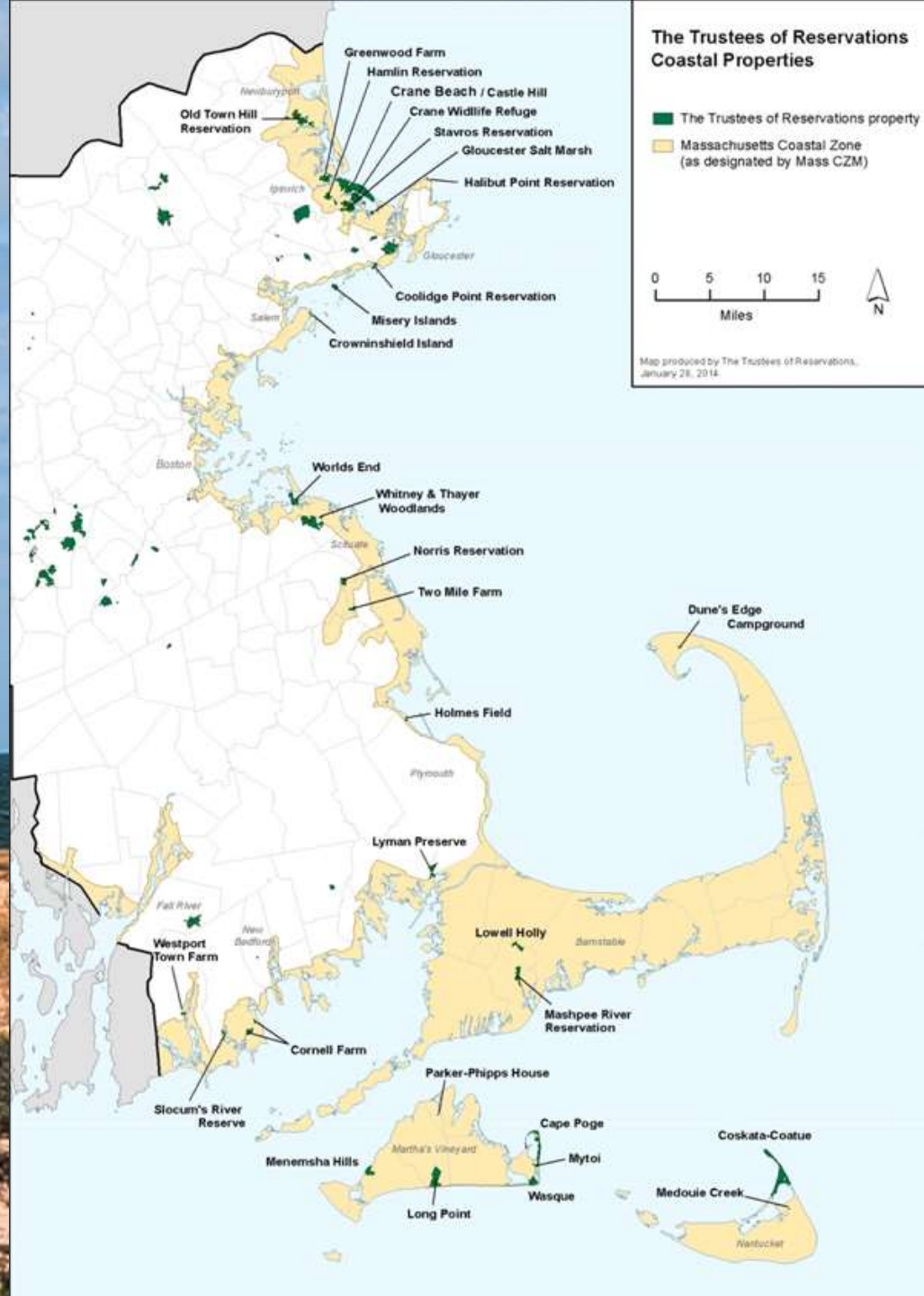
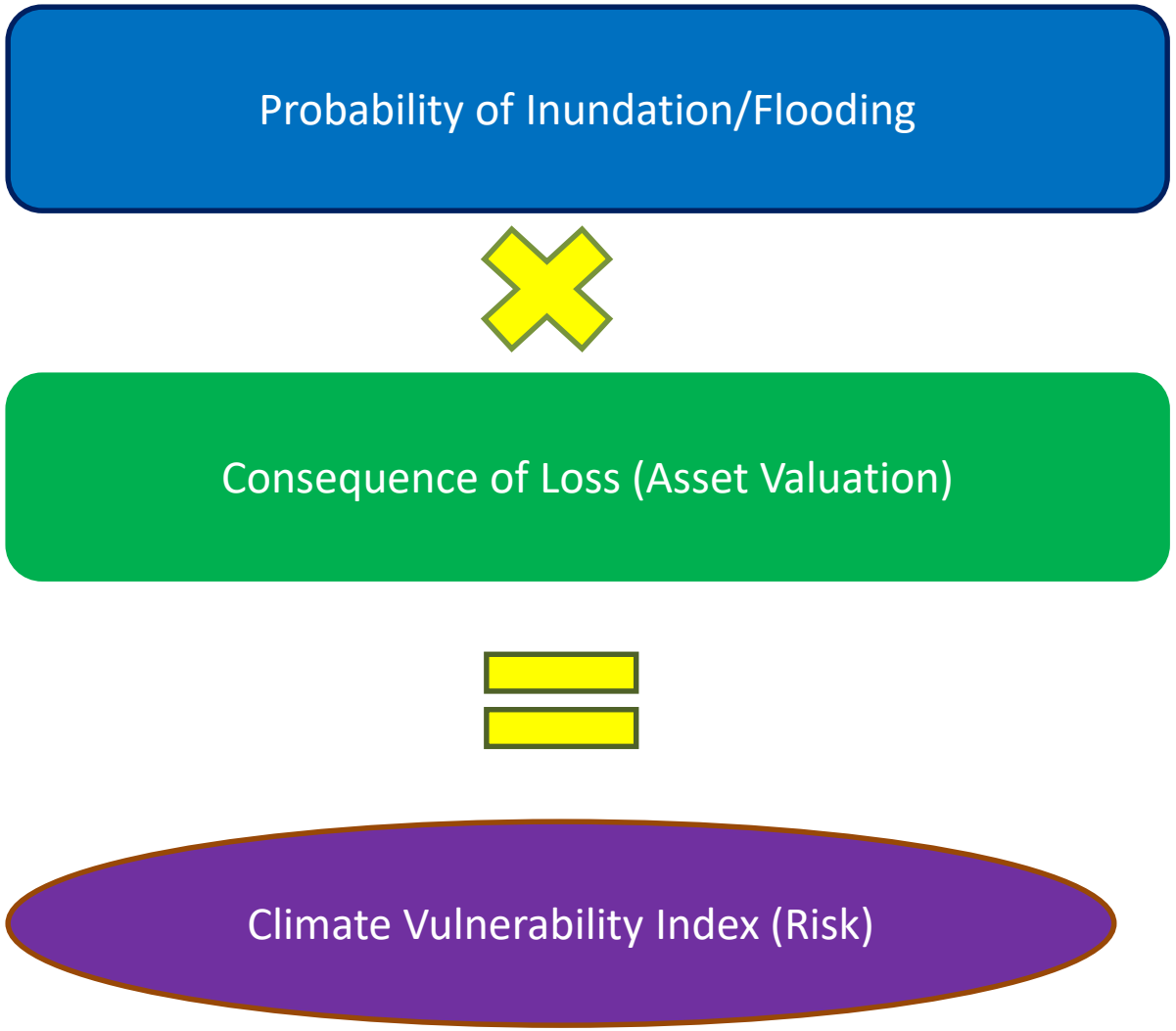
The Trustees

COASTAL STRATEGY



Chappy, Wasque recession

Coastal Vulnerability Assessment

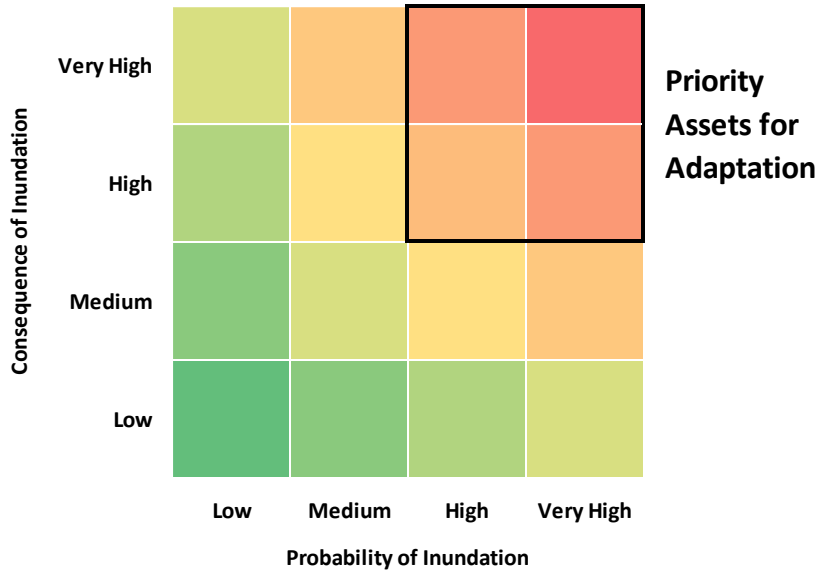


Vulnerability Assessment and Adaptation Planning

Risk Based Approach and Adaptation Investment Prioritization

- Phase I
  - SLR / Storm Surge Projections
  - Scenario Development
  - Gather asset data
  - Determine Asset Critical Elevations
- Phase II
  - Map Inundation Probability
  - Score Asset Inundation Consequence
  - Vulnerability/Risk Assessment
    - » *Risk = Probability * Consequence*
- Phase III
  - Prioritize High Risk Assets
  - Develop Adaptation Strategies for Priority Assets

Rating	Area of Service Loss	Duration of Service Loss	Cost of Damage	Impact on Public Safety & Emergency Services	Impact on Important Economic Activity	Impact on Public Health & Environment
5	Whole town/city	>30 days	>$10m	Very high	Very high	Very high
4	Multiple Neighborhoods	14-30 days	$1m-$10m	High	High	High
3	Neighborhood	7-14 days	$100k-$1m	Moderate	Moderate	Moderate
2	Locality	1-7 days	$10k-$100k	Low	Low	Low
1	Property	<1 day	<$10k	None	None	None



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Coastal Vulnerability Assessment

FID	Dataset	Property	Name	_IN	_SIG	_IN	_SIG	QUA	_SIG	_IC	_IMI	UP	TOTAL_CON	2070AVG	2030AVG	CVI2070AVG	CVI2030AVG
37	Infrastruct	Crane Beach	Argilla Road Culvert	0	0	0	0	3	2	5	5	5	44.4	100.0	100.0	4444	4444
82	Infrastruct	Wasque	Wasque Pt. Beach Stairs	0	0	0	0	5	5	4	5	0	42.2	100.0	100.0	4222	4222
90	Infrastruct	World's End	Damde Meadows Bridge	0	0	0	0	4	3	4	3	5	42.2	100.0	100.0	4222	4222
30	Infrastruct	Crane Beach	Crane-side Ferry Dock	0	0	0	0	2	1	5	5	5	40.0	100.0	99.6	4000	3985
89	Infrastruct	World's End	Damde Meadows Education Shed	0	0	0	0	4	4	5	3	0	35.6	100.0	100.0	3556	3556
41	Infrastruct	Crane Wildlife Refuge	Choate-side Ferry Dock	0	0	0	0	3	3	4	2	4	35.6	100.0	93.0	3556	3305
0	Infrastruct	Cape Poge Wildlife Refuge	Dike Bridge	0	0	0	0	5	5	5	5	0	44.4	100.0	70.7	4444	3141
2	Infrastruct	Cape Poge Wildlife Refuge	Dike Bridge Causeway	0	0	0	0	5	5	5	5	0	44.4	100.0	61.4	4444	2730
38	Infrastruct	Crane Beach	Fox Creek Bridge	0	0	0	0	3	2	0	5	5	33.3	88.8	80.0	2959	2667
40	Infrastruct	Crane Wildlife Refuge	Choate House Culvert	0	0	0	0	0	0	3	2	3	17.8	100.0	100.0	1778	1778
73	Infrastruct	Old Town Hill	Adam's Field Causeway Culvert	0	0	0	0	2	2	0	0	3	15.6	100.0	100.0	1556	1556
74	Infrastruct	Old Town Hill	Newman Road Culvert	0	0	0	0	2	2	0	0	3	15.6	100.0	100.0	1556	1556
75	Infrastruct	Old Town Hill	Newman Road Bridge	0	0	0	0	2	2	0	0	3	15.6	100.0	100.0	1556	1556
76	Infrastruct	Old Town Hill	Hay Street Bridge	0	0	0	0	2	2	0	0	3	15.6	93.4	82.3	1453	1281
70	Infrastruct	Norris Reservation	Gordon Pond Dam	0	0	3	3	3	4	0	0	0	28.9	81.1	31.1	2342	900
77	Infrastruct	Old Town Hill	Boardwalk	0	0	0	0	2	2	0	0	0	8.9	100.0	100.0	889	889
27	Infrastruct	Coskata-Coatue Wildlife Refuge	Coskata Life Saving Cottage	0	0	5	5	1	3	2	0	0	35.6	100.0	16.0	3556	570
54	Infrastruct	Long Point Wildlife Refuge	Off-season Road Culvert	0	0	0	0	3	5	1	2	0	24.4	100.0	20.0	2444	489
34	Infrastruct	Crane Beach	Store Septic Tank	0	0	0	0	0	0	0	4	4	17.8	100.0	25.0	1778	444
61	Infrastruct	Lyman Reserve	Red Brook Aluminum Bridge	0	0	0	0	0	2	0	0	0	4.4	100.0	91.2	444	405
25	Infrastruct	Coolidge Reservation	Coolidge Point Jetty	0	0	0	0	1	1	0	0	0	4.4	100.0	73.4	444	326
91	Infrastruct	World's End	Culvert	0	0	0	0	2	1	0	0	3	13.3	10.0	20.0	133	267
1	Infrastruct	Cape Poge Wildlife Refuge	Cape Poge Sand Planks	0	0	0	0	3	2	2	3	0	22.2	46.0	11.8	1021	262
72	Infrastruct	Norton Point Beach	Norton Pt. Air Station	0	0	0	0	5	5	2	5	2	42.2	100.0	5.0	4222	211
97	Infrastruct	World's End	Culvert	0	0	0	0	2	1	0	0	3	13.3	22.5	15.0	300	200

