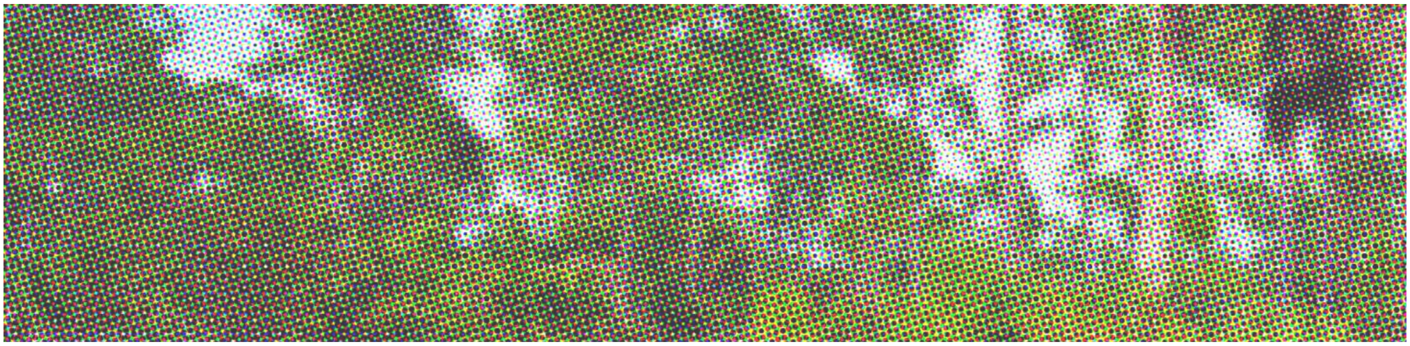
Engineering With Nature®
+
Landscape Architecture
Back Creek and Fishing Creek Jetties

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



Engineering With Nature®

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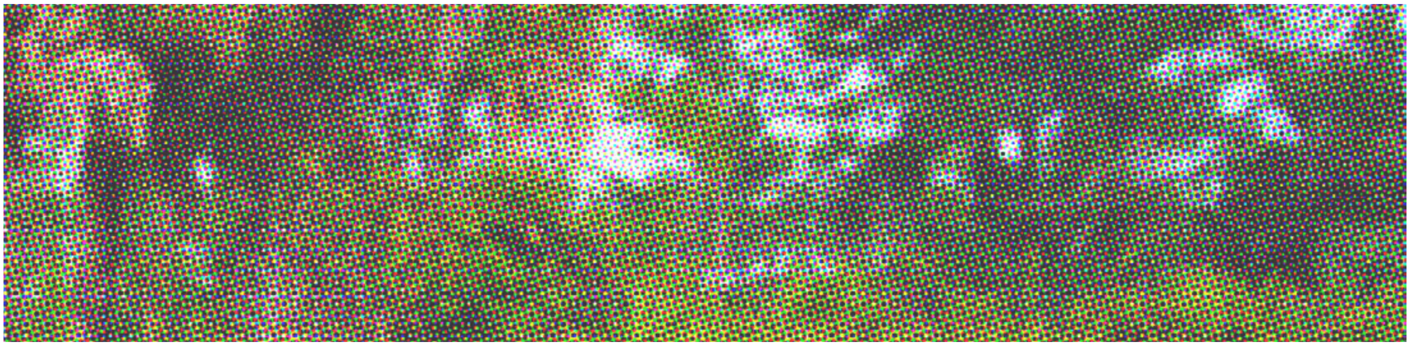

This report covers findings from research cooperative agreement W912HZ-18-2-0008 **Incorporating Engineering With Nature® (EWN®) and Landscape Architecture (LA) Designs into Existing Infrastructure Projects**, an agreement between the **U.S. Army Engineering Research Development Center** (ERDC) and **Auburn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

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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Fishing Creek North Jetty Project team members inspect existing conditions in October 2018

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 Back Creek and Fishing Creek jetties, which are the Baltimore 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

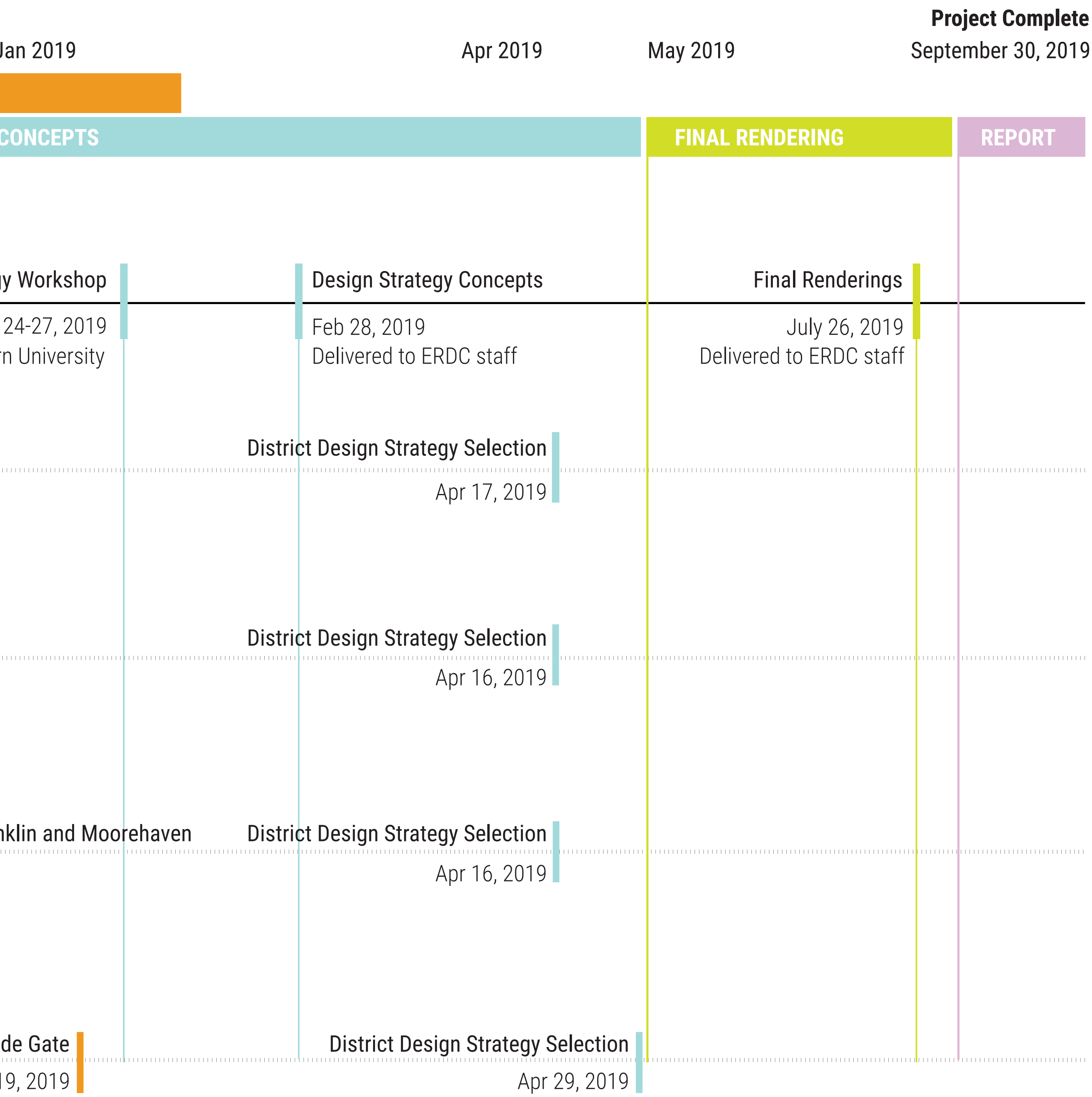
Site Visit to WP Fran

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
y Workshop
24-27, 2019
rn University
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

Baltimore District

Back Creek Jetty, Annapolis;
Fishing Creek Jetty, Chesapeake Beach

Jetties are a common engineered feature in Chesapeake Bay, used primarily to protect the mouths of navigation channels from shoaling. In fall 2018, the Engineering with Nature® and Landscape Architecture project delivery team (EWN®-LA PDT) was asked by the Baltimore District of the US Army Corps of Engineers (NAB) to look at three such jetties that NAB maintains. Two of these are in Chesapeake Beach, Maryland, at the mouth of Fishing Creek; the third is in Annapolis, Maryland, at the mouth of Back Creek.

These three jetties were selected because each is in some need of repair to address issues of settling, which has led to shoaling behind the jetties, which is compromising both private marinas and the publicly-maintained navigation channels at the mouths of the two creeks. The typical process for repairing the jetties would involve reinforcing the structure with large precast concrete blocks and using fabric to sand-tighten the core of the jetty. This study has examined alternative options, which are intended to both maintain the navigation-related performance criteria for the jetties and to provide enhanced ecological value on or in the vicinity of the jetties.

The following pages document the PDT's recommendations for the three selected jetties, including both the final recommendations and the process used to develop them. As there are dozens of jetties maintained by NAB in the Chesapeake, and many more jetties maintained by other districts around the country, it is hoped that these recommendations can be useful in considering the broader potential of the next generation of jetty infrastructure.

OPPORTUNITIES

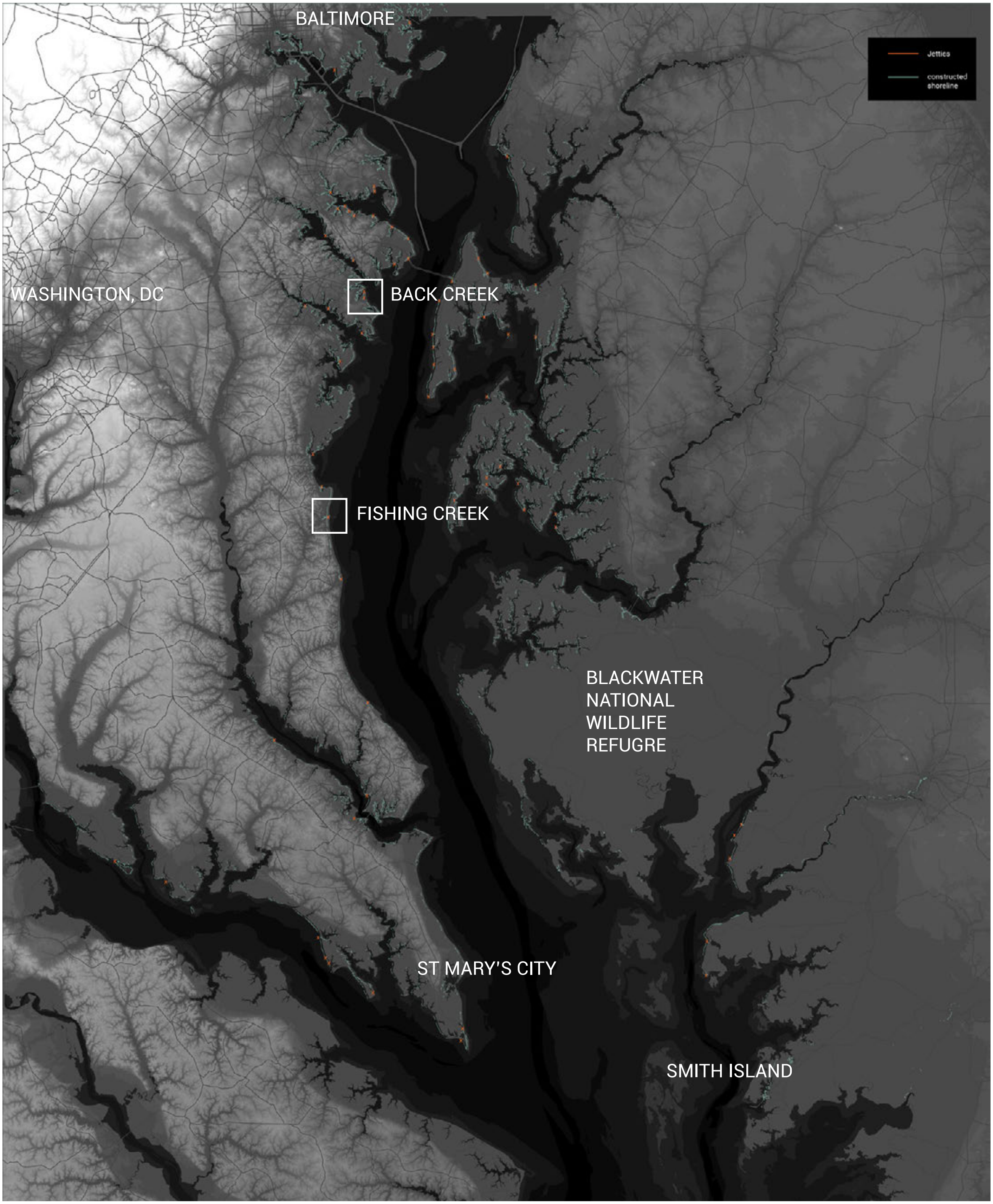
During the EWN®-LA workshop at Auburn University in January 2019, the project team identified a set of key opportunities that guided the development of design strategies and the final recommendation.

