environment.transportation.org

Reducing the Effects of Climate Change on Transportation Infrastructure Using Natural and Nature-based Solutions

May 9, 2022

The Center

- Developed in cooperation with FHWA
- Promotes environmental stewardship and encourages innovative ways to streamline the transportation delivery process
- The Center's website has resources for professionals, including case studies, webinar recordings, and Practitioner's Handbooks

Agenda

- Welcome & Introduction
- Presentation 1: "Insights on Using Nature-based Solutions for Highway Resilience" by Elizabeth Habic and Marissa Webber
- Presentation 2: "Can You Be Resilient and Soft? Living Shorelines and Shifting the FDOT Paradigm" by Casey Lyon
- Presentation 3: "Franklin-98: Protecting Community, Preserving the Coast" by Rick Harter and Evan Blythe
- Q&A Session
  - Please place your questions in the Q&A chat throughout the session.

Panelists

Elizabeth Habic (FHWA)

Marissa Webber (Carnegie Mellon Univ.)

Casey Lyon (FDOT)

Evan Blythe (ARPC)

Rick Harter (WSP)

U.S. Department of Transportation
Federal Highway Administration

Insights on Using Nature-based Solutions for Highway Resilience

May 9, 2022

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Office of Natural Environment
Federal Highway Administration

Marissa Webber
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Carnegie Mellon University

Disclaimer

U.S. Department of Transportation
Federal Highway Administration

- Except for any statutes or regulations cited, the contents of this presentation do not have the force and effect of law and are not meant to bind the public in any way. This presentation is intended only to provide information to the public regarding existing requirements under the law or agency policies.
- FHWA is the source of all images in this presentation unless otherwise indicated.

Coastal Nature-Based Solutions

U.S. Department of Transportation
Federal Highway Administration

The term "nature-based solutions" (or NBS) refers to use of natural materials and processes as alternatives to, or ecological enhancements of, traditional shoreline stabilization and infrastructure protection techniques.[1]

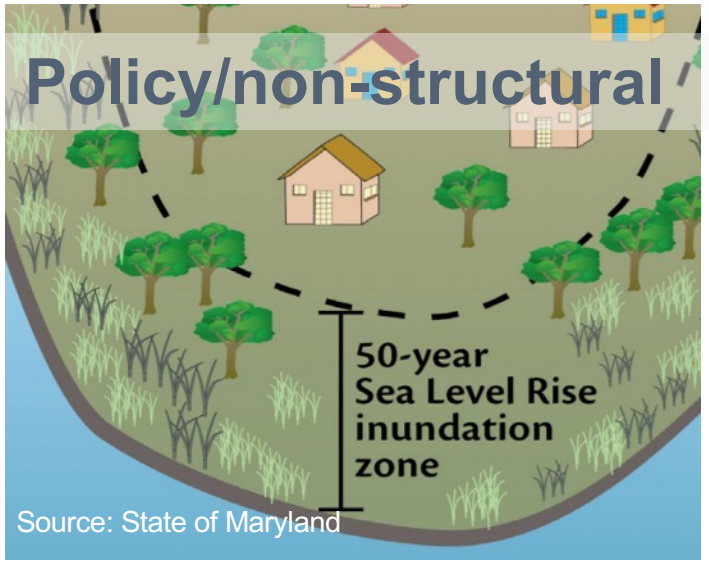
[1]FHWA-HEP-19-042, Nature-Based Solutions for Coastal Highway Resilience: An Implementation Guide (https://go.usa.gov/xu4gj)

“Natural Infrastructure”

- Section 11103 of the Bipartisan Infrastructure Law (BIL), enacted as the Infrastructure Investment and Jobs Act, Pub. L. 117-58 (Nov. 15, 2021), defined the term “natural infrastructure” under Title 23, United States Code.
- Definition at 23 U.S.C. 101(a)(17): The term “natural infrastructure” means infrastructure that uses, restores, or emulates natural ecological processes and--
  - (A) is created through the action of natural physical, geological, biological, and chemical processes over time;
  - (B) is created by human design, engineering, and construction to emulate or act in concert with natural processes; or
  - (C) involves the use of plants, soils, and other natural features, including through the creation, restoration, or preservation of vegetated areas using materials appropriate to the region to manage stormwater and runoff, to attenuate flooding and storm surges, and for other related purposes.
- BIL also provides that incorporation of “natural infrastructure” is an eligible construction activity under certain Title 23 programs. See for example the PROTECT program under 23 U.S.C. 176.

Research Gap: Nature-based Solutions and Integrated Approach

U.S. Department of Transportation
Federal Highway Administration



- Natural features
- Nature-based features
- Hybrid approaches

Program Overview

U.S. Department of Transportation
Federal Highway Administration

Nature-Based Solutions for Coastal Highway Resilience

- 5 pilot projects
  - OR DOT
  - ME & NH DOTs jointly
  - MS DOT
  - DE DOT
  - US Army Corps of Engineers in NJ
- White paper
- Regional peer exchanges
- Implementation Guide

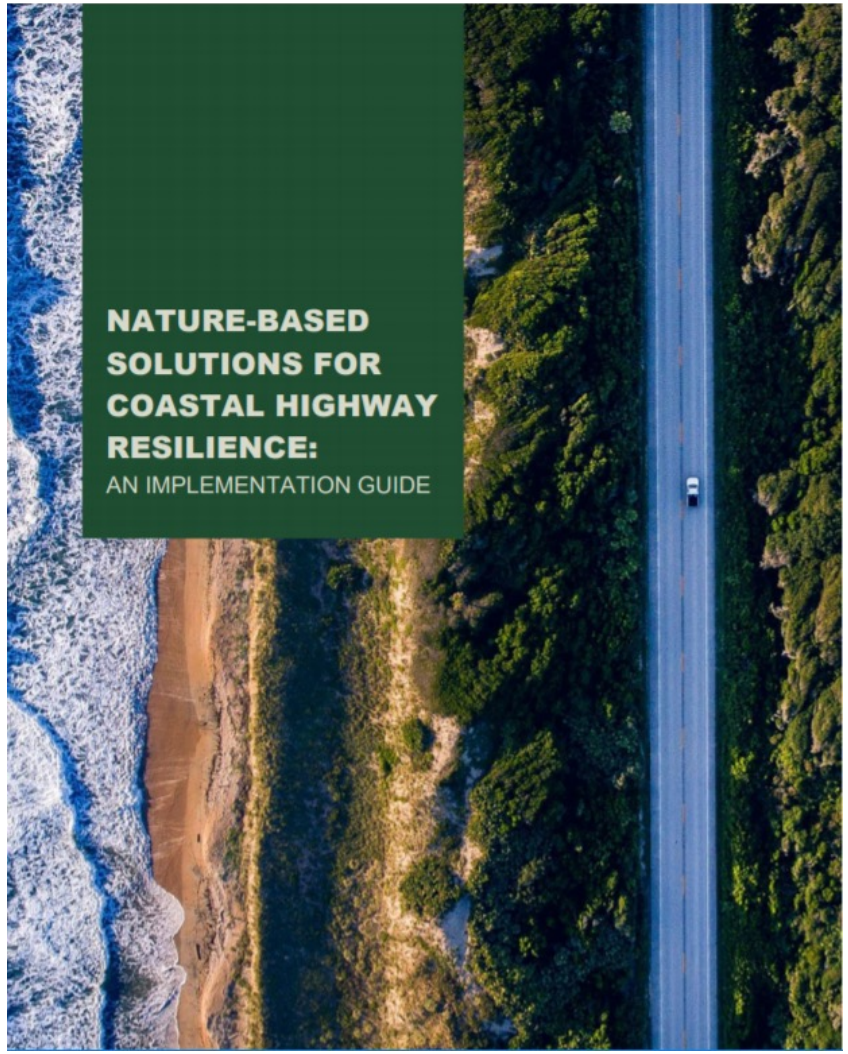
U.S. Rt 1B, New Hampshire. Credit: NH DOT

Participants at Alabama Peer Exchange. Credit: FHWA

For these resources, please refer to FHWA Nature-based Resilience for Coastal Highways Website:
https://www.fhwa.dot.gov/environment/sustainability/resilience/ongoing_and_current_research/green_infrastructure/

Implementation Guide

U.S. Department of Transportation
Federal Highway Administration



- Information to assist with implementing nature-based solutions to enhance the resilience of coastal highways
- Overview
  - Technical factsheets
  - Benefits and typical costs
  - Implementation considerations

https://www.fhwa.dot.gov/environment/sustainability/resilience/ongoing_and_current_research/green_infrastructure/implementation_guide/

Benefits of Nature-based Solutions

U.S. Department of Transportation
Federal Highway Administration

- ✓ Reduction in coastal flooding, wave heights, and erosion
- ✓ Ecological, water quality, habitat benefits
- ✓ Reasonable costs
- ✓ Naturally adapt to sea level rise
- ✓ Tourism and recreation benefits


Credit: Bret Webb

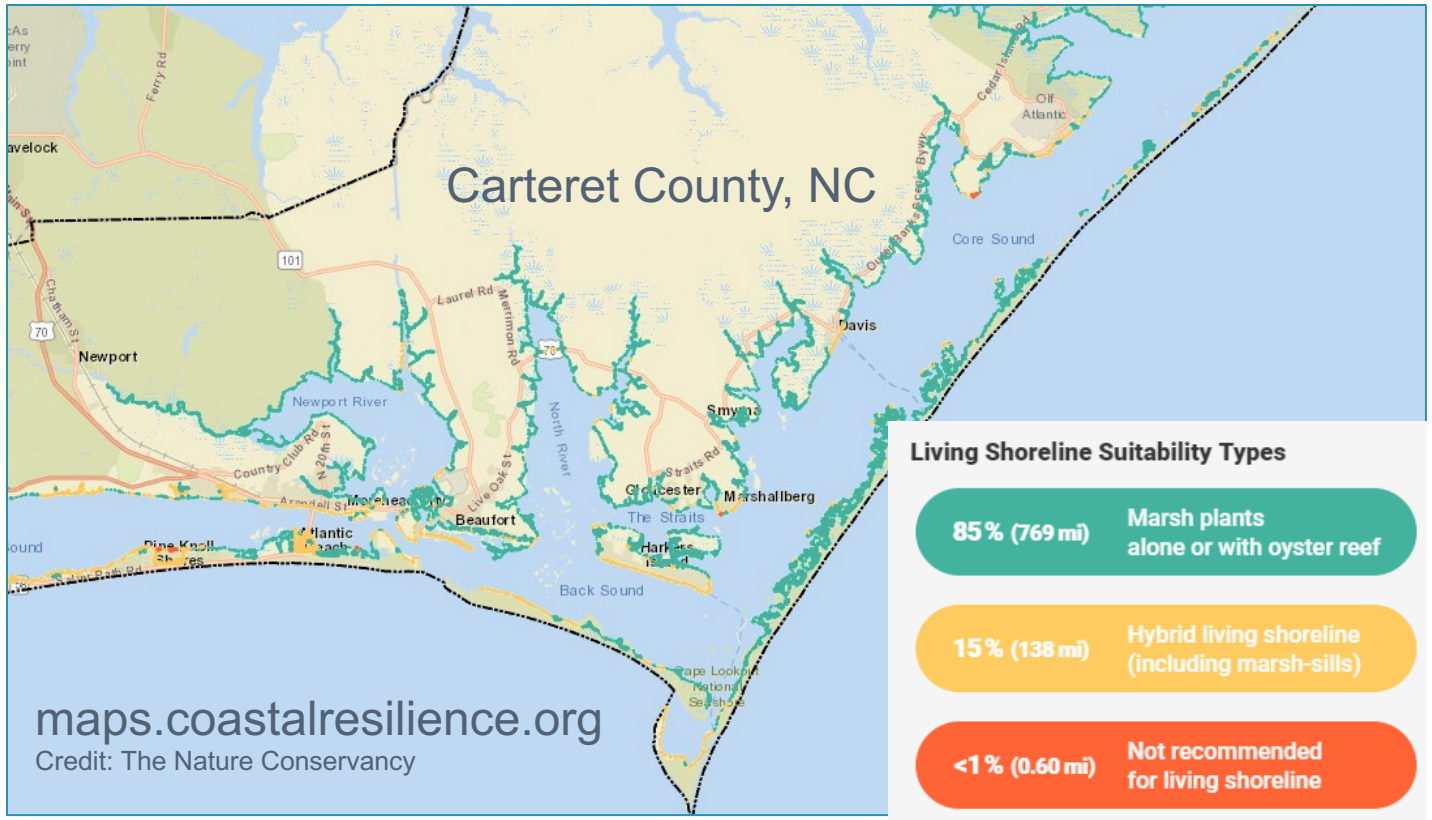

Credit: Suzanne Kaspar, Mobjack Bay, VA

Coastal habitats can reduce wave heights by 35-70% and are often less expensive than armoring.

