

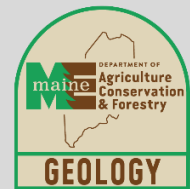
Testing Biodegradable and Hybrid Methods for Shoreline Stabilization

Saco Watershed Collaborative

March 22, 2022



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Funding from:



OFFICE FOR COASTAL MANAGEMENT
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

What's a "Living Shoreline"?

Living shoreline is a broad term that encompasses a range of shoreline stabilization techniques along estuarine coasts, bays, sheltered coastlines, and tributaries. A living shoreline:

- has a footprint that is made up **mostly of native material**.
- **incorporates vegetation** or other living, natural "soft" elements **alone or in combination with** some type of harder shoreline structure (e.g. oyster reefs or rock sills) for added stability.
- **maintains continuity of the natural land–water interface** and reduce **erosion** while providing **habitat value** and enhancing **coastal resilience**.

Most of Maine's experience with "living shorelines" has been related to dune restoration, construction and beach nourishment along the **open coast sand dune system** - this comprises *only about 2%* of Maine's coastline.



48% of the Maine coast is made up of erodible coastal bluffs and 1/3 are eroding and are being **armored at high rates**. *Armoring bluffs cuts off the supply of sediment to nearby mudflats and wetlands, which are natural living shorelines and serve as buffers for storm waves.*

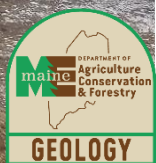


There are approximately 22,408 acres of tidal marshes in Maine*. **Shoreline armoring inhibits the natural landward migration of marshes, impacts sediment transfer to the marsh, and reduces habitat.**



Cameron and Slovinsky, 2014

P. Slovinsky, MGS

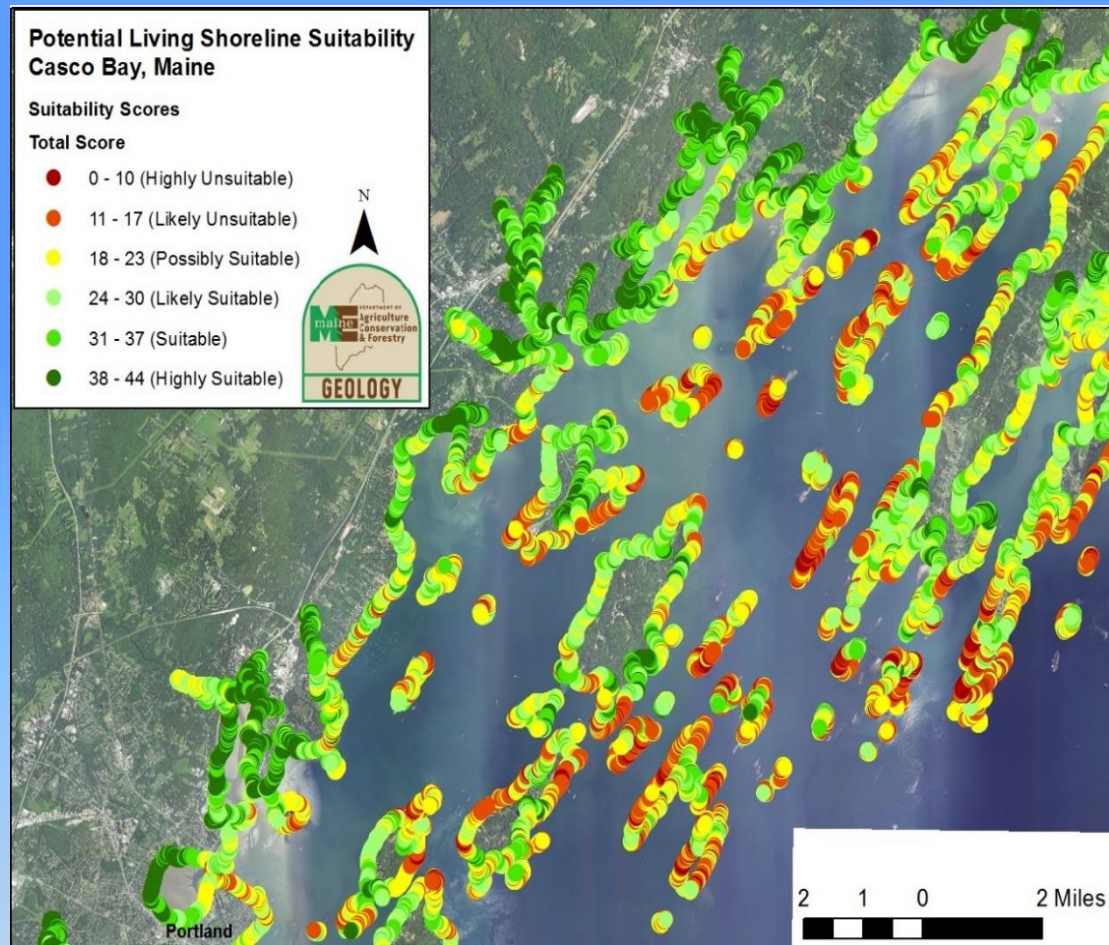


Increasing storms, sea level rise, subsequent erosion of bluffs and marshes, coupled with increasing development pressure, has resulted in a significant increase in requests for shoreline stabilization projects.

There has also been a noted increase in interest from homeowners and municipalities for “softer” approaches



Living-shoreline related results from previous NOAA-funded Maine and regional efforts



COASTAL PLANTING GUIDE

Planting for Slope Stabilization on Maine's Coastal Bluffs

Coastal Bluffs—defined as “a steep shoreline slope formed in sediment (loose material such as clay, sand, and gravel) that has three feet or more of vertical elevation just above the high tide line” (Maine Geological Survey)—make up about 38% of Maine’s coastline. Unstable bluffs can erode slowly or suddenly collapse, forming landslides. Some amount of bluff erosion is expected, and is beneficial to replenishment of beaches and other shoreline areas. However, because of significant risks to life and property, landowners and shoreline managers may wish to temper the speed of bluff erosion and reduce the risk of sudden collapse.

The stability of a coastal bluff is influenced by interactions with both the land and sea. This guide includes information for one of the most critical factors affecting bluff erosion rates and overall stability: vegetation. When selecting plant varieties for slope stabilization, there are many factors to be considered, including salt tolerance, soil depth, and water availability. This guide recommends native Maine plants that can be used to stabilize coastal shorelines and that have been determined to be suitable for restoration that uses a living, natural shoreline instead of armoring (such as with rip rap). Plant species are organized by whether they are classified as woody or herbaceous and whether they are recommended for shallow soil (<18”) or deep soil (>18”).

Not all bluff shorelines are suitable for living shorelines. Prior to planting a living shoreline, see the Suitability Table (Table 1), to determine if your site is suitable. If a shoreline is not a suitable option for stabilization, alternatives to traditional hard armoring should be considered. For example woody debris can be placed on or anchored to shorelines. In some cases “root wads” (also known as toe wood), as shown in Figure 1, may be used as an alternative. Woody structures can help protect and armor exposed soil, particularly in areas that receive large waves, by absorbing the wave energy.

Figure 1. Root wads inserted into unstable banks can help protect bare soil from erosion, from a project in coastal Oregon. In areas not suitable for living shorelines, root wads can be an effective alternative providing stabilization and habitat.

Image source: BioEngineering Associates, <http://bioengineers.com/seaside/>

Cumberland County Soil & Water Conservation District | 207-892-4700 | www.cumberlandswcd.org

Living Shorelines in New England: State of the Practice

Prepared For:
The Nature Conservancy

The Nature Conservancy
Protecting what matters. Preserving life.

Prepared By:
Woods Hole Group, Inc.

WOODS HOLE GROUP
100 Years

July 2017

BUILDING RESILIENCY ALONG MAINE'S BLUFF COASTLINE

Case Study: Mackworth Island | Falmouth, ME

Living Shorelines Introduction

A detailed profile page was created for each of the eight (8) living shoreline types listed below. The purpose of these profile pages is to provide a comprehensive overview of the design recommendations, siting criteria and regulatory topics pertinent to a range of living shorelines designs that practitioners and regulators can use as a quick reference in the field or as an informational tool when educating home owners.

Living Shoreline Types	1. Dune – Natural	2. Dune – Engineered Core	3. Beach Nourishment	4. Coastal Bank – Natural	5. Coastal Bank – Engineered Core	6. Natural Marsh Creation/Enhancement	7. Marsh Creation/Enhancement w/Toe Protection	8. Living Breakwater
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Design Schematics

The following living shoreline profile pages provide an example design schematic for each of the eight living shoreline types. Each schematic shows a generalized cross-section of the installed design. In addition, they illustrate each design's location relative to MHW and MLW, whether plantings are recommended, if fill is required, and any other major components of the design. It is important to note that these are not full engineering designs, and due to each sites unique conditions, a site specific plan, developed by an experienced practitioner is required for all living shoreline projects. Also note that these design schematics are meant to provide a general concept only, and are not drawn to scale.

NOT TO SCALE

Explanation of Design Overview Tables	
Materials	A description of materials most commonly used to complete a living shoreline project of this type.
Habitat Components	A list of what types of coastal habitats are created or impacted by a living shoreline project of this type.
Durability and Maintenance	Although specific timelines are impossible to provide in this context, general guidelines and schedules for probable maintenance needs, and design durability are detailed here.
Design Life	Although specific design life timelines will vary by site for each living shoreline type, this section provides some insight into factors that could influence design life.
Ecological Services Provided	This section provides an overview of the ecological services that could be provided or improved through the installation of that particular type of living shoreline project.
Unique Adaptations to NE Challenges (e.g. ice, winter storms, cold temps)	This section provides any unique practices or design improvements that could be made to improve the performance of the design given New England climactic and tidal challenges.

