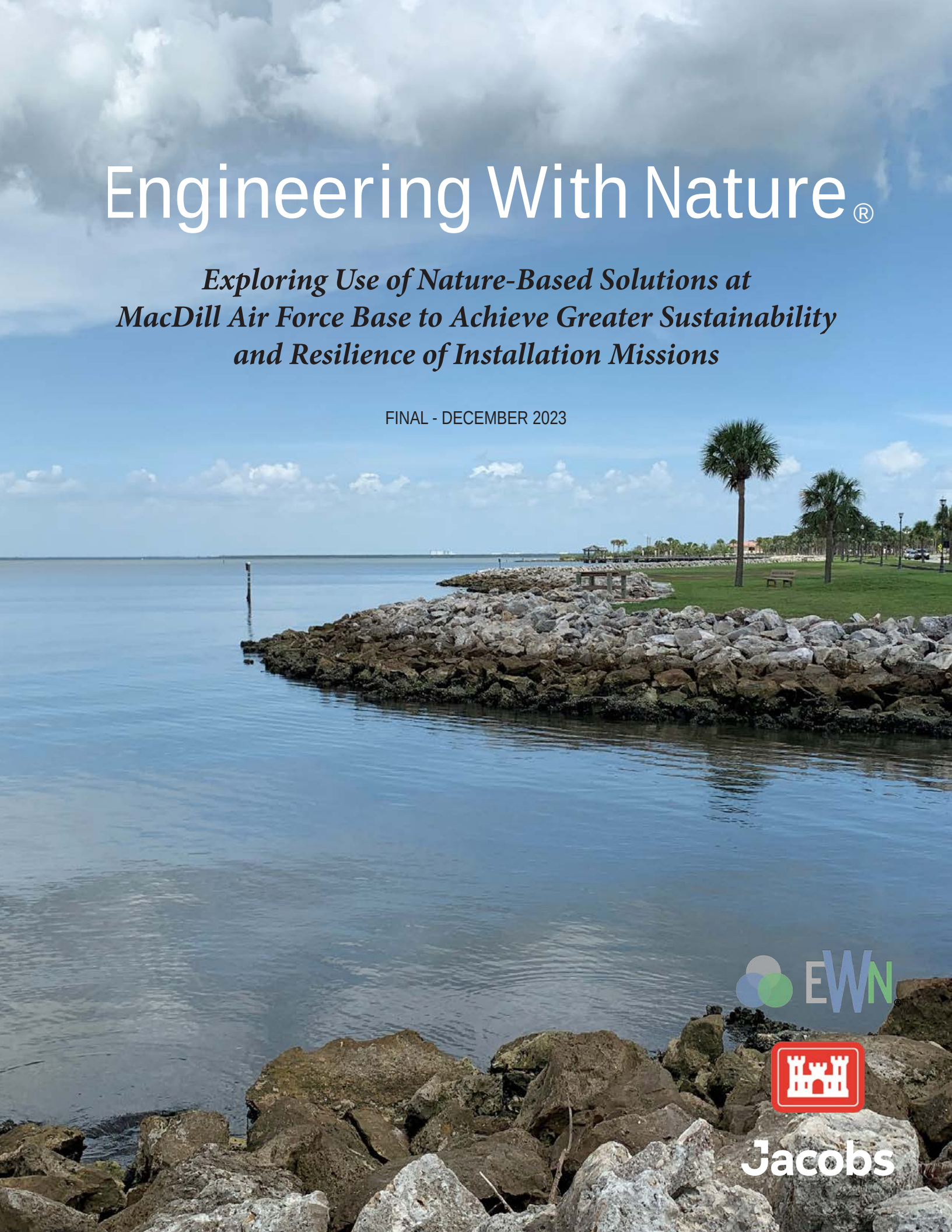
Engineering With Nature®

Exploring Use of Nature-Based Solutions at MacDill Air Force Base to Achieve Greater Sustainability and Resilience of Installation Missions

FINAL - DECEMBER 2023



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Jacobs

Foreword

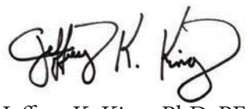
The use of nature-based solutions (NBS) as part of an overall strategy for increasing resilience to climate change has accelerated rapidly in recent years. The Engineering With Nature® (EWN®) program, and NBS in general, received major support from the highest level when President Joe Biden issued Executive Order 14072, "Strengthening the Nation's Forests, Communities, and Local Economies" on April 22, 2022. Production of the NBS Roadmap and NBS Resources Guides, issued by the White House Council on Environmental Quality, White House Office of Science and Technology Policy, and White House Domestic Climate Policy Office were also two outcomes that accelerated the Federal Government's recognition of nature's importance in creating greater resilience for communities.[1,2,3]

The Department of Defense (DoD) Climate Risk Analysis makes clear that *"climate change is reshaping the geostrategic, operational, and tactical environments with significant implications for U.S. national security and defense."*[4] DoD recognizes that climate threats will increasingly influence operations, with far-reaching implications for mission resilience and readiness. DoD is moving toward the goal of increasing investments in, and deployment of, NBS as an additional measure to build climate resilience at military installations.[5,6,7]

In July 2023, EWN partnered with MacDill Air Force Base (AFB) to conduct a 2-day workshop to explore opportunities for placement of NBS at the installation and in the immediately adjacent landscape. EWN brought together a multidisciplinary group of subject matter experts, practitioners, and stakeholders who shared knowledge about natural hazards and techniques for increasing coastal resilience. Participants also learned more about MacDill AFB vulnerabilities, and they worked collaboratively to identify possible NBS that should be further considered as a means of reducing climate risk.

The content of this document highlights the various activities that were pursued over the course of the 2-day workshop, as well as several project ideas that were revealed through meaningful discussions, field visits, and NBS visioning exercises. As with all EWN workshops, it is my sincere desire to see these NBS project ideas, and/or their derivatives, be more fully developed and integrated into an overall strategy for increasing resilience of MacDill AFB or other military installations experiencing similar threats and vulnerabilities. By broadly sharing this content, I believe more practitioners and decision makers will be inclined to champion their own NBS initiatives and projects.

We hope you enjoy learning about this workshop and its associated outcomes.



Jeffrey K. King, PhD, PE
National Lead and Program Manager
Engineering With Nature®, US Army Corps of Engineers

Citations:
1 White House Council on Environmental Quality and White House Office of Science and Technology Policy. 2023. Nature-Based Solutions Resource Guide 2.0. Washington, D.C.
2 White House Council on Environmental Quality, White House Office of Science and Technology Policy, and White House Office of Domestic Climate Policy. 2022b. Nature-Based Solutions Resource Guide. Washington, D.C.
3 White House Council on Environmental Quality and White House Office of Science and Technology Policy. 2023. Nature-Based Solutions Resource Guide 2.0. Washington, D.C.
4 Department of Defense, Office of the Undersecretary for Policy (Strategy, Plans, and Capabilities). 2021. Department of Defense Climate Risk Analysis. Report Submitted to National Security Council.
5 Department of Defense, Office of the Undersecretary of Defense (Acquisition and Sustainment). 2021. Department of Defense Draft Climate Adaptation Plan. Report Submitted to National Climate Task Force and Federal Chief Sustainability Officer. 1 September 2021.
6 Department of the Air Force, Office of the Assistant Secretary for Energy, Installations, and Environment. 2022. Department of the Air Force Climate Action Plan. Washington, DC.
7 Department of Defense, Office of the Undersecretary of Defense (Acquisition and Sustainment). 2022. Department of Defense Climate Adaptation Plan 2022 Progress Report. Report Submitted to National Climate Task Force and Federal Chief Sustainability Officer. 4 October 2022.

Executive Summary

The Department of Defense (DoD) recognizes that climate threats will increasingly set the context for military installations and operations, with negative impacts on mission resilience and readiness. Failing to acknowledge the consequences of climate change can incur high costs in terms of budget, recovery, and detriment to mission capabilities.

> *"Many global operational missions are accomplished and/or sustained from DoD installations. Changing climate provides an opportunity to reevaluate use of regional approaches that allow for flexibility to adjust to changing conditions while providing an appropriate level of standardization for resilience, efficiency, and costs."*
>
> *– Line of Effort 3: Resilient Built and Natural Installation Infrastructure Climate Adaptation Plan 2030, Department of Defense*

To explore the regionally common climate shocks and stressors and potential nature-based solutions (NBS), Engineering With Nature (EWN®) hosted a workshop with MacDill Air Force Base (AFB), Tampa, Florida, in July 2023. The workshop focused on climate change impacts and increasing natural hazards affecting MacDill AFB and the southeastern United States, including:

- Wind
- Erosion
- Flooding
- Sea Level Rise
- Wildfire

The workshop was divided into three parts: a site visit to see site conditions and the existing living shoreline project, presentations from experts in the field, and a NBS workshop to address site opportunities and constraints, as well as possible NBS solutions. Experts from the from the U.S. Army Corps of Engineers (USACE), National Oceanic and Atmospheric Administration (NOAA), U.S. Fish and Wildlife Service (USFWS), University of Florida, Tampa Bay Watch, Tampa Bay Estuary Program, and other local agencies provided case study examples from coastal communities in the Southeast, Mid-Atlantic, and the Northeast. The workshop agenda is provided in Appendix A, and the presentations can be found in Appendix B. The following NBS were identified during the workshop:

- Shoreline enhancement using oyster reef, rock breakwaters, and native coastal vegetation such as marsh grasses and mangroves to dissipate wave energy, reduce erosion, and stabilize the shoreline.
- Beneficial use of dredged material could reduce wave energy, slow storm surge, strengthen shorefront line of defense, and mitigate erosion. Examples include marsh enhancement, dune nourishment, intertidal shallows enhancement, creation of new submerged aquatic vegetation (SAV) habitats, and creation of offshore islands as a first line of defense. Other beneficial uses of dredged materials include creating upland berms or sand platforms to mitigate flooding and filling of legacy dredge holes.
- Stormwater treatment train improvements could include a sequence of connected green and gray stormwater infrastructure along the path of stormwater runoff. This system would help direct and slow stormwater flow, improve water quality, and reduce flooding.
- Native plant revegetation could include replacing mowed lawn areas with native planting to increase stormwater retention capacity, slow runoff, reduce flooding, and improve water quality.
- Invasive plant removal and prevention to encourage the establishment of native plant communities and to improve soil and water quality.

Table of Contents

Introduction

In July 2023, a 2-day onsite workshop was held at MacDill Air Force Base (AFB). The meeting was hosted and facilitated by the MacDill AFB leadership, 6 CES/CEIE (Civil Engineer Squadron/ Environmental Element), and the U.S. Army Corps of Engineers (USACE) Engineering With Nature (EWN) Program. The workshop was supported by Jacobs Engineering, USACE, U.S. Fish and Wildlife Service (USFWS), the University of Florida, Tampa Bay Estuary Program, Tampa Bay Watch, and the National Centers for Coastal Ocean Science (NCCOS)/National Oceanic and Atmospheric Administration (NOAA).

This meeting included a diverse group of installation personnel, resource managers, scientists, engineers, landscape architects, resilience planners, and stakeholders. The meeting offered participants an opportunity to learn more about the current state of practice in nature-based solutions (NBS) in coastal systems and to explore NBS project ideas for increasing the sustainability and resilience of MacDill AFB's mission. Meeting outcomes and products will be used to identify opportunities to pursue follow-on efforts, including the possibility of demonstration projects and full-scale implementation.

This report is divided into the following sections:

- Introduction
- Workshop Overview and Objectives
- Workshop Presentations
- Workshop Results

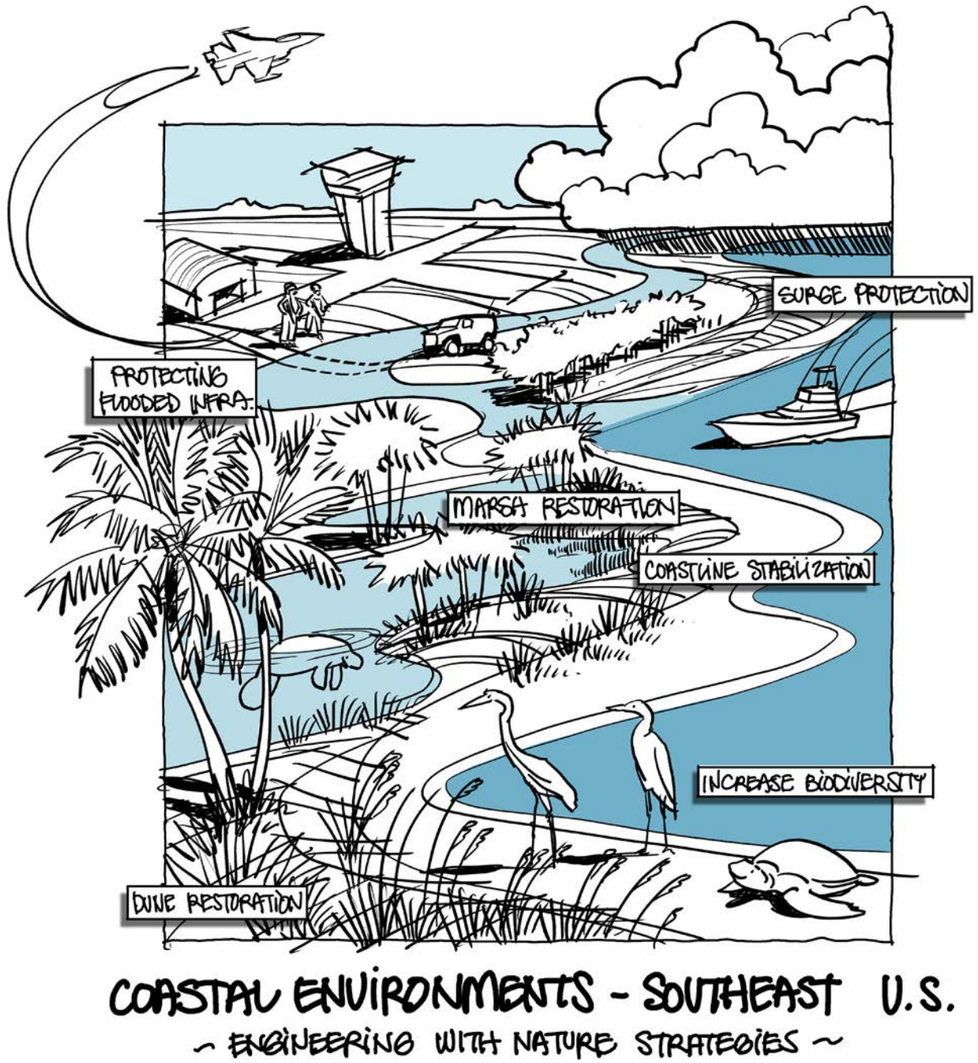


Figure 1. Opportunities for Enhancing Resilience in Coastal Environments in the Southeast
Sketch: Brett Wylie

Introduction

Figure 2. MacDill AFB Location
Credit: Courtesy of Jacobs

Existing Conditions

MacDill AFB is located approximately 5 miles south-southwest of downtown Tampa, Florida. It is home to the U.S. Central Command and U.S. Special Operations Command, the 927th Air Refueling Wing, and 28 other tenant units. The 6th Air Refueling Wing is the host wing and is organized into five groups: Operations, Maintenance, Mission Support, Medical, and the Wing Staff. The base's mission is to rapidly provide air-refueling power anywhere in the world. MacDill AFB has more than 19,900 Joint Service Active Duty and 2,900 Joint Service Civilians, and it supports 34,600 family members and 37,900 retirees in the surrounding community.

Challenges

Located on the southern tip of the Interbay Peninsula in Hillsborough County. The base covers approximately 5,695 acres and is surrounded by Tampa Bay to the south (Middle Tampa Bay), west (Old Tampa Bay), and east (Hillsborough Bay), and by the city of Tampa to the north and west. The topography at MacDill AFB is flat; ground elevations on the base range from sea level at the southern boundary and gradually rise to about 15 feet above sea level along the northern boundary. The mean elevation of the installation is only 4.7 feet above mean sea level. Because MacDill AFB is surrounded by water on three sides, its mission has the potential to be severely impacted by flooding and coastal surge during hurricanes. Ongoing concerns include coastal erosion and sea level rise.

Workshop Overview and Objectives

Objectives of the workshop included:

- Share and review information about natural hazards and vulnerabilities that MacDill AFB is experiencing or is likely to experience in the future;
- Share knowledge and information about NBS to support the resilience and sustainability of the installation's mission;
- Use facilitated dialogue and highlight use of NBS strategies and placement of NBS as a means to reduce risk;
- Visit locations around the MacDill AFB that are potential sites for projects and collaboratively explore project ideas while prioritizing an initial set of concepts, technical approaches, and potential NBS projects; and
- Document workshop proceedings and outputs for follow-on consideration and action in the form of a Natural Infrastructure Assessment Report, as appropriate.

On the first day of the workshop, the meeting was convened with a welcome and opening remarks from Amy Doye, P.E., Director, 6th Civil Engineer Squadron, and Jeff King, PhD, PE, EWN National Lead and Program Manager. Presentation topics included past EWN experience at DoD facilities, an introduction to MacDill AFB's mission and resilience, NBS projects at MacDill AFB, and EWN case studies from USACE and Tampa Bay Watch. A brief question-and-answer session was included at the end of each presentation. The day adjourned with an installation site visit.

EWN MacDill AFB Workshop Participants
Photo: Hollie Schmidt

The second day of the workshop featured presentations on Beneficial Use of Dredged Material (BUDM), modeling techniques, EWN research, and various EWN project and program case studies. Following the presentations, breakout sessions by Districts (geographical sub-areas within MacDill AFB) were conducted. Each breakout group discussed key challenges and opportunities presented to mission-critical facilities, potential EWN solutions that would help address these facilities, and co-benefits that the EWN solutions could generate. At the end of the breakout sessions, all workshop attendees reconvened and reported their key findings. The workshop then closed with a review of overall findings and next steps.

The workshop agenda is provided in Appendix A.

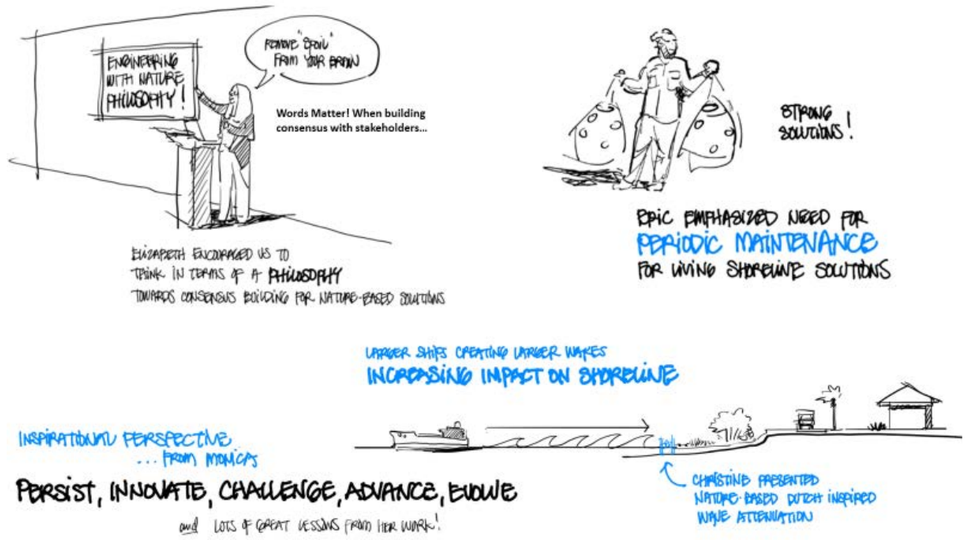


Figure 3. Workshop Themes
Sketch: Brett Wylie

RESILIENCE FOR MILITARY INSTALLATIONS

A 2019 report evaluated the risk and vulnerability of 79 installations to climate change and extreme weather.* NBS can lead to increased, broad-based resilience on military installations. Some of the benefits of using NBS are:

Scalable, which reduces cost and allows for adaptation over time as environmental conditions continue to evolve

Self-healing following storm events or other environmental hazards, which means mitigating or avoiding costly maintenance and repairs that conventional infrastructure can incur

Healthy and therapeutic, enhancing personal well-being of the people who work, train, and live at DoD facilities through environmental and social benefits.

** Citation: Office of the Under Secretary of Defense for Acquisition and Sustainment. 2019. Report on Effects of a Changing Climate to the Department of Defense (Washington, DC). https://media.defense.gov/2019/Jan/29/2002084200/-1/-1/1/CLIMATE-CHANGE-REPORT-2019.PDF*

BENEFICIAL USE OF DREDGED MATERIAL

In January 2023, the USACE issued formal guidance for expanding its beneficial use of dredged material (BUDM) program. The memo notes that dredged material is a valuable resource that should not be wasted, but should be used to benefit ecosystems, the economy, and the execution of the USACE mission for navigation, flood risk management, and aquatic ecosystem restoration projects. The guidance memo also established a goal for BUDM of 70% of dredged sediment derived from its Navigation program by 2030 (also known as the 70/30 goal), an increase over USACE's historical reuse of 30 to 40%.

Finally, the memo emphasized the importance of ongoing collaboration with partners and stakeholders, and it included a call to action for all its districts and divisions to participate in this shared vision.

Beneficial uses are defined as "productive and positive uses of dredged material, which cover broad use categories ranging from fish and wildlife habitat development, to human recreation, to industrial/commercial uses" (USACE Beneficial Uses of Dredged Material, Engineer Manual 1110-2-5026).

The USACE South Atlantic Division also notes that BUDM can provide the following benefits:

- Maintains sediment in the natural system and maintains natural system features in direct correlation to navigation benefits
- Saves dredged material management area/confined disposal facility capacity, which leads to lower lifecycle costs
- Builds habitat through creation and restoration of nature-based features with direct environmental and recreational benefits
- Protects installation and community infrastructure (for example, through coastal and sea level rise resilience projects) and reduces costs of trucking in material to build resiliency projects

ADVANCING THE USE OF NBS

NBS can effectively address some of the environmental and climate-related challenges and opportunities facing the DoD in the 21st century. Different definitions of NBS or EWN approaches and related terms (e.g., natural infrastructure, ecosystem-based approaches, and green infrastructure) have been used by organizations engaged in these activities. The common element among these definitions is the focus on conservation, restoration, and engineered replication of nature for the benefit of mission assurance, people, and ecosystem services.

To promote awareness of NBS and their practical applications, the EWN Program published *Engineering With Nature: An Atlas* (2018) and *Engineering With Nature: An Atlas (Volume 2)* (2021). Both volumes are available for download at ewn.erdc.dren.mil.

In October 2021, the EWN Program published *Engineering With Nature: Supporting Mission Resilience and Infrastructure Value at Department of Defense Installations*, in conjunction with Jacobs, with a focus specifically on how EWN approaches have been successfully applied to mitigate shocks and stressors that threaten mission readiness on DoD installations. Additional EWN publications to advance understanding and use of NBS in the United States and around the world are forthcoming.

Workshop Overview and Objectives

LIVING-SYSTEM SHORELINE STABILIZATION PROJECT

MacDill's Living-System Shoreline Stabilization Project has been ongoing since 2004 and demonstrates successful EWN solutions at work. A collaborative project between the base and Tampa Bay Watch, the project was designed to address significant erosion occurring along the base's shoreline. This erosion was causing the loss of native plant species and creating hazards for on-base activities and training. The project created a living oyster reef within the nearshore intertidal environment parallel to the shoreline. The project goals were to protect the base and the shoreline environment through reducing wave energy, accelerating sediment accumulation, and restoring the natural coastal vegetation. The stabilized shoreline and increased sediment encourage the growth of native marsh grasses and mangroves.

The oyster reef also offers environmental benefits by filtering water and increasing marine habitat, providing food, structure, and refuge for many fish species and other marine organisms.

Volunteer reef-building events engaged the community and created educational opportunities. More than 1,490 volunteers contributed nearly 4,500 hours to reef building and planting salt marsh. The project was implemented in five phases from 2004 to 2016 and won the Future of the Region Award for Natural Resources and Environment. Additional work is ongoing, including construction of Phase 6 to the north and the initiation of maintenance and enhancement work for Phase 1.

Major takeaways from this project include:

- Nearshore reef creation succeeded in reducing wave energy, accumulating sediment, and restoring coastal vegetation.
- The well-designed NBS is largely self-maintaining and is resilient to impacts from storms.
- NBS can achieve resilience goals while improving the marine habitat and benefiting marine life.
- Collaboration can help in achieving successful outcomes in shorter timeframes.
- Citizens want to volunteer for NBS efforts, creating educational opportunities for installations and nearby communities.

Team visits the Living-System Shoreline Project
Photo: Hollie Schmidt

Workshop Presentations

The workshop was convened with an introduction of the EWN Program by Jeff King. Hollie Janson Schmidt gave an overview of initial EWN work at Tyndall AFB and recent work on DoD facility adaptation for the U.S. Navy. Jason Bird presented on funding mechanisms recently implemented by the Tyndall Coastal Resilience Implementation Plan. The remaining workshop presentations were focused on three primary themes: local conditions and context/discussions of ongoing projects at MacDill AFB and the surrounding area, USACE and research-driven NBS solutions, and case studies from coastal communities in the Southeast, Mid-Atlantic, and Northeast.

LOCAL CONDITIONS AND ONGOING PROJECTS

Representatives from the installation and local project proponents gave briefings on existing conditions and ongoing projects at and around MacDill AFB. Andy Rider and Jason Kirkpatrick of MacDill 6 CES/CEIE (Civil Engineer Squadron/Environmental Element) gave the installation mission overview and resilience brief followed by a review of natural resources work and proposed future beneficial use projects at MacDill. Laurel Reichold of USACE South Atlantic Division gave an overview BUDM and the ongoing Tampa Harbor Navigation Improvement Project. Eric Plage of Tampa Bay Watch discussed the successes of the 20-year Living Shoreline Project, and Sinéad Borchert, USFWS Liaison to MacDill AFB, presented on coastal resilience and threatened and endangered species in the Tampa Bay area.

RESEARCH-DRIVEN SOLUTIONS AND CASE STUDIES

The workshop explored research-driven findings from university partners and the ERDC researchers and USACE practitioners. Jules Bruck of the University of Florida spoke about examples of coastal community resilience and nature-based shoreline solutions in the Delaware tidewater area; Hampton Roads, Virginia; and Joint Base Langley Eustis, Virginia. Christine Angelini of the University of Florida provided examples in northeast Florida from the University of Florida Center for Coastal Solutions and partnerships with EWN.

Elizbeth Godsey (USACE Mobile District) discussed the Mobile Harbor Case Study and related EWN project examples. Amanda Tritinger (ERDC/EWN) gave a presentation on hydrodynamic modeling and the EWN toolkit and site applications. Safra Altman of ERDC/EWN presented examples of marsh, reef, and SAV projects. Presentations also included other project case studies from across the country including Jenny Davis of NOAA presented a case study on island restoration in Chesapeake Bay, Maryland, Monica Chasten of the USACE Philadelphia District provided examples of Regional Sediment Management programs and innovative dredging and management programs in New Jersey, and Nick Cohn, ERDC/USACE, spoke on coastal change hazards and dune modeling at Tyndall AFB.

The following is a summary of presentations and case studies covered during the workshop. The presentations are provided in Appendix B.

PRESENTATIONS/CASE STUDIES

- *MacDill AFB and EWN Collaborative Introductions,* Jeff King, PhD, P.E, National Lead and Program Manager, EWN Program/USACE
- *Implementing Natural Infrastructure & EWN Solutions at DoD Installations,* Hollie Janson Schmidt, Global Senior Director, Sustainability & Climate Response Americas, Jacobs; Jason Bird, Resilience Market Solutions Leader, U.S. South, Jacobs
- *MacDill AFB Mission/Resilience Brief: SLR Projections and Floodplain Discussion,* Andy Rider, P.E., Chief, Environmental Element, MacDill AFB; Jason Kirkpatrick, Environmental Element Manager, Akima Support Operations (Akima), MacDill AFB
- *Introduction: MacDill's Natural Resources Work and Proposed Future Beneficial Use Project* Jason Kirkpatrick, (Akima) MacDill AFB
- *Beneficial Use of Dredge Material from the Tampa Harbor Navigation Improvement Project for MacDill Air Force Base,* Laurel Reichold, Director, South Atlantic Division, Regional Sediment Management Center of Expertise, USACE
- *MacDill Airforce Base Living Shoreline Project: Twenty Years in the Making,* Eric Plage, Tampa Bay Watch
- *Coastal Resilience and Threatened and Endangered Species: Opportunities and Constraints,* Sinéad Borchert, Fish and Wildlife Biologist, Liaison to MacDill AFB Florida Air Force Partnership, USFWS
- *Mobile Harbor Case Study and Related EWN Project Examples,* Elizabeth Godsey, P.E., Coastal and Regional Sediment Management Engineering Technical Lead and EWN Coastal Practice Lead, Mobile District USACE
- *USACE Modeling, the EWN Toolkit, and Site Applications,* Amanda Tritinger, PhD, Assistant Program Manager, EWN and Research Hydraulics Engineer Coast and Hydraulics Laboratory, USACE Engineer Research and Development Center (ERDC)
- *Performance of Island Restoration Projects in Chesapeake Bay,* Jenny Davis, PhD, Research Ecologist, NCCOS/National Oceanic and Atmospheric Administration (NOAA)
- *Marsh, Reef & Submerged Aquatic Vegetation (SAV) Projects + Applicable EWN Research,* Safra Altman, PhD, Research Coastal Ecologist, USACE ERDC Environmental Laboratory
- *Building Coastal Community Resilience with Nature-Based Shoreline Solutions,* Jules Bruck, PhD, RLA Director, School of Landscape Architecture and Planning Chair, Department of Landscape Architecture College of Design, Construction and Planning, University of Florida
- *Accelerating Science & Technology Innovation to Improve Coastal Health and Resilience,* Christine Angelini, PhD, Director, Center for Coastal Solutions and Associate Professor in Environmental Engineering Sciences, University of Florida
- *Advancing Practice for Coastal System Resilience,* Monica Chasten, Project Manager, USACE, Philadelphia District, Operations Division
- *Modelling Coastal Change Hazards,* Nicholas Cohn, PhD, Research Oceanographer, Coastal and Hydraulics Laboratory, USACE ERDC

Workshop Results

Because more than 94% of the installation is within a floodplain, MacDill AFB is vulnerable to coastal flooding. Inadequate stormwater drainage from increased impervious surface and land alterations over time also have worsened stormwater flooding during rain and storm events. Additionally, MacDill AFB's shoreline is prone to coastal erosion from storm surge and waves created by large ships. The challenge of flooding and erosion is further exacerbated by sea level rise.

Figure 4 shows the major constraints and opportunities at MacDill AFB.

Figure 4. Challenges and Opportunities at MacDill AFB
Credit: Brett Wylie

Specific climatic shocks and stressors related to flooding and coastal erosion include the following:

FLOODING

- Bayshore Boulevard (main base vehicular access)
- Electrical assets (i.e., transformers)
- Housing areas
- Runways and airfield supporting infrastructure
- Access/entry roads municipal wastewater treatment plant
- Munitions Storage Area (MSA)
- Aircraft fueling area and facilities

COASTAL EROSION

- Wastewater force main
- Bayshore Boulevard
- Electrical assets
- Municipal wastewater treatment plant
- Runways and airfield supporting infrastructure
- Habitats and sensitive ecosystems.

MISSION ASSURANCE

Flooding and shoreline erosion impact various areas on the base. Bayshore Boulevard, which is the main vehicular access road, floods during rain events and storm surge, limiting base access and operations. Flooding also damages the housing area along the eastern shore, presenting risks to base staff and families' safety and affecting base operations. Flooding also can impact electrical assets (such as transformers), runways and airfield infrastructure, and other adjacent mission-critical facilities. Flooding has occurred at the municipal wastewater treatment plant, the munitions storage area, and aircraft fueling facilities.

Coastal erosion threatens the wastewater force main that runs along Bayshore Boulevard, other infrastructure such as electrical assets, the municipal wastewater treatment plant and the runways and airfield supporting infrastructure.

Water quality is also a concern because of stormwater runoff pollutants and nutrient loading. Water quality has been degraded by municipal wastewater treatment plant discharges and spills, fuels and oils, and high levels of nitrogen and phosphorus.

USING NATURAL PROCESSES

The workshop discussions generated a range of potential solutions that should be explored and evaluated for future implementation. These potential solutions include:

- BUDM
- Rock breakwater and reef creation
- Shoreline stabilization
- Bioswales
- Aquaculture
- Green stormwater management
- Invasive plant removal and revegetation with native plants

BROADENING BENEFITS

Implementation of NBS projects can provide several co-benefits, including:

- Carbon sequestration
- Reduced operations and maintenance costs
- Improved water quality
- Habitat creation and enhancement
- Support for achieving USACE's BUDM goals
- Protection of threatened and endangered species

PROMOTING COLLABORATION

Workshop attendees and installation personnel identified several potential opportunities for collaboration, including with the following organizations and stakeholders:

- Department of the Air Force
- Jacobs
- MacDill AFB 6th Civil Engineering Squadron
- NCCOS/NOAA
- Tampa Bay Estuary Program
- Tampa Bay Watch
- University of Florida
- USACE ERDC
- USACE Mobile District, South Atlantic Division
- USACE Philadelphia District
- USFWS

EWN CRITICAL ELEMENTS

EWN's purpose is to intentionally align natural and engineering processes to efficiently and sustainably deliver economic, environmental, and social benefits through an integrated land management approach.

With recent advances in the fields of engineering and ecology, there is an opportunity to combine engineering and natural systems into a single collaborative and cost-effective approach for infrastructure functions and responsible environmental management. Triple-win outcomes are achieved by systematically integrating social, environmental, and economic considerations at every phase of an EWN project. The results are innovative and resilient solutions that are more socially acceptable, viable and equitable, and, ultimately, more sustainable.

EWN has defined four critical elements of its mission as:

- Mission Assurance
- Using Natural Processes
- Broadening Benefits (triple bottom line and co-benefits)
- Promoting Collaboration (stakeholders, funding, and community)

Workshop Results

District Analysis/Overview

After the site visit, the workshop participants divided into groups and identified EWN strategies by district. MacDill AFB is composed of five districts:

- **District 1** – West side of the base, south of adjacent off-base neighborhoods
- **District 2** – Flightline which includes the runway, taxiways, aprons, ramps and hangars.[5]
- **District 3** – South side between the base's built area along the shoreline, including extensive natural areas and golf course
- **Districts 4 and 5** – East and northeast side of the base, including administrative and airbase mission support functions

During the breakout session, an array of specific EWN opportunities were proposed for each district.

Figure 5. Overview of MacDill AFB Districts
Credit: Brett Wylie

[5] The Flightline (District 2) was not addressed in this study.

District 1 (West) EWN Opportunities/NBS Solutions

District 1 (West) Opportunities

- Removal of legacy mosquito ditches
- Filling of old dredge holes
- Extension of longshore sandbar
- Elevate perimeter security road with dirt levee
- Improve stormwater storage through vegetation management, removal of invasive plant species, and replanting with native plant species
- Reduction of potential bird habitat

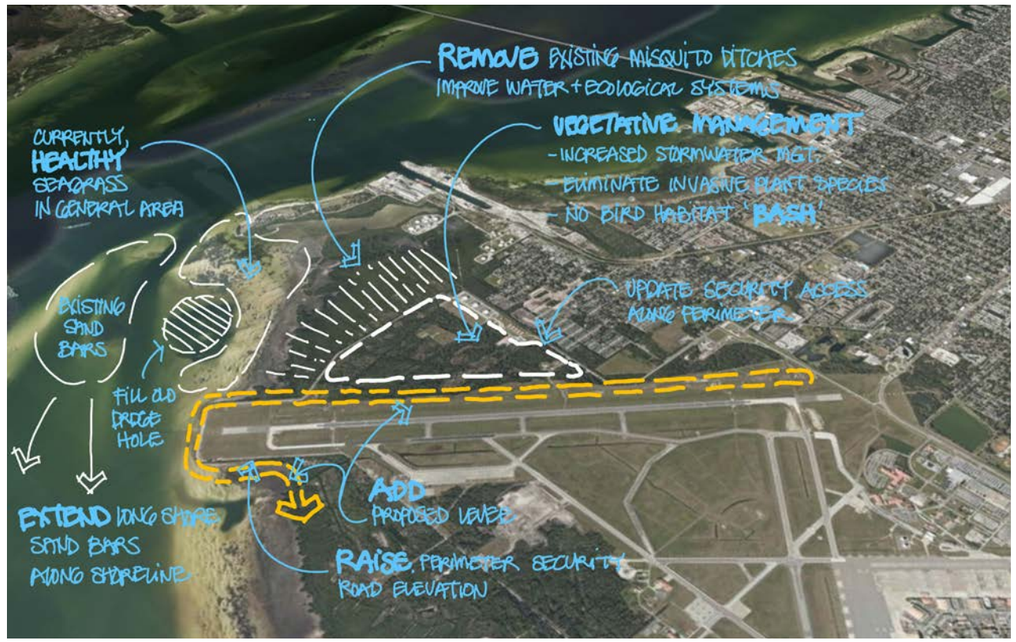


Figure 6. MacDill AFB District 1 Opportunities
Credit: Brett Wylie

District 1 (West) Possible NBS Solutions

- Shoreline enhancement using oyster reef, rock breakwaters, and native vegetation planting such as marsh grasses and mangroves to dissipate wave energy, reduce erosion, and stabilize the shoreline.
- Stormwater treatment train improvements could include a sequence of connected green and gray stormwater infrastructure along the path of stormwater runoff. This system would help direct and slow stormwater flow, improve water quality, and reduce flooding.
- Native plant revegetation could include replacing mowed lawn areas with native planting to increase stormwater retention capacity, slow runoff, reduce flooding, and improve water quality.
- Invasive plant removal and prevention to encourage the establishment of native plant communities and to improve soil and water quality.