(Source: FHWA-HEP-19-042, Nature-Based Solutions for Coastal Highway Resilience: An Implementation Guide (https://go.usa.gov/xu4gj)
)

Planning

- **Planning & Funding**
- Site Assessment
- Design
- Permitting
- Construction
- Monitoring



Incorporating NBS into transportation planning can help:

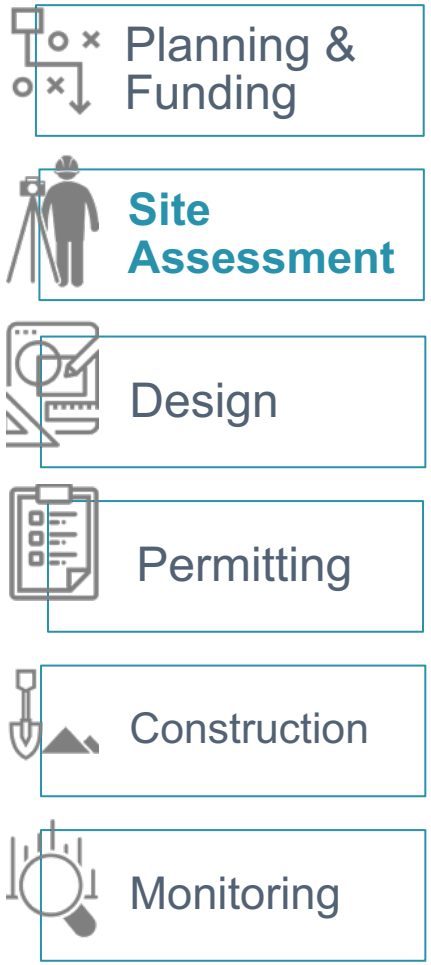
- Address both resilience and environmental objectives
- Allows systematic consideration
- Mobilize larger projects
- Take advantage of analyses by partners

Funding

- Funding opportunities:
  - Transportation
  - Coastal restoration
  - Hazard mitigation
- Example: Title 23 United States Code 176 (PROTECT)

Site Assessment Parameters

U.S. Department of Transportation
Federal Highway Administration



System Parameters	Hydrodynamic Parameters
1. Shoreline Type 2. Infrastructure 3. Erosion Rate 4. Sea Level Rise 5. Tide Range	1. Wind Waves 2. Boat Wakes 3. Currents 4. Ice 5. Storm Surge
Terrestrial Parameters	**Ecological Parameters**
1. Upland Slope 2. Shoreline Slope 3. Width 4. Nearshore Slope 5. Water Depth 6. Soil Strength	1. Water Quality 2. Soil Type 3. Sunlight 4. Salinity

Additional Parameters	
1. Permits	4. Species
2. End Effects	5. Debris
3. Constructability	6. Monitoring

Source: FHWA-HEP-19-042, Nature-Based Solutions for Coastal Highway Resilience: An Implementation Guide (https://go.usa.gov/xu4gj)

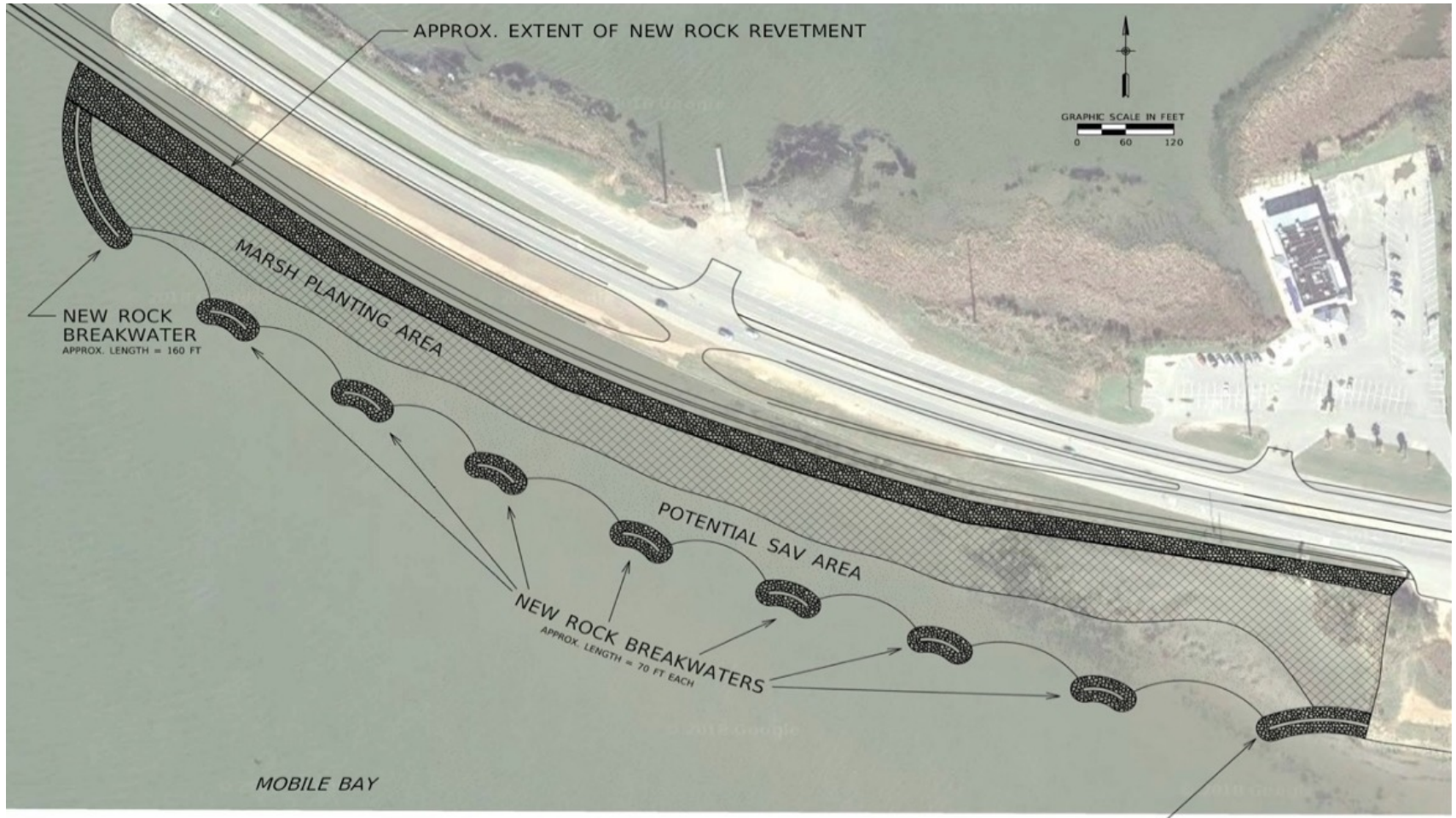
Design: Mobile Bay, AL

- Planning & Funding
- Site Assessment
- **Design**
- Permitting
- Construction
- Monitoring

An existing concrete seawall serves as bank stabilization for the Mobile Bay causeway.

Design: Mobile Bay, AL

Conceptual planform diagram of a constructed marsh and breakwater system for Mobile Bay, AL.



Conceptual planform diagram of a constructed marsh and breakwater system for Mobile Bay, AL. Credit: FHWA

Generalized Permitting Considerations

U.S. Department of Transportation
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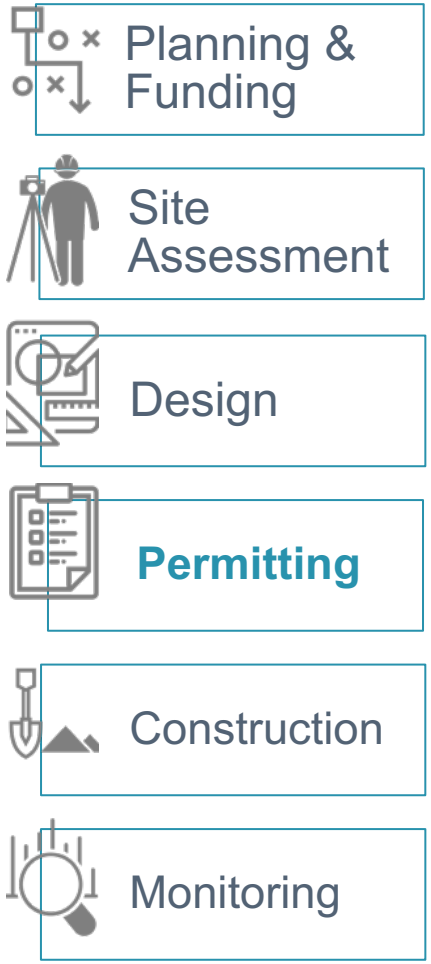


Permit Type:	Nationwide Permit	General Permit	Individual Permit
Project Complexity	Low to moderate	Moderate	Moderate to high
Permit Requirements	Strictly defined	Generally defined	Undefined
Benefits	Short review period	Moderate review period	Few design constraints
Challenges	Many design constraints	Some design constraints	Long review period

Construction

- Planning & Funding
- Site Assessment
- Design
- Permitting
- **Construction**
- Monitoring

- Consider using performance-based contracts[1]

Contractors placing geotextile fabric for the foundation of an offshore rock breakwater. Credit: Sam St. John

[1]FHWA-HEP-19-042, Nature-Based Solutions for Coastal Highway Resilience: An Implementation Guide (https://go.usa.gov/xu4gj)

Monitoring, Maintenance, & Adaptive Management

- Planning & Funding
- Site Assessment
- Design
- Permitting
- Construction
- **Monitoring**

- Measure and assess project performance and impacts
- Maintain to continue to provide expected benefits
- Implement adaptive management practices

Credit: Bret Webb

NHI Resilience Course Development

U.S. Department of Transportation
Federal Highway Administration

- Web trainings posted on NHI website:
  - FHWA-NHI-142081 Understanding Past, Current and Future Climate Conditions
  - FHWA-NHI-142082 Introduction to Temperature and Precipitation Projections
  - FHWA-NHI-142083 Systems Level Vulnerability Assessments
  - FHWA-NHI-142084 Adaptation Analysis for Project Decision Making

Work with Nature

U.S. Department of Transportation
Federal Highway Administration

Credits: Bret Webb

What are Riverine Nature-Based Solutions?

U.S. Department of Transportation
Federal Highway Administration

the use of **natural materials**, and **natural conditions**, along with engineered structures that incorporate **natural processes** and materials

"natural materials" refers to native vegetation and organic materials such as wood or rock, especially if they are locally sourced

"natural conditions" includes restoration of naturally occurring features important to river function, such as floodplains or wetlands

"natural processes" for rivers includes conveyance, river evolution, habitat, and connectivity

National Highway Institute training course 135096 for more information on river form and functions:
https://www.nhi.fhwa.dot.gov/course-search?tab=0&cat=7&srt=10&sf=0&course_no=135096

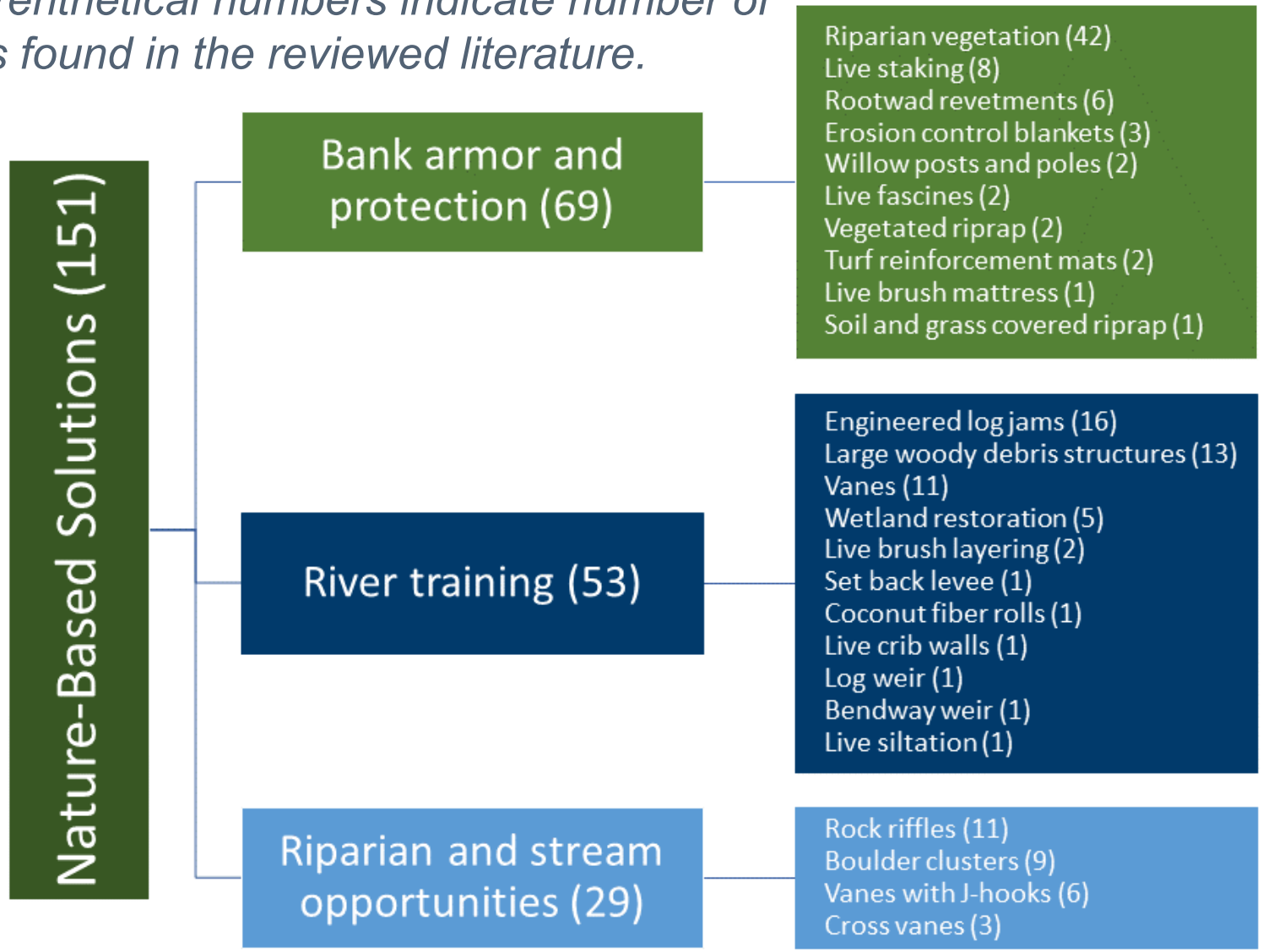
Benefits of Riverine Nature-Based Solutions

Note: The information provided on this and the next few slides resulted from a comprehensive literature review.

