Engineering With Nature®

Strategic Plan 2018-2023: Expanding Implementation

US Army Corps of Engineers®

The cover photo shows the development of Horseshoe Bend Island on the Atchafalaya River near Morgan City, LA. The project, which began in 2002, is an excellent example of using natural systems and processes to engineer with nature. The creation of the island and wetlands using strategic placement of sediment resulted in numerous engineering and environmental benefits, which were quantified beginning in 2012. Benefits include a reduced need for dredging and habitat provision for a diversity of species (see Horseshoe Bend Island creation photos on page 22).

This project won the 2015 Western Dredging Association Gold Environmental Excellence Award and the 2017 Western Dredging Association Adaptation to Climate Change Award. In 2017 it was certified as a World Association of Waterborne Transport Infrastructure (referred to as PIANC) "Working with Nature" project, and in November 2017, it was awarded the Dredging and Port Construction Working, Building, or Engineering With Nature Award in London, England.

Details on this project, and on many other EWN projects and initiatives, can be found on the website: www.engineeringwithnature.org

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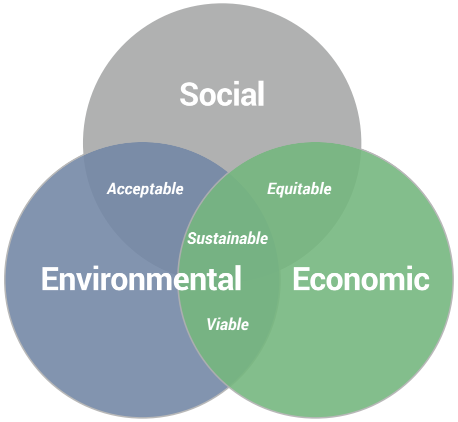
Dune creation project undertaken by an international partner on Piha Beach, New Zealand.



EWN Guiding Principles

As a leading practice, EWN is:

- **Holistic** – an ecosystems approach
- **Innovative** – science-based, solutions-oriented
- **Collaborative** – from design through implementation and monitoring
- **Adaptive** – supporting system sustainability and resilience
- **Socially responsive** – engaging stakeholders
- **Cost-effective** – efficient and value-adding


A local painter enjoys the benefits of the engineered landscape in a small park that overlooks a managed realignment project near Alkborough, UK, on the upper Humber Estuary. The project is providing flood storage capacity along with a range of environmental and social benefits.

1 Introduction

Sustainable development of water resources infrastructure presents both challenges and opportunities. Practical approaches are needed to better understand and integrate natural and engineered systems. Pursuit of these integrated outcomes will achieve more socially acceptable, economically viable, and environmentally sustainable projects. This is a goal shared by the US Army Corps of Engineers (USACE), its partner organizations, stakeholders, and the public.

Engineering With Nature (EWN) was initiated in 2010 by a team of scientists and engineers to enable and support more sustainable practices, projects, and outcomes.

Engineering With Nature is the intentional alignment of natural and engineering processes to efficiently and sustainably deliver economic, environmental, and social benefits through collaboration.

EWN Elements

Four major elements are involved in applying EWN to develop infrastructure projects:

- Using science and engineering to produce operational efficiencies
- Using natural processes to maximize benefit
- Increasing the value provided by projects to include social, environmental, and economic benefits
- Using collaborative processes to organize, engage, and focus interests, stakeholders, and partners

When these elements are considered and integrated into the design, construction, and operation of projects at any scale, a more sustainable outcome is achieved through the production of social, environmental, and economic benefits. While USACE and other organizations have been incorporating these elements, to varying degrees, into water resource projects for years, it is the intentional use of all four, in combination, that will make the exceptional projects of the past common practice in the future.

Since the inception of the EWN initiative in 2010, significant progress has been made in the development and application of practical methods that demonstrate the benefits of an ecosystem approach to infrastructure development and operations. There has been growing interest in the application of EWN principles and practices across multiple USACE missions and business lines, including Navigation, Flood Risk Management, Ecosystem Restoration, and beyond. By engaging partners and stakeholders, EWN is being applied to the missions of a range of US and international organizations. The application of leading social science practices for effective stakeholder engagement has been – and will continue to be – a key to success.

Vision

Building on the success of EWN to date, the EWN Strategy 2018-2023 will expand implementation by:

- Broadening and deepening engagement and collaboration with colleagues across mission areas and organizations;
- Growing the capability to apply EWN principles and practices at project and system scales; and
- Increasing the number and diversity of EWN applications while communicating effectively about accomplishments and future opportunities.

By doing so, EWN will continue to support and advance the USACE Civil Works' commitment to strengthen the Nation by bringing innovative and environmentally sustainable solutions to the Nation's water resources challenges while also contributing to the missions of its partners.

EWN continues to be recognized formally and informally for its significant contribution to sustainable water infrastructure at both the programmatic and project scale. The EWN initiative was awarded the USACE Chief of Engineers Environmental Award for Natural Resource Conservation (2013) and the USACE Sustainability Award for Green Innovation (2014).

The Horseshoe Bend Island project was awarded the Western Dredging Association Gold Environmental Excellence Award (2015) and the Western Dredging Association Adaptation to Climate Change Award (2017). On 29 November 2017, this EWN project was presented with the *Dredging and Port Construction* (DPC) Working, Building, or Engineering With Nature Award at the DPC awards ceremony in London, England. This international award recognizes projects that demonstrate an active and innovative response to the preservation and promotion of wildlife, reduction in air emissions, water quality, treatment of soils/sediments, community engagement, and sustainability. Each year, the Dredging and Port Construction magazine recognizes innovation and outstanding achievements that are changing the dredging and port construction sectors through new ideas, processes, technology, or equipment. The DPC Innovation Awards program consists of 15 categories honoring the most innovative and forward-thinking projects and people that the industry has to offer.

Several EWN Team members have also been individually recognized within USACE and their organizations for their substantial contributions to the EWN initiative.

2 Overview of EWN Strategic Plan 2018-2023: Expandi

Vision

Expand EWN application by incorporating the approach into the priorities and practices of USACE, partner organizations, and stakeholders while actively delivering, demonstrating, and communicating EWN's interconnected benefits to society, the environment, and the economy.

Strategy

The strategy to support the Vision is comprised of three interrelated Waves of activity, summarized below. Examples of EWN activities under the three Waves are further described in following sections.

