Nature-based Resilience for Coastal Highways

Tina Hodges
Environmental Protection Specialist
Federal Highway Administration
Tina.Hodges@dot.gov, 202-366-4287

International Conference on Coastal Engineering
July 29, 2018
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 eligible for FHWA funding

FHWA requires climate risk / resilience to be included in:

- Asset management plans (23 CFR 515)
- Transportation plans (23 USC 134, 23 CFR 450)
- Emergency relief (23 CFR 667)
- FHWA programs and policies (Order 5520)

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

Research

Gulf Coast 2 Study
Resilience Pilots with State DOTS & MPOs
Hurricane Sandy Project
Engineering Assessments Study

Resources

Vulnerability & Adaptation Framework
Engineering Guidance (HEC-25 & 17)
Project Development
Operations & Maintenance
Guidebooks under development on integrating resilience in:
- Asset Management
- Transportation Planning
- Nature-based solutions
Gap: How can transportation agencies use nature-based solutions as part of resilience strategies

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
FHWA Project: Nature-based Resilience for Coastal Highways

- 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

Oregon DOT Pilot

- 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

Cobble Beach, Credit: ODOT
Mechanically Stabilized Earth (MSE), Credit: ODOT
Sand Tube, Credit: Geo Synthetics
<table>
<thead>
<tr>
<th></th>
<th>Beverly Beach</th>
<th>Lost Creek</th>
<th>Ona Beach</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Photo credits:</strong></td>
<td>ODOT</td>
<td></td>
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<tr>
<td><strong>Conceptual Design</strong></td>
<td>Cobble beach covering large rock riprap keyed in at toe with piles, MSE slope with planted terraces</td>
<td>Cobble beach, artificial dune, replace culvert</td>
<td>Cobble beach, MSE slopes, sand tube core</td>
</tr>
<tr>
<td><strong>Total Cost</strong></td>
<td>$41 million</td>
<td>$2.8 million</td>
<td>$5.9 million</td>
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<td><strong>Cost per linear foot</strong></td>
<td>$19,500</td>
<td>$4,700</td>
<td>$5,000</td>
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<tr>
<td><strong>Protection</strong></td>
<td>Insufficient. Would need to increase materials, footprint, and cost.</td>
<td>Slight increase in elevation required</td>
<td>Sufficient</td>
</tr>
<tr>
<td><strong>Exception required?</strong></td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Maine & New Hampshire DOTs

- 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

Slide Credit: Bret Webb, University of South Alabama
USACE – New Jersey Pilot

• 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
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

- 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

- **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

- 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 Nature-based 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
Thank You!

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FHWA Nature-based Resilience for Coastal Highways Website:

In Search Engine: “FHWA green infrastructure”