Economic Benefits	Environmental Benefits	Social Benefits
• reduced erosion • avoided physical damage and costs • can preclude the need for more expensive armoring techniques	• improved aesthetics • improved air and water quality • can maintain ecologic integrity and habitats • reduced air and water temperature • reduced noise pollution	• improved aesthetics • flood protection and mitigation • avoided physical damage • avoided casualties

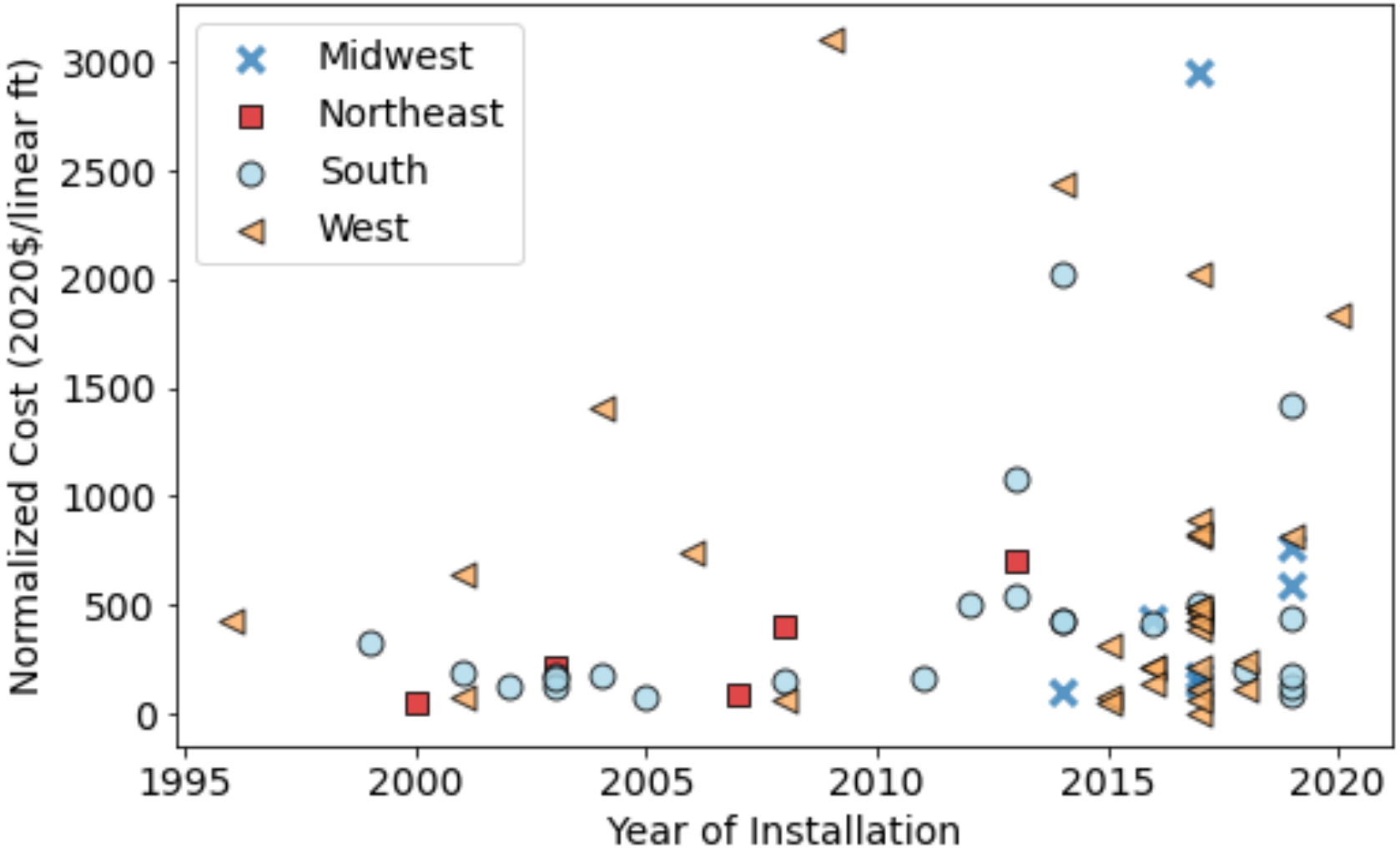
Current State of Practice: Types of NBS

Note: Parenthetical numbers indicate number of instances found in the reviewed literature.



Current State of Practice: Across the US

U.S. Department of Transportation
Federal Highway Administration



Current State of Practice: Resources

U.S. Department of Transportation
Federal Highway Administration

Project Design

Planning and Implementation

Monitoring and Maintenance

NCHRP 795: Design Methods for In-Stream Flow Control Structures (2014)

NCHRP 822: Evaluation and Assessment of Environmentally Sensitive Stream Bank Protection Measures (2016)

Living Streambanks: A Manual of Bioengineering Treatments for Colorado Streams (2016)

Vermont Standard River Management Principles and Practices (2016)

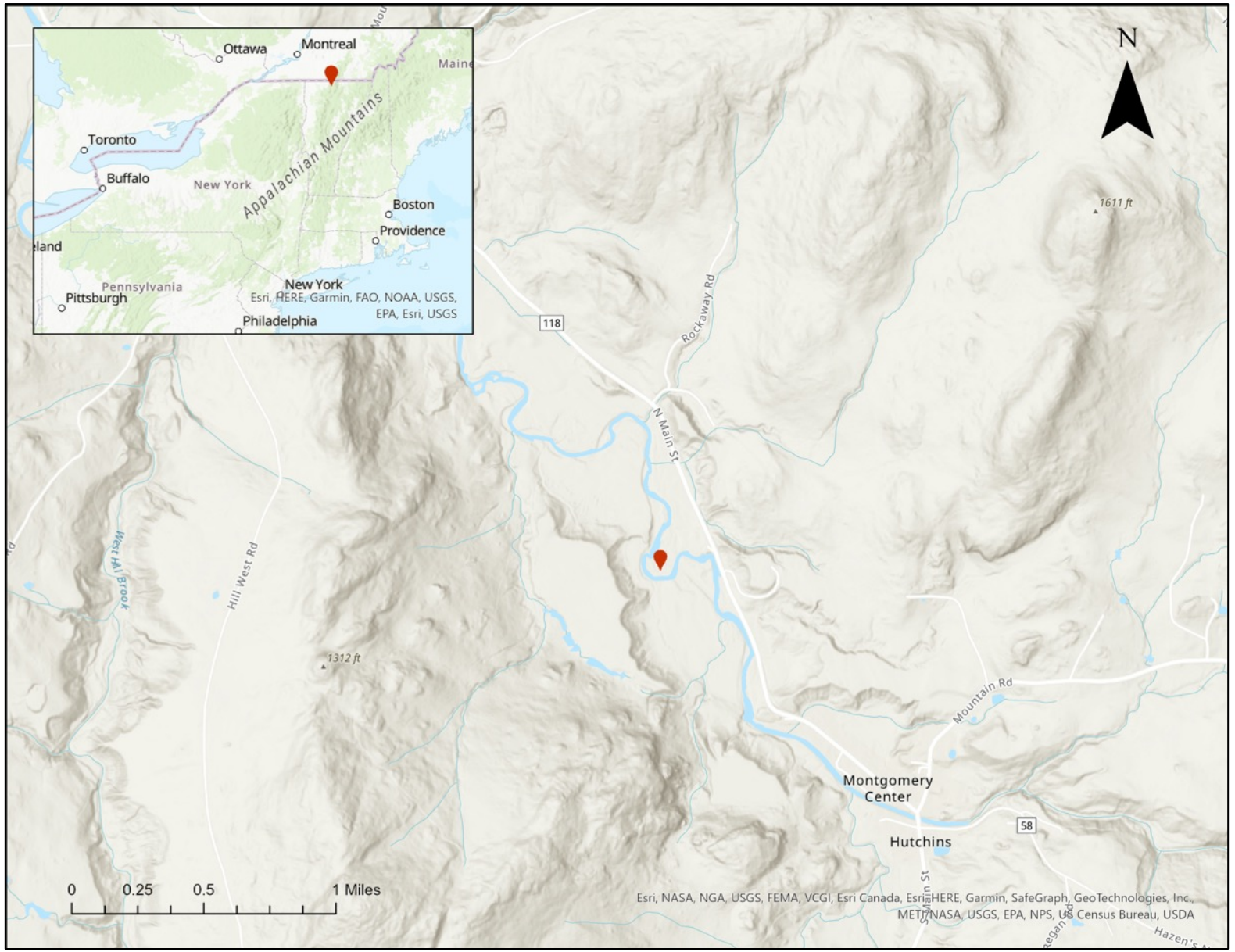
Maryland's Waterway Construction Guidelines (2005)

Ohio: Evaluation of the Palmiter Method for Erosion Control and Stream Management (2021)

Vermont Bioengineering Manual (2022)

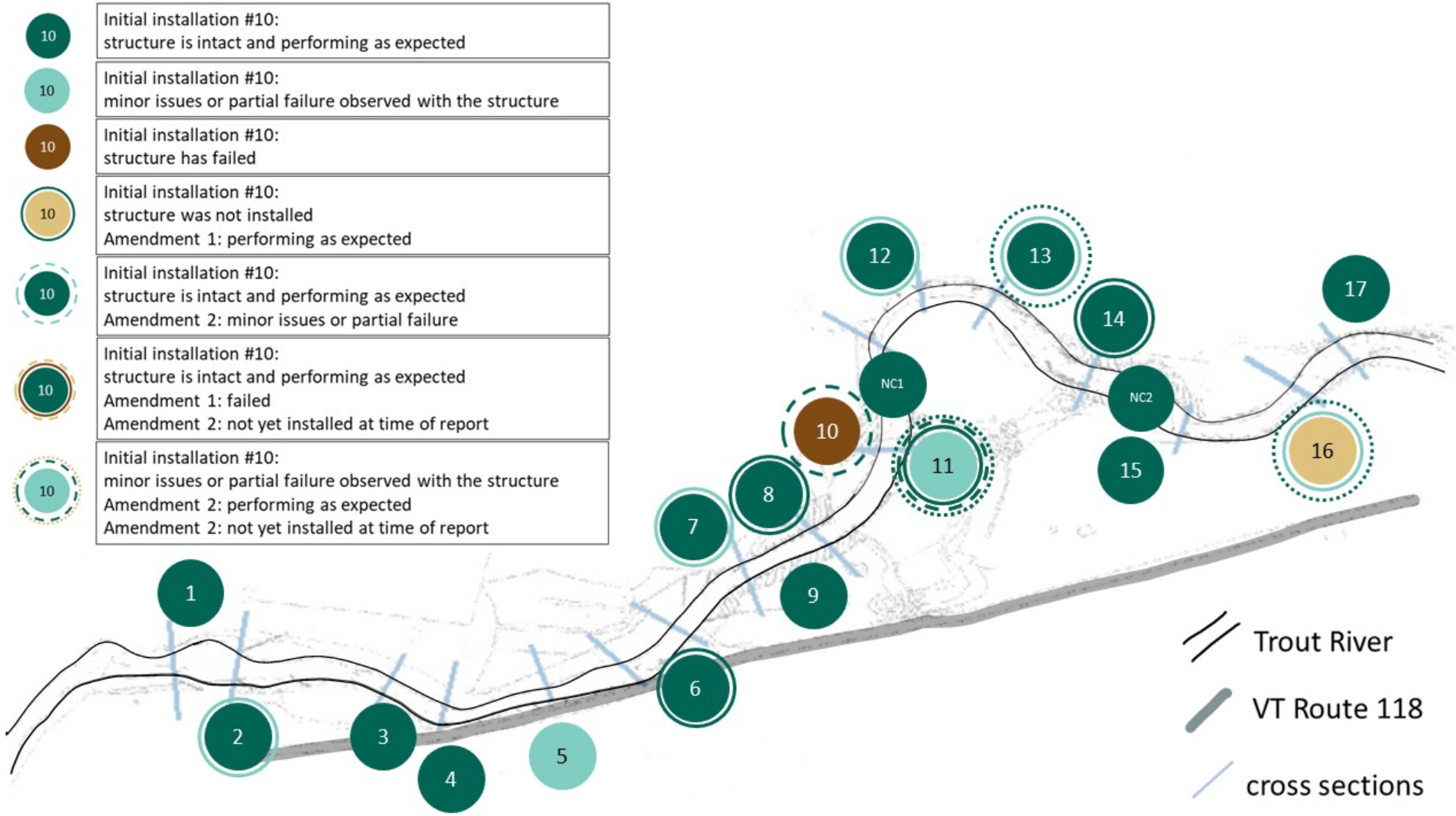
Trout River Restoration Project, VT (2001)