Wave I: Broaden and Deepen Partnerships	Wave II: Expand Capabilities	Wave III: Expand Applications and Communication
• Build the organization and internal capacity to support, grow, and sustain EWN • Expand by engaging districts and early adopters throughout USACE • Expand by engaging agency partners and key external stakeholders • Establish/expand collaboration through agreements with key international partners • Advance EWN through effective governance	• Continue to develop science and technical alliances • Leverage social science to better engage agency partners and stakeholders, and build capacity • Expand and focus the EWN research agenda to strengthen capabilities	• Support and document multi-scale demonstrations of EWN practices • Support and reinforce EWN progress through ongoing engagement and communication • Enable EWN application through development of policies and guidance

Wave I: Broaden and Deepen Partnerships

From its first applications within the USACE Navigation mission, EWN has expanded into projects across the USACE Civil Works mission, including Flood Risk Management, Ecosystem Restoration, and Water Operations. Internal to USACE, more than 25 districts, the respective divisions, the US Army Engineer Research and Development Center (ERDC), USACE Headquarters (HQ), and other USACE organizations have participated in EWN. Over the next five years, the focus will be on broadening and deepening the application of EWN principles and practices across USACE and partner organizations. The EWN Proving Grounds established in the Galveston, Buffalo, and Philadelphia Districts serve as strong models for such engagement. Providing demonstration projects, tools, and processes, and sharing lessons learned, will enable and encourage practitioners to actively seek opportunities to design, build, and operate projects that incorporate the principles and practices of EWN.

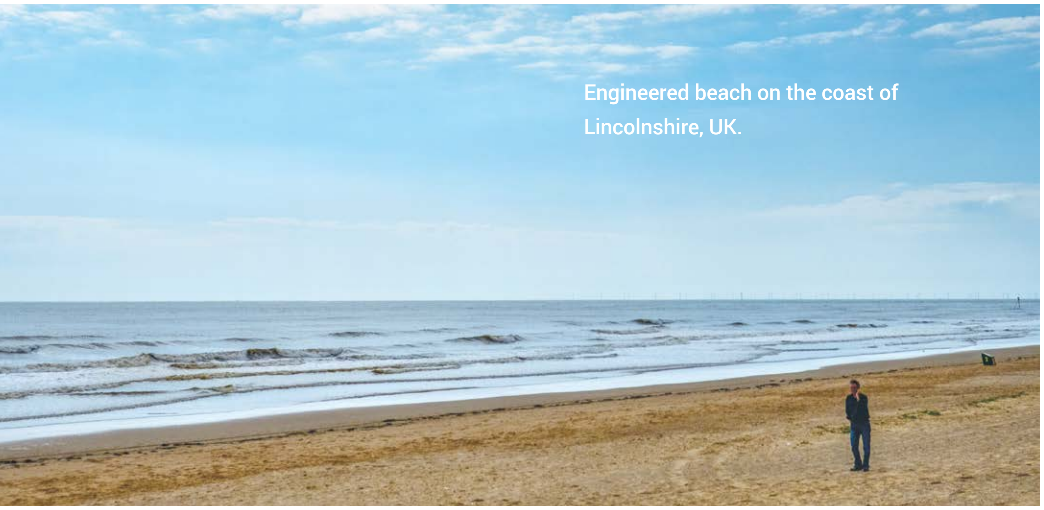
Collaborations and partnerships with federal agencies, non-governmental organizations (NGOs), and the private sector have, and will continue to, yield better projects, shared learning opportunities, and a desire to collaborate to achieve shared objectives. Similarly, engaging academia in the United States, Europe, and beyond will ensure leading scientists contribute their expertise to projects, and coach and mentor young scientists about the benefits of the EWN approach. Engagement with the private sector is also gaining momentum as companies witness the triple-win outcomes that are derived from the social, environmental, and economic benefits produced through EWN projects. International collaborations continue to grow, along with opportunities to work on larger-scale projects and strategic initiatives of mutual benefit. As new EWN opportunities emerge, the need and opportunity to collaborate will remain fundamental to the success of EWN.

Wave II: Expand Capabilities

Expanding capabilities and continuous learning are crucial to achieving the EWN Vision. By sharing leading science, technical developments, and EWN practices, we can undertake and produce benefits for a broader range of projects.

Leading social science methods and tools were used to develop the initial EWN concept and Strategic Plan. This foundation for successful partner and stakeholder engagement is producing dividends in the form of more affordable projects that are producing a broader array of benefits.

A cornerstone of the EWN Strategy is expanding and focusing a research agenda that strengthens capabilities across all partner and stakeholder organizations. Priorities include: development of supporting science, tools, and models; demonstration projects at a range of scales; and technical support to advance the practice of EWN in the field. Documenting and communicating EWN project design and implementation challenges and successes across the growing community of EWN scientists, engineers, and practitioners will expand expertise and skills.



Engineered beach on the coast of Lincolnshire, UK.

Wave III: Expand Applications and Communication

The ultimate measure of success is the acceptance of EWN principles and practices as the standard approach for water resources project development. While there have been many excellent examples within USACE and other organizations over the past several years, an overarching goal is to make these exceptional projects commonplace. We are actively working to demonstrate EWN's significant potential to expand benefits in the context of field-scale projects.

EWN applications will continue to expand through national and international partnerships and engagements. Workshops and conferences have been important venues for sharing EWN principles and discussing successes realized through demonstration projects and larger-scale, multi-organization partnerships. In turn, these engagements have led to more EWN collaborative opportunities with a diverse number of organizations.

Demonstrating the application of EWN at field-scale supports a critical need to produce and share science and engineering evidence of the significant project performance and value creation that can be achieved. Sharing best practices in project design, operations, and implementation through ongoing engagement and communication is critical to success. EWN meetings, workshops, and conferences have fostered, and continue to foster, interest and participation in EWN projects while also enabling technology transfer. Highlighting EWN practices and projects at major national and international venues, which offer the opportunity to share EWN experience as broadly as possible, will continue to be a priority.

In June 2013, ERDC launched the EWN website at **engineeringwithnature.org.** The website provides an overview of EWN principles and practices, and it provides guidance and collaboration opportunities for EWN projects, along with news on upcoming events, projects, and workshops. The website is an important channel for communicating about EWN and sharing resources across the community of practice.

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USACE Galveston District and the Texas Department of Transportation install Goliath Reef Balls to protect natural shorelines and provide habitat near the Gulf Intracoastal Waterway in West Galveston.

Wave I – Broaden and Deepen Partnerships

Collaboration is fundamental to EWN. Creating new efficiencies, taking full advantage of natural processes, and expanding the services and benefits provided by water infrastructure projects can only be achieved by working across technical disciplines, business perspectives, organizations, and geographic regions.

EWN, first implemented in the USACE Navigation community, began by focusing collaboration among infrastructure engineers and environmental scientists to achieve better project outcomes. Progress within the Navigation community was then used to develop collaborations to support Flood Risk Management, Ecosystem Restoration, and other missions and programs within USACE.

