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Lake Mattamuskeet Watershed Restoration Plan

October 16, 2018 Public Meeting

Agenda Overview

7:00 p.m. Welcome

7:05 p.m. Update on Plan Development: Erin Fleckenstein

7:10 p.m. Priority Actions as agreed upon by CST: Michael Flynn

7:20 p.m. Technical Presentations and Research Updates

- Carp removal study: April Lamb
- Conditions of outlet canals: Dr. Randall Etheridge
- Hydrologic modeling of Lake Mattamuskeet: Dr. Randall Etheridge
-Facilitating active water management: Daniel Brinn

8:10 p.m. Next Steps: Michael Flynn

8:15 p.m. Question and Comment Period: Panel

8:30 p.m. Adjourn

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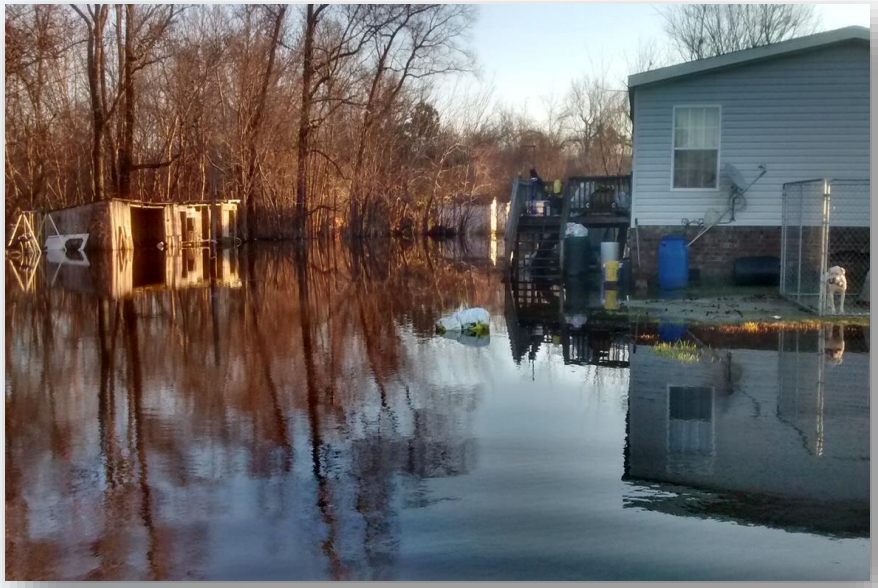
Developing a Watershed Restoration Plan

Concerns about Lake Mattamuskeet



Flooding of Residential and Agricultural Lands

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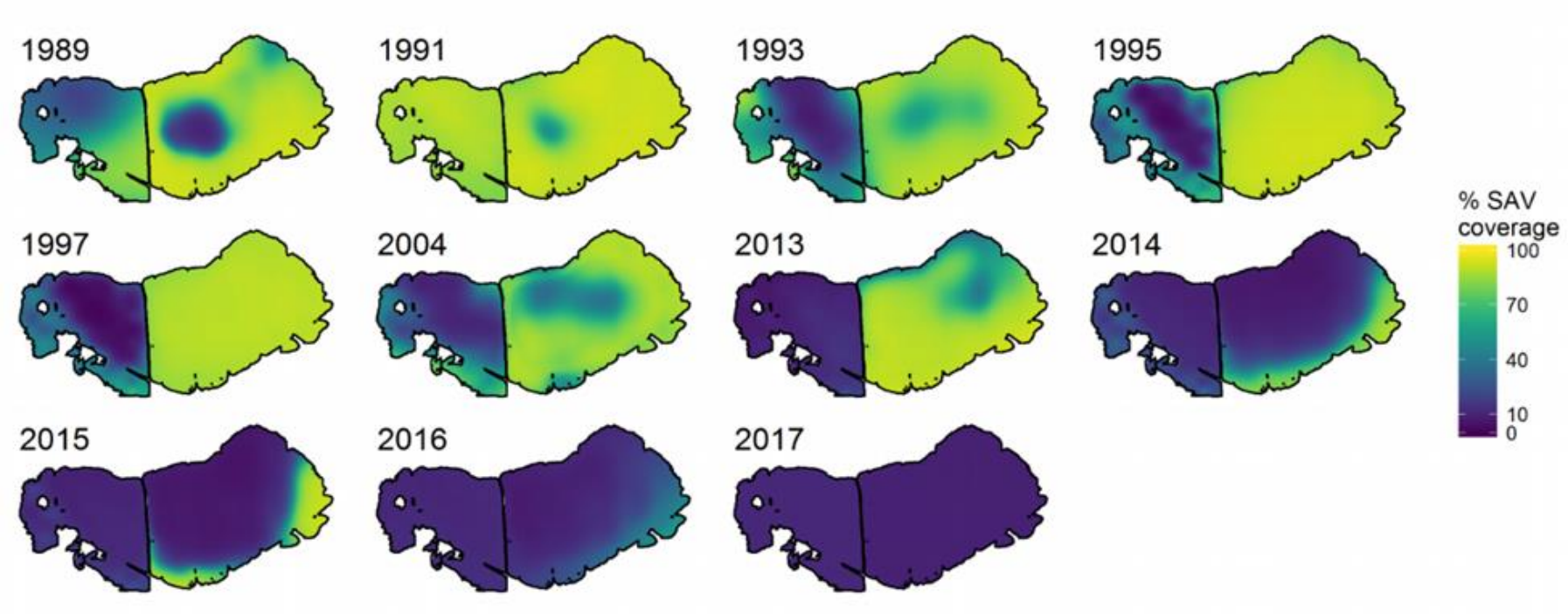
Concerns about Lake Mattamuskeet



Loss of SAV from the Lake by 2017

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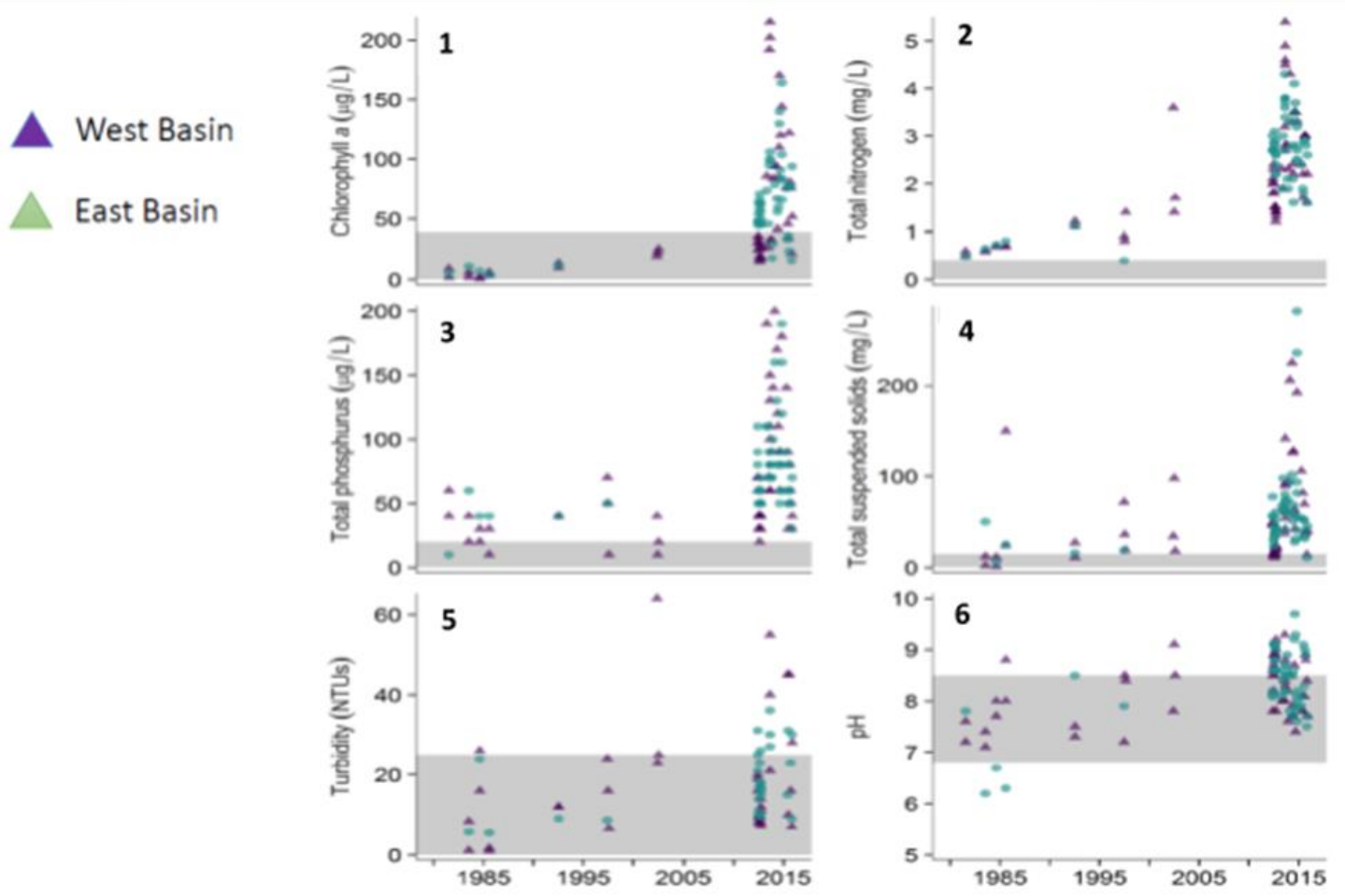
Concerns about Lake Mattamuskeet



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Lake was listed on NC303(d) list of impaired waters in 2016 for elevated levels of pH and chlorophyll-*a*

What is a watershed restoration plan?

- A voluntary plan for a specific waterbody
- Identifies pollutants and causes of impairment
- Provides the framework and guidance to restore an impaired waterbody and outlines future action
- Recommends management strategies devised by all stakeholders
- Adaptive plan that can be updated over time
- Once approved, it can be used to secure grant funds for implementation

Key Steps in Developing a Watershed Restoration Plan

Assemble Planning Team

Engage stakeholders and the public in the plan development

Determine Water Quality and Quantity Conditions and Impairments

- Summarize research on the current status and trends of the lake water quality
- Capture oral and written history of changes to or improvements in hydrology around the lake

Complete Watershed Characterization

Establish Plan Goals, Objectives and Action Items

Identify Stormwater Reduction or Water Management Techniques

Analyze impact of solutions

Develop Management Plan including priorities and next steps

Major Progress to Date

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Complete Watershed Characterization

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Analyze impact of solutions

Develop Management Plan including priorities and next steps

Stakeholder Team

Daniel Brinn- Hyde Drainage

Pete Campbell- U.S. Fish and Wildlife Service

Michael “Slim” Cahoon- Farming Community

Doug Howell- N.C. Wildlife Resources Commission

Art Keeney- Residential Community

Bill Rich- Hyde County Manager

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

Working with Stakeholders and the Public

5 Public Meetings

13 Stakeholder Meetings

Webpage for updates and comments:

nccoast.org/lakemattamuskeet

Press Releases

E-mail update after Public Meetings

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Watershed Restoration Plan

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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:

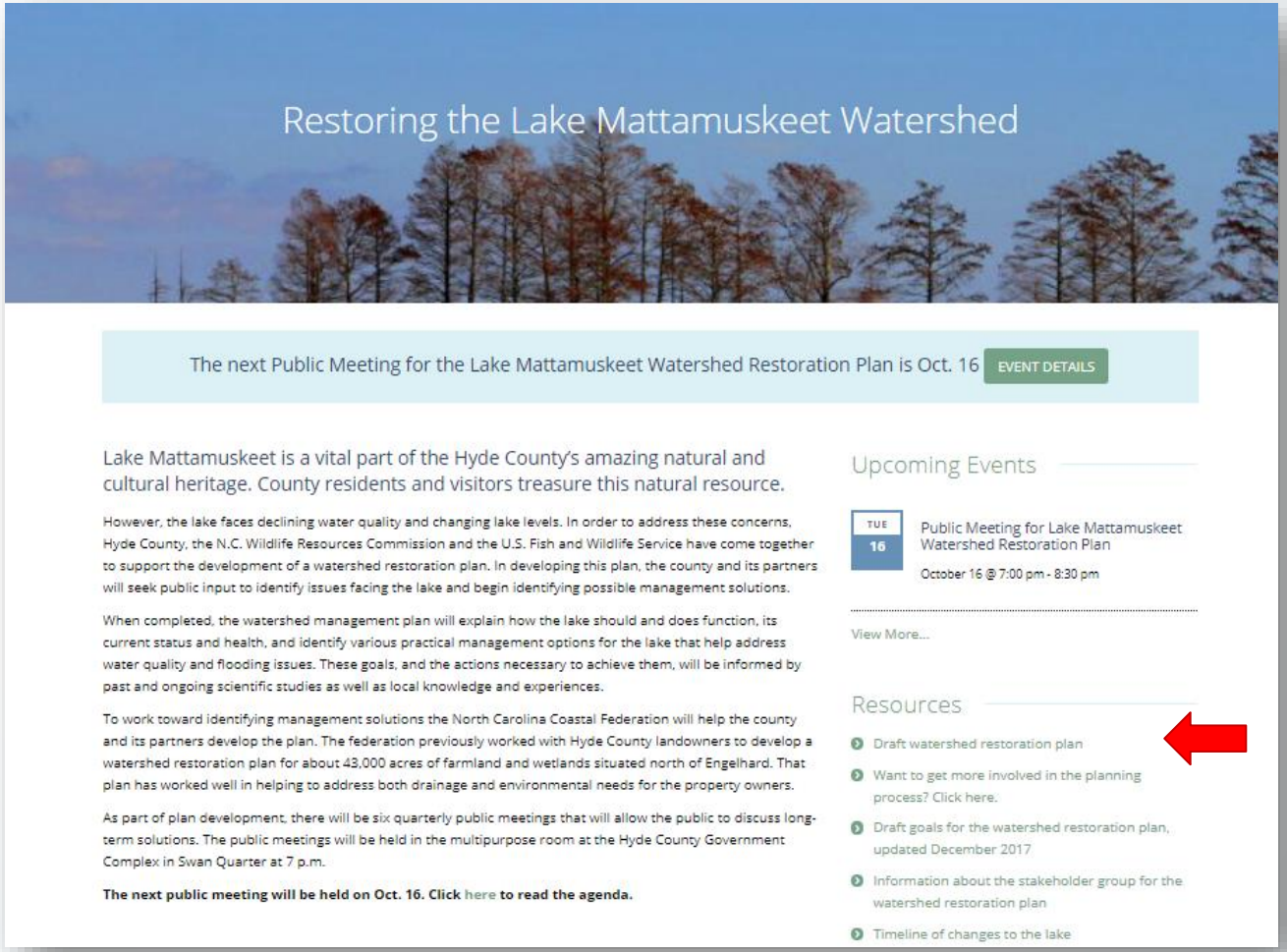
Minimize flooding of residential, business, and farm properties. Allow for annual drawdowns to establish and maintain submerged aquatic vegetation within the lake, and to establish and maintain a zone of emergent vegetation around the lake periphery.

