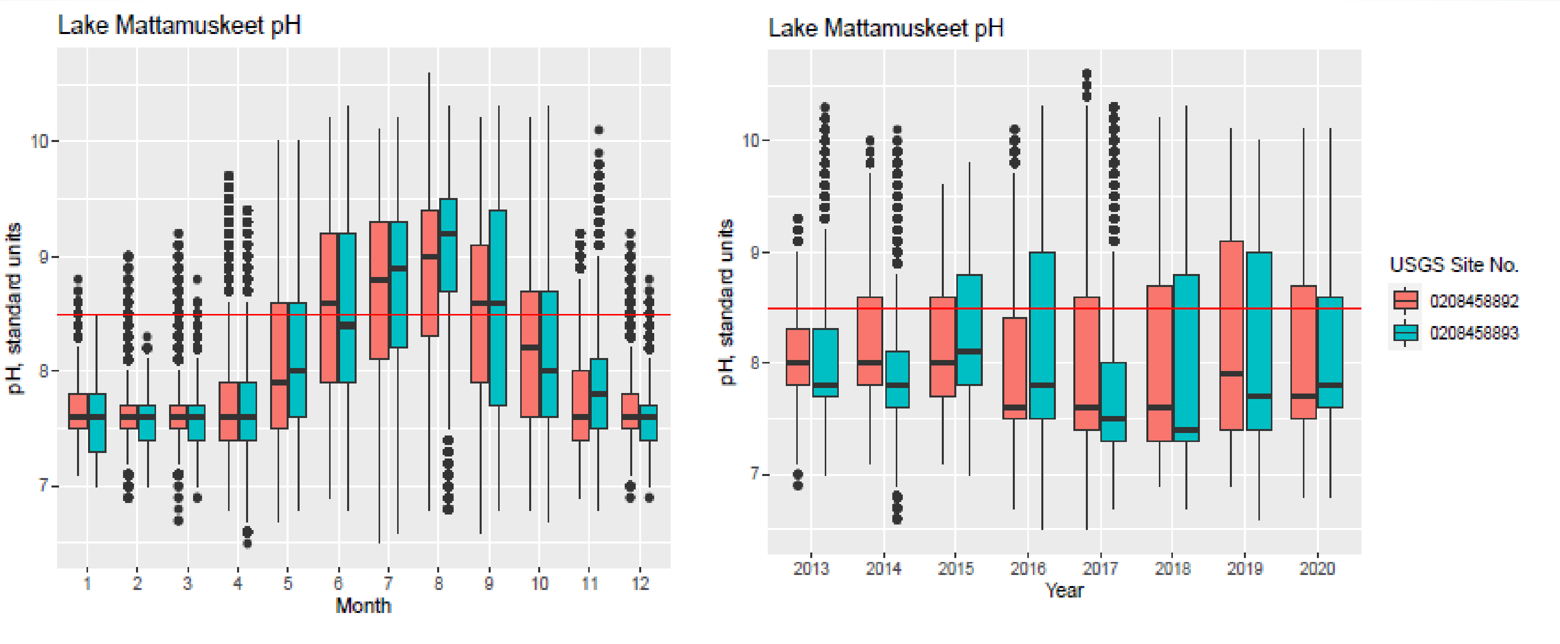


Maximum monthly water level measured each month. Yellow lines= gage heights for hot spot flooding, red lines = chronic flooding (as identified by local stakeholders)

USGS Continous WQ Stations:

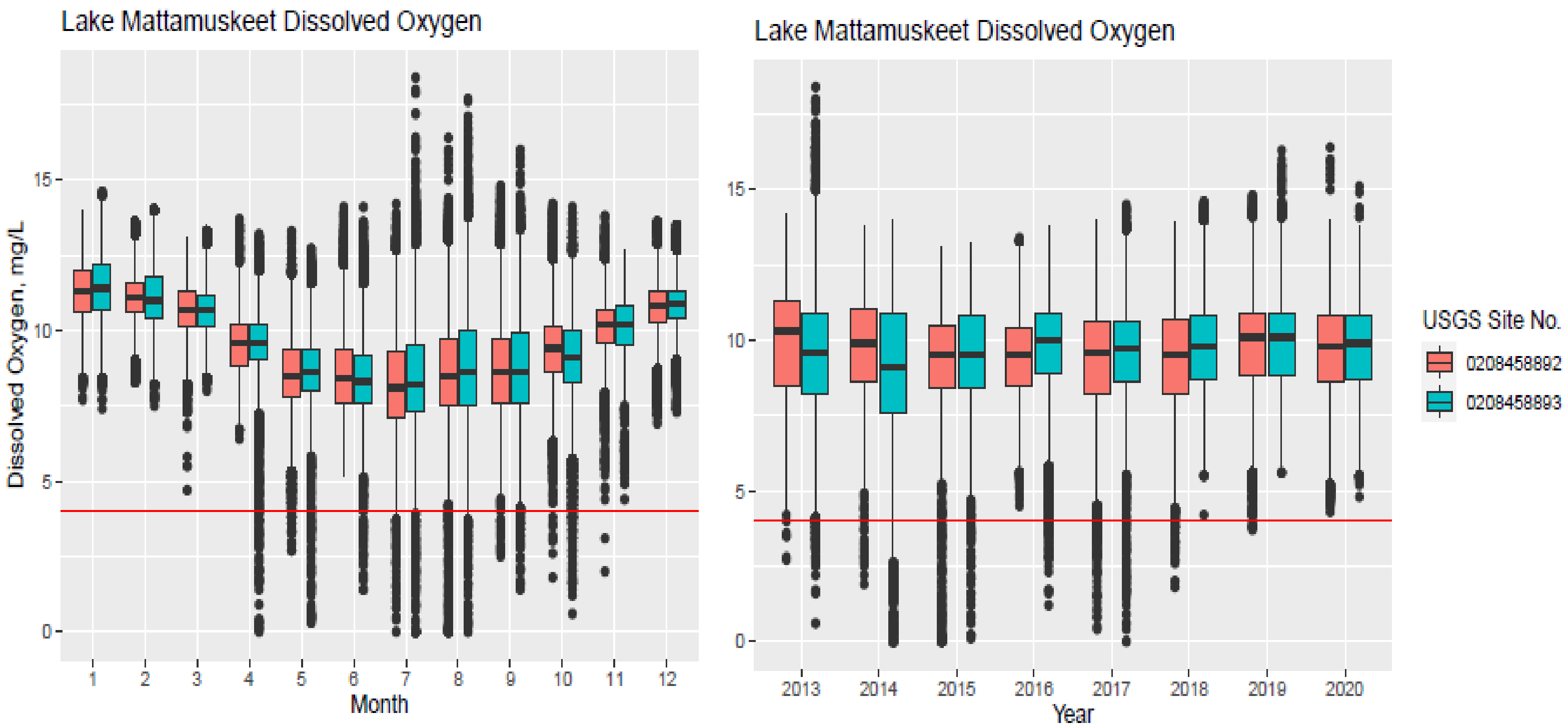
These graphs show trends in mean maximum salinity (ppt) and specific conductance by month and annually for 2013 – 2020. The red columns represent the east basin and the green represent the west basin of the lake.

USGS Continuous WQ Stations:



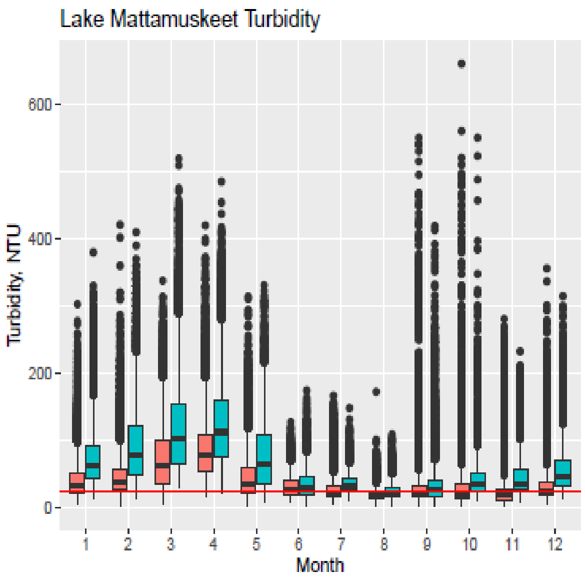
pH summarized by max monthly pH values measured each month. Red line = waters NOT meeting state water quality standard of 8.5 and indicative of an algae bloom..

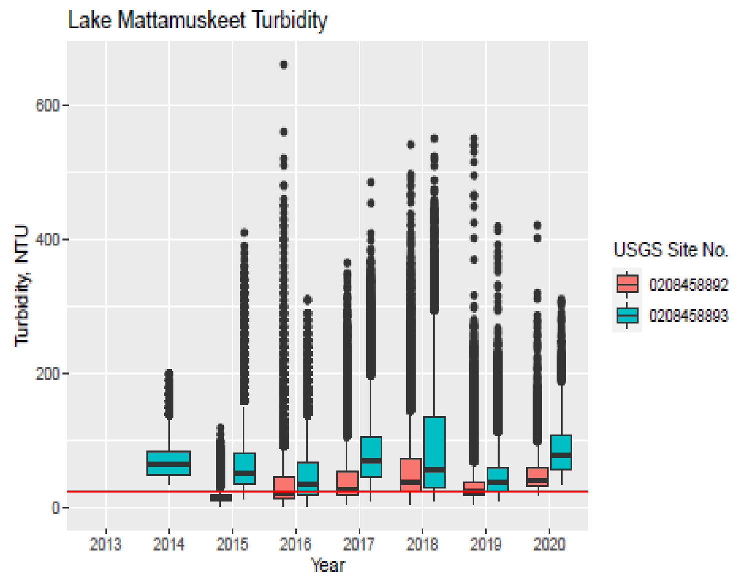
USGS Continuous WQ Stations:



These graphs show trends in mean dissolved oxygen by month and annually for 2013 – 2020. Red line is the threshold for waters NOT meeting state water quality standard of <4.

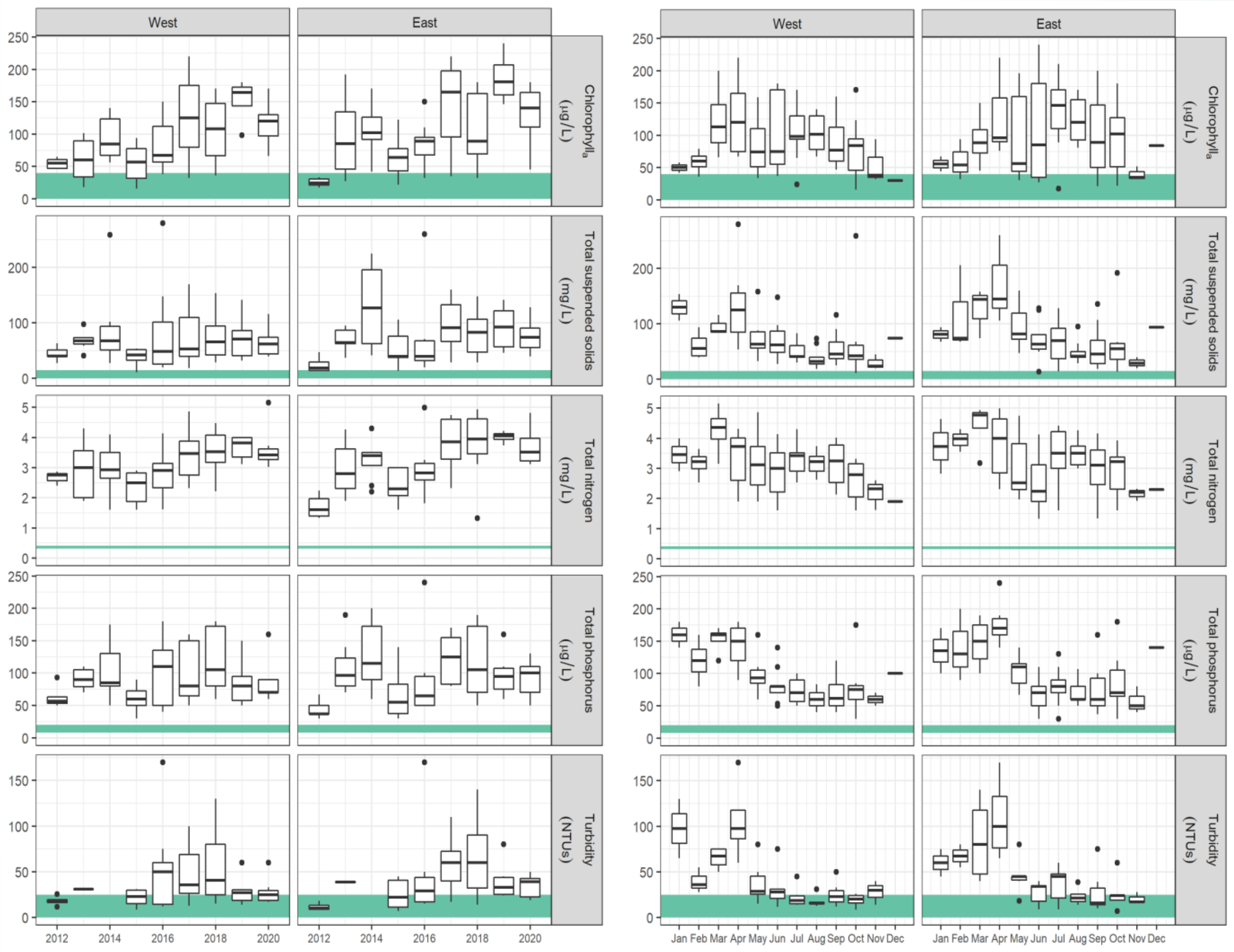
USGS Continuous WQ Stations:





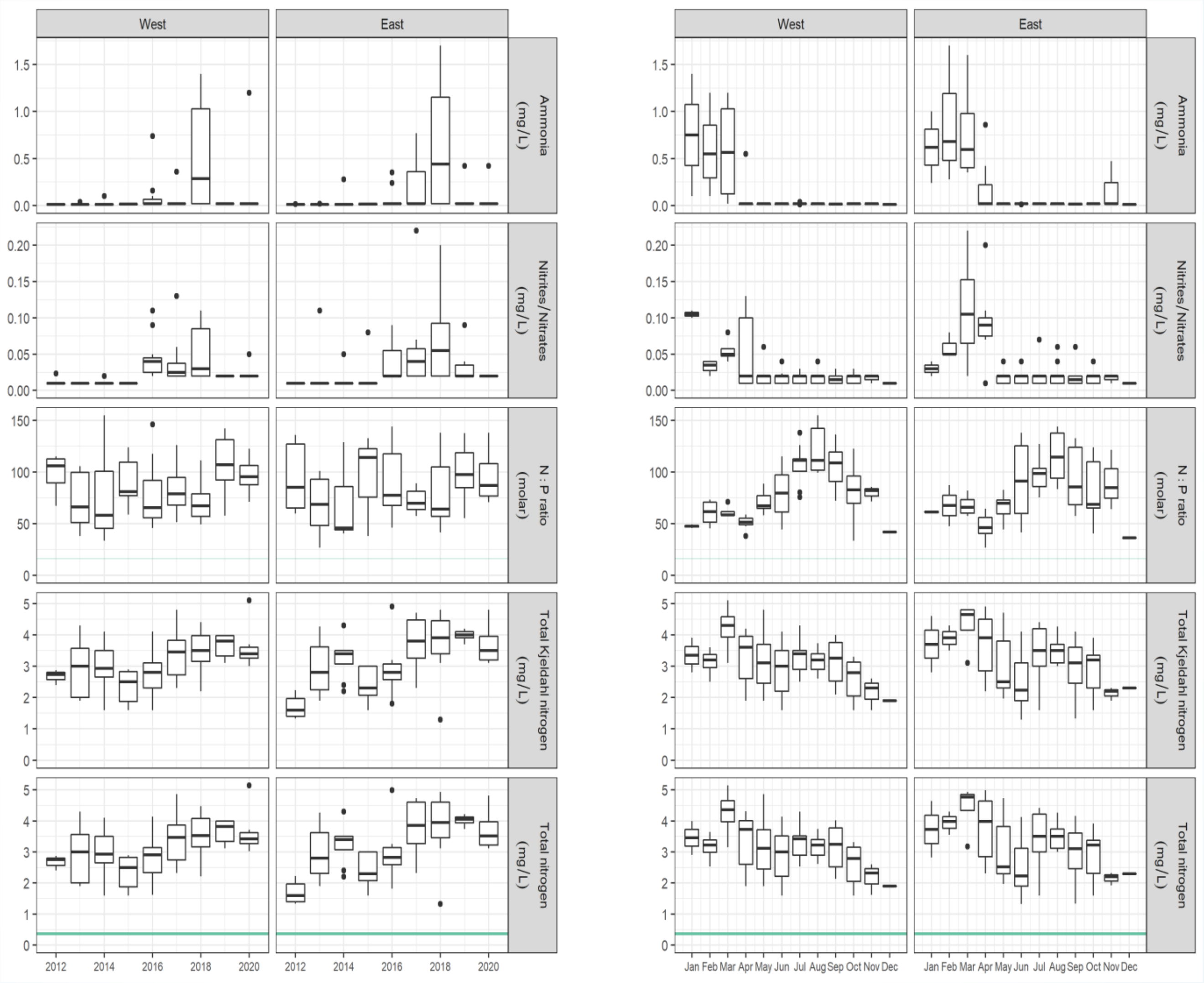
These graphs show trends in mean maximum turbidity by month and annually for 2013 – 2020. Red line is the threshold for waters NOT meeting state water quality standard of 25 NTU. It should be noted that the sondes measure FNU which is similar but not NTU.

Water quality data suggests lake has become more eutrophic since the 1980s and puts lake on 303d list for chl *a*, high pH and turbidity



Annual and monthly boxplots of core parameters. The green lines show state or EPA standards for acceptable water quality.

Water quality data suggests lake has become more eutrophic since the 1980s and puts lake on 303d list for chl *a,* high pH and turbidity



Annual and monthly boxplots of nitrogen parameters. The green lines show state or EPA standards for acceptable water

Carp Removal: Progress Made!

Draft EA and draft CD open for public comments March 29 – April 29, 2021

Contaminant analysis for human consumption

Retrofit debris gates to 2” spacing to prevent new carp enter

ECU Capstone project completed for hoist system.

NCWRC scatter stocking Bluegill into lake this week.

Photo credit Orvis.com

Carp Removal: Progress Made!

The NCWRC is scatter stocking 100,000 Bluegill into the lake at carp spawning locations. Bluegill hunt by sight and are voracious predators on carp eggs and larvae. The improvement in water clarity will increase their ability to effectively remove carp. NCWRC Fishery Biologists Kevin Dockendorf, Katy Potoka, Chris Smith, Fisheries Technician Barry Midgette, Wildlife Officers Robert Wayne and Alex McPhail and Watha State Fish Hatchery!

Carp Removal: Next Steps

- **Complete all compliance processes (compatibility determinations, NEPA, etc…)**
- **Complete all contracting documentation**
- **Purchase carp exclusion barriers and nets**
- **Implement MUM carp removal during 2023**

"Refuges resist the loss of land that is suitable for wildlife by preserving habitat or restoring where necessary, the conditions that wild things need in order to live." Rachel Carson (1947 refuge brochure: Mattamuskeet a National Wildlife Refuge)

The carp removal, in addition to reducing the nutrients and total suspended solids entering the lake, is necessary for SAV recovery, to restore Lake Mattamuskeet and support local economies.

Many thanks to all our partners and collaborators

Engineering Active Water Management

Alessa Braswell, PhD, PE, Geosyntec Consultants of NC, P.C.
Lindino Benedet, Coastal Protection Engineering of North Carolina, Inc.

