Engineering With Nature

Dr. Todd S. Bridges, ST
Senior Research Scientist, Environmental Science

U.S. Army Engineer Research and Development Center (ERDC)
Vicksburg, MS

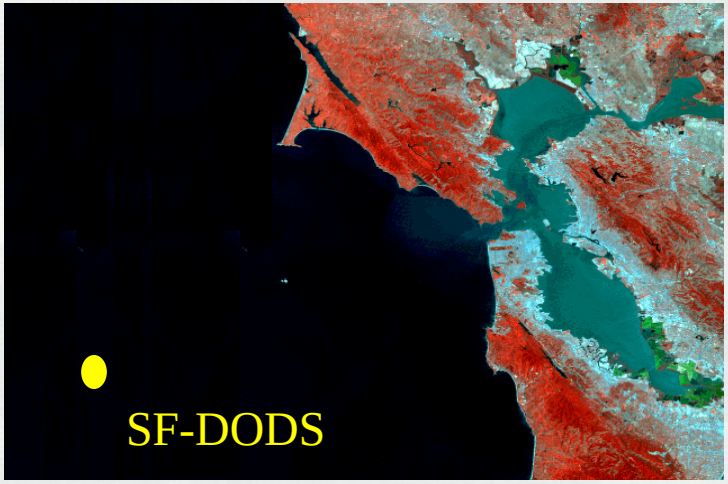
RSM-EWN Inland Working Meeting

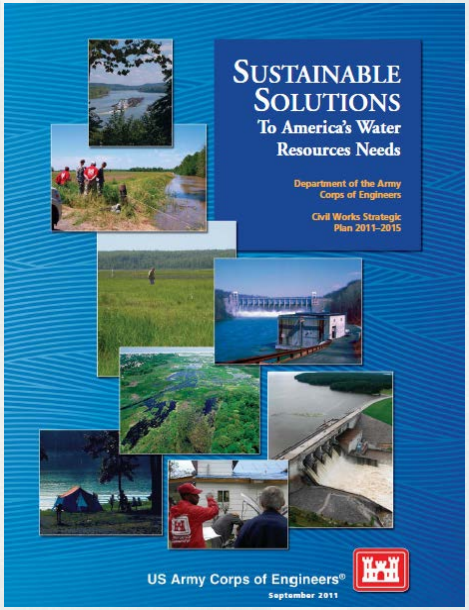
29 April 2014

todd.s.bridges@usace.army.mil

US Army Corps of Engineers
BUILDING STRONG®

Moving Beyond the *Status Quo*





Needs:

- Efficient, cost effective engineering and operational practices
- More collaboration and cooperation, less unproductive conflict.
  - Ports, commercial interests, regulators, NGOs, and others
- Sustainable projects. Triple-win outcomes integrating social, environmental and economic objectives.

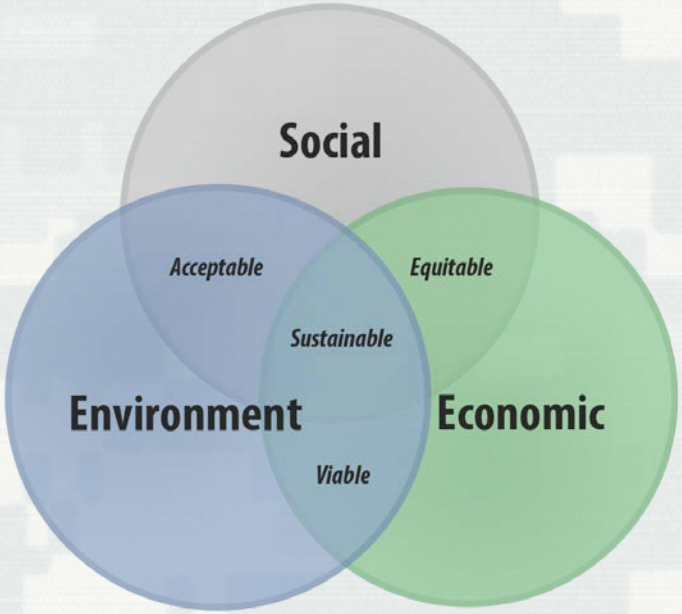
Sustainable Solutions Vision: "Contribute to the strength of the Nation through innovative and environmentally sustainable solutions to the Nation's water resources challenges."

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 Ingredients

- 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

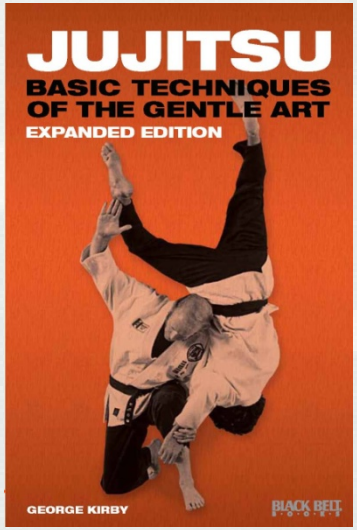


EWN Status

- *Engineering With Nature* initiative was started within the USACE Civil Works program in 2010. Over that period we have:
  - Engaged > 300 ind. across USACE Districts (23), Divisions, HQ; other agencies, NGOs, academia, private sector, international collaborators
    - Workshops (10), dialogue sessions, project development teams, etc.
  - Developed a strategic plan
  - Focused research projects on EWN
  - Initiated field demonstration projects
  - Begun implementing our communication plan

Considering EWN Opportunities

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



www.EngineeringWithNature.org
http://el.erdc.usace.army.mil/ewn

EWN

EWN ProMap

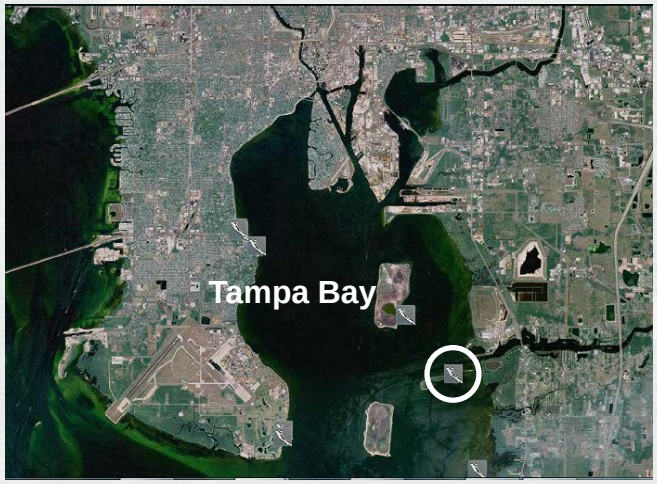
- Online GIS database of projects illustrating EWN principles and practices
  - Illustrating the key attributes of EWN
- Currently contains >200 projects
  - Name
  - Manager/Owner
  - Description
  - Infrastructure association e.g., jetty, breakwater, channel
  - Benefits e.g., fish habitat, bird habitat, recreation
  - Links, reports, photos
- Designed to facilitate communication about opportunities, lessons learned, and good practices
- Projects examples will be added through a process of self-nomination and independent evaluation

Lafitte's Cove, TX

- **Marsh sills created in front of bulkheads with cement bags**
- **Clean sand fill behind sill, *Spartina* planted**
- **Provide 14.7 acres of marsh**
- **Permit covers multiple properties on canal system**