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.

Review the Draft Plan



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Submit Comments Online

Submit Comments and Subscribe to Lake Mattamuskeet updates

Email *

First Name

Last Name

County

Please leave a comment for the watershed restoration planning team here. Please understand that the comments will be provided to the stakeholder team for their consideration. Comments received will not necessarily receive a personal response, but all will be taken into consideration in the development of watershed management strategies for the Lake watershed.

Notes

Submit

In The News

- "Restoring Lake Mattamuskeet In North Carolina" — June 29, 2017. U.S. Fish and Wildlife Service.
- "Secrets of Lake Mattamuskeet" — NC Science Now | UNC-TV
- "Where Has the Grass Gone?" — Wildlife in North Carolina, November/December 2016. Printed by N.C. Wildlife Resources Commission.

Additional Resources

- Study Shows New Flap Gates at Lake Mattamuskeet Bring Minimal Water Flow Change — N.C. Wildlife Resources Commission
- Mattamuskeet National Wildlife Refuge Website — U.S. Fish and Wildlife Service
- Updates on current and historic status of the lake's ecosystem and wildlife — U.S. Fish and Wildlife Service
- Continuous Water-Quality Monitoring at Lake Mattamuskeet, North Carolina — U.S. Geological Survey
- Mattamuskeet Foundation

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Lake Mattamuskeet Watershed Restoration Plan

Priority Actions

Current State of the Lake and Watershed

1. No active management of lake level other than tide gates
    - Flooding of residential property, septic system failures, & inadequate drainage of croplands
2. Turbid and hypereutrophic water (excessive nutrient levels)
    - Frequent phytoplankton & cyanobacteria blooms
3. SAV coverage is absent along lakebed
4. Minimal emergent vegetation
5. Abundance of common carp
6. Listed on NC 303(d) list of impaired waters
    - Chl-*a* (40 µg/l, AL, NC)
    - pH (8.5, AL, SW)

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* and pH within federal and state guidelines

Priority Actions

- Create a governing body that provides managing authority and a process for active water management.
- Perform hydrologic study of the watershed.
- Engineer for active water management of the lake watershed.
  - Infrastructure Improvements
  - Additional Outlet Evaluation
  - Potential Sheet Flow Sites

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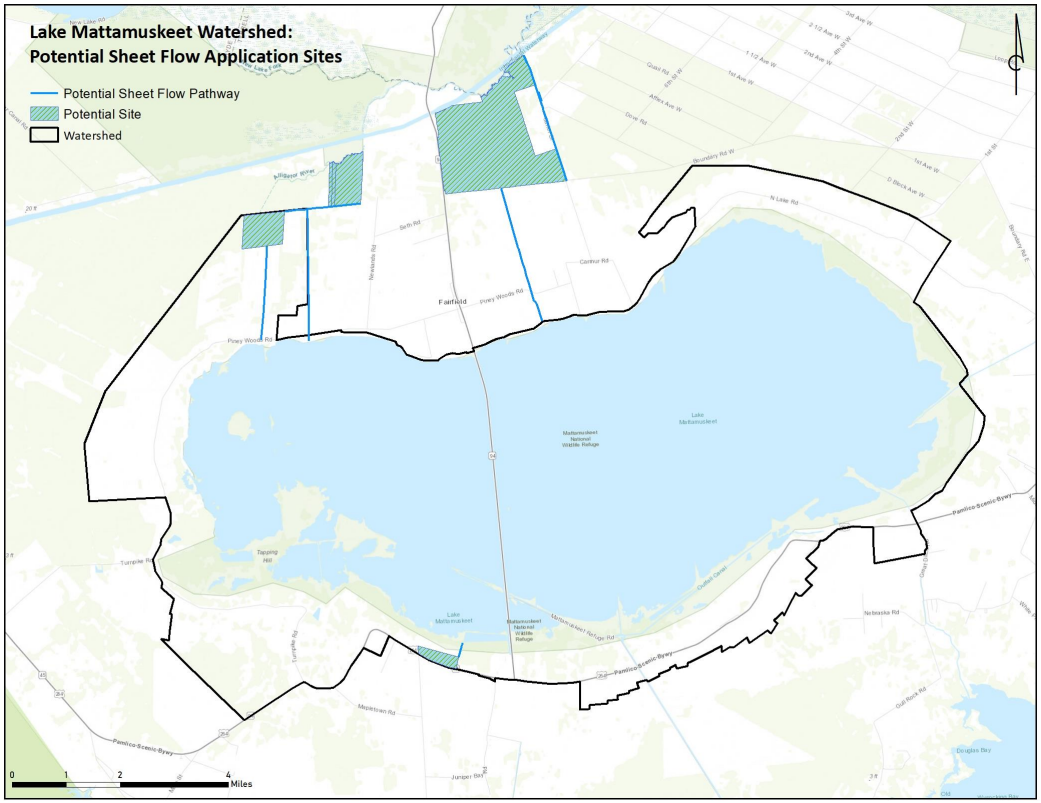
Potential Sheet Flow Sites

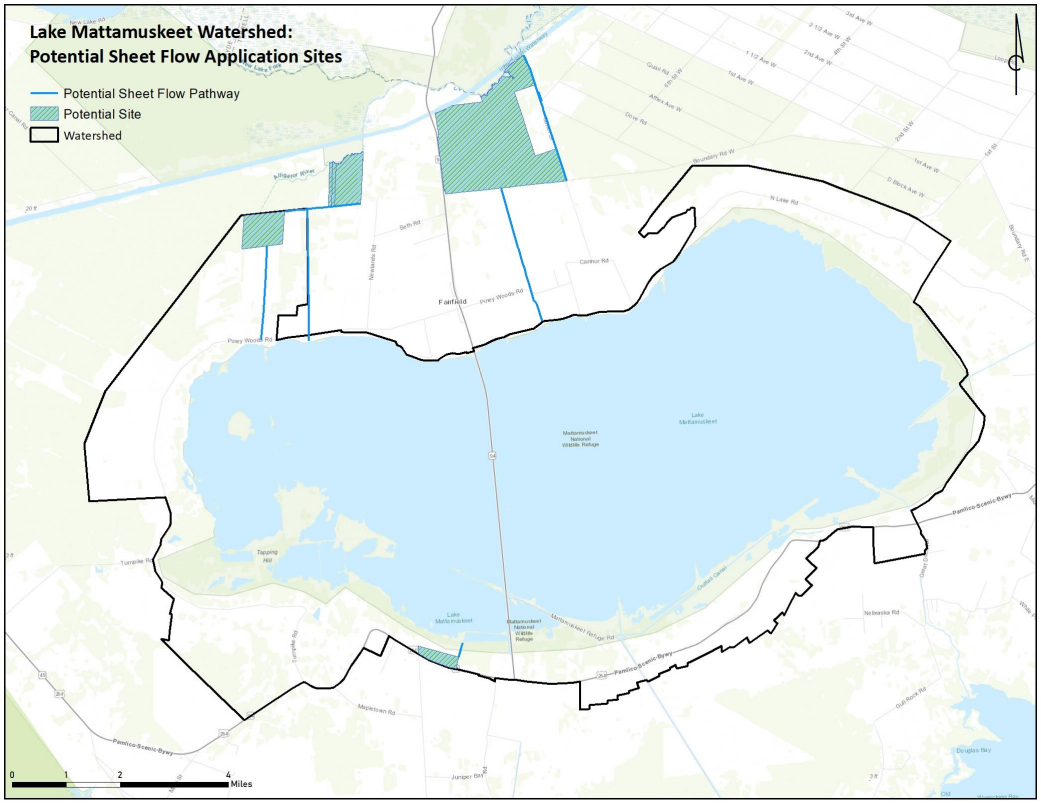


378 acres within watershed

2,477 acres outside watershed

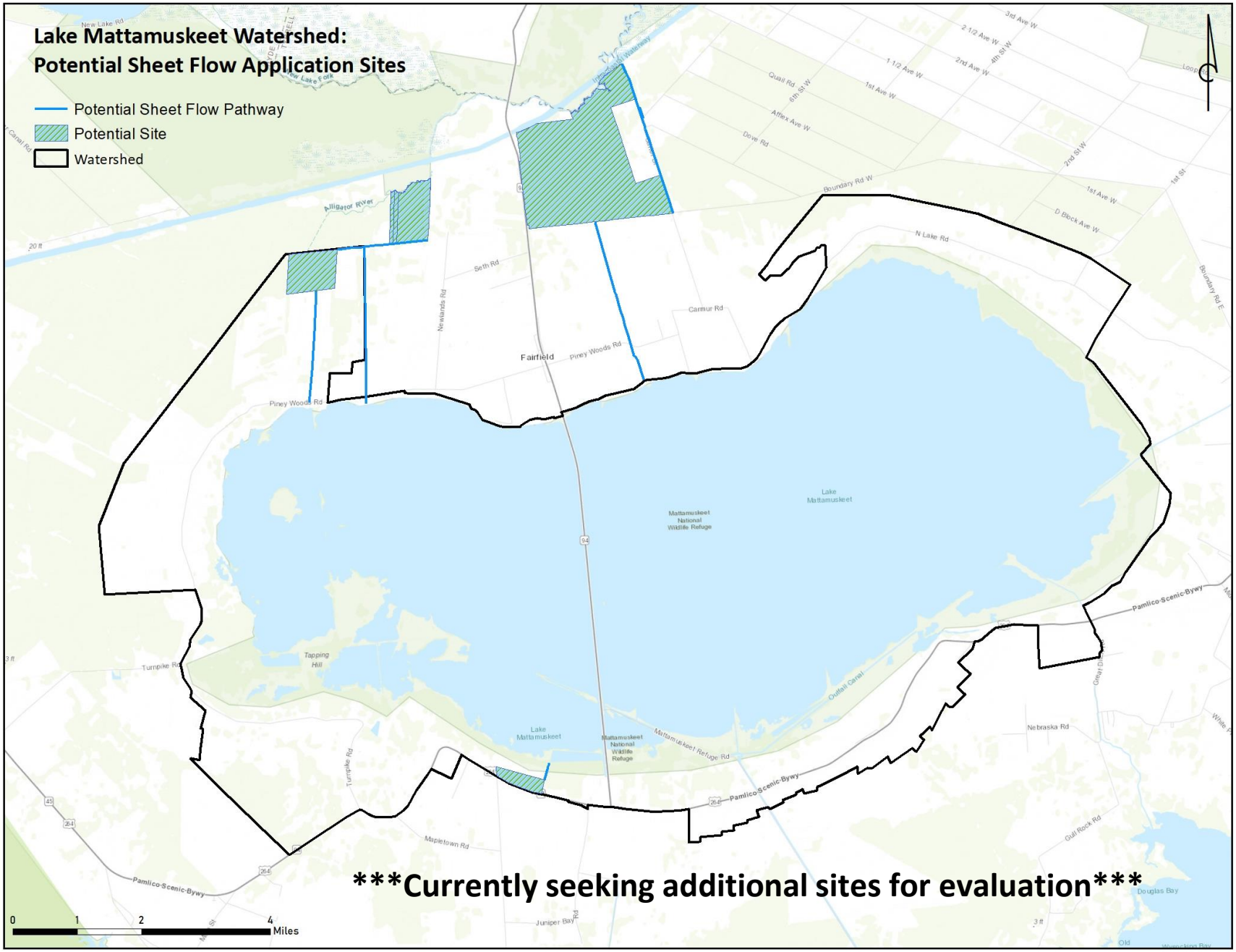
Currently seeking additional sites for evaluation.