These opportunities centered on two themes, sediment management and ecological performance. Recreational value was not considered a significant opportunity with these jetties, as all of them meet the shore on private property, so public recreational access is not likely to be significant. There is significant recreational boat traffic in the vicinity of all three, though, so the aesthetic qualities of each jetty, as they might be observed from a passing boat, were incorporated into consideration. The identified opportunities can be summarized as follows:

1 Habitat Development
The Chesapeake Bay is broadly recognized as a crucial habitat for a range of important species (see p. 20-21). The Bay's shores are particularly key; important habitats found at or near the shoreline include brackish marshes, oyster reefs, beds of submerged aquatic vegetation (SAV), and sand beaches. Given that the Bay's shoreline has been intensely developed, with many stretches hardened into bulkheads, piers, or walls, any opportunity to replace lost habitat will be valuable. Maintenance work that will likely be required on each of these jetties represents a potential opportunity to combine work that benefits a navigational mission with habitat improvement that can bring additional stakeholders and/or funding into a project.

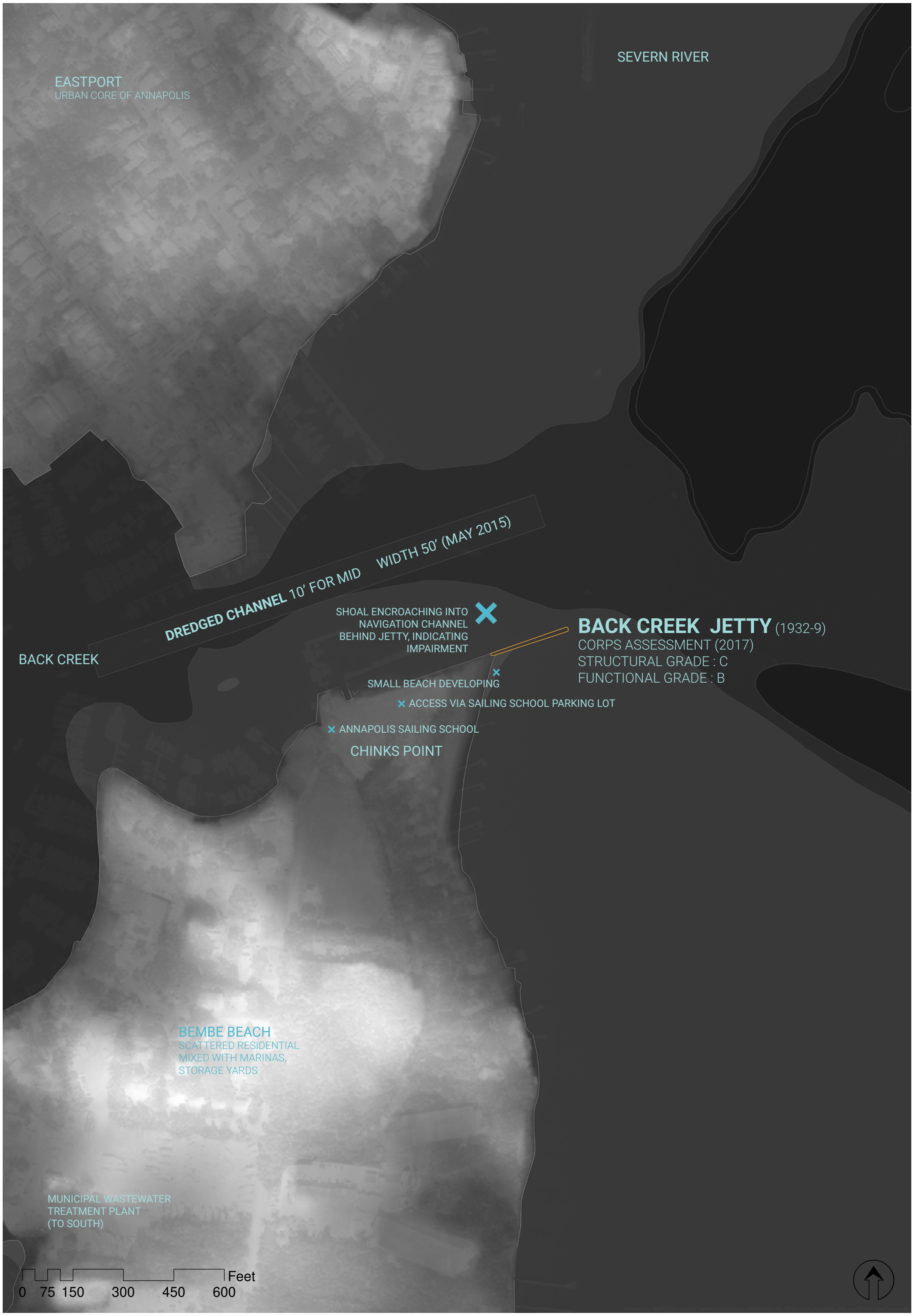
2 Beneficial Use
There are federally-authorized navigation channels at the mouths of both Back Creek and Fishing Creek. Though these channels are infrequently dredged, the material dredged from these channels — and perhaps other local channels or marinas — may present an opportunity for the beneficial use of sediment to create habitat adjacent to the jetties.

3 Passive Sediment Management
Traditional sediment management requires expensive, repeated mechanical maintenance operations, such as dredging. An emerging alternative paradigm, passive sediment management, involves two alternative means: (1) the strategic placement of large volumes of sediment in locations where it can be slowly redeposited by wave and tide action and/or (2) the construction of emergent or nearshore structures, such as groynes, breakwaters, and jetties, so as to alter depositional patterns in a beneficial fashion. Given the infrequent opportunities for mechanical dredging in the vicinity of these jetties, and the evident problems with shoaling, such jetties may present good opportunities to employ passive sediment management techniques.

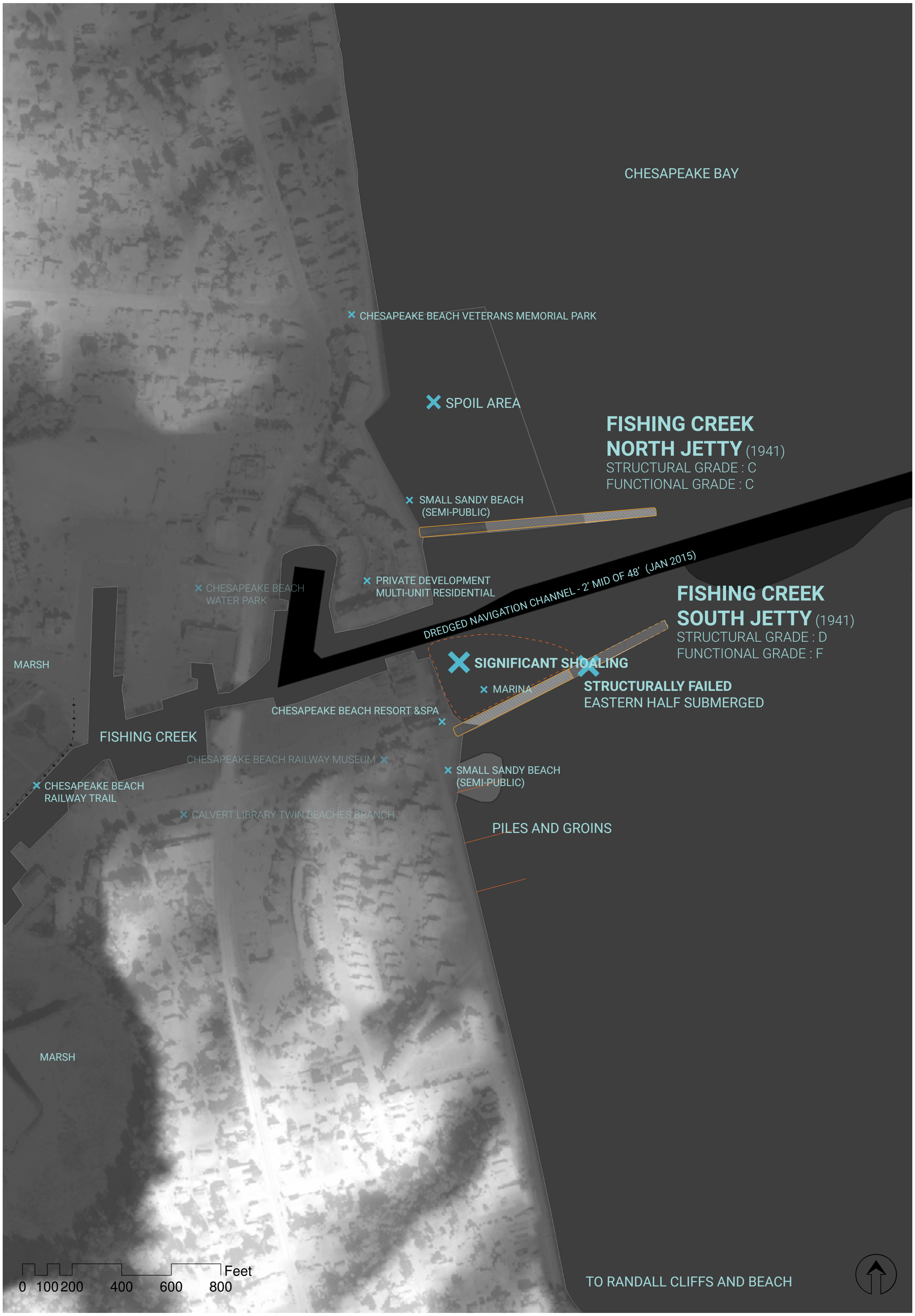


JETTIES AND CONSTRUCTED SHORELINES IN THE CHESAPEAKE BAY

JETTIES EXISTING CONDITIONS



BACK CREEK JETTY SITE



FISHING CREEK JETTY SITE

REGIONAL ECOLOGICAL CONTEXT

The Chesapeake Bay is the United States' largest and most productive estuary. Once known for its oysters (*Crassostrea virginica*), which could filter all the water of this expansive 4,479 mi^2 bay in a single week, this estuary's health has significantly declined since European settlement began in the seventeenth century. Development, exploitation, and mismanagement of resources over the last 300+ years have greatly reduced biological productivity. By the late twentieth century, oyster populations were so unsustainably harvested and damaged that it would take the remaining oysters over a year to filter the entire bay[1]. Despite this decline, the commercial fishery of the Chesapeake is still worth billions of dollars. Broad and far-reaching environmental protection and restoration initiatives since the 1980s, such as the Chesapeake Bay Program, have helped protect the Chesapeake Bay from further degradation, leading to notable improvements in the last few decades[2]. Yet the bay remains significantly impacted by human activities and in coming decades the bay will face extensive challenges as climate change and sea level rise are expected to heavily impact the Chesapeake Bay and its affiliated ecosystems.

Hosting expansive forests, wetlands, sandy beaches, and rivers, the Chesapeake Bay's watershed is home to 3,700 plant and animal species. It is also home to 18.1 million people (2016)[3] living in cities like Baltimore, Maryland and Washington, D.C. Currently, 39% of the watershed's land cover has been converted into agriculture, suburban, or urban use; these land uses grow approximately 100 acres every day[4]. Excess nutrients from agricultural run-off and other human activities often lead to anoxic conditions in the bay, which has in turn resulted in frequent fish kills and contributed to the declining fishery. Industrial, transportation, and commercial interests require that 4.5 million yd^3 of sediment be dredged from the watershed per year; this dredging both impacts the ecosystem and provides a potential resource for ecological restoration activities[5]. The Chesapeake Bay is also widely used for recreational activities like hunting, fishing, and boating.

Despite the land use change, 55% of the watershed remains as forest, with oak and hickory species dominating hardwood composition in the inland forests. Atlantic White Cedar (*Chamaecyparis thyoides*) and Bald Cypress (*Taxodium distichum*) are common species found in the inundated swamps and along the riparian zone of the bay. On the bay's shores, sandy beaches are home to the endangered Puritan Tiger Beetle (*Cicindela puritana*) and Northeastern Beach Tiger Beetle (*Cincindela dorsalis dorsalis*), whose populations are in rapid decline from both the direct impact of human use of beach habitat and the loss of habitat due to the indirect effects of infrastructure[6]. Pristine beach habitat loss is common throughout the East Coast and is responsible for the extirpation of these beetles from several states[7]. Beach loss is also a significant cause of declining wading and migratory bird populations throughout the Atlantic Flyway[8].

At the water's edge and in shallow reaches, the bay has 1.5 million acres of wetlands and has roughly 110,000 acres of submerged aquatic vegetation, providing critical habitat for many of the 300+ species of fish found throughout the bay. Having fresh, brackish, and saltwater, the Chesapeake Bay hosts fish that can live in a range of salinity levels along with other species like the American Shad (*Alosa sapidissima*), Alewife (*Alosa pseudoharengus*), and American Eel (*Anguilla rostrata*) which require time in both fresh and saltwater to complete their life cycles. Efforts are currently ongoing to restore the submerged aquatic vegetation to 185,000 acres of its historic coverage, up from less than 40,000 in 1984[9]. Submerged aquatic vegetation is also prime habitat for the Atlantic Blue Crab. Blue crabs are known for their great abundance throughout this estuary and represent the bay's most important fishery. In 2019, there was an estimated 594 million blue crabs, which was a significant increase from 2018 when tighter restrictions were put in place after two decades of below average populations[10]. The blue crab and beetle species serve as an important reminder that all facets of the Chesapeake Bay require close monitoring, strong protection, and innovative restoration efforts if it is to retain or grow its amazing biodiversity and productivity. The innovative use of NNBF, such as the NNBF jetties described in the design concepts that follow, can be one component of these efforts.

