



# Nature-Based Solutions for Coastal Highway Resilience: An Implementation Guide

ASCE Alabama Winter Meeting 2020

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Credit: Pixabay

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Federal Highway Administration



*“DOT will increase its effectiveness in ensuring that infrastructure is resilient enough to withstand extreme weather” – USDOT FY 2018-22 Strategic Plan*

## FHWA Resilience Pilots and Studies



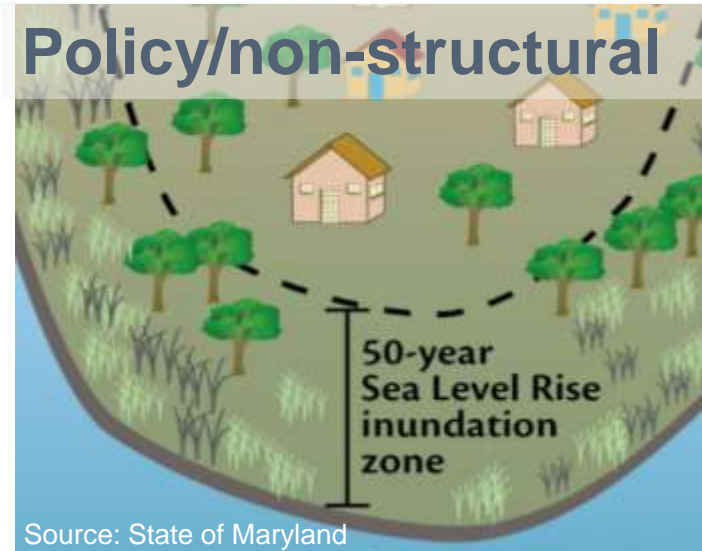


# Research Gap: Nature-based Solutions and Integrated Approach

## Structural solution



## Policy/non-structural



## Nature-based solution



- Natural features
- Nature-based features
- Hybrid approaches

## 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
- Incorporated into HEC-25



Participants at Alabama Peer Exchange. Credit: Susan Asam

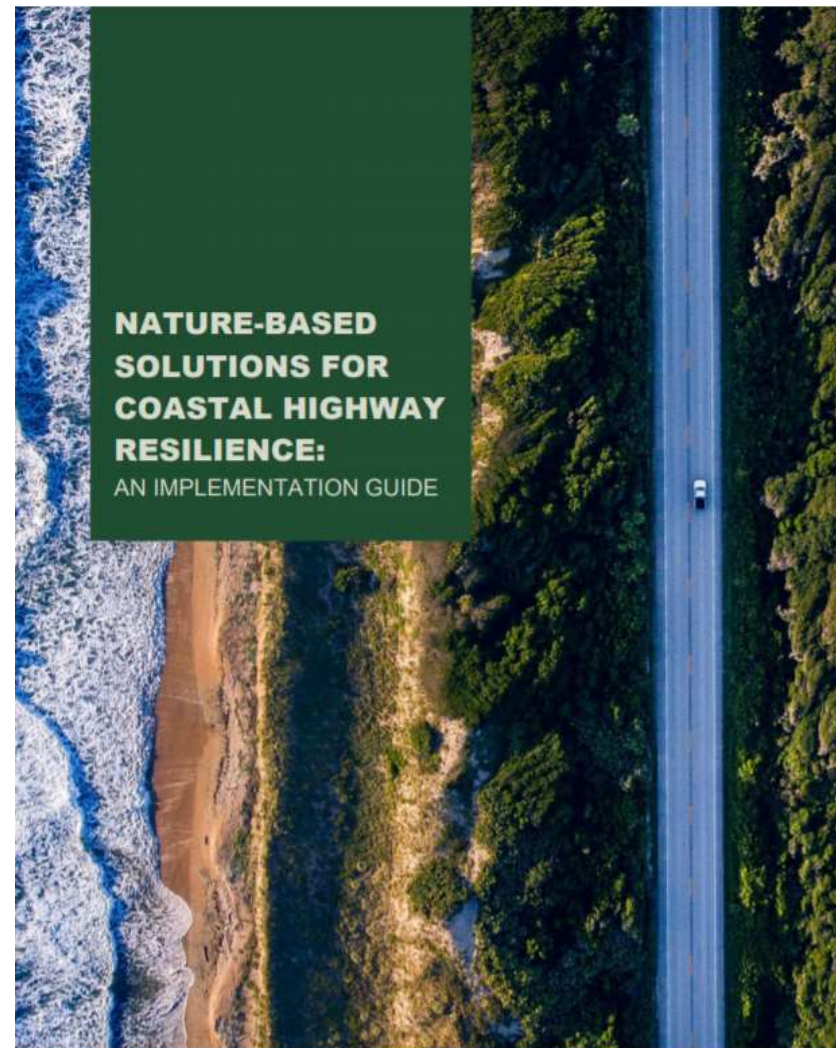
# Implementation Guide



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

**Now available for  
download at  
[bit.ly/FHWA\\_NBS](https://bit.ly/FHWA_NBS)**





# Nature-based Solutions



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*Use natural materials and processes to reduce erosion, wave damage, and flood risks.*



Credit: FHWA



Credit: Bret Webb



Credit: FHWA



Credit: FHWA

# Benefits



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- ✓ 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