Alafia Banks Bird Sanctuary, FL

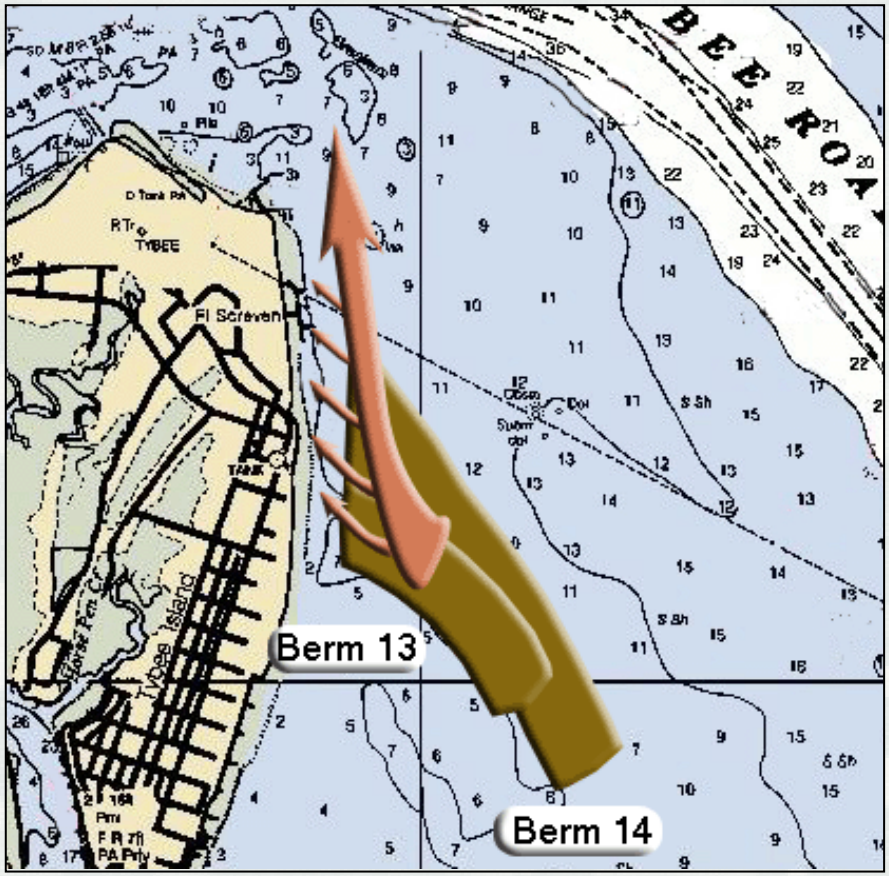
- 8000 lb reef module breakwaters (930 ft)
- Shore protection for Audubon bird sanctuary islands
- Help restore oyster populations
- Provide habitat



