Engineering With Nature to Create Project Value

Dr. Todd S. Bridges
Senior Research Scientist, Environmental Science
U.S. Army Engineer Research and Development Center,
U.S. Army Corps of Engineers
todd.s.bridges@usace.army.mil

Planning CoP Webinar

October 15, 2015

U.S. ARMY

US Army Corps of Engineers

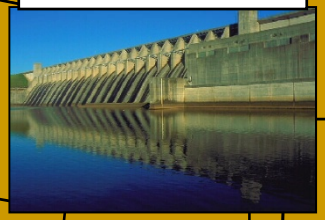
ERDC
Engineer Research and Development Center

USACE Water Resources Infrastructure

Recreation areas:
370 M Visitors/yr
Generate $16B in economic activity, 270,000 jobs

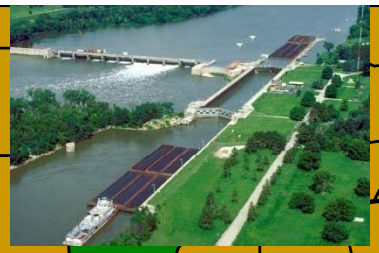
#1 Federal Provider
Of Outdoor Recreation
54,879 Miles Of Shoreline
at USACE Lakes

¼ of Nation's Hydropower:
$1.5B + in power sales



Stewardship of
12 Million Acres
Public Lands

12,000 miles of Commercial Inland Waterways transport goods at
½ the cost of rail or
1/10 the cost of trucks



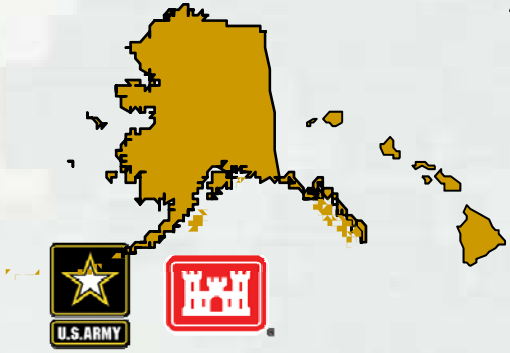
926 Shallow & Deep Draft Harbors

~14,500 Miles of Levees

Emergency Operations

Regulatory Responsibilities

137 Major Environmental Restoration Projects

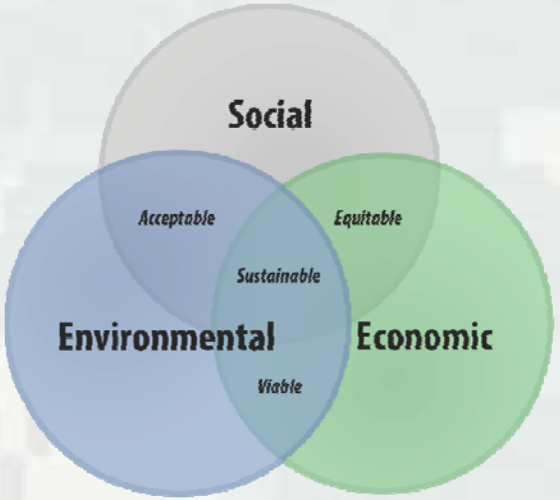


Engineering With Nature…

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

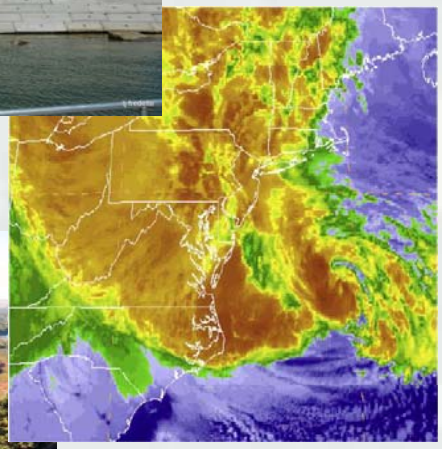
Key Elements:

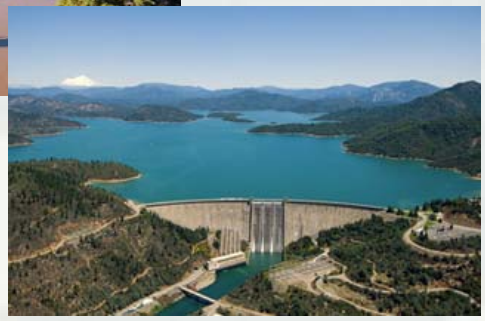
- Science and engineering that produces operational efficiencies
- Using natural process to maximum benefit
- Broaden and extend the benefits provided by projects
- Science-based collaborative processes to organize and focus interests, stakeholders, and partners



EWN Across USACE Mission Space

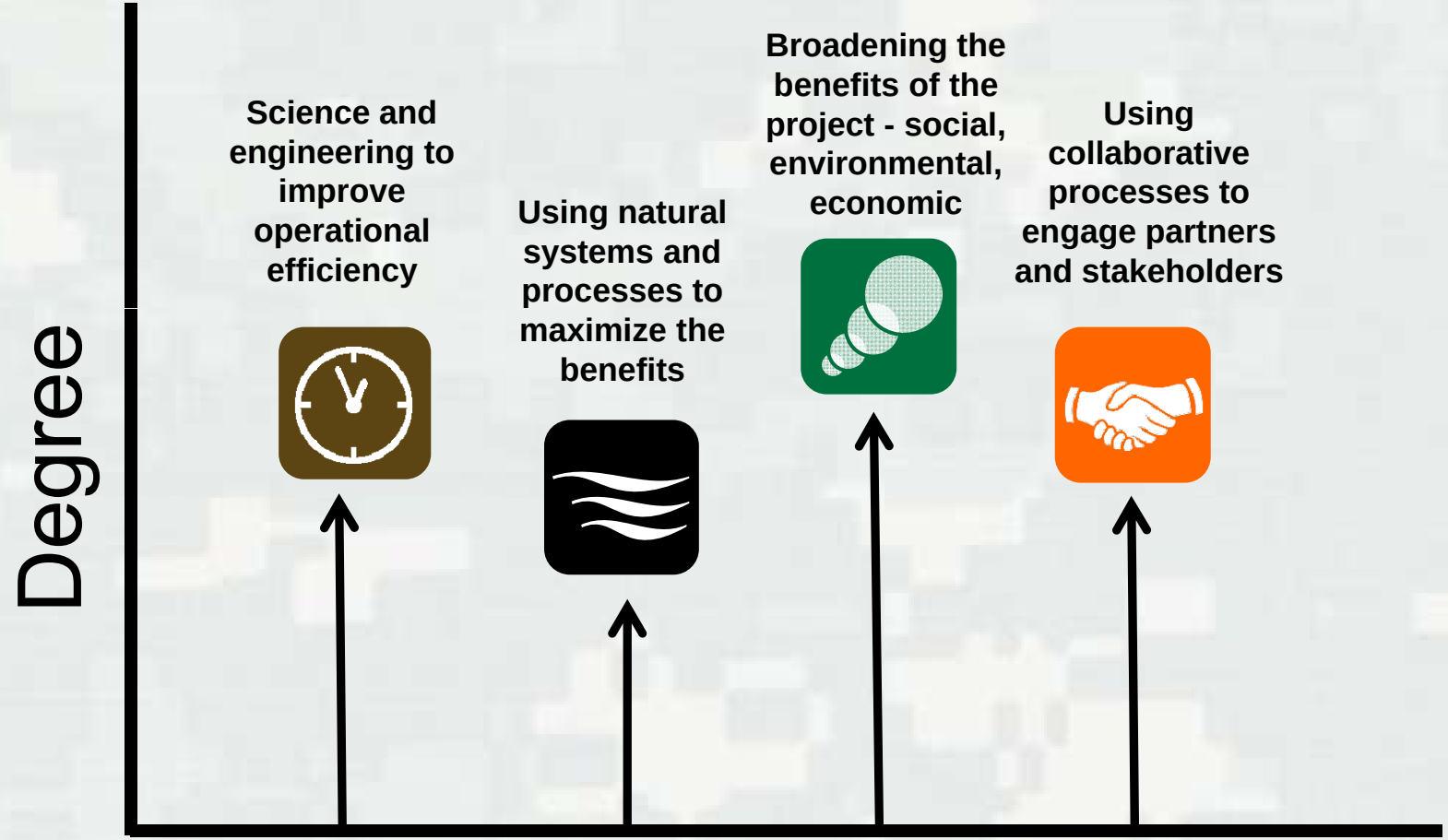
- Navigation
  - Strategic placement of dredged material supporting habitat development
  - Habitat integrated into structures
- Flood Risk Management
  - Natural and Nature-Based Features to support coastal resilience
  - Levee setbacks
- Ecosystem Restoration
  - Ecosystem services supporting engineering function
  - “Natural” development of designed features
- Water Operations
  - Shoreline stabilization using native plants
  - Environmental flows