1 Miller, Henry M. "The Oyster in Chesapeake History." Historic St. Mary's City. https://www.hsmcdigshistory.org/pdf/Oyster.pdf

2 Fincham, Michael W. 2013. "A Chesapeake Bay Recovery: Half Empty or Half Full." Chesapeake Bay Foundation. https://www.cbf.org/how-we-save-the-bay/chesapeake-clean-water-blueprint/chesapeake-bay-recovery-half-empty-or-half-full.html

3 "Population." Chesapeake Bay Program. https://www.chesapeakebay.net/state/population.

4 "Chesapeake Bay." National Wildlife Federation. https://www.nwf.org/Educational-Resources/Wildlife-Guide/Wild-Places/Chesapeake-Bay.

5 "Dredging." Sea Grant, Maryland. University of Maryland. http://www.mdsg.umd.edu/topics/dredging/dredging.

6 "Puritan Tiger Beetle." Connecticut Department of Energy and Environmental Protection. https://portal.ct.gov/DEEP/Wildlife/Fact-Sheets/Puritan-Tiger-Beetle

7 "Northeastern Beach Tiger Beetle." Chesapeake Bay Program. https://www.chesapeakebay.net/S=0/fieldguide/critter/northeastern_beach_tiger_beetle

8 Atlantic Flyway Shorebird Initiative: A Business Plan. 2015. http://atlanticflywayshorebirds.org/documents/AFSI_Business_Plan_11_2017.pdf

9 "Submerged Aquatic Vegetation (SAV)." *Chesapeake Progress*. Chesapeake Bay Program. https://www.chesapeakeprogress.com/abundant-life/sav.

10 "Blue Crabs." Chesapeake Bay Program: Science. Restoration. Partnership. https://www.chesapeakebay.net/state/blue_crabs

Back Creek jetty extends out from a small sand beach

Shoaling in the marina behind the Fishing Creek south jetty

Fishing Creek north jetty with recreational boat traffic

STRATEGIES

The following spreads (pages 24-27) 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 Baltimore District in April 2019.

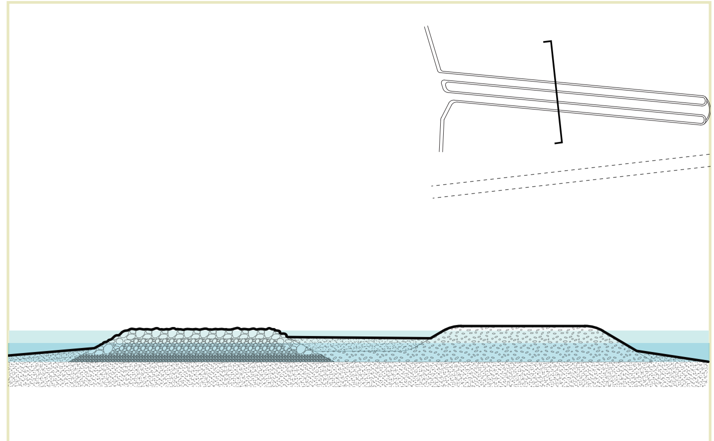
These strategies are intended to represent a broad range of options for implementing EWN® principles and NNBF in jetties like those found at Fishing and Back Creeks. While all of them had some potential for implementation and have been reviewed by the project team for some measure of feasibility, they were intended to explore a variety of both feasibilities and levels of expense.

Some of the ideas, such as the idea of a jetty that also functions as an artificial reef, like in strategies 2B and 2C, were selected as preferred and have been developed further into the recommendations (pages 29-43). Others, like the idea of a "beach" jetty at Fishing Creek South, 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.

1 HARD + SOFT JETTIES

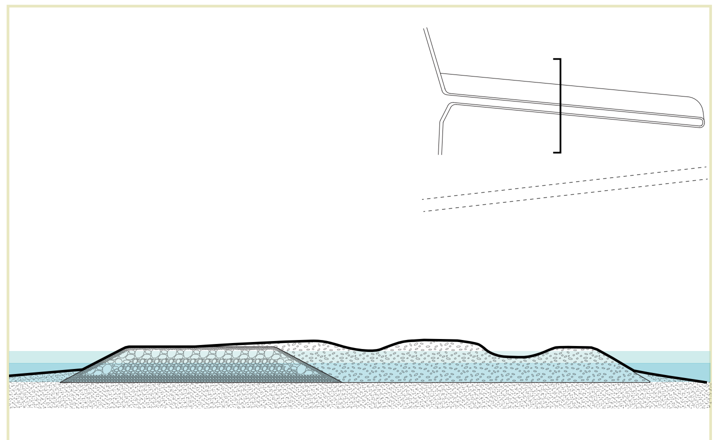
1A HARD AND SOFT

The existing jetty is left in place. Rather than sand-tightening the existing jetty, a new, softer jetty is constructed outside the existing jetty to address the jetty's engineering performance deficiencies and to provide habitat. The space between these two jetties is constructed as habitat, such as rock pools or high marsh.



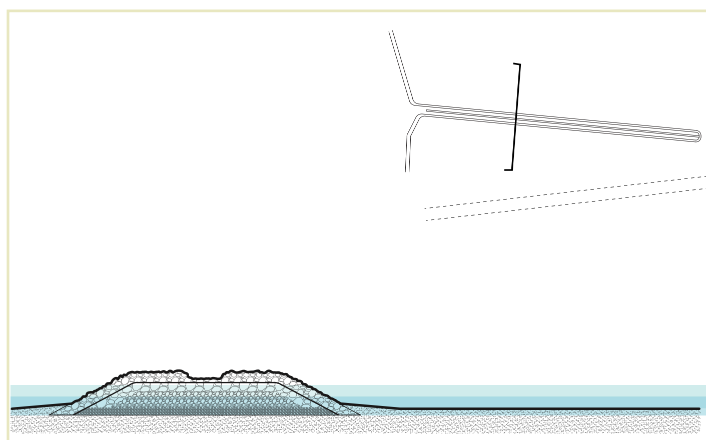
1B POROUS JETTY

A layer of relatively porous material (reef layer) is added to one side of the jetty. This reef layer would reduce sediment transport through the existing jetty, alleviating the need for sand tightening.. The reef layer would be composed of smaller, evenly graded material, which would have limited mobility over time, including the potential for depressions that could function as rock pools.



1C ROCK OVERLAY

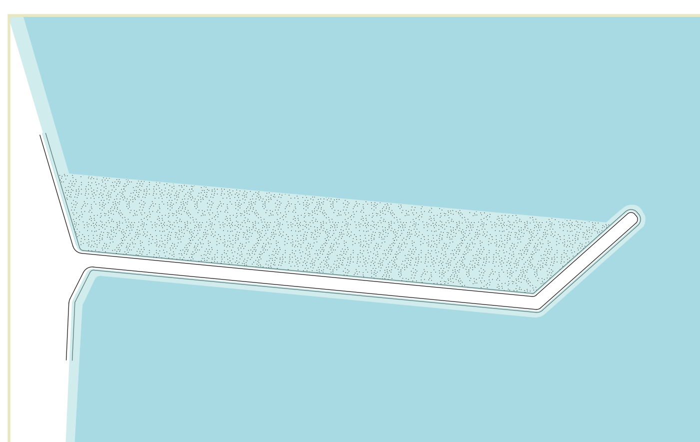
The simplest form of modification to the jetty would be to use the process of sand tightening and additional rock or block within the footprint of the existing jetty to structurally stabilize it while creating floodable rock pool habitat along its centerline.



2 THICKENED JETTY

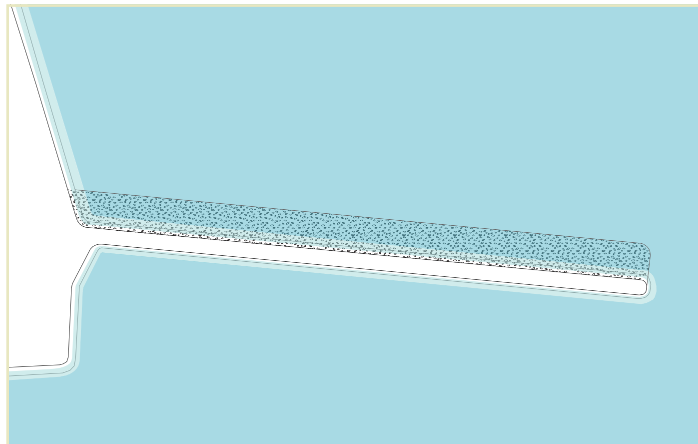
2A EMERGENT MARSH

This strategy would establish a marsh on the outer side of the jetty without structural reinforcement. The marsh would be dimensioned to ameliorate the existing deficiencies in the jetty's performance. See strategies 3A-3B for discussion of how the marsh might be built. (A wing extension similar to strategy 3A is shown in this diagram, but 3B offers an alternative.)



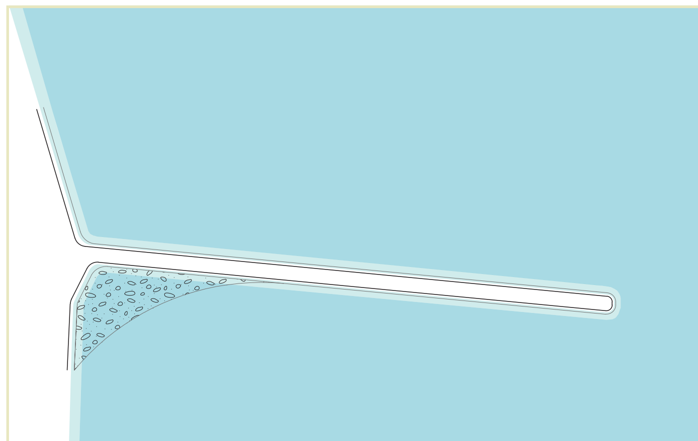
2B REEF

A reef could be created by scraping the top material of the jetty to create a very fat jetty that would build overtime, or by adding new rock and/or block. The dimensions of the new reef would be set by studying how thick the reef needs to be in order to provide the same standard of protection the jetty is currently engineered to.



2C PARTIAL REEF

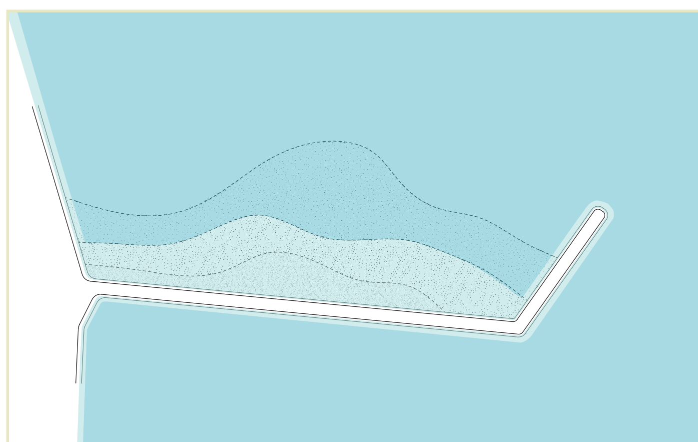
A new reef would be tucked in the elbow on the inner side of the jetty. Its primary purpose would be as a habitat supplement. It could use reef blocks or balls that would build and accrete over time.



3 MECHANISM OF MARSH BUILDING

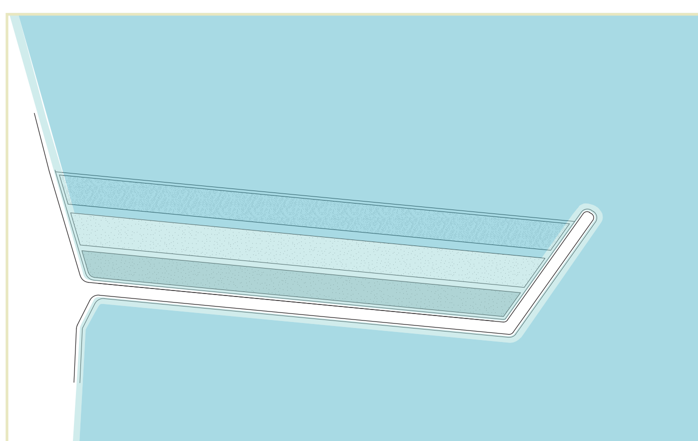
3A PASSIVE SEDIMENT ACCUMULATION

To establish and maintain a thickened jetty, a 'wing' extension would be added to the existing jetty to promote the accumulation of sediment as marsh substrate. If this strategy is selected for advancement, modeling should be done to determine relationships between accretion rate and wing design. (It is also possible that dredged material could be beneficially used to passively nourish this marsh after adjacent placement, similar to 4A and 4B.)