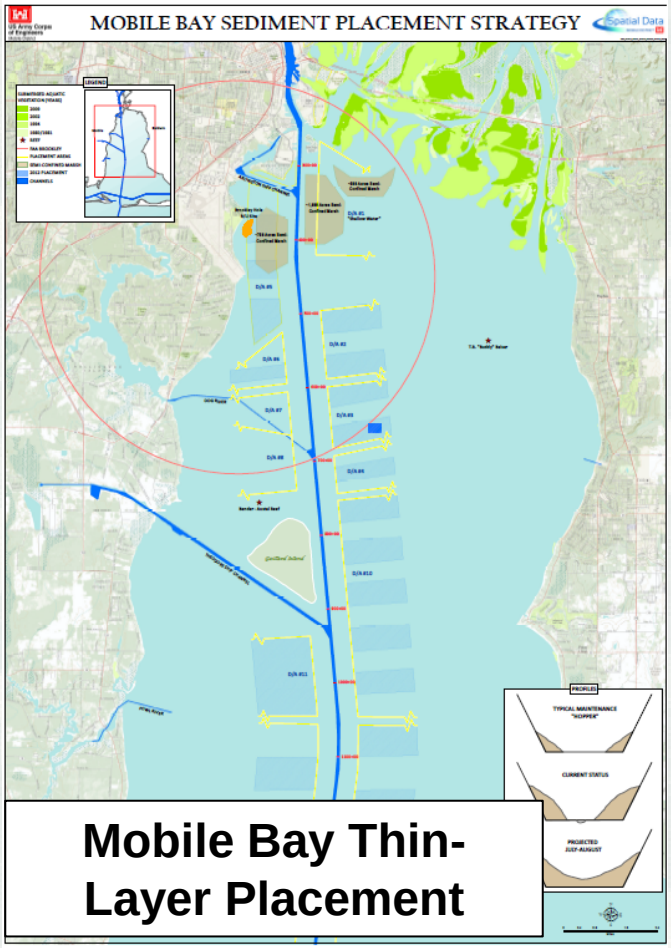
Example: www.reefball.org

Example EWN Solutions

Strategic Sediment Placement

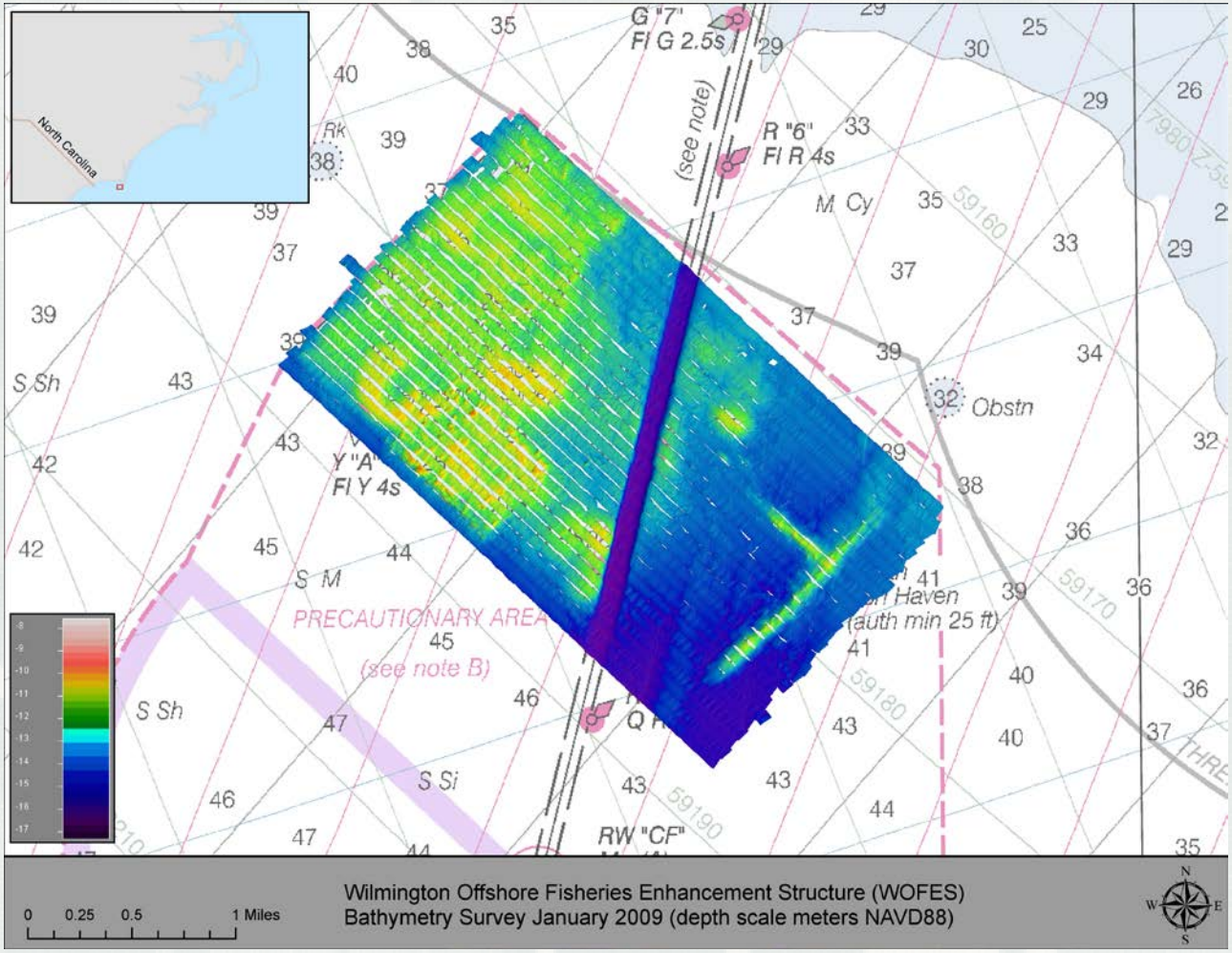


North Tybee Island
Savannah, Georgia



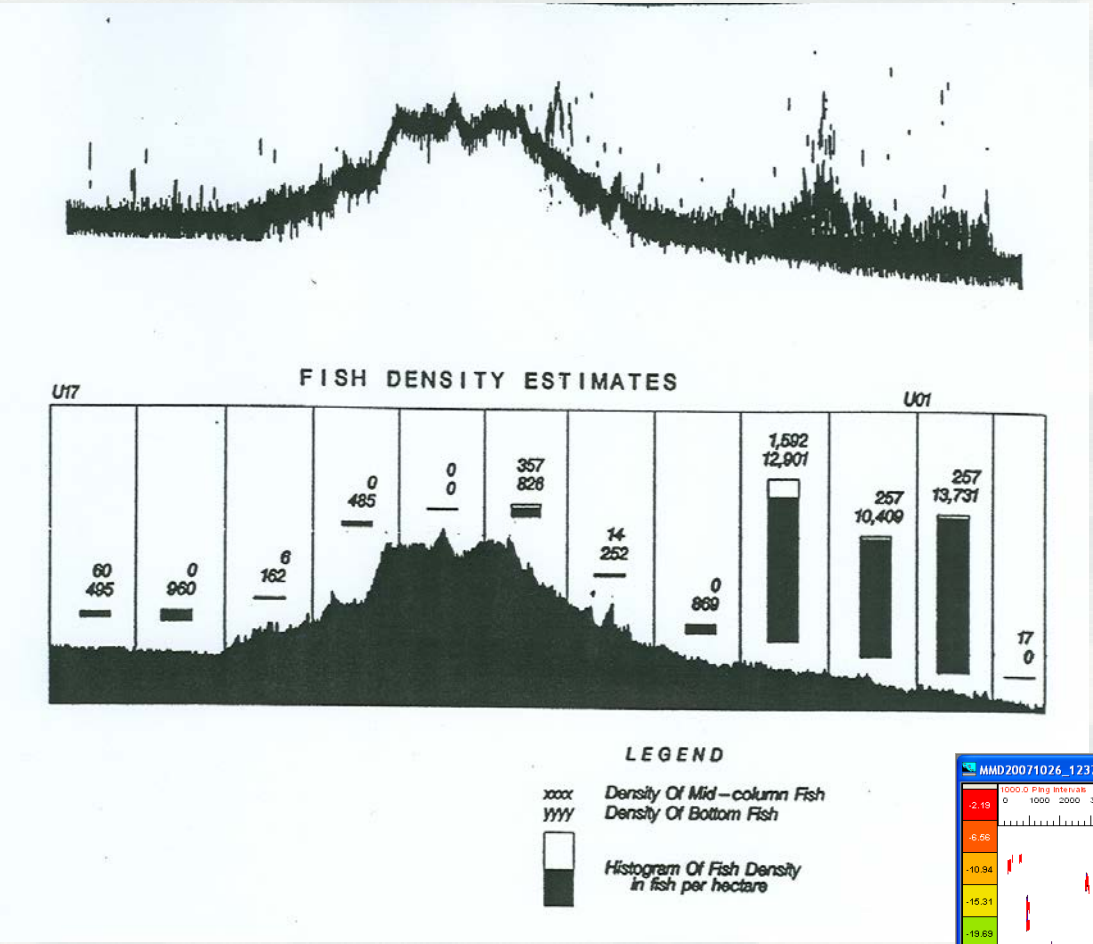
Mobile Bay Thin-Layer Placement

Example EWN Solutions

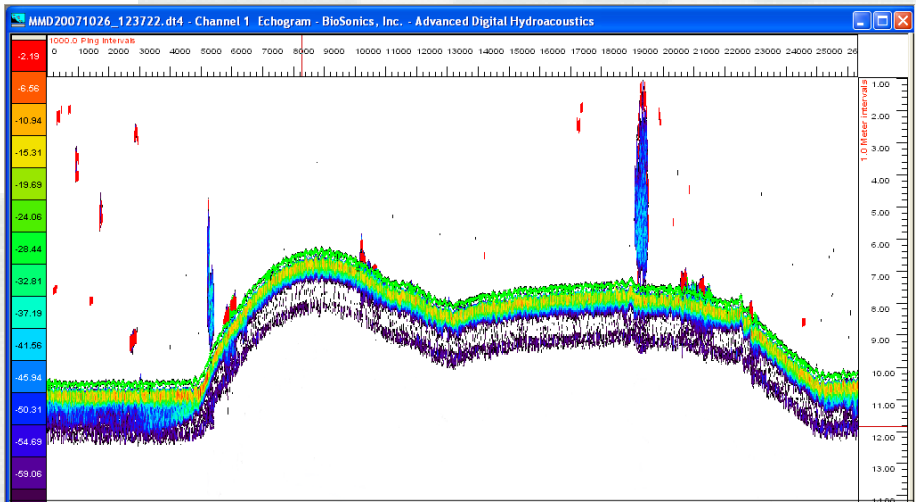


Wilmington Offshore Fisheries Enhancement Structure

Example EWN Solutions



Hydroacoustics and trawling data used to document fisheries benefits provided by topographic relief created with dredged material



Mobile Offshore Dredged Material Mound

Example EWN Solutions

Upper Mississippi River Training Structures: Chevrons

River Bendway Weirs

Environmentally Enhanced Breakwater Toe Blocks

Example EWN Solutions

Upper Missouri River Sandbar Habitat

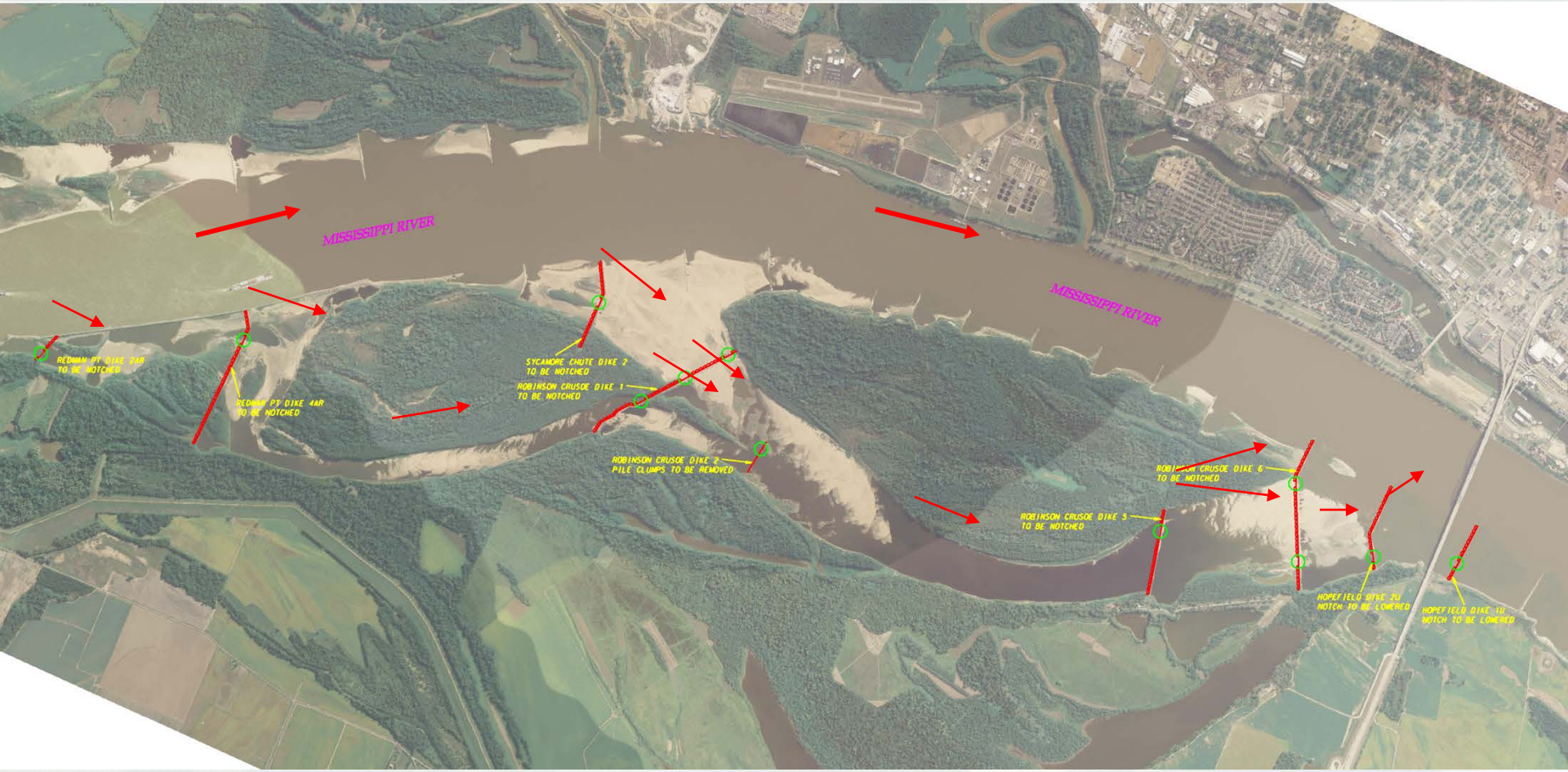
- $25 Million to construct 650 acres of sandbar
- 16,000 acres created by the flood of 2011