ERDC

Engineering With Nature
Elements



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

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

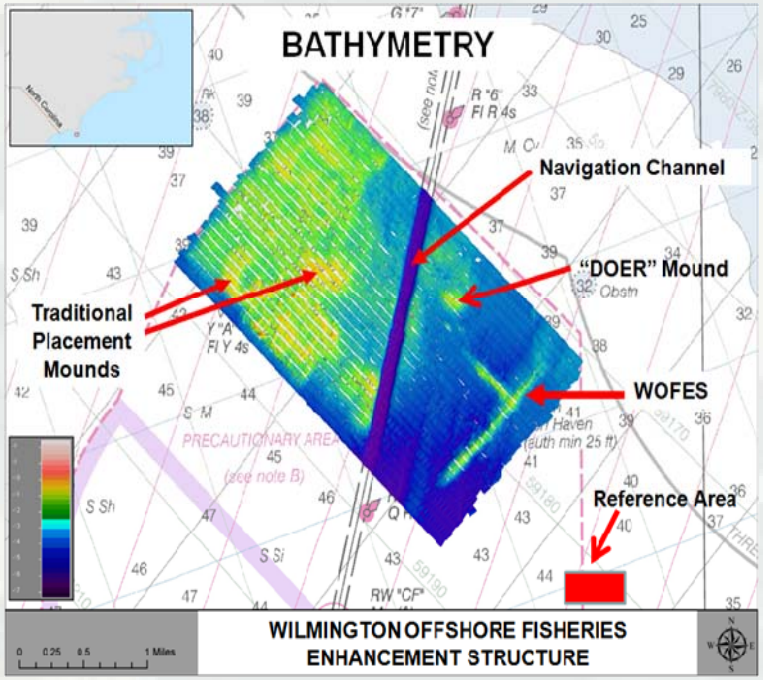
US Army Corps of Engineers
Buffalo District
BUILDING STRONG®

Evia Island, Galveston Bay, TX

- 6-acre island was constructed using sediment dredged during the deepening of the Houston Ship Channel in 1998
- Island provides substantial bird and other habitat
- Producing significant environmental benefits

WOFES, Wilmington, NC

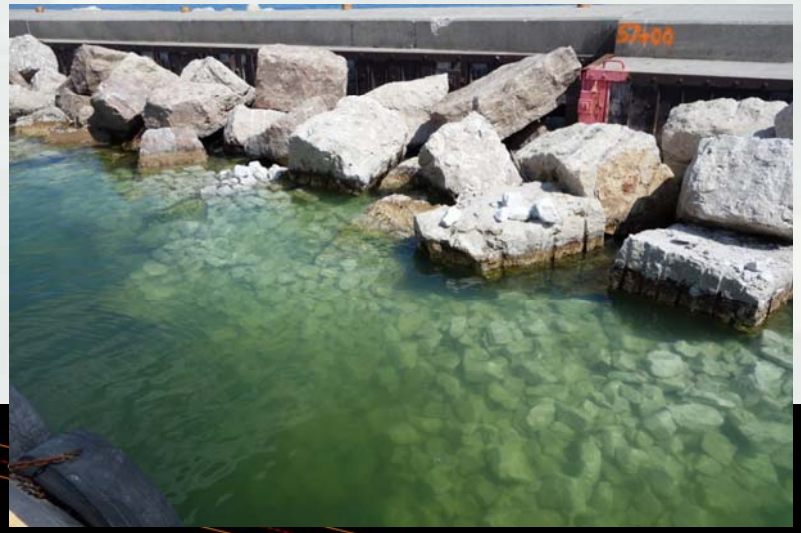
- Created in 1994-1997 from 764,600 cubic meters of limestone dredged as part of the Wilmington channel deepening
- Located three nautical miles off of the mouth of the Cape Fear River in North Carolina
- The location and design of the reef involved extensive participation by stakeholders, and the North Carolina Department of Environment and Natural Resources supported the project as a local sponsor.
- Produced significant social benefits as a popular destination for fishing

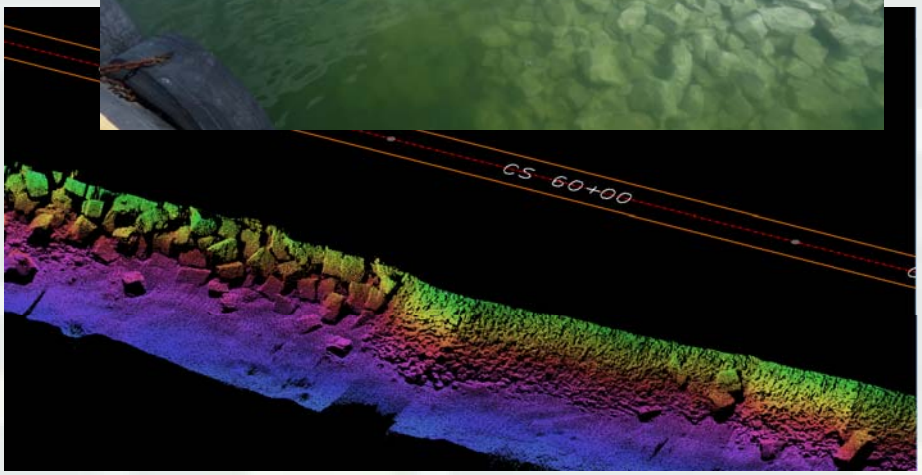


Example EWN Solutions: Green Breakwaters

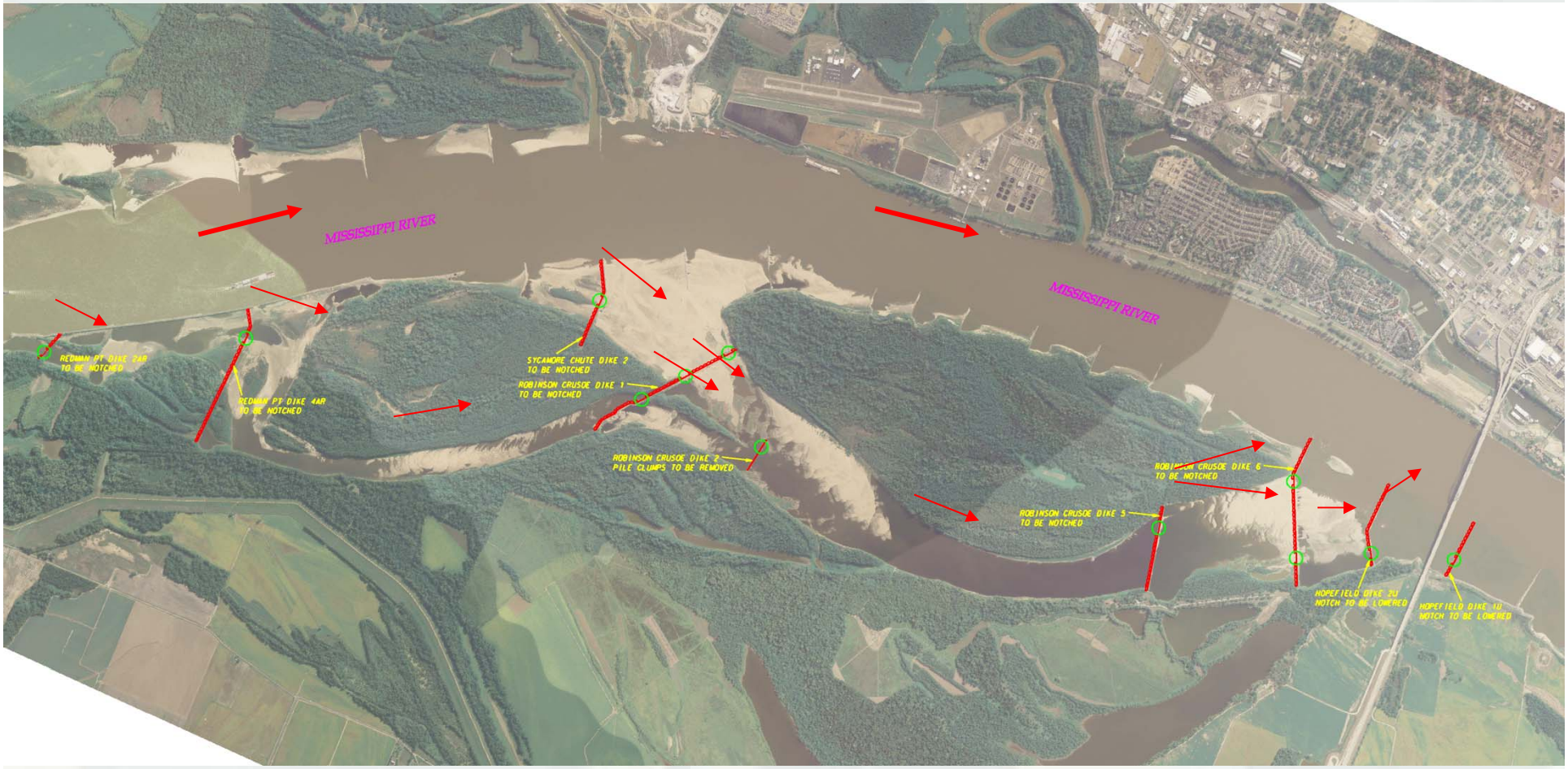
Ashtabula Harbor

Milwaukee Harbor





Example EWN Solutions



Loosahatchie Bar

Strategic Sediment Placement: Nearshore Berms

Small Dispersive Placements

Shark River Inlet (NAN)