Engineering Active Water Management Updates

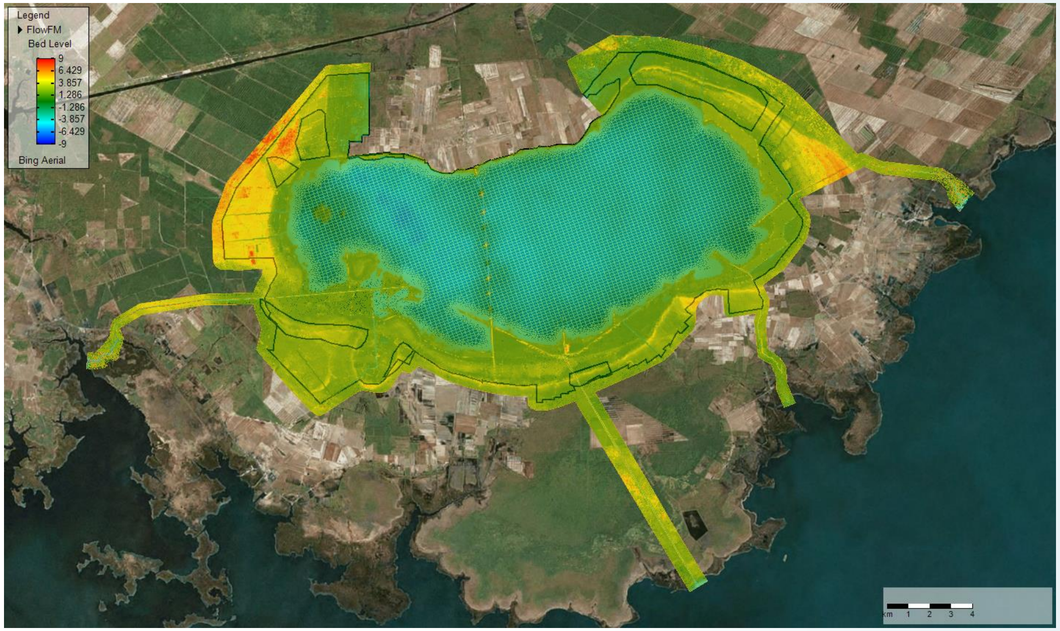
- Review Study Goals and Objectives
- Existing Conditions Model
- Wetland Siting and Capacity Analysis
- Engineering Alternatives Analysis
- Conceptual Costs

Study Goals and Objectives

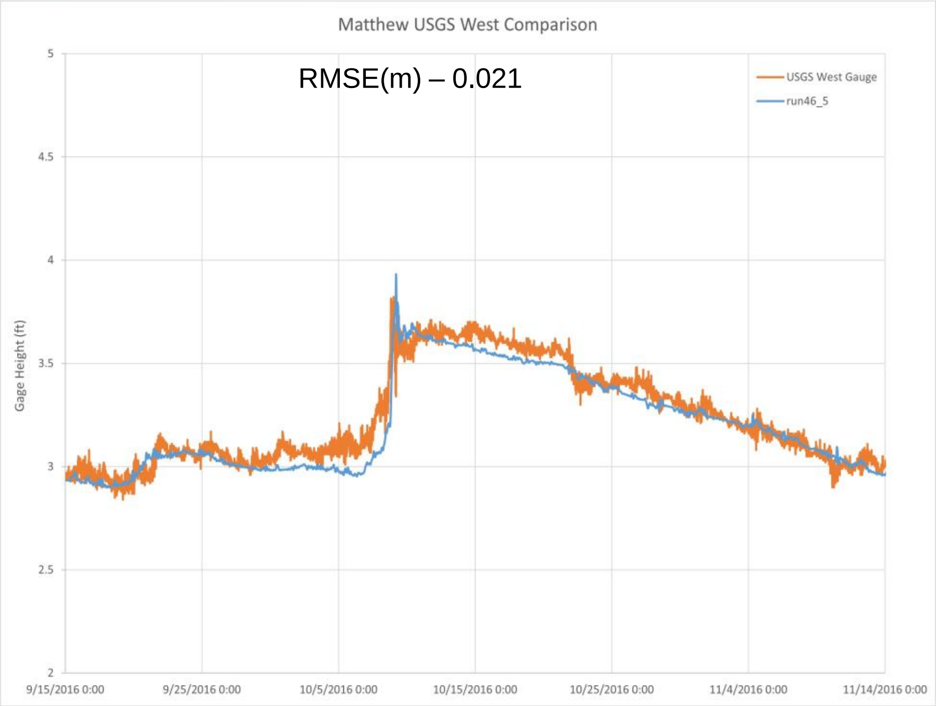
- Develop H&H model
- Calibrate to Hurricanes Matthew and Joaquin
- Simulate calibrated model under various design storm scenarios in existing and future sea level rise
- Evaluate engineered options to actively manage lake levels during design storms
- Progress preferred alternative to permit-level plans

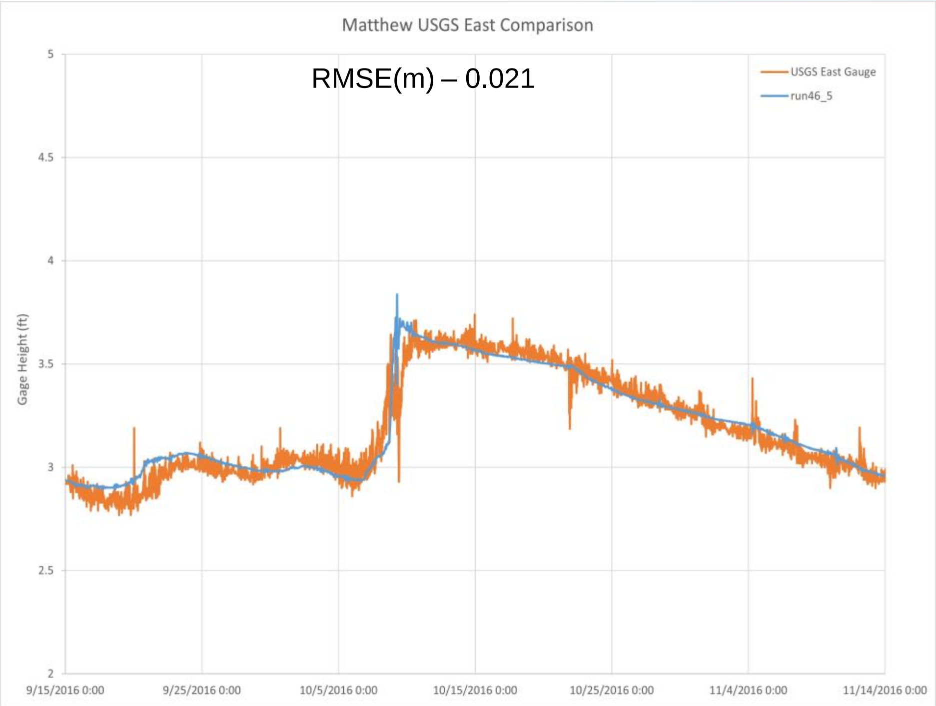
Existing Conditions Model

- Calibration Improvements
- Design storm scenarios
- Hurricane scenarios
- Existing and Future Sea Level Rise

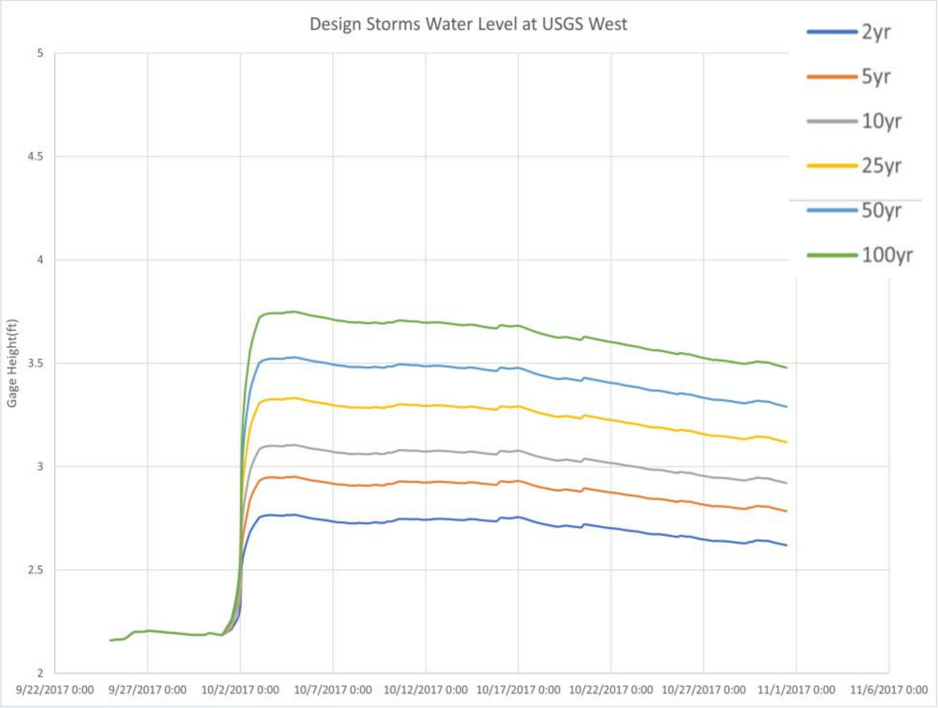


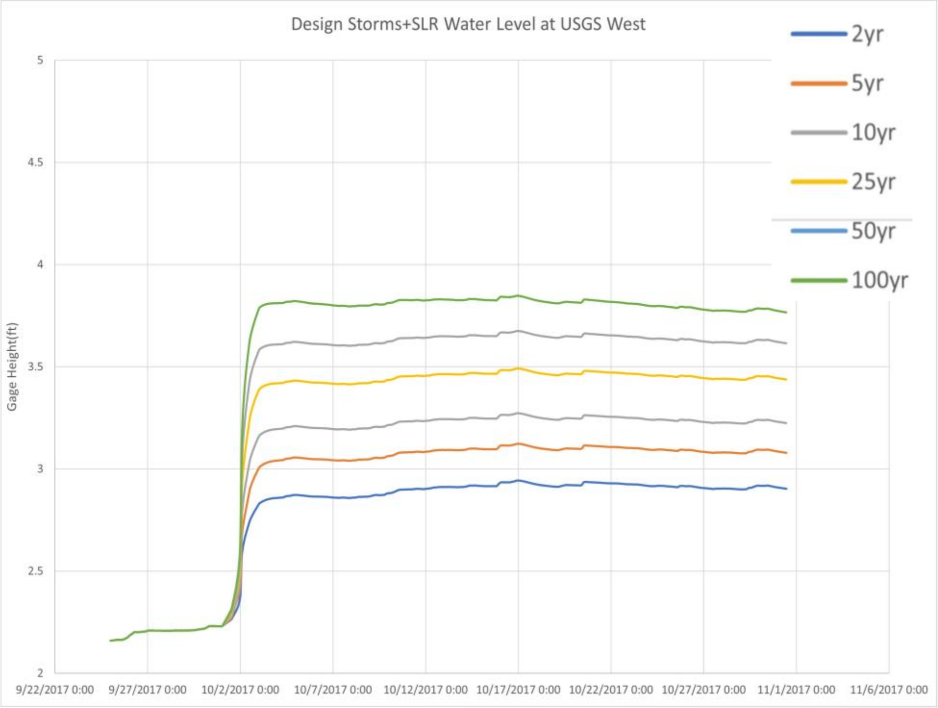
Calibration of H&H model





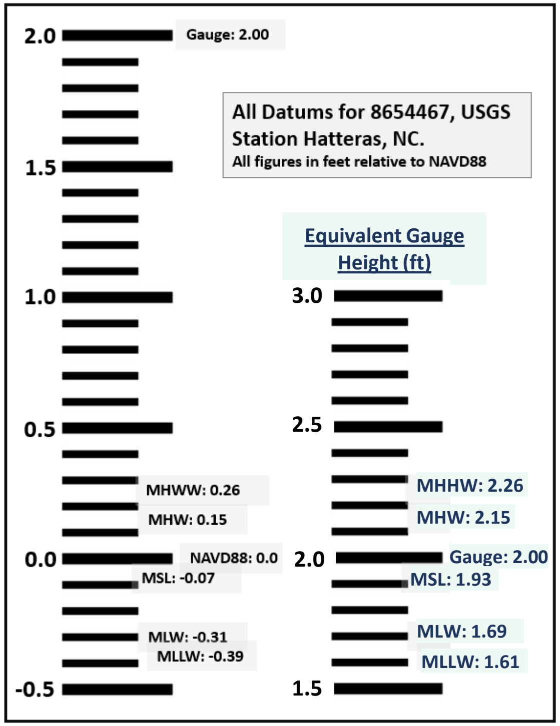
Design Storm Scenarios: Existing Sea Level & Future Sea Level Rise





Desired Lake Operational Levels

- Gauge height is equivalent to 2 ft above NAVD88
  - Gauge Height 0 ft = -2.0 ft NAVD88
  - Gauge Height 2 ft = 0 ft NAVD88
  - Mean Sea Level Gauge Height: 1.93 ft
  - Mean Low Low Water Gauge Height: 1.61 ft
- Desired operational lake levels
  - 1.0 ft, 1.5 ft, 2.0 ft, and 2.5 ft gauge
- Lower water levels desired during growing season (March – early June)
- Higher water levels desired during October to January (up to 2.5 ft)



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Storage Capacity Needs: Existing Seasonal Lake Levels

To operate at desired lake levels, we need to understand existing seasonal water levels AND storage needs during design storm events

Season	East Gauge Period of Record: 9/20/2012 – 11/02/2020			West Gauge Period of Record: 10/1/2013 – 11/02/2020		
	Minimum Gauge Height (ft)	Average Gauge Height (ft)	Maximum Gauge Height (ft)	Minimum Gauge Height (ft)	Average Gauge Height (ft)	Maximum Gauge Height (ft)
Winter (January, February, March)	0.96	2.33	3.40	1.20	2.40	3.63
Spring (April, May, June)	1.10	2.11	2.97	1.27	2.14	2.99
Summer (July, August, September)	0.85	1.92	3.33	1.22	2.03	3.18
Fall (October, November, December)	0.52	2.19	3.74	0.76	2.24	3.82

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Storage Capacity Needs

Desired Lake Level Gauge Height (ft)	Estimated Volumetric Difference Between Desired Lake Level and Average Lake Level (acre-ft)	
	Average Winter Gauge Height (2.37 ft)	Average Summer Gauge Height (1.98 ft)
1.0	55,000	39,000
1.5	35,000	19,000
2.0	16,000	1,200
2.5	-5,700	-22,000

Lowering and raising lake water levels seasonally will require initial and ongoing management measures to accept/store/release this volume

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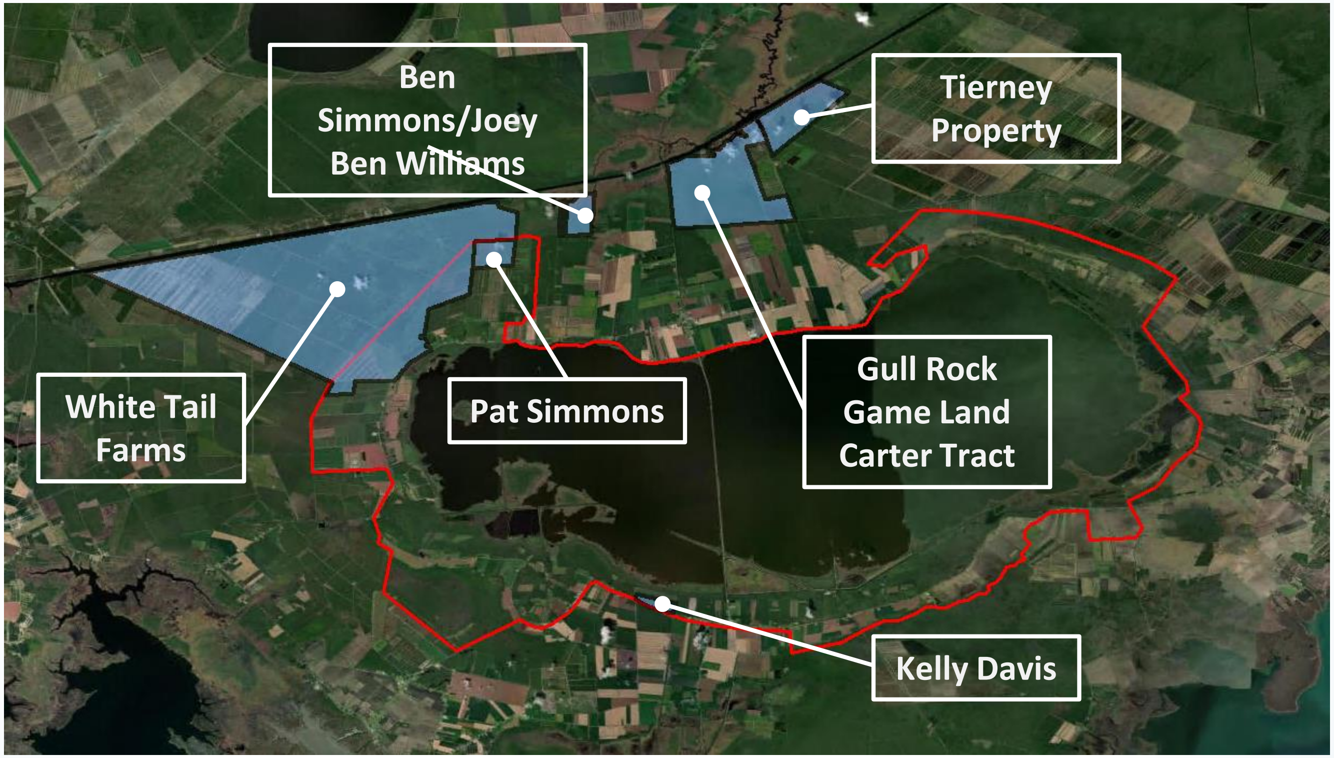
Design Storm Volumes and Hurricane Volumes

Storm Event	Approximate Storm Volume	
	ac-ft	Million gallons
Hurricane Matthew	58,000	19,000
Hurricane Joaquin	30,207	9,842
2-year	27,333	8,906
10-year	44,415	14,472
50-year	67,036	21,842
100-year	79,192	25,803

Dropping water level from 2.37 ft to 1.00 ft approximately equivalent to managing storm volume from Hurricane Matthew

Wetland Siting and Capacity Analysis



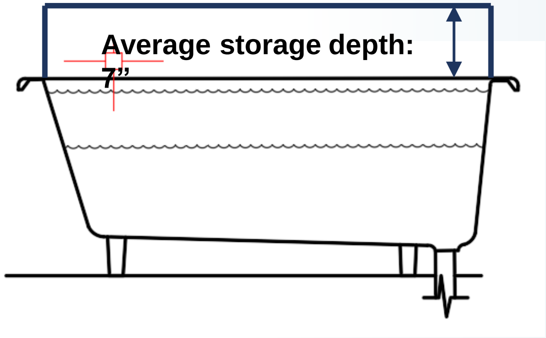
Wetland Siting and Capacity Analysis

- Storage Capacity
- Soil type
- Presence of Environmental Features
- Flood Risk
- Constructability
- Permitting

Storage Capacity

Sheet Flow Site	Area	Temporary Storage Volume	
	ac	ac-ft	Million gallons
Gull Rock Game Land Carter Tract	2,139	1,700	560
Tierney Property	791	570	190
Kelly Davis	95	79	26
Pat Simmons	294	220	72
Ben Simmons/Joey Ben Williams	338	290	96
White Tail Farms	10,792	5,600	1,800

Storage capacity estimated by calculating approximate storage volume available in 12 inches across site with small perimeter berm and check dams or adjustable weir outlet structure where applicable



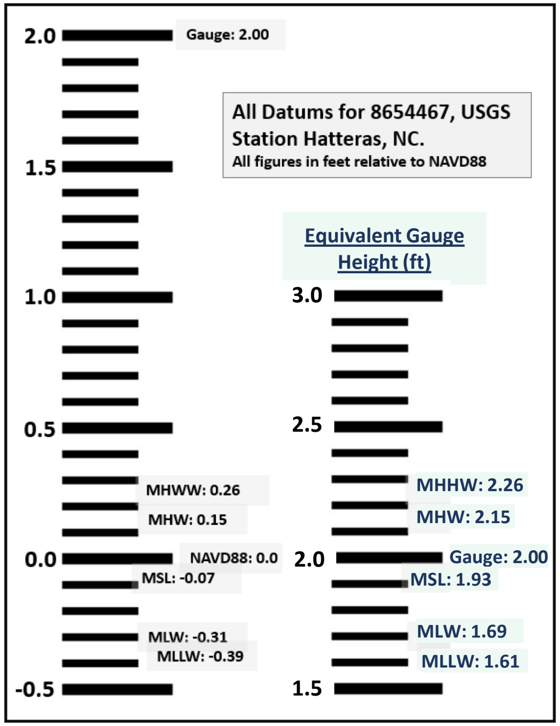
TOTAL: ~ 8,500 ac-ft

Wetland Siting and Capacity Analysis

Sheet Flow Site	Storage Capacity (ac-ft)	Soil Type	Environ-mental Features	Flood Risk	Construct-ability	Permitting
Gull Rock Game Land Carter Tract	1,707	Most Suitable	Large Presence	~ 99%	Possible	Possible
Tierney Property	572	Most Suitable	Some Presence	~ 100%	Possible	Difficult
Kelly Davis	79	Suitable	Large Presence	~ 30%	Feasible	Feasible
Pat Simmons	220	Most Suitable	Minimal Presence	~ 100%	Feasible	Feasible
Ben Simmons/Joey Ben Williams	295	Most Suitable	Large Presence	~ 100%	Feasible	Difficult
White Tail Farms	5,575	Suitable	Minimal Presence	~ 5%	Difficult	Possible

