New Hampshire Experiences with Living Shorelines for Fringing Salt Marshes

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COASTAL HABITAT RESTORATION TEAM
CHART

Salt marshes are among our most productive and valuable ecosystems

Plants support food webs

Secondary production

Plant structure for habitat

Support of biodiversity

Protection from flooding

Protection from coastal erosion

Removal of sediments & excess nutrients

Aesthetic, Recreational & Educational values

Self-sustaining ecosystems

Long term carbon storage

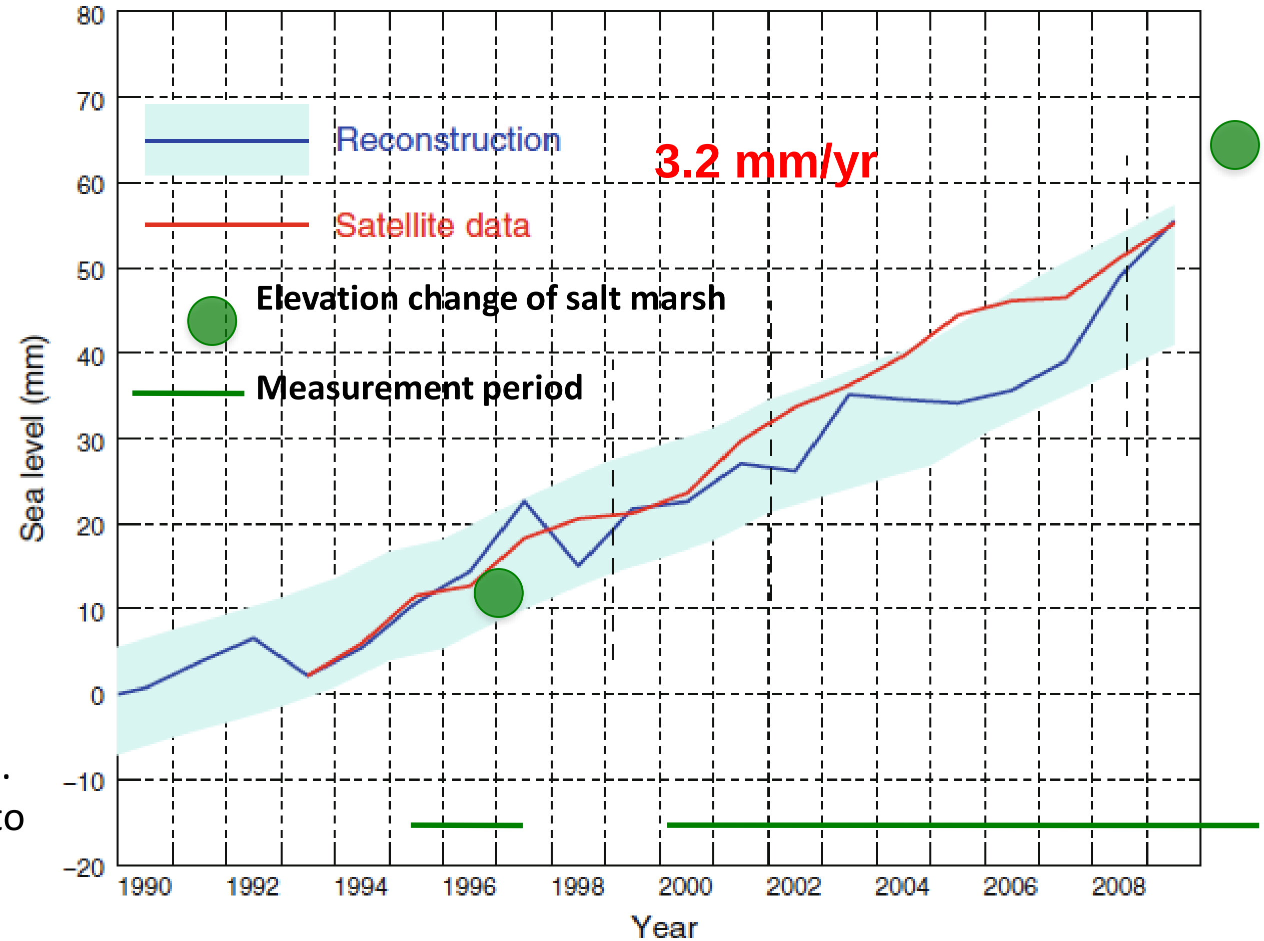
The Case for Building Salt Marshes into Living Shorelines

- Loss of 30% of historical salt marshes in NH
- Future for marshes is not bright – sea level rise and climate change at faster rates
- Salt marshes and peat develop slowly as sea levels rise – most marshes are over 1,000 years old
- Created marshes erode EVEN if LOW physical exposure
  - 1993 salt marsh creation lost 20% of area in five years in North Mill Pond
- Salt marshes protect, survive and can heal following storms
  - Gittman et al. 2014

Global Sea Level Rise Measurements (Church & White 2011) Reflected in Salt Marsh Responses Found in Great Bay

Portsmouth Tide Gauge: 1.76 mm/yr 1927-2001

Sediment Elevation Table
Great Bay Elevation change
1.7 mm/yr 95-97
4.3 mm/yr 00-11

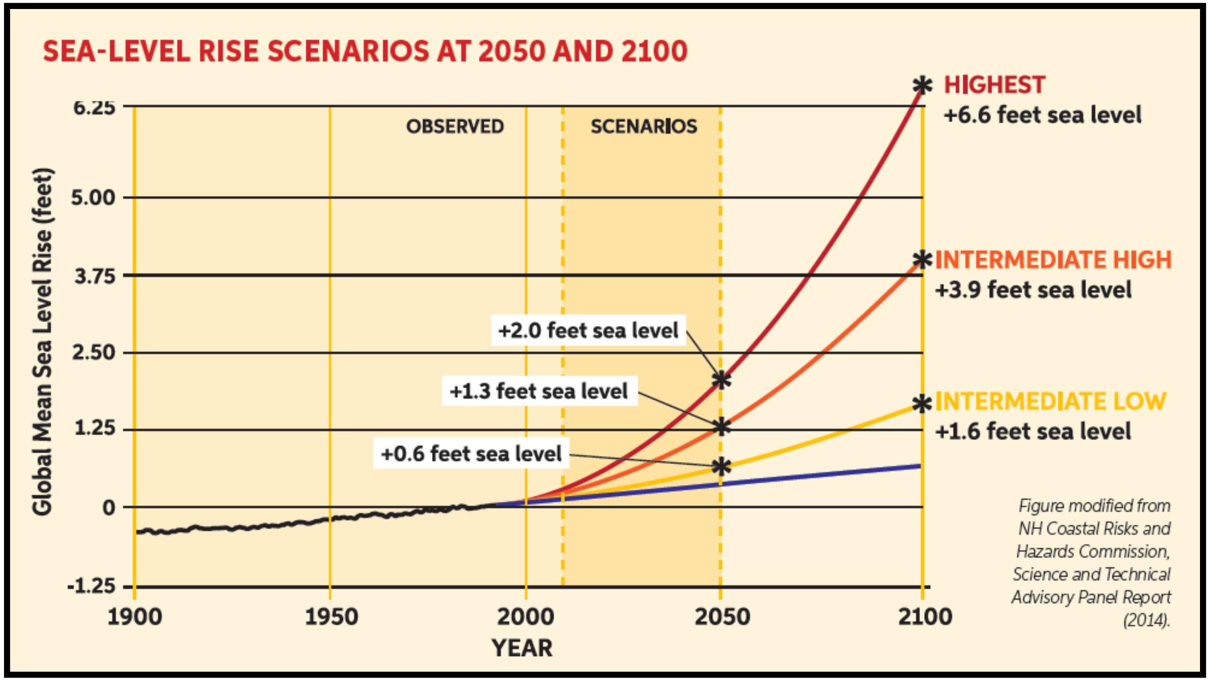


Church, J. A. and N.J. White. 2011. Sea-level Rise from the Late 19th to the early 21st Century. Survey Geophysics 32:585-602

Fig. 4 Global average sea level from 1990 to 2009 as estimated from the coastal and island sea-level data (*blue* with one standard deviation uncertainty estimates) and as estimated from the satellite altimeter data from 1993 (*red*). The satellite and the in situ yearly averaged estimates have the same value in 1993 and the in situ data are zeroed in 1990. The *dashed vertical lines* indicate the transition from TOPEX Side A to TOPEX Side B, and the commencement of the Jason-1 and OSTM/Jason-2 records

SHORELINE **TOMORROW**

SEA-LEVEL RISE



PROJECTIONS

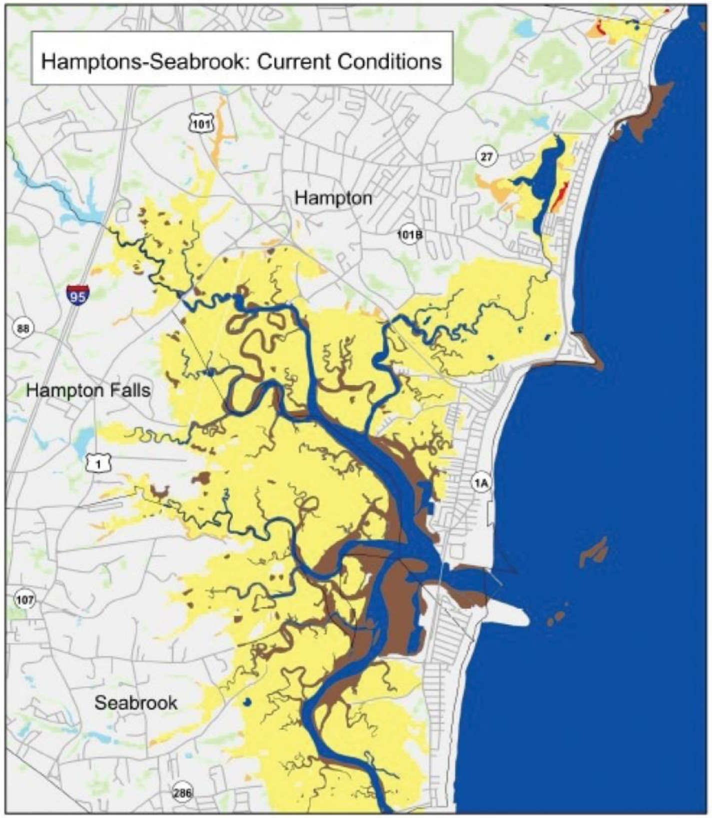
- 0.6 – 2.0 ft. by 2050
- 1.6 – 6.6 ft. by 2100

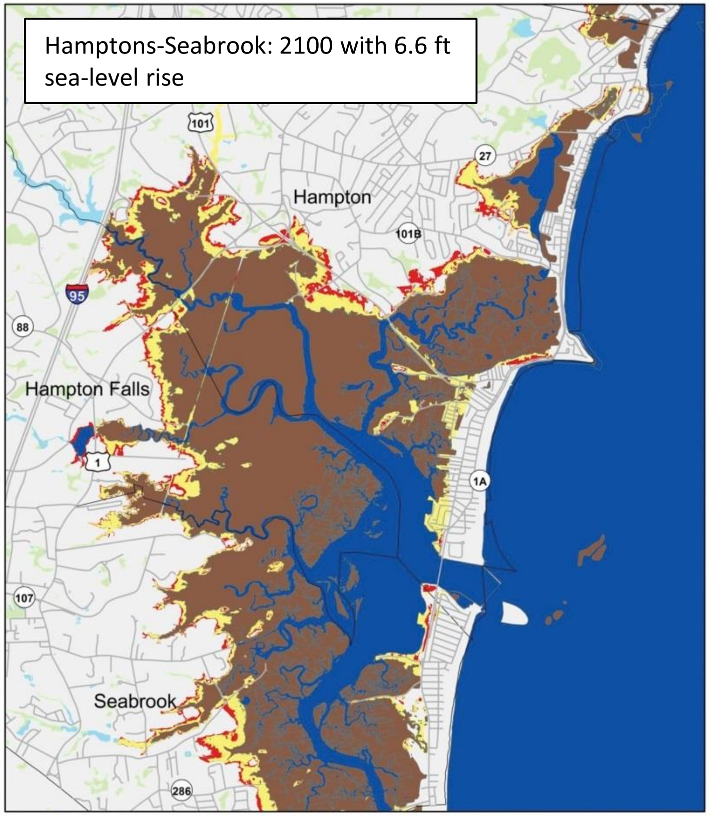
HOW TO PREPARE

1. Select time period
2. Commit to manage ***intermediate high***
3. Adjust if necessary

Example: If the design time period is 2050-2100, commit to manage 3.9 ft. of sea-level rise, but be prepared to manage and adapt to 6.6 ft. if necessary.