Huntington Beach (SANDAG)

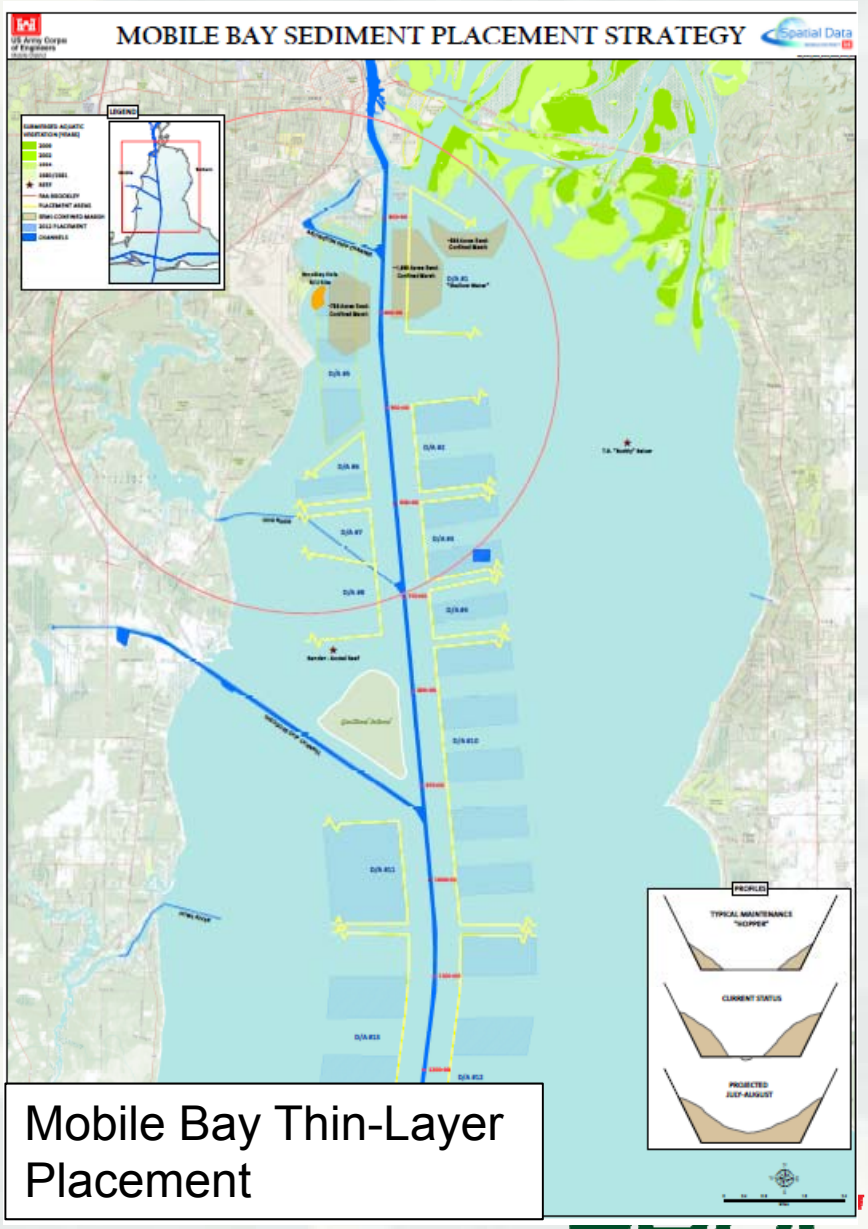
Assateague Island, MD (NAB)

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

Strategic Sediment Placement in Mobile Bay

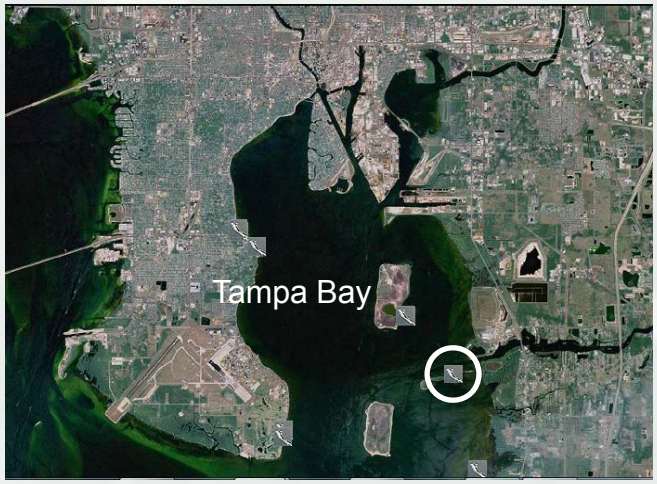
- 25 years ago, in-bay disposal of dredged material was banned
  - Shoreline erosion and loss of habitat followed
- Thin-layer placement was demonstrated on full-scale to restore sediment processes
- Many opportunities for in-water beneficial use
- Ecosystem benefits being documented



Mobile Bay Thin-Layer Placement

Alafia Banks Bird Sanctuary, FL

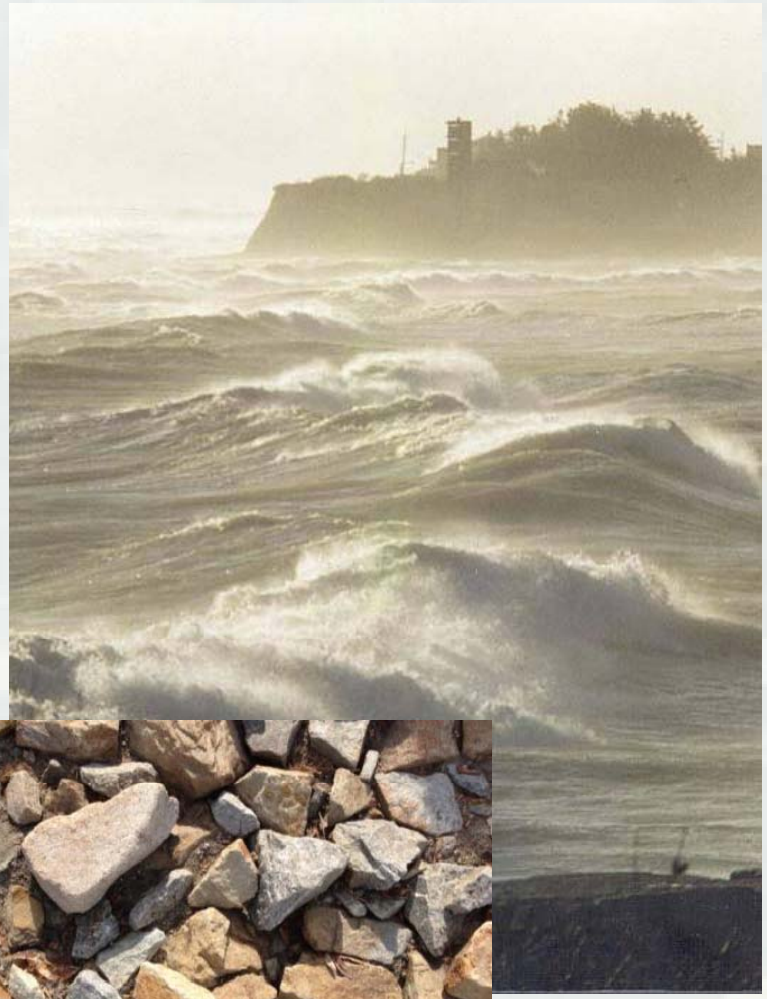
- 8000 lb reef module breakwaters (930 ft)
- Shore protection for Audubon bird sanctuary islands
- Help restore oyster populations
- Provide habitat



