USACE ENGINEERING WITH NATURE PROVING GROUNDS: A REVIEW OF THE PROCESS, ACHIEVEMENTS, AND LESSONS LEARNED

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ABSTRACT

The Engineering Research and Development Center (ERDC), part of the U.S. Army Corps of Engineers (USACE), has been championing a pioneering program called the Engineering With Nature® (EWN®) initiative, which aims to promote the use of nature-based solutions (NBS) for coastal and fluvial flood risk management. As part of the EWN program, ERDC initiated a proving ground (PG) concept under which USACE districts and divisions may elect to prioritize, where possible, NBS pilot tests or projects, gather data, and improve upon existing EWN tools and techniques. This paper provides a review of the EWN PG process and key lessons learned.

INTRODUCTION

The EWN and Beneficial Use (BU) programs are critical to USACE and ERDC's mission to develop sustainable civil works projects and provide technical direction to USACE districts around the nation. The EWN program is based on using the principles of NBS, where feasible, to advance sediment management and related infrastructure measures arising from USACE's Civil Works mission, specifically navigation. In order to advance the implementation of EWN across the enterprise, USACE has a handful of districts that have self-nominated to function as "proving grounds," where innovative projects and initiatives can be pilot-tested. This paper is a companion document to a panel discussion being held at the 2024 WEDA Dredging Summit & Expo in Tampa, Florida, that examines the process, initiatives, and lessons learned from four regions: the Great Lakes districts (Chicago, Detroit, and Buffalo), the Philadelphia District, the Mobile District, and the San Francisco District. EWN techniques were developed as part of ongoing district projects as well as new system- and decadal-scale projects (to "move the needle"). EWN techniques included wetland restoration and creation, sediment dispersion cells, littoral drift management methods, natural solutions for back-bay storm protection, innovative confined disposal facility (CDF) reuse concepts, environmental justice-based flood control projects, nature-based levee designs, strategic sediment placement, sediment injection, bay-to-creek connectivity projects, beach fan deltas, innovative dune designs, island and reef restoration projects, and others.

Keywords: Dredging, beneficial use, regional sediment management, coastal resilience, natural and nature-based features.

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BACKGROUND

EWN is the intentional alignment of natural and engineering processes to efficiently and sustainably deliver economic, environmental, and social benefits through collaboration. There are four key elements to EWN: (1) using science and engineering to produce operational efficiencies; (2) using natural process for maximum benefit; (3) broadening the range of benefits provided by a project; and (4) working collaboratively across organizations and perspectives. The objective of the EWN PGs effort is to foster the continued development of EWN and BU programs throughout USACE via targeted centers of expertise that can function as "proving grounds" for project development and implementation. These EWN PGs can then advise other USACE districts and staff on key aspects of EWN and NBS (also known as natural and nature-based features [NNBF]) project formulation, planning, engineering, design, construction, and monitoring. The EWN PGs thus function as technology deployment centers from where best management practices and key lessons learned can be knowledge-shared with other USACE districts.

USACE, as an agency, has always been the pioneer in terms of leadership in promoting innovative and sustainable environmental solutions, particularly when it comes to the ocean and coastal environment (USACE 2023a). The USACE Chief of Engineers recently released a command philosophy notice outlining a goal of beneficially using at least 70% of all dredged material (DM) that USACE dredges in the United States (as part of its civil works and navigation mission) by the year 2030 (known as the 70/30 goal; USACE 2023b). The Chief's Beneficial Uses of Dredged Sediment (BUDM) vision emphasizes three key tenets: (1) DM is a valuable resource; (2) there are opportunities to expand BUDM within the federal standard and (3) strategic collaborative partnering is the key to success. Achieving enterprise wide BUDM requires multistakeholder collaboration comprising strong partnerships and teamwork, especially to overcome potential barriers (Ousley et al. 2024; Lopes 2023). The EWN initiative led by ERDC provides an ideal way to combine sustainable sediment management as part of NBS while protecting the increasing vulnerabilities of our coastal regions.

EWN PROVING GROUNDS

The EWN and NNBF programs are critical to USACE's and ERDC's mission to provide technical direction and guidance to USACE districts around the nation. The ERDC EWN program, based on science and engineering, produces operational efficiencies; uses natural processes for maximum benefit; increases diversity of infrastructure value; and uses science-based collaboration to organize and focus interests, stakeholders, and partners. Due to the emerging nature of EWN and NBS (also known as NNBF), there is a need for guidance for the practitioners, including USACE staff. Some of the common questions associated with EWN include (1) how to develop EWN projects as part of civil works projects; (2) what are the available EWN and NBS tools that can be incorporated into USACE projects; (3) lessons learned and data from existing or past EWN projects; (4) how to design EWN projects, particularly regarding the design and performance criteria and standards; and (5) how to monitor and maintain such projects.

To address these questions and to provide proof-of-concept for USACE-wide EWN project implementation, ERDC and USACE selected a handful of districts and divisions to serve as EWN PGs. Existing PGs include the following:

- Buffalo District
- Philadelphia District
- Mobile District
- St. Louis District
- San Francisco District
- South Atlantic Division
- South Pacific Division

Additional districts and divisions will be added to the program in future years as the program evolves.