U.S. Department of Transportation
Federal Highway Administration



Trout River, VT: Types and Success of NBS

U.S. Department of Transportation
Federal Highway Administration



Source: Vermont Department of Environmental Conservation (2001)

Trout River, VT: Lessons Learned

U.S. Department of Transportation
Federal Highway Administration

- NBS can be successfully used for river management and to achieve multiple objectives
- Greater national consensus of natural channel design concepts and permitting processes is needed
- NBS projects could benefit from a longer design phase and dedicated construction crew
- Extensive documentation may be required for permitting
- Interagency cooperation and volunteer group efforts are important for successful project funding and management

Source: Vermont Department of Environmental Conservation (2001)

Thank you!

Contact:
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mwebber2@andrew.cmu.edu

Can You Be Resilient and Soft?
Living Shorelines and Shifting the FDOT Paradigm

Casey Lyon
Environmental Permits Supervisor
Florida Department of Transportation
District 5
May 2022

Florida Department of Transportation

What is a Living Shoreline?

A shoreline management practice that provides erosion control benefit; protects, restores or enhances natural shoreline habitat; and maintains coastal processes through the strategic placement of plants, stone, sand fill, and other structural organic materials (e.g. biologs, oyster reefs, etc.).

-National Oceanic and Atmospheric Administration

LIVING SHORELINES SUPPORT RESILIENT COMMUNITIES

Living shorelines use plants or other natural elements—sometimes in combination with harder shoreline structures—to stabilize estuarine coasts, bays, and tributaries.

One square mile of salt marsh stores the carbon equivalent of **76,000 gal of gas** annually.

Marshes trap sediments from tidal waters, allowing them to **grow in elevation** as sea level rises.

Living shorelines improve **water quality**, provide fisheries **habitat**, increase **biodiversity**, and promote **recreation**.

Marshes and oyster reefs act as natural **barriers** to waves. **15 ft** of marsh can **absorb 50%** of incoming wave energy.

Living shorelines are **more resilient** against storms than bulkheads.

33% of shorelines in the U.S. will be **hardened** by **2100**, decreasing fisheries habitat and biodiversity.

Hard shoreline structures like **bulkheads** prevent natural marsh migration and may create seaward **erosion**.

The National Centers for Coastal Ocean Science | coastalscience.noaa.gov

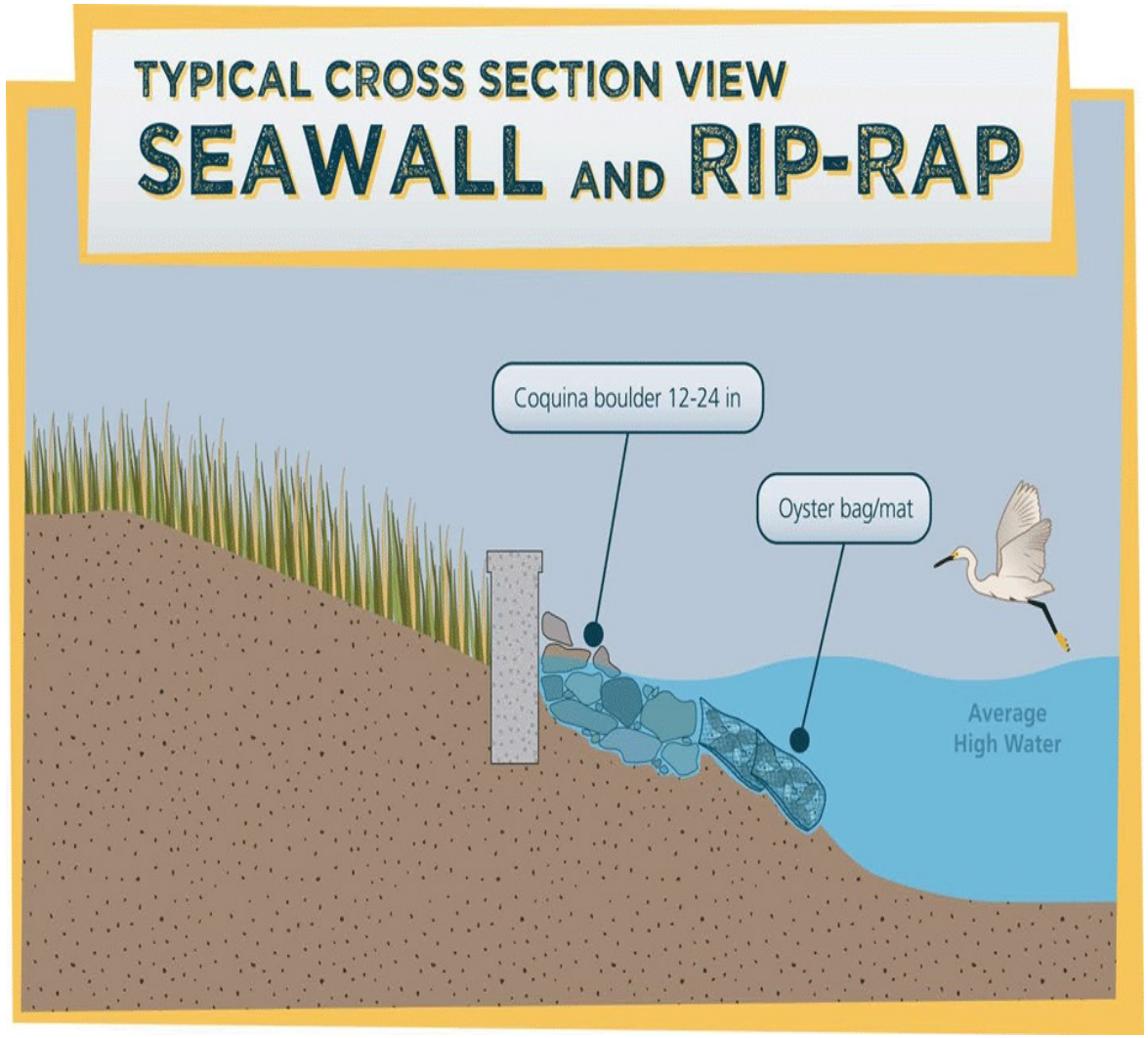
Some graphics courtesy of the Integration and Application Network, University of Maryland Center for Environmental Science (ian.umces.edu/symbols/)

Benefits to FDOT

- Protect infrastructure
- Reduced costs
- Environmental stewardship

Types of Living Shorelines

- Living Shoreline
  - Slopes, plants and oysters
  - Terracing, plants and oysters
- Hybrid Living Shoreline
  - Retaining wall, plants and oysters
  - Native limestone rip rap, plants and oysters
- Redeemed Seawall
  - Existing seawall, native limestone rip rap, plants and oysters

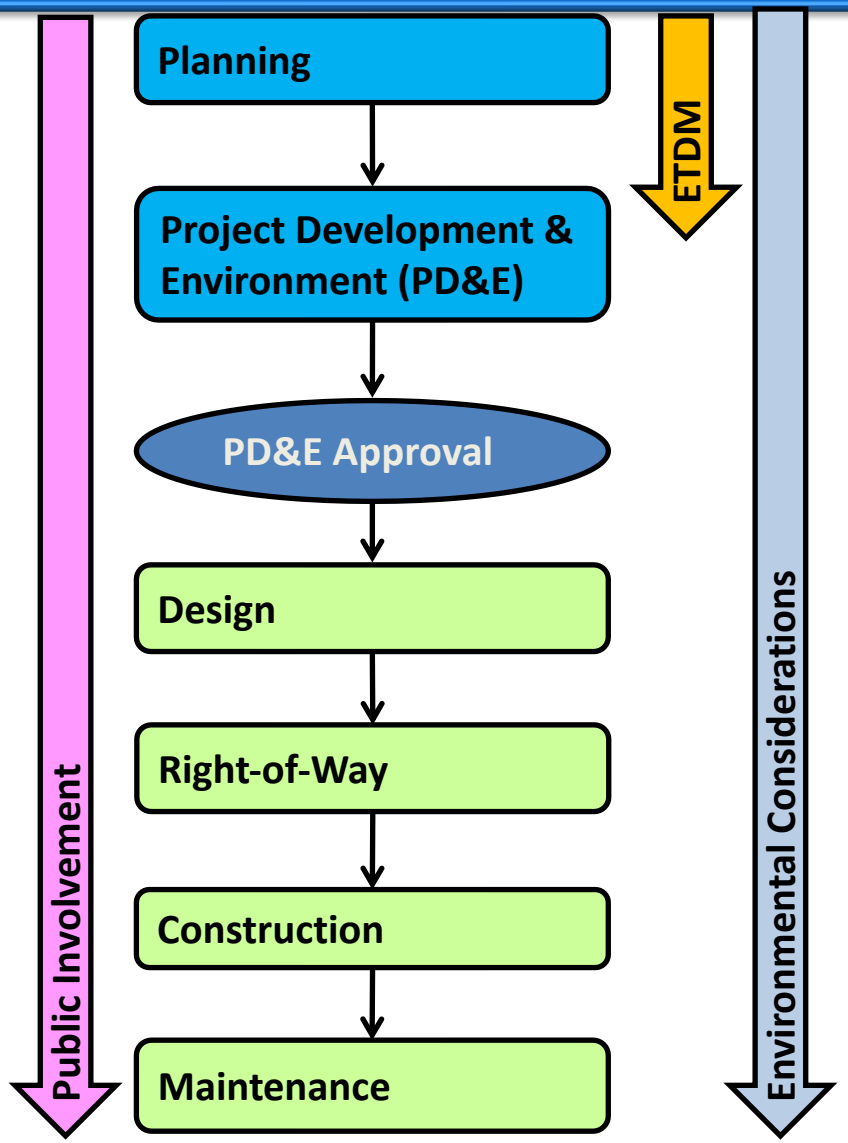


Breakwater Structures

- Wave Attenuation Devices (WADs)
  - Dissipate wave energy
  - Reduce erosion
  - Allow for sand accretion
  - Provide fish habitat

When Can Living Shorelines Be Utilized?