Example: www.reefball.org

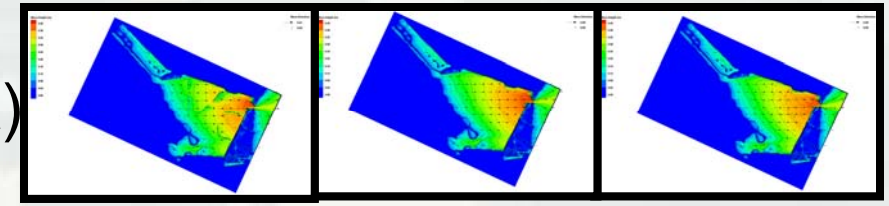
Deepening of Boston Harbor

- 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



Hamilton Wetland, San Pablo Bay

- Beneficial use of dredged material to restore army air field to wetlands
- ERDC monitoring to quantify waves, other physical processes and accretion
- ERDC modeling wave generation and dissipation, testing different shapes for barriers to fetch
- Approach being replicated for Sonoma Baylands (Sears Point)
  - Collaboration with Sonoma Land Trust



Linear Berms (As-Built) | No Berms (Control) | Mounds (ala Sears Pt.)

Coastal NJ, Philadelphia District

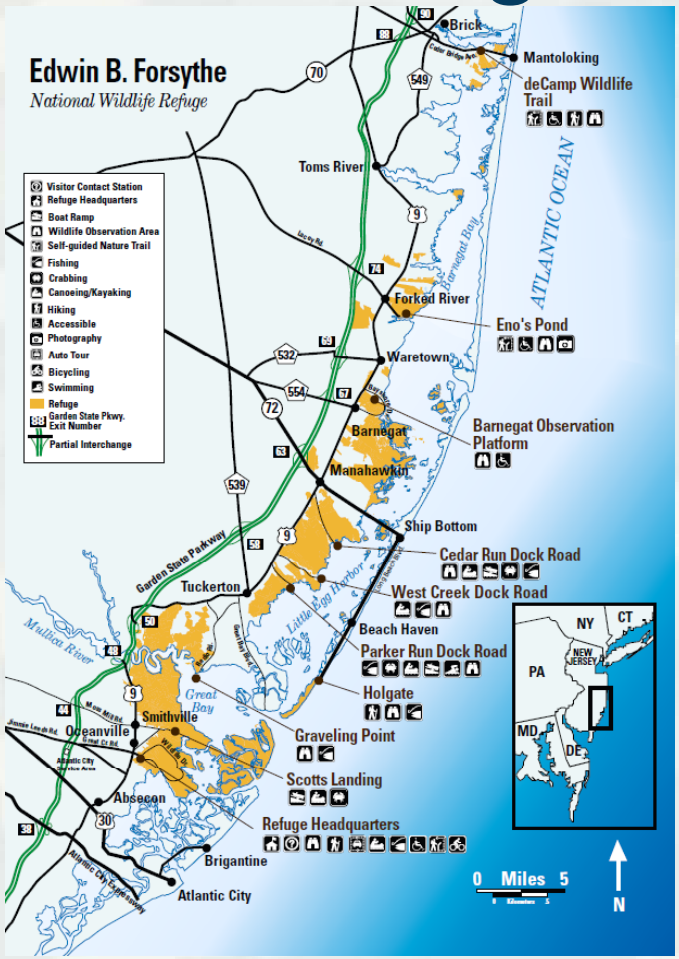
December 2014

Stone Harbor

Avalon

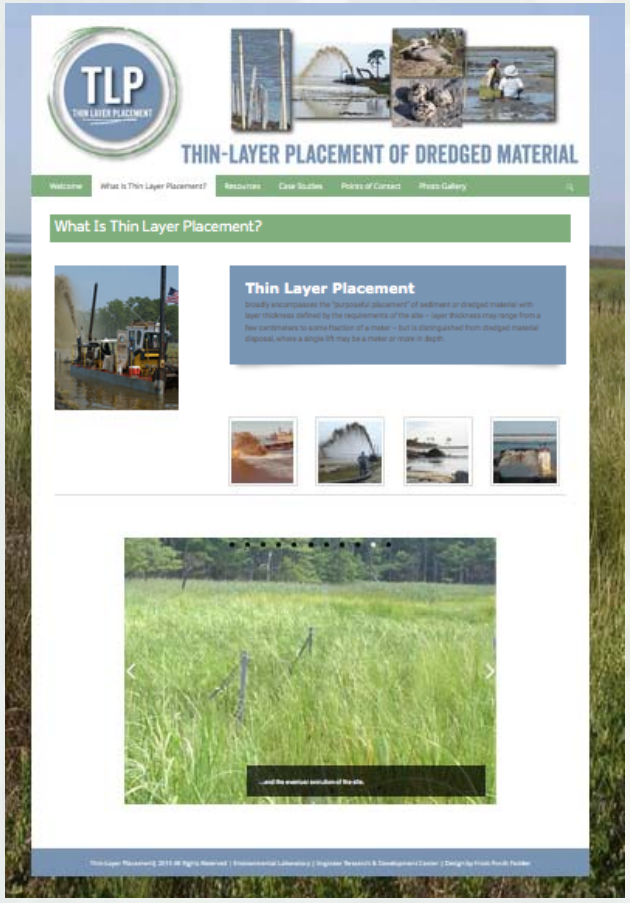
US Fish and Wildlife Service
Forsythe National Wildlife Refuge

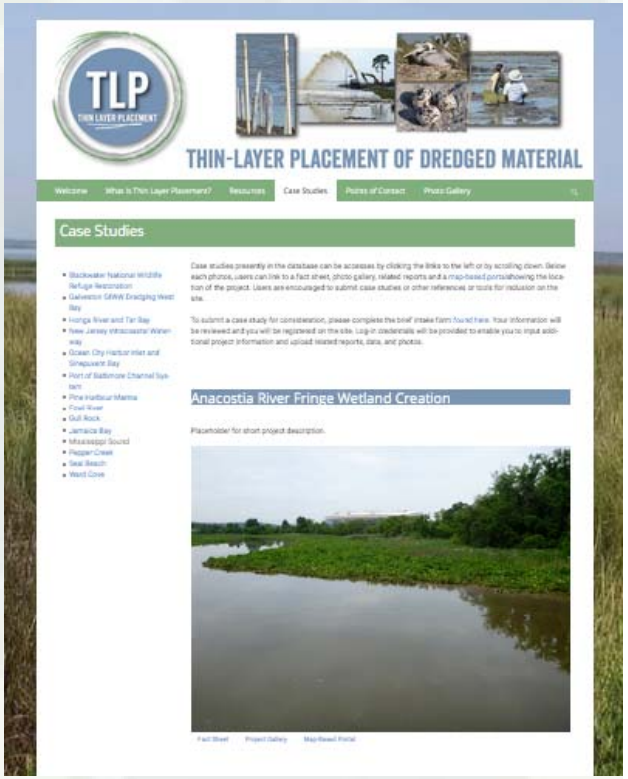
- Forsythe NWR: >40,000 acres of wetlands and other habitat in coastal NJ
- Collaboration objective: Enhance ecosystem resilience through engineering and restoration
- Means: Smart use of sediment resources and EWN principles and practices