Acronyms and Definitions

Misquamicut Beach Dune Restoration, Westerly, RI
Photo courtesy of Janet Friedman

Increasing resilience and reducing risk through successful application of nature based coastal infrastructure practices in New England



Expected Project Outcomes

- Pilot demonstration living shoreline treatments in all five New England states
- Documentation of required design and permitting process
- Development and implementation of regional, standardized monitoring metrics and protocols
- Development of state and federal policy recommendations to incentivize practices

New England Project Locations



Marsh Creation/Enhancement with Toe Protection

- North Mill Pond, Portsmouth NH
- South Mill Pond, Portsmouth NH
- Cutts Cove, Portsmouth NH
- Wagon Hill Farm, Durham NH
- Collins Cove, Salem MA
- Wharton Point, Brunswick ME
- Maquoit Conservation Lands, Brunswick ME

Dune Restoration/Nourishment

- Duxbury Beach, Duxbury MA (sand dune nourishment)
- Long Beach, Plymouth MA (cobble dune nourishment)

Coastal Bank - Natural

- Lanes Island, Yarmouth ME

Multi-Approach Projects

- Stratford Point Living Shoreline, Stratford CT – Living breakwater, marsh and dune restoration
- Rose Larisa Park, East Providence RI – Intertidal sill, coastal bank with engineered core, and marsh creation
- Gray's Beach, Kingston MA – Marsh creation/enhancement with toe protection, and dune nourishment
- Coughlin Park, Winthrop MA – Coastal bank with engineered core and cobble nourishment

**Regional Demonstration Projects /
Monitoring Sites**

Increasing resilience and reducing risk through successful application of nature based coastal infrastructure practices in New England



Funding from:



Can we implement low-cost biodegradable vs. synthetic treatments that *beneficially reuse naturally occurring materials* to mitigate coastal erosion along marsh edges and coastal bluffs?

Tree wads and tree trunks



Project goal: select, design, permit, construct, and monitor small transferable demonstration gray-green living shoreline treatments

Oyster shell



Demonstration Site Selection Criteria

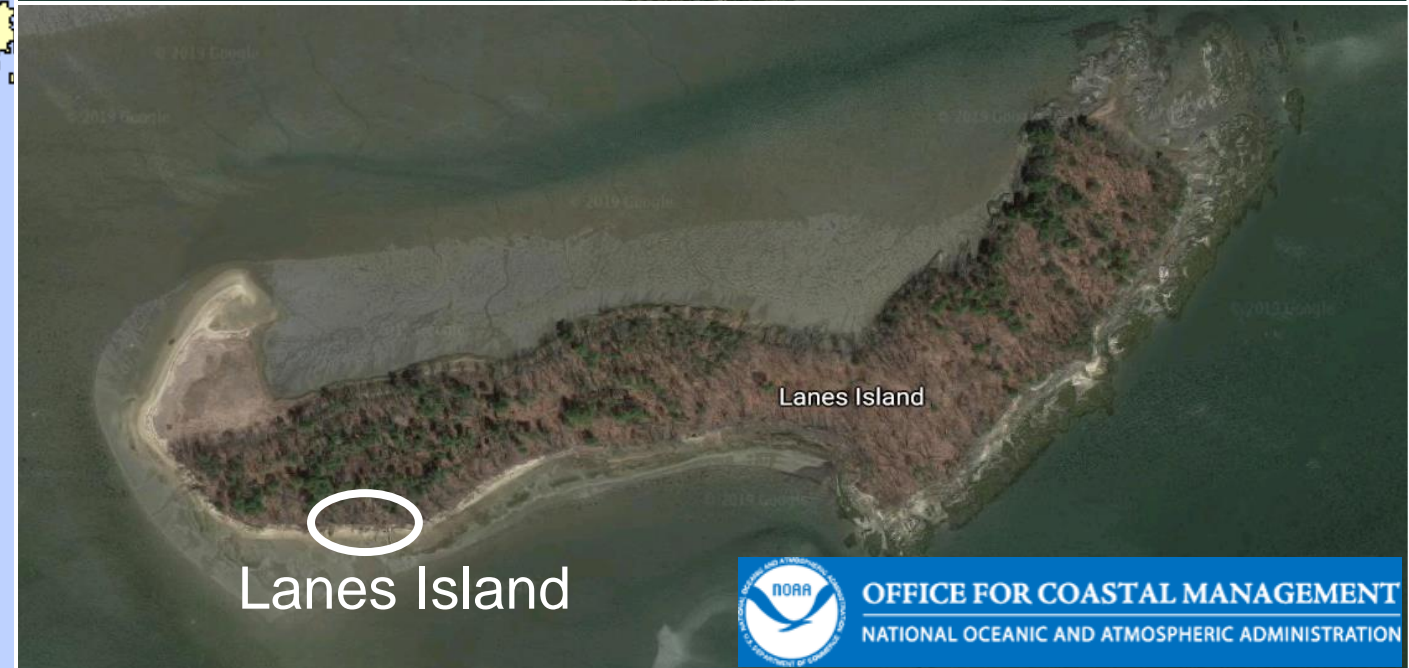
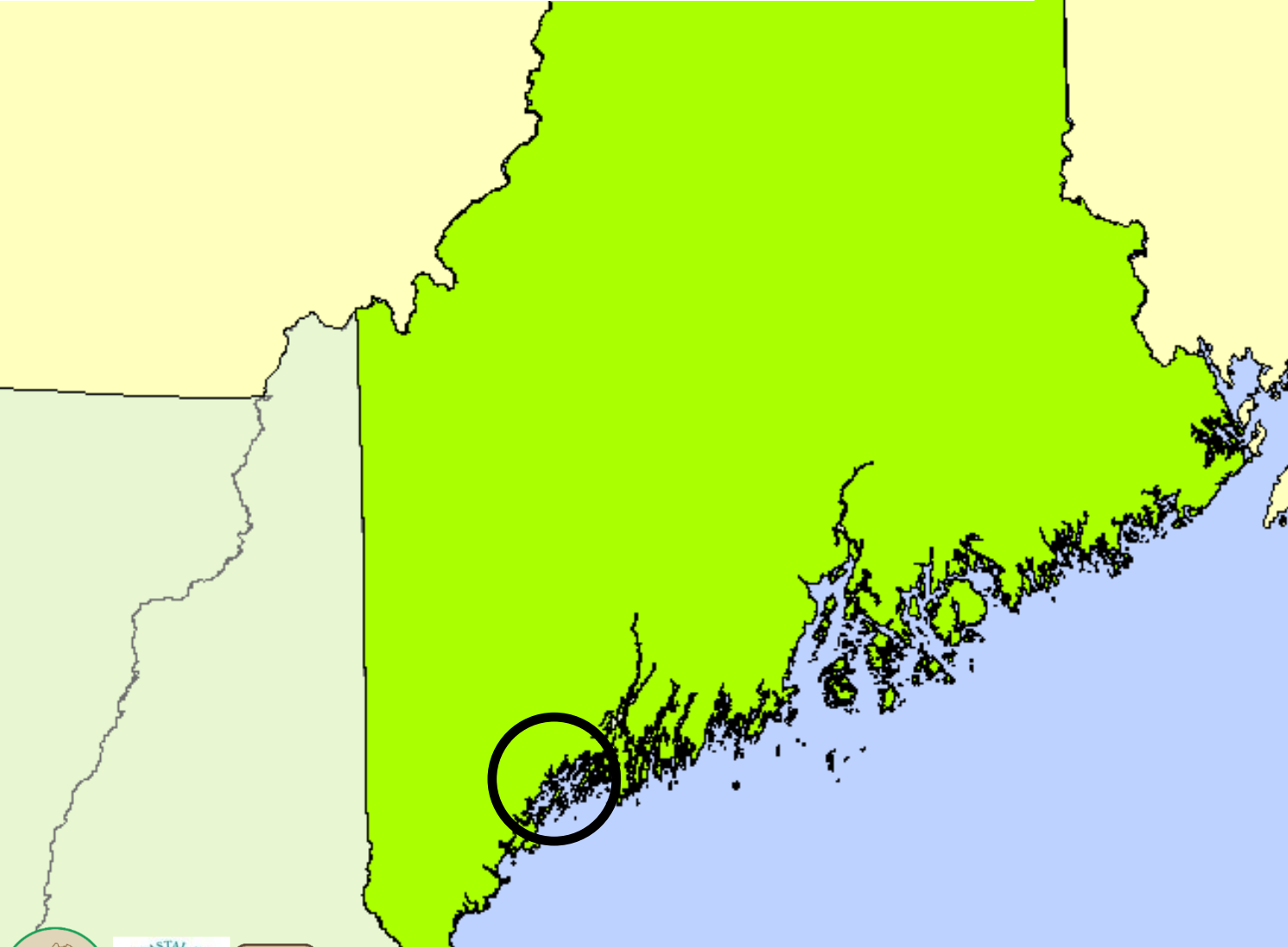
- Eroding bluff or marsh toe
- Representative geography/geology of larger region
- Ownership by a Project Partner
- Relatively easy or representative site access
- Relatively straight/consistent shore type of 150 feet or more
- Appropriate range of MGS Living Shoreline Suitability Scores
- Educational/public viewing opportunities

Project Location:

Maquoit Bay, Town of Brunswick

Lanes Island, Town of Yarmouth

Casco Bay, Maine



MGS Living Shoreline Suitability Tool

Wharton Point, Brunswick – Moderately to Highly Suitable (35 - 37 out of 44)



Living Shorelines Decision Support Tool for Casco Bay
Maine Geological Survey

Find address or place

Woodside Rd
Maquott Rd

Total Scores

Total Score	37
Total Class	36 - 44 (Highly Suitable)
Fetch Score	6
Fetch Class	Low (>0.5 and <=1.0 mi)
Bathymetry Score	6
Bathymetry Class	Shallow (<1 m within 30 m)
Landward Shoreline Type Score	6
Landward Shoreline Type Class	Wetlands, swamps, marshes, low banks
Seaward Shoreline Type Score	1

[Zoom to](#)

https://www.maine.gov/dacf/mgs/hazards/living_shoreline/index.shtml

Maxar, Microsoft | Maine Geological Survey | Esri Community Maps Contributors, BuildingFootprintUSA, Esri, HERE, Garmin, SafeGraph, INCRE... 

