Lake Mattamuskeet Watershed Restoration Plan

Virtual Public Meeting
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 your 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.
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-α, 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
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 in 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

Restoring the Lake Mattamuskeet Watershed

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.
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.

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Subscribe for Updates/Submit Comments Online

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

In The News

- Lake’s Health Requires Ridding It of Carp: https://www.coastalreview.org/2020/10/lakes-health-requires-ridding-it-of-carp/
- “Secrets of Lake Mattamuskeet” — NC Science Now | UNC-TV

nccoast.org/lakemattamuskeet
Updates from Mattamuskeet Technical Working Group

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

*SAV is the indicator for water quality in Lake Mattamuskeet*
Water warning signs are posted at public use areas around the refuge.
Model of submerged aquatic vegetation productivity (Davis and Brinson, 1980). Arrows indicate the trend of parameters that have been monitored and analyzed.

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.

Light attenuation, toxicity, and biomass removal are three general stressors which can be influenced by other specific factors (from Davis and Brinson 1980).
Monitoring parameters for water quality include:

**USGS Continual Water Quality Stations (e & w sides of lake):**
- Water depth
- pH,
- Specific conductance
- *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 (µg/L)
- Cyanotoxin samples
- Light attenuation

**Canal water quality parameters:**
- Water depth (ft)
- Temperature (°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

Mattamuskeet NWR Submerged Aquatic Vegetation - 2020

*Chara spp.*

No SAV in deeper water

% SAV cover

100
75
50
25
0
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 Continuous 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.
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 entering lake.
ECU Capstone project completed for hoist system.
NCWRC scatter stocking Bluegill into lake this week.
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
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

RMSE(m) – 0.021

RMSE(m) – 0.021
Design Storm Scenarios: Existing Sea Level & Future Sea Level Rise

![Graphs showing water level changes](image-url)
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)
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

<table>
<thead>
<tr>
<th>Season</th>
<th>East Gauge Period of Record: 9/20/2012 – 11/02/2020</th>
<th>West Gauge Period of Record: 10/1/2013 – 11/02/2020</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum Gauge Height (ft)</td>
<td>Average Gauge Height (ft)</td>
</tr>
<tr>
<td>Winter (January, February, March)</td>
<td>0.96</td>
<td>2.33</td>
</tr>
<tr>
<td>Spring (April, May, June)</td>
<td>1.10</td>
<td>2.11</td>
</tr>
<tr>
<td>Summer (July, August, September)</td>
<td>0.85</td>
<td>1.92</td>
</tr>
<tr>
<td>Fall (October, November, December)</td>
<td>0.52</td>
<td>2.19</td>
</tr>
</tbody>
</table>
## Storage Capacity Needs

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

Lowering and raising lake water levels seasonally will require initial and ongoing management measures to accept/store/release this volume.
# Design Storm Volumes and Hurricane Volumes

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

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

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

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

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

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

**Graph:**

- Blue line: No Action
- Orange line: Pump Station – 350,000 gpm
- Red line: Pump Station – 700,000 gpm
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

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

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

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

![Diagram showing storm water levels with improved/new canals]
Comparison of Alternative Simulations

No Action

Pump Station – 350,000 gpm

Pump Station – 700,000 gpm
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

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

*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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Randall Etheridge
etheridgej15@ecu.edu

Raymond Smith
smithraym17@ecu.edu
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
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
Pat Simmons' property
Reduce flooding
Improved water quality
Create habitat
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

<table>
<thead>
<tr>
<th>Items</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Cost (Engineer)</td>
<td>$167,000</td>
</tr>
<tr>
<td>Construction Berms (Earth Moving)</td>
<td>$250,000</td>
</tr>
<tr>
<td>Wetland Planting</td>
<td>$135,000</td>
</tr>
<tr>
<td>Weir Plate</td>
<td>$100,000</td>
</tr>
<tr>
<td>Control Structure x2</td>
<td>$700,000</td>
</tr>
<tr>
<td>Pump Upfront cost</td>
<td>$90,000</td>
</tr>
<tr>
<td><strong>Total Upfront Cost</strong></td>
<td><strong>$1,442,000</strong></td>
</tr>
</tbody>
</table>
# Longterm Costs (~40 years)

<table>
<thead>
<tr>
<th>Items</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel Cost</td>
<td>$1,150,000</td>
</tr>
<tr>
<td>Pump Maintenance</td>
<td>$52,000</td>
</tr>
<tr>
<td>Management Cost</td>
<td>$7,000</td>
</tr>
<tr>
<td>Replace Control Structure Gates</td>
<td>$13,000</td>
</tr>
<tr>
<td>Control Structure and Weir Replacement</td>
<td>$156,000</td>
</tr>
<tr>
<td>Total Longterm Costs</td>
<td>$1,378,000</td>
</tr>
<tr>
<td>Total Longterm Cost at 2.25% Inflation rate</td>
<td>$2,331,000</td>
</tr>
</tbody>
</table>
## Total Cost

<table>
<thead>
<tr>
<th>Items</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Upfront Cost</td>
<td>$1,442,000</td>
</tr>
<tr>
<td>Total Longterm Cost (~40 years) at 2.25% inflation rate</td>
<td>$2,331,000</td>
</tr>
<tr>
<td>Total Cost</td>
<td>$3,773,000</td>
</tr>
</tbody>
</table>
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

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
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
WEIR DESIGN

Side View

H = Maximum Head
P = Height of Weir Crest
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
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

<table>
<thead>
<tr>
<th>Design Component</th>
<th>Annual Cost</th>
<th>Total Estimated Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pumps</td>
<td>$280,410</td>
<td>$1,600,000</td>
</tr>
<tr>
<td>Jarvis Canal Improvements Including Weir</td>
<td>$20,000</td>
<td>$215,500</td>
</tr>
<tr>
<td>Wetlands</td>
<td>$153,000</td>
<td>$445,000</td>
</tr>
<tr>
<td><strong>Total Estimated Cost</strong></td>
<td><strong>$453,410 per year</strong></td>
<td><strong>$2,260,500</strong></td>
</tr>
</tbody>
</table>
PERMITS

• Erosion and sediment permit
• CAMA Major
• FEMA
• Army Corps of Engineers
QUESTIONS?

Contact information
- Carlo Ablan: ablanc17@students.ecu.edu
- 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
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
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
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
Pre-Hurricane water level is about 0.5 ft lower with our solution.
Only dredging Outfall to 70 ft by 8ft
Pre-Hurricane water level is about 0.5 ft lower with our solution.
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\(^4\)

\(^1\) 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
Question and Comment Period
Zoom Functionality

Please use the Q&A function to type questions or comments
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.
Question and Comment Period
Thank you for attending!