July 2009

November 2011

Courtesy: G. Pavelka
USACE, 2012

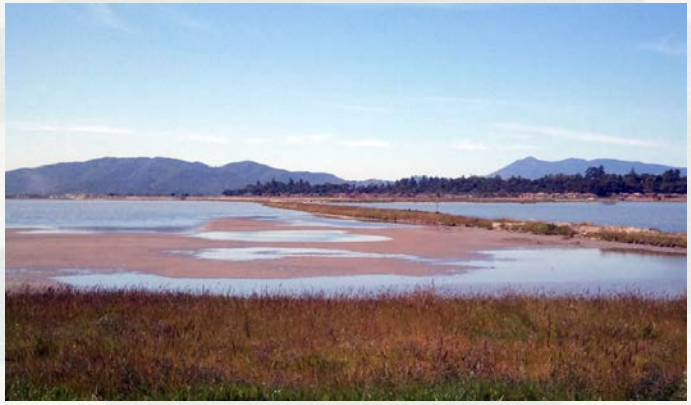
Example EWN Solutions



Loosahatchie Bar
Aquatic Habitat Rehabilitation

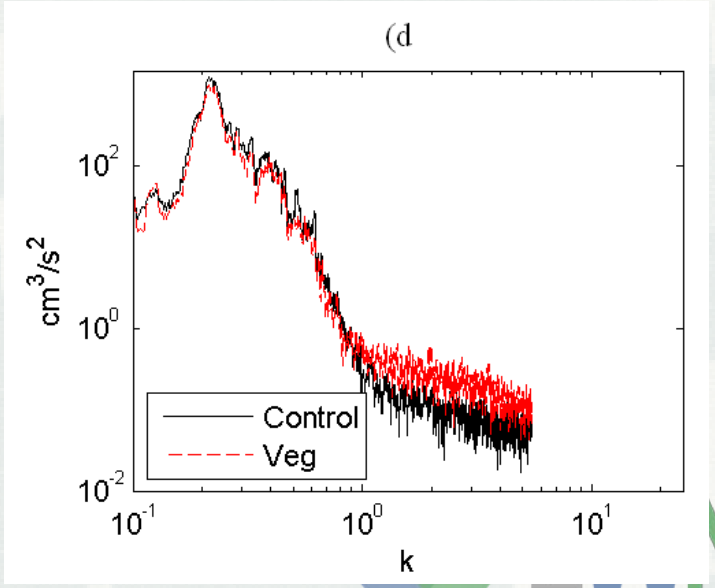
EWN Action Demonstration Projects

- 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

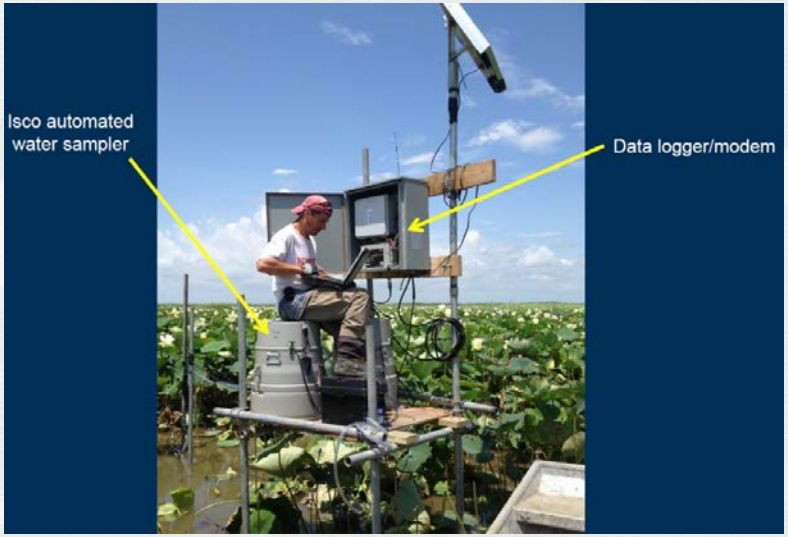


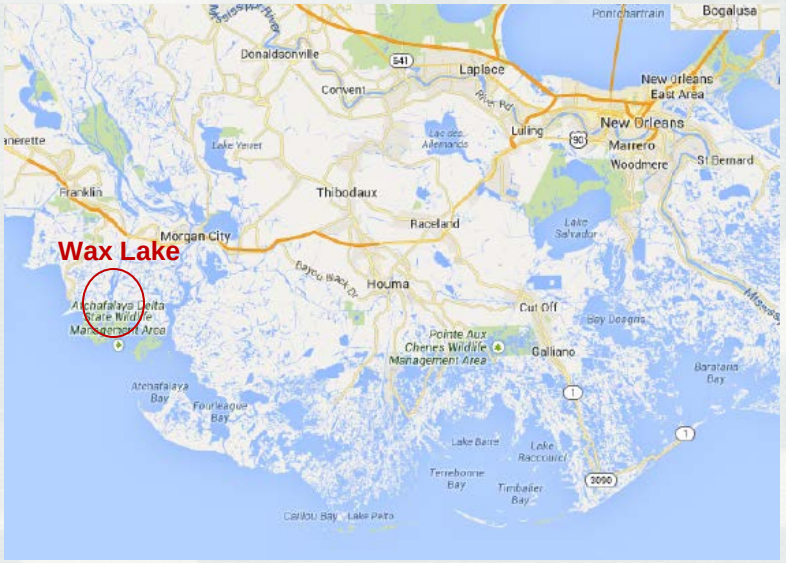
Process Research: Physical Processes within Wetlands

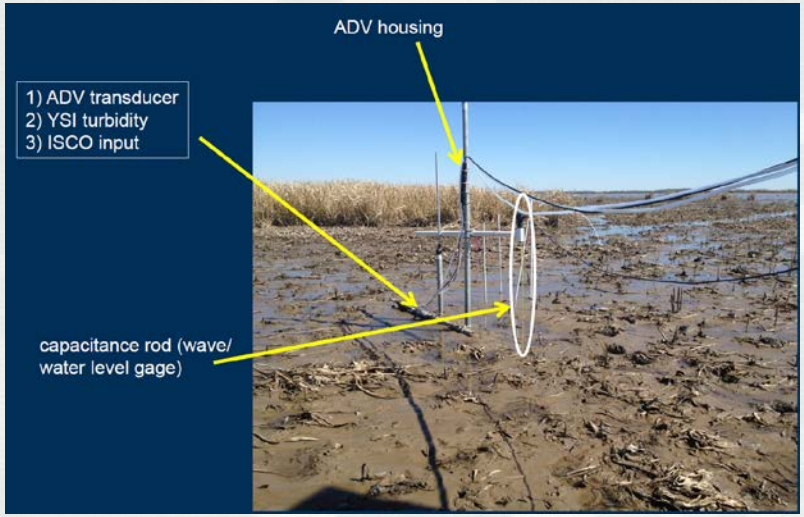
- Problem
  - Poor understanding of mixed sediment transport in vegetated regions with waves and currents
  - Unacceptable uncertainty when evaluating nearshore and wetland placement alternatives
- Approach
  - Laboratory experiments to quantify hydrodynamic and transport processes in vegetation
  - Laboratory experiments → 10' flume; Investigated wave energy transformation and limited sediment studies
  - Field experiments (planned) → Tampa SAV, Fort Saint Phillip, Currituck Sound



Process Research: Sediment Processes in a Accreting Delta (Wax Lake, LA)