Wharton Point, Brunswick

high tide
(approx.)

Eroding marsh edge

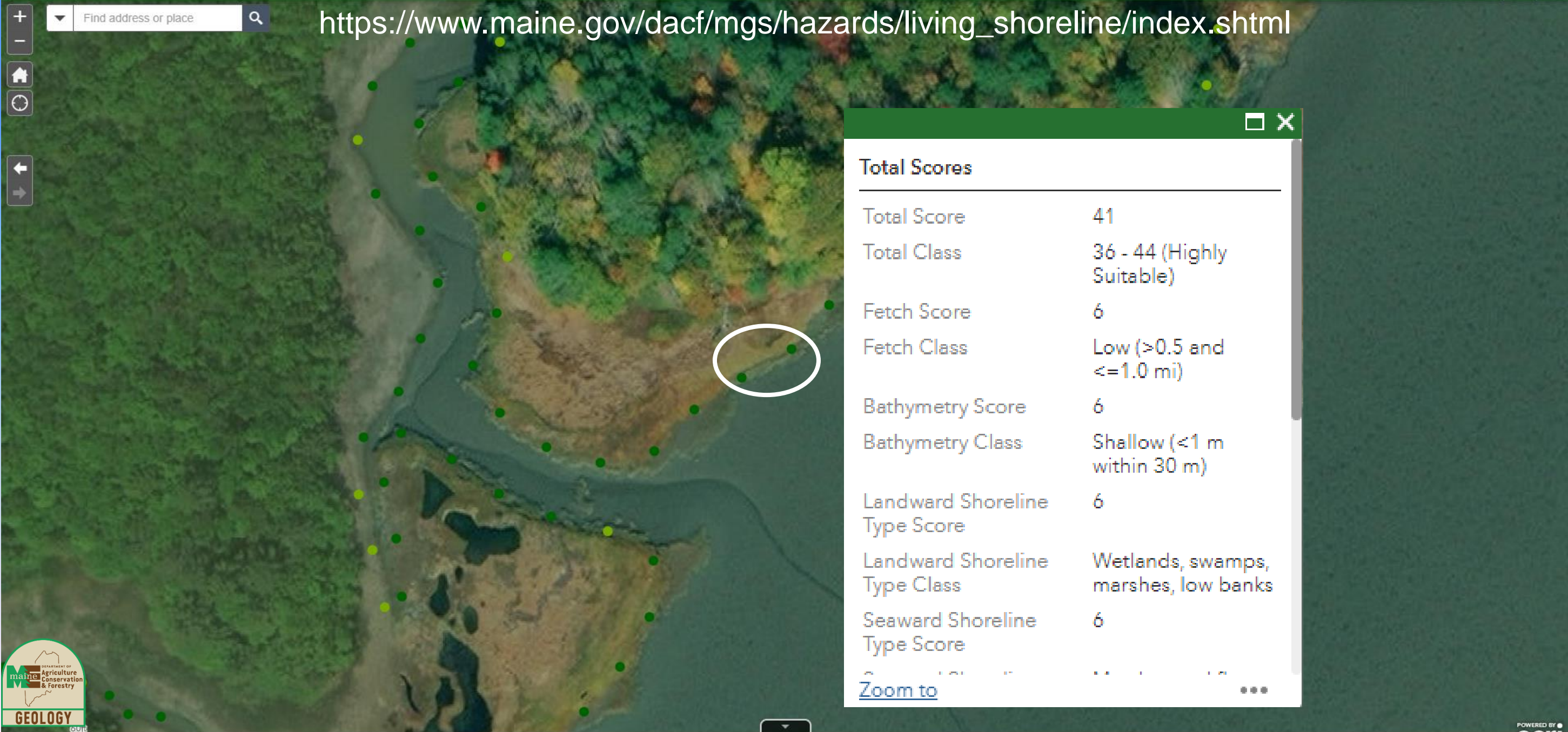
In-situ log

Proposed
treatment
location



MGS Living Shoreline Suitability Tool

M. Bay Cons. Lands Brunswick – Highly Suitable (37 - 41 out of 44)



Total Scores	
Total Score	41
Total Class	36 - 44 (Highly Suitable)
Fetch Score	6
Fetch Class	Low (>0.5 and <=1.0 mi)
Bathymetry Score	6
Bathymetry Class	Shallow (<1 m within 30 m)
Landward Shoreline Type Score	6
Landward Shoreline Type Class	Wetlands, swamps, marshes, low banks
Seaward Shoreline Type Score	6
Zoom to	...

Maquoit Bay Conservation Lands, Brunswick

high tide
(approx.)



eroding
marsh edge



Proposed
treatment
location



mudflat

MGS Living Shoreline Suitability Tool

Lanes Island, Yarmouth – Low end of Moderately Suitable (30 - 31 out of 44)

Find address or place

https://www.maine.gov/dacf/mgs/hazards/living_shoreline/index.shtml



Total Scores	
Total Score	30
Total Class	29 - 35 (Moderately Suitable)
Fetch Score	6
Fetch Class	Low (>0.5 and <=1.0 mi)
Bathymetry Score	6
Bathymetry Class	Shallow (<1 m within 30 m)
Landward Shoreline Type Score	5
Landward Shoreline Type Class	Beaches, scarps, banks
Seaward Shoreline Type Score	5

[Zoom to](#)



Lanes Island, Yarmouth

eroding bluff
(10-12 ft)

beach

Proposed
treatment
location

marsh



View south along marsh and bluff and potential demonstration site.

P.A. Slovinsky, MGS

**Some Project
CHALLENGES, SOLUTIONS and
LESSONS LEARNED**

Permitting and review requirements and timeframes

- Pre-application meetings held with state and federal regulators (5/31/2019, 6/27/2019)
- **MGS served as applicant/agent for the property owners**, including Town of Brunswick, Brunswick-Topsham Land Trust, Maine Inland Fisheries and Wildlife, and Maine Coast Heritage Trust
- Brunswick review was internal since Brunswick was owner for the 2 Brunswick sites; Yarmouth Shoreland Zoning review was required for Lanes Island project
- **MEDEP Permit-by-Rule and USACE General Permit** applied for on **8/7/2019**
- **MEDEP Permit-by-Rule (Chapter 305)** was issued on **8/22/2019** with review and input from MEIFW, MEDMR, and SHPO under **13. Habitat creation or enhancement and water quality improvement activities** (available to resource agencies, DOT, and conservation groups, or municipality in conjunction with resource agency)
- **USACE Tier 2 General Permit** was issued on **12/11/2019** with review and input from US EPA, NOAA NMFS, USFWS, and Tribal HPOs
- Required **5 years of monitoring** with a specific focus on synthetic material degradation

Challenge: regulatory concerns about easily *degradable* plastics



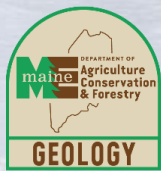
Challenge: Account for the impacts of ice



Wharton Point



Maquoit Bay Conservation Lands



2/26/2019 P.A. Slovinsky, MGS

2/26/2019 P.A. Slovinsky, MGS

Solution: develop and test *new* heavy-fiber weave biodegradable oyster shell bags



Solution: test *new* UV and abrasion-resistant synthetic products



“Georeef”