The Trustees of Reservations

OBJECTIVES

Mission-based Criteria Used in Scoring Asset Values

- Natural Resource Integrity and Significance
- Cultural Resource Integrity and Significance
- Visitor Experience Integrity and Significance
- Public Programs
- Revenue Impact
- Operational Support

WOODS HOLE GROUP | 30 YEARS

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The Trustees of Reservations

COASTAL RESOURCES

- 35 Reservations (8,000 acres)
- 39 Parking Areas
- 103 Buildings
- 106 Other Structures
- 60 miles of trail (320 segments)
- 158 Cultural Resources points
- 48 State-listed Species
- Over 100 Natural Communities

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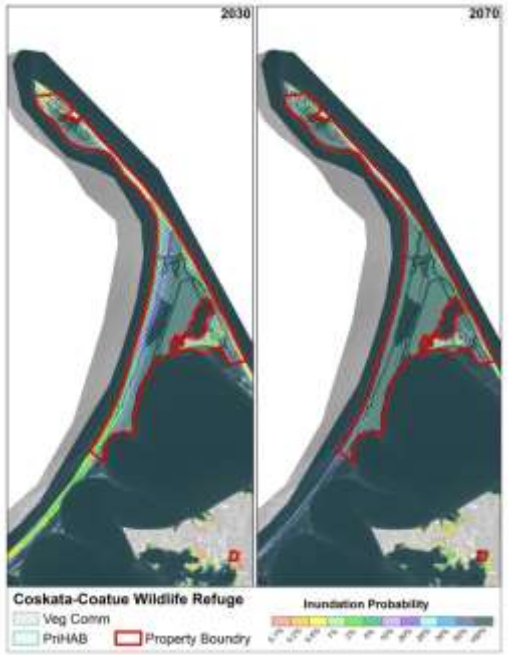
Coskata-Coatue Wildlife Refuge



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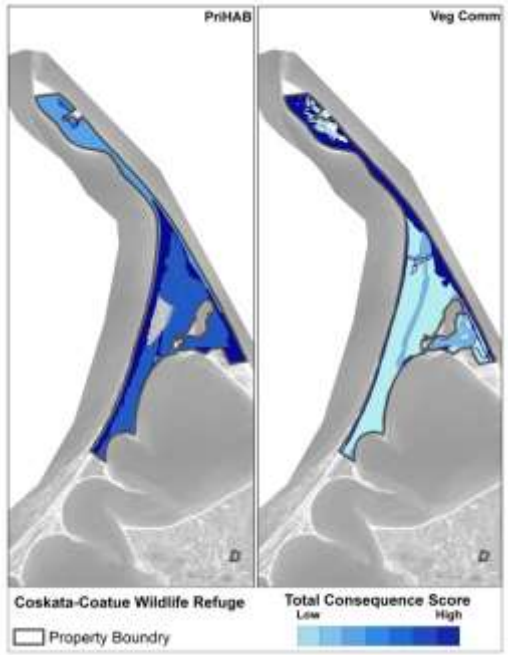

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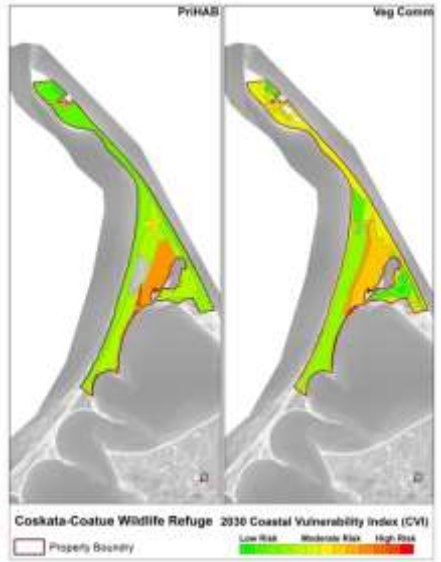

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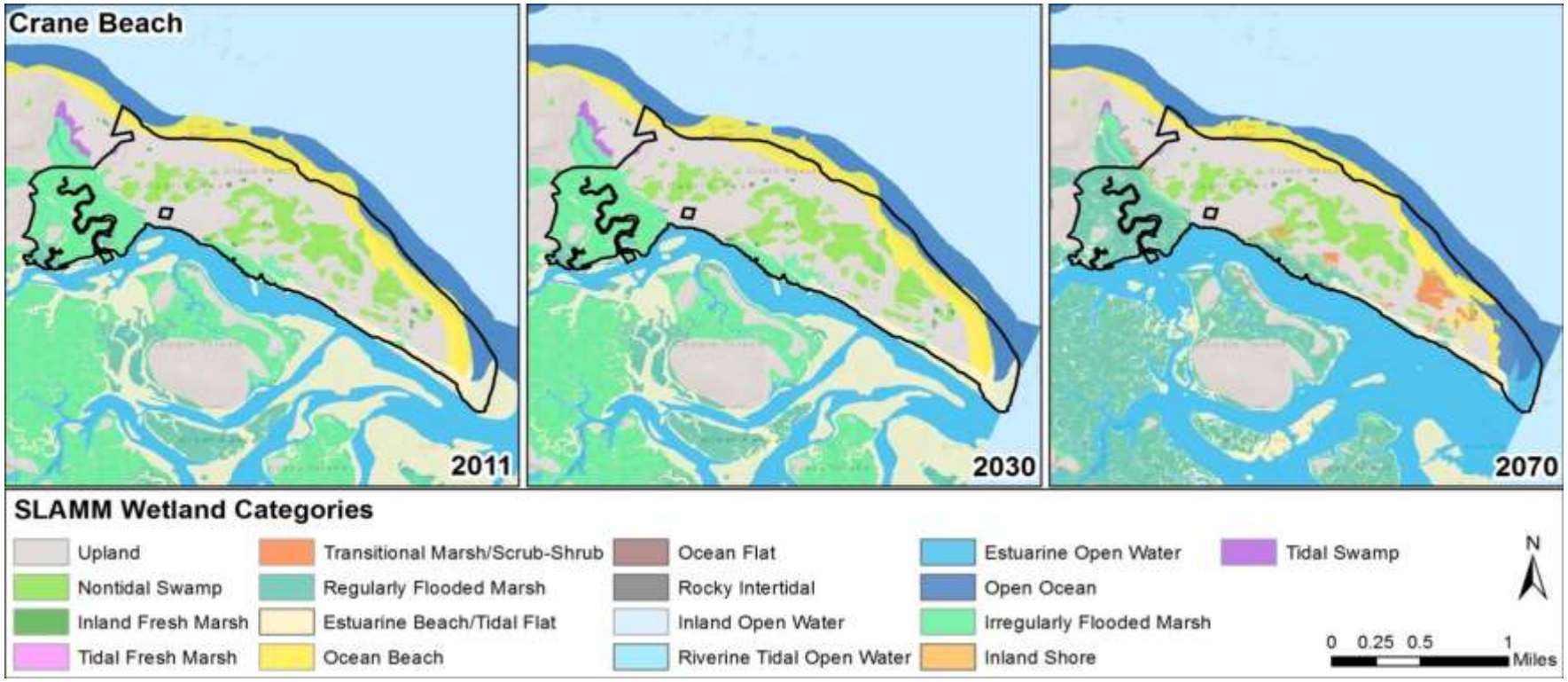
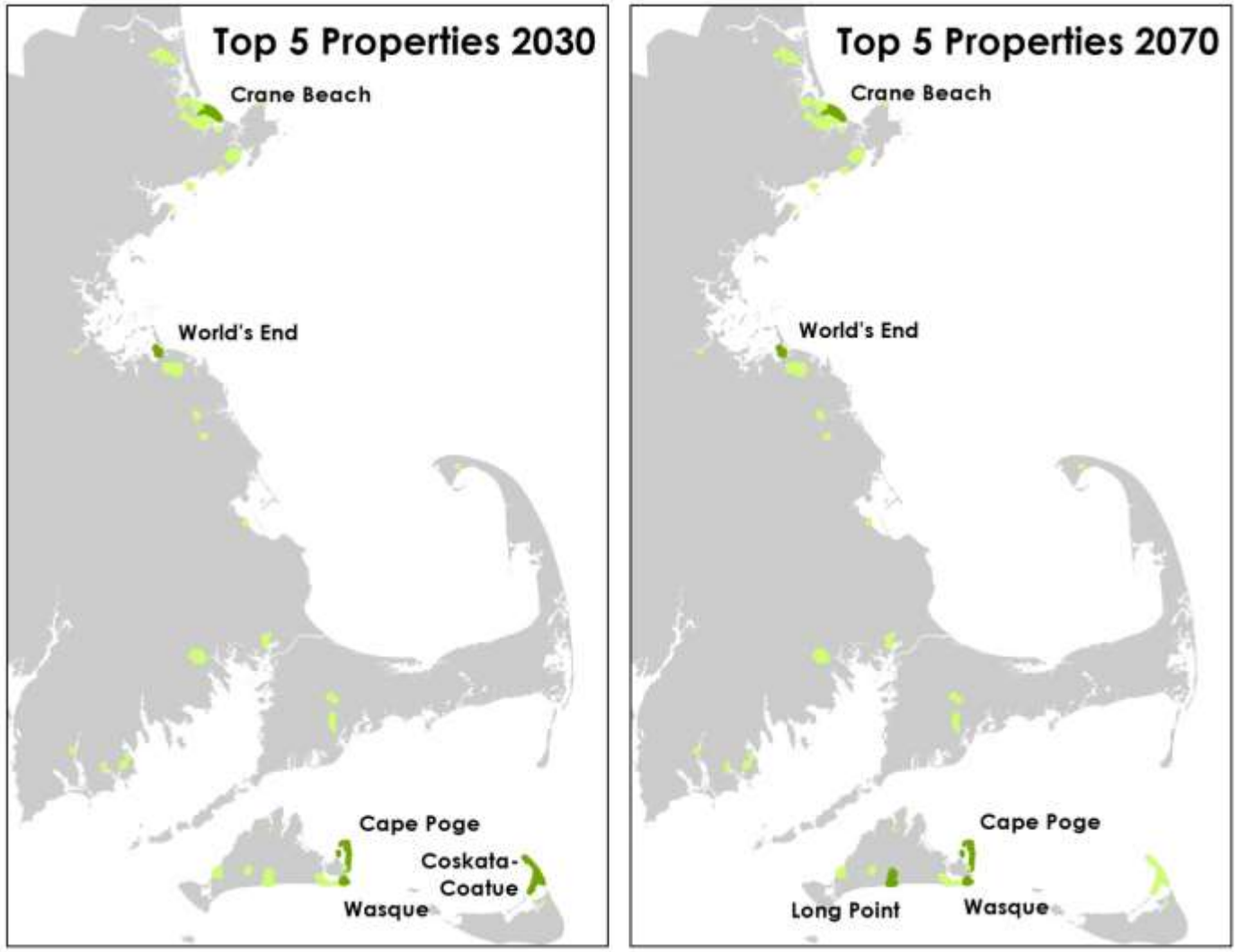
SLAMM Modeling– Example Results



Top 5 Properties

LARGEST CONCENTRATION OF HIGH RISK



Summary of Results

TRENDS

5 – 7 Properties with highest risk

Coastal wetlands (salt marsh) and beaches have the highest CVIs

Irregularly flooded marshes are shifting to regularly flood marshes

Impacts to priority habitats

Certain buildings, roads for public access, cultural resources (archaeological sites on beaches) and parking lots

Respond to a Changing Coast

COASTAL STRATEGY

- Protect and Advocate for a Healthy Coast
- Inspire a Love of Coast
- Focus on Our Most Vulnerable Places

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Protect and Advocate

COASTAL STRATEGY

- Shape a coastal land protection vision
- Publish a State of Our Coast Report
- Convene coastal conferences

Inspire an Informed Love of Coast

COASTAL STRATEG

- Build two coastal education initiatives
- Launch public awareness campaign
- Design interpretative elements

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Focus on our Most Vulnerable Places

COASTAL STRATEGY

- Design resilient public access
- Innovate nature-based coastal resilience trials
- Invite citizen scientists and researchers to monitor coastal change
- Showcase places of non-intervention