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

Credit: Bret Webb



Credit: Suzanne Kaspar, Mobjack Bay, VA



- Incorporating into transportation planning can help:
  - Address both resilience and environmental objectives
  - Allows systematic consideration
  - Mobilize larger projects
  - Take advantage of analyses by partners

**Planning & Funding**

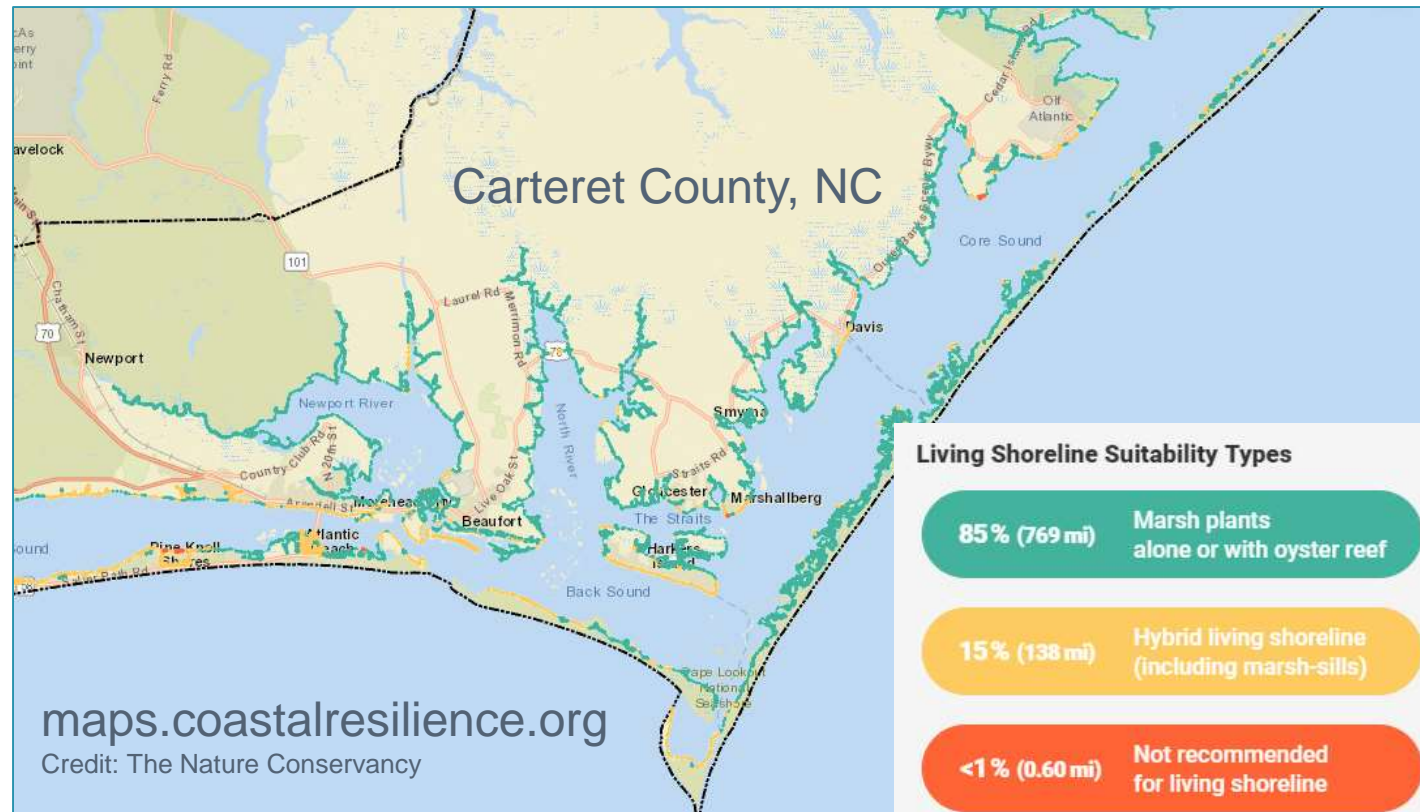
**Site Assessment**

**Design**

**Permitting**

**Construction**

**Monitoring**





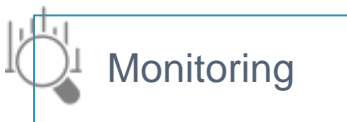
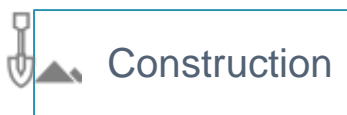
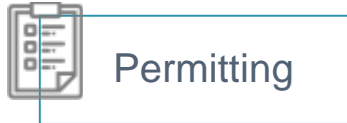
# FHWA's Eco-Logical Approach



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## Eco-Logical Framework



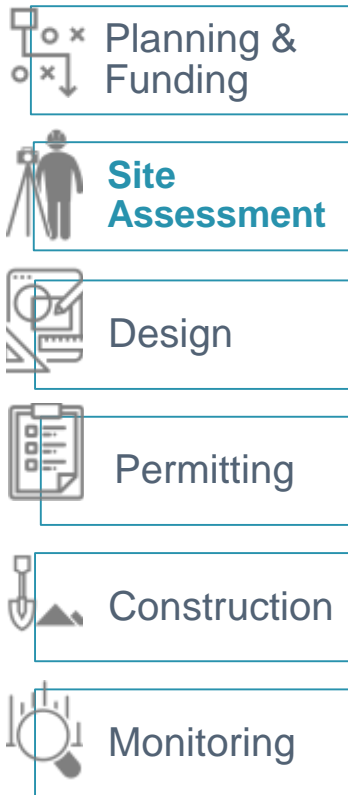


- Funding opportunities:
  - Transportation
  - Coastal restoration
  - Hazard mitigation
- Example: [National Coastal Resilience Fund](#) (NOAA & NFWF) funds nature-based solutions to protect coastal communities