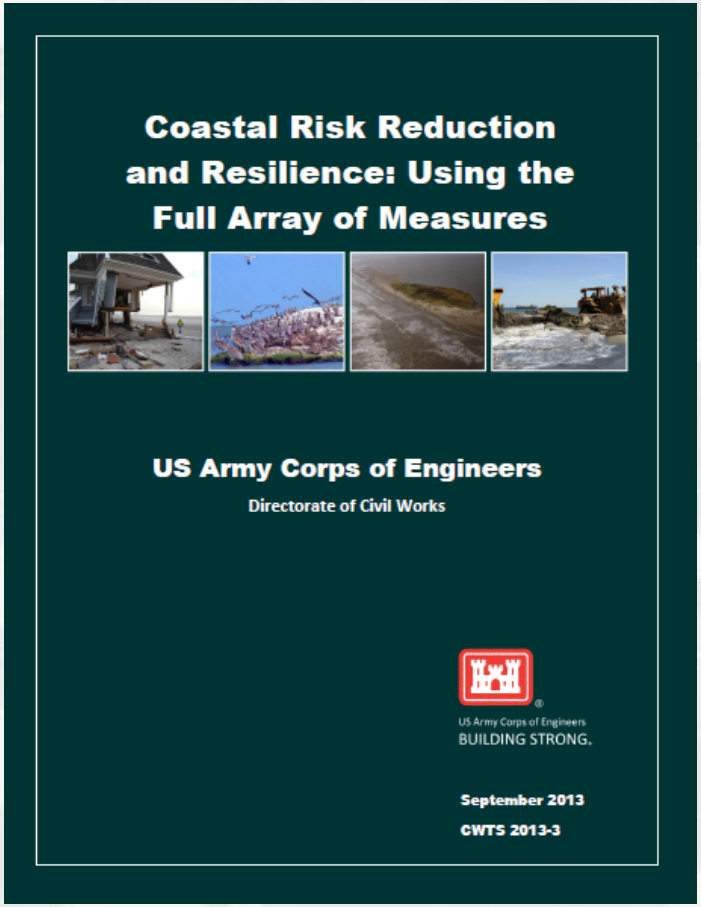






Systems: Coastal Risk Reduction and Resilience

"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."*



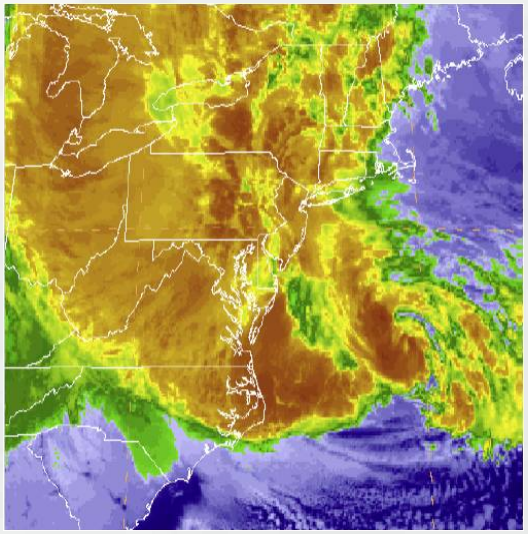
North Atlantic Coast Comprehensive Study, Natural and Nature-Based Features: Multi-Disciplinary Team

Project Leaders:

- Todd Bridges (EL)
- Paul Wagner (IWR)

Task Leaders:

- Kelly Burks-Copes (EL)
- Craig Fischenich (EL)
- Edmond Russo (EL)
- Deborah Shafer (EL)
- Ty Wamsley (CHL)



Study Team Members:

- Scott Bourne (EL)
- Pam Bailey (EL)
- Kate Brodie (EL)
- Zach Collier (EL)
- Sarah Miller (EL)
- Patrick O'Brien (EL)
- Candice Piercy (EL)
- Bruce Pruitt (EL)
- Burton Suedel (EL)
- Lauren Dunkin (CHL)
- Ashley Frey (CHL)
- Mark Gravens (CHL)
- Linda Lillycrop (CHL)
- Jeff Melby (CHL)
- Andy Morang (CHL)
- Cheryl Pollock (CHL)
- Jane Smith (CHL)
- Jennifer Wozencraft (CHL)
- Jae Chung (IWR)
- Michael Deegan (IWR)
- Michelle Haynes (IWR)
- Lauren Leuck (IWR)
- David Raff (IWR)
- Lisa Wainger (U. Maryland)
- Sam Sifleet (U. Maryland)

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

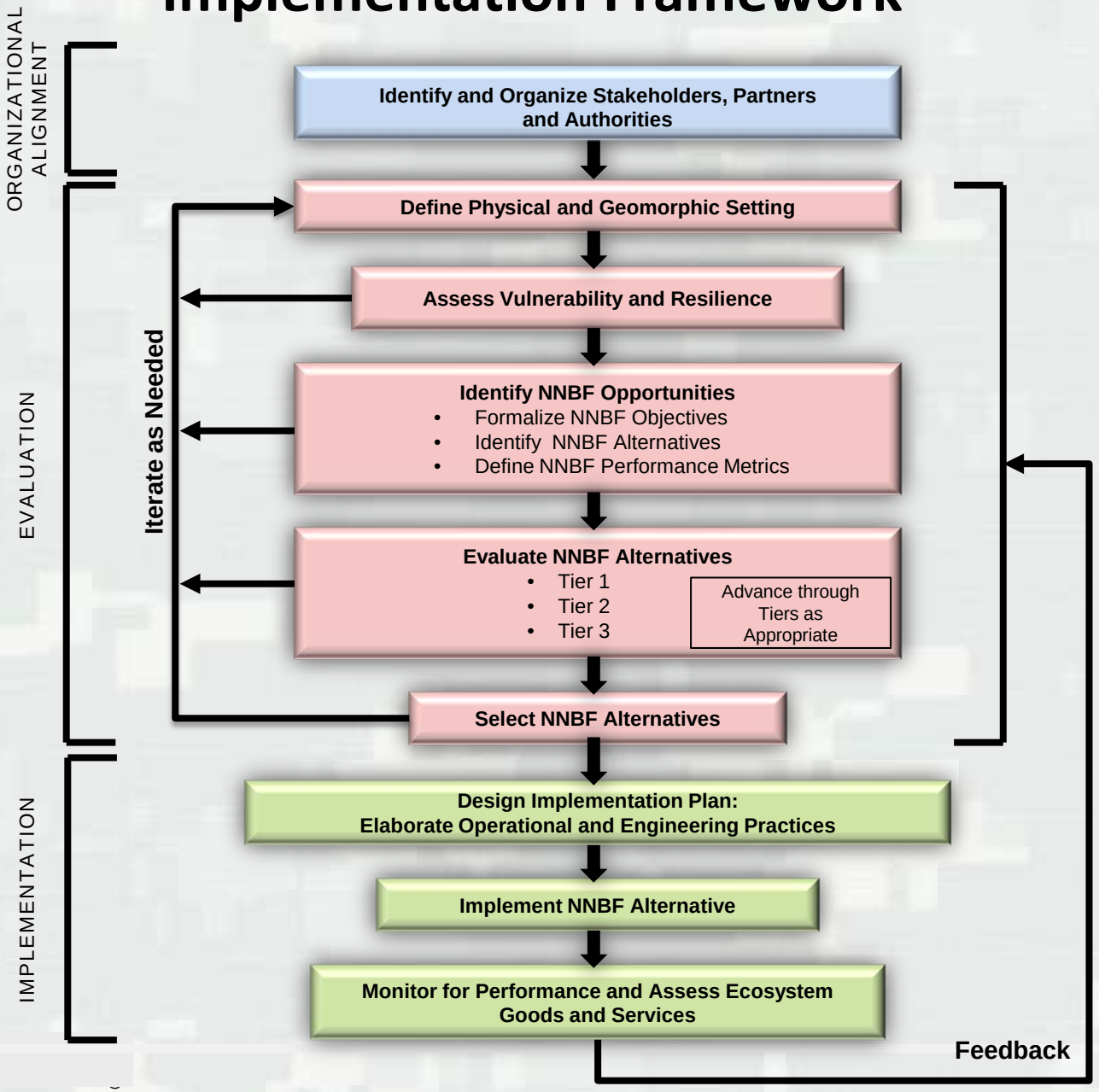
Vegetation height and density

Forest dimension

Sediment composition

Platform elevation

Natural and Nature-Based Features Evaluation and Implementation Framework



Resilience

The ability of a system to resist, recover and/or adapt to the stresses of adverse events

- **Engineering:** resist damage, or return to a prior relatively stable state following a disturbance.
- **Ecological:** resist damage, or self-organize into a new configuration after disturbance.
- **Community/Social:** learn and adapt to avoid loss in functionality; develop new functions in response to disturbance.