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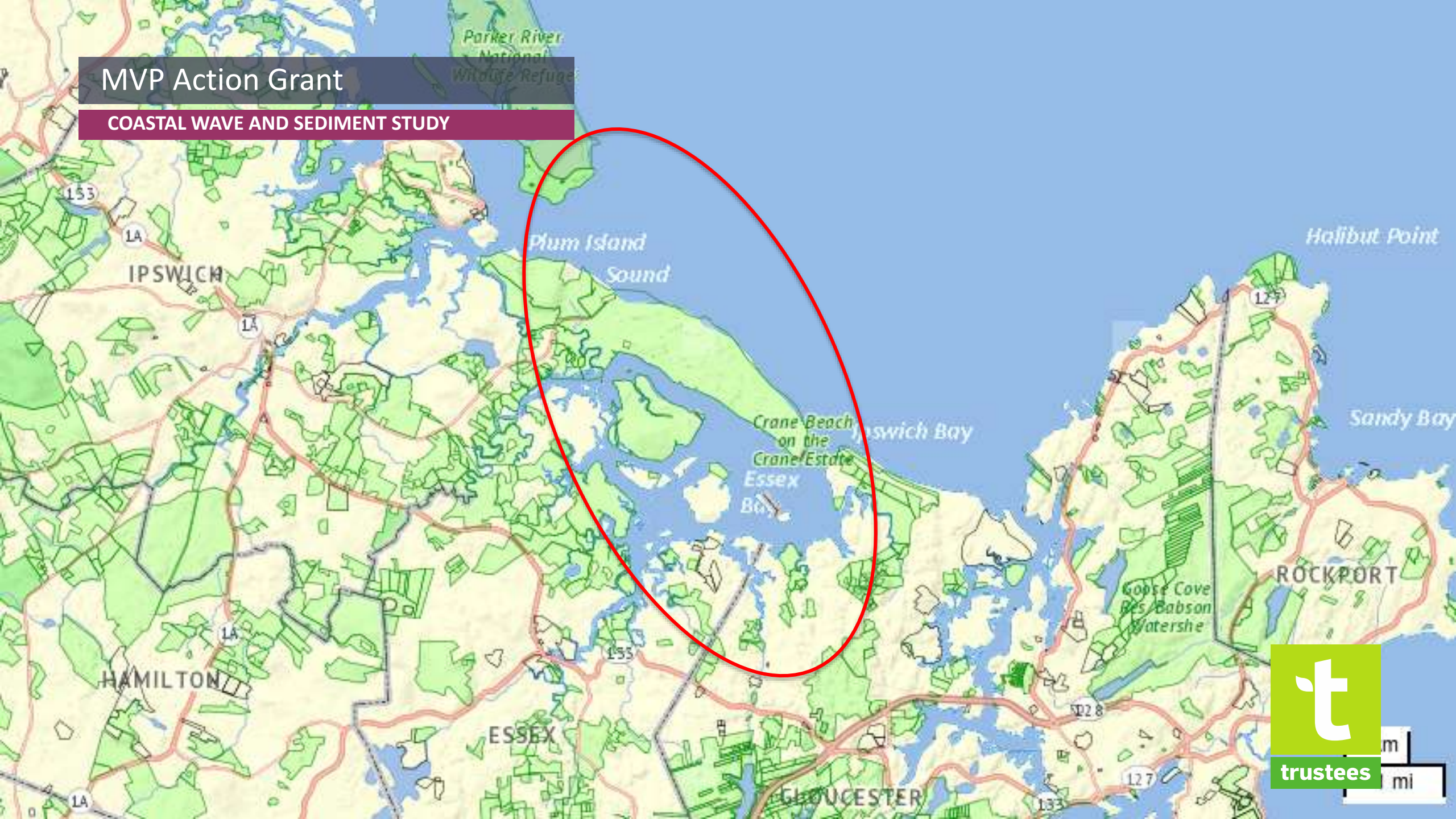
MVP Action Grant

COASTAL WAVE AND SEDIMENT STUDY



Known as The Galls (3), this area of Nantucket's barrier beach was breached in both 1984 and 1991, making Great Point, temporarily, an island.

1. GREAT POINT & GREAT POINT LIGHT

2

2. ACCESS ROADS TO LIGHTHOUSE

3

MONOMOY ISLAND, CHATHAM

4

5

Beach and Dune Restoration

BEACH PROFILING AND WAVE/SEDIMENT STUDY

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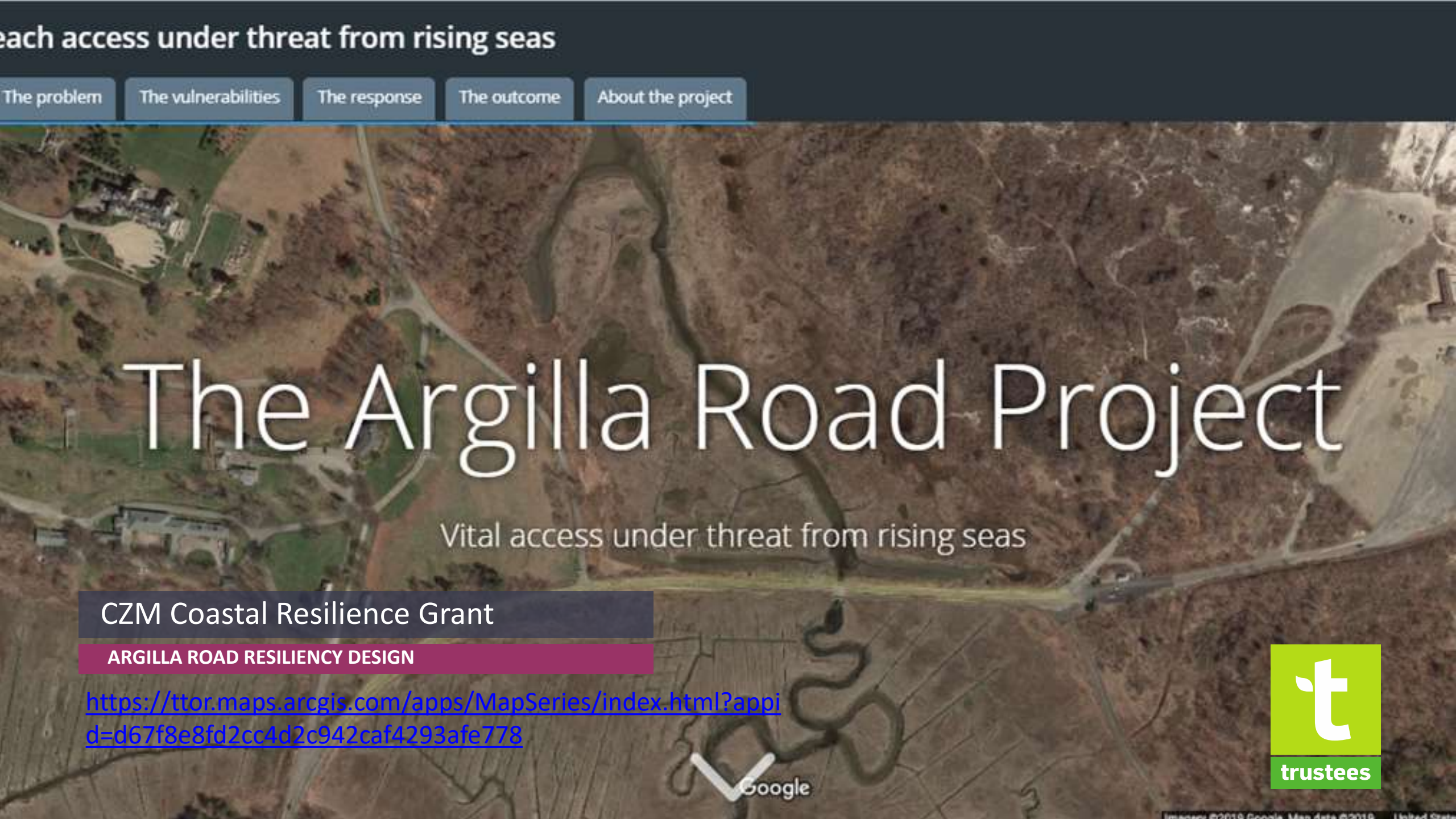
each access under threat from rising seas
The problem
The vulnerabilities
The response
The outcome
About the project
The Argilla Road Project
Vital access under threat from rising seas
CZM Coastal Resilience Grant
ARGILLA ROAD RESILIENCY DESIGN
https://ttor.maps.arcgis.com/apps/MapSeries/index.html?appid=d67f8e8fd2cc4d2c942caf4293afe778
Google
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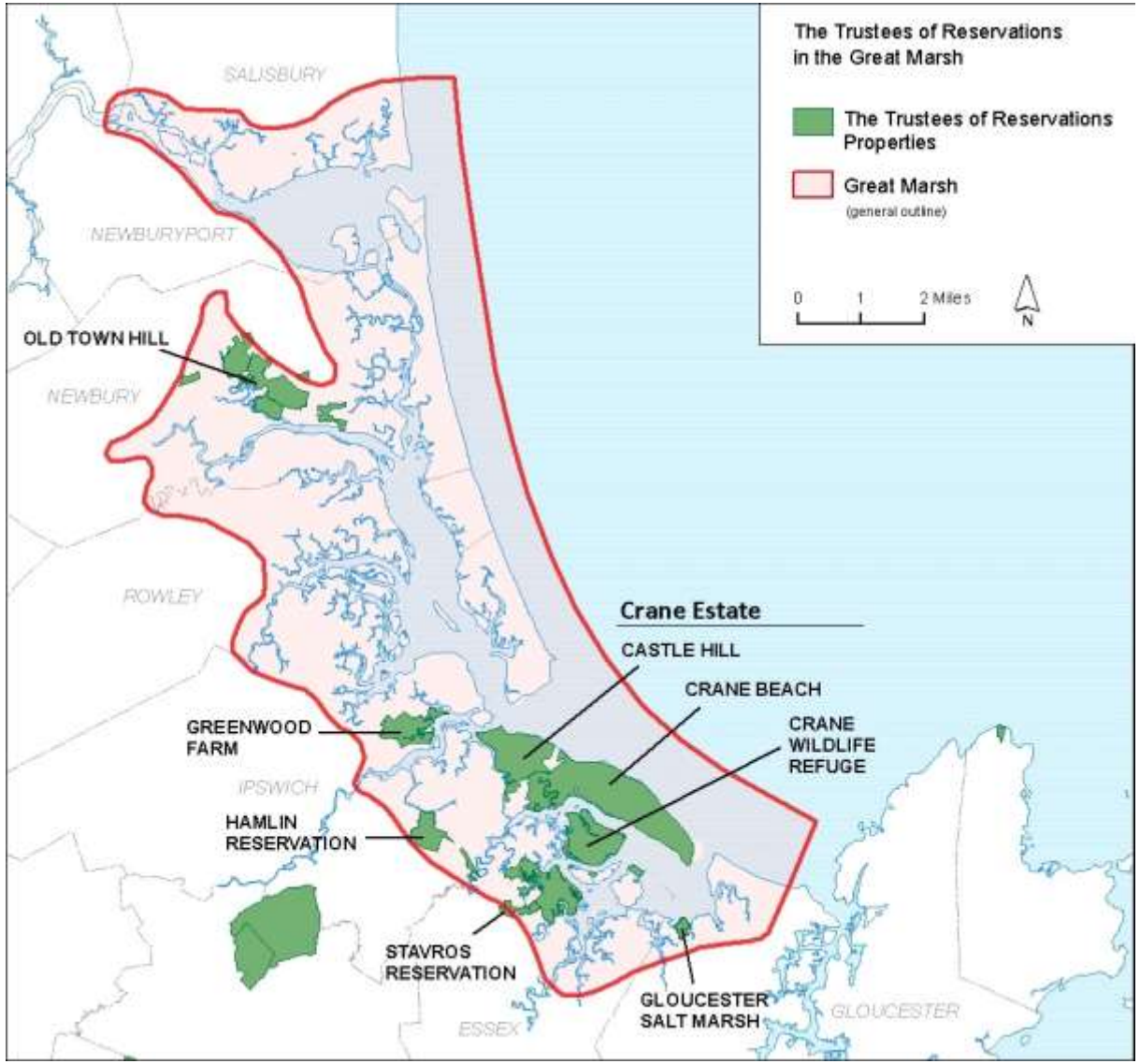
Old Town Hill Reservation

Salt Marsh Resiliency Project – Helping Salt Marshes Keep Pace with Sea-Level Rise

Great Marsh

TRUSTEES PROPERTIES



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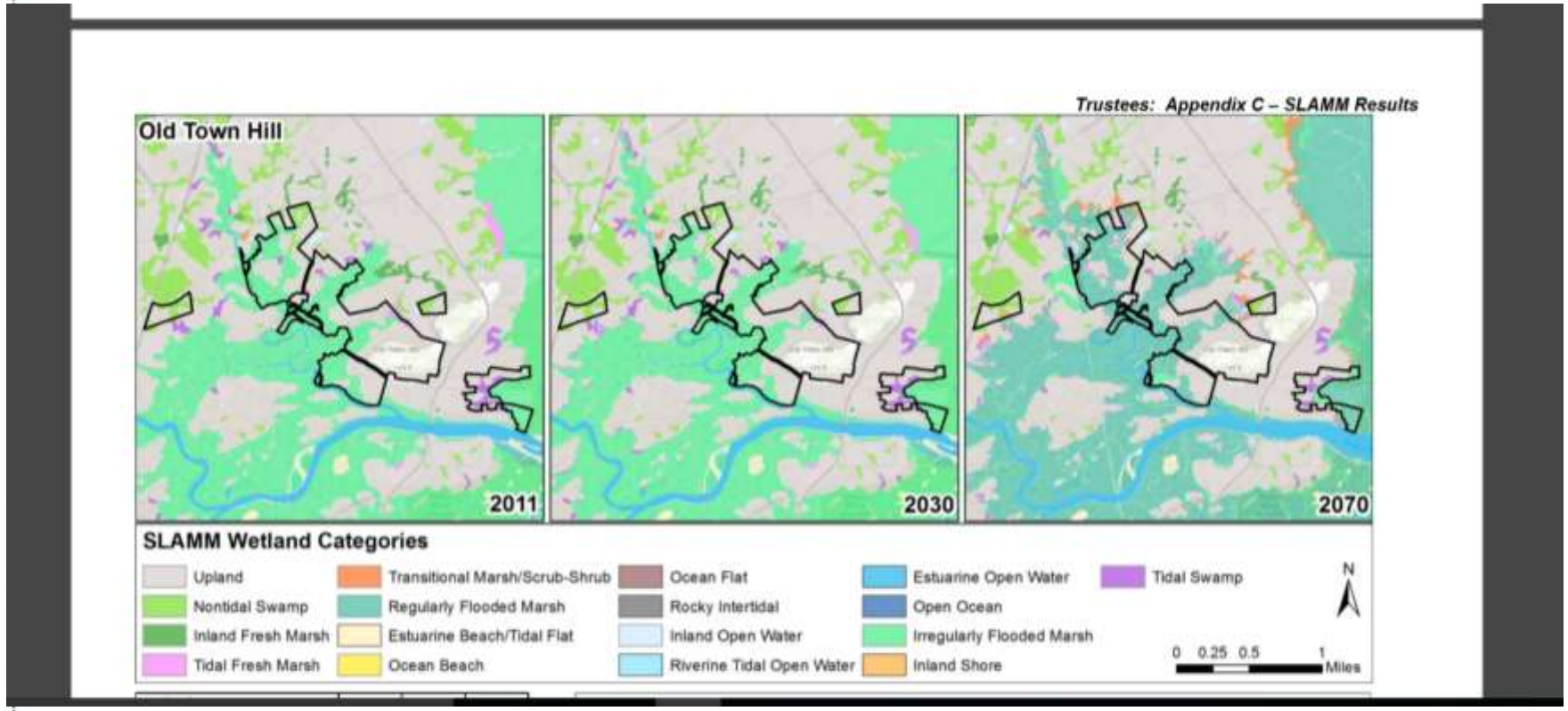
SLAMM Modeling– Example Results



