An Adaptive Approach to Tidegate Management for Estuary Restoration at the Herring River: Truro/Wellfleet, Massachusetts

- NROC/NALCC Science Delivery Workshop

- Wednesday April 5, 2017

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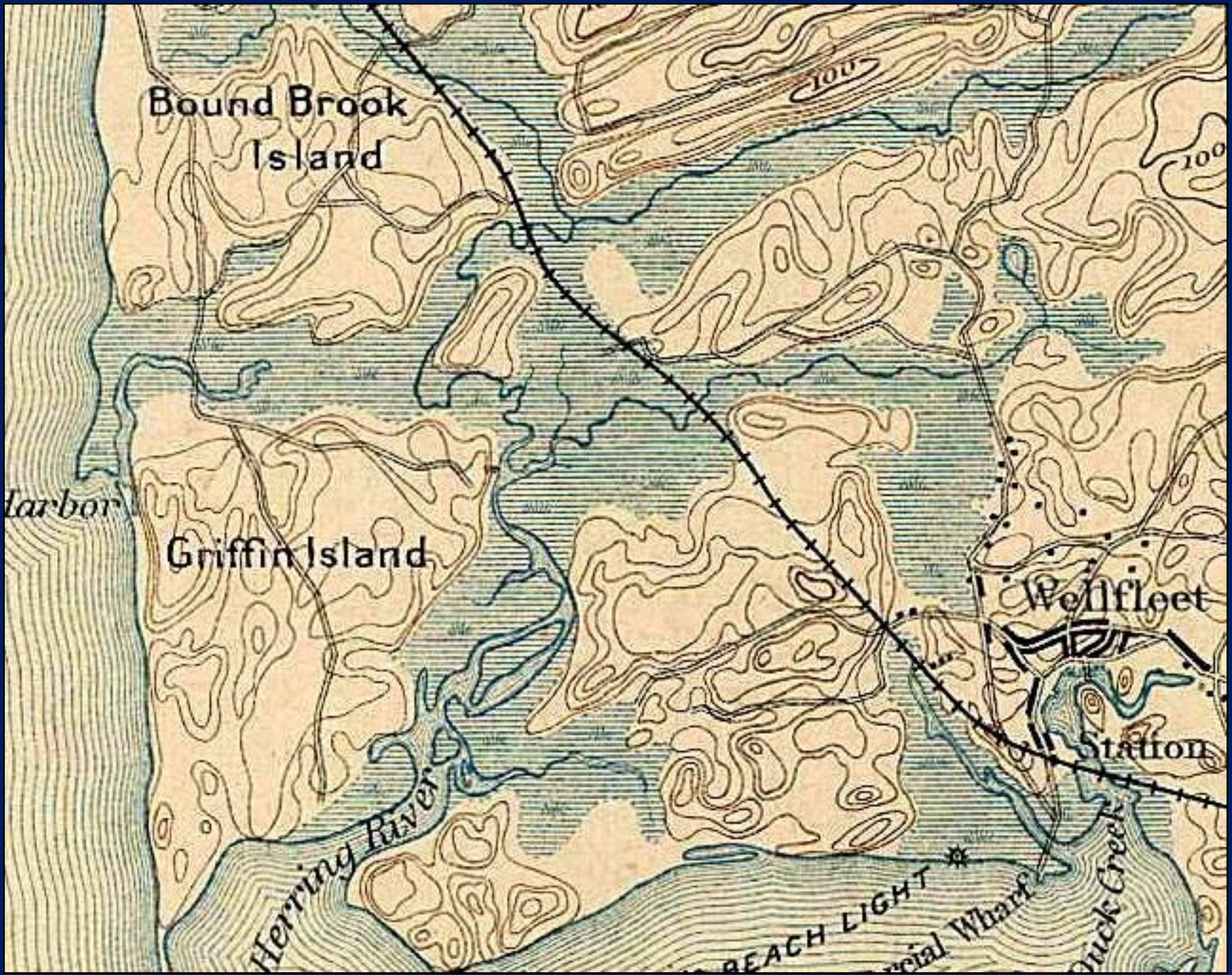
- Project Overview and Summary
  - Tim Smith, Restoration Ecologist
  - National Park Service
  - Cape Cod National Seashore
- Hydrodynamic and Ecosystem Modeling
  - Kirk Bosma, Senior Coastal Engineer
  - Woods Hole Group, Inc.
- Adaptive Tide Gate Management and Decision-Making
  - Eric Derleth, Partners for Fish and Wildlife Program Supervisor
  - U.S. Fish and Wildlife Service
  - New England Field Office

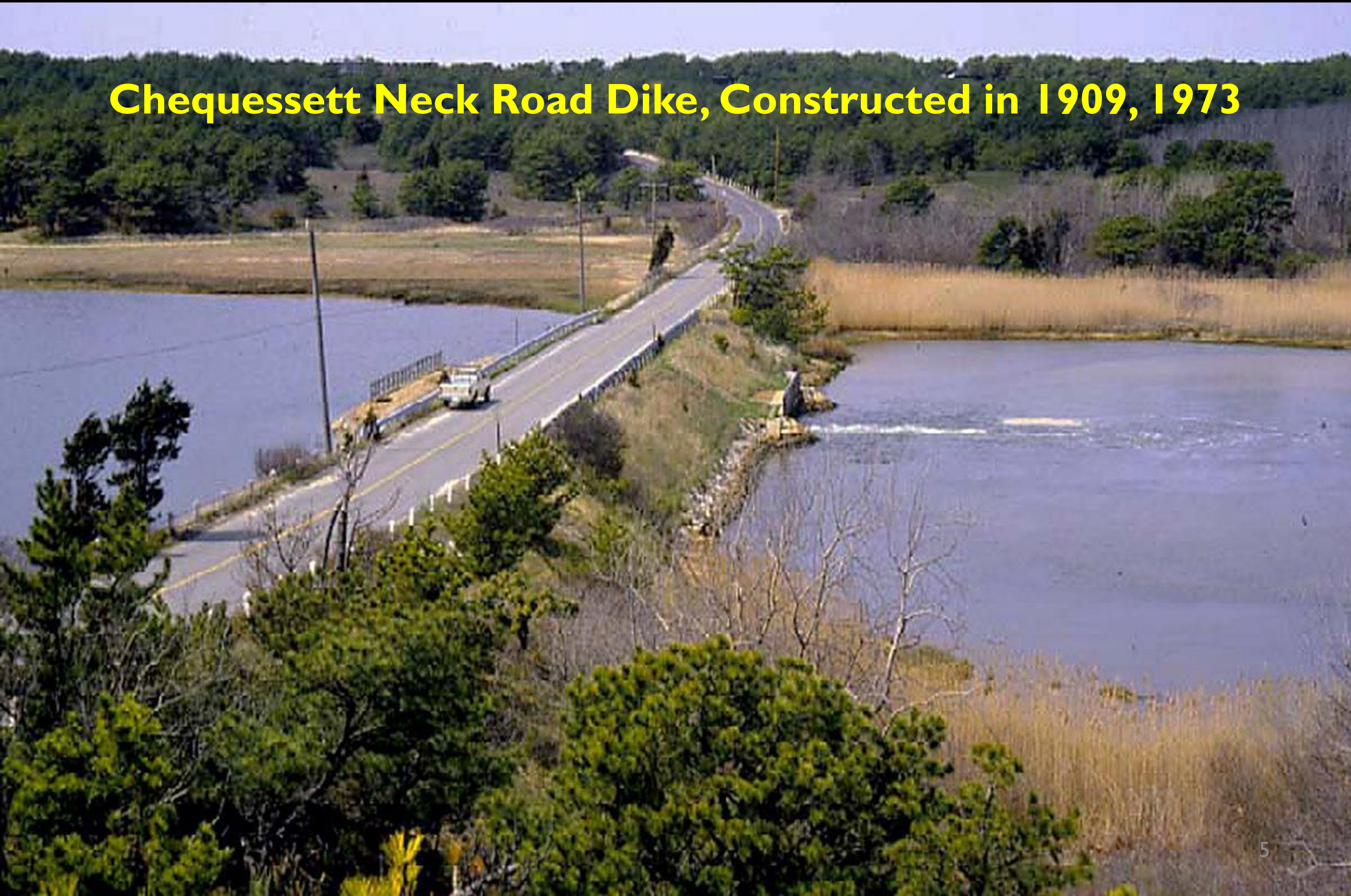
Background / History of Herring River

Project Area: Herring River Floodplain and Tributaries

Background / History of Herring River

Coastal Survey, c. 1888




Chequessett Neck Road Dike, Constructed in 1909, 1973

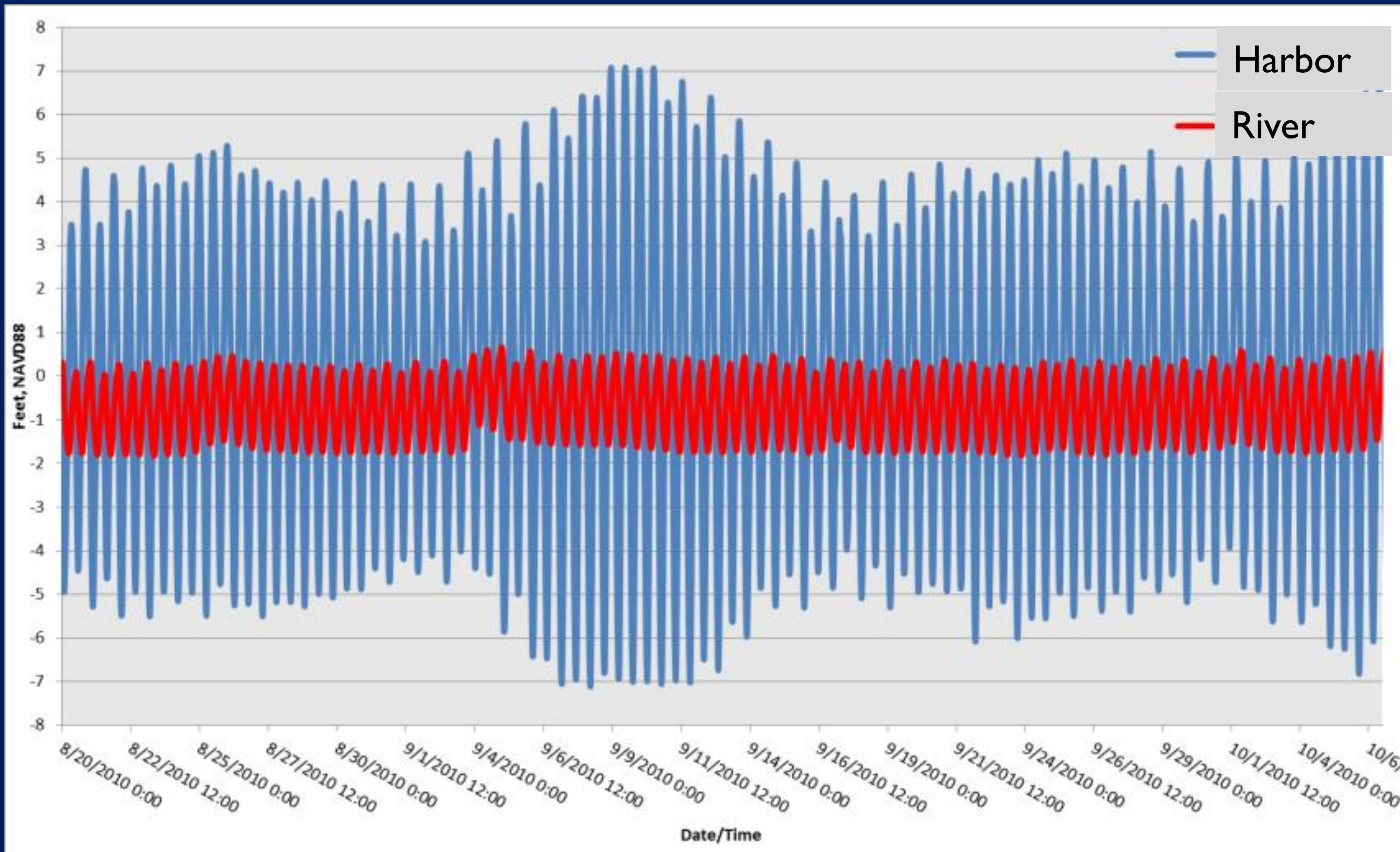
Cape Cod National Seashore
Towns of Wellfleet and Truro

Background / History of Herring River

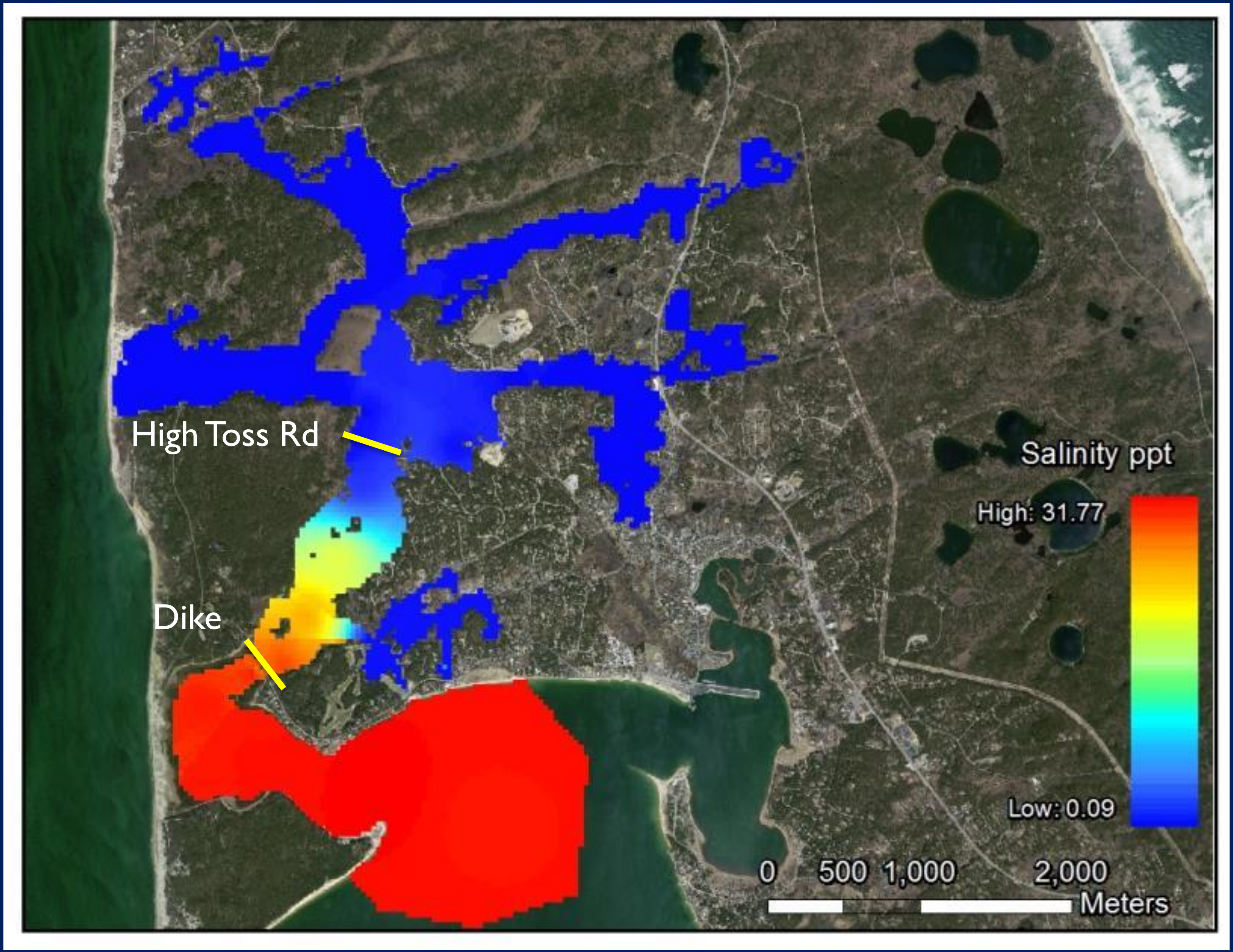
Chequessett Neck Road Dike: Original vs. Current Opening

Current Conditions of Herring River

Restricted Tide Range: Lower Basin Tides, Aug-Sept. 2010



Herring River, Current Salinity



National Park Service
Cape Cod National Seashore

Herring River: On-Going Effects of Tidal Restriction

Loss of Estuarine Productivity

Fecal Coliform Bacteria Pollution = Closed Shellfish Areas

Degraded Habitat for River Herring; Acidification

Poor Water Quality/Low Dissolved Oxygen = Fish Kills

Proposed Project / Preferred Alternative

Tidal restoration for Herring River = *The controlled removal of tidal restrictions to allow incremental restoration of tides, salinity, water quality and plant and animal communities.*

Cape Cod National Seashore
Towns of Wellfleet and Truro

Project Benefits and Impacts

RESTORED COASTAL HABITAT

- ✓ 890 Acres of Intertidal Habitats
- ✓ 580 Acres of Salt Marsh
- ✓ 11+ River Miles for River Herring
- ✓ Access to 160 Pond Acres for Spawning
- ✓ Improved Water Quality
- ✓ 200+ Acres Clam and Oyster Habitat
- ✓ Increase and Sustain Declining Salt Marsh Habitat
- ✓ Habitat for Marine Species; Striped Bass, Winter Flounder, Diamond-back Terrapin
- ✓ Engine of Productivity for Near- and Off-Shore Marine Habitats

Proposed Project / Preferred Alternative

Final EIS/EIR "Alternative D", Project Component Types:

1. Remove or Retrofit Tidally Restrictive Structures

2. Prevent Impacts to Low-Lying Roads and Structures

3. Marsh Habitat Management (As Informed by Monitoring)

Final Environmental Impact Statement/Report "Alternative D", Project Components:

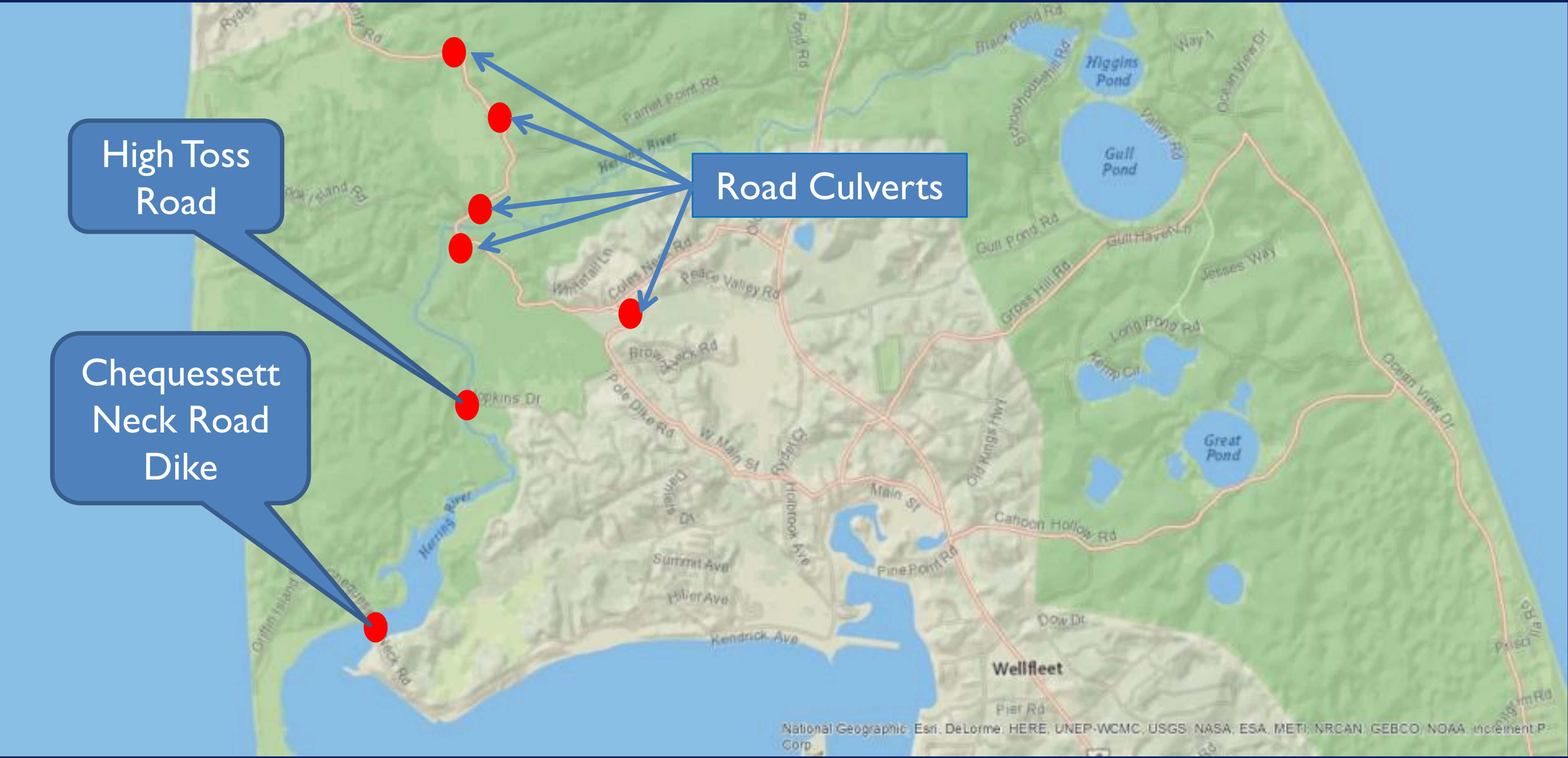
1. Remove or Retrofit Tidally Restrictive Structures

- Rebuild Chequessett Neck Road Dike
- Restore Natural Channel at High Toss Road (Road Eventually Discontinued)
- Enlarge Pole Dike, Bound Brook, and Old County Road Culverts

Cape Cod National Seashore
Towns of Wellfleet and Truro

Final Environmental Impact Statement/Report "Alternative D", Project Components:

1. Remove or Retrofit Tidally Restrictive Structures



Cape Cod National Seashore
Towns of Wellfleet and Truro

Final Environmental Impact Statement/Report "Alternative D", Project Components:

Rebuild Chequessett Neck Road Dike and Tidal Control Structure

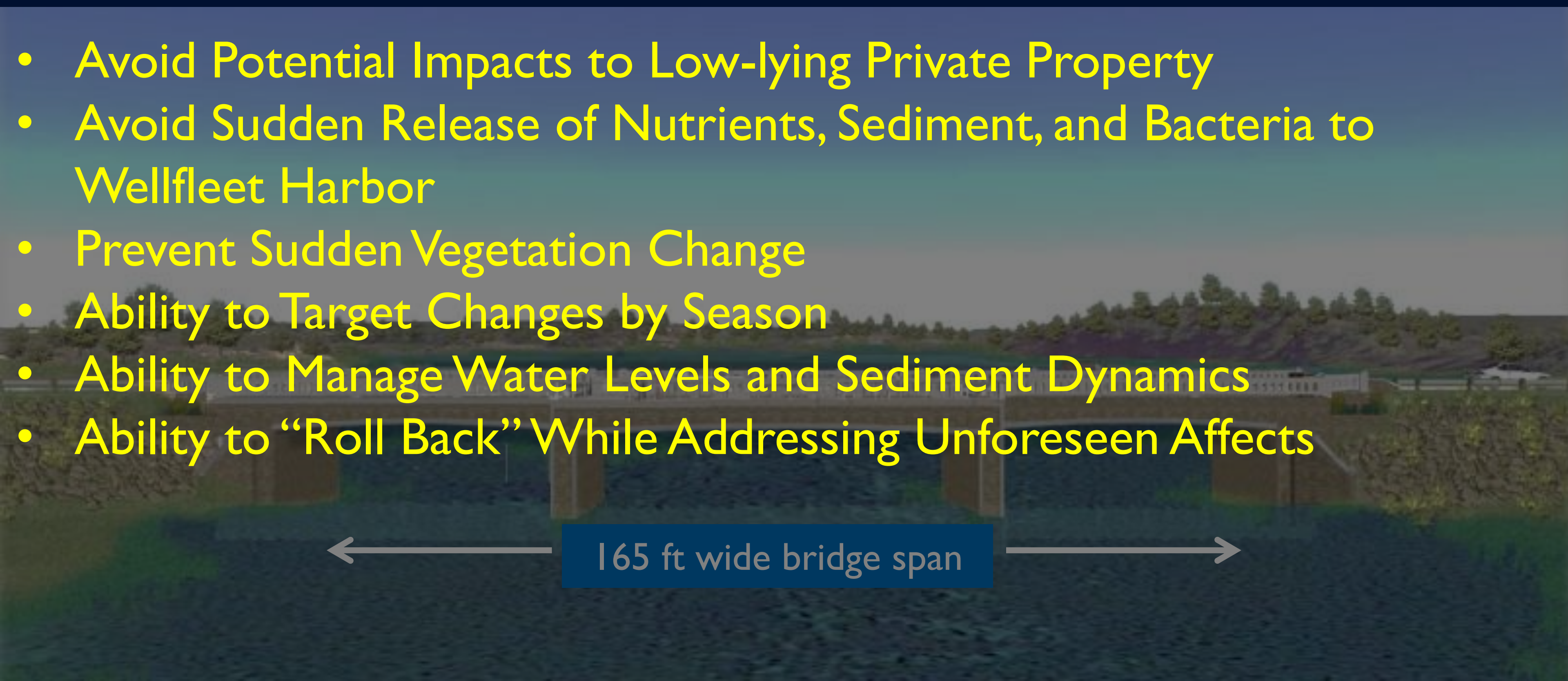
18 ft wide culverts with gates

Final Environmental Impact Statement/Report "Alternative D", Project Components:

Rebuild Chequessett Neck Road Dike and Tidal Control Structure

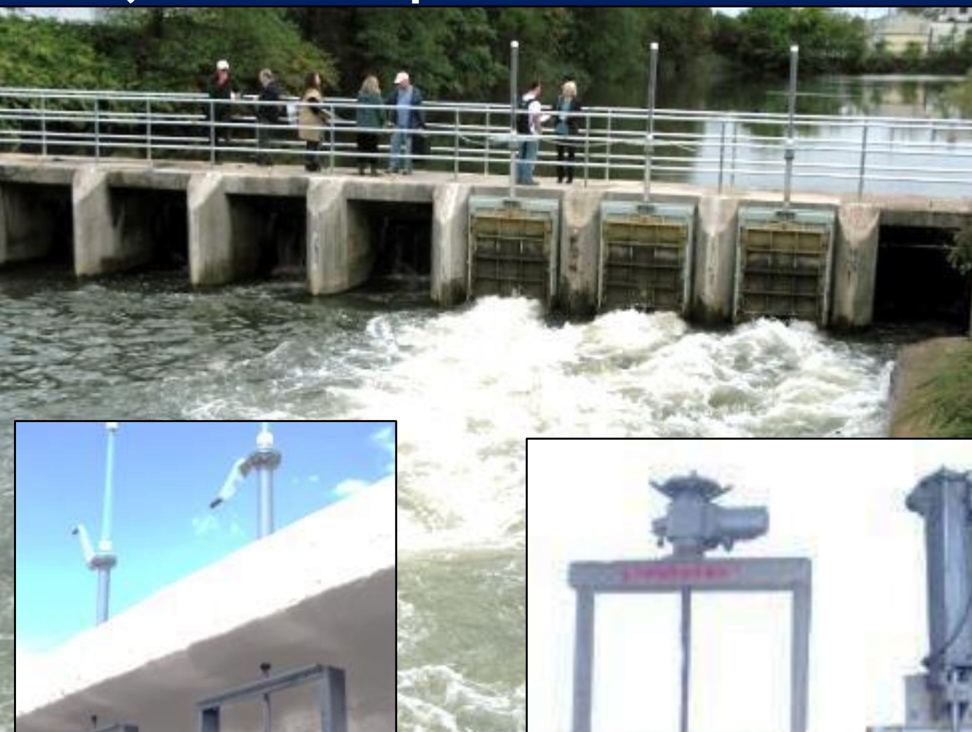
Reasons for Incremental Tidal Restoration:

- Avoid Potential Impacts to Low-lying Private Property
- Avoid Sudden Release of Nutrients, Sediment, and Bacteria to Wellfleet Harbor
- Prevent Sudden Vegetation Change
- Ability to Target Changes by Season
- Ability to Manage Water Levels and Sediment Dynamics
- Ability to "Roll Back" While Addressing Unforeseen Affects