Tensar®

D. Bannon, GEI

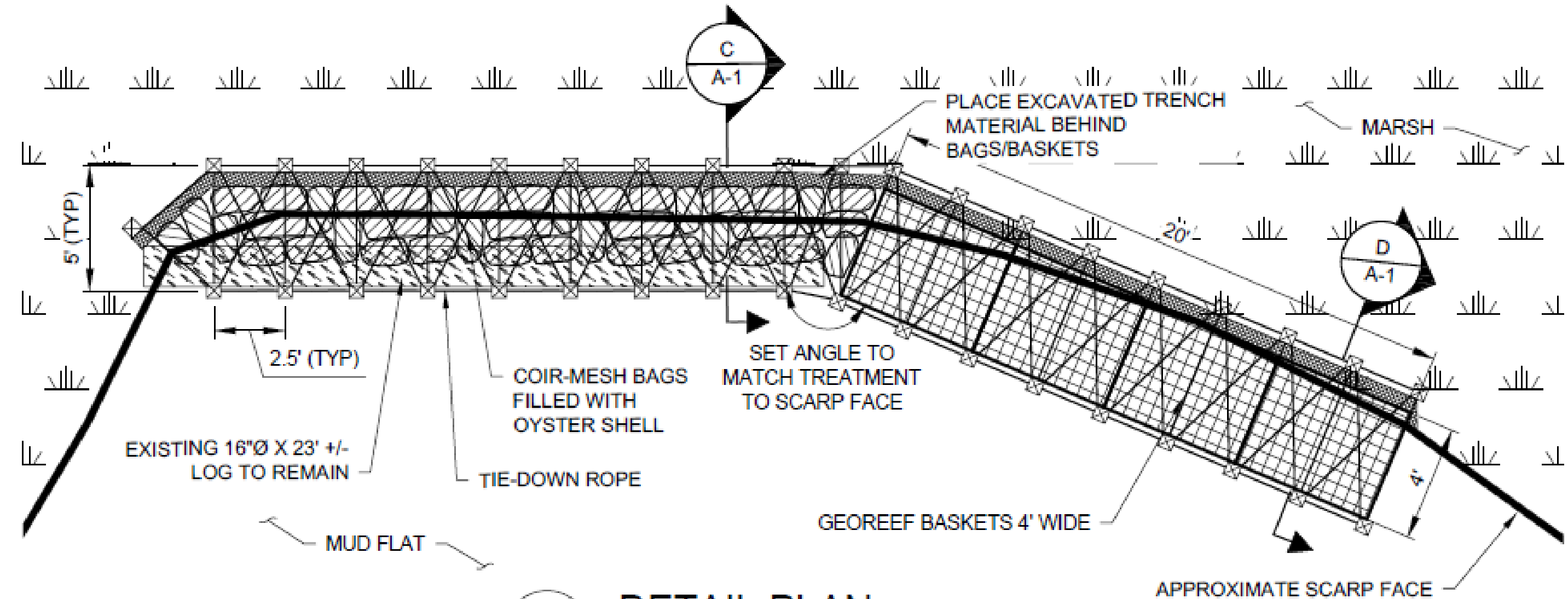
Challenge: Bagging oyster shell with volunteers (during a pandemic)

Solution: bagging stations, sewing stations, and dedicated volunteers



Integrate synthetic and biodegradable materials and trees

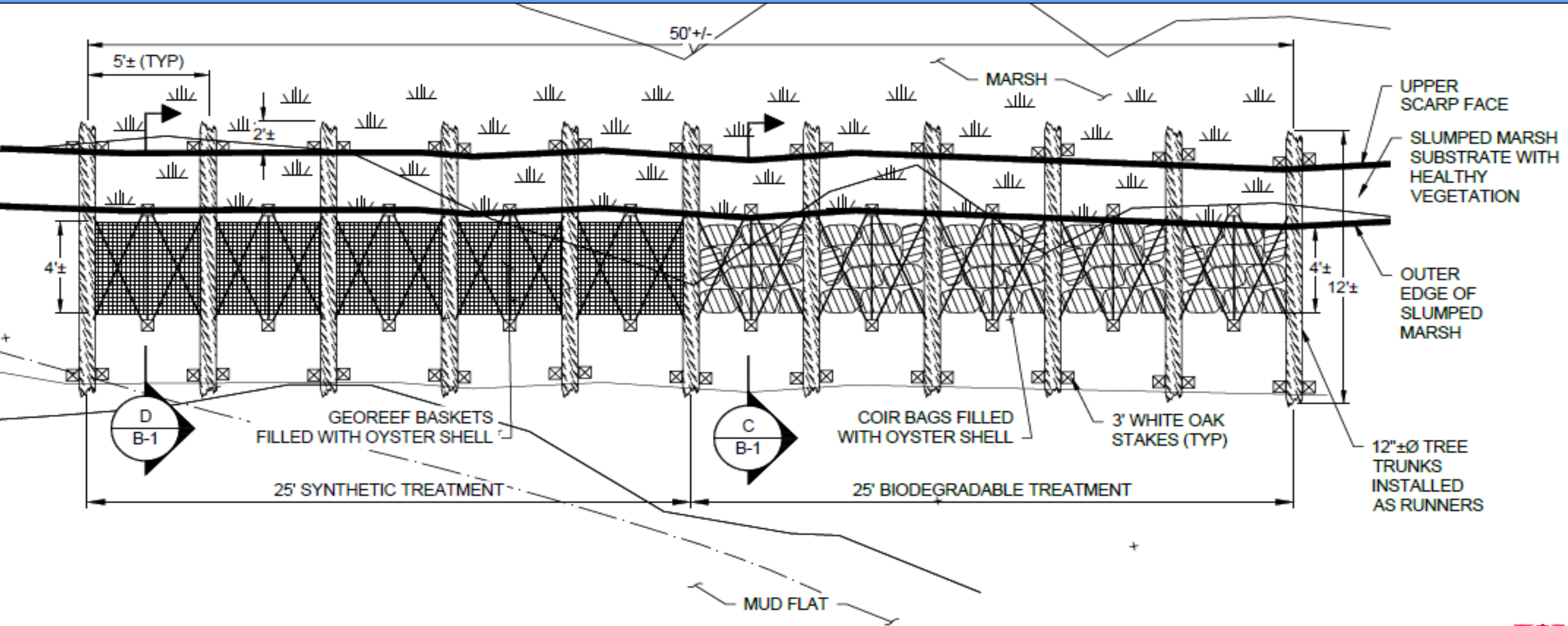
Wharton Point



A DETAIL PLAN
A-1 SCALE: 1"=5'-0"

Solution: Integrate synthetic and biodegradable materials and trees

Maquoit Bay Conservation Lands



A
B-1 PLAN VIEW OF LIVING SHORELINE TREATMENT
SCALE: 1"=5'-0"

Integrate *trees* into demonstration treatments to break up ice

Wharton Point



P. Slovinsky, MGS

Maquoit Bay Conservation Lands



D. Bannon, GEI

Challenge: "Dirty" oyster shell



Solution: Develop an on-the-fly method to clean oyster shell





Challenge: delivering supplies while accounting for tides
Solution: Project partners, barges and airboats!





Wharton Point





Maquoit Bay Conservation Lands



Wharton Point



Maquoit Bay Conservation Lands

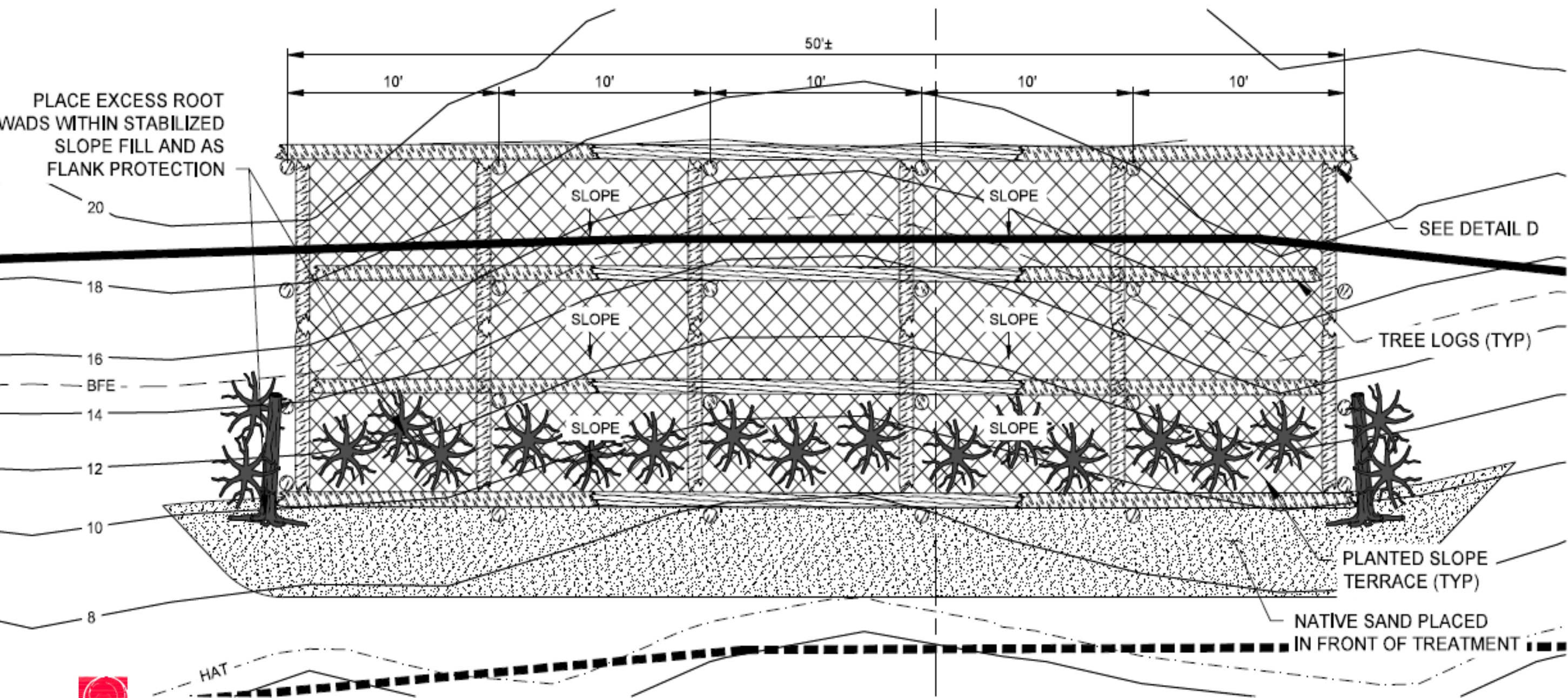


Lanes Island, Yarmouth, ME



Challenge: Use a living shoreline to stabilize an unstable bluff on an island using trees = not an inexpensive proposition