District Analysis/Overview

DISTRICT 3 (SOUTH) EWN OPPORTUNITIES/NBS SOLUTIONS

District 3 (South) Opportunities

- Place nearshore sand to restore historical longshore bar.
- Fill dredge holes.
- Continue beach renourishment.
- Create of feeder berm using in-bay sediment placement.

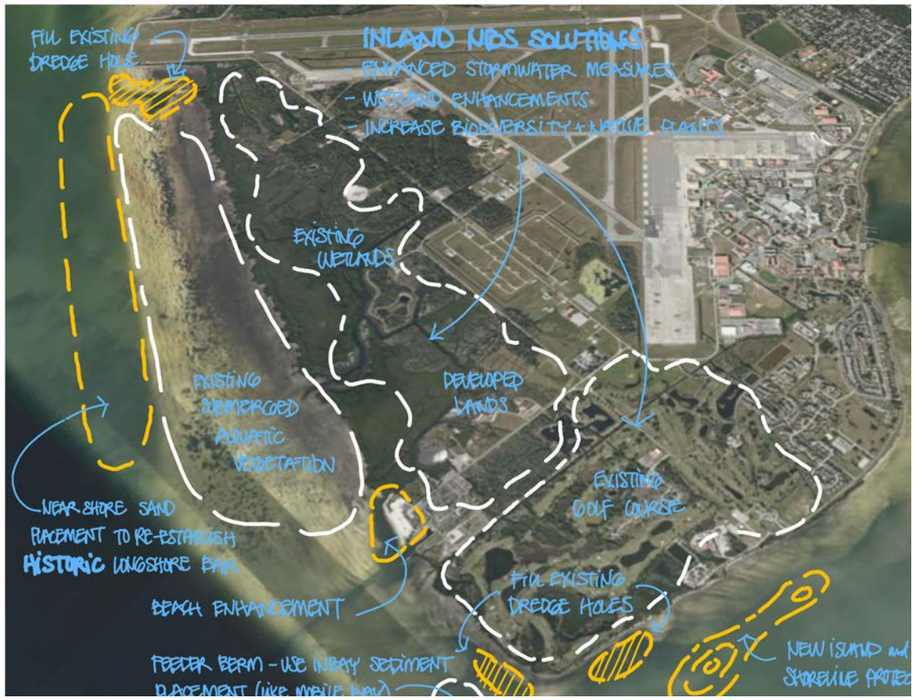


Figure 7. MacDill AFB District 3 Opportunities
Credit: Brett Wylie

District 3 (South) Possible NBS Solutions

- Enhance shoreline using oyster reef, rock breakwaters, and native coastal vegetation planting such as marsh grasses and mangroves to dissipate wave energy, reduce erosion, and stabilize the shoreline.
- BUDM could reduce wave energy, strengthen shorefront line of defense, and mitigate erosion. Examples include marsh enhancement, dune nourishment, intertidal shallows enhancement, creation of new native coastal vegetation habitats, and creation of offshore islands as a first line of defense. Other beneficial uses of dredged materials include creating upland berms or sand platforms to mitigate flooding and filling of legacy dredge holes.

DISTRICTS 4&5 (EAST AND NORTHEAST) EWN OPPORTUNITIES /NBS SOLUTIONS

- Consider BUDM islands.
- Consider horizontal levees.
- Raise Bayshore Drive.
- Implement bioswales/rain gardens.
- Utilize dredged materials to elevate new buildings.
- Add to existing tree canopy.

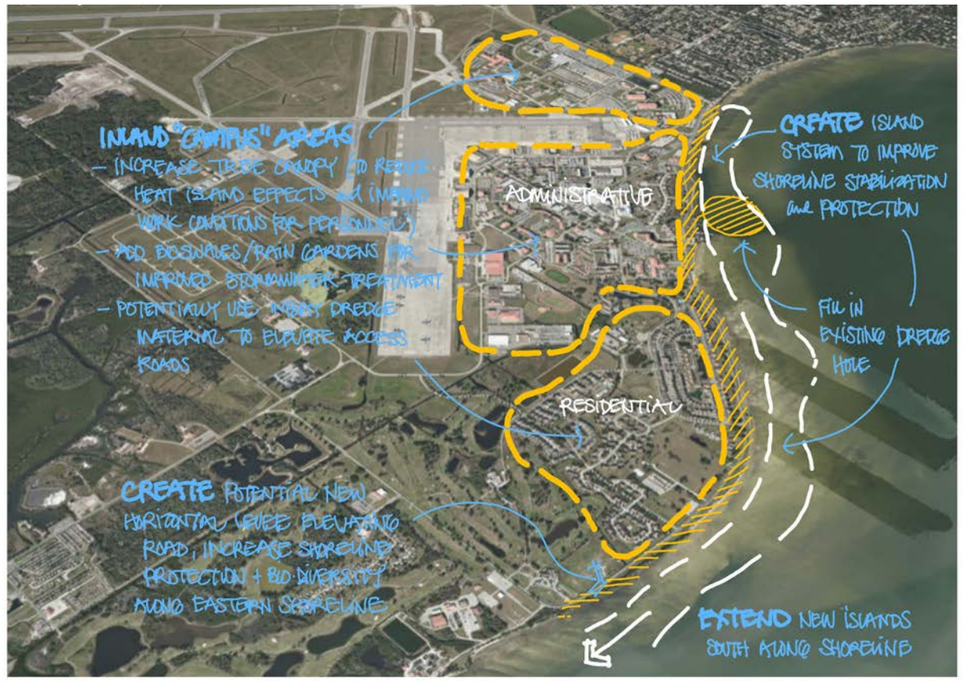


Figure 8. MacDill AFB District 4 and 5 Opportunities
Credit: Brett Wylie

Districts 4 and 5 (East and Northeast) Possible NBS Solutions

- Enhance shoreline using oyster reef, rock breakwaters, and native vegetation plantings such as marsh grasses and mangroves to dissipate wave energy, reduce erosion, and stabilize the shoreline.
- Stormwater treatment train improvements could include a sequence of connected green and gray stormwater infrastructure along the path of stormwater runoff. This system would help direct and slow stormwater flow, improve water quality, and reduce flooding.
- Native plant revegetation could include replacing mowed lawn areas with native planting to increase stormwater retention capacity, slow runoff, reduce flooding, and improve water quality.
- Invasive plant removal and prevention to encourage the establishment of native plant communities and to improve soil and water quality.

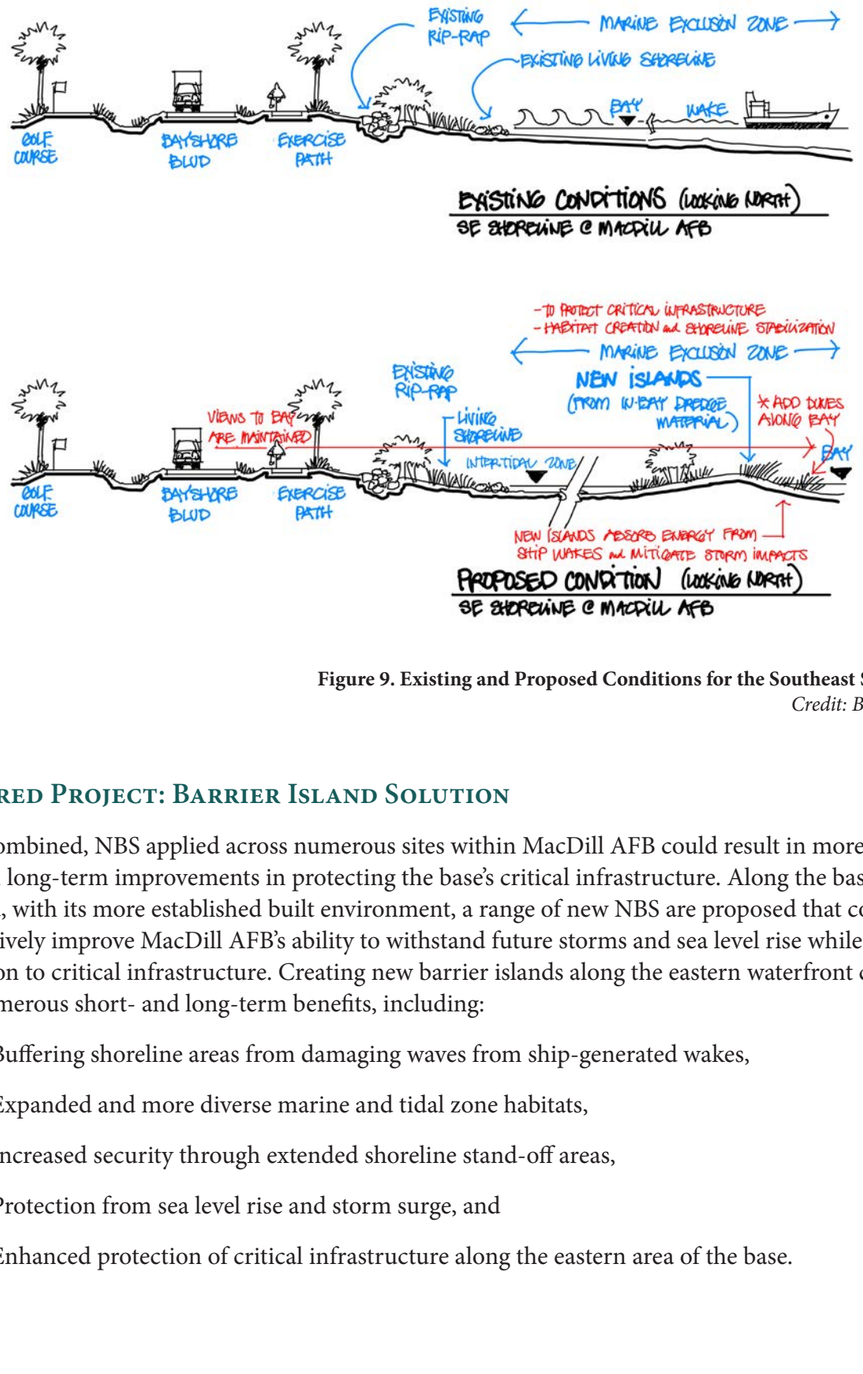


Figure 9. Existing and Proposed Conditions for the Southeast Shoreline
Credit: Brett Wylie

Featured Project: Barrier Island Solution

When combined, NBS applied across numerous sites within MacDill AFB could result in more resilient, long-term improvements in protecting the base's critical infrastructure. Along the base's east area, with its more established built environment, a range of new NBS are proposed that could substantively improve MacDill AFB's ability to withstand future storms and sea level rise while adding protection to critical infrastructure. Creating new barrier islands along the eastern waterfront could have numerous short- and long-term benefits, including:

- Buffering shoreline areas from damaging waves from ship-generated wakes,
- Expanded and more diverse marine and tidal zone habitats,
- Increased security through extended shoreline stand-off areas,
- Protection from sea level rise and storm surge, and
- Enhanced protection of critical infrastructure along the eastern area of the base.

Figure 10. Barrier Island Solution Concept Sketch
Credit: Brett Wylie

Figure 11 illustrates the creation of new barrier islands along with new horizontal levees and tidal estuaries, which would establish a layered protective NBS network along MacDill AFB's eastern shoreline.

Figure 11. Potential NBS for MacDill's Eastern Shoreline
Credit: Brett Wylie

Conclusion

The workshop successfully identified several NBS project ideas that should be further evaluated for integration into a broader strategy for increasing resilience at MacDill AFB. BUDM was viewed by most participants as the priority opportunity for further consideration and analysis. Considerations for BUDM include nearshore placement to fill old dredging holes, thin layer placement to enhance nearshore habitat, and possible creation of underwater sills and breakwaters/ islands to mitigate wave energy from the Tampa Harbor shipping channel, which is causing erosion along the installation's eastern shoreline. These projects would support the USACE goal of increasing the use of BUDM from 30-40% to 70% by the year 2030. Designs and potential configuration of islands, feeder berms, oyster reefs, and vegetation plantings were also inventoried during breakout sessions and archiving of workshop results. Proposed next steps and goals that would support implementation of EWN strategies include MacDill AFB working with USACE and other collaborative organizations to develop, design, and permit several BUDM projects proposed for construction along MacDill's eastern and southern shoreline.

As one of the next steps toward having shovel-ready, BUDM projects by 2026, MacDill AFB intends to host a facilitated workshop that would bring together representatives of regulatory and resource agencies, among others. The workshop would offer a venue for participants to become more familiar with project ideas and associated data needs while also offering opportunities to answer questions and discuss potential project concerns. Such a workshop would help to identify and fast track needs of the regulatory agencies while also serving as a primer for more frequent and informed conversations about the NBS projects, which creates an incubator that streamlines the permitting process and satisfies the National Environmental Policy Act (NEPA).

Conclusion

Appendix A: Workshop Agenda

Agenda for Onsite Meeting

Tuesday, July 11th, 2023: Travel to MacDill AFB, FL

Wednesday, July 12th, 2023: DAY 1 (All times listed are Eastern Daylight Time)

Time	Action	Lead or Speaker
0800 – 0830	Arrive MacDill AFB Day 1 workshop location Building 252 (MacDill Education Center); 8102 Condor Street, Tampa, FL 33621	
0830 – 0900 (30 mins)	Welcome, Opening Remarks, and Introduction of Workshop Attendees	Mrs. Amy Doye, P.E., Director, 6th Civil Engineer Squadron and Jeff King, PhD, PE National Lead and Program Manager, Engineering With Nature® Program US Army Corps of Engineers
0900 – 0915 (15 Minutes)	Introduction to EWN and Activities Supporting DoD Installations	Jeff King
0915 – 0945 (30 mins)	Tyndall AFB and DoN Installation Experiences	Hollie Schmidt Global Senior Director, Sustainability & Climate Response, Americas, Jacobs
0945 – 1000	BREAK	
1000 – 1030 (30 mins)	MacDill Presentation #1 – Mission/Resilience Brief: SLR Projections and floodplain discussion.	Andy Rider, P.E., Chief, Environmental Element and Jason Kirkpatrick, Environmental Element Manager, Contractor, Akima Support Operations, LLC

1030 – 1200 (1.5 hours)	MacDill Presentation #2 – MacDill's previous NBS projects, and future plans and concepts for increasing installation resilience. Conceptual plans for NBS projects and needed quantities (estimated) of beneficial use material. And USACE Presentation – Quantities and types of beneficial use materials	Jason Kirkpatrick, Environmental Element Manager, Contractor, Akima Support Operations, LLC Laurel Reichold Director, South Atlantic Division, Regional Sediment Management (RSM) Center of Expertise (RSX) US Army Corps of Engineers
1200 – 1300 (1 hour)	LUNCH (Food Trucks in Close Proximity to Workshop Location)	
1300 – 1330 (30 minutes)	Tampa Bay Watch – Living Shoreline work at MacDill AFB	Eric Plage Tampa Bay Watch
1330 – 1400 (30 minutes)	MacDill Presentation: Coastal Resilience and T&E Species: Opportunities and Constraints	Sinéad Borchert Fish & Wildlife Biologist USFWS Liaison to MacDill AFB Florida Air Force Partnership U.S. Fish and Wildlife Service
1400 - 1445 (30 mins)	USACE Presentation – Mobile Harbor Case Study and other EWN-related Project Examples	Elizabeth Godsey, PE Coastal and Regional Sediment Management Engineering Technical Lead and EWN Coastal Practice Lead Mobile District US Army Corps of Engineers
1445 – 1500	BREAK	
1500 - 1700	Installation Site Visit: Visit priority area along SE shoreline and other locations of interest	All
1700	Adjourn	

Thursday, July 13th, 2023 (All times listed are in Eastern Daylight Time)

Time	Action	Lead or Speaker
0800- 0830	Arrive at Building 252 (MacDill AFB Education Center); 8102 Condor Street, Tampa, FL 33621	
0830 – 0945	USACE Modeling, the EWN Toolkit, and Site Applications Performance of Island Restoration Projects in Chesapeake Bay	Amanda Tritinger, PhD Assistant Program Manager Engineering With Nature® and Research Hydraulics Engineer Coastal and Hydraulics Laboratory US Army Engineer Research and Development Center And Jenny Davis, PhD Research Ecologist National Centers for Coastal Ocean Science (NCCOS) National Oceanic and Atmospheric Administration (NOAA)
0945 – 1000	BREAK	
1000 – 1145	Enhancing Coastal Wetland and Dune Resilience through Strategic Re-use of Dredged Material	Christine Angelini, PhD Director, Center for Coastal Solutions and Associate Professor in Environmental Engineering Sciences University of Florida And

	Building Coastal Community Resilience with Nature-Based Shoreline Solutions	Jules Bruck, PhD, RLA Director, School of Landscape Architecture and Planning Chair, Department of Landscape Architecture College of Design, Construction and Planning University of Florida
	Marsh and Reef Projects + Applicable EWN Research	And Safra Altman, PhD Research Coastal Ecologist Environmental Laboratory US Army Engineer Research and Development Center
1145 – 1300	LUNCH (Food Trucks in Close Proximity to Workshop Location)	
1300 – 1415	Projects and EWN Activities in New Jersey Back Bays	Monica Chasten Project Manager Operations Division Philadelphia District US Army Corps of Engineers
	Sediment Transport Modeling and Applicable Projects	Nicholas Cohn, PhD Research Oceanographer Coastal and Hydraulics Laboratory US Army Engineer Research and Development Center

1415 – 1445	Break and Move to Building 30 (Civil Engineering Building) **1st Floor of 6th CES HQ, Bldg 30, 7621 Hillsborough Loop Drive)**	
1445 – 1500	Instructions for Breakout Groups	Jeff King and Hollie Schmidt
1500 – 1630	Breakout Group Exercise	
1630 – 1700	Report Out and Review of Next Steps	
1700	Adjourn	
	Group Dinner	

Appendix B: Workshop Presentations

MacDill AFB and EWN Collaborative Introductions, Jeff King, PhD, P.E, National Lead and Program Manager, EWN Program/USACE

Implementing Natural Infrastructure & EWN Solutions at DoD Installations, Hollie Janson Schmidt, Global Senior Director, Sustainability & Climate Response Americas, Jacobs; Jason Bird, Resilience Market Solutions Leader, U.S. South, Jacobs

MacDill AFB Mission/Resilience Brief: SLR Projections and Floodplain Discussion, Andy Rider, P.E., Chief, Environmental Element, MacDill AFB; Jason Kirkpatrick, Environmental Element Manager, Akima Support Operations (Akima), MacDill AFB

Introduction: MacDill's Natural Resources Work and Proposed Future Beneficial Use Project Jason Kirkpatrick, (Akima) MacDill AFB

Beneficial Use of Dredge Material from the Tampa Harbor Navigation Improvement Project for MacDill Air Force Base, Laurel Reichold, Director, South Atlantic Division, Regional Sediment Management Center of Expertise, USACE

MacDill Airforce Base Living Shoreline Project: Twenty Years in the Making, Eric Plage, Tampa Bay Watch

Coastal Resilience and Threatened and Endangered Species: Opportunities and Constraints, Sinéad Borchert, Fish and Wildlife Biologist, Liaison to MacDill AFB Florida Air Force Partnership, USFWS

Mobile Harbor Case Study and Related EWN Project Examples, Elizabeth Godsey, P.E., Coastal and Regional Sediment Management Engineering Technical Lead and EWN Coastal Practice Lead, Mobile District USACE

USACE Modeling, the EWN Toolkit, and Site Applications, Amanda Tritinger, PhD, Assistant Program Manager, EWN and Research Hydraulics Engineer Coast and Hydraulics Laboratory, USACE Engineer Research and Development Center (ERDC)

Performance of Island Restoration Projects in Chesapeake Bay, Jenny Davis, PhD, Research Ecologist, NCCOS/National Oceanic and Atmospheric Administration (NOAA)

Marsh, Reef & Submerged Aquatic Vegetation (SAV) Projects + Applicable EWN Research, Safra Altman, PhD, Research Coastal Ecologist, USACE ERDC Environmental Laboratory

Building Coastal Community Resilience with Nature-Based Shoreline Solutions, Jules Bruck, PhD, RLA Director, School of Landscape Architecture and Planning Chair, Department of Landscape Architecture College of Design, Construction and Planning, University of Florida

Accelerating Science & Technology Innovation to Improve Coastal Health and Resilience, Christine Angelini, PhD, Director, Center for Coastal Solutions and Associate Professor in Environmental Engineering Sciences, University of Florida

Advancing Practice for Coastal System Resilience, Monica Chasten, Project Manager, USACE, Philadelphia District, Operations Division

Modelling Coastal Change Hazards, Nicholas Cohn, PhD, Research Oceanographer, Coastal and Hydraulics Laboratory, USACE ERDC

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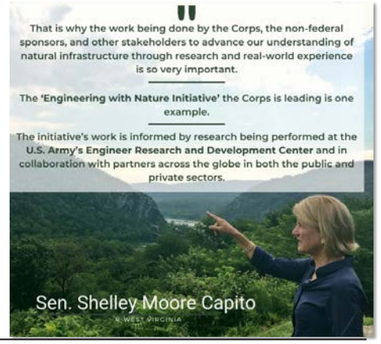
Background

EWN® Program was funded by Congress to conduct a limited number of installation-level studies to identify and evaluate natural infrastructure (NI) strategies and project alternatives to support installation resilience.

Ranking Member Capito and Chairman Carper of the Senate Environment and Public Works Committee.



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EWN at Installations across the US

- ✓ 3 Army
- ✓ 2 Air Force
- ✓ 4 Marine Corps
- ✓ 6 Navy
- ✓ More Expected

Jeffrey.k.king@usace.army.mil

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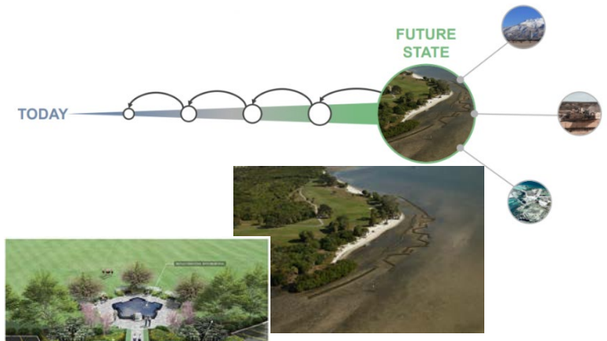
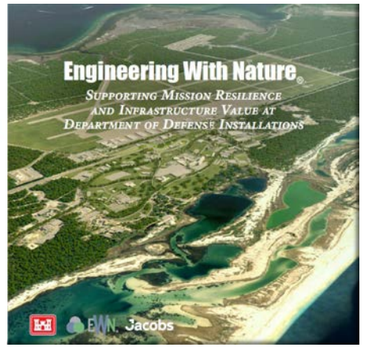
Engineering With Nature for the Department of Defense (DoD)





Outputs of AUG '21 "EWN Across DoD" Workshop and "EWN for DoD" Book available at www.engineeringwithnature.org

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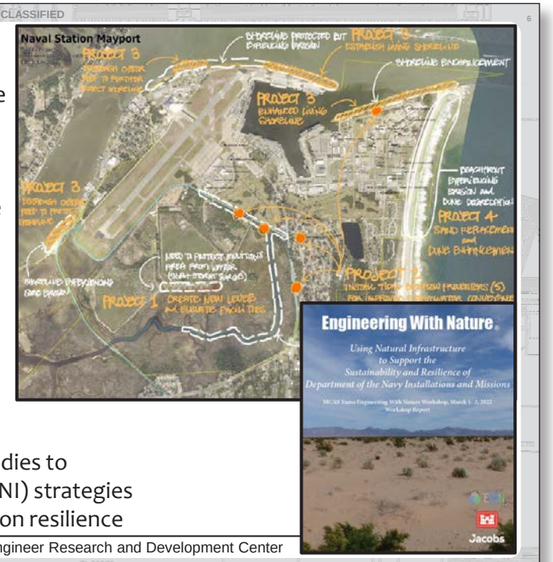
Approach

- Identify installations that want to participate
- Learn more about the installation
- Review best available information about the installation, existing natural systems, and surrounding area
- Begin a preliminary assessment and analysis
- Conduct site visits and talk more with installation POCs and stakeholders
- Pursue deeper dive into installation-level studies to identify and evaluate natural infrastructure (NI) strategies and project alternatives to support installation resilience



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MCAS Beaufort

- EWN host onsite workshop at MCAS Beaufort w/ Marine Corps Leadership and stakeholders (~ 60 participants) July 26-27, 2022
- Documentation of workshop discussions around topics such as:
  - Descriptions/sketches of "scaled-up"-integrated opportunities
  - Potential additional studies and resources
  - General timelines
  - Current or planned initiatives occurring on installation
  - Permitting and NEPA considerations
  - Potential partnerships and stakeholders including roles, responsibilities, lead entities

EA Engineering, Science, and Technology, Inc.

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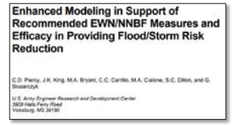
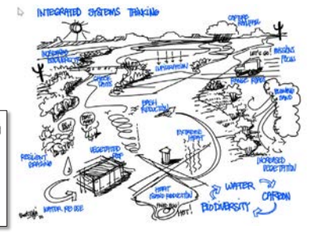
UNIVERSITY OF GEORGIA

Study Products

At the conclusion of the effort, study products may include:

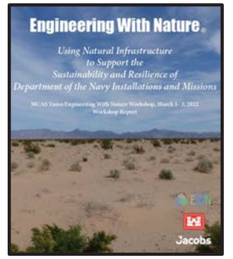
- Modeling results of NI performance





- A study report identifies NI strategies and project alternatives that could be integrated into the landscape for the purpose of increasing resilience and reducing impacts to mission

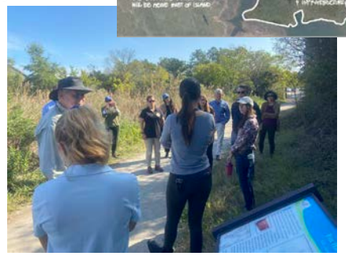

Water Surface Elevation Effect, Storm 636



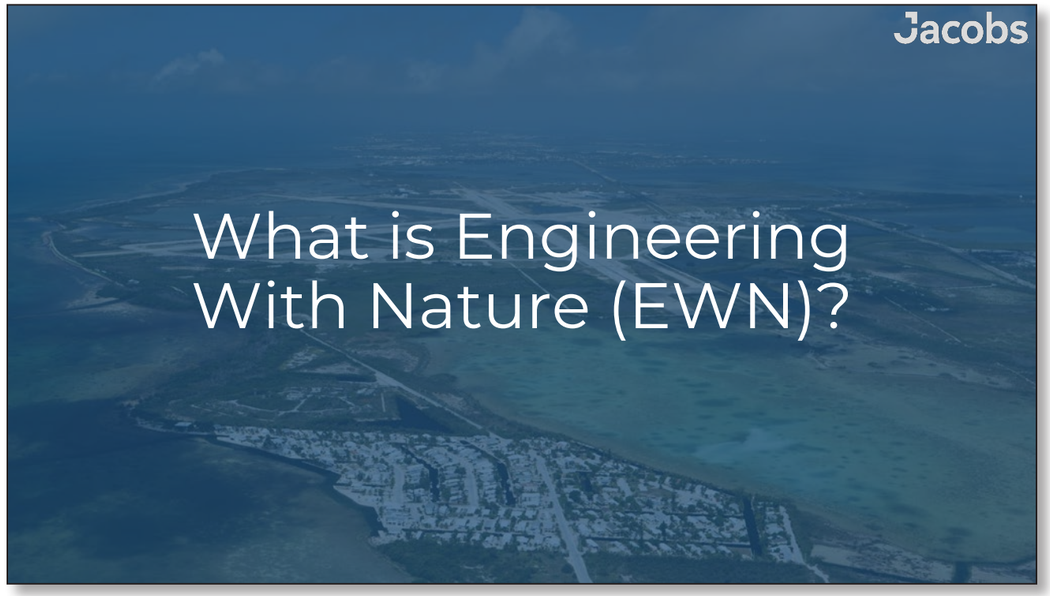
- Briefings and briefing materials
- Others as appropriate

Example Next Steps

- Legacy Program NBS Nominations/Awards
  - MCAS Cherry Point
  - NS Detachment Fallbrook
  - MCAS Yuma
- Marine Corps Investments in NBS Projects
  - MCAS Cherry Point
  - MCAS Beaufort
  - Marine Corps Base Hawaii
- Continued EWN R&D Investment at several installations



Implementing Natural Infrastructure & EWN Solutions at DoD Installations, Hollie Janson Schmidt, Global Senior Director, Sustainability & Climate Response Americas, Jacobs; Jason Bird, Resilience Market Solutions Leader, U.S. South, Jacobs



HOLLIE SCHMIDT
Director,
Senior Global Director,
Sustainability & Climate Response,
Americas

JACOBS

INTRODUCTION

- Hollie Schmidt is also the Director of the Resilience & Sustainability Business Advisory for the Americas
- Landscape architect and master planner with 28 years experience, 23 with Jacobs
- Project Executive for Engineering With Nature (EWN) program
- She led the infrastructure strategy for the reconstruction of Tyndall Air Force Base
- Leads large-scale, complex mega-projects for truly integrate, multi-disciplinary teams

Jacobs

WHAT IS EWN?

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

Engineering With Nature® Initiative

- Formally began in 2010 within the U.S. Army Corps of Engineers as an approach for highlighting good past-practice examples while advancing current and future capabilities for delivering nature-based solutions
- Has grown to include many partner organizations and collaborators in the U.S. and abroad

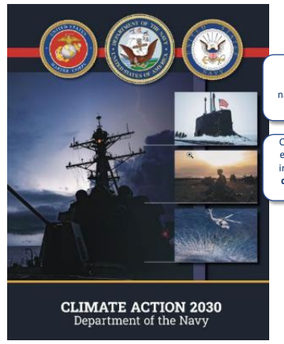
WHAT IS EWN?

“Revolutionizing” Practice Through Nature-Based Solutions

- **Policy development**
  - Engagement with policymakers
  - Policy/procedure “modernization”
- **Engagement, partnering, and teaming**
  - Within USACE, e.g., EWN Proving Grounds
  - With other organizations inside and outside government
- **Innovation**
  - Creating a vision of the future
  - Establishing goals, targets and conditions
  - New science and engineering and tools for delivery
- **On-the-ground projects and demos**
  - Across the spectrum of applications and project development (i.e., from planning to operations)
  - Scaling up nature-based solutions
- **Strategic communications**
  - Individual research papers
  - Communication tools, e.g., EWN Atlas Vol 1 and 2
  - Education, e.g., academic curricula, training

WHAT IS EWN?

Military Installation Resilience: Built + Natural Infrastructure

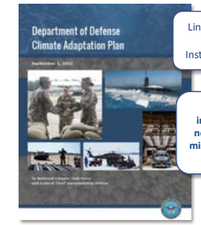


The DON will also deploy nature-based solutions to mitigate shoreline erosion, protect mission-critical assets, and improve natural assets that are key to achieving resilient infrastructure and operations.

Over the past three years, the DON has updated criteria to reflect extreme weather events, including higher winds from hurricanes, increased seismic activities, storm surge, and flooding, and is **now developing new criteria for implementing nature-based climate resilience measures**.

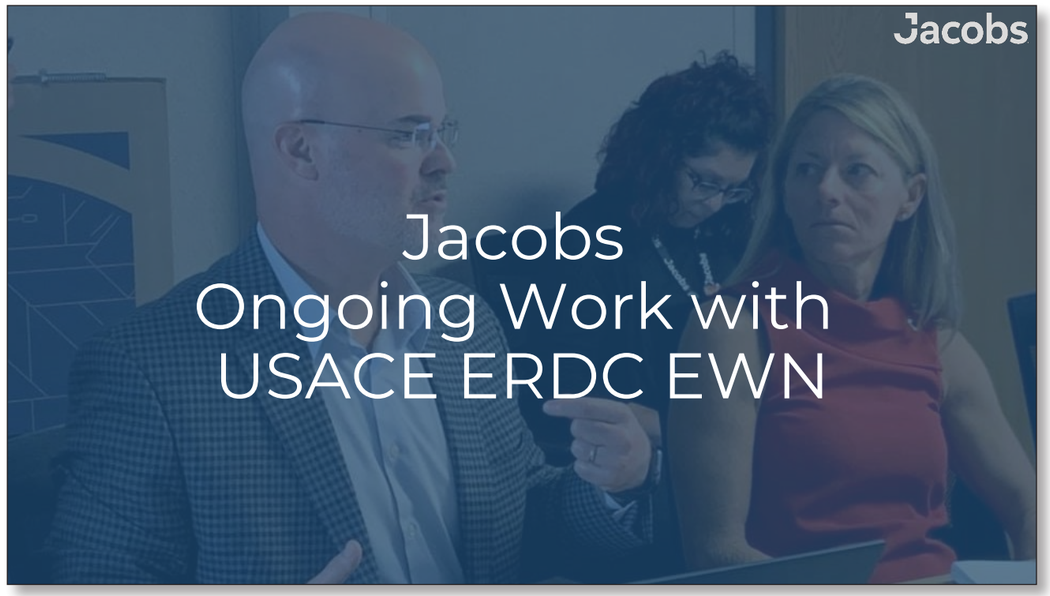
Objective 1.j.1: **Develop Roadmap for incorporating EWN tools and techniques** into MILCON planning and design processes

Objective 1.j.3: **Incorporate nature-based solutions**, risk-based climate science, tools, technology, and adaptation measures into installation land management plans and disaster preparations.



Line of Effort 3: Resilient Built and Natural Installation Infrastructure

“Built and natural infrastructure are both necessary for successful mission preparedness and readiness.”



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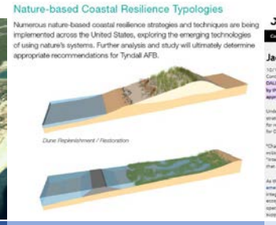
USACE ERDC EWN & JACOBS RELATIONSHIP



1

Tyndall Air Force Base Rebuild

Integrated EWN design solutions for the natural and built environment

2

Co-Published EWN Atlas

Supporting Mission Resilience and Infrastructure Value at Department of Defense Installations

3

Tyndall Coastal Resilience Strategy

Definition of Pilot Projects, Stakeholder Engagement, Funding Strategy, Implementation Plan

4

EWN DoD Facility Adaptation Planning

3-Year Contract for vulnerability assessments at DoD Installations that can be mitigated with EWN solutions

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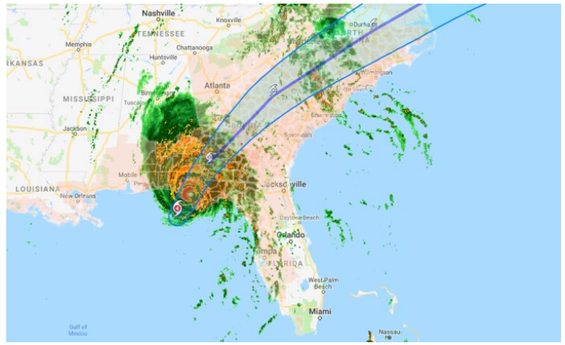
EWN at TAFB

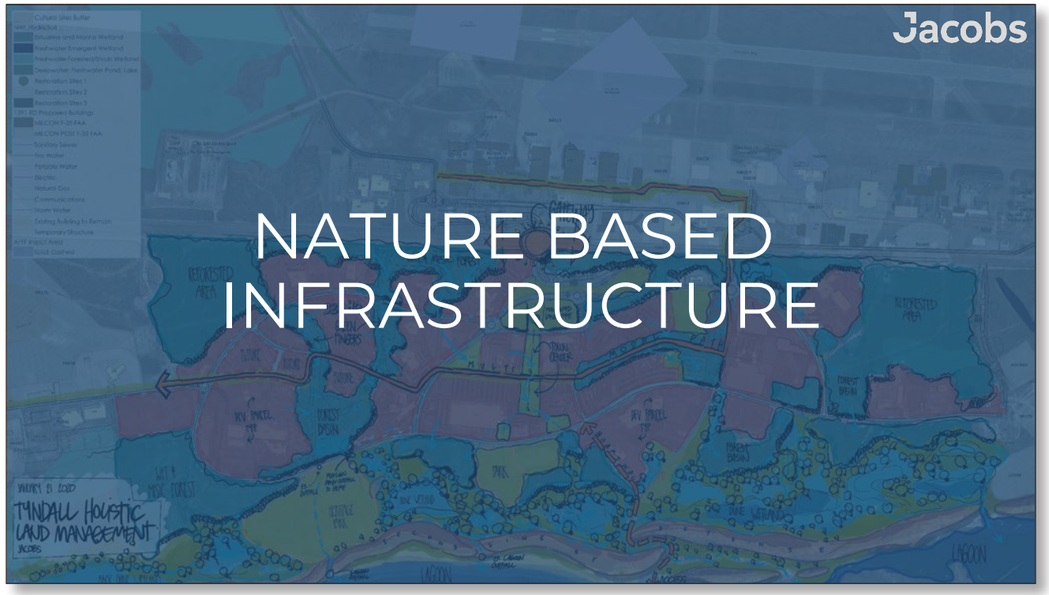
In October 2018, Tyndall Air Force Base was hit with a **category five hurricane** which resulted in **damage to 100% of its assets**.

The goal of this project was to rebuild the base to be more **resilient, sustainable**, and **smart** to be an **Installation of the Future**.