- Local support
- Environmental commitments
- Avoidance and minimization
- Mitigation credits
  - Wetlands
  - Listed species
  - Essential Fish Habitat (EFH)
- Basin Management Action Plan (BMAP) credits
- Retrofits



Barracuda Bridge Replacement – New Smyrna Beach, FL

- Oysters on rip-rap
- Environmental commitments to National Marine Fisheries Service (NMFS)
  - Relocate oysters where possible
- Partnering with Florida Fish and Wildlife Conservation Commission and local Marine Discovery Center
- Marsh restoration support
  - Oysters will help maintain restored tidal creeks

Barracuda Bridge Replacement – New Smyrna Beach, FL

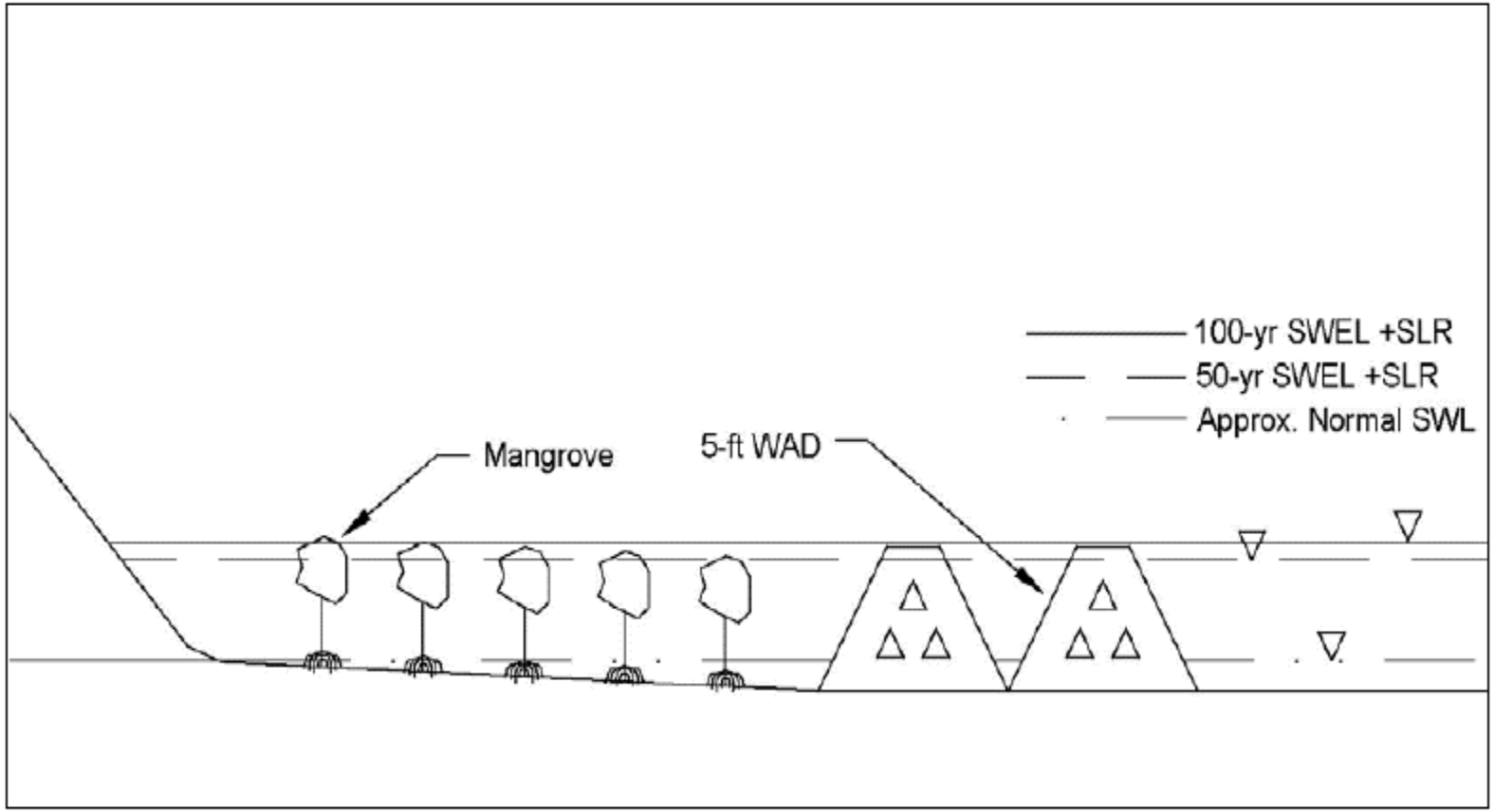
US1 Erosion Study – Melbourne, FL

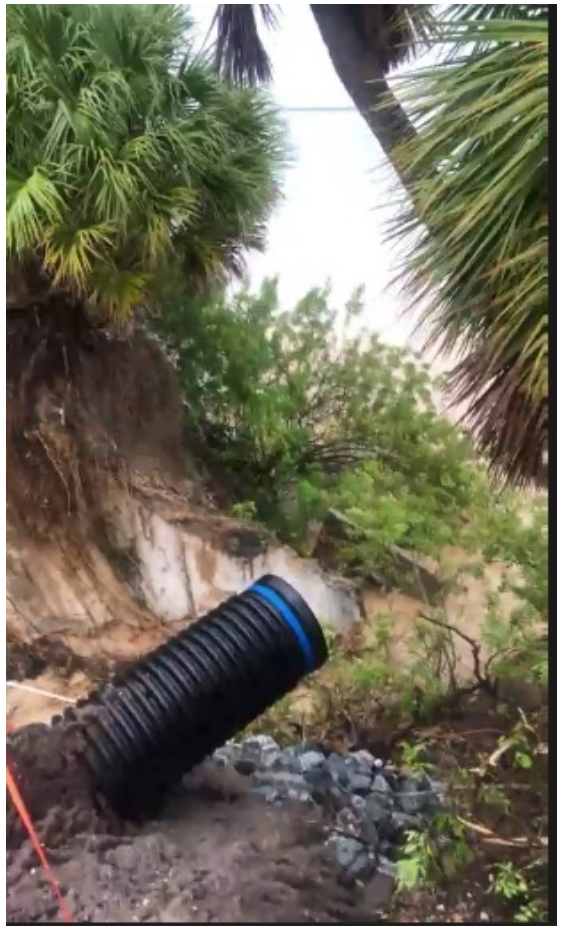
- Severe erosion
  - Embankment being undermined by wave action
  - Roadway at risk
- Indian River Lagoon
  - Environmentally sensitive area
- Feasibility study
  - Performance
  - Engineering
  - Environmental

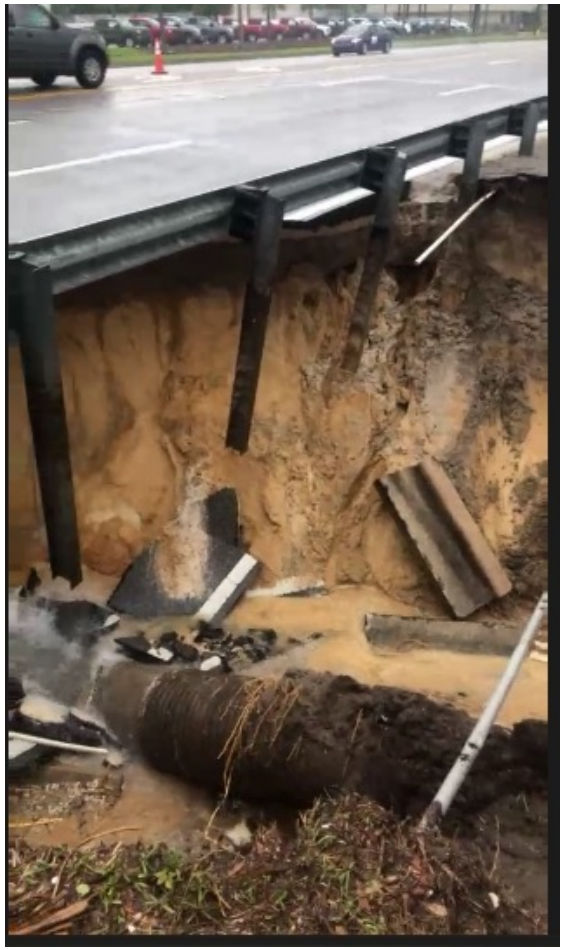
Alternative	Material Type	Evaluation Criteria		
		Performance	Engineering	Environmental
Revetment	Rock	High	Medium High	Low
	Marine Mattress	High	Medium	Low
Nearshore Breakwater	Rock	High	Medium	Medium High
	WADs	High	High	Medium High
	Gabions	High	Medium	Medium
Sill	Rock	High	Medium	Medium
	WADs	High	High	High
	Gabions	High	Medium	Medium
Bulkhead	Concrete	High	Medium	Medium Low
	Steel Sheet Pile	High	Medium	Medium Low
	Marine Cell	High	Medium	Low

US1 Erosion Study – Recommended Alternative

- WADs Sill with Plantings
  - Individual Permit with Water Management District
  - 404 Dredge and Fill Permit (US Army Corp of Engineers)
  - Jacksonville Biological Opinion (NMFS)
  - In-Water Work Conditions (US Fish and Wildlife Service and NMFS)
  - Sovereign Submerged Lands (Florida Department of Environmental Protection)
- Issues
  - No upland interest
  - Wetland and EFH mitigation







Questions?

DO I NEED TO STOP?

TWO LANE

Vehicles traveling in both directions **MUST** stop.

MULTI-LANE PAVED ACROSS

Vehicles traveling in both directions **MUST** stop.

DIVIDED ROADWAY

On a highway divided by a median, care traveling in the opposite direction are not required to stop but should proceed with caution.

AASHTO Webinar
May 9, 2022

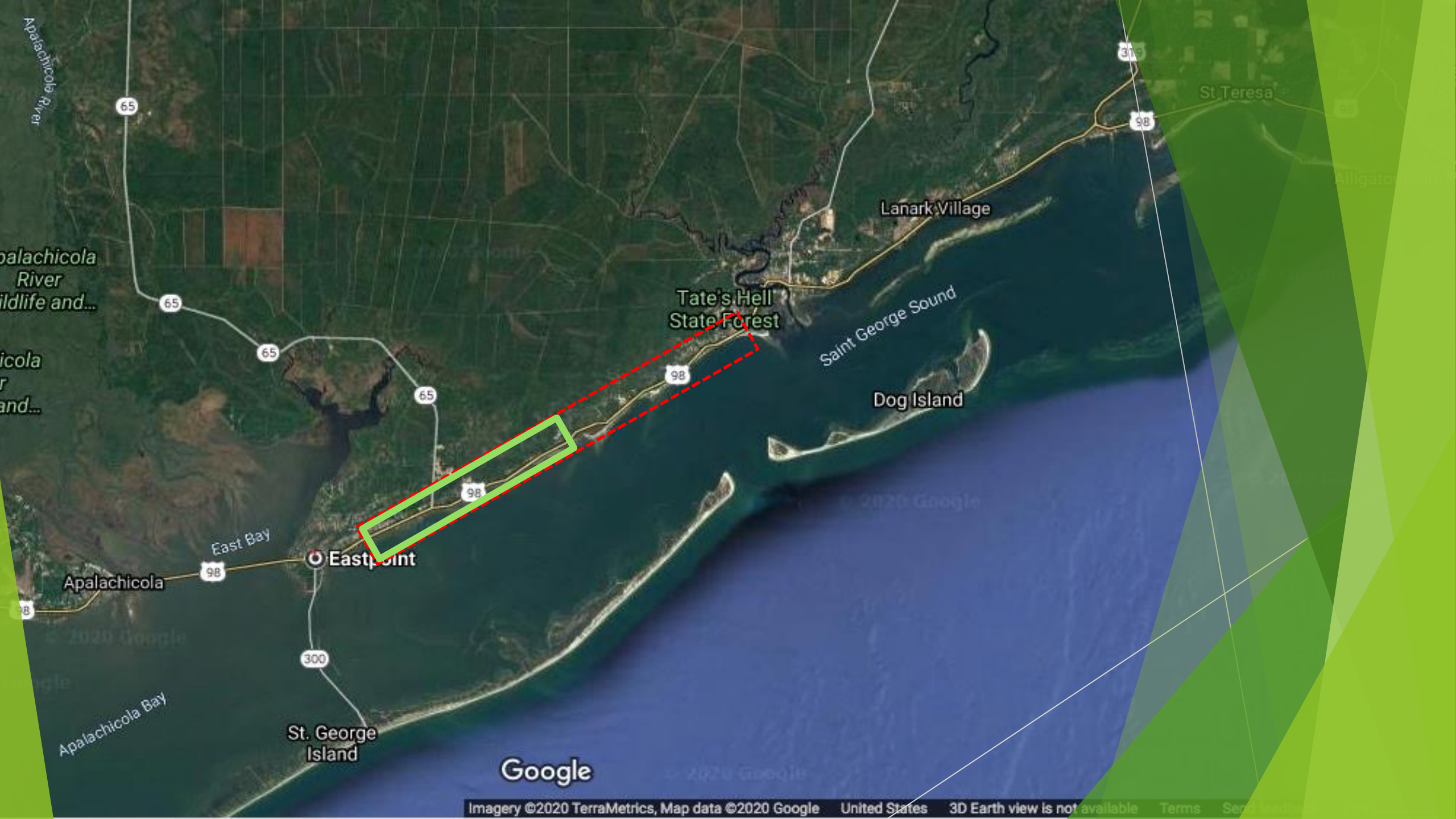
FRANKLIN 98
Protecting community, conserving the coast.

Evan Blythe,

Apalachee Regional Planning Council (ARPC)

Rick Harter,

WSP USA, Inc.