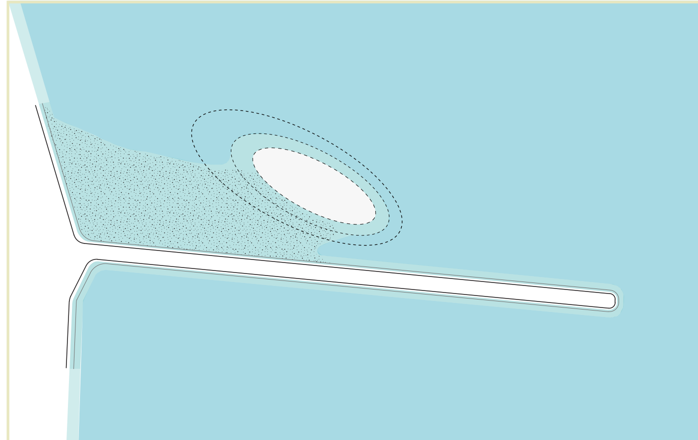


3B BENEFICIAL USE PLACEMENT

To establish and maintain a thickened jetty, a 'wing' extension would be added to the existing jetty to hold multiple placements of beneficial use material. Shallow sill perimeters would hold and support the continuing accretion of that material to push the mean low low out further and further. Additional placements of beneficial use material could be added to feed the marsh over time, see "Feeder Ridges".

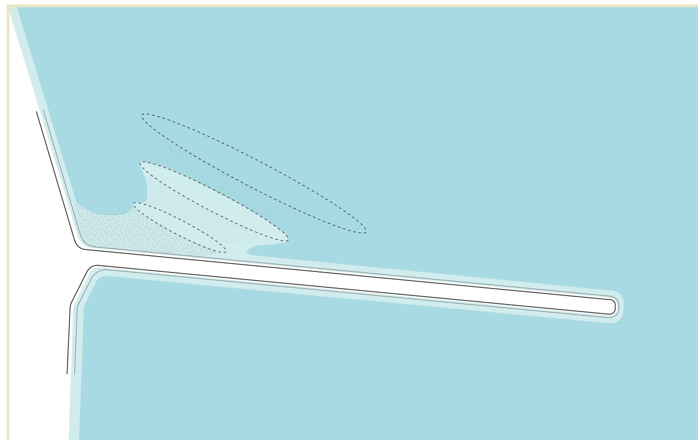


4 HABITAT ENHANCEMENTS OUTSIDE OF FOOTPRINT



4A ONE BIG FEEDER BERM

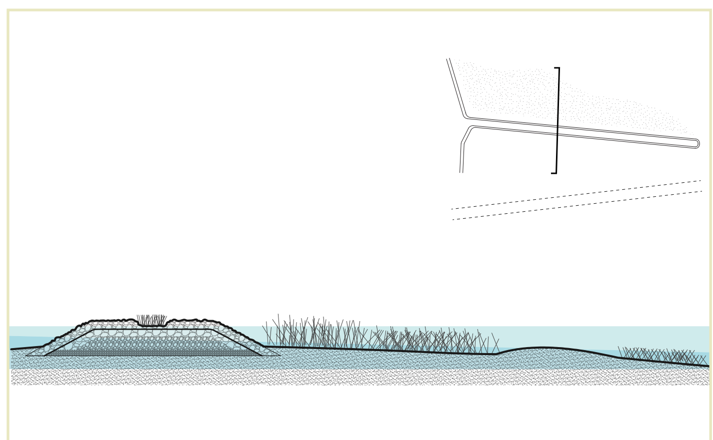
To establish a thickened jetty, a large berm of dredged material would be placed in-water near the jetty. This sediment would be moved over time by waves and currents toward the jetty, where it would accrete and form marsh, SAV, or oyster bed substrate.



4B FEEDER RIDGES

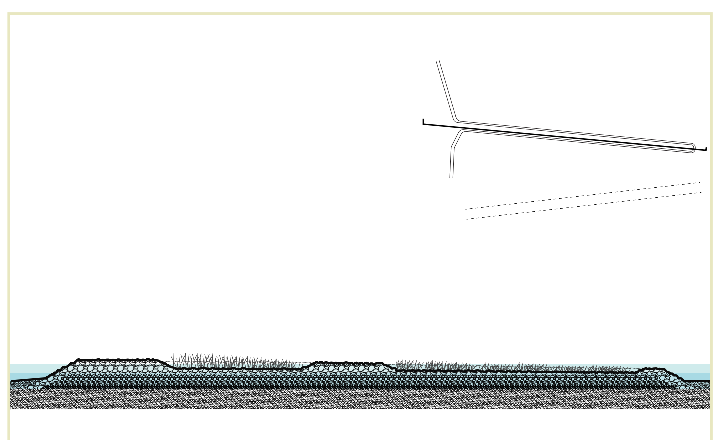
To establish a thickened jetty, a series of berm ridges of dredged material would be placed subsequently further from the jetty to feed the emerging marsh over time. The ridges could be placed as maintenance dredging occurs, depending on the frequency of maintenance dredging for this or other nearby channels.

5 ECOLOGICAL GRADIENTS



5A PARALLEL

A jetty could be redesigned so that it provides a gradient of elevation and corresponding habitat types from a high point at shore, which could be upland bird habitat, out along its length to a low point offshore.



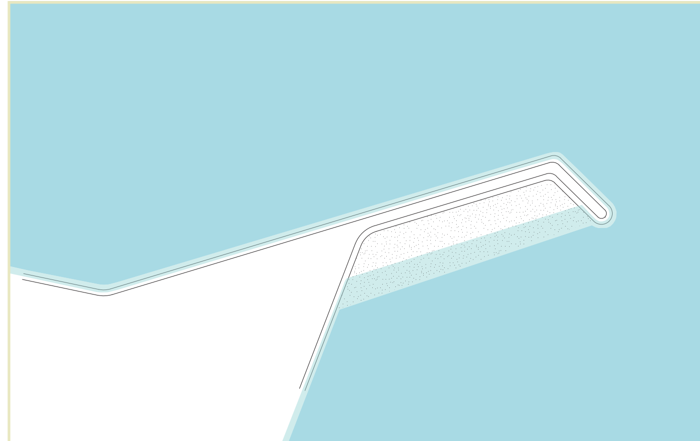
5B PERPENDICULAR

Alternatively, a jetty could be redesigned with a difference of height along its perpendicular cross section. This would have a hardened edge (possibly with ecocrete or similar products) that could be dredged right up to the toe on the inner side. A descending gradient of habitats from upland bird nesting to oyster and/or SAV beds would be found on the outer side.

6 SITE DIVERSITY

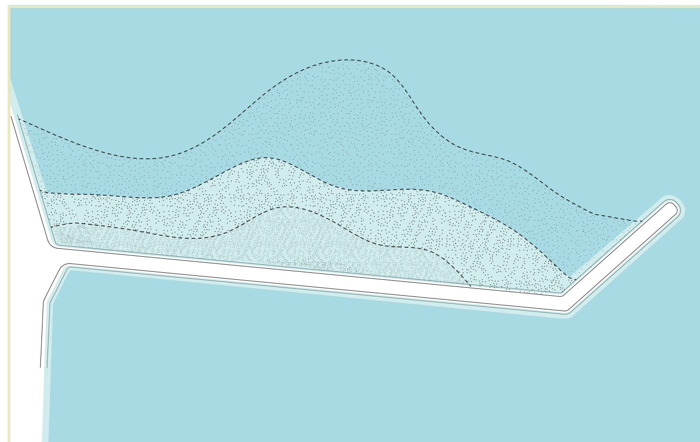
6A BACK CREEK: SAILING SCHOOL AND BEACH

A ‘wing’ jetty extension to create sand beach, SAV, and mudflat would support habitat, extending the existing beach and the small upland plant community above the current jetty. The sailing school currently makes use of the small existing beach for events, so this extended beach might be desirable for its purposes.



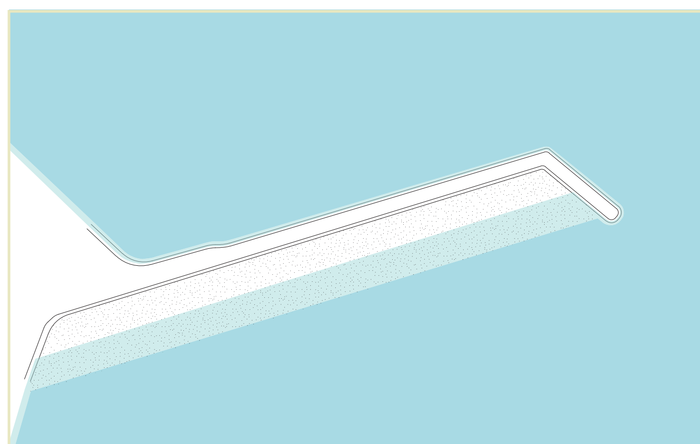
6B FISHING CREEK (NORTH): OYSTER, MARSH, AND SAV

The north side of the north jetty at Fishing Creek would be a good opportunity to develop a marsh as well as oyster and/or SAV beds. As wave energy is a concern for the establishment of oyster habitat this zone could be protected with a solid or notched berm (possibly made of rock).



6C FISHING CREEK (SOUTH): PURITAN TIGER BEETLE AND BEACH

The south side of the south jetty at Fishing Creek could support beach habitat for the endangered Puritan Tiger Beetle. These beetles depend on habitat formed along the Bay edge through erosive processes, and the south jetty is located just north of Calvert Cliffs, which is the type of cliff that provides sediment through erosion for the beetles’ habitat.



PREFFERED STRATEGIES

The following summarizes feedback received from NAB regarding the strategies.

1 Hard and Soft Jetties
Strategy 1A, supplementing the existing hard jetty with a new, softer jetty on the outside, was not preferred, and has not been explored further. Strategy 1C, Rock Overlay, is explored in combination with other options in the recommendations that follow.

2 Thickened Jetty
Strategy 2A, in which an emergent marsh would be formed on the outside of an existing jetty, was not preferred, and has not been explored further. Strategies 2B and 2C, in which an existing jetty would be thickened into an artificial reef, were preferred. The recommendation for Fishing Creek South shows what such a jetty might be like.

3 Mechanism of Marsh Building
Passive sediment accumulation and beneficial use of sediment in feeder ridges were both considered acceptable. The former has been explored in the recommendation for Back Creek and the latter in the recommendation for Fishing Creek North.

4 Habitat Enhancements outside of footprint
No preference was expressed between these two options. The recommendation for Fishing Creek North explores a modified version of strategy 4B.

5 Ecological Gradients
The perpendicular option was preferred to the parallel option. A perpendicular option has been integrated into the recommendation for Fishing Creek South.

6 Site Diversity
The strategies for Back Creek and Fishing Creek North were found acceptable, and have been incorporated into those recommendations. The "beach" strategy for Fishing Creek South (6C) was not preferred; the reef strategy (2B) has been explored instead in that recommendation.

RECOMMENDATIONS

The EWN®-LA PDT's recommendations follow, with one recommendation provided for each of the three jetties studied. The recommendation for Fishing Creek's south jetty is the most detailed, as that jetty, which was constructed in 1941, has been assessed as the most structurally and functionally deficient of the three studied jetties, suggesting that it is likely to be the first of the three to be repaired.

For each jetty, a plan shows the general layout of the recommendation, indicating significant features. An oblique aerial diagram indicates the primary performance issues that each recommendation is intended to address. A perspective rendering indicates something of the potential character of the jetty if the recommendation were implemented. For Fishing Creek South, this rendering is also cut to reveal the potential structure of the recommendation.