National Park Service, Cape Cod National Seashore
Herring River Restoration Project

Final Environmental Impact Statement/Report "Alternative D", Project Components:

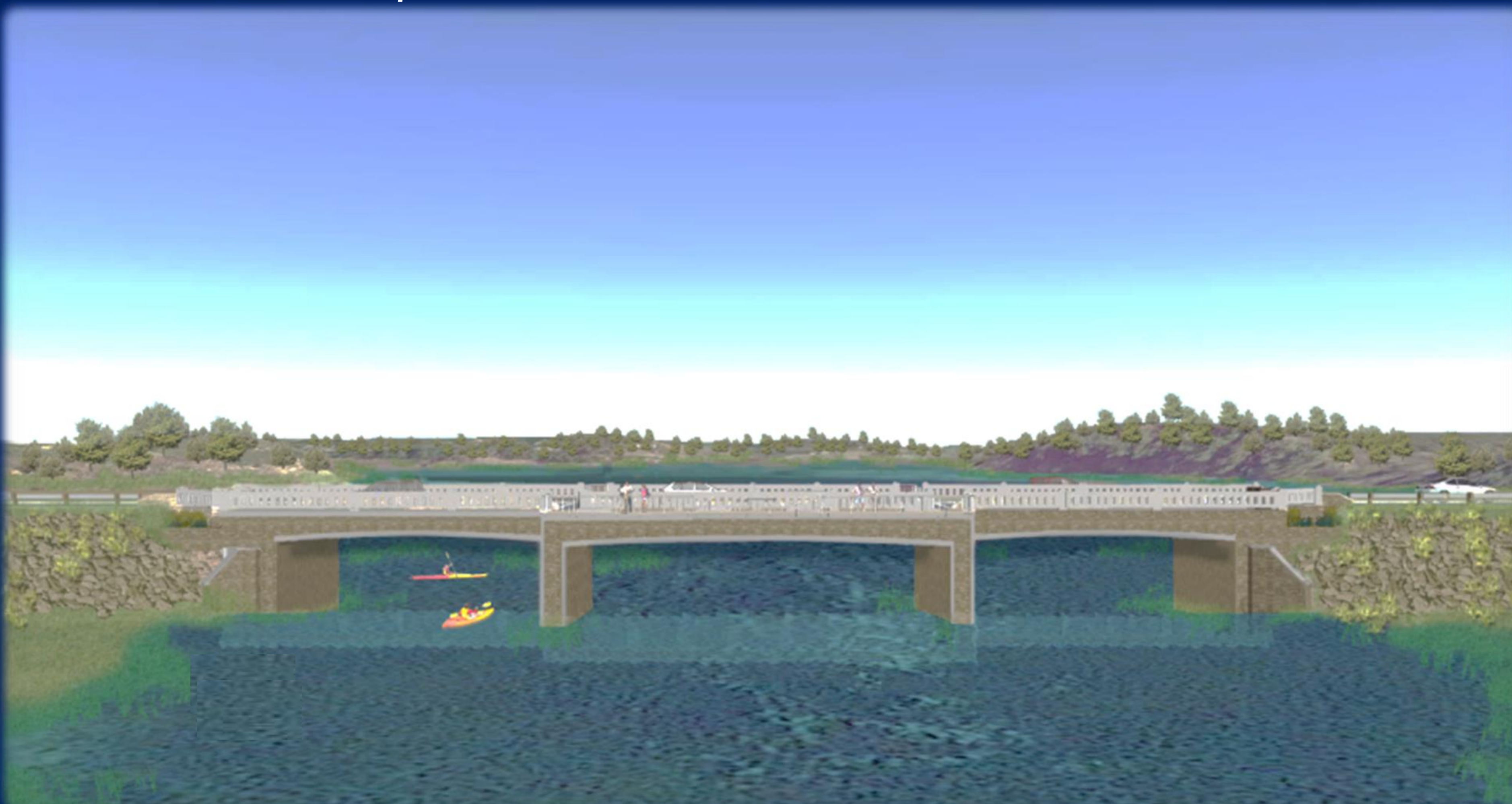


Examples of Tide Control Gates

Cape Cod National Seashore
Towns of Wellfleet and Truro

Final Environmental Impact Statement/Report "Alternative D", Project Components:

Rebuild Chequessett Neck Road Dike and Tidal Control Structure



Proposed Project / Preferred Alternative

Final EIS/EIR "Alternative D", Project Components:

1. Remove or Retrofit Tidally Restrictive Structures
2. Prevent Impacts to Low-Lying Roads and Structures
3. Marsh Habitat Management/"Secondary Management" (As Informed by Monitoring)

- Manage Trees, Shrubs, and Non-Native Invasive Vegetation
- Dredge Accumulated Sediment
- Create Small Channels and Ditches to Improve Tidal Circulation
- Restore Natural Channel Sinuosity
- Remove Dredge Spoil Berms and Other Anthropogenic Material to Facilitate Drainage of Ponded Water
- Apply Sediment to Build Up Subsided Marsh Surfaces

Next Steps to Move Forward

- ✓ Final Environmental Impact Statement/Report, National Park Service Record of Decision (National Environmental Policy Act)
- ✓ Cape Cod Commission Opens Development of Regional Application
- ✓ Establish Management Structure to Implement and Oversee the Project: MOU-III

- Complete Technical Designs for Chequessett Neck Dike, Other Water Control Structures, and Roadway Flood Prevention: Underway
- Develop Agreements with Affected Property Owners and Complete Technical Designs for Flood Prevention Measures: Underway
- Finalize Adaptive Management and Monitoring Plan: Underway

- ➢ Prepare and Submit Permit Applications: 2017
- ➢ Obtain Funding: Estimated $40-60 million over 5-10 years
- ➢ Initiate Construction, Soonest Foreseeable Start Date: 2020

Herring River Restoration Project:

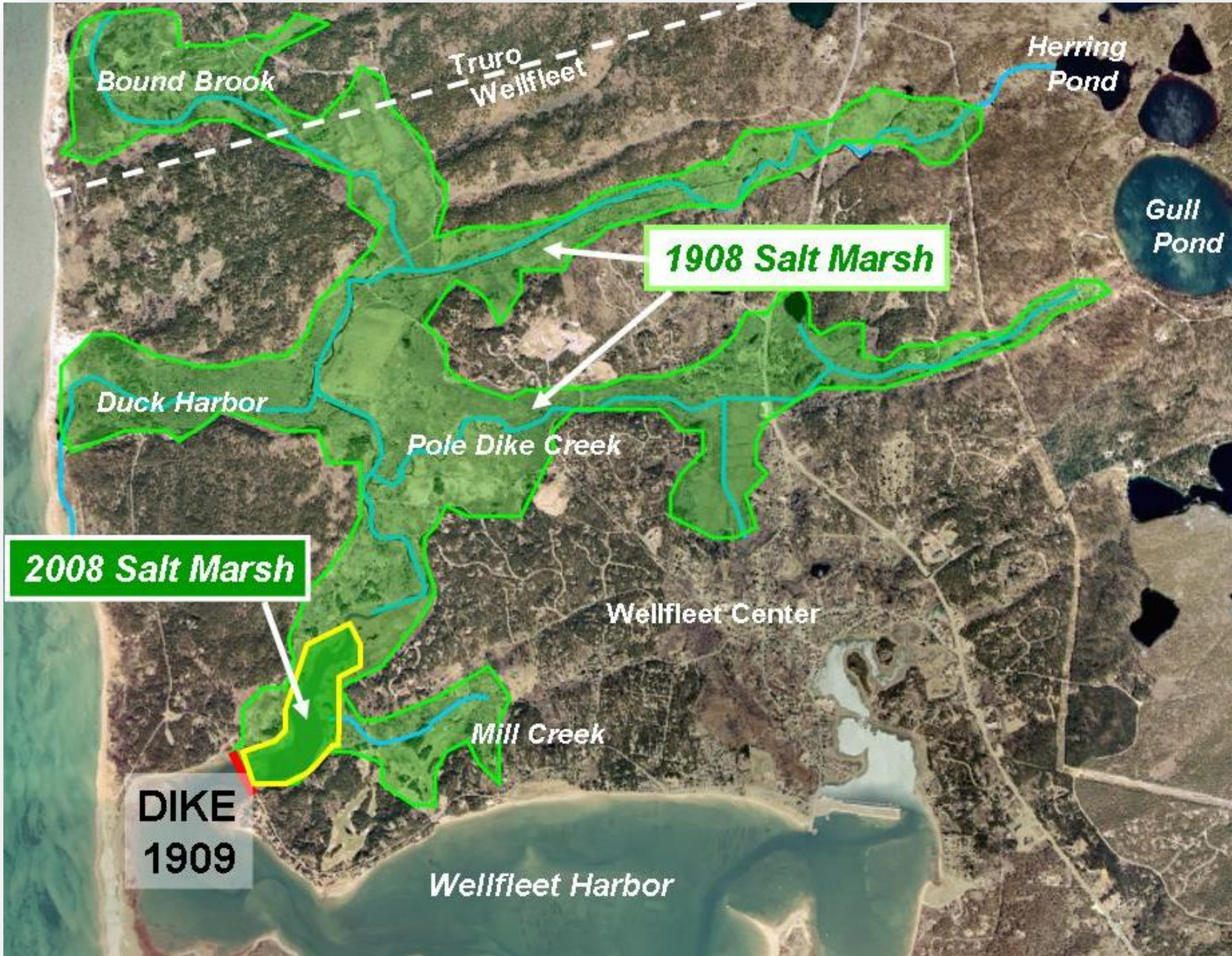
Hydrodynamics and Ecological Modeling

WOODS HOLE GROUP

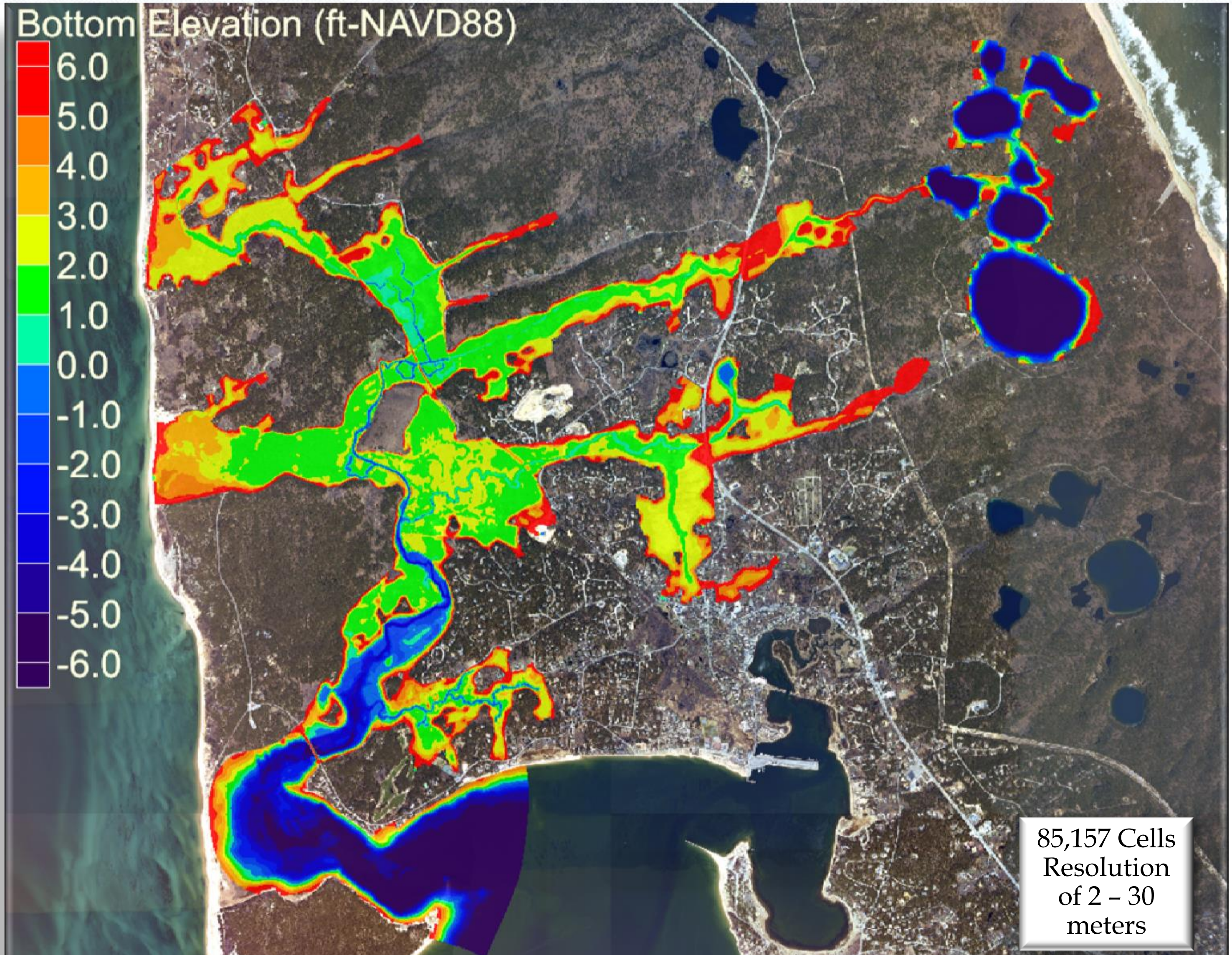
NROC
Northeast Regional Ocean Council

North Atlantic Landscape Conservation Cooperative

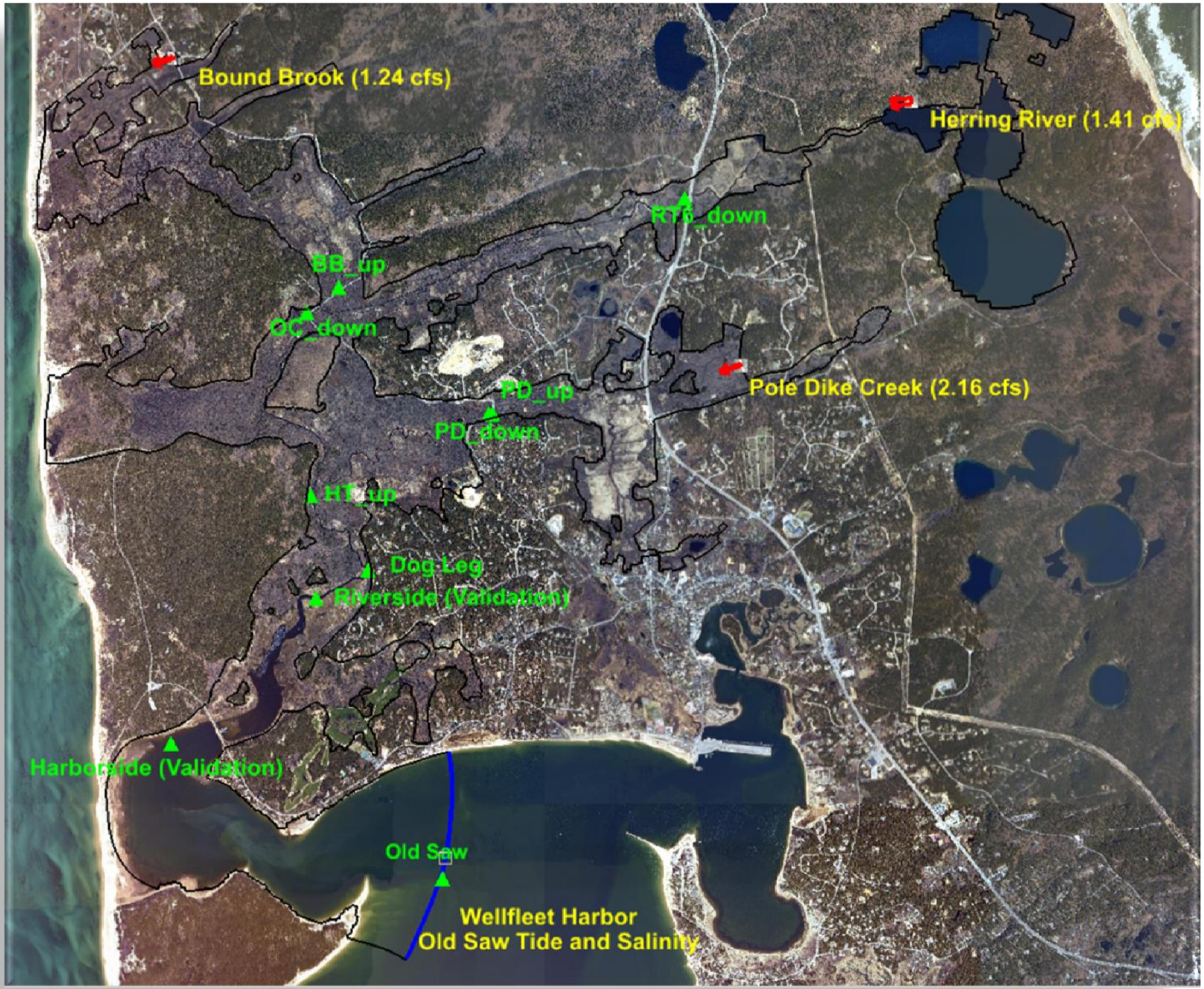
Loss of Salt Marsh



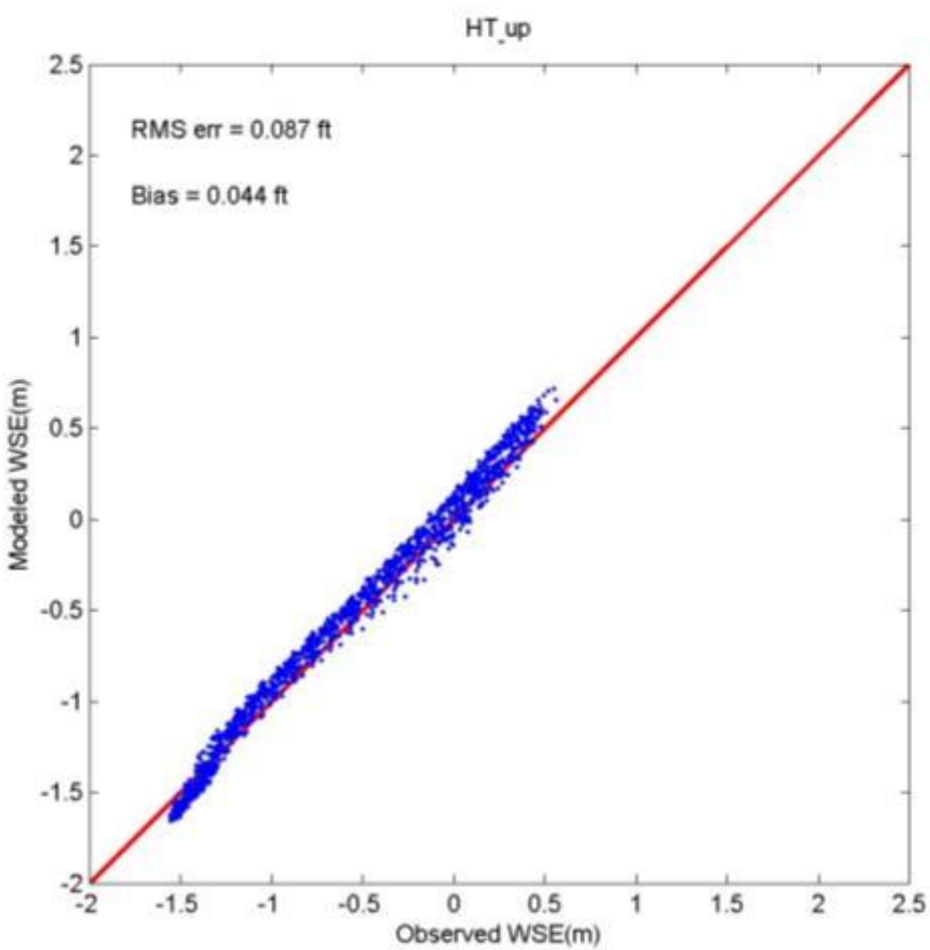
Bathymetric Mesh

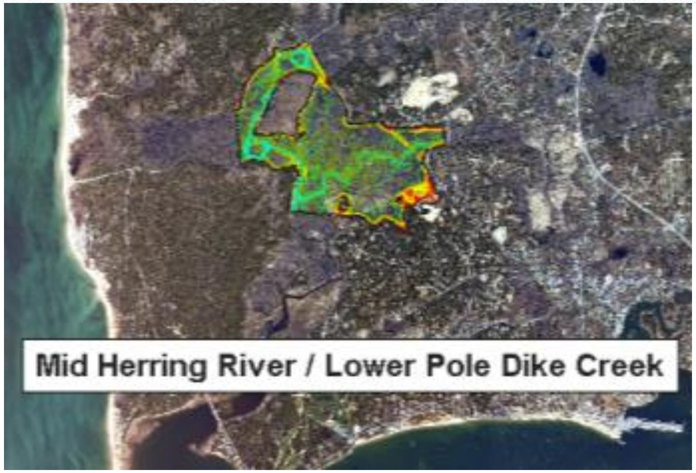


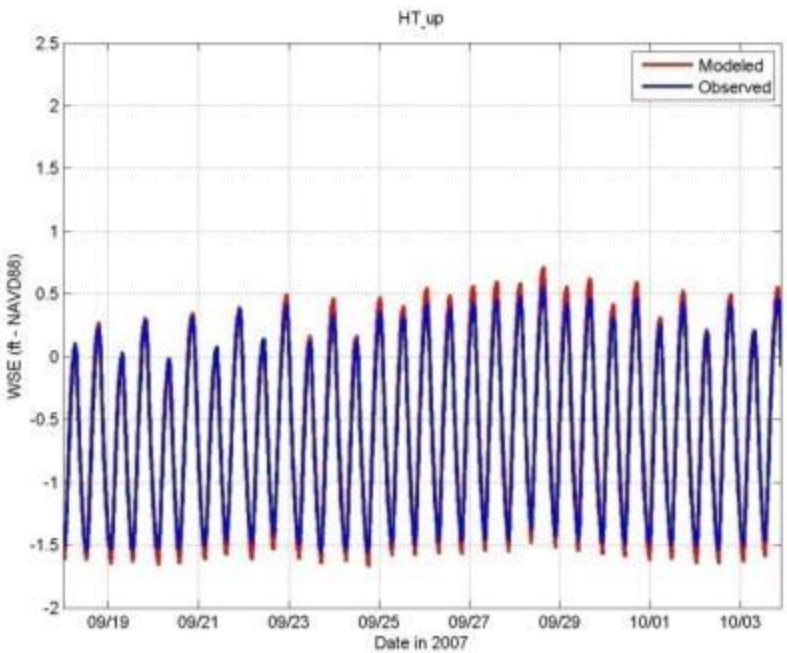
Gage Locations



Model Calibration



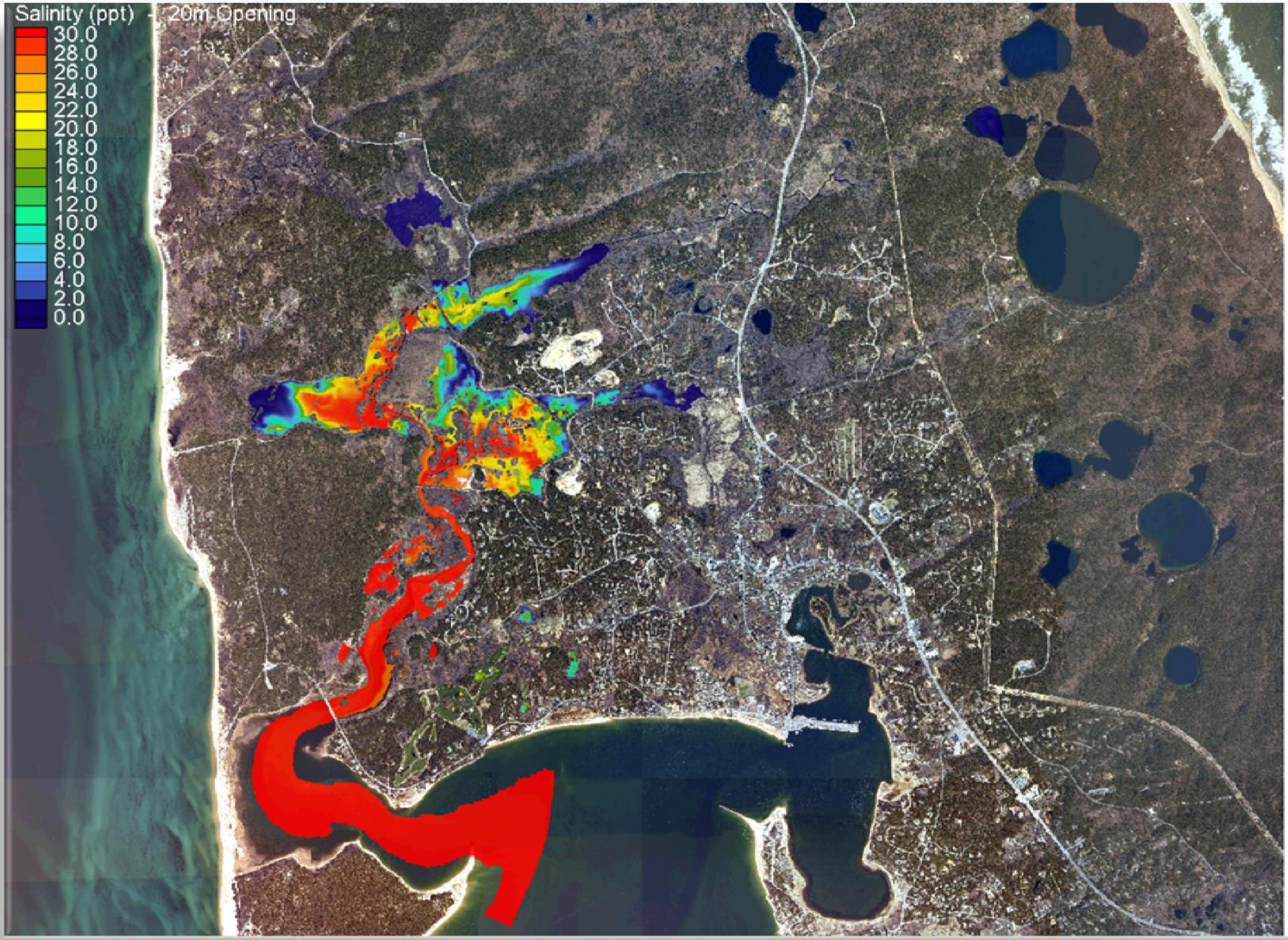




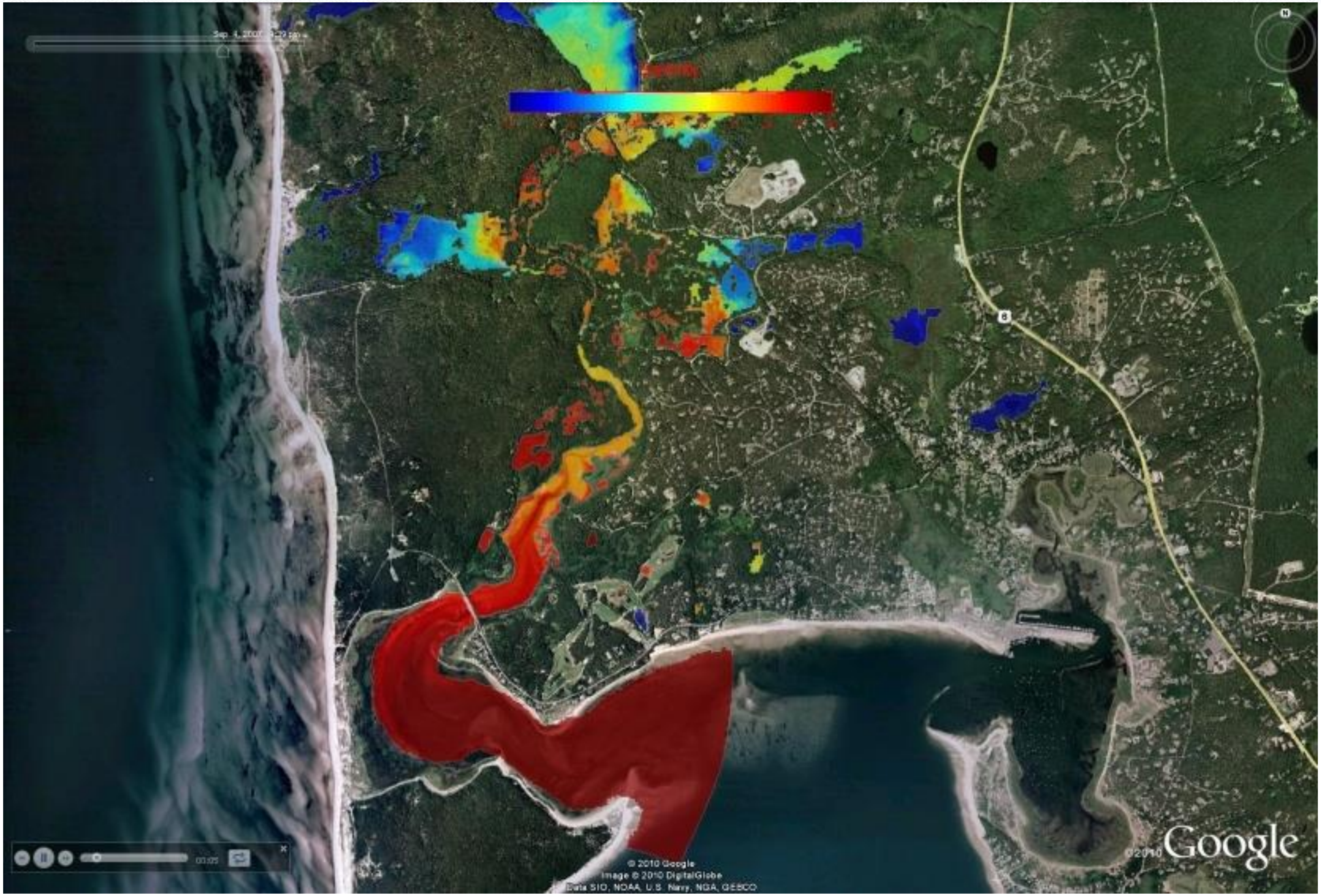
WOODS HOLE GROUP

Existing Conditions

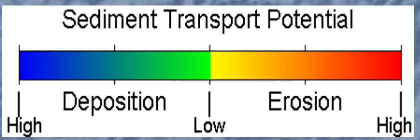
Alternative Simulations

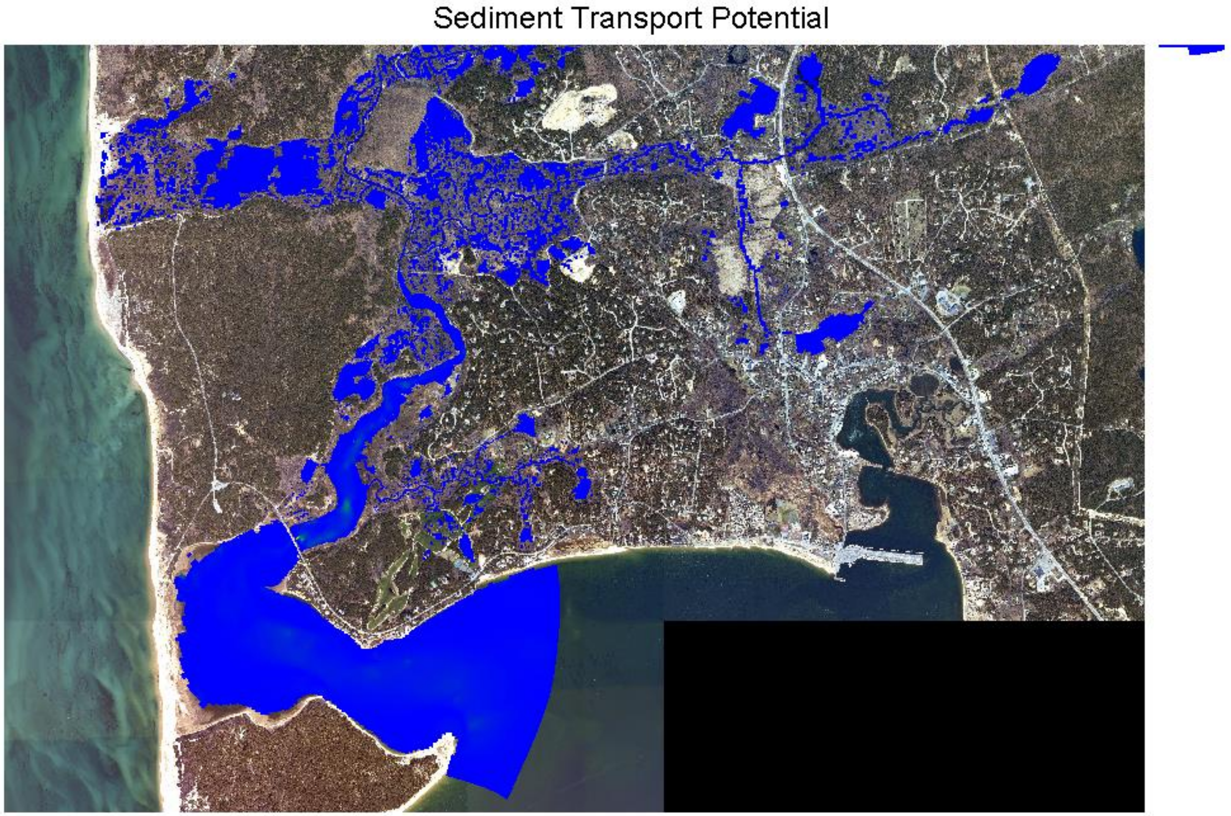


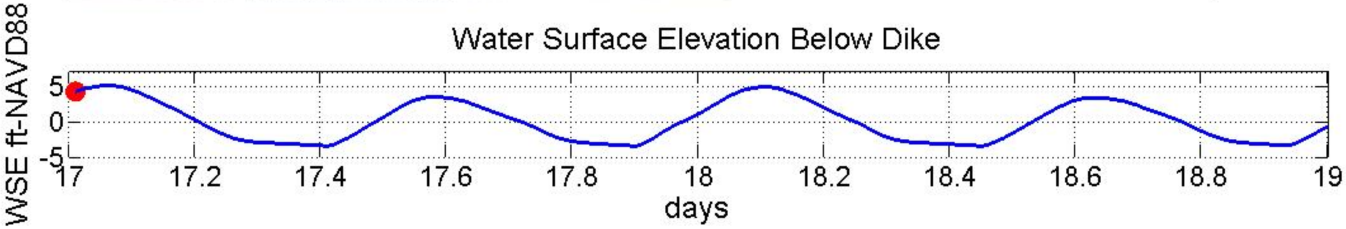
Interactive Exploration



Sediment Transport







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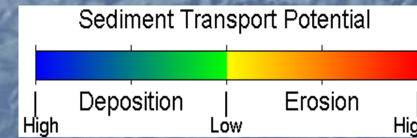

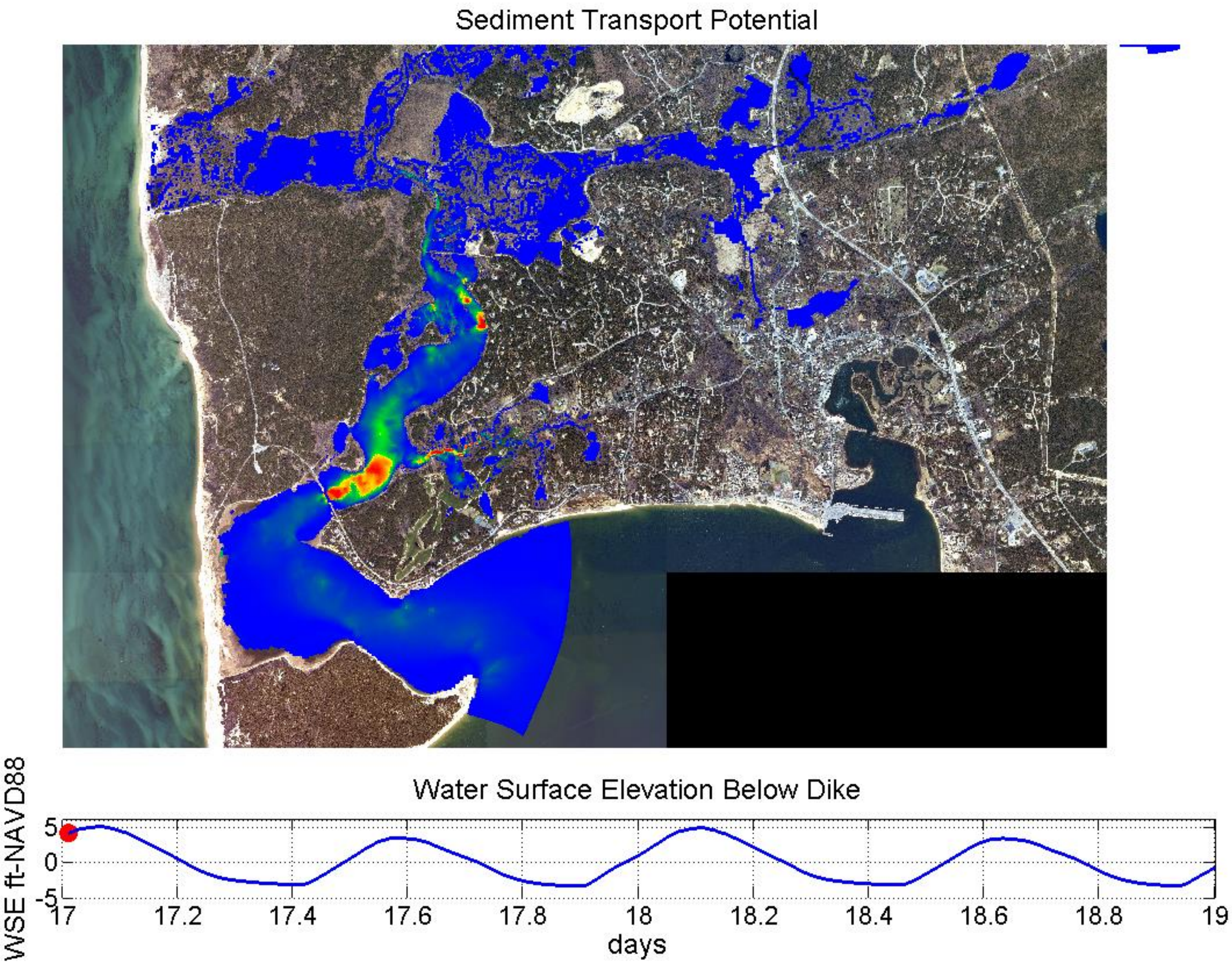

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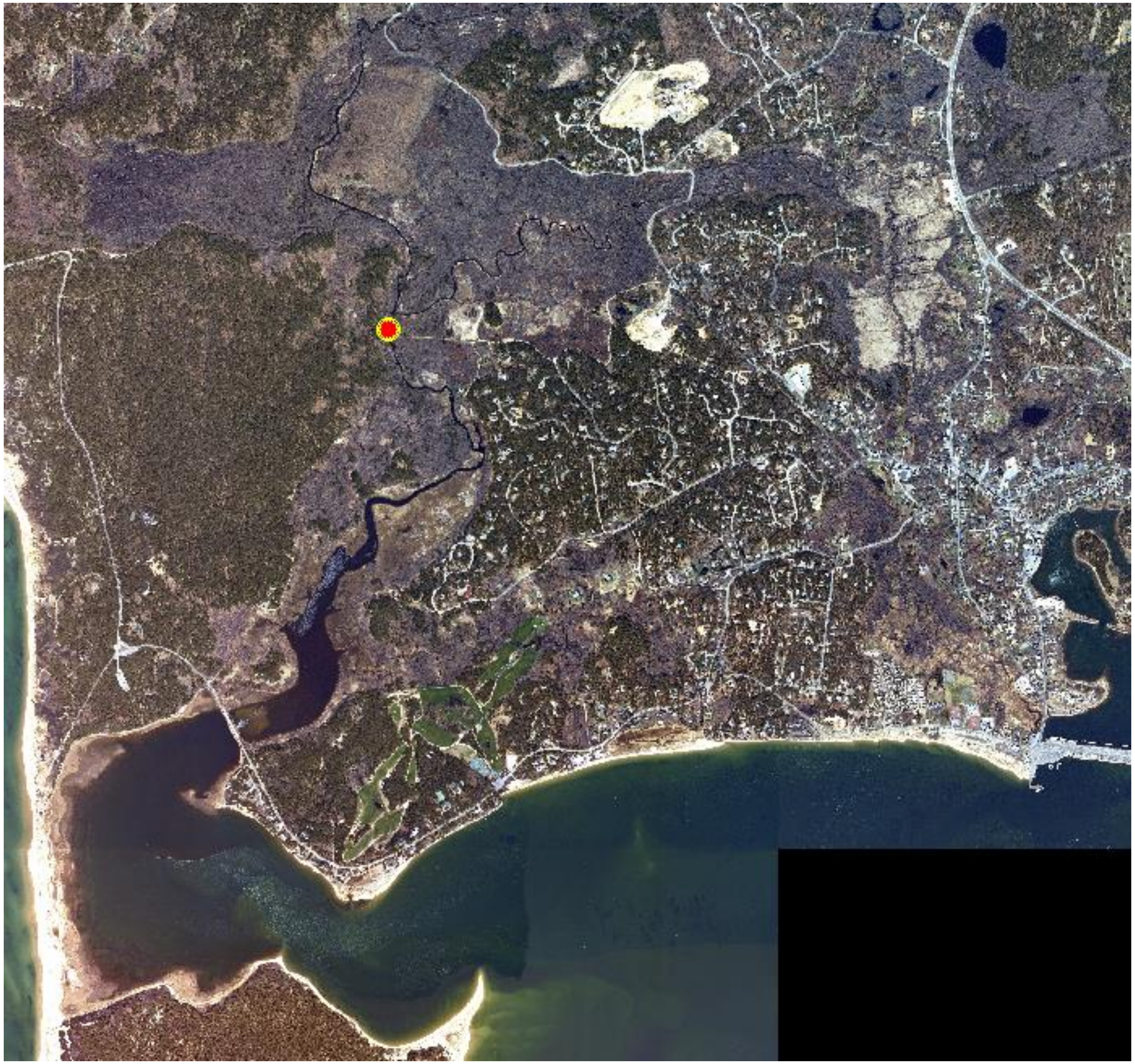
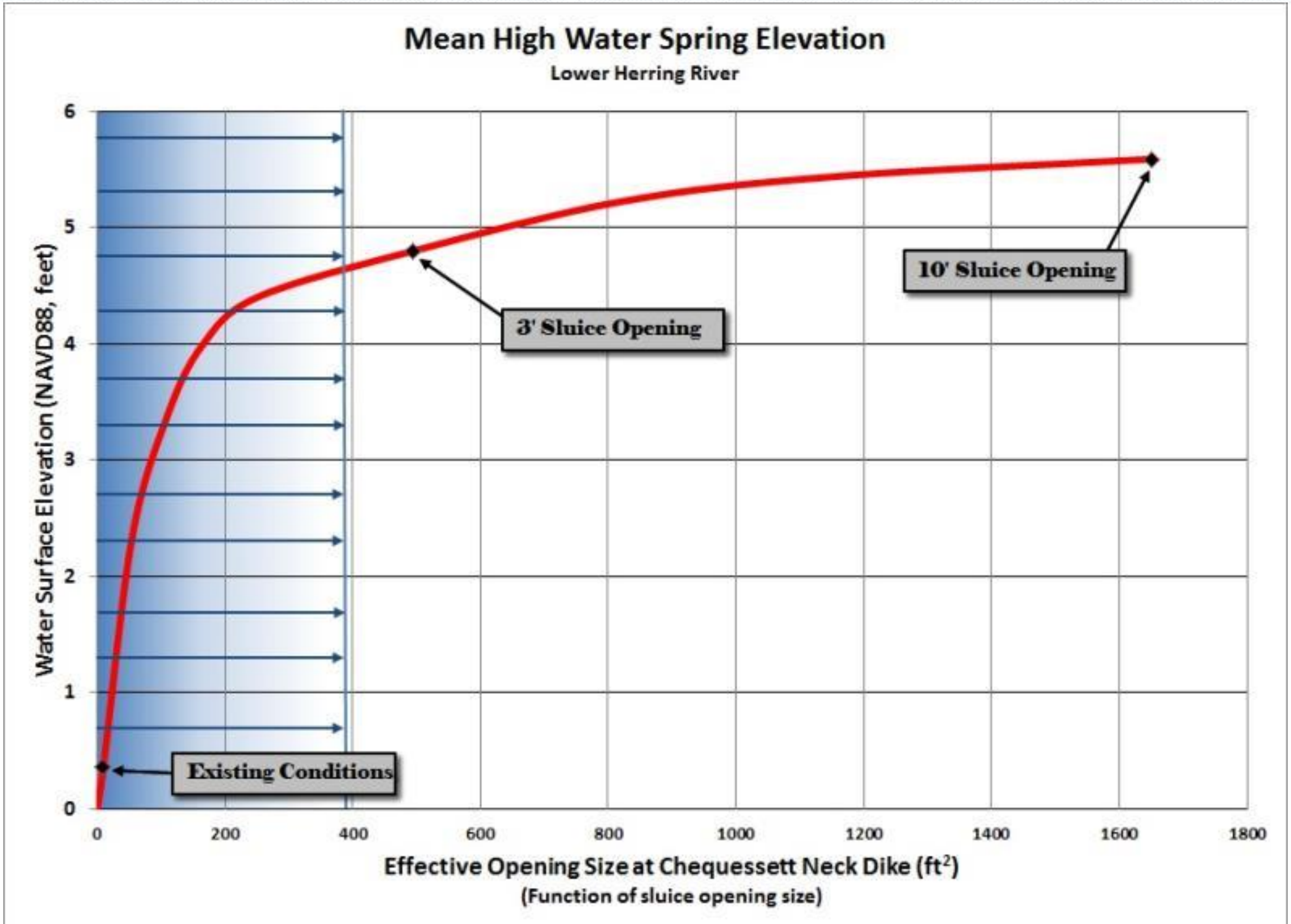
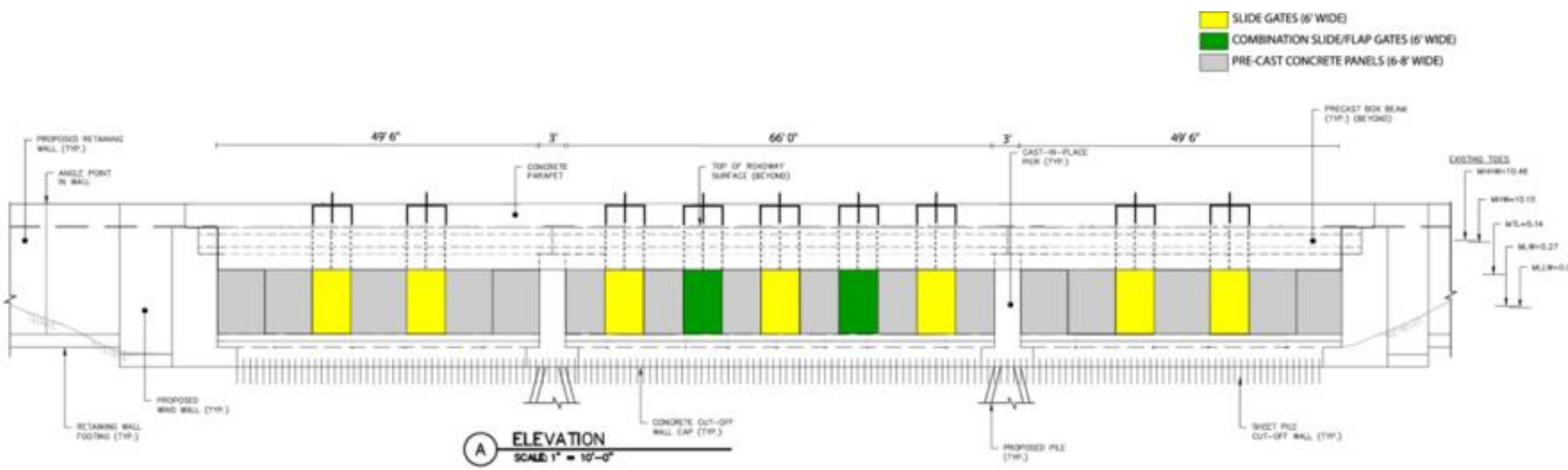


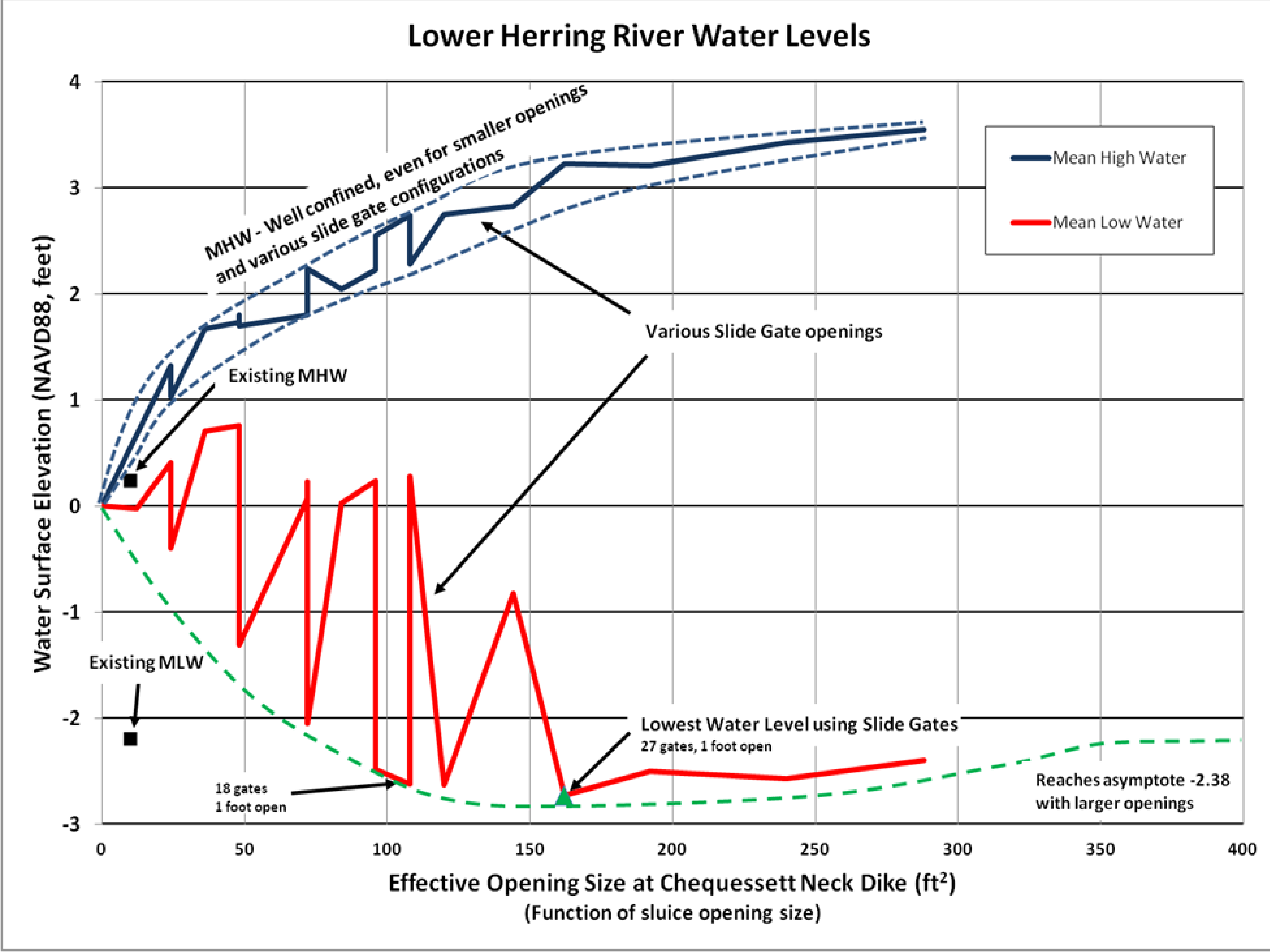
Adaptive Management



Engineering Design



- 7 slide gates, 2 combination slide/flap gates, 16 pre-cast concrete panels
- Provides full operational control during all phases of the restoration
- In the early stages, the restoration process will rely on slide and combination gates and not full panel removal

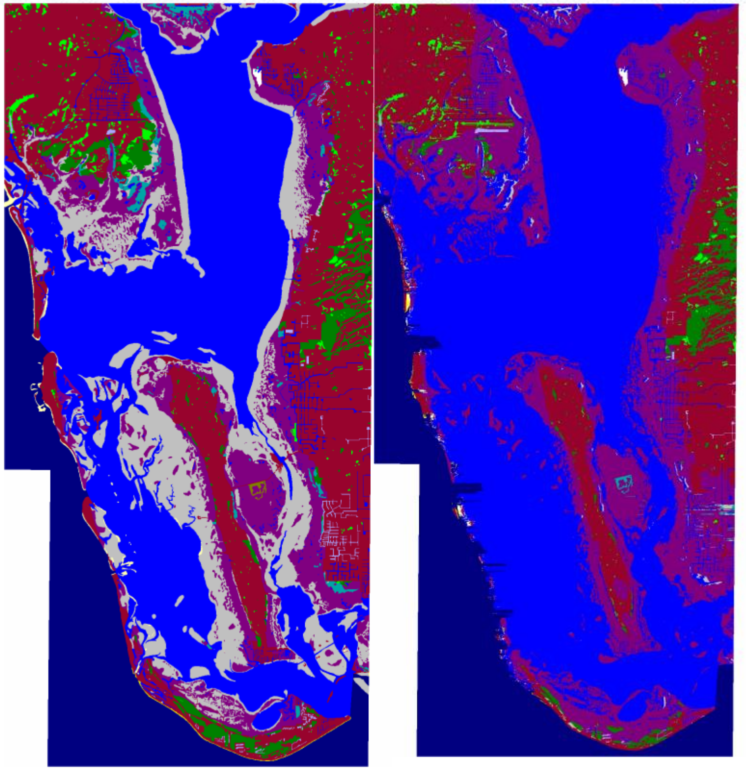


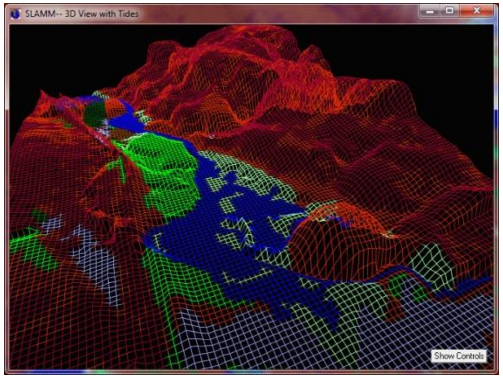
Lower Herring River Water Levels
Water Surface Elevation (NAVD88, feet)
4
3
2
1
0
-1
-2
-3
0
50
100
150
200
250
300
350
400
Effective Opening Size at Chequessett Neck Dike (ft2)
(Function of sluice opening size)
Mean High Water
Mean Low Water
MHW - Well confined, even for smaller openings
and various slide gate configurations
Various Slide Gate openings
Existing MHW
Existing MLW
Lowest Water Level using Slide Gates
27 gates, 1 foot open
18 gates
1 foot open
Reaches asymptote -2.38
with larger openings

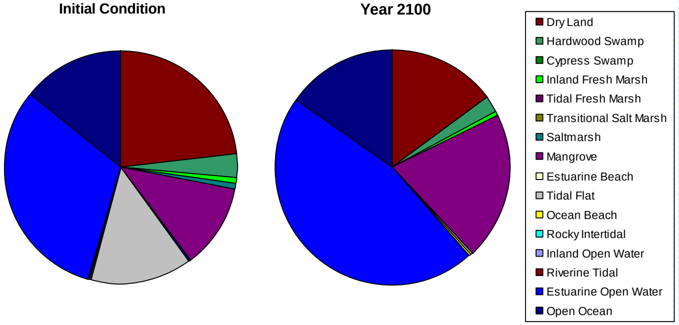
Sea Level Affecting Marshes Model (SLAMM)

- Input
  - SLR
  - Elevations
  - Tide range
  - Height of salt water
  - Accretion rates
  - Erosion rates
- Strengths
  - Open source
  - Simple
  - Includes most major processes
  - Limited computational requirements
- Limitations
  - No hydrodynamics
  - Simple erosion model
  - Empirical accretion rates
  - No mass balance of solids
  - Overwash component