Three EWN Proving Grounds—Galveston, Buffalo, and Philadelphia Districts—were established to support a model of solution co-development that integrates the USACE research and development enterprise with district-led project teams. Such co-development is producing benefits for field-scale projects across the full range of USACE missions.

Broadening partnerships to expand the value provided by water infrastructure projects includes working across organizations. Strong partnerships have been forged with federal agencies, including the U.S. Fish and Wildlife Service (USFWS), the National Oceanic and Atmospheric Administration (NOAA), and NGOs such as The Nature Conservancy, Sonoma Land Trust, and Wildlife Conservation Society, along with a range of private sector companies. These have resulted in better projects, shared learning experiences, and a desire to continue to work collaboratively. Similarly, engaging academia in the United States, Europe, and beyond will ensure that cutting-edge researchers contribute their expertise to projects while coaching and mentoring the next generation of scientists and engineers on the utility and benefits of EWN. Adoption of EWN practices within the private sector is also gaining momentum. For example, ventures such as the Natural Infrastructure Initiative led by Caterpillar Inc. will succeed as organizations achieve greater returns on investments through the triple-bottom-line outcomes made possible by EWN. Finally, international collaborations, including those with the Rijkswaterstaat and Deltares (Netherlands), the Environment Agency (United Kingdom), the World Bank, and the UN Development Program, among others, provide the means to share project examples, techniques, and experiences that strengthen the capabilities of the expanding community committed to creating project value by engineering with nature. The current range of activities supporting the use of Natural and Nature-Based Features (NNBF) exemplifies the power of partnerships. Broadening and deepening partnerships of all kinds will be a major focus over the next five years.

Attendees at an international workshop convened by the World Bank, Deltares, UNDP, and Ecoshape in pursuit of nature-based, flood-risk reduction in Delft, Netherlands (April 2017).

Attendees at the USACE/NOAA NNBF Workshop at NOAA's Hollings Marine Laboratory in Charleston, South Carolina (March 2016).

Dr. Todd Bridges (top row, second from right) participates in a panel discussion at the Restoring Natural Infrastructure Summit organized by Caterpillar Inc. in New York City, New York (November 2015).

USACE Proving Grounds

Commitment to becoming a "EWN Proving Ground" means the district teams will actively seek opportunities to apply EWN principles and practices within their projects and programs, will document and communicate key learnings, and will serve as mentors for others interested in applying EWN. Members of the Proving Ground district teams share implementation experiences, challenges, and successes; create synergy among EWN practitioners; and continuously build and enhance EWN practices.

Wave I – Galveston District

EWN provides solutions to address shoreline slope failure along the Gulf Intracoastal Waterway (GIWW). USACE maintains the GIWW through a combination of traditional and EWN approaches, working as often as possible to implement EWN measures with non-federal partners along the entire Texas Coast.

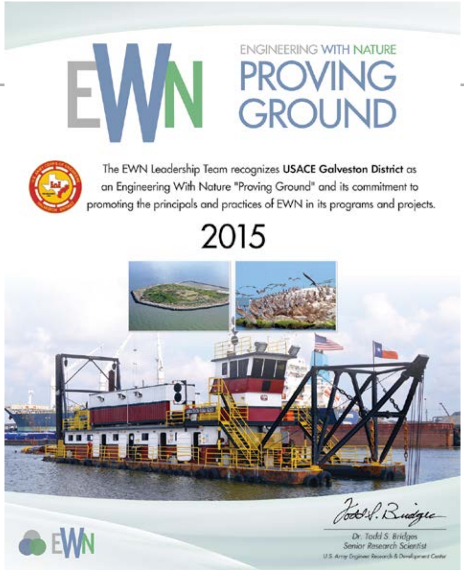
In October 2014, Galveston District was recognized as the first USACE district to become an EWN Proving Ground. The district has integrated EWN principles and practices into its business practices, projects and programs. The Coastal Texas Protection and Restoration Study is an excellent example of a large planning project that incorporates EWN strategies, and practices to achieve Navigation, Flood Risk Management, and Ecosystem Restoration outcomes that benefit the Nation.

Bolivar Marsh beneficial use cells. USACE Galveston District manages dredged material in these cells to create aquatic habitat and provide protection to the adjacent waterway and other structures.

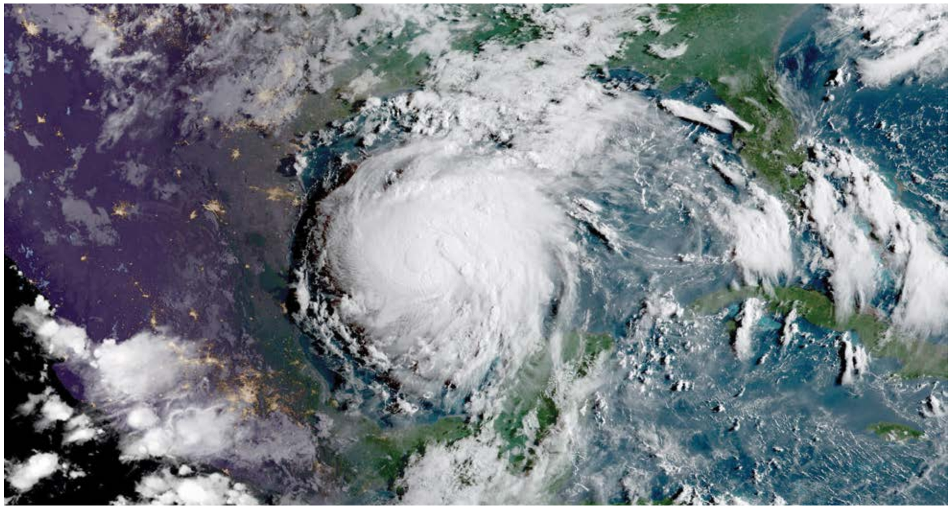
The Galveston Team is focused on initiating and/or completing several EWN projects in the next five years. Two such projects include the Houston Ship Channel Deferred Environmental Restoration Plan and the Galveston Bay Bottom Restoration Plan. The Houston Ship Channel project will use nature-based features to expand dredged material management areas close to the navigation channel. The Galveston Bay Bottom Restoration Project will support the restoration of areas historically mined for oyster shells in the Galveston Bay using dredged material. Both projects incorporate EWN elements and will deliver outcomes that support significant engineering and ecosystem service benefits.

Galveston District exemplifies the partnering and collaboration that are key to the EWN approach. Shared visioning and steering of project design, planning, and construction have been successfully incorporated to identify, reduce, and mitigate potential barriers to progress and accelerate completion of projects. The Coastal Science and Engineering Collaborative (CSEC) is another example of collaboration in action. Within the CSEC, multiple partner organizations, such as the Texas General Land Office (TGLO) and Texas A&M University, work with USACE to leverage resources, capabilities, and funding. Engagement within the CSEC has resulted in the development of innovative EWN projects and the pursuit of research initiatives that will ultimately create sustainable engineering and ecosystem service benefits along the Texas coast.

