Engineering With Nature® + Landscape Architecture

Moses Lake Tide Gate

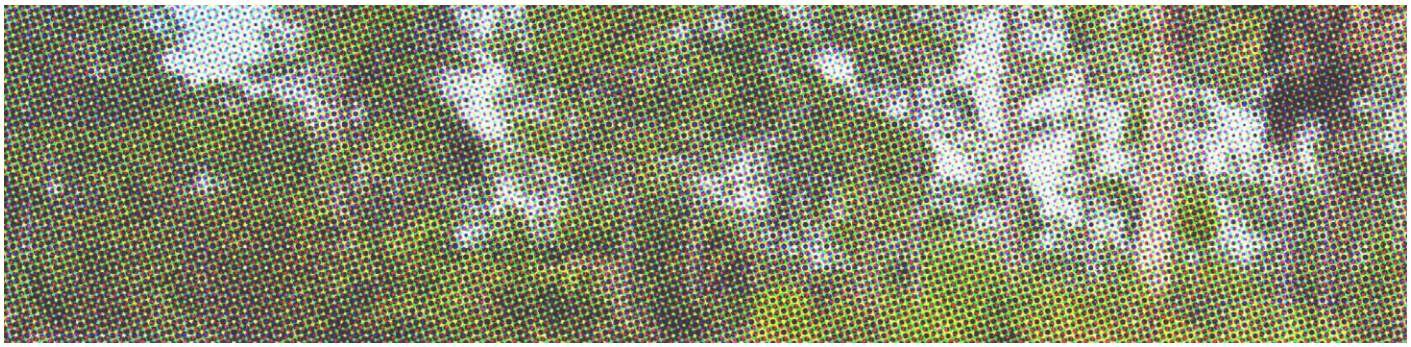
a report identifying design concepts for incorporating Engineering With Nature® and Landscape Architecture approaches into US Army Corps of Engineers project infrastructure

US Army Corps of Engineers®

EWN®

AUBURN UNIVERSITY

Dredge Research Collaborative



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EWN®

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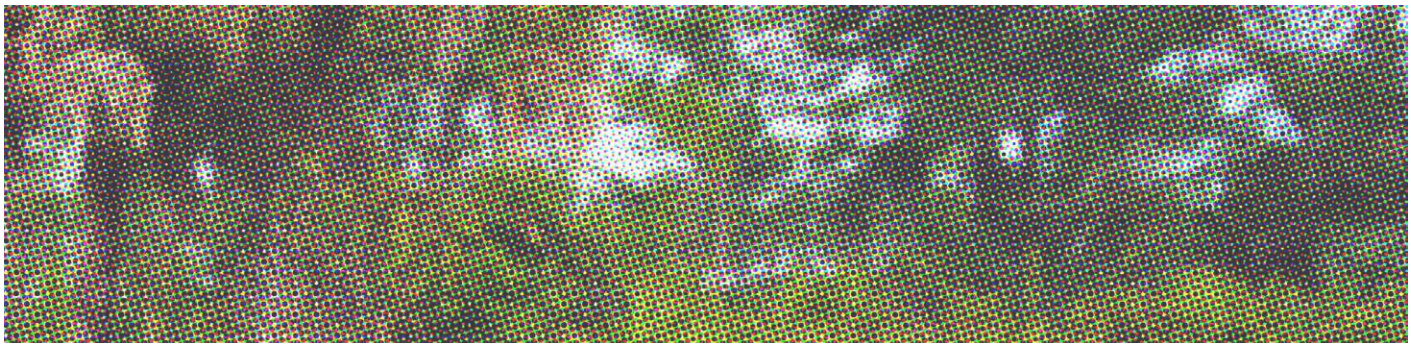

This report covers findings from research cooperative agreement W912HZ-18-2-0008 **Incorporating Engineering With Nature® (EWN®) and Landscape Architecture (LA) Designs into Existing Infrastructure Projects**, an agreement between the **U.S. Army Engineering Research Development Center** (ERDC) and **Auburn University** (AU) for FY18-19.

This report has been prepared by the PI at **Auburn University** and consultants from the **Dredge Research Collaborative**; it also incorporates research and insights from ERDC's **Engineering With Nature®** project team. The full report covers projects of all four participating districts; this excerpt includes only SWG.

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

Sustainable development of water resources infrastructure is supported by solutions that beneficially integrate engineering and natural systems. With recent advances in the fields of engineering and ecology, there is an opportunity to combine these fields of practice into a single collaborative and cost-effective approach for infrastructure development and environmental management.

The Dredge Research Collaborative is an independent 501c3 nonprofit organization that investigates human sediment handling practices through publications, an event series, and various other projects. Its mission is to advance public knowledge about sediment management; to provide platforms for transdisciplinary conversation about sediment management; and to participate in envisioning and realizing preferred sedimentary futures.

http://engineeringwithnature.org
http://dredgeresearchcollaborative.org/

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Moses Lake Tide Gate Project team members inspect existing conditions in January 2019

Introduction

This report concerns the development of innovative design concepts for a set of existing project infrastructures identified by the US Army Corps of Engineers' Engineer Research and Development Center (USACE ERDC). These design concepts combine Engineering With Nature® (EWN®) approaches to infrastructure design with landscape architectural (LA) approaches to infrastructure design in order to identify promising directions for the renovation, replacement, or augmentation of the identified case study infrastructures. Some of the case study infrastructures were completed decades ago, and now require replacement, providing the opportunity to rethink their engineering, form, and performance. Others are transitioning from one stage of their lifespan to another, and require modifications to meet new project goals. A third and final group of case studies are new project infrastructures currently in the design and planning stages, where these proposed designs might be modified to incorporate EWN® and LA principles.

Overall, the aims of this work have been to beneficially apply landscape architectural knowledge to selected public infrastructure resources, to advance transdisciplinary working methods that bring engineers, scientists, and landscape architects together to deal with infrastructural design problems, and to advance understanding of the role of Natural and Nature-Based Features (NNBF) in infrastructure design. As described by the EWN® initiative, "Natural and Nature Based Features are landscape features that are used to provide engineering functions relevant to flood risk management, while producing additional economic, environmental, and/or social benefits. These features may occur naturally in landscapes or be engineered, constructed and/or restored to mimic natural conditions. A strategy that combines NNBF with nonstructural and structural measures represents an integrated approach to flood risk management that can deliver a broad array of ecosystem goods and services to local communities."

The projects selected for the first year of this EWN®-LA research initiative represent a diverse cross-section of the USACE's portfolio of water infrastructure projects: a diversion canal in Louisiana, jetties in Baltimore, a pair of former dredged material placement sites in Florida, and a reservoir tide gate in Texas. Correspondingly, they have presented the project team with the opportunity to consider a diverse range of potential NNBF, which are documented in the following pages.

The full report covers all four case studies. This document is an excerpt that includes only the Moses Lake Tide Gate, which is the Galveston District case study.

BACKGROUND

This collaborative research project emerged out of a workshop held at the US Army Corps of Engineers Engineering Research and Development Center in Vicksburg, Mississippi in Summer 2017. In that workshop, personnel from the USACE, members of the Dredge Research Collaborative, and a diverse group of landscape architects identified opportunities to integrate EWN® and LA approaches into new and existing water infrastructure projects and operations.

Engineering With Nature® is an initiative of the US Army Corps of Engineers. It is the intentional alignment of natural and engineering processes to efficiently and sustainably deliver economic, environmental, and social benefits through collaborative processes.

In the EWN® approach, sustainable development of water resources infrastructure is supported by solutions that beneficially integrate engineering and natural systems. With recent advances in the fields of engineering and ecology, there is an opportunity to combine these fields of practice into a single collaborative and cost-effective approach for infrastructure development and environmental management."

EWN® outcomes are "triple-win", which means that they systematically integrate social, environmental, and economic considerations into decision-making and actions at every phase of a project, in order to achieve innovative and resilient solutions that are more socially acceptable, viable, and equitable, and, ultimately, more sustainable.