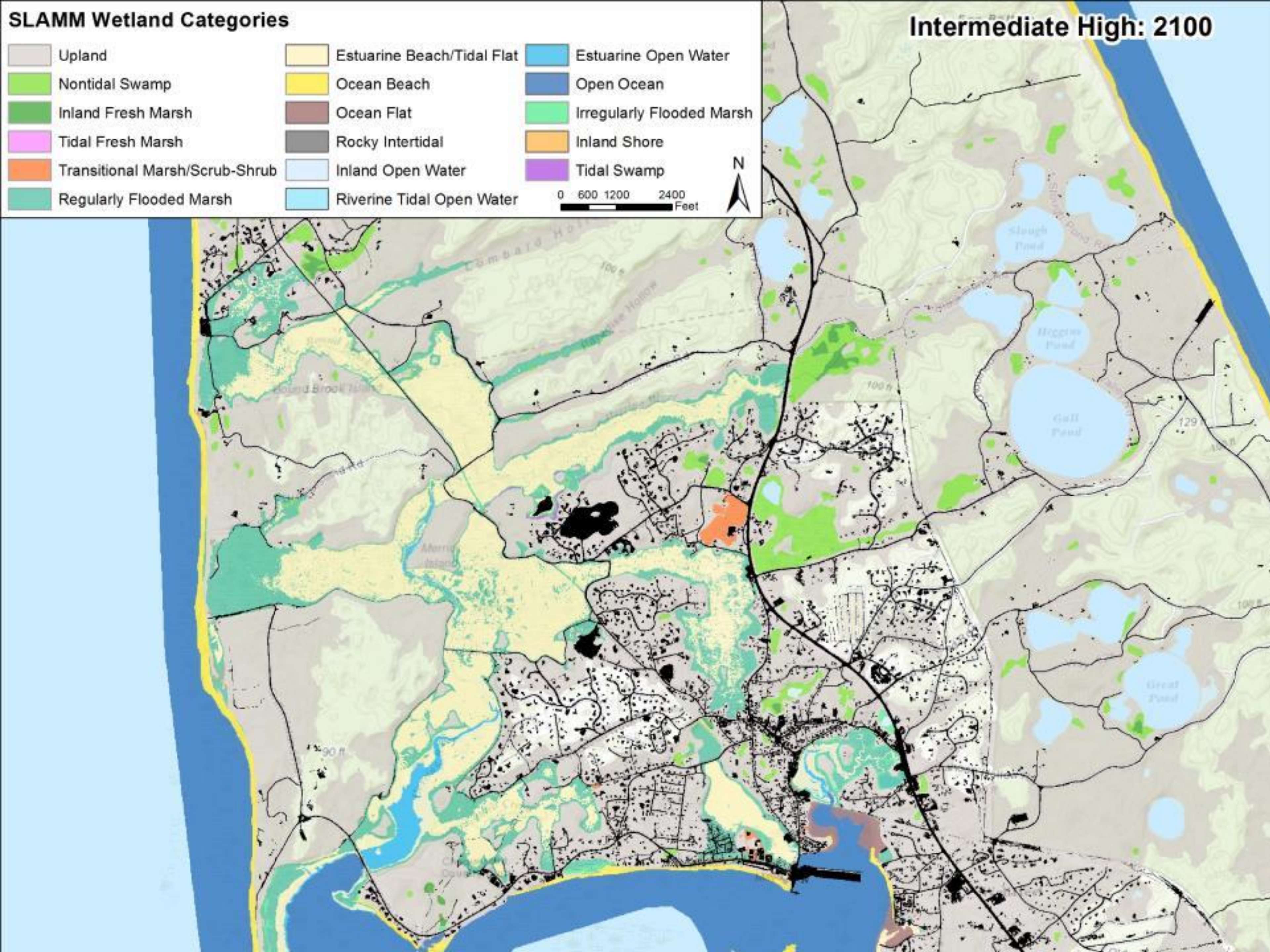
Output



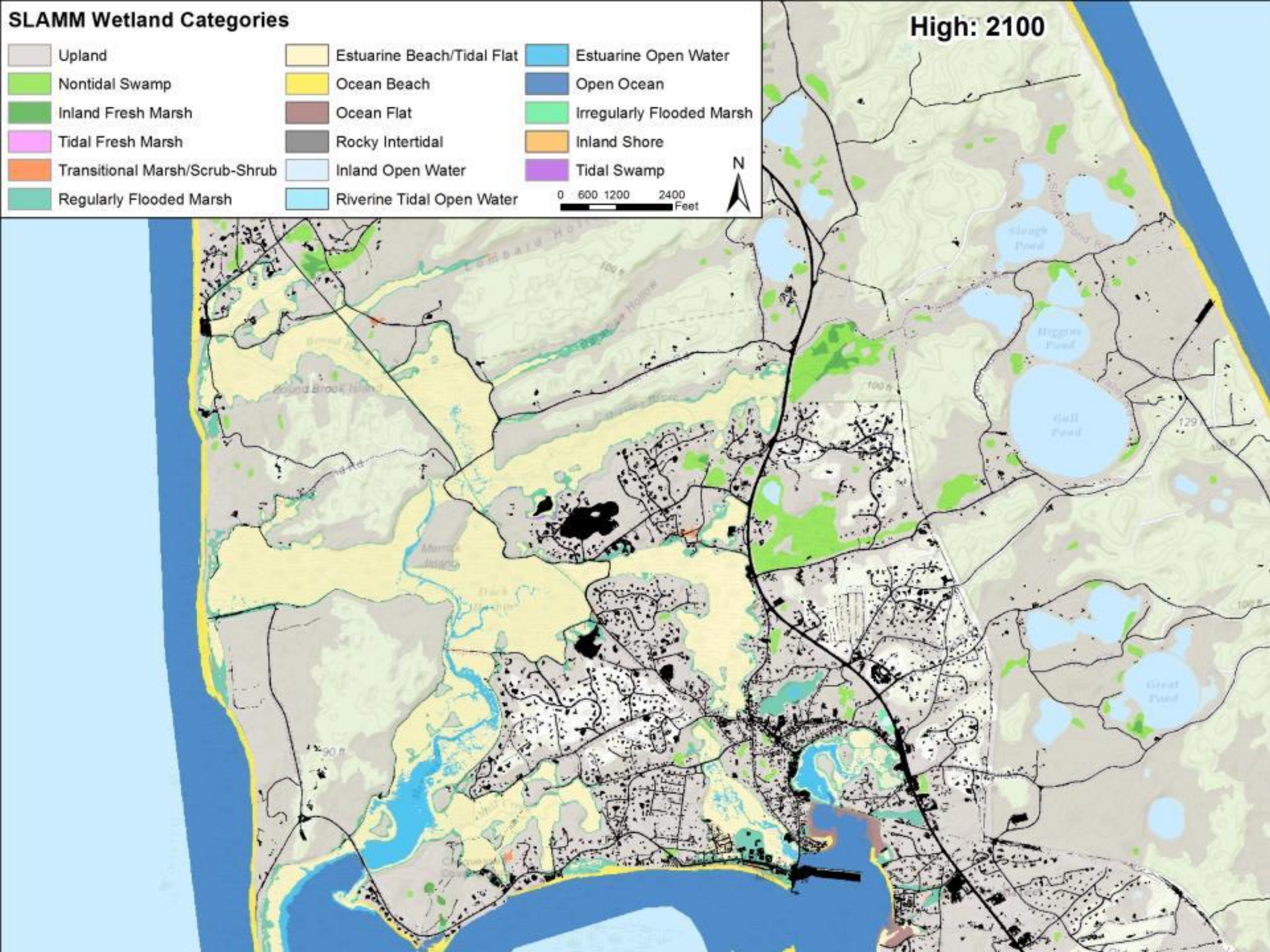




WOODS HOLE GROUP



SLAMM Wetland Categories
Upland
Nontidal Swamp
Inland Fresh Marsh
Tidal Fresh Marsh
Transitional Marsh/Scrub-Shrub
Regularly Flooded Marsh
Estuarine Beach/Tidal Flat
Ocean Beach
Ocean Flat
Rocky Intertidal
Inland Open Water
Riverine Tidal Open Water
Estuarine Open Water
Open Ocean
Irregularly Flooded Marsh
Inland Shore
Tidal Swamp
0 600 1200 2400
Feet
N
Intermediate High: 2100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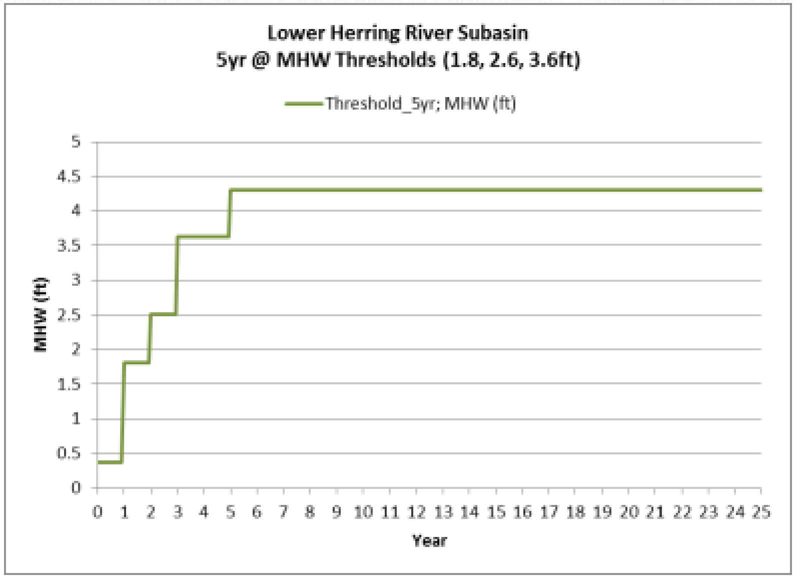
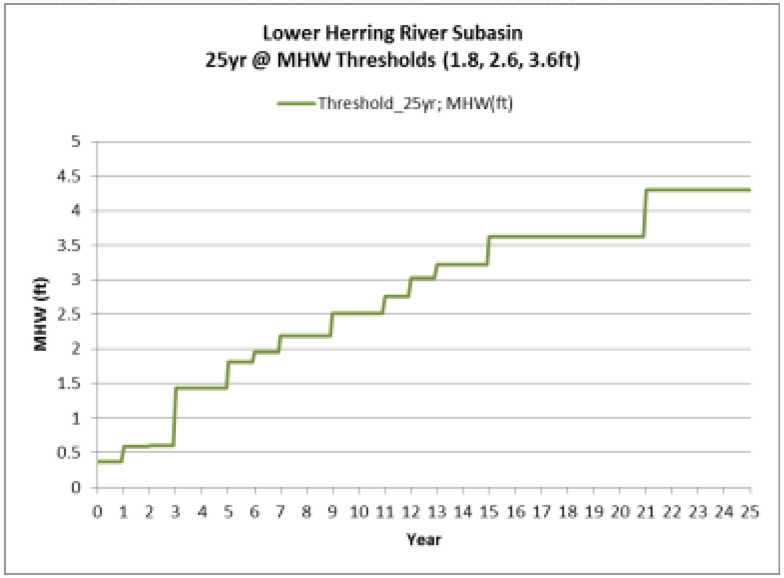
Riverine Tidal Open Water
Estuarine Open Water
Open Ocean
Irregularly Flooded Marsh
Inland Shore
Tidal Swamp
N
0 600 1200 2400
Feet
High: 2100
Gull Pond
Higgins Pond
Great Pond
Slough Pond

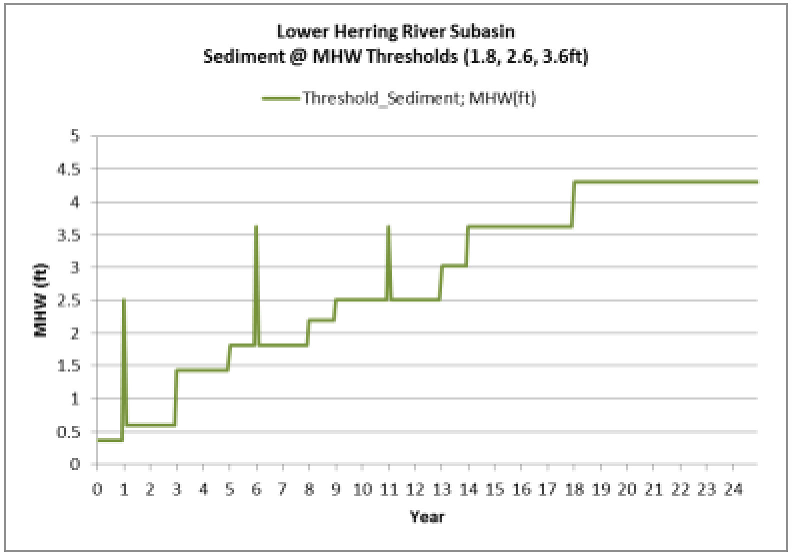
Herring River Tidal Restoration Project

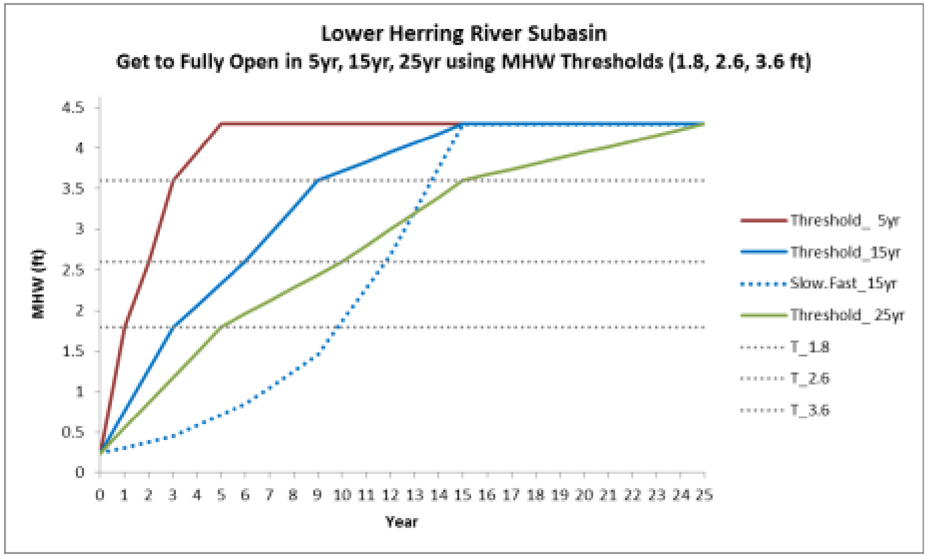
Image courtesy of the Herring River Restoration Committee

Ecological Modeling - Adaptive Management







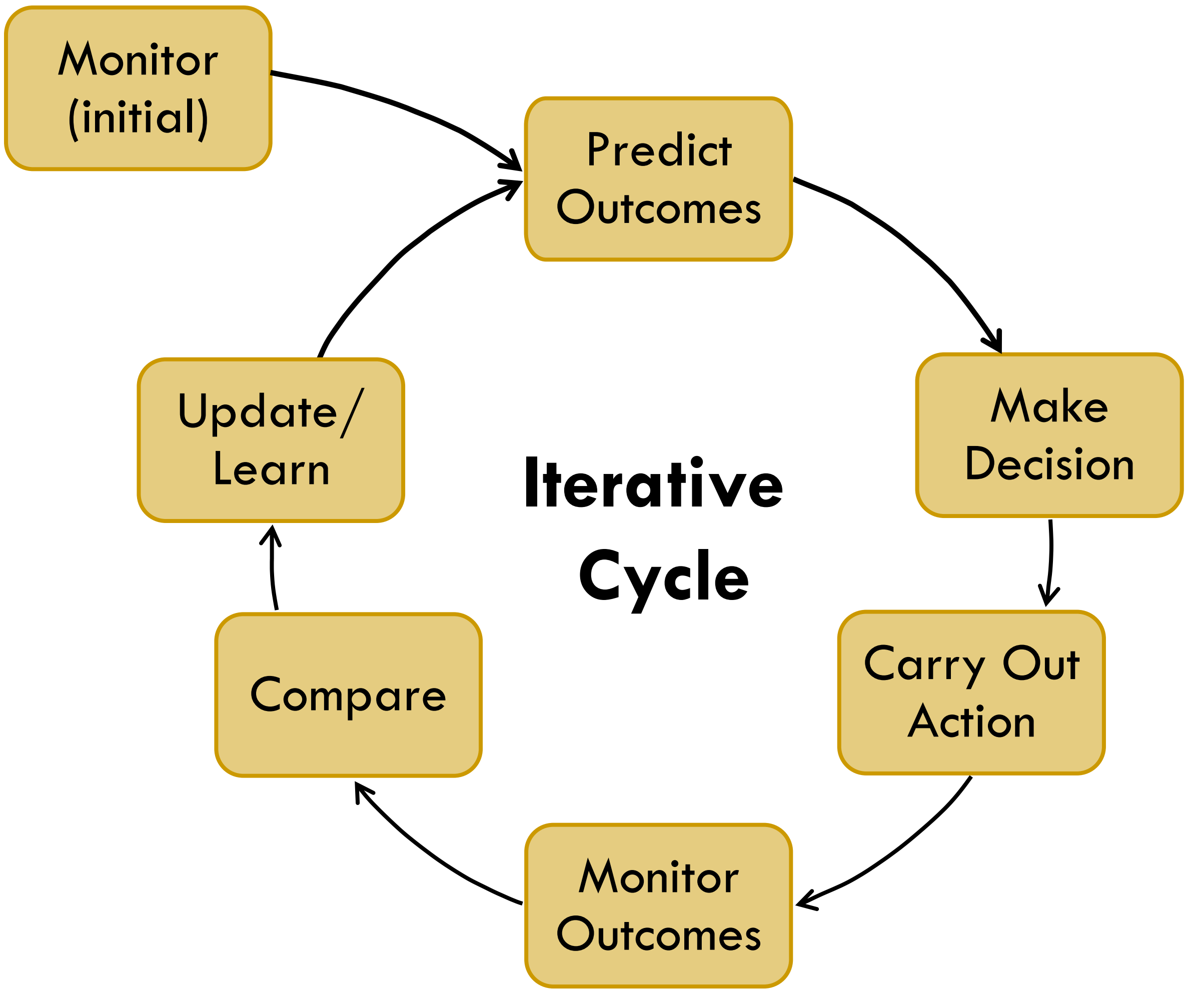


HERRING RIVER ADAPTIVE MANAGEMENT:

INTRODUCTION TO THE DECISION FRAMEWORK

Northeast Regional Ocean Council
April 5, 2017

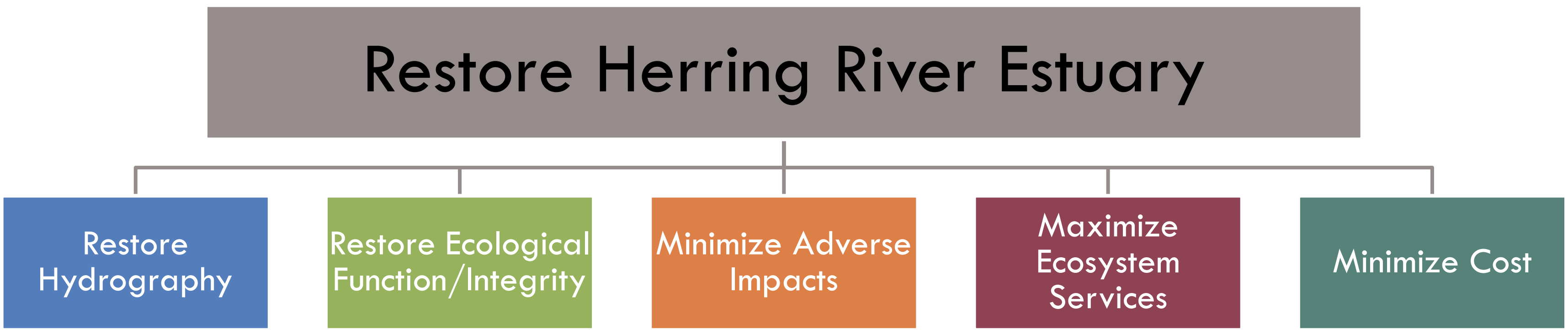
Iterative Cycle: Managing & Learning



Why an AM Approach is Appropriate for Restoration of the Herring River Estuary

- There are uncertainties about how the system will respond to restoration actions
- Decisions regarding actions must be made in the face of this uncertainty
- The long-term nature of the restoration provides the opportunity to formally learn – through a repeated cycle of prediction, decision making, and focus monitoring – and to adapt the decisions regarding management actions based on this learning

AM Framework for Restoration of the Herring River Estuary - Objectives



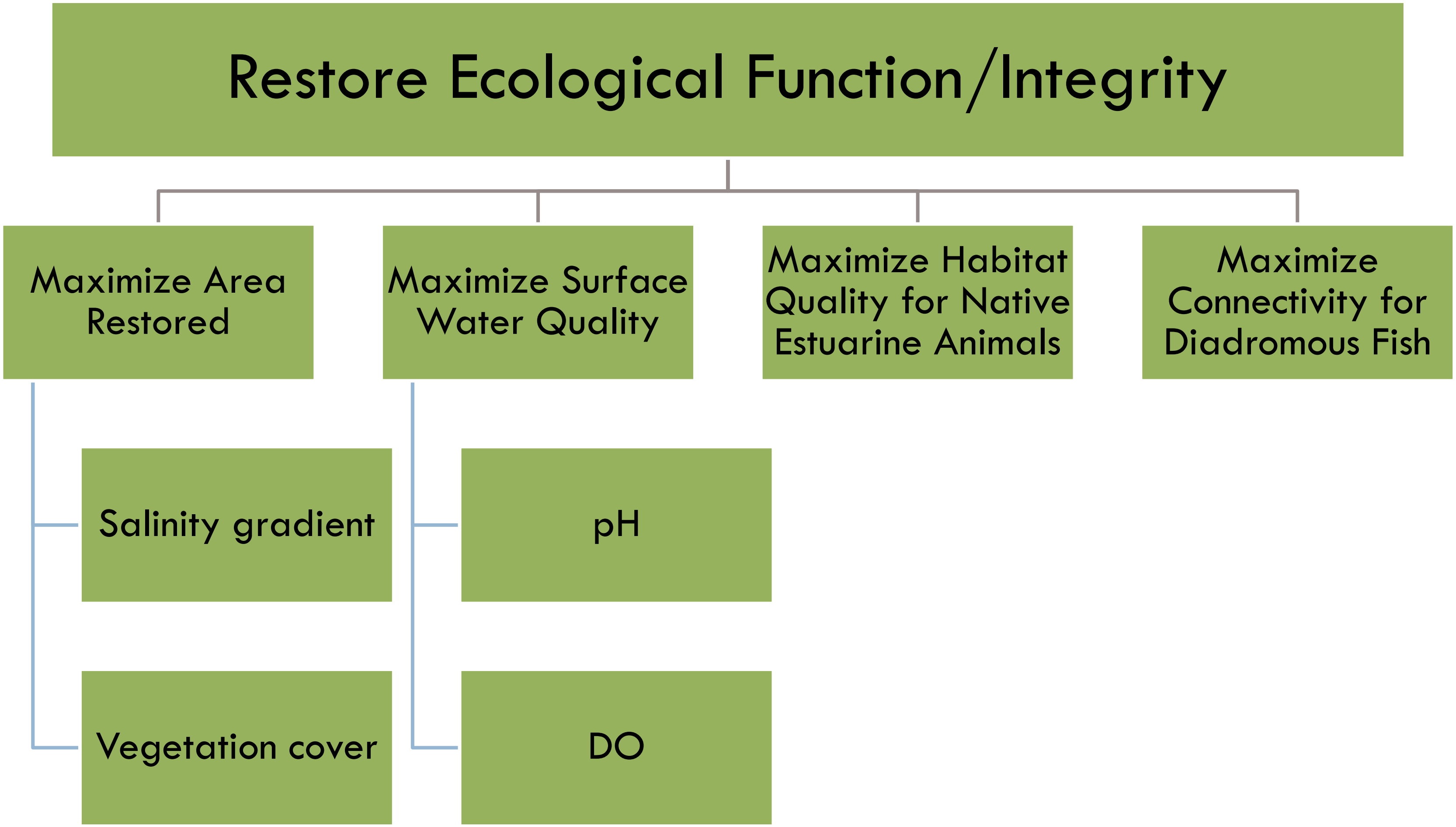
AM Framework for Restoration of the Herring River Estuary - Objectives

- For each objective
  - Performance measure
  - Unit
  - Direction
  - Spatial scale
  - Temporal scale
  - Prediction method
    - Preliminary
    - Improved
    - Ideal
  - Monitoring method

AM Framework for Restoration of the Herring River Estuary - Objectives

- Restore Hydrography
  - Restore Tidal Range
    - Low Tide
    - High Tide
  - Restore Hydroperiod
    - Frequency of flooding
    - Duration of flooding
  - Maximize Marsh Surface Drainage
  - Maximize Marsh Surface Elevation
    - Marsh surface sediment deposition
    - Below surface accretion