Potential Sheet Flow Sites

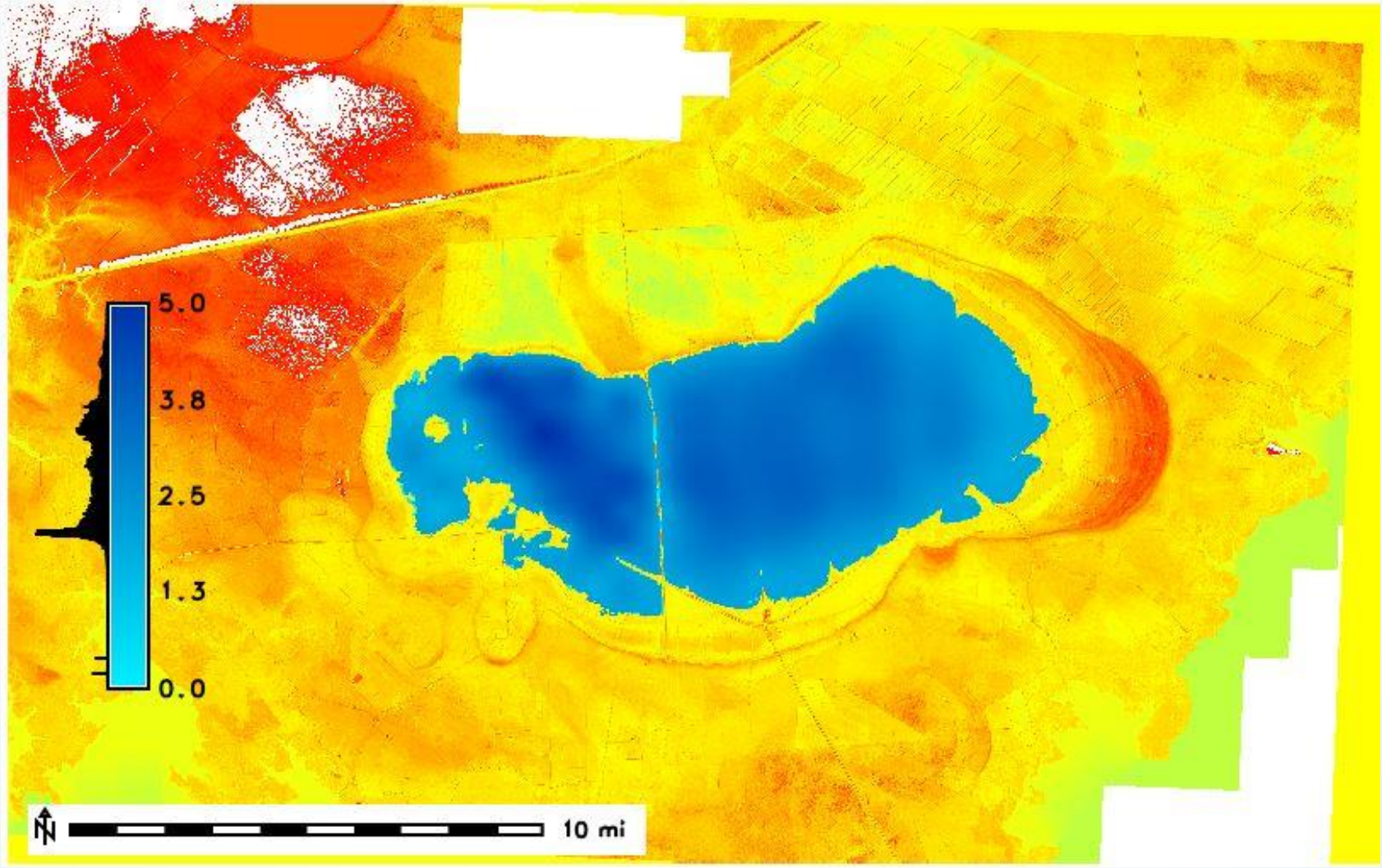


Benefits include:

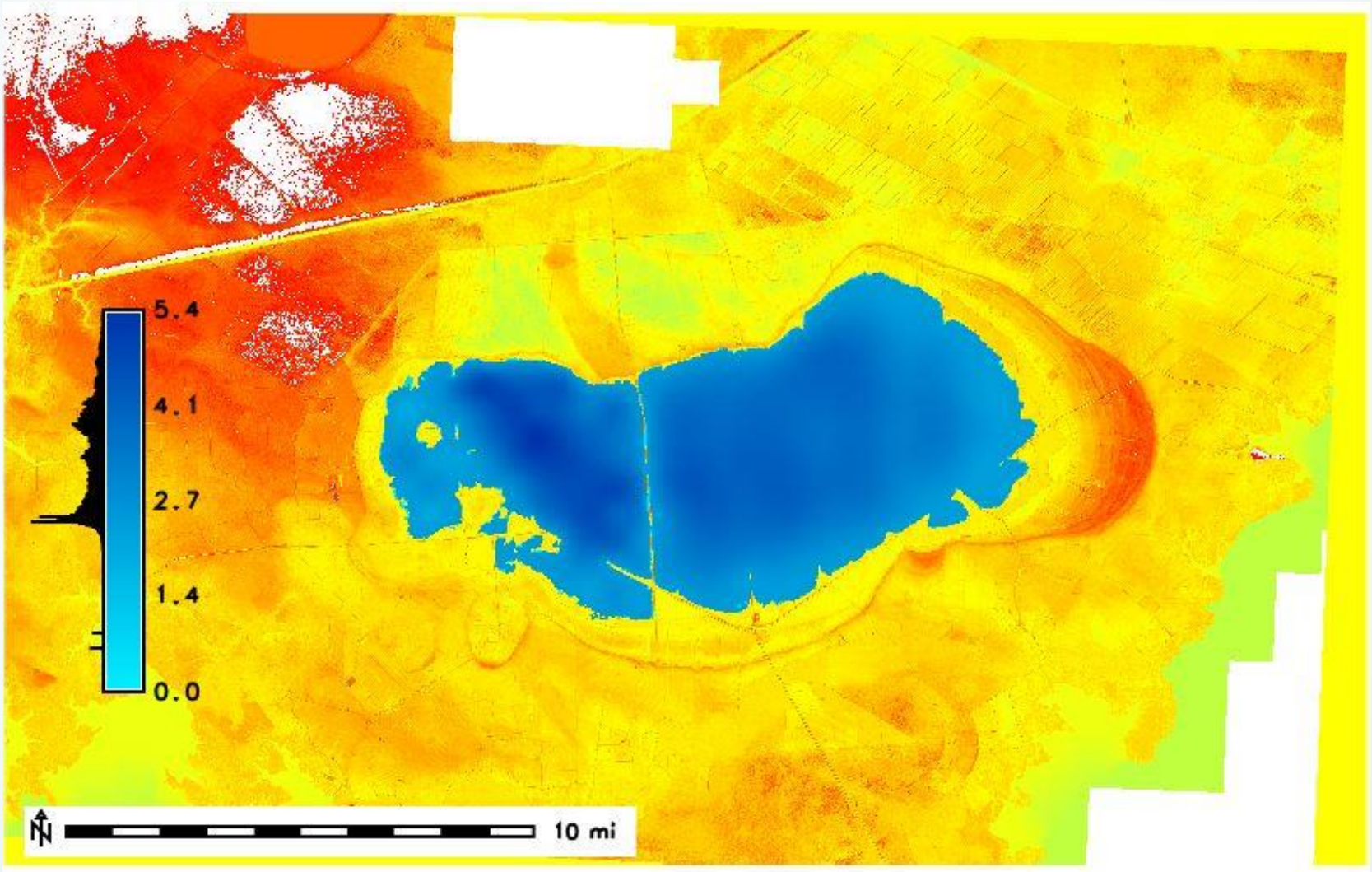
- Water quality treatment
- Restoring the natural hydrology
- Reduction of water volume draining to the lake


Lake Mattamuskeet Watershed:
Potential Sheet Flow Application Sites
Potential Sheet Flow Pathway
Potential Site
Watershed
Currently seeking additional sites for evaluation
0
1
2
4
Miles

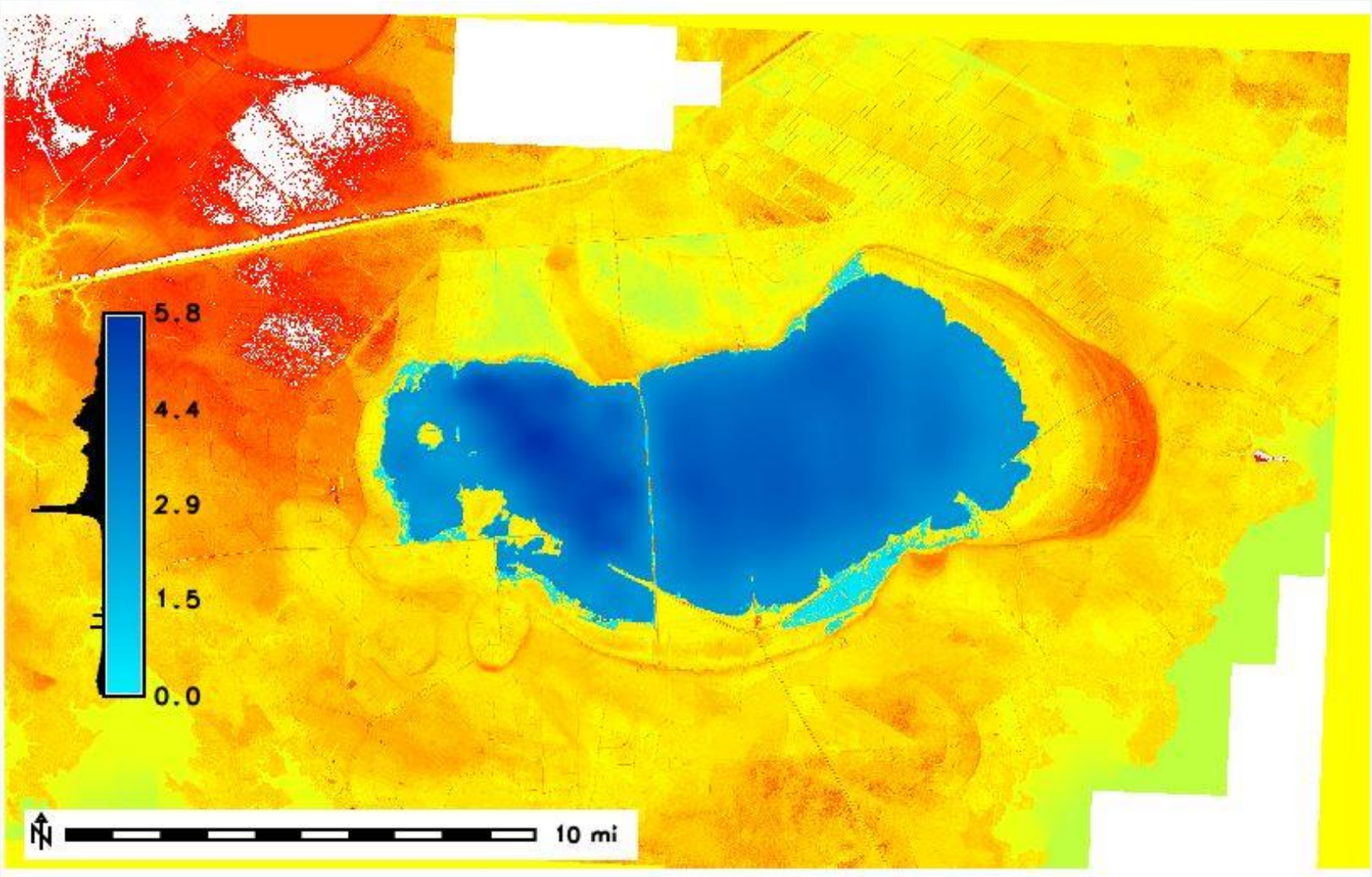
Water Level = -0.3 ft (MSL)



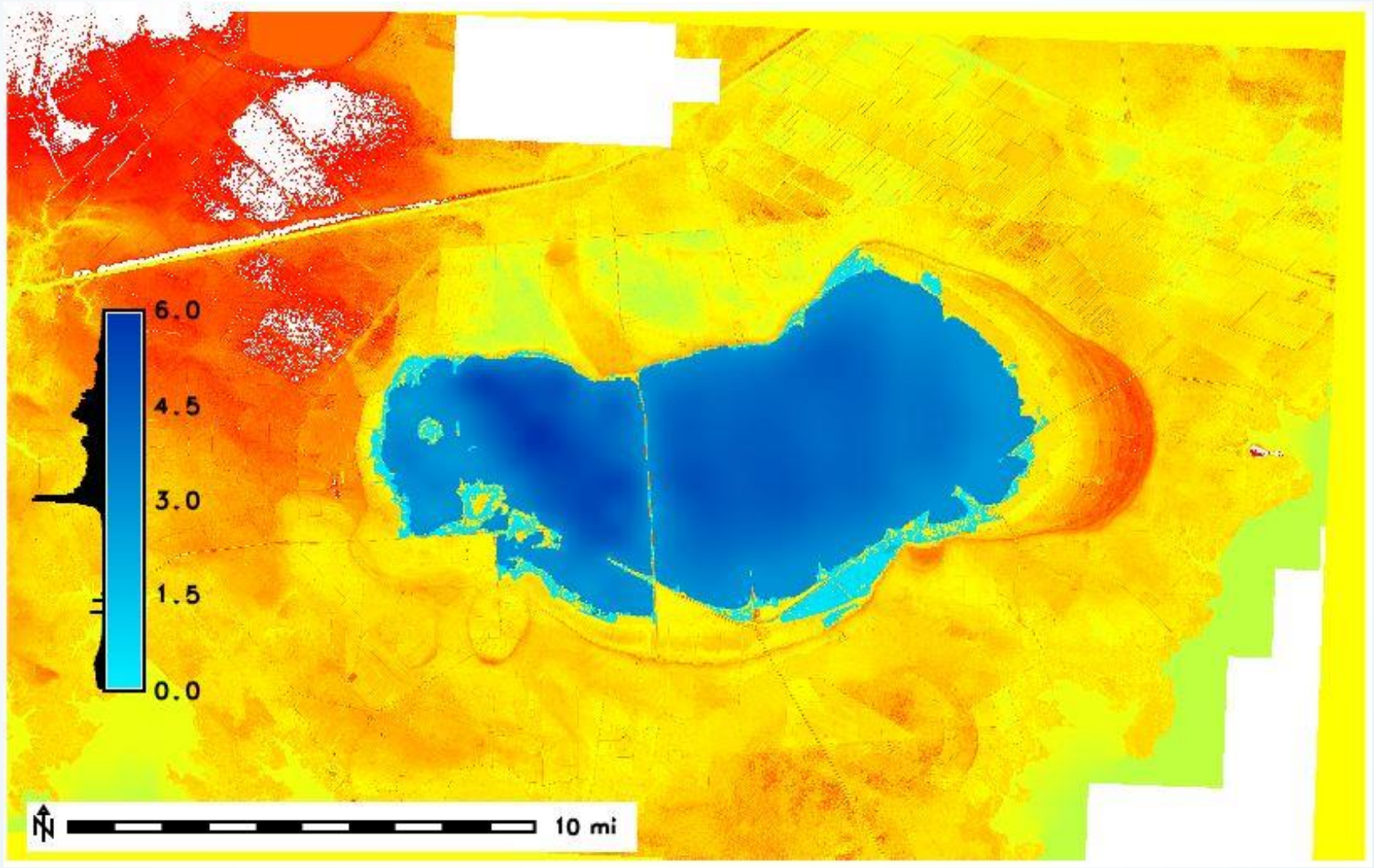
Water Level = 0.1 ft (MSL)