As a field, **landscape architecture** is presently concerned with many of the same issues of infrastructural performance and potential that EWN® is currently pursuing, including in particular the re-imagination of existing infrastructure to meet more diverse criteria encompassing engineering functions, ecological value, recreational opportunities, and aesthetic benefits. This overlap in concerns suggests that the design principles and precedent knowledge summarized as EWN® approaches may be beneficially combined with the design principles and precedent knowledge that has been accumulating in landscape architectural approaches to infrastructure, such as the work of landscape architects on recent international design competitions that deal with issues of coastal storm protection, public space, and ecological performance, like Rebuild by Design NYC and the Resilient by Design Bay Area Challenge. Moreover, landscape architects bring additional methods and expertise, including design, representation, and communication skills, that can aid in achieving the shared goals of EWN® and landscape architecture.

The members of the **Dredge Research Collaborative** work in precisely this area of contemporary landscape architecture, with a particular focus on coastal and riverine infrastructures that interact with sediment systems, and are correspondingly able to bring familiarity with both the challenges and the opportunities inherent in deploying EWN® approaches to water infrastructure.

PROJECT GOALS

1 Develop Innovative EWN ®-LA Design Concepts

Develop innovative design concepts that integrate multiple benefits including engineering function, ecological value, recreational benefits, and aesthetic experiences into the selected existing infrastructures. These concepts should incorporate NNBF as a means of achieving these benefits. In some cases, this may mean developing completely new infrastructure design concepts and renderings (in lieu of integration into existing infrastructure) in order to advance the overall purpose of this research project and demonstrate use of alternatives to the existing (or originally proposed) structure(s).

2 Visually Demonstrate Alternatives

Illustrative design drawings and renderings are a primary tool within this project for demonstrating the nature of proposed design concepts. These images are intended to communicate both the form and performance of design concepts.

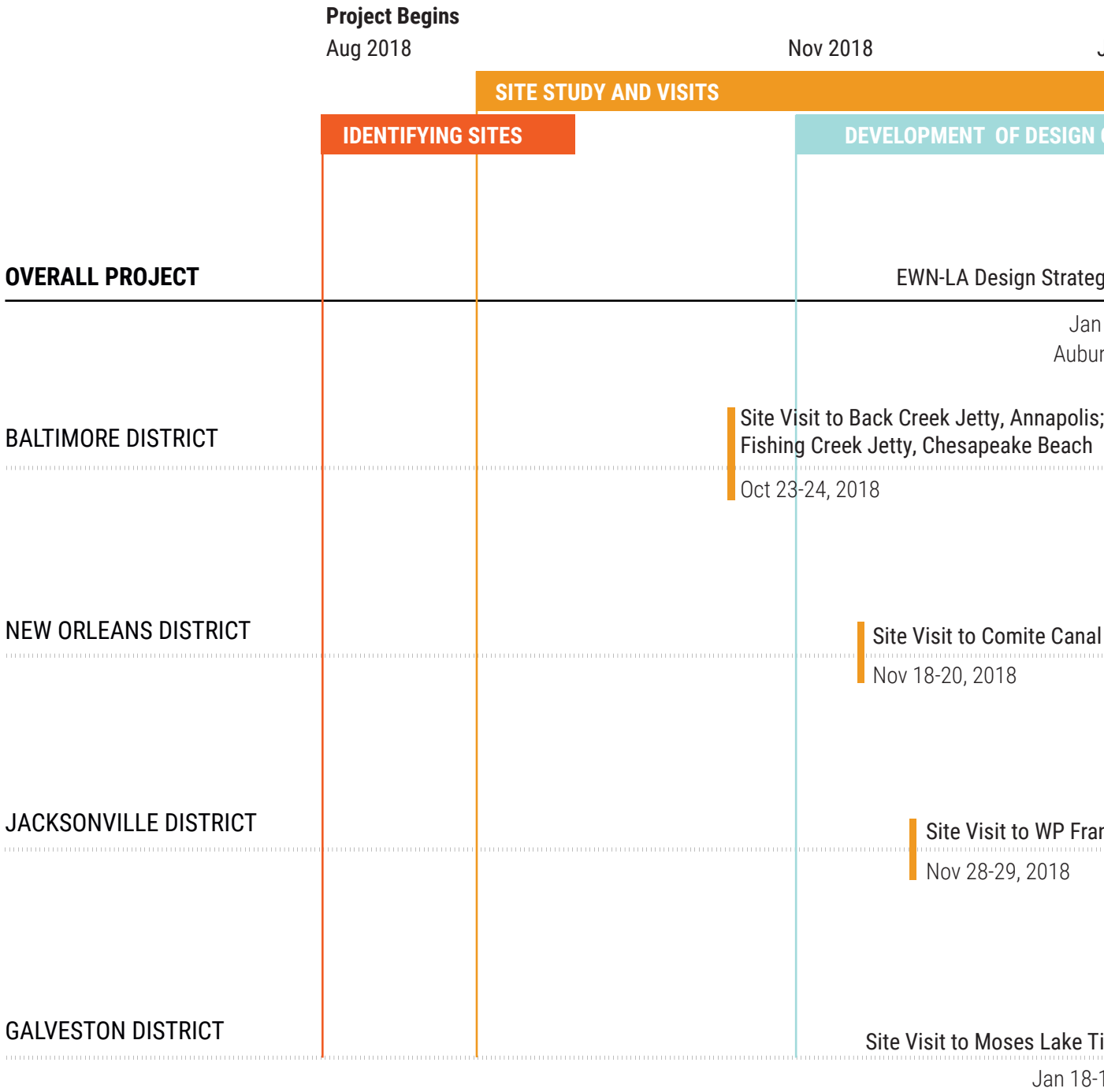
3 Document Concepts and Process

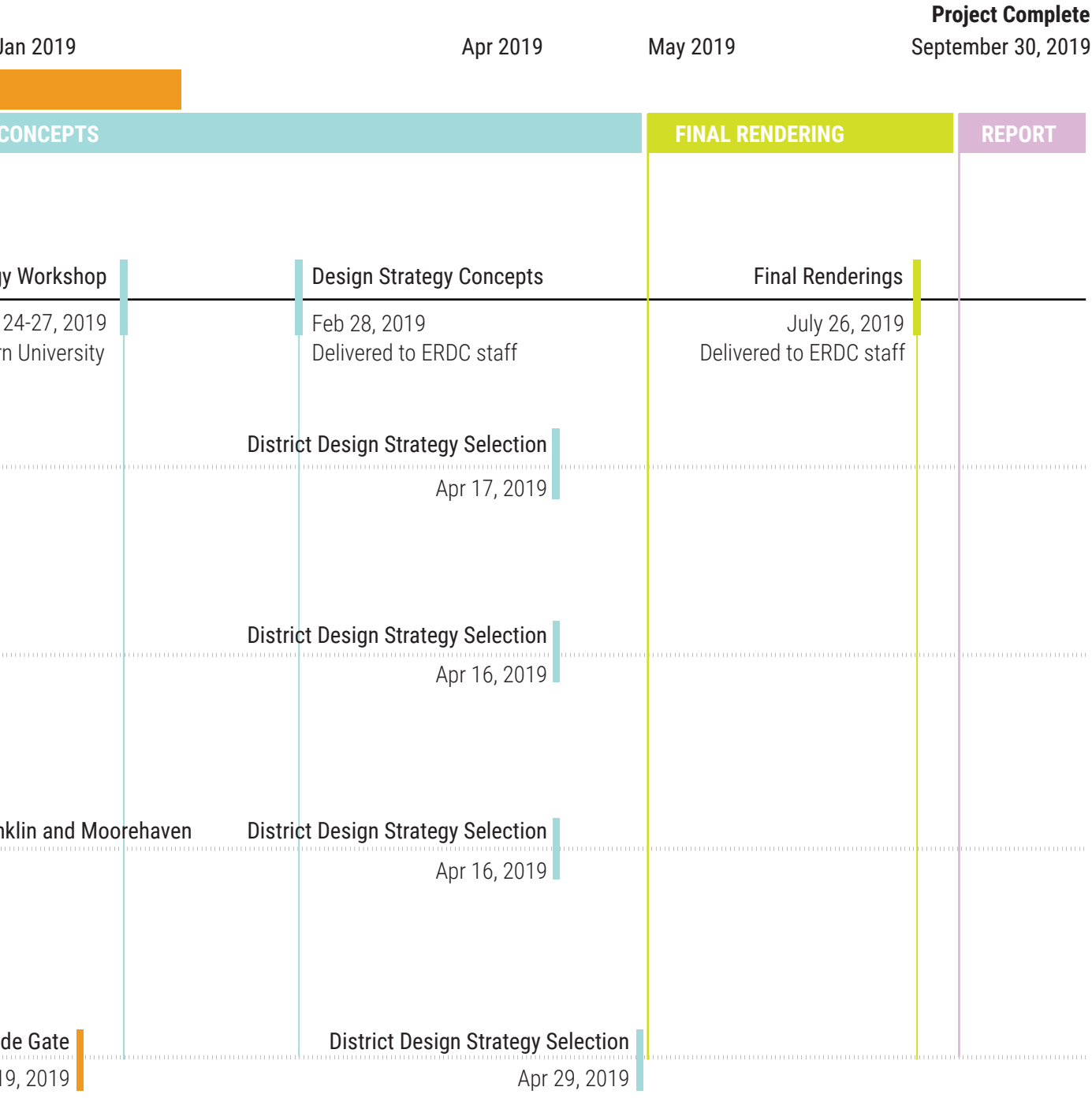
The project team will develop a report that showcases potential improvements to the infrastructure projects. This report will contain both recommendations of the EWN ®-LA project team and a detailed description of the research process, including other alternatives that were not selected for the primary recommendations.