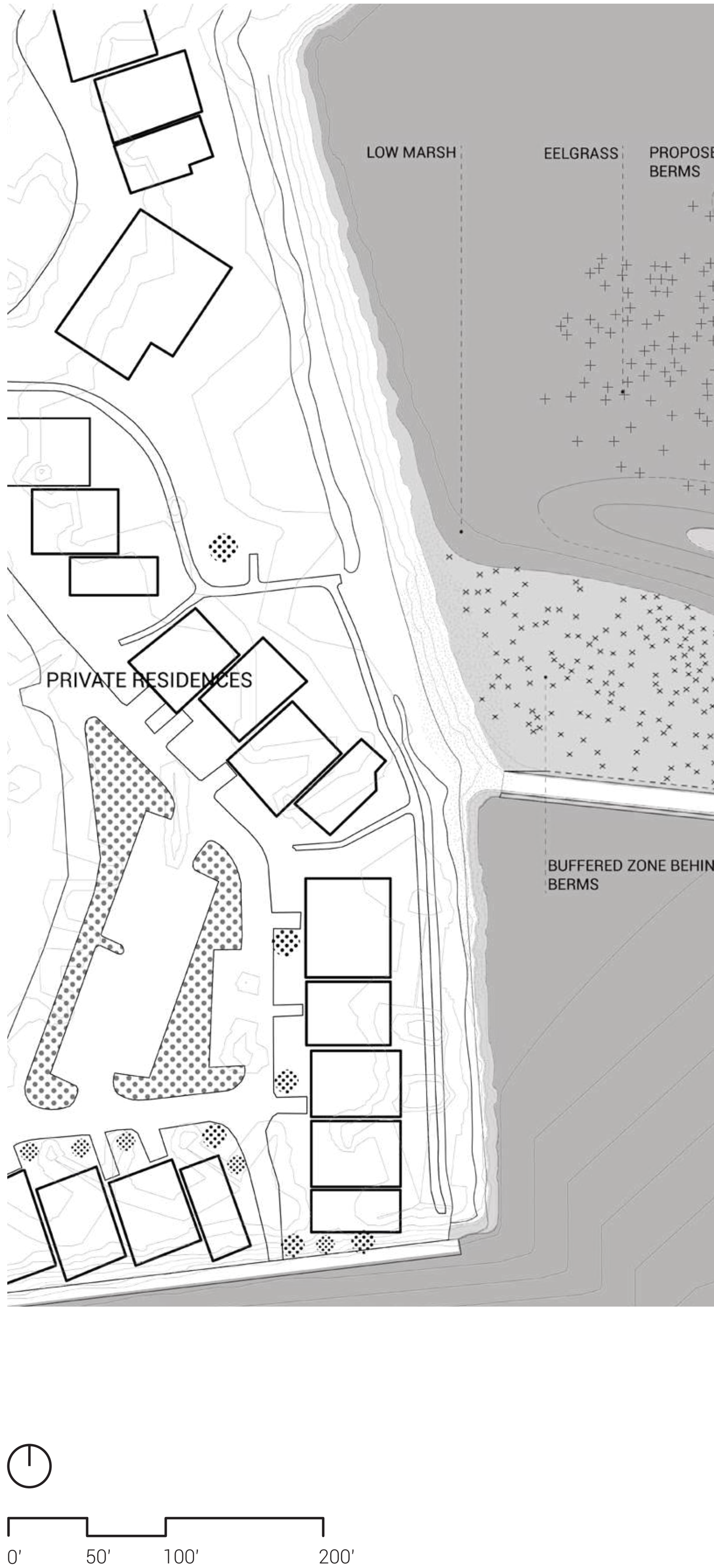
FISHING CREEK NORTH

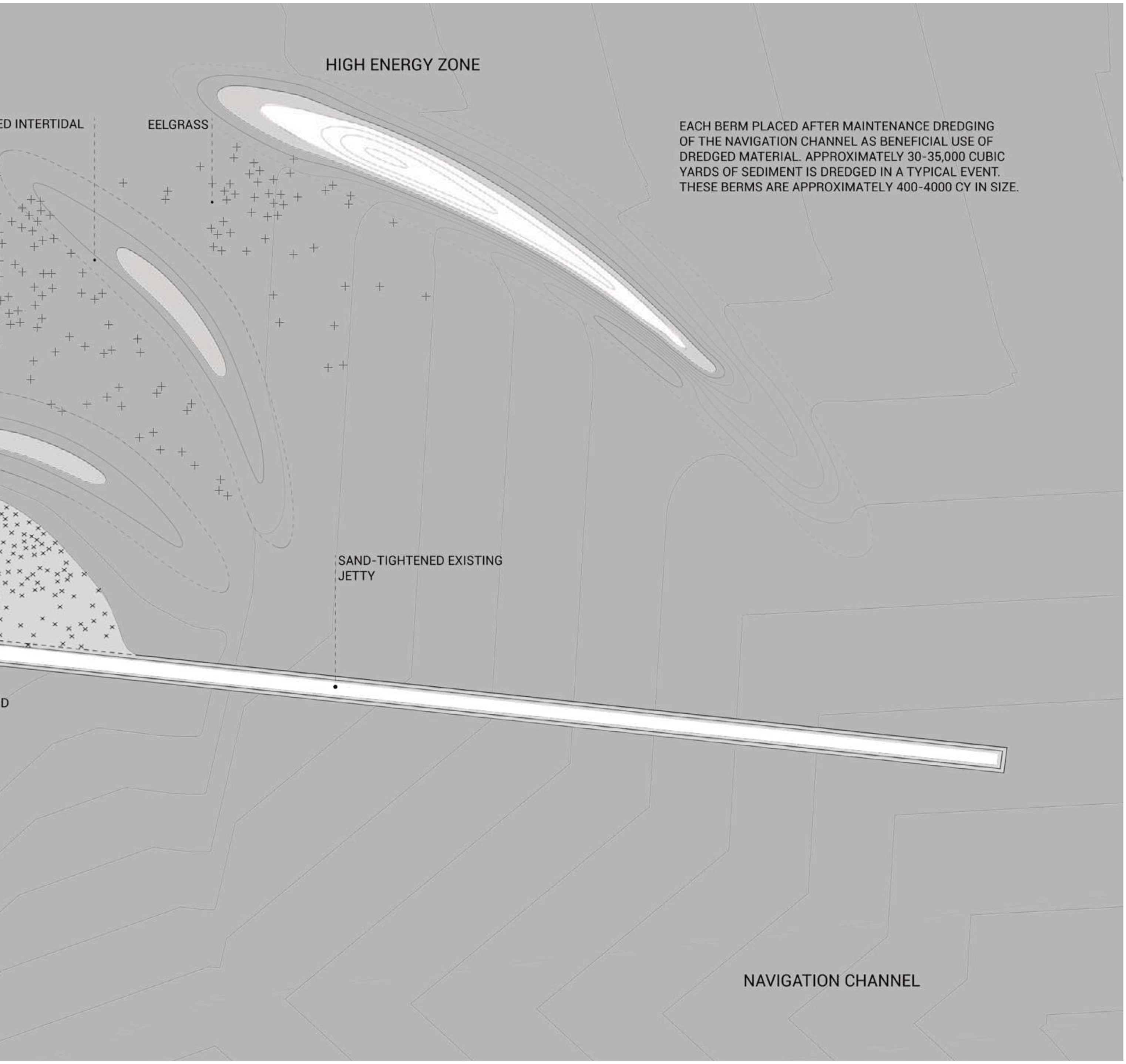
RECOMMENDATION

The north jetty at Fishing Creek is in a relatively good condition, relative to the south jetty, and NAB has indicated that, in the near term, repair work is likely to be limited to the south jetty. This recommendation, therefore, focuses on the possibility of the beneficial use of dredged material to create a series of **emergent and subtidal berms**, shallowing the area north of the jetty, producing protected habitat for emergent marsh and submerged aquatic vegetation, and prospectively, over time, reducing wave energy to and sediment transport through the jetty.

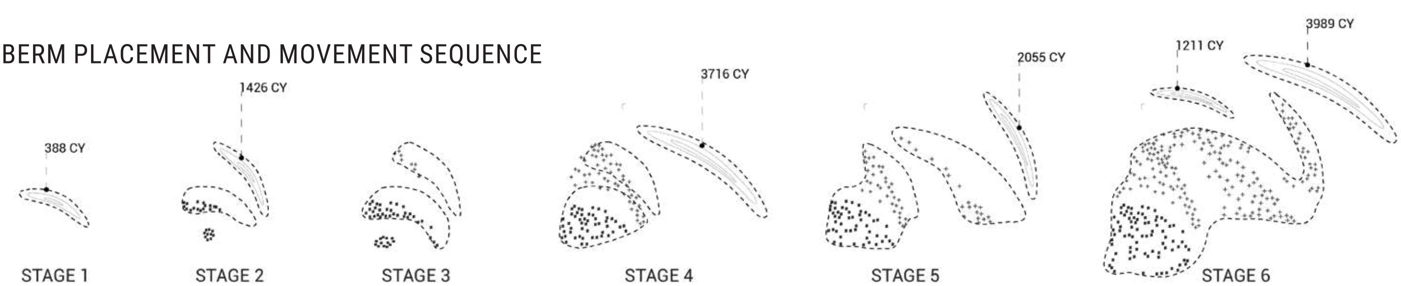
The area north of the jetty, where these berms would be placed, is already shallow, due to the placement of dredged material as an "oyster bed" in the 1980s and 1990s. It is believed that the establishment of the oyster bed here failed in part due to the high energy wave environment. The proposed berms could protect vegetation, such as eel grass, during establishment; these roughened zones could then, in turn, protect the jetty structure. The Fishing Creek channel is currently dredged approximately every ten years to a depth of 9'. Typically, this material is placed on the adjacent beaches or in a nearby upland placement site, with the location dependent on the quality of the material dredged. Material redirected to the proposed berms would need to be tested to determine its suitability for subaqueous berm construction.

The drawings on this page show one potential way in which a sequence of strategic placements of dredged material and subsequent development of habitat areas might proceed. While the placement volumes are based on dredging volumes in a typical event from the adjacent channel, this sequence is diagrammatic and not modeled. Hydrodynamic and sediment transport modeling would be required to explore the potential behavior of this passive sediment management system before proceeding with design and implementation. It should also be noted that this jetty is located in front of a small private community, which makes use of the beach adjacent to the jetty. This community should be consulted and engaged in the potential process of an ecological renovation of the jetty.





BERM PLACEMENT AND MOVEMENT SEQUENCE



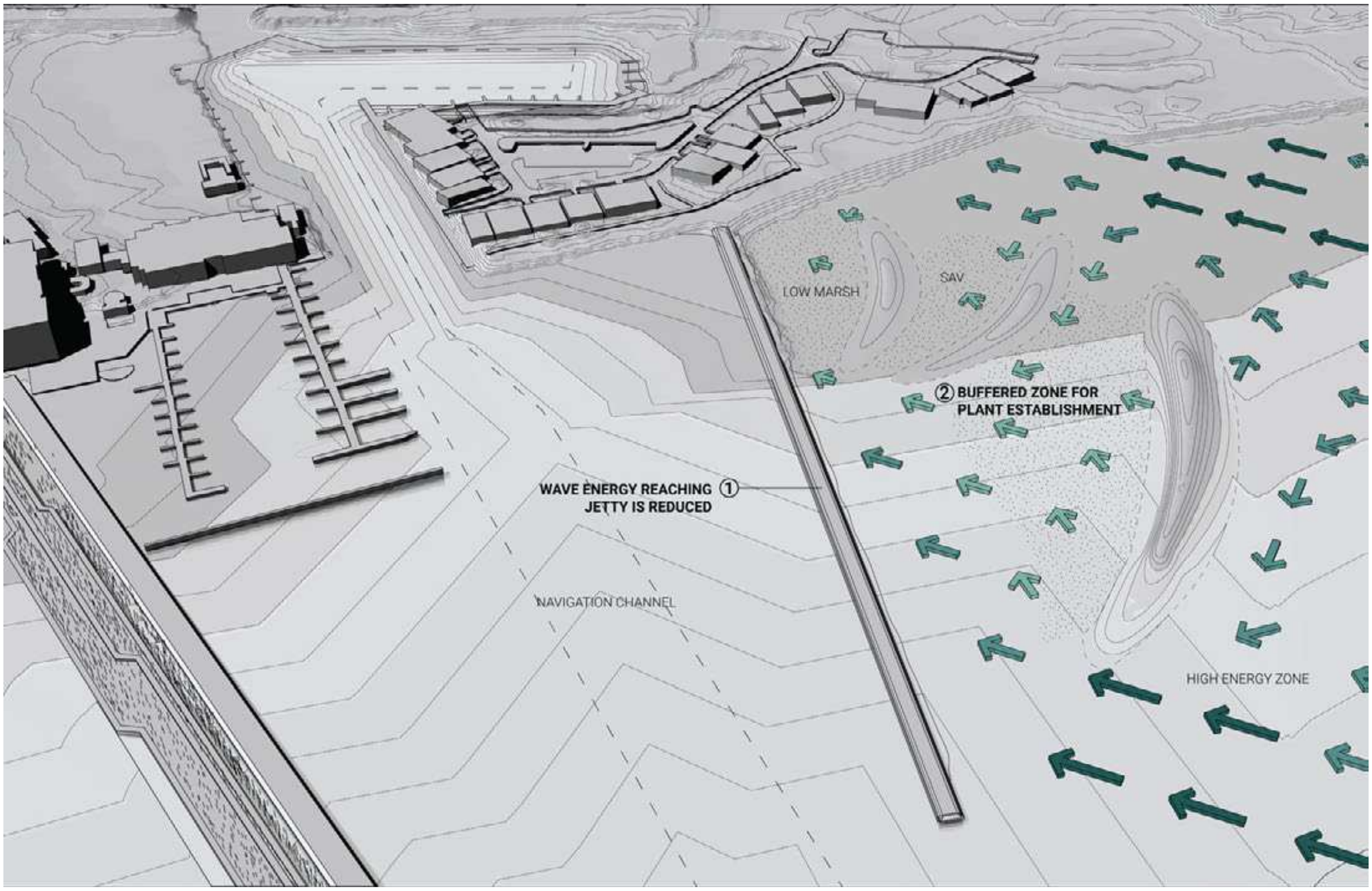


Diagram of primary goals of the recommendation for Fishing Creek north jetty

The two primary aims of this recommendation are to (1) to reduce the amount of wave energy that reaches the jetty and (2) to establish a buffered zone for plant establishment. As shown in the diagram above, wave energy arrives from the north, and would be reduced by both the berms themselves and vegetation, as it establishes. It is suspected that one of the primary reasons that oyster beds have not established in this zone already, given that it has already been shallowed by the placement of dredged material in the latter half of the 20th century, is that wave energy is too high for oyster recruitment and establishment.

Over time, wave energy would gradually distribute the berms into more shallow zones behind the initial placement lines. New placement events could expand north and east, allowing the ecological zone to grow over time as the navigation channel is dredged.