Apalachicola River
65
St Teresa
98
Lanark Village
palachicola
River
ildlife and...
65
Tate's Hell
State Forest
65
Saint George Sound
98
Dog Island
icola
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and...
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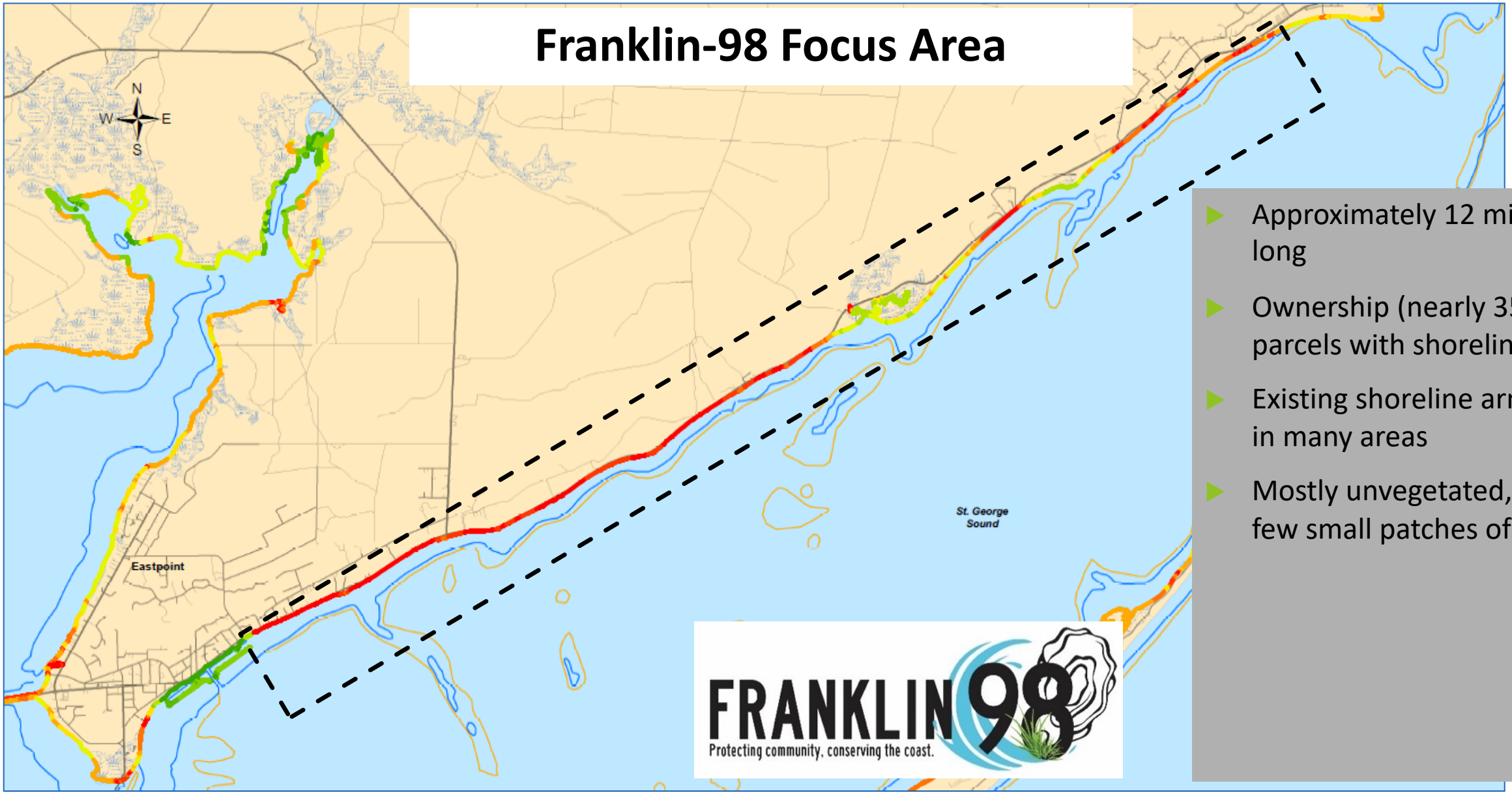
East Bay
Eastpoint
Apalachicola
98
300
Apalachicola Bay
St. George
Island
Google
Imagery ©2020 TerraMetrics, Map data ©2020 Google
United States
3D Earth view is not available
Terms

Franklin-98 Focus Area



- Approximately 12 miles long
- Ownership (nearly 350 parcels with shoreline)
- Existing shoreline armoring in many areas
- Mostly unvegetated, with a few small patches of marsh

Data Sources:

0 1 2 Kilometers

0 1 2 Miles

Lowest Priority — Highest Priority

3' Depth

5.9' Depth

ecology and environment, inc.
Global Environmental Specialists

SHORELINE HABITATS AND RESILIENT COASTS
ST. GEORGE SOUND FOCUS AREA

Apalachicola Bay, Florida

How Green or Gray Should Your Shoreline Solution Be?

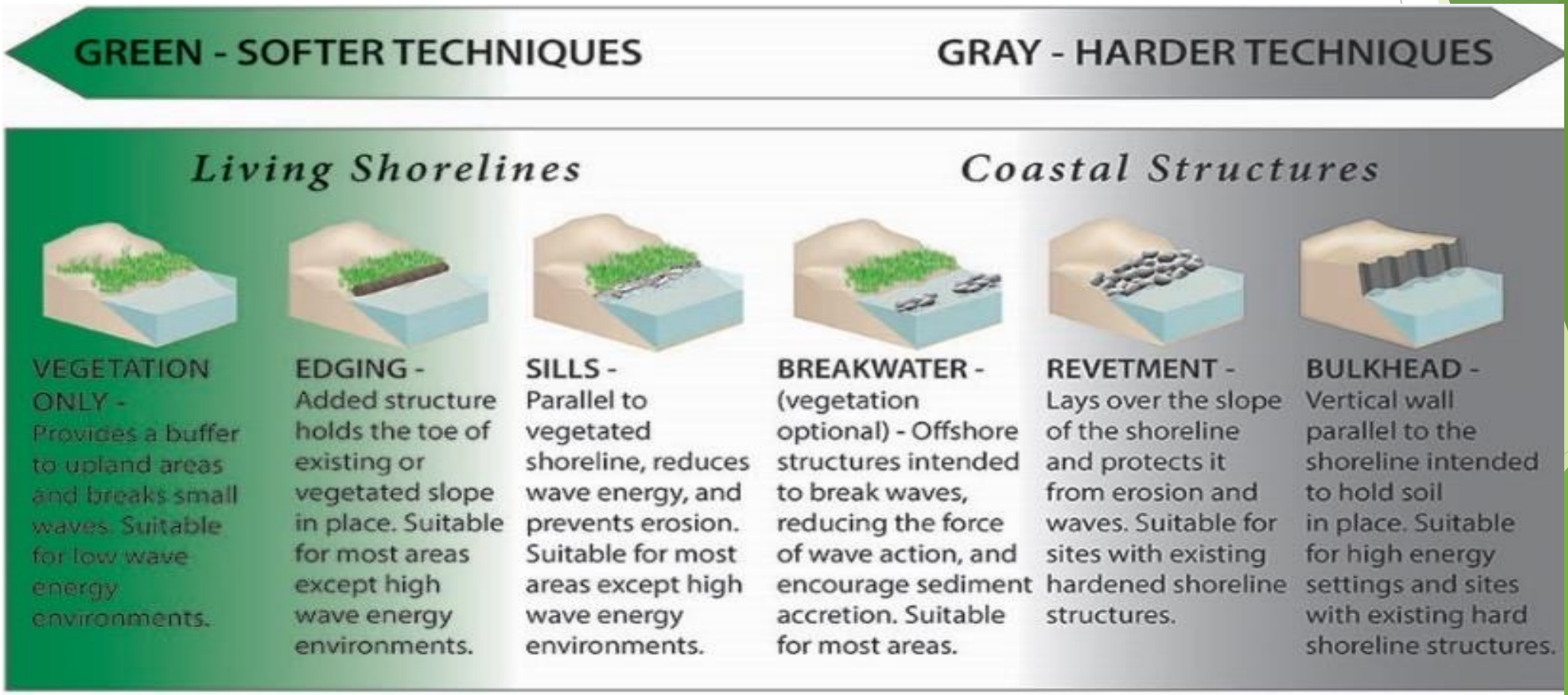
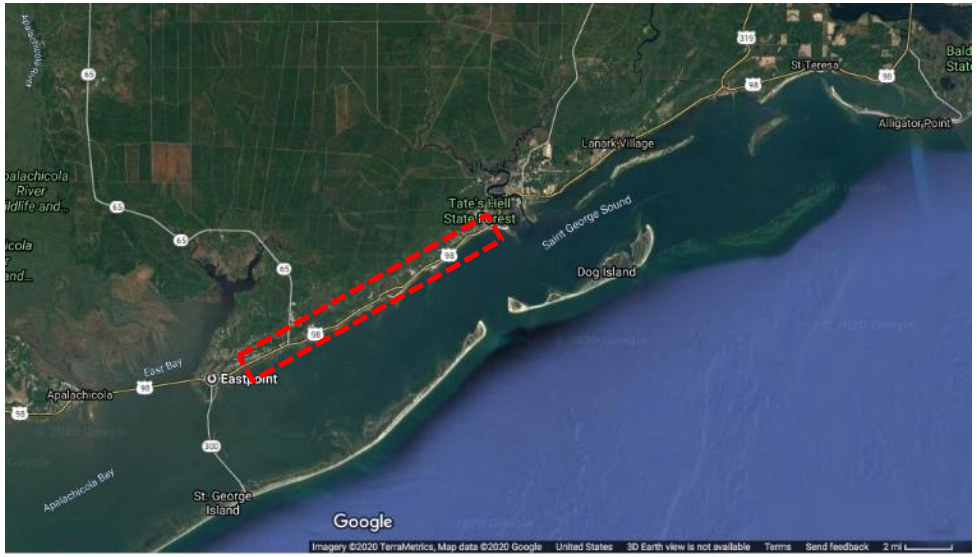


Diagram from NOAA Living Shorelines.

Before Hurricane Michael

After Hurricane Michael

Background



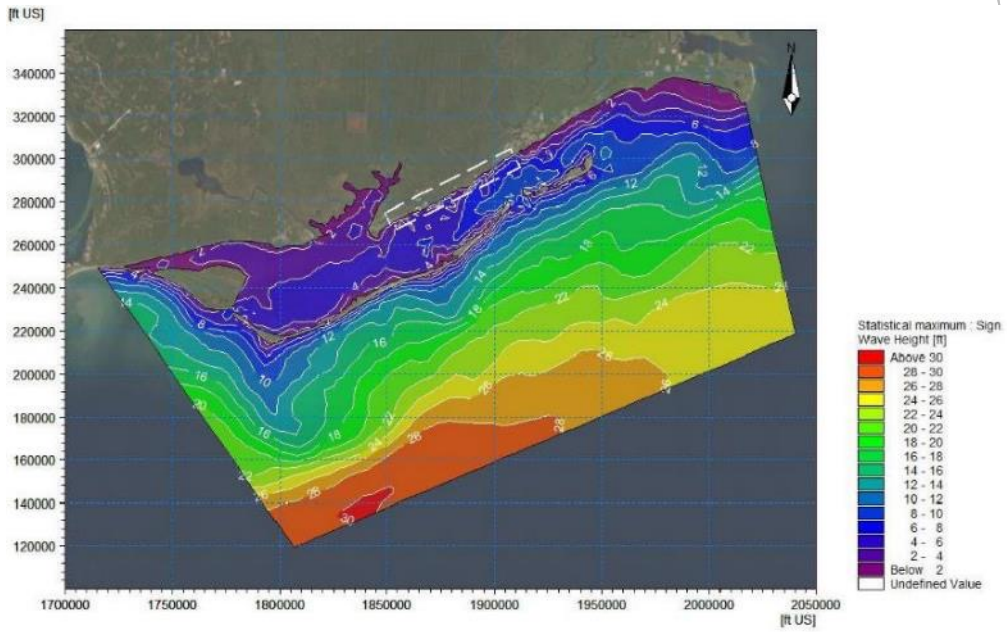
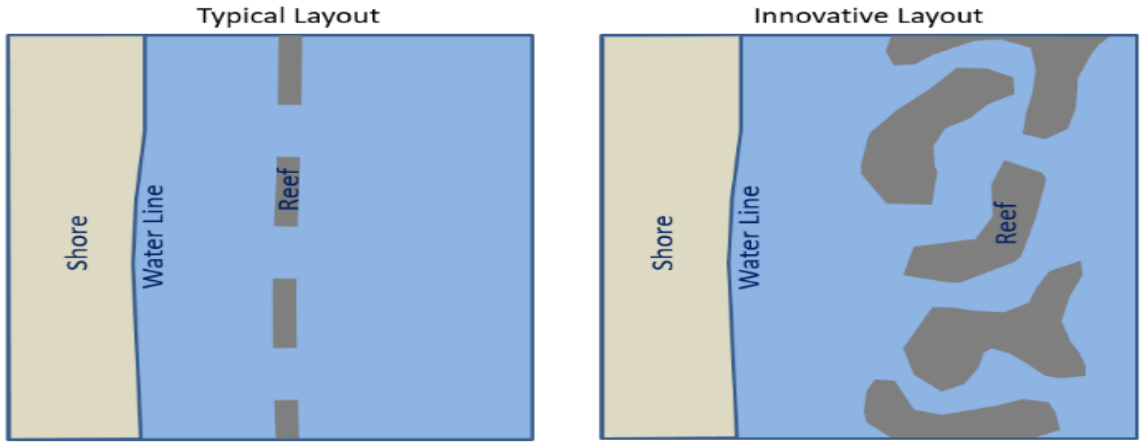


Figure above: Maximum Significant Wave Heights for Category 3 Storm Conditions, model overview

Goals/Vision

FRANKLIN 98
Protecting community, conserving the coast.