4 Disseminate Findings

The project team will incorporate project design concepts into conference presentations and journal articles in order to share the findings of this research. Part of the reason for showcasing alternatives that are not part of the final recommendation is in the hopes that these findings may be useful to other USACE districts considering similar projects in the future.

TIMELINE


Project Begins
Aug 2018
Nov 2018
SITE STUDY AND VISITS
IDENTIFYING SITES
DEVELOPMENT OF DESIGN
OVERALL PROJECT
EWN-LA Design Strateg
Jan
Aubur
BALTIMORE DISTRICT
Site Visit to Back Creek Jetty, Annapolis;
Fishing Creek Jetty, Chesapeake Beach
Oct 23-24, 2018
NEW ORLEANS DISTRICT
Site Visit to Comite Canal
Nov 18-20, 2018
JACKSONVILLE DISTRICT
Site Visit to WP Fran
Nov 28-29, 2018
GALVESTON DISTRICT
Site Visit to Moses Lake Ti
Jan 18-1


Project Complete
Jan 2019
Apr 2019
May 2019
September 30, 2019
CONCEPTS
FINAL RENDERING
REPORT
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24-27, 2019
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Design Strategy Concepts
Feb 28, 2019
Delivered to ERDC staff
Final Renderings
July 26, 2019
Delivered to ERDC staff
District Design Strategy Selection
Apr 17, 2019
District Design Strategy Selection
Apr 16, 2019
nklin and Moorehaven
District Design Strategy Selection
Apr 16, 2019
de Gate
19, 2019
District Design Strategy Selection
Apr 29, 2019

PROCESS

The first year of this research initiative has been an opportunity to establish a set of collaborative work procedures that involve all of the major project partners: the EWN® project team, including USACE, Auburn, and DRC personnel, and, most importantly, the individual districts that have offered up projects as case studies. These procedures can be divided into four major phases.

Identifying Sites

The first step of work was identifying specific project infrastructures that could benefit from the EWN®-LA research initiative. This work was done primarily through communication between the EWN® team, led by Dr. Jeff King, and the individual district partners.

Site Study and Visits

The second phase involved site visits by the EWN®-LA team to each project site, where the team was hosted by the project staff from the local district. This provided a crucial opportunity to understand the existing performance parameters of the project infrastructure, to understand project needs based on conversations with the local district, and to understand how proposed NNBF might be integrated with existing ecological and human systems.

Before and after these site visits, Auburn and DRC personnel developed study drawings to understand existing conditions at each site, focusing particularly on engineering needs (such as risk reduction), ecological systems, and human factors (such as the availability of recreational opportunities for nearby communities). Some of these drawings are included in this report.

Development of Design Concepts

With the information gleaned from the second phase in hand, the EWN®-LA team assembled in Auburn in January 2019 for a design strategy workshop. The aim of this workshop was to put all possible options for NNBF on the table for each case study, so that each district would be able to evaluate a broad array of options. Over two and a half days of discussion and drawing, the team produced initial versions of the design strategies, each of which contained a distinct idea for bringing EWN®-LA principles to bear on a case study.

After the workshop, Auburn and DRC personnel developed refined 'design strategy diagrams' documenting these ideas. (These diagrams can be found later in this report.) After review by ERDC staff, the diagrams were presented via webinar to each district. Feedback from each district was collected, focusing on which preferred strategies should be further developed for inclusion in the final report.

Final Rendering and Report

Following the receipt of this feedback, the EWN®-LA team worked to synthesize the district's preferred strategies into a single, more fully-developed design concept recommendation for each project infrastructure. Final renderings were developed and then documented in this report. While further collaboration will be necessary in order to bring these recommendations to fruition, the final renderings are intended to provide a compelling visual description of the great potential that each of these sites offers for incorporating successful, impactful NNBF into the project infrastructure.

Winter Design Workshop Project team members discuss design concepts in January 2019

Galveston District

Moses Lake Tide Gate, Texas City

Moses Lake lies on the western shore of Galveston Bay, within the municipality of Texas City. The Lake is fed from the west by Moses Bayou; generally shallow, it has a narrow outlet on its eastern side, which opens to Galveston Bay. Texas City is ringed by the Texas City Flood Protection System; in the vicinity of Moses Lake, the Flood Protection System is an earthen levee, which lies between the lake and the bay. The Moses Lake Tide Gate was built in 1966 as part of this system in order to facilitate control of flooding around the lake.

Today, the area around the gate is a popular location for recreational fishing, which happens both on the bay and lake sides of the levee's shoreline. Because of the strong tidal flows through the narrow gate mouth, the shoreline has been armored with rip-rap. The tide gate itself is likely to need some form of repair, refurbishment, or replacement in the near future. The Galveston District of the US Army Corps of Engineers (SWG) has, in partnership with local project sponsors including Galveston County, been evaluating opportunities related to all of these activities and issues.

In fall 2018, the Engineering with Nature and Landscape Architecture project delivery team (EWN-LA PDT) was asked to develop recommendations for how those potential responses might incorporate EWN principles and NNBF. The following pages document the process of developing these recommendations and the recommendations themselves.