SHORELINE **TOMORROW**



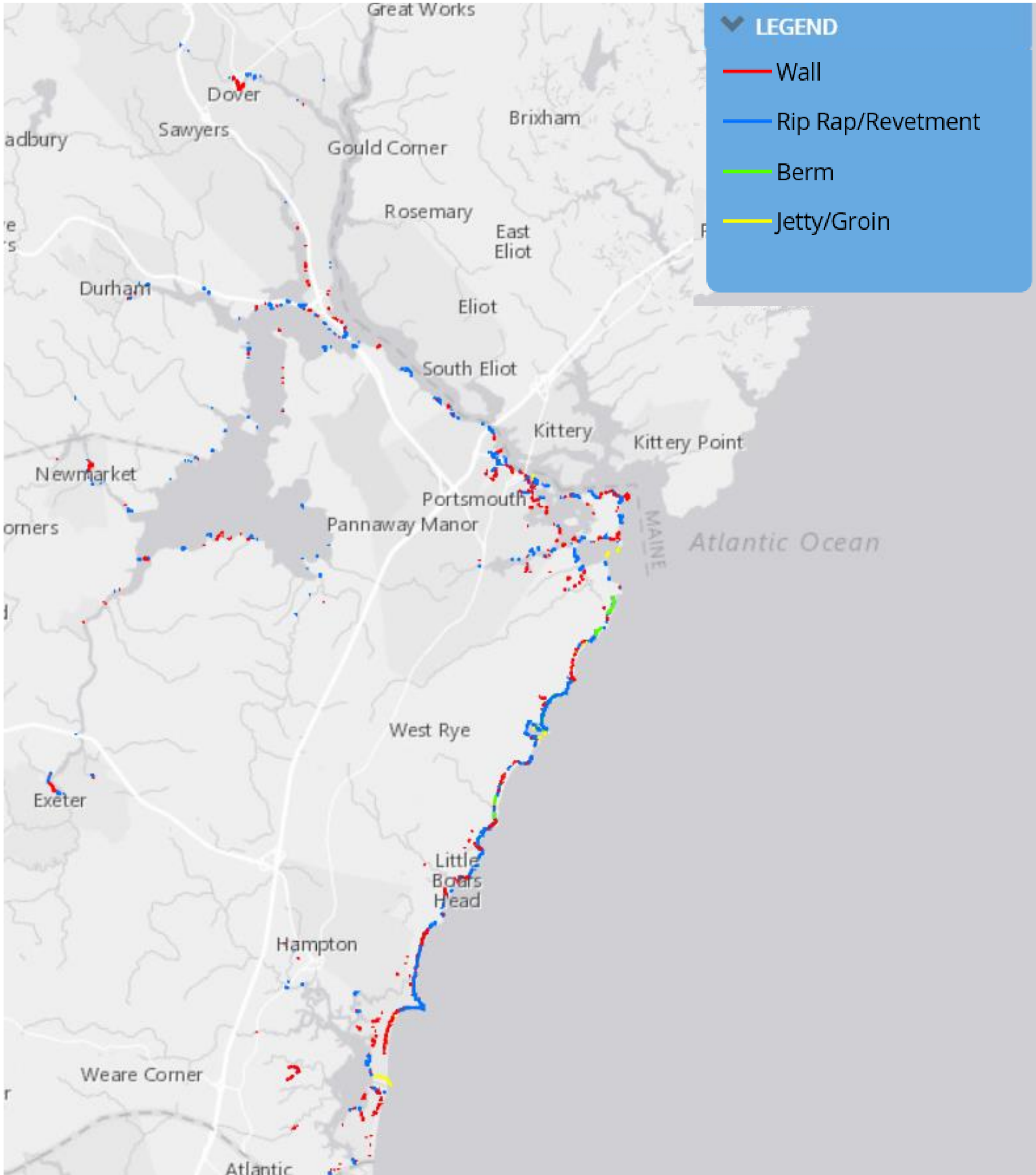


NH Fish & Game 2014

95 percent of existing salt marsh could be lost with 6.6 feet of sea-level rise

THE SALT MARSH SQUEEZE

marsh migration
+
stabilization
=
salt marsh squeeze



SHORELINE TODAY

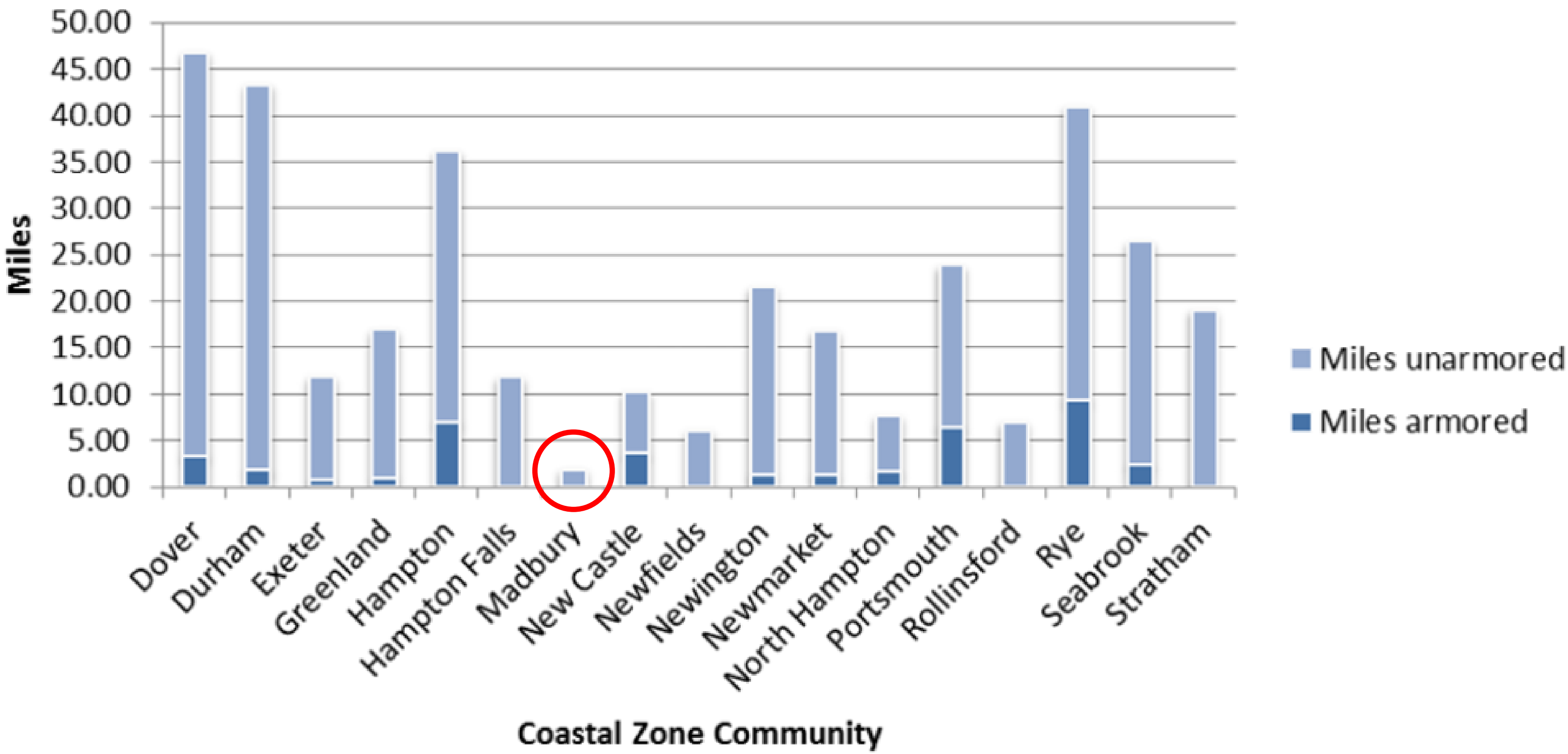
12% Total Armored

70% Atlantic Coast

5% Great Bay

Blondin & Howard 2014

SHORELINE TODAY

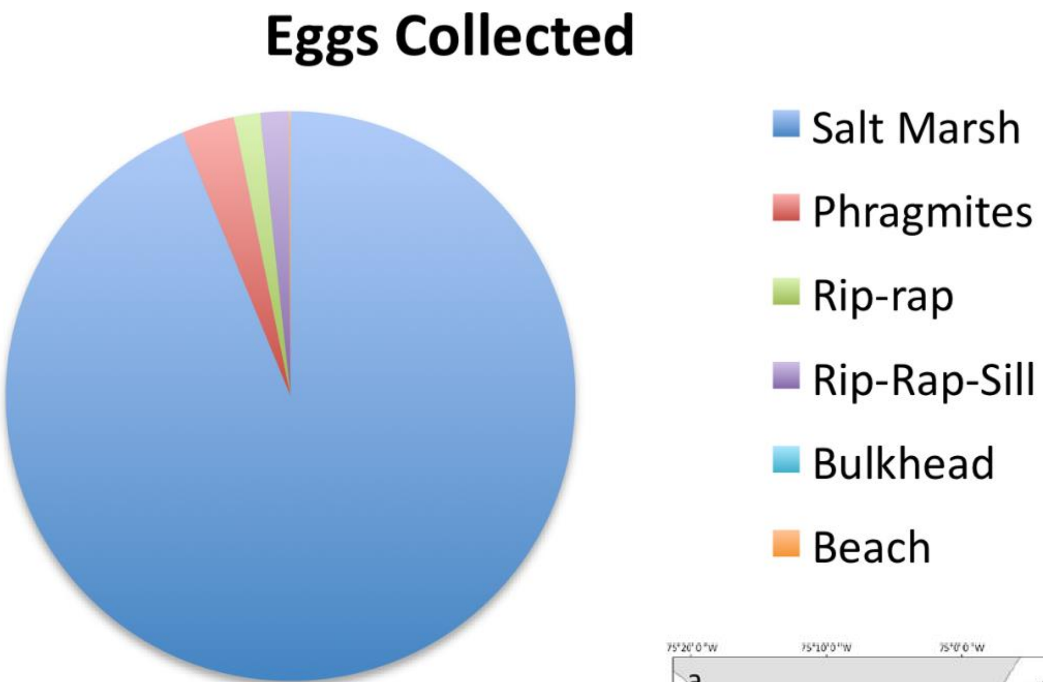


Blondin & Howard 2014

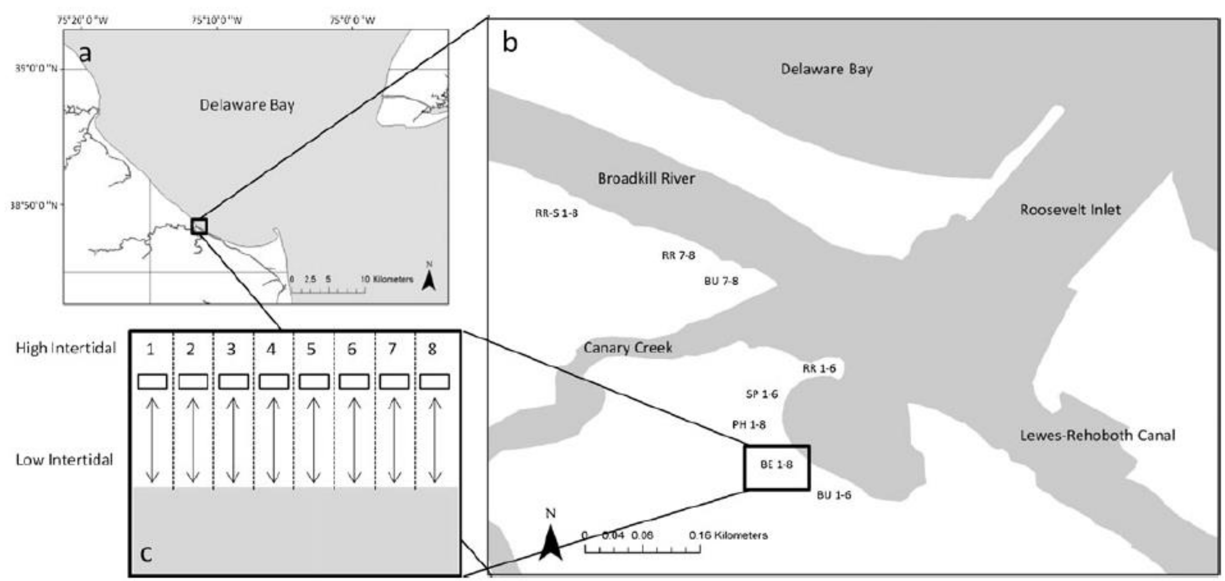
The Case for Building Salt Marshes into Living Shorelines

- What functions and values are lost?
  - Plant productivity, food web support, 2^{ary} production, biodiversity
  - Nutrient and sediment removal from water
  - Ability to grow with sea level rise
  - Ability to reduce wave energy
  - Ability to heal following storms
  - Carbon storage
  - Aesthetic value

Atlantic silversides spawn in Spartina



From Balouskus & Targett 2012



Tidal Marsh Ecosystem Services
Value per Annum per Hectare

Value per Annum per Hectare

- Costanza et al. 1987: $9,900
- In 2008 $ (Gedan et al. 2009): $14,400

New Services:

- Carbon sequestration (European market): $135
- Denitrification (Piehler and Smyth 2011): $6,128

Future Services: . . . ?

Definition

- *Living shorelines maintain continuity of the natural land–water interface and reduce erosion while providing habitat value and enhancing coastal resilience.* (NOAA, Guidance for Considering the Use of Living Shorelines, 2015)
- *Living shorelines maintain the continuity of natural land-water interface and provide ecological benefits which hard bank stabilization structures do not, such as improved water quality, resilience to storms, and habitat for fish and wildlife.* (COE NWP, 2016) – Focus is EROSION

Critical Living Shoreline Components

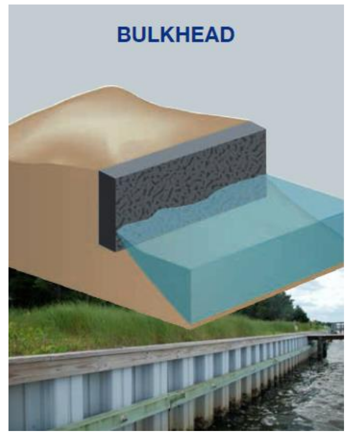
- Continuity of shoreline water-sediment characteristics/interaction
- Habitat
  - Aquatic
  - Riparian

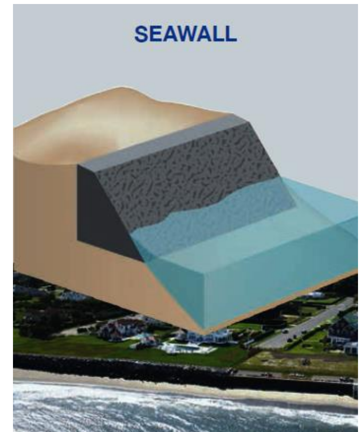
Does not necessarily include plants, but "*Living shorelines must have a substantial biological component…*" (COE, NWP, 2016)

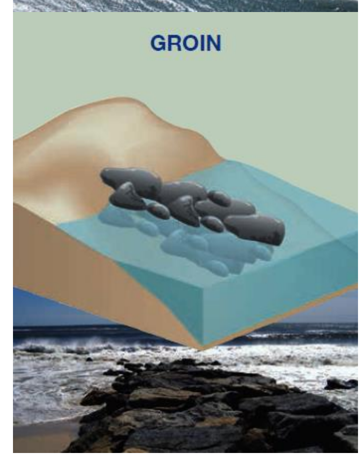
What Is Not "Living" Shoreline?

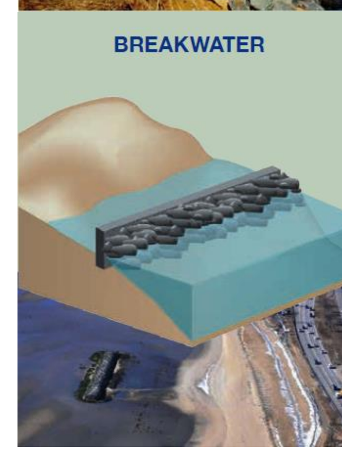
- Bulkhead
- Seawall
- Revetment
- Groins
- Breakwater
- Sills
- Composite

However some may be components of living shoreline systems









Shoreline Issues Addressed by Living Shoreline Solutions

- Erosion (from waves, currents–longshore drift, ice)
- Habitat loss (historic and recent losses of oyster reefs, salt marshes, tidal buffer zone)
- Sea level rise (salt marshes build with sea level rise – up to a point)
- Infrastructure protection (bridge abutments, roads, pipelines, sewers, etc.)