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



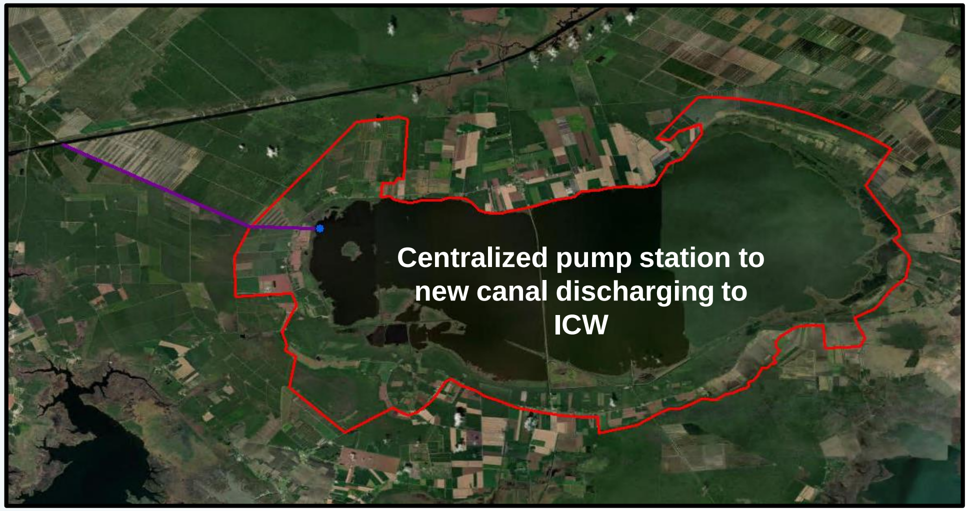
List of Potential Engineered Alternatives

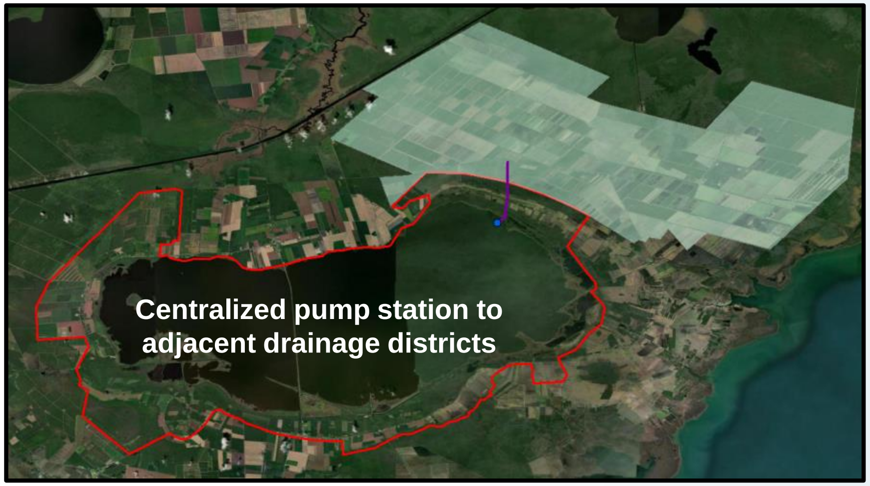
- Mid-sized pump station to drainage districts
- Large pump station to ICW
- Pump station with optimized pumping rate to ICW
- Sheet flow sites
- Dredge existing outlet canals
- Optimized outlet structures
- Dredge canals + optimized outlet structures
- Gravity-drained canals to drainage districts

10-Year Design Storm Screening Scenario

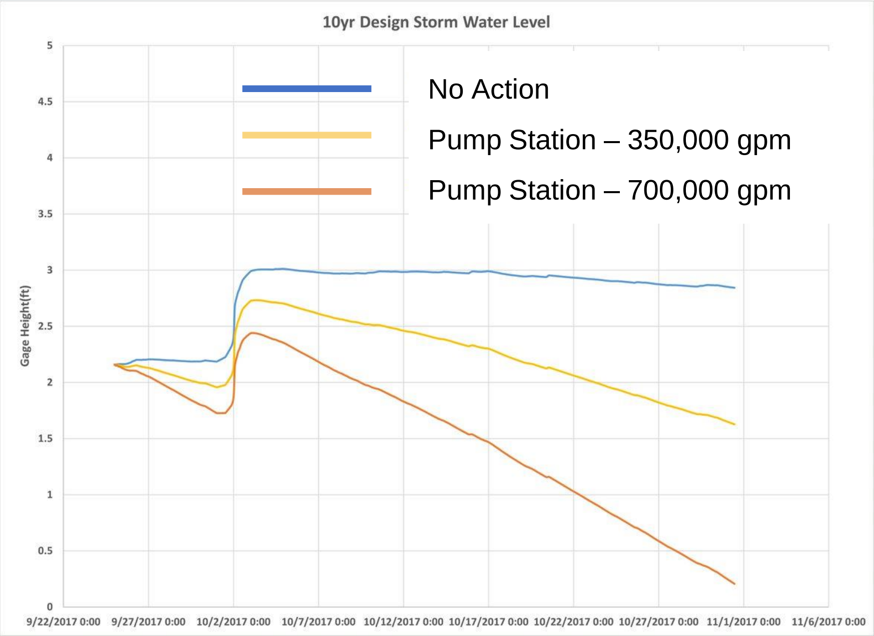
- Simulate each alternative with 10-year design storm
  - Starting water level of 2.17 ft (October average)
  - Soundside boundary condition corresponding to Hurricane Matthew record with storm surge
- Evaluate performance metrics including:
  - Peak water level
  - No. of days pumping if option includes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

Engineering Alternative: Centralized Pump Station



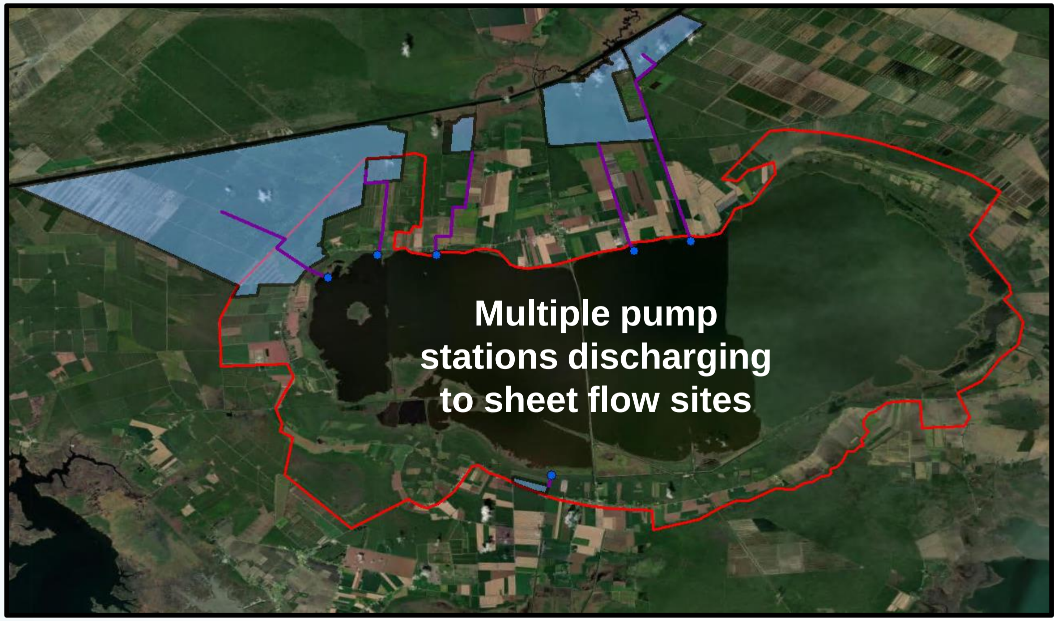


Engineering Alternative: Centralized Pump Station



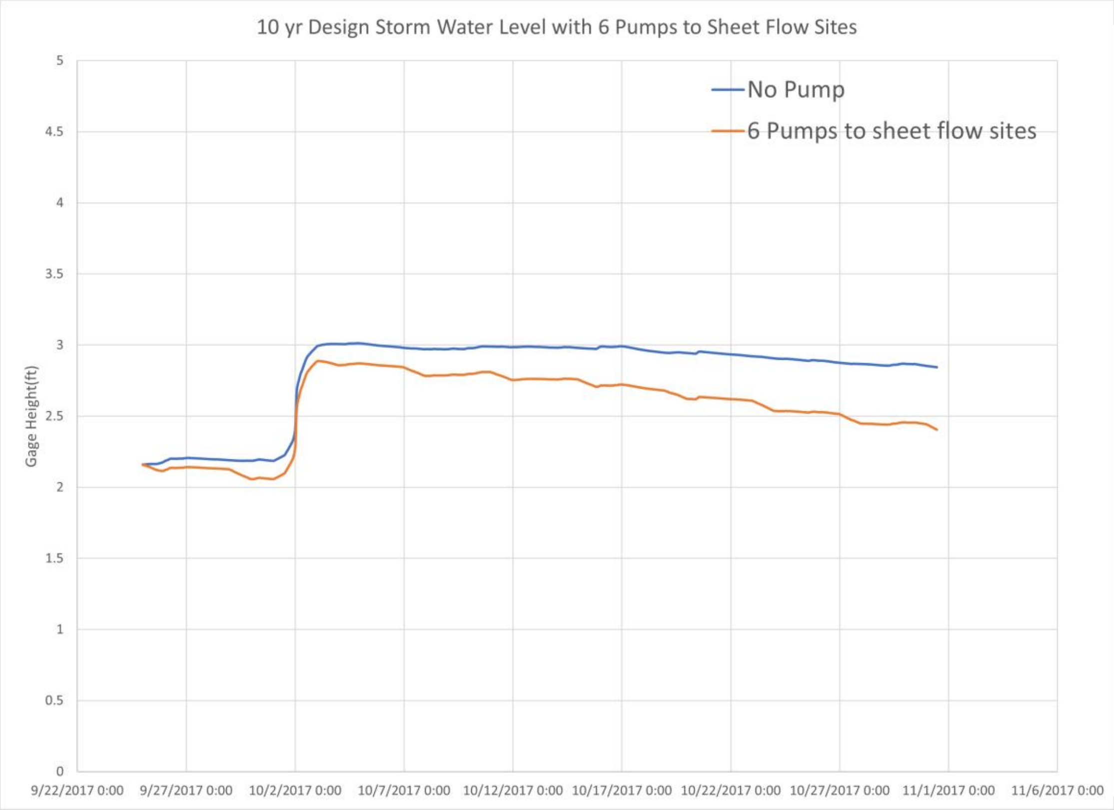
Evaluation Metric	No Action	350,000 GPM	700,000 GPM
Peak Water Level – West Gauge (Gauge Ht.)	3.01 ft	2.73	2.44
No. of Days of Pumping During Simulation	-	36.5 days	36.5 days
No. of Days for Lake Levels to Return to 2.17 ft Gauge Height OR Final Water Level at End of Simulation	2.84 ft Gauge Ht. in 36.5 days	24.6 days	12.2 days

Engineering Alternative: Sheet Flow Sites



- Pumping to 6 Sheet Flow Sites
- Rate: 47,000 to 190,000 gpm
- Cyclical Pumping (1 day on and 3 off)

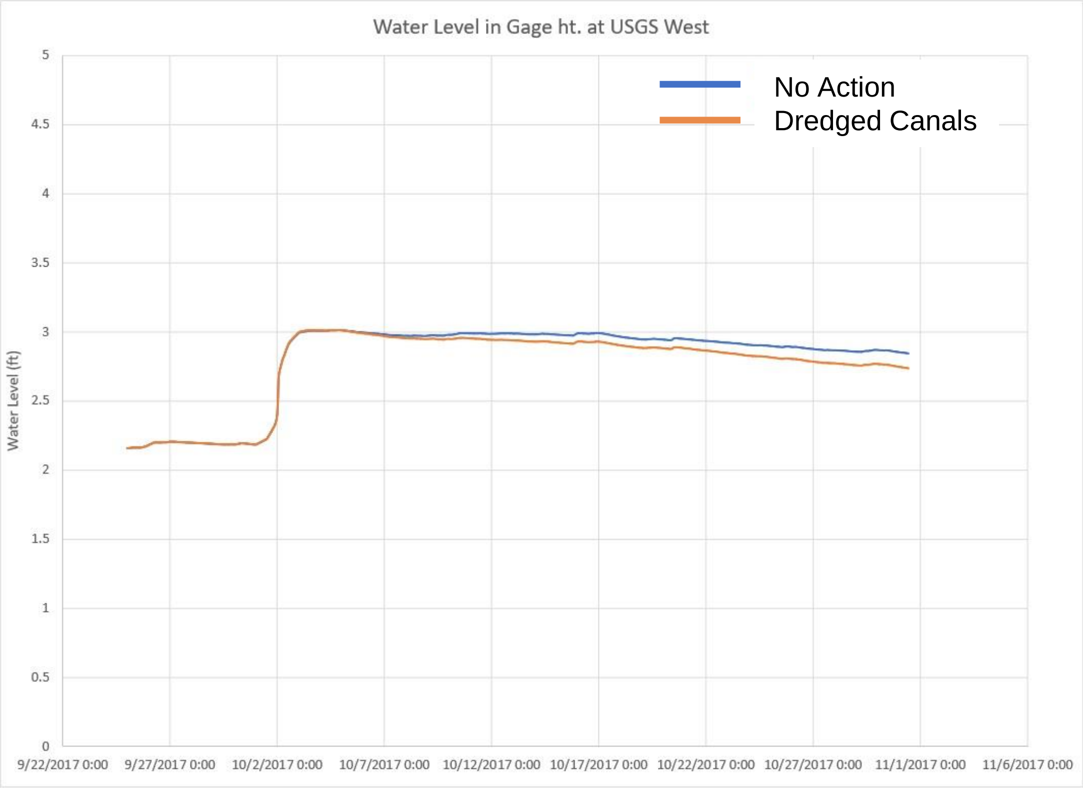
Engineered Alternative: Sheet Flow Sites



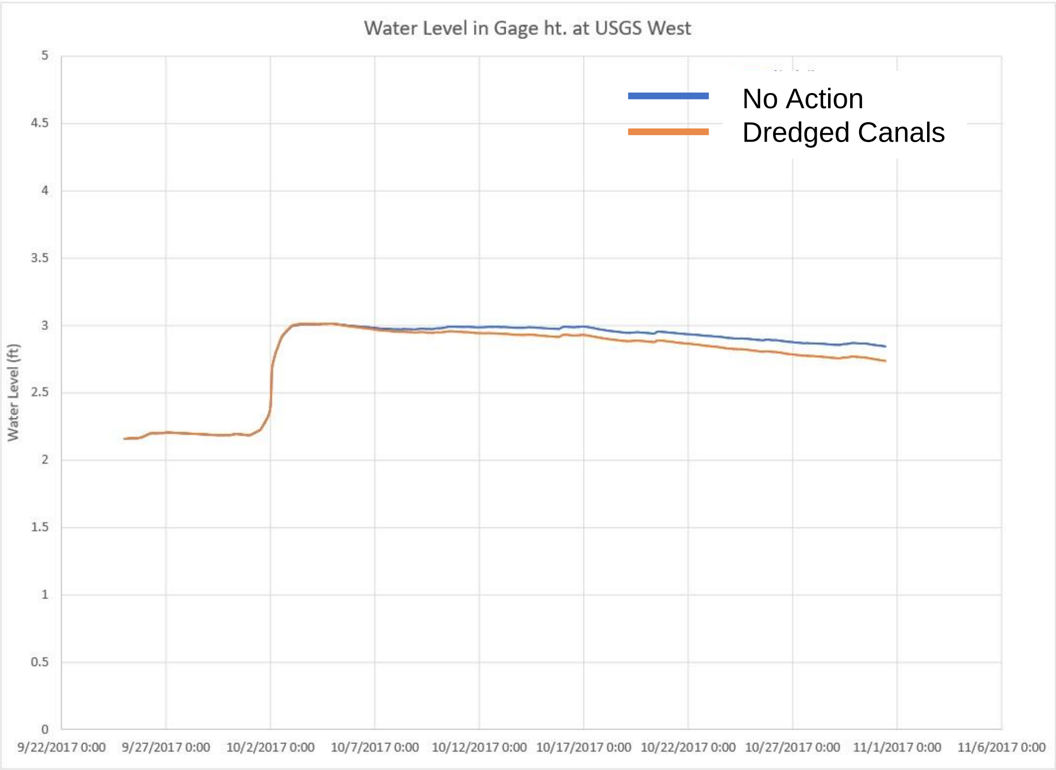
Evaluation Metric	No Action	Sheet Flow Sites
Peak Water Level – West Gauge (Gauge Ht.)	3.01 ft	2.89 ft
Number of Days of Pumping During Simulation	-	9 days
No. of Days for Lake Levels to Return to 2.17 ft Gauge Height OR Final Water Level at End of Simulation	2.84 ft Gauge Ht. in 36.5 days	2.40 ft Gauge Ht. in 36.5 days

Engineering Alternative: Dredge Existing Outlet Canals to Design Depth

- Assumed Canal Dimensions
  - Outfall Canal
  - Rose Bay Canal
  - Waupoppin Canal
  - Lake Landing Canal
- Overall impact minimal compared to no action

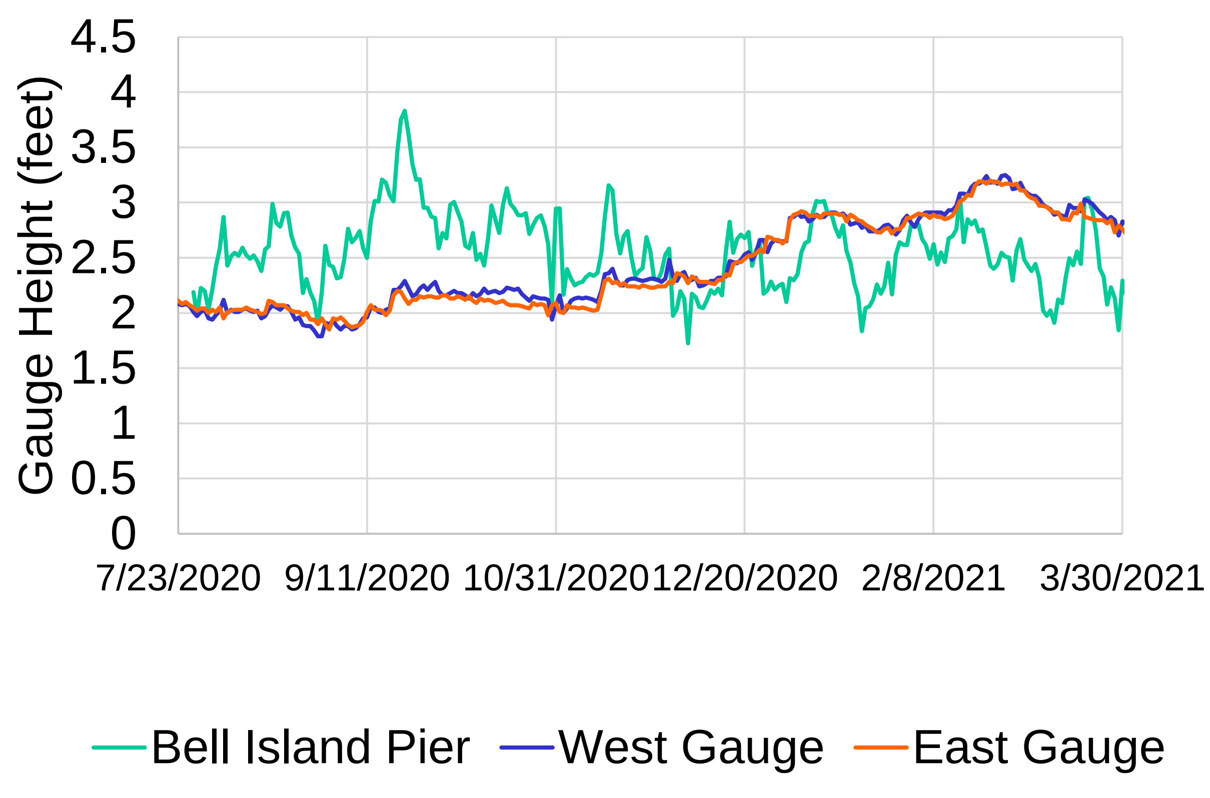


Engineering Alternative: Dredged Existing Canals to Design Depth



Evaluation Metric	No Action	Dredged Canals
Peak Water Level – West Gauge (Gauge Ht.)	3.01 ft	3.01 ft
No. of Days of Pumping During Simulation	-	-
No. of Days for Lake Levels to Return to 2.17 ft Gauge Height OR Final Water Level at End of Simulation	2.84 ft Gauge Ht. in 36.5 days	2.74 ft Gauge Ht. in 36.5 days