In the future, the district will leverage its growing EWN portfolio and the CSEC to accelerate the transfer of new knowledge into practice, delivering science and engineering that improve coastal project performance and resilience, while reducing cost. Future EWN projects and associated applications, developed in Galveston and promoted within the CSEC, will also link academia to real-world applications of science and engineering while promoting student interest in the EWN approach.



Planting undertaken in an EWN workshop demonstrates the use of plants for engineering and environmental functions.



NOAA satellite image of Hurricane Harvey.

Wave I – Buffalo District

Buffalo District became the second EWN Proving Ground in December 2014. The District has subsequently made great progress incorporating EWN principles and practices into its project planning and construction processes. Its EWN portfolio includes diverse projects that demonstrate what is possible when engineering and natural processes are intentionally aligned to create more robust environmental and social benefits. These examples include relatively simple EWN-based modifications to two breakwater projects in the Cleveland and Ashtabula Harbors. In Cleveland Harbor, design modifications focused on the standard concrete toe blocks used for breakwater maintenance. The improved design provides features that create new habitat opportunities for Great Lakes fish and invertebrates. Similarly, focused

Rubblemound breakwater, constructed as part of Braddock Bay Ecosystem Restoration Project. It was designed to allow for marsh/wetland habitat to develop along the structure over time.

repairs and improvements to a breakwater in Ashtabula Harbor based on USEPA and USACE's "green breakwater" initiative created nesting habitat for the Common Tern. These simple design modifications created benefits for fish, birds, and engineering.

The Braddock Bay Restoration Project is a multi-partner, ecosystem restoration project to restore and protect Braddock Bay's coastal wetlands. Constructed in 2016 and 2017, the project includes restoring wetland habitat, treatment for invasive species, and improving the coastal resiliency of existing wetlands. This has been accomplished, in

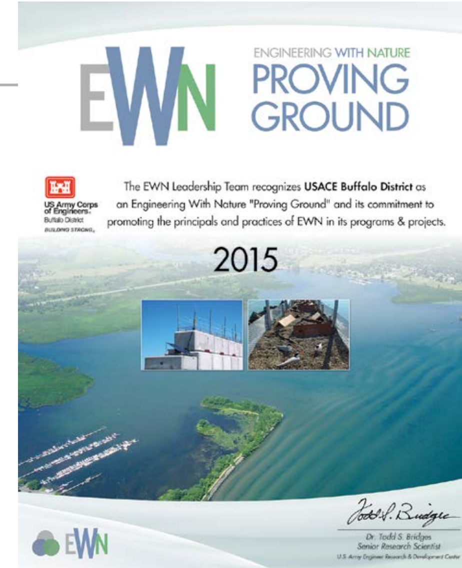
Armor stone repair of a breakwater in Ashtabula Harbor, OH. The project included creating nesting habitat at the top of the structure for the locally-threatened Common Tern.

The addition of Tern habitat was included in conjunction with routine maintenance activities on the breakwater. With this harbor protection project, Buffalo District achieved greater benefits by applying EWN practices.

Predator/competitor exclusion cables are part of the design. Tern decoys are used to attract passing terns to chick shelters installed at the site.

part, by augmenting a stone breakwater with nature-based features that ultimately promote the formation of a barrier beach, which mimics the historical natural barrier beach at this location. In turn, the barrier has reduced erosion and generated a secondary benefit of restoring natural littoral drift processes. In addition to the restoration of wetlands and aquatic habitat, the commercial fishery will also benefit greatly from this project. The U.S. Environmental Protection Agency (USEPA) worked collaboratively with the Buffalo District to develop and complete the project. The town of Greece, NY, and the New York State Department of Conservation also supported the implementation of the project. Collectively, these EWN projects exemplify the "triple-win" outcomes made possible through this approach. As Buffalo District continues to expand its EWN portfolio, the team will work to identify new and strategic endeavors, including NNBF additions along the Lake Ontario shoreline.

Integral to Buffalo District's success with EWN projects is the collaborative approach. Early partnering with federal agencies, such as the U.S. Geological Survey (USGS), NOAA, and USEPA has been critical to achieving the desired EWN outcomes.



Given the strategic importance of the Great Lakes, Buffalo District is looking to expand collaboration to include state partners and NGOs such as the Healing Our Waters coalition, the Great Lakes Commission, and the Great Lakes Fisheries Commission. In fact, positive experience with EWN collaborations in the Great Lakes has revealed the value of a Regional Proving Ground that integrates the opportunities and capabilities of multiple organizations.

Wave I – Philadelphia District

Aerial photo of Mordecai Island in Beach Haven, NJ, following placement of dredged material beneficially used to reconnect the island segments.

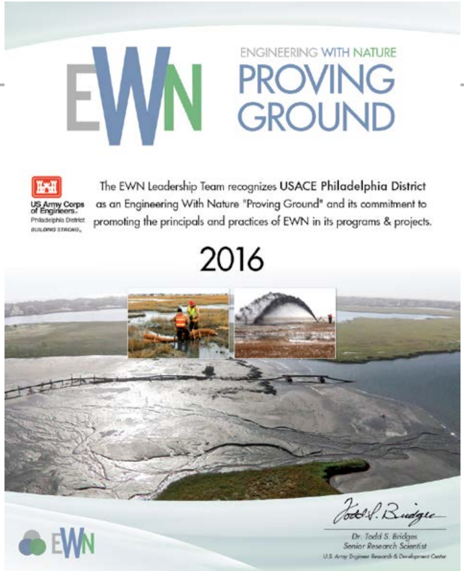
Project engineers discuss placement of sediment on Mordecai Island. This project restored a contiguous island with historical elevations and contours. The island now offers storm protection to an adjacent community; bird nesting habitat, and other ecosystem services have also been created.

In June 2016, Philadelphia District became the third EWN Proving Ground. In the years following the devastating impacts of Hurricane Sandy, the district and its partners gained momentum and regional cooperation in the pursuit of improving coastal resilience, enhancing ecosystems, and adopting natural infrastructure solutions. The district team has continued to evolve its business model to incorporate EWN principles and practices.

Success as an EWN Proving Ground has been achieved on many fronts. For example, thin-layer placement (TLP), which the Philadelphia District has used as an alternative method for relocating maintenance dredged material from navigation channels, offers a revolutionary approach along the Atlantic Coast. With this approach, the district was able to restore navigation along critical stretches of waterways while incorporating flood risk management benefits and enhancing ecosystems in nearby coastal wetlands. Examples of EWN success stories include the reconnection of Mordecai Island, habitat creation on Ring Island, and the restoration of degraded marshes in Avalon, NJ. These projects exemplify the adoption of EWN strategies, which, given the improvements in resource agency coordination, have resulted in operational efficiencies and the broadening of project benefits to include social and environmental outcomes.