155 MPH
Sustained Winds

~14'
Storm Surge



EWN at TAFB

NBI Myth Busting

MILCON will not pay for landscape, it will never get installed

Landscape is “nice to have” and should not be installed at sacrifice to the mission, it has no value

The base will not maintain NBI solutions

Nature Based Infrastructure costs more and requires more maintenance

Landscaped areas attract snakes, bears and mosquitoes

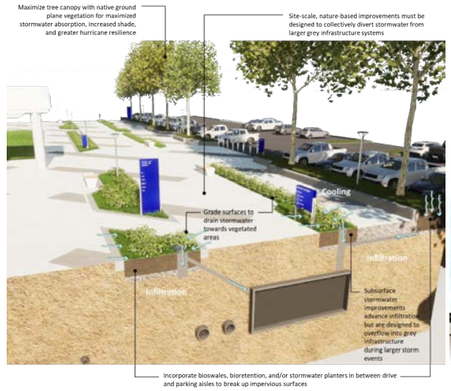
AT/FP

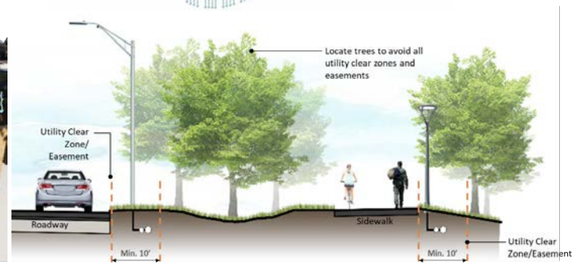
Landscaped areas are a security concern

Proposed solutions will restrict or constrain future development and pose a threat to mission

EWN at TAFB

Utilities & Stormwater





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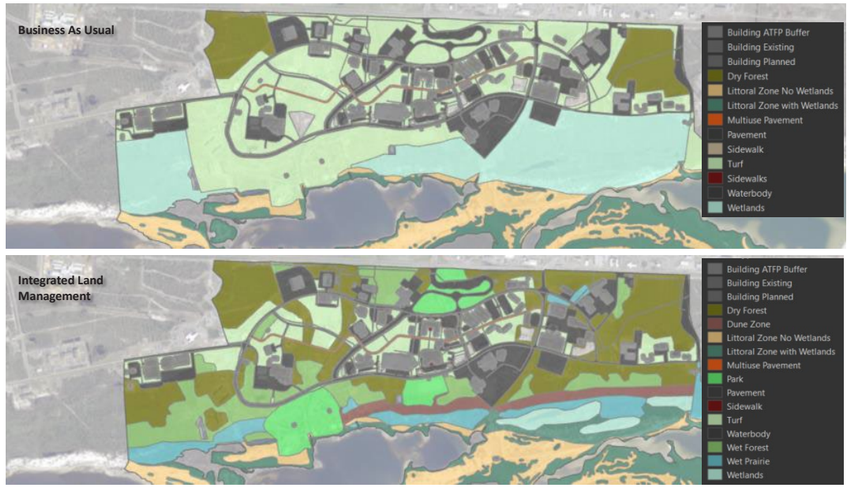
EWN at TAFB

Beyond Business As Usual



EWN at TAFB

Beyond Business As Usual

Current State

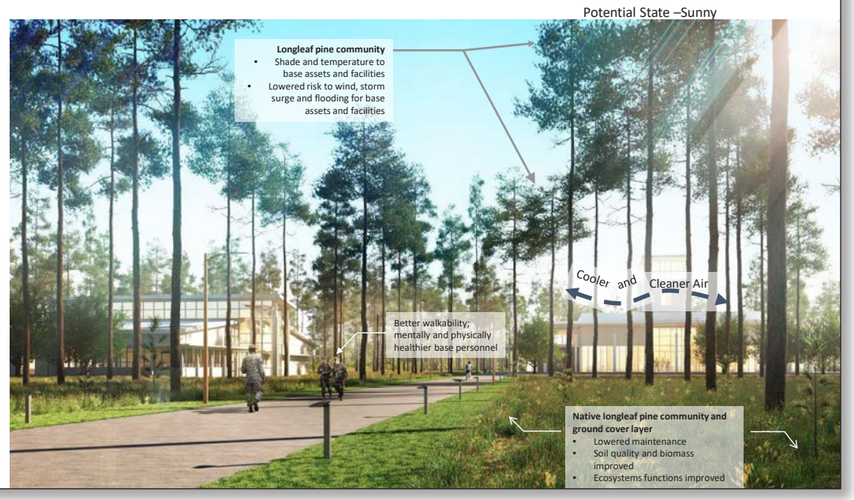
Current State

16

EWN at TAFB

Beyond Business As Usual

- **Larger aggregates of land turned over to native ecosystem**
- **Longleaf pine forests, grass savannahs, wet prairies, wetlands, and dune landscapes**
- **Approaches that are natural or combine nature, design, and engineering to mimic natural processes**
- **A combination of approaches designed as a larger ecologically-based system to achieve regional benefits**
- **Designed with maintenance in mind to achieve "known" maintenance**



EWN at TAFB

Beyond Business As Usual

- **Greater climate resilience that creates conditions which are flexible, reversible, and adaptive to changing conditions versus grey infrastructure alone**
- **More cost effective and simpler maintenance over built grey infrastructure such as water treatment facilities and pipes alone**
- **Improved health and quality of life as Biophilic approaches reduce stress, improve health, mental restoration, and reduced fatigue for greater recruitment and retention**

EWN at TAFB

Maintenance Standards

Landscape Master Plan: Stormwater Management Maintenance Guidelines

Do8.2 Swales/Rain Gardens/Open Channels

Bioswale failure rates within the first 5 years are very high due to insufficient maintenance. Since bioswale's function is an important component of every jurisdiction's watershed improvement plan, or Watershed Implementation Plan (WIP), more frequent and higher quality maintenance is sorely needed. Some common and easily controlled performance issues affecting vegetation are unwanted standing water in a BMP, water not reaching certain parts of the Best Management Practices (BMP), side slope sedimentation, inlet clogging, etc. Mandated periodic BMP inspection is required to be aware of the needed maintenance issues and respond as appropriate. The following charts have common failures or problems that can occur in bioswales or raingardens and provide suggested maintenance activities and tasks.

Exhibit D-13. Typical Maintenance Activities for Vegetated Filter Strips Bioswales, Open Channels, and Grass Channels

Frequency	Maintenance Tasks
As Needed	• Mow grass channels and dry swales during growing season to maintain grass heights between 4-6 inches. • Look for and stabilize any bare soil or sediment sources in contributing drainage area (CDA).
4 Times a Year	• Keep CDA, inlets and facility surface areas clear of debris. • Keep CDA stabilized. Spot seed where needed. • Remove sediment and oil/grease from inlets, pretreatment devices, flow diversion and overflow structures. • Repair undercut and eroded areas at inflow and outflow structures.
Annually	• Add reinforcement planting to maintain 90% turf or vegetative cover. Re-seed any silt killed vegetation. • Remove accumulated sand or sediment deposits behind check dams. • Inspect upstream and downstream check dams for undercutting or erosion. Remove trash or blockages at weep holes. • Inspect channel bottom for erosion, braiding, excessive ponding or dead grass. • Inspect inflow points for clogging and remove any sediment. • Inspect side slopes and grass filter strips for evidence of any rill or gully erosion and repair as needed. • Inspect elevation of turf as related to the inflow surface to ensure turf doesn't block inlet.

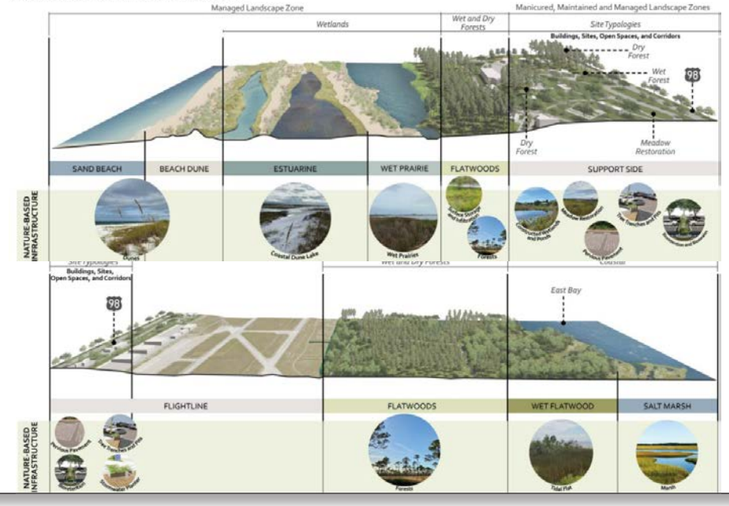

Remove all silt and trash from swales and channels

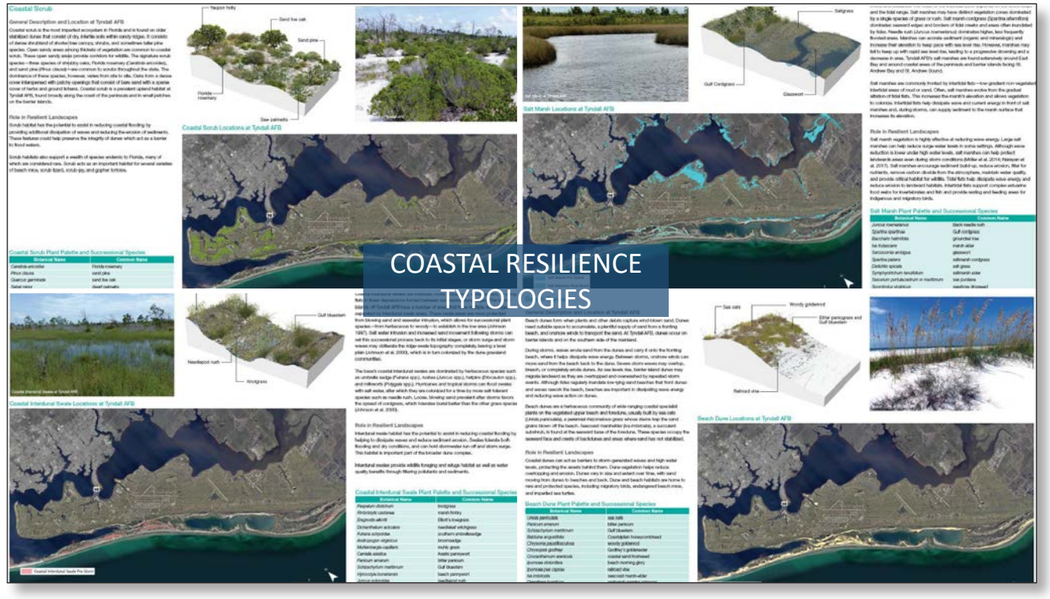

Remove all trash and debris from channel

EWN at TAFB

Beyond Business As Usual

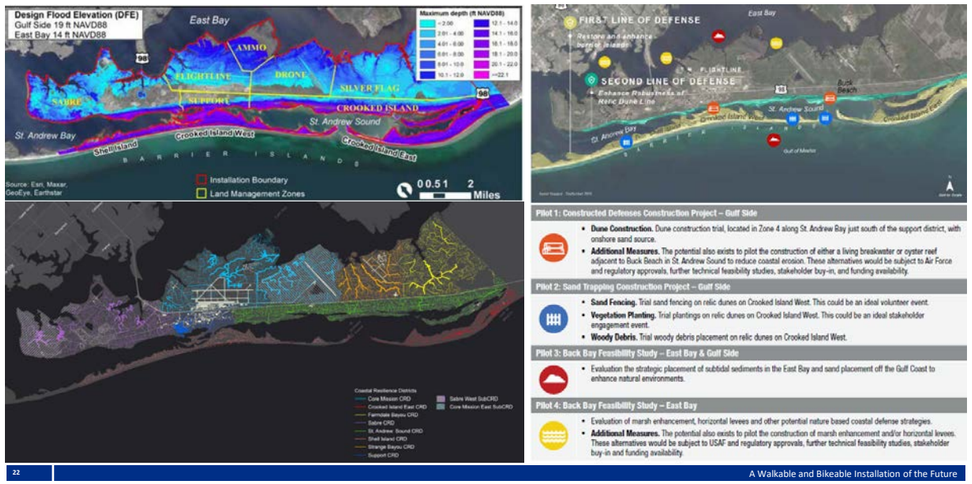
Exhibit 804-6. Best Management Practices in the Support District





EWN at TAFB

Jacobs



22 A Walkable and Bikeable Installation of the Future

EWN at TAFB

Tyndall Coastal Resilience: Project Partners

- The Nature Conservancy
  - Project Director
  - FT Project Manager
  - Knowledge Transfer
- Jacobs
  - Project Design
  - Modeling
  - Permitting
- University of Florida
  - Monitoring
  - Modeling Support
- Naval Research Lab
  - Mapping
  - Modeling Support
- Rutgers
  - Materials Source

U.S. AIR FORCE

The Nature Conservancy
Protecting nature. Preserving life.

UF UNIVERSITY of FLORIDA

Jacobs

U.S. NAVAL RESEARCH LABORATORY

RUTGERS

EWN at TAFB

Tyndall Coastal Resilience: Grants

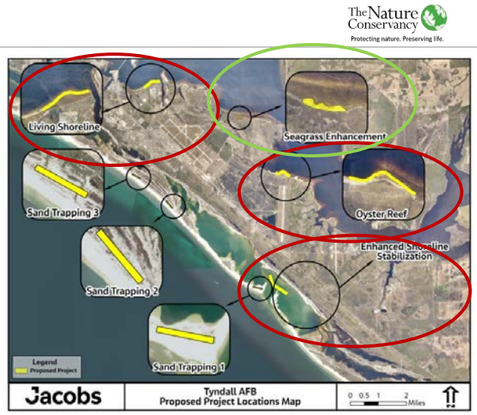
2021 REPI Challenge / NFWF-NCRF ($4.8 M) *Executed*
- Programmatic Environmental Assessment (All NBS)
- Data collection, Surveys, Modeling, Engineering Design & Permitting (3 NBS "Pilot" Projects)

FY21 REPI Program / NFWF-NCRF ($3 M) *Dedicated*
- Construction

2022 NFWF-NCRF ($12.7 M) *In Review*
- Construction
- Monitoring

RESTORE Act – Bay Co. Board of Commissioners ($500 K) *Dedicated*
- Data Collection & Surveys (Seagrass Enhancement)
- Monitoring
- Design & Permitting

U.S. Fish & Wildlife Service ($950 K) *Dedicated Match*
- Sand trapping



Oyster reef - 1,500 linear feet
Living shoreline - 1,000 linear feet
Enhanced shoreline stabilization - 3,500 linear feet
Seagrass Enhancement – 5 acres

EWN at TAFB

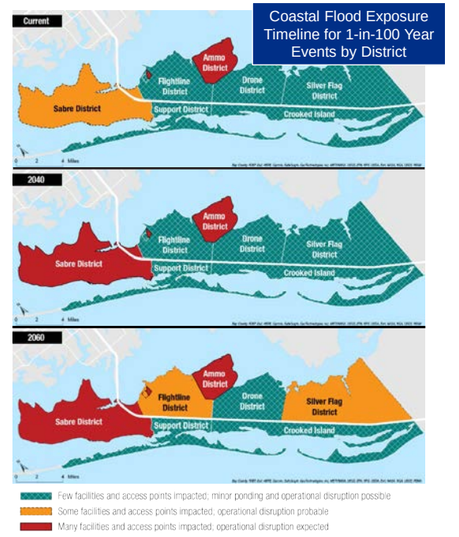
Tyndall Coastal Resilience: Coastal Resilience Implementation Plan

- Purpose of the CRIP is to provide a roadmap to guide coastal resilience based on the evolution of coastal flood risk from climate change.
- CRIP includes:
  1. Understanding of how the base's vulnerabilities will increase over time.
  2. Evaluation of coastal resilience options to reduce risk and maintain mission assurance.
  3. Path forward for implementation.
- Technical Appendix of all supporting analysis and materials.

EWN at TAFB

Tyndall Coastal Resilience: Evolving Hazards and Flooding

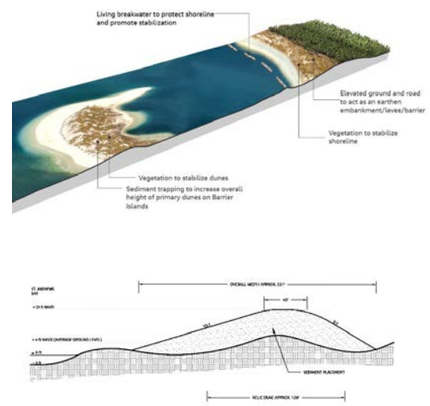
- The planning horizons evaluated for the CRIP include 2040, 2060, 2080 and 2100.
- Ammo and Sabre Districts and portions of the Flightline District are expected to experience flooding and potential operational disruptions from the 1-in-100-year event sooner than other areas of the base.
- Other Districts require interventions for future flood risk.



EWN at TAFB

Tyndall Coastal Resilience: Role of Nature Based Solutions / EWN

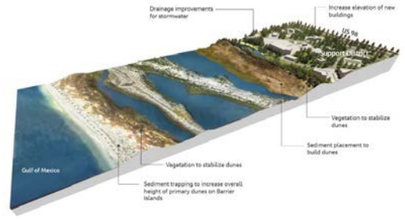
- The nature-based pilot projects that are currently in design will provide proof of concept and design precedents that could be scaled up and implemented in the future as the need arises.
- Regular monitoring of near-shore and offshore conditions, and storm response, should be performed to determine the most appropriate nature-based solutions over time.
- Additionally, a reoccurring funding stream should be identified so that additional nature-based features can undergo design and construction, as needed.
- Project planning and design should start a few years in advance of needs, due to time for NEPA, design, permitting and construction.



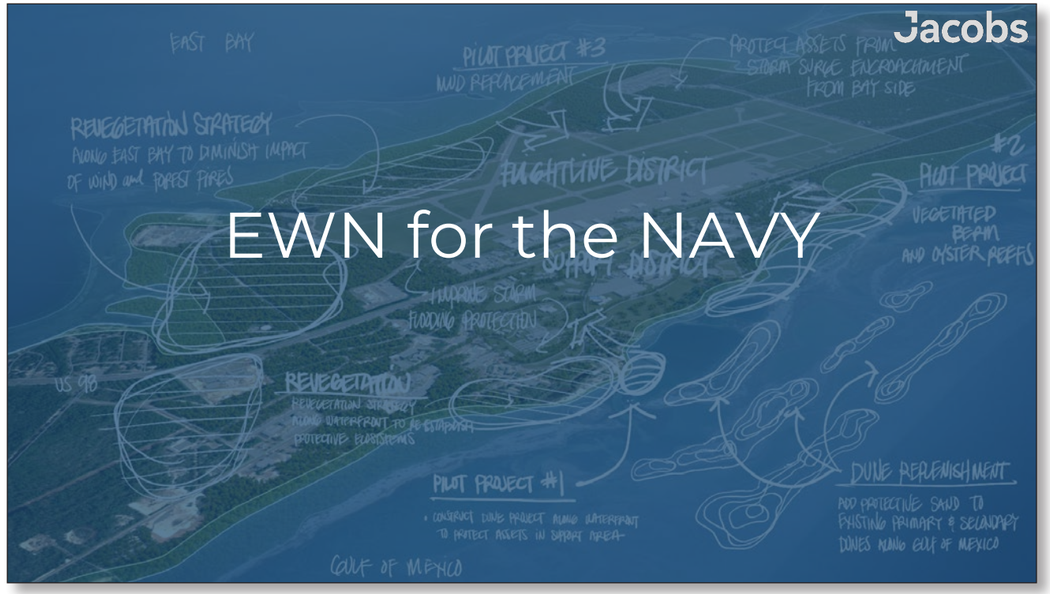
EWN at TAFB

Tyndall Coastal Resilience: Proposed Actions

- The recommended strategies provide both a strong positive performance against the defined objectives and have a strong positive economic business case.
- Incorporate nature-based solutions, where practicable, as part of all structural/non-structural projects, to enhance their long-term performance.
- Additional considerations that could further strengthen the case for action include:
  - Evaluation of indirect economic benefits of projects, on base mission and across region.
  - Consider phasing capital investments over time, as flood risk increases.
  - Monitoring the evolution of the Gulf coast barrier islands geomorphology, which can affect coastal flood risk.
  - Update facility and infrastructure database as base rebuild is completed and as mission and use of facilities evolves to identify changes in vulnerabilities over time to inform timing and scale of coastal defense measures.



Coastal Resilience Implementation Plan



EWN at TAFB

Tyndall Coastal Resilience: Next Steps

Scaling up Pilot Projects

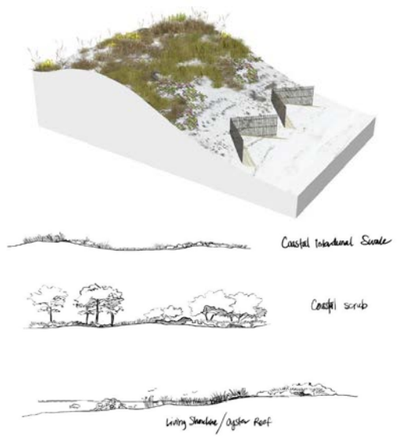
- The nature-based coastal solution pilot projects will provide vital lessons learned on the process of planning, designing and implementing nature-based projects in near shore waters around Tyndall.
- Pilots will test various strategies to understand performance over time related to the intended outcomes.

CRIP Maintenance

- Regular updates to the CRIP is recommended, as the programmatic EA and sea level rise projections are valid for approximately 5-years. Updates may also occur related to mission, policy and environmental conditions.

Continued Regional Stakeholder Engagement

- Continue to collaborate with regional collaborators to identify regional needs and opportunities and leverage network and resources to benefit Tyndall and the regional environmental resources.



Coastal Resilience Implementation Plan

EWN for the NAVY

Engineering With Nature®

for the Department of Navy

11

DoD Installation Participated

30+

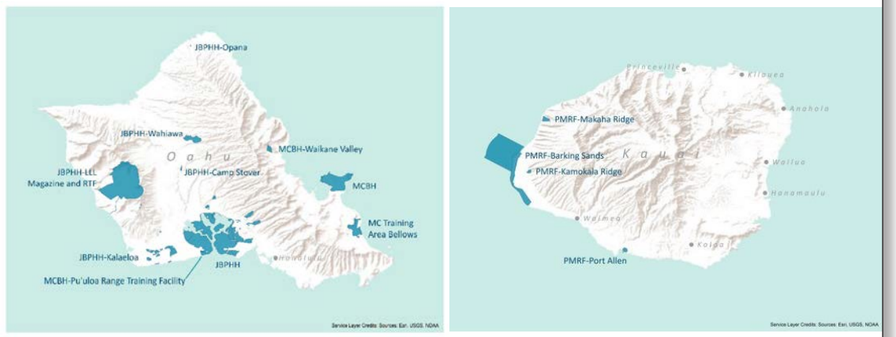
Projects Defined

SLIDE / 32

EWN for the NAVY

Engineering With Nature

HI participating DoD installations



SLIDE / 33

EWN for the NAVY

Engineering With Nature

DoN HI installations & Partners

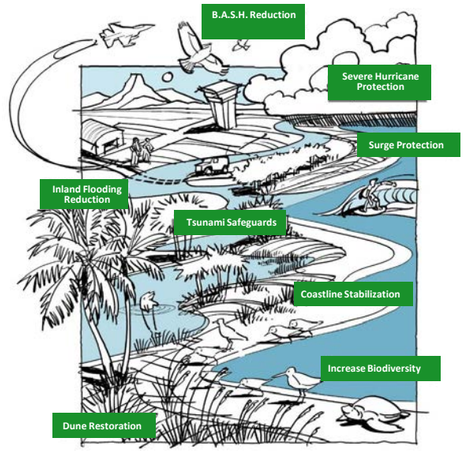
Pacific Missile Range Facility (PMRF)	Joint Base Pearl Harbor Hickam - Oahu (JBPHH)	Marine Corp Base Hawaii (MCBH)	Department of the Navy
NAVFAC	ERDC	Jacobs Team	EA Team

EWN for the NAVY

Engineering With Nature

SCALING-UP OPPORTUNITIES

- Project Replication
- Combining Projects
- Geographic footprint
- Timing / phasing
- Systems-thinking / One-water solutions



SLIDE / 35

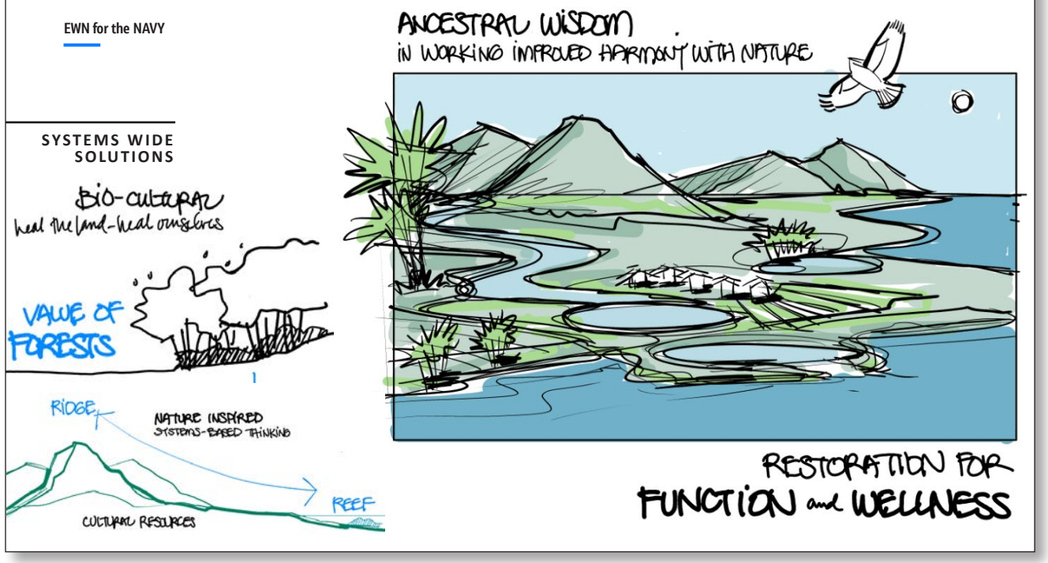
EWN for the NAVY

SYSTEMS WIDE SOLUTIONS

SLIDE / 36

EWN for the NAVY

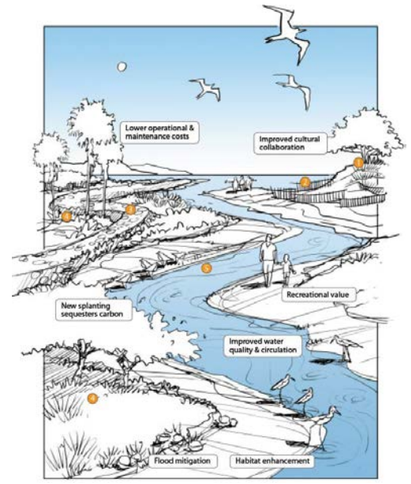
SYSTEMS WIDE SOLUTIONS



EWN for the NAVY

Stream Restoration at Marine Corps Base Hawaii:

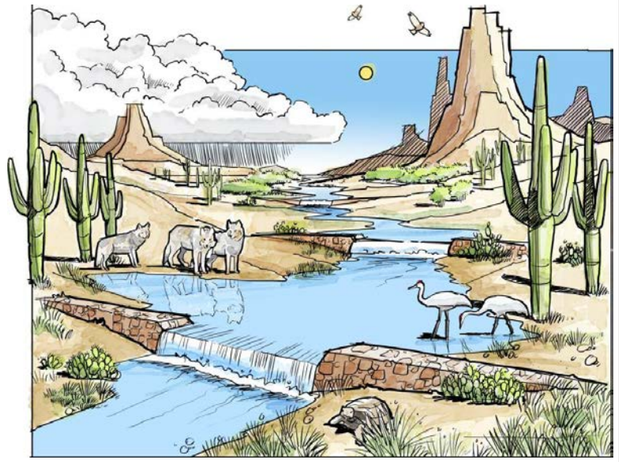
1. Dune restoration
2. Dune fencing
3. Jetty repair and extension
4. Invasive trees removal and new planting
5. Channel dredge



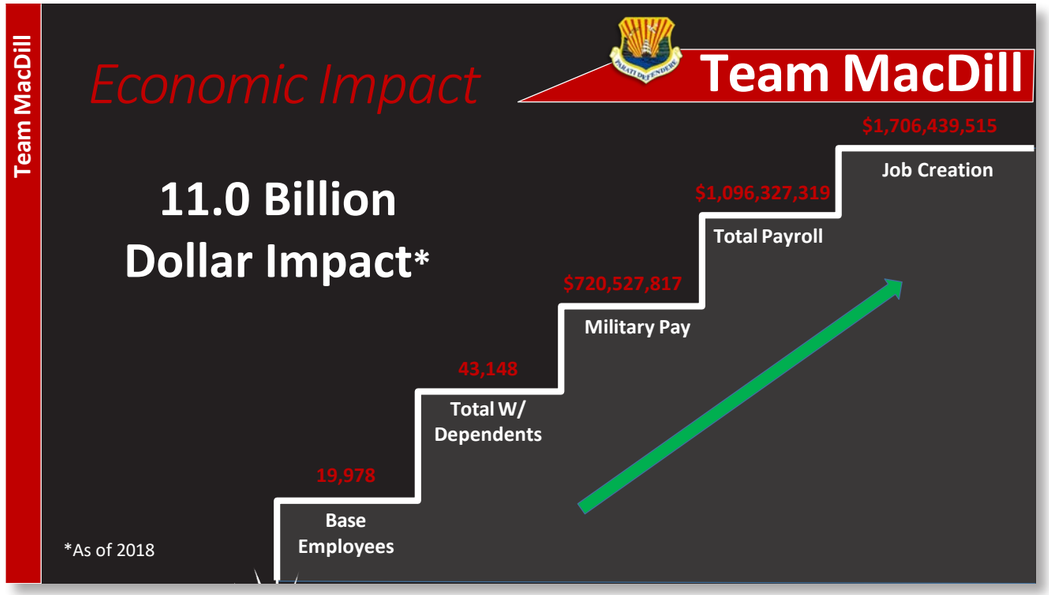
EWN for the NAVY

Check Dam Deployment at MCAS Yuma

- Mimic Beaver's "check dams"
- Slows the water flow, allows sedimentation, encourage biodiversity, potentially mitigate flooding



MacDill AFB Mission/Resilience Brief: SLR Projections and Floodplain Discussion, Andy Rider, P.E., Chief, Environmental Element, MacDill AFB; Jason Kirkpatrick, Environmental Element Manager, Akima Support Operations (Akima), MacDill AFB



Mission Partners

Mission Partners

6 ARW

6TH AIR MOBILITY WING
2,924 Authorized
2,447 Active Duty (125 at GSUs)
477 Civilians
Also 389 Contractors

USCENTCOM
1,917 Authorized
1,014 Active Duty
903 Civilians *
1,010 IMAs
Also
Approx. 400 Contractors

USSOCOM
2,070 Authorized
807 Active Duty
1,263 Civilians *
497 IMAs
Also
600-650 Contractors

927th Air Refueling Wing
941 Assigned (including 114 ART/Civilians)

SOCCENT
493 Authorized

JCSE
416 Authorized

MARCENT
193 Authorized

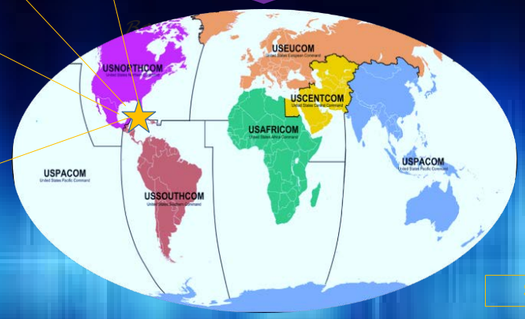
NAVCENT
6 Authorized

*2015 Data

Unified Combatant Commands

Functional Commands

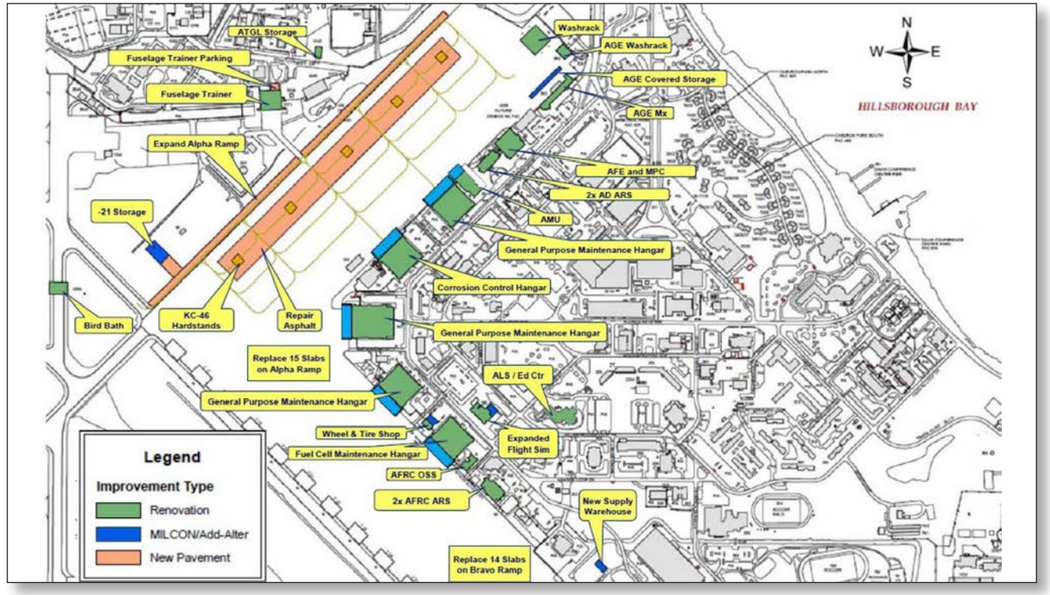
Regional Commands



Supported by MacDill AFB

KC-46A Bed Down

- 24 KC-46A aircraft will replace 24 KC-135 aircraft on a 1 for 1 basis
- National Environmental Policy Act (NEPA) completion projected 1st Quarter of FY24
- 1st aircraft projected 1st Quarter FY27
- Last aircraft projected 3rd Quarter FY28
- MacDill Initial Operating Capability projected 12 months after 1st aircraft arrival
- MacDill Fully Operational Capability 12 months after last aircraft arrival



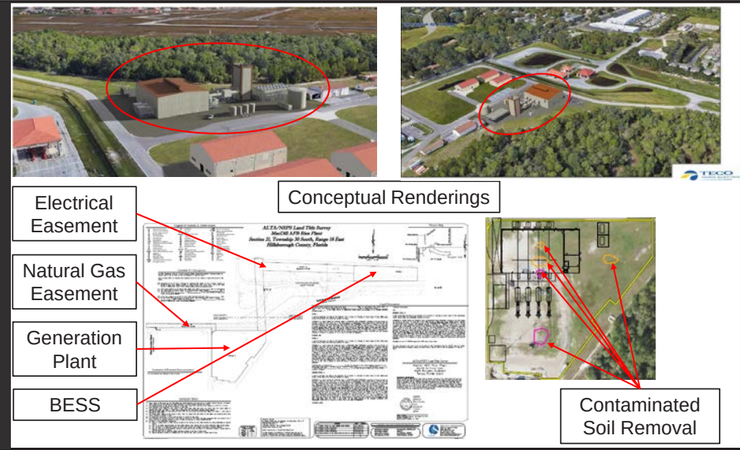
MACDILL AFB
Community Planning

A Really Small Town With a Really Big Airport

CUI

(U) MacDill/Tampa Electric Energy Assurance Lease

- (CUI) **AFCEC & TEC Signed, [DATE]**
- (CUI) **~4.5 acres + utility easements**
- (CUI) **Distributed Power Generation Facility**
  - (CUI) **4-Natural Gas Engines, 76 megawatts (MW), 2 initial construction**
  - (CUI) **Battery Energy Storage System (BESS), 20 MW, 2-hour life**
- (CUI) **Contaminated Soil Removal**
- (CUI) **Electrically Islanded Operations (EIO) Agreement**
  - (CUI) **Generation Facility will serve all TEC customers during normal grid operations**
  - (CUI) **EIO engagement to power MacDill**
  - (CUI) **Necessary to construct ERCIP Transmission & Substation Project**
- (CUI) **Design/Construction Coord underway**
- (CUI) **~2-yr construction schedule, Dec start**
  - (CUI) **Soil removal, Dec 22**
  - (CUI) **Permitting, Mar 22**
  - (CUI) **UG Work & Foundations, Apr 23**
  - (CUI) **AG Work, Feb 24**
  - (CUI) **Commercial Operation, ~Dec 24**



Bottom Line | MacDill EAL creates a redundant energy source that can immediately mitigate grid disruptions and provide installation resiliency

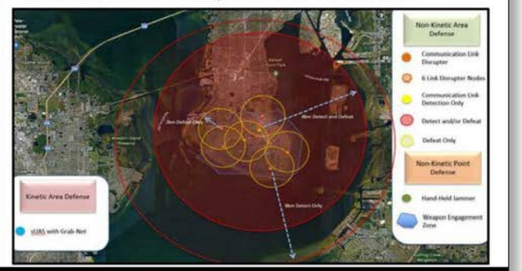
(CUI) MacDill Waterside & c-UAS Security

COASTAL RESTRICTED AREA (CRA) ENFORCED w/RADAR, CAMERAS & WATERBORNE OPERATIONS

- (CUI) **SF enforces CRA along 7.2 miles w/ Waterside Security System (WSS) Towers & Waterborne Ops (vessels)**
- (CUI) Current WSS: Anduril Lattice. Artificial Intelligence (AI) able to detect/classify/track vessel, person, or other threats
- (CUI) 90+% coverage - only limited by advanced sensors, terrain, marsh & heavy vegetation

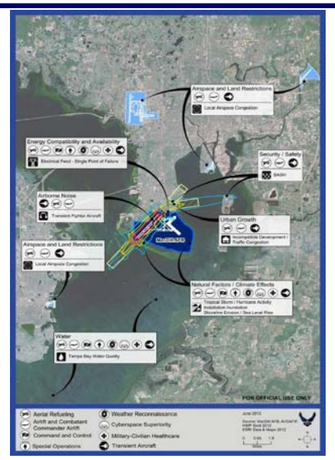
RESTRICTIONS FOR sUAS/DRONES ON MACDILL, IMMEDIATELY/INDEFINITELY

- **sUAS/Drones prohibited on MacDill AFB & w/in 5 mi IAW FAA restrictions (14 CFR § 99.7 & 10 USC §130i)**
- (CUI) NINJA c-sUAS system capable of detecting/controlling drones w/in system library
- Drones discovered within the base perimeter may be subject to seizure, fines or both by local or base authorities.