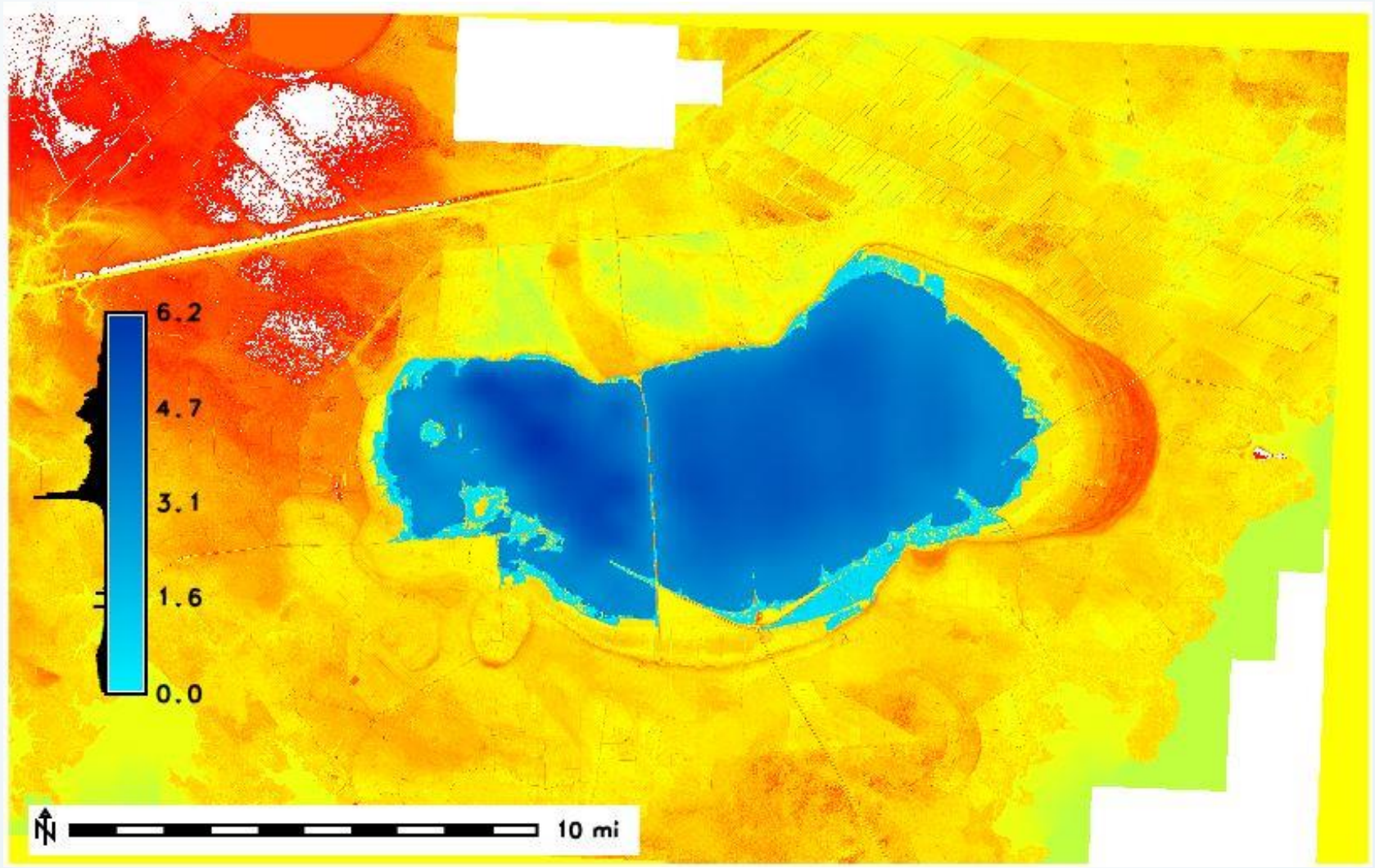
Water Level = 0.5 ft (MSL)



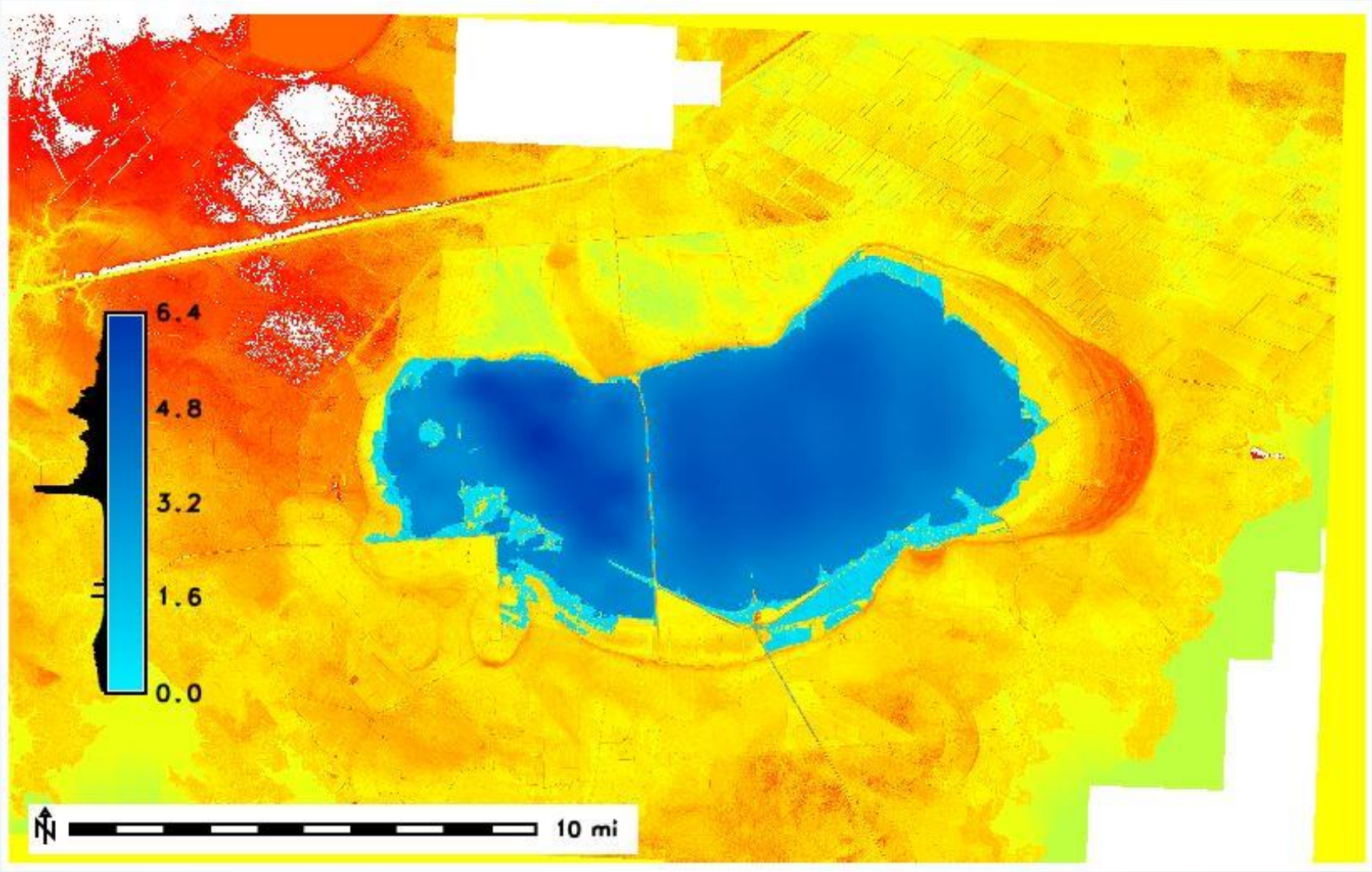
Water Level = 0.7 ft (MSL)



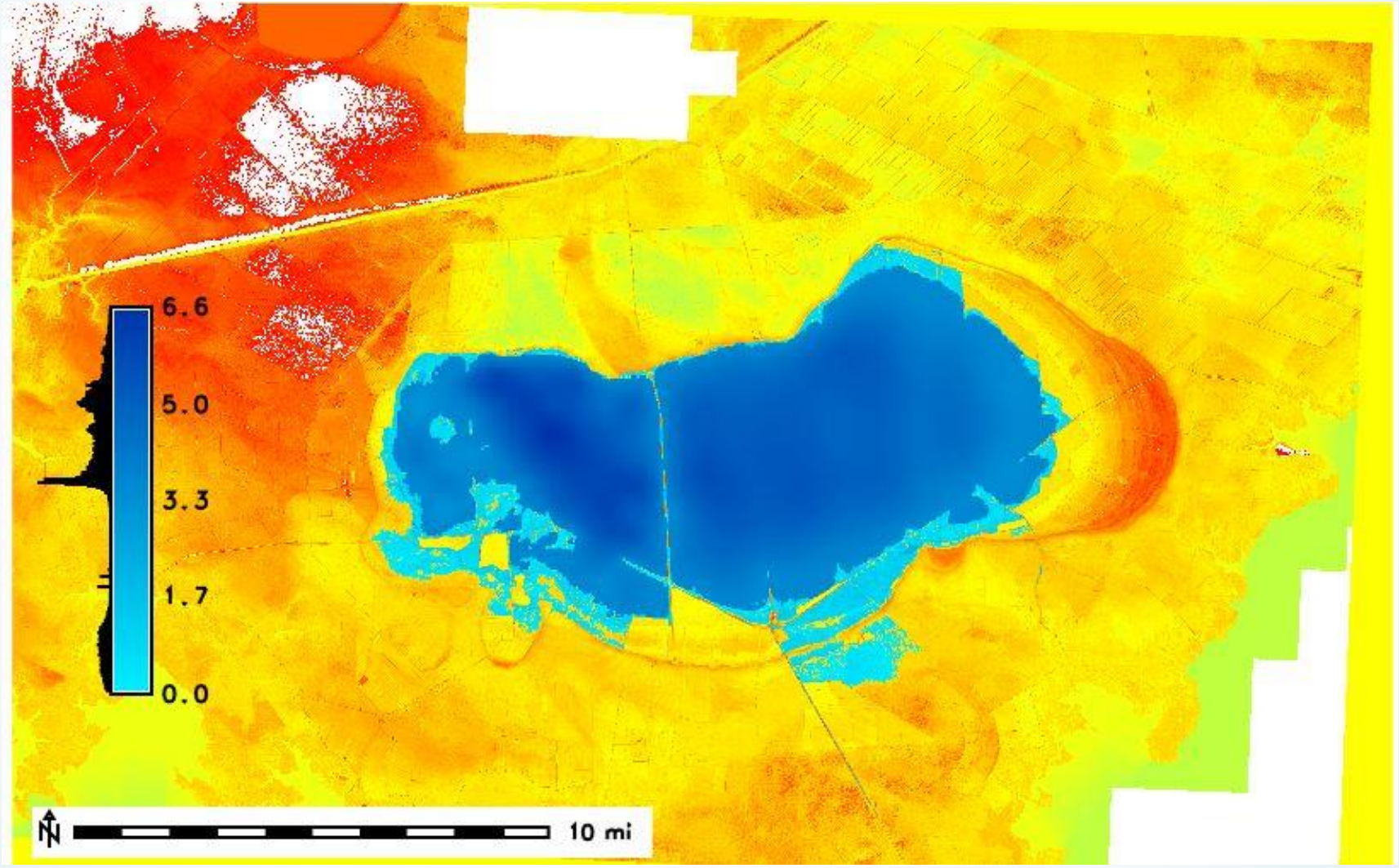
Water Level = 0.9 ft (MSL)