Project Goal:

Restore marsh-sustaining hydrology to a heavily ditched site in order to:

- *reverse* trends of marsh *subsidence*
- *re-establish* and retain *high marsh* habitat
- *support* obligate marsh *species* (saltmarsh sparrow)
- allow marsh to *keep pace with SLR* more effectively

Salt Marsh Management Impacts at Old Town Hill Reservation

- Abandoned Agricultural Structures and Ditch Maintenance Impacts
- Failing Drainage Structures Create Waterlogged Conditions That Increase Smooth Cordgrass (*Spartina alterniflora*) Cover
- Urgency based on competing trajectories of subsidence vs SLR

Salt Marsh Management Impacts at Old Town Hill Reservation

- Abandoned Agricultural Structures and Ditch Maintenance Impacts
- Failing Drainage Structures Create Waterlogged Conditions That Increase Smooth Cordgrass (*Spartina alterniflora*) Cover
- Over Time, Vegetation Density Decreases and Mega-pool Formation Increased Shallow Standing Water on Marsh Platform

Ditch Remediation

- Restores Single Channel Hydrology in Fractured Tidesheds that have Persistent Multi-channel Hydrology
- Uses Salt Marsh Hay, Trapped Sediments, and Natural Plant Recruitment to Develop Salt Marsh Peat and Reduce Flow in Auxiliary Ditches
- Reinforces Naturalized Tidal Channel Network Within Existing Ditching Infrastructure

Ditch Remediation Plan for Old Town Hill Reservation

- As Auxiliary Ditches Vegetate, Flow Potential is Reduced
- The Remaining Untreated Ditches Transition to the Naturalized Tidal Channel Network
- Auxiliary Ditches Continue to Allow for Drainage, While Trapping Sediment and Seed Over Time
- Final Bottom Elevation of Auxiliary Ditches Defined by Plant Growth Over Time

Timeline of Actions and Expectations

Year	Action	Expectation	Adaptive Management
1 Fall 2019	Add salt hay to ditch	Twine holds salt hay through winter storms; Hay starts to trap sediment and seeds immediately	
2	Consider adding another layer	Check for seedlings and new shoots	Adjust hay within ditch to allow drainage; Add another layer of salt hay
3	Consider adding another layer	Check for expansion of vegetated areas, increased density of shoots	Make sure plant groups do not impede drainage
4		Plant roots should now be out of zone of saturation; system on proper trajectory	Add hay if not above zone of saturation; be sure water is not impounded in ditch

Monitoring

Based on Gulf of Maine Council on Marine Environment

Taylor, P.H. 2008. Salt Marshes in the Gulf of Maine: Human Impacts, Habitat Restoration, and Long-term Change Analysis. Gulf of Maine Council on the Marine Environment. www.gulfofmaine. org. IV+42 pages.

Tiered approach.

- Tier 1: Core Variables: Basic monitoring of hydrology, soils and sediments, and vegetation
- Tier 2/3: Adds faunal Core Variables
- Tier 2/3: Intensive monitoring of select variables should occur at a small number of sites
- Tier 4: Additional Variables

Saving The Great Marsh

HELPING MARSHES KEEP PACE WITH SEA LEVEL RISE

Project Partners:

- MassBays and MA CZM
- USFWS, Partners Program
- USFWS, Atlantic Coast Joint Venture
- MA Division of Ecological Restoration
- Northeast Wetland Restoration
- Rimmer Environmental Inc
- University of New Hampshire

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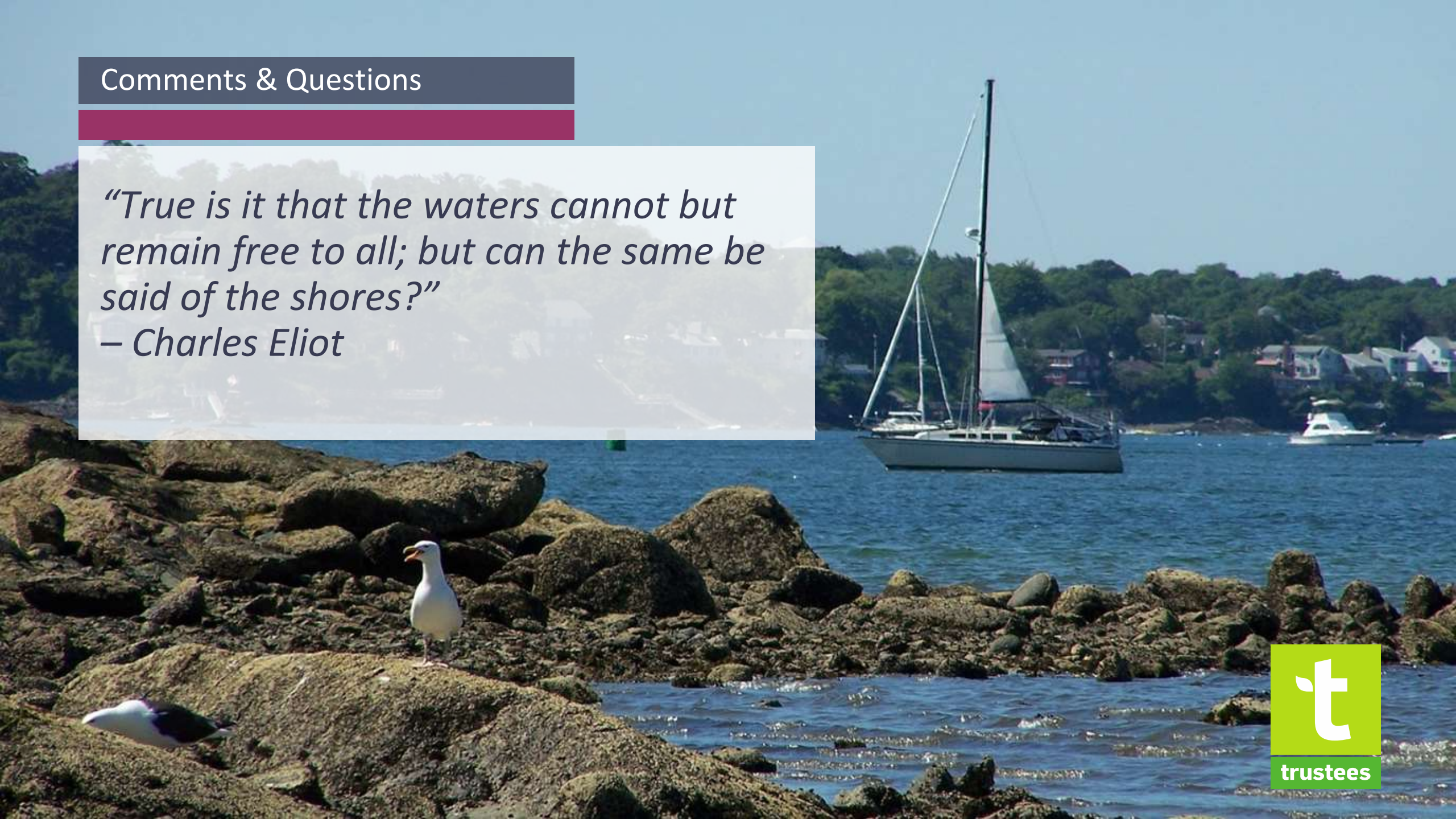
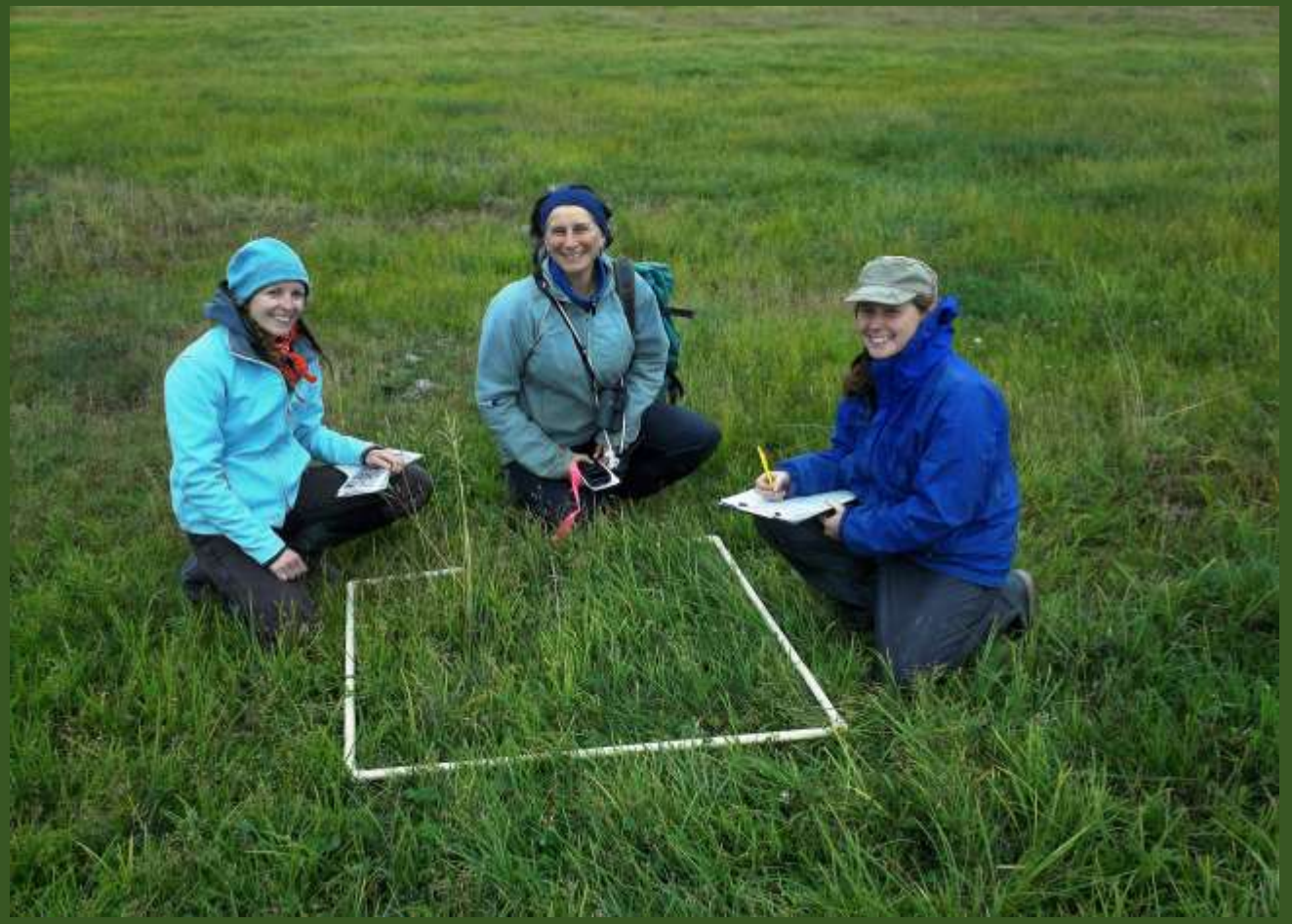
Comments & Questions

“True is it that the waters cannot but remain free to all; but can the same be said of the shores?”
– Charles Eliot



Tier 1

Vegetation within ditches will be measured with ocular % cover using 1 sq. meter plots.
Transects using point intercept will be placed perpendicular to ditches to measure vegetation at ditch edges and midway between ditches. 12-14 remediation ditches and a similar number of unrestored ditches will be monitored.



Tier 1

Elevation of ditches will be measured using calibrated laser level (1 cm resolution) based on permanent benchmarks. Ditch elevation will be monitored short-term annually for up to 5 years or until ditch elevations have been restored to the marsh plain.

Tier 1

Hydrology signal.

Measured with water-level loggers (5) upstream and downstream to measure changes on the marsh plain between treated and untreated areas. Loggers will be deployed for 1 lunar cycle (4 weeks) and repeated for up to 4 months.

Tier 2

Breeding birds will be monitored as the faunal core variable

Salt marsh bird surveys following the **SHARP protocol** will be conducted in year 2 and 5.

Ten plots have been established in the study site and baseline data was collected in 2018.

Marsh species will be measured by relative density and species richness.

Tier 2/3

Mosquito Monitoring: Permanent stations in a Before-After-Control-Impact design.