AM Framework for Restoration of the Herring River Estuary - Objectives

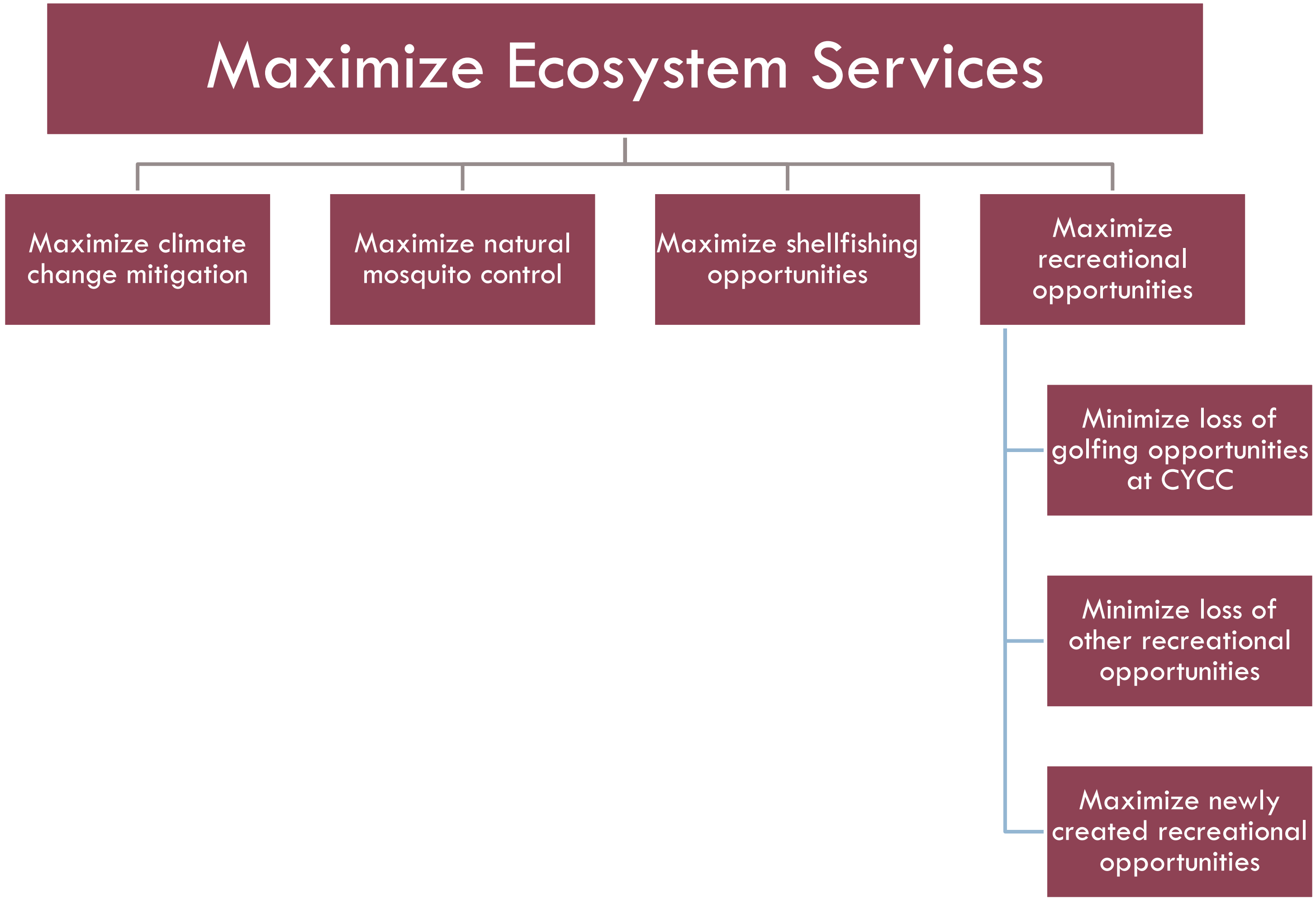


AM Framework for Restoration of the Herring River Estuary - Objectives

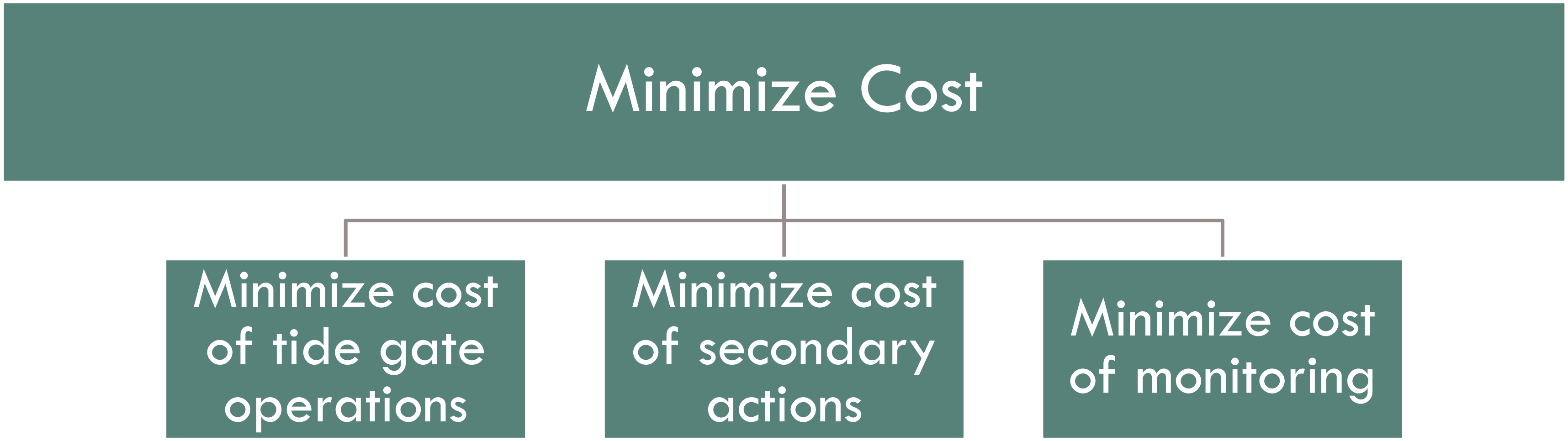
Minimize Adverse Impacts

- Prevent damage to structures and roads
  - Drinking wells
  - Private structures and landscaping
  - Public roads
- Minimize risk to public safety
  - At water control structure
  - Public risk elsewhere
- Prevent adverse impacts to harbor shellfish beds
  - Prevent ammonium export
  - Prevent fecal coliform
  - Prevent sediment deposition on shellfish beds
- Maximize public satisfaction
  - Minimize loss of privacy for abutters
  - Improve public viewscapes
  - Minimize appearance of dead woody veg from private property
- (public satisfaction continued)
  - Minimize adverse smell
  - Minimize community conflict

AM Framework for Restoration of the Herring River Estuary - Objectives



AM Framework for Restoration of the Herring River Estuary - Objectives



Consequence Table

- Parts of the table
  - Objectives
  - Measurable Attributes (Performance Metrics)
  - Unit
  - Desired Direction
  - Alternative Actions (Policies)
  - **Predicted Outcomes**
- Consequence Table
  - Six different timeframes
  - **Predictions capture uncertainty (low, most likely, high, confidence)**

Evaluating Alternative Actions

Objectives	Alternative Actions: How Much and How Quickly to Open Gates			
	Small/ Slow	-------------	-------------	Large/ Fast
Min Sediment export				
Max Shellfishing opp.				
Max Tide range				
Max Water quality				
Min Cost				

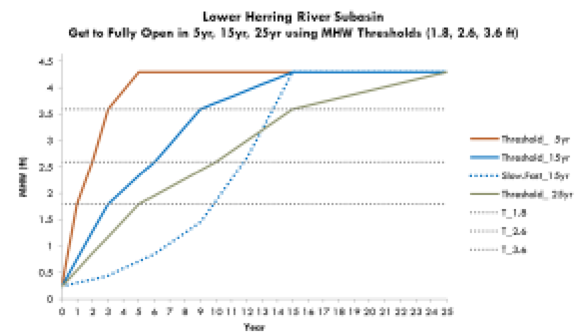
Predicted outcomes of each potential action for each objective

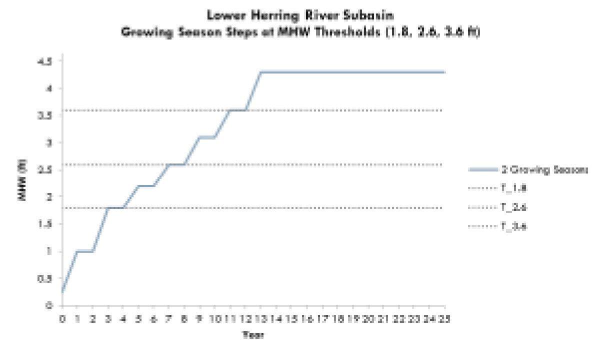
Alternatives

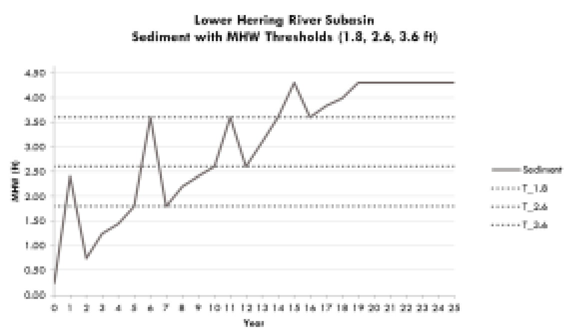
A menu of actions or choices for management decisions

Alternative Gate Policies

- Six different policies
  - Manipulation of the CNR dike gates
    - Platform policies on which Secondary Actions will be added
  - Each policy identifies a complete sequence of gate manipulations that would occur over a 25-year timeframe
  - Based on six distinct hydrographs of MHW







Inclusion of Secondary Management Actions

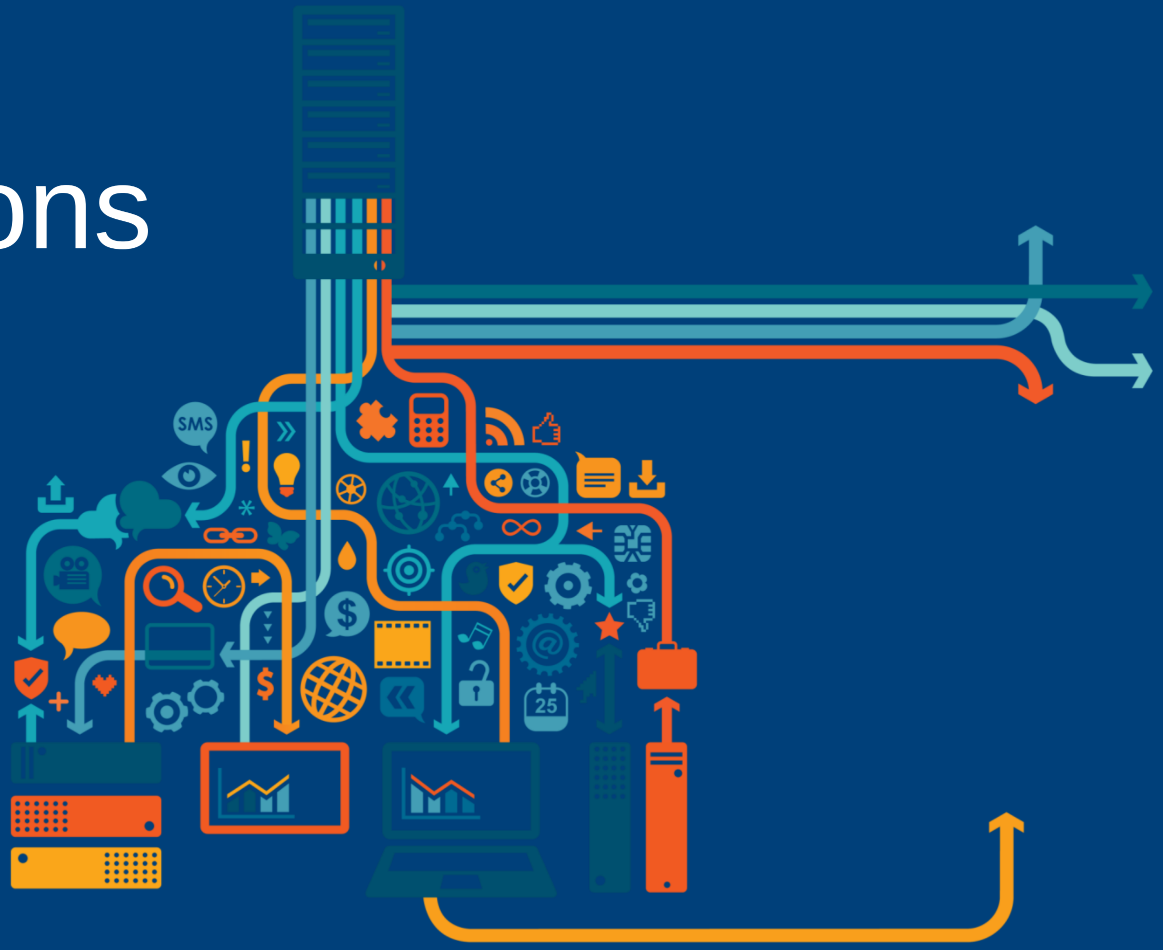
- Types of actions
  - Vegetation management
  - Sediment management
  - Channel and pool management
  - Wildlife, fish, and shellfish management
  - Recreation management
- Secondary actions are 'added on top of' gate policies
  1. Identify the best performing gate policies
  2. Add secondary policies to improve performance
  3. Select best overall policy (gate mgmt plus secondary actions)
- Inclusion of secondary actions is one way of adapting as restoration progresses

Future Steps

- Trade-Off Analysis
  - Process to compare predicted outcomes and associated utilities in the consequence table
  - Assign relative weights of each objective

- Sensitivity Analysis
  - Look for policy that most frequently performs best (most robust)

Transportation Decisions in Uncertain Times



Judy C. Gates
MaineDOT Environmental Office

NROC/NALCC

April 5, 2017

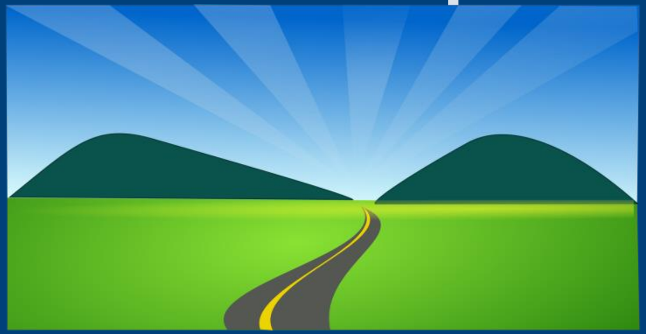
Risk?

How vulnerable are we REALLY?

- **What is the size of the problem?**
- **Is there a design ‘sweet spot’ we can tolerate?**
- **Can we say for sure that we’ll be better off?**
- **How can we afford to throw the baby out with the bath water?**

“Roads and culverts are barriers to everything”, says everyone.

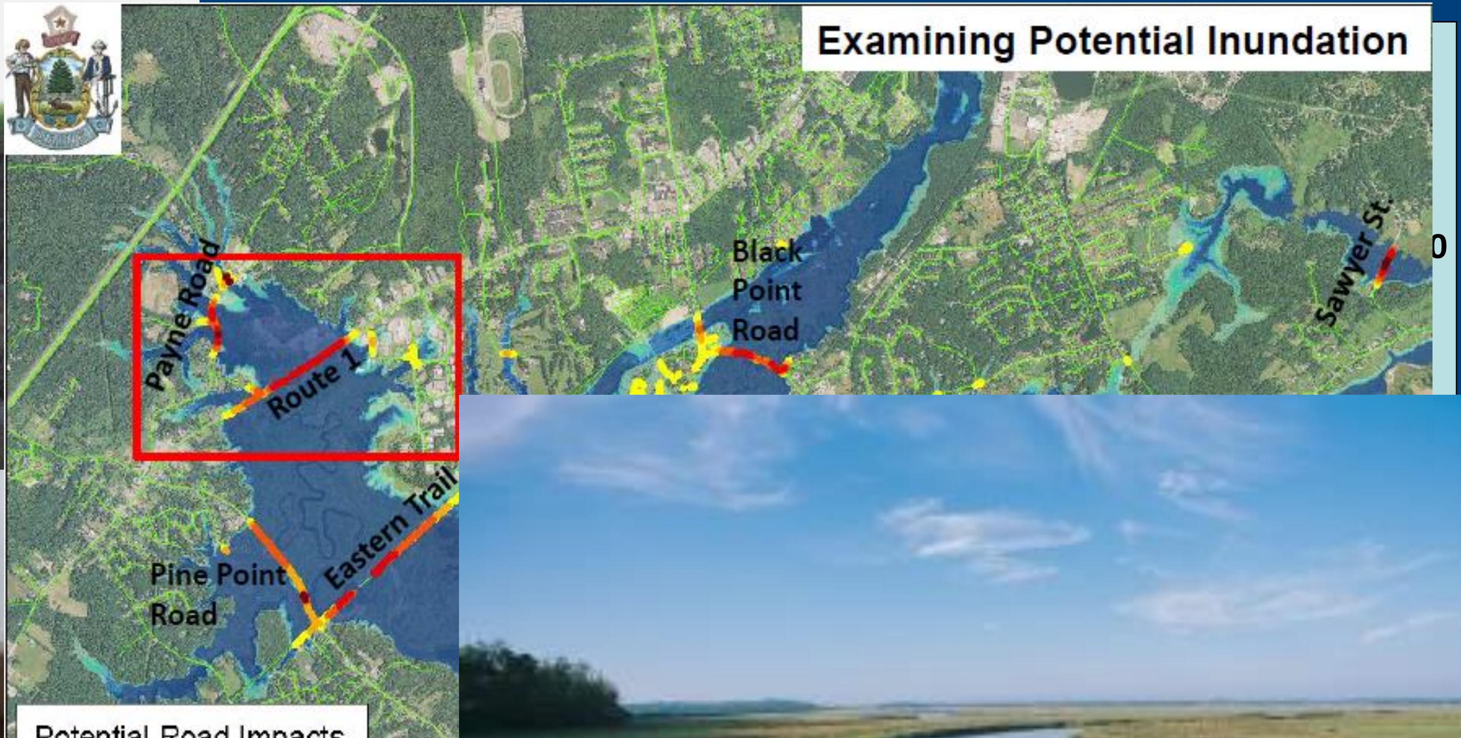
“We don’t need transportation infrastructure”, says no one

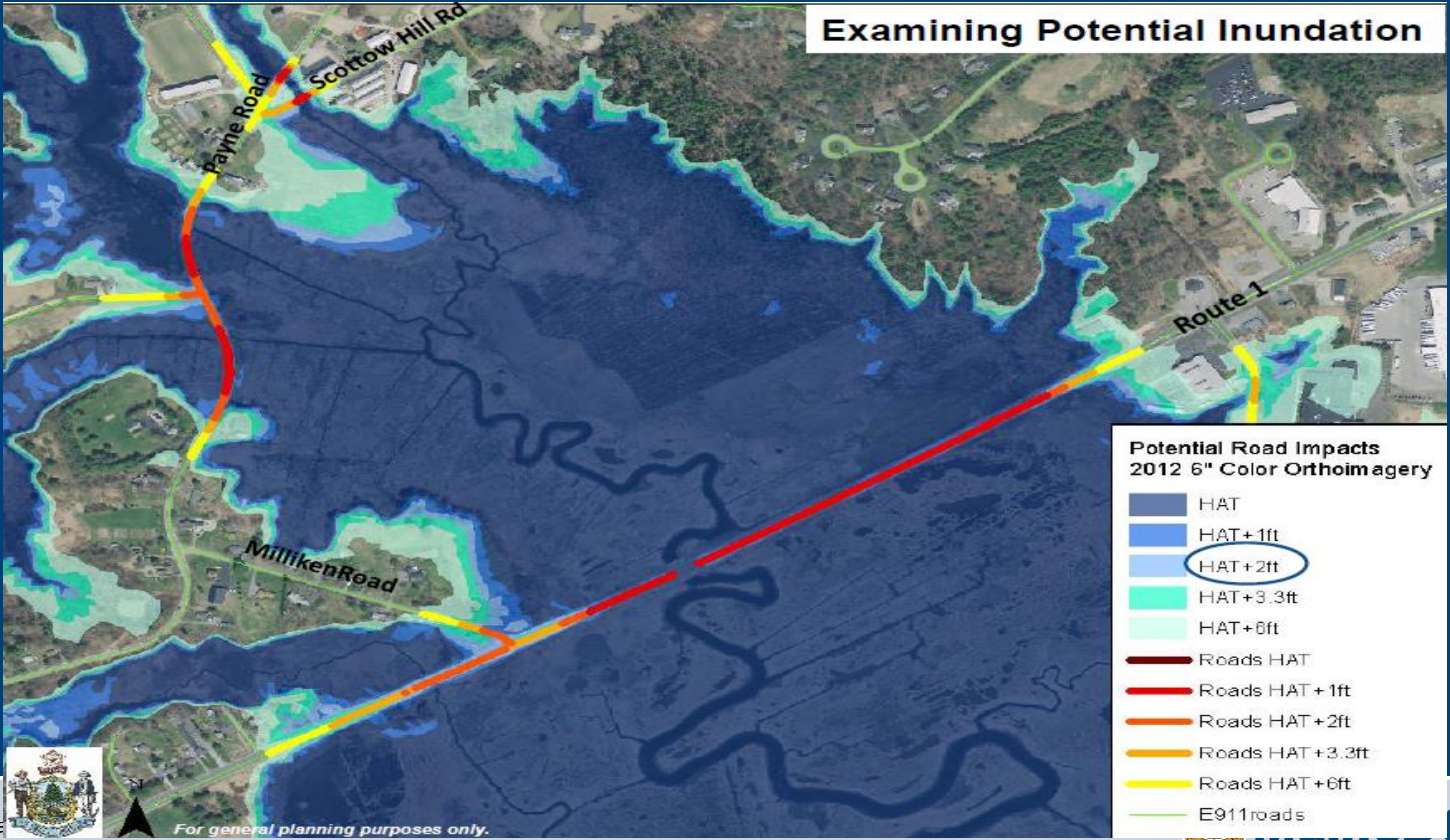


How vulnerable are we really?
FHWA Climate Change Initiative Grant
Plan A

1. Apply **three sea level rise scenarios**;
2. Design options for **one asset** in each of **six coastal towns**;
3. Apply depth-damage function to design options;
4. Create **Decision Support Tool** to rate level of vulnerability;
5. Truth DST results to "I remember when…";
6. Ask: can we **automate** decision support tool to assess **risk** as part of MaineDOT asset management process?

Route 1 & Scarborough Marsh




Examining Potential Inundation
Scottow Hill Rd
Payne Road
Route 1
MillikenRoad
Potential Road Impacts
2012 6" Color Orthoimagery
HAT
HAT+1ft
HAT+2ft
HAT+3.3ft
HAT+6ft
Roads HAT
Roads HAT+1ft
Roads HAT+2ft
Roads HAT+3.3ft
Roads HAT+6ft
E911roads
For general planning purposes only.

Unfortunately, the answer depends.

Is there a design ‘sweet spot’ we can tolerate?

- Fish
- Habitat
- Water
- Property
- Safety

- Safety
- Property
- Water
- Fish
- Habitat

Customer Service Level

Safety

Condition

Service

Large Culvert Sizing Engineering Guidance

- 1.2 bank full width
- Q100
- Q50

Uncertainty = Risk

[probability that a project schedule/budget won't be met

x

probability that a decision will not be "right"]

x

consequences

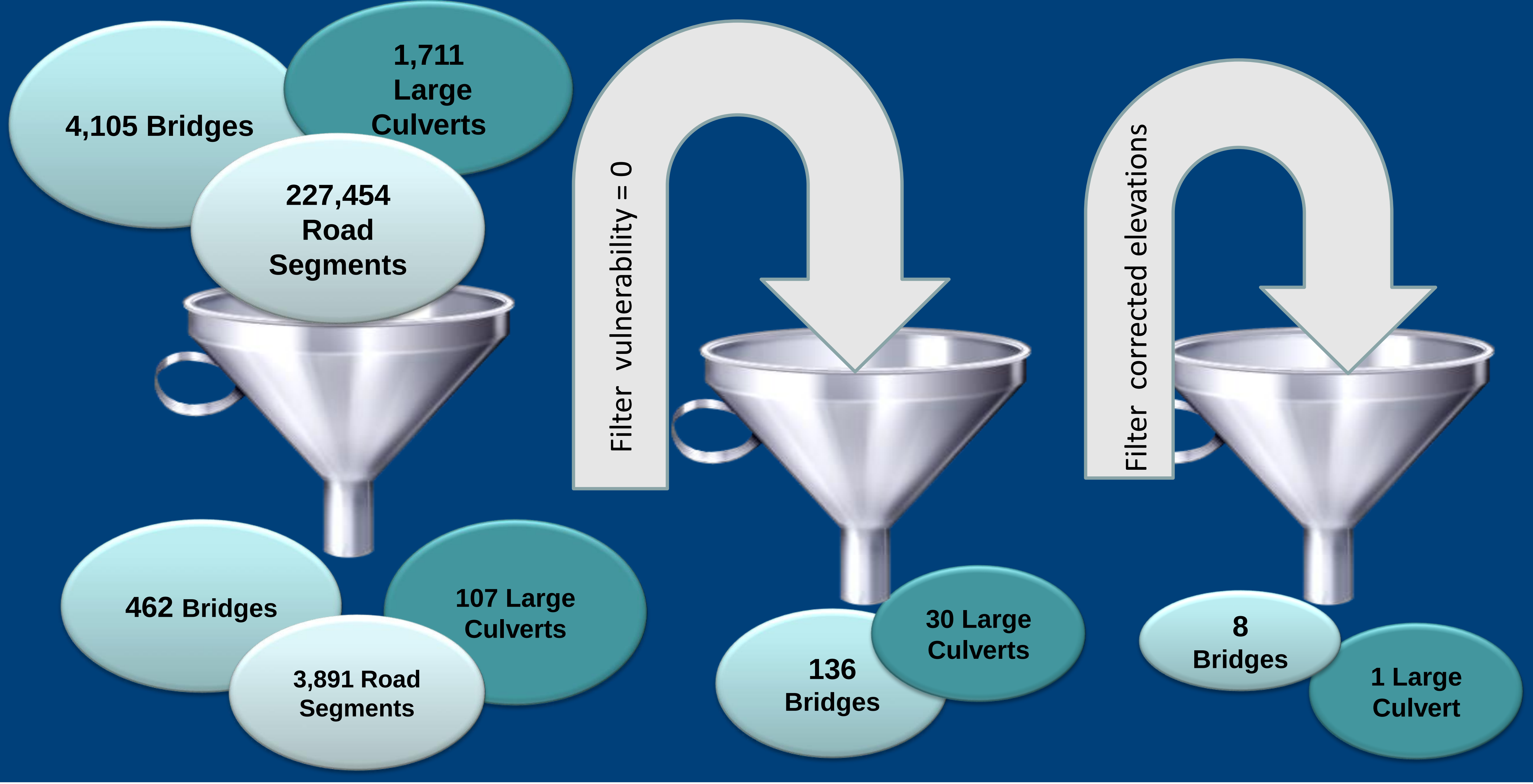
Coastal asset vulnerability…Will we be better off?

- Coastal assets
  - Roads
  - Bridges/facilities
  - Large culverts
- Vulnerabilities
  - Low SLR in 2065 (1 ft)
  - High SLR in 2065 (2 ft)
  - Low SLR in 2115 (2 ft)
  - High SLR in 2115 (5 ft)
  - 100-yr storm surge
  - We did not combine storm surge and sea level rise

Useful vs. Meaningful

- MaineDOT asset & location information
- NOAA's terrain and depth grids to extract values of:
  - **Ground elevation**
  - **Water surface elevations from SLR (tidally influenced)**
- Select tolerable future scenarios
- Flooding polygon overlays on roads, bridges, and culverts translated to vulnerability ratings (0-5)
- T-COAST depth damage functions for 'most' vulnerable
- Institutional knowledge

Filter #3: correcting for elevations


4,105 Bridges
1,711 Large Culverts
227,454 Road Segments
462 Bridges
107 Large Culverts
3,891 Road Segments
Filter vulnerability = 0
136 Bridges
30 Large Culverts
Filter corrected elevations
8 Bridges
1 Large Culvert

Ecological
- Atlantic salmon, EBKT, NLEB
- Mapped stream barriers
- Wildlife passage

X Weighting Factor (0-4) = Ecological Risk Score (0 – 20)

Hydrologic/Hydraulic
- Watershed size
- 100 year flows
- Flooding history

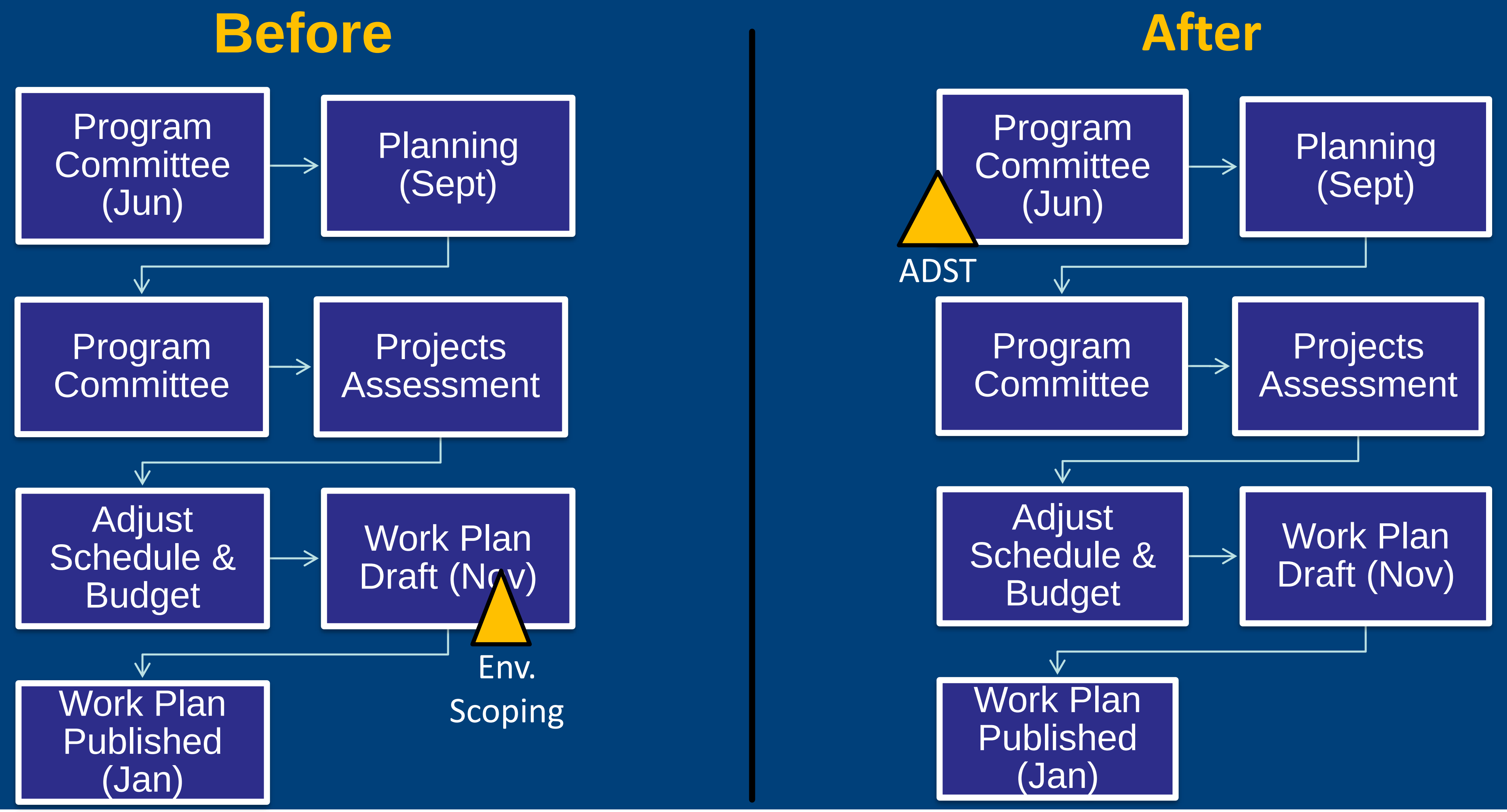
X Weighting Factor (0-3) = Hydrologic Risk Score (0-22)