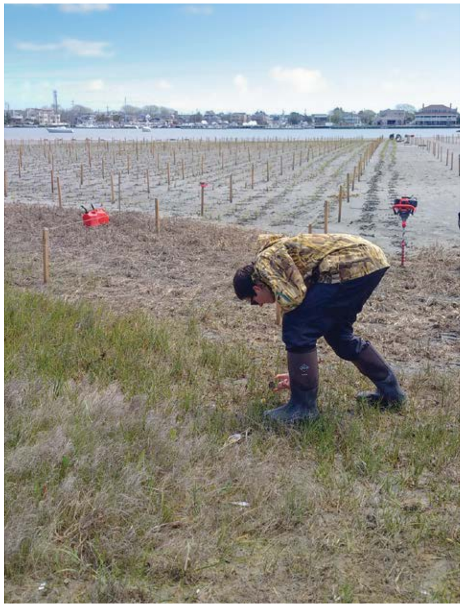
As an EWN Proving Ground, Philadelphia District and partners now work with other USACE districts and interested organizations to develop EWN strategies for similar project initiatives around the country. The team continues to incorporate new EWN practices as they pursue innovative engineering solutions on near-term projects. Future EWN projects include placement of additional dredged material on adjacent islands and creating new islands, as well as the beneficial reuse of sand and planting in backfill areas that have been subject to erosion. They are also looking for EWN opportunities throughout the district including the five flood risk management reservoir projects in Pennsylvania.

Philadelphia District has demonstrated the value of proactive and ongoing engagement with a wide range of partners and stakeholders from the initial planning stages of new projects. Project partners, including the New Jersey Department of Environmental Protection, The Nature Conservancy, Green Trust Alliance, the Stone Harbor Wetlands Institute, and the Mordecai Land Trust, have collaborated to achieve outstanding project outcomes. Future EWN activities will build on these relationships and successful project results, as the team continues to monitor, develop lessons learned, and improve practices within the district.



Aerial photo of Mordecai Island, NJ

Marsh vegetation was planted to stabilize newly placed materials while enhancing ecological functions.



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Sears Point Restoration Project near San Francisco, CA, is a joint project of Sonoma Land Trust and Ducks Unlimited. The project is restoring 1000 acres of wetlands and habitat to form a large, continuous band of tidal marsh along the bayfront between Petaluma River and Tolay Creek. It will also establish a natural, wetlands-uplands transition that will benefit Federal Trust species as well as other at-risk fish and wildlife species. The EWN initiative and Sonoma Land Trust collaborated to evaluate the performance of design features that are making use of natural processes to accelerate restoration. The property is now part of the USFWS's San Pablo Bay National Wildlife Refuge, CA.

Wave II – Expanding Capabilities

Applying EWN principles and practices to water infrastructure projects requires innovation at multiple levels. The research and development community is engaged in developing new science, technologies, models, and engineering techniques that support the integration of natural systems and processes to achieve engineering objectives, as well as the use of engineered systems that support the production of ecosystem goods and services. USACE research and development programs across the mission areas of Navigation, Flood Risk Management, Ecosystem Restoration, and Water Operations are collaborating to develop a range of capabilities that support EWN. Partnering and collaborating with USACE districts on the development and application of these research products provide mechanisms for accelerating the successful transfer of these capabilities to field practice while supporting project execution and delivery.

EWN involves thinking differently about challenges and opportunities. The outdated belief that infrastructure development always occurs at the expense of nature and, conversely, that environmental considerations always constrain the development and operation of infrastructure, has been replaced by the goal of sustainable development.

Examples of EWN Across USACE Mission Space

Navigation

- Strategic placement of dredged material supporting habitat development
- Habitat integrated into engineered structures
- Enhanced natural recovery of contaminated sediments

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 and connectivity

The focus now is on achieving a balanced distribution of “value creation” in projects that simultaneously support a diversity of benefits. This is achieved by providing engineering, environmental, and social benefits for multi-purpose, multi-benefit projects. As this thinking evolves, it stimulates creativity which produces new ideas and methods. People with different experience, talents, and objectives are coming together to propose new triple-win solutions.

The EWN Team prioritizes the use of structured dialogue and workshops to create the social conditions that are conducive to ideation, creation, and co-development of solutions. More than 25 EWN workshops involving a broad range of perspectives, disciplines, and organizations took place in the initiative’s first seven years. These workshops provided an invaluable approach for identifying opportunities to engineer with nature, growing the EWN community, and expanding capabilities to deliver better projects. The workshops are key to technology transfer and the adoption of this holistic approach.

The EWN research at Hamilton Wetlands, CA, is evaluating the use of engineering actions that harness natural process in order to accelerate restoration. The pontoon boat was used to construct platforms and extract sediment core samples to measure erosion.

One of the four platforms in Hamilton Wetlands that measure water elevation, turbidity, water temperature, water conductivity, velocity, wave height, wave period, and bed elevation. The instruments are powered by solar panels.

Wave II – Expanding Capabilities

NOAA Engagement ▼

USACE and NOAA will continue to collaborate in diverse ways that advance capabilities and achieve multiple outcomes. The agencies have a shared interest in the use of NNBF to support coastal resilience and sustainability, including the production of economic/engineering, social/community, and ecosystem/environmental services. In March 2016, USACE and NOAA co-organized a workshop to identify opportunities to work together to advance NNBF practice, which included field demonstration projects and joint research activities. USACE and NOAA-National Marine Fisheries Service (NMFS) held a workshop in October 2016 to identify EWN opportunities that support infrastructure development and operations, as well as fish and natural resource habitats. These and other USACE and NOAA engagements are leveraging resources and expertise within the two agencies, expanding capabilities, and broadening the reach of EWN practices.

NOAA staff collect benthic samples off Mordecai Island, NJ, to assess environmental benefits from the beneficial use of dredged sediment to restore the island.

An EWN workshop brought people together from multiple organizations around Galveston Bay, TX. The workshop focused on opportunities to use plants to accomplish restoration and engineering objectives.

Engineering With Nature Using Native Plant Communities ▲

In 2014, USACE published *Engineering With Nature Using Native Plant Communities* on the use of native plants to engineer with nature. The guide provides information on the rich history of using native plant communities to shape landscapes, support engineering and architectural purposes, and provide a range of ecosystem goods and services. Case examples highlight opportunities to use native plants to produce a range of outcomes, and methods and tools are provided to support project managers. Around the US, research and field demonstrations are being conducted to expand capabilities related to the engineering of nature-based features and the development of sustainable dredged material placement areas. Current demonstration projects are underway at the Blue Lake Marsh at Delaware Seashore State Park and at demonstration sites at Chocolate Bay and Galveston Bay along the Texas coast.