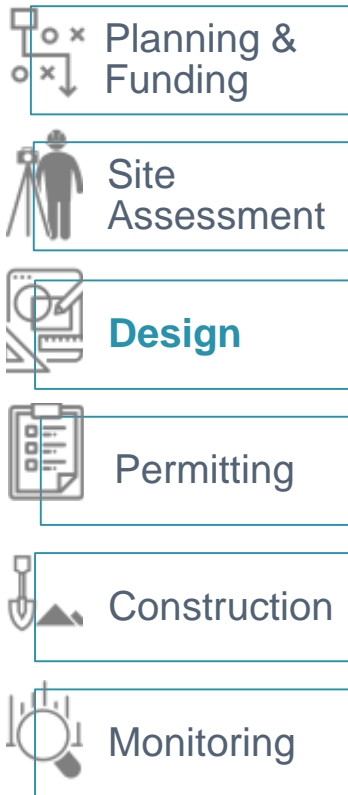
Credit: DeIDOT

# Site Assessment



System Parameters	Hydrodynamic Parameters
<ol style="list-style-type: none"> <li>1. Shoreline Type</li> <li>2. Infrastructure</li> <li>3. Erosion Rate</li> <li>4. Sea Level Rise</li> <li>5. Tide Range</li> </ol>	<ol style="list-style-type: none"> <li>1. Wind Waves</li> <li>2. Boat Wakes</li> <li>3. Currents</li> <li>4. Ice</li> <li>5. Storm Surge</li> </ol>
Terrestrial Parameters	Ecological Parameters
<ol style="list-style-type: none"> <li>1. Upland Slope</li> <li>2. Shoreline Slope</li> <li>3. Width</li> <li>4. Nearshore Slope</li> <li>5. Water Depth</li> <li>6. Soil Strength</li> </ol>	<ol style="list-style-type: none"> <li>1. Water Quality</li> <li>2. Soil Type</li> <li>3. Sunlight</li> <li>4. Salinity</li> </ol>
Additional Parameters	
<ol style="list-style-type: none"> <li>1. Permits</li> <li>2. End Effects</li> <li>3. Constructability</li> </ol>	<ol style="list-style-type: none"> <li>4. Species</li> <li>5. Debris</li> <li>6. Monitoring</li> </ol>





- Illustrative lessons learned:
  - Loose substrate (e.g., oyster shell), coir fiber logs, and woody debris have not performed well when exposed to wave action.
  - Protection structures should primarily address the most common water level and wave conditions, in addition to considering infrequent but extreme events.
  - One common mistake is placing structures at sites where they may exacerbate shoreline erosion.

# Example: Marsh

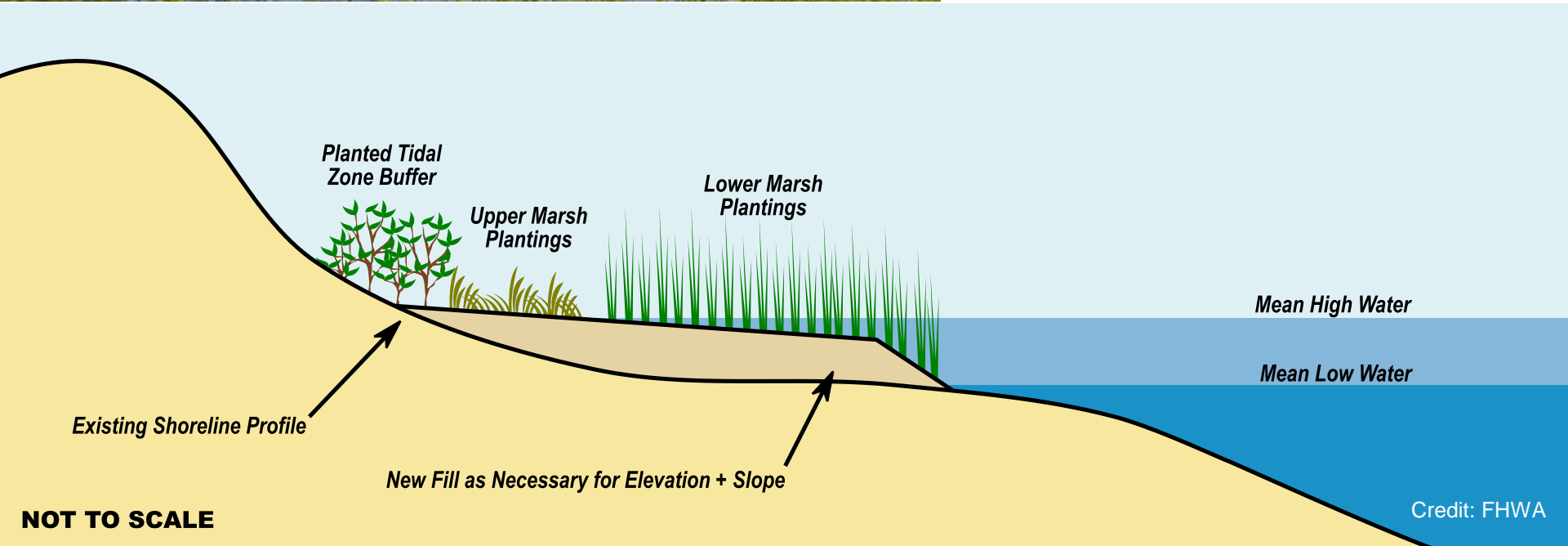


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- Wave height reduction of 60 – 80% over 30ft-wide marsh
- Can adapt to rising seas by trapping sediment to increase in elevation or migrate inland
- Filter runoff, retain sediment, habitat for fisheries