Structural
- Condition
- Scour
- Size
- Depth of cover
- **Corridor Priority**

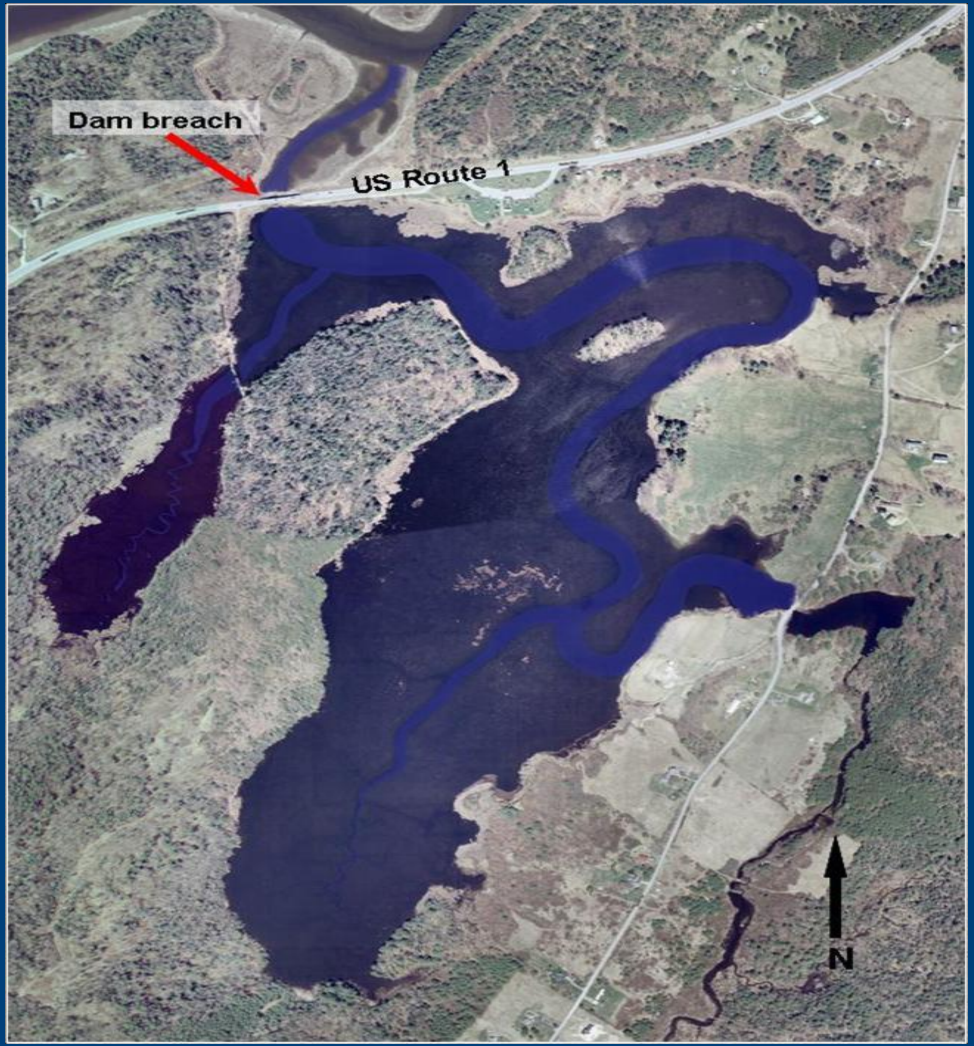
X Weighting Factor (1-4) = Structural Risk Score (3-43)

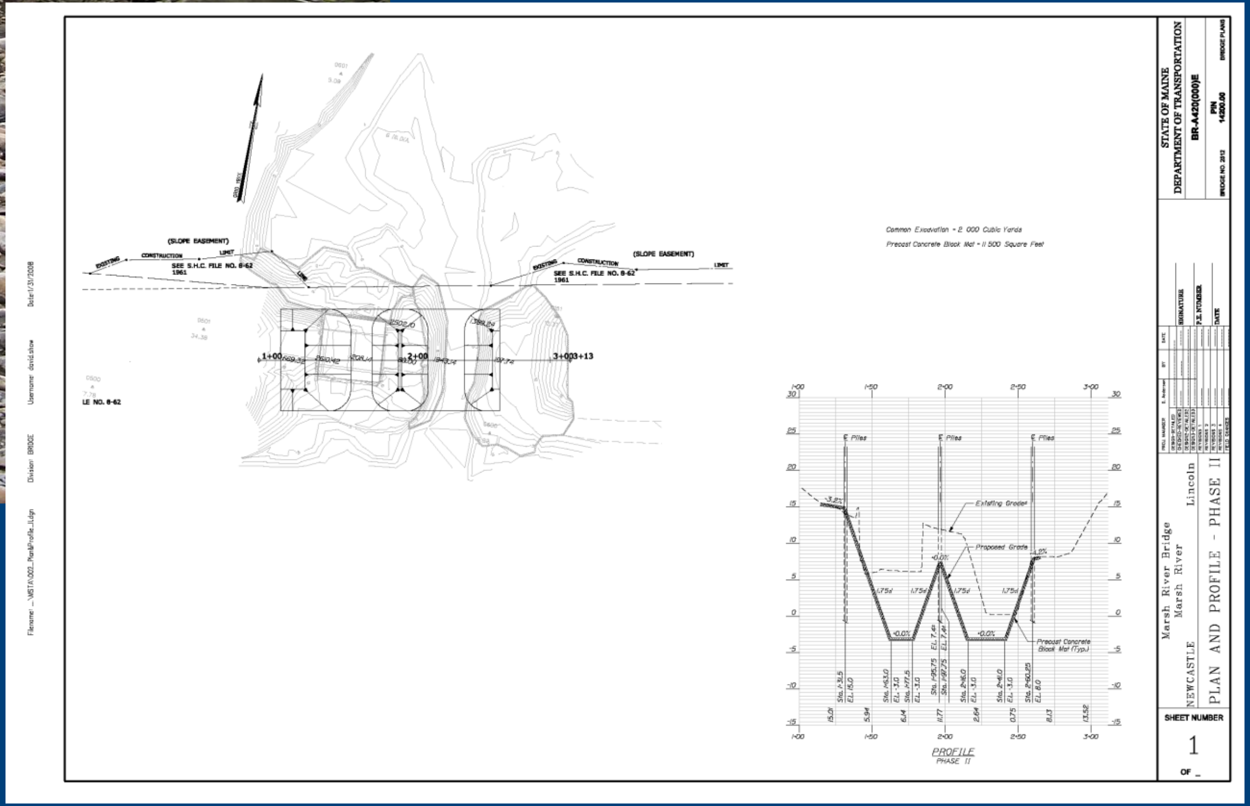
Final Risk Score (3-85)

Making Transportation Decisions in Uncertain Times



Newcastle US-1 Sherman Marsh 2008





STATE OF MAINE
DEPARTMENT OF TRANSPORTATION
BR-A420(000)E
PIN 14200.00
BRIDGE PLANS
Common Excavation = 2 000 Cubic Yards
Precast Concrete Block Mat = 11 500 Square Feet
(SLOPE EASEMENT)
SEE S.H.C. FILE NO. 8-62 1961
Existing Grade
Proposed Grade
Precast Concrete Block Mat (Typ.)
PROFILE
PHASE II
Marsh River Bridge
Marsh River
NEWCASTLE
Lincoln
PLAN AND PROFILE - PHASE II
SHEET NUMBER
1
OF _

Responding…

Remove old causeway;

Add new Channel;

Invasive control

Machias
Dyke
20??

Reinforcing…?

Risk "Multipliers"

Carrabassett Valley bridge failures, Hurricane Irene, 2011

The usual suspects…

- Extreme weather
- Increased precipitation/runoff
- Sea level rise

The less obvious…

- Political climate
- Organizational paralysis
- Pace of evolving science

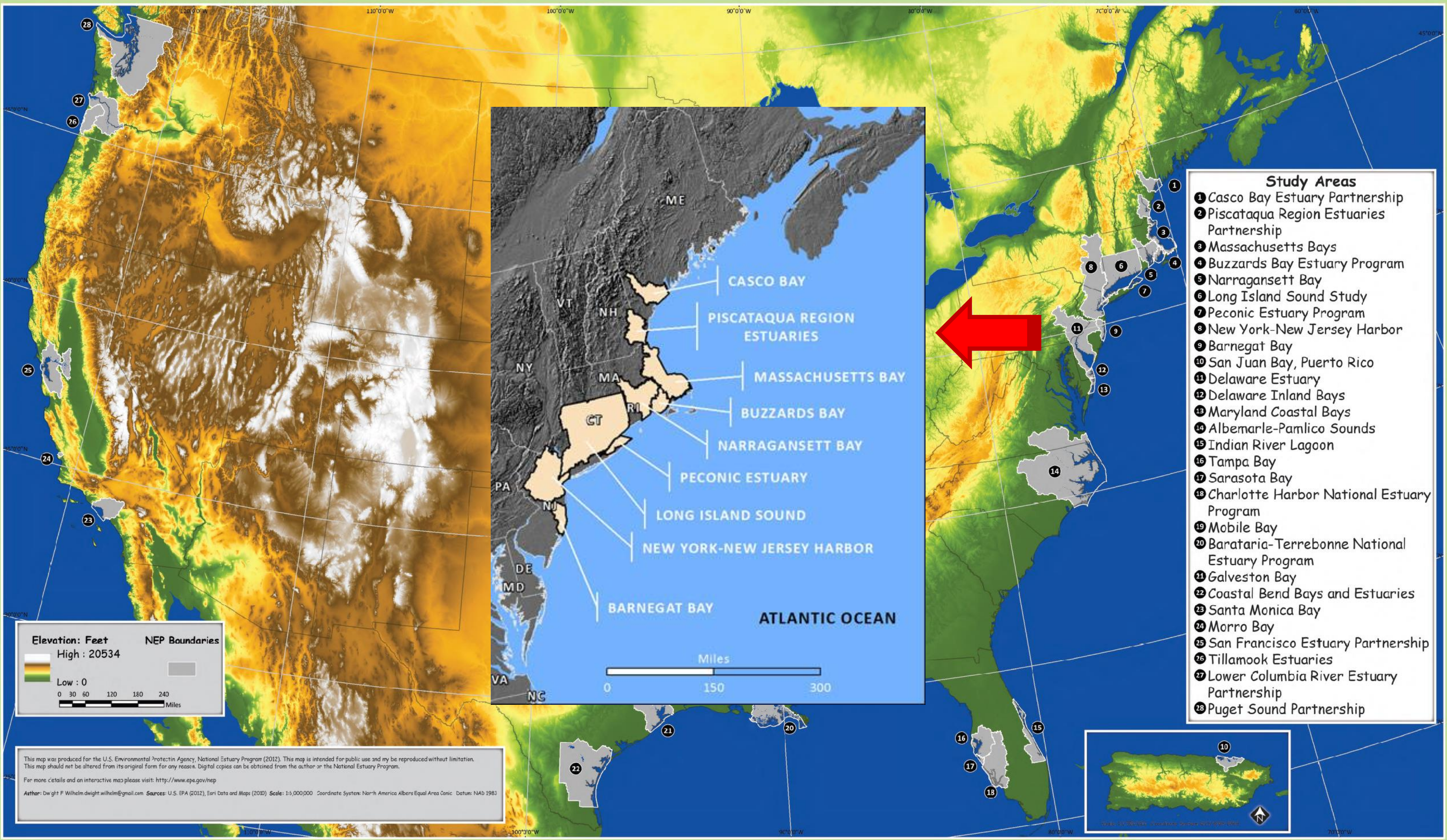
Insights?

- Adapting to sea level rise and storm surge is more of an organizational problem than a technical one
- We still don’t know what we don’t know (e.g. elevations)
- The dumpy splooge
- Uncertainty is not palatable for an engineering agency
- Is anyone out there?

Against the tide: An inventory of tide gates in Massachusetts

Pam DiBona
Massachusetts Bays National Estuary Program
April 5, 2017

NATIONAL ESTUARY PROGRAM STUDY AREAS



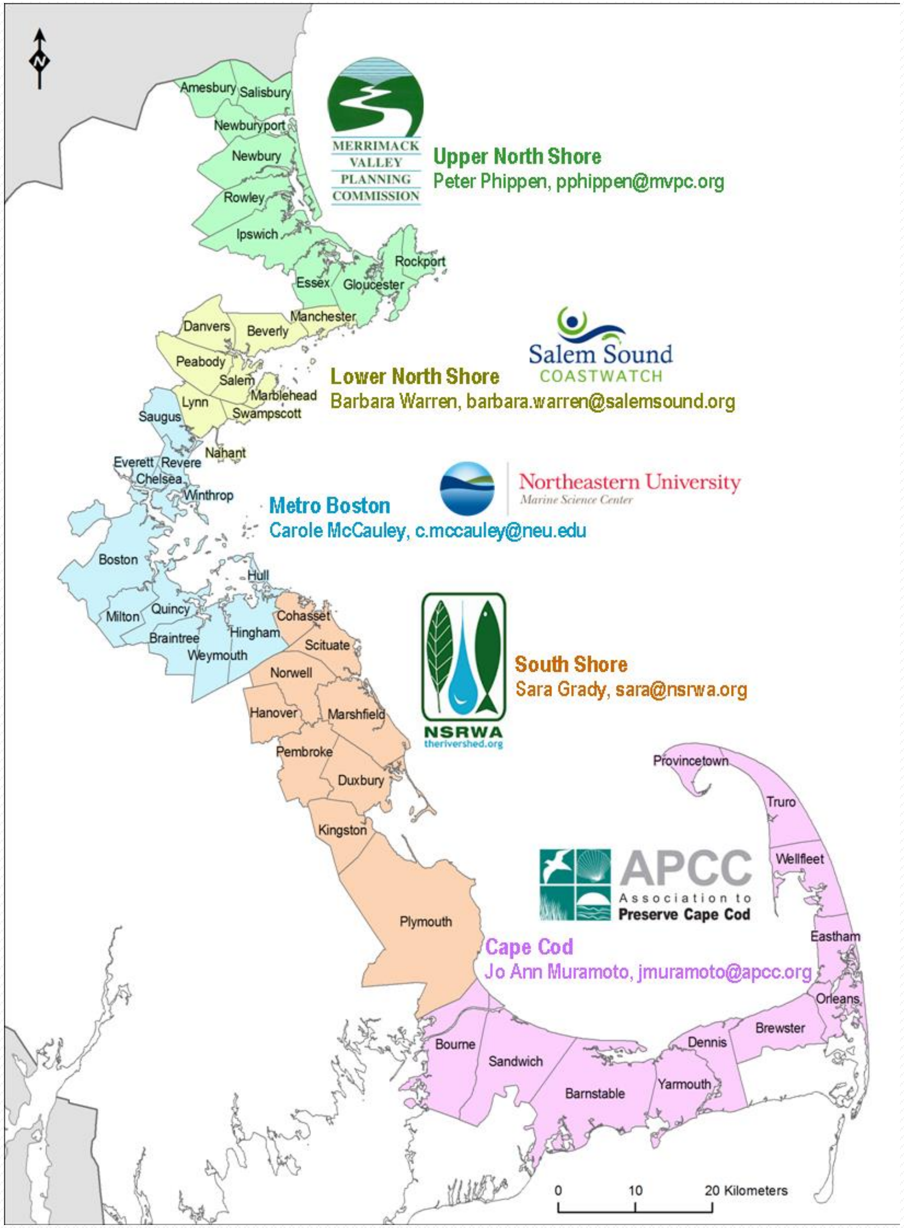
Massachusetts Bays
NATIONAL ESTUARY PROGRAM

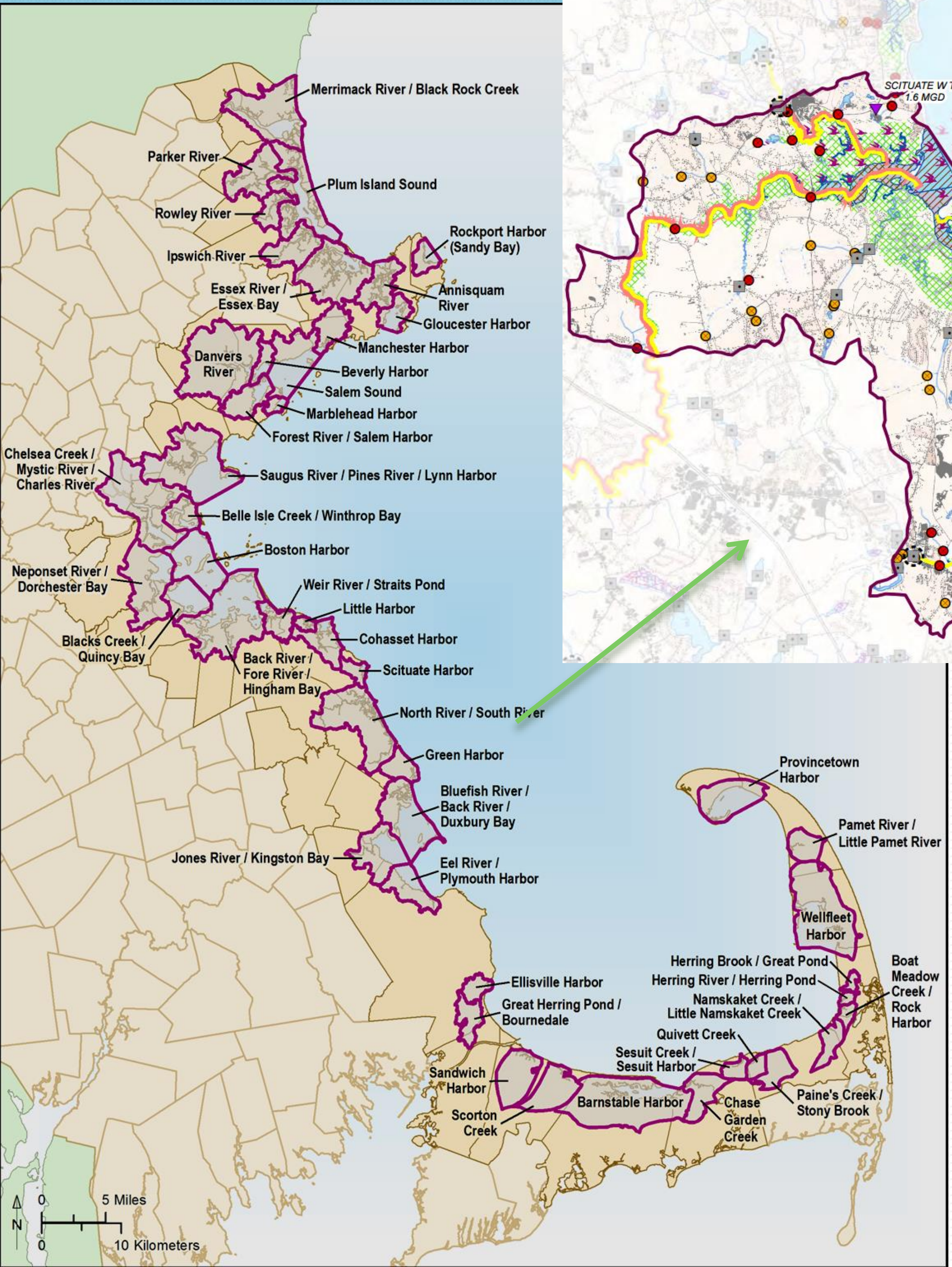
Central Staff

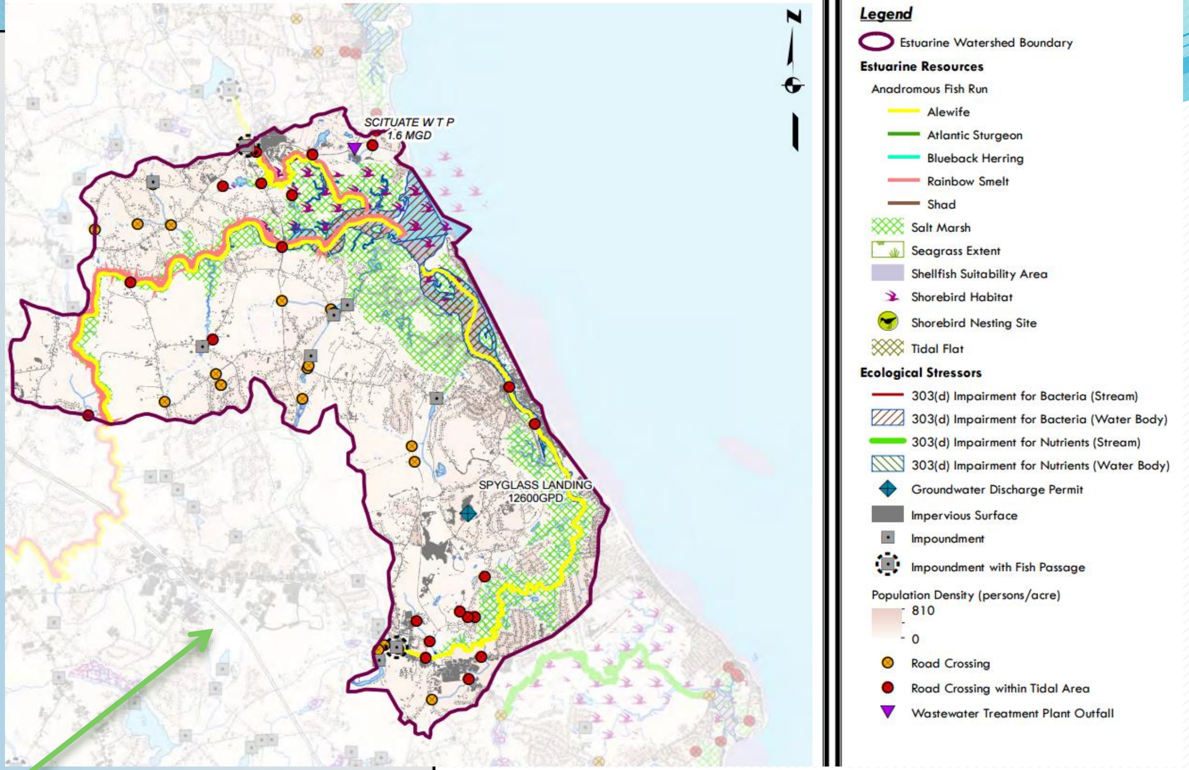
MASSACHUSETTS OFFICE OF
COASTAL ZONE MANAGEMENT

5 Regional Coordinators

50 communities
1100 miles of coastline







- 47 embayments delineated through Estuary Delineation & Assessment (2012)
- Landward and seaward boundaries
- Identified resources stressors

Tide Gate Inventory and Assessment

- Impetus
- Purpose
- Process & protocols
- Findings
- Next steps

Tide gate = any conveyance of tidal flow with the ability to passively or actively manipulate water flow.

Why tide gates?

- How many?
- Where?
- What condition?
- What purpose?
- Who owns them?
- Who is managing them, and how?
- What are the impacts?
- What are the implications?

2015 NOAA Project of Special Merit

Objectives:

- Locate and characterize existing tide gates
- Initiate, inform, and prioritize management for ecological benefit and hazard mitigation
- Prompt an increase in active and appropriate local management of tide gates.

2015 NOAA Project of Special Merit

Project leads

MassBays
NATIONAL ESTUARY PROGRAM

Massachusetts Office of Coastal Zone Management

Project consultant

Geosyntec consultants
engineers | scientists | innovators

Project advisors

NOAA – National Oceanic and Atmospheric Administration, U.S. Department of Commerce

Massachusetts Department of Fish and Game – Division of Ecological Restoration – Invested in Nature and Community

MarineFisheries – Commonwealth of Massachusetts

United States Environmental Protection Agency

Massachusetts Department of Environmental Protection

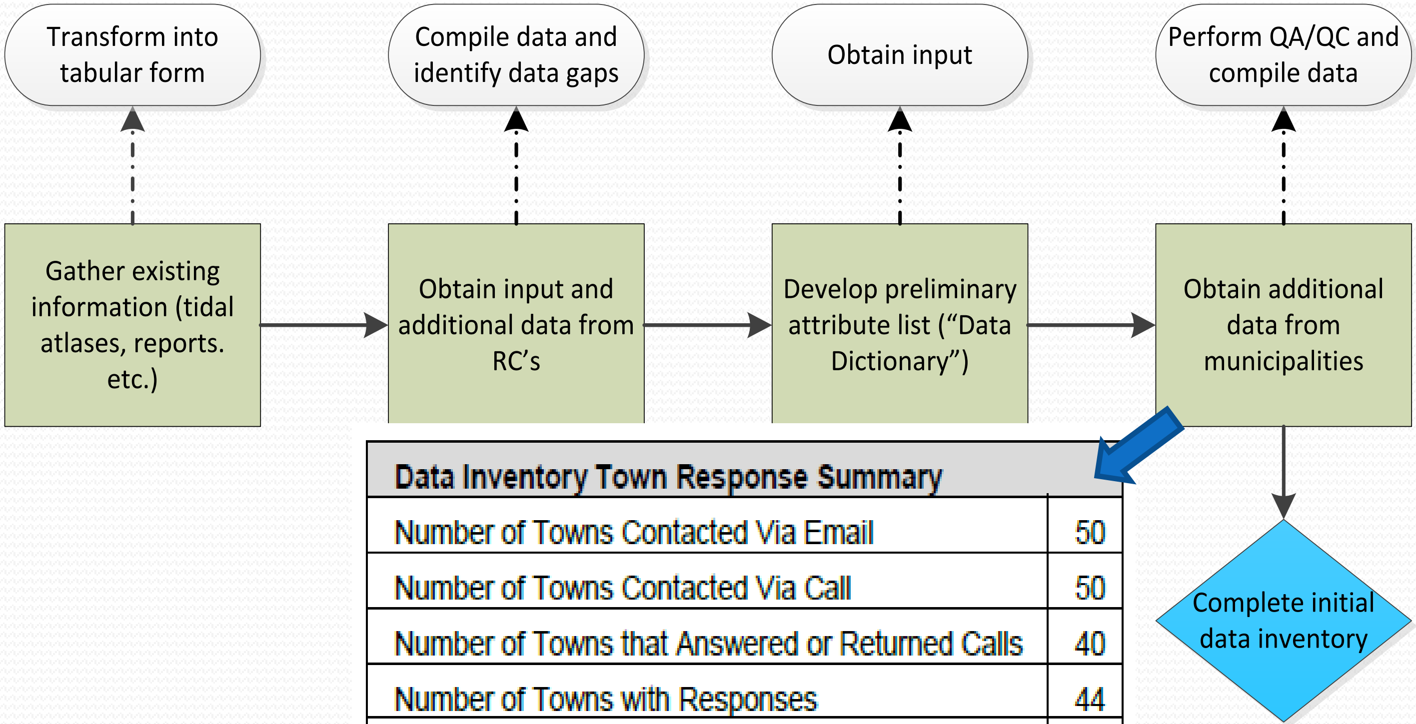
dcr Massachusetts

Process & protocols

- Data mining
- Field assessments

Process & protocols

- Data mining



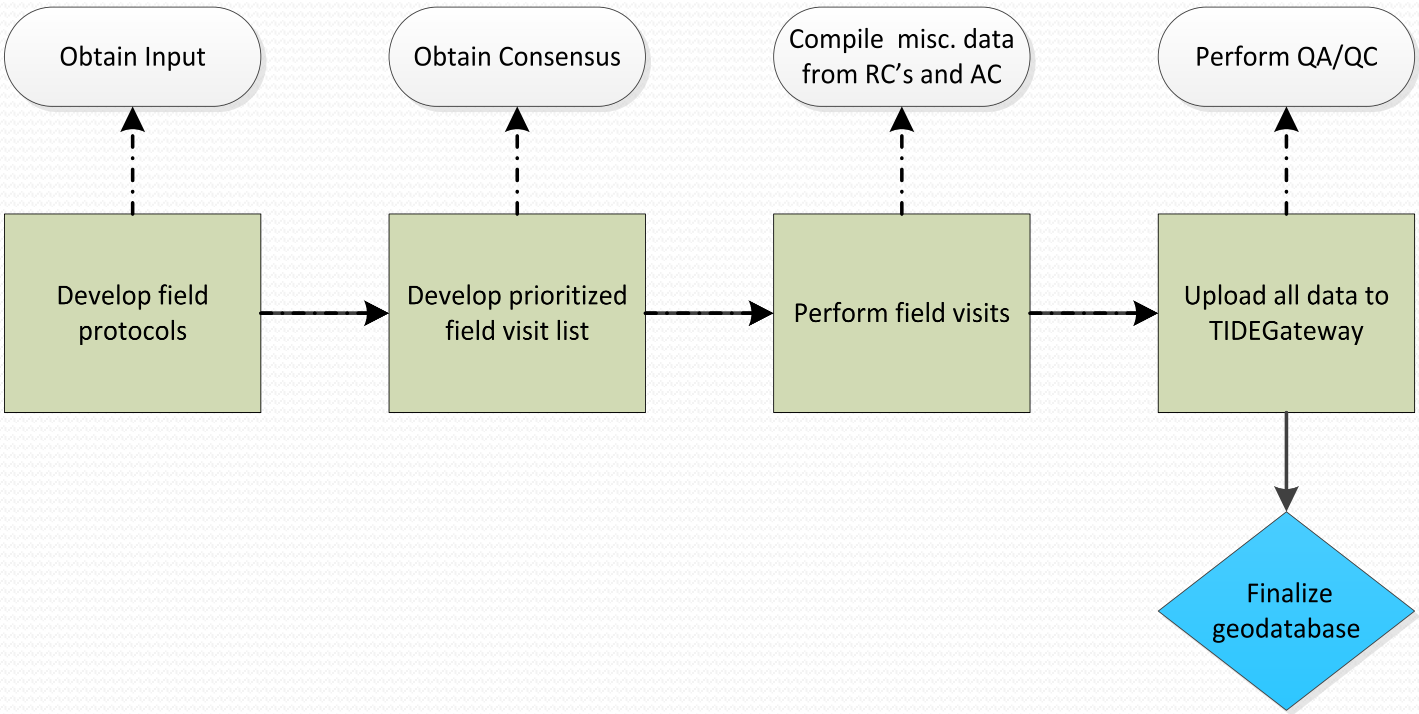
Data Inventory Town Response Summary	
Number of Towns Contacted Via Email	50
Number of Towns Contacted Via Call	50
Number of Towns that Answered or Returned Calls	40
Number of Towns with Responses	44
Number of Towns that Updated SharePoint	15
Number of Updated Tide Gate Records	25
Number of New Tide Gates	9