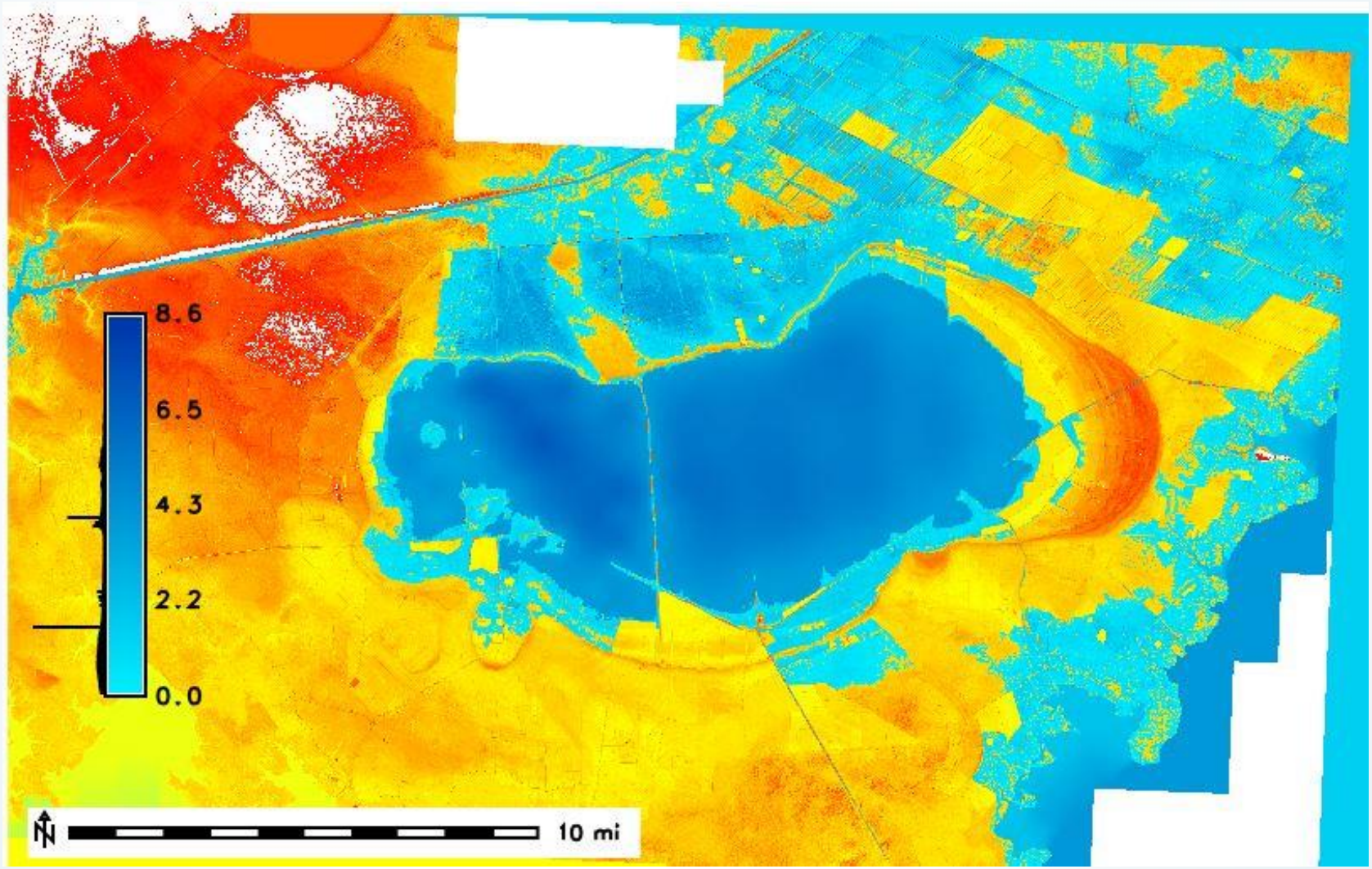
Water Level = 1.1 ft (MSL)



Water Level = 1.3 ft (MSL)



Water Level = 1.5 ft (MSL)



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Technical Presentations and Research Updates

Evaluating the Feasibility of Common Carp Exclusion and Targeted Vegetation Restoration in Lake Mattamuskeet

April D. Lamb and Jesse R. Fischer
North Carolina State University, Department of Applied Ecology

NC STATE UNIVERSITY

April D. Lamb

M.S. student in Applied Ecology
NSF Graduate Research Fellow

Dr. Jesse R. Fischer

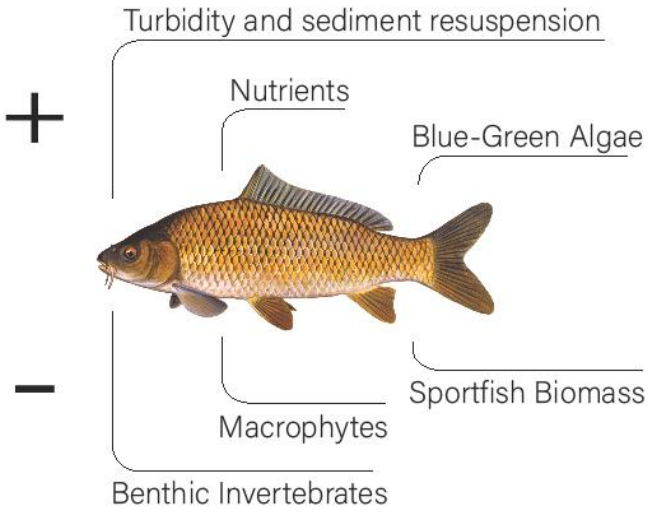
Assistant Professor in Applied Ecology

- **Not** to be confused with **Grass Carp**, which eat living aquatic vegetation
- Or **Crucian Carp**, which are essentially goldfish that have been introduced into systems
- Or **Silver Carp**, **Bighead Carp**, or other Asian "carp" which are invasive in the US

<u>None of these fish are in Lake Mattamuskeet</u>

How do Common Carp impact shallow lakes?

- Affect both “top-down” (predator abundance) and bottom-up (phytoplankton levels) biological processes



The history of Common Carp in Lake Mattamuskeet

COMMERCIAL CARP REMOVAL AT LAKE MATTAMUSKEET, NORTH CAROLINA

Willie G. Cahoon [1]

U. S. Fish and Wildlife Service, New Holland, North Carolina

Lake Mattamuskeet is famous as a National Wildlife Refuge for a wintering concentration of swans, Canada geese and ducks. The 50,000-acre lake is located in Hyde County, North Carolina, seven miles north of Pamlico Sound. Prior to 1915 the lake was an open body of water with no obstructions to mar the surface. The marsh was limited to a narrow band of low flats on the south shore. There was only one small outlet canal draining this vast area.

In 1915 the lake was purchased by a stock company and the largest pumping plant in the world, at that time, was installed. The lake was drained and approximately 20,000 acres were reclaimed for farm lands. Except for short periods, these lands were cultivated until the fall of 1932, when the lake refilled after financial failure of the drainage project.

On October 30, 1934 the Federal Government purchased the lake as a wintering ground for migratory waterfowl. After the refuge was established improvements were begun to manage the area for the purpose desired. More canals were constructed to secure drainage by gravity, not only for the purpose of influencing plant life in the marsh, but also to assist crop production on adjacent private farm lands. An earthen causeway, with five bridges, constructed in 1941-42, more or less divides the lake in halves.

At present, levels are controlled by gates on six canals draining into Pamlico Sound. The lake receives no creek or river drainage, being fed by runoff and agricultural drainage from the surrounding watershed. The open water consists of approximately 30,000 acres, bordered by 20,000 acres of marsh and upland. It is the practice to lower the lake water level during the growing season to expose shorelines as early in the spring as possible for proper growth of native emergent waterfowl food-plants. The number of waterfowl utilizing the area has increased substantially as a result of this drawdown.

Until 1949 the lake water was so turbid that submerged aquatic plants could not exist. Secchi disc visibility in the lake proper was approximately six inches in waters that averaged three feet deep. The salt content of the open lake for the past five years averaged 875 p.p.m. chlorides, or 2.5% sea strength. After the first agricultural drainage the fish population naturally was reduced to a minimum; but, subsequent to the 1932 water rise, there developed a tremendous population of largemouth bass, crappie and white perch, which provided excellent sport-fishing. Since 1937 the lake fishery

[1] Appreciation is expressed to W. P. Baldwin, U. S. Fish and Wildlife Service, for assistance in the preparation of this article.

Is removal an option?

- Common Carp removal has been shown to increase water clarity and facilitate the re-emergence of aquatic vegetation

- But is this a "one and done" fix?
  - If not enough carp are removed, they may bounce back even stronger, because Common Carp are excellent at surviving and producing offspring

- A carp management plan is critical to ensuring that population numbers remain at a manageable level

This project aims to investigate the role of Common Carp in the regime shift observed at Lake Mattamuskeet and assess the feasibility of Common Carp removal as a restoration strategy for submerged aquatic vegetation.

Large-scale Common Carp Removal Experiment

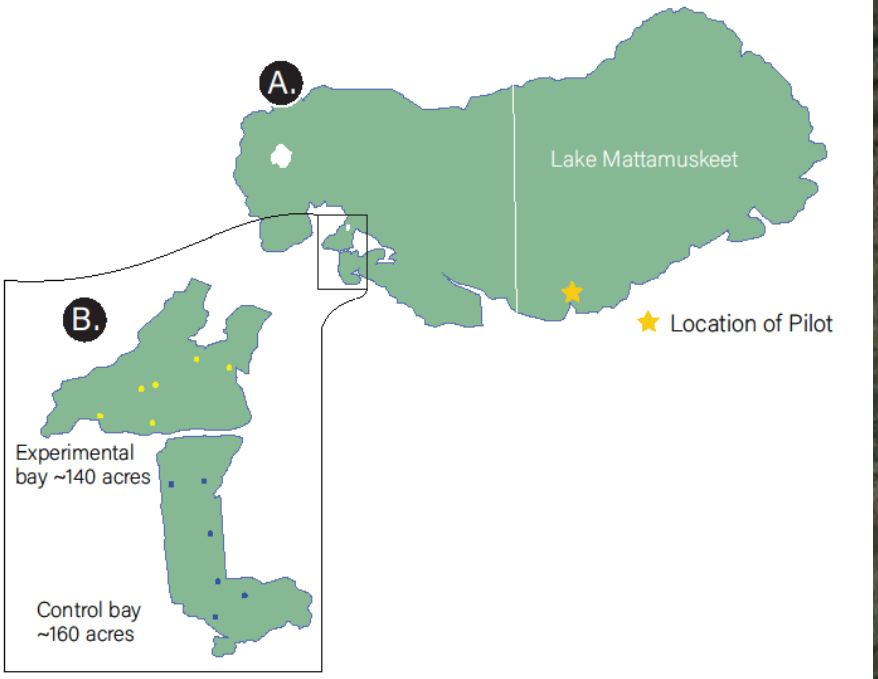
Prototype carp fence (Oct 2017 – March 2018)

October 2017

March 2018

- Constructed using galvanized steel cattle panels
- Panels attached using wire connectors and overlaid with chicken wire using zip-ties
- Left standing overwinter to test structural integrity of materials

Site selection



Rose Bay Canal ➡

Construction the full-scale carp fence

Public notices

- Signs are posted at the Rose Bay Boat Ramp and the Osprey Nest Campground Boat Ramp
- Restricted area signs are placed at each fenced off entrance to the control bay

Carp fence post Hurricane Florence

How many carp are in the bay?

- Simple mark-recapture to estimate population density
- 200 fish captured from outside experimental bay
- Fish were marked via a caudal, or tail, fin clip
- Fish were held for 24 hours before being released in NE, NW, SE, SW corners of the bay
- Then given a 48 hour adjustment period before recapture attempt

Density Estimate

- Three days
- Five electrofishing boats
- Seven WRC biologist from five districts
- 15+ volunteers from NC State, Mattamuskeet NWR, and Pocosin Lakes NWR
- 33 Total hours of “pedal-down” time

Density Estimate - Results

Day	Effort (hours)	Captures	Average Weight (kg)	Average Length (mm)	Recaptures
1	10.01	78	2.07	538.2	8
2	11.25	68	2.09	545.0	1
3	12.22	61	2.13	545.0	3
Total	33.48	207	2.09	542.4	12

$$\hat{N} = \frac{MC}{R}$$

N = true population size M = marked
C = total capture R = total recaptures

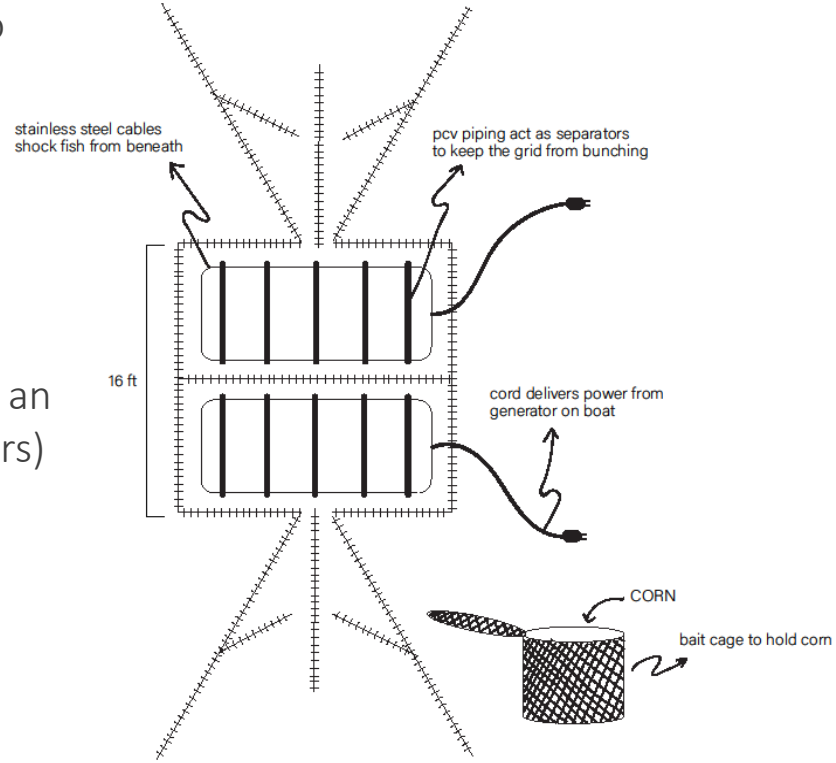
- Length, weight, and DNA sample taken for all individuals
- Using the Lincoln-Peterson Index (left) we estimate there to be 3,200 individuals, or 10/ha, present in the embayment.