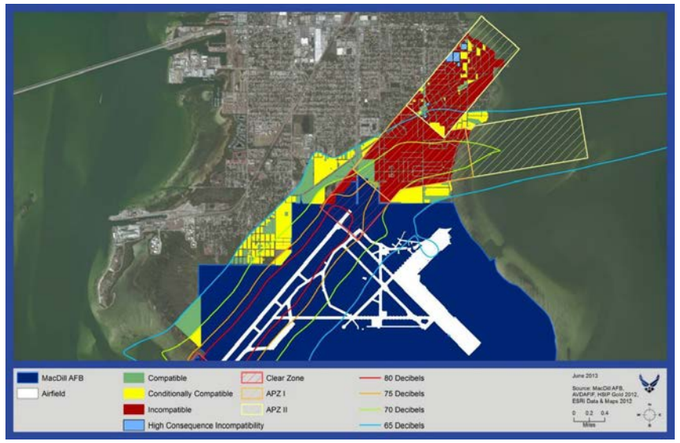
Bottom Line | **Defense in Depth Across 3 Dimensions: Land, Sea, & Air**

Installation Complex and Mission Footprint (ICEMAP)



CUI

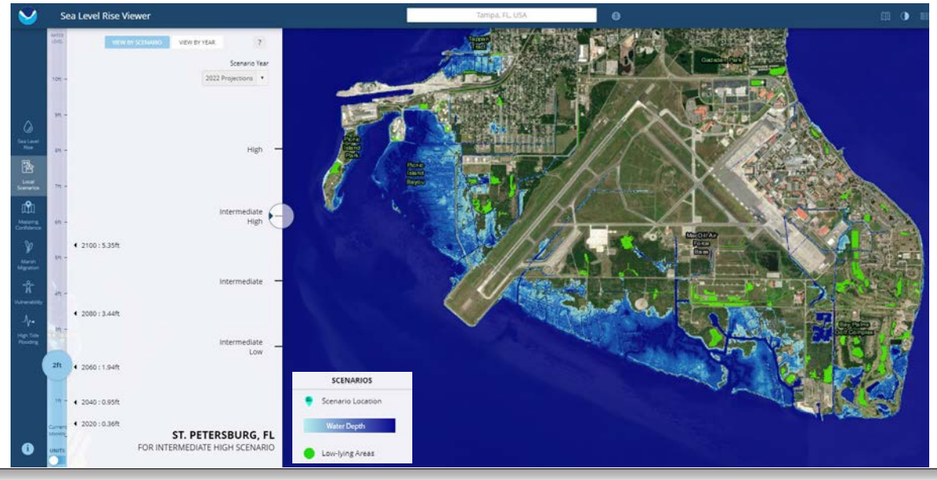
Incompatible Development in the CZ and APZ I & II (AICUZ and JLUS)



CUI

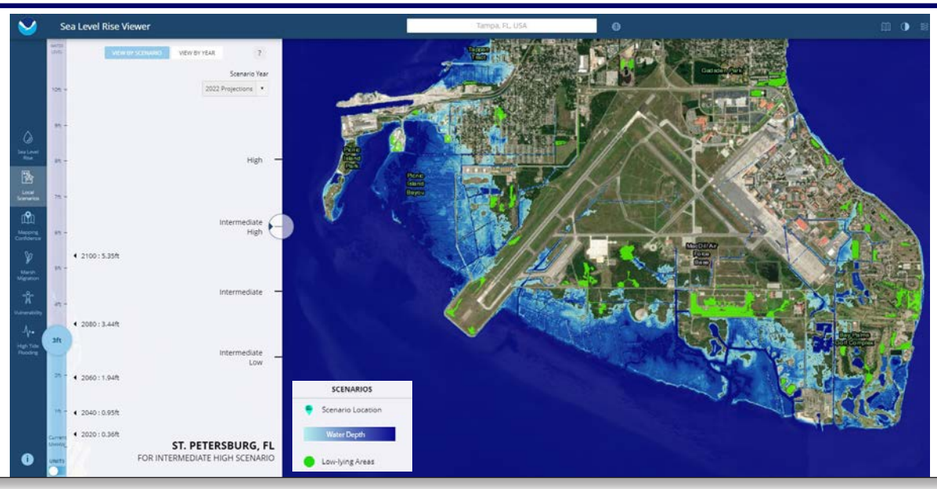
13

NOAA Sea Level Rise Projection – 2 feet ~ 2060

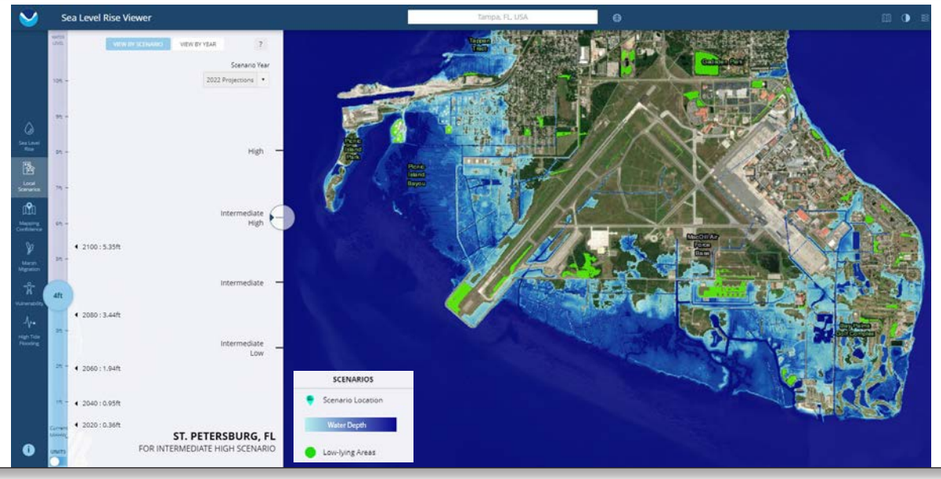


NOAA Sea Level Rise Projection – 1 foot ~ 2040

NOAA Sea Level Rise Projection – 3 feet ~ 2075



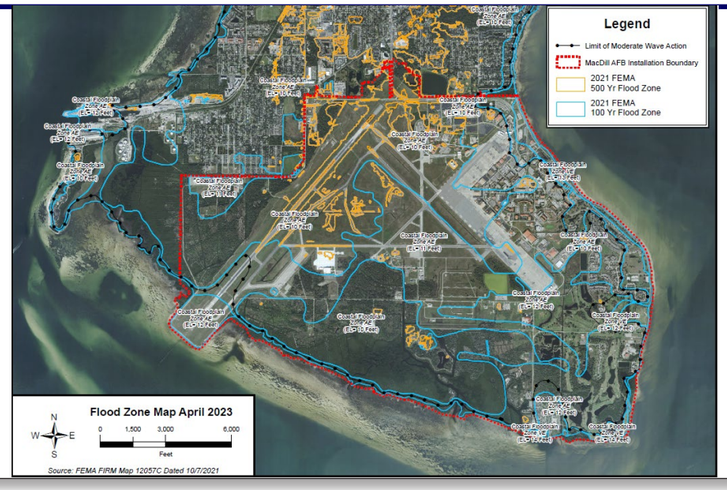
NOAA Sea Level Rise Projection – 4 feet ~ 2085



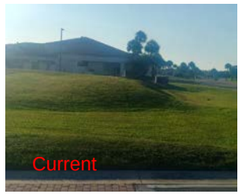
SLR and Floodplain Concerns/Priorities

- SLR will hinder our ability to drain stormwater increasing short-term flooding during storms, which is not shown on the SLR maps
- How can we reduce/shrink the Limit of Moderate Wave Action (LiMWA)?
- Any nature-based solutions/alternatives for elevating new construction above the BFE?
  - Over 94% of MacDill is w/in the floodplain
  - 2021 Changes to the FEMA FIRM increased the elevation requirements for new construction
- Inland/near shoreline/in water NBS's for resiliency

2021 FEMA Flood Zone



Resiliency Planning at MacDill AFB



CUI

Resiliency Planning at MacDill AFB




CUI

Military Installation Resiliency Review MIRR

- Support the MacDill AFB Mission
  - Implement Resilient Strategies
    - Policy
    - Emergency and Recovery Planning
    - Data Collection and Analysis
    - Utilities/One Water
    - Land Use
    - Transportation
  - How do we interface with a changing climate?
    - How will it impact the base and surrounding community?
    - How can the base become more resilient?
    - How can stakeholders collaborate with the base to implement strategies?

Resiliency Planning at MacDill AFB






CUI

Military Installation Resiliency Review MIRR (Cont.)

- MIRR is more than a study, it's a partnership
  - The Team:
    - TBRPC
    - DoD Office of Local Defense Community Cooperation (OLDCC)
    - MacDill AFB
    - Utilities
    - City of Tampa
    - South Tampa Community
    - Experienced Consultant Team
  - MIRR will:
    - Identify Risks and Vulnerabilities
    - Define Goals and Measures of Success
    - Develop Strategies for Implementation

Introduction: MacDill's Natural Resources Work and Proposed Future Beneficial Use Project Jason Kirkpatrick, (Akima) MacDill AFB

SWIM Phase III Restoration

Project partner:
Southwest Florida Water Management District

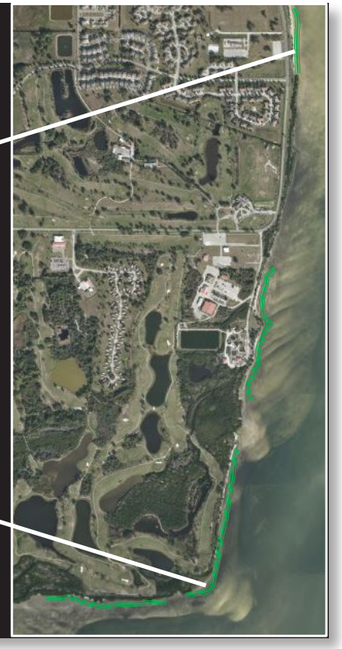
Wetland Creation

- Converted disturbed upland into 6.5 acres of seasonal freshwater marsh
- Converted 1.1 acres of dredge spoil ‘road’ back to estuarine wetland
- Enhanced 1.2 acres of existing high marsh

Wetland Creation

6.5 acres of freshwater marsh adjacent to estuarine ecosystem

Shoreline Stabilization



Shoreline Stabilization

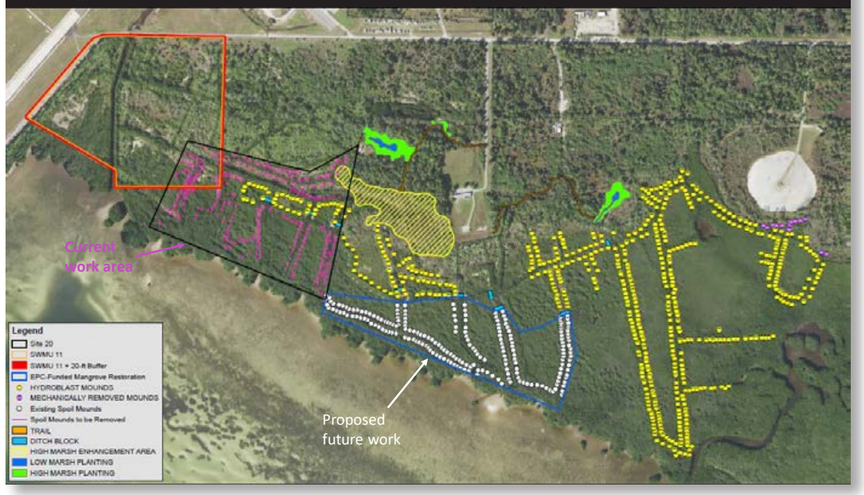
Project Partners:
Tampa Bay Watch
USFWS
NOAA
TBEP
HCEPC

Marsh and mangrove habitat is well established, traditional back-bay ecosystem returned.

No more pretty beach.

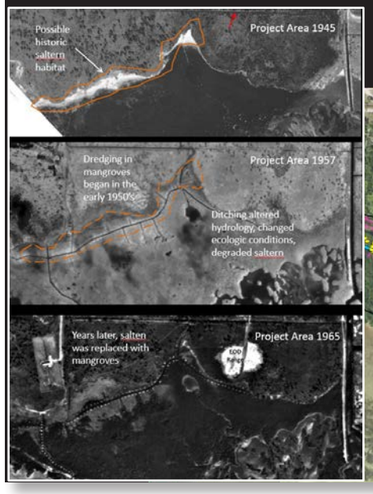
Mangrove Restoration plus Saltern and High Marsh

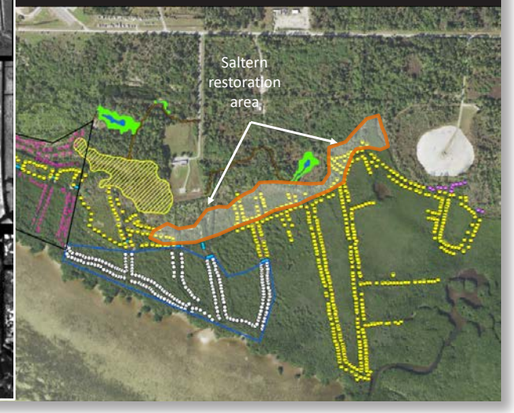
Project partner:
Ecosphere Restoration Institute



Mangrove Restoration plus Saltern and High Marsh

Project partner
Ecosphere Restoration Institute





Invasive Plant Species Control

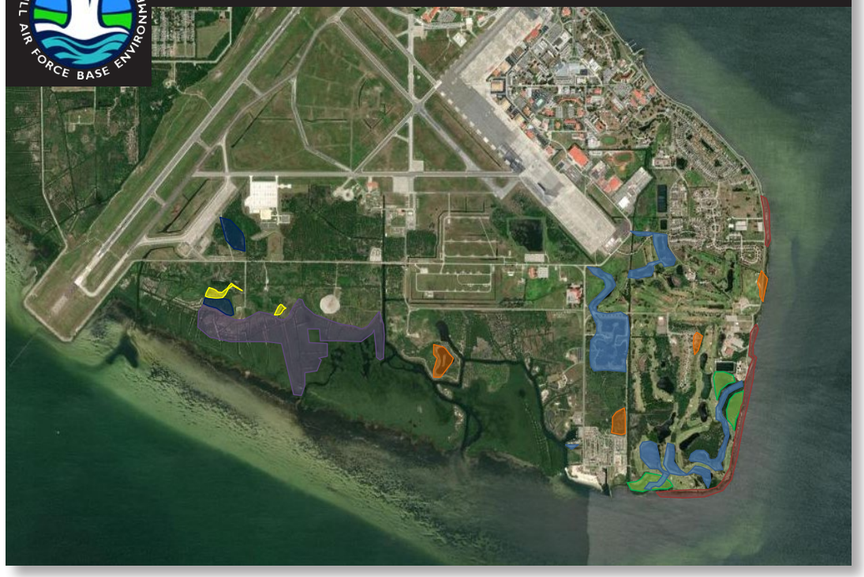
Progress being made, but far from complete
Funding is biggest hurdle

Prescribed Burn Program

Work supported by
Air Force Wildland Fire Branch

Progress being made, but much more needs to be done
Weather, mission constraints, AFWFB availability, lack of 'burn culture' (historically) have been our greatest challenges

Habitat Restoration Basewide

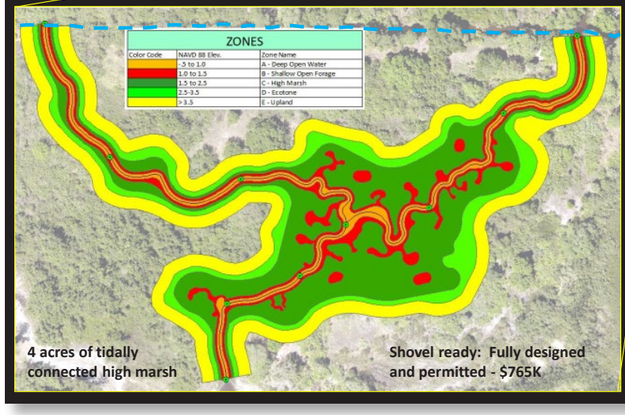


MacDill works continuously to improve our natural infrastructure – making every effort to work with nature

When we repair/restore/utilize natural systems we capitalize on the ecosystem services that nature provides us. At MacDill these services include:

- **Flood protection and control**
- **Storm surge protection**
- **Reducing coastal erosion**
- **Creating natural buffers**
- **Improved training areas**
- Restore ecosystem health
- Better habitat for wildlife, including T&E
- Increase biodiversity
- Increase recreational opportunities

Planned: High Marsh Creation for Eastern Black Rail



4 acres of tidally connected high marsh

Shovel ready: Fully designed and permitted - $765K

Benefits:

- Creates tidal storage
- Adsorb and disperse tidal surge
- Removes invasive plants
- Provides habitat for EBR & others

Further Down the Road…..

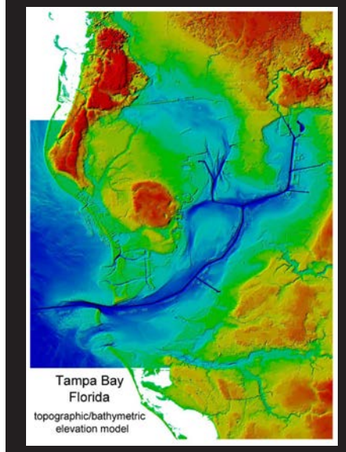
Continue to increase our focus on incorporating installation resilience into ecosystem restoration plans

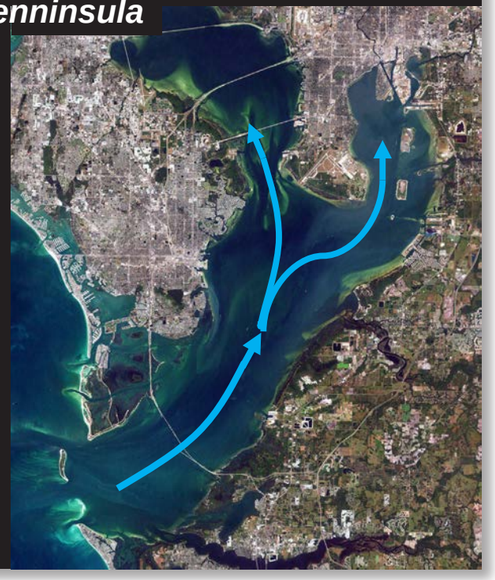
To the south:
- Shallow nearshore water reduces wave energy
- Wetland and wooded uplands adsorb water and winds
- Very low development

Along southeastern side:
- Some vegetative buffers
- Only lightly developed
- No shallow shelf
- High exposure to wind and waves

At northeastern end:
- No vegetative buffers
- Heavily developed
- High exposure to wind and waves
- Rip-rap revetment offers some protection
-

Daily Tidal Movement Shapes the Interbay Penninsula





Substantial Erosion of the shoreline in the past

Southeast Corner Stabilized??

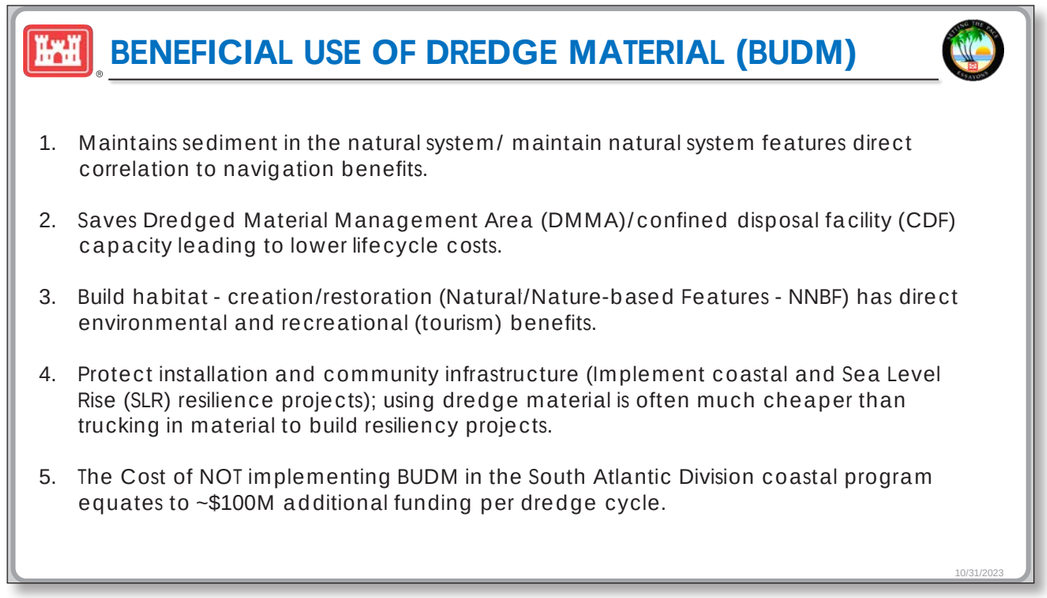
Underwater Rock Barrier for Defense

Backfill with sediment, encourage seagrass growth

Create living breakwaters to reduce tidal sweep of sediment along SE side

More breakwaters = more protection

Beneficial Use of Dredge Material from the Tampa Harbor Navigation Improvement Project for MacDill Air Force Base, Laurel Reichold, Director, South Atlantic Division, Regional Sediment Management Center of Expertise, USACE



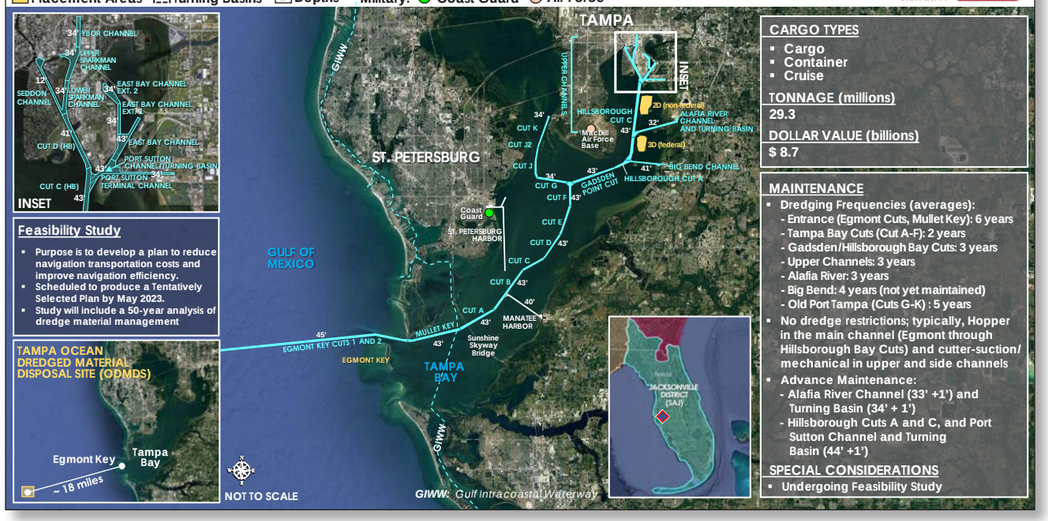
U.S. ARMY CORPS OF ENGINEERS | JACKSONVILLE DISTRICT

TAMPA HARBOR

Local Sponsor: Port Tampa Bay

Placement Areas | Turning Basins | # Depths | Military: Coast Guard | Air Force

U.S. ARMY



CARGO TYPES
- Cargo
- Container
- Cruise

TONNAGE (millions)
29.3

DOLLAR VALUE (billions)
$ 8.7

MAINTENANCE
- Dredging Frequencies (averages):
  - Entrance (Egmont Cuts, Mullet Key): 6 years
  - Tampa Bay Cuts (Cut A-F): 2 years
  - Gadsden/Hillsborough Bay Cuts: 3 years
  - Upper Channels: 3 years
  - Alafia River: 3 years
  - Big Bend: 4 years (not yet maintained)
  - Old Port Tampa (Cuts G-K) : 5 years
- No dredge restrictions; typically, Hopper in the main channel (Egmont through Hillsborough Bay Cuts) and cutter-suction/ mechanical in upper and side channels
- Advance Maintenance:
  - Alafia River Channel (33' +1') and Turning Basin (34' + 1')
  - Hillsborough Cuts A and C, and Port Sutton Channel and Turning Basin (44' +1')

SPECIAL CONSIDERATIONS
- Undergoing Feasibility Study

Feasibility Study
- Purpose is to develop a plan to reduce navigation transportation costs and improve navigation efficiency.
- Scheduled to produce a Tentatively Selected Plan by May 2023.
- Study will include a 50-year analysis of dredge material management

TENTATIVELY SELECTED PLAN

Tampa Harbor Navigation Improvement Study

PLAN COMPONENTS:

Incremental Deepening to 47'
(Main Stem + Big Bend Channel)
*Note that the NED Plan is for deepening the Main Stem + Big Bend Channel to 45')

Upper Channel Deepening:
- Port Sutton: 42'
- Sparkman (Upper and Lower): 41'
- East Bay Extension Cuts: 39'
- Ybor Channel: 39'

Entrance Extension
(9,900' to access natural depths consistent with channel deepening)

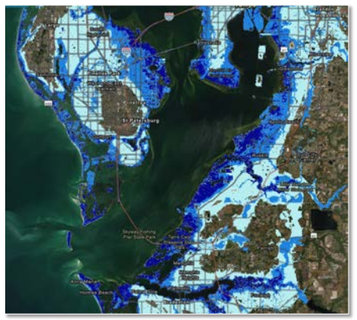
Extension of Federal Channel:
- Big Bend East Channel
- East Bay Channel

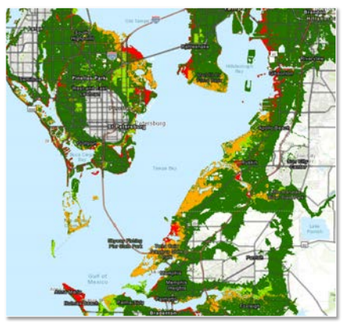
Turn Widener Improvements:
- Cut F (TB) to Gadsden Point Cut
- Cut C (HB) to Big Bend Channel
- Cut C (HB) at Alafia River Channel
- Hooker's Point to Port Sutton

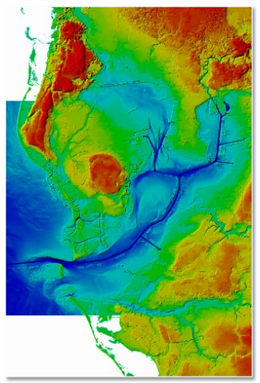
East Bay Turning Basin Improvements

NOTE: Alternative 2c from the Final Array was chosen as the TSP.

HOLISTIC SYSTEMS APPROACH







(Gesch et. al. 2001)

TAMPA HARBOR PLACEMENT STRATEGY

LEGEND

Other Federal Channels

Sediment Characteristics
- Rock (70-90%)
- Interbedded Silt & Rock
- Sand-Rock-Silt Mix
- Sand (>90%)
- Silt & Sand (50/50, No Rock)
- Silt (>90%)

Placement Areas (capacity)
- Ocean Dredged Material Disposal Site (50 mcy)
- DMDF 3-D (3.7 mcy)
- Upland Fill (~5 mcy)
- Hardbottom Creation (~5 mcy)
- Island Restoration (~4-5 mcy)
- Beach Placement (1 mcy)
- Dredged Hole Restoration (1 mcy)
- Seagrass Resiliency (750 kcy)

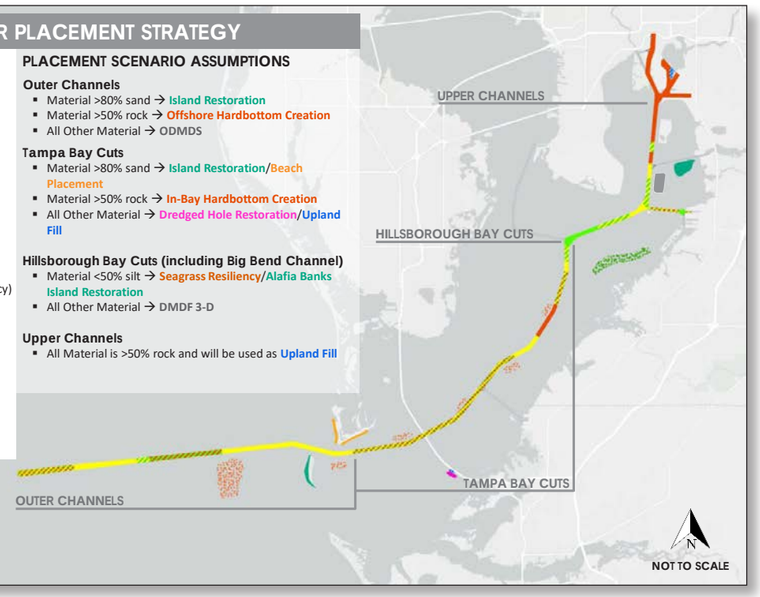
PLACEMENT SCENARIO ASSUMPTIONS

Outer Channels
- Material >80% sand → Island Restoration
- Material >50% rock → Offshore Hardbottom Creation
- All Other Material → ODMDS

Tampa Bay Cuts
- Material >80% sand → Island Restoration/Beach Placement
- Material >50% rock → In-Bay Hardbottom Creation
- All Other Material → Dredged Hole Restoration/Upland Fill

Hillsborough Bay Cuts (including Big Bend Channel)
- Material <50% silt → Seagrass Resiliency/Alafia Banks Island Restoration
- All Other Material → DMDF 3-D

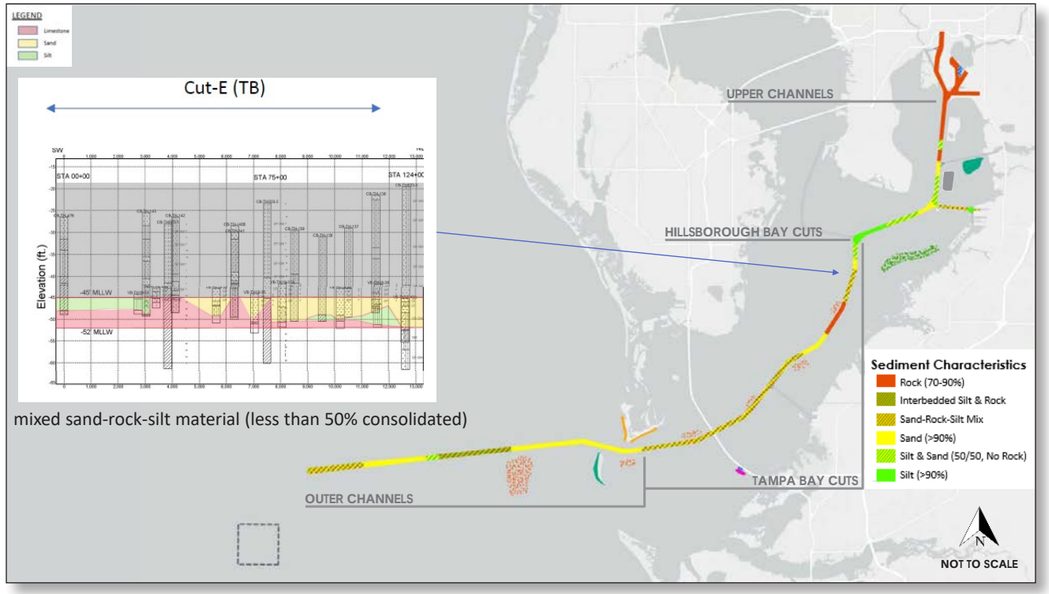
Upper Channels
- All Material is >50% rock and will be used as Upland Fill



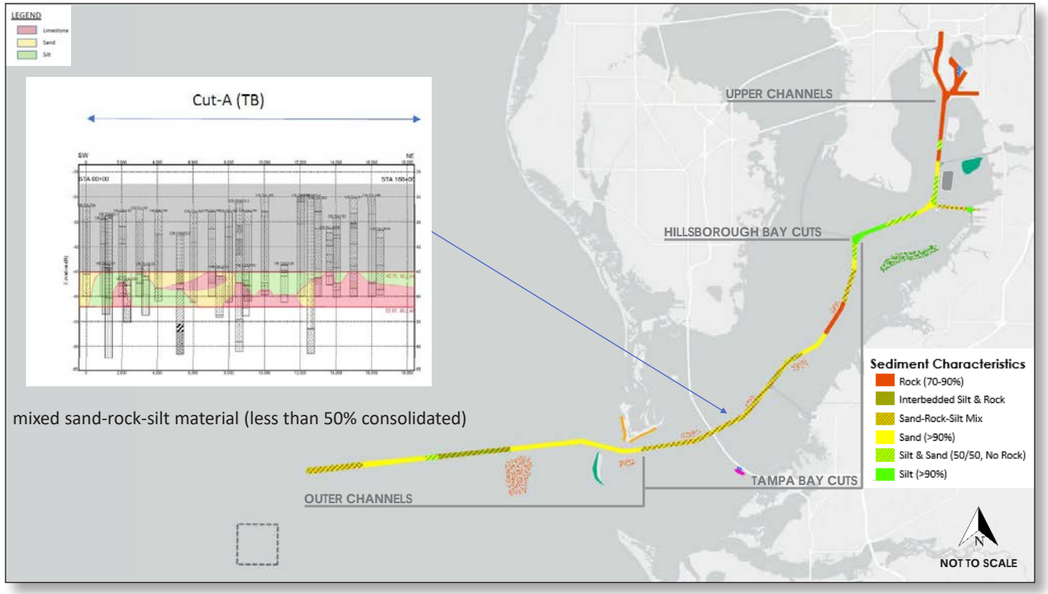
CURRENT PLAN FOR DREDGE MATERIAL

Placement Site	VOLUME (CY) DREDGED	
	Limited BU Scenario	Expanded BU Scenario
ODMDS	3,558,599	982,042
Upland DMDF-3-D	3,990,113	3,719,582
Egmont Island (beach and nearshore) (BU)	6,904,611	6,499,520
Hardbottom (in-bay creation) (BU)	3,847,681	2,697,173
East Bay Port Expansion (BU)	4,819,530	4,939,899
Ft. Desoto (BU)		405,091
Manatee Boat Ramp (BU)		1,133,439
Seagrass Resiliency (BU)		645,153
Alafia Banks (BU)		1,068,496
MetroPort (BU)		1,030,139
Total Volume (cy)	**23,120,534**	**23,120,534**

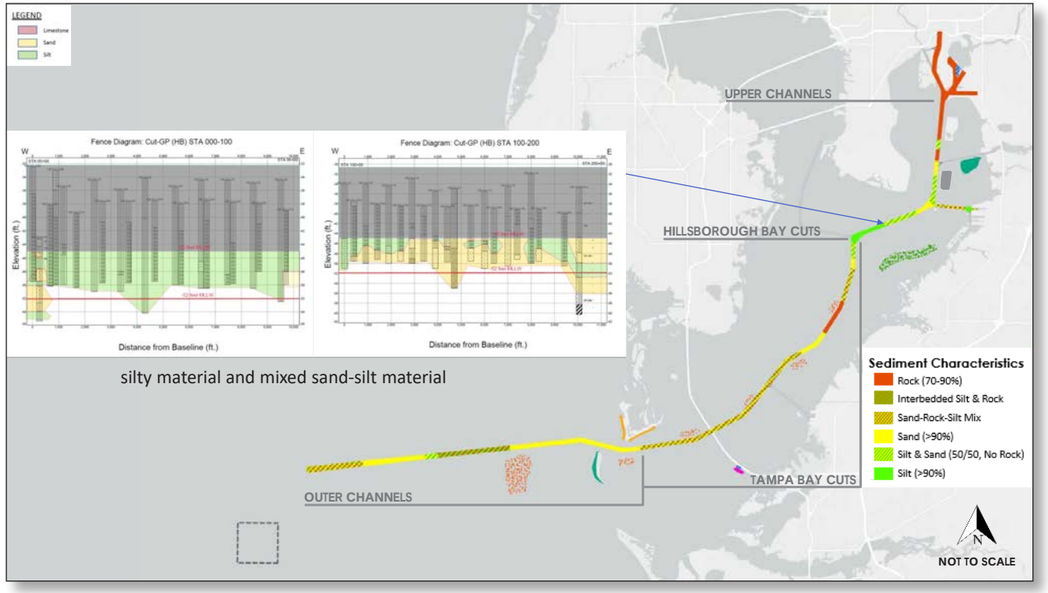
10/31/2023



mixed sand-rock-silt material (less than 50% consolidated)



mixed sand-rock-silt material (less than 50% consolidated)



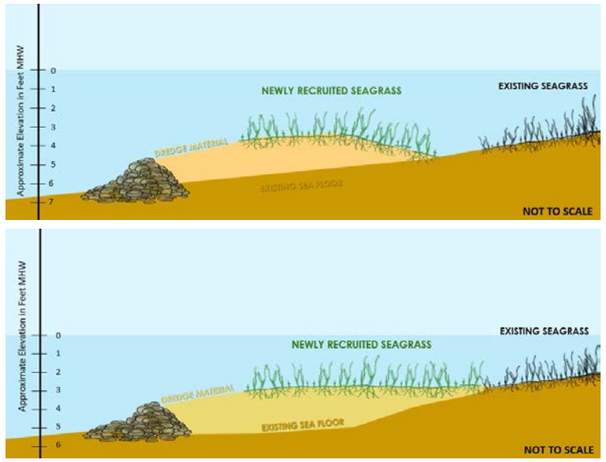
silty material and mixed sand-silt material

INITIAL CONCEPTS FOR BUDM AT MACDILL

SEAGRASS RESILIENCY PILOT PROJECT

Tampa Harbor is piloting an innovative method to combat seagrass die-off due to sea level rise in Tampa Bay.