Soundside Water Level

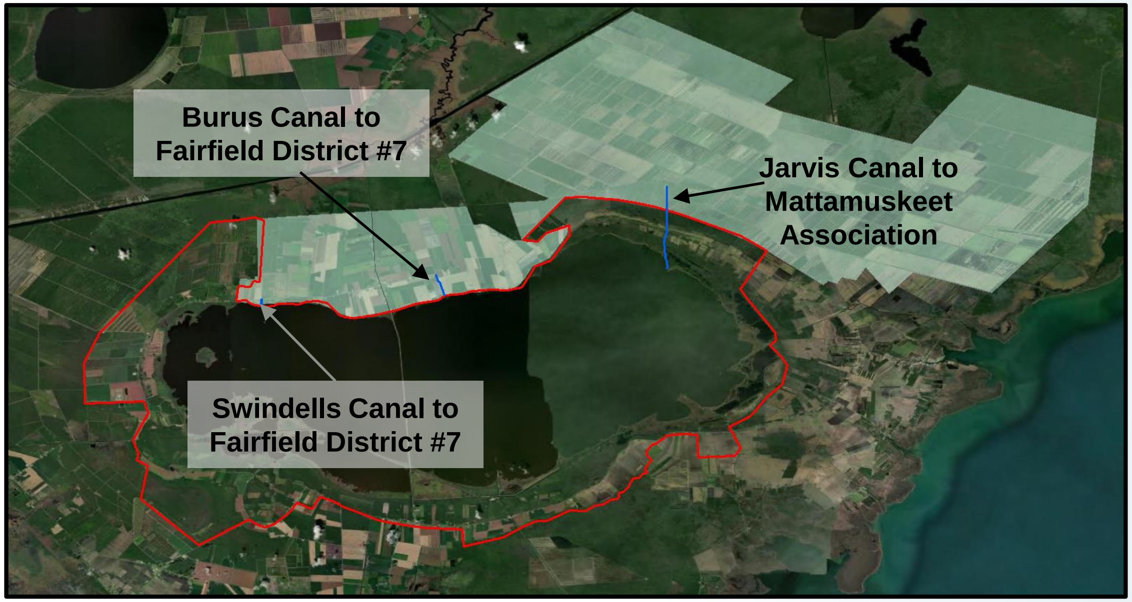


Over the last 270 days, the average sound level was greater than average lake water level 44% of the time

NOTE: Also simulated sensitivity of model to outlet structure configuration. Minimal impact compared to no action

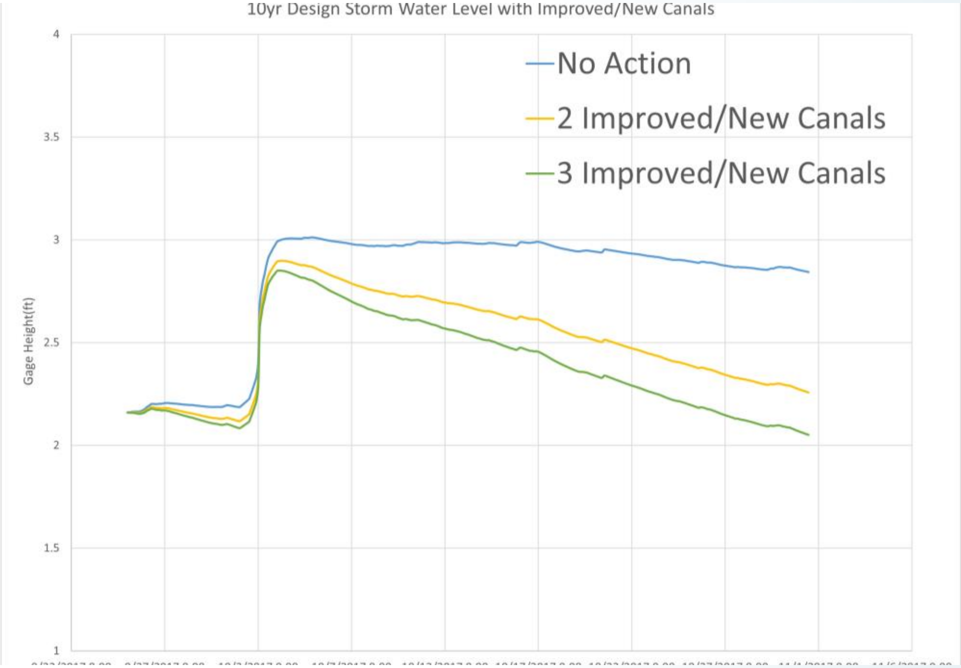
Gravity-Drained Canals to Drainage Districts

- Improve Jarvis Canal to Mattamuskeet Association
- Improve Burus Canal and Swindells Canal (adjacent to Oyster Nest Campground) to Fairfield District #7
- Draw down lake using adjustable water control structure (weir outlet set at 1 ft gauge [-1 ft NAVD88] for initial simulation)

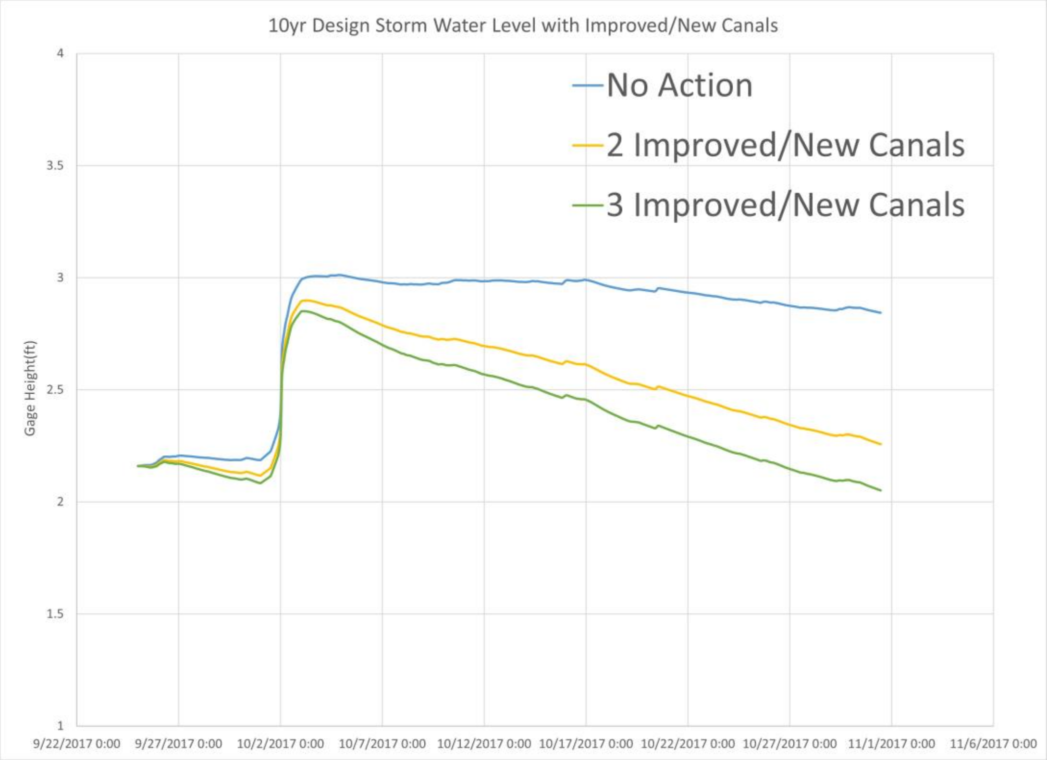


Gravity-Drained Canals to Drainage Districts

- Upgrade pump capacity at pump stations in drainage districts to handle additional volume (approximately 425,000 gpm)
- Drainage districts would charge on a volume basis
- Added third canal after initial simulations to increase drainage capacity
- Improved drainage capacity with third canal and some canal adjustments

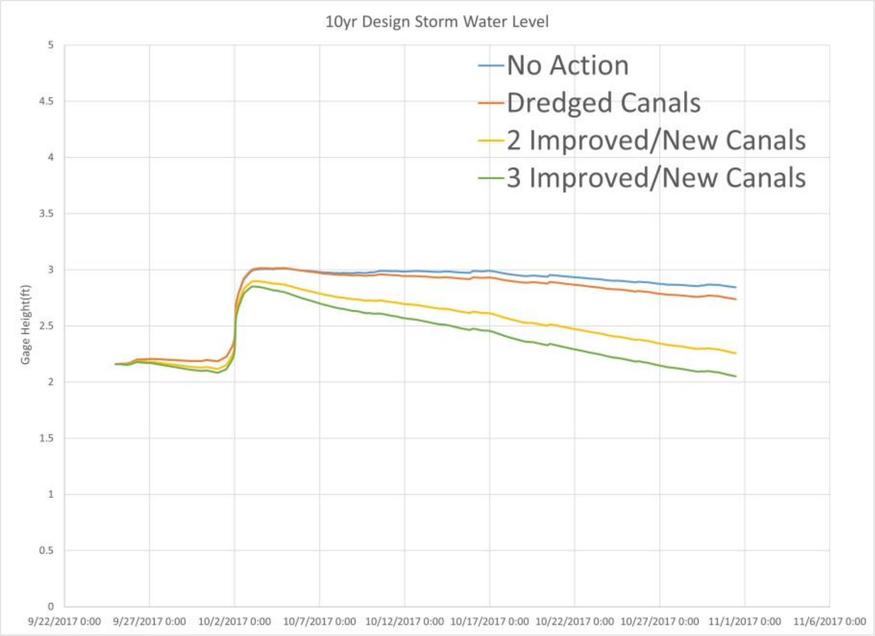


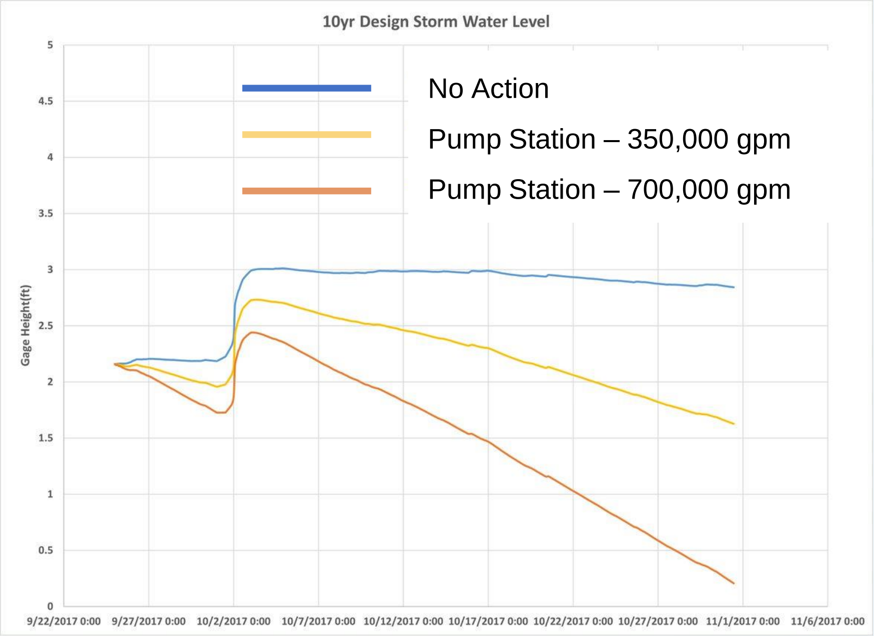
Gravity-Drained Canals to Drainage Districts



Evaluation Metric	No Action	Gravity-Drained Canals (Burus and Jarvis)	Gravity-Drained Canals (Burus, Jarvis, and Swindells)
Peak Water Level (West Gauge)	3.01 ft	2.90	2.85 ft
No. of Days of Pumping During Simulation	-	-	-
No. of Days for Lake Levels to Return to 2.17 ft Gauge Height OR Final Water Level at End of Simulation	2.84 ft Gauge Ht. in 36.5 days	2.26 ft Gauge Ht. in 36.5 days	31.5 days

Comparison of Alternative Simulations





Conceptual Costs Evaluation

- Evaluated three alternatives for conceptual capital costs
  - Pump station with optimized pumping rate
  - Sheet flow sites
  - Gravity-drained canals to drainage districts
- Evaluated based on design parameters utilized in the model (e.g., cut/fill amount in digital elevation model, pump capacity simulated in model) and other typical ancillary costs
- Does not include annual operational costs and/or life-cycle costs or design fees

Conceptual Costs Comparison

Parameter	No Action Alternative	Centralized Pump Station (350,000 gpm)	Sheet Flow Sites	Gravity-drained Canals (2 canals)	Gravity-drained Canals (3 canals)	Dredged Canals*
Conceptual Costs with 30% Contingency	-	$7,800,000 to $17,300,000	$13,300,000 to $23,500,000	$3,500,000 to $8,700,000	$6,900,000 to $13,900,000	$5,600,000 to $8,300,000
Peak Water Level	3.01	2.73	2.89	2.90	2.85	3.01
Ending Water Level	2.84	1.70	2.40	2.26	2.08	2.74
Difference in Ending Water Level from No Action	-	1.14	0.44	0.64	0.76	0.10
$/acre/ft of water level drop during 10-year storm	-	$100 - $220	$440 - $770	$90 - $220	$130 - $265	$810 - $1200

*Detailed cost analyses not performed; based on $40/LF - $60/LF plus 30% contingency

Next Steps

- Stakeholder team to select two alternatives to evaluate for all design storms
  - 2-year, 10-year, 50-year, 100-year, Hurricane Joaquin, Hurricane Matthew
  - Simulate under existing and future sea level rise
- Hyde County Board of Commissioners to select engineered alternative to progress to permit-level plans

Using Undergraduate Engineers and Community Engagement

Dr. Randall Etheridge, East Carolina University

Student Design Projects

Leadership Team

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ECU ENGINEERING

ECU SUSTAINABLE ENERGY AND ENVIRONMENTAL ENGINEERING

Design Projects

- Goal: Develop concept plans for 3 projects that reduce flooding and/or improve water quality in the lake
- Concept plans include estimates of cost and effectiveness for reducing flooding and/or improving water quality
- The stakeholders will decide how to move forward based on the concept plans
- Completion of the concept plans does not mean any of the projects will be constructed

Project Selection

- Support from the community
- Greatest potential to reduce flooding on residential property and farms in the watershed
- Landowners willingness to grant access
- Meet the educational objectives for the students

Local Research

- Site visits
- Meetings with key personnel
- Consultation with Geosyntec
- Design feedback from focus groups with residents and other interested parties

What is next?

- Final presentations tonight
- Final design reports completed in late April or early May

- Leadership team will attend future stakeholder and public meetings to answer questions about designs and explain how what was learned through these projects can be applied to future projects
- Contact the leadership team if you are interested in developing concept plans for other potential projects starting next fall

Design Projects

1. Pat Simmons Property Sheet Flow
2. Mattamuskeet Association Sheet Flow
3. Dredging the Outflow Canals

ECU ENGINEERING

ECU SUSTAINABLE ENERGY AND ENVIRONMENTAL ENGINEERING

LAKE MATTAMUSKEET: LANDOWNER PROJECT

By: Shelby Wiggins, Dustin Holland, Ahmad Abdeljawad, Loring Penna-Welch

TEAM INTRODUCTIONS

LORING PENNA-WELCH

ENVIRONMENTAL ENGINEER

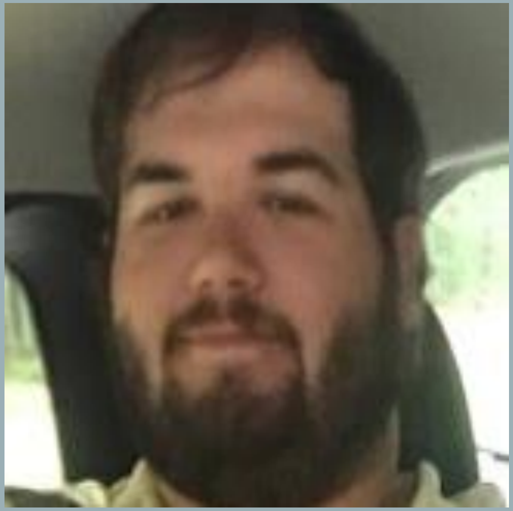
SHELBY WIGGINS

ENVIRONMENTAL ENGINEER

TEAM INTRODUCTIONS

DUSTIN HOLLAND

MECHANICAL ENGINEER

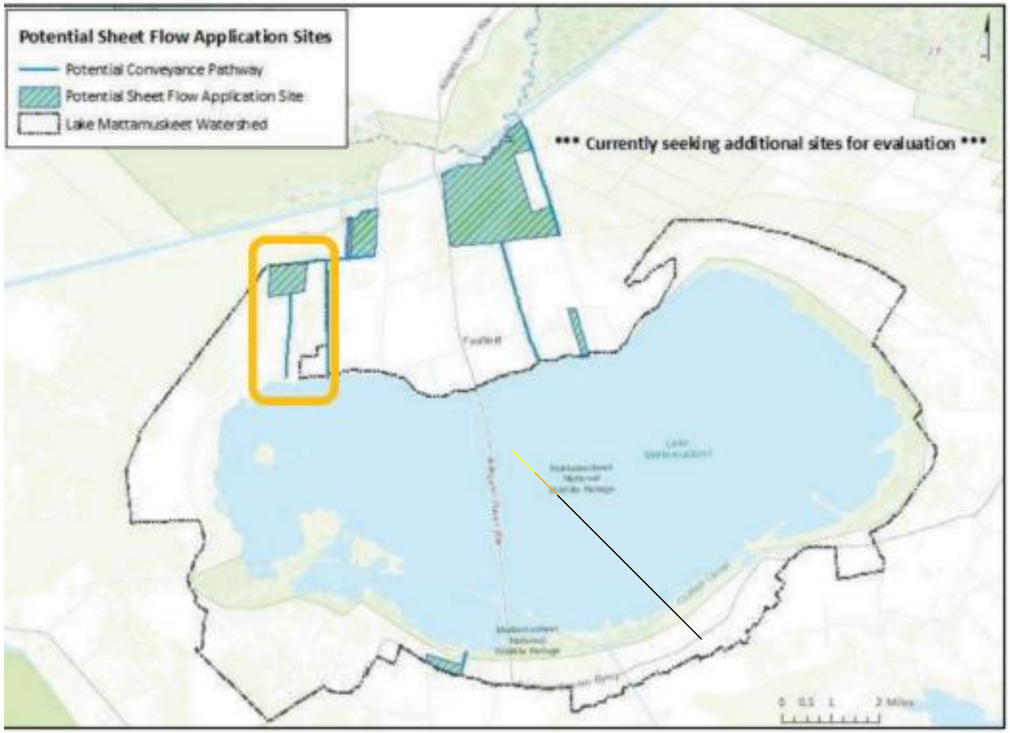


AHMAD H. ABDELJAWAD

INDUSTRIAL SYSTEMS ENGINEER

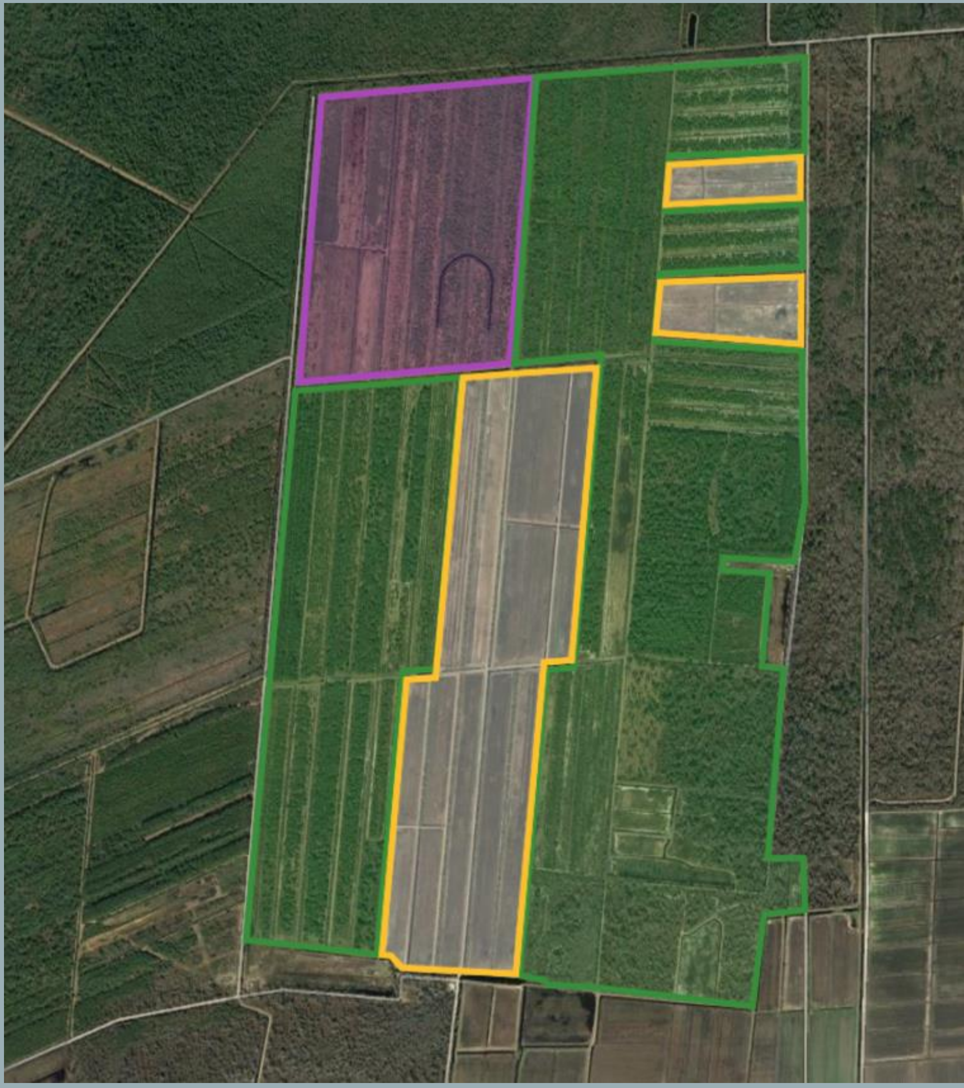
PROJECT INTRODUCTION

- Pat Simmons' property
- Reduce flooding
- Improved water quality
- Create habitat