What Elevation Range Do We Find Salt Marsh?

McKee and Patrick, 1988

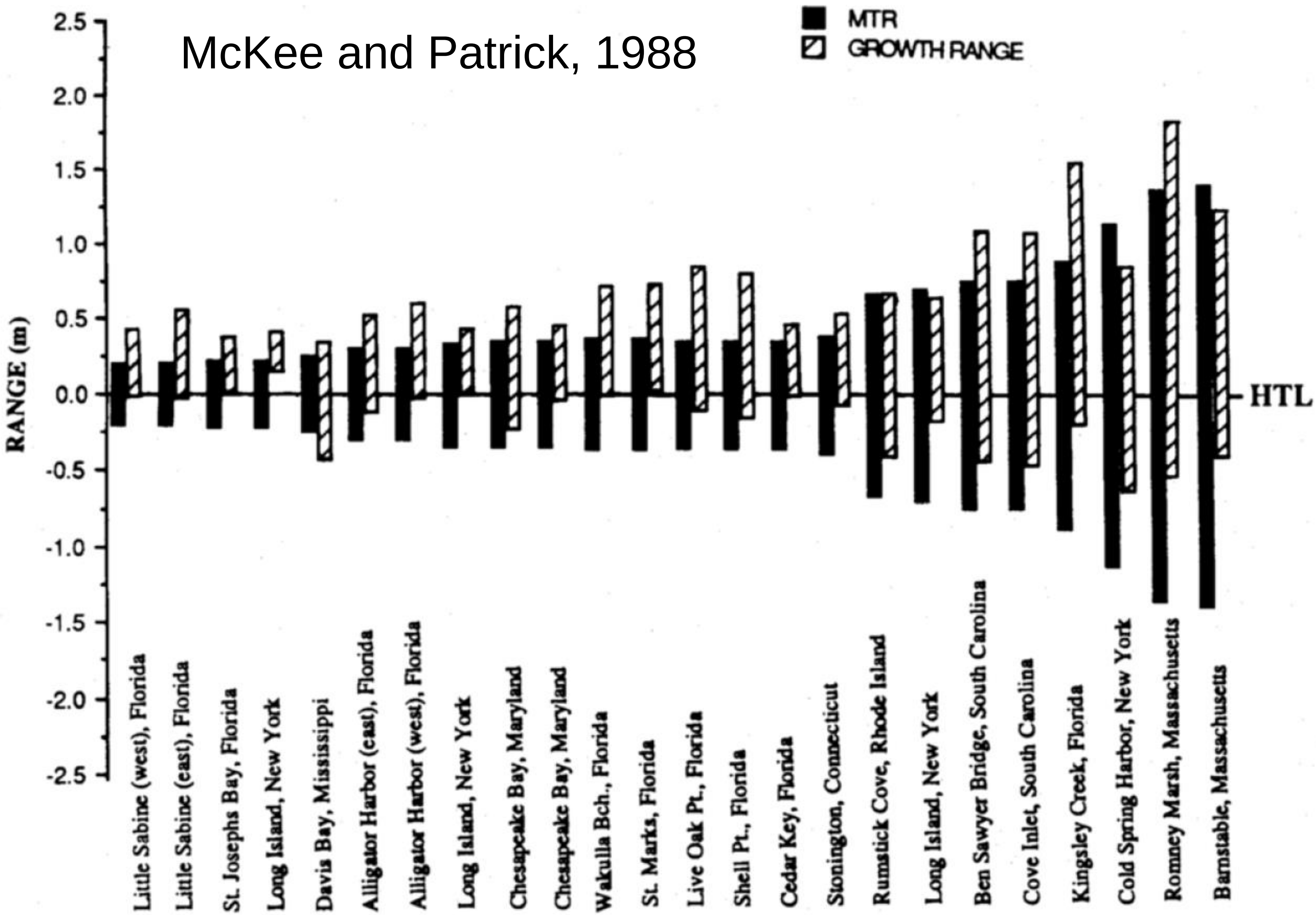


Fig. 2. The elevational range of growth of *Spartina alterniflora* relative to mean tide range (MTR) at selected locations along the Atlantic and Gulf coasts (arranged in order of increasing tidal amplitude). The half tide level (HTL) is the plane midway between mean high water (MHW) and mean low water (MLW).

Salt Marsh Vegetation

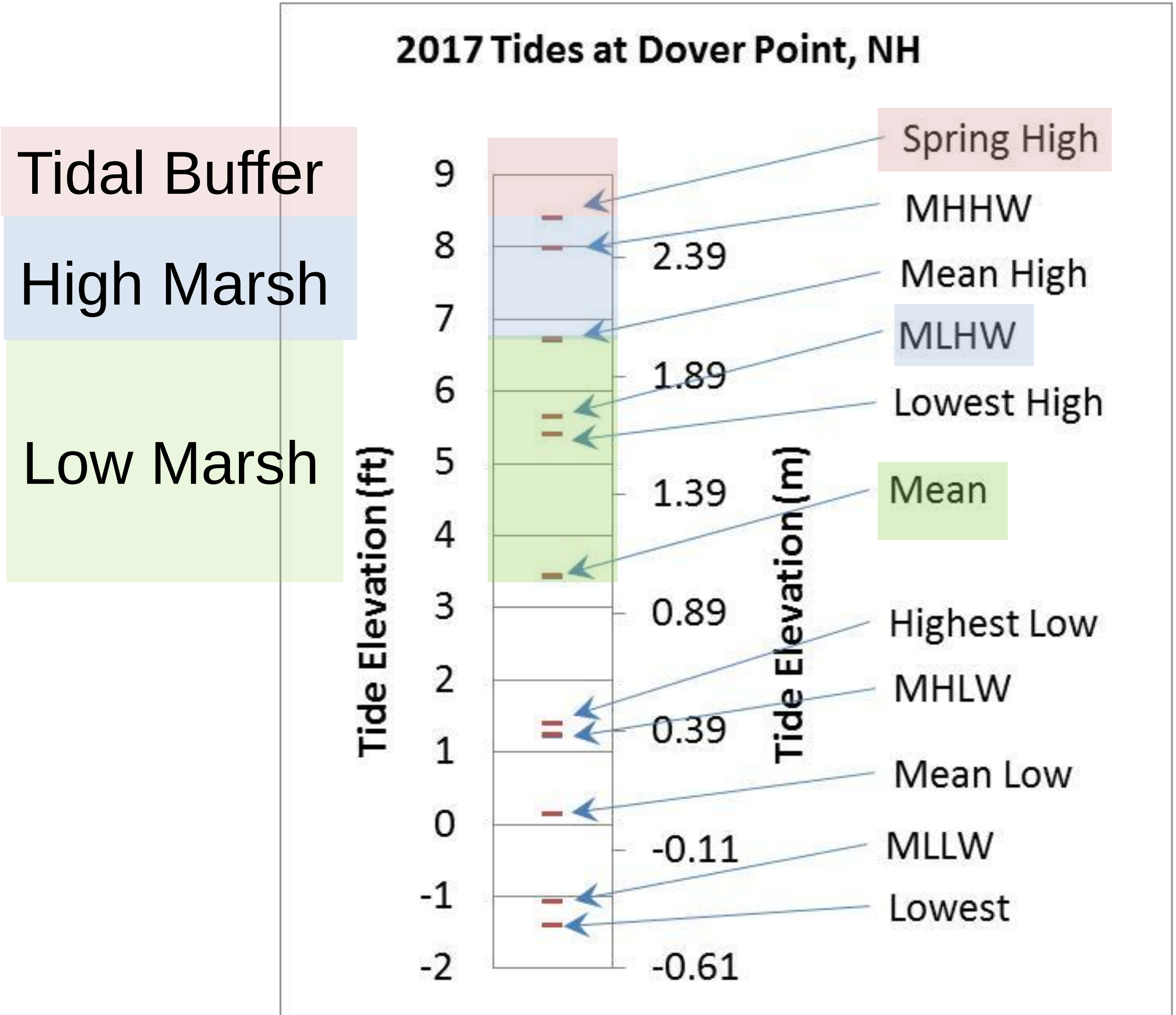
- Low Marsh:
  - *Spartina alterniflora* (smooth cordgrass)
- High Marsh:
  - *Spartina patens* (salt hay)
  - *Puccinellia americana* (alkali grass)
  - *Distichlis spicata* (spike grass)
  - *Juncus gerardii* (black grass)
- Tidal Buffer Zone:
  - *Panicum virgatum* (switchgrass)
  - *Solidago sempervirens* (seaside goldenrod)

Spartina alterniflora

Ecozones

- Low Marsh - Near the MSL; (McKee and Patrick 1988). *Spartina alterniflora* is the only important plant.
- High Marsh - Begins at MHW and extends up to high tide line – A reasonable lower limit for a built/planted marsh might be 10 cm higher than that. Practically, it is best to plant *S. alterniflora* as much as 25 cm above MHW – it will do fine at these elevations; high marsh plants should be planted too and may replace *S. alterniflora* .
- Tidal Buffer Zone - Begins at or above the spring high tide but certainly below the highest observable tide (HOT) and extends as much as two feet higher, depending on exposure. - A transition from the highest of the high marsh plants (like seaside goldenrod and high tide bush) to quackgrass and then shrubs at even higher levels (beach plum, shad bush, bayberry, etc.)

The Zones


Tidal Buffer
High Marsh
Low Marsh
2017 Tides at Dover Point, NH
Tide Elevation (ft)
9
8
7
6
5
4
3
2
1
0
-1
-2
2.39
1.89
1.39
0.89
0.39
-0.11
-0.61
Tide Elevation (m)
Spring High
MHHW
Mean High
MLHW
Lowest High
Mean
Highest Low
MHLW
Mean Low
MLLW
Lowest

Challenges of Living Shorelines In General

- Causes of impairment or loss (wind/wave, climate, etc.)
- Geomorphic setting
- Permitting
- Access
- Vegetation survival
- Tidal range
- Water quality
- Sea level and sea level rise
- Run-on and drainage
- Orientation (sun exposure, wind)

Challenges of northern shoreline projects

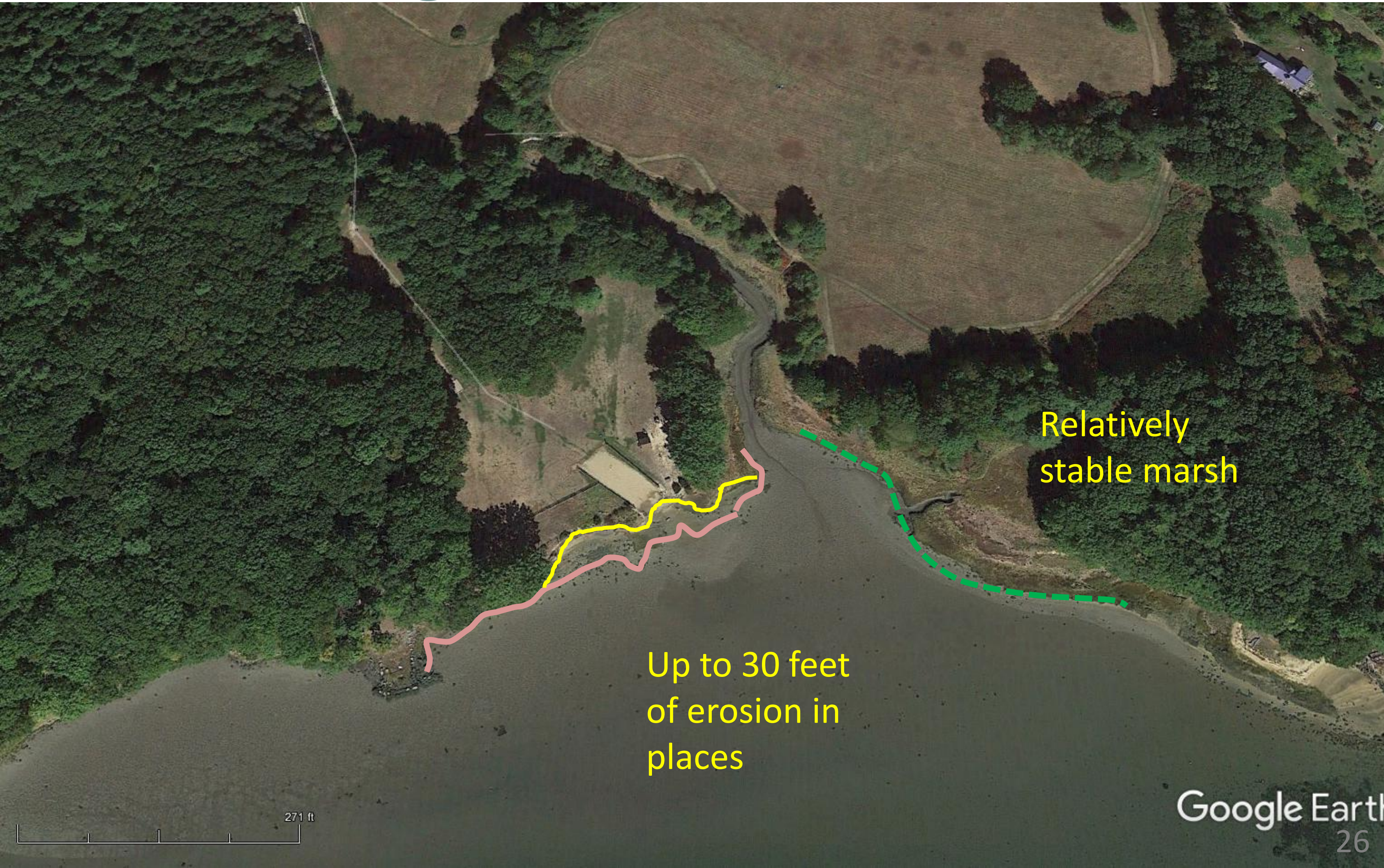
- Low light
- Short growing season
- Large tidal range
- Ice

But, How to “Restore” or “Rebuild”

- Define or measure “impairment”
- What are the appropriate geometric and hydrologic metrics for restoration (analogy to streams)?
  - Use analytical methods at each site
  - Employ geomorphic characteristics of reference sites
- What is “success”?

