

Nature-based Resilience for Coastal Highways

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FHWA & Climate Resilience



- Must protect public safety, federal infrastructure investment, and economy.
- Strategic Plan, 2017: "DOT will increase its effectiveness in ensuring that infrastructure is resilient enough to withstand extreme weather."
- Climate adaptation activities <u>eligible</u> for FHWA funding
- FHWA requires climate risk / resilience to be included in:
 - Asset management plans (<u>23 CFR</u> <u>515</u>)
 - Transportation plans (23 USC 134, 23 CFR 450)
 - Emergency relief (<u>23 CFR 667</u>)
 - FHWA programs and policies (<u>Order</u> <u>5520</u>)

FHWA Resilience Website: https://www.fhwa.dot.gov/environment/ sustainability/resilience/



Flooding from Hurricane Harvey, Credit: TTI



April 2017 flooding in Washington State, Credit: WSDOT

FHWA Resilience Resources



Gap: How can transportation agencies use nature-

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How to protect highways from coastal flooding by using or mimicking natural processes.

Integrated Approach:

- **Structural** (e.g. armoring, raise road, widen culvert, pavement materials)
- **Natural features**: created through the action of physical, geological, biological, and chemical processes over time (e.g. wetlands, dunes)
- Nature-based features: created by human design, engineering, and construction to provide risk reduction in coastal areas by acting in concert with natural processes (e.g. wetland restoration, artificial reefs, beach nourishment)
- **Non-structural** (e.g. land use policies, infrastructure siting, insurance policies)

Why talk about nature-based solutions (also called **green infrastructure**)?

May be cheaper; effective; more adaptable; and benefit habitat, fisheries, recreation



Rock revetment, Photo credit: Tina Hodges



Concept for protecting Bay Bridge, Oakland, CA, Credit: MTC

FHWA Project: Nature-based Resilience for Coastal Highways

U.S. Department of Transportation Federal Highway Administration

- Goal: Provide research and technical assistance to help state DOTs and MPOs implement nature-based solutions to protect coastal highways from storm surge and sea level rise.
- Build off USACE and NOAA work
- 5 pilot projects completed
 - OR DOT
 - ME & NH DOTs jointly
 - MS DOT
 - DE DOT
 - US Army Corps of Engineers in NJ
- White paper, Winter 2018
- Regional peer exchanges, Spring 2018: AL, CA, DE, NC
- Implementation guide, 2019

https://www.fhwa.dot.gov/environment/sustainability/resil ience/ongoing_and_current_research/green_infrastructu re/index.cfm



Photo Credit: Tina Hodges



Map Credit: Google Earth

Oregon DOT Pilot



Cobble Beach, Credit: ODOT



Mechanically Stabilized Earth (MSE), Credit: ODOT

- US 101 in Lincoln County, OR
- Chose 3 sites threatened by bluff erosion and storm surge
- Included regulatory partners in study team
- State regs require exception to armor shoreline
- Considered cobble beaches, sand dunes, mechanically stabilized earth, etc.
- Analyzed protection for 2050 sea level rise under 100 yr storm with wave run-up



Sand Tube, Credit: Geo Synthetics

	Beverly Beach	Lost Creek	Ona Beach
Photo credits: ODOT			
Conceptual Design	Cobble beach covering large rock riprap keyed in at toe with piles, MSE slope with planted terraces	Cobble beach, artificial dune, replace culvert	Cobble beach, MSE slopes, sand tube core
Total Cost	\$41 million	\$2.8 million	\$5.9 million
Cost per linear foot	\$19,500	\$4,700	\$5,000
Protection	Insufficient. Would need to increase materials, footprint, and cost.	Slight increase in elevation required	Sufficient
Exception required?	Yes	No	Yes

Maine & New Hampshire DOTs

US. Department of Transportation Federal Highway Administration

- Joint study
- Route 209 in Maine:
 - Goal: extend time before gray infrastructure solution (sheet pile wall or riprap) necessary
 - Considered combos of seaweed management, fence, coir log or root wad crib, plantings
 - Costs: \$0.5 million to \$12.3 million, and from \$173k - \$282k when viewed as dollars per additional year of access preserved.
- Route 1B in New Hampshire:
 - Under intermediate-high sea level rise, causeway may be inundated 188 times in 2060 and 338 times in 2065.
 - Considering raising causeway
 and enhancing marsh
- Study includes conceptual drawings, cost estimates