Credit: Bret Webb



Existing Shoreline Profile

Planted Tidal Zone Buffer

Upper Marsh Plantings

Lower Marsh Plantings

Mean High Water

Mean Low Water

New Fill as Necessary for Elevation + Slope

Credit: FHWA

**NOT TO SCALE**

# Example: Dune Restoration



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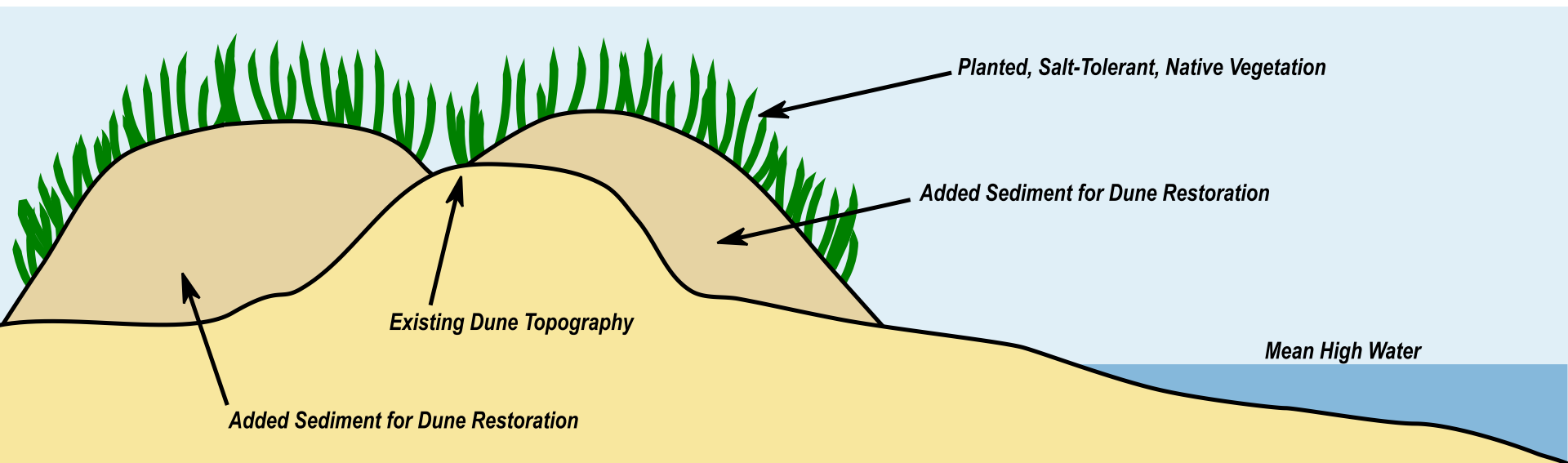
Dune volume required to protect against a storm having a T-year return period