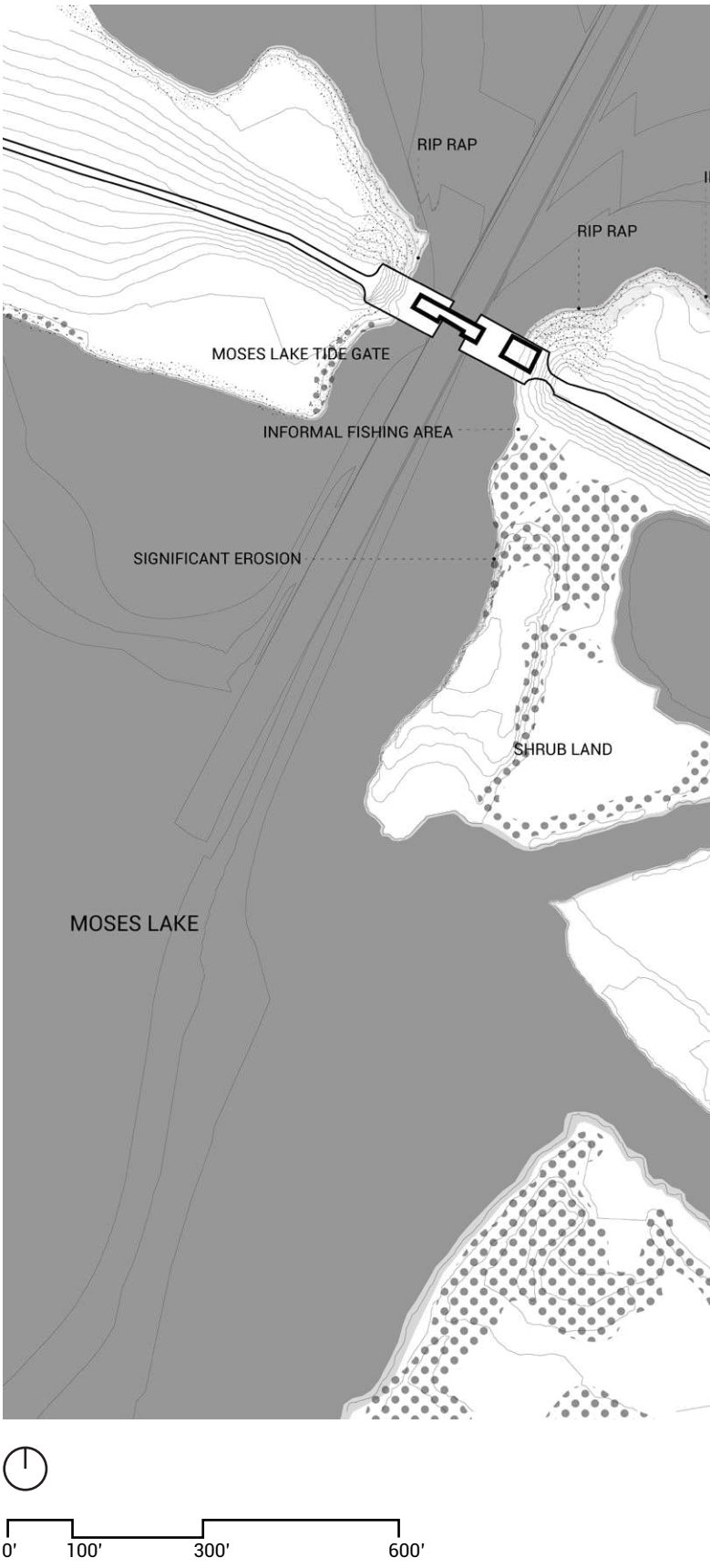
OPPORTUNITIES

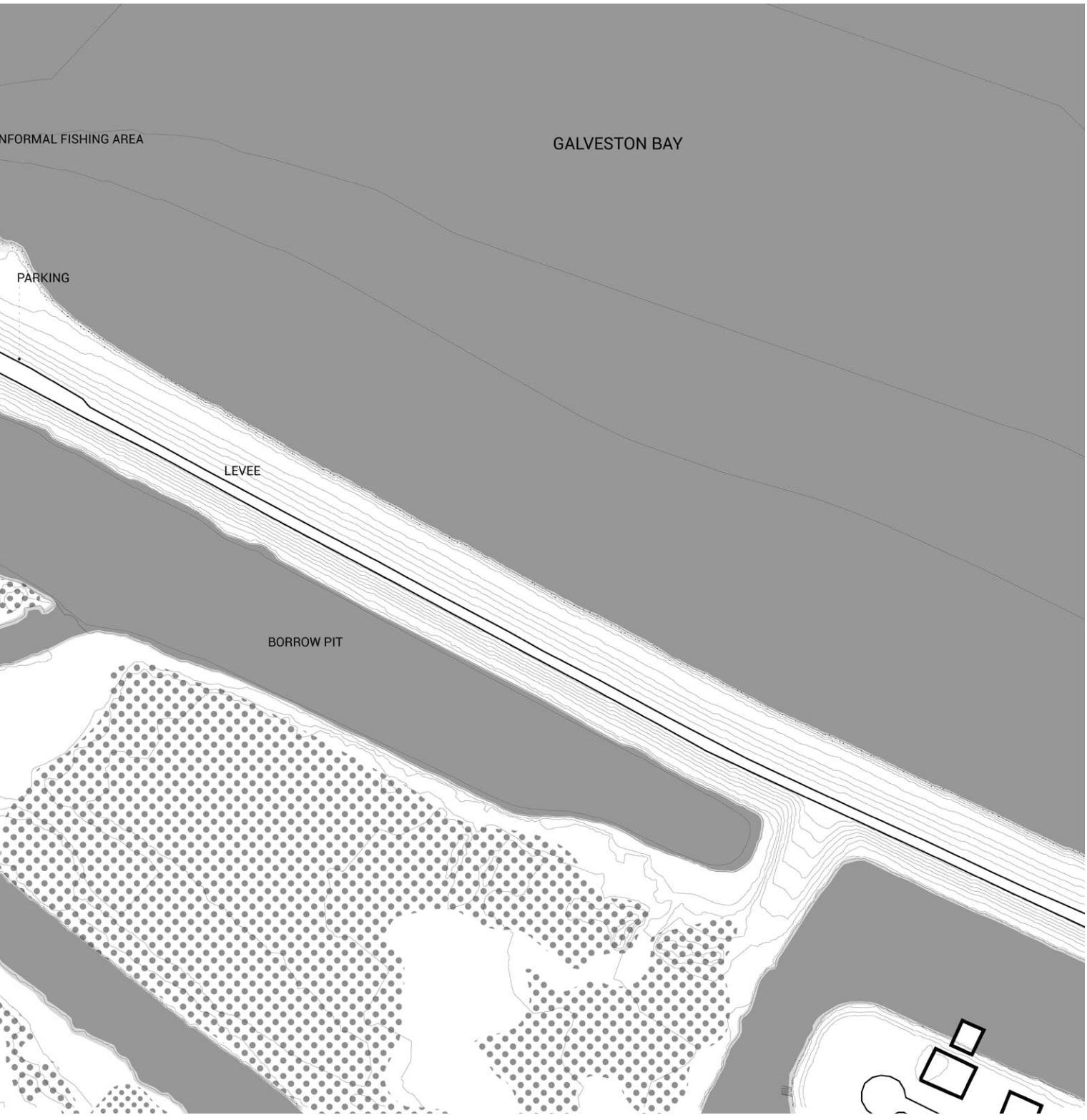
During the EWN-LA workshop at Auburn University in January 2019, the project team identified a set of key opportunities that guided the development of design strategies and the final recommendation.

1 Shoreline Improvements
The current strategy for protecting the shoreline near the tide gate from erosion relies on stone and concrete armoring. NNBF strategies such as bioblock, subtidal berms, or plantings offer opportunities to combine shoreline protection with aesthetic and/or ecological benefits.

2 Recreational Access
The area around the tide gate is already significantly utilized as a recreational resource. Fishing, both from shore and in small boats, is common. Informal walking trails lead from the levee into the shrublands and marshes along Dollar Bay. Due to a lack of formal recreational infrastructure, though, these recreational uses often produce undesirable consequences, including the accumulation of trash along the shoreline and erosion from foot traffic.

3 Beneficial Use of Dredged Material
Navigational dredging activity in the local Moses Lake channel as well as the nearby Galveston Ship Channel may provide an opportunity to use dredged material as a resource for the enhancement of ecological communities close to the tide gate.