Photo Credit: NHDOT



Mississippi DOT Pilot



Green Solutions

Natural Adaptations

Constructed Dunes

Control Forests

>

Use Existing ROW

Vegetated Berms & Constructed Wetlands







USACE – New Jersey Pilot



Photo credit: USACE

Photo credit: USACE

- U.S. Army Corps of Engineers partnering with multiple organizations
- Great Bay Boulevard in Barnegat Bay, NJ subject to flooding
- Monitored marsh conditions
- Examined marsh restoration that would protect road
 - Thin layer placement of sediment at two low lying areas to elevate marsh (194,000 CY)
 - Living reef or wave attenuation device to diminish wave energy during nor'easters

Delaware DOT

- State Route 1 through beach towns
- Low elevation, high relative sea level rise, storm surge, urban stormwater runoff, high groundwater, poorly draining soil
- 30+ existing pipe outfalls to the Bay, sediment deposition in the outfall swales, pipes below sea level at high tide and wind events
- Vulnerability assessment (flood elevation, wave energy, buffer resilience)
- Looked for sites where coastal and stormwater green infrastructure practices could be combined



DE SR 1, 1/24/2017 Credit: DelDOT





Read Avenue (Top)

- Design: rock sill, marsh plantings, dune enhancements, oyster reef, box culvert, tide gate: \$170,000
- Improves protection from 1 yr event to 4 yr event
- National Guard Site (Right)
- Propose spreading stormwater discharge to multiple sites, forebays, level spreaders, runnels
- Cost not estimated but would save on dredging



Photo credits: DelDOT

White Paper

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- Summarizes current state of knowledge of marsh, mangrove, reef, beach, forest, dunes ability to dissipate wave energy, reduce flooding
- Provides highway related examples
- Lessons learned from prior projects
- Knowledge gaps and implementation hurdles





Top: Project Green Shores, Pensacola, FL protects 1 mi segment of Bayfront Parkway. Constructed 2003. FL DEP led. **Left:** Pocket beaches protect Water St in Yorktown, VA. York County lead. VDOT contributed funding. Constructed 1994. Map Credit: Google Earth

Peer Exchanges

U.S. Department of Transportation Federal Highway Administration

- Purpose:
 - Exchange ideas between transportation professionals and coastal engineers / ecologists
 - Provide input to implementation guide
- Participants: state transportation departments (hydraulics, environmental review, maintenance), state natural resource agencies, USFWS, USACE, NOAA, universities, non-profits, engineering firms, FHWA Divisions and HQ
- Agenda: site visit, intros, breakout sessions (defining success, policy opportunities, planning process, selection of nature-based approaches, design and monitoring)

Photo Credits: FHWA





Themes so Far

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- Opportunity to meet multiple goals
 - Protect road
 - Protect surrounding community
 - Mitigation required under NEPA
 - Fits well with Eco-Logical approach
 - Habitat creation
- DOTs want data on costs and benefits of nature-based solutions in relation to traditional projects
- DOTs have right-of –way in coastal areas, offering potential for nature-based solutions, though when more space required, need to partner with other landholders.
- Need to work on multiple geographic and time scales
- Proactive approaches involve protecting natural system (e.g. protect marsh with oyster reef before you have to use sheetpile and riprap to protect road).
- Need information on maintenance





Photo credits: Tina Hodges

Implementation Guide

Draft Outline

- 1. Introduction
- 2. Planning & Funding
 - Integrating transportation, coastal, and ecosystem plans
 - Look for mitigation opportunities
 - Estimating costs and benefits
- 3. Selecting a Nature-based Solution
 - Site characterization
 - Problem characterization
- 4. Tools for Design
 - Performance information
 - Resilience to climate change
- 5. Permitting
- 6. Construction
- 7. Monitoring & Maintenance
- 8. Adaptive Management

Appendices

- A. Examples of nature-based solutions
- B. Technical Fact Sheets on Naturebased solutions
- C. Site Characterization Questionnaire
- D. Evaluation Matrix
- > To be completed July 2019.
- Info will be incorporated into update of HEC-25



Photo Credit: Suzanne Kaspar, Mobjack Bay, VA

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In Search Engine: "FHWA green infrastructure"