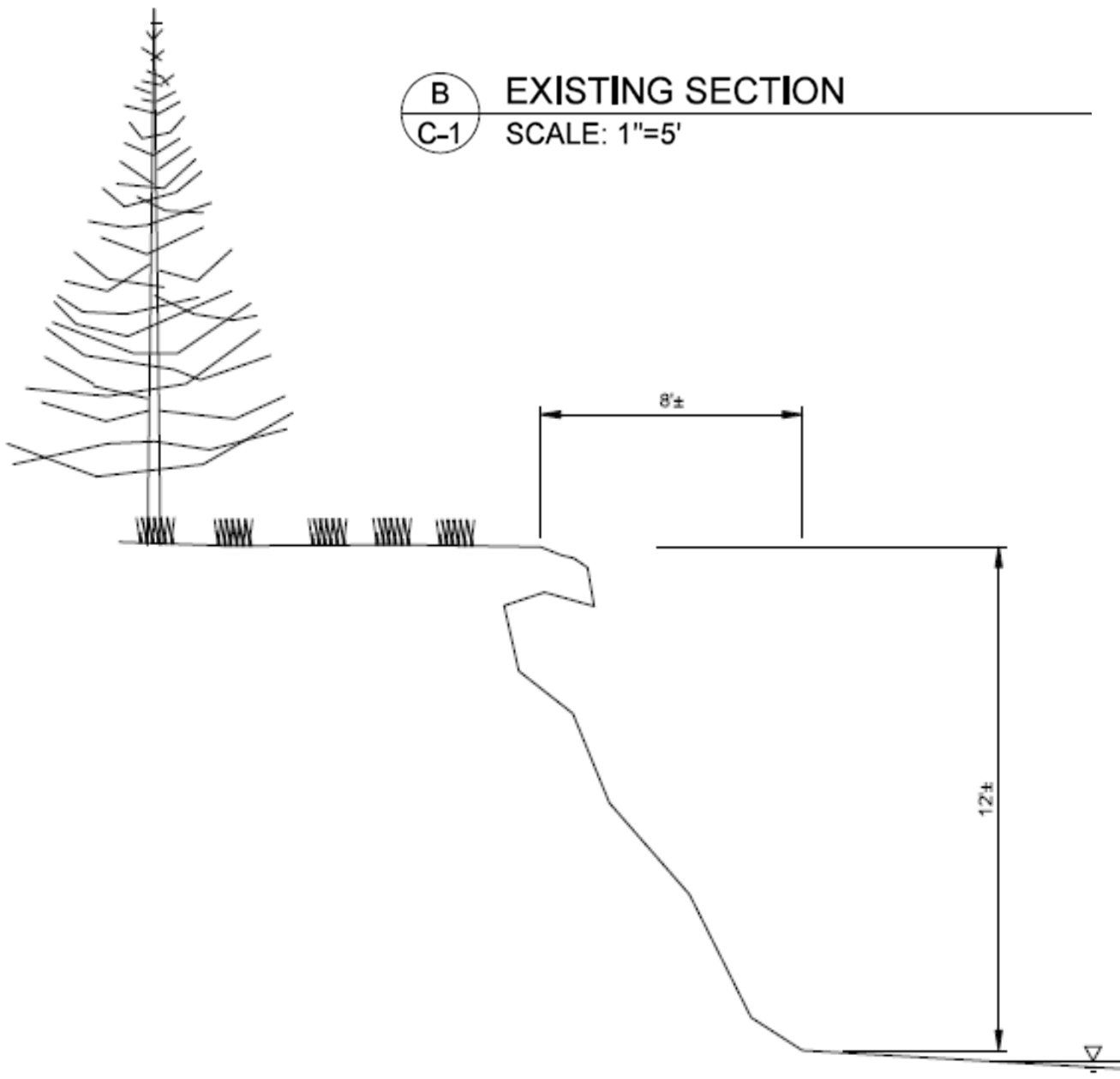
Solution? regrade bluff and beneficially reuse trees



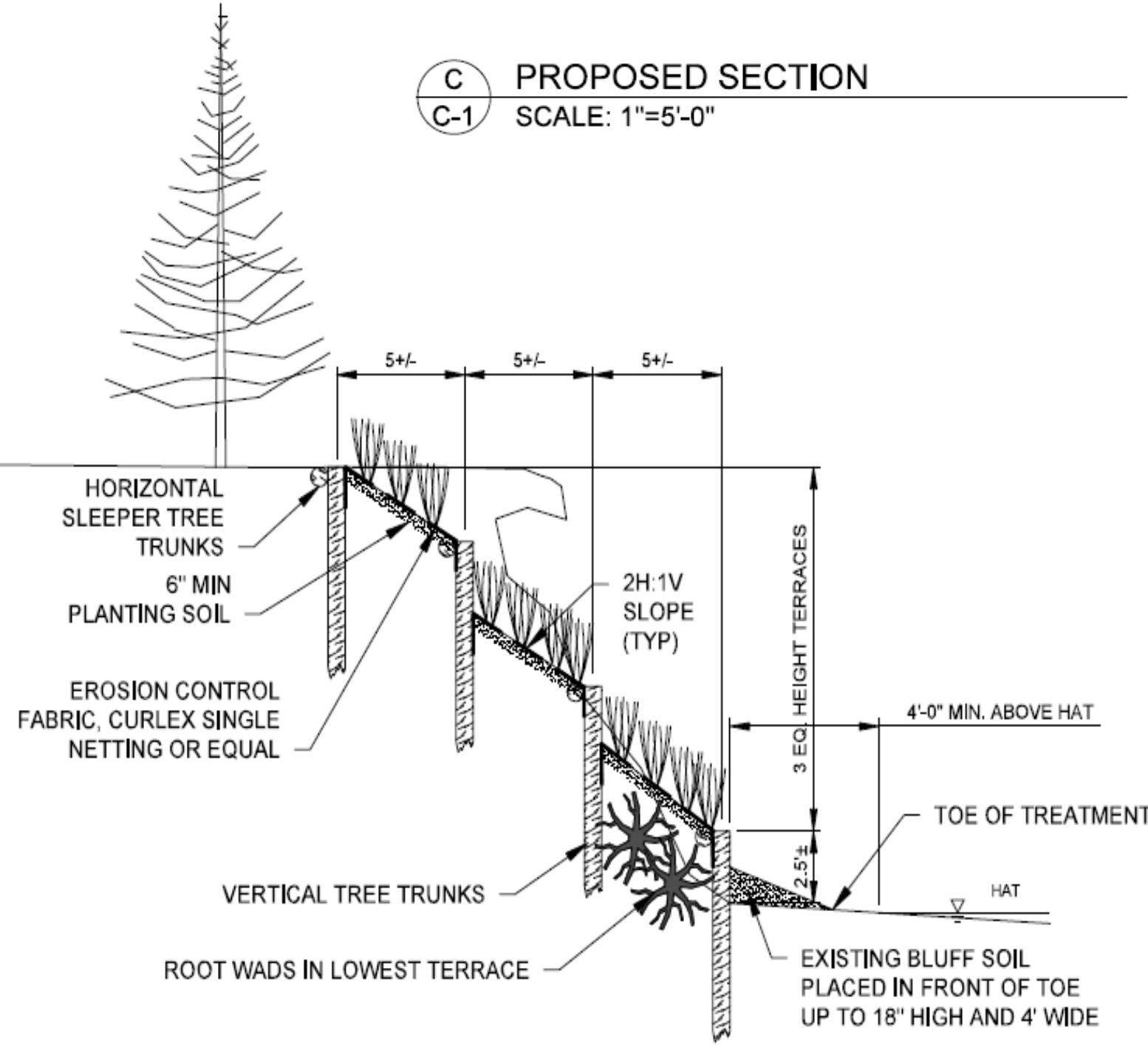
A SLOPE STABILIZATION PLAN
C-1 SCALE: 1"=5'-0"

Solution? regrade bluff and beneficially reuse trees

B EXISTING SECTION
C-1 SCALE: 1"=5'



C PROPOSED SECTION
C-1 SCALE: 1"=5'-0"



Lanes Island, Yarmouth



Lanes Island, Yarmouth



Informational Signage Placed at Each Site

Slowing Erosion the Natural Way at Wharton Point

What's happening to the shoreline? Wharton Point is an important area for recreational and commercial access to Maquoit Bay and for wildlife. The marsh bank has been eroding because of currents and waves and this erosion will increase with more frequent storms and sea-level rise. These conditions are common along the Maine coastline.

What are we doing about it? Researchers are studying how natural materials, sometimes mixed with synthetic materials, can be used to slow erosion and whether they can survive Maine's long and icy winters. This approach is called a "living shoreline" because it is made up of mostly natural materials and provides habitat as compared to retaining walls or rocks. There are different types of living shorelines. Here, we are using aged oyster shell in biodegradable bags and plastic mesh baskets. It is a low-cost project that holds promise for eroding shorelines in Maine.



How long will the living shoreline be here? This living shoreline was built in spring 2020 and will be here for at least 5 years. It will be monitored by scientists to see how it is working and if it is damaged by storms and ice. This research is part of a New England-wide effort to increase the use of natural materials for shoreline erosion control.