EWN PROVING GROUNDS: PROJECT IDEAS DEVELOPMENT PROCESS

As part of the EWN PG program, ERDC initiated a project ideas handbook (PIH) project in 2022 to further advance collaboration and engagement with the districts. The project goal was to promote selection and appropriation of large-scale, regional EWN projects for advancement and construction, focusing on geographic (landscape) diversity, systemwide and decadal-scale benefits, and innovative tools and techniques. The ambitious project goal required an interdisciplinary approach involving close collaboration between engineers, landscape architects, districts, and local partners. Anchor QEA partnered with the Dredge Research Collaborative (DRC; a consortium of landscape architects from the University of Pennsylvania, the University of Virginia, and Auburn University) to implement the PIH project. The DRC/Anchor QEA team worked in close collaboration with ERDC and USACE to implement this project. As part of its first phase, our team worked with the following districts: San Francisco (California), Philadelphia (Pennsylvania), Chicago (Illinois), Buffalo (New York), Detroit (Michigan), and Mobile (Alabama).

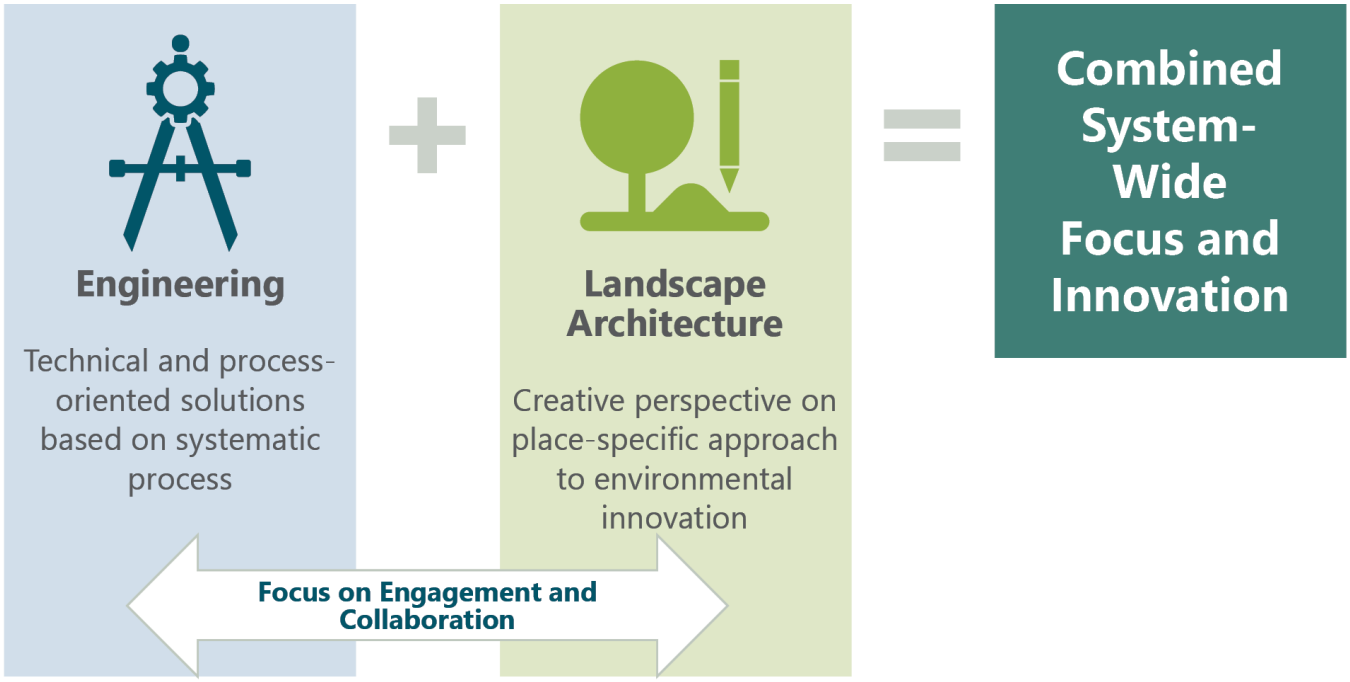

Figure 1. Interdisciplinary approach to EWN PIH project development (Strevig et al. 2024).

The collaboration between engineers and landscape architects combines engineering analysis and numerical simulation capabilities (along with constructability and performance aspects) with the landscape visioning and concept development capabilities of the architect (see Figure 1). Such collaboration, especially when done early in the design process, allows for the development of unique infrastructure concepts through an iterative process of concept development, technical assessment, and refinement. Broadly, the engineers on the research team bring a precise and analytical approach based on values that can be quantified, while the landscape architects offer a synthetic approach that considers cultural values alongside environmental characteristics (Holmes et al. 2024). This collaborative integration of engineering and landscape architecture promotes a holistic alignment in developing and visualizing EWN design concepts.