Rendering of a potential view from the beach on the south side of the jetty

Areas of submerged aquatic vegetation would likely include plant species such as eelgrass (*Zostera marina*). Eelgrass beds are a significant focus for restoration efforts in the Chesapeake Bay, as they are the primary SAV beds found in the saltier portions of the bay and an important source of shelter and food for juvenile crabs, fish, and waterfowl. Lack of shallow water zones is an important barrier to eelgrass restoration efforts, which the beneficial use of dredged material could address here.

Emergent marsh could also develop in this area; it would likely be dominated by Smooth cordgrass (*Sporobolus alterniflorus*) and Saltmeadow cordgrass (*Sporobolus pumilus*), depending on the elevation of the marsh. Like eelgrass beds, it would also provide habitat and forage for many species, such as juvenile American Shad.

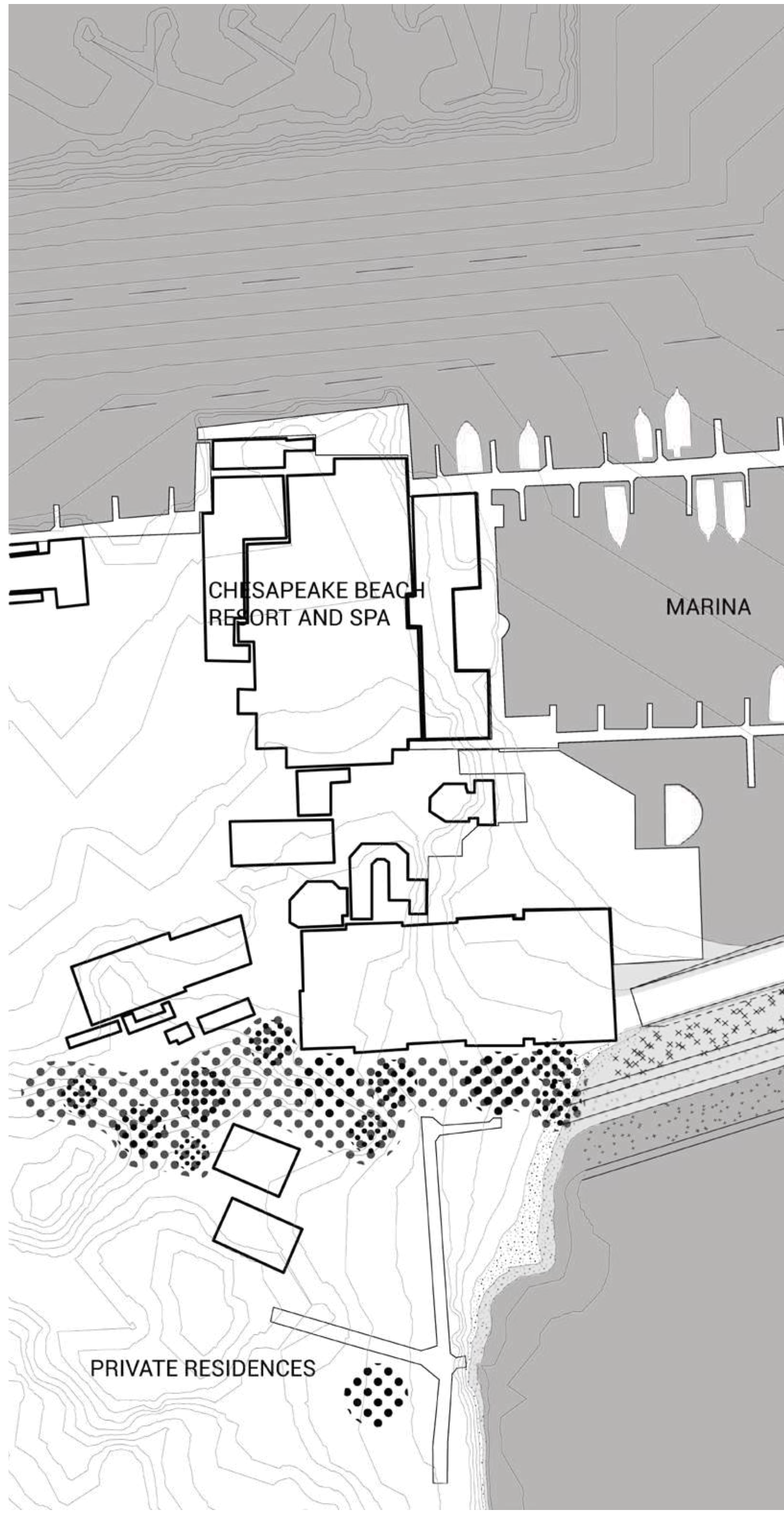
FISHING CREEK SOUTH

RECOMMENDATION

The south jetty at Fishing Creek is the most structurally and functionally compromised of the three jetties studied, and it is consequently likely to be the first jetty to be repaired. As a result, the recommendation for the south jetty has been explored in the most detail of any of these three studies.

The south jetty extends into the bay from the property of the Chesapeake Bay Resort and Spa, which has a small beach that accesses the base of the jetty. To the south of the jetty, private residences stretch along the shoreline. These residents have expressed concern about groin deterioration and beach loss. Public access is not likely to be significant, but there is a private marina on the north (channel-side) of the jetty, which is used primarily for oyster, rockfish, and blue crab harvests (both commercial and charter). This marina is significantly impacted by shoaling from sediment that passes through the compromised jetty.

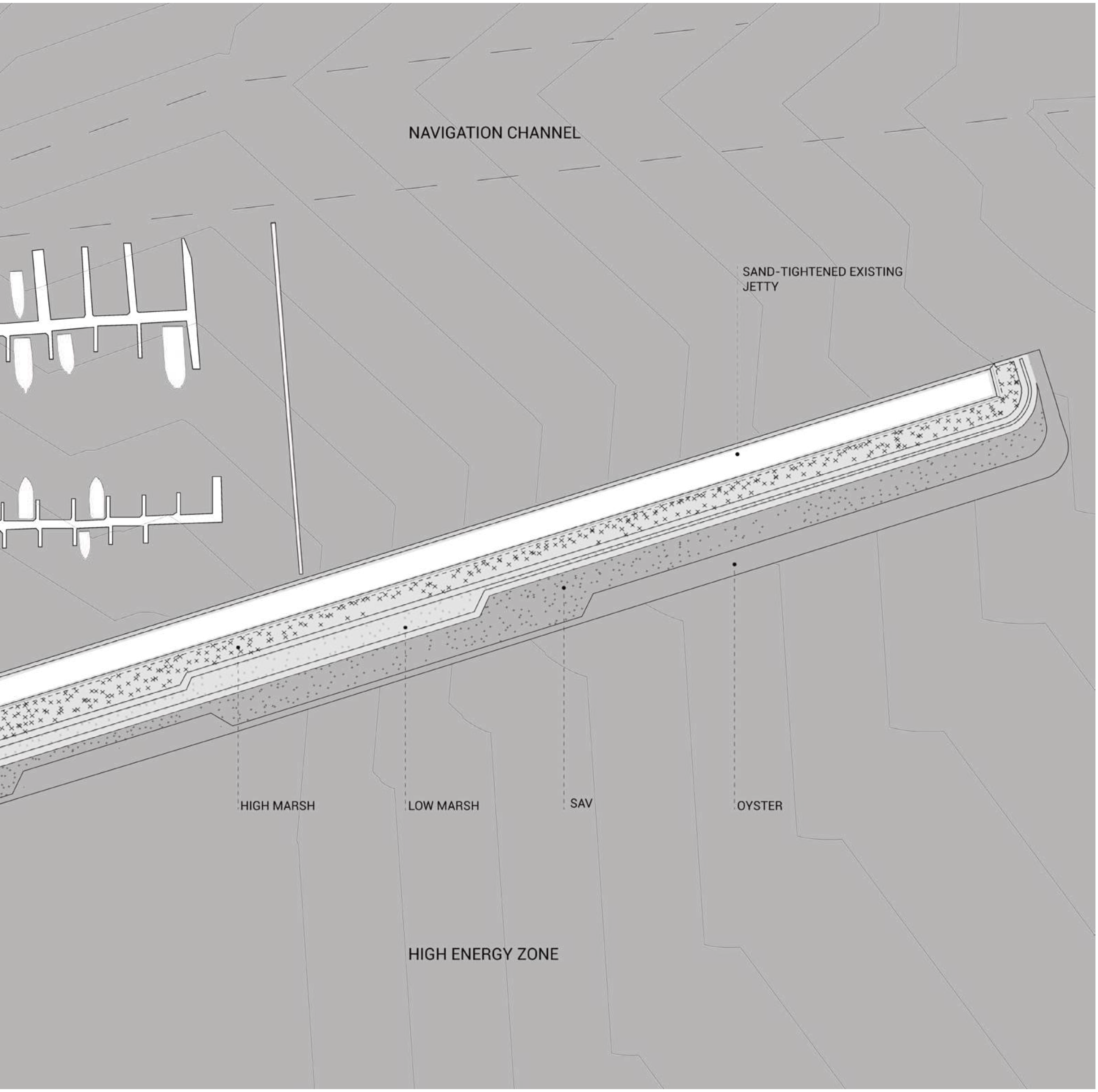
We recommend expanding the ecological performance and structural resilience of the jetty by first sand-tightening the existing core and supplementing it with additional rock (or concrete block units) as necessary to address the current structural failures. With that new core in place, the jetty would be widened in a series of terraces that step down from high marsh to low marsh to submerged aquatic vegetation beds to oyster reefs. (The oyster reef would provide the outer layer so as to protect the SAV beds from wave energy, facilitating plant establishment.) This **terraced jetty** would be structured using ecoblock concrete units and fill.



Legend

- Tidal
- Subtidal and open water
- Beach
- Submerged Vegetation
- Vegetation

0' 50' 100' 200'

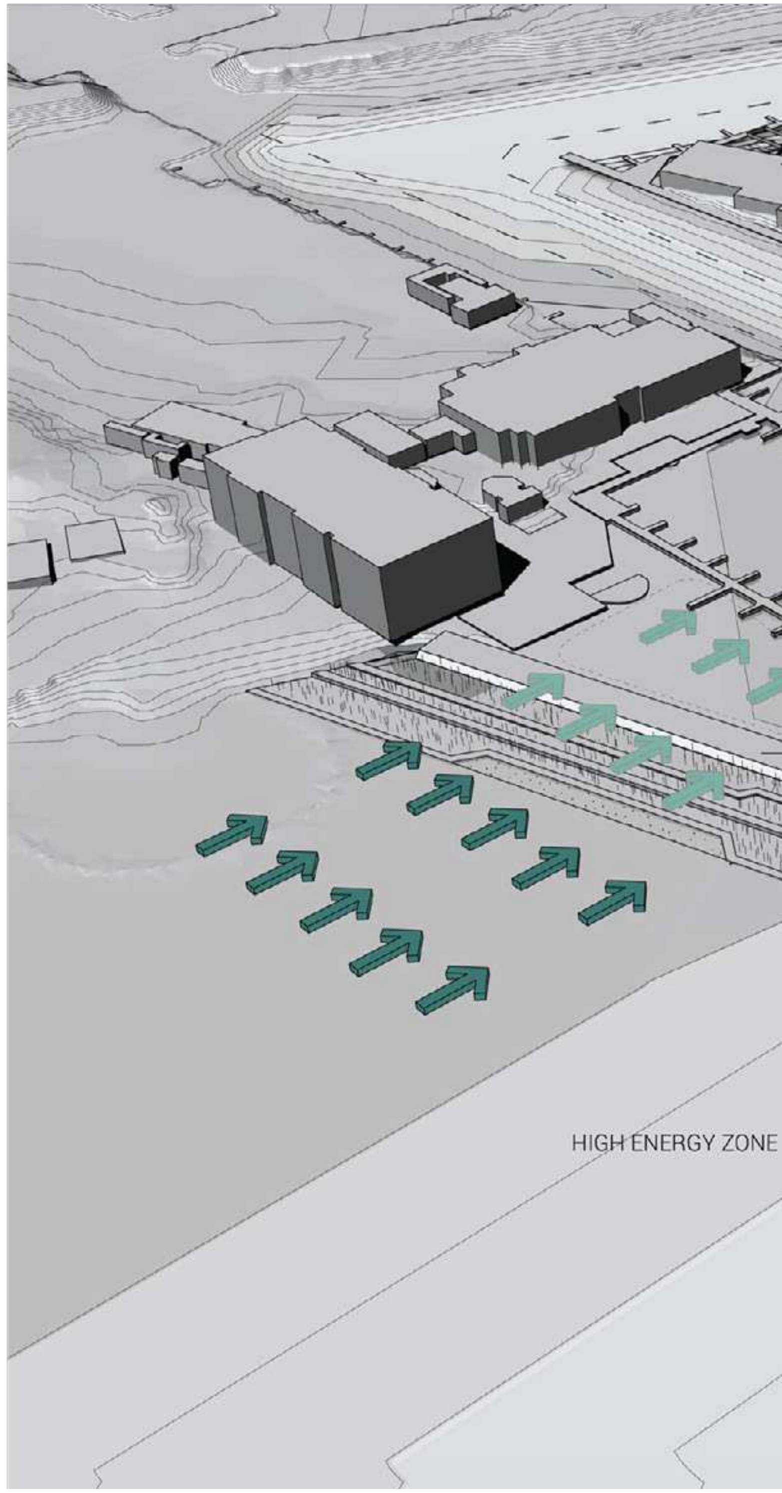

NAVIGATION CHANNEL
SAND-TIGHTENED EXISTING JETTY
HIGH MARSH
LOW MARSH
SAV
OYSTER
HIGH ENERGY ZONE

RECOMMENDATION

As shown in the diagram at right, the primary goals of this recommendation are to halt sediment transport through the jetty, which has been particularly problematic in the marina, and to establish a set of valuable habitats. The **habitat jetty** is similar in concept to structures like SCAPE Landscape Architecture's "Living Breakwaters" (Staten Island, New York), which also seek to redesign a coastal infrastructure composed of concrete block units to improve habitat function without compromising engineering function.

