Engineering with Nature for Coastal Resilience

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New York State Great Lakes
Nature-Based Shorelines Workshop

November 5, 2015
Coastal Resilience is Serious Business: Lives are at Stake

Galveston Hurricane (1900)
- Landfall 8 September 1900
- Estimated Category 4 Hurricane
  - 145 mph winds
- Estimated death toll: 6,000-12,000
- Galveston Seawall
  - Constructed: 1902-1963
  - >10 miles long
Coastal Resilience is Serious Business: Lives are at Stake

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Nature-Based Features Perform During Hurricane Sandy (2012)

The North Atlantic Coast Comprehensive Study

Coastal Risk Reduction and Resilience: Using the Full Array of Measures

US Army Corps of Engineers, Directorate of Civil Works

September 2013

North Atlantic Coast Comprehensive Study: Resilient Adaptation to Increasing Risk

MAIN REPORT
Final Report
January 2015

Use of Natural and Nature-Based Features (NNBF) for Coastal Resilience

Final Report
January 2015
### Natural and Nature-Based Infrastructure at a Glance

**General Coastal Risk Reduction Performance Factors:**
- Storm intensity, track, and forward speed, and surrounding local bathymetry and topography

<table>
<thead>
<tr>
<th>Natural Feature</th>
<th>Benefits/Processes</th>
<th>Performance Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dunes and Beaches</strong></td>
<td>Break offshore waves, attenuate wave energy, slow inland water transfer</td>
<td>Berm height and width, beach slope, sediment grain size and supply, dune height, crest, width, presence of vegetation</td>
</tr>
<tr>
<td><strong>Vegetated Features:</strong> Salt Marshes, Wetlands, Submerged Aquatic Vegetation (SAV)**</td>
<td>Break offshore waves, attenuate wave energy, slow inland water transfer</td>
<td>Increase infiltration, marsh, wetland, or SAV elevation and continuity, vegetation type and density</td>
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<tr>
<td><strong>Oyster and Coral Reefs</strong></td>
<td>Break offshore waves, attenuate wave energy, slow inland water transfer</td>
<td>Reef width, elevation and roughness</td>
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<tr>
<td><strong>Barrier Islands</strong></td>
<td>Wave attenuation and/or dissipation, sediment stabilization</td>
<td>Island elevation, length, and width, land cover, breach susceptibility, proximity to mainland shore</td>
</tr>
<tr>
<td><strong>Maritime Forests/Shrub Communities</strong></td>
<td>Wave attenuation and/or dissipation, shoreline erosion stabilization, soil retention</td>
<td>Vegetation height and density, forest dimension, sediment composition, platform elevation</td>
</tr>
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</table>
A Systems Approach: Coastal Risk Reduction and Resilience

“The USACE planning approach supports an integrated approach to reducing coastal risks and increasing human and ecosystem community resilience through a combination of natural, nature-based, non-structural and structural measures. This approach considers the engineering attributes of the component features and the dependencies and interactions among these features over both the short- and long-term. It also considers the full range of environmental and social benefits produced by the component features.”

Resilience: the ability of a system to *Prepare for*, *Resist*, *Recover*, and *Adapt* to achieve functional performance under the stress of disturbances through time.
In the Context of Coastal Resilience…

- What opportunities are there for achieving better alignment of natural and engineered systems?
  - Can improved alignment reduce risks to life and property?
  - What range of services can be produced through such alignment?
  - What are the science and engineering needs in order to achieve better alignment?

Sustainable Solutions Vision: “Contribute to the strength of the Nation through innovative and environmentally sustainable solutions to the Nation’s water resources challenges.”
Natural and Nature-Based Features Evaluation and Implementation Framework

1. Identify and Organize Stakeholders, Partners, and Authorities
2. Define Physical and Geomorphic Setting
3. Assess Vulnerability and Resilience
4. Identify NNBF Opportunities
   - Formulate NNBF Objectives
   - Identify NNBF Alternatives
   - Define NNBF Performance Metrics
5. Evaluate NNBF Alternatives
   - Tier 1
   - Tier 2
   - Tier 3
   - Advance through Tiers as Appropriate
6. Select NNBF Alternatives
7. Design Implementation Plan: Elaborate Operational and Engineering Practices
8. Implement NNBF Alternative
9. Monitor for Performance and Assess Ecosystem Goods and Services

Feedback
1 A 1-1. Drowned River Valley
Examples: Chesapeake and Delaware Bays

NOT TO SCALE

II B 1. Marine Depositional Barrier Coast
Examples: Virginia coast

NOT TO SCALE
System Performance Evaluation

- **Level 1** – Qualitative characterization of performance
- **Level 2** – Semi-quantitative characterization of performance
- **Level 3** – Quantitative characterization of performance

72 individual performance metrics identified for NNBF
D2M2: Dredged Material Management Decisions
Engineering With Nature…

…the intentional alignment of natural and engineering processes to efficiently and sustainably deliver economic, environmental and social benefits through collaborative processes.