$$V = 86.1 T^{0.4}$$

V = dune volume above Stillwater level in cubic feet per foot of shoreline



Credit: Bret Webb



**NOT TO SCALE**

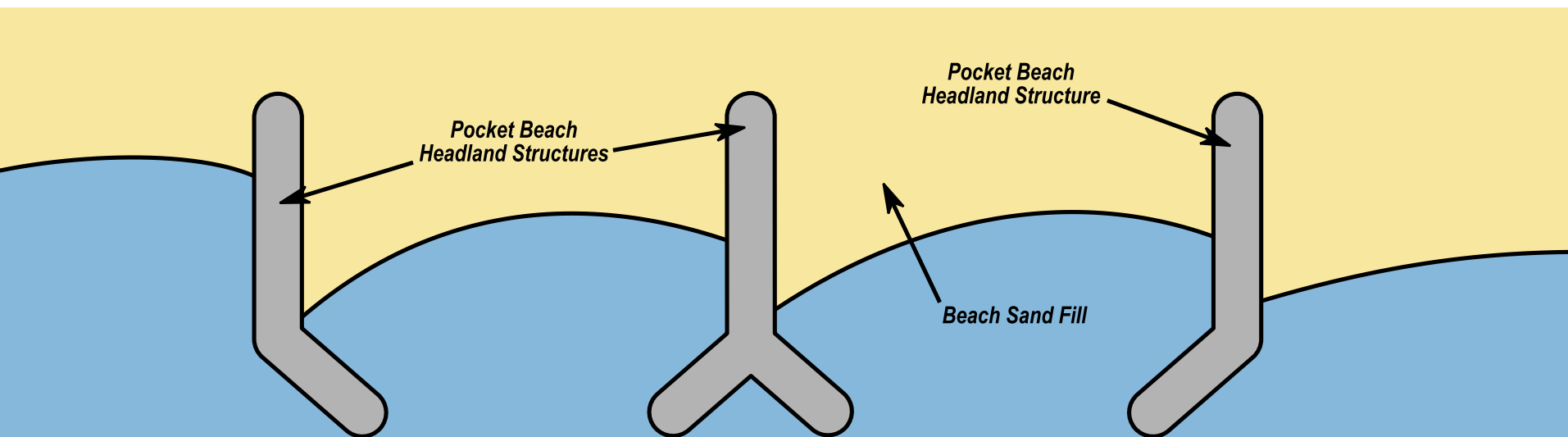
Credit: FHWA



# Example: Pocket Beach



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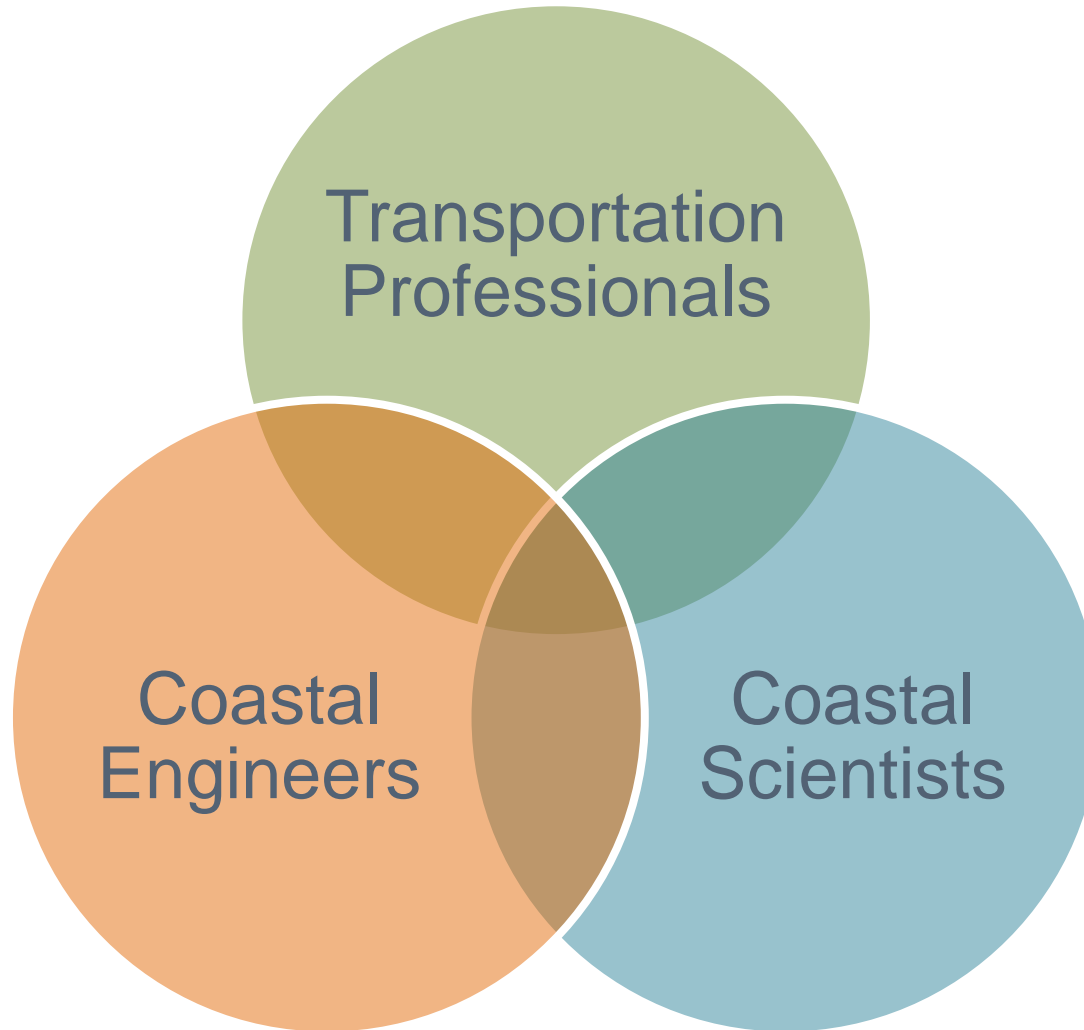
NOT TO SCALE

Credit: FHWA

# Who is Required for Success?



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# Strategic Partnerships



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Federal Highway Administration