Permanent stations in pool/wet areas, with 3 dips of 350-milliliter cup in 3-meter-radius circles, at impacted/restored and reference sites (10 dip stations/site)

Tier 4

Elevation Change:

- High precision Surface Elevation Tables (SET)
- Short- & long-term trends
- Capacity to compare to regional trends
- Capacity to compare to SLR rates

Tier 4

Sediment Accretion

- Feldspar marker horizon plots in-ditch
  - Cryo-core extraction
  - Assess accumulation of sediment and organic material

Permitting

1. **Massachusetts Department of Environmental Protection:**

   Combined Wetlands Protection Act and 401 Water Quality Certification review through an Ecological Restoration Notice of Intent

   No Chapter 91 Licensing anticipated

2. **Army Corps of Engineers – Section 404 of Clean Water Act**

   Pre-project consultation to determine compliance with General Permit

3. **Massachusetts Division of Fisheries and Wildlife:**

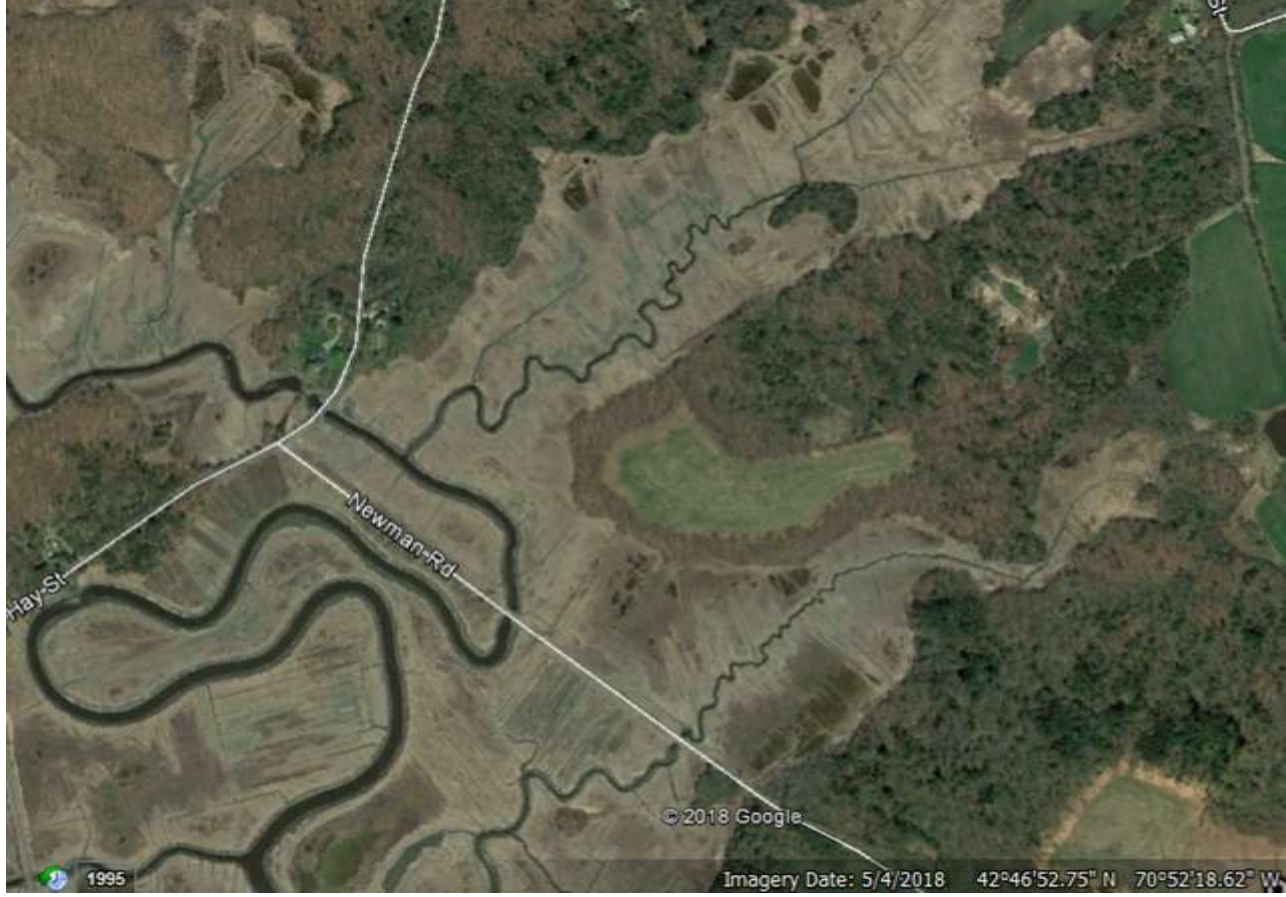
   Massachusetts Endangered Species Act Review for work in Priority Habitat

4. **Massachusetts Division of Marine Fisheries**

   Pre-project consultation

Funding

OLD TOWN HILL SALT MARSH PROJECT



Total Project Cost - $256,000

Funding Source(s) – $160,000

- MassBays - $15,740 for design and permitting

- MA Division of Ecological Restoration
  FY19 awarded $25,000
  FY20 requested $40,000

- USFWS Partners Program for ‘at-risk species’ - $30,000

- USFWS NAWCA Small Grant - $50,000 pending for restoration of 30 acres (+$50,000 for land acquisition of salt marsh migration pathways)

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Building Resilience through Adaptation Designs Argilla Road Phase I - Ipswich, MA

Tonight's Speakers

- **Frank Ventimiglia**, Town of Ipswich, Department of Public Works
- **Tom O'Shea**, The Trustees
- **Ted Wickwire**, Woods Hole Group
- **Matt Shultz**, Woods Hole Group
- **Jen Ducey**, Stantec

With Technical Support from:

- **Peter Pinciaro**, The Trustees
- **Carole McCauley**, The Trustees
- **Kathryn Glenn**, MA Office of Coastal Zone Management

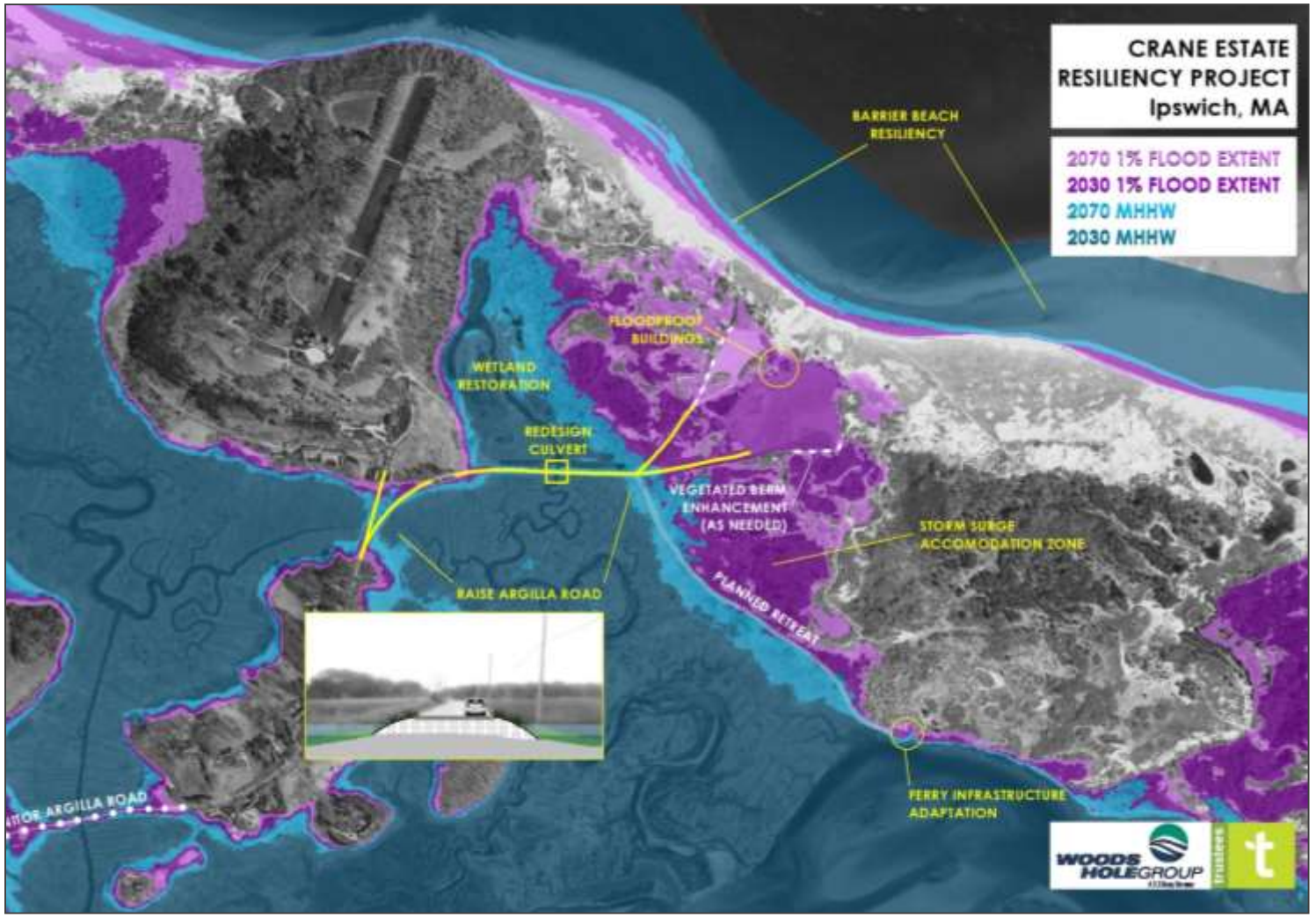
Why Argilla Road

Historic Flooding

- Extreme high tides
- Storm surge
- Increase during recent years

Trustees Coastal Vulnerability Study

- Looked at flood inundation on Trustees' coastal properties using various sea level rise scenarios
- Most susceptible area: Argilla Road between Castle Hill and Crane Beach entrances
- By 2030, more sections of the road will be susceptible to flooding at high tide
- By 2070, significant portions of the road will be underwater at high tide



Argilla Road Flood Mitigation Project

Scope of Work

- Complete a “30% design” for a flood-resilient Argilla Road that uses living shoreline techniques for slope stabilization
- Identify design alternatives that incorporate analysis of collected data
- Evaluate permitting issues with proposed improvement work

What is a 30% Design?

- A 30% design is part-way to a full design
- Includes enough detail/specs to allow engineers to realistically model and assess design alternatives
- Survey work carried out in Autumn 2018

Data Collection: Existing conditions survey

Purpose:

- Site survey to obtain spot elevations and map visible surface features
- Validate marsh elevations for modeling efforts

Methods:

- Field work using standard survey techniques
- Record plan review
- Basemap creation in AutoCAD

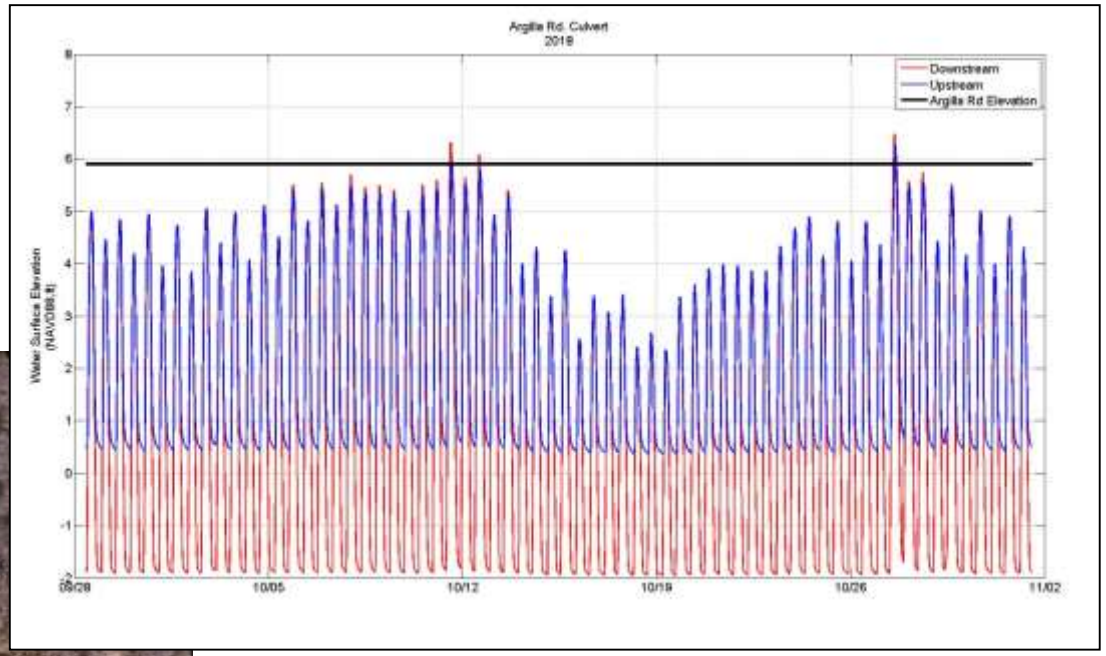
Data Collection: Tidal data

Purpose:

- Measure a full lunar month of tidal cycles, including astronomically high tides to establish local tidal datums

Methods:

- Tide gauges placed on a weighted grate placed gently on the creek bed on either side of the culvert
- Retrieve after 30 days
- Use data in combination with NOAA Tide Station Data (continuous collection) to inform hydrodynamic model



Data Collection: Wetland survey and channel profiles

Purpose:

- Delineate the extent of wetlands as defined by the Commonwealth
- Identify important species and communities found at the site
- Create a topographic map of the wetland/channels to support hydrodynamic modeling

Methods:

- Soil and vegetation characterization fieldwork
- Review of existing site studies/plans
- Profiles generated using a high resolution geographic positioning system (GPS)

Data Collection: Subsurface investigation

Purpose:

- Understand what makes up the current roadbed and embankment, in particular the thickness and consistency of each soil strata

Methods:

- Five test borings were drilled along the roadway ranging in depth fr0m 17 to 26 feet below the ground surface
- Samples were tested in the laboratory for grain size, organic content and plasticity