Where can I get more information? Visit the Maine Geological Survey's website at: <https://www.maine.gov/dacf/mgs/explore/marine/living-shorelines/>

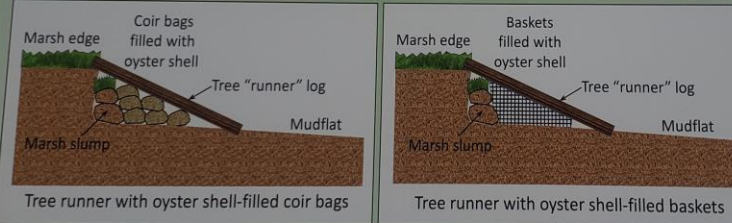
PLEASE DO NOT DISTURB THIS AREA!



Slowing Erosion the Natural Way at Maquoit Bay Conservation Lands

What's happening to the shoreline? Maquoit Bay Conservation Lands is an important area for public access to the bay and for wildlife. The marsh bank has been eroding because of currents and waves, and erosion will increase with more frequent storms and sea-level rise. These conditions are common along the Maine coastline.

What are we doing about it? Researchers are studying how natural materials, sometimes mixed with synthetic materials, can be used to slow erosion and whether they can survive Maine's long and icy winters. This approach is called a "living shoreline" because it is made up of mostly natural materials and provides habitat as compared to retaining walls or rocks. There are different types of living shorelines. Here, we are using fallen trees and aged oyster shell in biodegradable bags and plastic mesh baskets. It is a low-cost project that holds promise for eroding shorelines in Maine.



How long will the living shoreline be here? This living shoreline was built in spring 2020 and will be here for at least 5 years. It will be monitored by scientists to see how it is working and if it is damaged by storms and ice. This research is part of a New England-wide effort to increase the use of natural materials for shoreline erosion control.

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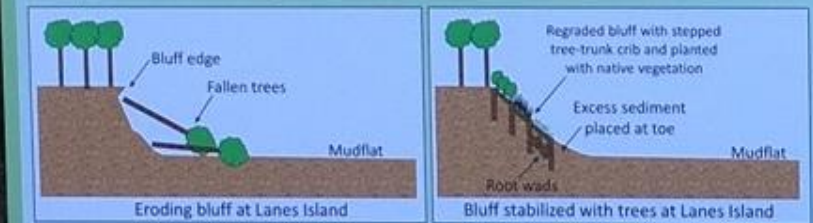
PLEASE DO NOT DISTURB THIS AREA!



Slowing Erosion the Natural Way at Lanes Island

What's happening here? Lanes Island is an important area for public and for wildlife. The bluff at Lanes Island has been eroding because of currents and waves, and erosion will increase with more frequent storms and sea-level rise. These conditions are common along the Maine coastline.

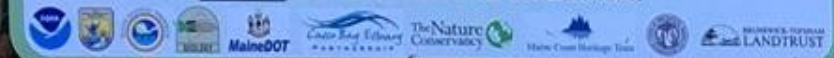
What are we doing about it? Researchers are studying how natural materials, sometimes mixed with synthetic materials, can be used to slow erosion and whether they can survive Maine's long and icy winters. This approach is called a "living shoreline" because it is made up of mostly natural materials and provides habitat as compared to retaining walls or rocks. There are different types of living shorelines. Here, we are regrading the unstable bluff and arranging fallen trees into a "stepped crib" and planting vegetation to decrease the erosion of the bluff. It is a project that holds promise for other eroding bluff shorelines in Maine.



How long will the living shoreline be here? This living shoreline will be built in 2020 and will be here for at least 5 years. It will be monitored by scientists to see how it is working and if it is damaged by storms and ice. This research is part of a New England-wide effort to increase the use of natural materials for shoreline erosion control.

Where can I get more information? Visit the Maine Geological Survey's website at: <https://www.maine.gov/dacf/mgs/explore/marine/living-shorelines/>

PLEASE DO NOT DISTURB THIS AREA!



Construction Timeframe Summary

Ship oyster shell to Brunswick = 1 day, August 2019

Develop, test, and secure coir fiber bags = September 2019 to January 2020

Find, cut and store appropriate logs for MBCL = January 2020 to April 2020

Build bagging stations = April 2020

Secure Tensar GeoReef = April 2020

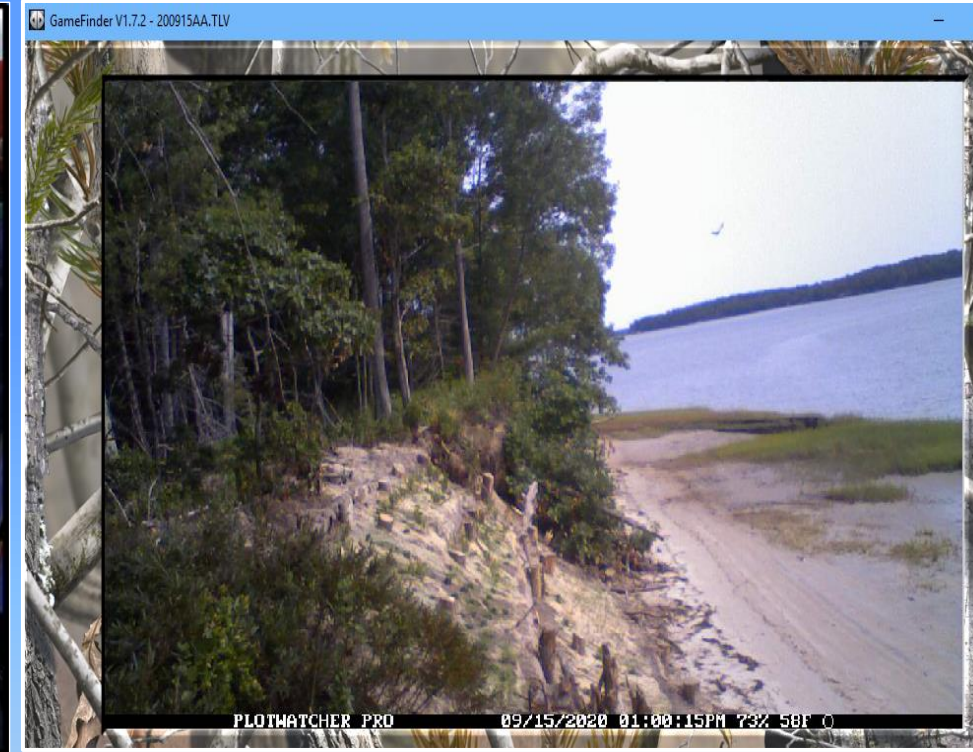
Prep and fill 400 shell bags = 3 days, 6-8 volunteers (May 2020)

Brunswick sites construction = 7 days, 6-8 volunteers (May – June 2020)

Lanes Island site construction = 17 days, SumCo Eco-Contracting (August – September 2020)

Project Monitoring – CBEP and MGS

- 5-year monitoring follows an **EPA-approved QAPP** and regionally developed protocols
- Focuses on **geophysical environment, erosive forces, biota, vegetation, structural integrity/movement, and plastic degradation.**
- **Topographic transect** lines established at each site and natural control sites
- **Vegetative and biologic plots** collected along transects
- **Photo monitoring** including game cameras
- Detailed monitoring for **pre-construction, as-built** (post-construction), and scheduled for **spring/early summer** (April-June), **fall/late summer** (August-October), and **Winter** (as possible).



So how have the installations fared thus far?

Wharton Point (completed late May/early June 2020)



Wharton Point



Wharton Point (since June 2020)

Main Observations

Georeef

Very minor settlement
Has not had to be re-staked/re-twined
No replacement needed
Marsh edge has settled on top of reef
Sedimentation, algae and wrack
Baskets have not degraded