Sea Grant



Office for Coastal Management  
NATIONAL ESTUARINE  
RESEARCH RESERVES



US Army Corps  
of Engineers®



RESTORE  
AMERICA'S  
ESTUARIES



# Design: Mobile Bay, AL



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



Credit: Bret Webb

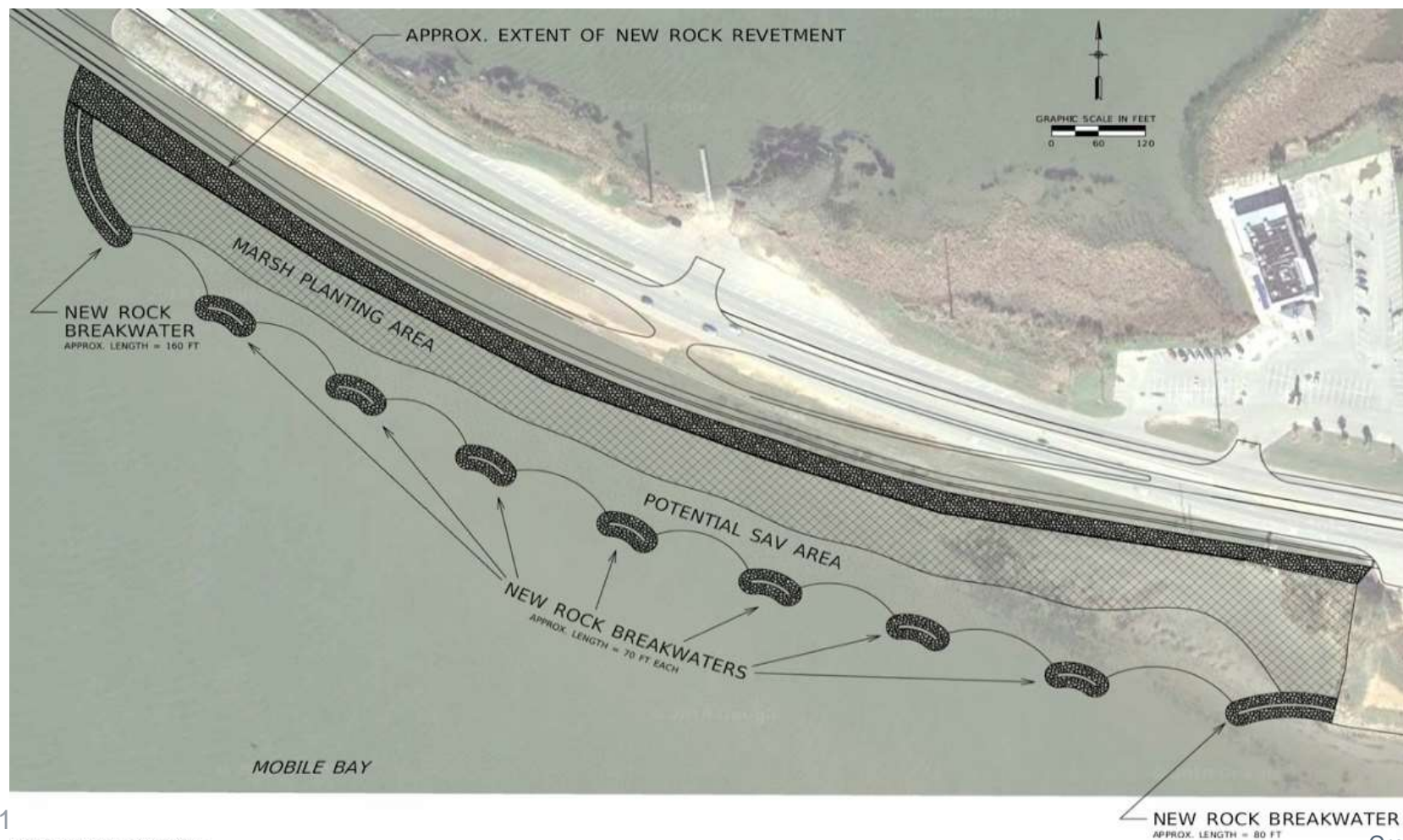
An existing concrete seawall serves as bank stabilization for the Mobile Bay causeway.

# Design: Mobile Bay, AL



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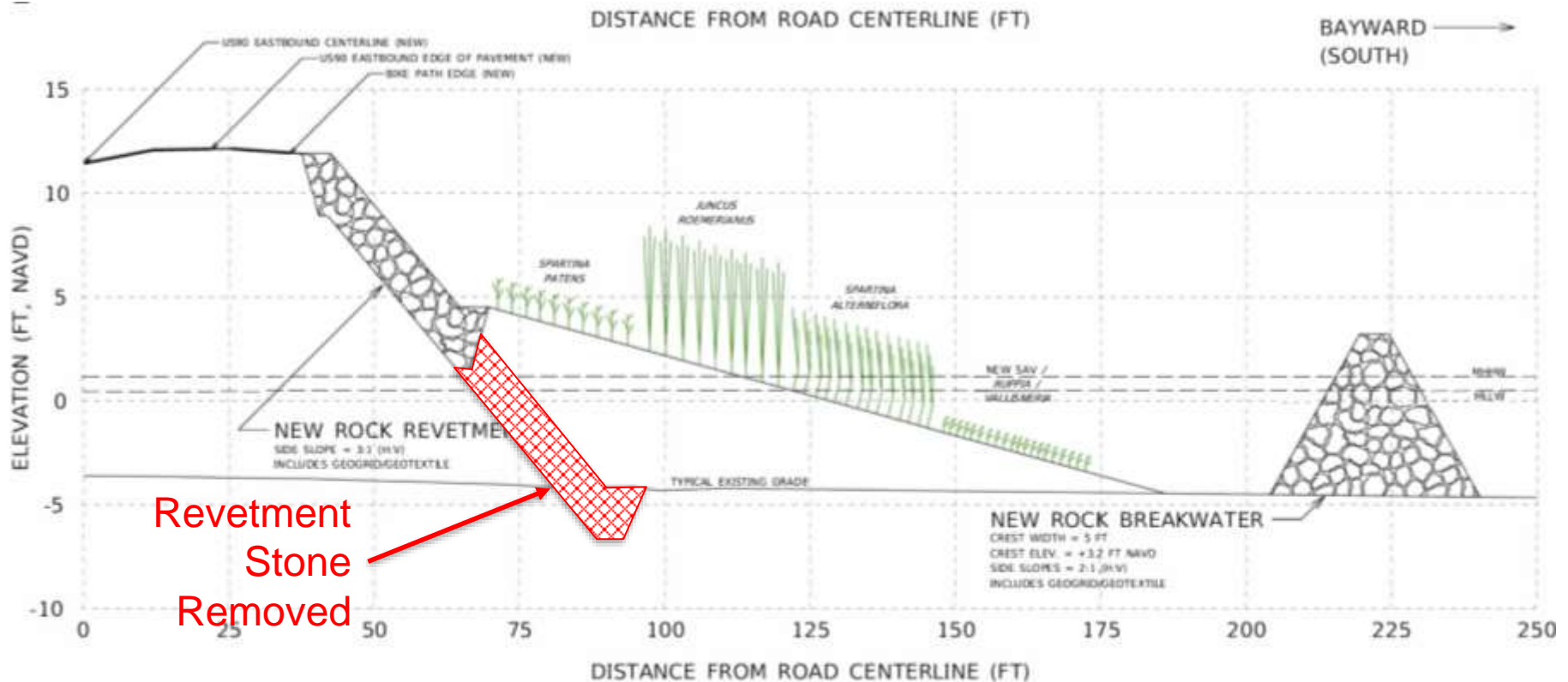
Conceptual planform diagram of a constructed marsh and breakwater system for Mobile Bay, AL.