Hydrodynamic and sediment transport modeling would be needed to understand the protective benefit of the terraces and to select ideal widths for each terrace. Biologists and ecologists should be consulted in order to ensure that the terrace designs have the best possible chance of successfully producing and sustainably maintaining viable habitat.

The section-perspective on the following page shows what the implemented habitat jetty might look like as well as how it would be constructed. In addition to the ecological and protective value of the habitat jetty, it is anticipated that the habitat jetty would offer a significant aesthetic improvement.



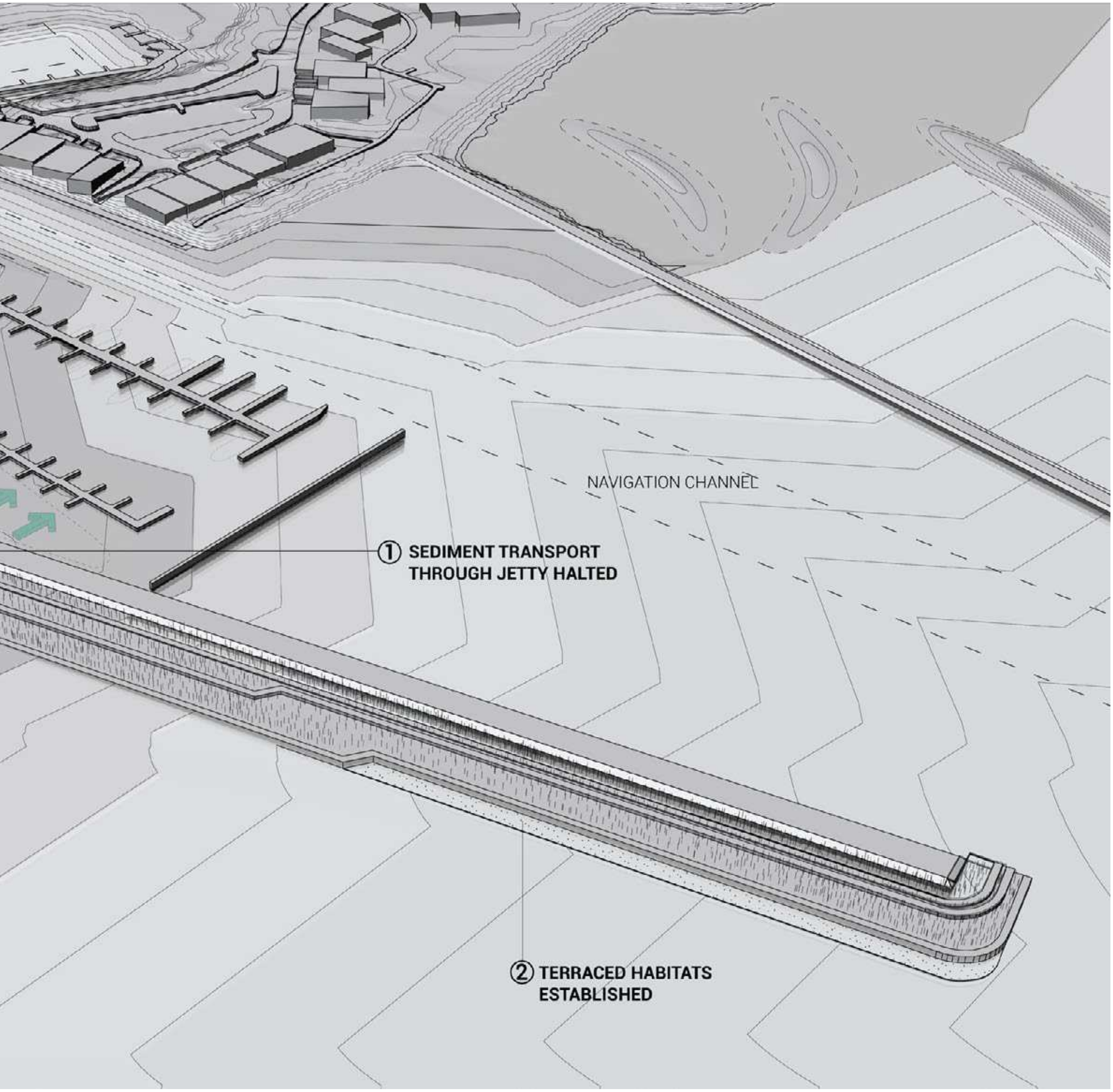
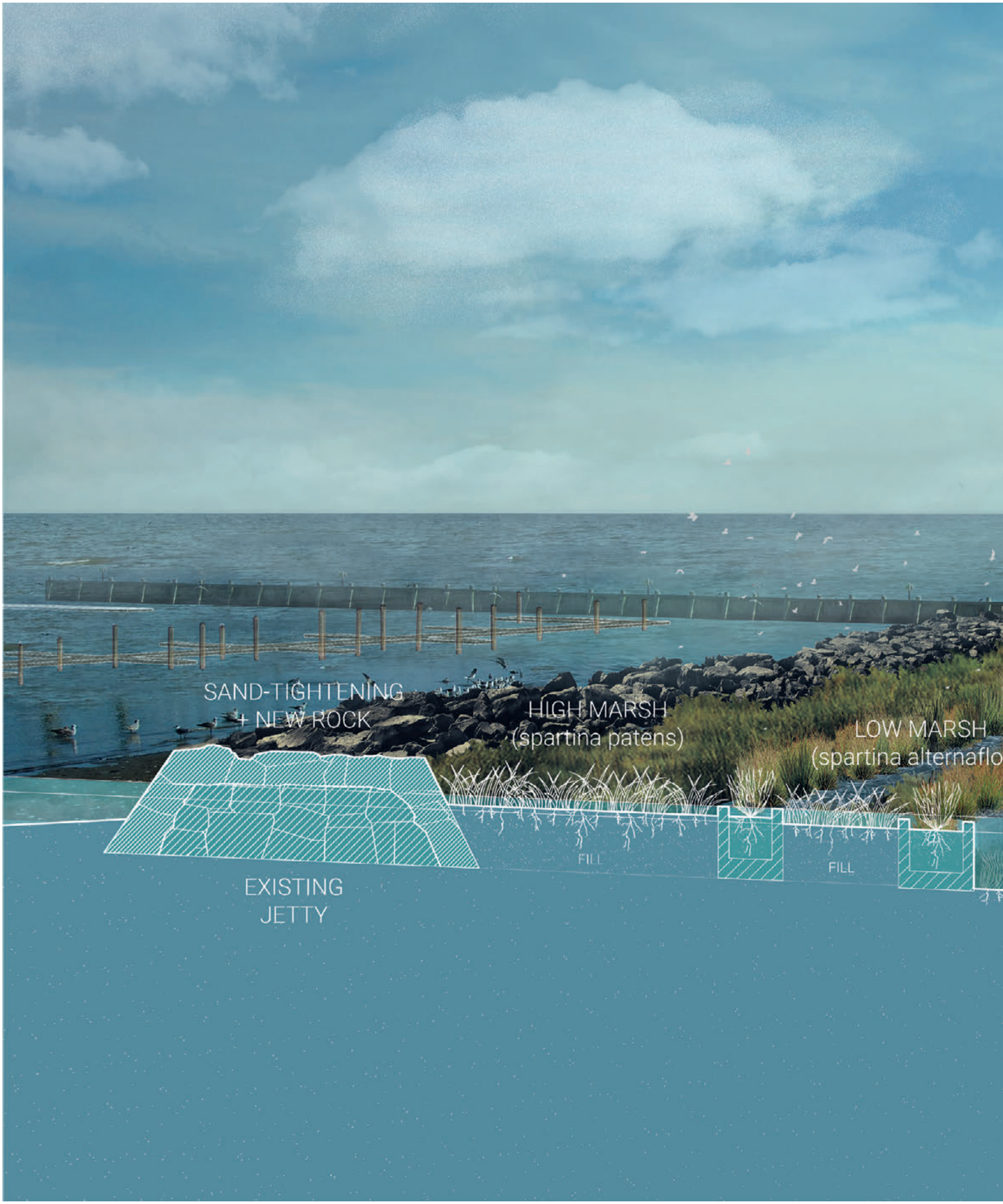
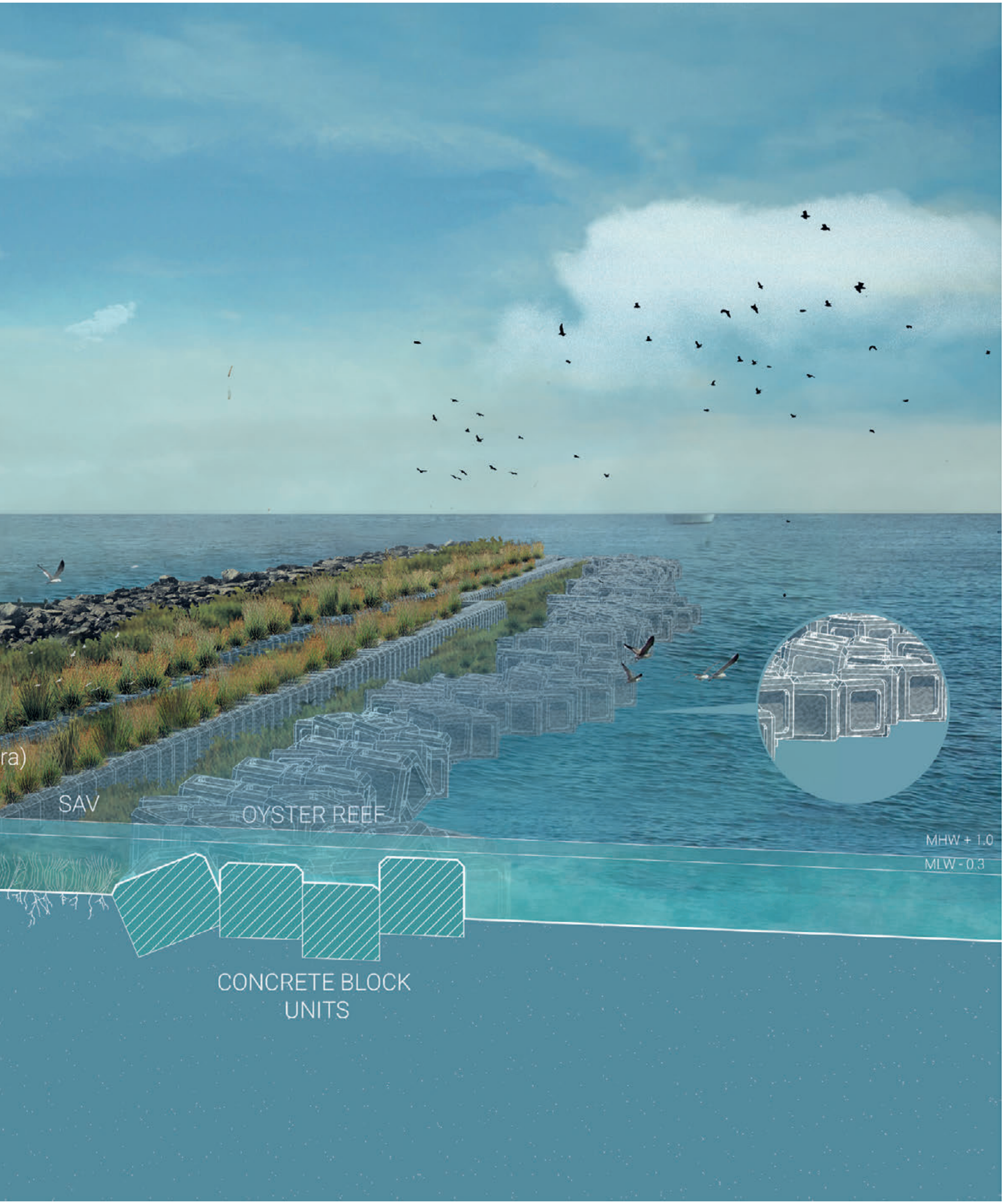


Diagram of the primary goals of the recommendation for Fishing Creek south jetty


SAND-TIGHTENING
+ NEW ROCK
HIGH MARSH
(spartina patens)
LOW MARSH
(spartina alternaflo
FILL
FILL
EXISTING
JETTY