NFORMAL FISHING AREA
GALVESTON BAY
PARKING
LEVEE
BORROW PIT

REGIONAL ECOLOGICAL CONTEXT

Galveston Bay is the largest estuary in Texas and the seventh largest in the United States, measuring just short of 600 mi^2. The bay is formed by Galveston Island and the Bolivar Peninsula partially cutting off the flow of saltwater from the Gulf of Mexico. Freshwater from the San Jacinto and Trinity Rivers flow into the bay's protected interior with many thousands of acres of bayous and wetlands, including Buffalo Bayou, scattered along the low-lying edges. The mixing of the salt and freshwater sources and great diversity of habitats generates a rich convergence of life and the second most productive estuary in the nation[1]. This impressive productivity has declined in the 20th and 21st centuries, in large part as a result of human activities, such as urban development, within the bay's watershed. The major metropolitan areas of Dallas and Fort Worth are found in the watershed's headwaters, while the development of the Houston metropolitan region has significantly altered the land use composition of the upper and lower bay system. The Galveston Bay Foundation currently rates the bay's overall health as having a C grade, with wildlife and habitats receiving a D grade, or "requiring action", and sea level rise as an F, or "having critical umet needs"[2].

From the early 1950s to the late 80s, Galveston Bay lost over 35,000 acres of wetlands from human activities and sea level rise[3]. Since the early 1990s, wetland loss in the Lower Galveston Bay has remained nearly constant at .3% or roughly 2,600 acres per year, according to a 2011 study[4]. Wetlands have been further degraded by invasive species introduction and spread. Chinese Tallow Tree (*Triadica sebifera*) and Phragmites (*Phragmites australis*) are the main invasive species that have significantly changed the species composition in the Galveston Bay[5]. The native wetland species present in the estuary change along its salinity gradient. Salt Marsh is largely composed of Smooth Cordgrass (*Spartina alterniflora*), Glasswort (*Salicornia* Spp.), Saltgrass (*Distichilis spicata*), and Saltwort (*Batis maritima*), while Brackish Marsh is home to mostly Saltgrass (*Distichilis spicata*) and Marsh Hay (*Spartina patens*)[6]. Both of these marshes are home to numerous species of fish, shrimp, oysters, and crabs.

As the bay's primary waterbody depth averages only 8 feet, it has been significantly altered by dredging and the construction of infrastructure in order to faciltiate commercial shipping[7]. Adjoining bayous, lakes, rivers, and wetlands that comprise the Galveston Bay have also been altered to accommodate industry and development. The Moses Lake-Dollar Bay system is a great example of such change. This 8 mi^2 lake and bay is composed of brackish marsh, fed from the freshwater of the Moses Bayou. It was once surrounded by unbroken high-quality prairies, with salt marsh at the Dollar Bay's mouth. To facilitate the operations of the shrimping industry and to protect Texas City from floods, infrastructure projects have been constructed in the Dollar Bay and Moses Lake system. The USACE, working with local nonfederal sponsors, has dredged the lake for better fishing fleet mobility and built a tidal control gate, levees, pumps and ponding areas to address sea level rise and hurricanes[8]. As a result of shoreline development,

land use change, wave energy from boats, sea level rise, and these infrastructure projects, widespread shoreline erosion is affecting the quality of the Moses Lake system. Efforts to improve the shorelines and restore the estuarine marsh are ongoing and are beneficial to many plant and animal species[9]. Investments in this lake-bay system, and those like it scattered across Galveston Bay, are also important for people in local communities, whose livelihoods and recreational opportunites can be improved by restorative actions to bay habitats. The construction of NNBF at Moses Lake Tide Gate, like those documented in this report, represents one such opportunity to link infrastructure projects to ecological and social value.

[1] "Charting the Course to 2015: Galveston Bay Strategic Action Plan." Galveston Bay Estuary Program. https://www.tceq.texas.gov/assets/public/comm_exec/pubs/gi/gi-385.pdf

[2] *Galveston Bay Report Card 2018*. Galveston Bay Foundation and HARC. https://www.galvbaygrade.org/wp-content/uploads/2018/08/2018_Galveston_Bay_Full_Report.pdf

[3] "Status and Trends of Wetlands for Galveston County, Texas 2004-2009." U.S. Fish & Wildlife Service Southwest Region. https://www.fws.gov/wetlands/Documents/Status-and-Trends-of-Wetlands-for-Galveston-County-Texas-2004-2009.pdf

[4] Lester, L. J. and L. A. Gonzalez, Eds. 2011. *The State of the Bay: A Characterization of the Galveston Bay Ecosystem*, Third Edition. Texas Commission on Environmental Quality, Galveston Bay Estuary Program, Houston, Texas, 356 pp.

[5] Lester, James L. Chapter Seven. In Lester, L. J. and L. A. Gonzalez, Eds. 2011. *The State of the Bay: A Characterization of the Galveston Bay Ecosystem*, Third Edition. Texas Commission on Environmental Quality, Galveston Bay Estuary Program, Houston, Texas, 356 pp.

[6] "Estuarine Wetlands." Galveston Bay Status and Trends. https://www.galvbaydata.org/www.galvbaydata.org/Habitat/Wetlands/EstuarineWetlands/tabid/849/Default. html

[7] "Charting the Course to 2015: Galveston Bay Strategic Action Plan." *Galveston Bay Estuary Program*. https://www.tceq.texas.gov/assets/public/comm_exec/pubs/gi/gi-385.pdf

[8] "Moses Lake." TSHA: Texas State Historical Association. https://tshaonline.org/handbook/online/articles/rrm06.

[9] Blaha, John. 2018. "Moses Lake Shoreline Protection Project." *Texas Saltwater Fishing*. March. https://www.texassaltwaterfishingmagazine.com/fishing/education/conservation/moses-lake-shoreline-protection-project.

STRATEGIES

The following spreads (pages 22-25) show a series of potential design strategies developed in the EWN®-LA workshop at Auburn University in January 2019. These strategies were presented to the Galveston District in April 2019.

These strategies are intended to represent a broad range of options for implementing EWN® principles and NNBF in the vicinity of the Moses Lake Tide Gate. While all of them had some potential for implementation and have been reviewed by the project team for some measure of feasibility, they were intended to explore a variety of both feasibilities and levels of expense.

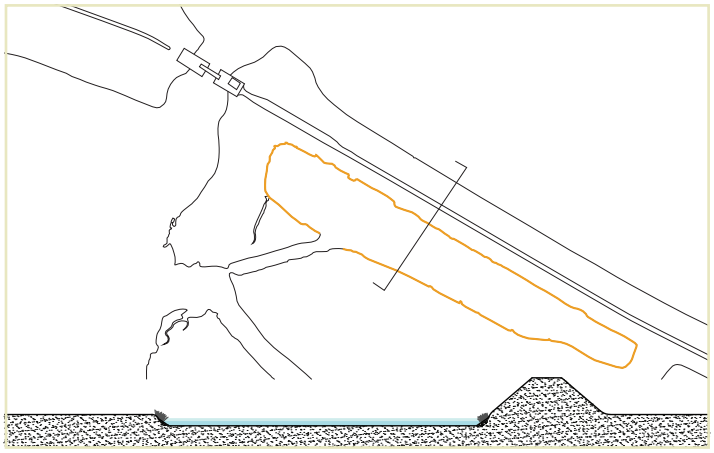
Some of them, like the idea of rearmoring the gate zone with ecoblock, have been developed further and are reflected in the recommendation (pages 26-29). Others, like the idea of "full" fill in the borrow pit behind the levee, were determined to be infeasible or undesirable for a variety of reasons, and so have not been developed any further. All are documented here both as a reflection of the process involved in preparing this report and in the hopes that they may be useful to future efforts to incorporate EWN® and NNBF in other contexts.