- Specific Restoration Goals:
  - 20 acres of new reef
  - 30 acres of new marsh
- Project Benefits:
  - Ecological Productivity
  - Resiliency
  - Economic Development



Our innovative design approach will maximize habitat and coastal resiliency, while achieving better aesthetics through natural design.

FRANKLIN 98

Protecting community, conserving the coast.

Phase 1 funded by FDEP:

Phases 2 & 3 funded by: NFWF

Design Considerations

I. Site Conditions
   A. Seagrass Coverage
   B. Wave Climate
   C. Bathymetry
II. Design Considerations
   A. Regulatory
   B. Stakeholder Input
   C. Coastal Infrastructure

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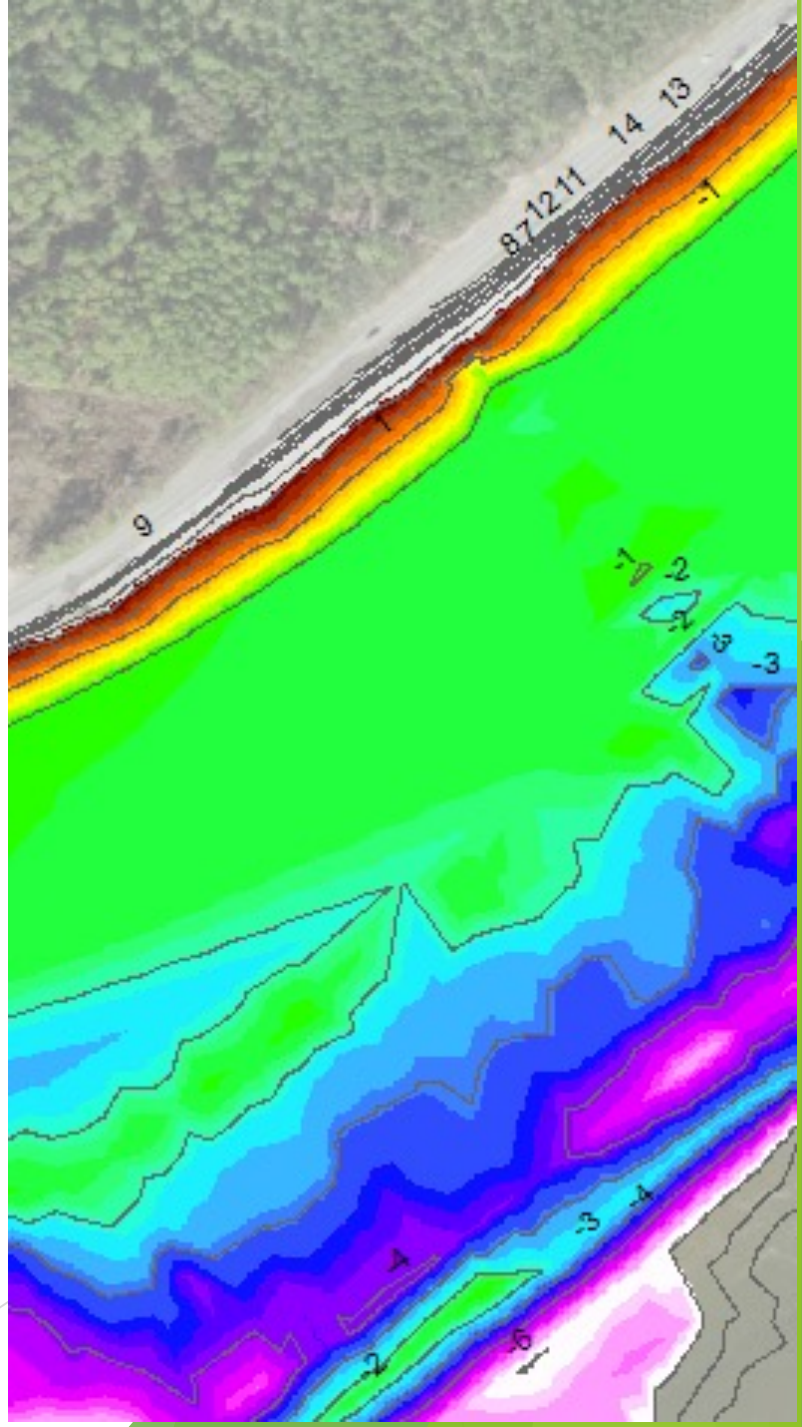
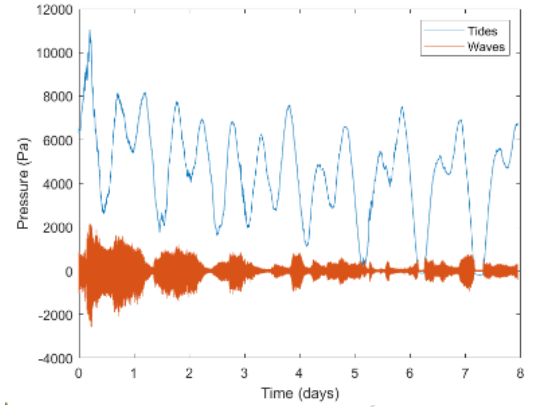
Protecting community, conserving the coast.

Data Collection & Analysis

Detailed site information to complete the engineering and final project design:

- Bathymetric/topographic (elevation) surveys
- Ecological characterization
- Threatened and endangered (T/E) species survey
- Benthic habitat mapping
- Hydrodynamic data collection
- Geotechnical survey

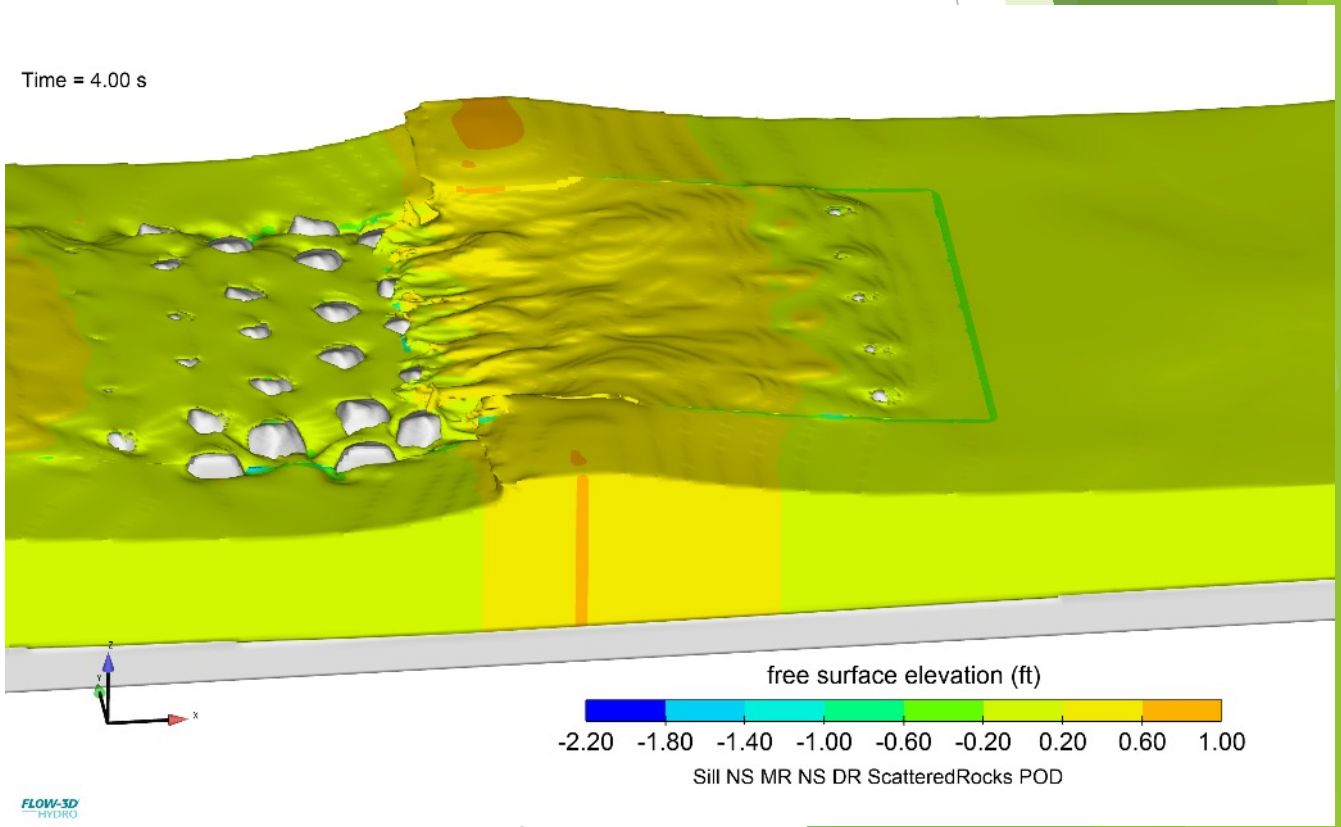




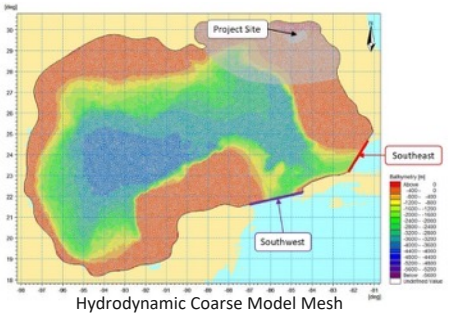
Engineering and Design

Materials Assessment - Wave Attenuation

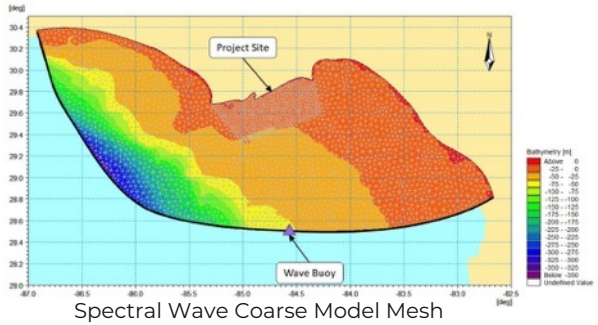
- Little information available in literature regarding wave attenuation effects
- CFD modeling completed to accurately model impacts to waves
- This information will be used to inform larger coastal wave models to incorporate a similar amount of attenuation.