Complications

- 3,200 is a lot of Common Carp
- Electrofishing shown to be **inadequate** for large-scale removal
- Potential complications during sampling
  - Weather conditions (> 90 degree F)
  - Carp are sensitive to sound
  - Difficult to reach all areas of the embayment due to phragmites coverage

Removal Alternatives

- Currently, we're baiting "carp traps" with deer corn to specifically target Common Carp
  - Two traps to date, but more will be built
  - Only Common Carp and catfish will eat corn
  - Will be modifying to limit corn loss and chance of an encounter from unwanted predators (e.g. alligators)
  - Alternative bait options: dog food, soybean cake



Water Quality Monitoring

- Sampling sites chosen randomly in ArcGIS under given constraints
  - 50 m from documented osprey nests
  - 10 m from shore
- Water samples will be taken monthly and will be analyzed for the following parameters

Physical and Chemical Water Quality Parameters	
Chlorophyll *a*	Temperature
Total Phosphorous	Dissolved Oxygen
Orthophosphorous	pH
Nitrate	Salinity
Nitrite	Conductivity
Ammonia	
Turbidity	
Suspended Solids	

Temperature and light attenuation will be measured continuously using Hobo™ data loggers

Vegetation Revegetation Experiment

- Species chosen based on
  - ecosystem value
    - *Vallisneria americana* – Wild celery
  - biological characteristics – increased survival in turbid system
    - *Nymphaea odorata* – White waterlily

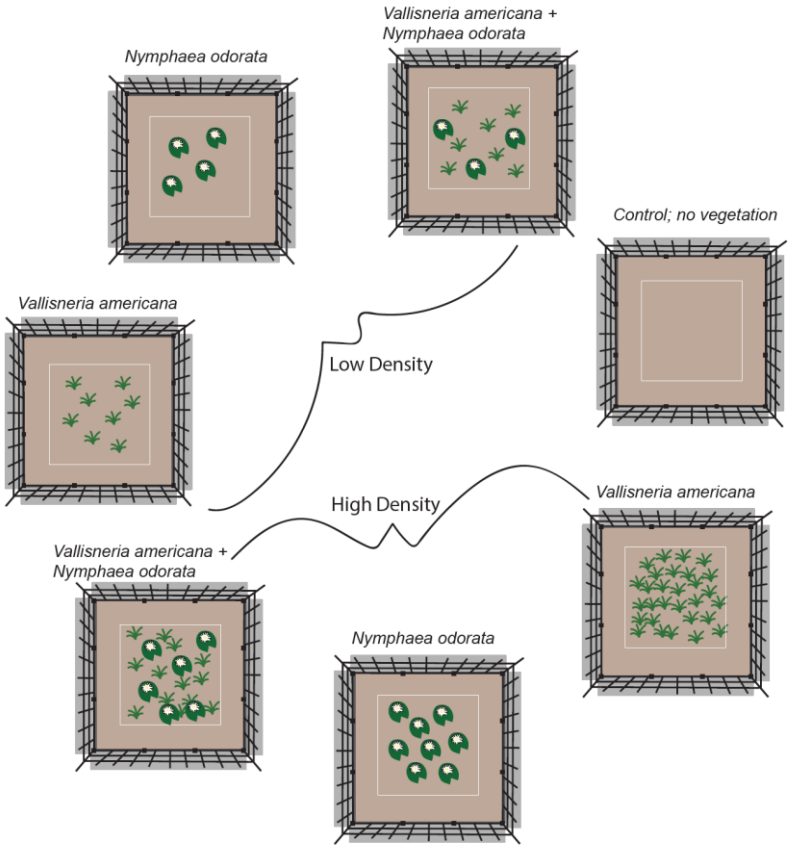
- Plots will be fully caged to help vegetation establish easier
  1. Prevents Common Carp from uprooting
  2. Prevents turtles and birds from snacking

- Plant health and growth will be measured monthly using a combination of destructive and non-destructive sampling techniques

Vallisneria americana

Nymphaea odorata

Vegetation Restoration Experiment



- 12 total revegetation “clusters”
  - 6 in bay with reduced carp biomass (fence)
  - 6 in control bay (no fence)
- 72 total cages planned with vegetation
- Cages are being built this fall
- Planting will be in early Spring 2019
  - If you’re interested in volunteering to help us transplant and plant vegetation please see me after the meeting.

Vegetation Restoration Experiment

Public Notices

- Additional signage (shown here) will be placed at each vegetation cluster in the control bay
- We kindly ask that people do not interfere or tamper with these plots in any way.

Special thanks to our supporters and collaborators from:

-Funding for this project has been provided by:

NSF Graduate Research Fellowship Program
Mattamuskeet National Wildlife Refuge
USFWS Inventory and Monitoring Fund
USFWS Migratory Bird Fund

Flow Reduction of Lake Mattamuskeet Outlet Canals

October 16, 2018

Randall Etheridge
East Carolina University
Department of Engineering, Center for Sustainable Energy and Environmental Engineering

In partnership with:
Hyde County Soil & Water Conservation District

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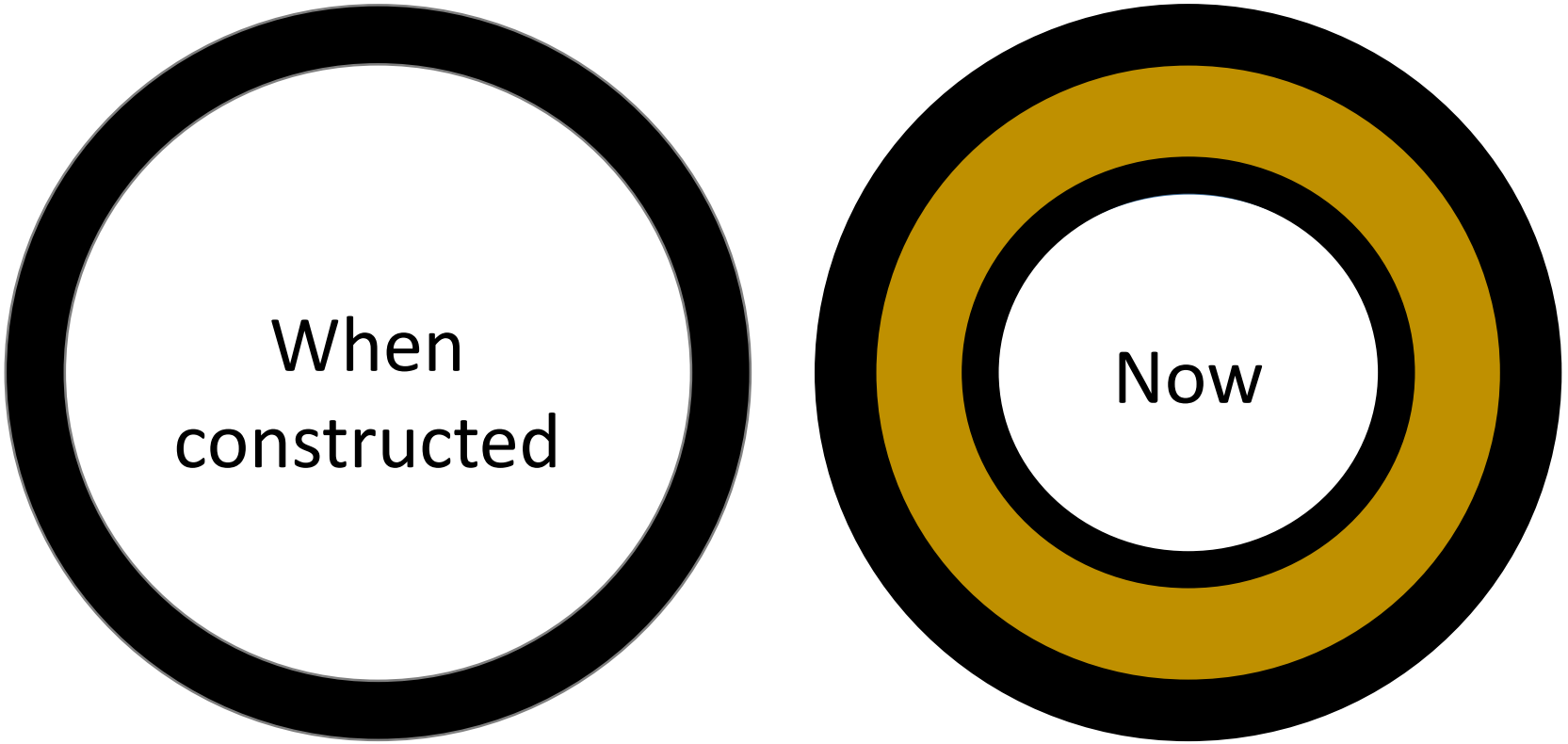
Sedimentation



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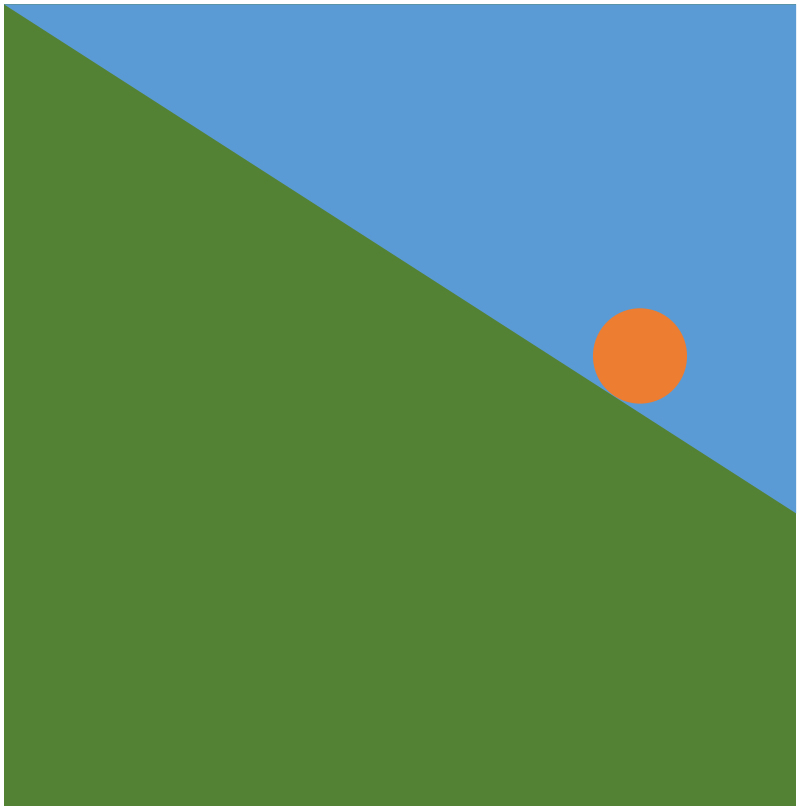
Sea Level Rise



When constructed

Now

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Tide Gates

- Flow occurs only when water level in the lake is above water level in the sound
- Dredging will have minimal impact on when tide gates are open

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Goals for study

- Use a model to determine how much sedimentation has reduced the flow in the four outlet canals
- Use a model to determine how much sea level rise has and will continue to reduce flow in the outlet canals
- Simulate the impact of dredging the canals on lake water levels during Hurricane Joaquin (2015) and Hurricane Matthew (2016)

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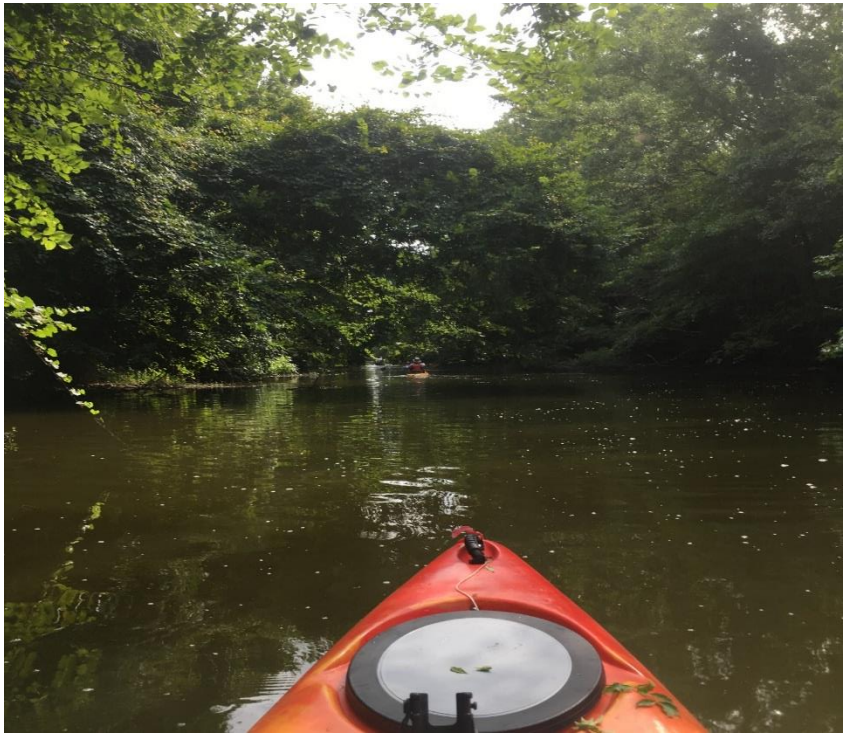
Methods