Schultz et al. (2012)

Military
Civil Works

USGS science for a changing world

Sandy
Comp
Study

FEMA

NSF

EPA

Military

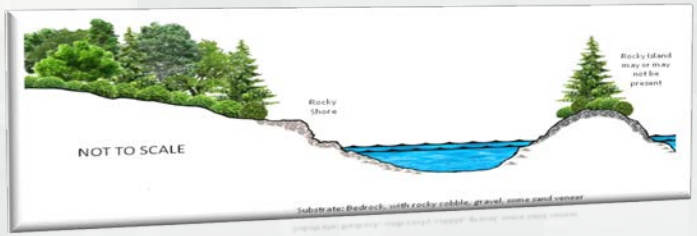
U.S. DEPARTMENT OF HOMELAND SECURITY

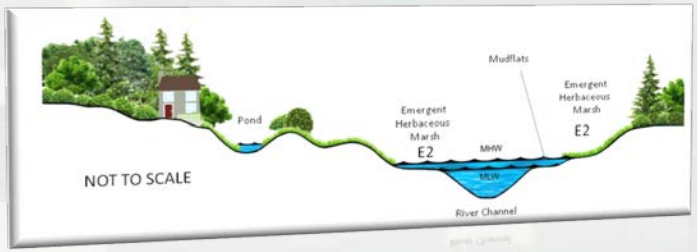
USAID FROM THE AMERICAN PEOPLE

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

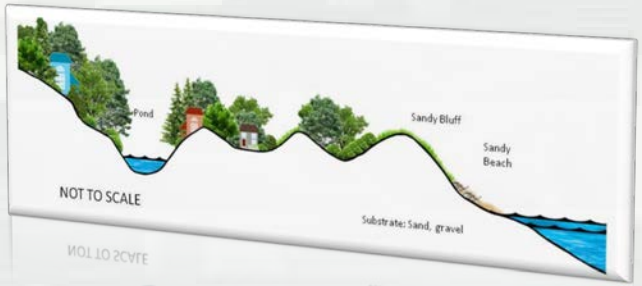
Vulnerability

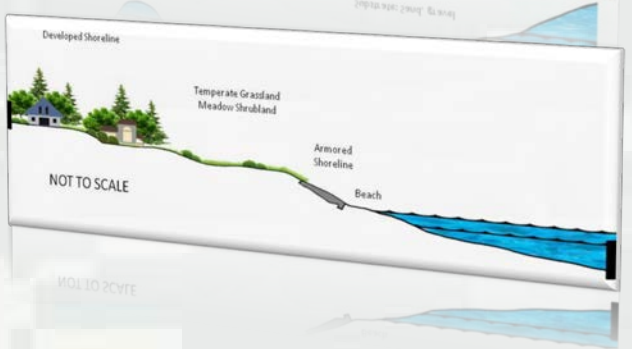
Vulnerability wrt Nature-Based Features in the Coastal Zone





Relative vulnerability of coastal landscapes; how nature-based features affect vulnerability



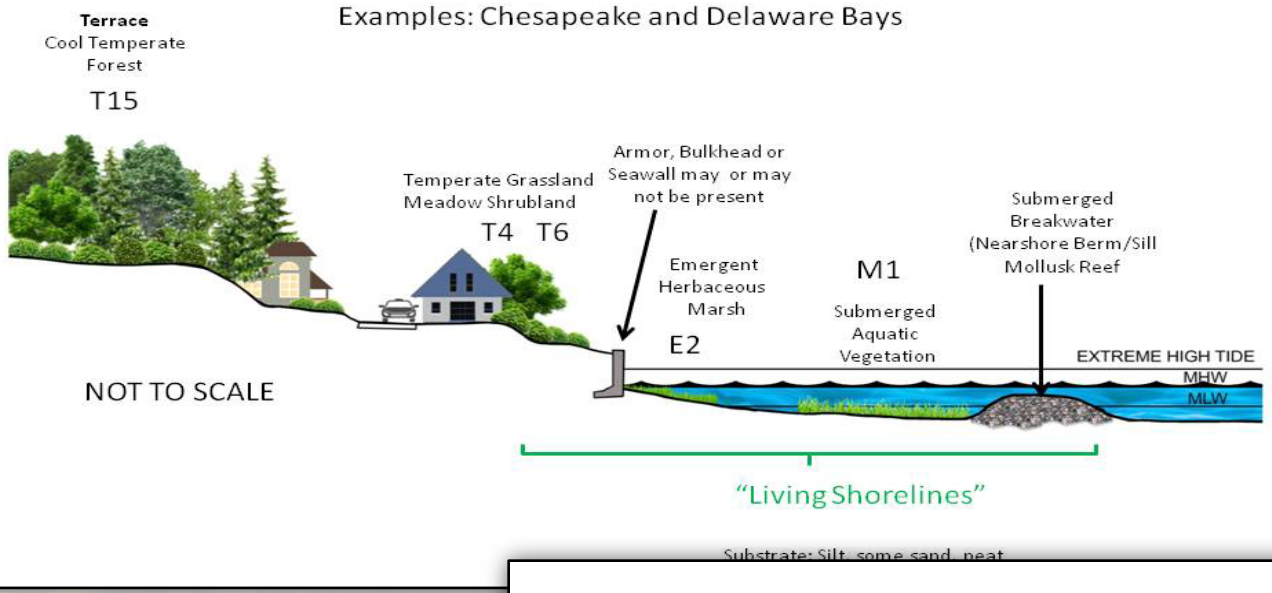


Vulnerability: Degree to which a system is susceptible to, and unable to cope with, adverse effects from a hazard; vulnerability is a function of the character and magnitude of a hazard to which a system is exposed, its sensitivity, and its adaptive capacity.

Wamsley et al. 2013 (in review)