PAT SIMMONS PROPERTY

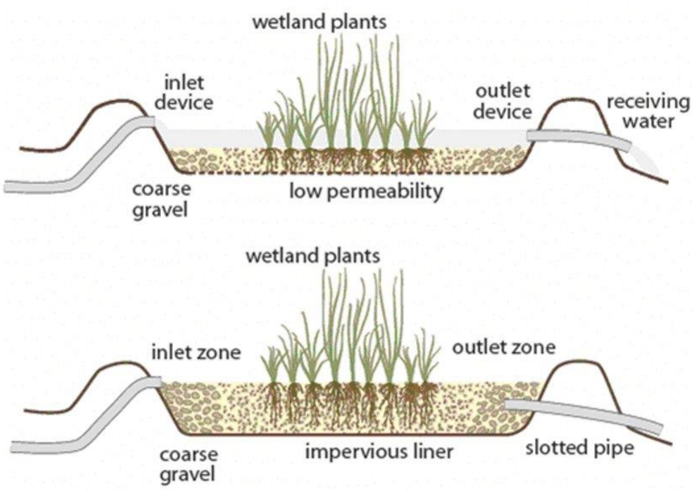
SIMMONS PROPERTY



BENEFITS OF APPLICATION

Per EPA Handbook of Constructed Wetlands:

- Water quality improvement
- Flood storage
- Nutrient cycling
- Habitat for wildlife
- Recreation (i.e., hunting)
- Landscape enhancement



APPLICATION ON SIMMONS PROPERTY

- Water flows through pre-existing canal
- Water control structures
- Pump utilization
- Temporary storage
- Water discharged into ICW

WETLAND SIZING & LOCATION

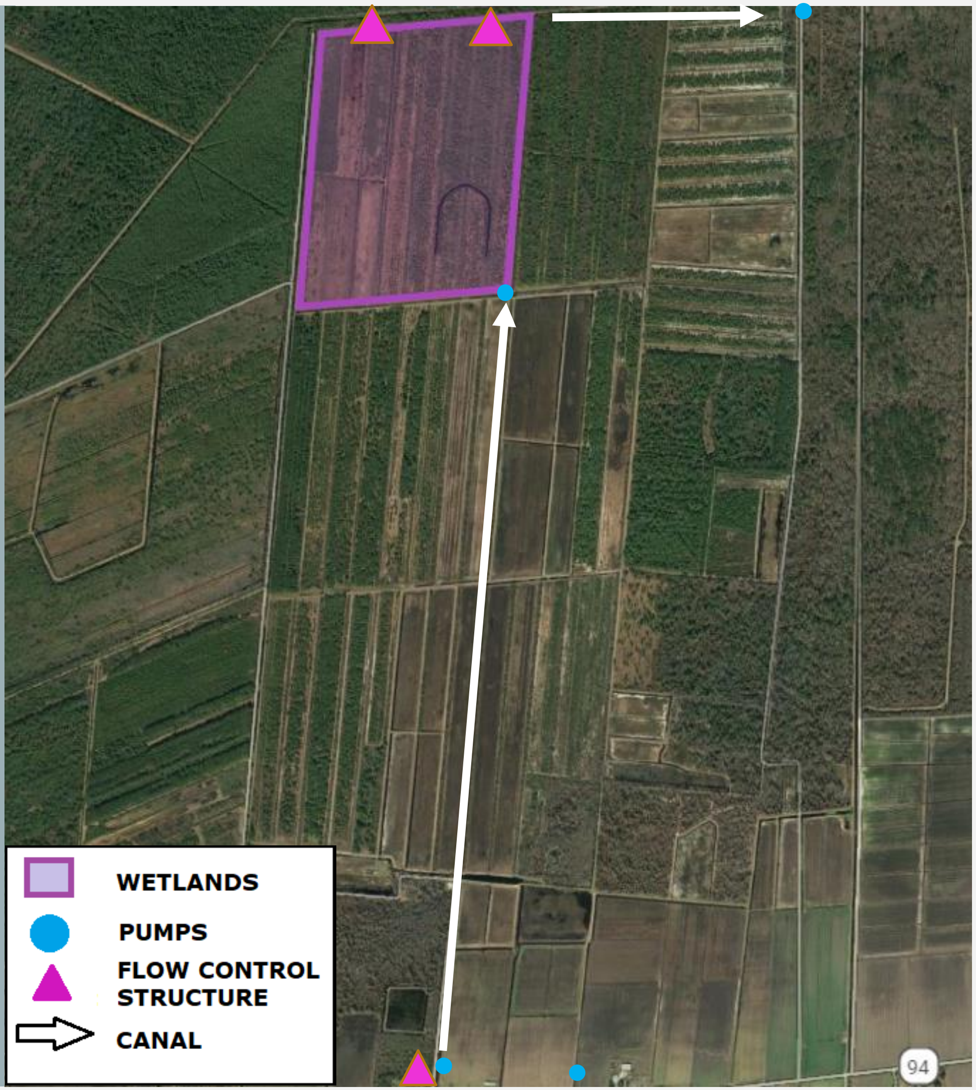
Northwestern block of land

Area: 164.7 acres

Maximum depth of wetland: 2 feet

Potential daily storage capacity: 330 acre-feet (>107 million gallons)

Axial Flow 24" diesel powered pump



WATER QUALITY

Agricultural land : Wetland

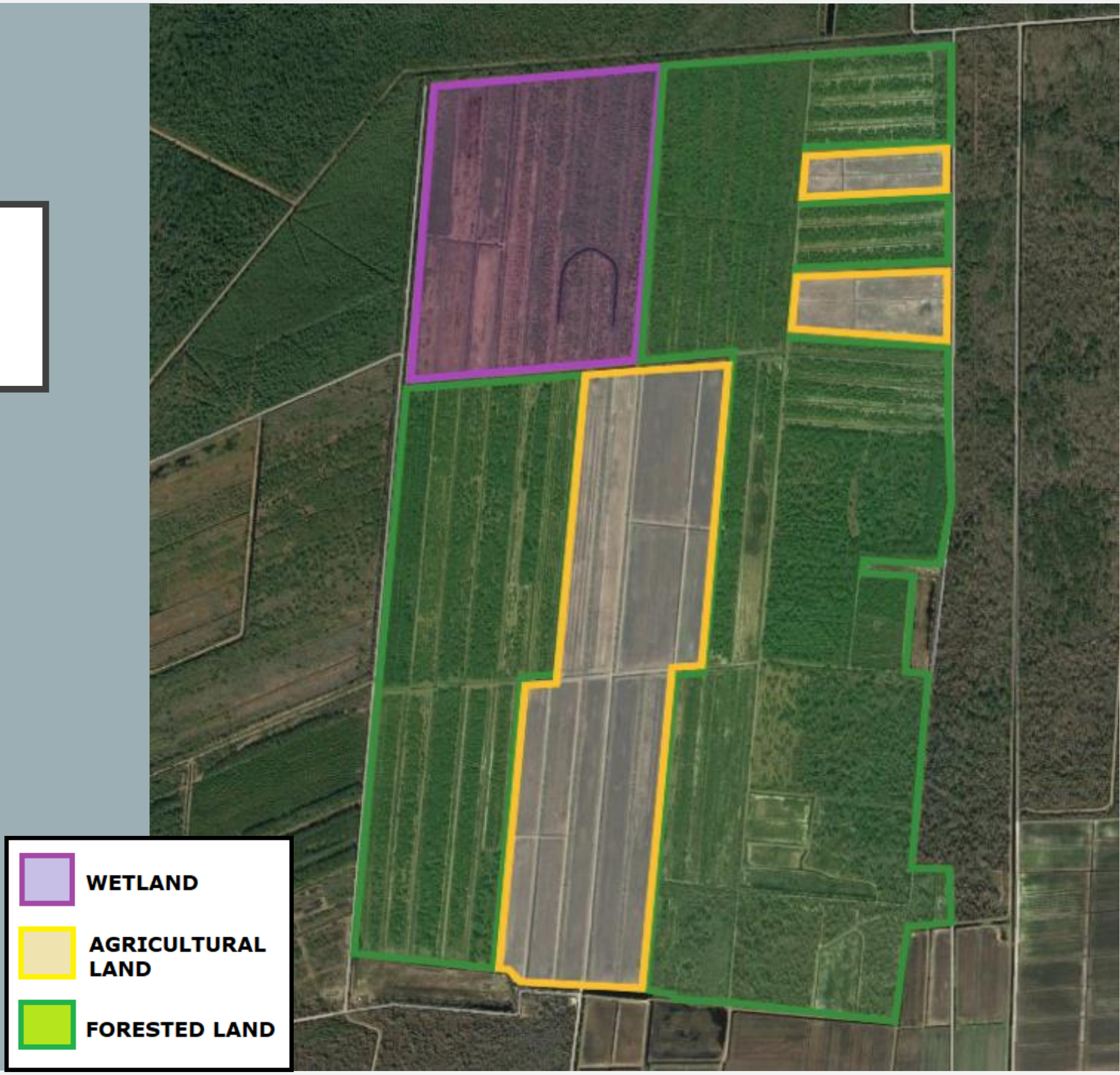
According to a published study,

18:1 : 50% decrease in nitrogen content

5:1 : 79% decrease in nitrogen content

The Simmons' property will have a 1.6:1 ratio

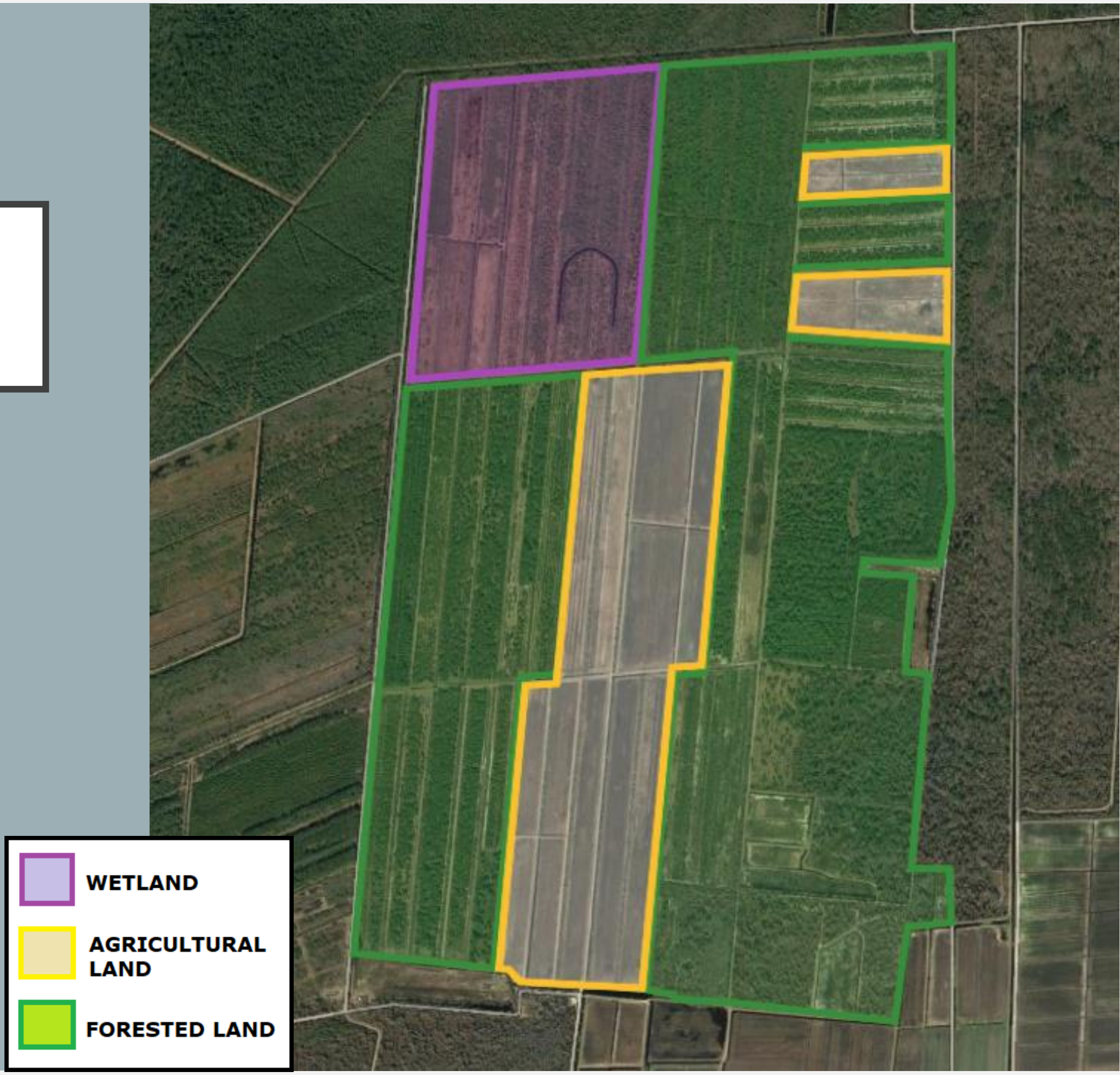
Estimated 1,500 kg reduction in inorganic nitrogen input in the lake

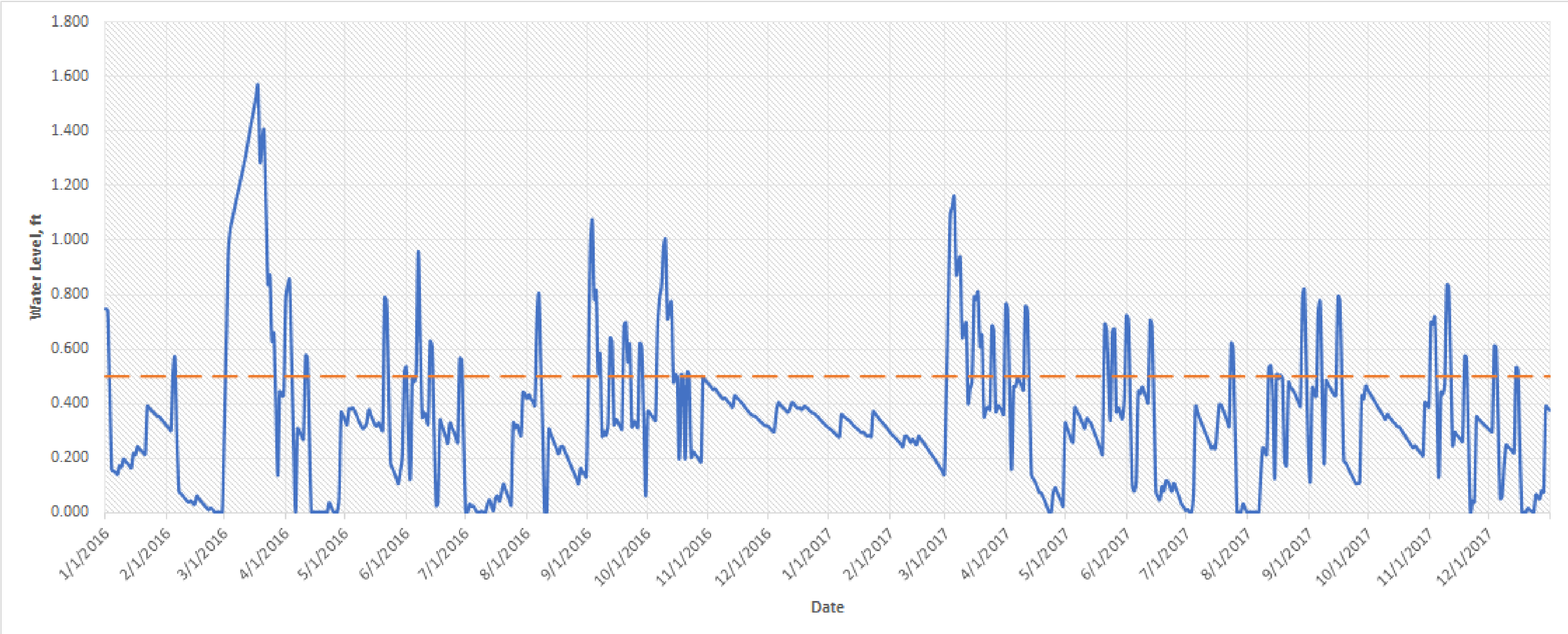


WATER BALANCE

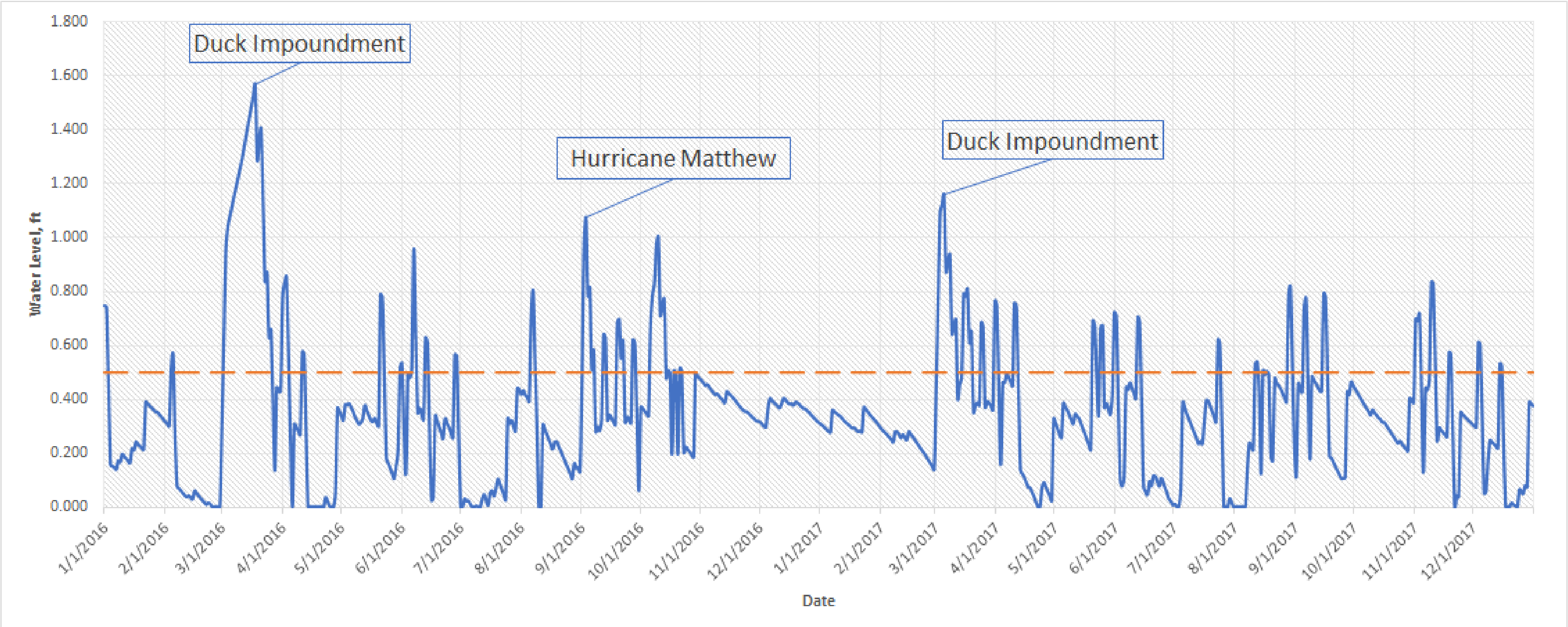
The water balance model takes into consideration:

- Precipitation
- Inflow from surrounding land
- Evaporation/Evapotranspiration
- Water control structures (outflow)
  - Multiple rectangular weirs





WATER LEVEL IN WETLAND



WATER LEVEL IN WETLAND

Upfront and Initial Costs

Items	Total Cost
Design Cost (Engineer)	$167,000
Construction Berms (Earth Moving)	$250,000
Wetland Planting	$135,000
Weir Plate	$100,000
Control Structure x2	$700,000
Pump Upfront cost	$90,000
Total Upfront Cost	$1,442,000

Longterm Costs (~40 years)

Items	Total Cost
Fuel Cost	$1,150,000
Pump Maintenance	$52,000
Management Cost	$7,000
Replace Control Structure Gates	$13,000
Control Structure and Weir Replacement	$156,000
Total Longterm Costs	$1,378,000
Total Longterm Cost at 2.25% Inflation rate	$2,331,000