Wagon Hill Farm

Change from 1992 to 2015



Observed Erosion Most Tidal Cycles

Erosion Pins Monitored Quarterly

The Groundwater Well Installed in 2000

Erosion Pins

upper

Erosion Rates

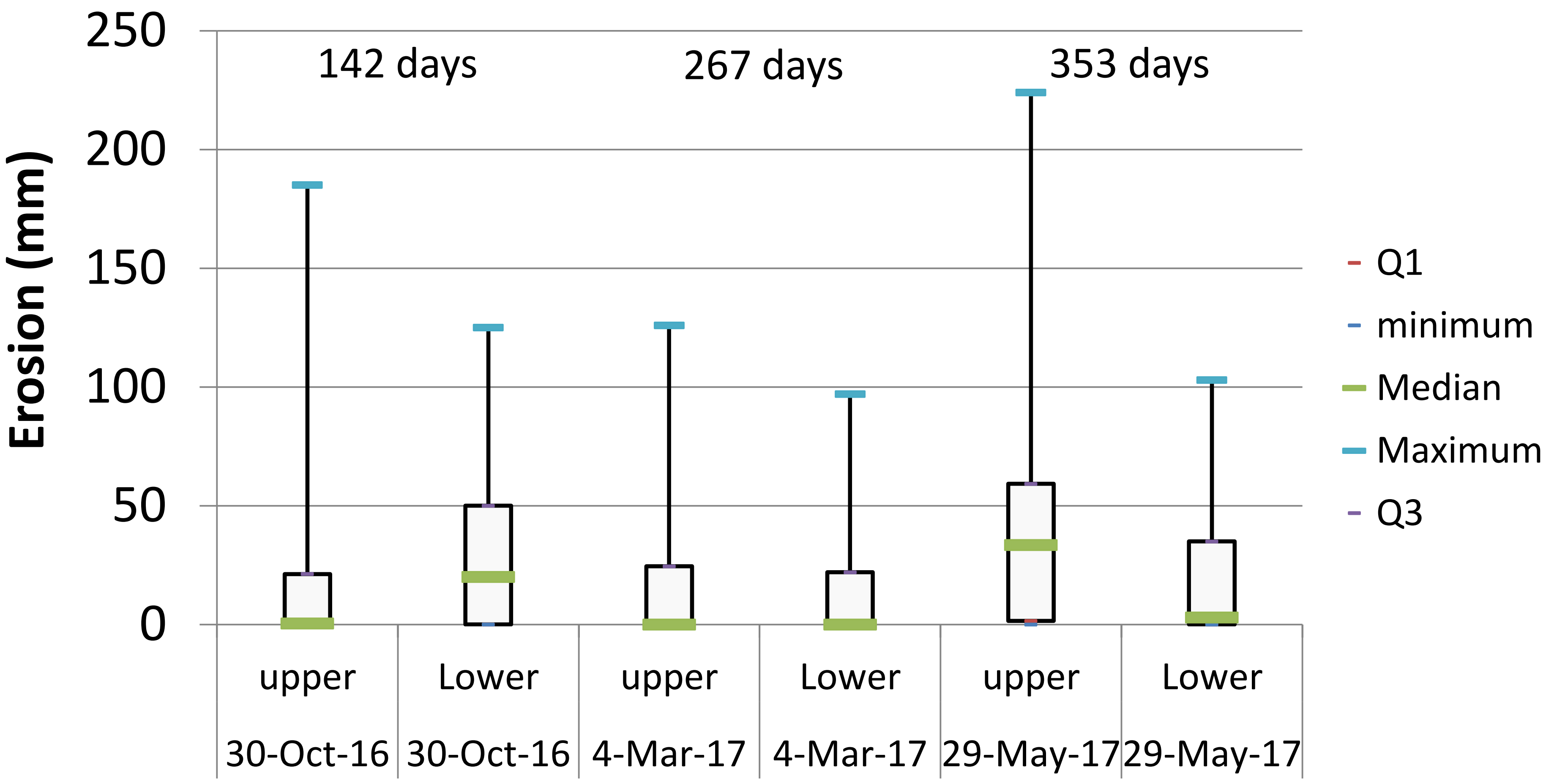
(ft/yr)

	upper	lower
Average	0.208	0.148
Minimum	0.000	0.000
Median	0.129	0.054
Maximum	0.875	0.930

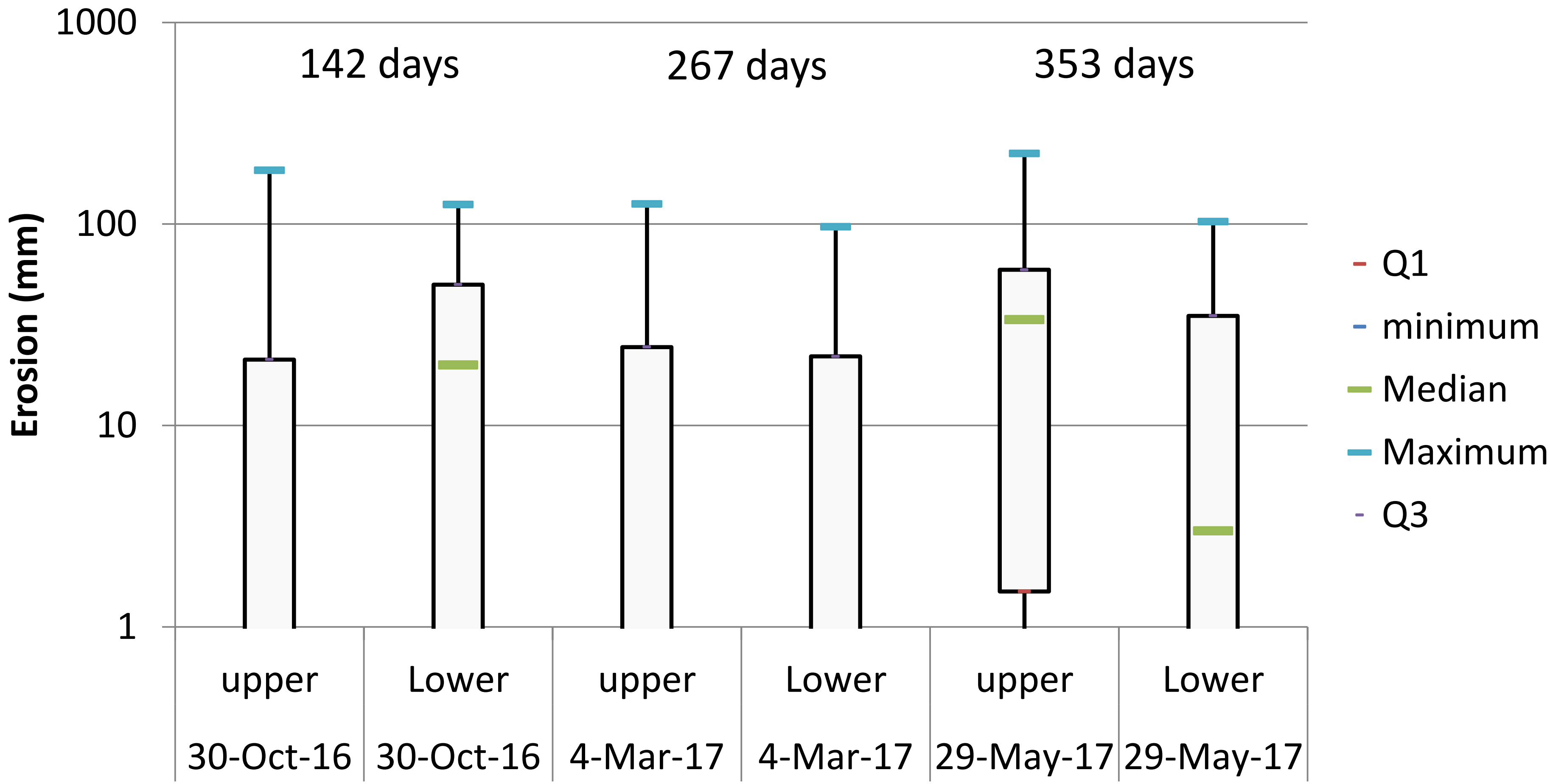
(mm/yr)

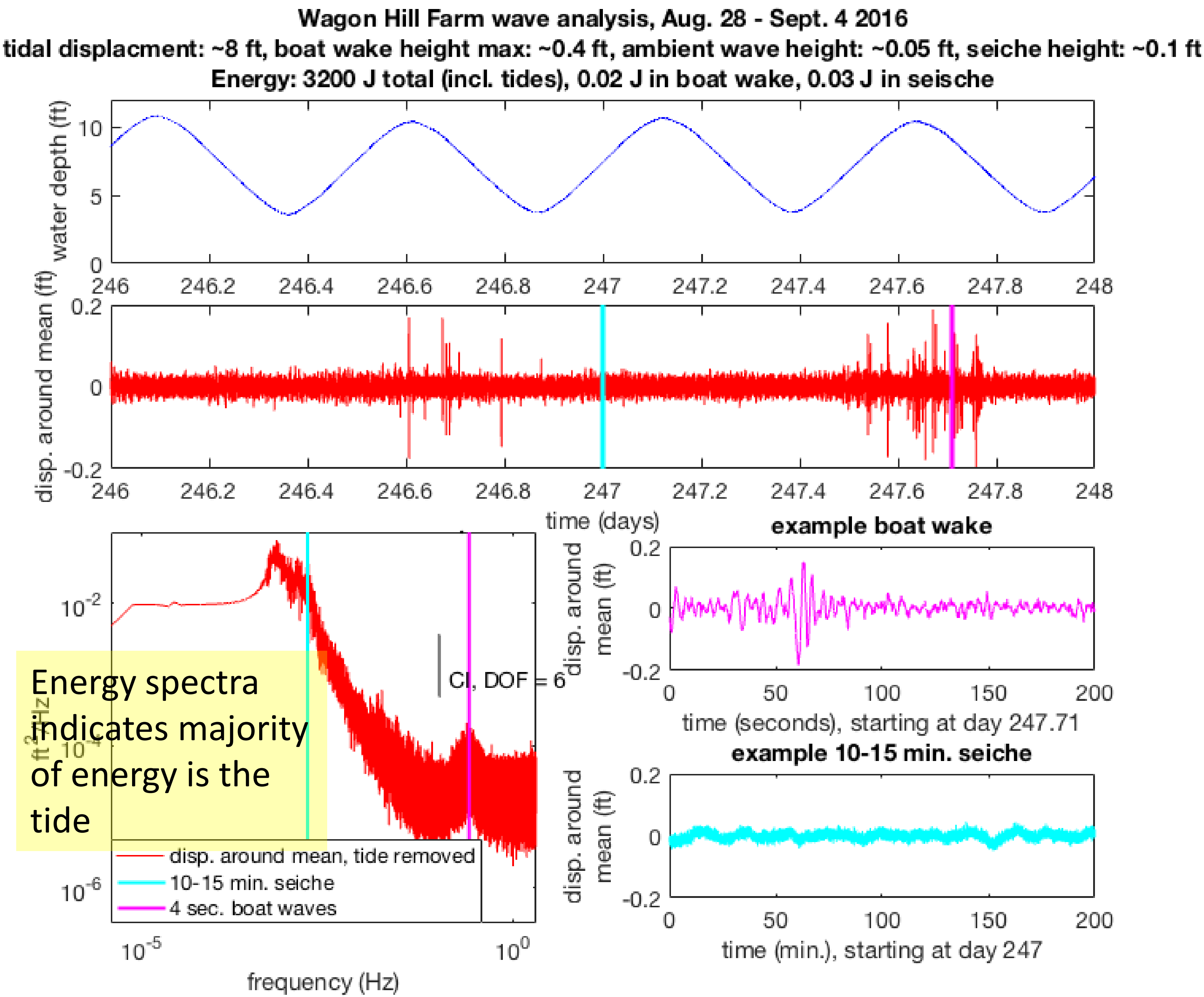
	upper	lower
Average	66.7	47.5
Minimum	0	0
Median	41.4	20.7
Maximum	266.8	283.3

Erosion Pin Readings



Erosion Pin Readings (log scale)




Wagon Hill Farm wave analysis, Aug. 28 - Sept. 4 2016
tidal displacment: ~8 ft, boat wake height max: ~0.4 ft, ambient wave height: ~0.05 ft, seiche height: ~0.1 ft
Energy: 3200 J total (incl. tides), 0.02 J in boat wake, 0.03 J in seische
water depth (ft)
disp. around mean (ft)
time (days)
example boat wake
time (seconds), starting at day 247.71
example 10-15 min. seiche
time (min.), starting at day 247
CI, DOF = 6
disp. around mean, tide removed
10-15 min. seiche
4 sec. boat waves
frequency (Hz)
Energy spectra indicates majority of energy is the tide