As a first step in the PIH process, our team reviewed coastal settings (including coastal processes, shoreline, and ecosystem challenges), dredging and regional sediment management (RSM) considerations, and stakeholder interest in EWN and NBS projects. We provided meeting facilitation with USACE and key stakeholders to gather input on potential projects and to learn from past and ongoing projects. Based on the meetings, we developed concept-level designs for various EWN and NBS options to be incorporated as part of planned USACE projects, as well as potential new (decadal-scale) EWN opportunities. Throughout the process, close coordination with district leadership (including project managers) was maintained so that local preferences were always considered as part of

the project development process. Where required, concepts were modeled (using hydrodynamic or sediment transport models) to simulate field processes to gauge if the EWN techniques would work as envisioned in the field. A summary of the project development process is presented in Figure 2, essentially consisting of three main steps, the first two of which are 1) close coordination with districts to identify the landscape characteristics, challenges, and opportunities; and 2) identification of "needle-mover" projects—i.e., impactful EWN projects that consider systemwide concepts and RSM, have decadal-scale influence, and use or test innovative EWN tools. Once that step is completed with a particular district, we then move on to the concept design phase shown in Figure 3.

In the concept design phase, the team meets to brainstorm concepts and ideas and develops preliminary design ideas for various coastal units or regions of similar characteristics. Various ideas developed through such a brainstorming session can be combined, if needed, to develop optimal design plans.

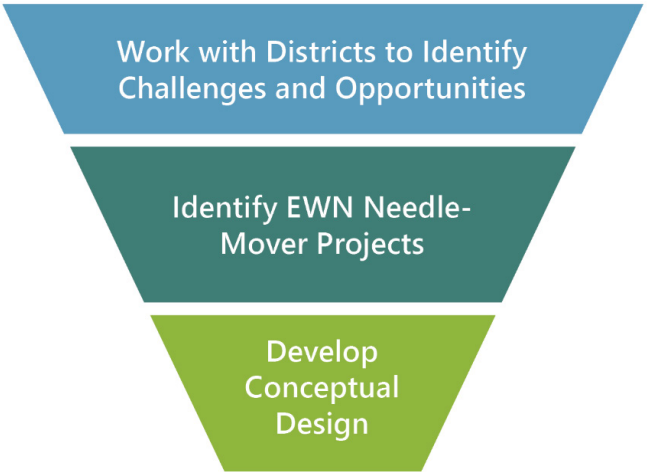

Figure 2. PIH project development process.

Figure 3. Initial PIH project concept development.

Great Lakes Region (Chicago, Detroit, and Buffalo Districts)

The USACE Great Lakes Division includes three districts—Buffalo, Chicago, and Detroit—and covers the Great Lakes states spanning from Minnesota to New York. The Great Lakes Division's primary focus includes navigation, coastal and flood risk management, and ecosystem restoration, spanning the overall basin and adjacent uplands.

To explore EWN opportunities within the division, an initial 2-day EWN concept design workshop was held at the USACE Chicago District in January 2023. Following the workshop, initial example EWN concepts for three potential coastal challenges were developed in close coordination with district staff from Buffalo, Chicago, and Detroit (see Figure 4). These concepts ranged from strategic sediment traps and lakeshore containment structures to enhance sedimentation and naturally establish a self-perpetuating marsh to provide resiliency (e.g., at Duck Creek, Wisconsin) to innovative sediment reuse facilities constructed at existing DM management facilities (e.g., at Conneaut Harbor, Lake Erie) to in-lake sediment placement and dispersion cells to feed littoral drift and compensate for shoreline erosion (e.g., eroding bluffs along Lake Michigan). These concepts were further developed with the Great Lakes districts in workshops throughout 2023. Presentations to the districts and state-level stakeholders included a meeting in February 2024 with 15 state and local representatives for the Duck Creek project, whose design concept is presented in Figure 5. Initial wave and hydrodynamic models were developed to aid the districts and state partners in considering the potential of the techniques enabled by an EWN approach. Project development efforts and stakeholder meetings will continue through 2024 to garner additional input and develop additional considerations for a Great Lakes-specific guide ("playbook") for EWN and NNBF to improve future coastal resiliency. Details on ongoing work can be found at USACE ERDC et al. (2024a).