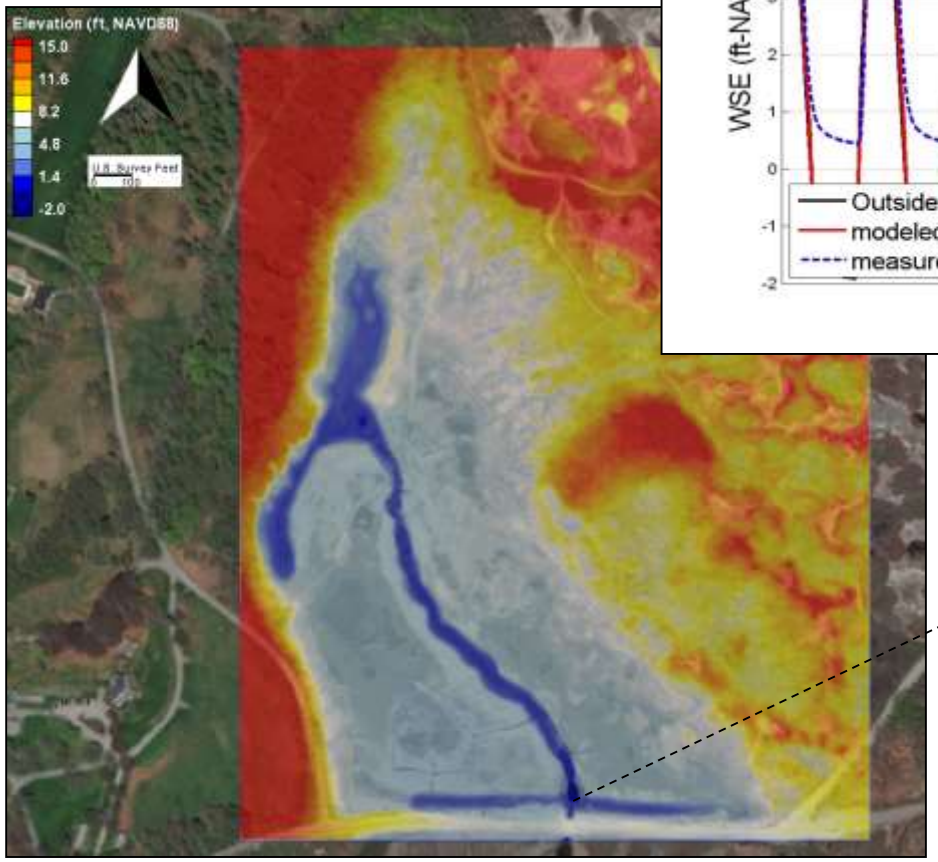
Data Analyses: Tidal hydraulics modeling

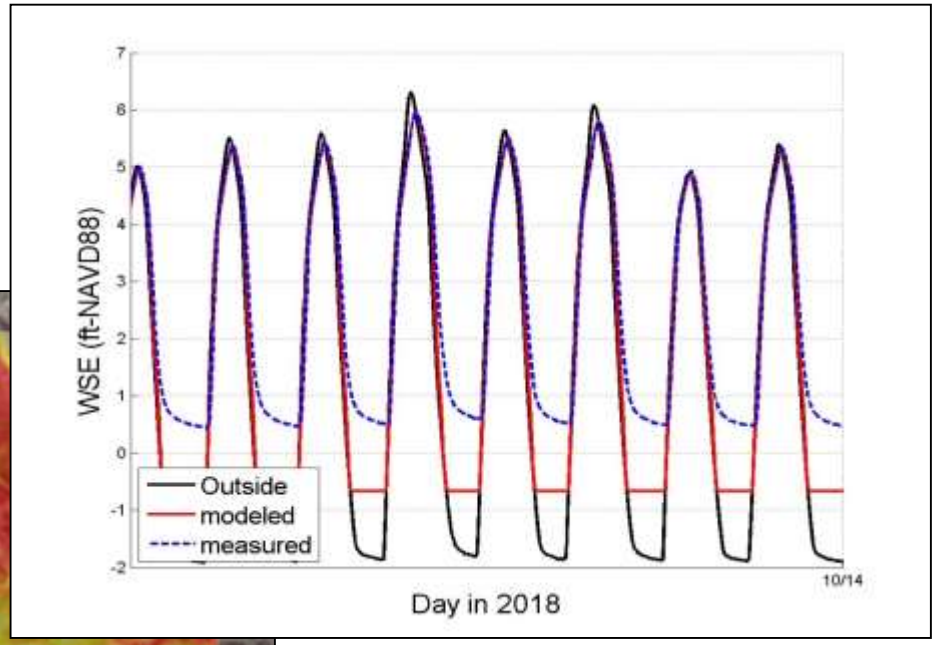
Purpose:

- Inform culvert redesign (size, elevations, etc.) and potential salt marsh restoration

Methods:

- Analytical 1-D culvert-estuarine model
- Model calibrated and validated to measurements
- Simulations of typical tides for present-day sea level and with 2.3 feet of sea level rise





Data Analyses: Culvert analysis

Purpose

- Determine recommended specs for culvert replacement

Methods

- Hydraulic modeling helps to determine the best size for a culvert

From hydraulic model:
Recommend a box culvert with 10’ high by 8’ wide opening to restore full tidal range and reduce velocities

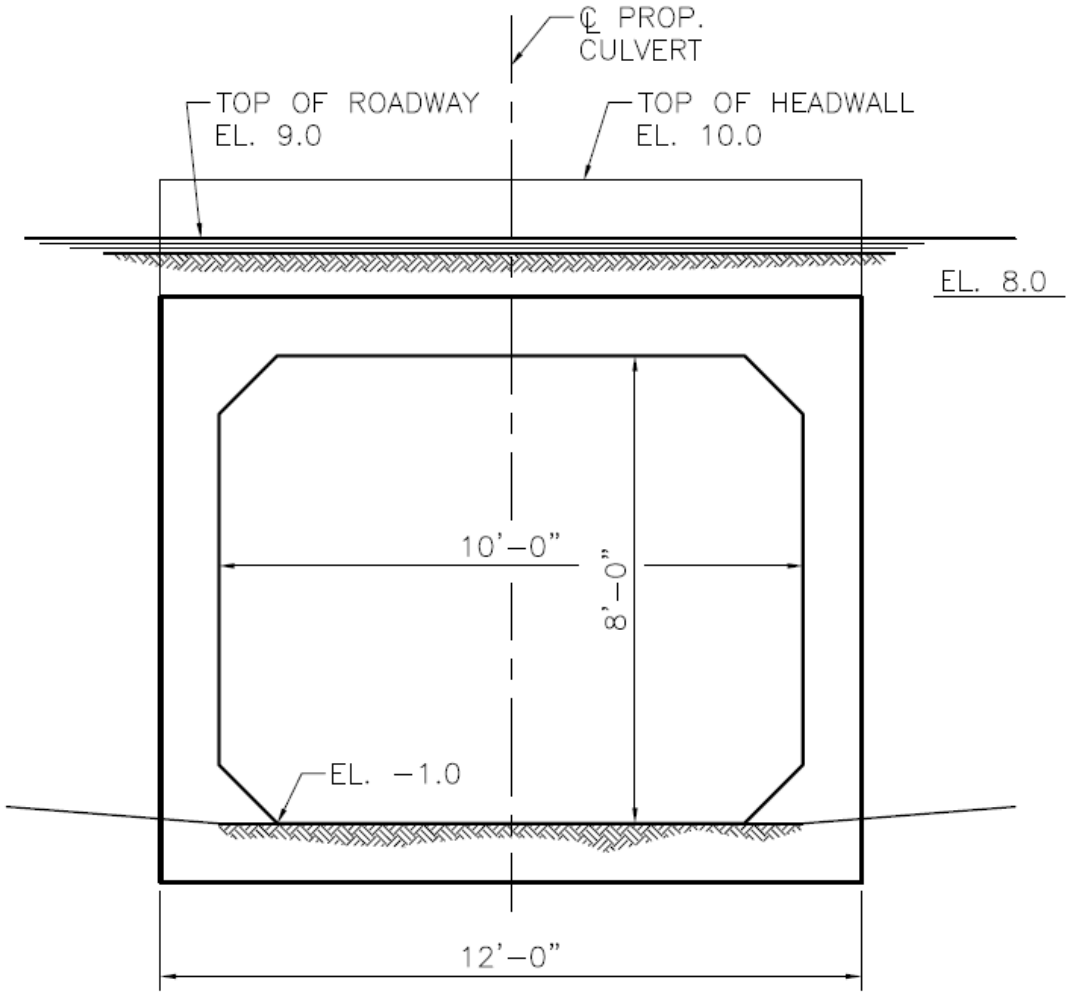
Design Development: Replacement culvert

Goals

- Increase hydraulic opening to restore full tidal range and reduce velocities
- Use durable structure material for salt water environment
- Minimize tidal flow interruption during construction
- Minimize demo/construction timeframe

Alternatives

- Single Precast Box Culvert
- Three-Sided Precast Culvert
- Twin Precast Box Culvert



Design Development: Roadway

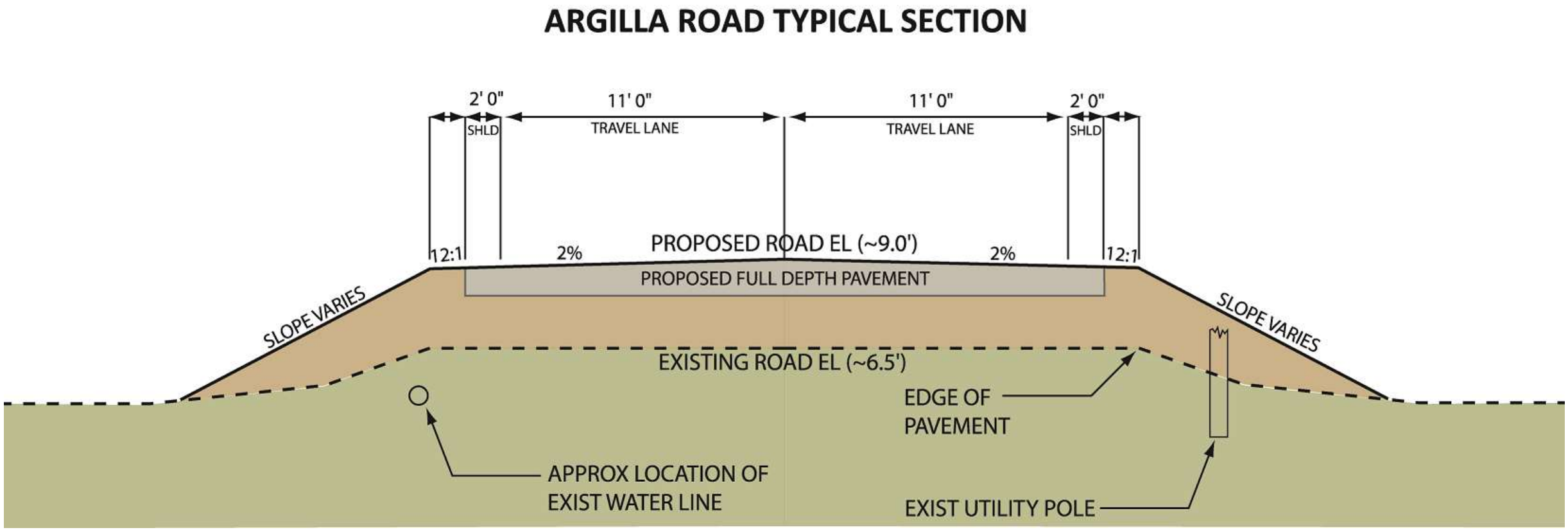
Goals

- Design a resilient roadway structure
- Assess impacts to adjacent resource areas
- Limit interruptions to beach and estate access during construction

Key Considerations

- Proximity of adjacent resource areas
- Match existing paved footprint
- Maintain existing utilities on-site
- Constructability and anticipated construction sequence/timing

Design Development: Roadway



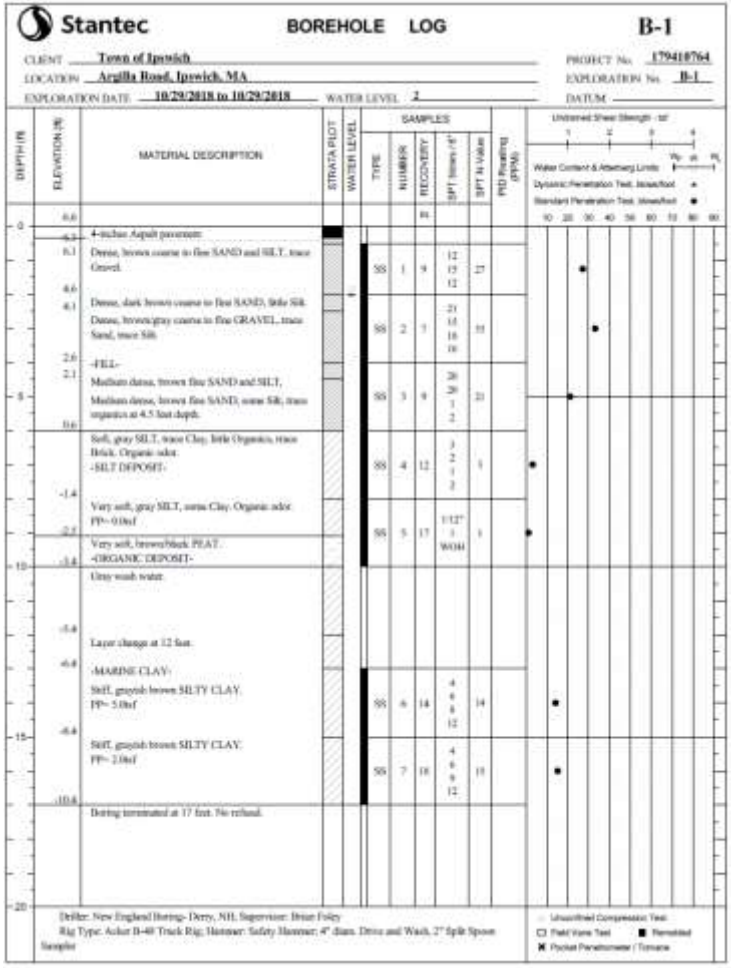
Design Development: Geotechnical

Goals

- Provide culvert foundation recommendations
- Estimate settlement that may occur
- Evaluate side slope stability

Key Considerations

- Long term performance of the roadway and culvert
- Proximity of adjacent resource areas


Stantec BOREHOLE LOG B-1

CLIENT Town of Ipswich
LOCATION Argilla Road, Ipswich, MA
EXPLORATION DATE 10/29/2018 to 10/29/2018
WATER LEVEL 2
PROJECT No. 179410764
EXPLORATION No. B-1
DATUM