Thin-Layer Placement Website

Coming soon to www.engineeringwithnature.org



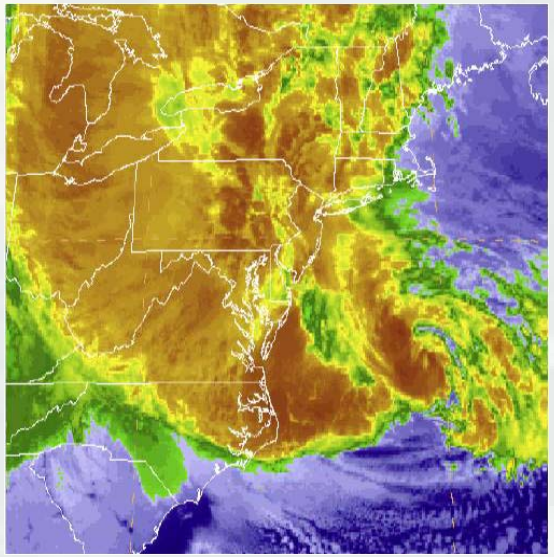


ERDC

Hurricane Sandy

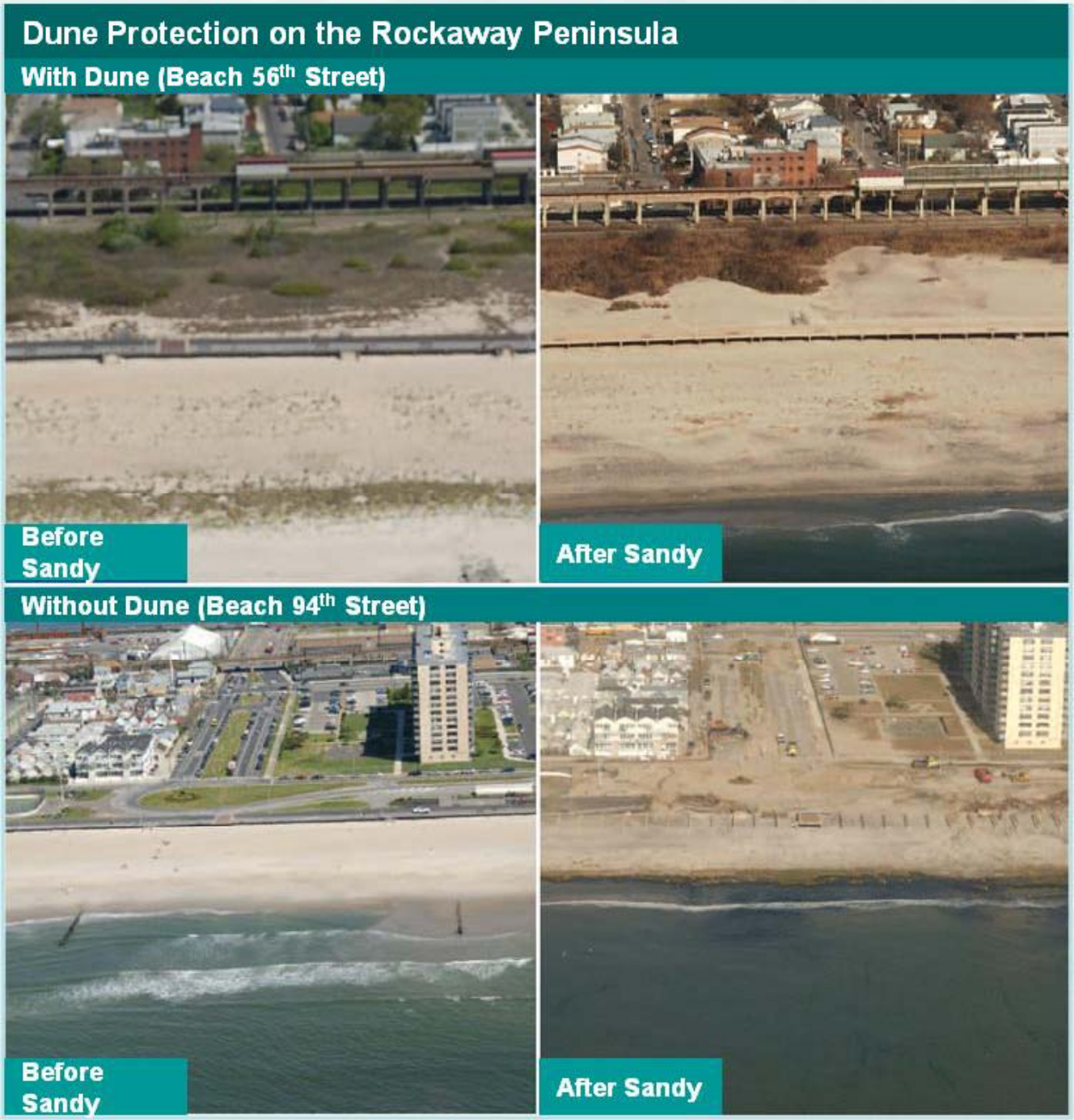
Storm Impacts and Damages: 22-29 October 2012

- **Human**
  - 286 people killed (159 in the US)
  - 500,000 people affected by mandatory evacuations
  - 20,000 people required temporary shelter
  - Extensive community dislocations – continuing today in some areas
- **Economic**
  - $65B in damages in the U.S.
  - 26 states affected (10 states and D.C are in the NACCS study area)
  - 650,000 houses damaged or destroyed



Rockaway Peninsula

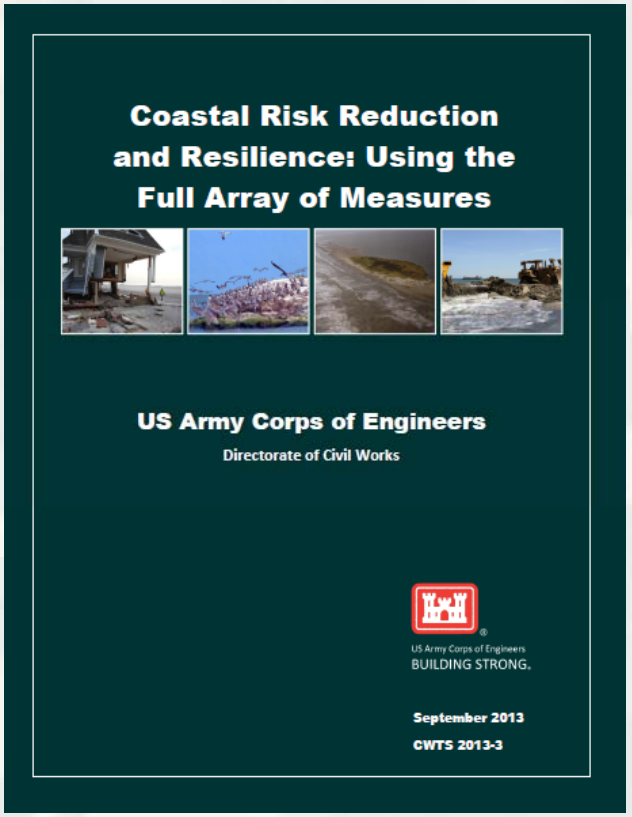
Before & After Sandy



http://www.nyc.gov/html/sirr/html/report/report.shtml

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."*



http://www.corpsclimate.us/docs/USACE_Coastal_Risk_Reduction_final_CWTS_2013-3.pdf

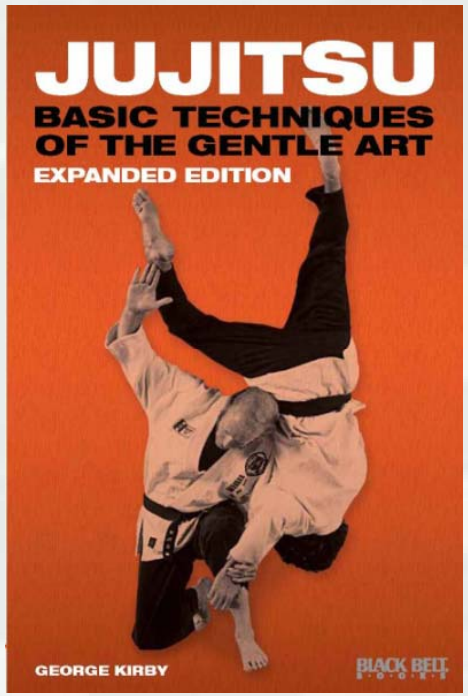
In the Context of Coastal Resilience…

- 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."