- Current canal dimensions - surveying
- Original canal dimensions – Drainage Record Book 1 for Outfall and soil probe for others
- Only takes into account portion of canal between tide gate and sound



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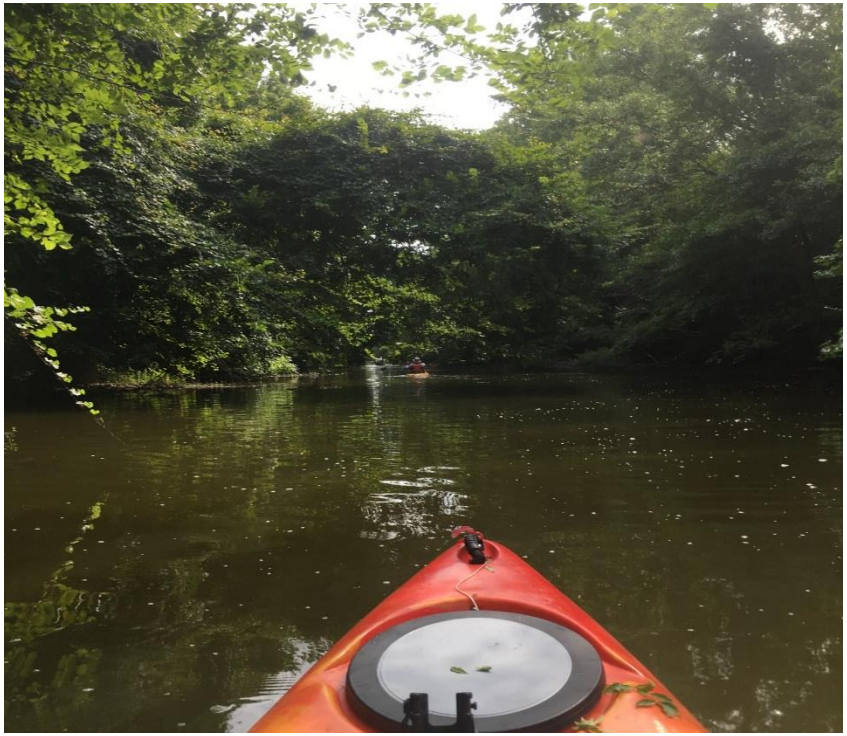

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Methods

- Current flow rates – acoustic Doppler profiler
- Model: HEC-RAS from U.S. Army Corps of Engineers
- Hurricane simulation: Water balance

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Results - Outfall

Maximum flow rate to maintain the water level below 1.5 ft at the tide gate.

Downstream Water Level (ft)	Original Canal Dimensions Flow (cfs)	Current Canal Dimensions Flow (cfs)	Sedimentation Reduction
-1	2230	332	85%
0	1830	309	83%
1	1120	217	81%

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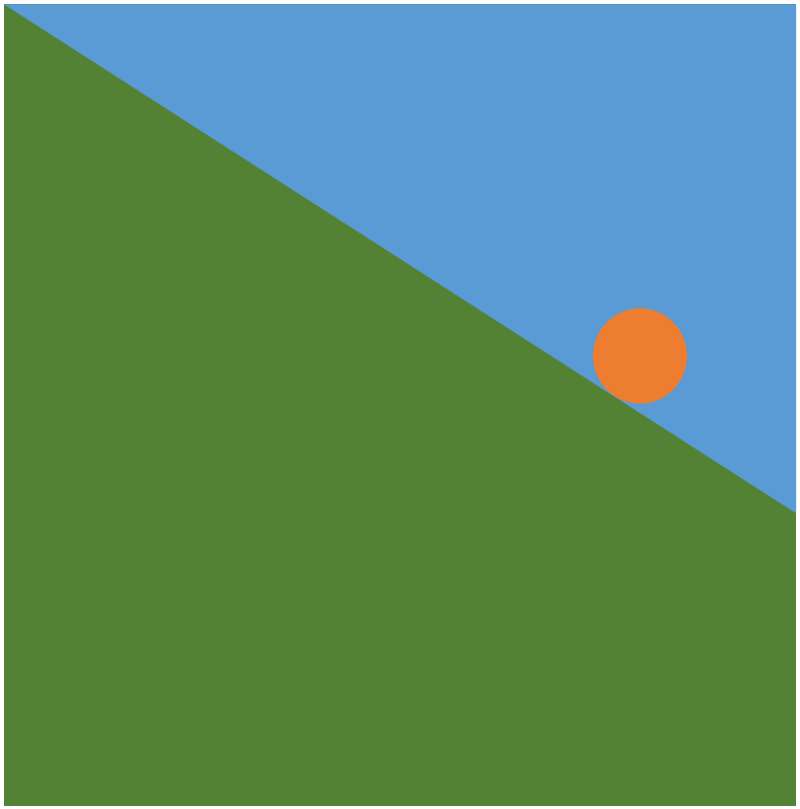
Sea Level Rise



When constructed

Now

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Results - Outfall

49% Reduction in flow due to 2 ft rise in sea level even if canals are dredged

Downstream Water Level (ft)	Original Canal Dimensions Flow (cfs)	Current Canal Dimensions Flow (cfs)	Sedimentation Reduction
-1	2230	332	85%
0	1830	309	83%
1	1120	217	81%

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Results – All Canals

- Percent reduction in flow for sedimentation and sea level rise are independent of each other and not additive
- Dredging the canals will not result in full restoration of flow due to sea level rise

Canal	Original Canal Flow (cfs)	Sedimentation Reduction	2 ft Sea Level Rise Reduction
Outfall	2230	85%	49%
Lake Landing	1260	80%	45%
Rose Bay	864	66%	48%
Waupoppin	631	76%	44%

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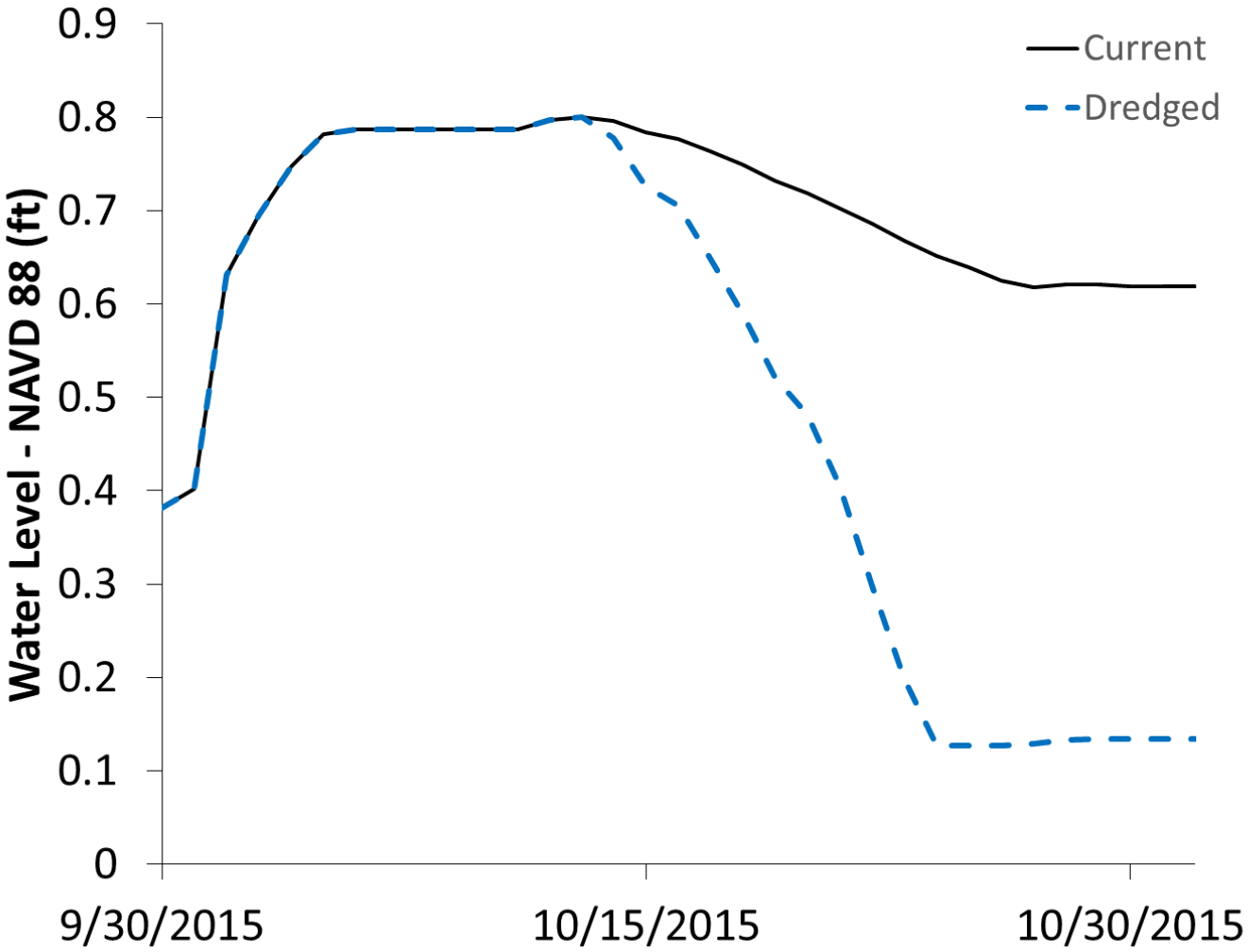
Results – Hurricane Joaquin



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Results - Hurricanes

- Hurricane Joaquin – number of days before water level drops below 0.7 ft
  - Current canals: 22 days
  - Simulated dredged canals: 17 days
- Hurricane Matthew – number of days before water level drops below 0.9 ft
  - Current canals: 47 days
  - Simulated dredged canals: 21 days

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Summary

- Flow in the canals does not occur when the water level in the sound is higher than the water level in the lake
- Dredging the canals will increase the flow in the four outlet canals
- Dredging the canals could reduce the duration of flooding
- Sea level rise will continue to reduce the flow in the canals whether they are dredged or not

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Questions?

Randall Etheridge
etheridgej15@ecu.edu
252-737-1930

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The Hydrological Modeling of Lake Mattamuskeet

Raymond Smith[1]
Randall Etheridge[1,2]
East Carolina University
[1]Department of Engineering
[2]Center for Sustainable Energy and Environmental Engineering

Why Model Lake Mattamuskeet?

- Develop an understanding of lake stage level in response to variations in input.
- Provide a resource to support decision-makers and stakeholders in pursuit of watershed restoration goals.
- Provide a resource to explore identified scenarios, management policies, and *what-if's* leading to improved water management.

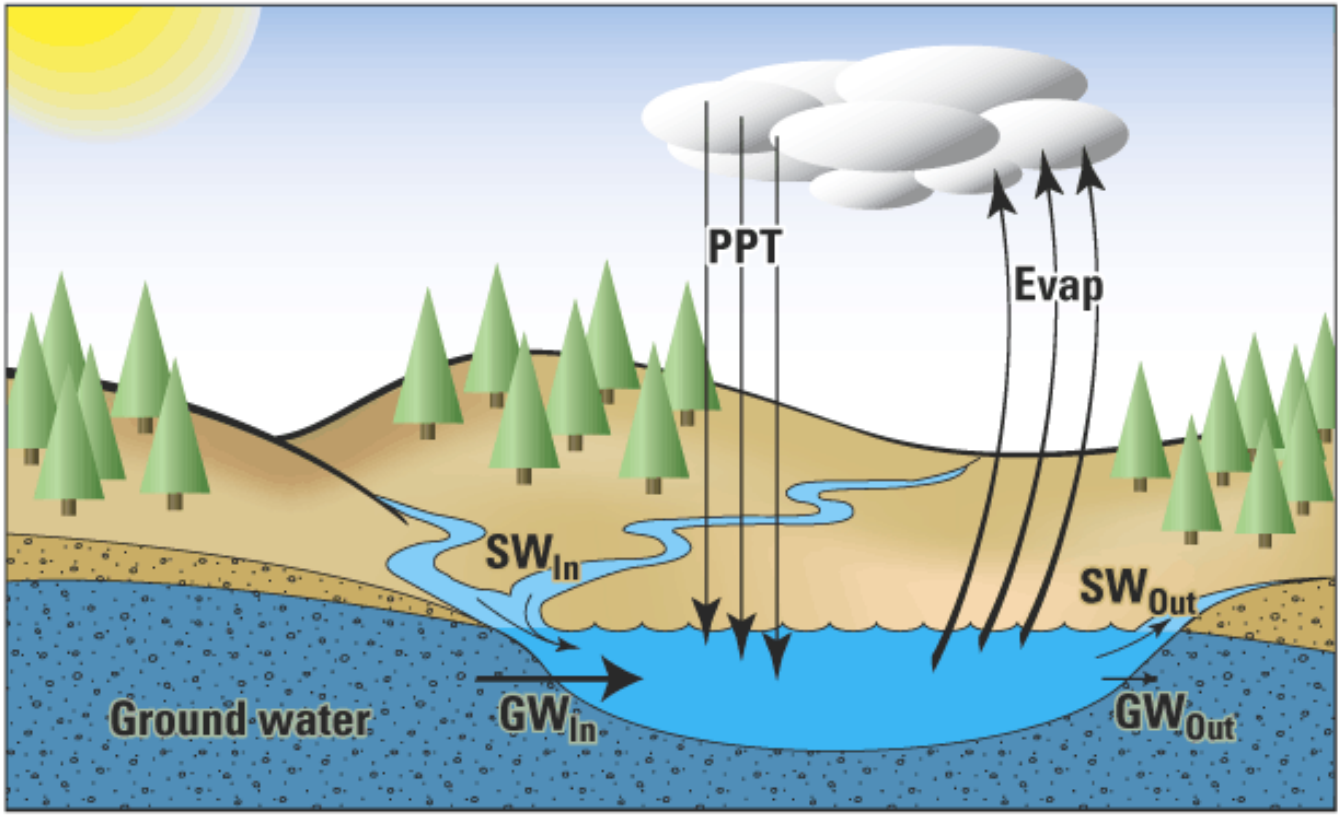
What is a Hydrologic Model?