DEPTH (ft) | ELEVATION (ft) | MATERIAL DESCRIPTION | STRATA PLOT | WATER LEVEL | SAMPLES: TYPE, NUMBER, RECOVERY (in), SPT blows/6" | SPT N Value | PID Reading (PPM) | Unconfined Shear Strength - tsf | Water Content & Atterberg Limits | Dynamic Penetration Test, blows/foot | Standard Penetration Test, blows/foot

0 | 0.6 | 4-inches Asphalt pavement
0.1 | Dense, brown coarse to fine SAND and SILT, trace Gravel. | SS | 1 | 9 | 12 15 12 | 27
4.1 | Dense, dark brown coarse to fine SAND, little Silt. Dense, brown/gray coarse to fine GRAVEL, trace Sand, trace Silt. | SS | 2 | 7 | 21 16 16 16 | 32
2.6 | -FILL- | SS | 3 | 9 | 20 20 1 2 | 21
2.1 | Medium dense, brown fine SAND and SILT, Medium dense, brown fine SAND, some Silt, trace organics at 4.5 feet depth.
0.6 | Soft, gray SILT, trace Clay, little Organics, trace Brick. Organic odor. -SILT DEPOSIT- | SS | 4 | 12 | 3 2 1 2 | 3
-1.4 | Very soft, gray SILT, some Clay. Organic odor. PP= 0.0tsf
-2.7 | Very soft, brown/black PEAT. -ORGANIC DEPOSIT- | SS | 5 | 17 | 1/12" 1 WOH | 1
-3.4 | Gray wash water.
10 | Layer change at 12 feet. -MARINE CLAY- Stiff, grayish brown SILTY CLAY. PP= 5.0tsf | SS | 6 | 14 | 4 6 8 12 | 14
-8.4 | Stiff, grayish brown SILTY CLAY. PP= 2.0tsf | SS | 7 | 18 | 4 6 9 12 | 15
-10.4 | Boring terminated at 17 feet. No refusal.
15
20

Driller: New England Borings- Derry, NH. Supervisor: Brian Foley
Rig Type: Acker D-40 Truck Rig. Hammer: Safety Hammer; 4" diam. Drive and Wash, 2" Split Spoon Sampler

Unconfined Compression Test
Field Vane Test
Remolded
Pocket Penetrometer / Torvane

Boring Location Plan
Argilla Road Adaptation Designs
Ipswich, Massachusetts
November 21, 2018

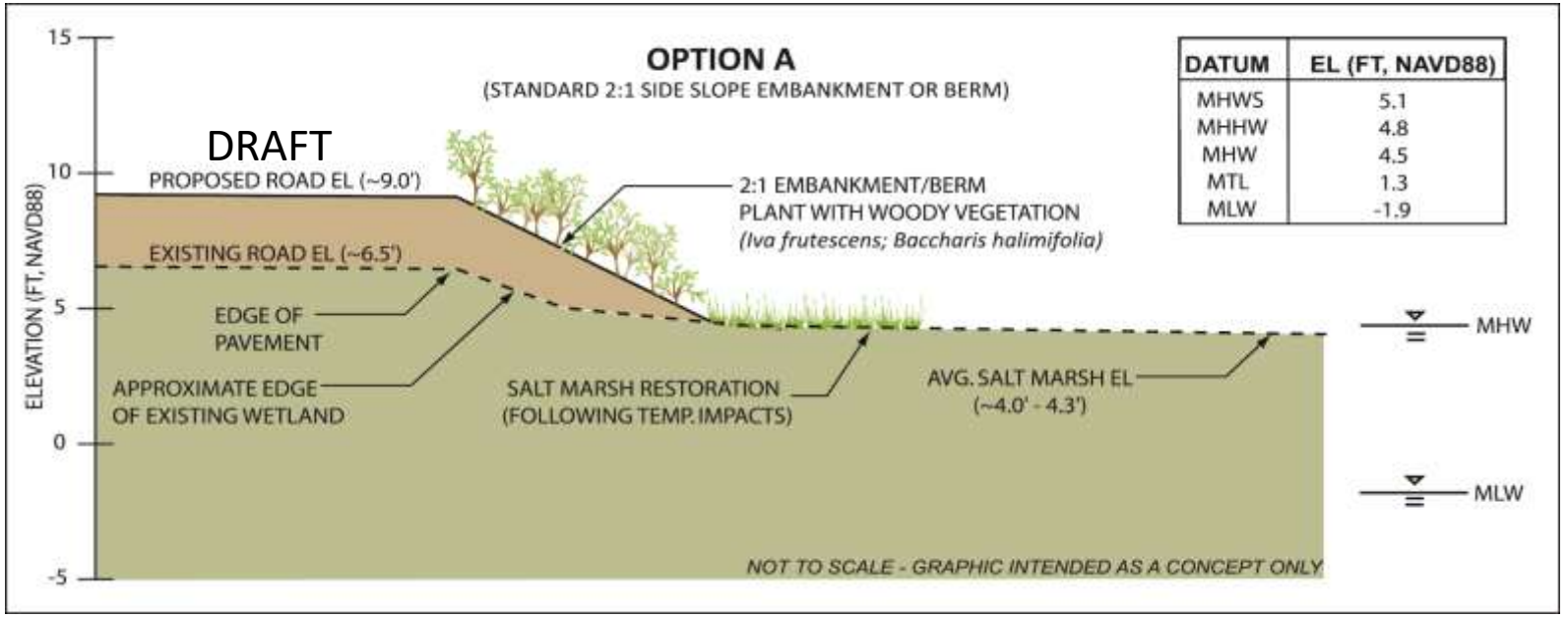
Data Analyses: Living shorelines

Concepts

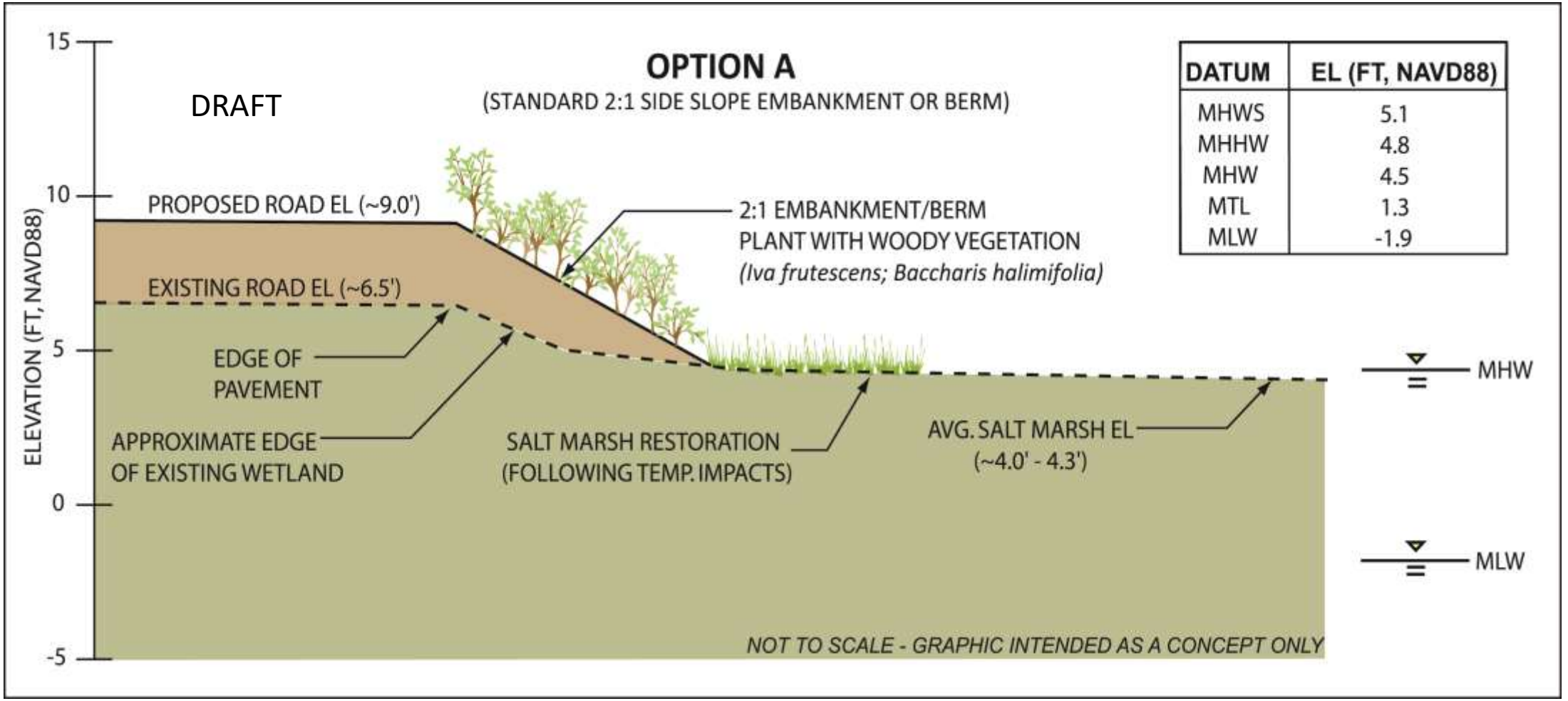
- New approach for road side slope stabilization
- Primary goal – stabilize the road for safety
- Use natural components (plants, stone, soil)
- Test two different designs for durability, function, maintenance requirements
- Include monitoring Program
- Permitting is key challenge – need to evaluate net balance of salt marsh acreage
- Consider impact of overtopping

Alternatives

- Choose 2 (maybe a hybrid of draft concepts)
- Calculate temporary and permanent changes to existing wetland areas
- Final Selection TBD



Data Analyses: Living shorelines



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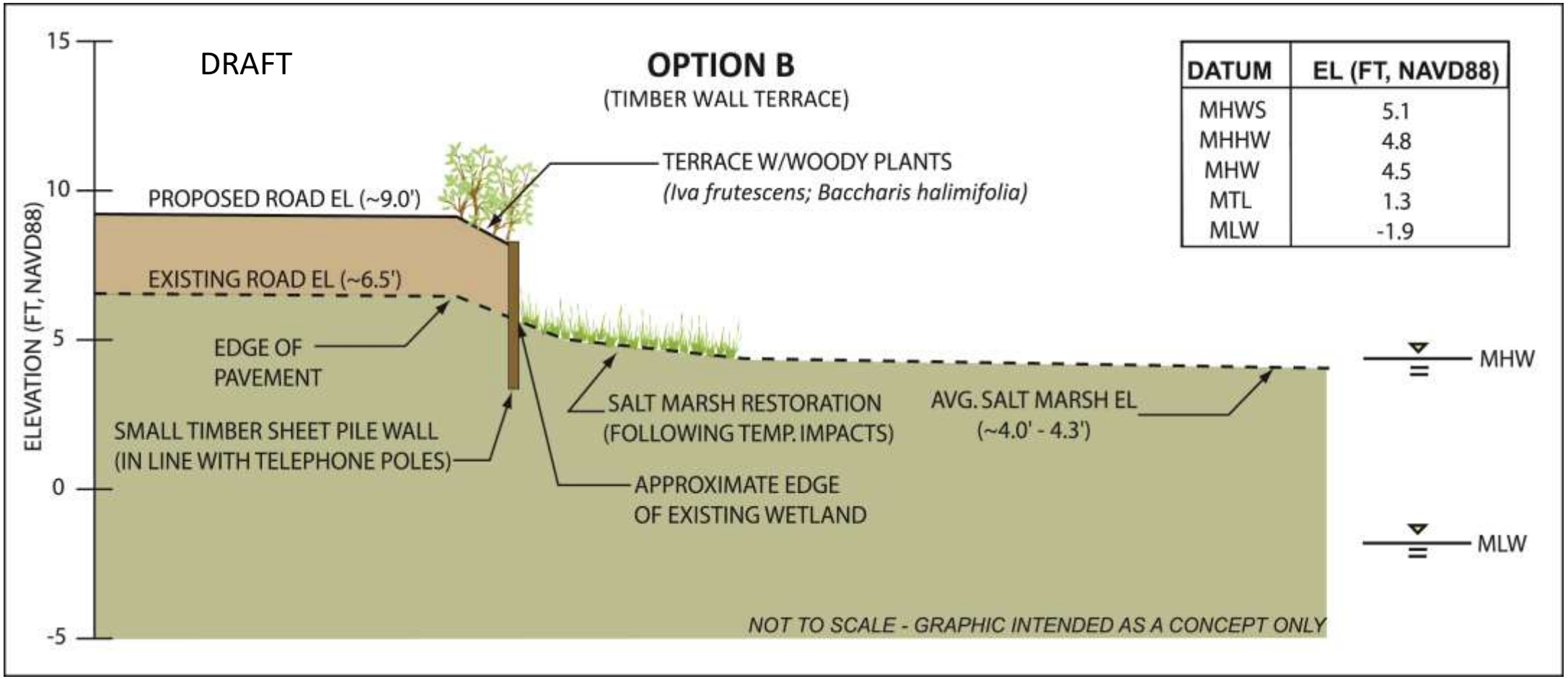