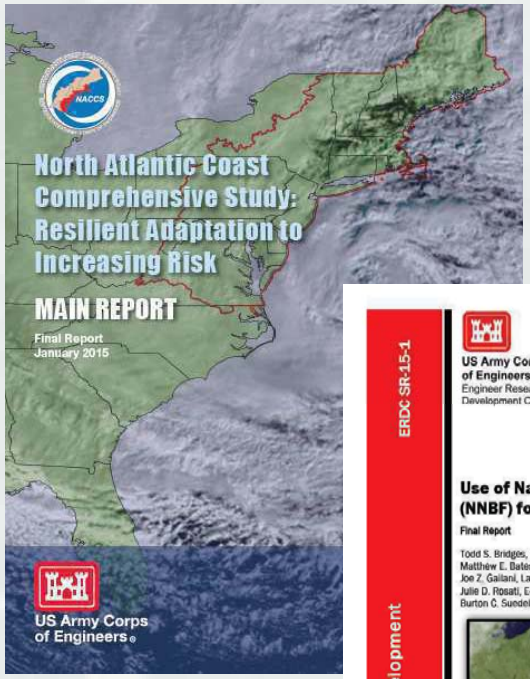
Opportunities to *Engineer With Nature*

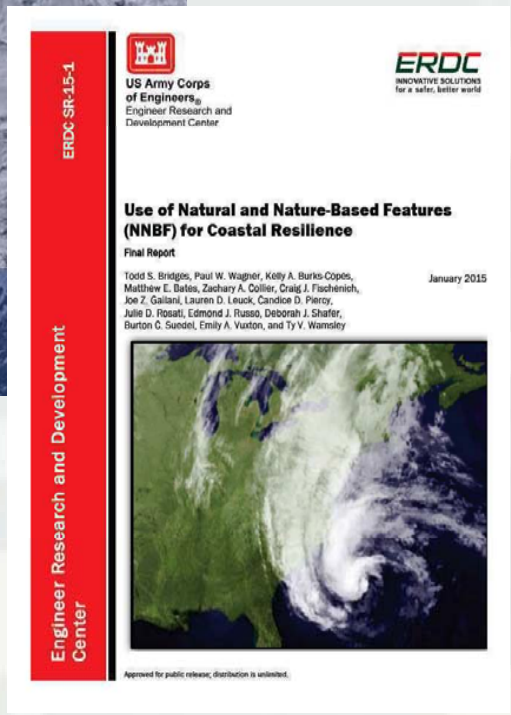
- **Key Factors, the 4 Ps**
  - ► Processes
    - Physics, geology, biology…
    - Foundation of “coastal engineering Jujitsu”
  - ► Programmatic context
    - Planning, engineering, constructing, operating, or regulating
  - ► Project scale
    - Individual property owner to an entire coastal system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

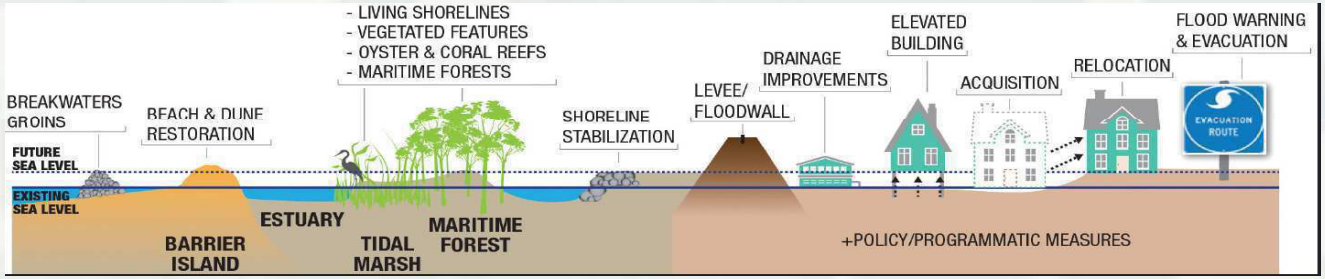


Natural and Nature-Based Features: North Atlantic Coast Comprehensive Study

- Opportunities to integrate Natural and Nature-Based Features (NNBF) with structural and non-structural measures to provide multiple lines of defense against storms and sea level rise, generating a full array of relevant economic, environmental and social ecosystem goods and services.







See Bridges et. al., 2015
http://www.nad.usace.army.mil/CompStudy

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

Dunes and Beaches

Benefits/Processes

Break offshore waves

Attenuate wave energy

Slow inland water transfer

Performance Factors

Berm height and width

Beach Slope

Sediment grain size and supply

Dune height, crest, width

Presence of vegetation

Vegetated Features: Salt Marshes, Wetlands, Submerged Aquatic Vegetation (SAV)

Benefits/Processes

Break offshore waves

Attenuate wave energy

Slow inland water transfer

Increase infiltration

Performance Factors

Marsh, wetland, or SAV elevation and continuity

Vegetation type and density

Oyster and Coral Reefs

Benefits/Processes

Break offshore waves

Attenuate wave energy

Slow inland water transfer

Performance Factors

Reef width, elevation and roughness

Barrier Islands

Benefits/Processes

Wave attenuation and/or dissipation

Sediment stabilization

Performance Factors

Island elevation, length, and width

Land cover

Breach susceptibility

Proximity to mainland shore

Maritime Forests/Shrub Communities

Benefits/Processes

Wave attenuation and/or dissipation

Shoreline erosion stabilization

Soil retention

Performance Factors

Vegetation height and density

Forest dimension

Sediment composition

Platform elevation

Natural and Nature-Based Features Evaluation and Implementation Framework

ORGANIZATIONAL ALIGNMENT

EVALUATION

IMPLEMENTATION

Iterate as Needed

Identify and Organize Stakeholders, Partners and Authorities

Define Physical and Geomorphic Setting

Assess Vulnerability and Resilience

Identify NNBF Opportunities
- Formalize NNBF Objectives
- Identify NNBF Alternatives
- Define NNBF Performance Metrics