- A simplification of a real-world system that aids in the understanding, predicting, and managing water resources.

- Hydrologic analyses are performed to quantify the flow rate of water draining from the watershed over time.

Reference: https://www.scribd.com/document/248148732/What-is-the-Difference-Between-Hydrology-and-Hydraulics

Hydrologic Balance of a Lake



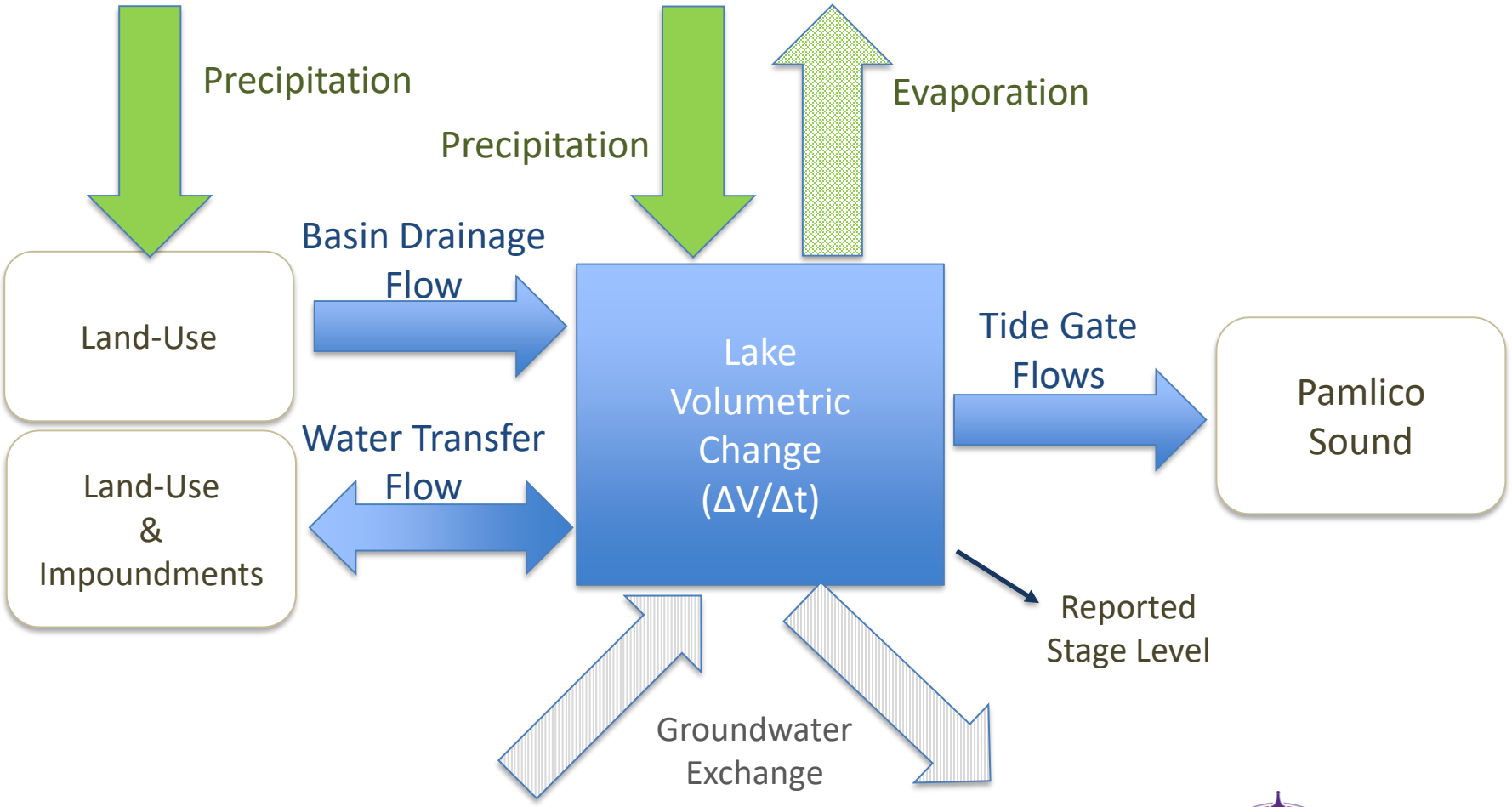
NOT TO SCALE

EXPLANATION

Evap	Evaporation
GW_{In}	Ground-water inflow
GW_{Out}	Ground-water outflow
PPT	Precipitation
SW_{In}	Surface-water inflow
SW_{Out}	Surface-water outflow

Reference: https://serc.carleton.edu/integrate/teaching_materials/earth_modeling/student_materials/index.html

Hydrologic Balance of Lake Mattamuskeet
"A Water Budget"



Steps of the Modeling Process

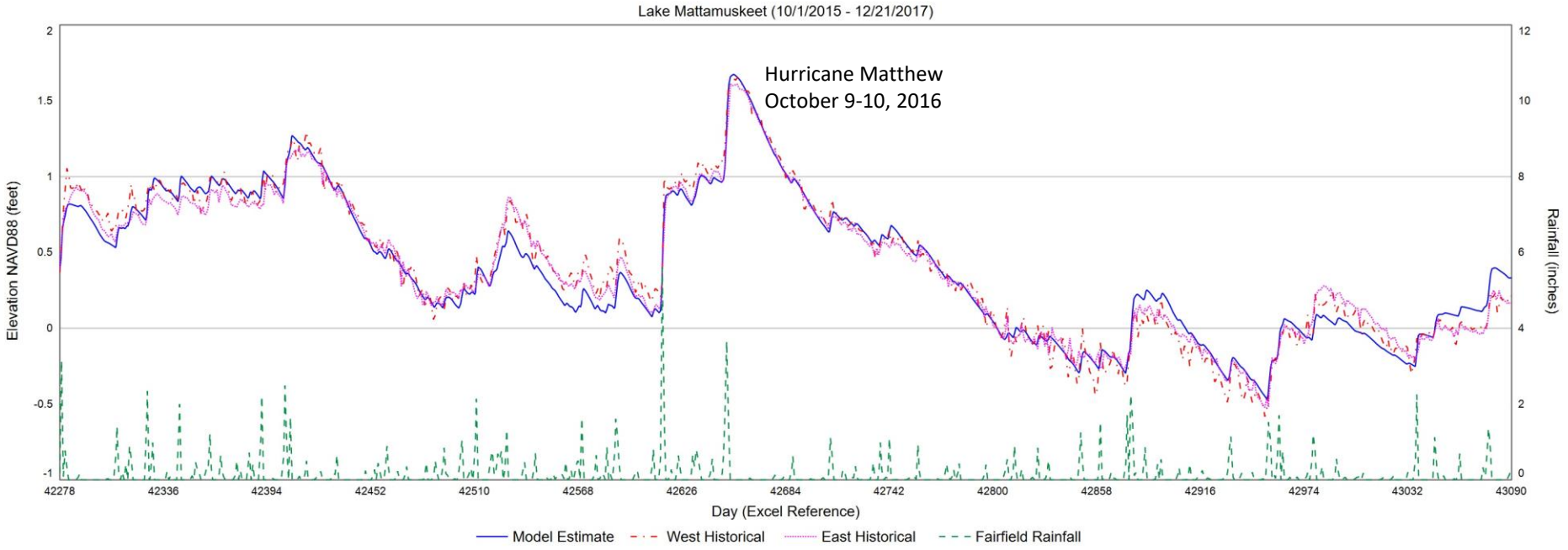
1. Articulate the goals
2. Perform appropriate data collection
3. Build and calibrate the model
4. Validate the built model
5. Policy design and evaluation
6. Conduct simulation experiments
7. Analyze results and report findings

Iterative

Preliminary Model Dynamics

(unvalidated model 8/1/2018)

Lake Mattamuskeet - Stage Level (feet)



Next Steps

1. Secure research funding resources
2. Enhancement of the model:
   a) Incorporate surrounding land-use types and interactions
   b) Incorporate water transfers *into* and *out of* impoundments
   c) Evaluate impact of wind
   d) Obtain additional observational data
3. Perform model calibration
4. Conduct a rigorous model validation

Then …

5. Study identified scenarios, management policies, and *what-if* questions through experimentation and report findings.

Questions

Raymond Smith

smithraym17@ecu.edu

252-328-9722

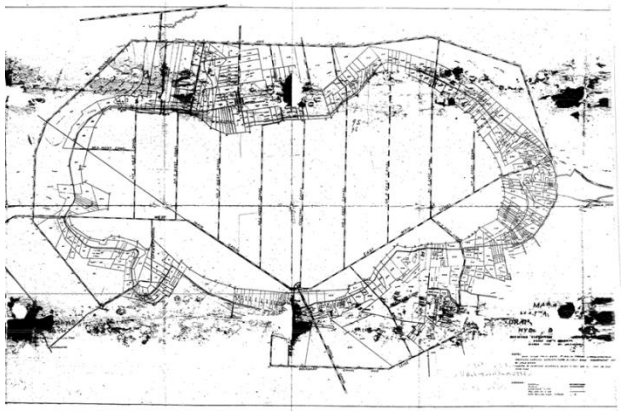
Facilitating Active Water Management

Lake Mattamuskeet Watershed

Daniel Brinn

Historic Water Management Activities

- Lake Landing Canal
  - Earliest efforts in 1773, Constructed in 1837
- Hyde County Drainage District #1
  - Public Law 509
  - The creation of the Mattamuskeet Drainage District set in motion a plan that eventually drained Lake Mattamuskeet three times—in 1916, 1920 and in 1926.
- Rose Bay Canal

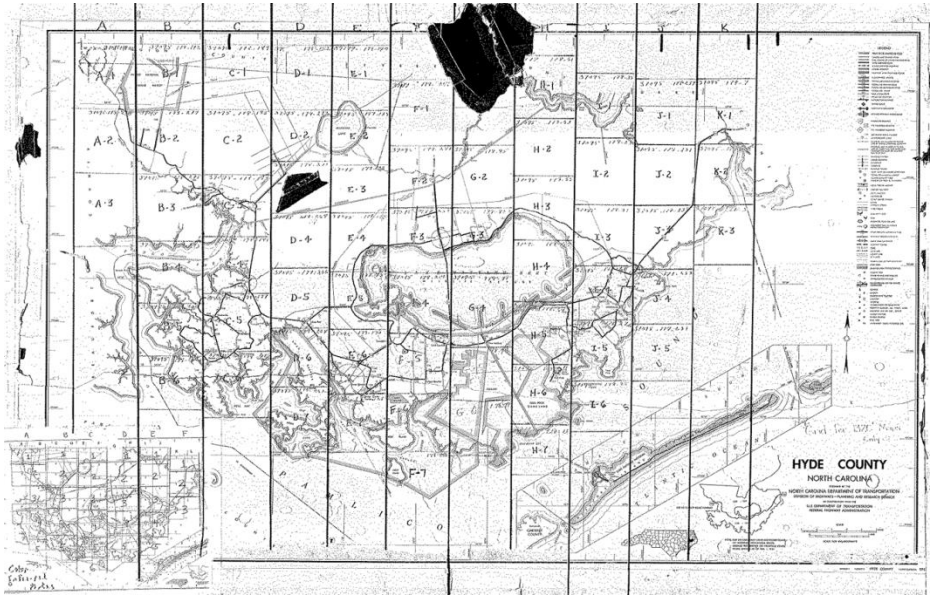


The Need for Active Management

- Preserving the way of life within the watershed
- Water Quantity issues
- Water Quality concerns

Making it Happen

- Plan
- Engineering
- Infrastructure
- Funding
- Continued Operation



Establishing a Service District for the Lake Mattamuskeet Watershed

- NCGS 153
- Process
- Boundaries
- Responsibilities
- Governance
- Funding

North Carolina
Coastal Federation
Working Together for a Healthy Coast

Lake Mattamuskeet Watershed Restoration Plan

Next Steps

Next Steps

- Review the Draft Plan at nccoast.org/lakemattamuskeet
- Please submit comments by Friday, November 2
- Incorporate feedback
- Finalize the plan by the end of November
- Public Symposium on December 3, 2018 at Martelle's Feed House in Engelhard
- Initiate implementation of management actions and BMPs

Questions and Comments