# Design: Mobile Bay, AL









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





# Design: New Castle, NH

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

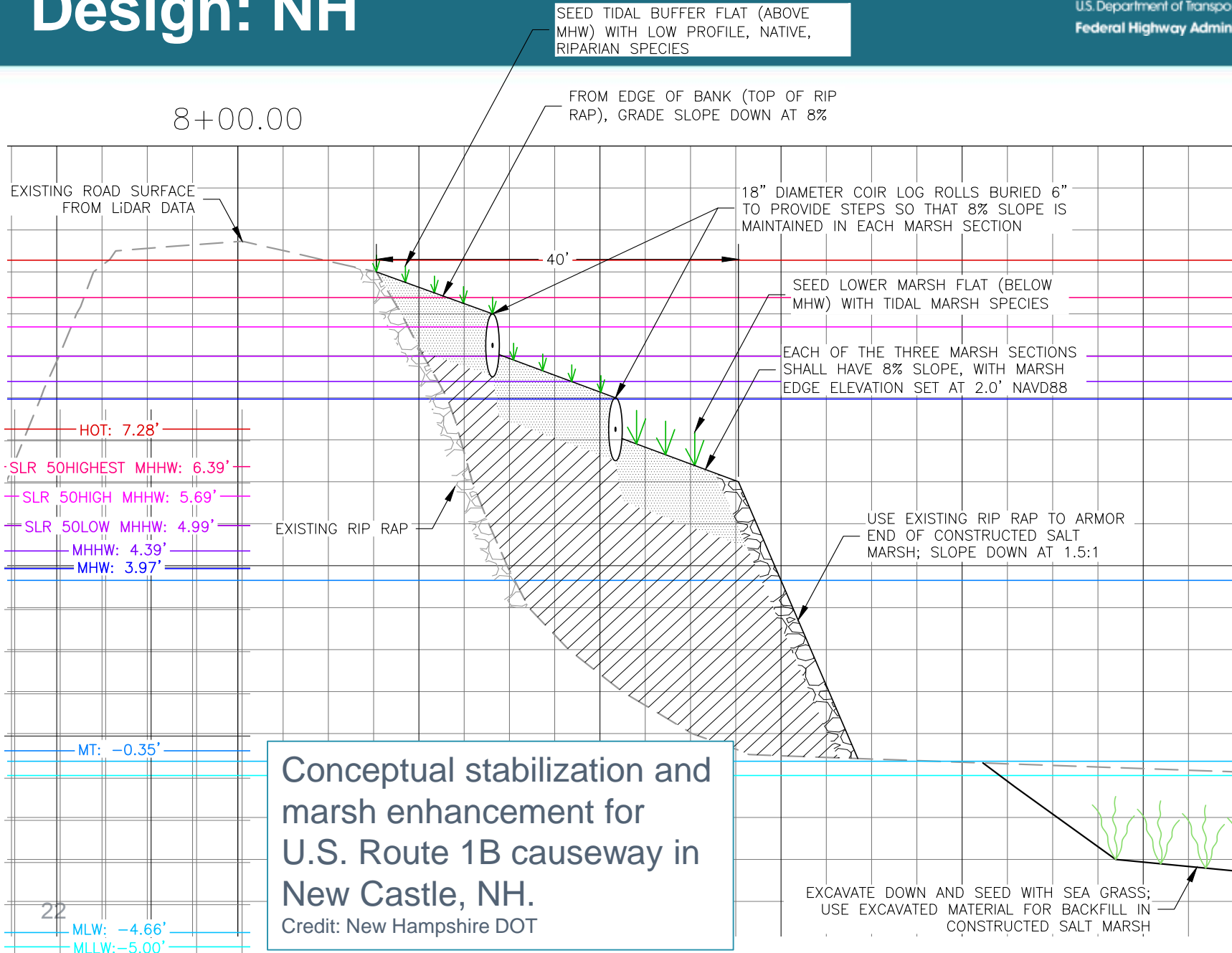


U.S. Route 1B causeway in New Castle, NH.