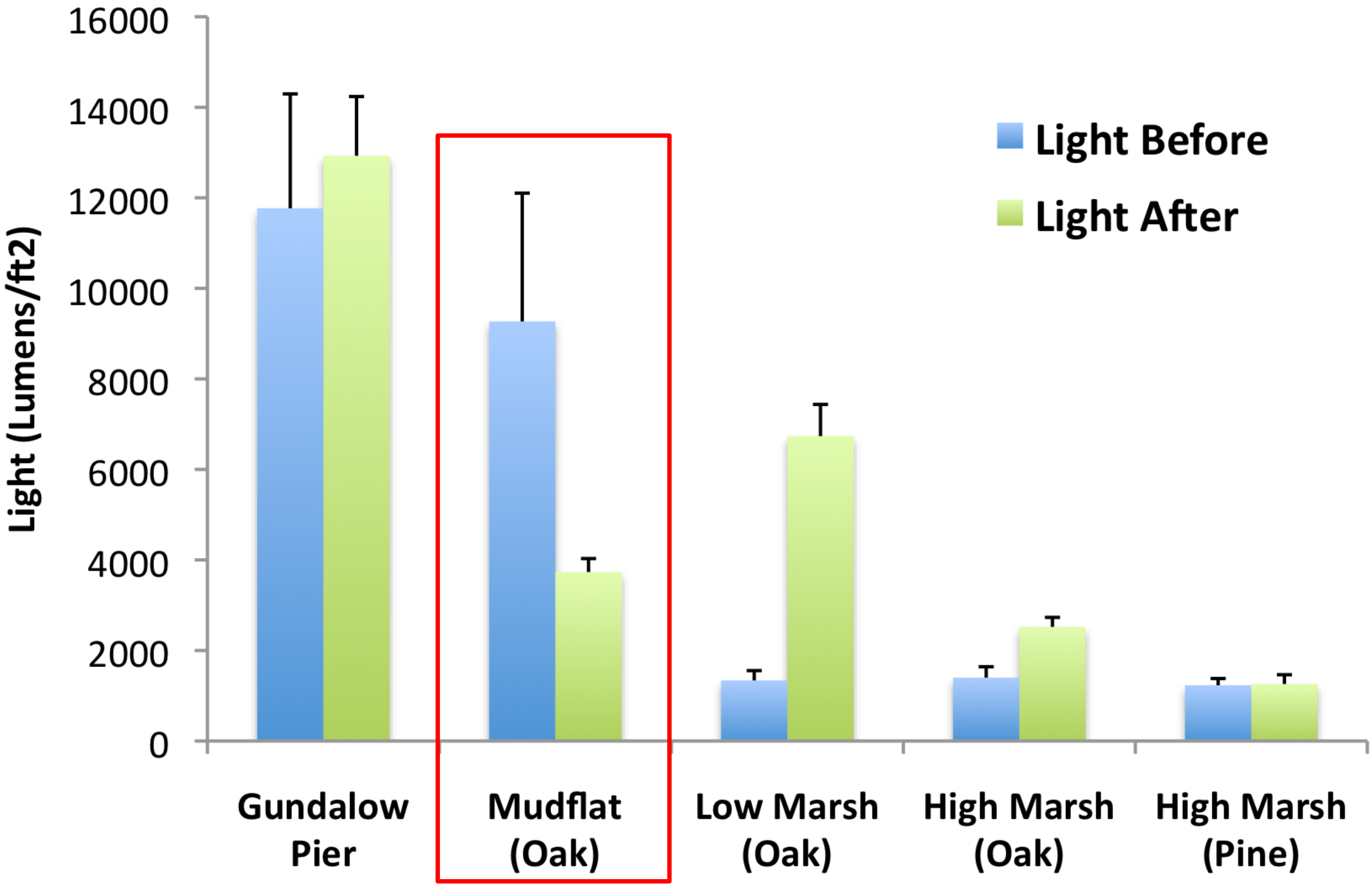
Sunlight Effect on Stability

2016 pre-trimming – note light meter on stake at center of image

2016 post trimming


2016 post trimming

Light Reaching Marsh Surface Before and After Limbing



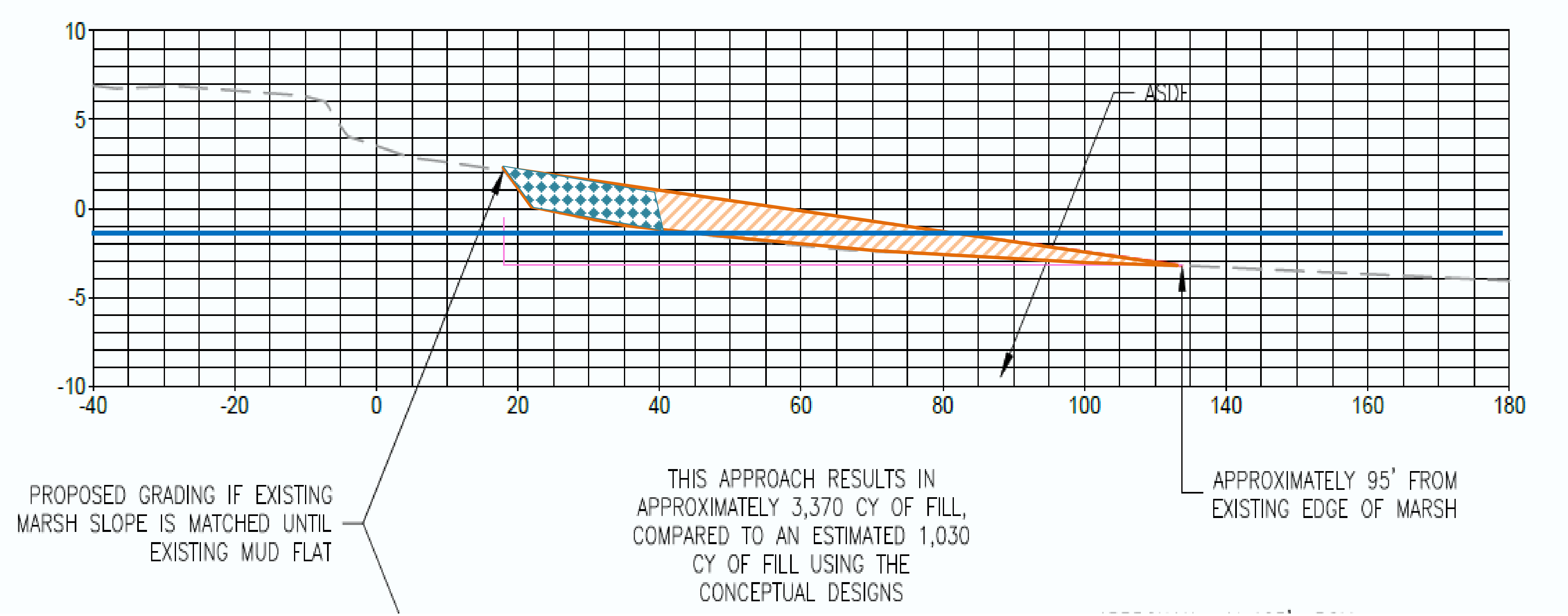
Foot Traffic


LIVING SHORELINE
PILOT PROGRAM
PLEASE DO NOT
APPROACH
TOWN OF DURHAM - UNH - NHDES

Get out!

Stormwater Runoff

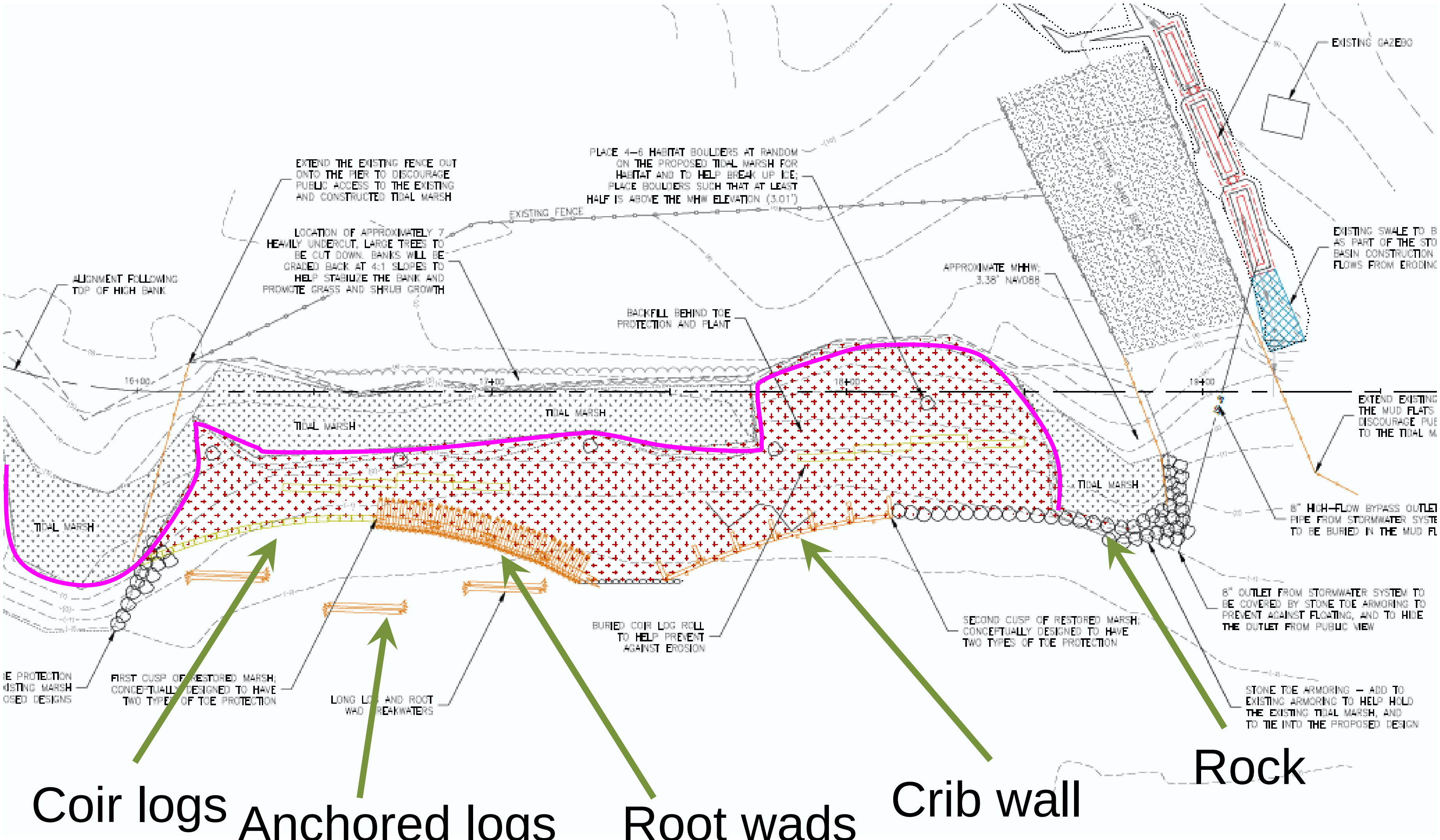
"Softer" Edge



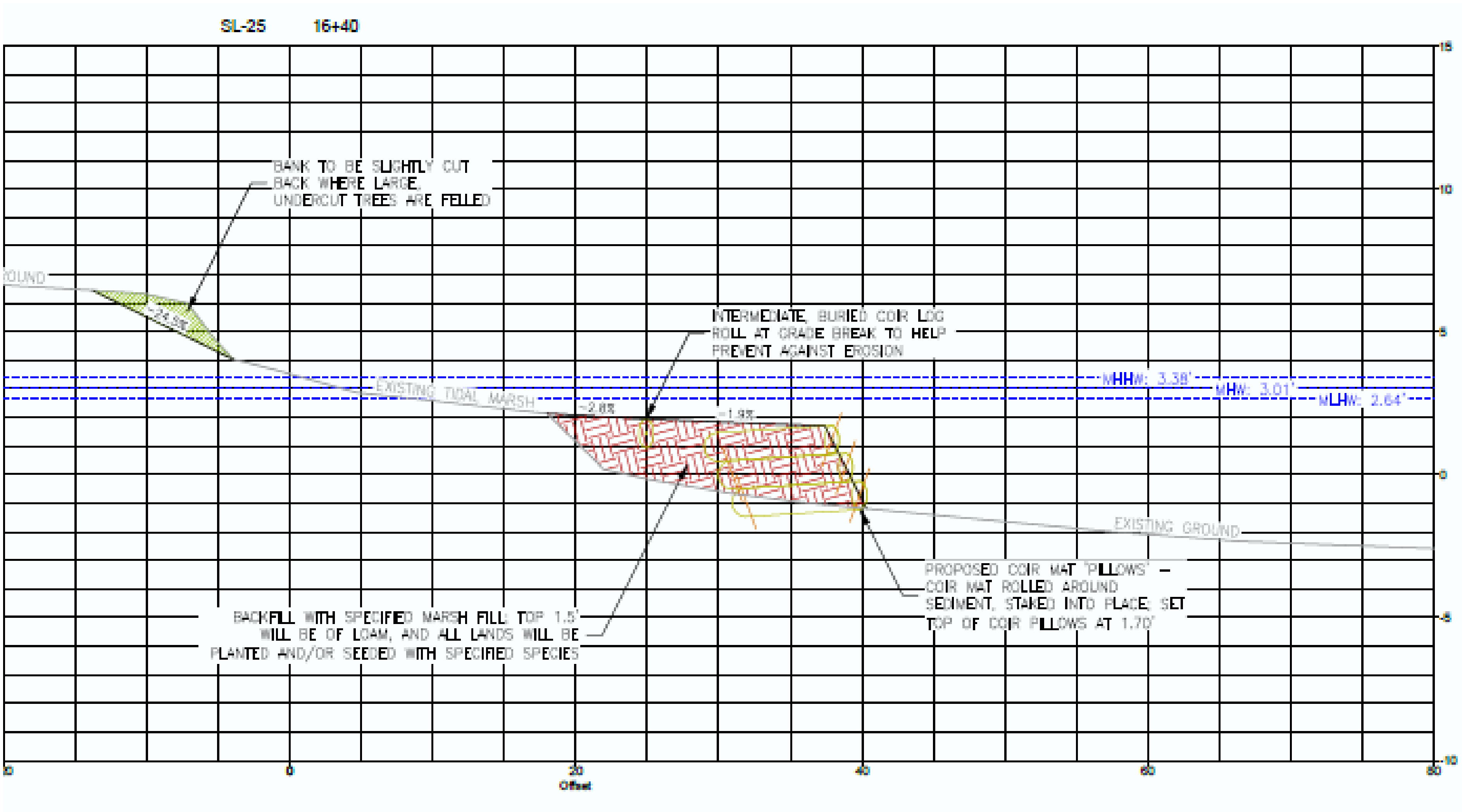
Can extend the sediment to avoid hard edge, but cannot grow anything over most of the fill. Would most likely erode

EXTEND THE EXISTING FENCE OUT ONTO THE PIER TO DISCOURAGE PUBLIC ACCESS TO THE EXISTING AND CONSTRUCTED TIDAL MARSH
PLACE 4-6 HABITAT BOULDERS AT RANDOM ON THE PROPOSED TIDAL MARSH FOR HABITAT AND TO HELP BREAK UP ICE; PLACE BOULDERS SUCH THAT AT LEAST HALF IS ABOVE THE MHW ELEVATION (3.01')
EXISTING FENCE
LOCATION OF APPROXIMATELY 7 HEAVILY UNDERCUT, LARGE TREES TO BE CUT DOWN. BANKS WILL BE GRADED BACK AT 4:1 SLOPES TO HELP STABILIZE THE BANK AND PROMOTE GRASS AND SHRUB GROWTH
APPROXIMATE MHHW; 3.38' NAVD88
BACKFILL BEHIND TOE PROTECTION AND PLANT
17+00
18+00
TIDAL MARSH
TIDAL MARSH
BURIED COIR LOG ROLL TO HELP PREVENT AGAINST EROSION