The PDT walks on one of the informal paths near the tide gate

The Moses Lake Tide Gate, seen from the muddy shoreline of Moses Lake

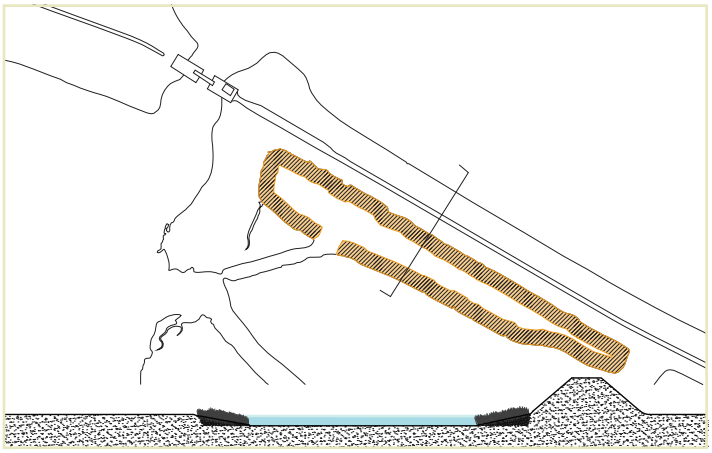
Fishing on the riprap in the vicinity of the tide gate

1 BORROW PIT



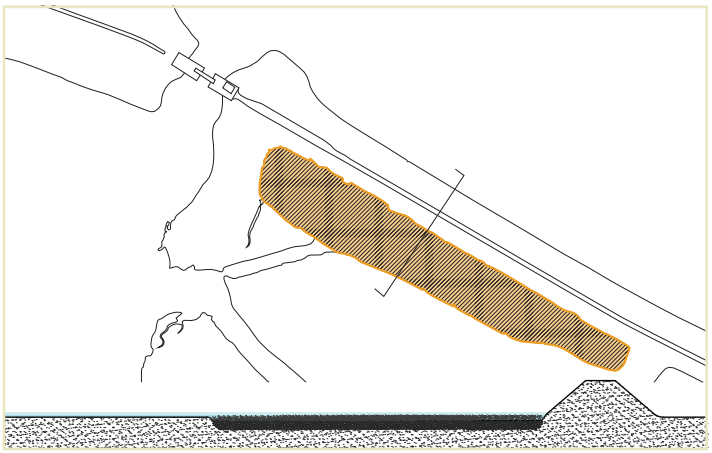
1A NO FILL

A marsh fringe could be encouraged by strengthening the borrow pit's connection to Moses Lake through the narrow inlet and minor regrading of the pit's edges.



1B FRINGE

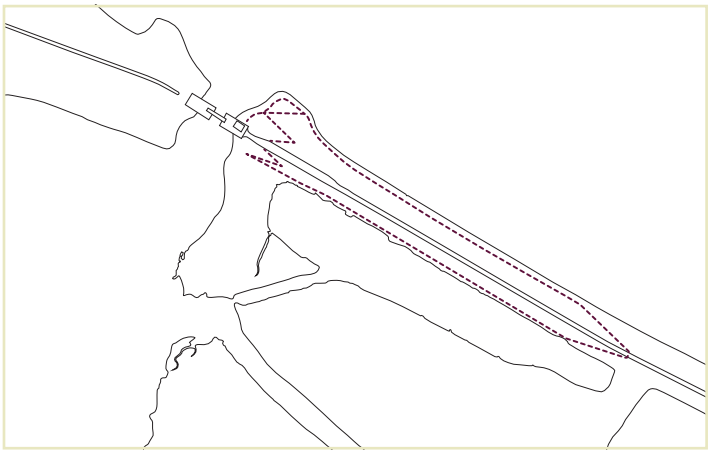
A more significant ring of marsh could be created by placing dredged material around the edges of the borrow pit and connecting it hydrologically to Moses Lake.



1C FULL

By filling the borrow pit and connecting it hydrologically, marsh could be created throughout the entire borrow pit footprint.

2 PATHS

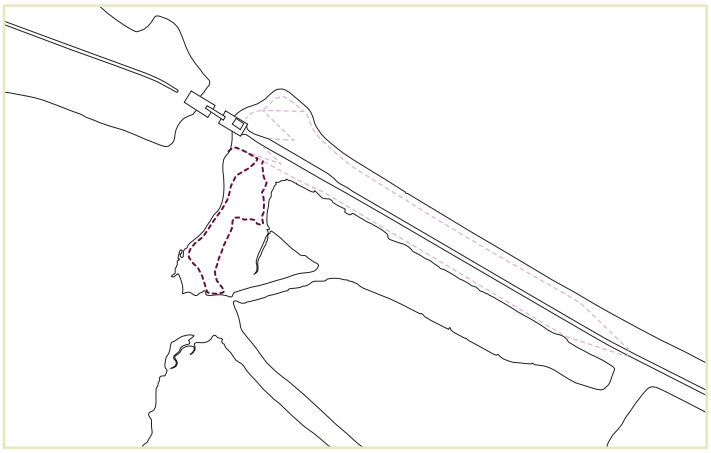


2A LEVEE LOOP

This path would include the levee in the path network. This path, as well as the others, would be intended to focus foot traffic away from levee vegetation, so that foot traffic does not increase erosion potential on the levee or other parts of the landscape.

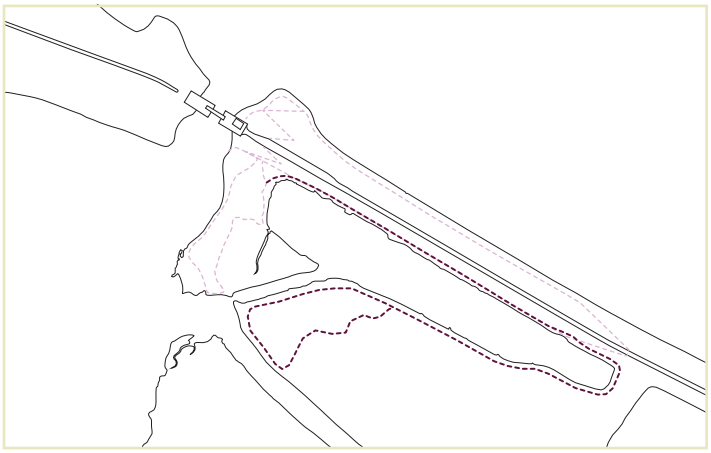
2B BLUFF LOOP

Taking note of the well-worn informal paths that already exist on the bluffs, a designed path would provide recreational access on a loop through this shrubland.



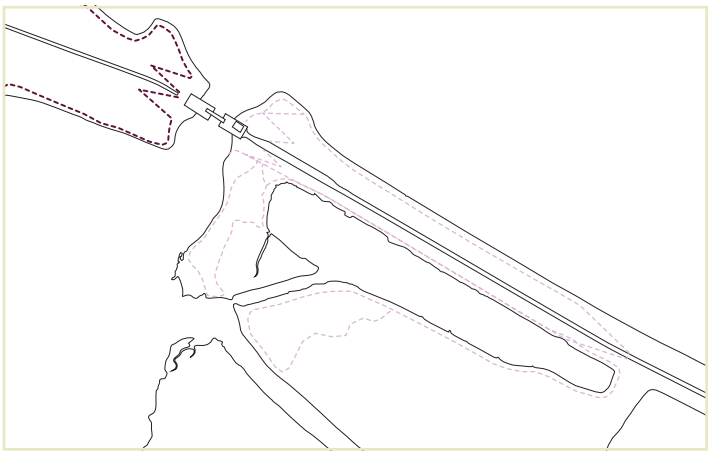
2C PIT LOOP

This path would circle the borrow pit and create a recreational loop. Depending on the strategy used for the borrow pit, this path could be used for birding and marsh viewing.