Field site visit to NNBF project at Alkborough, UK.

International Natural and Nature-Based Features Guidelines ▲

Beginning in 2016, USACE organized a group of more than 20 government, academic, and private sector organizations from several countries to collaborate in developing international guidelines on the use of NNBF to support both coastal and fluvial systems. There is significant interest and a growing knowledge base focused on the use of NNBF to achieve both engineering and environmental goals. International experience on field-scale projects, research, and policy development has been integrated through this collaborative effort to support sustainable, nature-based infrastructure around the world. The NNBF Guidelines are scheduled for publication in 2020.

EWN Guide ▶

Incorporating EWN principles and practices into water resources and infrastructure projects requires a diversity of perspectives and expertise that spans the range of science, engineering, and social systems. A practical *EWN Guide* for project teams is being developed that identifies how the needed perspectives and expertise can be efficiently integrated to support the planning, engineering, and operation of water resources projects.

EWN Implementation Process

- Step 1 — EWN Opportunity Initiation
- Step 2 — EWN Opportunity Evaluation
- Step 3 — EWN Project Delivery
- Step 4 — EWN Project Evaluation

Social Benefits Produced through Synergy with Landscape Architecture ▼

A fundamental goal of EWN is to expand the benefits and services provided by water resources projects. While the primary justification for a Navigation or Flood Risk Management project is economic (for example, economic productivity related to the movement of commercial goods or to avoid flood damages), these projects can produce a range of other benefits, such as habitat for wildlife. Important social benefits, including recreation, educational opportunities, and community resilience, are also possible when projects are designed and operated so that people can interact with the project.

Connecting people to constructed landscapes lies at the heart of the landscape architecture (LA) practice. In July 2017, the USACE hosted an EWN collaborative workshop with academic and private LA practitioners to begin a dialogue focused on expanding capabilities and project benefits produced through the dynamic interplay of environmental and social systems. Workshops like this expand EWN applications through the synergy of complementary concepts, methods, and tools.

The Noordwaard Project in the Netherlands integrates agriculture, wildlife habitat, and recreation in a 10,000-acre landscape that provides flood storage capacity, environmental, and social benefits.

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A bird island created in a dredged material containment area (DMCA) managed by Savannah District, GA. The island provides nesting habitat in a DMCA that is not currently in use. Strategic management of seven active DMCAs achieves engineering requirements while generating numerous environmental benefits.

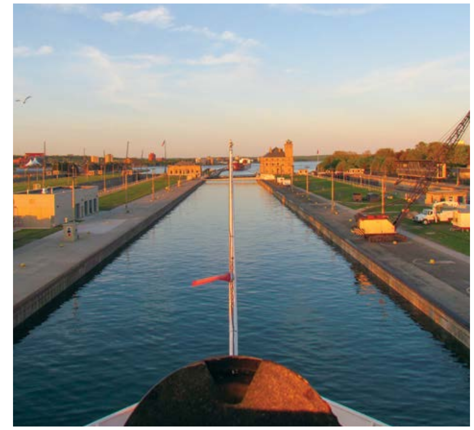
Wave III – Expanding Applications and Communication

The acceptance of EWN principles and practices as the standard approach for developing water resources projects is a key objective of the initiative. There are many excellent examples where economic, engineering, environmental, and social objectives have been integrated within USACE projects and those of other organizations. One overarching goal of the EWN initiative is to make these exceptional projects commonplace by sharing cases and supporting practices that expand project benefits. In most cases, these demonstrations involve trying something new. Innovation always requires buy-in across the team, including from decision-makers, and stakeholders. This buy-in involves accepting the risks that are inherently associated with a new approach and/or doing things differently. The tradeoff for assessing and managing risks is a better project with more benefits, innovative applications, and expanded capabilities that can be applied elsewhere. Documenting and communicating case studies and sharing these project "stories" is critical to building capacity and sustaining progress within organizations and the EWN community-at-large.

Water resources projects, regardless of the nature of their original motivation or justification, have the potential to produce multiple benefits. For example, dredged material from a navigation project can be used to construct a nature-based feature that significantly reduces flood risk, while also providing wildlife habitat. Recognizing opportunities to produce tangible "triple-win" results like this is critical to broadening and deepening the application of EWN.

Significant progress in developing multi-purpose projects through EWN can be made by leveraging the authorities, assets, expertise, and perspectives of others. Progress can and should be made within individual organizations to fully use and integrate their existing authorities and means to engineer with nature. There are also substantial opportunities to leverage the authorities, assets, and resources among government agencies and with the private sector. Ongoing collaboration between USACE and NOAA demonstrates the power of such leverage. The collaboration between USACE and the Natural Infrastructure Initiative, led by Caterpillar Inc., is working to develop the means to focus private and public investment in natural infrastructure.

In addition to expanding the value of individual projects, more attention is being given to the relationships and contributions made by the network of projects and actions undertaken at the system scale. For example, a given coastline, river or watershed could include dozens of individual projects that were built by multiple government and private organizations over many years to serve a variety of individual purposes. When addressed as a system, the benefits of these larger-scale efforts can be significant. Project teams should consider the potential of the entire network to "efficiently and sustainably deliver economic, environmental, and social benefits through collaboration."



Picture from bow of ship as it travels through the Soo Locks, MI.

An EWN information display at the Soo Locks Visitor Center on the St. Mary's River, MI, between Lake Superior and Lake Huron. The Soo Locks EWN Project is helping to support fish habitat development in association with Lock operations.

Engineering With Nature to Create Horseshoe Bend Island on the Atchafalaya River, LA ▼

Horseshoe Bend Island, LA.

Changes in dredging practices at Horseshoe Bend Island on the Atchafalaya River, LA, in the late 1990s came about due to a lack of feasible sites to create additional wetlands along the river banks. USACE New Orleans District team members determined they could "partner" with the river to create a mid-river-island-wetland habitat by placing dredged material from the navigation channel in a position just upstream of an existing shoal. Over more than a decade, this modified dredging practice created Horseshoe Bend Island, a diverse, approximately 100-acre wetland-island complex that is producing a broad range of ecosystem and engineering services. The mid-river feature has resulted in a more efficient navigation channel that shortens the transit distance of commercial traffic and also transports sediment more efficiently, which has substantially reduced dredging costs.

As mentioned on page 5, this EWN project has received numerous awards. Several papers written on different aspects of the project are available on the EWN website.