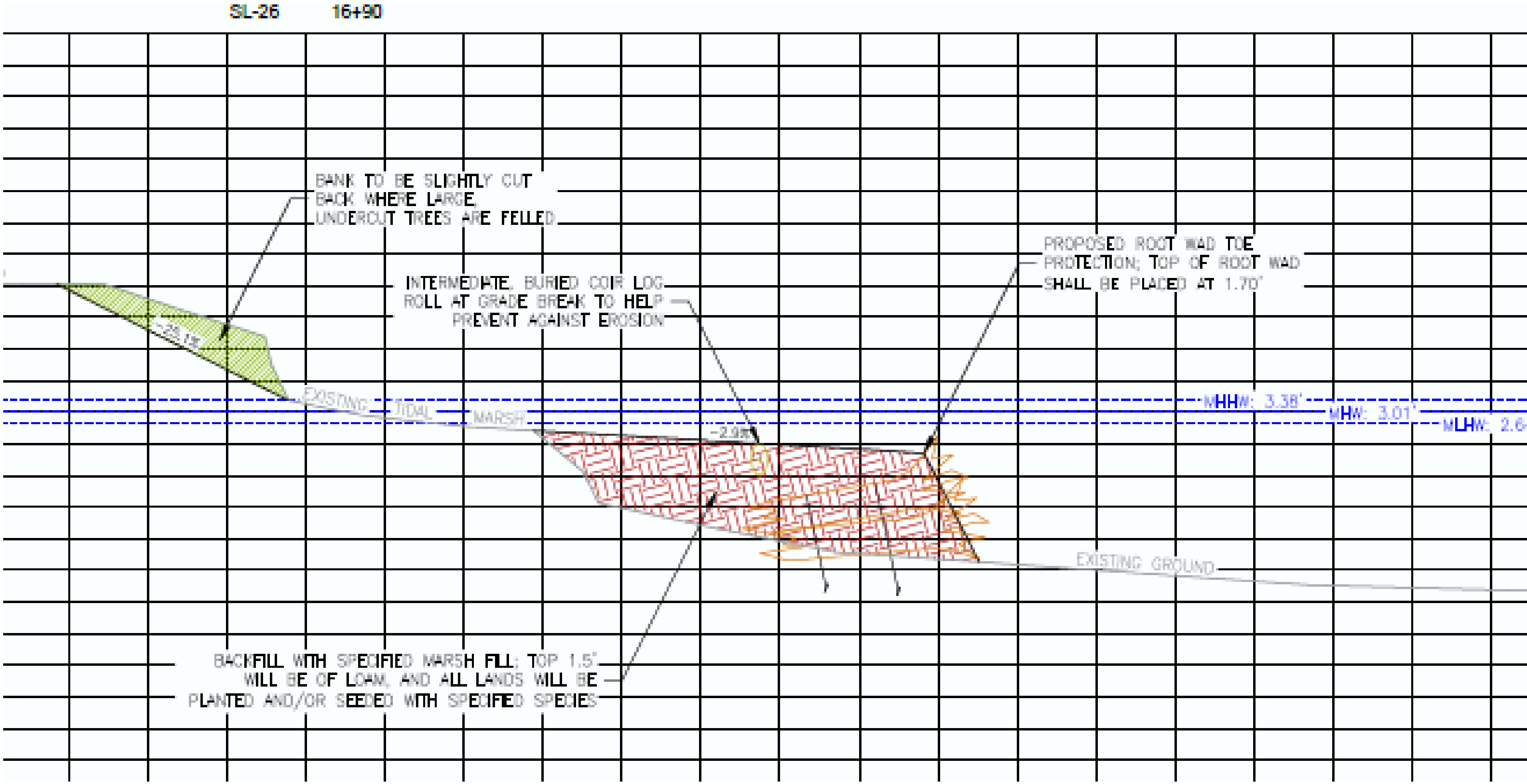
Potential First Phase - Plan



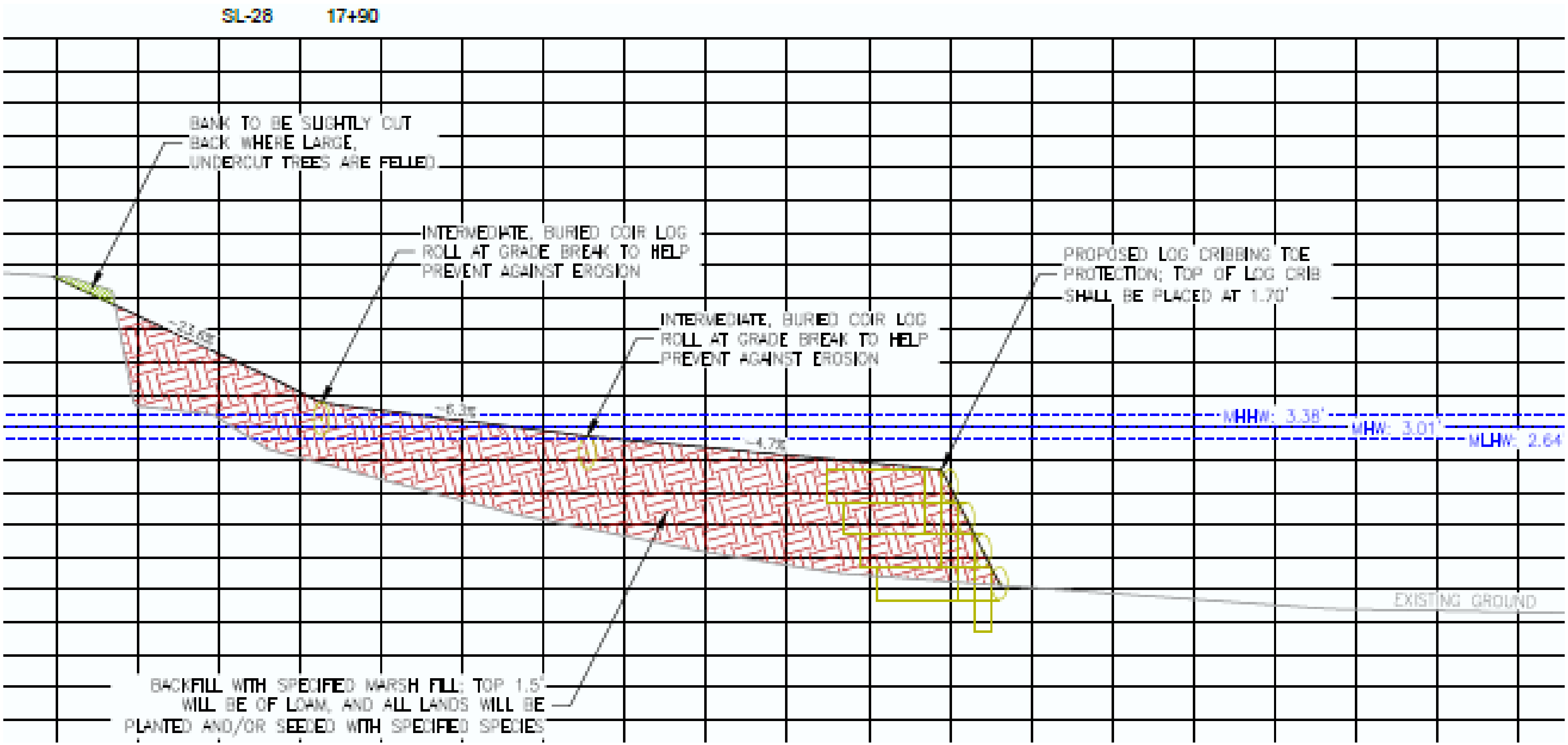
Profile Type 1 – Coir Log



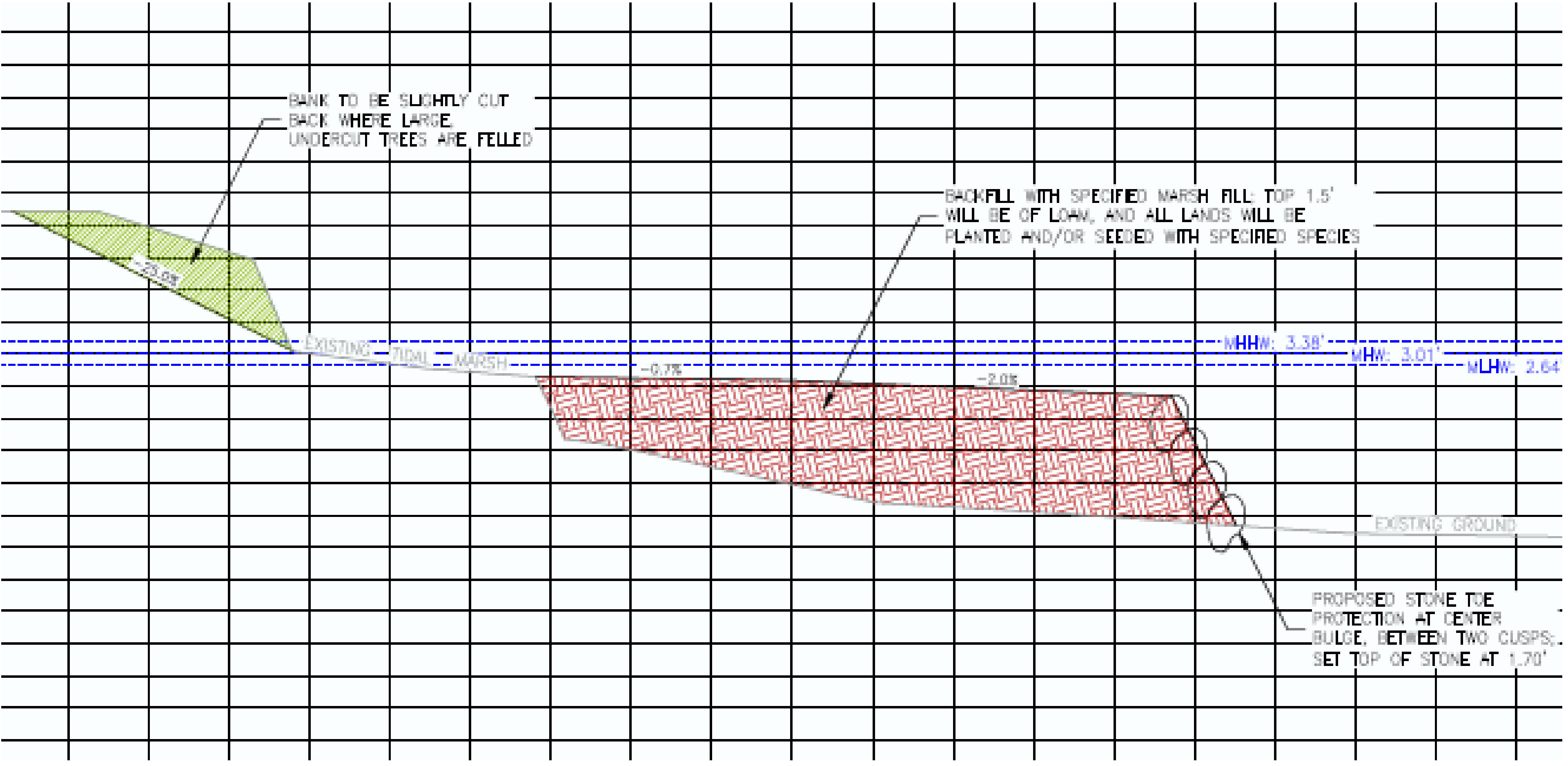
Profile Type 2 – Root wads



Profile Type 3 – Crib wall



Profile Type 4 - Rock



Test Structure Mock up

Completed Test Structure – 6 June 2017

Postcard View

Coir Logs and Root Wad

STRUCTURE TODAY

Lesson Learned

Test Structure Today

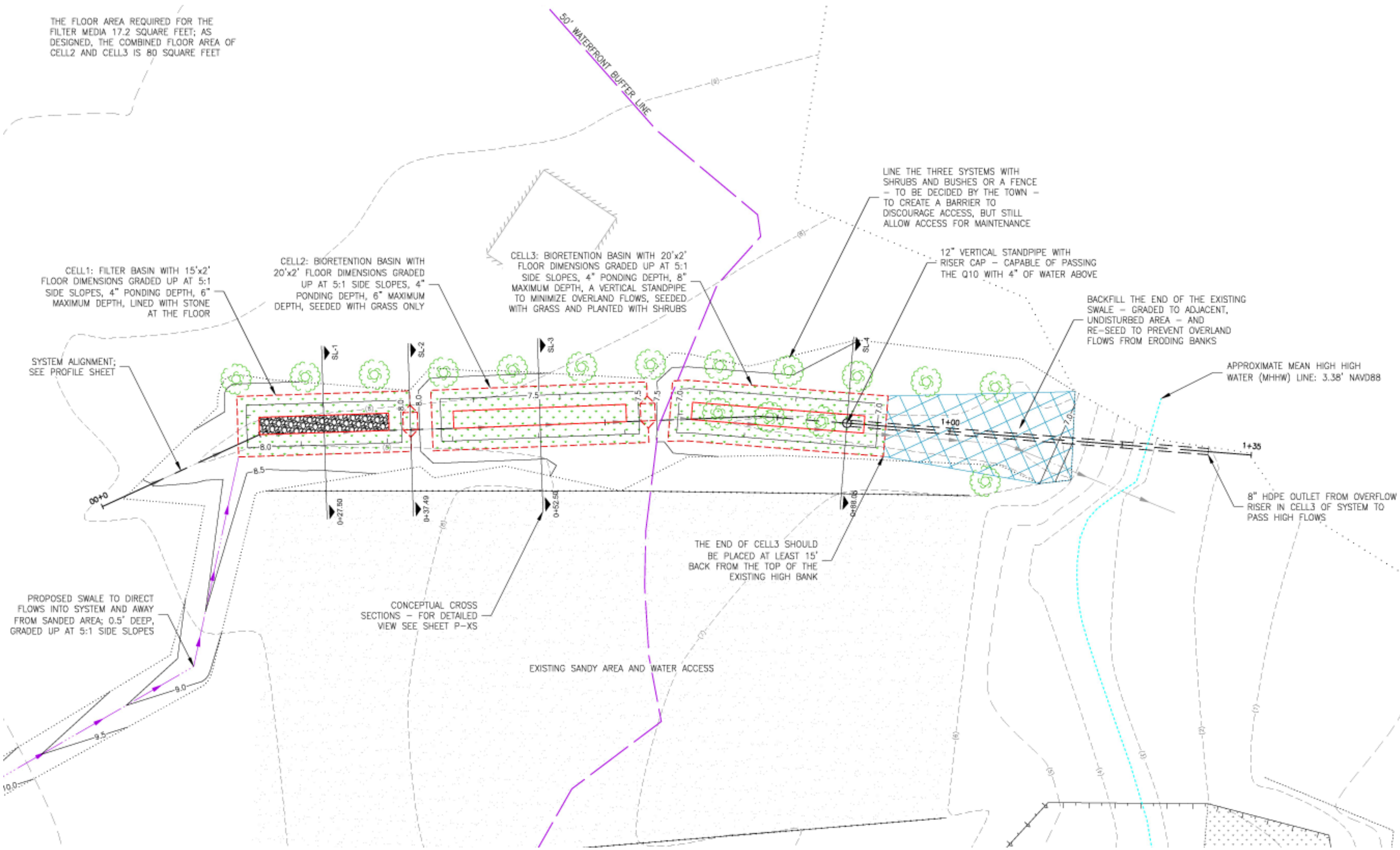
- Most coir failed
- Log was transported after major tide event
  - Likely due to ice
- Lessons learned
  - Need stronger cable/anchor system
  - Coir staking/cabling suspect