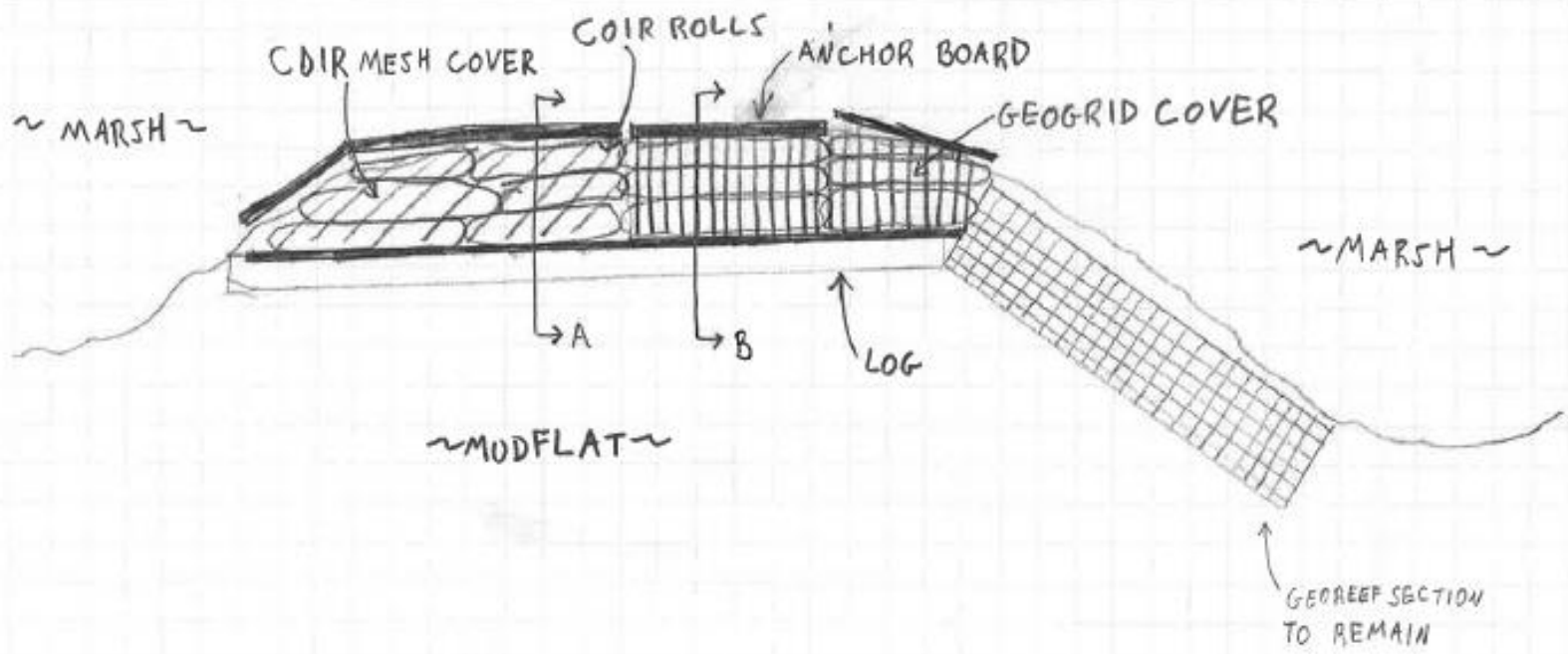
Very storm resistant

Bags

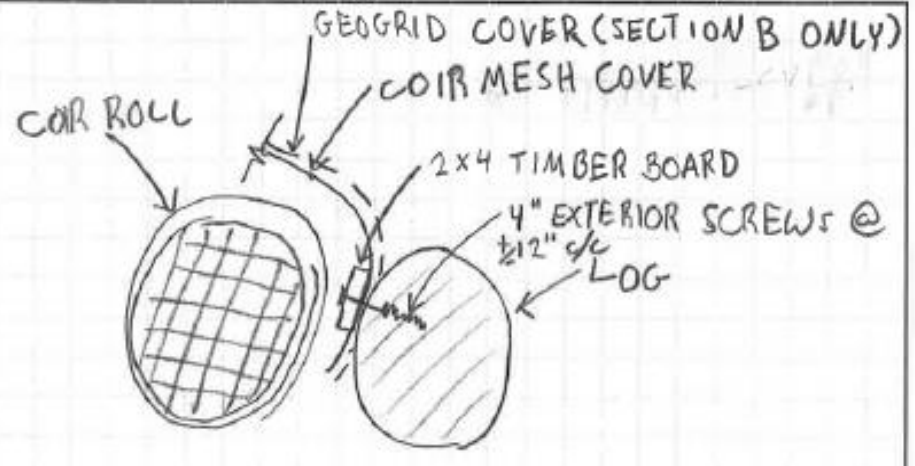
Constant shifting
Re-twined *twice*
Replaced 45 bags (2/21, 8/21)
Marsh continues to be eroded above bags
Release of shell into intertidal as bags break
Bags appear to fall apart <2 years regardless of twining failure

Not very storm resistant

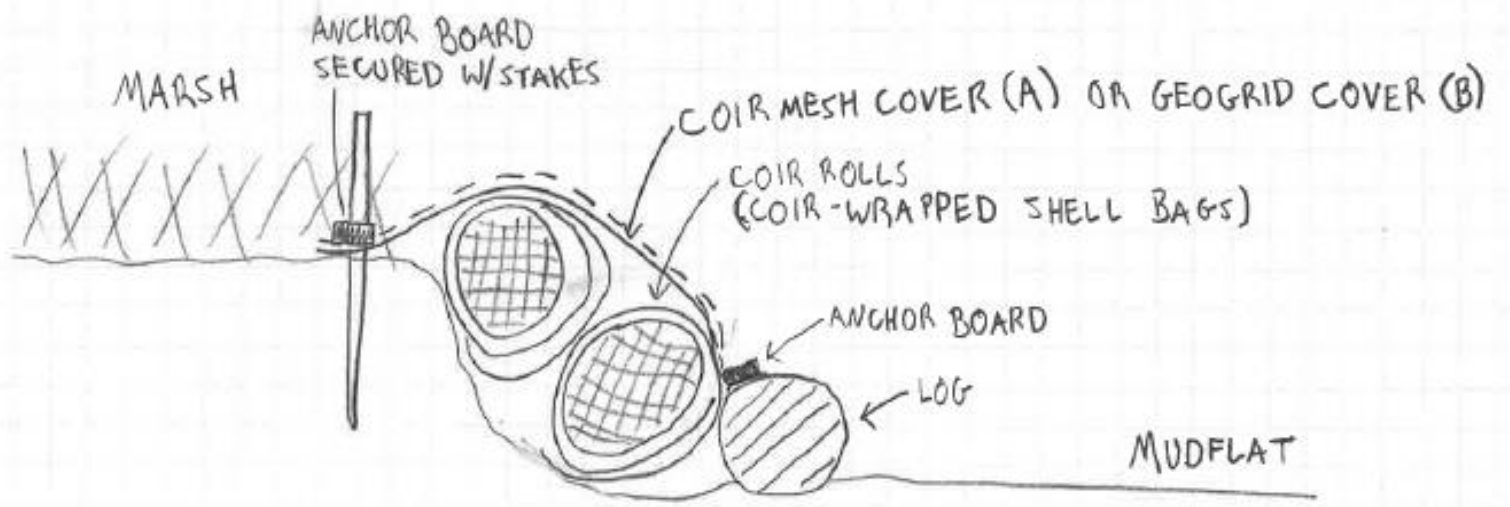
Findings: *twining needs to be of a stronger material. Tie-down methods employed do not hold bags in place well. Individual light (<30 lb) bags are not robust enough to survive storm battering.*



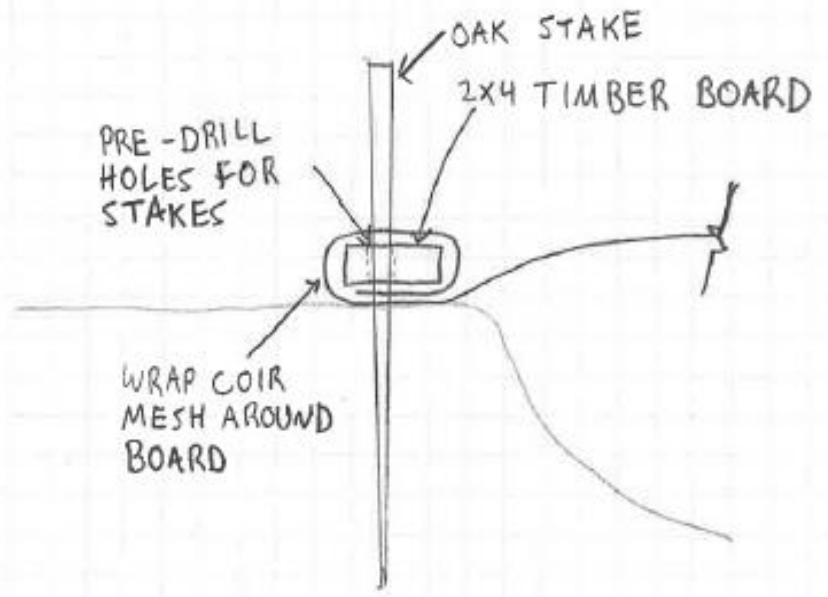
PLAN



BOTTOM ANCHOR BOARD DETAIL



SECTION A/B



TOP ANCHOR BOARD DETAIL

Maquoit Bay Conservation Lands (completed late May/early June 2020)



Maquoit Bay Conservation Lands



Maquoit Bay Conservation Lands



Maquoit Bay Conservation Lands (since June 2020)

Main Observations

Georeef

Minor settling
No need to re-stake/re-twine
No need to replace
Marsh edge settled on top
Sedimentation, algae and wrack
Baskets have not degraded
Storm resistant