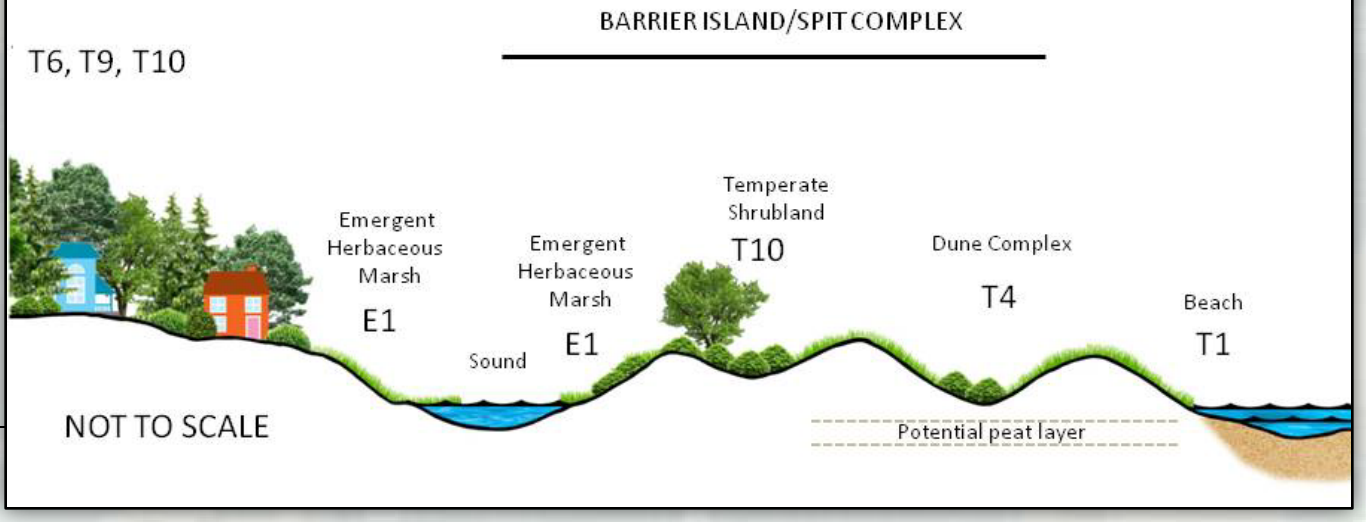
1 A 1-1. Drowned River Valley

Examples: Chesapeake and Delaware Bays



II B 1. Marine Depositional Barrier Coast

Examples: Virginia coast

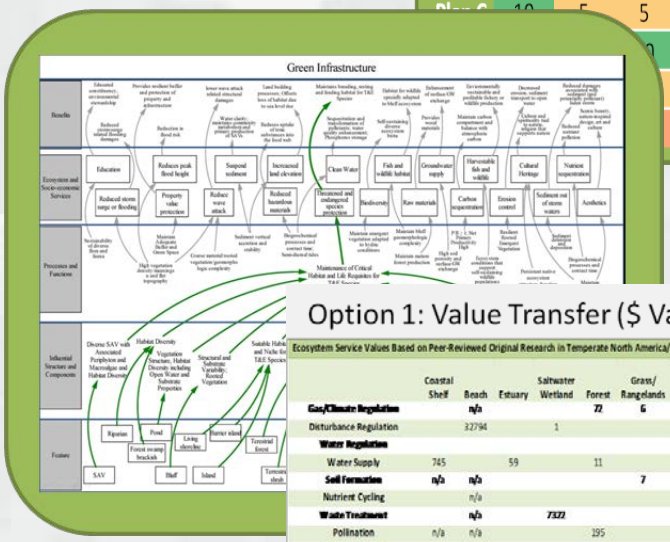


System Performance Evaluation

- **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		
	B1	B2	B3	B4	B5	Mean	Wtd
Plan A	10	8	5	1	0	4.8	49
Plan B	10	10	0	0	0	4	30	
			5	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)

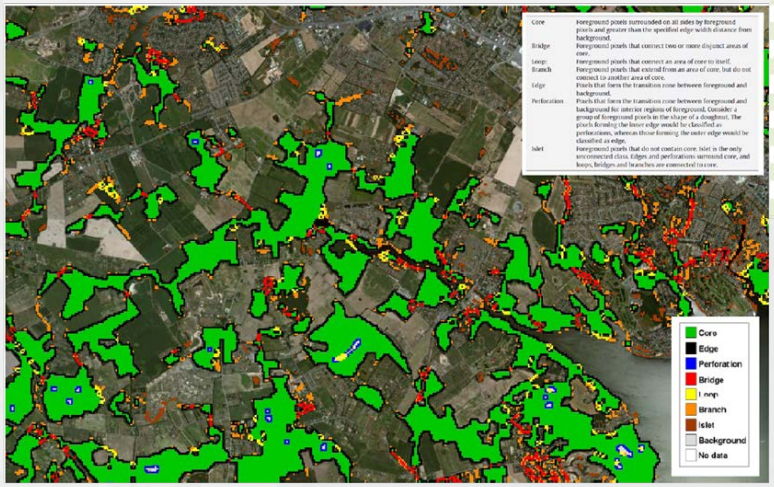
Ecosystem Service Values Based on Peer-Reviewed Original Research in Temperate North America/Europe (2012 $/(ac*yr))

	Coastal Shelf	Beach	Estuary	Saltwater Wetland	Forest	Grass/ Rangelands	Cropland	Freshwater Wetland	Open Fresh Water	Riparian Buffer	Urban Greenspace	Urban/ Barren
Gas/Climate Regulation		n/a			72	6					404	
Disturbance Regulation		32794		1						106		
Water Regulation								7162			7	
Water Supply	745		59		11			1396	492	2310		
Soil Formation	n/a	n/a				7			n/a			
Nutrient Cycling		n/a										
Waste Treatment		n/a		7322								
Pollination	n/a	n/a			195		10		n/a			
Biological Control		n/a										
Habitat/Refugia			438	277	1110			6				
Aesthetic/Recreation		17851	364	31	156	1	18	1889	428	1647	2562	
										5		

Option 2: Ecosystem Production Functions

Literature, and Meta-analysis Studies in Temperate North America/Europe (2012 $/(ac*yr))

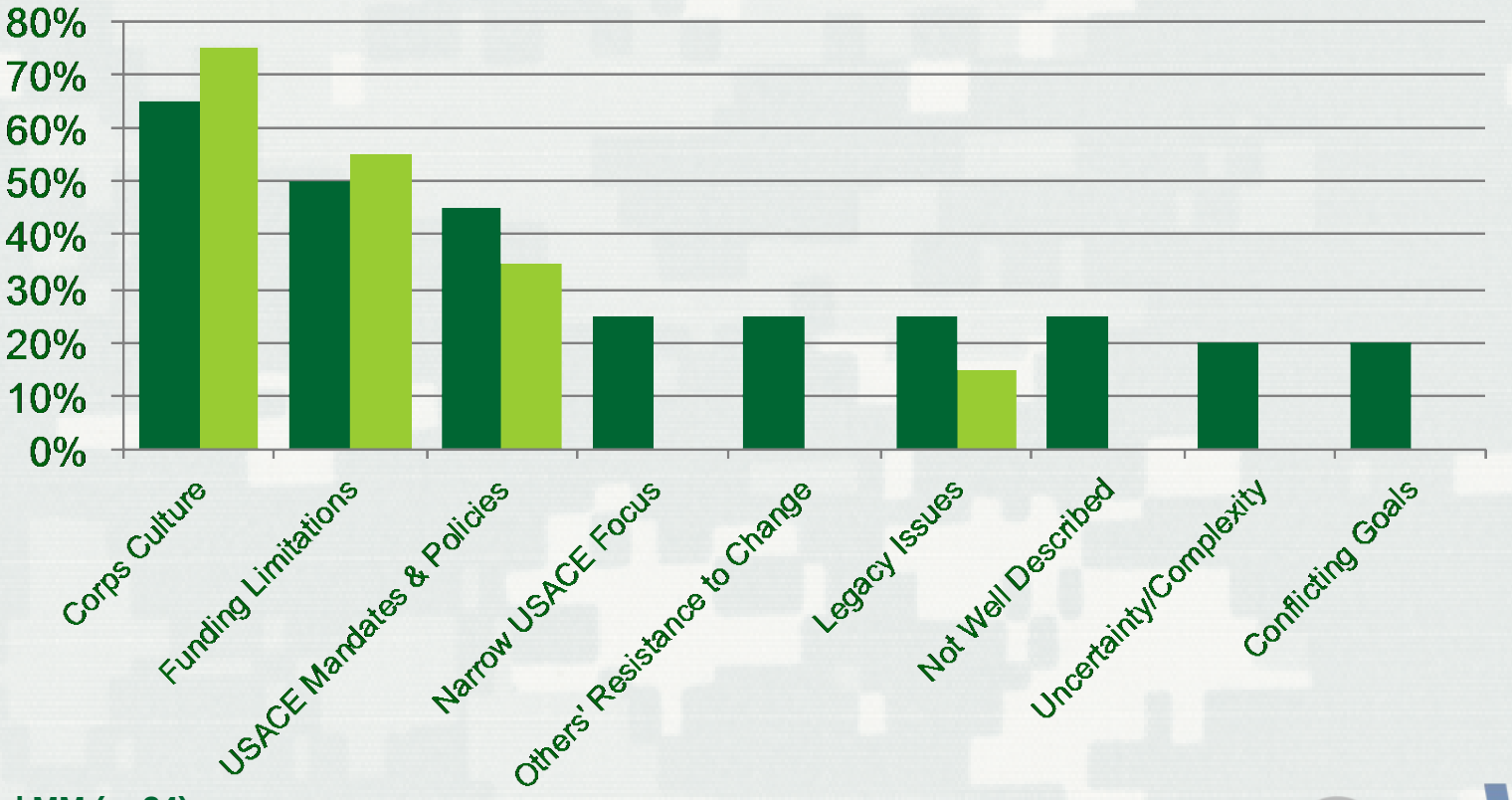
Forest	Grass/ Rangelands	Cropland	Freshwater Wetland	Open Fresh Water	Riparian Buffer	Urban Greenspace	Urban/ Barren
65	4		161			404	
			4397		106		
	2		3590			7	
196			1856	492	2310		
6	4			n/a			
53	53		1888				
195	16	10		n/a			
2	14	14					
1110		999	136				
147	1	18	1690	428	1647	2562	
1			1070		5		



Facilitating Change: Dialogue Sessions on EWN

- 22 internal USACE stakeholders representing a diverse specialty areas and geography
  - Specialty Areas: Senior Leadership, Research, Navigation, Flood Risk Management, Operations and Regulatory, Coastal, Planning, Environment, Water Resources
  - Geographical Areas: Washington DC, Mississippi, Florida, New York, Massachusetts, Texas, Oregon, Alabama, New Jersey, South Carolina, Nebraska
- 34 external stakeholders representing a diverse population of organizations and regions
  - Stakeholder Types: Academia, Federal Government Agencies, State Government Agencies, Non-Governmental Organizations, Private Industry and European Experts with Related Expertise.
  - Geographical Areas: Those with responsibilities and expertise in coastal areas, rivers and lakes.