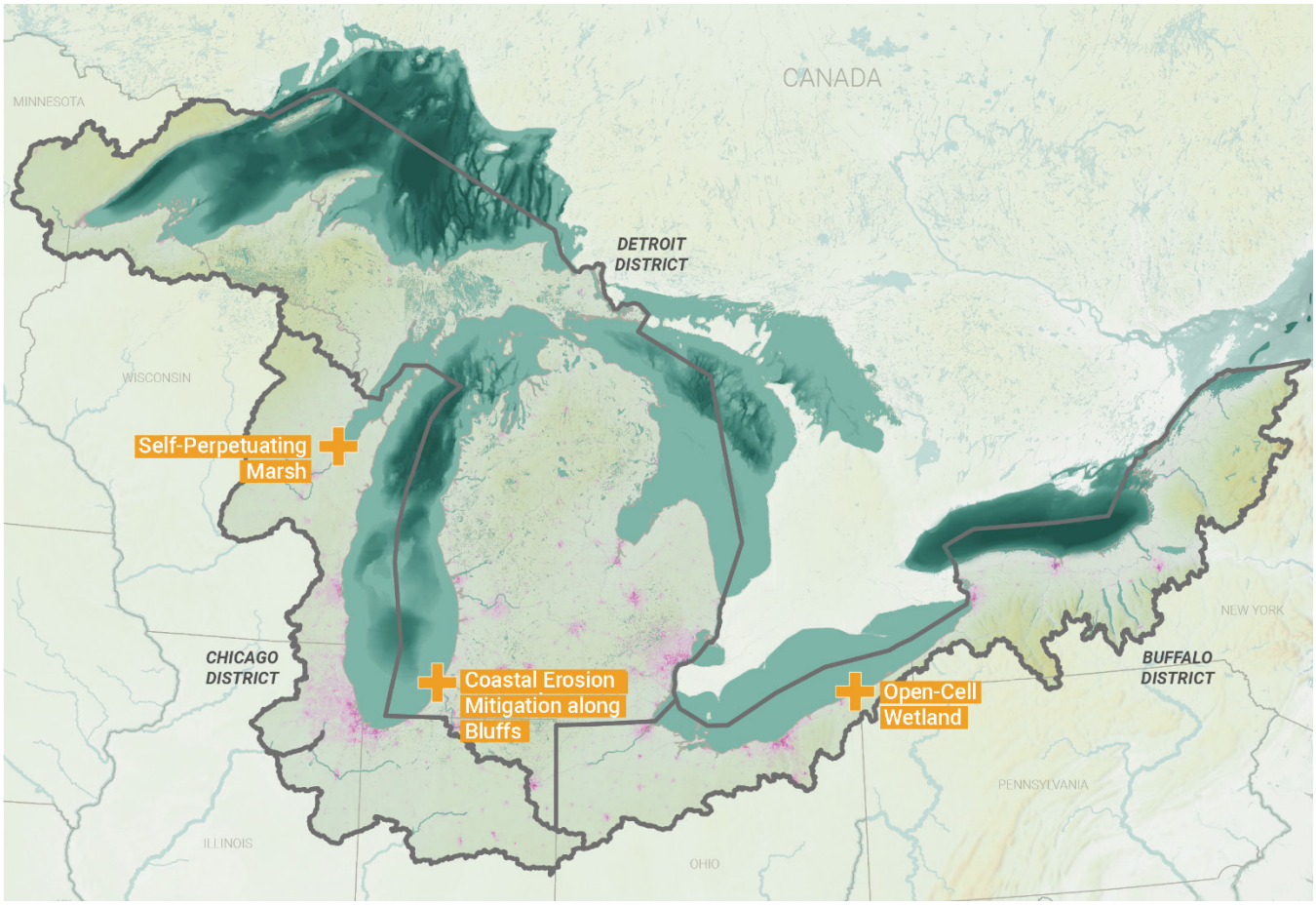

Figure 4. EWN concepts for the Great Lakes region.

Source: USACE ERDC et al. 2024a, EWN Proving Ground, Chicago District—Preliminary Concepts (Courtesy of DRC/Auburn University and Anchor QEA)