Evaluate NNBF Alternatives
- Tier 1
- Tier 2
- Tier 3

Advance through Tiers as Appropriate

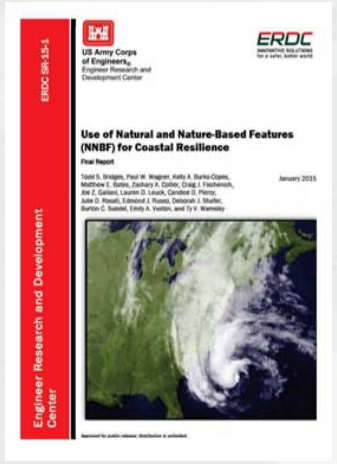
Select NNBF Alternatives

Design Implementation Plan: Elaborate Operational and Engineering Practices

Implement NNBF Alternative

Monitor for Performance and Assess Ecosystem Goods and Services

Feedback




FOREST SERVICE
US
DEPARTMENT OF AGRICULTURE


U.S.
FISH & WILDLIFE
SERVICE
DEPARTMENT OF THE INTERIOR


U.S. DEPARTMENT OF
HOMELAND SECURITY
FEMA


MDE


USGS
science for a changing world


BOEM
Bureau of Ocean Energy Management


UNITED STATES
NAVY


NATIONAL
PARK
SERVICE

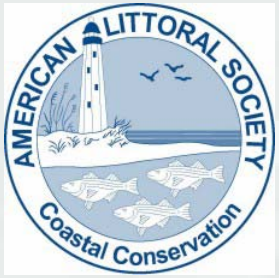

NEW JERSEY
DEPARTMENT OF ENVIRONMENTAL PROTECTION


UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY


The Nature
Conservancy


COMMONWEALTH of MASSACHUSETTS
DIVISION of FISHERIES & WILDLIFE


DELAWARE DIVISION
FISH & WILDLIFE


AMERICAN LITTORAL SOCIETY
Coastal Conservation


NATIONAL
WILDLIFE
FEDERATION


NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE


U.S. DEPARTMENT OF THE INTERIOR
MARCH 3, 1849


ASCE
American Society of Civil Engineers


CHESAPEAKE
BAY TRUST


CONNECTICUT DEPARTMENT
ENVIRONMENTAL PROTECTION


MARYLAND
DEPARTMENT OF
NATURAL RESOURCES

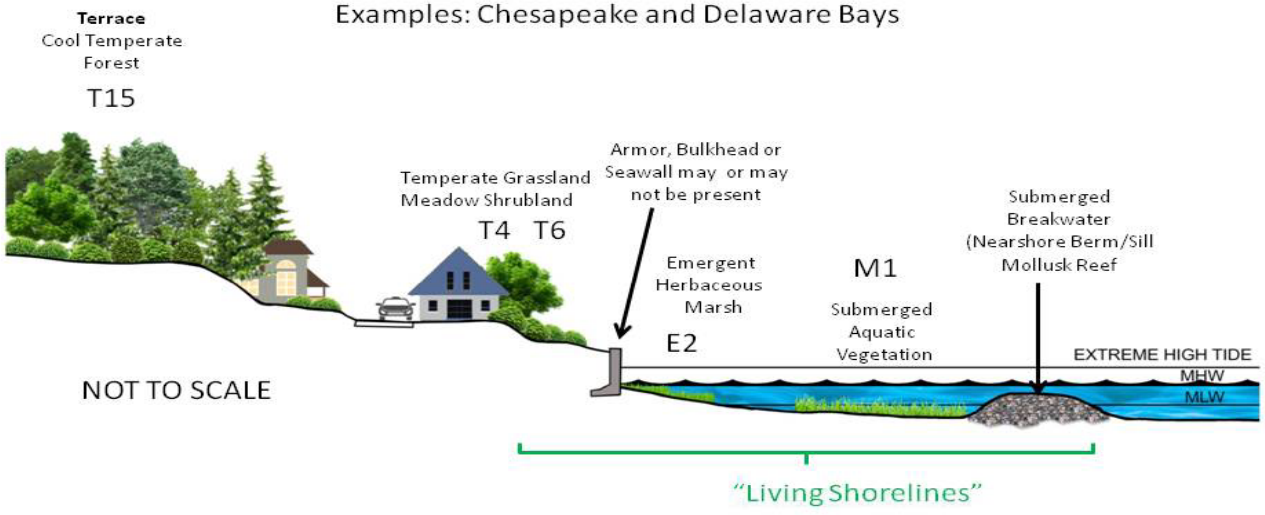

D·E·M


MASSACHUSETTS OFFICE OF
COASTAL ZONE MANAGEMENT


THE PORT AUTHORITY
OF NEW YORK & NEW JERSEY

1 A 1-1. Drowned River Valley

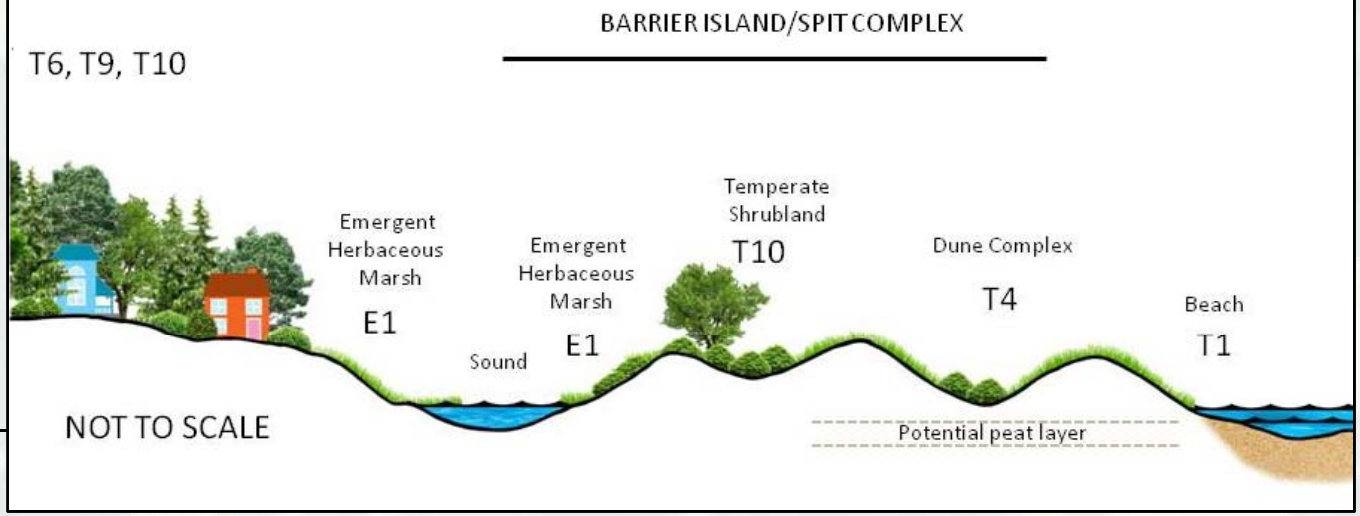
Examples: Chesapeake and Delaware Bays



Substrate: Silt, some sand, peat

II B 1. Marine Depositional Barrier Coast

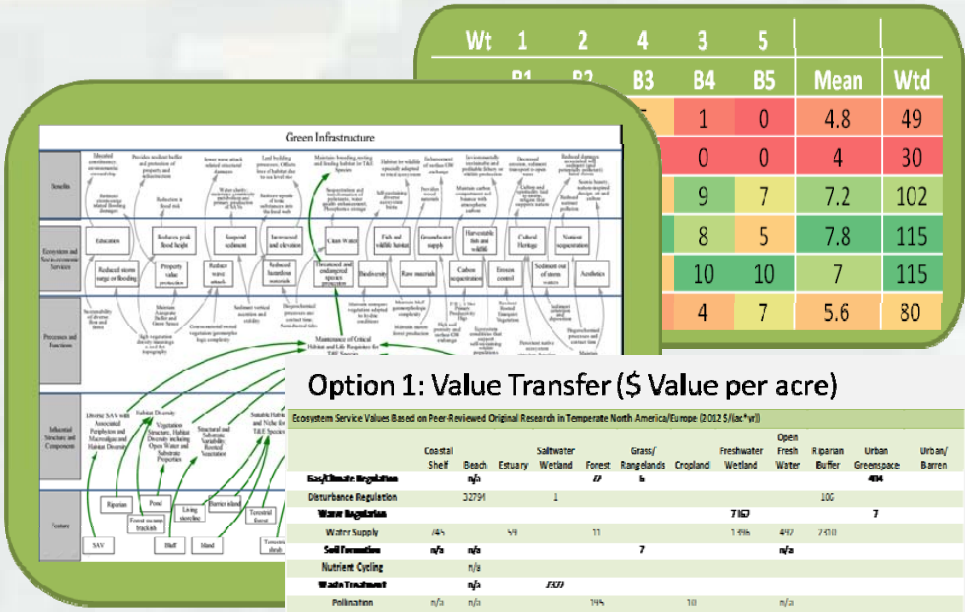
Examples: Virginia coast



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



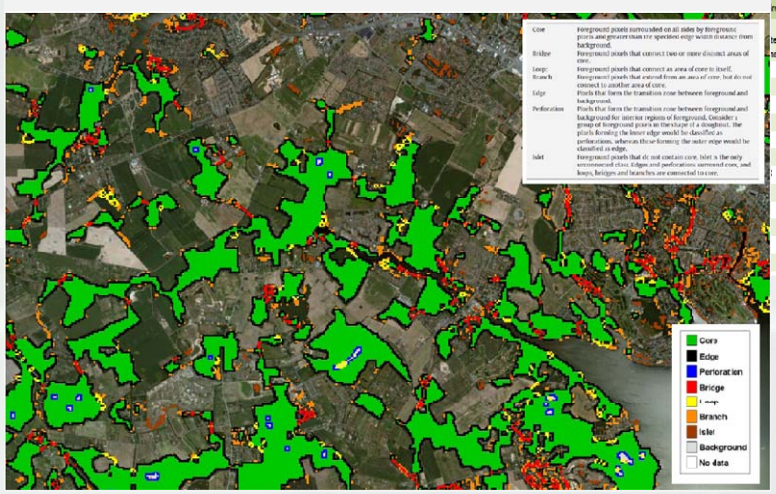
Wt	1	2	4	3	5		
			B3	B4	B5	Mean	Wtd
				1	0	4.8	49
				0	0	4	30
				9	7	7.2	102
				8	5	7.8	115
				10	10	7	115
				4	7	5.6	80

Option 1: Value Transfer ($ Value per acre)