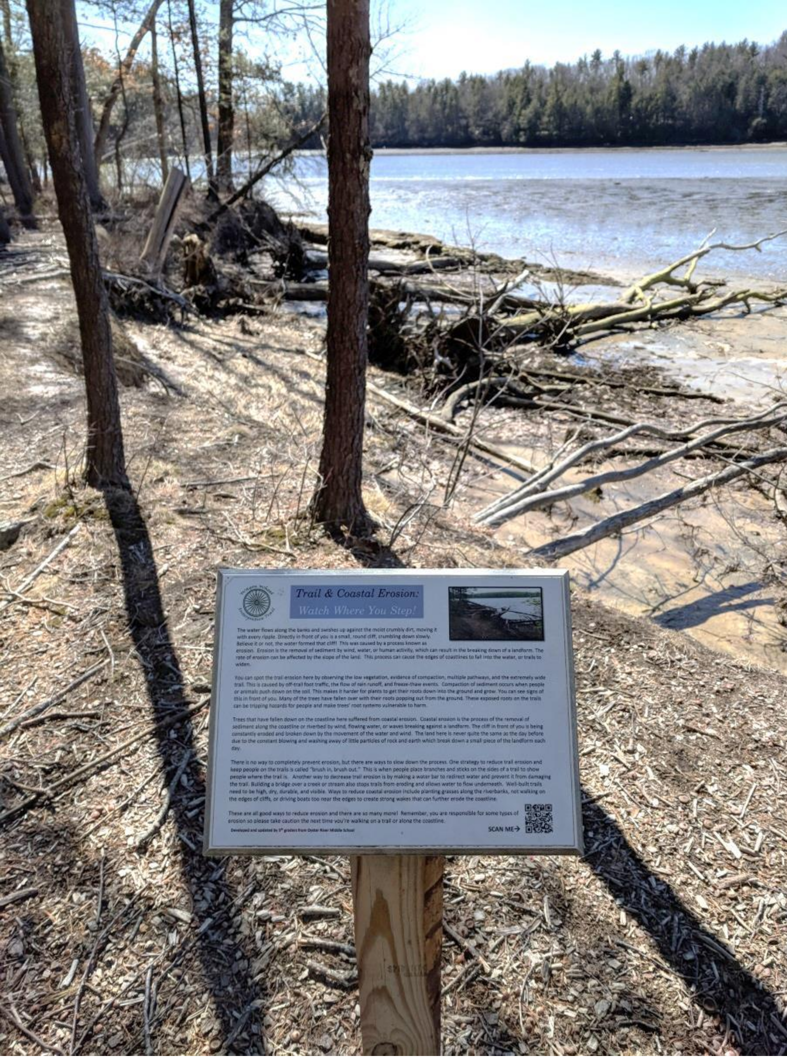
Wagon Hill Outlook

- Thinking of salt marsh mats rather than individual plant sets
- Armored (rock) sill most likely candidate
- Possible use of random root wads in rock sill as well as seaward of sill

Stormwater Management Site

Conceptual Stormwater Design





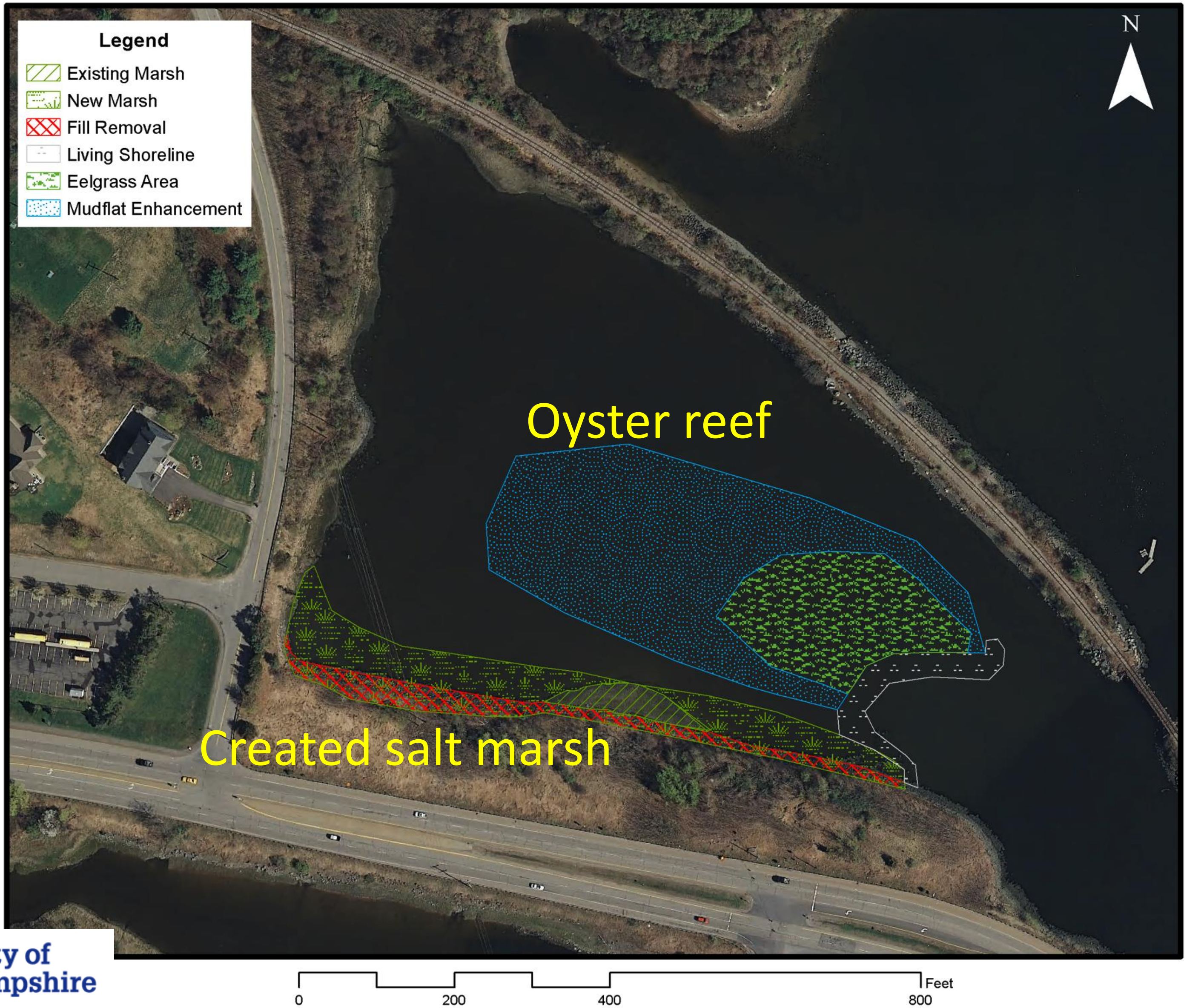
Strong Public Outreach Efforts Example: Durham Day at Wagon Hill Farm