- Mixed rock-sand material would be used at the perimeter to stabilize softer sediments.
- Sand and silty sand would be hydraulically placed (potentially slow-flow adapters to allow for more precise placement)
- Two options for placement:
  1. Set apart from existing beds to ensure no sedimentation occurs (top figure); or
  2. Adjacent to existing beds to create seamless habitat (bottom figure).



10/31/2023

CONTACTS AND LINKS OF INTEREST

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Laurel.P.Reichold@usace.army.mil
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C: 904-401-3871

Aubree Hershorin, Ph.D.
Planning Technical Lead, USACE
Aubree.G.Hershorin@usace.army.mil
O: 904- 232-2136

ARCGIS WEBVIEWER:

Visit the ArcGIS WebViewer link for interactive project viewing: https://usace-saw.maps.arcgis.com/apps/mapviewer/index.html?webmap=61e9701d559641c295ffcbe5ccfeaeea

PROJECT WEBSITE:

USACE project website: https://www.saj.usace.army.mil/Tampa-Harbor/

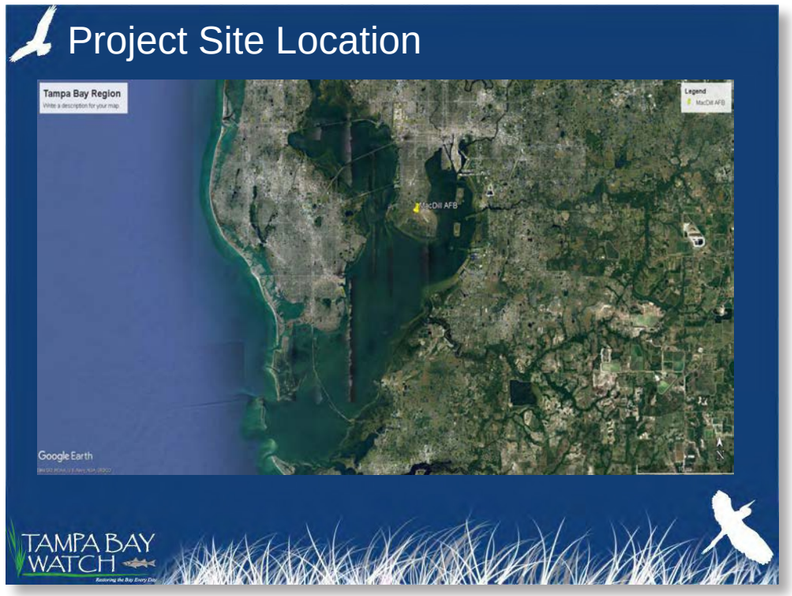
THANK YOU!!

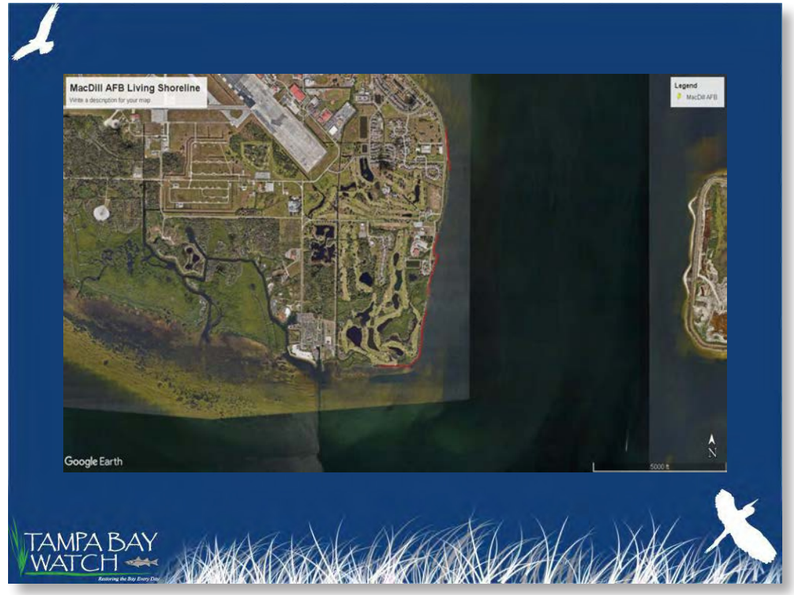
U.S. ARMY
US Army Corps of Engineers
RSM RCX

"The views, opinions and findings contained in this report are those of the authors(s) and should not be construed as an official Department of the Army position, policy or decision, unless so designated by other official documentation."

10/31/2023

MacDill Airforce Base Living Shoreline Project: Twenty Years in the Making, Eric Plage, Tampa Bay Watch





Construction



TAMPA BAY WATCH

Construction




TAMPA BAY WATCH

Volunteers




TAMPA BAY WATCH

Transportation




TAMPA BAY WATCH

Installation Techniques




TAMPA BAY WATCH


TAMPA BAY WATCH



TAMPA BAY WATCH

Placement (Phase I) -2004

TAMPA BAY WATCH

Placement (Phase III) - 2006

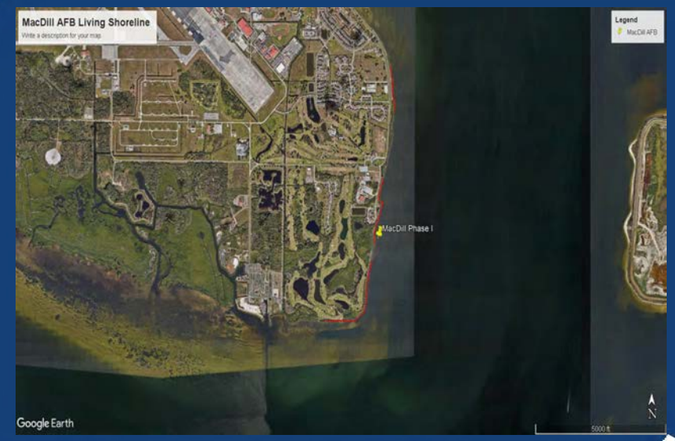
TAMPA BAY WATCH

Placement (Phase VI) - 2022

TAMPA BAY WATCH

Placement (Phase IV) - 2009

TAMPA BAY WATCH

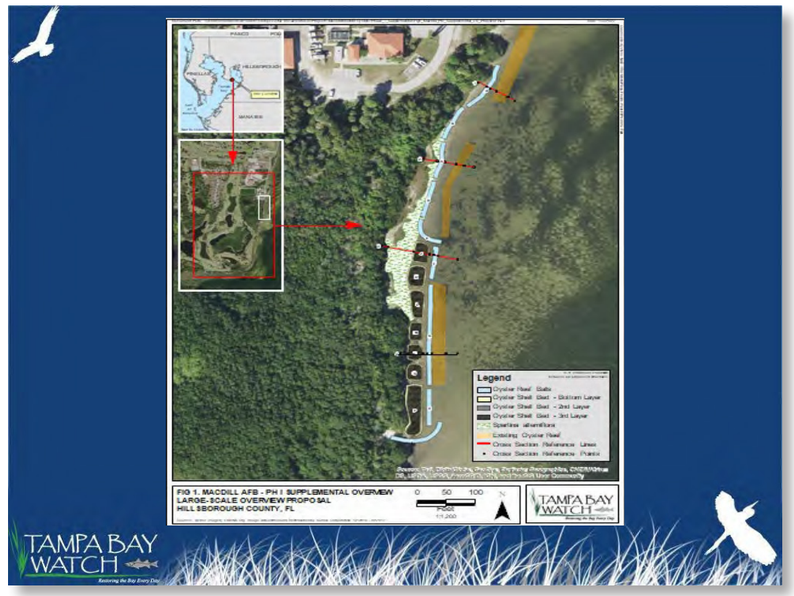


TAMPA BAY WATCH

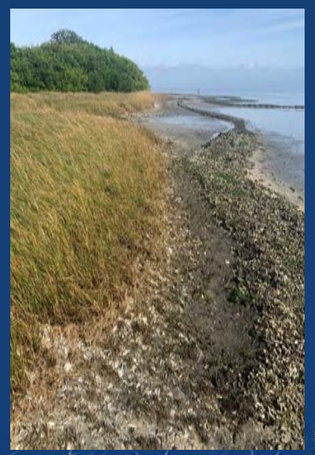

2006
TAMPA BAY WATCH


2009
2022
TAMPA BAY WATCH


Phase I – 2022
TAMPA BAY WATCH


Legend
FIG 1. MACDILL AFB - PH I SUPPLEMENTAL OVERVIEW
LARGE-SCALE OVERVIEW PROPOSAL
HILLSBOROUGH COUNTY, FL
TAMPA BAY WATCH

Phase III – 2016 & 2022



TAMPA BAY WATCH

Phase IV – 2016 & 2022

TAMPA BAY WATCH

Funders & Supporters

ENVIRONMENTAL PROTECTION COMMISSION

TAMPA BAY ENVIRONMENTAL RESTORATION FUND

TBEP TAMPA BAY ESTUARY PROGRAM PARTNERSHIP FOR A HEALTHY BAY

Reef Innovations WWW.REEFINNOVATIONS.COM

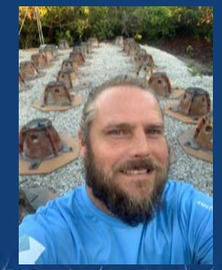
TAMPA BAY WATCH

MacDill Airforce Base Living Shoreline Project: Twenty Years in the Making

Restore Americas Estuaries 2022

Eric Plage

Oyster Reef Ball Program Coordinator
Tampa Bay Watch, INC
eplage@tampabaywatch.org



Coastal Resilience and Threatened and Endangered Species: Opportunities and Constraints, Sinéad Borchert, Fish and Wildlife Biologist, Liaison to MacDill AFB Florida Air Force Partnership, USFWS

Outline

1. **Natural resources management on military installations**
   - INRMPs - Sikes Act and the ESA
   - Marine Security Zone
2. **Current habitat conditions at MAFB**
   - Seagrass mapping/coverage and long-term transects
3. **T&E species distribution and use of nearshore waters**
4. **Conservation opportunities and possible constraints**
   - Maximizing conservation benefits
   - Pre- and post-project monitoring
   - Potential critical habitat designations
   - ESA Section 7 Consultation

1. Natural Resources Management on Military Installations

- Sikes Act of 1960
  - Integrated Natural Resources Management Plans (INRMPs)
- Endangered Species Act of 1973
  - Section 7 consultations
    - USFWS/NOAA NMFS
    - 7(a)(1) – aid in conservation
    - 7(a)(2) – jeopardy or adverse modification
  - Projects that benefit threatened and endangered species
- Natural areas within installation boundary
  - Also nearshore waters?
  - Marine Security Zone

2. Current Habitat Conditions

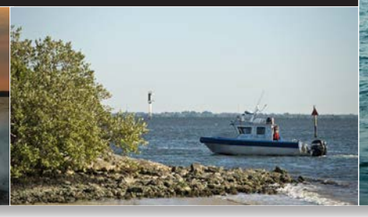
- Past habitat restoration/creation and resilience projects
  - Hydro-blasting for restoration of mangroves, saltern, and hydrologic flow
  - Living shoreline/oyster reef work
  - “Inland” wetland creation projects - tidally connected
  - SWFWMD SWIM stormwater
  - Future: eastern black rail high marsh creation?
- Marine Security Zone
  - Seagrass restoration?
  - Spoil islands?
- Current datasets available

Marine Security Zone

- History
- Control of the MSZ
  - MAFB, USCG, USACE, and Tampa Port Authority
- Approvals and permitting

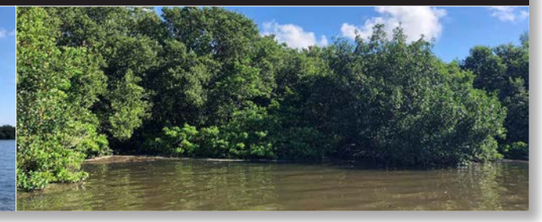
Marine Security Zone

- 1,000 yards from coastline/2,000 yards from runway
- Security Forces Squadron - Marine Patrol



2. Current Habitat Conditions

- Data sources
  - Seagrasses
    - Southwest Florida Water Management District Seagrass Mapping
    - Tampa Bay Estuary Program's long-term seagrass monitoring transects
- Manatee telemetry data
  - FWC FWRI




Seagrass
2018
Continuous Seagrass
Patchy Seagrass
N
0 0.5 1 2
Miles
Source:
SWFWMD


Seagrass
2022
Continuous Seagrass
Patchy Seagrass
N
0 0.5 1 2
Miles
Source:
SWFWMD

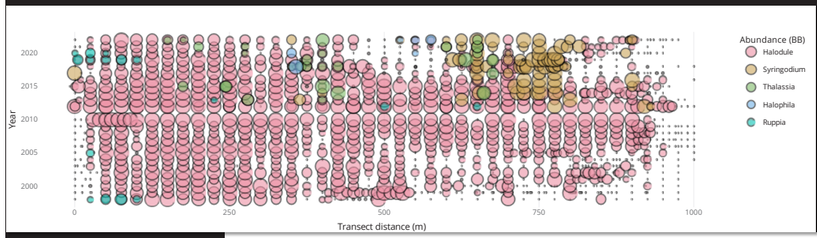

Seagrass
2020
Continuous Seagrass
Patchy Seagrass
N
0 0.5 1 2
Miles
Source:
SWFWMD


Seagrass
2022
Continuous Seagrass
Patchy Seagrass
Bay bottom
borrow pits
N
0 0.5 1 2
Miles
Source:
SWFWMD

TBEP Seagrass Transects

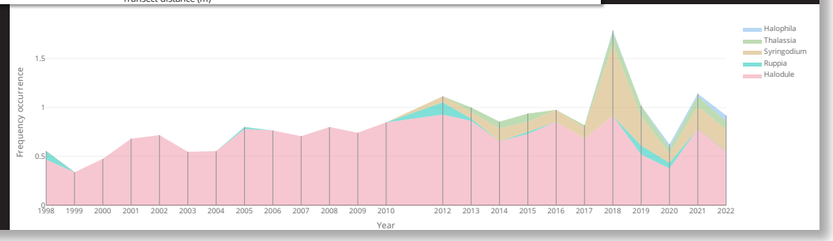
TBEP Seagrass Transects

TBEP Transect Data



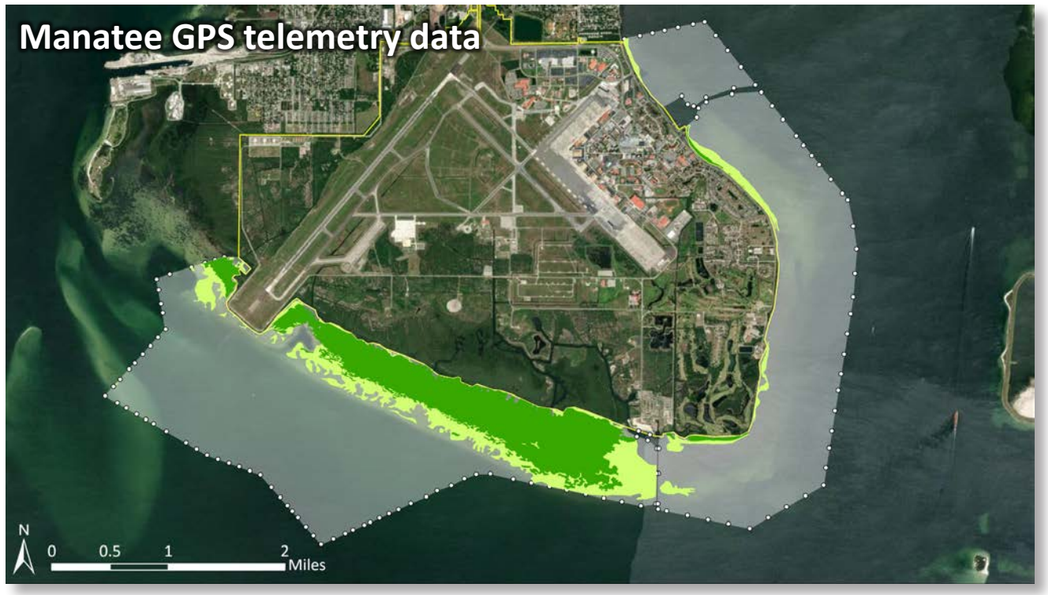
Source: Tampa Bay Seagrass Transect Dashboard

shiny.tbep.org

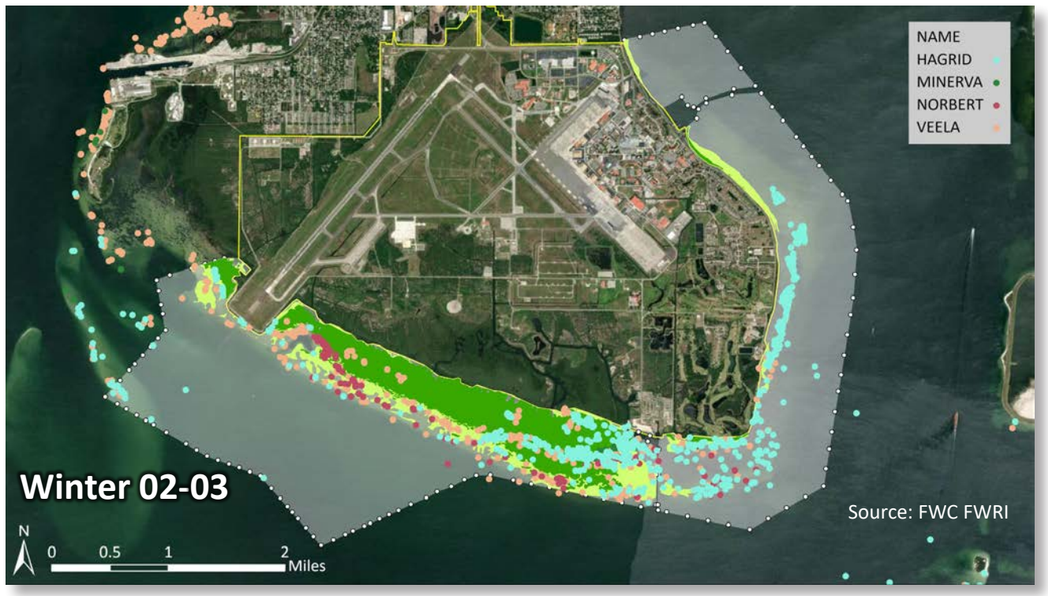


3. T&E species distribution and use of nearshore waters - manatees

- Federally threatened
- Threats
- Target habitat conditions
- Use of MAFB
  - FWC telemetry Data


Manatee GPS telemetry data
N
0 0.5 1 2
Miles


Spring 03
Source: FWC FWRI
N
0 0.5 1 2
Miles


NAME
HAGRID
MINERVA
NORBERT
VEELA
Winter 02-03
Source: FWC FWRI
N
0 0.5 1 2
Miles


Summer 03
Source: FWC FWRI
N
0 0.5 1 2
Miles


NAME
YERTLE
Fall 03
Source: FWC FWRI
N
0 0.5 1 2
Miles


NAME
HEDGE
WUMBUS
YERTLE
Spring 04
Source: FWC FWRI
N
0 0.5 1 2
Miles


NAME
BOFA
BREVE
YERTLE
Winter 03-04
Source: FWC FWRI
N
0 0.5 1 2
Miles


Summer 04
Source: FWC FWRI
N
0 0.5 1 2
Miles


Fall 04
N
0 0.5 1 2
Miles
Source: FWC FWRI


NAME
DANA
KAI
Spring 05
N
0 0.5 1 2
Miles
Source: FWC FWRI

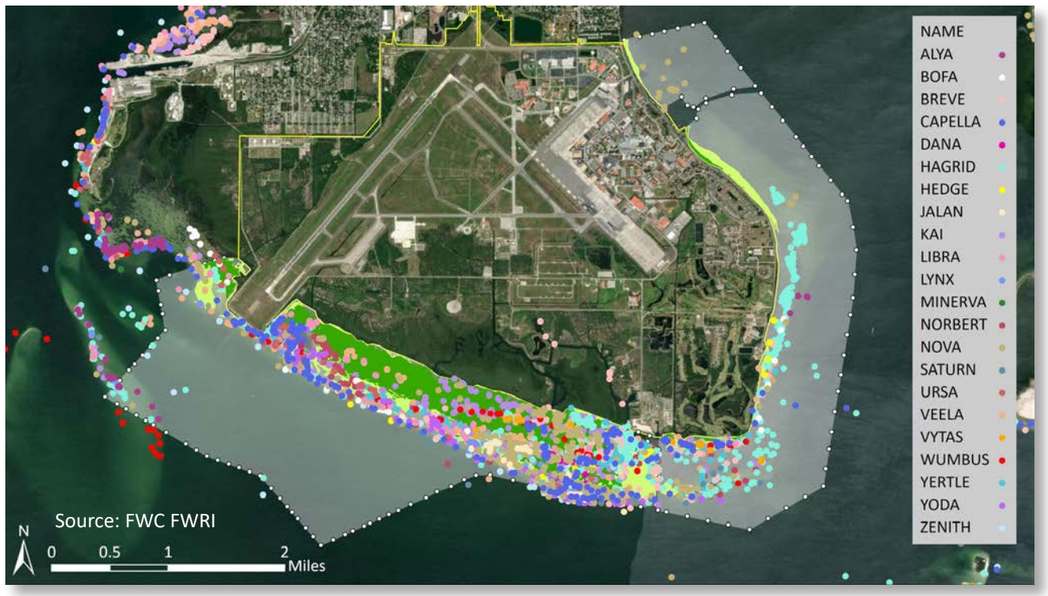

NAME
DANA
KAI
VYTAS
Winter 04-05
N
0 0.5 1 2
Miles
Source: FWC FWRI


Summer 05
N
0 0.5 1 2
Miles
Source: FWC FWRI


Fall 05
N
0 0.5 1 2
Miles
Source: FWC FWRI

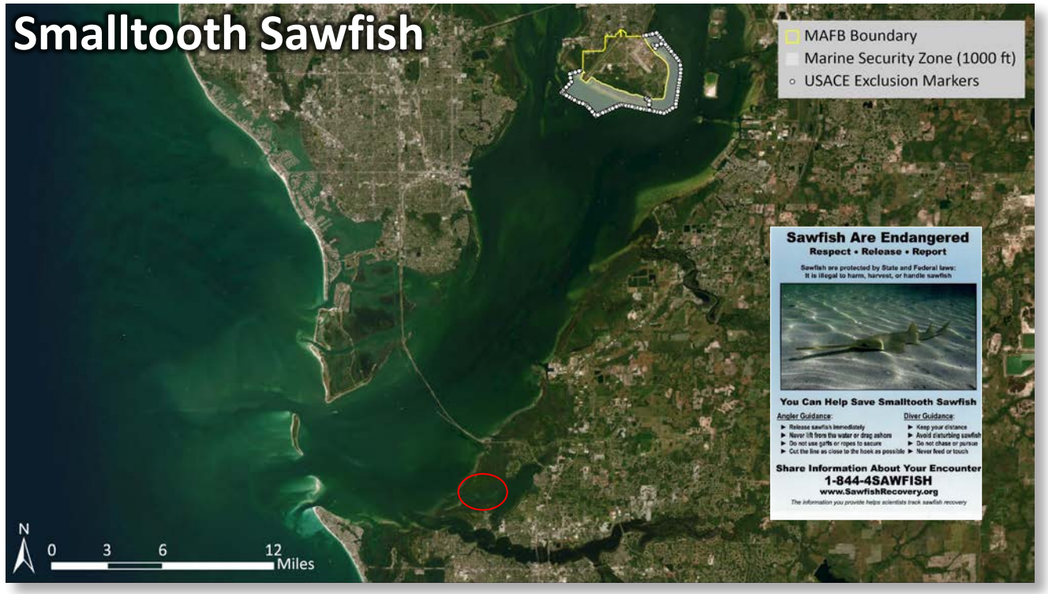

NAME
ALYA
NOVA
Spring 06
N
0 0.5 1 2
Miles
Source: FWC FWRI


NAME
CAPELLA
JALAN
LIBRA
LYNX
NOVA
SATURN
URSA
YODA
ZENITH
Winter 05-06
N
0 0.5 1 2
Miles
Source: FWC FWRI


NAME
ALYA
BOFA
BREVE
CAPELLA
DANA
HAGRID
HEDGE
JALAN
KAI
LIBRA
LYNX
MINERVA
NORBERT
NOVA
SATURN
URSA
VEELA
VYTAS
WUMBUS
YERTLE
YODA
ZENITH
Source: FWC FWRI
N
0 0.5 1 2
Miles

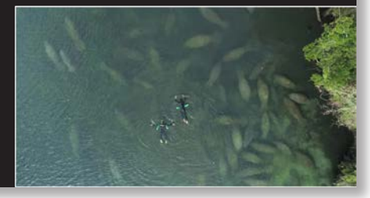
3. T&E Species distribution and use of nearshore waters – smalltooth sawfish

- Federally endangered
- Habitat preferences
  - Juveniles: shallow estuaries
  - Adults: expand range other coastal habitats
  - Target habitat conditions: mangroves, shallow sandy areas



Conservation Opportunities

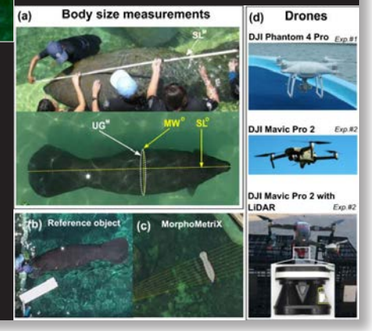
- Coastal resilience AND habitat creation
  - Creating coastal habitat with dredged material
  - Reducing erosion/contraction of the coastline
  - SLR adaptation
  - Storm surge absorption
  - Accomplish INRMP objectives
- Pre- and post- project monitoring
  - Smalltooth sawfish receivers with NOAA?
  - UAS/drone surveys of manatees (and sea turtles?)



Conservation Opportunities – UAS Monitoring

Rees et al. 2018
Endangered Species Research

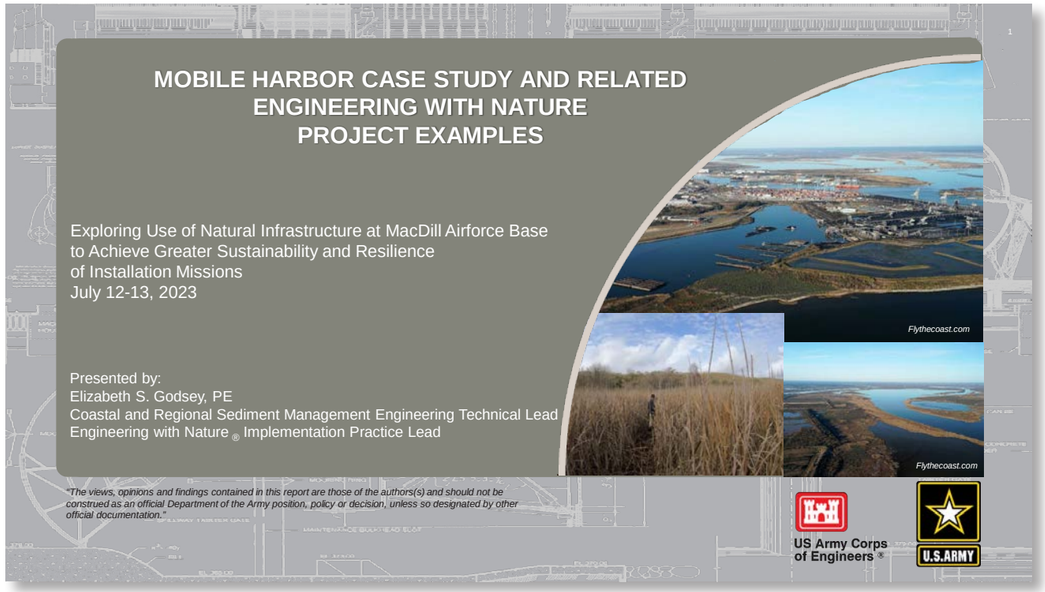
Ramos et al. 2022
Mammalian Biology

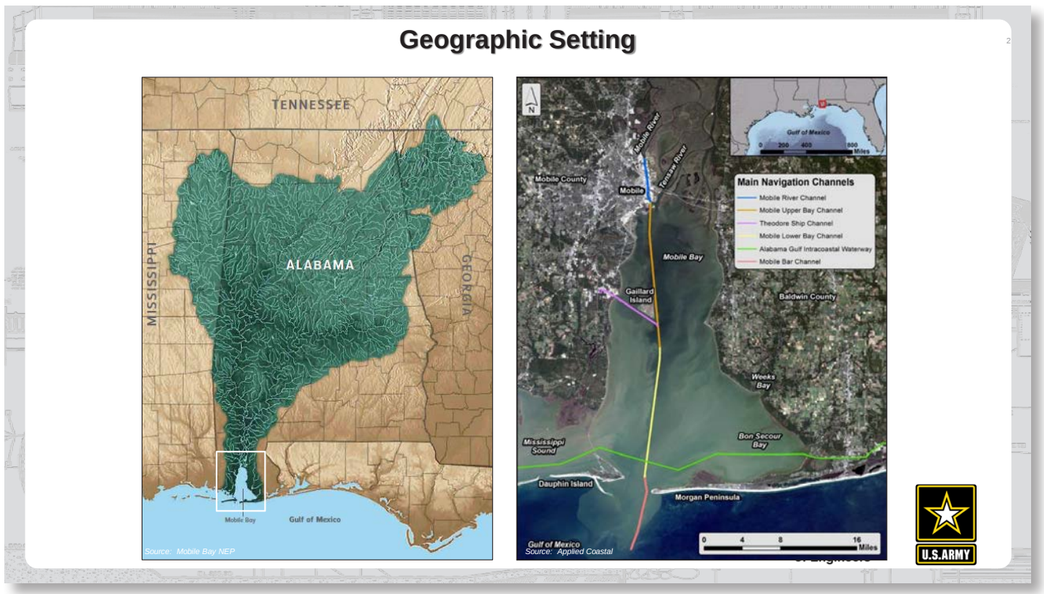


Potential Constraints

- MAFB waters are being considered for critical habitat
  - Manatee – USFWS
  - Green sea turtle – NOAA
- ESA Section 7 Consultation
  - Individual/Species Level: loggerhead sea turtle, green sea turtle, manatee, smalltooth sawfish, rufa red knot, piping plover, wood stork
  - ALSO effects determinations for CH
    - PBFs
    - Consultation complexity increases
  - Projects must demonstrate conservation benefit to these species
    - Increase seagrass, not damage it
    - Create shallow shelves for foraging
    - Increase shorebird and waterbird foraging and nesting habitat (i.e. islands, tidal flats, other wetland habitats)?
    - Essential Fish Habitat
    - Improve water quality?
- Future projects e.g. Tampa Bay Passenger Ferry route and terminal?

Mobile Harbor Case Study and Related EWN Project Examples, Elizabeth Godsey, P.E., Coastal and Regional Sediment Management Engineering Technical Lead and EWN Coastal Practice Lead, Mobile District USACE





Engineering With Nature® (EWN)

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

EWN Guiding Principles

As a leading practice, EWN is:

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

Regional Sediment Management (RSM)

RSM is a systems approach using best management practices for more efficient and effective use of sediments in coastal, estuarine and inland environments = Healthy Systems.

Beneficial Use of Dredged Materials

Beneficial uses are defined as “productive and positive uses of dredged material, which cover broad use categories ranging from fish and wildlife habitat development, to human recreation, to industrial/commercial uses” (USACE Beneficial Uses of Dredged Material, Engineer Manual 1110-2-5026).

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Mobile Bay Interagency Working Group

- Alabama State Port Authority (ASPA)
- USACE, Mobile District
- USACE, Engineering Research and Development Center (ERDC)
- Alabama Dept. of Conservation and Natural Resources (ADCNR), State Lands Division
- ADCNR, Marine Resources Division (MRD) ADCNR, Wildlife and Freshwater Fisheries Division (WAFF)
- Alabama Dept. of Environmental Management (ADEM)
- Geological Survey of Alabama (GSA) •U.S. Fish and Wildlife Service (FWS)
- National Marine Fisheries Service (NMFS), Habitat Conservation Division
- Mobile Bay National Estuary Program (NEP) Environmental Protection Agency (EPA)
- Dauphin Island Sea Lab (DISL)
- The Nature Conservancy (TNC)
- Mobile County Environmental Department Mobile Bay Keeper

Goals:

Development of in-bay disposal strategies both short and long term

Utilizing environmentally accepted alternatives for beneficial uses of dredged material

Identify, evaluate, and utilize new and existing engineering techniques and management models/tools to evaluate alternative management options

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Mobile Harbor Historic Maintenance Overview

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Mobile Bay, Alabama

ERDC ADEM The Nature Conservancy EWN

“Is it smart to continue removing 4 MCY from the Bay and hauling it to the Ocean?”

Macro Sediment Budget 1917/18 to 1984/2011 (Byrnes, 2012)

Thin Layer Placement
Brookley Hole Restoration
Oyster Shell Mining

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Mobile Bay Open Water Thin Layer Placement Demo

Summer of 2012

- ❑ Exercised emergency action in permit
- ❑ Placed 9 MCY in pre-established historic open water disposal areas

  Disposal Areas 1-3, 10,11 and 13
- ❑ Utilized hydraulic cutterhead dredge
- ❑ Thin-layer disposal techniques
- ❑ IWG used the emergency action as a demonstration to monitor and model behavior of sediment movement in the system

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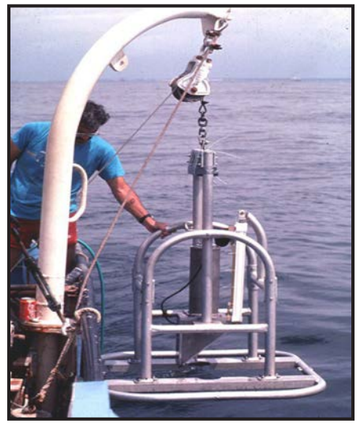
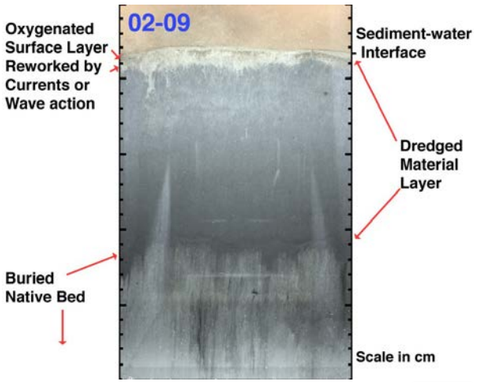
Thin Layer Placement Sediment Profiling Imagery





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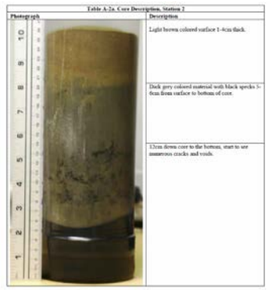
Mobile Bay Open Water Thin Layer Placement Monitoring

- ❑ Sampling conducted September 2012
- ❑ Collected sediment profiling imagery at 219 stations
- ❑ Collected push cores for grain size analysis and geotechnical properties at about 185 stations
- ❑ TLP stations represented time series from 24 hours to 6 months post-placement
- ❑ Also included “natural” bay bottom



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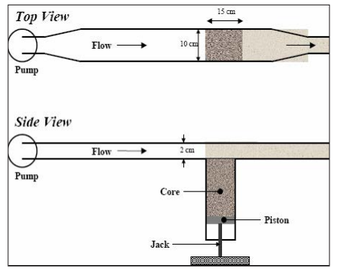
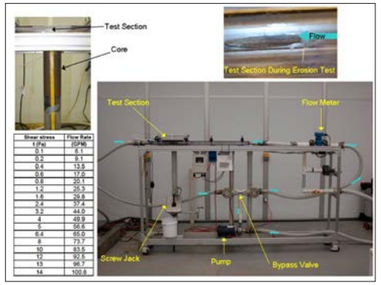
Sediment Flume Analysis





Shear stress τ (Pa)	Flow Rate (GPM)
0.1	6.1
0.2	6.1
0.4	13.5
0.6	17.6
0.8	20.1
1.0	25.3
1.2	29.8
1.4	33.4
1.6	37.6
1.8	41.0
2	44.0
4	49.9
6	56.6
8	65.0
8.4	73.7
10	83.5
12	92.6
13	96.7
14	100.8

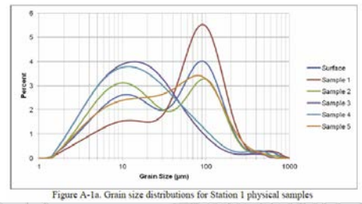


Figure A-1a. Grain size distributions for Station 1 physical samples

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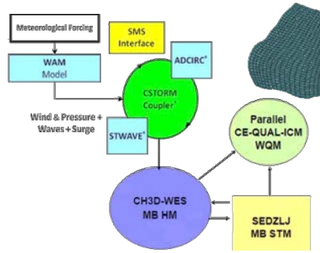
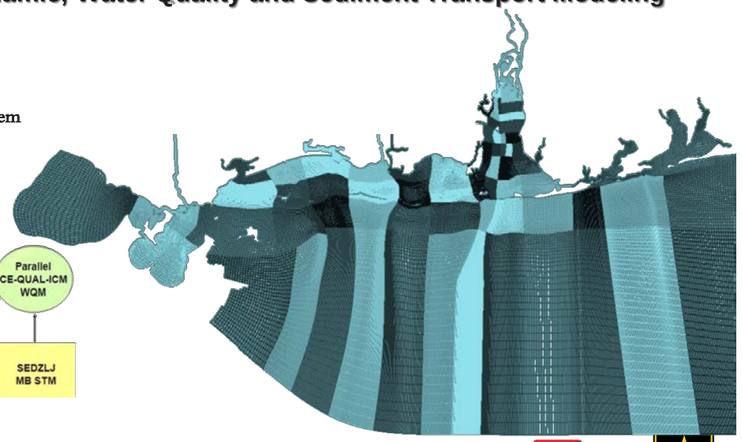
3D Hydrodynamic, Water Quality and Sediment Transport Modeling

Geophysical Modeling System
Multi-Block





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A Two-fold Need

Source: Modified from Resource Management Group, Inc., 2010 with records to 2016

	Area (Acres)[1]	Projected Maximum Dike Elevation (ft)[1]	Total Idealized Volumetric Capacity (CY)[1,2]
North Blakeley	69	50	3,172,000
Mud Lake 6	70	46	3,388,000
Mud Lake 7	129	46	8,562,000
South Blakeley	196	65	12,087,000
North Pinto	48	47	3,434,000
Totals	512		30,644,000
20 year Project Capacity Needs of River Channel (1.3 mcy/year)			26,247,000
Remaining Capacity After 20 Years			4,396,000

1) Taken from Table 7 of Resource Management Group, Inc., 2010 updated with USACE dredge material placement records through 2016.
2) Idealized volumetric capacity includes interior capacity plus the volume to build projected maximum dike height cross-sections minus the volume in the spur dikes.