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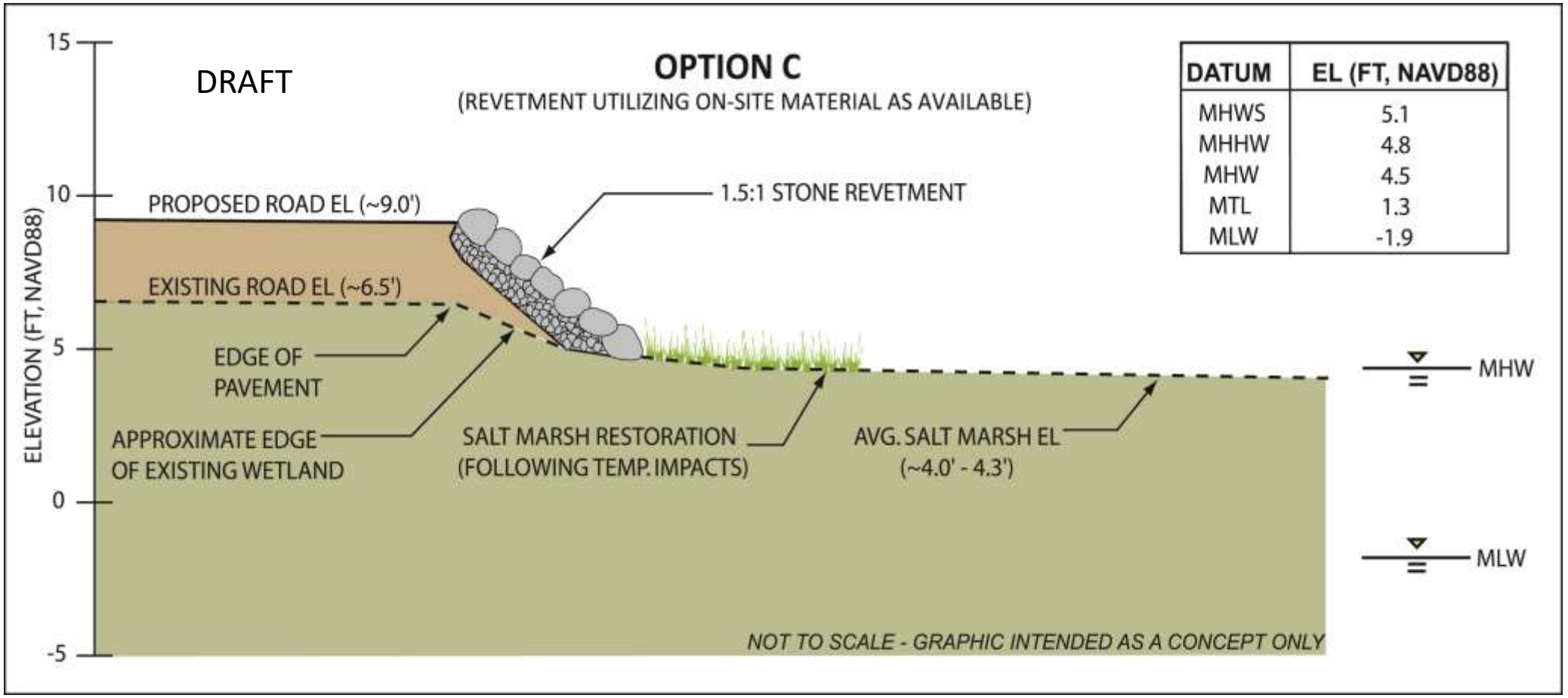

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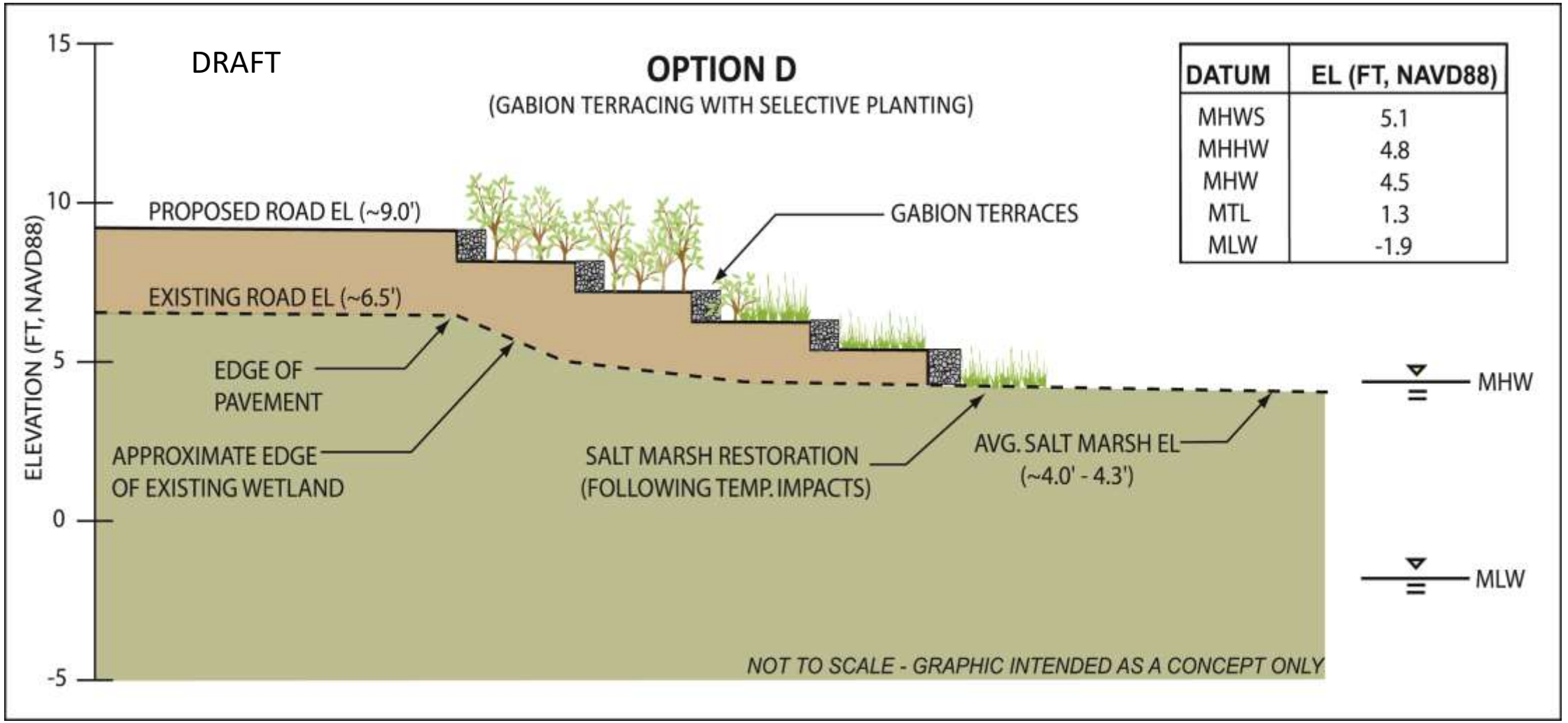

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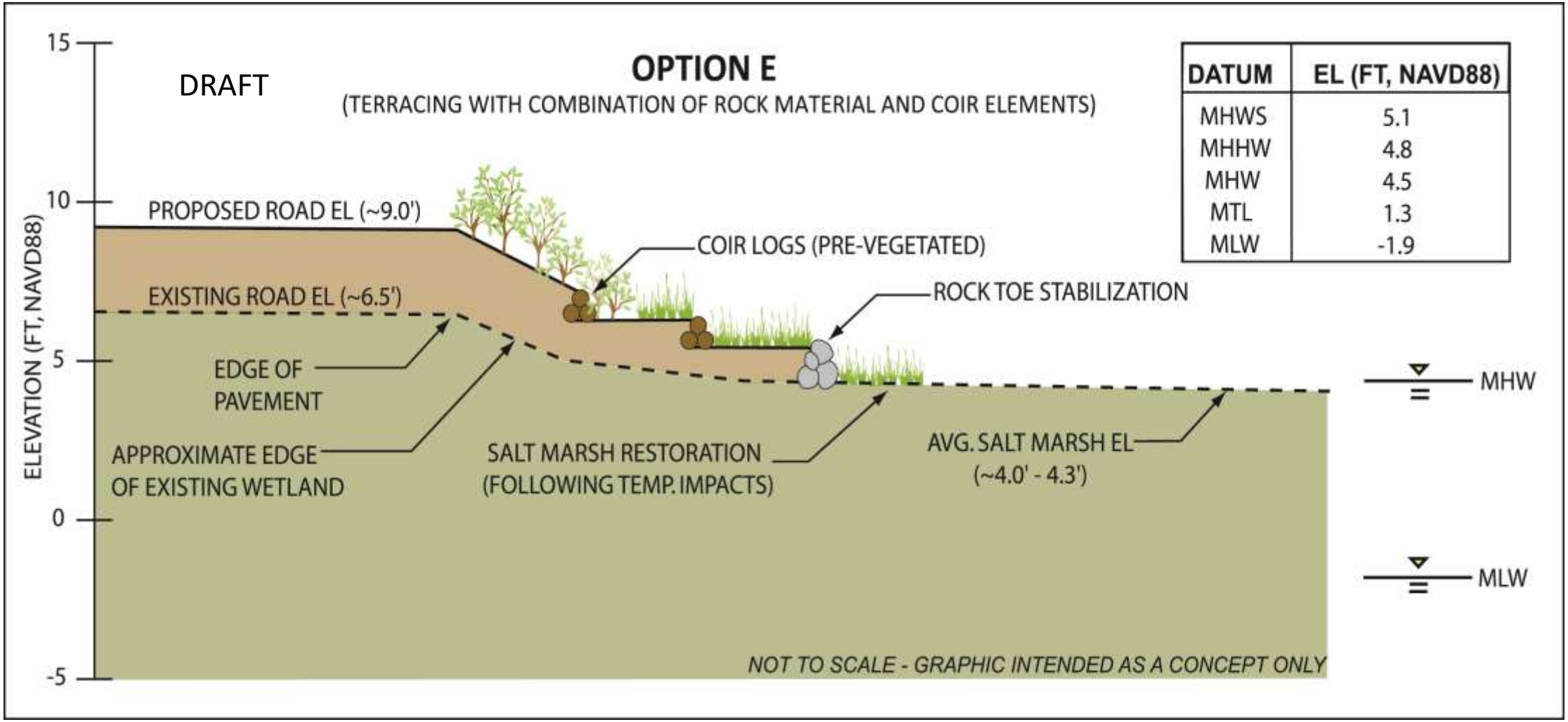

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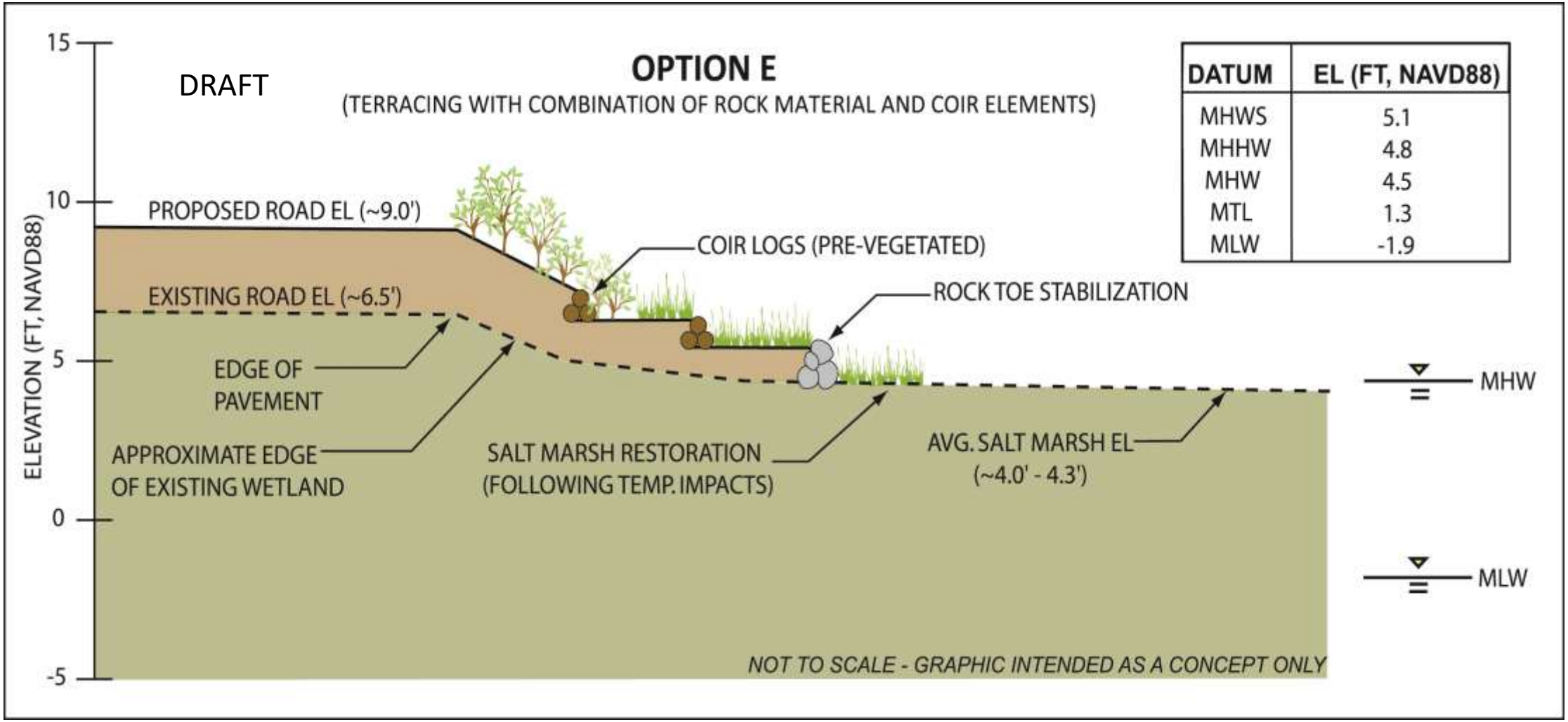

Next steps

- Phase 2: Design and permitting (2020)
- Phase 3: Construction (2022-23)
- Considerations
  - Additional funds needed
  - Town will seek grant funding to carry the project forward
  - The Trustees will continue to partner with the Town as both have a significant stake in providing public access to the beach
- Transferability of lessons learned to other sites around the Commonwealth
  - Technical paper to be produced

Nantucket
Coskata-Coatue

COASTAL STRATEGY

- One of our most significant coastal properties
- Coastal storm and climate impacts
- Impact on Nantucket Harbor
- Future coastal research
- Resiliency projects

trustees