Rendered section perspective of proposed habitat jetty

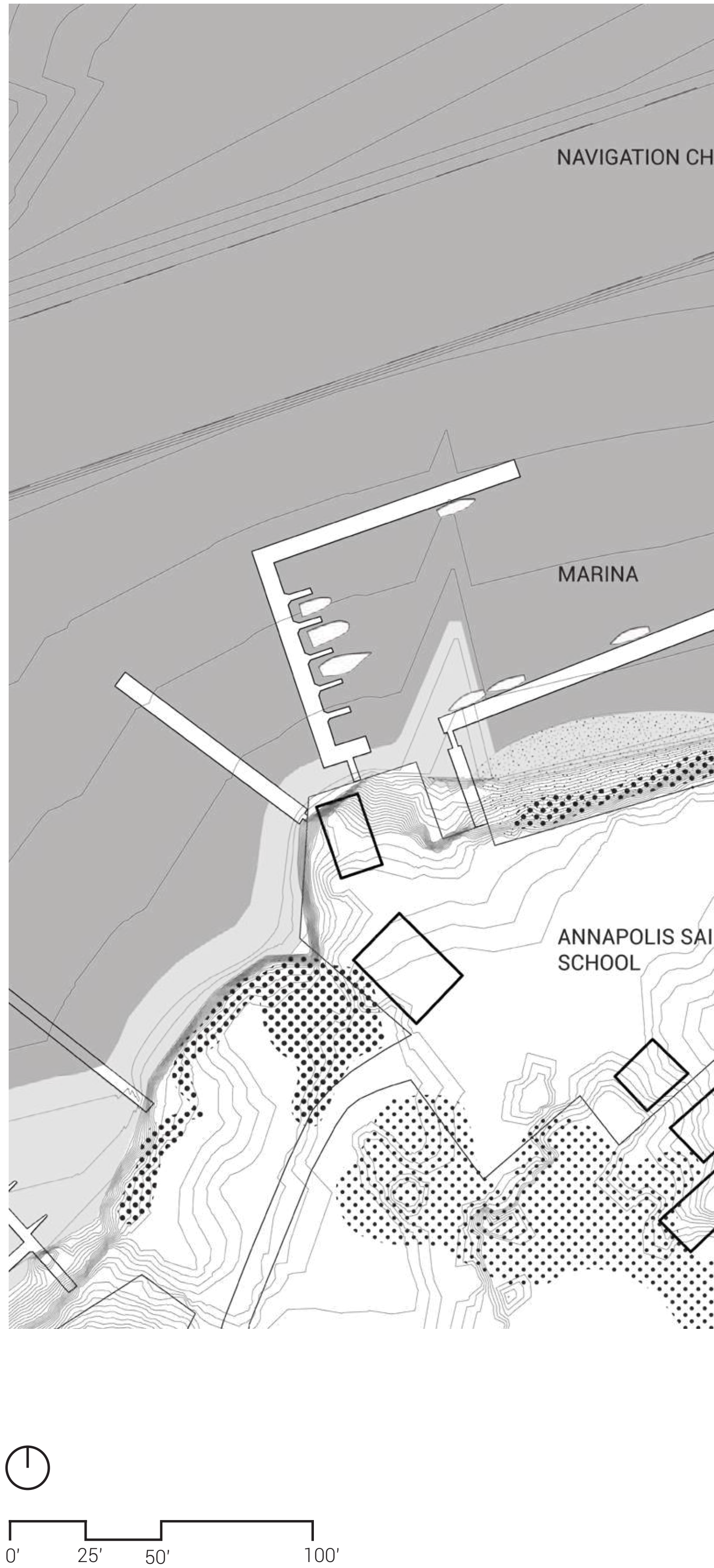
RECOMMENDATION

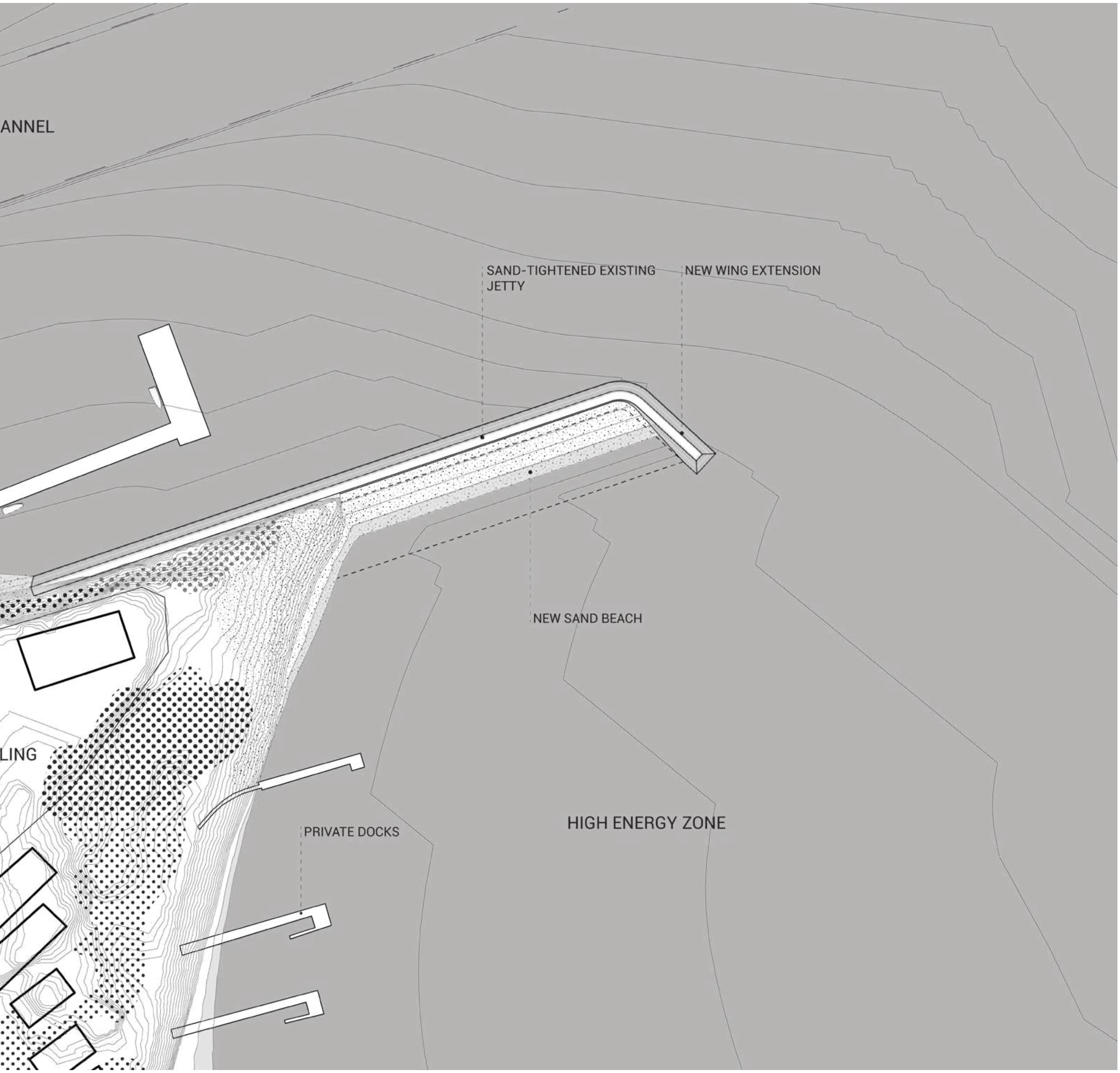
The Back Creek jetty extends out from Chinks Point into the Severn River and Chesapeake Bay, south of downtown Annapolis. The jetty attaches to the point at a small beach, which appears to be developing due to sand accumulation on the high energy side of the jetty. This beach can only be accessed from the Annapolis Sailing School parking lot, which is private property, so general public access is not anticipated. The Sailing School does, however, appear to make significant use of the beach, so it would likely be amenable to seeing the beach expanded, as in this recommendation.

In addition to the formation of the sand beach, shoaling in the area behind the jetty, including the Sailing School's marina, indicates some impairment of jetty function. We recommend sand-tightening the existing jetty and adding a new jetty wing in order to enhance the capture of sandy sediment on the high-energy side of the jetty. If a beach can be induced into forming over time on the side of the jetty, this will buffer the jetty from wave energy and reduce sediment transport through the jetty, as shown in the diagram on the following page.

This new **jetty beach** could fill an important habitat role. Due to intense development in the region, sand beach is relatively rare habitat. Notable local fauna, including the Puritan Tiger Beetle, Fiddler Crab, and Sanderling, depend on beach habitat. Given the potential value of such habitat to an endangered species like the Puritan Tiger Beetle, there may be opportunities to explore ESA Section 7(a)1 synergies with other Federal agencies like the USFWS.

As with the recommendations for Fishing Creek, hydrodynamic and sediment transport modeling would be required to determine effective jetty configurations for encouraging beach formation. Sufficient sediment supply is a crucial constraint on beach formation, and will need to be studied.




ANNEL
SAND-TIGHTENED EXISTING JETTY
NEW WING EXTENSION
NEW SAND BEACH
LING
PRIVATE DOCKS
HIGH ENERGY ZONE

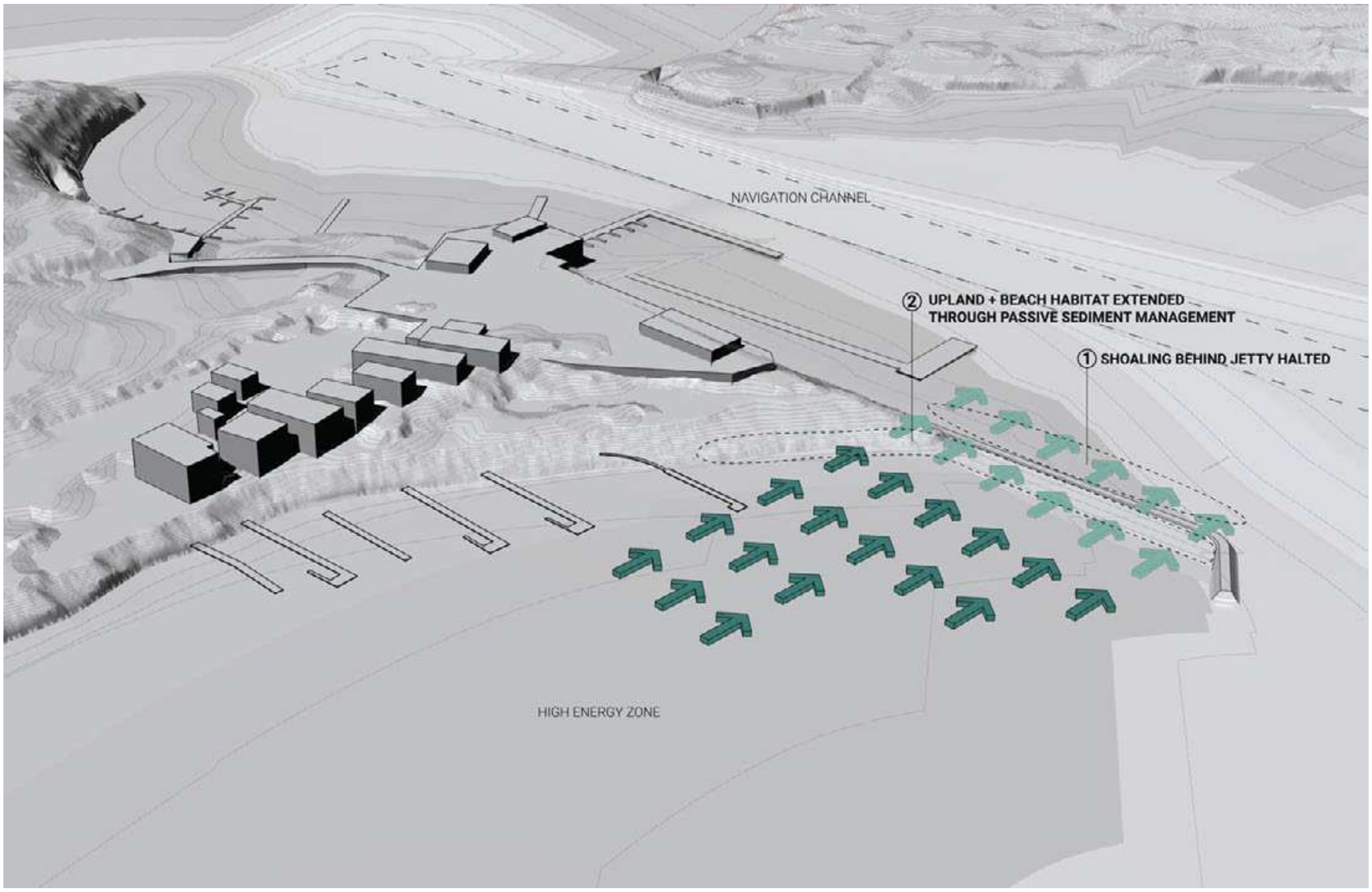


Diagram of the primary goals of the recommendation for Back Creek jetty

As shown in the diagram above, the primary goals of the jetty beach are to (1) halt shoaling behind the jetty and (2) extend the small existing upland and beach habitat along the length of the the jetty.

Perspective view looking across the jetty toward the channel, showing the developing beach

Like the terraced jetty, it is anticipated that the jetty beach would not only provide additional engineering performance and habitat value, but also contribute aesthetic benefits.

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 NAB.

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