Source: Modified from Resource Management Group, Inc., 2010.

2020-2023 Strategic Beneficial Use Placement Opportunities

- Collaborative effort between Mobile District, ERDC and Regional Stakeholders
- Funded by the FY20 RSM National Program to develop and framework to implement beneficial use of dredge material for wetland resiliency.

Scope:

Evaluate **cost effective** and **sustainable** beneficial use options in support of marsh resilience. Data collection and model tool development to assess the current and future states of marsh nearby to Mobile Harbor upland dredge material placement sites.

RSM

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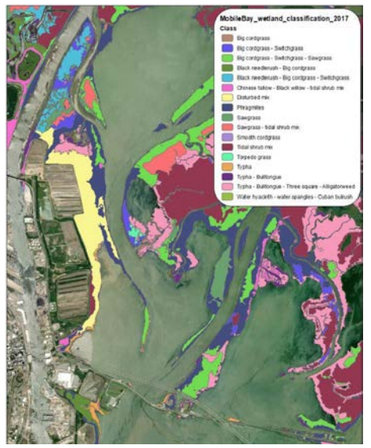
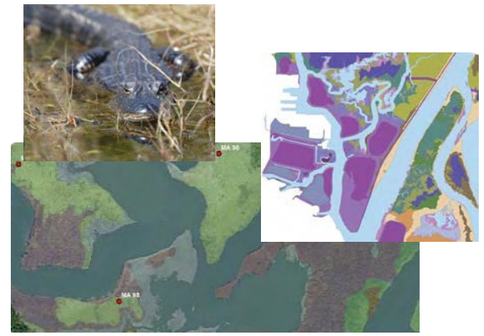
Field Data Collection and Analysis

USACE 2017 Wetland Classification



Field Work



RSM

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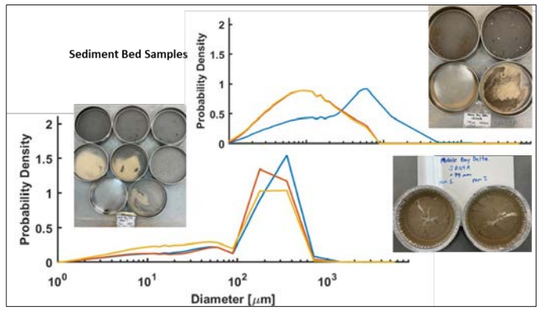
Field Data Collection and Analysis

Sediment Bed Samples

Sediment Characteristics



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Field Data Collection and Analysis

Geotechnical Grab Samples

Summary of Material Properties

Sample Location	Hole Number	No 200 (%)	D50 (mm)	Visual Shell Content (%)	D2487 Unified Soil Classification System	Wet Colors	Dry Colors Before Washing	Dry Colors After Washing on No. 230
Mobile River Upland Disposal Area	MRUDA-1	5.8	0.25	0.4	Poorly Graded Silty Sand (SP-SM).	10YR/ Brown 5/3; 2.5Y/ Dark Gray 4/1	10YR/ Pale Brown 6/3; 2.5Y/ White 8/1	10YR/ VeryPale Brown 8/2
Mobile River Upland Disposal Area	MRUDA-2	1.2	0.28	0.19	Poorly Graded Sand (SP).	10YR/ Pale Brown 6/3	10YR/ Very Pale Brown 7/3	10YR/ Light Gray 7/2
Mobile River Upland Disposal Area	MRUDA-3	0.7	0.30	0.03	Poorly Graded Sand (SP).	10YR/ Pale Brown 6/3	10YR/ Very Pale Brown 7/3	10YR/ Very Pale Brown 8/2
Mobile River Upland Disposal Area	MRUDA-4	7.6	0.24	0	Poorly Graded Silty Sand (SP-SM).	10YR/ Brown 4/3; 2.5Y/ Gray 6/1	10YR/ Light Yellowish Brown 6/4; 2.5Y/ White 8/1	10YR/ Very Pale Brown 8/2
Mobile River Upland Disposal Area	MRUDA-5	23.2	0.15	0.01	Silty Sand (SM).	10YR/ Brown 4/3	10YR/ Brown 5/3	10YR/ Very Pale Brown 8/2
Mobile River Upland Disposal Area	MRUDA-6	8.7	0.25	0.05	Poorly Graded Silty Sand (SP-SM).	10YR/ Brown 5/3	10YR/ Pale Brown 6/3	10YR/ Very Pale Brown 8/2
Mobile River Upland Disposal Area	MRUDA-7	2	0.33	0.47	Poorly Graded Sand (SP).	10YR/ Brown 5/3	10YR/ Pale Brown 6/3	10YR/ Very Pale Brown 8/2

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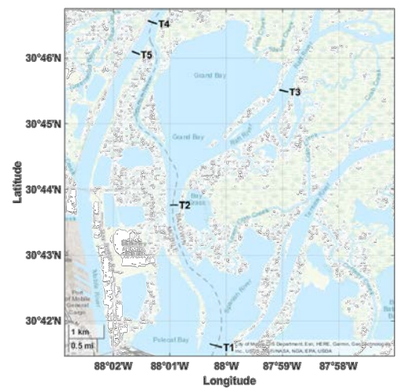
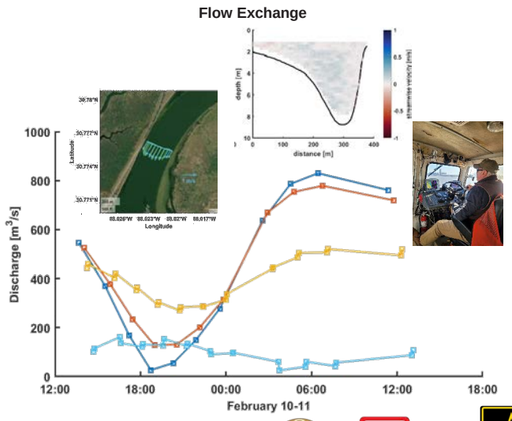
Field Data Collection and Analysis

Flow Discharge Measurement



Flow Exchange



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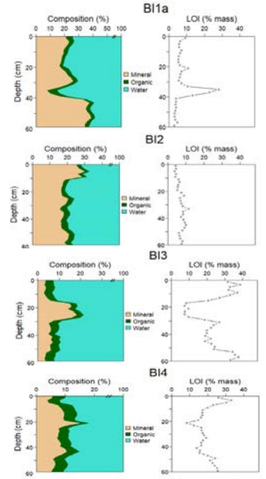
Field Data Collection and Laboratory Analysis

Core Locations



Field Work

Physical composition and LOI % of each core from 0 to 60 cm by 2 cm intervals

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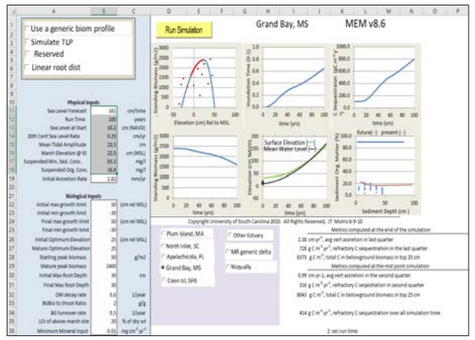
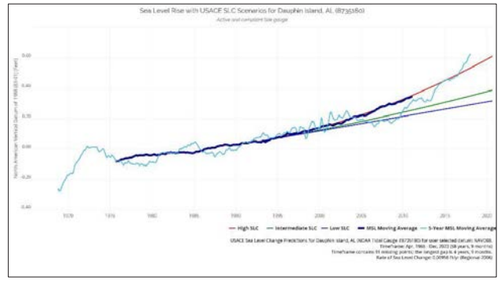
Model Evaluation and Future Marsh Conditions

Marsh Equilibrium Model Interface





Values for input variables used in MEM. Low, medium, and high values were determined based on the literature to capture a variety of potential scenarios.

	SLR (cm/century)	SSC (mg/L)	Marsh Elevation (cm MSL)	Placement
Rate				
Low	30	23.8	-5	15 cm every 10 years
Med	61	47.5	8	NA
High	161	95	50	30 cm every 20 years
Source	USACE 2017	Ramirez et al. In Review	Morris et al., unpublished data, 2016	

Strategic Sand Placement Options

Marsh Thin Layer Placement Options

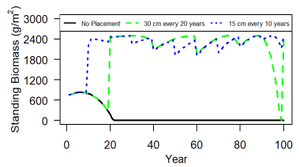
Two distinct TLP strategies to restore elevation were simulated. The two scenarios placed 15 cm every ten years and 30 cm every 20 years.

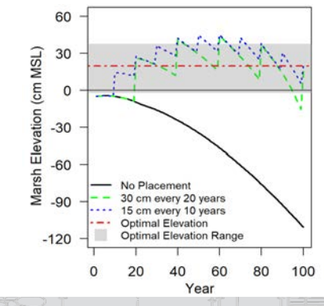
Analysis applied the most extreme elevation deficit (high SLR, low SSC, low initial marsh elevation) to determine maximum placement capacity and develop a conservative BU estimate

The two placement scenarios developed belowground biomass through high vegetative productivity.

Placement strategies increased marsh elevation to an elevation near optimal for vegetative productivity for most of the model timespan.

In each placement scenario marsh elevation was outside of the optimal range at some point, indicating that an adaptive placement strategy would be required.



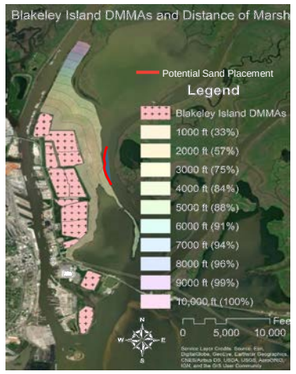


Potential Benefits

Potential of 1,300 acres of wetlands

1.3 Mcy of Sediments

Potential of 45 acres of sandbars



$2.50 per cubic yard to manage material within a CDF to ensure prolonged capacity of the site.

$10-15 to haul out of the existing CDFs

$1-$2, increase is expected for direct placement of dredge material into the adjacent wetlands and river

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Mobile Harbor Channel Improvements Beneficial Use

US Army Corps of Engineers ®

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Mobile Harbor, Alabama Channel Improvements

RSM/Beneficial Use Relic Shell Mined Areas

Relic Shell Mined Areas

US Army Corps of Engineers
Mobile District

	Area (acres)	Placement Volume (cy) Placement Thickness assumed 1.5 foot[1]	Bulking Factor = 1.2 O&M, 1.8 New Work	Approximate Distance from Channel (ft) Center to Placement Center
A[2]			0	18,000
B	920	2,226,000	1,237,000	18,000
C	1306	3,161,000	1,756,000	12,000
D	770	1,863,000	1,035,000	22,000
E	702	1,699,000	944,000	16,000
F	403	975,000	542,000	12,000
Total	4101	9,924,000	5,514,000	

Notes:
1) Area A is located within the bounds of existing open water placement sites used for operation and maintenance material and was therefore not considered here for new work.
2) The volumes are computed based on a relative difference in surface area. These placement volumes do not reflect the available capacity based on the 1 foot tolerance.

Placement Areas

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Mobile Harbor Deepening and Beneficial Use

1

Strategic Placement for Wetlands

Using Regional Sediment Management Strategies to provide more than 1.3 million cubic yards of beneficial use sediment sources to help restore wetlands in degraded systems from developmental and climate related stressors.

2

Deer River (Mobile Bay National Estuary Program)

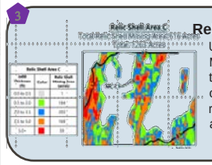
Design Partner: thompson

Working with partners to provide approximately 200,000 cubic yards of beneficial use sediment sources to help restore wetlands and reduce erosion to adjacent habitats.

3

Relic Shell Mine Areas

Design Partner: ANCHOR QEA



Using Regional Sediment Management Strategies to provide more than 5.5 million cubic yards of beneficial use sediment sources to restore bay elevations in relic shell mining areas in the bay.

4

Dauphin Island Causeway (Mobile County)

Design Partner: moffatt & nichol

Working with partners to provide over 800,000 cubic yards of beneficial use sediment sources to help restore wetlands and reduce damages to critical infrastructure.

5

Sand Island Beneficial Use Placement

Using Regional Sediment Management Strategies to place dredge material along nearshore shoal systems providing an estimated 500,000 cubic yards of sediment a year to the downdrift shoal systems and islands.

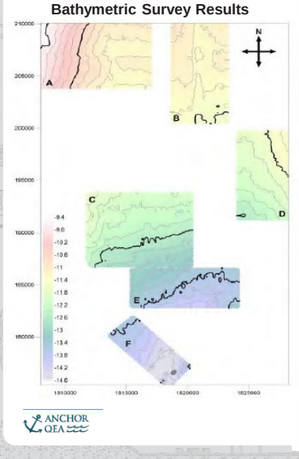
PROJECT COLLOBRATORS & PARTNERS

US Army Corps of Engineers
Mobile District

Mobile Harbor, Alabama Channel Improvements

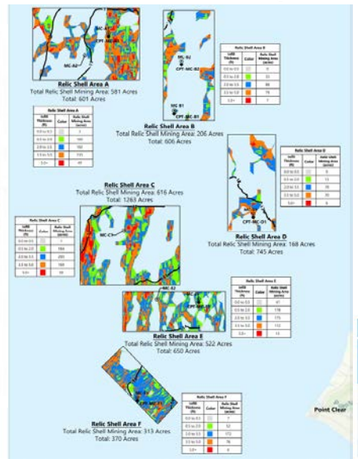
RSM/Beneficial Use Relic Shell Mined Areas

Bathymetric Survey Results

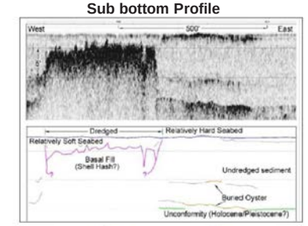


ANCHOR QEA

Sample Locations and Infilling



Sub bottom Profile



SHEAR STRENGTH OF EXISTING SEDIMENTS (MUD WAVE POTENTIAL)

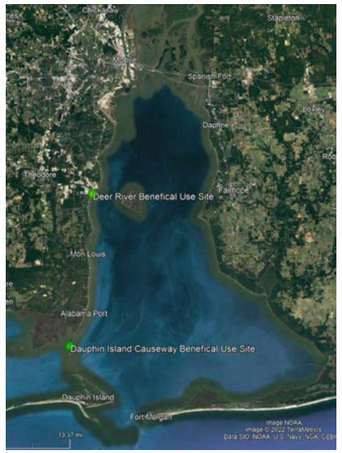
STORAGE CAPACITY FOR DREDGE MATERIAL

Settlement Magnitude and Time Rate

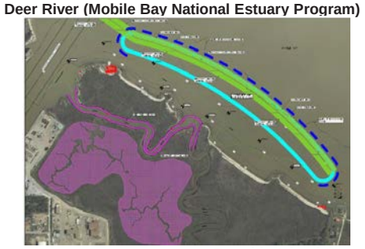
Historic Shell Hash Removal Thickness (ft)	Dredge Material Placement Thickness (ft)	Estimated Settlement (ft)	Estimated Settlement Duration (months)
1 to 2	1-4	< 0.5	1
2 to 3.5	1-4	0.5 to 1	1-3
3.5 to 5	1-4	0.5 to 1	3-5
5+	1-4	0.5 to 1	4-8+

Mobile Harbor, Alabama Channel Improvements
Beneficial Use through NFWF and RESTORE Projects

Site Locations

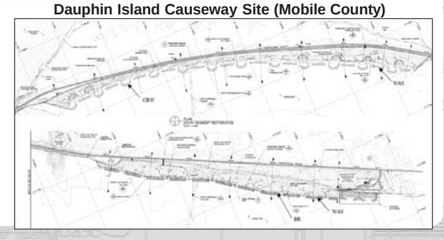


Deer River (Mobile Bay National Estuary Program)



thompson ENGINEERING

Dauphin Island Causeway Site (Mobile County)



Geosyntec consultants

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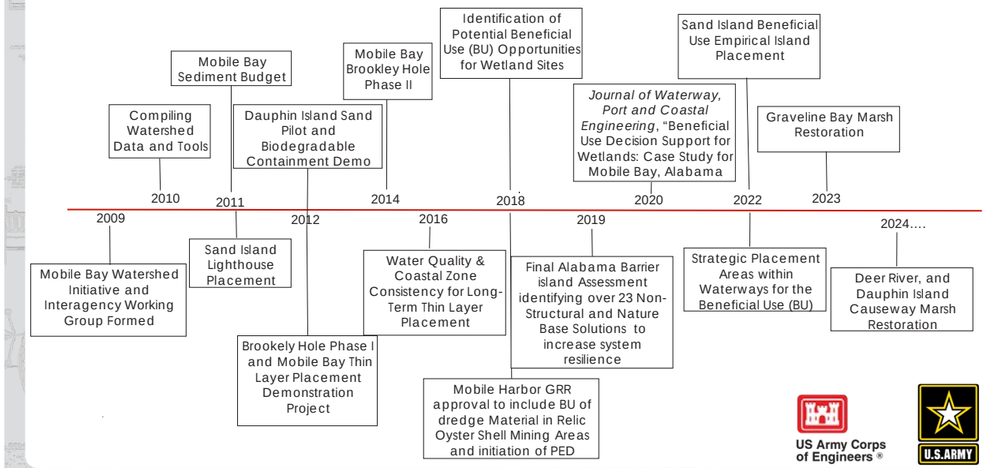
Timeline of Mobile Bay Initiatives Aligning with RSM and EWN Principles



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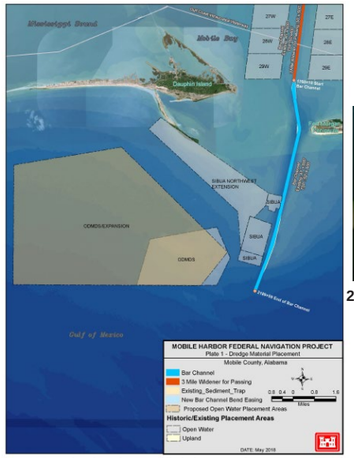
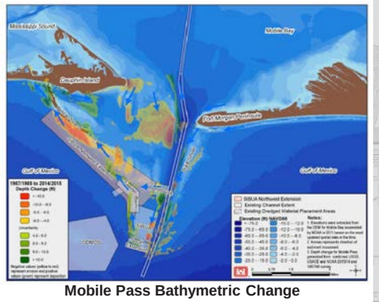
Mobile Harbor, Alabama Channel Improvements
Sand Island Beneficial Use Placement



Sand Island Beneficial Use Placement

2022 Dredge Material Placement



Mobile Pass Bathymetric Change

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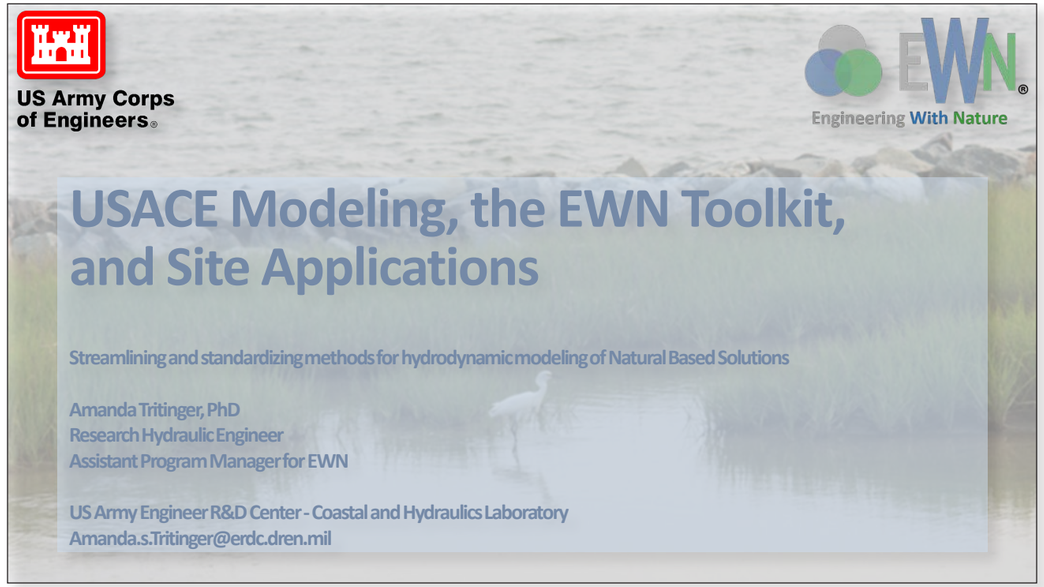
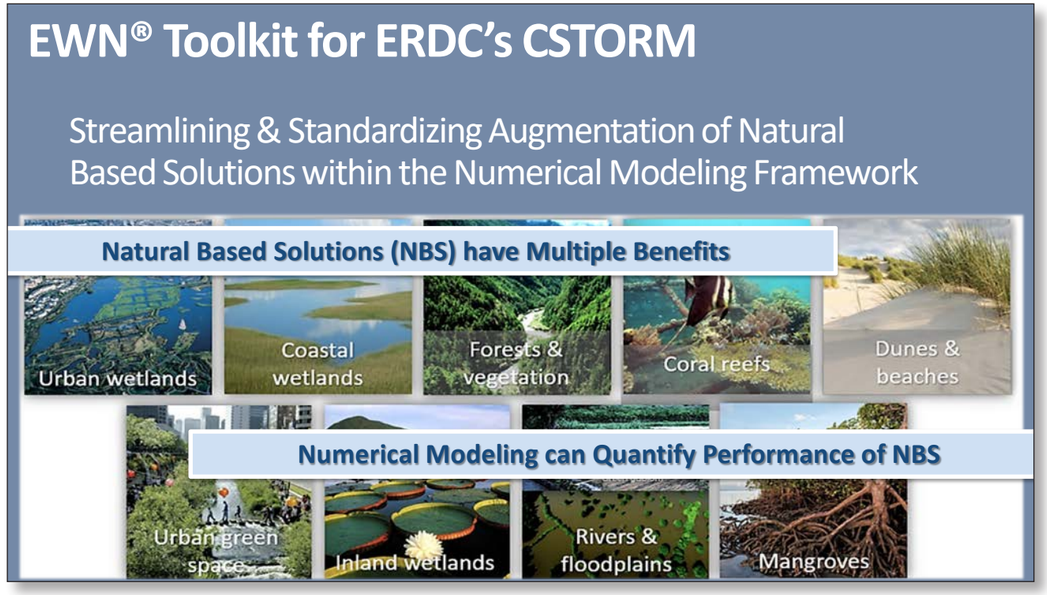
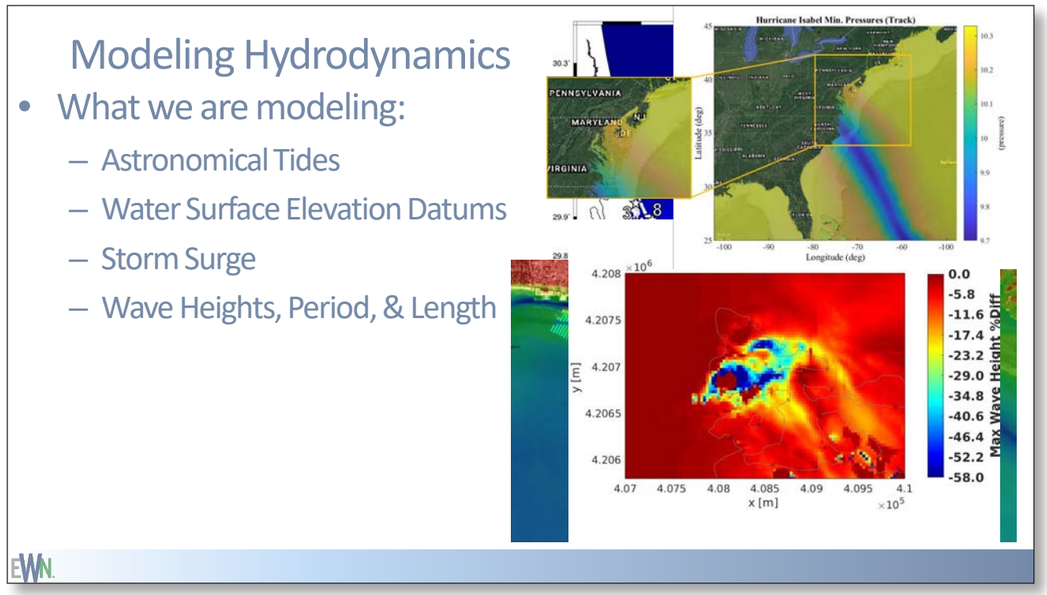
USACE Modeling, the EWN Toolkit, and Site Applications, Amanda Tritinger, PhD, Assistant Program Manager, EWN and Research Hydraulics Engineer Coast and Hydraulics Laboratory, USACE Engineer Research and Development Center (ERDC)





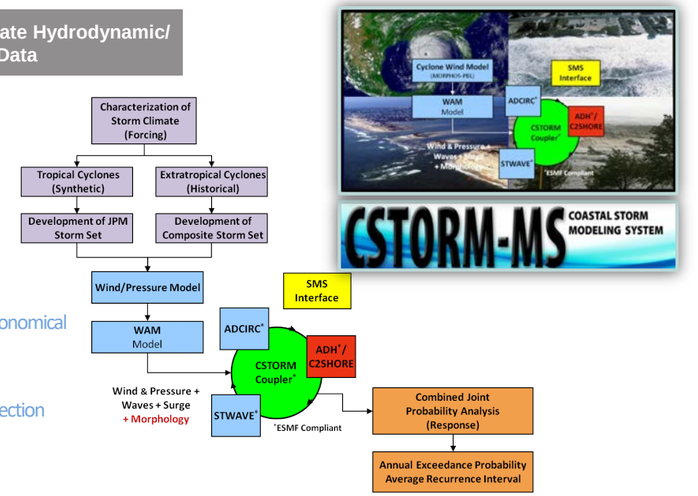


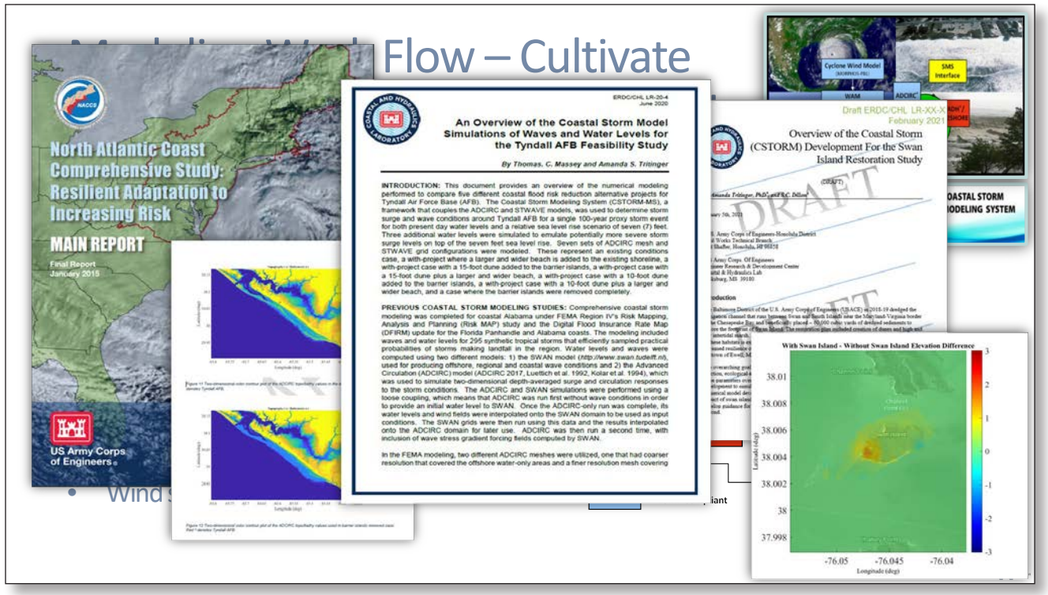
EWN® Toolkit for ERDC's CSTORM

Problem	Solution	Impact
• Inclusion of NNBFs into numerical modeling is time consuming, and needs expert level commitment • Approach has not been standardized, so effort tends to be completed differently per model.	• Develop a semi-automatic GUI that rapidly integrates NNBFs into existing models by; • Adjusting topography/bathymetry • Enhancing resolution accurately • Setting roughness coefficient based on extensive literature review	• Time commitment, expert level needed per modeling project • Allows for MORE designs to be tested • Allows for more innovation opportunities using NNBFs in flood risk management • Expands the EWN practice

Modeling Work Flow – Cultivate Hydrodynamic/ Meteorologic Data

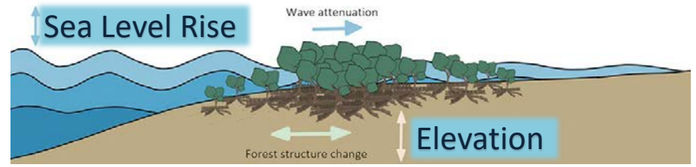
- *Forcing*
  - Tropical cyclones
  - Extratropical cyclones
  - River Flows
- *Response*
  - Water level (storm surge, astronomical tide, SLC)
  - Currents
  - Wave height, peak period, direction
  - Wind speed, direction



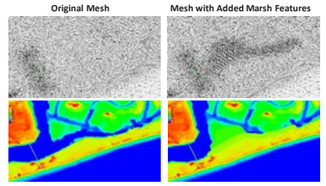


Modeling Hydrodynamics with Natural Based Solution (NBS) Features

- Adjust for;
  - Elevation
  - Drag
  - Model Resolution
  - *Sea Level Rise*

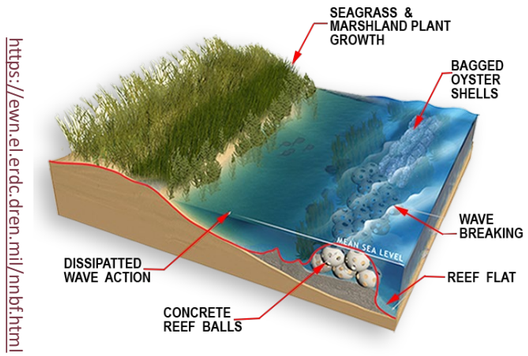


Gijsman Rik, Horstman Erik M., van der Wal Daphne, Friess Daniel A., Swales Andrew, Wijnberg Kathelijne M. *Nature-Based Engineering: A Review on Reducing Coastal Flood Risk With Mangroves*



Elevation Adjustment

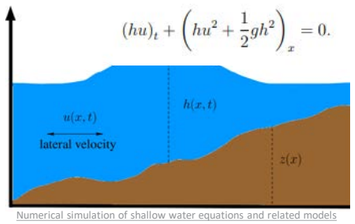
Topography	Bathymetry	--> Momentum Flux



https://ewn.el.erdc.dren.mil/nnbf.html

Essentially, change in pressure,

$$(hu)_t + \left(hu^2 + \frac{1}{2}gh^2\right)_x = 0.$$



Numerical simulation of shallow water equations and related models
H. Gunawan

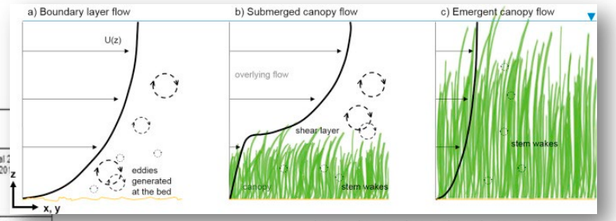
and changes wave energy calc.

Resolution Adjustment

Area of Interest	Mesh Resolution	Resolved for Features

Flow Through Vegetation Adjustment

- Coef. Of Drag



Alexis Beudin, Tarandeep S.Kalra, Neil K.Ganju, John C.Warner
Development of a coupled wave-flow-vegetation interaction model

Nature-based Feature	Region	Grouped species	Mannings n	Drag Coefficient	Source
Mangroves	East coast	Rhizophora mangle	0.124 - 3.00 (depending on the range of Re and Fr)	0.4 – 10 (an inverse relationship between Re and CD)	Narayanan et al 2 Vanegas et al 20
	Gulf coast	Avicennia germinans, Rhizophora mangle (Florida)	0.124 - 3.00 (depending on the range of Re and Fr)	0.4 – 10 (an inverse relationship between Re and CD)	Noarayanan et al 2012; Vanegas et al 2019
Low and High marsh	East and Gulf coast	Spartina patens, Spartina alterniflora, Distichlis spicata, Bolboschoenus robustus, Juncus roemerianus		0.1-1.1; 1-2.5; 1-4 (bulk drag coefficient); 0.2-3.2 (depending on the distribution)	Augustin et al 2009; Anderson and Smith 2014; Jadhav and Chen 2012; Peruzzo et al 2018
		Phragmites australis, Solidago sempervirens, Typha domingensis	0.018-0.024 (depending on location in the furrow and inflow rates; unsure of plant properties!!)	1.49-26.24 (decreased as the flow rate increased)	Malapalli et al 2008; Zhao et al 2017

Suggested Vegetation Roughness for Numerical Modeling in the Coastal Region – A Lookup Table tool

A journal publication *Title subject to change*

Rachel Innocenti, Candice Piercy, Amanda Tritinger, Chris Massey, and Mary Bryant

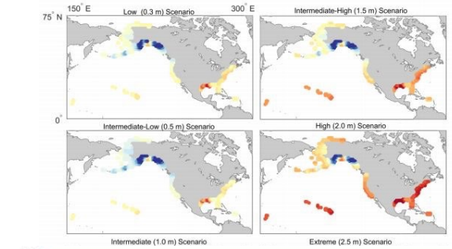
Coastal and Hydraulics Laboratory [Text Wrapping Break] *U.S. Army Engineer Research and Development Center* [Text Wrapping Break] *3909 Halls Ferry Road* [Text Wrapping Break] *Vicksburg, MS 39180-6199*

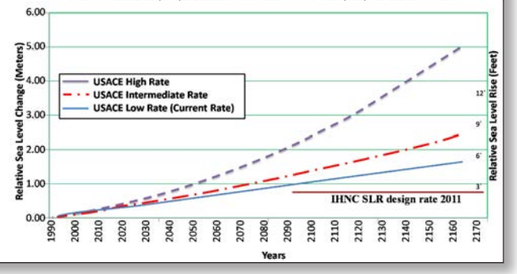
Abstract: USACE storm surge and wave model users typically adjust the drag coefficient, or bottom roughness, in order to capture the effects of vegetation in their model. A vegetation roughness look up table was developed as a tool to

Sea Level Rise (SLR) Adjustment

SLR Considerations:

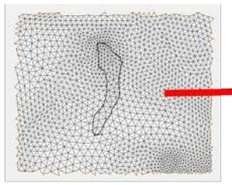
- Eng. Regulation 1110-2-8162 (June 2019) – Incorporating Sea Level Change in Civil Works Programs
- Eng. Pamphlet 1100-2-1 (June 2019) – Procedures to Evaluate Sea Level Change: Impacts, Responses, and Adaptation
- USACE Sea Level Change Curve Calculator (Version 2021.12) (https://cwbi-app.sec.usace.army.mil/rccslc/slcc_calc.html)

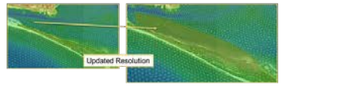


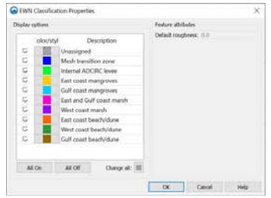


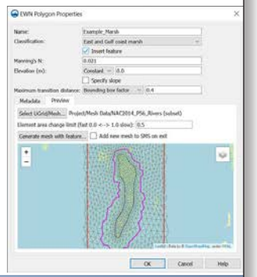
The EWN® Toolkit for ERDC's CSTORM

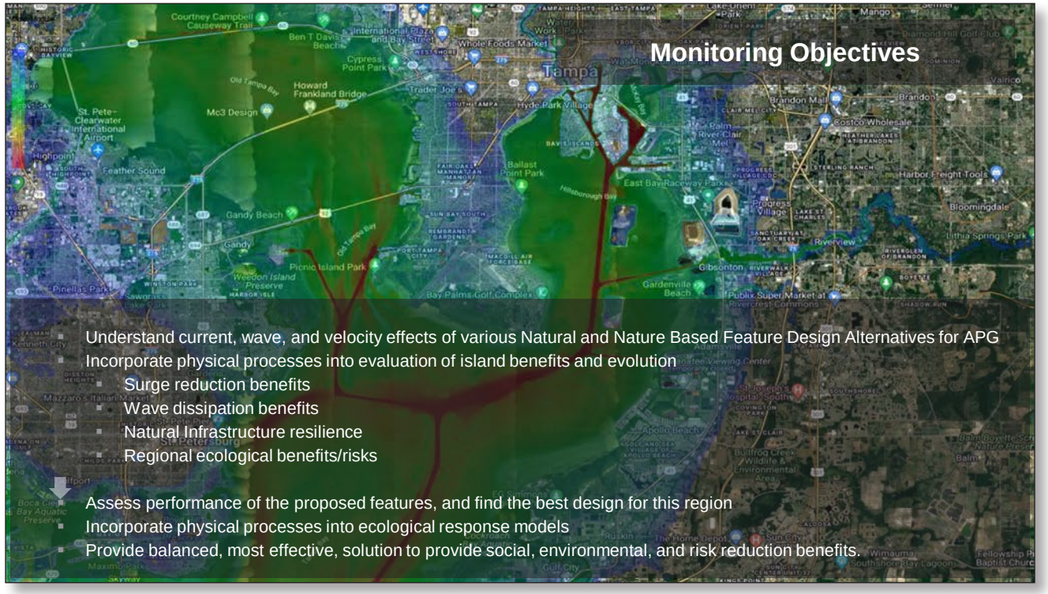
- The Toolkit allows for rapid representation of EWN features within a coastal, estuarine, and fluvial numerical model background.
- EWN properties will be assigned as the polygons that represent those features are generated.
- The topographic and bathymetric changes will be assigned by the user and the Manning's n value will be available in a look up table.