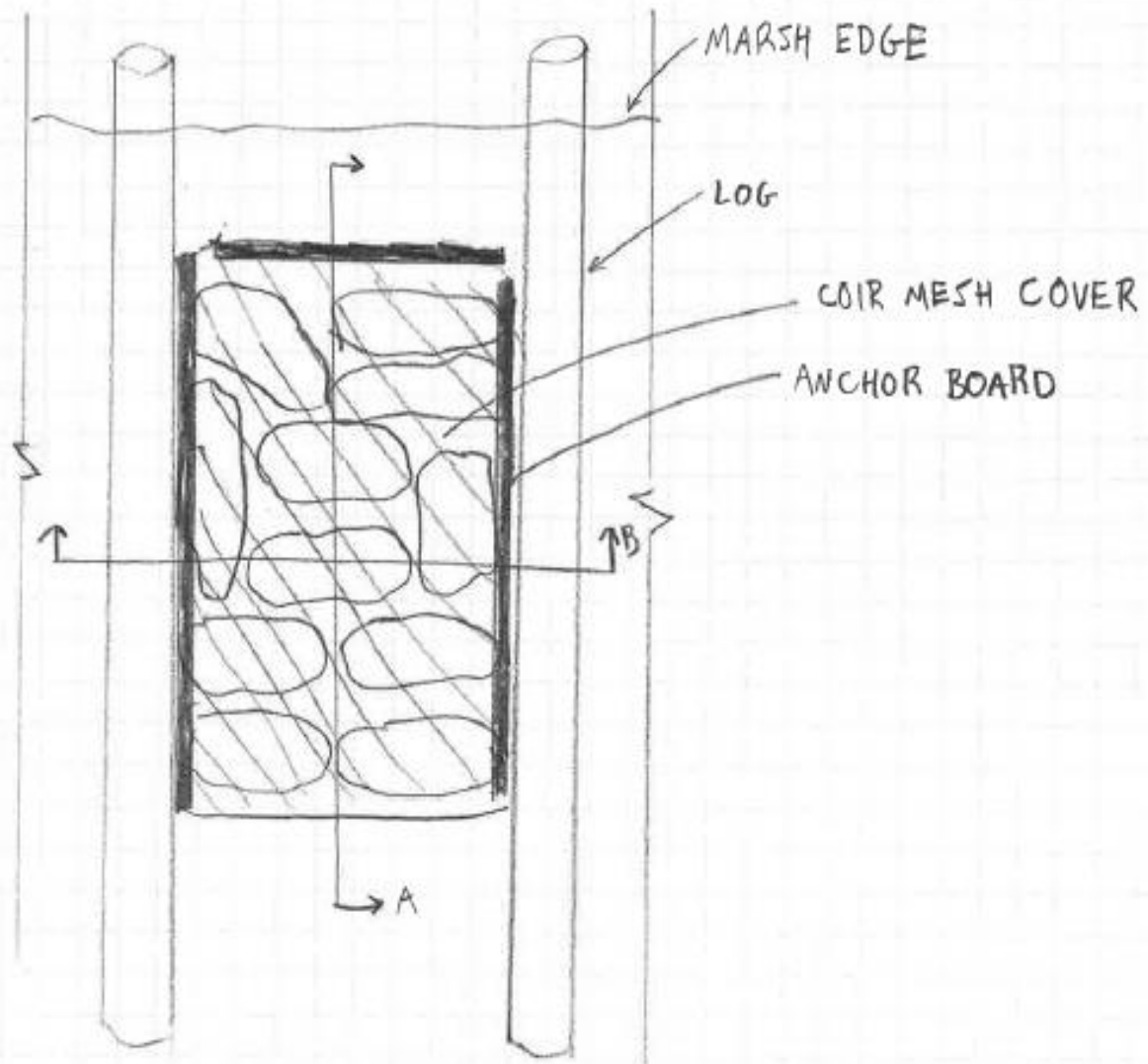
Bags

Minor shifting
Re-twined once
Replaced 5 bags (4/21)
Marsh eroded above
Sedimentation, algae and wrack
All bags degraded and released shell into intertidal
Fairly storm resistant

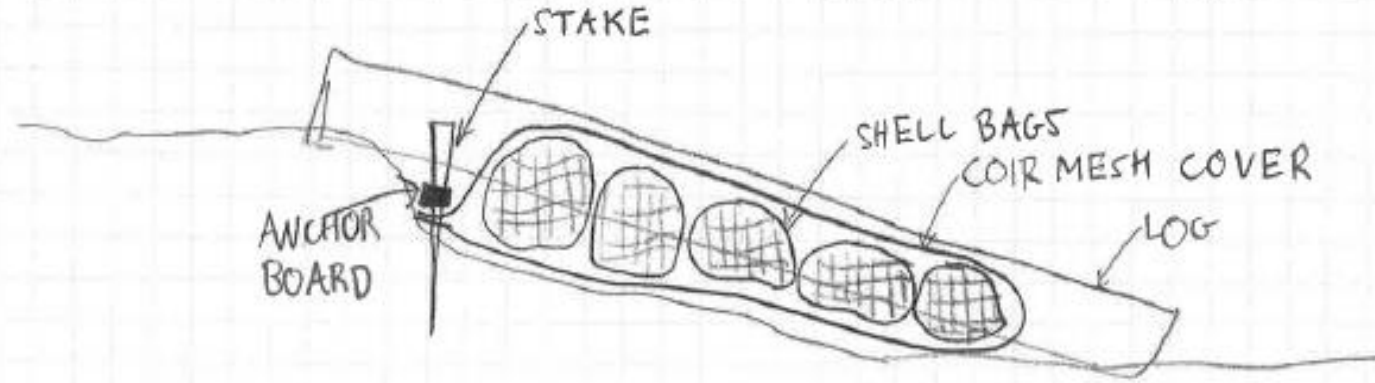
Logs

Minor twisting/settling
No need to reanchor
No need to replace
N/A

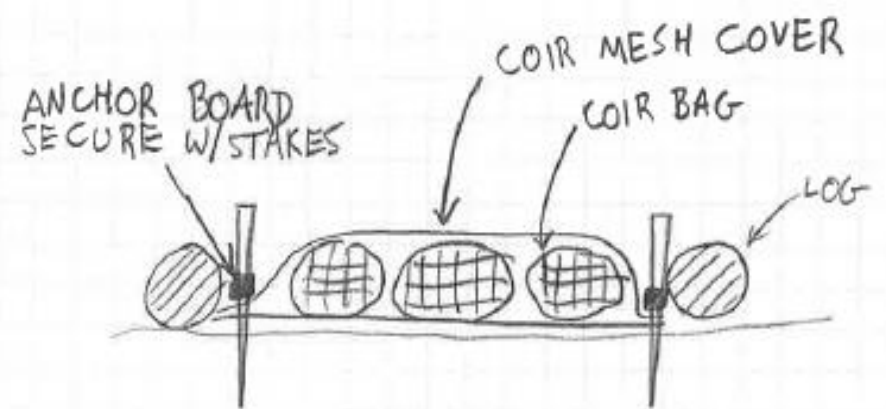
Findings: *twining needs to be of a stronger material. Although only had to replace a few bags due to storms, all bags have biodegraded < 2 years. Logs could be anchored a different way in the future (wrapped around log ends instead of attached to log ends)*



PLAN



SECTION A



SECTION B

Lanes Island (completed mid-September 2020)



Lanes Island



Lanes Island



Lanes Island (since Sept 2020)

Main Observations

Project hit by strong southeaster storms in November, December 2020 and January 2021

Extensive erosion along entire island (10-15 feet of bluff erosion measured as of 8/2021)

Loss of first “step” and some end-effect erosion

Sacrificial sediment placed above the HAT was lost within a month

Step failure released large amounts of sediment to the adjacent beach, as designed

Change rate exceeded planned monitoring

Extremely difficult winter monitoring

Site is likely *too dynamic* for living shoreline approaches

Findings: log structure appears to be stable though sediment eroded. If project was constructed and plantings placed in late spring (as opposed to fall), it's possible that project would be performing a bit better, but the extent of high erosion along the 400-foot bluff would still likely have caused erosion of the site.

Some Lessons Learned

Biodegradable Products Tested

- Biodegradable twine is *not adequate* for holding down bags. Once it gets wet, it stretches.
- Biodegradable bags, though easy to work with, are likely too light to hold up to storm events.
- Biodegradable bags, even when held in place, will fall apart in <2 years.
- We will implement **an adapted biodegradable design** to test for efficacy at the Wharton Point and MBCL sites. A **new staking approach** will also be implemented.

Some Lessons Learned

Synthetic and Log Products Tested

- Tensar GeoReef, especially at Wharton Point where the baskets were filled to create the rectangle shape, appears to be holding up very well in terms of shape, stability, ability to hold shell, and degradation.
- Tensar GeoReef at MBCL could have been filled with more shell to help retain shape, but it is very difficult to do this under the log runners.
- Shore parallel log at Wharton Point may not be high enough to efficiently break up wave energy so close to the installation. Shore perpendicular log runners at MBCL have performed relatively well.
- Recommend altering future attachment to tree runners using duckbills in future.

Some Lessons Learned



Stepped Crib and Vegetative Plantings

- Lanes Island shoreline changes may be too dynamic for a “living shoreline”
- Scale is extremely important: a small scale, 50-foot treatment may not be appropriate for determining efficacy of a treatment type along long shoreline lengths that are highly eroding.
- Projects employing vegetative plantings should be completed in the spring so that vegetation has an entire growing period to establish.
- Though the installation eroded, it performed as expected in terms of its “failure”. We still feel a stepped-crib approach that beneficially uses trees is a transferable technique that can work along eroding bluff shorelines.

Some Lessons Learned



Monitoring

- **Photographic documentation and shoreline change measurements** (using RTKGPS and total station) have been the **best source of monitoring data**.
- **Detailed biologic and vegetative monitoring** have not shown any significant changes and are extremely labor intensive and likely shouldn't be implemented unless significant planting is part of a project.
- **Accessibility has been a key factor** in being able to obtain good monitoring data, especially during the winter months.

For more information on living shorelines in Maine

Living Shorelines in Maine (MGS)

<https://www.maine.gov/dacf/mgs/explore/marine/living-shorelines/>

Living Shorelines Demonstration Project Video (GPCOG)

<https://vimeo.com/485528619>

Living Shorelines in New England (TNC)

<https://www.conservationgateway.org/ConservationPractices/Marine/Pages/new-england-living-shorelines.aspx>

Living Shoreline Pilot Project Case Studies (TNC)

<https://www.nature.org/en-us/what-we-do/our-priorities/protect-water-and-land/land-and-water-stories/northeast-living-shorelines/>

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