Process & protocols

- Data mining
  - Operator & operator type
  - Installation date
  - Intended purpose
  - Permits
  - Operation & maintenance plan

Process & protocols

- Field assessments

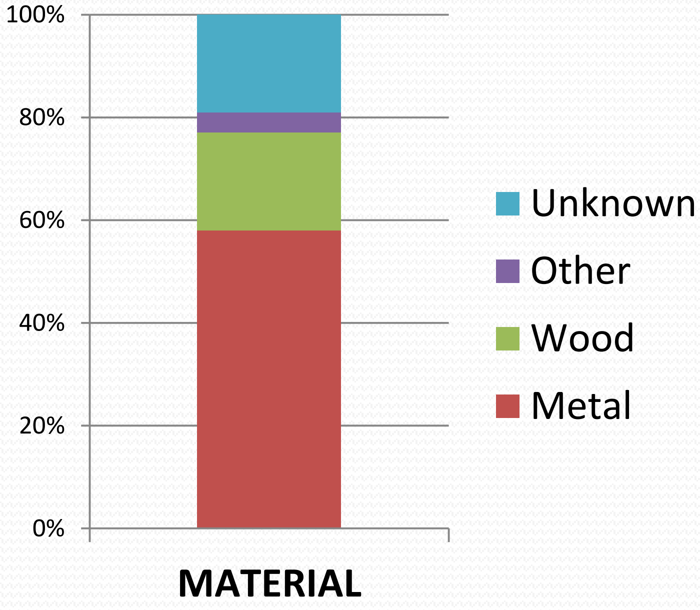


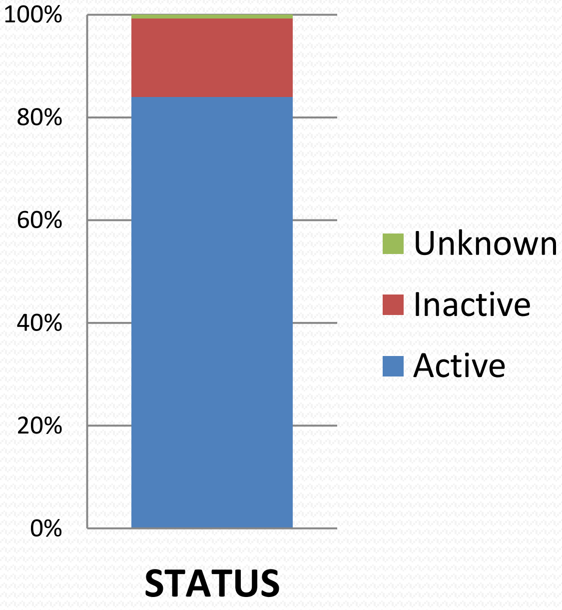
Process & protocols

- Field assessments
  - Coordinates
  - Control type & mechanism
  - Tide gate material and dimensions
  - Culvert material and dimensions
  - Tide gate & culvert condition
  - Presence/absence of (named) invasive species
  - Invert elevation
  - Upstream and downstream tidal influence
  - Upstream & downstream photos

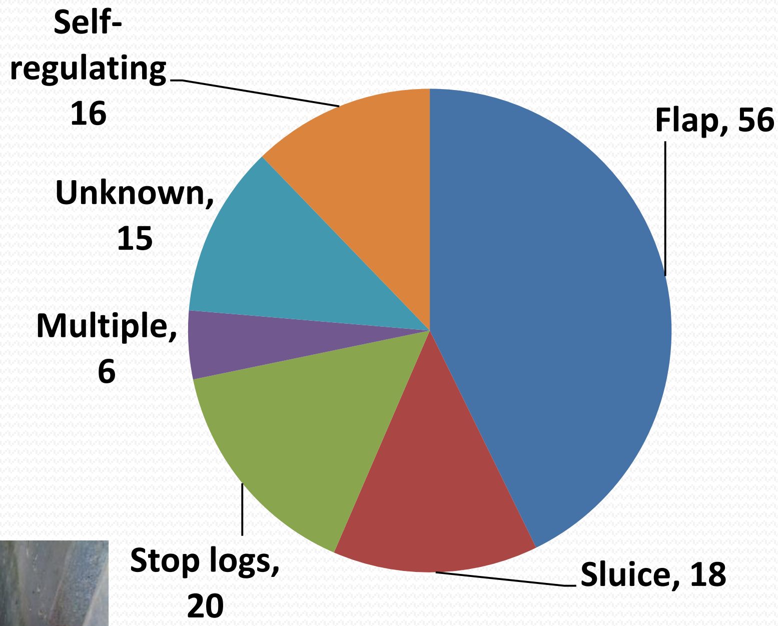
Findings: Material & Status

131 tide gates!

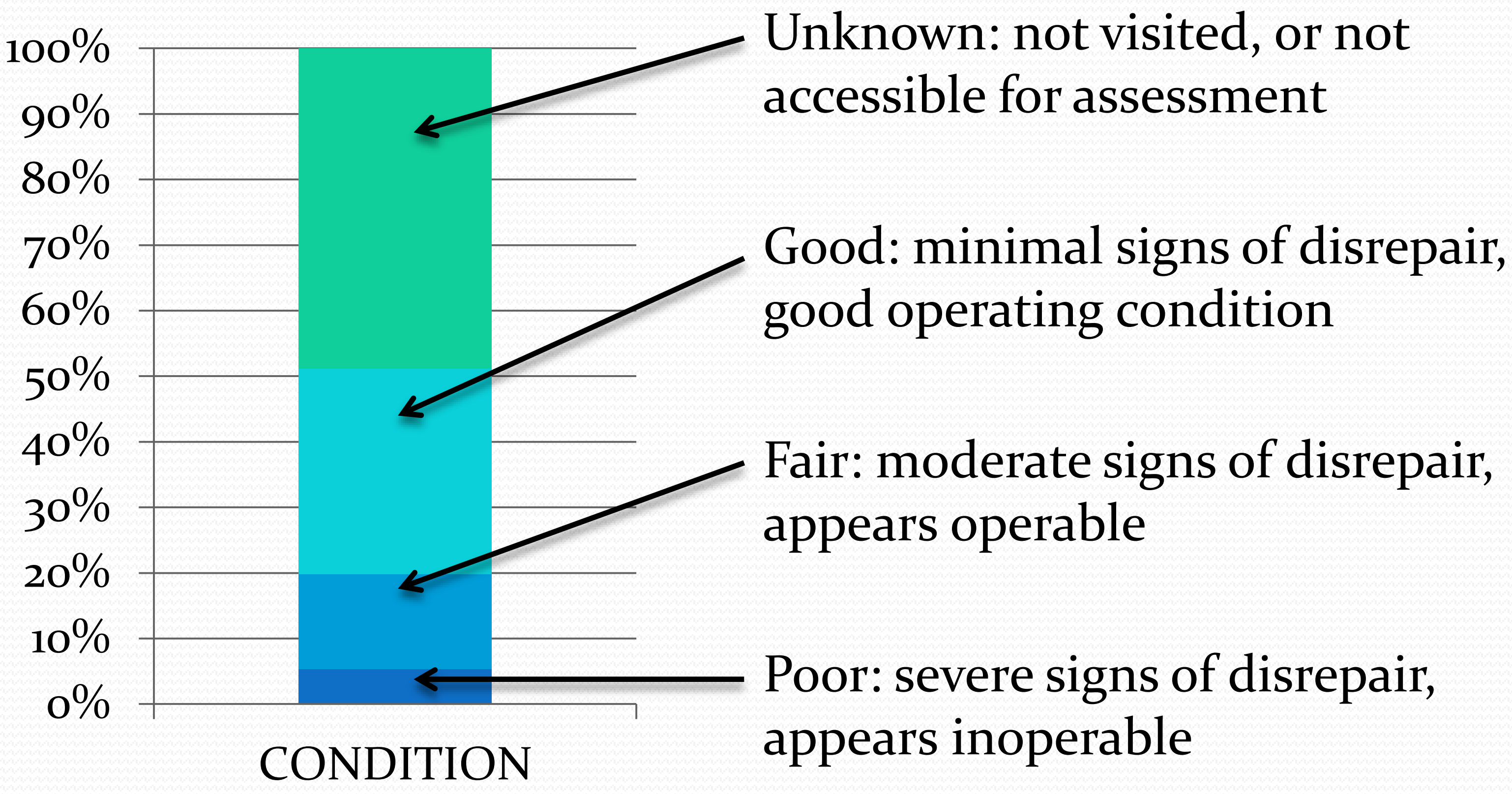




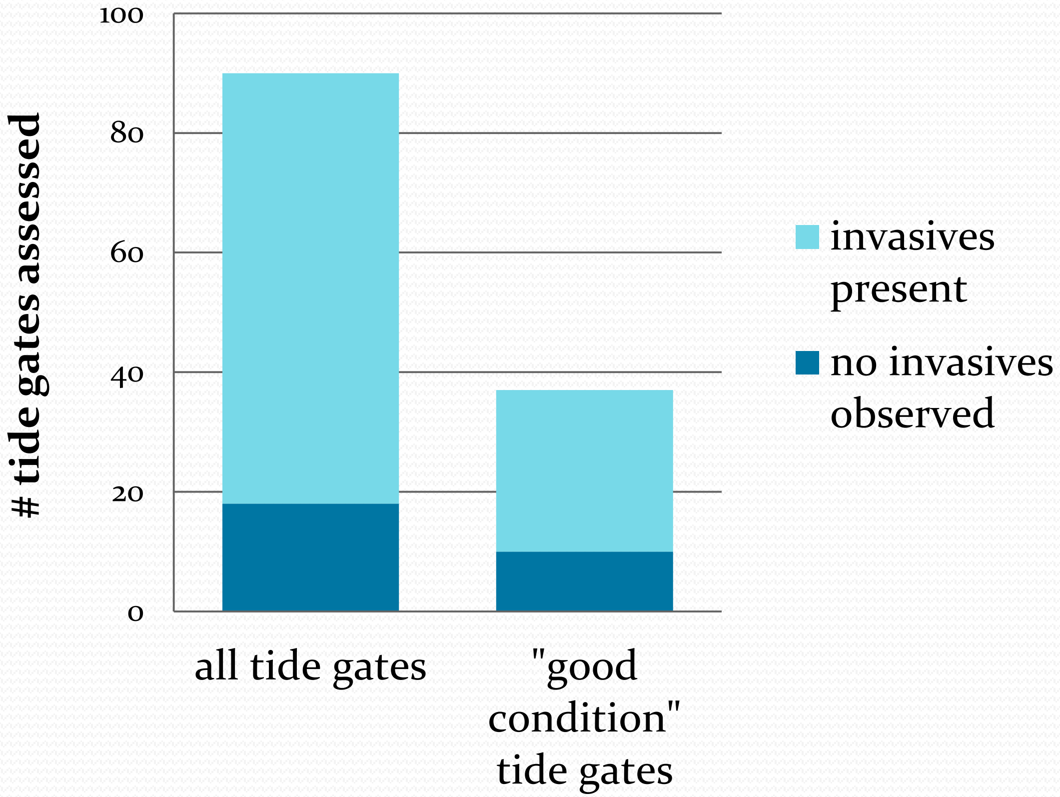
Findings: Control type



Findings: Condition



Findings: Invasive species



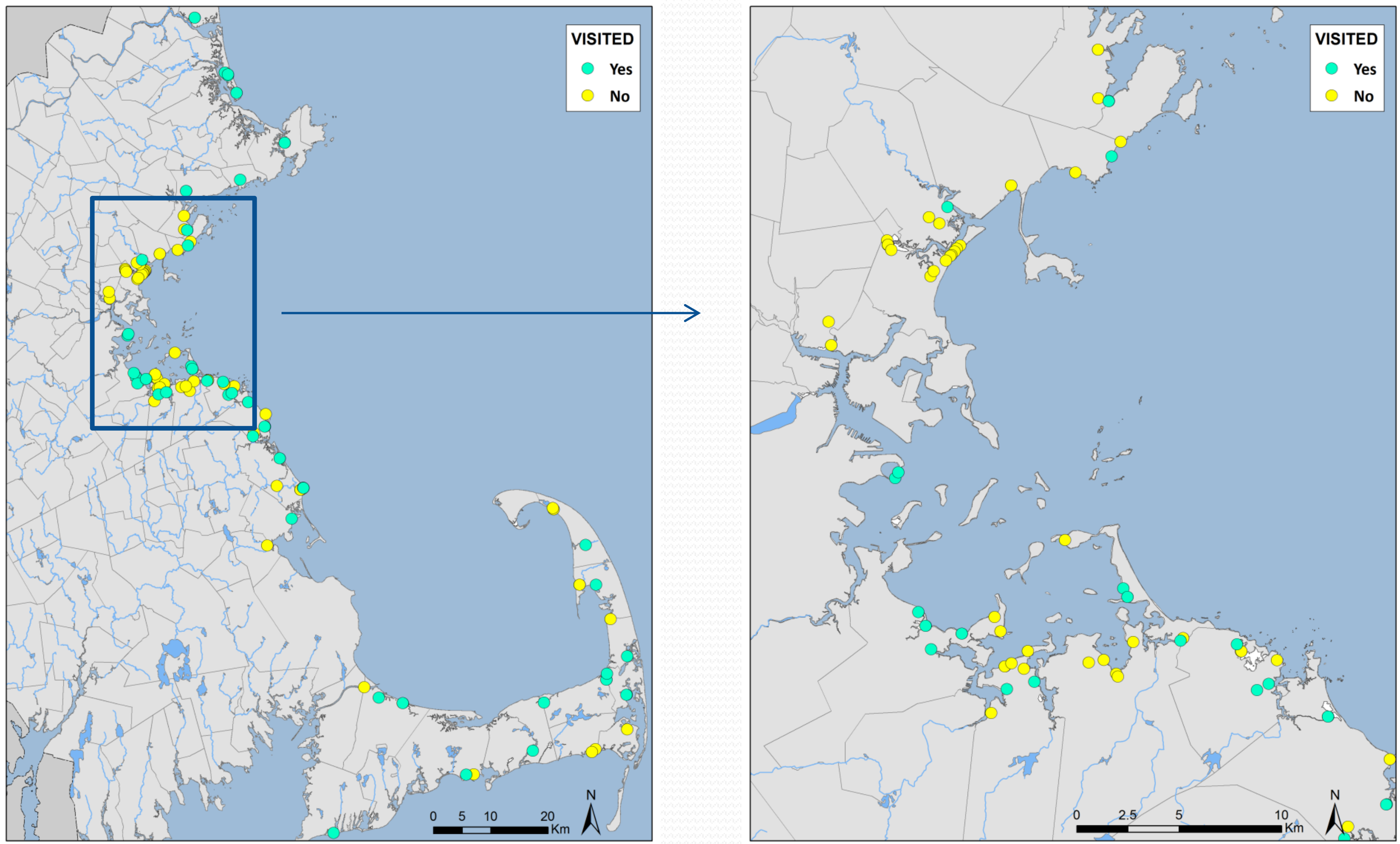
Next steps

- Document & data mining
- Modeling?
- Policy discussions
- Municipal outreach

Next steps

- Document & data mining
  - Conduct additional field assessments
  - Add more parameters to database
  - Locate and upload permits & plans
  - Implement additional field protocols
  - Incorporate additional restrictions & conveyances

Site visits



Next steps

- Document & data mining
- Modeling?

Next steps

- Document & data mining
- Modeling?
- Policy discussions
  - Prioritize regulatory & permitting action
  - Identify potential restoration sites
  - Upstream development planning

Next steps

- Document & data mining
- Modeling?
- Policy discussions
- Municipal outreach
  - Town-specific fact sheets
  - Regional workshops
  - One-on-one meetings & technical support
  - Restoration & management

Massachusetts Bays
NATIONAL ESTUARY PROGRAM

Pam DiBona

pamela.dibona@state.ma.us



Assessing New Hampshire's Tidal Crossings for Coastal Resilience

April 5, 2017

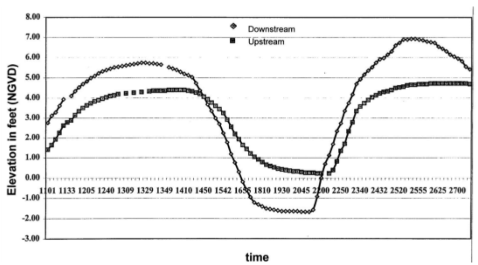
Kevin Lucey
NHDES Coastal Program

Pete Steckler
The Nature Conservancy



Complex Decision Making at Tidal Crossings

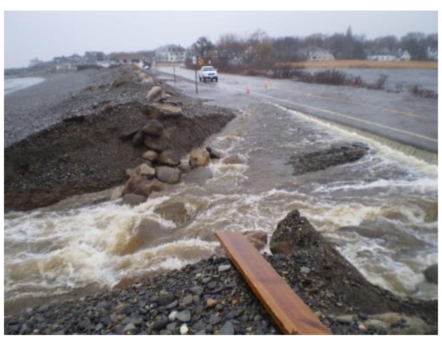
Bi- Directional Flow



Salt Marsh
Functions and Values

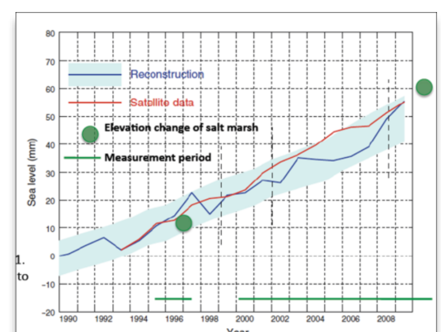
Low Lying
Infrastructure

Increased Storm
Intensity



Operations &
Maintenance

Rising Sea Levels



Tidal Crossings Assessments Workshop

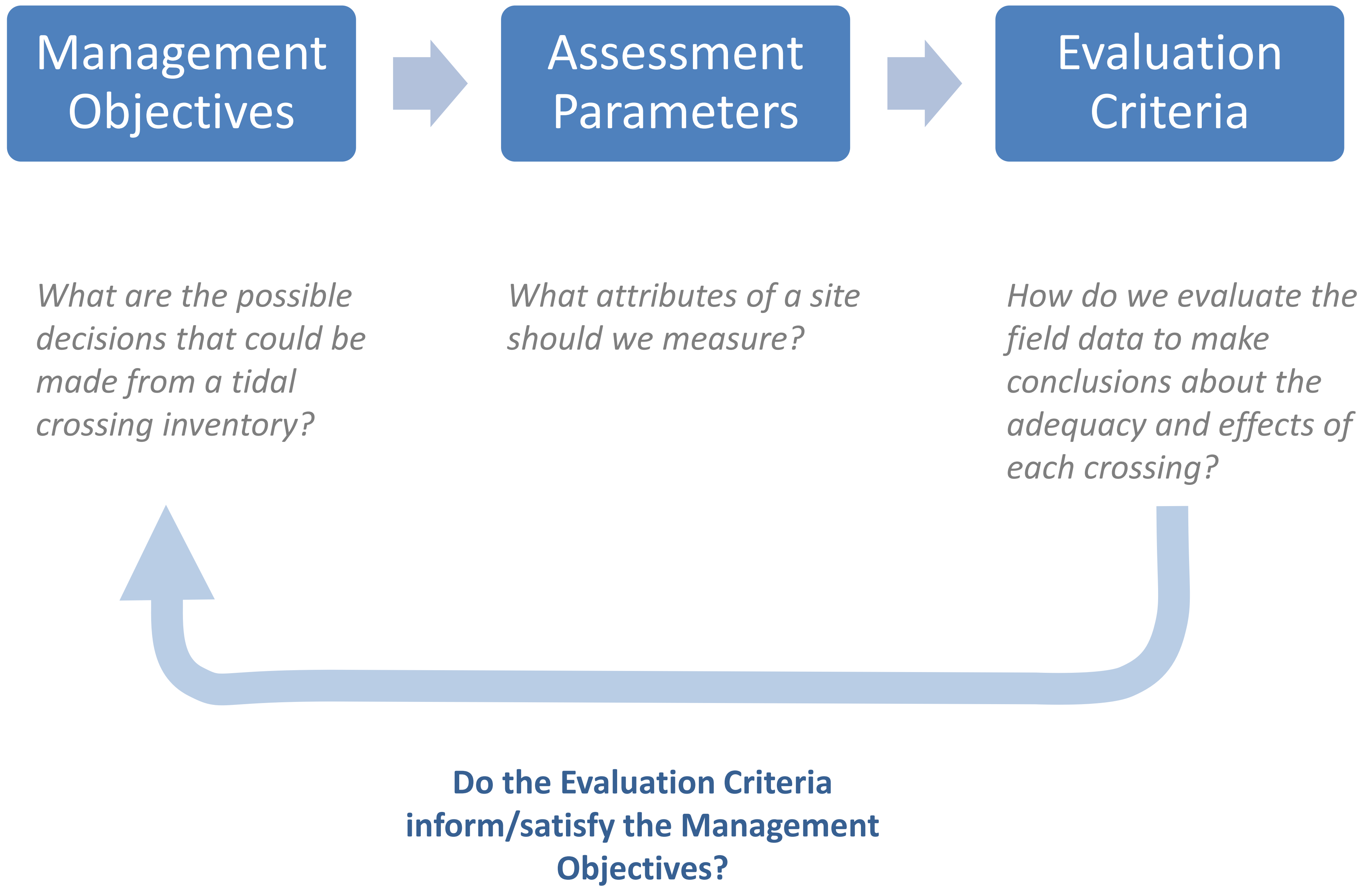
September 10, 2015

Portsmouth, New Hampshire


NROC
Northeast Regional Ocean Council

Gulf of Maine Council on the Marine Environment
Celebrating 25 years of action for a healthy environment

North Atlantic LCC
North Atlantic Landscape Conservation Cooperative


Management Objectives
Assessment Parameters
Evaluation Criteria
What are the possible decisions that could be made from a tidal crossing inventory?
What attributes of a site should we measure?
How do we evaluate the field data to make conclusions about the adequacy and effects of each crossing?
Do the Evaluation Criteria inform/satisfy the Management Objectives?

To identify locations of tidal crossings
To identify locations of tidal restrictions
To determine the condition of the tidal crossing
To determine aquatic organism passage
To identify opportunities for salt marsh migration
To identify flood inundation risk
To identify conflicting uses
To determine feasibility of replacement
To prioritize replacement
To develop standardized baseline information for permitting, mitigation, engineering and design.