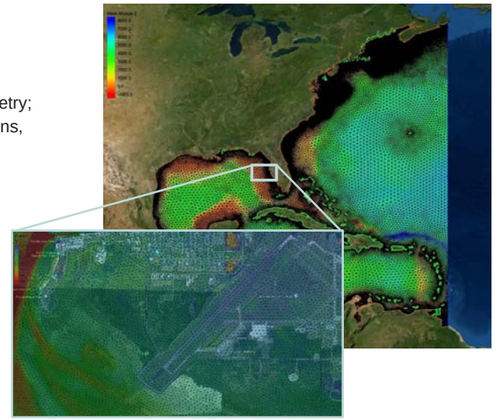


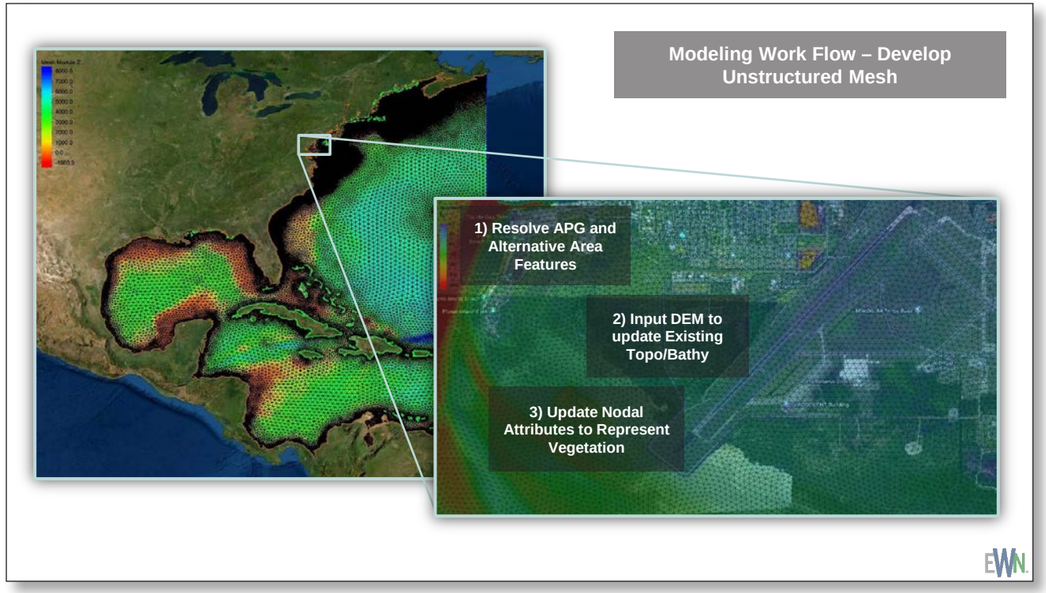


Goal: to hydrodynamic data that can feed ecological, coastal resiliency, and performance evaluations that quantify the protective and ecological benefits of NNBF based solutions.

Monitoring Process

- Digitize the topography and bathymetry of APG and the surrounding area based on collected elevation data, and existing databases, into a DEM.
  - Develop two versions of this topography and bathymetry;
    - One that includes APG NNBF Alternative Designs,
    - One with no alternatives (as is conditions).
- Develop, validate, and run a hydrodynamic model that adequately represents the region surrounding APG.
- Analyze the results of these runs to inform the following;
  - How are these alternatives performing during;
    - High Frequency Events
    - Historical Events
    - Sea Level Rise Scenarios
    - Extreme Storm Events
    - Compound Flooding

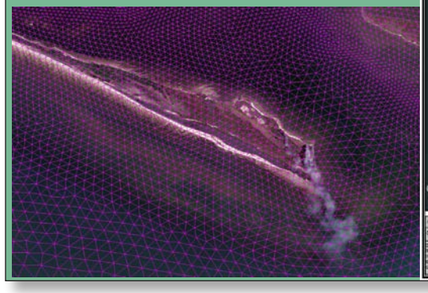


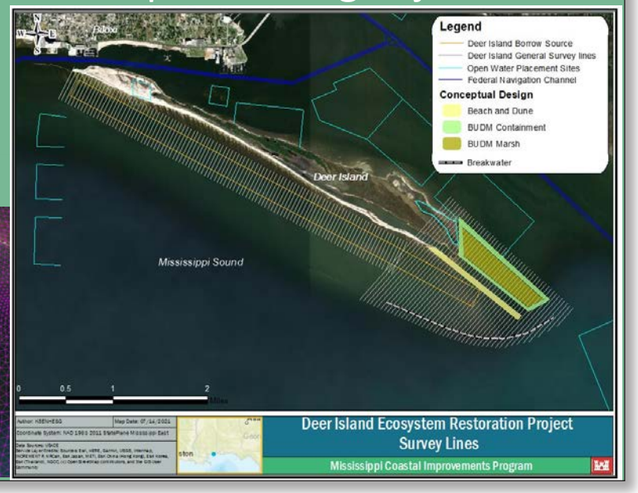


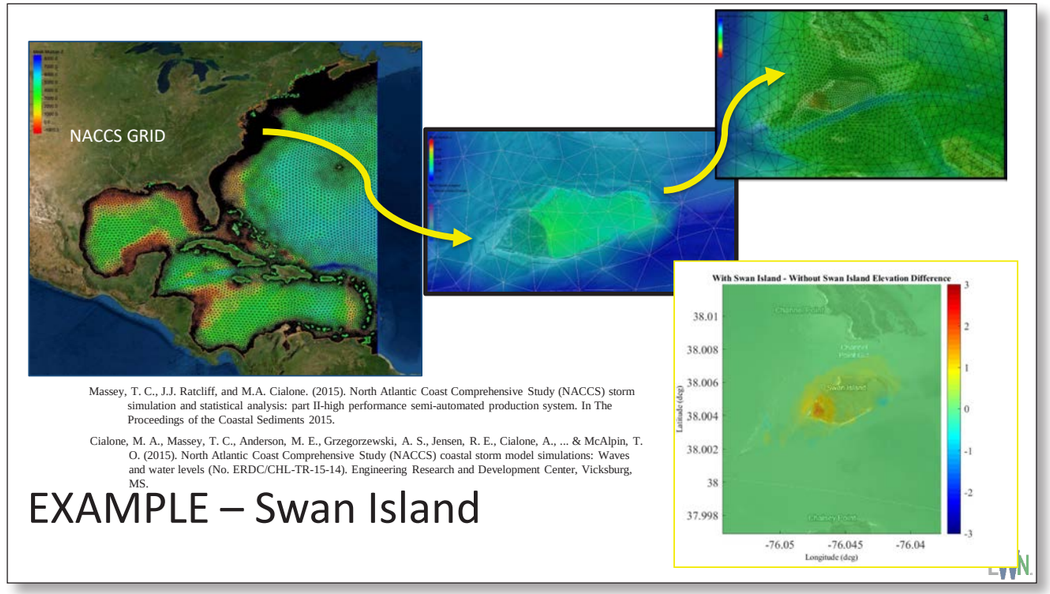
EWN® Toolkit for ERDC's CSTORM

Example Meshing Adjustments

Initial Regional Scale Mesh







Massey, T. C., J.J. Ratcliff, and M.A. Cialone. (2015). North Atlantic Coast Comprehensive Study (NACCS) storm simulation and statistical analysis: part II-high performance semi-automated production system. In The Proceedings of the Coastal Sediments 2015.

Cialone, M. A., Massey, T. C., Anderson, M. E., Grzegorzewski, A. S., Jensen, R. E., Cialone, A., ... & McAlpin, T. O. (2015). North Atlantic Coast Comprehensive Study (NACCS) coastal storm model simulations: Waves and water levels (No. ERDC/CHL-TR-15-14). Engineering Research and Development Center, Vicksburg, MS.

EXAMPLE – Swan Island

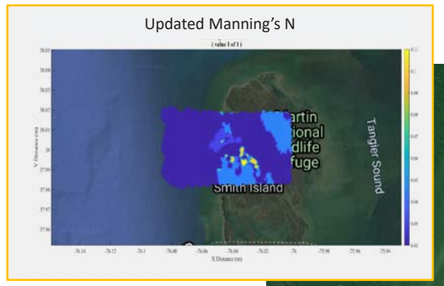
The Power of Partnership: *Swan Island*

Engineering With Nature

US Army Corps of Engineers

https://coastalscience.noaa.gov/project/evaluating-efficacy-of-island-restoration-and-enhancement-for-coastal-protection/

Adapted Nodal Attribute File using SAV data

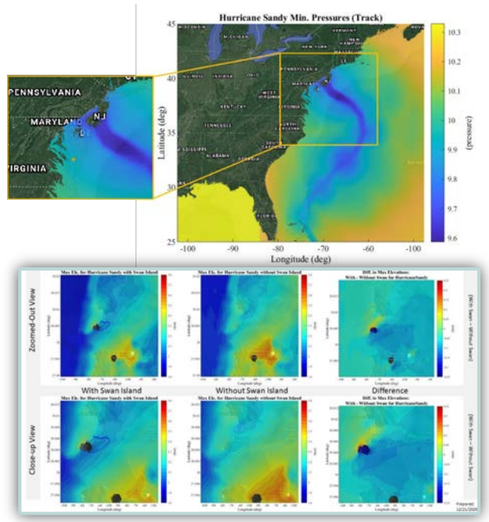


Future Modeling and Design Approach

- Pull 10+ (still working on this #) statistically significant storms (from synthetic tropical NACCS storms) to run with and without project scenarios
  - Statistically significant: 10-yr, 50-yr, 100-yr, 250-yr, and 500-yr storm water levels for the region
  - Without project: As is conditions
  - With project: Compare several different design alternatives
- Compare the numerically modeled water levels with and without project for each storm event
- Compare wave heights with and without project

Develop New Set Of Alternatives

- Run model again….

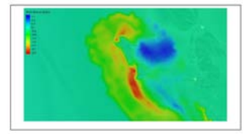


EWN Toolkit Resources

To learn more about the EWN Toolkit, check out the following resources:

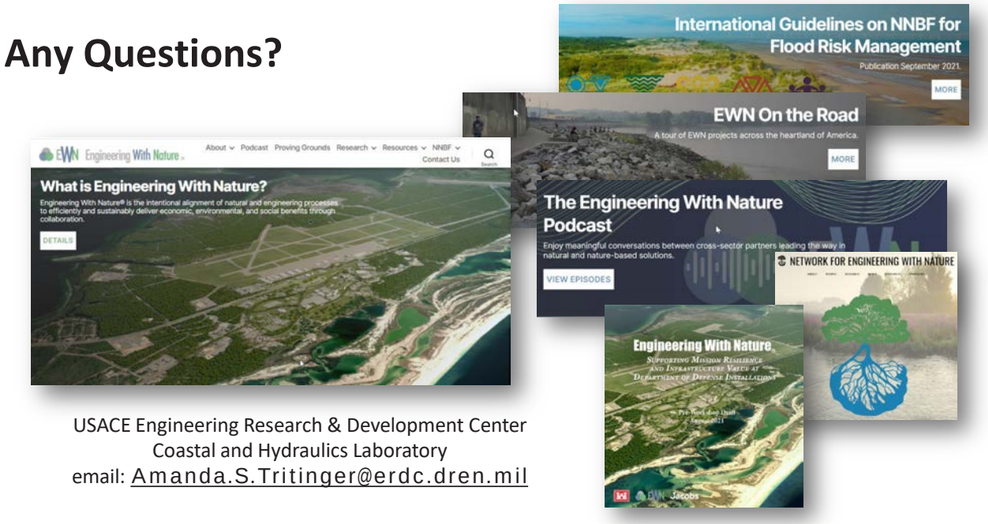
- EWN Toolkit Story Map
- SMS Tutorials from Aquaveo
- EWN Toolkit Coastal Storm Risk Management (CSRM) Course Lecture Video/Tutorial
- CSRM course being offered at Coastal and Hydraulics Laboratory in Vicksburg, MS in late winter/early spring 2023 – details forthcoming

SMS 13.1 Tutorial
EWN Update Manning's N Nodal Attributes



ERDC AQUAVEO CHL

Any Questions?



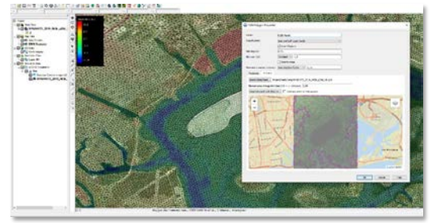
USACE Engineering Research & Development Center
Coastal and Hydraulics Laboratory
email: Amanda.S.Tritinger@erdc.dren.mil

Any Questions?

Please email:

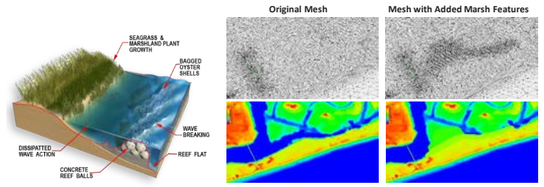
Amanda.S.Tritinger@erdc.dren.mil

USACE Engineering Research & Development Center
Coastal and Hydraulics Laboratory

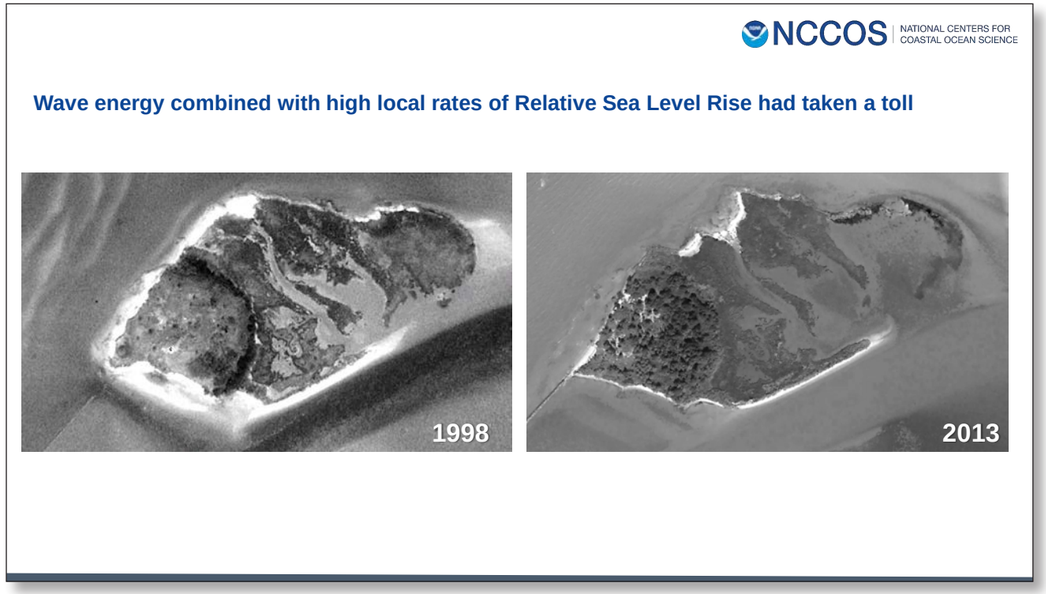


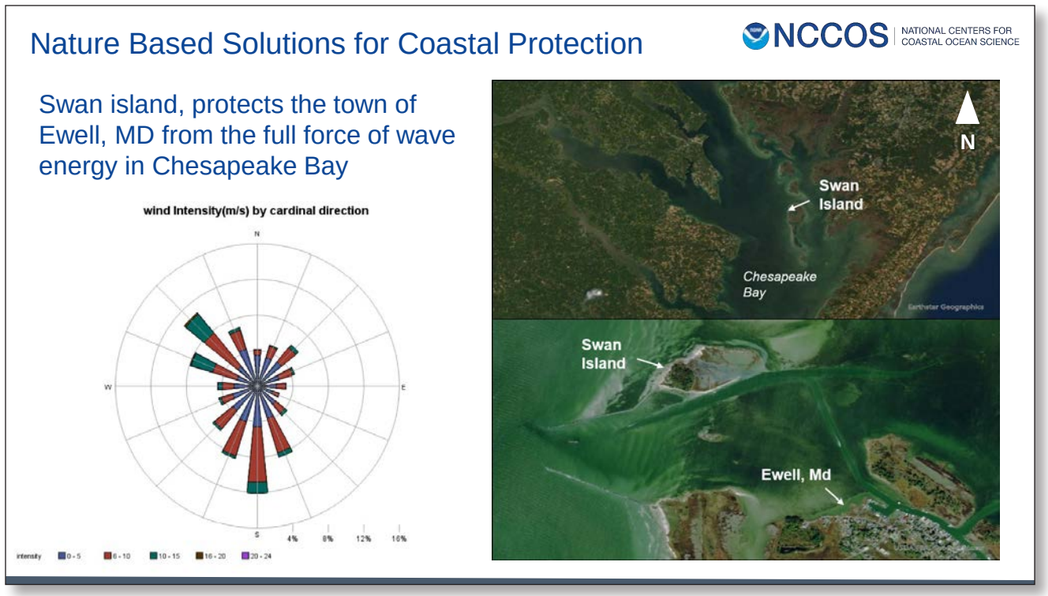
www.engineeringwithnature.org

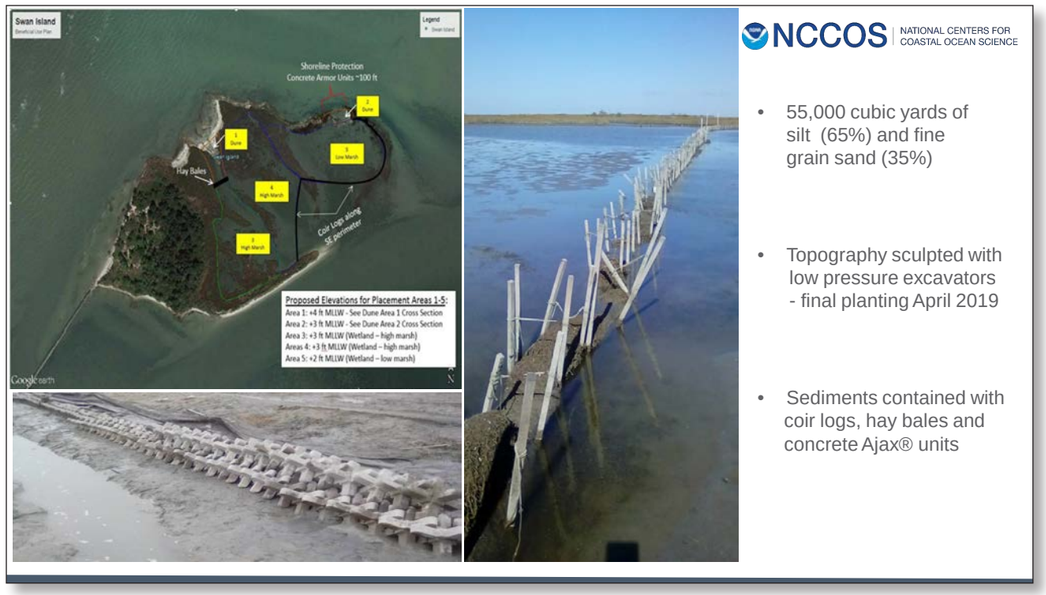
ERDC CHL



Performance of Island Restoration Projects in Chesapeake Bay, Jenny Davis, PhD, Research Ecologist, NCCOS/National Oceanic and Atmospheric Administration (NOAA)







NCCOS NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE

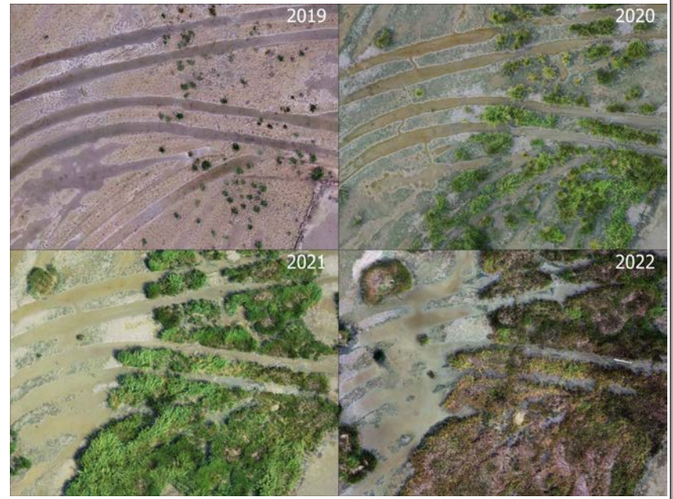
Dense vegetative canopies:

- contribute to resilience by trapping/stabilizing sediments
- baffle wave energy
- provide habitat
- mediate water quality

NCCOS NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE

Performance Evaluation

The low marsh is being recolonized by vegetative spread of the few existing plants that survived the initial placement



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Performance Evaluation: how closely does the project mirror the plans (and how does that change over time)?

High marsh grew rapidly and continues to expand

Plantings failed in large parts of the low marsh due to inappropriate species selection

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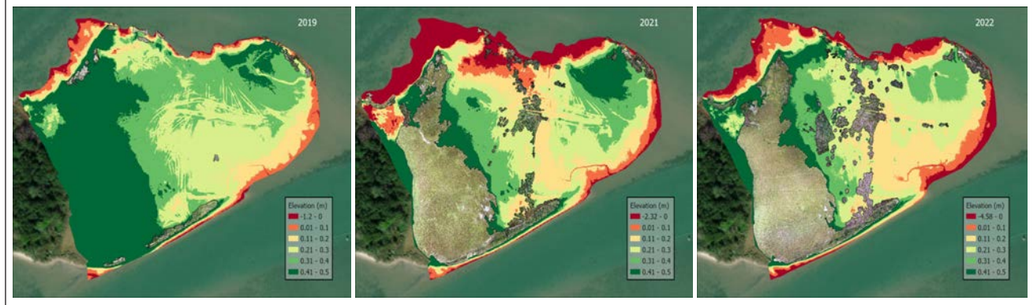
Performance Evaluation: how closely does the project mirror the plans (and how does that change over time)?

Submerged Aquatic Vegetation

The coir log structure was not effective at containing fine sediments; the SAV bed was buried by ~30 cm of sediment

Changes in Footprint and Elevation Profiles Over time

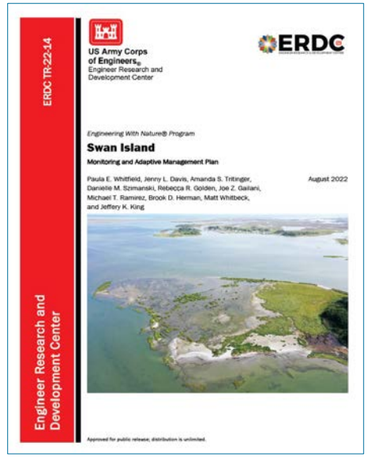


Dune on the NE side was not adequately protected and has been flattened over time
Vegetation has been very effective at trapping sediment
The area that was formerly an SAV bed is getting deeper and more conducive to SAV growth

Sediment Stabilization

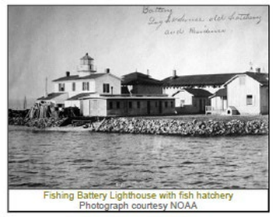
Dense marsh vegetation is trapping sediment and facilitating the development of small interior dunes

Adaptive Management



20,000 additional plants added in 2021

Fishing Battery Island


Fishing Battery Lighthouse with fish hatchery
Photograph courtesy NOAA

Placement occurred in 2013
95% medium grained sand
No containment
Planted with 65,000 plants

There has been a significant amount of natural vegetative recruitment in the placement area


black locust


hackberry


red cedar


red maple

10 years after completion…

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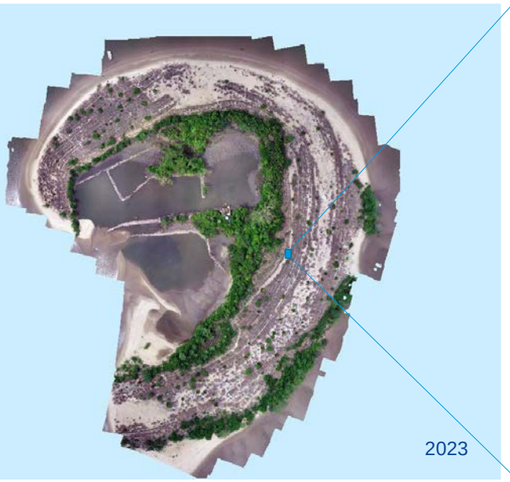
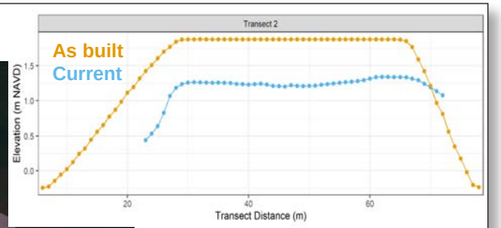
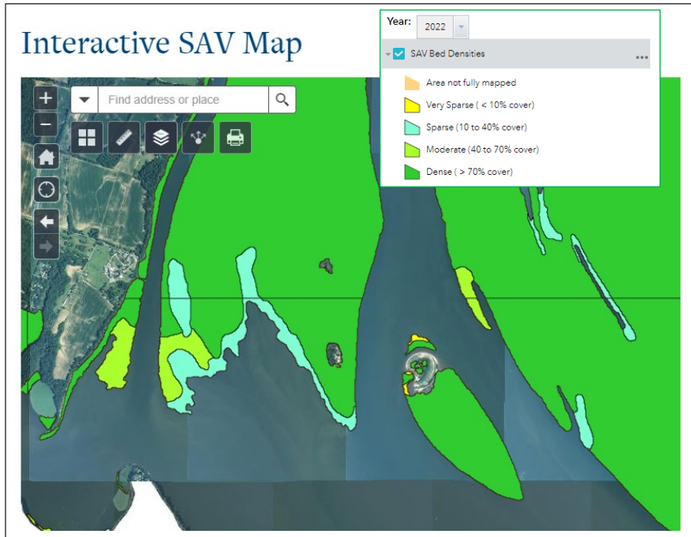


Performance Evaluation



Interactive SAV Map



https://www.vims.edu/research/units/programs/sav/access/maps/index.php

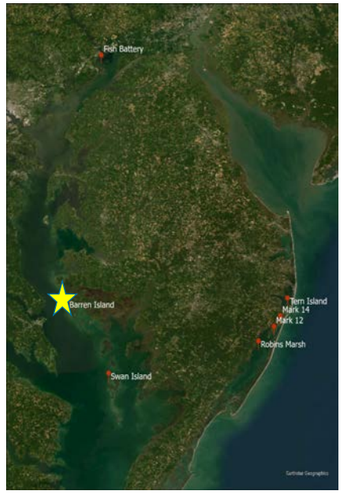
NCCOS | NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE

Fish Battery is within Susquehanna Flats SAV bed

Potential impacts to SAV recovery were a significant concern

Long-term monitoring data suggest no negative impacts of island construction

Barren Island



Sediment placement and planting (40,000 plugs) occurred in 2009

Foot traffic can be a significant challenge to management of these sites

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Coastal Natural Infrastructure

Can provide an effective option for shoreline stabilization and protection

Rapid vegetative establishment is essential

Should include monitoring and adaptive management plan and funds to support it as part of the design

Comes with a manageable amount of uncertainty

US Army Corps of Engineers®

ERDC ENGINEER RESEARCH & DEVELOPMENT CENTER

U.S. FISH & WILDLIFE SERVICE

MARYLAND DEPARTMENT OF NATURAL RESOURCES

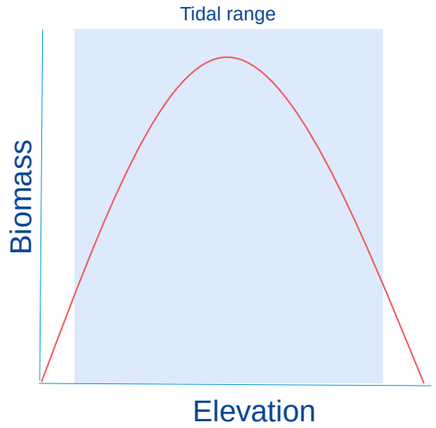
EA Engineering, Science, and Technology, Inc., PBC

EWN Engineering With Nature®

The restored marsh has been stable since project completion and appears to be gaining elevation over time.

Is not easily distinguished from the Island's natural marshes

Marsh Elevation:Biomass Relationship

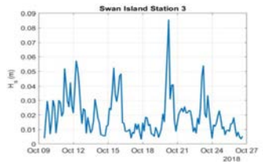


Vegetated intertidal habitats break wave energy and build elevation

Typical distribution of marsh vegetation suggests an "optimal" elevation for growth

At optimal elevation, biomass is maximized and as a result, so is the capacity to build elevation

Intended Benefits: Wave Energy Mitigation



Field collected data and EWN modeling toolkit are being used to quantify the wave mitigation benefits of Swan Island

Measuring Accretion with a Feldspar Marker Horizon

Marsh, Reef & Submerged Aquatic Vegetation (SAV) Projects + Applicable EWN Research, Safra Altman, PhD, Research Coastal Ecologist, USACE ERDC Environmental Laboratory

US Army Corps of Engineers®

Engineering With Nature

Marsh, Reef, & SAV Projects + Applicable EWN Research

Safra Altman, Ph.D.
Wetlands and Coastal Ecology Branch
ERDC Environmental Laboratory

Coastal Wetlands and NNBF – Guidelines

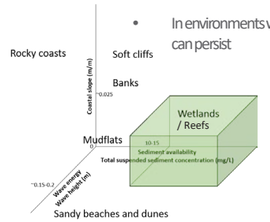
HOW DO YOU DESIGN A WETLAND NNBF SOLUTION?

Focus on the aspects of the design you can control.

Design parameter	Performance factors
Size and configuration (x,y)	Location in estuary Distance from shoreline to upland or structure Total storage volume as a function of water level
Platform elevation (z)	Elevation relative to tidal datum/tide range Topography of wetland and transitions to other habitats
Channel network	Drainage density, sinuosity, junction angles etc. Channel width and depth
Vegetation	Species, height, shape, density, flexibility, roots, distribution
Sediment properties	Grain size, organic matter, bulk density, shear strength
Nearshore bathymetry	Depth, slope, sediment properties of adjacent subtidal mud/sand flats Proximity to deep water
Proximity to traditional defenses	Distance to defense, configuration and geometry of defense

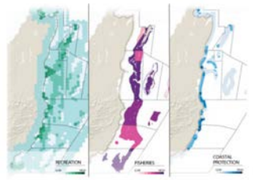
Coastal Wetlands and Reef NNBF – Guideline Considerations

- In environments where wetlands or reefs can persist



These boundaries are not rigid.

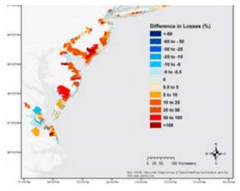
- Where they can provide the desired co-benefits



Co-benefits are not uniformly produced at all locations.

InVEST documentation

- Where they can provide the required engineering performance



Wetlands or reefs in some areas can reduce erosion but may increase it in others.

from Narayan and Beck 2017

- Where they are accepted

Education, outreach, and guidance are required to ensure reefs are accepted.

from TNC *Mangroves for Coastal Defence: Guidelines for coastal managers & policy makers*

2

Coastal Wetlands and NNBF – Guidelines

WETLAND NNBF: GUIDING PRINCIPLES AND SUMMARY

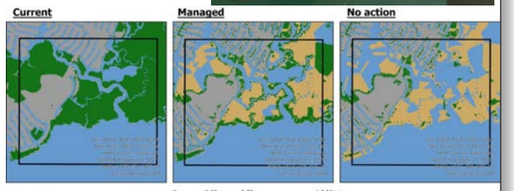
20

- Wetland NNBF combines aspects of flood/erosion risk management and wetland restoration.
- FRM capacity of wetlands depends on critical biophysical and geomorphological characteristics *including the location in the landscape.*
- The temporal and spatial dynamics of wetlands need to be considered.
- Wetland design solutions are diverse.
- Monitoring and maintenance are critical.
- Key questions remain to be addressed.
  - Sustainability, cost-benefit, performance, co-benefits

NETWORK FOR ENGINEERING WITH NATURE

Value of salt marshes during coastal storms

- Multiple studies found existing New Jersey salt marshes reduce flood damages from coastal storms (reductions ranging from 0.36-52%)[1]
- Salt marsh degradation and loss due to sea level rise will increase flood risk in coastal areas
- Building new marshes in this area is not feasible because of limited sediment availability
- Management of existing salt marshes is a cost-effective risk management measure *in combination with other measures*[2]



[1]Narayan et al., 2017; Rezaie et al., 2020; Sheng et al 2021; Piercy et al., *in review*
[2]New Jersey Back Bays Coastal Storm Risk Management Draft Feasibility Report

NETWORK FOR ENGINEERING WITH NATURE

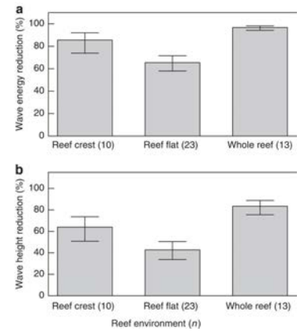
Value of salt marshes between storms

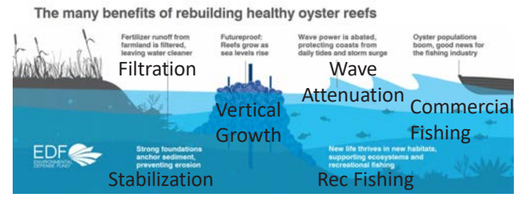
- Managing salt marshes in coastal NJ to reduce flood damages also
  - Results in 11 – 173% greater marsh area near critical back bay reaches in 2080 compared to no action[1]
  - Prevents on average 560 cubic yards of sediment per acre from being transported into the marine system[1]
  - Prevents trapped carbon in these marshes from being released to the atmosphere[2]
  - Maintains critical habitat patches along Atlantic migratory bird flyway[2]
  - Regionally, salt marsh produces 4x greater value to fisheries than mud flat[3]

[1]Piercy et al., *in review*, [2]Barbier et al., 2019, [3]Johnston et al., 20

Why use reefs?