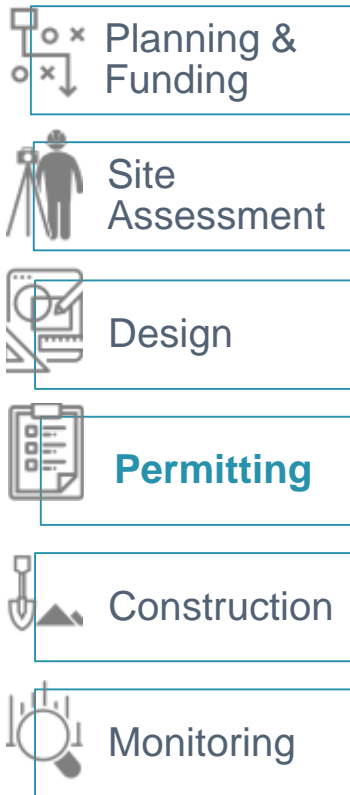
# Design: NH



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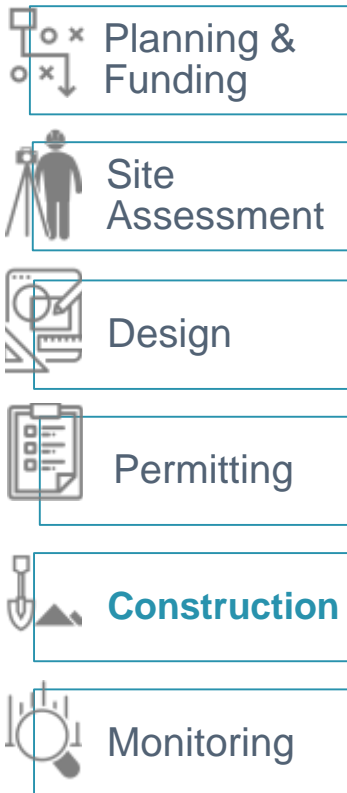
Conceptual stabilization and marsh enhancement for U.S. Route 1B causeway in New Castle, NH.  
Credit: New Hampshire DOT



- USACE generally acts as federal clearinghouse, issues permits under Clean Water Act Section 404 (discharge of dredge or fill into waters of US)

Permit Type:	Nationwide Permit	General Permit	Individual Permit
Permit Requirements	Strictly defined	Generally defined	Undefined
Review Period	Short	Moderate	Longer

- Relevant Nationwide Permits (NWP):
  - NWP 54: Living Shorelines (2017)
  - NWP 13: Bank Stabilization
  - NWP 27: Aquatic Habitat Restoration
- NEPA satisfied programmatically for NWP & general permits
- Nature-based solutions may help meet compensatory mitigation requirements



- Performance-based contracts allow innovation in construction techniques, can be good option for including maintenance. See [A Procurement Guide to Nature-based Solutions](#).
- Land-based (soft soils may require timber mat or lighter equipment) or water-based (may need to time construction for high tide in shallow areas)
- Nature dictates timing. Beware nesting season. Time for plant, oyster, etc. optimal growth.
- Signage – “Pardon our Mess” and interpretive signs



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



# Construction



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



## Step 1

- Protect upland and bank.
- Build platform, place geotextile.



## Step 2

- Add sand fill.
- Add stone or structural elements.



## Step 3

- Check slope, grade, elevations.
- Wait ~3 weeks.



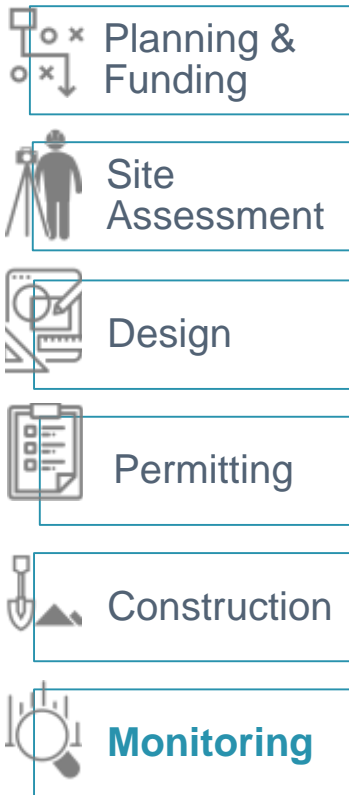
## Step 4

- Stage plants at site.
- Plant vegetation.

# Monitoring, Maintenance, & Adaptive Management



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



## Preventive Marsh Maintenance

Remove Excess Debris and Trash

Replace Plugs

Prune Shade Trees

Remove Non-Native and Invasive Species

Do Not Mow!

Avoid Chemicals

Discourage Foraging

# Work with Nature



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Credits: Bret Webb

# Thank You!



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*Implementation Guide available for download at*  
**[www.bit.ly/FHWA\\_NBS](http://www.bit.ly/FHWA_NBS)**

*Peer exchange report, pilot reports, fact sheet, etc. available at:*  
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