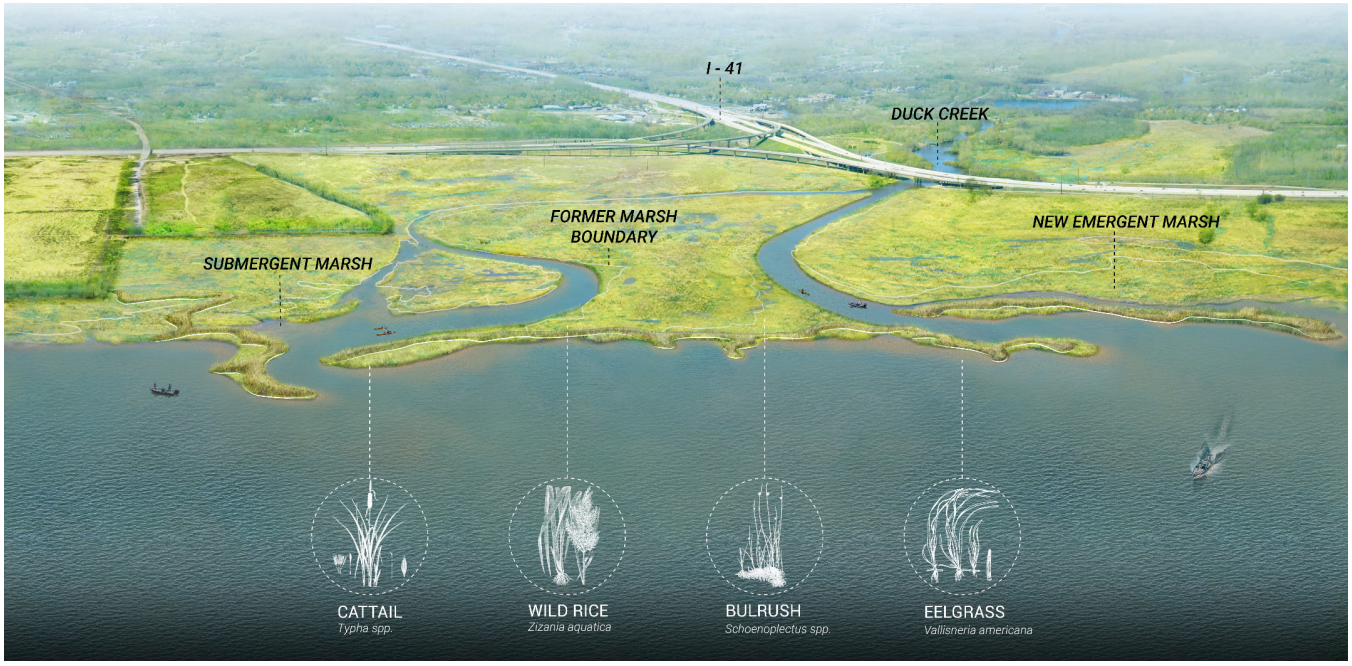

Figure 5. Illustration of Duck Creek Delta wetlands 10 to 20 years after catchment island construction.
Source: USACE ERDC et al. 2024a, EWN Proving Ground, Chicago District—Preliminary Concepts (Courtesy of DRC/Auburn University and Anchor QEA)

Philadelphia District

The USACE Philadelphia District spans approximately 550 miles of waterways, 150 miles of coastline, and 1.1 million acres of wetlands and encompasses portions of New York, Pennsylvania, New Jersey, and Delaware. As part of its navigation mission, the district dredges major rivers, coastal inlets, and the New Jersey Intracoastal Waterway and manages the placement of associated DM, often in a beneficial manner.

Given the district's mission in navigation, coastal storm and flood risk mitigation, and ecosystem restoration, coupled with its role as an active EWN PG, the district's Seven Mile Island Innovation Laboratory in New Jersey is looked upon as a premier PG for innovative EWN concepts and studies.

Several planning-level meetings were held between the project team and Philadelphia District staff to evaluate coastal challenges and EWN opportunities. Via these meetings, various ideas were explored for the coastal regions of interest that lie within the jurisdiction of the Philadelphia District (see Figure 6), including the Delaware River (urban flood protection levee in Eastwick, Pennsylvania) and Delaware Bay (BU marsh restoration along Murder Kill, Delaware; habitat-producing CDF in Cape May, New Jersey) as well as the Atlantic shorelines of New Jersey and Delaware and their respective back bays (storm surge mitigation in Holgate, New Jersey; dune resiliency research concepts for potential applications along Delaware and New Jersey coasts). For the aforementioned projects, initial conceptual-level designs were developed and shared with district staff for review and feedback. A hydrodynamic modeling analysis was also performed for the Holgate flood risk management study. Based on feedback received, concepts were finalized and presented in a technical report (USACE ERDC et al. 2024b).