Working in the Back Bay: Avalon and Ring Island, NJ ▼

USACE Philadelphia District and the EWN initiative partnered with the State of New Jersey and others to leverage the Navigation program to enhance the resilience of New Jersey's Back Bay. Sediment dredged from the New Jersey Intracoastal Waterway has been used since 2013 in a series of projects to address degraded conditions and habitats. Approximately 50,000 cubic yards of sediment from the waterway were used to enhance wetlands at Avalon, which provide habitat and also serve to buffer waves for the boroughs immediately adjacent to Avalon. Sand dredged from the waterway was also used to create two acres of habitat for Black Skimmer and other valued birds on Ring Island, NJ. This thin-layer placement technique demonstrates how sediment can be used to create additional elevation for existing habitat and coastal resilience.

Thin-layer placement of sediment at Avalon, NJ.

Natural and Nature-Based Features (NNBF) and the North Atlantic Coast Comprehensive Study (NACCS)

In 2012, Hurricane Sandy produced widespread damage along the East Coast of the US and elsewhere. The success of NNBF projects during the storm focused attention on the opportunity to make wider use of NNBF as a part of a systems-scale approach to enhancing coastal resilience. The NACCS, led by USACE, included a large effort involving more than 25 scientists and engineers, and support from many organizations to develop concepts, processes, and a framework to support the development and use of NNBF. This effort, among others, has stimulated a range of activities, including new research within USACE and other organizations, and the development of international guidelines on the use of NNBF.

Engineering With Nature for Coastal Resilience: Hamilton and Sears Point, CA ▼

Researchers place a bentonite clay layer on top of the surface of the inter-tidal zone in Hamilton Wetlands, CA. Using coring techniques, the researchers will test and calculate the rate of future sediment accretion on top of the bentonite.

The current conditions in San Francisco Bay, CA, are the consequence of more than 150 years of modifications to freshwater discharge rates, sediment processes, and shoreline development. Shoreline diking, used for a range of purposes, is one historical source of wetland loss in the Bay. Several current and proposed restoration projects in the Bay are using dike breaching to reconnect historical wetland and aquatic areas with the Bay through the influence of tidal flooding. Two such projects, Hamilton Wetlands and Sears Point, are part of an EWN research project that represents a partnership between the EWN initiative, the USACE San Francisco District, and Sonoma Land Trust, a regional NGO. The EWN project will inform the broader restoration efforts in San Francisco Bay, contributing to the potential success of the growing San Francisco Bay National Wildlife Refuge Complex, of which Sears Point is now a part. The purpose of the EWN project is to apply and enhance the capability to monitor—in real time—and model the physical forces affecting sediment accretion in the restoration areas. In turn, results from these activities will help decision-makers ascertain the effectiveness of alternative designs for innovative sub-tidal sediment structures that are intended to accelerate sediment accretion and habitat restoration.

Enhancing the Environmental Value of Conventional Infrastructure ▼

Breakwater in Ashtabula Harbor, OH.

The EWN initiative, the Buffalo District Proving Ground, NY, and regional partners are successfully enhancing the habitat value of existing navigation infrastructure in the Great Lakes Region during repair and rehabilitation efforts. Through partnerships with USEPA's Great Lakes Restoration Initiative, The Nature Conservancy, and other organizations, the diverse EWN Team has successfully demonstrated how to incorporate ecological habitat functions in the form of: (1) modified breakwater blocks to accommodate Common Tern nesting habitat in Ashtabula Harbor, OH; (2) modified breakwater block surface textures to facilitate benthic community development in Cleveland Harbor, OH; and (3) the use of small stone to provide suitable habitat for valued fish and other aquatic species in Milwaukee Harbor, WI. This focus on identifying regional opportunities for EWN is exemplified by the Soo Locks project, which is enhancing fish habitat in conjunction with upgrades made to compensation gates, through partnerships between the USACE Detroit District, the Great Lakes Restoration Initiative program, the International Joint Commission, and the EWN initiative.

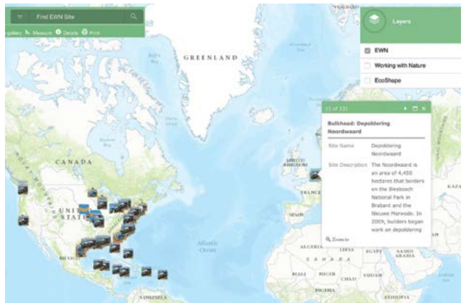
Wave III – Resources

EWN Website

The EWN website **engineeringwithnature.org** is a key tool for expanding the application of EWN around the world. The website has been structured to provide users with general information as well as guidance for EWN approaches. The information provided on the site includes insight on current R&D activities, projects and initiatives, links to applicable tools, and announcements for potential collaboration opportunities. News and information regarding upcoming conferences and workshops is presented along with access to past briefings and publications. The products of EWN projects, including project updates, workshop reports, technical notes, and technical reports are also available to download.

Over the next five years, the website will be expanded to showcase the growing number of EWN projects and partnerships.

EWN ProMap



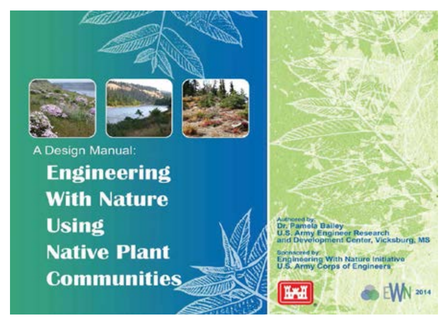
The EWN Project Mapper (EWN ProMap) is a geography-based data viewer that enables users to explore information about demonstration and full-scale projects that illustrate the principles, practices, and major elements of EWN. By reviewing archived project data, practitioners can obtain information to help plan, design, and construct their own projects. Projects can be viewed on a map according to infrastructure type (e.g., dredging-based application, breakwater, lock and dam), or by their intended environmental or social benefits.

More than 200 projects are displayed on EWN ProMap, and the database is currently being expanded to include projects from Ecoshape's Building with Nature Program in the Netherlands – https://www.ecoshape.org/en/. Projects that have been certified as Working with Nature (WwN) projects by PIANC are also being incorporated into the database. PIANC is using its Working with Nature philosophy to promote sustainable navigation infrastructure projects, which align well with EWN principles.