2D NORTHWEST SIDE TOO

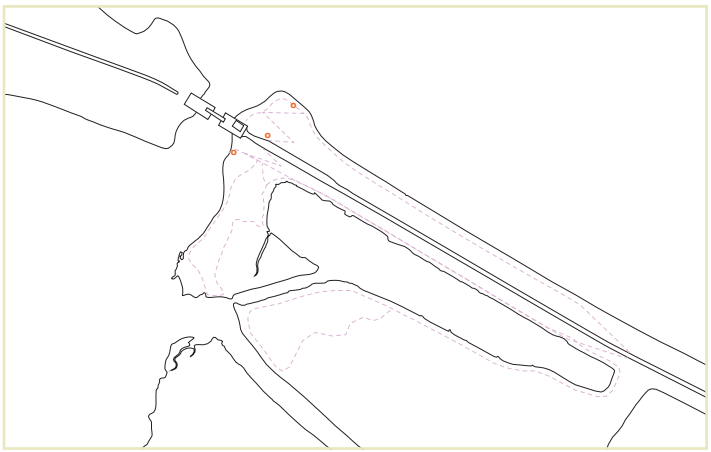
A path network could also be provided on the other (northwest) side of the tide gate.



3 RECREATIONAL INFRASTRUCTURE

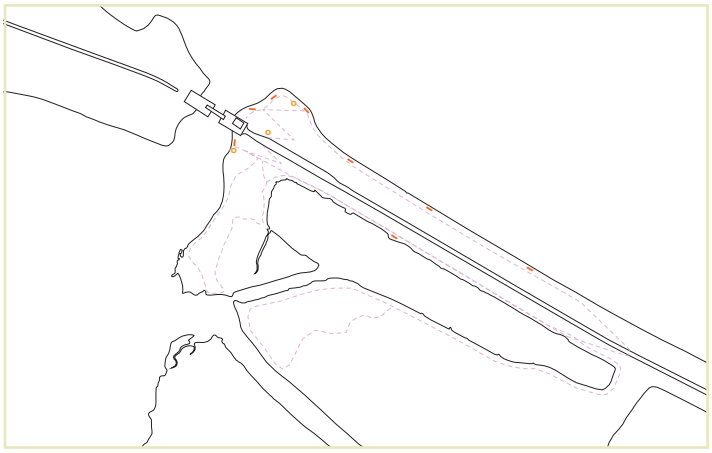
3A TRASH SOLUTION

During the site visit there was a considerable amount of trash on the site and, undoubtedly, much of that trash will make its way into the water. Waste receptacles in locations aligned with recreational opportunities would help reduce waste and disturbance.



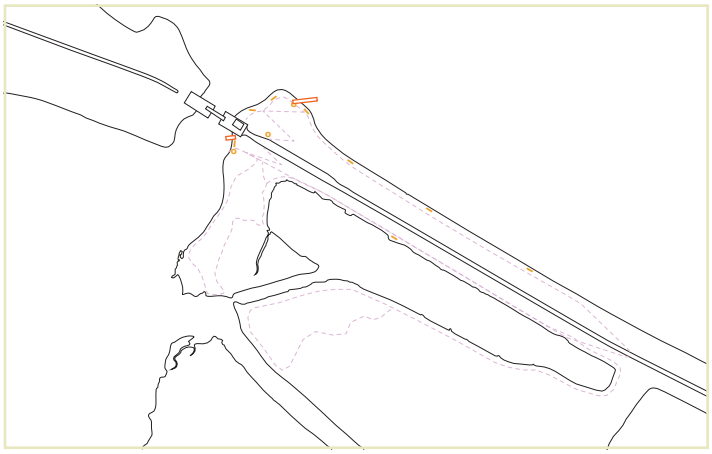
3B BENCHES AND TABLES

Given the visible popularity and use of the area, benches and tables would support recreation, eating, and trash disposal in locations.



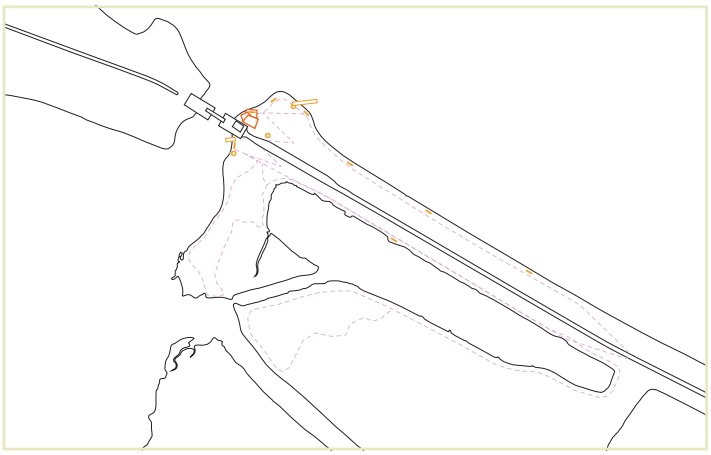
3C FISHING PIER (LAKE AND BAY)

Both sides of the lock, the lake and the bay, are popular fishing locations. A fishing pier on either or both sides would support this recreation and create opportunities for fishing slightly offshore in deeper waters.



3D OVERLOOK TERRACES

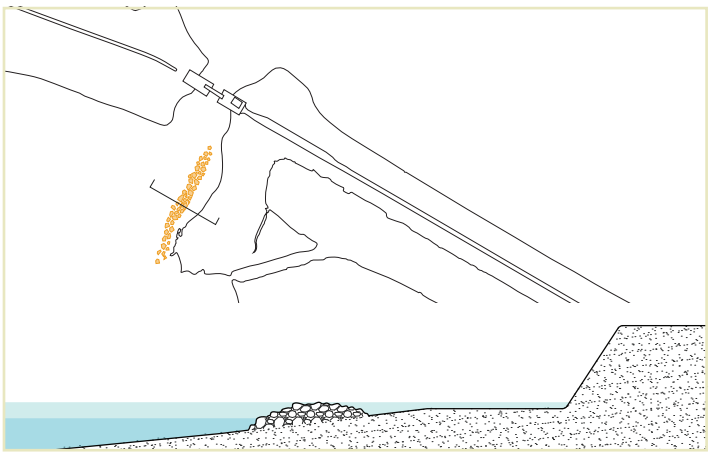
The armored slope on the bay side of the lock is an ideal location for public recreational infrastructure. Terraces would provide safe surfaces for enjoying views of the lock and the bay. Benches and tables would complement this strategy.



4 SHORELINE

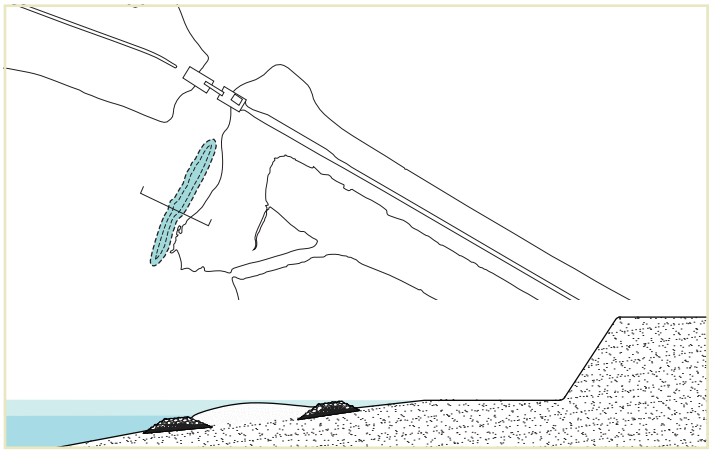
4A BLUFF REEF

Using ecoblocks, reef balls, or another material for reef creation, a reef in front of the bluff could help reduce wave and current energy that is producing erosion of the bluff.