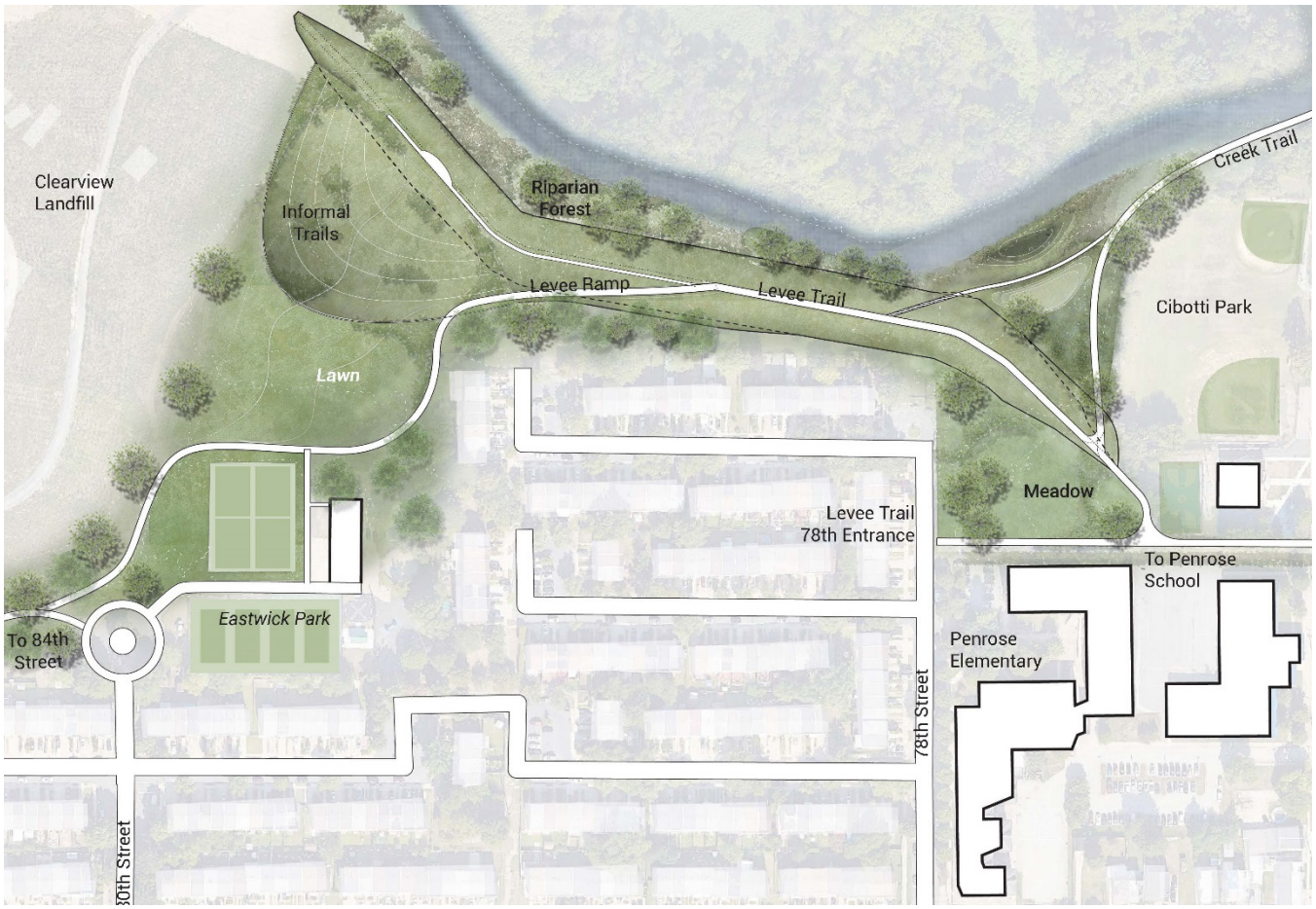

Figure 6. EWN Concepts for a Flood Control Levee (Philadelphia, Pennsylvania).
Source: USACE ERDC et al. 2024b, EWN Proving Ground, Philadelphia District—Preliminary Concepts (Courtesy of DRC/Auburn University and Anchor QEA)

Mobile District

The USACE Mobile District maintains over 2,200 miles of navigation channels and ports and several lakes and recreation areas (USACE ERDC et al. 2024c). The district has been undertaking innovative sediment management strategies along Mobile Bay for decades and is considered the Southeast's and Gulf Coast's primary regional center of expertise for BU. Several planning-level meetings were held between the project team and Mobile District staff and their stakeholders to evaluate RSM and coastal storm damage reduction challenges and to identify EWN opportunities. Through these collaborative meetings, several project ideas were developed to further advance the district's ongoing BU and EWN projects. The concepts that were evaluated to a preliminary design level of detail included Escatawpa River and Grand Bay (holistic river connectivity), Mobile Bay (BU for ecological restoration, including sediment dispersion islands and areas, beach ridges and fans, islands, and nearshore placement concepts), and Perdido Bay (choreographing natural infrastructure). Further details of these concepts can be found at USACE ERDC et al. (2024c).

Figure 7. EWN Concept for Fort Morgan Peninsula Restoration (Mobile Bay, Alabama).
Source: USACE ERDC et al. 2024c, EWN Proving Ground, Mobile District—Preliminary Concepts (Courtesy of DRC/Auburn University and Anchor QEA)

San Francisco District

The USACE San Francisco District spans 900 miles of shoreline including the San Francisco Bay, the Pacific Coast's largest estuary system. With its diverse landscape (including the abundance of estuarine wetlands within its boundaries), the district has been a West Coast pioneer in piloting and implementing EWN projects, including many innovative tools such as strategic sediment placement, and sediment mobilization concepts. Most of the BU projects led by the district span decades and have a good track record of monitoring and success. Our work with the district is summarized in the Four Coasts report (USACE ERDC et al. 2024d), which documents five projects that include innovative approaches and often span decades in their ecosystem benefits across regional scales while providing economic, ecological, and social resilience.

The work summarized in the Four Coasts report includes development of several preliminary design concepts and sediment choreography (Humboldt Bay), strategic sediment placement and sediment mobilization (San Francisco Bay), shoreline resilience projects (South Bay), and flood protection and ecological enhancement of levees (Pajaro River). Strategic sediment mobilization (SSM) is an innovative nature-based technique for taking advantage of naturally occurring, periodic high flow events to transport sediment from mud-locked tidal channels in need of dredging. This approach works with water to move sediment downstream to nourish mudflats and marshes (see Figure 8). Further details of these concepts can be found at USACE ERDC et al. (2024d).