Cutts Cove


95
Forrest St
Cutts Ave
Brigham Ln
Michael Succi Dr
Chase Dr
Market St
Clark Dr
Sarah Mildred Long Bridge
1

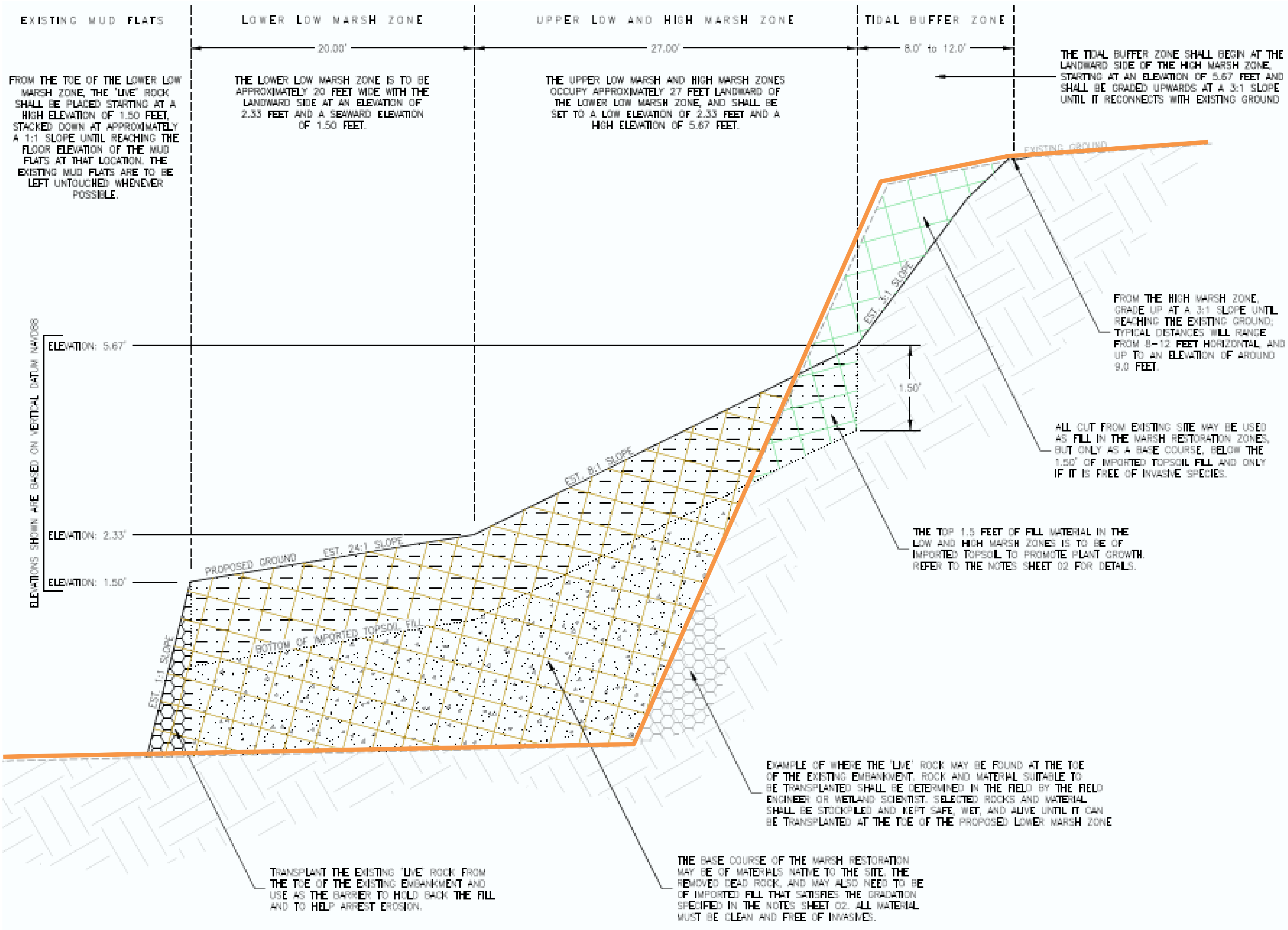
Rip Rap Armor at Cutts Cove

Cutts Cove Concept

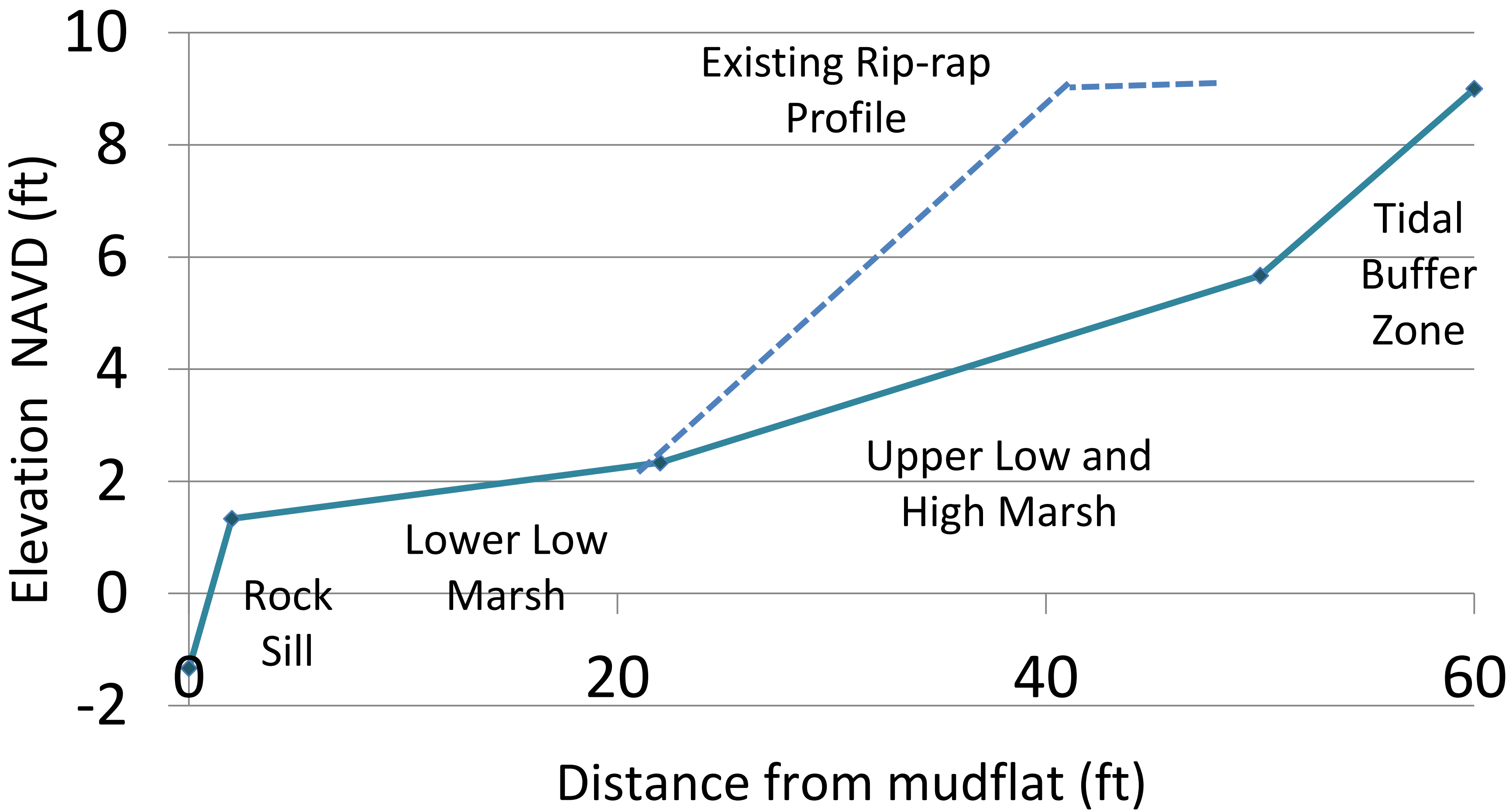


Enhanced Mudflat
-shell from oyster conservationist and recycling program

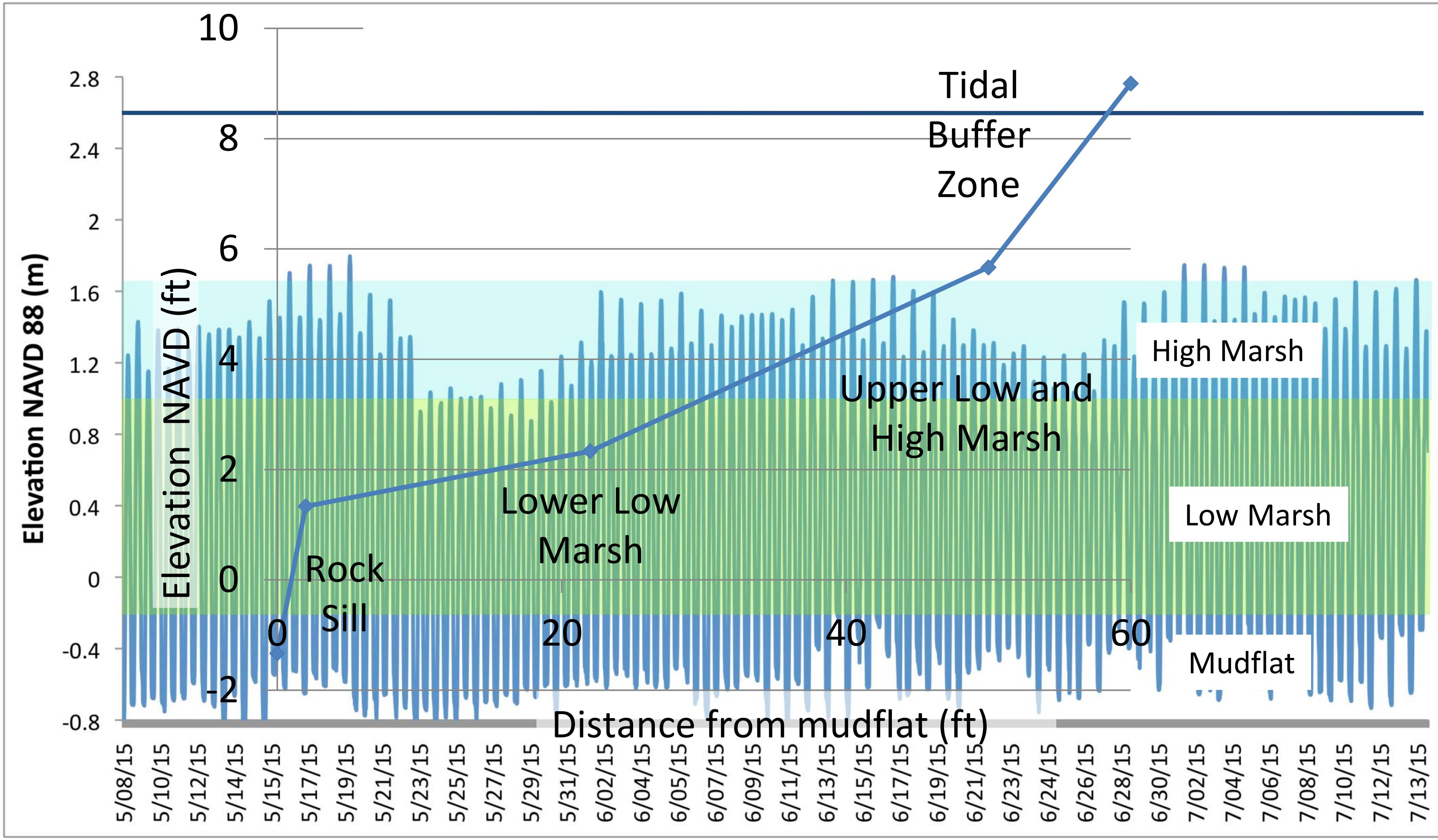
Proposed Cutts Profile



Cutts Profiles and Ecosystems



Tides and existing marshes in Cutts Cove



Measures of Success

- Monitoring
  - Erosion
  - Plant establishment and growth
  - Animal use of habitat
- Maintenance
  - Low to none

Construction


CAT

Living Shoreline at Cutts Cove, Portsmouth

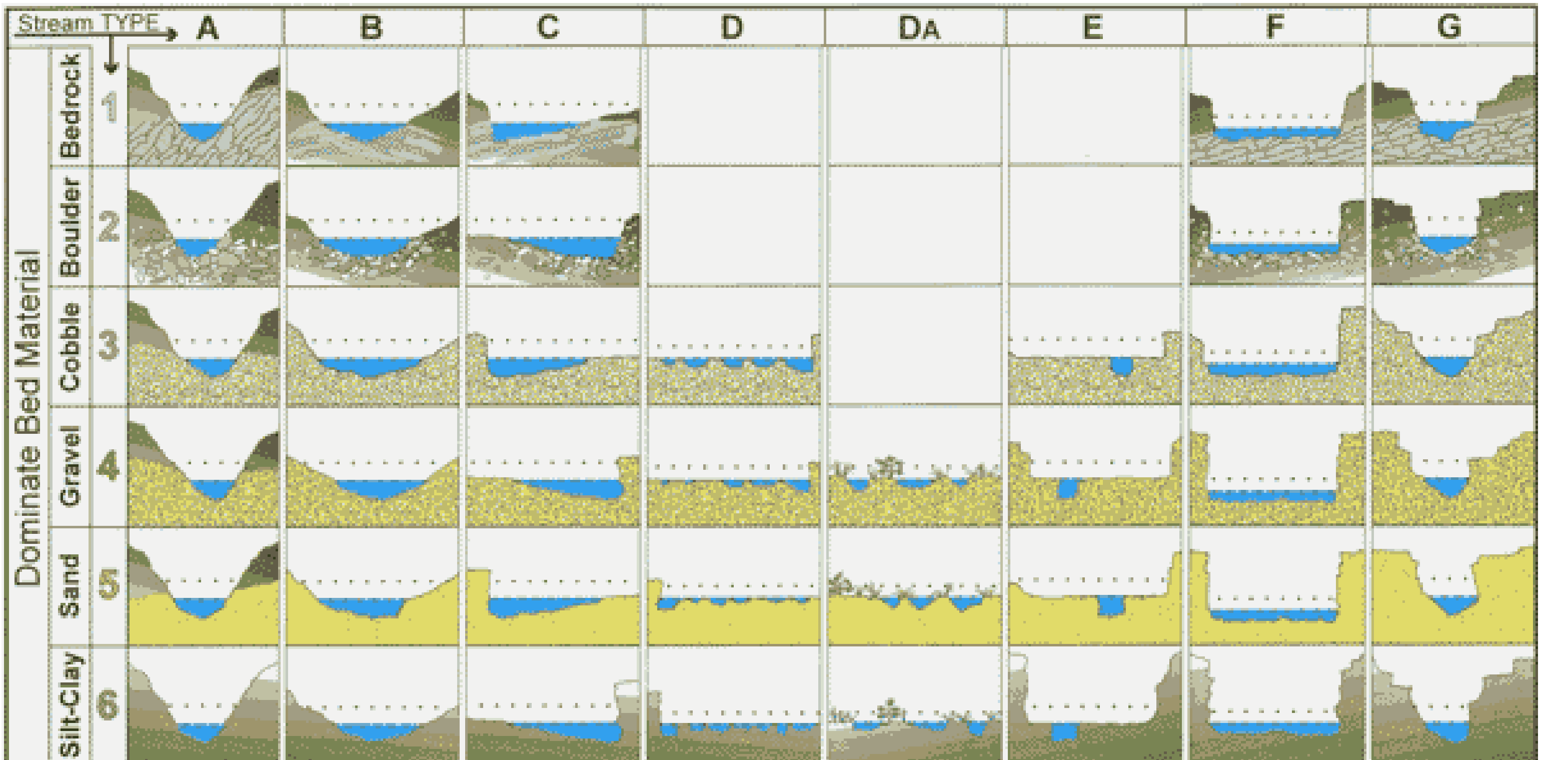
Completed Plantings

Winter Can Be Cruel

Upcoming Project

- Locations all around the Great Bay
- Field data collection for geomorphic, physical, and observational metrics
- Additional metadata obtained offline
- Goal is to develop a database of metrics and metadata that describe the spectrum of stable to impaired fringing salt marshes
- Similar to stream restoration using natural channel design

Natural Channel Design - Rosgen



Stream TYPE	A	B	C	D	DA	E	F	G
Entrchmnt	< 1.4	1.4 - 2.2	> 2.2	n/a	> 4.0	> 2.2	< 1.4	< 1.4
W/D Ratio	< 12	> 12	> 12	> 40	< 40	< 12	> 12	< 12
Sinuosity	1 - 1.2	> 1.2	> 1.2	n/a	variable	>1.5	> 1.2	>1.2
Slope	.04-.099	.02-.039	< .02	< .04	< .005	< .02	< .02	.02-.039

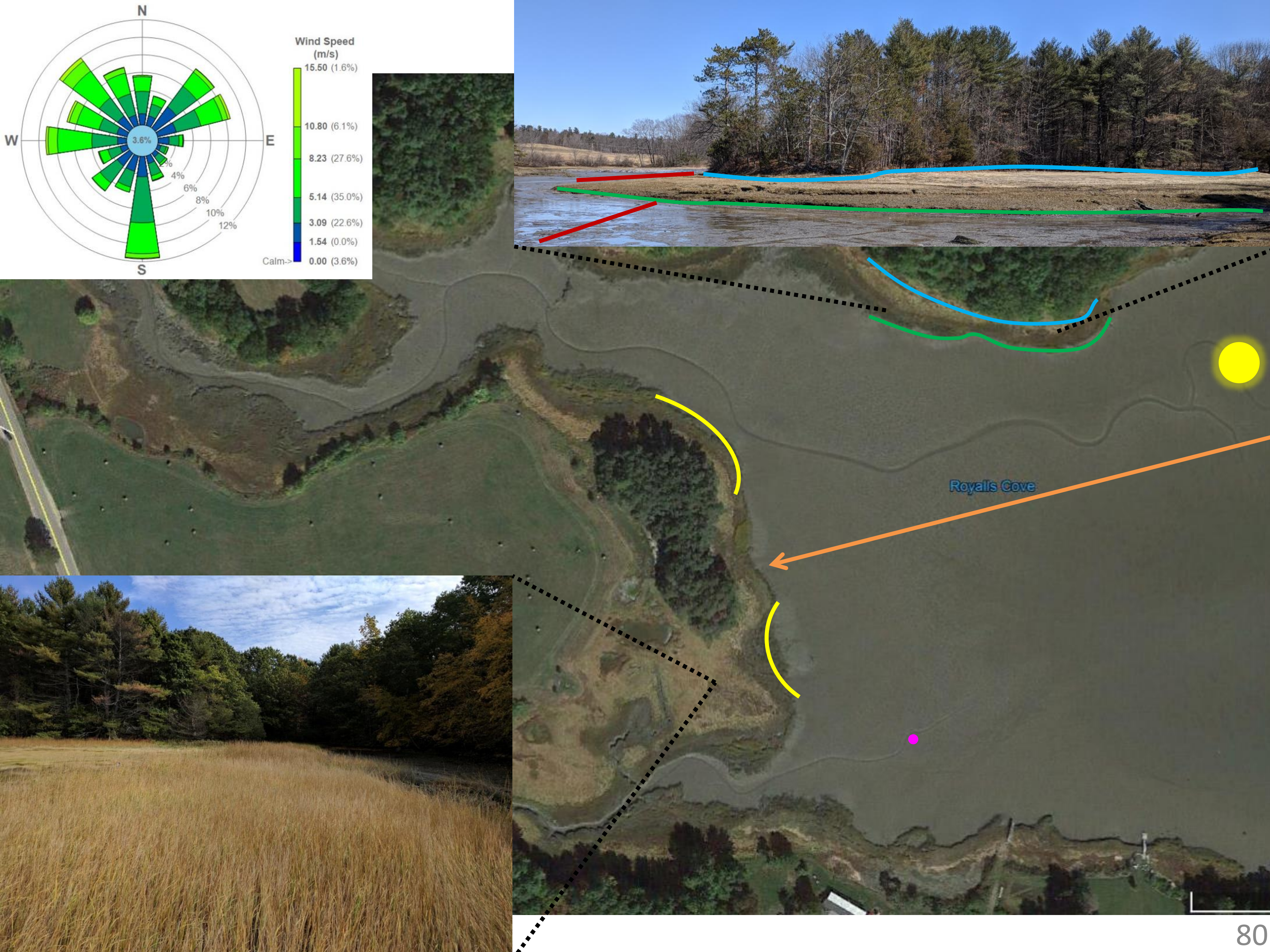
Applied River Morphology . Pagosa Springs: Wildland Hydrology Books, 1996. www.wildlandhydrology.com

Field Data Collection

- Geomorphic
  - Elevations
  - Dimensions
  - Slopes (upper, lower, mud flat)
  - Arc/cusp radius, length, depth
  - PSDs
- Physical
  - Topographic survey
  - WSEL during survey
  - Tidal elevations
  - Features (pools, paths, logs)
  - Densities
  - Debris lines, staining
- Observational
  - Species
  - Degradation
  - Shade
  - Use and access
  - Upland setting

Online Metadata

- Wind rose data
- Fetch distances
- Orientation
- Land use
- Tide predictions
- Boat traffic


N
S
E
W
3.6%
4%
6%
8%
10%
12%
Wind Speed (m/s)
15.50 (1.6%)
10.80 (6.1%)
8.23 (27.6%)
5.14 (35.0%)
3.09 (22.6%)
1.54 (0.0%)
0.00 (3.6%)
Calm->
Royalls Cove