Total Cost

Items	Total Cost
Total Upfront Cost	$1,442,000
Total Longterm Cost (~40 years) at 2.25% inflation rate	$2,331,000
Total Cost	$3,773,000

WETLAND IMPACT ON COMMUNITY

- Reducing flooding around the lake
- Improving water quality around the lake
- Supporting food and habitat for fish and wildlife
- Serves as a pilot project for future wetlands

THANK YOU

Questions and feedback are
welcome at this time

LAKE MATTAMUSKEET DRAINAGE AND FLOODING REMEDIATION ANALYSIS

COLLEGE OF ENGINEERING AND TECHNOLOGY

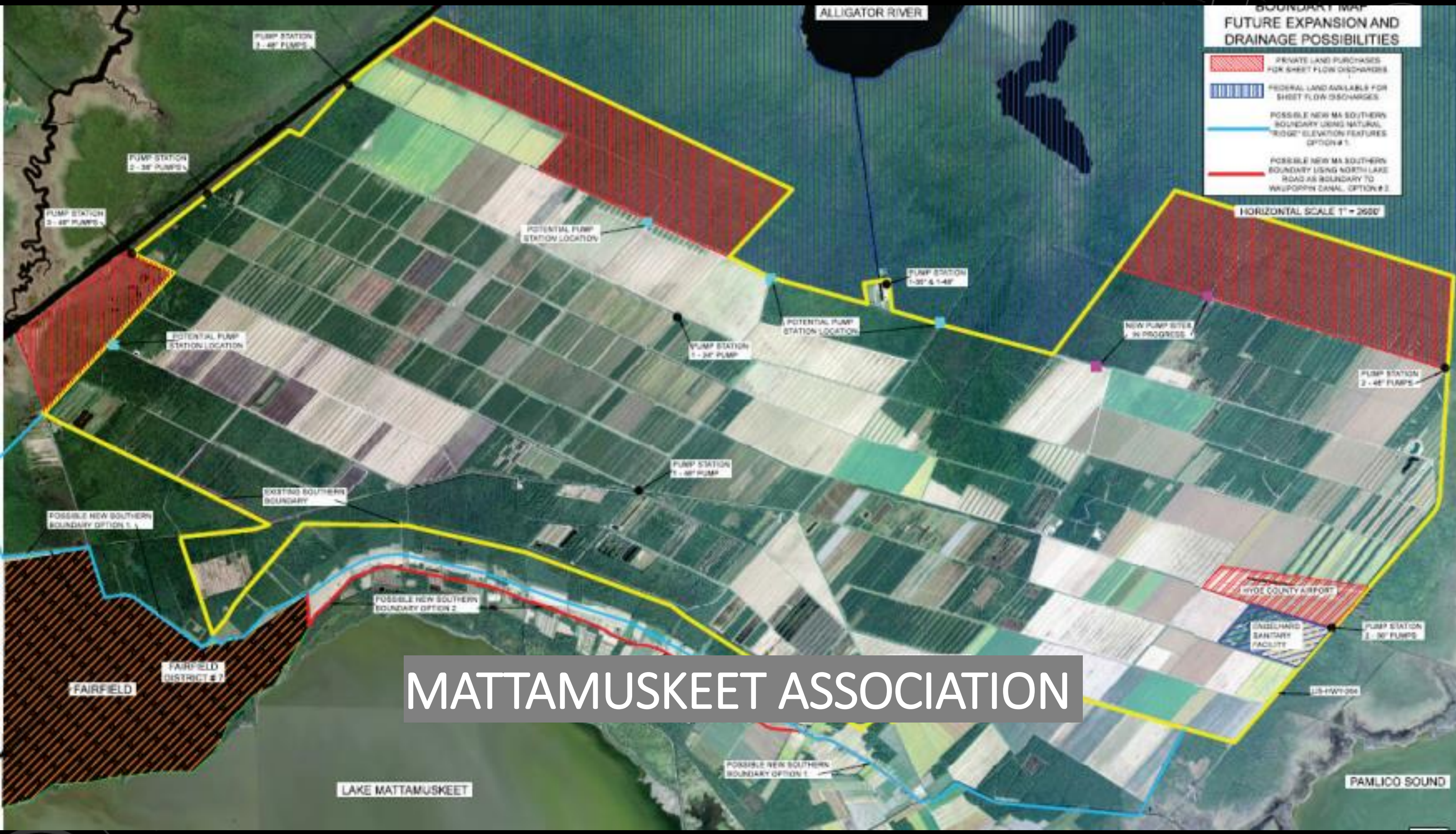
PROJECT TEAM: CHARLES ABLAN, ASHLEY MILLER, OLIVIA SESSOMS, CJ SHAW

PROJECT ADVISORS: DR. RANDALL ETHERIDGE, DR. RAYMOND SMITH

PRESENTATION OUTLINE

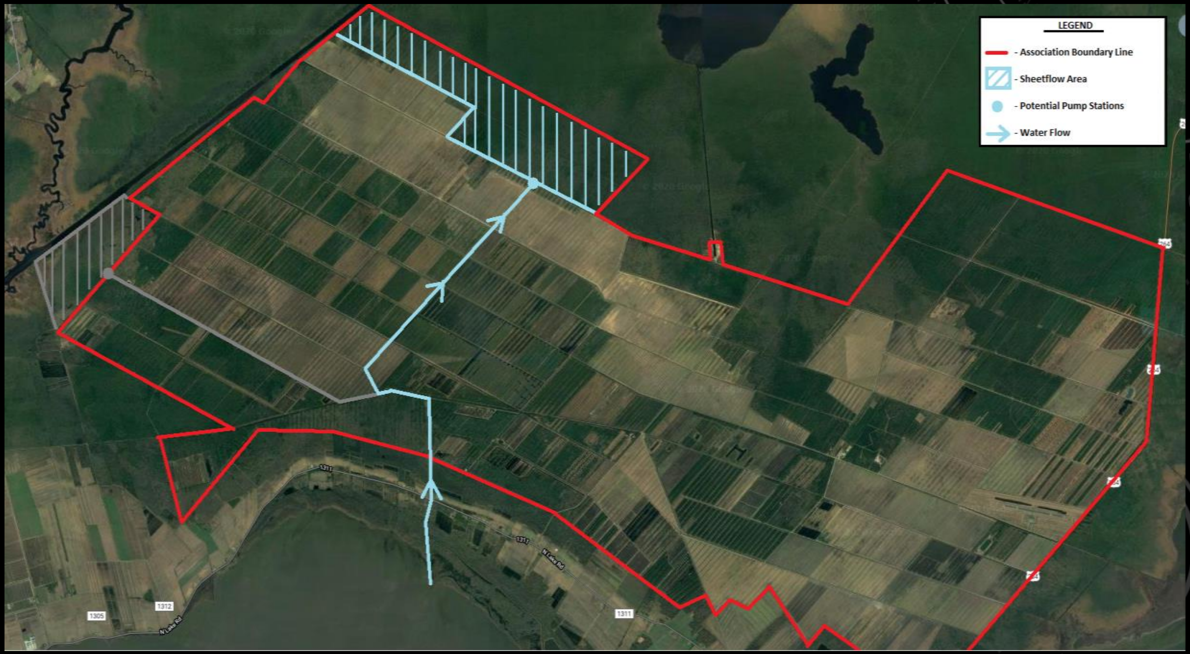
- Final Design
- Model Validation
- Weir Design
- Modeling Analysis
- **Constructed Wetlands**
- **Costs**
- **Permits**

MATTAMUSKEET ASSOCIATION



FINAL DESIGN

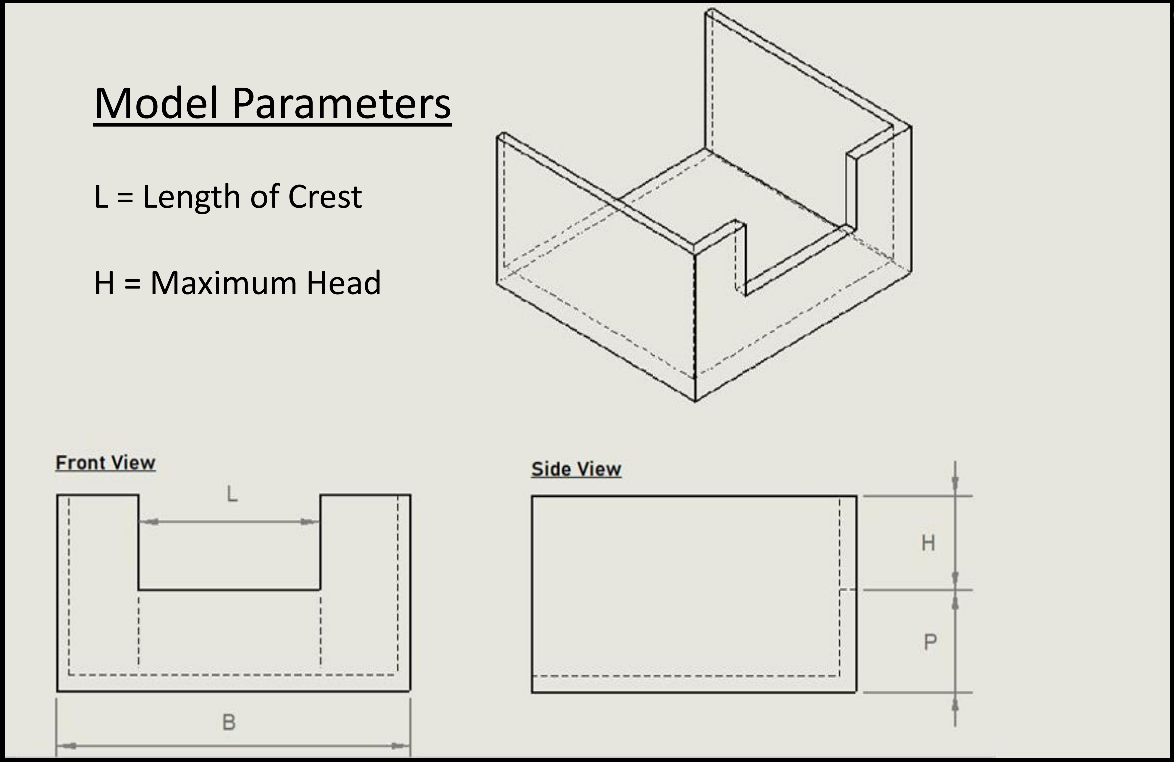
- Feasibility and Decision Analyses, along with advisor and stakeholder review, led to choosing our final design
- The final design utilizes a water control structure to control outflow and a constructed wetland across the chosen sheetflow site northwest of the Mattamuskeet Association



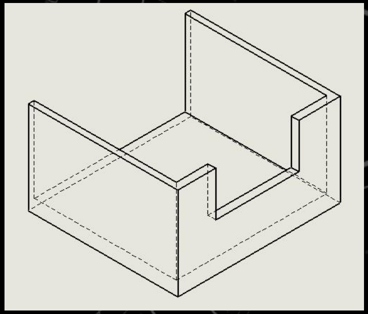
MODEL VALIDATION

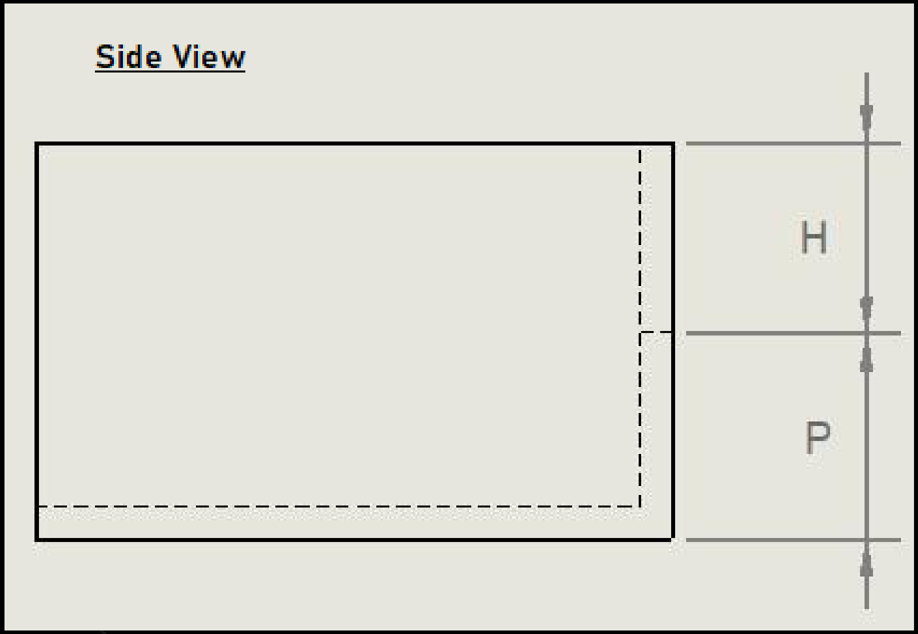
- A model has been developed to assess the design's ability to reroute and treat both daily and hurricane-level inflows of water
- The model considers long-term conditions and can accommodate hurricane occurrence
- Used to determine ideal dimensions of the water control structure, if improvements to canals are needed, and the ability of the sheet-flow site to handle and treat the quantity of water being pumped through it

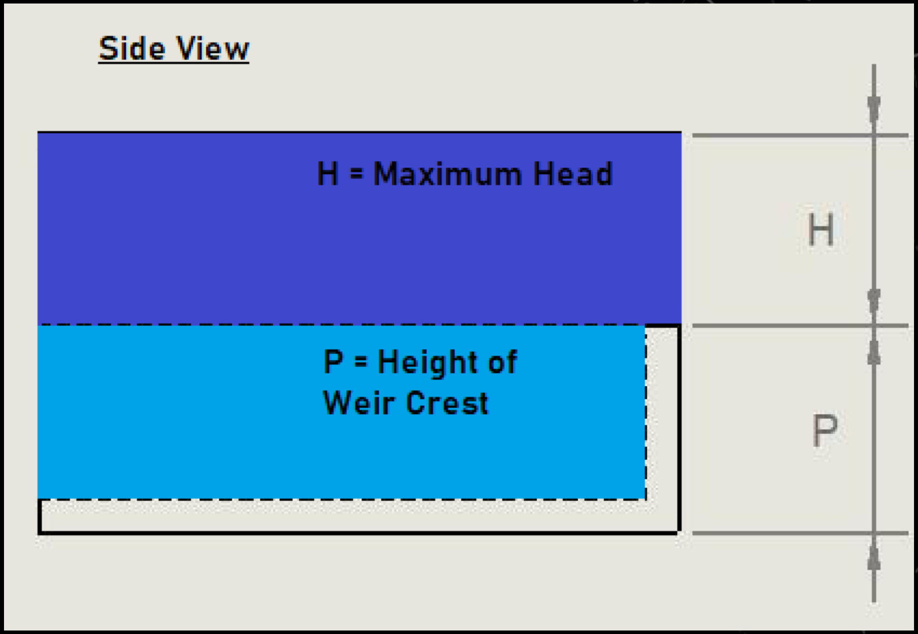
WEIR DESIGN


Model Parameters
L = Length of Crest
H = Maximum Head
Front View
L
B
Side View
H
P

WEIR DESIGN




Side View
H
P

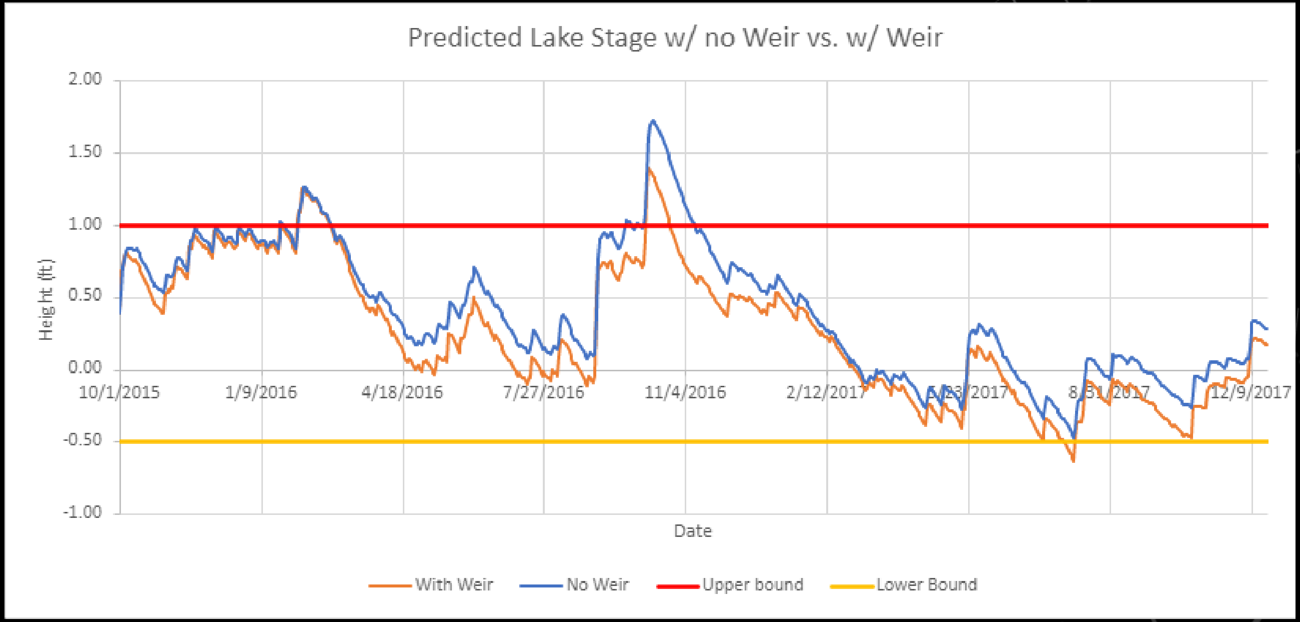

Side View
H = Maximum Head
P = Height of Weir Crest
H
P

MODELING APPROACHES WITH/WITHOUT WEIR

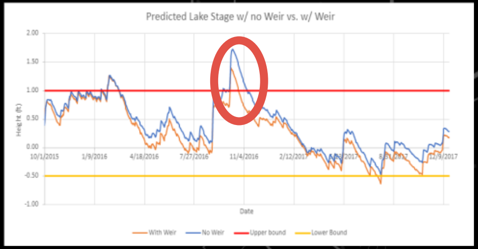
Historical Data
- Oct. 1, 2015 – Dec. 12, 2017
- Flooding Duration = 66 days

Metrics for Flooding
- Flood risk set at 1ft (NAVD88)

Implemented Design
- Flooding Duration = 40 days
- Reduced Flooding by 25%

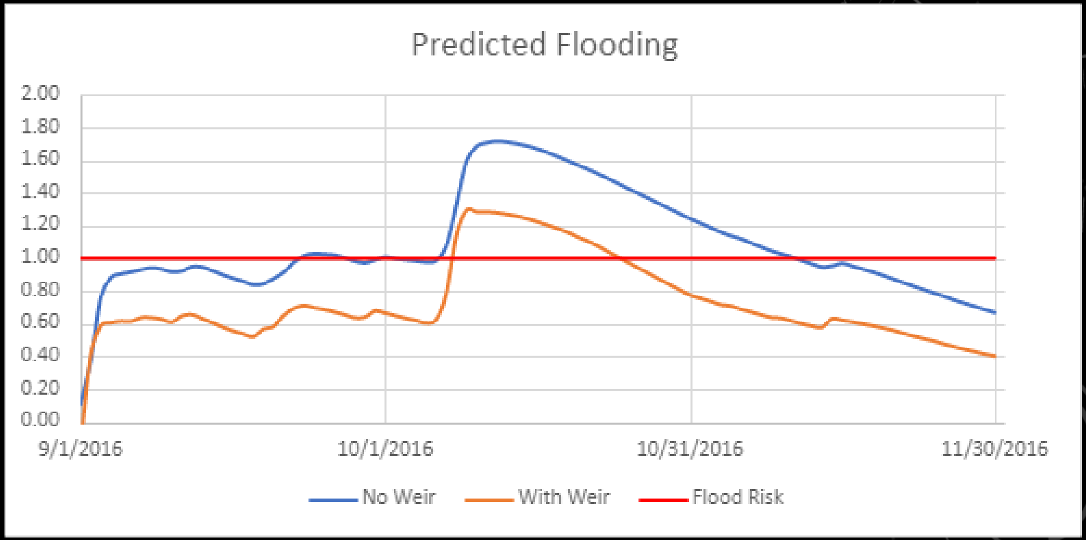


FLOODING REMEDIATION ANALYSIS



Original:
- Flooding occurs 10/7/16
- Reached normal levels on 11/11/16
- Duration = 35 days

Design:
- Flooding does not start until 10/8/16
- Drops to normal levels* at 10/25/16
- Duration = 17 days