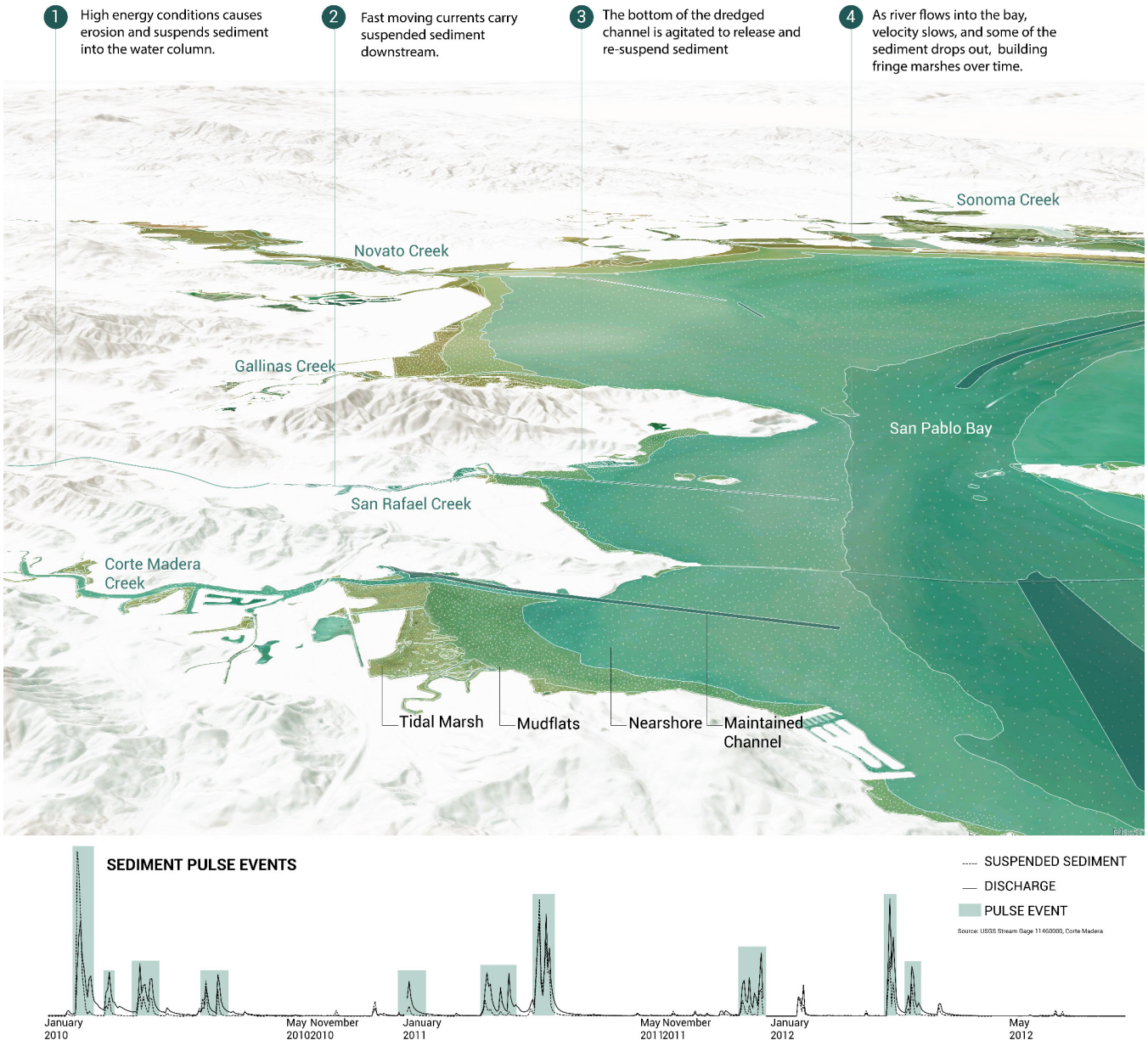

Figure 8. SSM concept for Marin County, California.

Source: USACE ERDC et al. 2024d, EWN Proving Ground, San Francisco District—Preliminary Concepts (Courtesy of DRC/Auburn University and Anchor QEA)

REFLECTIONS ON THE EWN PG PROCESS AND KEY LESSONS LEARNED

Overall, the EWN PG project is considered a huge success, especially by strengthening existing partnerships and collaboration between key EWN leaders and subject matter experts (SMEs). Each PG district had a slightly different focus on the project development process (largely driven by local preferences as well as stakeholder dynamics) in addition to region-specific needs and project type preferences. Specific feedback from district leadership is captured as follows:

Great Lakes Division (Chicago, Detroit, and Buffalo Districts)

The EWN concepts that were developed provided tremendous value to the districts' exploration of potential projects, with the visualization likely to play a critical role in tackling some of the near future funding and regulatory hurdles. The timeline for the Green Bay and Duck Creek Delta project complemented the work the district was conducting on behalf of the U.S. Environmental Protection Agency. The modeling and conceptual drawings enhanced the coordination with the Wisconsin Department of Natural Resources and area stakeholders by providing clear visualization and data to aid in decision-making.

The work product was very useful in coordinating with stakeholders to visualize potential restoration measures and ultimately identify a preferred plan for further development. The project team did a great job developing products on a short timeline. While the project was a great success, the process could have been more efficient by including a kickoff meeting with the project stakeholders to improve alignment of expectations.

Philadelphia District

The Philadelphia District has been an EWN PG since 2016, and the PG project was key for advancing our progress and evolving concepts for future efforts. These concepts will hopefully launch more project implementation in multiple mission areas. The brainstorming sessions and virtual meetings were quite useful; however, in-person meetings, ideally with larger teams from the district, would have been more productive. The 1-year time frame seemed about right from kickoff to end report, but quarterly touch-base meetings would be a great addition to make district team members feel more a part of the process along the way. This was an important EWN PG project, and more in-person collaboration with the district staff would have improved the process further.