Key Elements:
- Science and engineering that produces operational efficiencies
- Using natural process to maximum benefit
- Broaden and extend the benefits provided by projects
- Science-based collaborative processes to organize and focus interests, stakeholders, and partners
EWN Across USACE Mission Space

- **Navigation**
  - Strategic placement of dredged material supporting habitat development
  - Habitat integrated into structures

- **Flood Risk Management**
  - Natural and Nature-Based Features to support coastal resilience
  - Levee setbacks

- **Ecosystem Restoration**
  - Ecosystem services supporting engineering function
  - “Natural” development of designed features

- **Water Operations**
  - Shoreline stabilization using native plants
  - Environmental flows
EWN Status

- *Engineering With Nature* initiative started within USACE Civil Works program in 2010. Over that period we have:
  - Engaged across USACE Districts (23), Divisions, HQ; other agencies, NGOs, academia, private sector, international collaborators
    - Workshops (>20), dialogue sessions, project development teams, etc.
  - Implementing strategic plan
  - Focused research projects on EWN
  - Field demonstration projects
  - Communication plan
  - District EWN Proving Grounds established
  - Awards
    - 2013 Chief of Engineers Environmental Award in Natural Resources Conservation
    - 2014 USACE National Award-Green Innovation

www.engineeringwithnature.org
Opportunities to Engineer With Nature

- **Key Factors, the 4 Ps**
  - **Processes**
    - Physics, geology, biology…
    - Foundation of “coastal engineering Jujitsu”
  - **Programmatic context**
    - Planning, engineering, constructing, operating, or regulating
  - **Project scale**
    - Individual property owner to an entire coastal system
  - **Performance**
    - Configuring the system
    - Quantifying the benefits
Strategic Sediment Placement: Nearshore Berms

Small Dispersive Placements

Shark River Inlet (NAN)

Huntington Beach (SANDAG)

Assateague Island, MD (NAB)
Dutch Sand Engine

- 2011 construction
- 21.5 mcm of sand
Horseshoe Bend, Atchafalaya River

- Options for managing dredged material via shore-based wetland creation were exhausted
- Strategic placement of sediment (0.5-1.8 mcy/1-3 yrs) was used to create a ~35 ha island
- Producing significant environmental and engineering benefits
- Project won WEDA’s 2015 Award for Environmental Excellence
Example EWN Solutions: Green Breakwaters

Ashtabula Harbor

Milwaukee Harbor
Deepening of Boston Harbor

- Project anticipates generating 10+ MCY of clay/till and 0.5 to 1 MCY of rock
- Evaluating potential beneficial use:
  - Capping of offshore radioactive waste disposal site
  - Nearshore placement of rock to create reefs and berms to attenuate waves and support habitat development
Beaches Provide Critical Habitat

- Many rare and/or endangered species depend on beaches for foraging and breeding

- Example:
  - 685 miles of SE Atlantic and Gulf beaches designated as critical habitat for loggerhead sea turtles

- A current need: defining engineering approaches that integrate shoreline protection and habitat requirements
Coastal Dunes
Alafia Banks Bird Sanctuary, FL

- 8000 lb reef module breakwaters (930 ft)
- Shore protection for Audubon bird sanctuary islands
- Help restore oyster populations
- Provide habitat

www.reefball.org
USACE Galveston and Buffalo Districts: EWN “Proving Grounds”

- EWN Proving Ground Kick-Off Workshops
  - October (SWG) and December (LRB) 2014
  - ~70 participants
  - SWG, SWD, LRB, ERDC, IWR and HQ

- Identified opportunities to implement EWN within current and future programs and projects

- Emphasis on solution co-development
Coastal NJ, Philadelphia District

December 2014

Stone Harbor

Avalon
US Fish and Wildlife Service
Forsythe National Wildlife Refuge

- Forsythe NWR: >40,000 acres of wetlands and other habitat in coastal NJ
- Collaboration objective: Enhance ecosystem resilience through engineering and restoration
- Means: Smart use of sediment resources and EWN principles and practices
Thin-Layer Placement Website

Coming soon to www.engineeringwithnature.org
EWN Action Demonstration Projects, 1

- Sediment Retention Engineering to Facilitate Wetland Development (San Francisco Bay, CA)
- Atchafalaya River Island and Wetlands Creation Through Strategic Sediment Placement (Morgan City, LA)
- Portfolio Framework to Quantify Beneficial Use of Dredged Material (New Orleans and New England)
- Engineering Tern Habitat into the Ashtabula Breakwater (Ashtabula, OH)
- Living Shoreline Creation Through Beneficial Use of Dredged Material (Duluth, MN)
- A Sustainable Design Manual for Engineering With Nature Using Native Plant Communities
EWN Action Demonstration Projects, 2

- Landscape Evolution of the Oil Spill Mitigation Sand Berm in the Chandeleur Islands, Louisiana
- Guidelines for Planning, Design, Placement and Maintenance of Large Wood in Rivers: Restoring Process and Function (Collaboration with BoR)
- The Use and Value of Levee Setbacks in Support of Flood Risk Management, Navigation and Environmental Services (a strategy document)
- Strategic Placement of Sediment for Engineering and Environmental Benefit (an initial guide to opportunities and practices)
- Use of Activated Carbon to Manage Contaminant Exposures Associated with Open-Water Placement
Next Steps for Science and Engineering…

- How will integrated infrastructure systems evolve over time in dynamic coastal environments?
- What processes and engineering requirements are critical to performance?
- How can integrated systems be assembled to reduce long-term operations and maintenance?
- How can field-scale demonstration projects be used to accelerate progress?

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High Points

- Develop a coherent vision!
  - And stories to make it tangible
- Focus energy to facilitate innovation in both technical and business processes
- Elevate communication about advancing practice
-Accelerate progress through co-development of solutions
  - Across government
  - Between government and industry
  - Among government, industry, academia, and NGOs