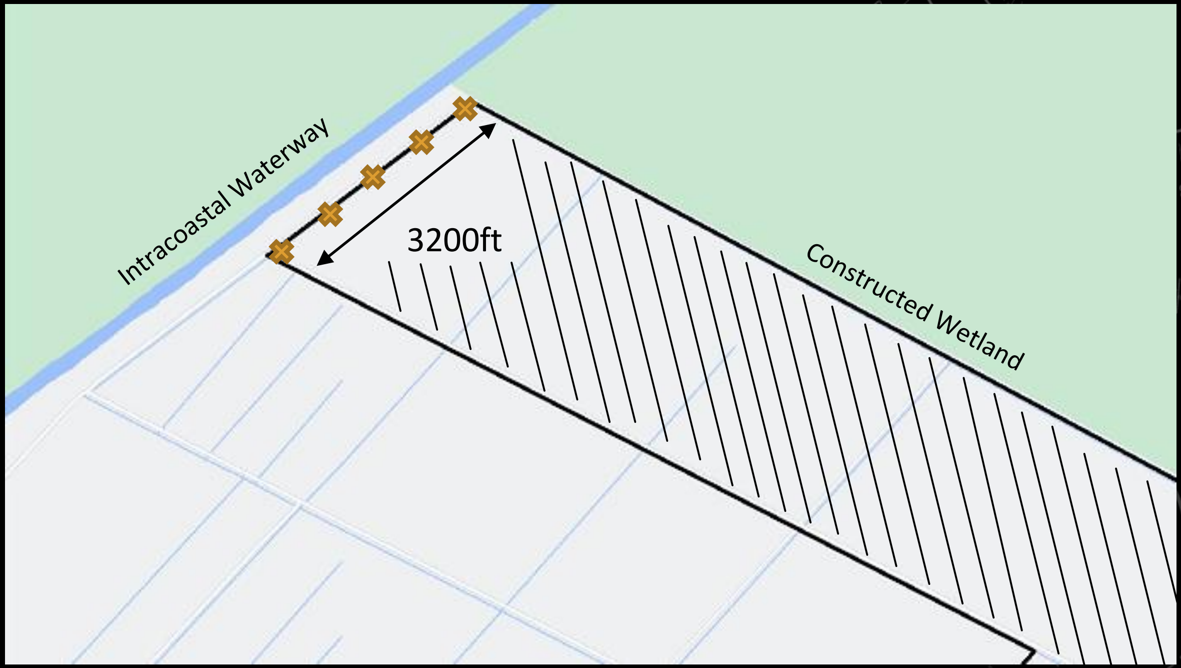
*Normal levels are below a water level of 1ft above sea level (NAVD88)

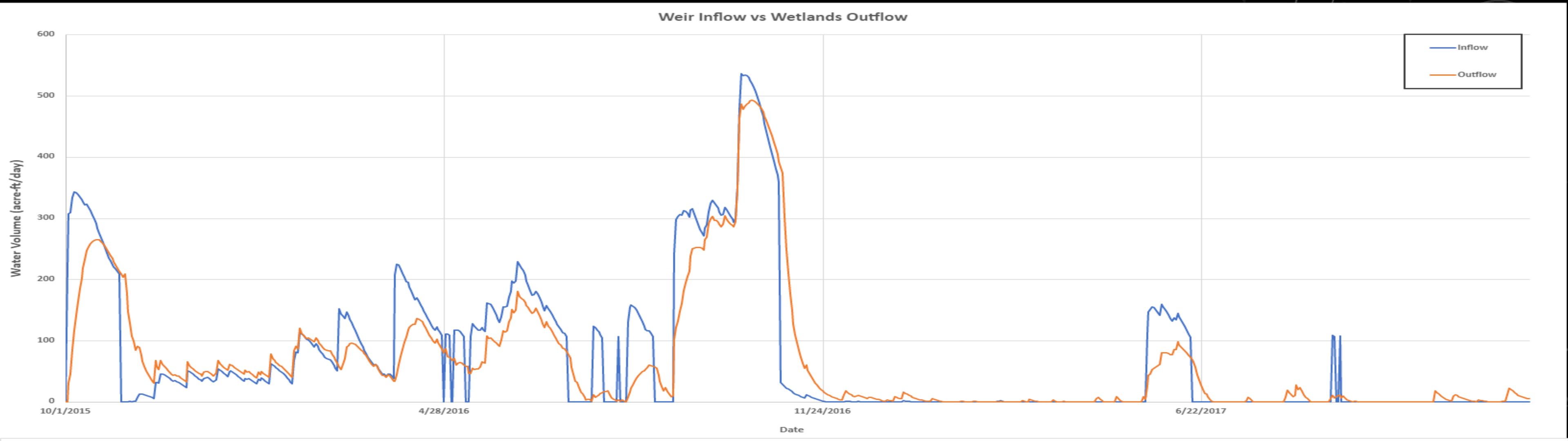
CONSTRUCTED WETLAND DESIGN

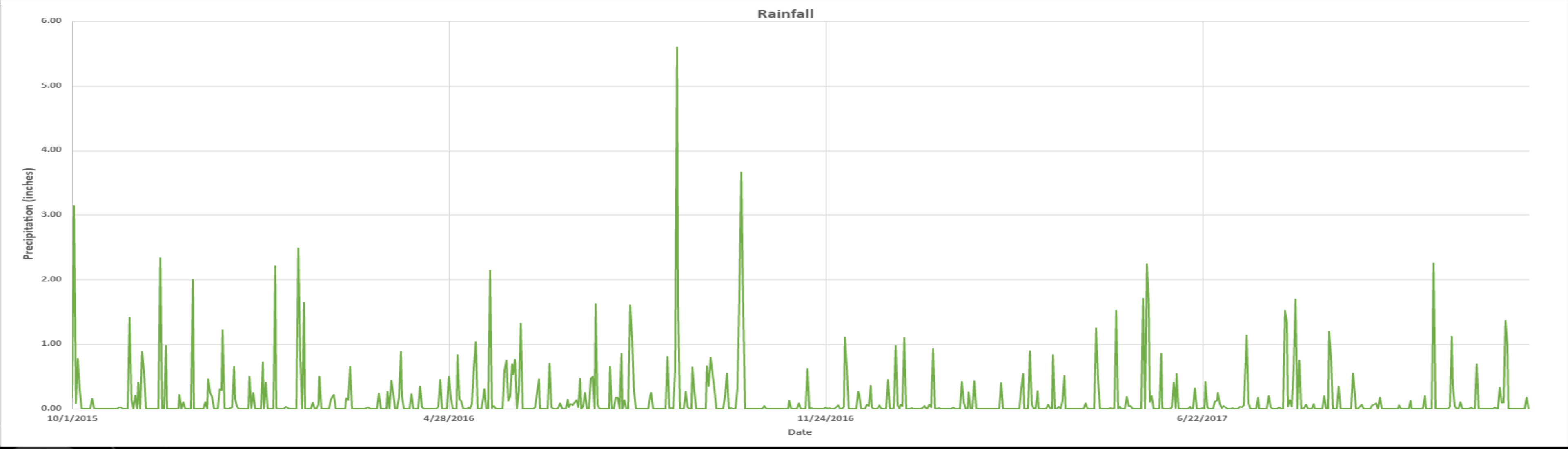
- Pump Selections
  - 2 48” pumps with 2 backup pumps
- Wetland Dimensions
  - Area = 2115 (acres)
  - Depth = 3 (ft)
  - Volume = 6345 (acre-ft)
- Outflow Structures
  - Multiple small weirs
  - Also known as “flashboard risers”

OUTFLOW STRUCTURES

- Estimated available length = 3200ft
- Structures will be spaced out evenly by about 640ft




Weir Inflow vs Wetlands Outflow
Inflow
Outflow
Water Volume (acre-ft/day)
600
500
400
300
200
100
0
10/1/2015
4/28/2016
11/24/2016
6/22/2017
Date


Rainfall
Precipitation (inches)
6.00
5.00
4.00
3.00
2.00
1.00
0.00
10/1/2015
4/28/2016
11/24/2016
6/22/2017
Date

WATER QUALITY

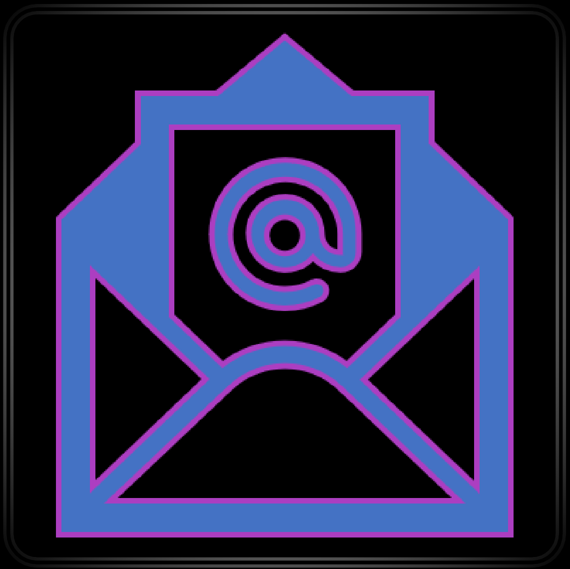
- Nutrient concentration will be reduced close to natural levels prior to discharge into the intracoastal waterway
- Nutrient uptake/reduction is largely driven by our design's mean hydraulic retention time of 15.5 days

COST ESTIMATES

Design Component	Annual Cost	Total Estimated Cost
Pumps	$280,410	$1,600,000
Jarvis Canal Improvements Including Weir	$20,000	$215,500
Wetlands	$153,000	$445,000
Total Estimated Cost	**$453,410 per year**	**$2,260,500**

PERMITS

- Erosion and sediment permit
- CAMA Major
- FEMA
- Army Corps of Engineers



QUESTIONS?

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- Ashley Miller: milleras18@students.ecu.edu
- Olivia Sessoms: sessomso17@students.ecu.edu
- CJ Shaw: shawch14@students.ecu.edu

Lake Mattamuskeet: Canal Dredging

TEAM MEMBERS: BRANSON ROGERS, NATALIE MARTINEZ, BRIANNA HAMILTON, JOSEPH HUSS

EAST CAROLINA UNIVERSITY

Team Introduction

Branson Rogers
Mechanical & Environmental Engineering

Joseph Huss
Mechanical Engineering

Brianna Hamilton
Environmental Engineering

Natalie Martinez
Environmental Engineering

Introduction

- The four major canals are no longer at their original dimensions and have been filled with sediment, restricting water from Lake Mattamuskeet to properly flow into the Pamlico Sound.
- Storm events cause an influx of rain and runoff in the lake, raising the water level for extended periods of time. This leads to flooding in the surrounding area.
- Flooding causes damage to surrounding land, residential homes, businesses, and crops.
- Goal: Reduce flooding by redesigning canal drainage system


Waupoppin Canal
Rose Bay Canal
Lake Landing Canal
Outfall Canal
NC 45
0
2.5
5
Miles
N

Proposed Solutions

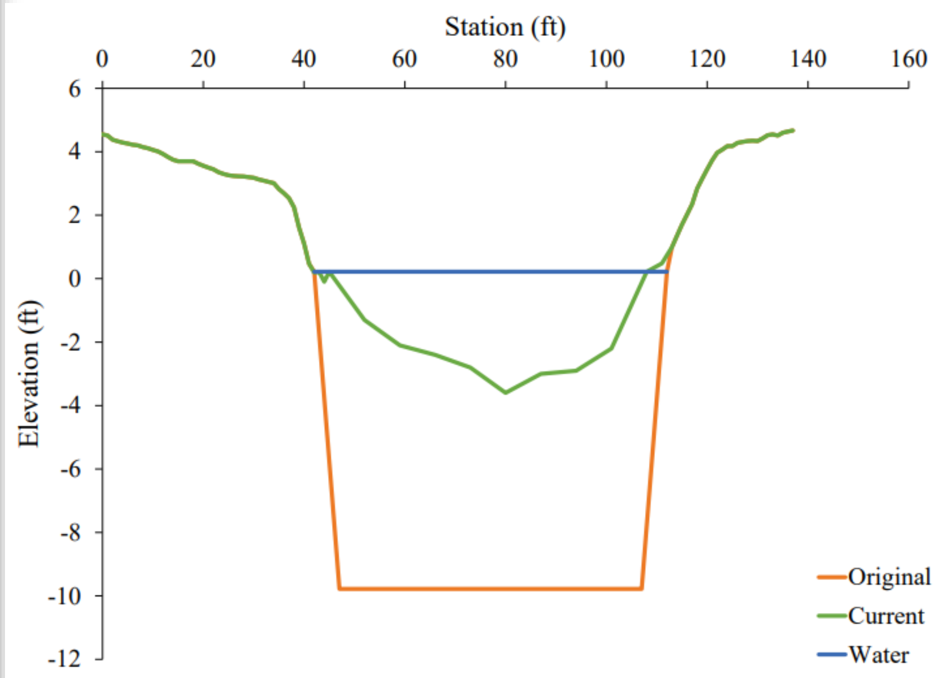
- Dredge all four canals to their original dimensions (size varies based on the canal)

- Only dredge Outfall Canal (70 ft by 8ft)

Proposed Solution- Dredging all Canals to Original Dimensions

- 80% reduction in area of flow
- Blue line is water
- Green line is the current profile of the Outfall Canal
- Orange line is the profile of Outfall Canal if it were dredged to Original Dimensions

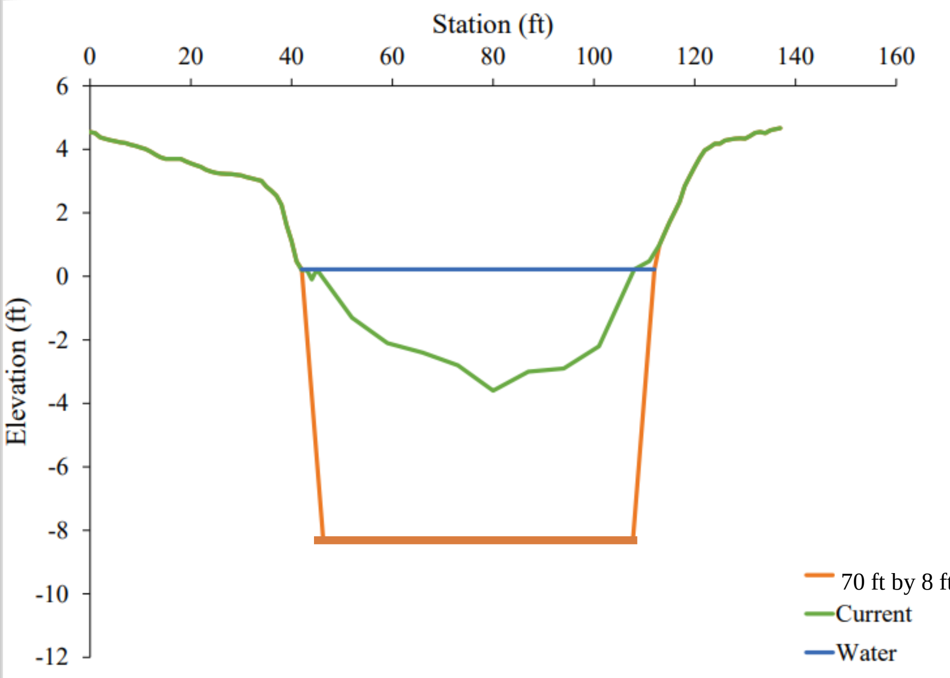
Outfall Canal



Proposed Solution-Dredging Outfall Canal to 70 ft by 8 ft

- Significantly cheaper
- Not as effective, but there is still a reduction in flooding
- This canal was chosen because:
  - Potential to move the most water
  - Most accessible canal

Outfall Canal



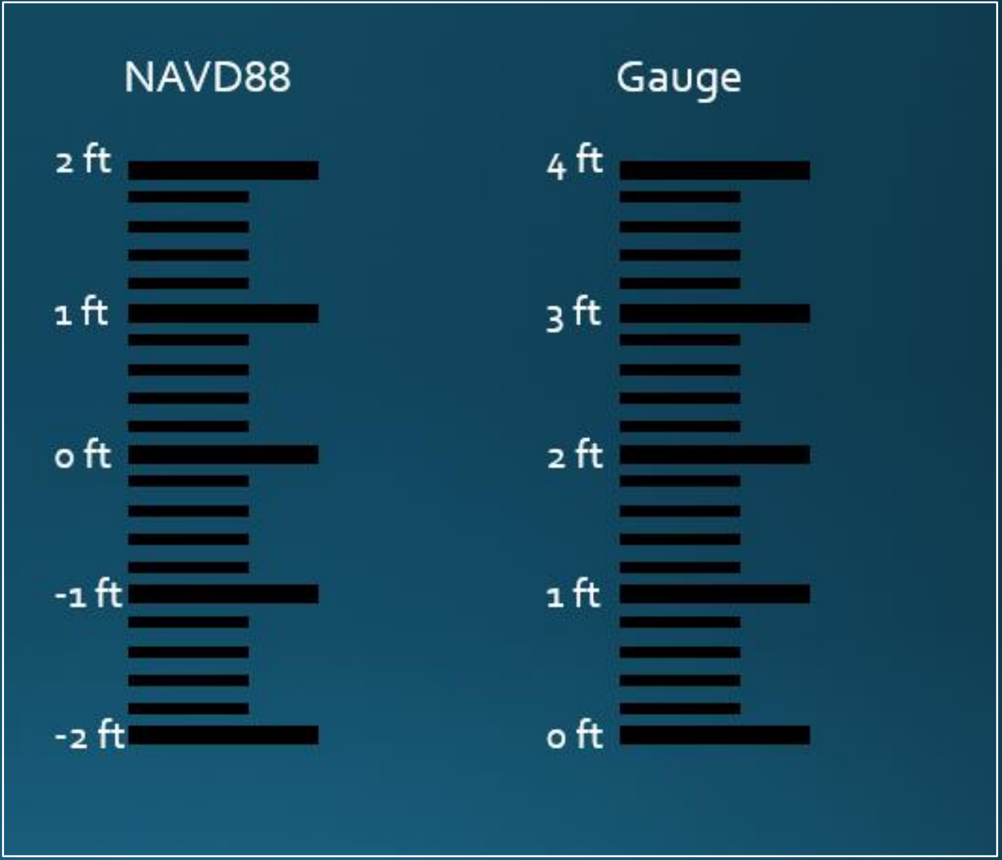
How did we determine the best alternative?

- We used a hydrologic process model for the Lake Mattamuskeet watershed created by Dr. Smith that acts as a water balance to see how much water our alternatives can move out of the lake.