The document as a whole will be beneficial to advance EWN concepts, especially the renderings. The PG project enabled the staff to innovate ideas and develop potential solutions, thereby challenging the thought processes versus more traditional approaches. The EWN PG process identified the need for some bridging of ideas with USACE policies or constraints in order for the concepts to be efficiently implemented in the future.

The summary work product (the EWN Project Ideas Handbook; King et al. 2024) was quite effective for stakeholder coordination and communication, while the larger report (Four Coasts) was good to summarize overall effort and recommendations; a summary slide deck of the process and results would be beneficial. Finally, an out-brief to the district at the end of the PG project would be helpful in developing strategies to further advance the project concepts so that they can be implemented at some point in the future.

Mobile District

The EWN PG development process was straightforward, as the Mobile District had a longstanding RSM Working Group and Coastal Resiliency Program made up of multidisciplinary and agency teams committed to working together to implement regional sediment management and EWN philosophies and projects where appropriate. Development of conceptual designs within the EWN PIH was helpful in communicating the vision to stakeholders and furthering collaboration with partners. Overall, it provided opportunities to identify innovative ideas and solutions that could meet multiple stakeholder objectives. As a byproduct, this has broadened partnerships and helped determine possible creative funding sources.

EWN PG efforts should be a multiagency initiative. It is the collective that makes these projects happen. Monitoring data from EWN PG projects that are implemented should be integrated back into the research to improve development of tools and guidance. In addition, as projects are implemented, sharing this information should continue to help others plan, design, and justify NBS projects. EWN PIH and Atlas products highlight possible and completed NBS projects by stakeholders and USACE districts, which help communicate the benefits and get others excited about the possibilities in their regions. These types of products not only help expand the application of NBS within an EWN PG, but they can also help broaden the application of NBS beyond PGs.

San Francisco District

The district launched the PG in 2021 through a series of workshops with staff across disciplines and leadership at the district and South Pacific Division. The district has been training staff through monthly webinars (including interactive sessions) and supporting SMEs in being added to project delivery teams (PDTs). The division has initiated a "scoping cadre" for new starts, and EWN is a discipline involved in this process. This allows an SME to help a new PDT scope properly for EWN and NBS features from the beginning of a study.

The EWN PG is fully integrated into environmental, planning, engineering, and other disciplines (such as project and program management, real estate, and office of counsel). This takes collaboration across the entire range of discipline. The PG is a helpful concept to have leadership buy in, in that it helps team members think outside the box and think creatively. The umbrella it creates for new ways of thinking is really a philosophical change, which paves the way for creative funding sources. In some cases, EWN features have saved projects in construction costs, which is a huge win-win for helping people across the chain understand the benefits of NBS.

The PGs provide an umbrella to work under—a helpful starting place to build consensus, structure, culture change, and capacity. For champions of EWN, it is helpful to work under a "proving ground" to spread the message and lessons learned in a "testing ground" environment. However, the goal is to build EWN into all aspects of work regardless of PG status. Currently, PG and practice leads support other districts with EWN and NBS efforts. This could be more formalized, with regional technical specialists at both the division and district levels who could weigh in on PDTs regularly, or more practice leads who are funded to participate in PDTs and meaningfully connect science and applications to support projects in the planning or construction process.

The demand for support at the project level is huge. District staff are asked regularly for support on PDTs of all shapes and sizes across the South Pacific Division. Sometimes, it is a few meetings to help a team brainstorm and connect them to resources. Sometimes, it is actually joining a PDT or connecting them with someone who has the right expertise. When NBS are successfully integrated into coastal storm risk management or flood risk management projects or an EWN approach is taken on any type of endeavor, our leadership, resources agencies, public, and staff all feel bought in and supportive. The collaboration that EWN PG inherently brings has helped to build trust between USACE and other organizations.

The next phase of the EWN PG projects will build upon the feedback from the initial EWN PG districts.

SUMMARY AND CONCLUSIONS

EWN Proving Grounds are USACE districts and divisions committed to the broad integration of EWN principles and practices into all business lines in the form of constructed projects. PGs are places where innovative ideas are tested on the ground throughout USACE missions. They document processes, project milestones, and lessons learned in the implementation of EWN measures so others can learn from their experience.

The EWN PG PIH project was a unique undertaking and required consideration of multiple factors. While the objective was to push the frontiers of EWN technology and project scoping, local stakeholder preferences and regional regulatory requirements sometimes posed challenges as well as opportunities during the project development process. Early and frequent coordination was a key to successful project development, and the ability to be flexible and adaptable to district personnel (and stakeholder) feedback or concerns (by sometimes redesigning or even moving on to a different project) was a key to building trust and longstanding relationships. Data gathering, from past as well as ongoing and future projects, is expected to provide more comfort to all parties, especially the district-level project managers who can then have more confidence in project outcomes.

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