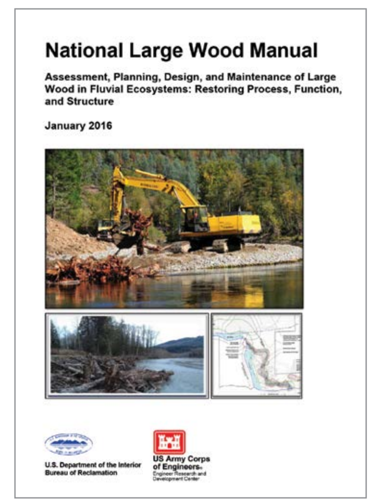
EWN Products and Resources

A range of products and resources that support EWN have been produced, often in collaboration with partners. The following publications are some examples:

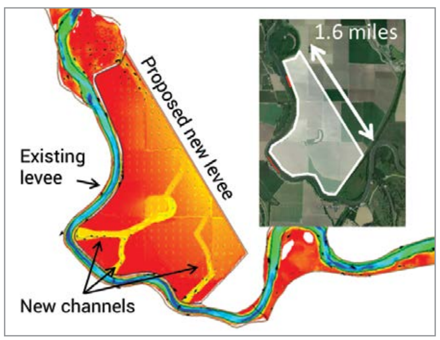
- **Engineering With Nature Using Native Plant Communities:** This design manual describes how to use plant communities to support restoration and engineering objectives to create more sustainable landscapes. The manual identifies sources of information about native plants to accomplish multiple purposes and presents case studies illustrating the value of integrating native plants as a part of design and infrastructure development.



- **National Large Wood Manual:** Historically, the presence of large wood in rivers played a significant role in the development, dynamics, and functions of rivers. This national manual provides guidelines for the planning, design, placement, and maintenance of large wood in rivers to restore process and function, including engineering and ecosystem functions. This resource was developed through a partnership and collaboration between USACE and the US Bureau of Reclamation (BoR) that was supported by the EWN initiative and other programs within USACE and BoR.



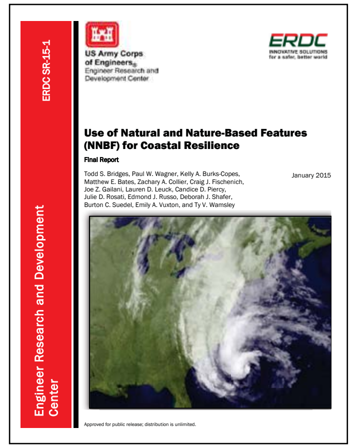
- **Levee Setbacks: An Innovative, Cost-Effective, and Sustainable Solution for Improved Flood Risk Management:** Levee setbacks (moving levees back from the river channel) represent an approach for reducing flood risks while also producing environmental benefits consistent with EWN, USACE Environmental Operating Principles, and the USACE Resilience Initiative Roadmap. The report reviews and discusses levee setback practice and provides case study examples that illustrate opportunities, challenges, and practices.



- **Strategic Placement of Sediment for Engineering and Environmental Benefit:** This technical report offers details regarding the strategic placement of dredged material to support multiple purposes, including NNBF. Strategic placement is the process of placing sediment at one location so that natural processes (e.g., hydrodynamics) will transport specified classes of sediment to other desired locations. When consistent with local conditions and project objectives, strategic placement can represent a cheaper, more environmentally sensitive method for using dredged material beneficially, compared to direct placement.

Sand Motor Project illustrating strategic sediment placement in the Netherlands.

- **North Atlantic Coastal Comprehensive Study (NACCS)-Use of NNBF for Coastal Resilience:** This report offers details regarding the use of NNBF to improve coastal resilience, and was designed to support post-Hurricane Sandy recovery efforts under the NACCS. The report presents an integrative framework and approach for classifying NNBF, characterizing vulnerability, developing performance metrics, incorporating regional sediment management, monitoring and adaptively managing from a systems perspective, and addressing key policy challenges.



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

Final Report

Todd S. Bridges, Paul W. Wagner, Kelly A. Burks-Copes, Matthew E. Bates, Zachary A. Collier, Craig J. Fischenich, Joe Z. Gailani, Lauren D. Leuck, Candice D. Piercy, Julie D. Rosati, Edmond J. Russo, Deborah J. Shafer, Burton C. Suedel, Emily A. Vuxton, and Ty V. Wamsley

January 2015

Engineer Research and Development Center

Approved for public release; distribution is unlimited.

Future Resources

Ongoing EWN research and development, and project results will lead to more capabilities and resources over the next five years. Technology transfer of EWN-based knowledge, tools, and products will also expand its application in new and exciting ways. Ultimately, the experience and evidence gained from project outcomes will accelerate the development of policies, guidance, and best practices that support EWN and the missions of participating organizations. In turn, this will influence the organizational priorities that guide their people and programs toward sustainable practice.

Data collection at a wetland restoration site in San Francisco Bay, CA.

6

Golden Plover feeding at a DMCA managed by USACE Savannah District, GA. Savannah District's management cycle of DMCAs allows for maintenance dredging of the Savannah Harbor while also providing bird habitat.

Governance and Path Forward

Since its inception, the EWN initiative has received considerable attention as interested practitioners and stakeholders seek to identify more sustainable solutions for their engineering needs and challenges. This interest has grown substantially to include proponents at both the national and international level. Consequently, the EWN Leadership Team determined that the initiative's governance should evolve to facilitate broader and deeper engagement.

The new structure and process will support the interests, needs, priorities, and recommendations of a large and growing number of partners and stakeholders.

Execution of the 2018-2023 EWN Strategic Plan will be guided by a Steering Team made up of leaders from USACE. As EWN grows, individuals from partner organizations will be added to the Team. The Steering Team's primary responsibility will be to provide overall direction and decision-making in support of the EWN initiative.

Updates to the governance structure will further enable and support implementation and expansion of EWN.

An EWN Advisory Committee comprised of leaders, scientists, researchers, and practitioners from USACE and partner and stakeholder organizations will provide individual recommendations to the Steering Team on opportunities for advancing EWN.

To support the EWN Initiative, a Secretariat will be established. Its role will be to support the implementation of the EWN Strategy by ensuring that regular meetings of the Steering Team and the Advisory Committee are appropriately designed, facilitated, and documented.

The new governance structure will enable public and private organizations, stakeholders, and organizations across USACE to provide input to the Steering Team about priorities within the EWN portfolio, including project and research opportunities that should be explored. The new structure will increase the diversity of organizations and perspectives contributing input to the EWN initiative as it continues to grow and evolve.

By engaging this broad community of interests, the EWN initiative will be well positioned to achieve its Vision:

"Expanding the application of EWN by integrating its approaches into the priorities and practices of USACE, partner organizations and stakeholders while actively delivering, demonstrating, and communicating its interconnected benefits to society, the environment and the economy".

Egret feeding in the Chincoteague National Wildlife Refuge, VA. The bird is standing on a guy-wire anchor that is used to stabilize a power pole. The recent road and power pole alignment was coupled with the creation of a shallow water habitat derived from the road berms.

For more information, please go to **www.engineeringwithnature.org**

The EWN Steering Team thanks all who contributed case studies and photos from their EWN field work.