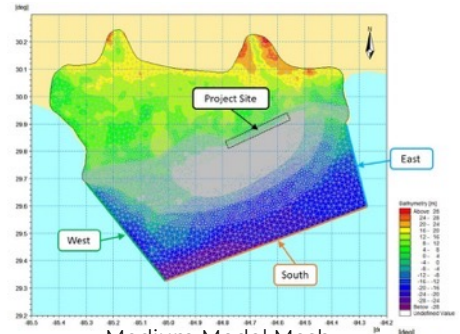
Coastal Modeling



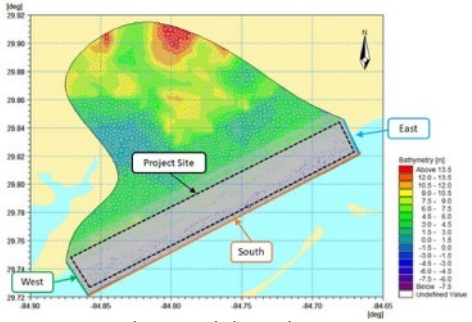
Hydrodynamic Coarse Model Mesh



Spectral Wave Coarse Model Mesh



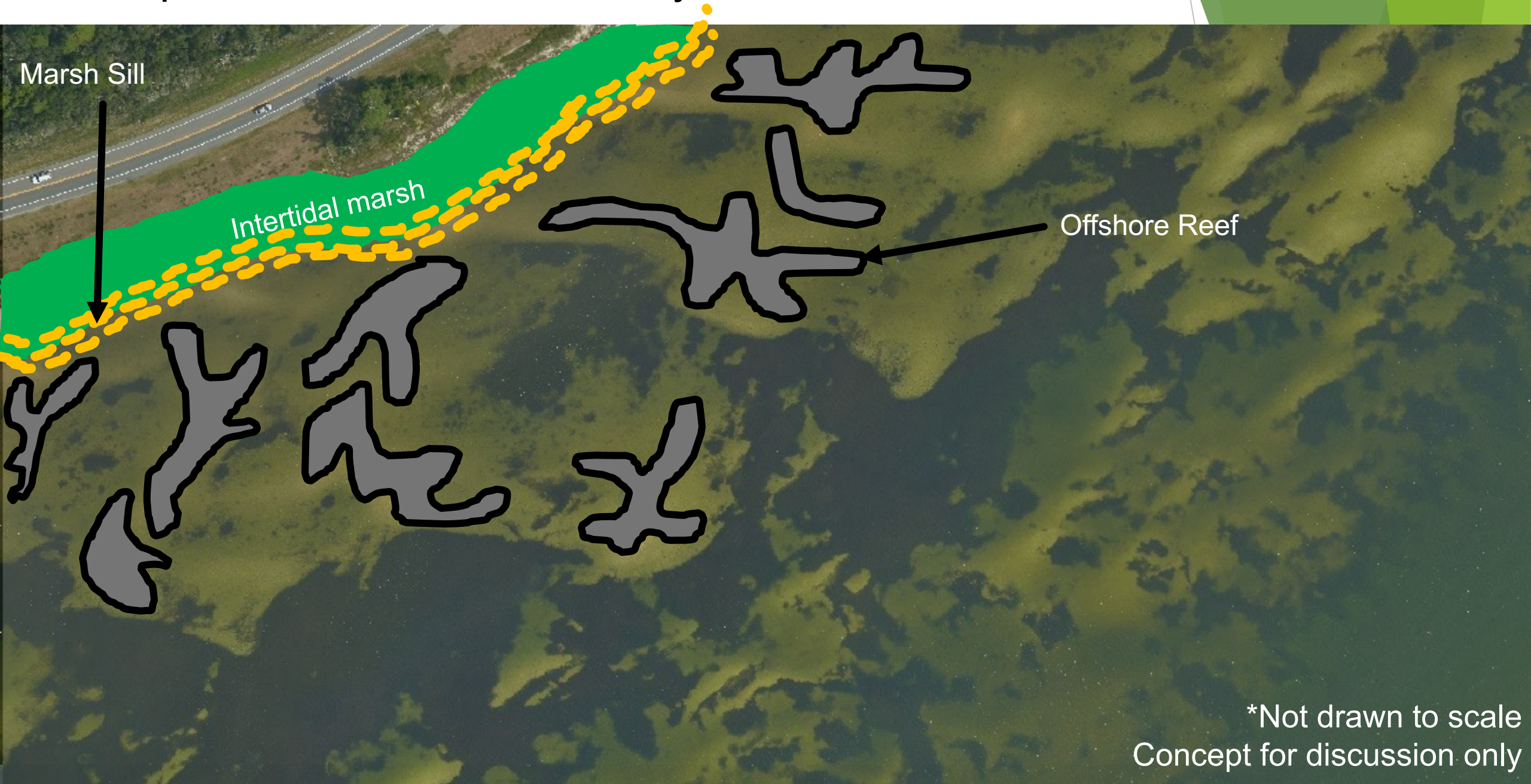
Medium Model Mesh



Fine Model Mesh


Intertidal Zone
Bare Areas
Bare Areas
Bare Areas

Conceptual Reefs and Marsh Layout



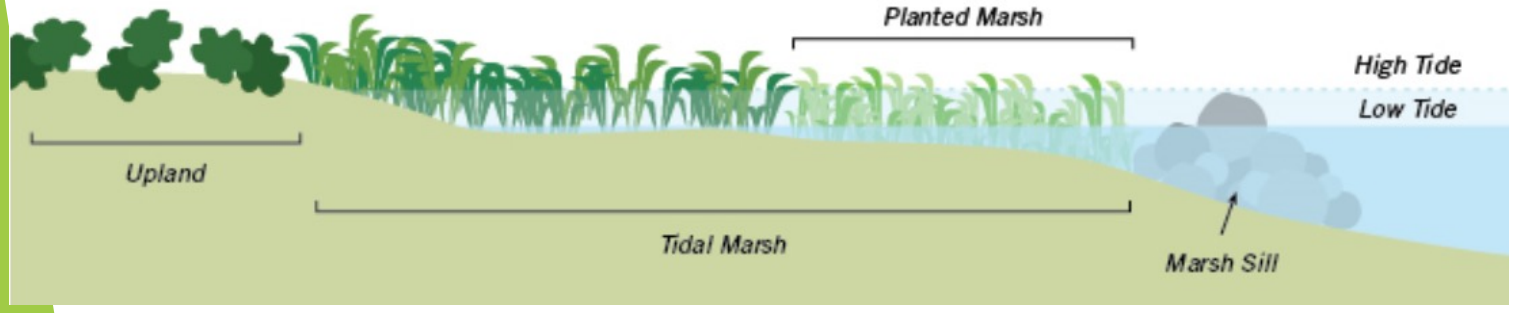
Proposed Marsh Sill (Edge Protection)

Purpose of sills:

1. Stabilize edge of marshes
2. Provide substrate/habitat

Marsh Sill

Marsh sills are low elevation structures (e.g., rocks or bagged oyster shell) that run parallel to the shoreline and are below water at high tide. The area between the sill and the marsh is often filled and planted with marsh vegetation to speed up shoreline stabilization.

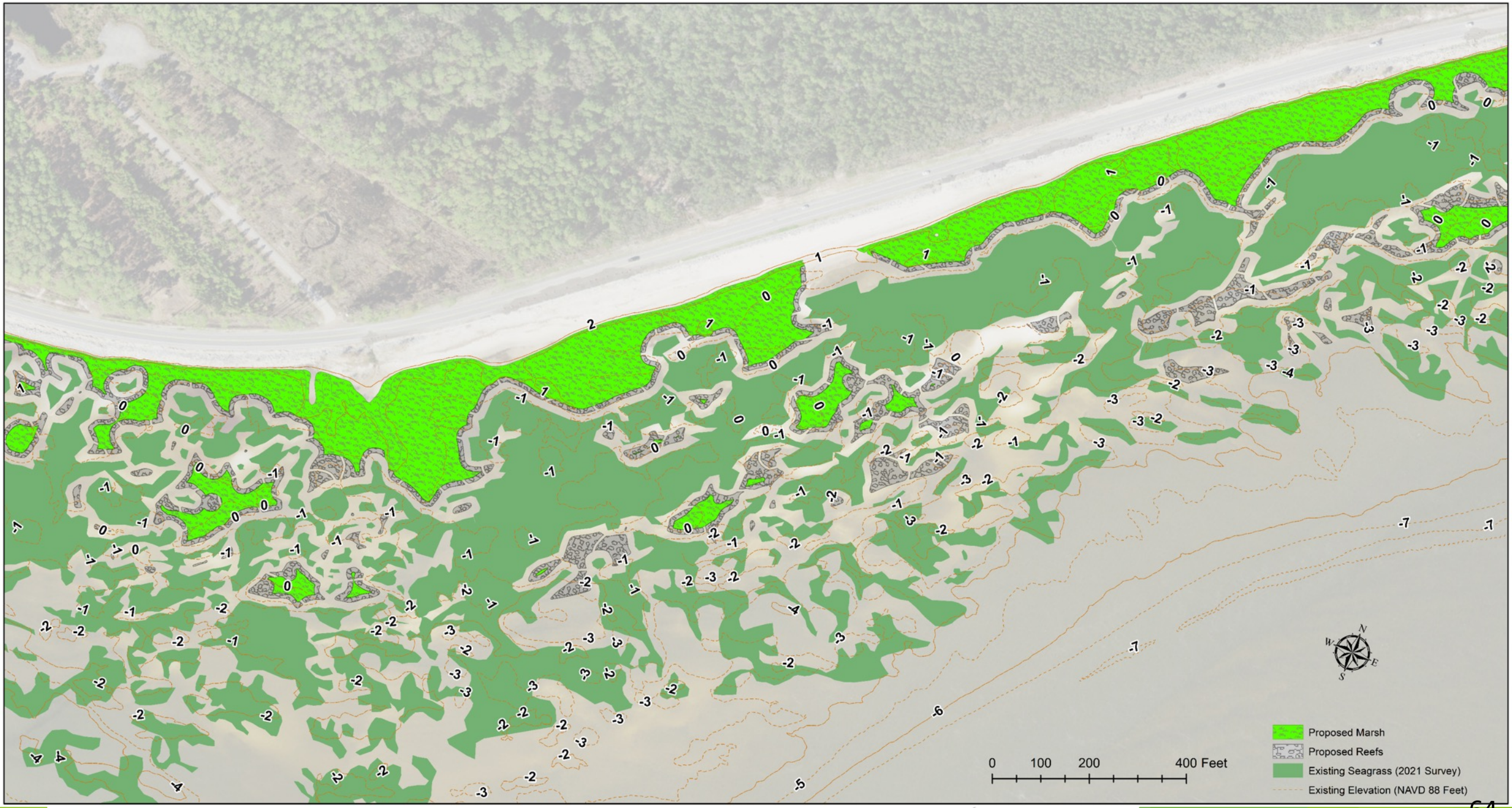


Graphic from www.CoastalResilience.org

Examples of Different Sills:

Photo credit: J. Bradshaw

Photo credit: North Carolina Coastal Federation

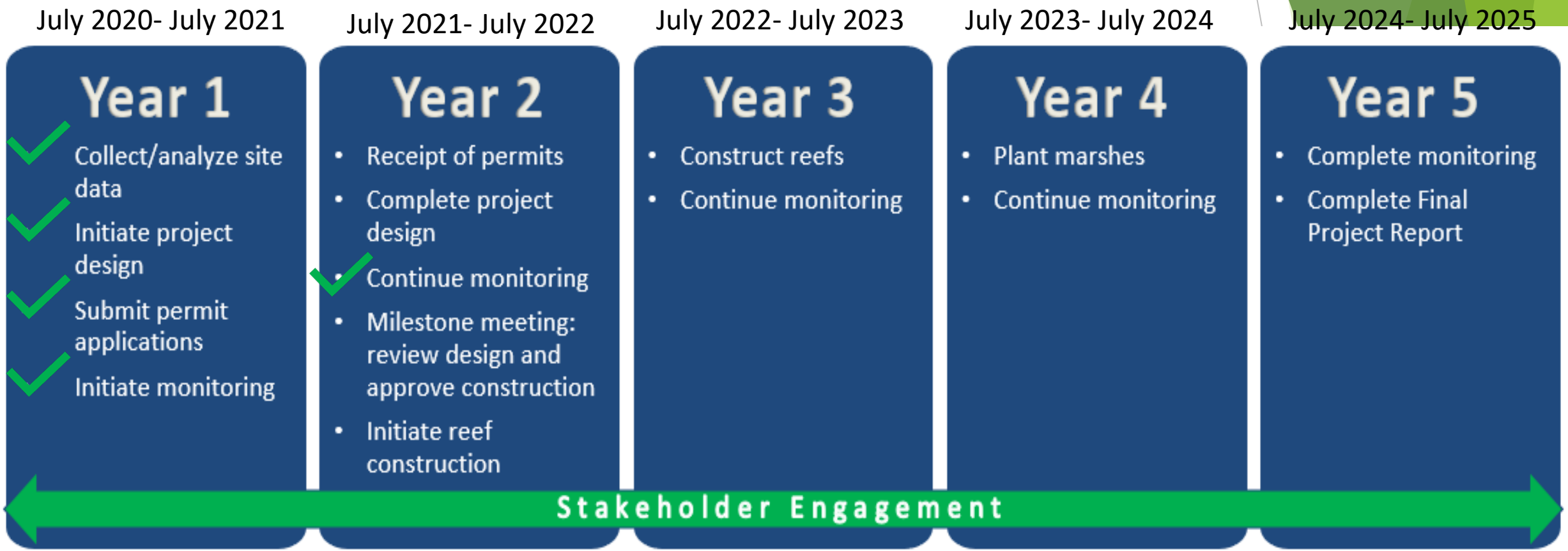

Proposed Marsh
Proposed Reefs
Existing Seagrass (2021 Survey)
Existing Elevation (NAVD 88 Feet)
0 100 200 400 Feet
N
W
E
S

Proposed Reef Materials

Hollow Concrete Domes

Riprap/recycled concrete

Key Project Milestones



Monitoring

- 5 years total (i.e., 5 annual events)
- Monitoring will continue to evaluate the following metrics:
  - Reefs – acreage, live/dead oyster density, and size frequency distribution
  - Intertidal marsh – acreage and percent cover by species
  - Erosion Control – change in shoreline position and elevation

Imagine the Possibilities


Existing Conditions
Proposed Conditions

Questions or Comments?

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Thank you!

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