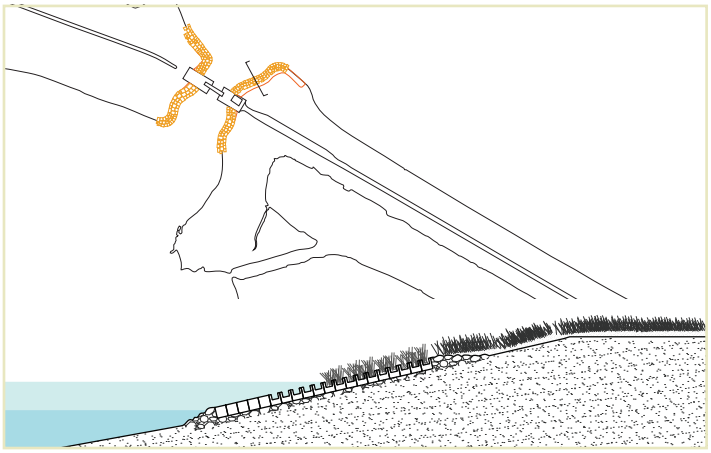
4B SUBTIDAL BERM (BLUFF)

Alternatively, creating a subtidal berm in front of the bluff landform could help reduce wave and current energy. Material from the same source could also be used to restore the eroded shoreline.



4C GATE ZONE REARMORING (ECOBLOCK)

Given the substantial erosion around the structure, the gate zone's armoring could be supplemented using ecoblocks to create subaqueous habitat. The area behind this armor could be backfilled, permitting the development of terraced plantings of native vegetation for both habitat and additional risk reduction.



RECOMMENDATION

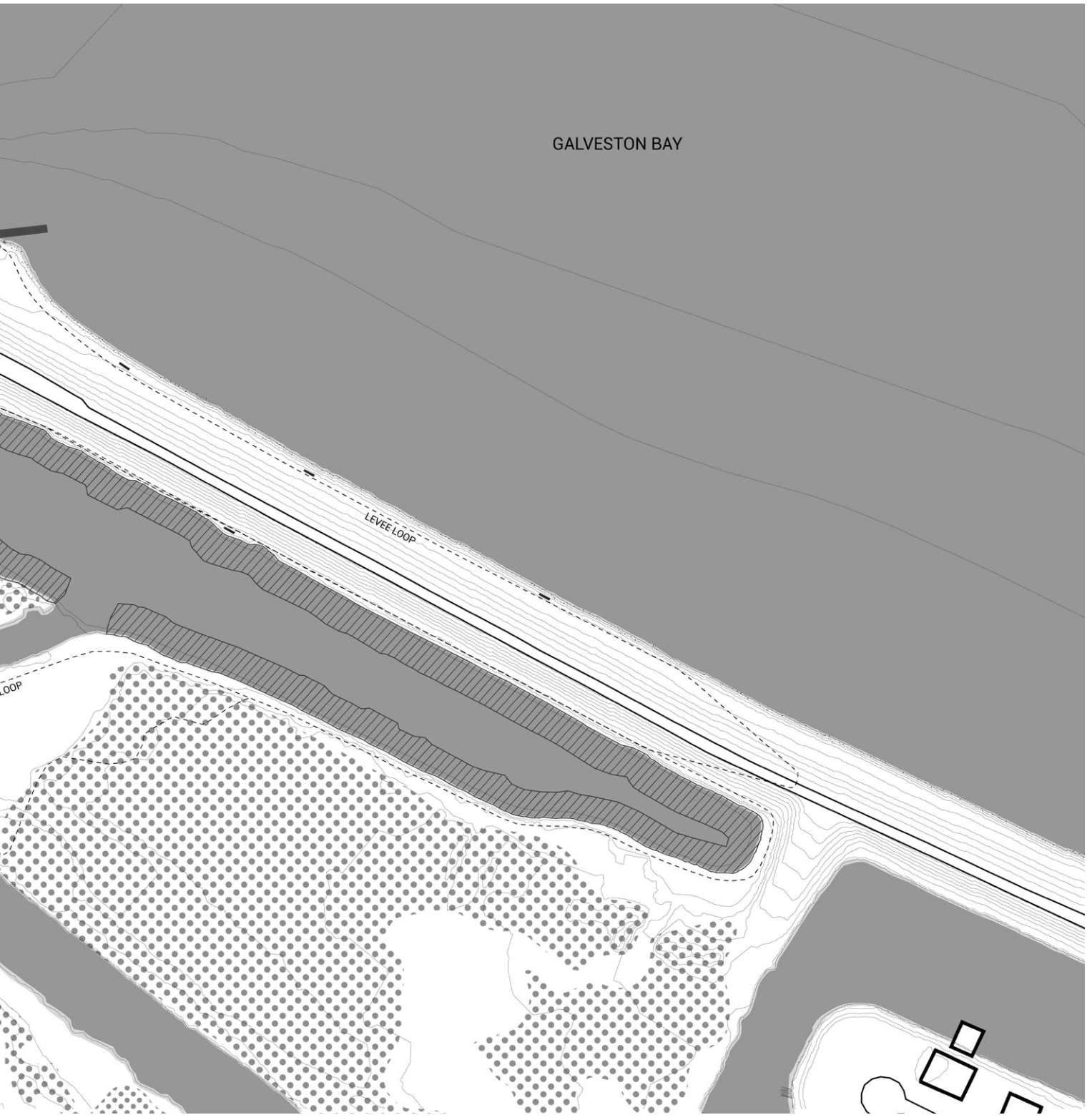
Our recommendation combines strategies for addressing shoreline protection in the vicinity of the tide gate, for recreational infrastructure, for paths, and for enhancing the ecological performance of the borrow pit area. Near the tide gate, we recommend using ecoblock and terraced plantings of native shore vegetation to contribute to risk reduction, enhance habitat, and improve the aesthetic value of the tide gate zone.

We recommend formalizing and updating paths and recreational infrastructure. The "levee loop" trail in particular represents an educational opportunity, where citizens using the trail could learn about the role of the levee itself and the broader FPS in protecting Texas City via both signage and views of the infrastructure. The extent to which this could be done is dependent on both coordination with local property owners, as the levee ROW does not extend much beyond the toe of the levees, and level of available funding, but our assessment is that all of the recommended improvements would have significant recreational value if they could be implemented.

For the borrow pit, we recommend looking at it as a site for the beneficial use of dredged material over coming navigational maintenance cycles. Shallowing its shores could contribute valuable marsh habitat, supporting ecological productivity in Moses Lake.

Legend

- Concrete Eco Units
- Fishing Piers
- Benches and Tables
- Waste Receptacles
- Paths
- Marsh Fringe
- Vegetation


GALVESTON BAY
LEVEE LOOP
LOOP

ECOBLOCK AND VEGETATED TERRACES

The rendering at right shows what the vicinity of the tide gate might look like after the placement of ecoblock units along both shorelines. Ecoblock units would vary in design in order to accommodate both growing media for coastal upland and salt marsh plants and roughened substrate surfaces for encouraging oyster accumulation. In the foreground, a cutaway reveals how the units might be modified to incorporate growing media. Along the waterway, units with oyster substrate are lightly indicated, as they lie below the waterline.


COASTAL UPLAND
PRIMARY GRASSES: *SCHIZACHYRIUM LITTORALE, SPARTINA PATENS*
PRIMARY SHRUBS: *MORELLA CERFERA, BACCHARIS*
HIGH SALT MARSH
PRIMARY SPECIES: *SPARTINA PATENS, SALICORNIA, DISTICHLIS SPICATA*
LOW SALT MARSH
PRIMARY SPECIES: *SPARTINA ALTERNIFLORA, SCRIPUS MARITIMES, JUNCUS ROEMARIANUS*
MHW
MLW
ECO BLOCK
INCLUDING OYSTER SUBSTRATE

This report covers findings from research cooperative agreement W912HZ-18-2-0008 **Incorporating Engineering With Nature® (EWN®) and Landscape Architecture (LA) Designs into Existing Infrastructure Projects**, an agreement between the **U.S. Army Engineering Research Development Center** (ERDC) and **Auburn University** (AU) for FY18-19.

This report has been prepared by the PI at **Auburn University** and consultants from the **Dredge Research Collaborative**; it also incorporates research and insights from ERDC's **Engineering With Nature®** project team. The full report covers projects of all four participating districts; this excerpt includes only SWG.

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