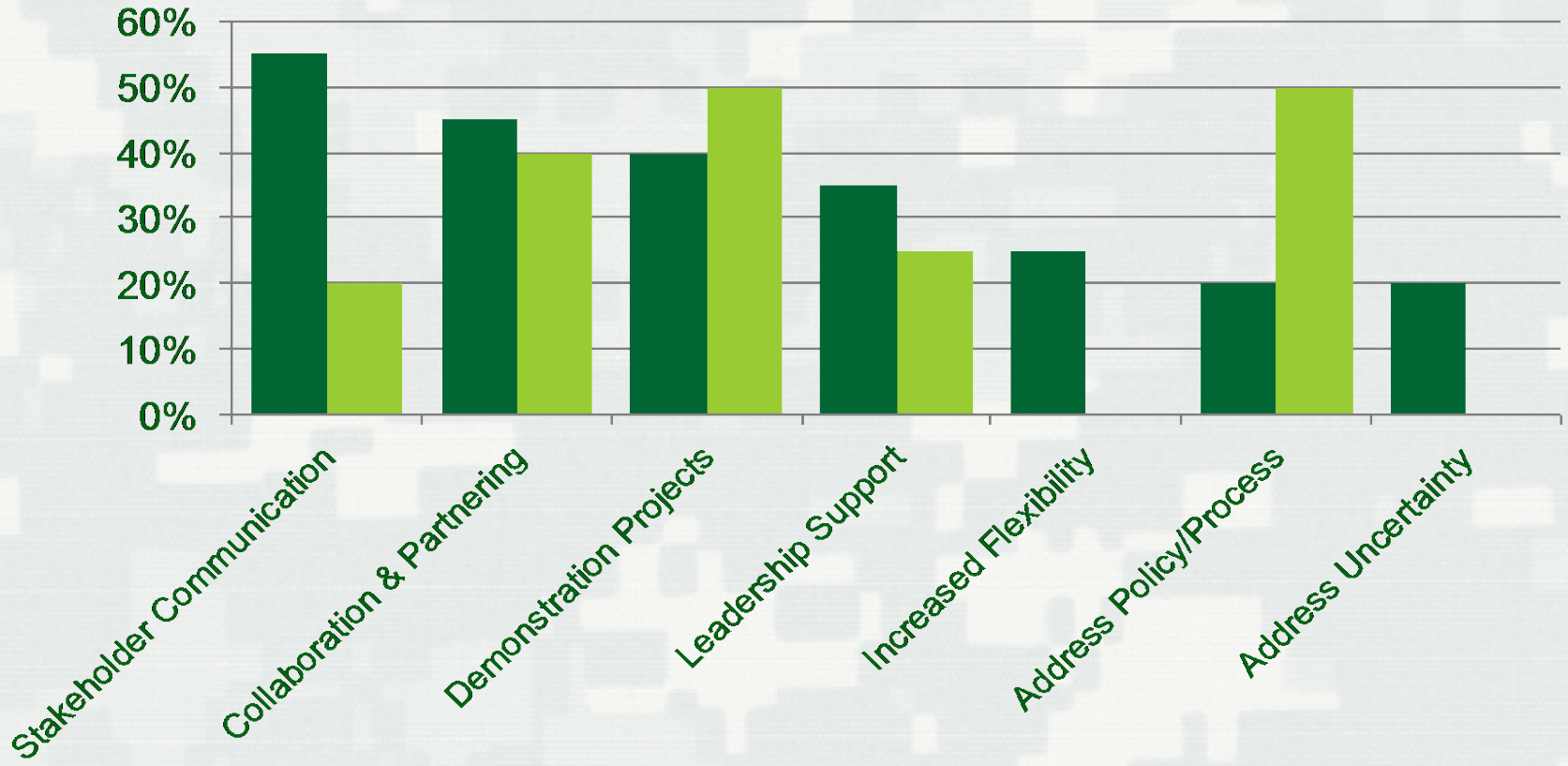
Barriers to EWN Adoption



External MM (n=34)

Internal MM (n=22) *(Only common factors shown)*

Overcoming Barriers to EWN

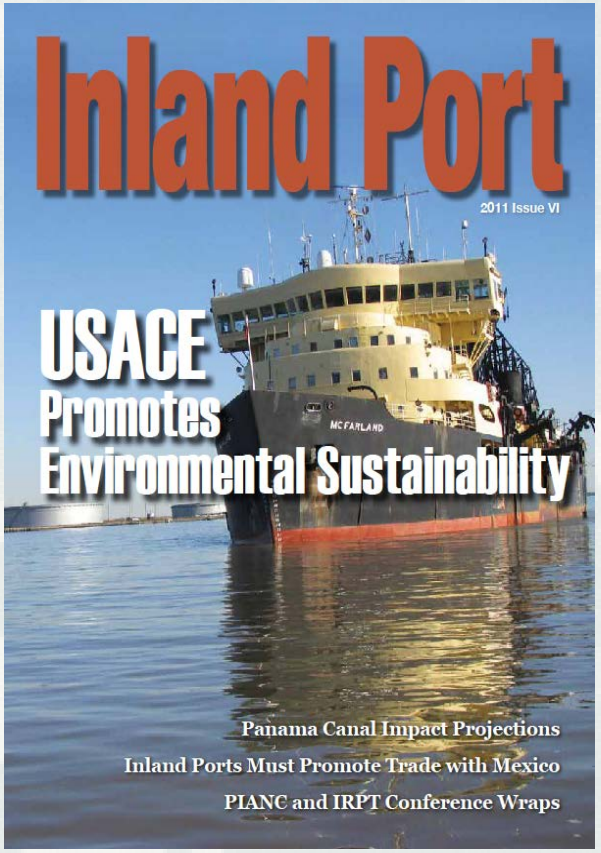


External MM (n=34)

Internal MM (n=22) *(Only common factors shown)*

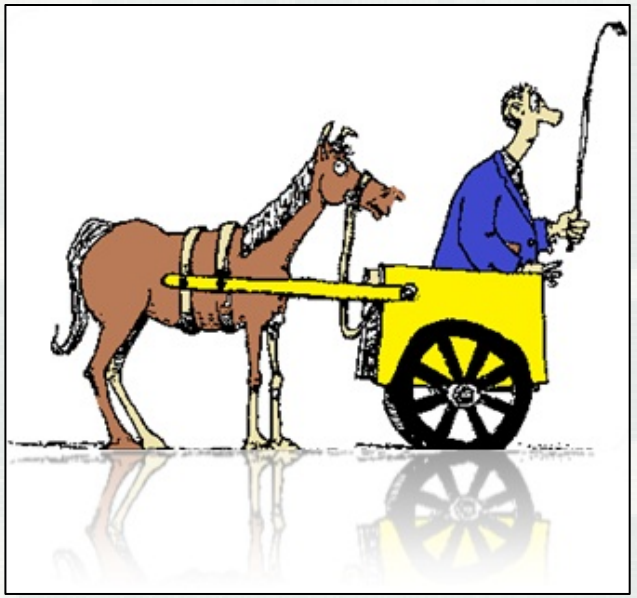
Engineering With Nature

- Expand the range of benefits provided through water-based infrastructure
  - ► Create value!
- Balancing consideration of environmental risks with project **benefits**
- A path to more sustainable projects



The Sequence of Questions

1. What are the big ideas and opportunities for inland infrastructure, restoration and operations projects in regard to EWN?



THEN

2. What science is needed to support these projects?
3. What engineering tools are needed facilitate the application of EWN principles and practices?
4. What communication and collaboration practices are needed?