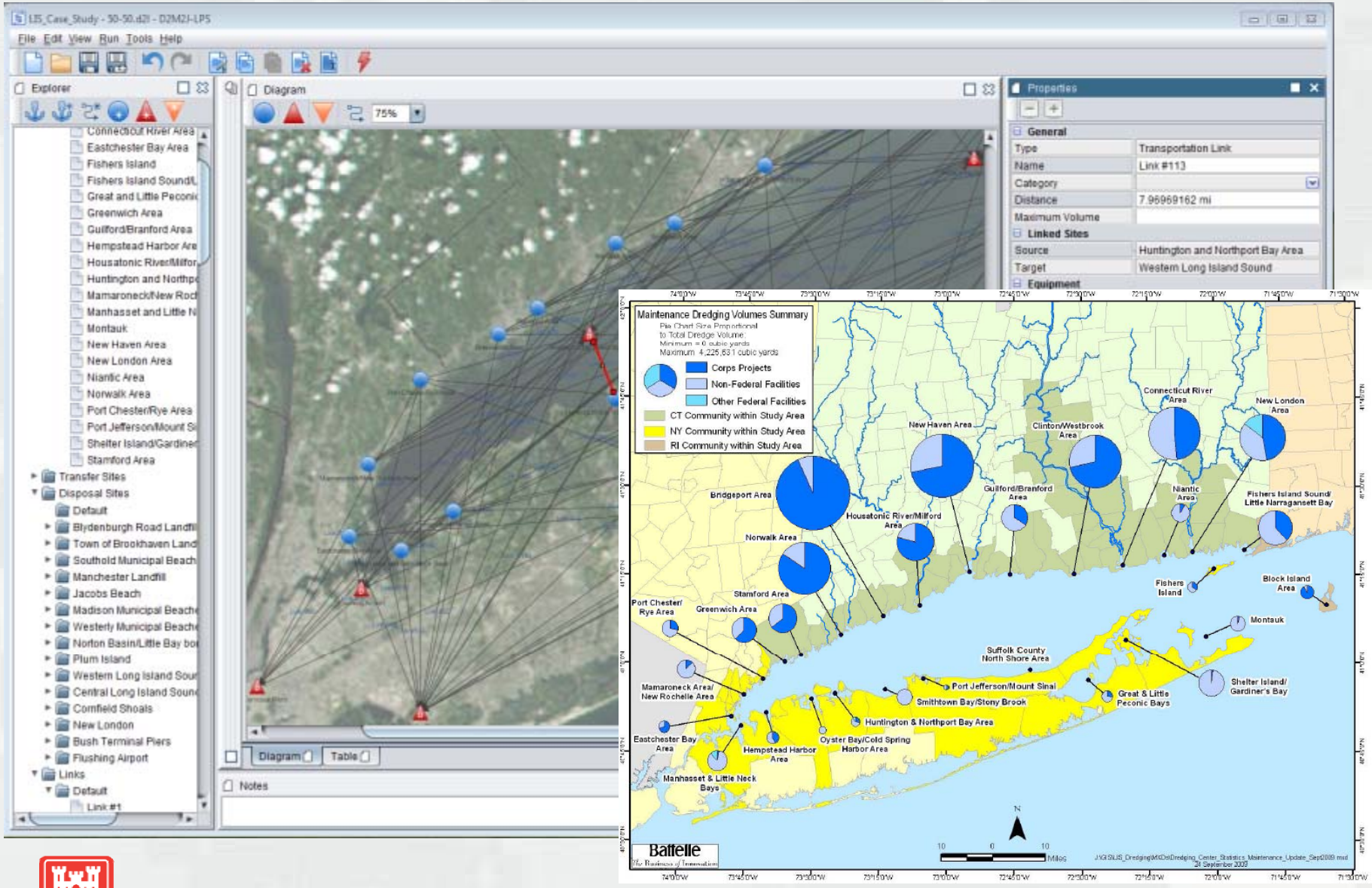
Ecosystem Service Values Based on Peer-Reviewed Original Research in Temperate North America/Europe (2012 $/(ac*yr))

	Coastal Shelf	Beach	Estuary	Saltwater Wetland	Forest	Grass/ Rangelands	Cropland	Freshwater Wetland	Open Fresh Water	Riparian Buffer	Urban Greenspace	Urban/ Barren
Disturbance Regulation		32791		1						100		
Water Regulation								7157			7	
Water Supply												
Soil Formation						7						
Nutrient Cycling												
Waste Treatment												
Pollination												

Option 2: Ecosystem Production Functions



D2M2: Dredged Material Management Decisions



BUILDING STRONG®

Performance Evaluation Case Studies

- **Proof of concept analysis**
  - Quantify benefits of environmental restoration projects using ecosystem goods and services
- **Hurricane Sandy case study**
  - Use extreme event to improve understanding of restoration effectiveness & benefits
- **Focused on two general types of services:**
  - Flood damage Reduction
  - Wildlife Habitat (emphasis on T&E species)
- **3 Study Sites**
  - Jamaica Bay
  - Cape May Meadows
  - Cape Charles South

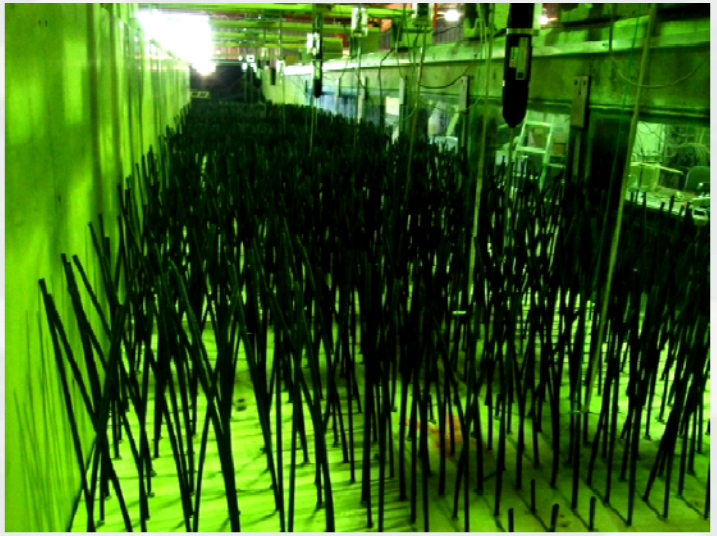
Science, Engineering, Technology Research Targets

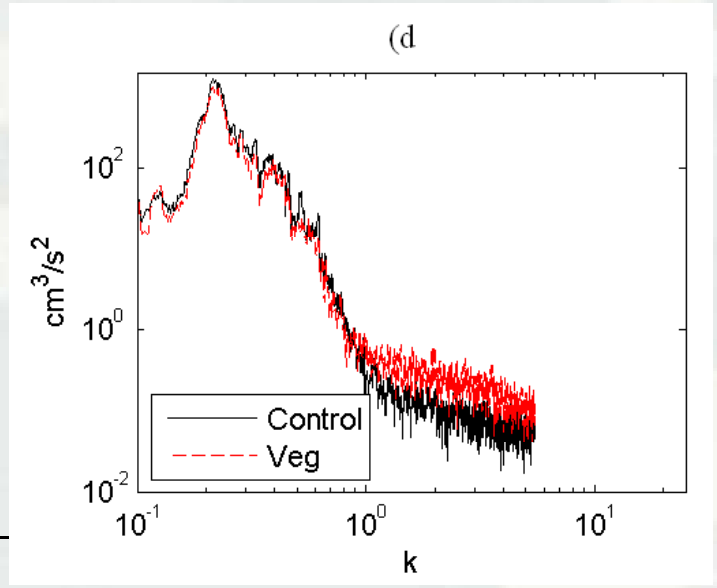
- Fundamental processes
  - Sediment transport through and around NNBF
  - Long-term engineering and environmental performance of features
  - Environmental Services provided by engineered features and structures
  - Processes contributing to system-scale resilience
- Modeling systems that support broad-scale application
  - Planners, stakeholders and decision-makers
  - Engineering design
  - Operations and maintenance
- Reliable, cost-efficient monitoring technologies
  - Measuring system evolution
  - Infrastructure/feature performance
- Demonstration/pilot projects to innovate, evaluate, and learn at relevant field scales
  - Facilitate necessary collaboration
  - Evolve organizational culture and practice
  - Produce credible evidence of success
  - Fuel the “power of the story”

ERDC

R&D Example: Engineering Performance of NNBF

- What are the engineering benefits of wetlands with respect to waves?
- Studies being performed in the 10 ft flume
  - Complemented with field studies
- Wave attenuation was found to:
  - increase with stem density
  - increase with submergence ratio
  - slight increase with incident wave height
- Sedimentation processes:
  - Reduced velocity, but increased turbulence





EWN Action Demonstration Projects, 1

- Sediment Retention Engineering to Facilitate Wetland Development (San Francisco Bay, CA)
- Realizing a Triple Win in the Desert: Systems-level Engineering With Nature on the Rio Grande (Albuquerque, NM)
- 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

Coastal Resilience: The Environment, Infrastructure, and Human Systems

- USACE was the primary sponsor and host (USEPA and USDOE were co-sponsors)
  - Dr. Todd Bridges, Conference Chair
  - Ms. Cynthia Banks, Conference Organizer
- 85 participants from 8 countries (Barbados, Fiji, Mexico, The Netherlands, South Africa, South Korea, United Kingdom, and United States)
  - Diversity of organizational perspectives:
    - USACE, NOAA, USEPA, USFWS, OMB, CEQ, DOE, US Navy, Treasury Department, State Department, TNC, AAPA, Water Institute of the Gulf, National Wildlife Federation, Great Lakes Dredge & Dock Company, Environ Corp., Dewberry, several universities, and many other organizations
- Conference consisted of a series of plenary presentations and panel discussions
  - Share information about science and engineering relevant to coastal resilience

The audio and visuals for each presentation are at:
http://el.erdc.usace.army.mil/ewn/workshop.cfm?List=14MayCR

High Points

- Focus energy to motivate and facilitate innovation in both technical and business processes
- Important to elevate communication about advancing practice within and external to USACE
  - Creating project value
- Accelerate progress through co-development of solutions!
  - Districts with ERDC
  - USACE with others