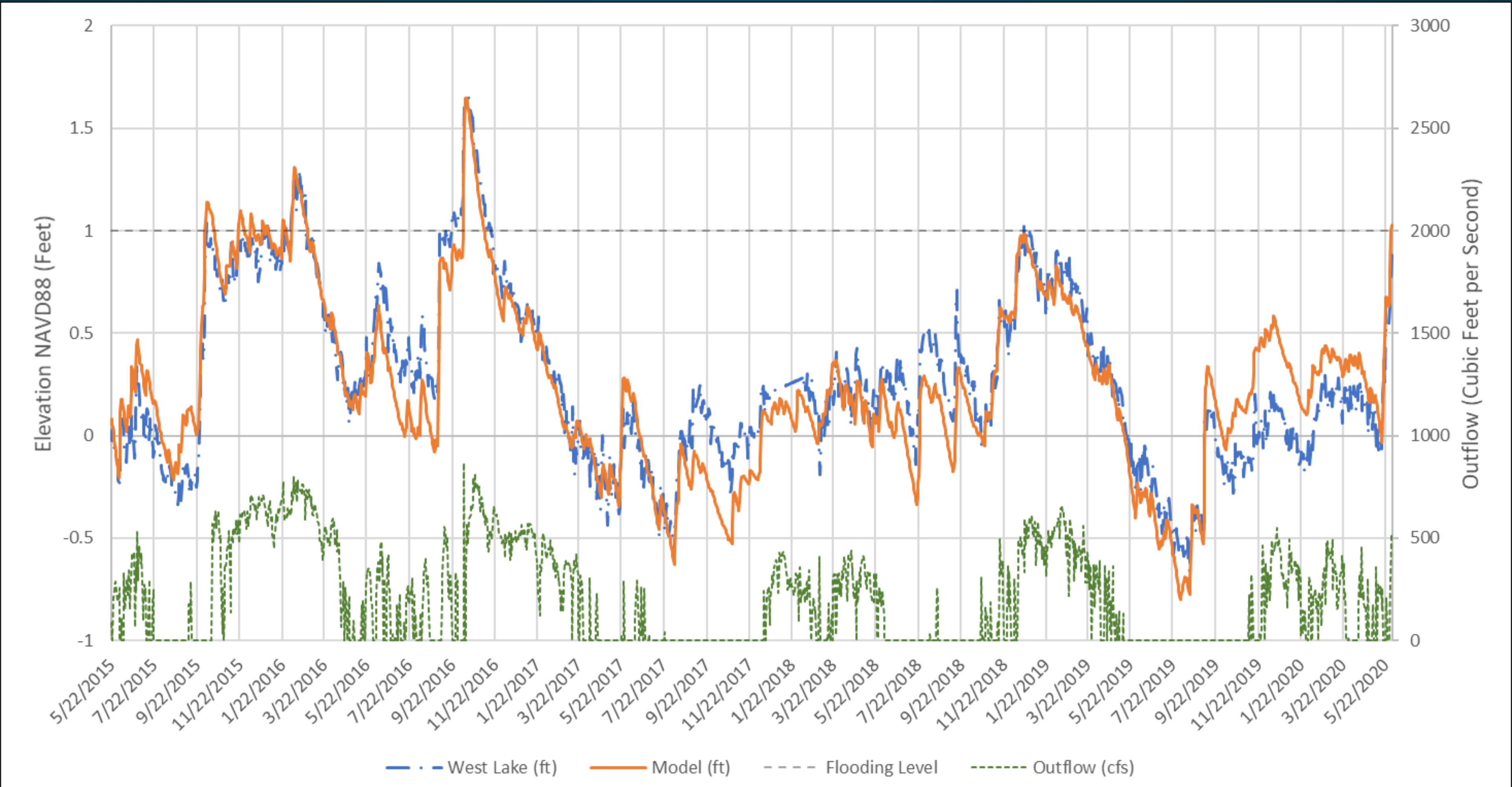
- Scenarios that were ran in the model:
  - Canals dredged to original dimensions
  - Outfall Canal dredged to 70ft by 8ft

Datums

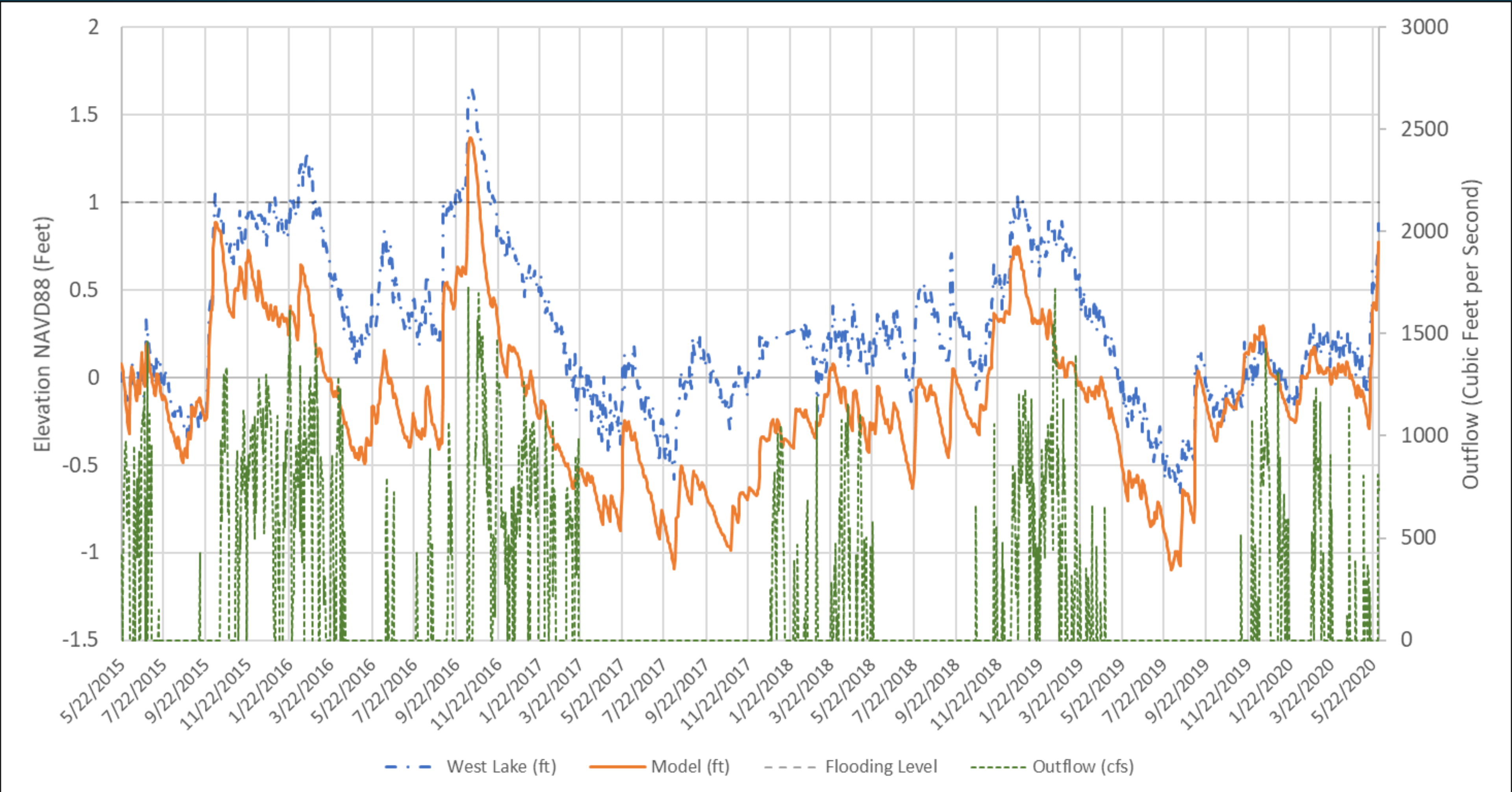
- The following picture indicates the relationship between gauge height and NAVD88
- Gauge height is 2 ft higher than NAVD88
- Our plots reference NAVD88

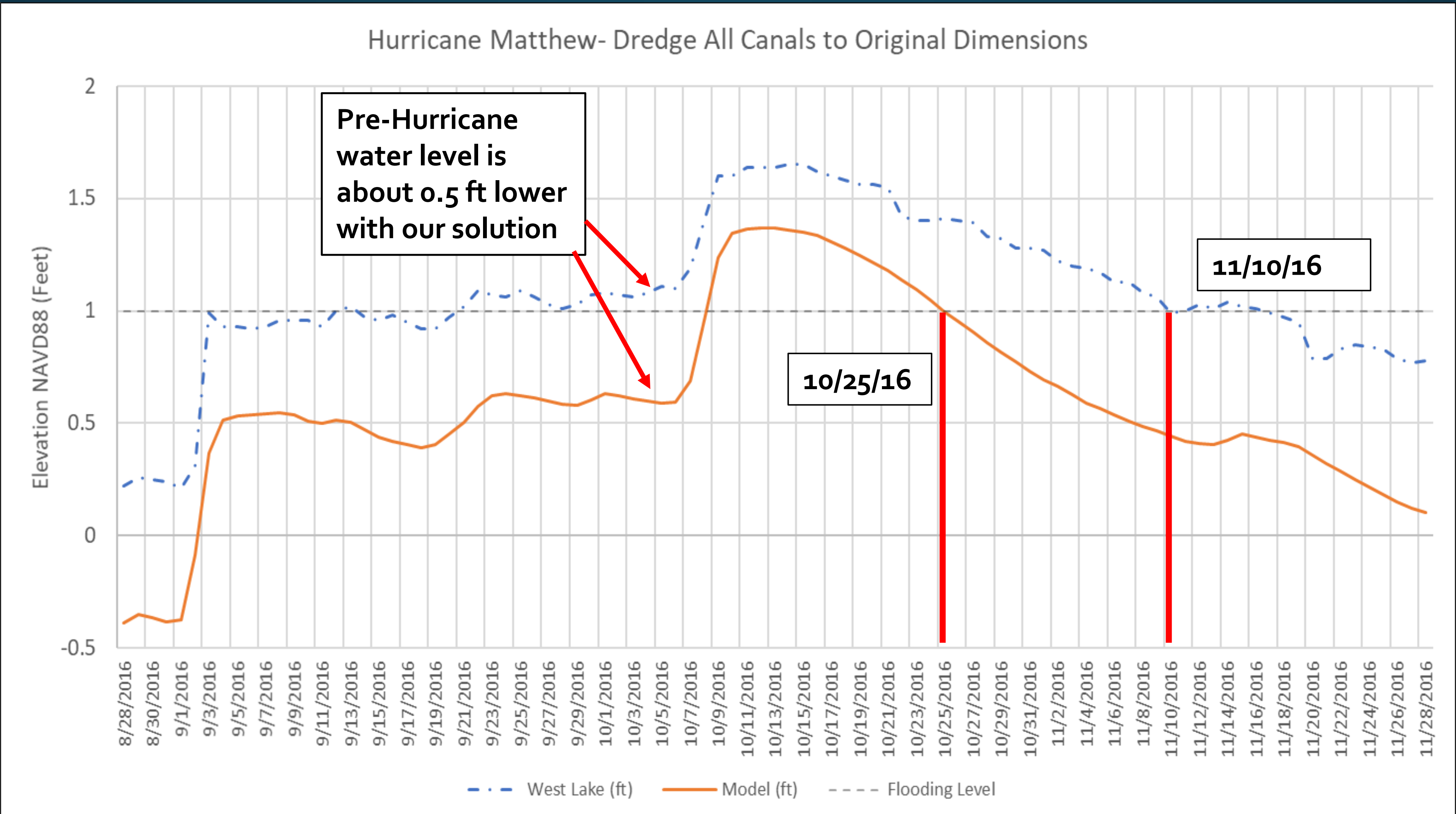


Current Condition of Canals



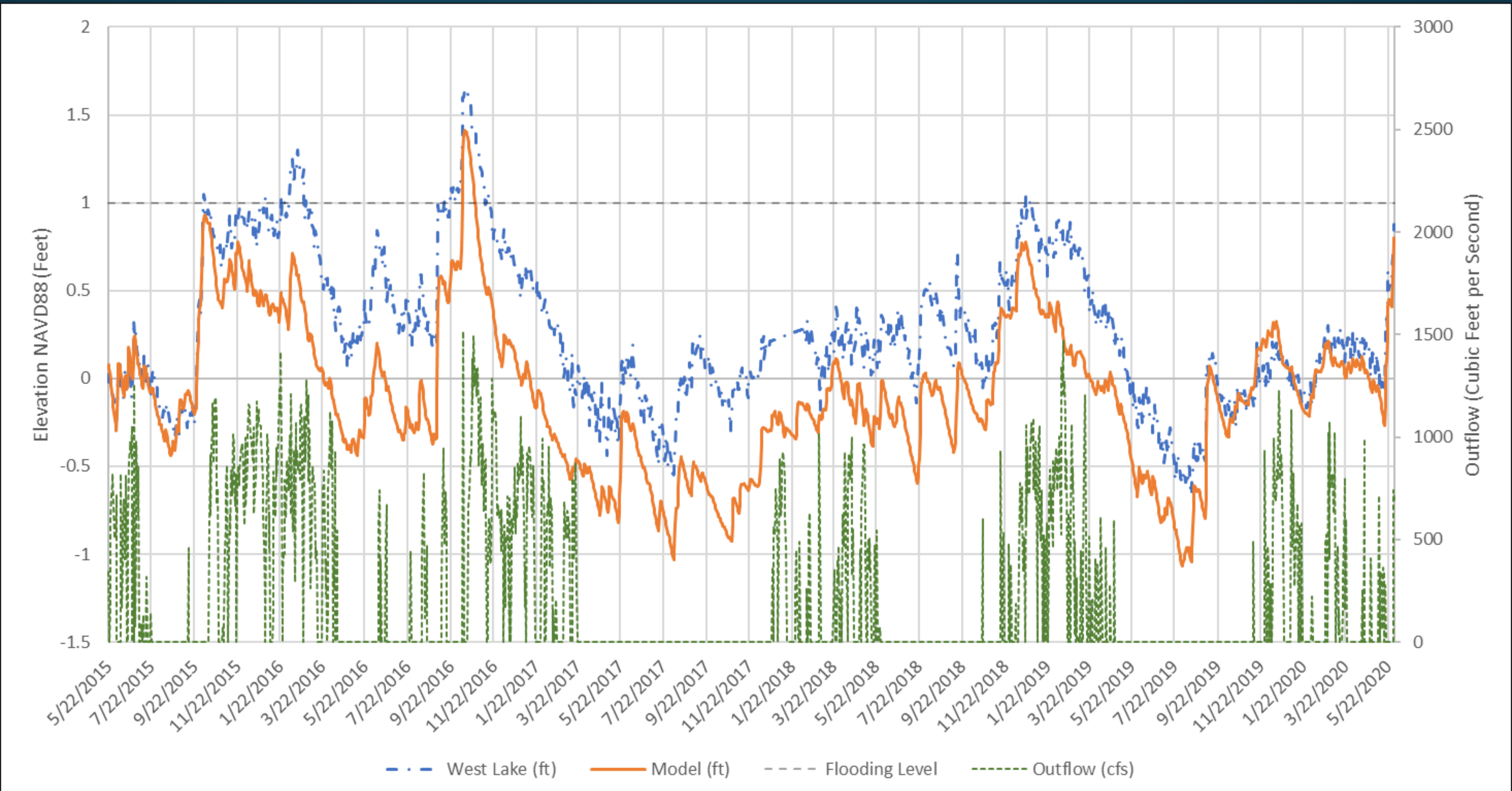
Dredging All 4 Canals to the Original Dimensions

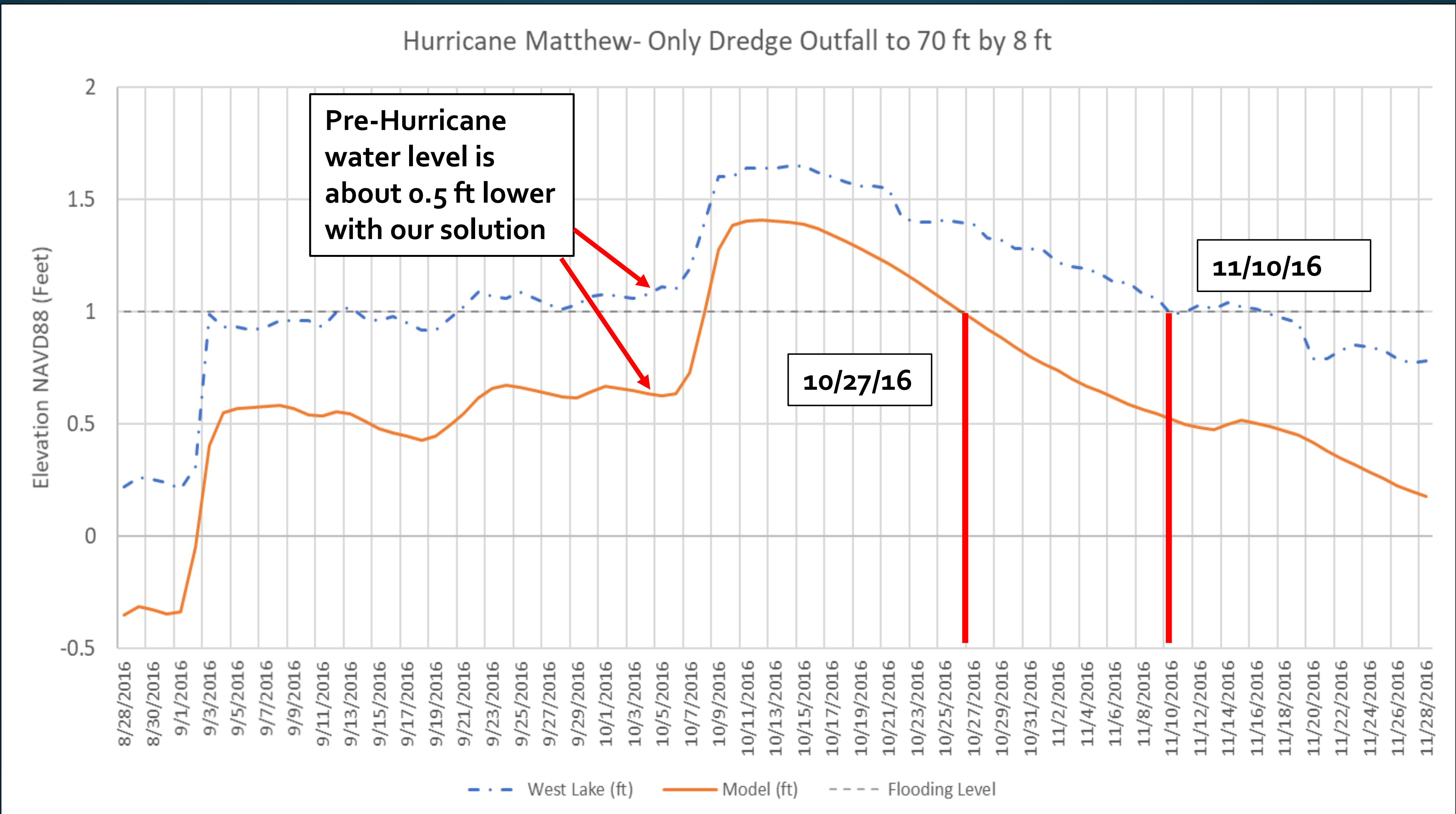




Hurricane Matthew- Dredge All Canals to Original Dimensions
Pre-Hurricane water level is about 0.5 ft lower with our solution
11/10/16
10/25/16
Elevation NAVD88 (Feet)
2
1.5
1
0.5
0
-0.5
8/28/2016
8/30/2016
9/1/2016
9/3/2016
9/5/2016
9/7/2016
9/9/2016
9/11/2016
9/13/2016
9/15/2016
9/17/2016
9/19/2016
9/21/2016
9/23/2016
9/25/2016
9/27/2016
9/29/2016
10/1/2016
10/3/2016
10/5/2016
10/7/2016
10/9/2016
10/11/2016
10/13/2016
10/15/2016
10/17/2016
10/19/2016
10/21/2016
10/23/2016
10/25/2016
10/27/2016
10/29/2016
10/31/2016
11/2/2016
11/4/2016
11/6/2016
11/8/2016
11/10/2016
11/12/2016
11/14/2016
11/16/2016
11/18/2016
11/20/2016
11/22/2016
11/24/2016
11/26/2016
11/28/2016
West Lake (ft)
Model (ft)
Flooding Level

Only dredging Outfall to 70 ft by 8ft





Hurricane Matthew- Only Dredge Outfall to 70 ft by 8 ft
Pre-Hurricane water level is about 0.5 ft lower with our solution
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10/1/2016
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10/29/2016
10/31/2016
11/2/2016
11/4/2016
11/6/2016
11/8/2016
11/10/2016
11/12/2016
11/14/2016
11/16/2016
11/18/2016
11/20/2016
11/22/2016
11/24/2016
11/26/2016
11/28/2016
West Lake (ft)
Model (ft)
Flooding Level

Pumps

- Scenarios with pumps were being considered, however the canals will still have to be dredged to handle that amount of flow
- The main use of pumps would be to bring the major flooding spikes down from major storms like Hurricane Matthew
- Pumps may be infeasible due to long term maintenance and cost associated
- Permitting could be difficult due to water quality concerns affecting shellfish
- Pumps would be used as a “safety net” for when major storms are anticipated, but is this worth the cost it would take to implement them

Permits

- A CAMA major permit will be required because Hyde County is covered by CAMA and our project is in an Area of Environmental Concern (AEC)
- Permits that will likely be needed:
  - Dredge and Fill[1]
  - Water Quality Certification[2]
  - Section 10 of the Rivers and Harbors Act[3]
  - Section 404 of the Clean Water Act[4]

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[1] Required by the N.C. Dredge and Fill Act for any project involving excavation or filling in estuarine waters, tidelands, marshlands or state-owned lakes.

[2] Required by the N.C. Division of Water Quality for any activity that may discharge fill into waters or wetlands and that requires a federal permit.

[3] Required by the U.S. Army Corps of Engineers for dredging, filling and other work in navigable waters.

[4] Required by the U.S. Army Corps of Engineers for discharge into waters or wetlands

Economic Analysis

- Dredging Process: Long-arm excavators dredging costs range from \$4-\$6 per cubic yard and depends on field conditions. Spoil will be disposed along banks.
- Dredging All Canals to Original Dimensions
  - Low end: \$6.4 million
  - High end: \$9.5 million
- Dredging only Outfall Canal
  - Low end: \$1.9 million
  - High end: \$2.9 million

Tree Removal

- For a densely forested area, tree removal would be around \$6,000 - \$7,000 per acre. Around 18 acres of land needs to be cleared along both sides of the bank, 36 acres total.

- Estimated cost: \$216,000 - \$252,000

Clearing the Canals leading to Outfall Tide gates

Cost for clearing canals leading to Outfall Tide gates

- The length that would need to be cleared is 34,860 ft which is 6.6 miles
- 607,000 CY would need to be removed costing $2.4-$3.6 million
- There is a bridge restricting flow at the middle canal, so it may not be feasible to dredge this canal

Final Solution

- Only dredging Outfall Canal to 70ft by 8ft
- Very close alternative to dredging all 4 canals in terms of effectiveness
- Significantly more cost efficient
- Final total cost estimate: \$4.5 - \$6.75 million

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Question and Comment Period

Zoom Functionality

Please use the Q&A function to type questions or comments

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Zoom Functionality

Mute/Unmute

Use the raise hand function if you would like to speak during the question and comment period at the end of the meeting.

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Question and Comment Period

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Thank you for attending!