Landscape Position
Structure Condition
Structure Dimension and Type
Channel Characterization
Relative elevations of structure, road, marsh, channel
Fish and Wildlife Observations
Vegetation Characterization (field and desktop)
Sea Level Rise Comparison (desktop)
SLAMM Comparison (desktop)

Structure Condition

Crossing Ratio

Erosion Classification

Vegetation Comparison

Tidal Range Comparison

Salt Marsh Migration Potential

Inundation Risk to Crossing Structure

Inundation Risk to Road

Inundation Risk to Low Lying Infrastructure

Replacement Feasibility

Crossing Type & Condition

Draft February 2017
New Hampshire's Tidal Crossing Assessment Protocol Data Sheet

CROSSING TYPE & CONDITION (*field evaluation*)

Crossing Type:

- Round Culvert
- Elliptical Culvert
- Box Culvert
- Embedded Round Culvert
- Open Bottom Arch
- Bridge with Abutments
- Bridge with Side Slopes
- Bridge w/ S. Slopes and Abutments
- Ford

Structure Materials:

- Concrete
- Plastic-Corrugated
- Plastic-Smooth
- Tank
- Stone
- Steel-Corrugated
- Steel-Smooth
- Aluminum-Corrugated
- Wood
- Other

Structure ____ of ____ at Crossing

Crossing Dimensions (feet):

	Upstream	Downstream
Dimension A:		
Dimension B^{CB}:		
Dimension B^{LT}:		
Dimension C:		
Dimension D:		

SKETCH OF STRUCTURE

	Upstream	Downstream
Low Tide Perch:		
High Tide Perch:	N/A	

Angle of Stream Flow Approaching Structure:

Upstream	Downstream
Sharp Bend (>45°)	Sharp Bend (>45°)
Mild Bend (5-45°)	Mild Bend (5-45°)
Naturally Straight	Naturally Straight
Channelized Straight	Channelized Straight

Crossing Condition:	Pipe Corrosion Severity:	Pipe Deformation:	Spalling Severity:	Joint Separation
Good	None	None	None	None
Eroding	Low	Low	Low	Partial
Collapsing	Medium	Medium	Medium	< 1"
Rusted	High	High	High	1 - 3"
	N/A	N/A	N/A	> 3" or piping
				no joints
				N/A

Headwall Materials:

- Metal
- Concrete
- Masonry
- Gabion
- Dry Fit Stone
- Plastic
- Other
- None

Headwall Condition:

Upstream	Downstream
Excellent	Excellent
Good	Good
Fair	Fair
Poor	Poor
N/A	N/A

Scour at Structure (circle all applicable):

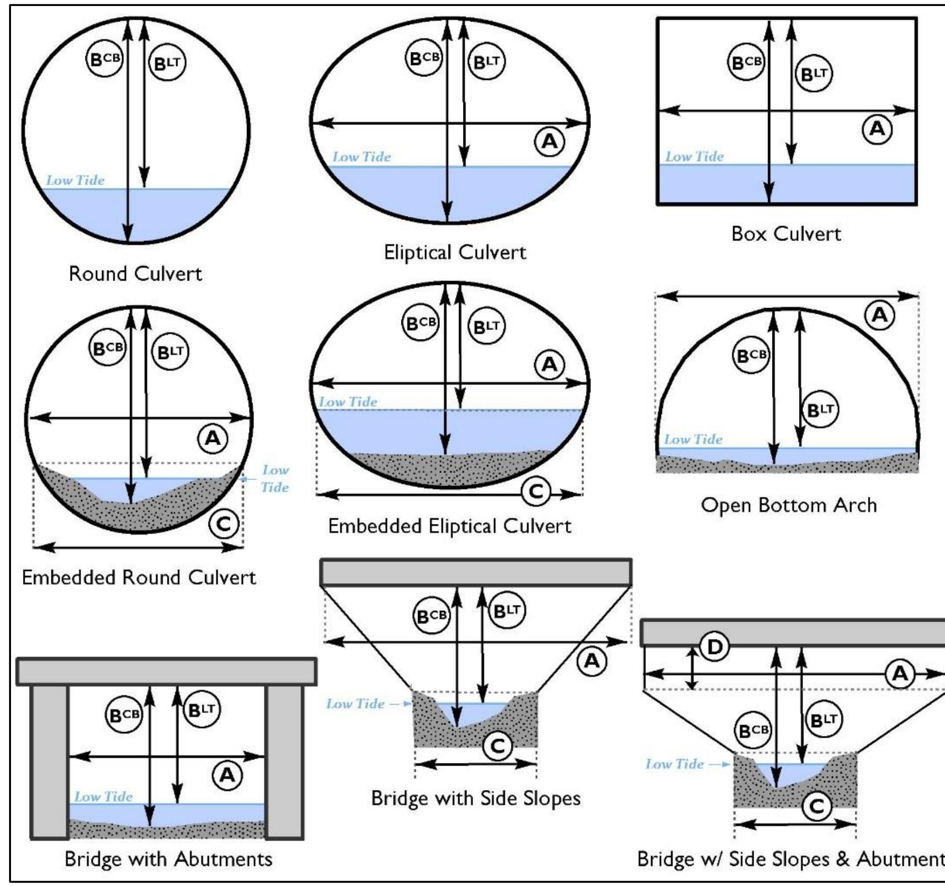
Upstream	In Structure	Downstream
None	None	None
Culvert	Culvert	Culvert
Footer	Footer	Footer
Wing Walls	Abutment	Wing Walls
Abutment	Channel	Abutment
Headwall	Armoring	Headwall
Armoring		Armoring

Severity of Scour

Upstream	In Structure	Downstream
None	None	None
Low	Low	Low
Medium	Medium	Medium
High	High	High

Crossing Type/Condition Comments:
(Note obstructions at structure openings and road surface conditions)

Page 2



Longitudinal Profile:

LONGITUDINAL PROFILE AND HIGH WATER INDICATORS (*field evaluation*)

Indicate in the solid outlined boxes if the elevation was taken from the:
- **R**oadway level setup (**R**)
- **U**pstream level setup (**U**)
- **D**ownstream level setup (**D**)

	US Height	DS Height
Low Tide Water Elevation		

Height of Establsihed Control Point:

Describe Control Point:

Height at Road Centerline:

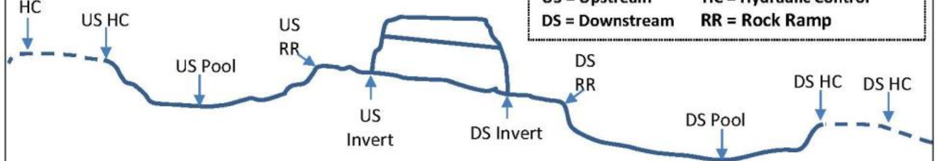
HWI, Roadway & High Marsh Elevations

Feature	**US Height**	**DS Height**
HWI Stain		
HWI Wrack		
Ceiling of Structure		
Road Surface		
High Marsh Shot 1		
High Marsh Shot 2		
High Marsh Shot 3		
High Marsh Shot 4		

Comments:

IF NEEDED:	**US Height**	**DS Height**
TP Foresight		
TP Backsight		

Longitudinal Profile Feature Code Abbreviations
US = Upstream **HC = Hydraulic Control**
DS = Downstream **RR = Rock Ramp**



Distance	Height	Feature Code	Sub-strate	Shot From (R/U/D)

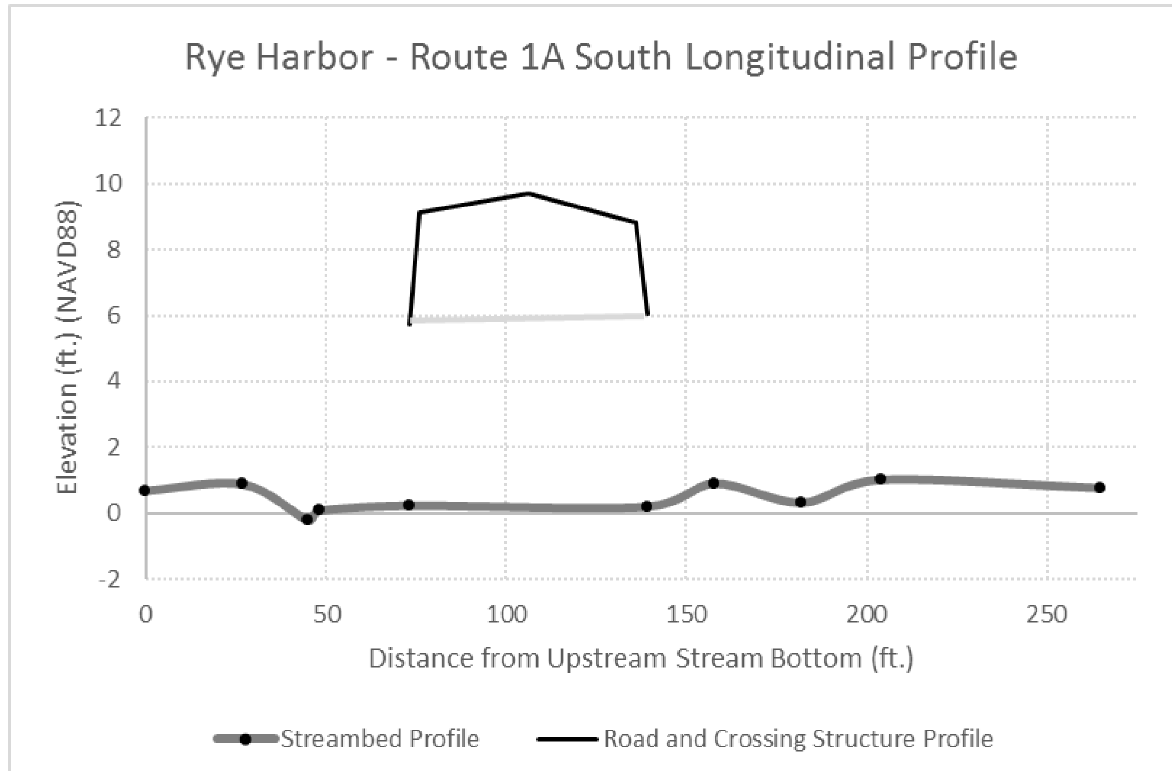
QC - Height of Establsihed Control Point:

Benefits of a Longitudinal Profile

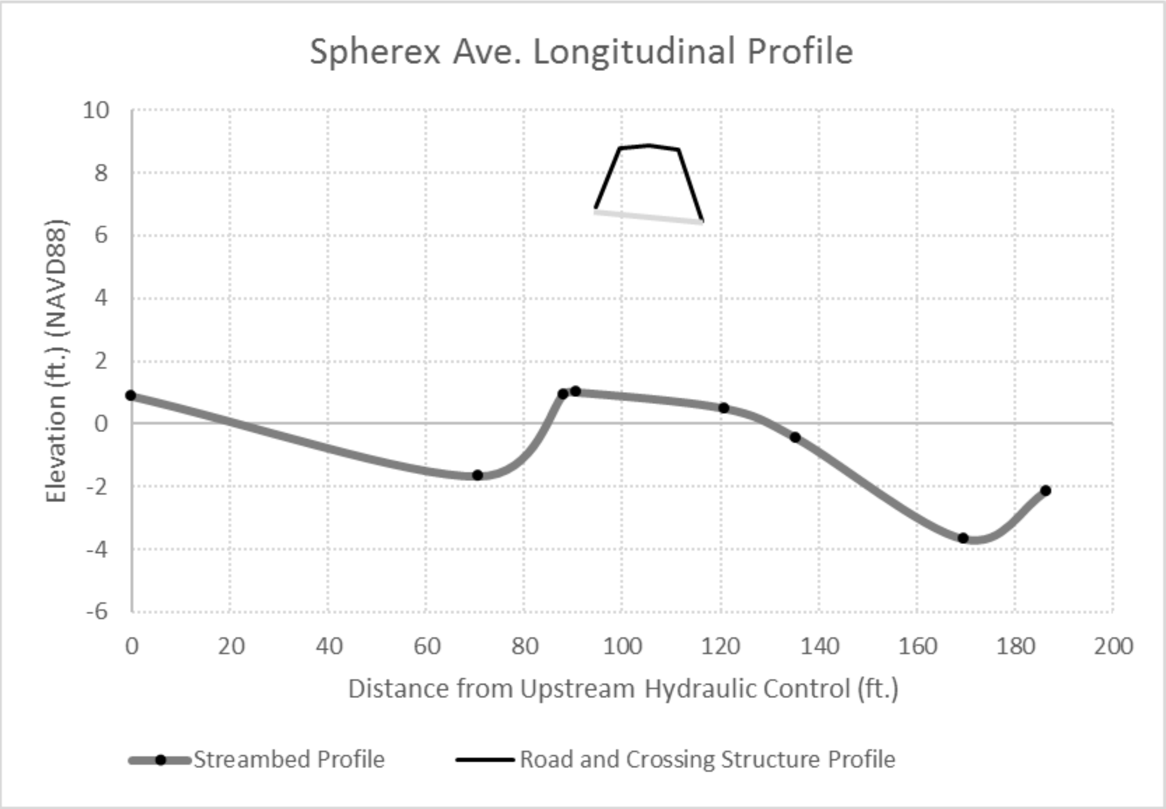
Understand…

- Compatibility of the Crossing Structure with the Tidal System
- Tidal Range and Aquatic Organism Passage
- Inundation Risk to the Structure and Roadway
- And more!

Crossing Structure Compatibility



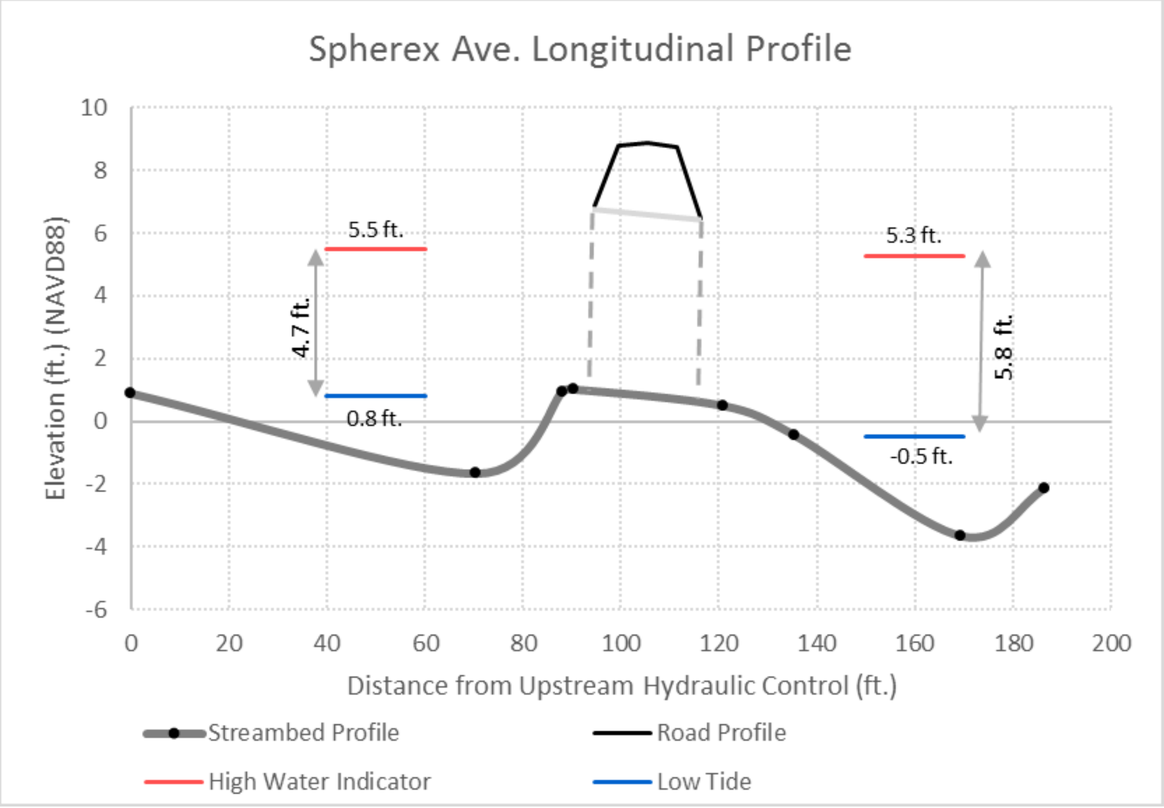
Crossing Structure Compatibility



Tidal Restriction Evaluation

Tidal Range Ratio: An Indicator for Aquatic Organism Passage

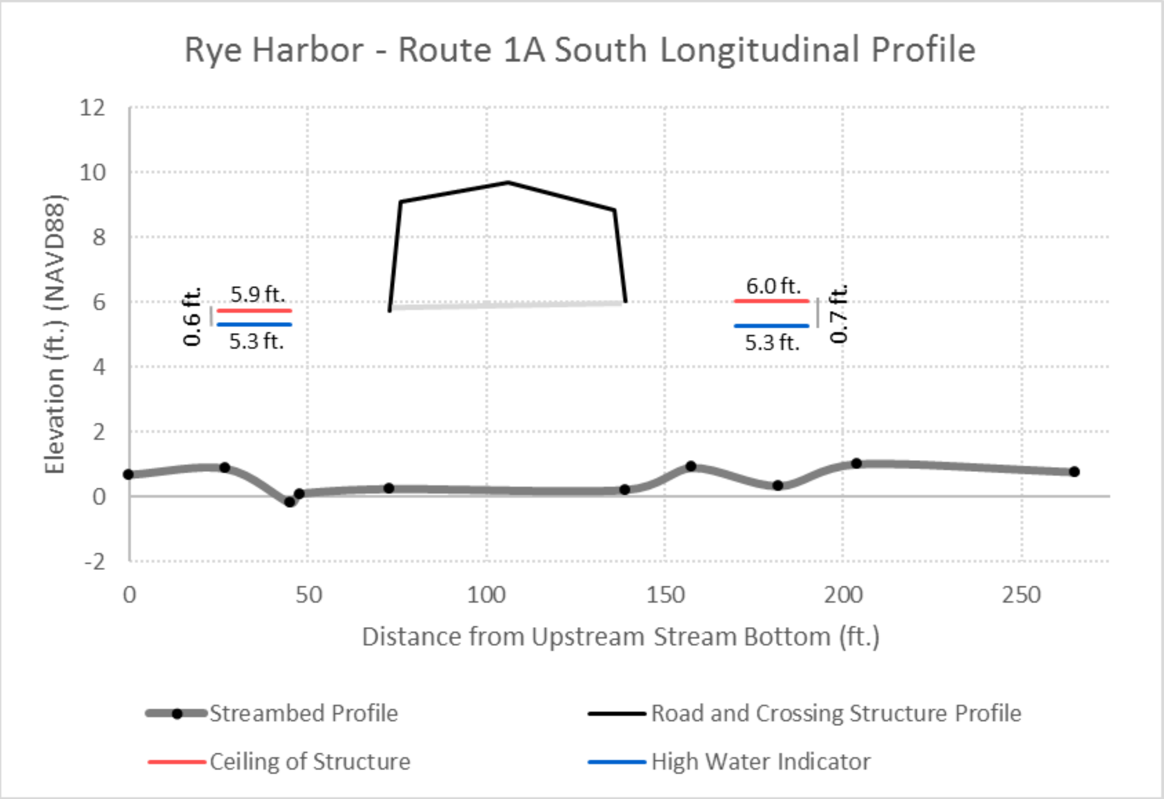
SCORE	Classification Criteria
1	No perch at low tide; stream grade through the crossing matches that of the natural system (<10% difference)
2	Tidal range downstream is between 10 and 20 percent greater than upstream
3	Tidal range downstream is between 20 and 30 percent greater than upstream
4	Tidal range downstream is between 30 and 50 percent greater than upstream
5	Downstream invert is perched at high tide, or tidal range downstream exceeds upstream tidal range by more than 50 percent



High Water Indicators?

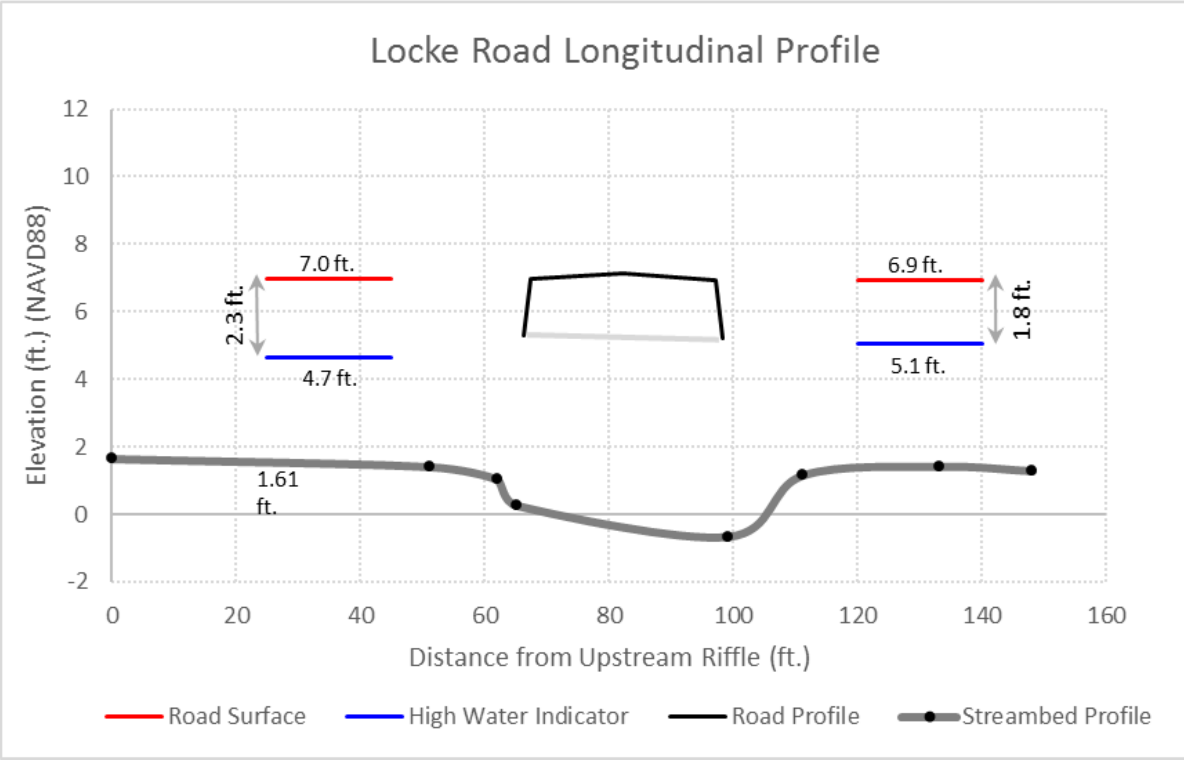
Inundation Risk to the Crossing Structure

SCORE	Classification Criteria
1	High water indicator is greater than 3' from ceiling of structure
2	High water indicator is between 2 and 3' from ceiling of structure
3	High water indicator is between 1 and 2' from ceiling of structure
4	High water indicator is less than 1' from ceiling of structure
5	High water indicator is above ceiling of structure

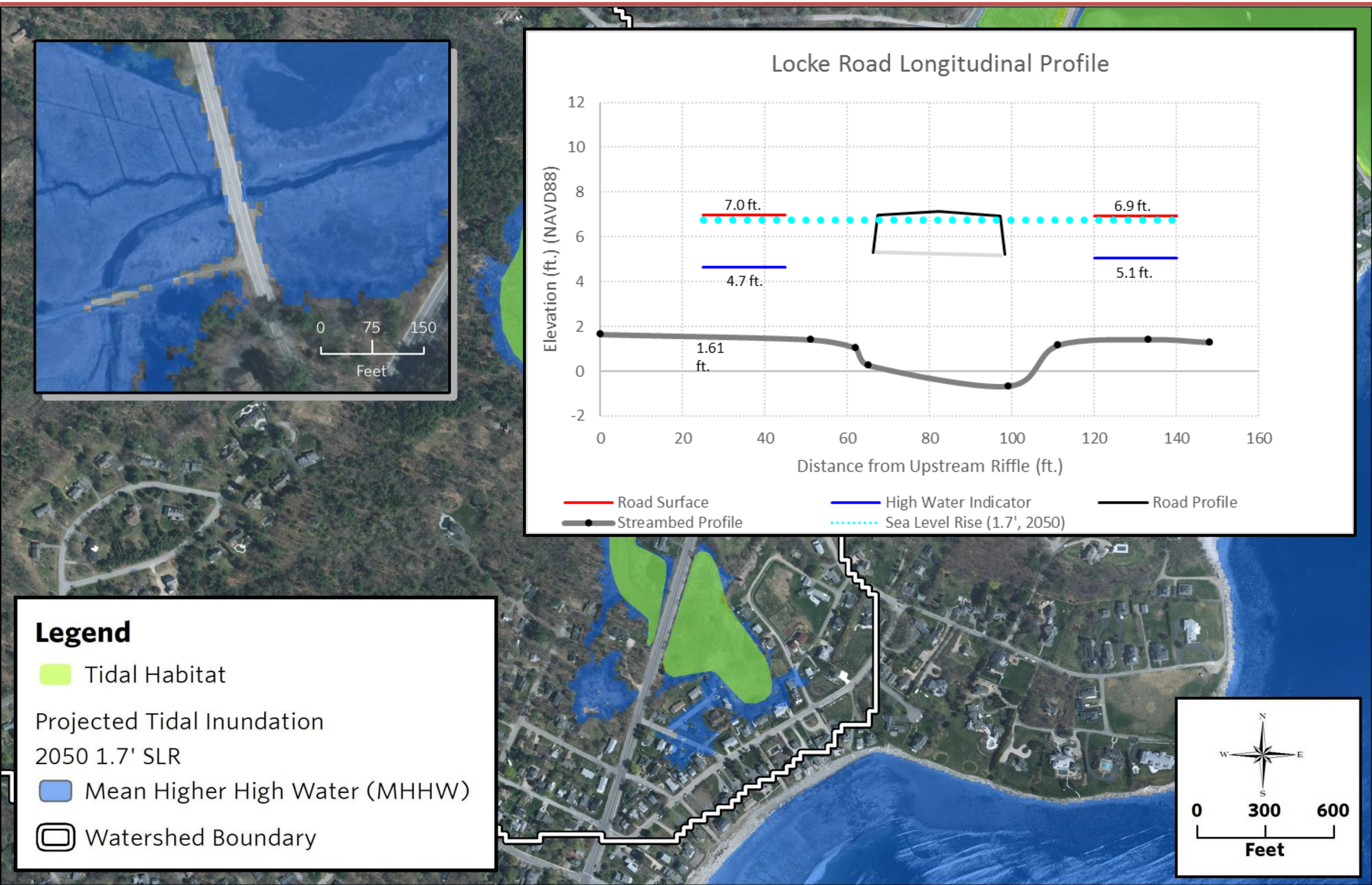


Inundation Risk to the Roadway

SCORE	Classification Criteria
1	High water indicator is greater than 6' from road surface
2	High water indicator is between 3 and 6' from road surface
3	High water indicator is between 1.5 and 3' from road surface
4	High water indicator is less than 1.5' from road surface
5	High water indicator suggests road is occasionally inundated

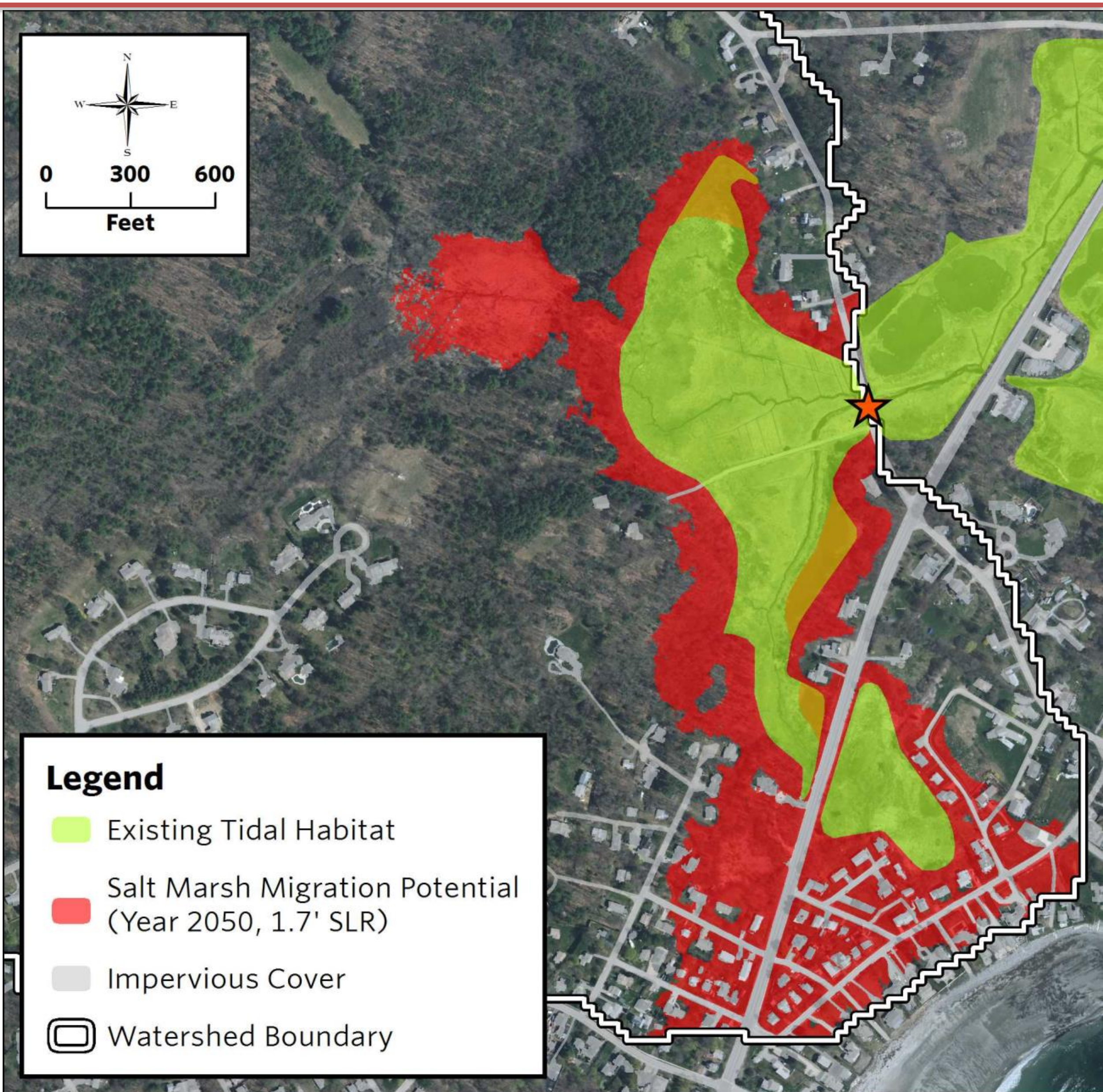


Inundation Risk



Salt Marsh Migration

SCORE	Classification Criteria
1	0-1 acre increase
2	1-2 acre increase
3	2-5 acre increase
4	5-10 acre increase
5	>10 acre increase (35 ac.!)



Scoring & Prioritization

Theme Scores

- Crossing Condition
- Tidal Restriction
- Ecological (marsh migration, vegetation comparison, aquatic organism passage)
- Inundation Risk

Plus an "Overall Score"

Next Steps & Questions?