- Reefs act as the first line of defense
  - reduce the wave energy and wave-driven coastal flooding (often by >90%; Ferrario et al. 2014)
  - Reduce coastal erosion
  - Shoreline stabilization
- Co-Benefits
  - food, spawning and nursery grounds for commercially-important fish
  - Improve water quality
  - compounds for medicines
  - tourism
  - fishing, and recreational activities
  - cultural value





How reefs deliver flood and coastal erosion risk reduction

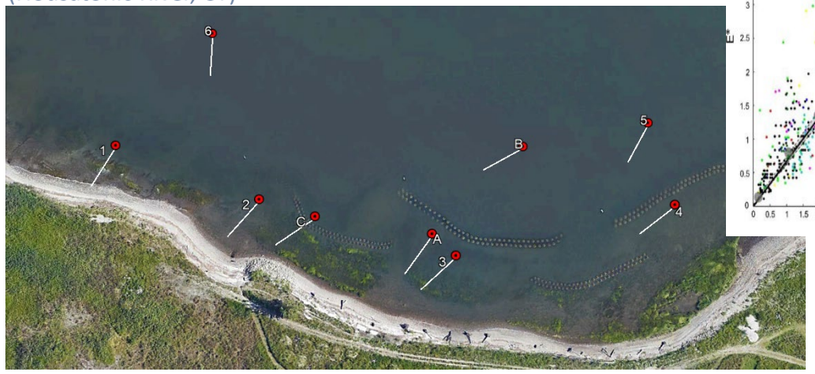
Effects increase	Performance factors	Potential Co-Benefit	Example
Wave energy dissipation	Elevation relative to water level, proximity to shore, width/height of reef, surface roughness/porosity, coral species (morphology & growth)	Reduce flood risk, reduce erosion, reduce damage of coastal infrastructure during storms	Fringing coral reefs in the tropical Indo-Pacific and Caribbean
Shoreline creation	Sand production, sand/sediment trapping	Coastal tourism	coral reef islands, coral atolls
Wetland enhancement and growth	Erosion reduction and shoreline stabilization creating suitable conditions for wetlands and promoting growth	Surge reduction, further wave reduction and shoreline stabilization	Oyster reefs in front of salt marshes and coral reefs in front of mangroves
Shoreline stabilization	Bathymetric configuration, surf zone, current, and sediment transport patterns	Coastal tourism through beach protection	oyster reefs adjacent to coastlines
Erosion reduction	Ability to reduce/shift wave energy, current and increase shoreline stability	Reduced damage of coastal infrastructure during storms	Reduction of erosion during tropical cyclones (e.g. Cuttler et al. 2018)

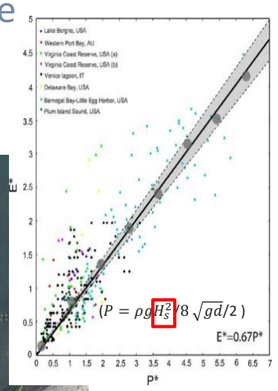
Reef NNBF: guiding principles and summary

- Significant experience with oyster reef restoration for coastal erosion reduction
- Limited field scale examples of coral reef restoration for risk reduction
- But, lots of existing engineering knowledge on low crested submerged breakwaters design, and physical processes along coastlines.
- Remains a challenge of meeting risk reduction and conservation benefits so that structural and co-benefits are obtained
- Future efforts needed in quantifying protection benefits and adaptive management

Connecticut Institute for Resilience & Climate Adaptation (CIRCA, UCONN)

Wave Dampening by an array of Reef Balls in the Inter-Tidal Zone (Housatonic River, CT)

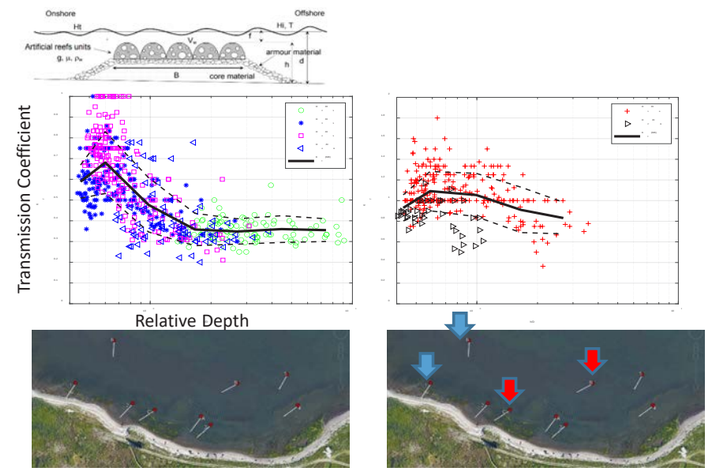




Leonardi, N., N. K. Ganju, and S. Fagherazzi (2016)

O'Donnell, Ilia, Speers, Howard-Strobel, O'Donnell, and Liu

Wave Dampening by an array of Reef Balls in the Inter-Tidal Zone



1. Calculated Transmission coefficient
2. Quantified wave energy reduction (0.25-0.5)
3. Marsh edge erosion rates should be substantially reduced as well (scale with wave energy)
4. Reef balls performed better than small-scale lab tests
5. Comparable to traditional submerged breakwaters
6. Developed a very high-resolution simulation of the wave field to assist in the design at other sites

O'Donnell et al., CIRCA (UCONN)

REEFENSE

Oysters
Rutgers University creates technologies for protecting temperate shorelines

Corals
University of Miami creates technologies for Caribbean shoreline protection using corals

Corals
University of Hawaii creates technologies for Pacific and Indo-Pacific shoreline protection

Rutgers University | University of Miami | University of Hawaii

Vision: Develop hybrid biological and engineered reef-mimicking structures to mitigate wave and storm damage that increasingly threaten DoD personnel and infrastructure

EWN and DARPA Reefense

- **Program Vision**: Develop hybrid biological and engineered reef-mimicking structures to mitigate wave and storm damage that increasingly threaten DoD personnel and infrastructure
- **Program Kickoff:** July 2022
- **Three Performer Teams:** Rutgers University (oyster), University of Miami (coral), University of Hawaii (coral)
- **ERDC Role**: Leading Independent Verification & Validation Team
- 3 Technical Areas
  - Structure Design and Structure
  - Adaptive Biology
  - Ecosystem Engineering
- 5 Year Program
  - Pre-design and Deployment (18 months)
  - Ecosystem Optimization (18 months)
  - Environmental Resilience (24 months)
- 2 Reef Habitats
  - Oyster
  - Coral

Lum, 2014

MDGovPics, 2013

14

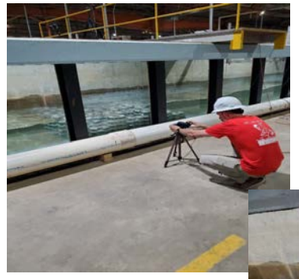
Ecosystem Engineering

Auburn University Shellfish Laboratory

Wave Energy Reduction

University of Western Australia

ERDC Coastal & Hydraulics Laboratory (Bryant)

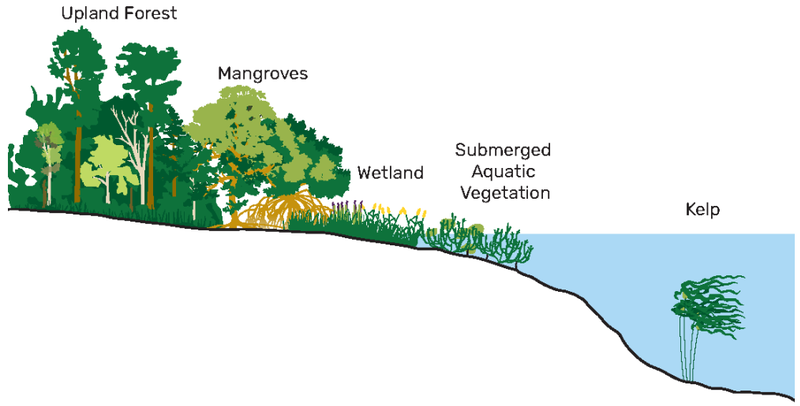


Adaptive Biology

Tyndall AFB

Auburn University Shellfish Laboratory

Plant Systems NNBF (SAV): guiding principles and summary



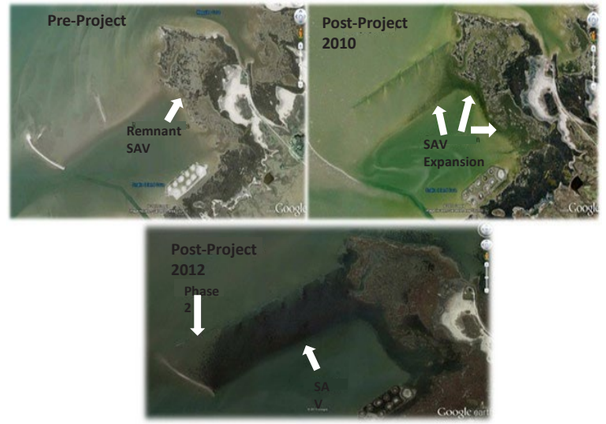
Plant Systems NNBF (SAV): guiding principles and summary

- Can provide coastal protection through sediment stabilization and wave attenuation. SAV near shorelines can absorb waves and slow water movement.
- Magnitude of wave attenuation is dependent on height and rigidity of the canopy relative to the total water column height.

  For SAV : Maximized when canopy height = water column height
- SAV provides additional ecological co-benefits (nursery habitat water quality improvements).
- It is important to use these features at appropriate scales, often menas combined mosaic approaches (especially for larger projects)
- It is critical to match the plant system to the site.
- SAV habitats are spatially dynamic. Robust monitoring is required to understand condition and trajectory.

Snake Island Cove, Galveston TX

- Lost more than 200 acres SAV habitat since 1956
- Marsh fragmenting and eroding 5 ft/yr
- 2007-2011, Galveston Bay Foundation
- 4900 ft geotextile breakwater
  - Protect marsh
  - Create more than 75acres shallow water habitat
- SAV began to re-establish



La Quinta Channel Expansion, Corpus Christi TX

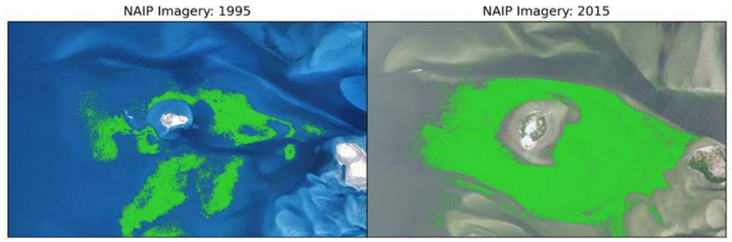
- Used dredge material from expansion and deepening projects
- Constructed an armored levee for wave protection, and submerged nearshore levee
- Dredged material placed at elevations to favor SAV and marsh habitat
- Phase 1 – Mitigation berm constructed, *Spartina* planted
- Phase 2 – earthen protection berm constructed nad covered with geotextile scour apron
- Actively planted SAV (Halodule)
- No observed habitat losses when Hurricane Harvey hit in 2017

Promoting SAV Habitat Sustainability through Innovative Dredging and Placement Practices

Barnegat Bay, NJ – Oyster Creek Channel

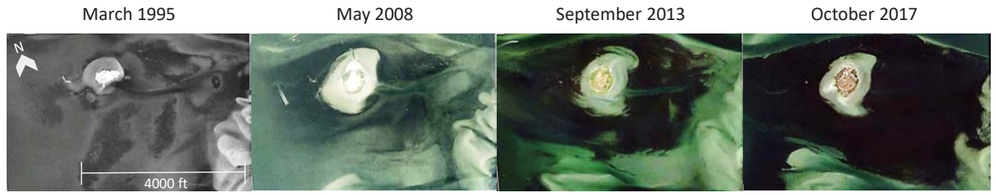
- **Oyster Creek Channel – Dredged ~2 years between 1981-2017**
- **Material placed at 2 open-water disposal areas that became islands**
  - **26A (East) – inactive since 2008, now a Heron Rookery**
  - **26B (West)**

Barnegat Bay, NJ – 26B SAV



SAV area: 0.59 km^2 SAV area: 1.57 km^2

Barnegat Bay, NJ – 26B SAV



Last placement: 1991
Next placement: 1996

Last placement: 2004
Next placement: 2009

Last placement: 2010
Next placement: 2015

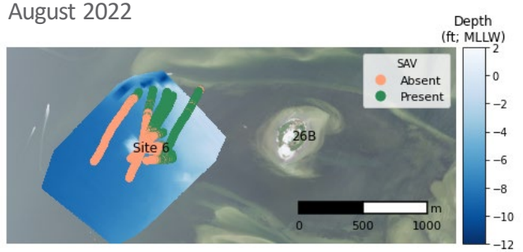
Last placement: 2017*

Imagery from GoogleEarth

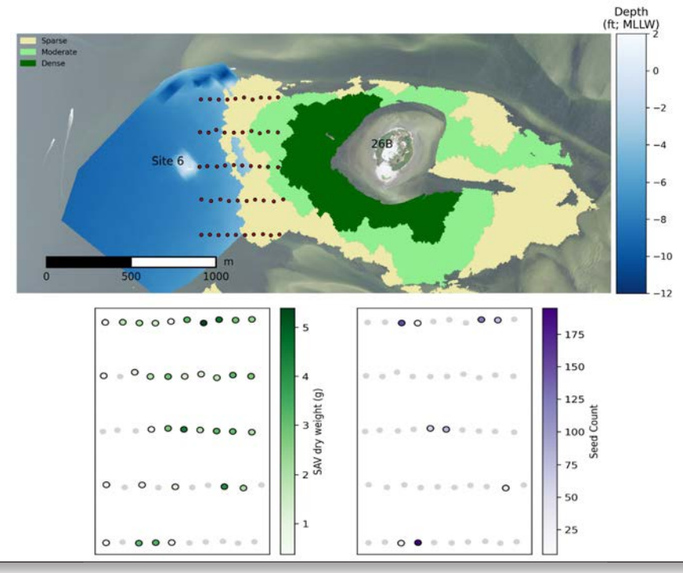
Barnegat Bay, NJ – Site 6

- WRDA 1122 Pilot Project
  - Support navigation mission and use sediments beneficially
- ~1 km west of 26B, deeper, no SAV (yet)
- Started placing sediment Fall 2020

August 2022

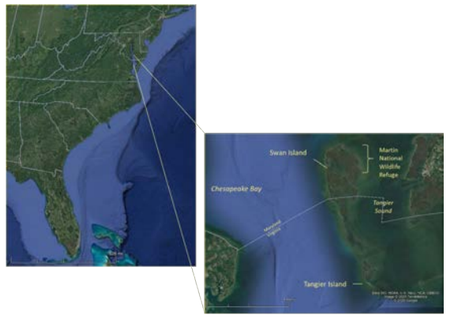


May 2023



Swan Island Restoration

- **Rapid erosion (~3m/yr) since 1942 – fragmented low-elevation marsh**
- **Important benefits to Smith Island Communities (wave break)**
- **BU Application of EWN principles**
  - Material from nearby navigation channel
  - Placement (and planting) to restore marsh and dune habitat



Quantifying and predicting island resilience

- **Modeling Goal: Develop integrated model to quantify island resilience**
  - Waves/currents
  - Island Profile
  - Sediment availability
  - **Vegetation (including SAV)**

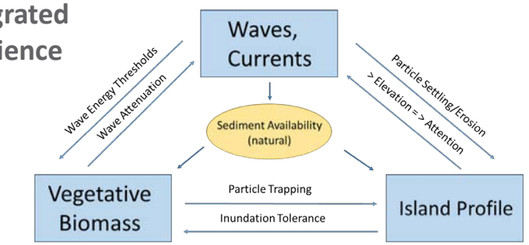
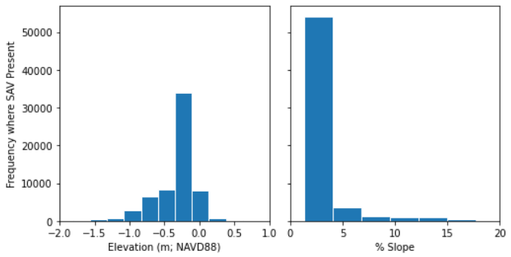
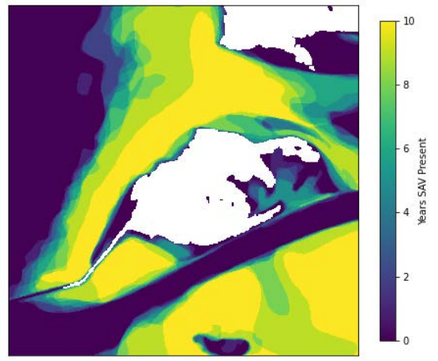


Image Credit: Herman et al. (2023)

SAV Habitat Suitability Model – Presence/Absence

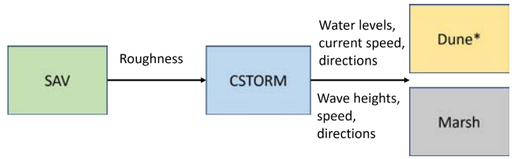
- **SAV presence is light dependent**
- **Elevation is a proxy for light availability**





Next Steps: Integrated Island Model

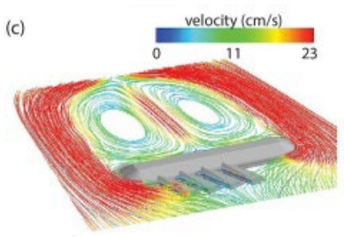
- **SAV determines roughness**
- **Hydrodynamics (CSTORM)**
- **Water levels, wave heights, velocities go into dune/marsh models**



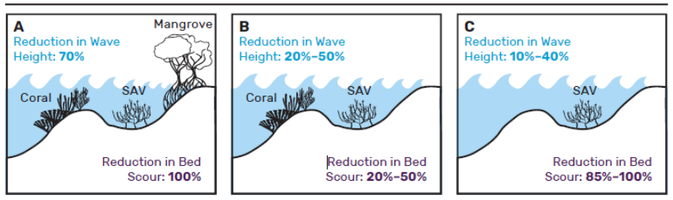
Concluding thoughts

- There are a lot of examples that highlight a particular aspect of NNBF
- Consider how to use examples for design to meet specific metrics/goals
- Be creative in aligning
  - Adaptive management strategies
  - Monitoring efforts
  - Quantifying NNBF performance over time and under varied conditions
- Develop mechanisms to share the results and learned lessons

Benefits of combined NNBF solutions

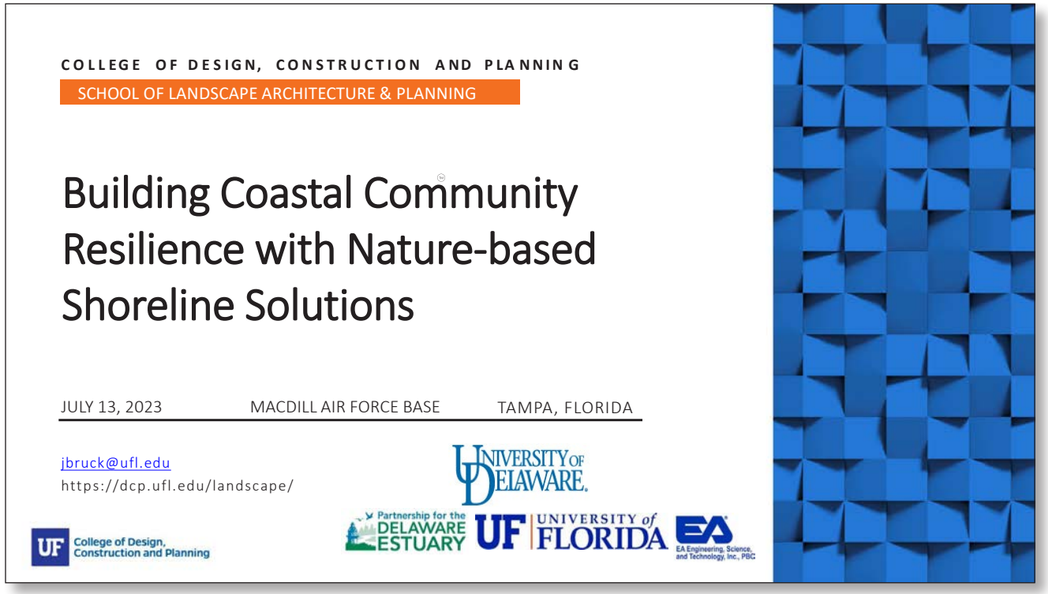


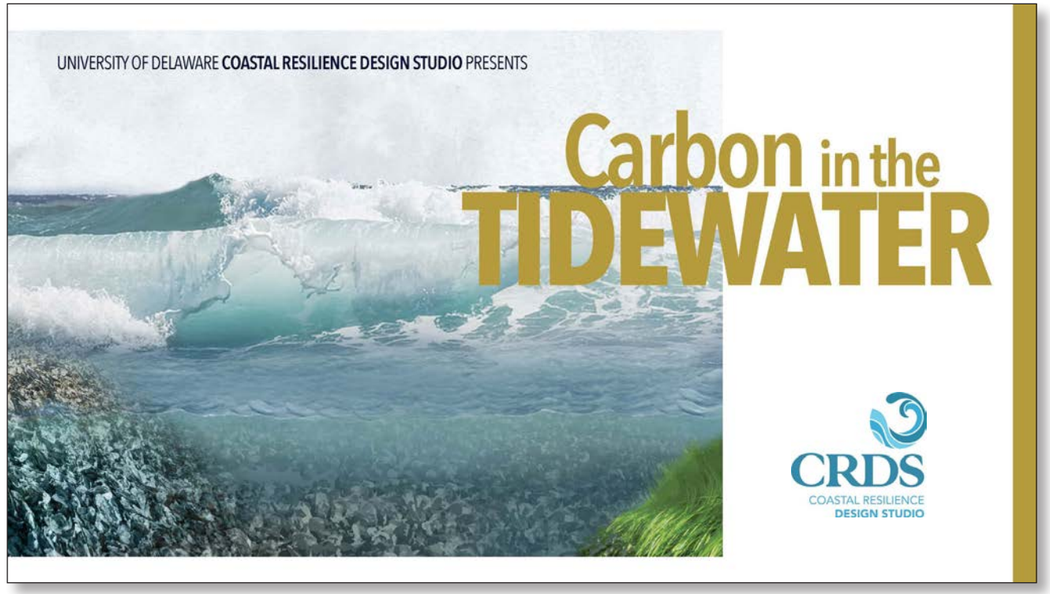
Living Breakwaters Project, Raritan Bay, NY

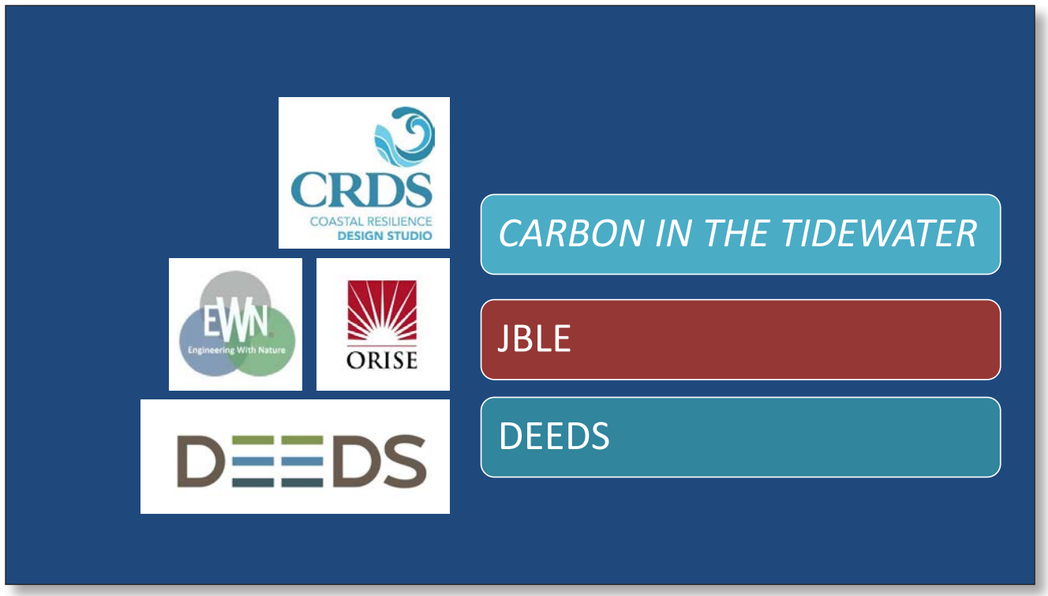


Note: Strategies that incorporate multiple NNBF measures provide more effective shoreline and storm protection.

Building Coastal Community Resilience with Nature-Based Shoreline Solutions, Jules Bruck, PhD, RLA Director, School of Landscape Architecture and Planning Chair, Department of Landscape Architecture College of Design, Construction and Planning, University of Florida







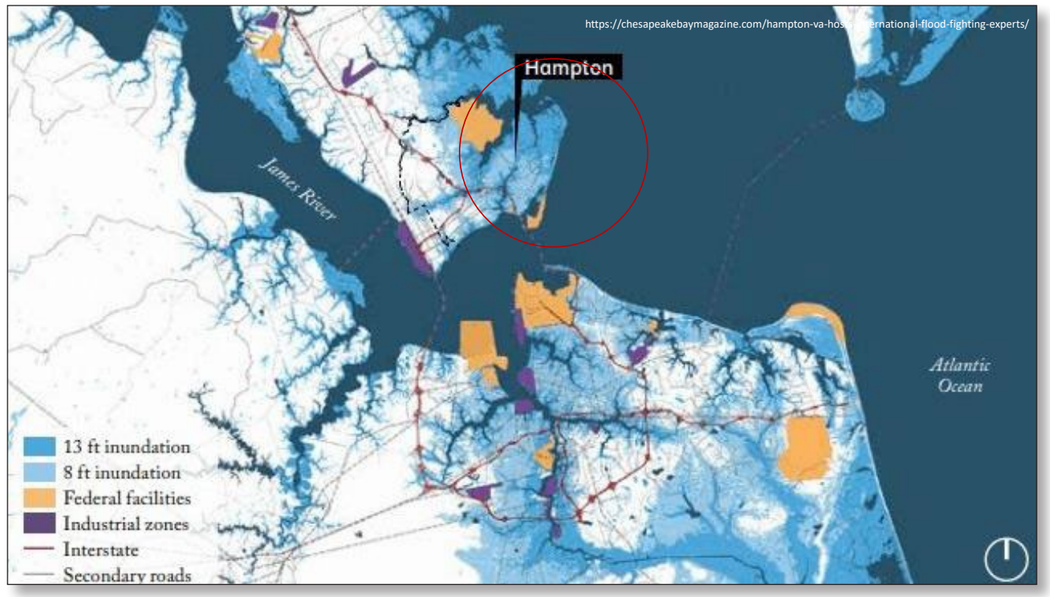
Population
•Population: 137,746 people

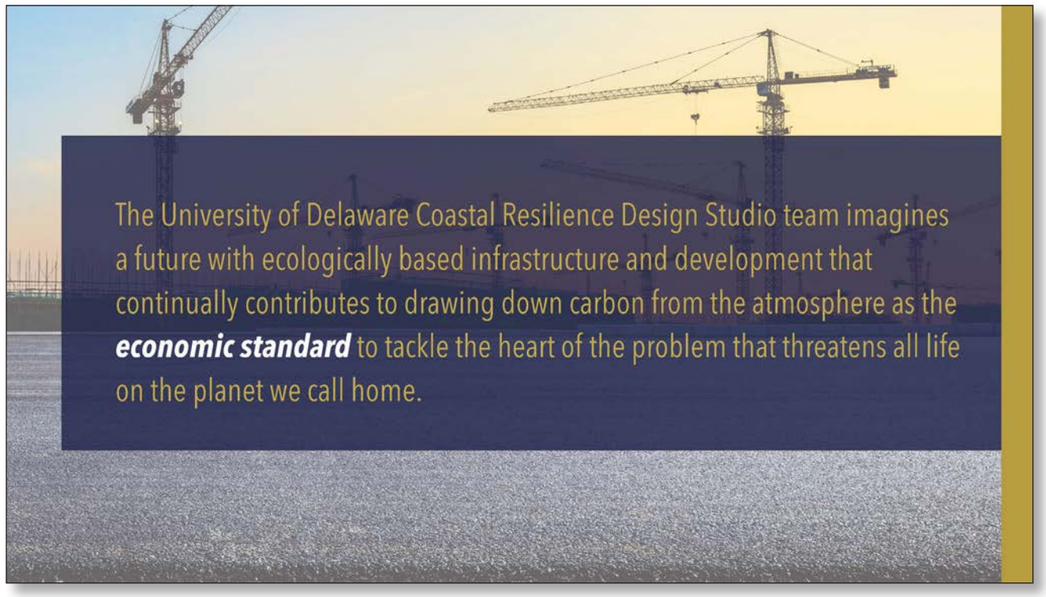
Ethnicity Percentages
•African American: 51.7%
•White: 40.1%
•Hispanic or Latino: 6.3%
•Identified by two or more: 6.6%
•Asian: 2.2%
•American Indian and Alaska Native: 0.4%
•Native Hawaiian and Pacific Islander: 0.1%

Households
•Households: 57,116
•Median household income: $59,380

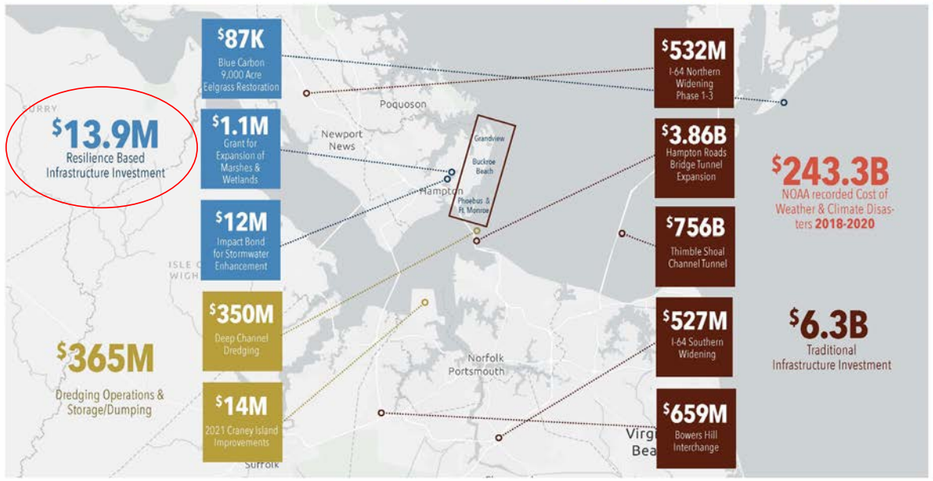
Education
•High school graduates: 92.6%
•Bachelor's Degree or higher: 27.3%

UF College of Design, Construction and Planning





REGIONAL INVESTMENT

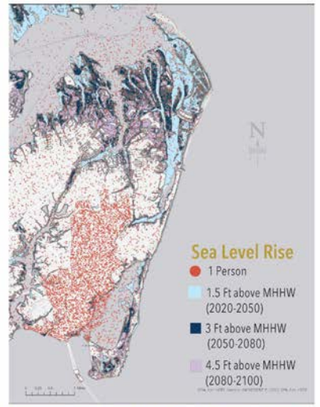


https://www.hrtac.org/page/hrtac-projects/ https://www.dredgingtoday.com/2021/04/23/dredgit-nabs-craney-island-contract/
https://www.portofvirginia.com/who-we-are/newsroom/dredging-to-make-virginia-the-east-coasts-deepest-port-is-underway/ http://www.rbbt.com/project-description/

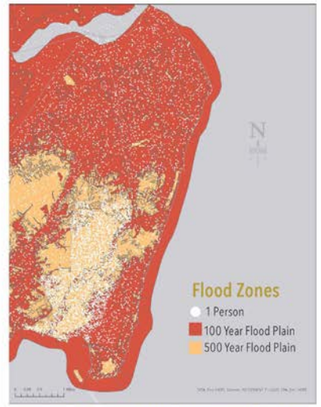
TEAM APPROACH

We approached the design solution by examining
human risk, ecological systems and associated risks, and economic and environmental policies affecting the coastline of Hampton, Virginia.

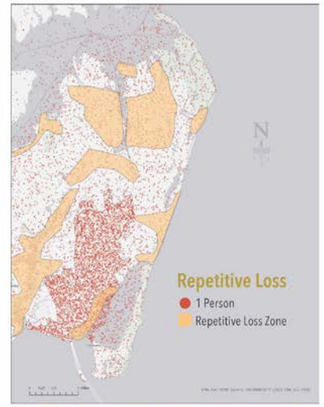
HUMAN RISK



Population Density data from the 2019 Community Survey living in the City of Hampton SLR zones indicate the largest area affected will occur at the 1.5' level

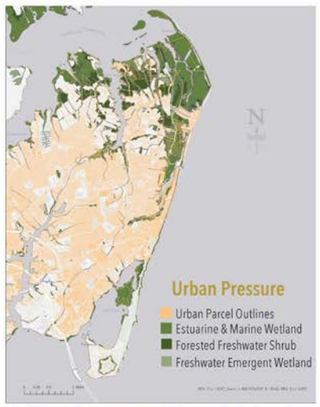


Population Density living in the FEMA designated 100 and 500 Year Floodplain show high density in the lower risk zone, however, this limits increased capacity in that area

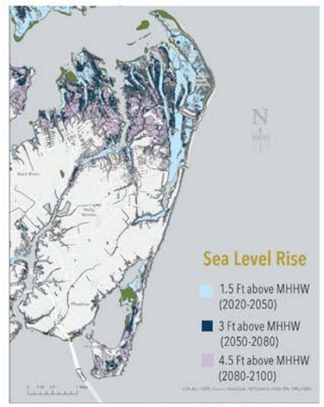


Clusters of Repetitive Loss & Insurance Claims indicate that population density does not directly correlate with recurrent property loss and recovery payouts

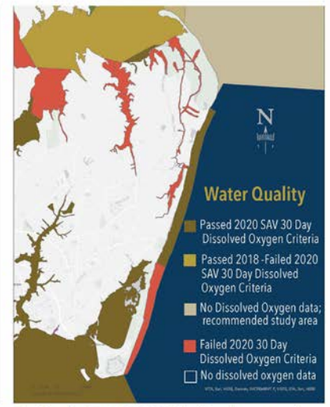
ECOLOGICAL RISK



Analysis of urban pressure on existing wetlands shows the existing parcel lines encroaching on wetlands from the west leaving no space for migration due to sea level rise.

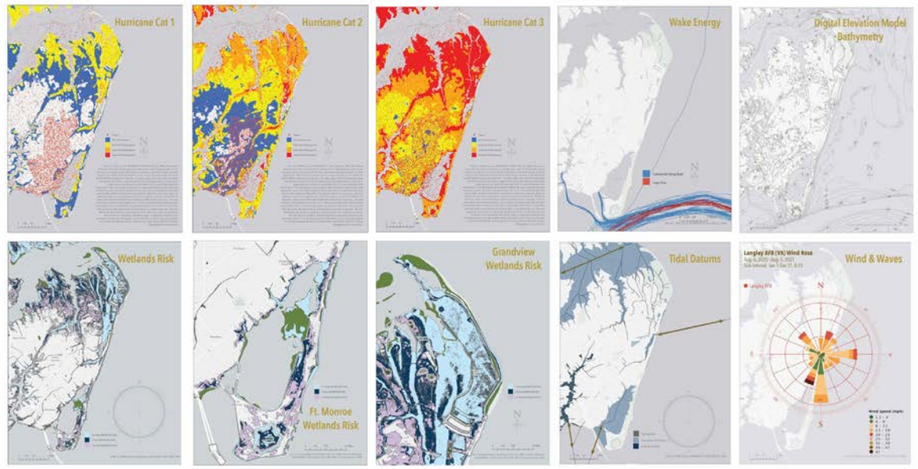


Sea level rise impacts on existing wetlands indicate the greatest area of loss to vital wetland ecosystems will occur at the lowest level of predicted sea level rise



Data from the Virginia DEQ 2020 facilitated a water quality analysis to evaluate areas of potential for future SAV resto-ration and creation

COASTAL ANALYSIS



THE IDEA

The team synthesized scientific research, emerging engineering technologies, resilience based case studies, policy, and interviewed experts in the fields of resilience, soils, engineering, and carbon capture.
The result is a ***four layer approach*** that addresses the need for coastline protection that is regenerative and adaptive, harnessing the ***global carbon market*** as a finance tool.

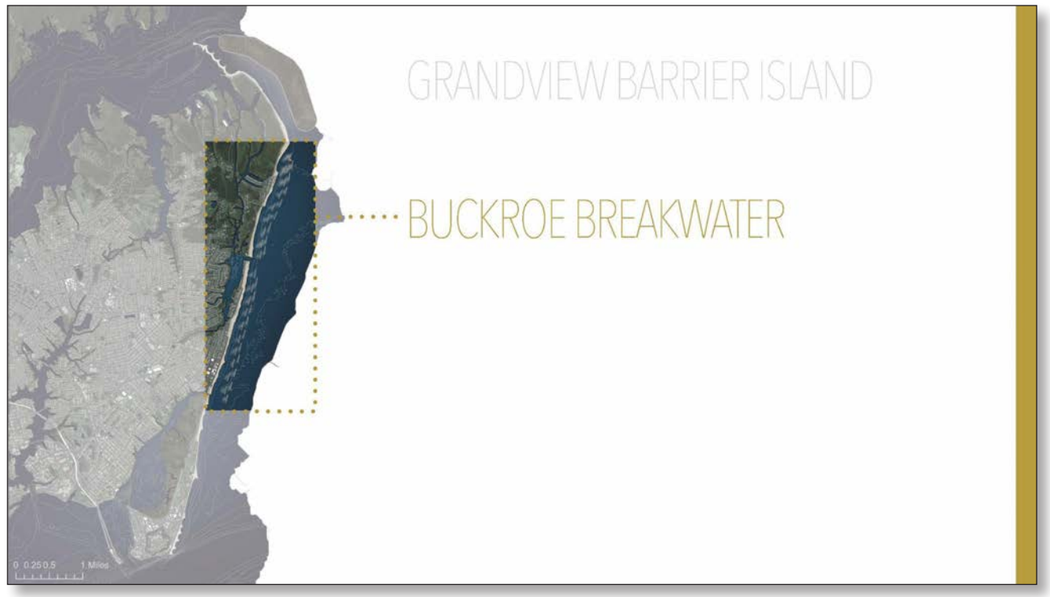
OUR PLAN

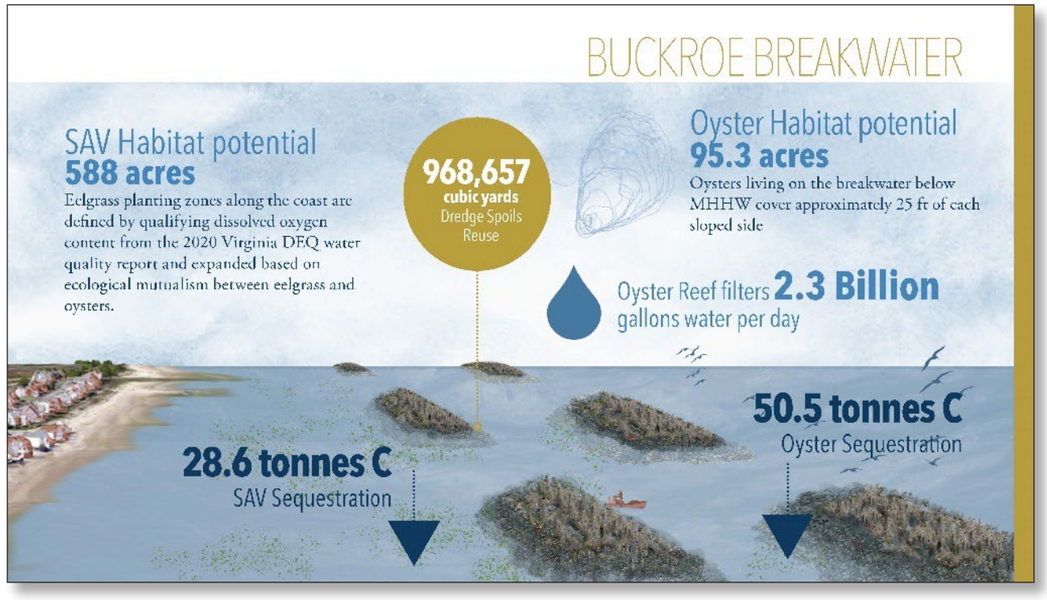
RESILIENT SELF-GENERATIVE INFRASTRUCTURE

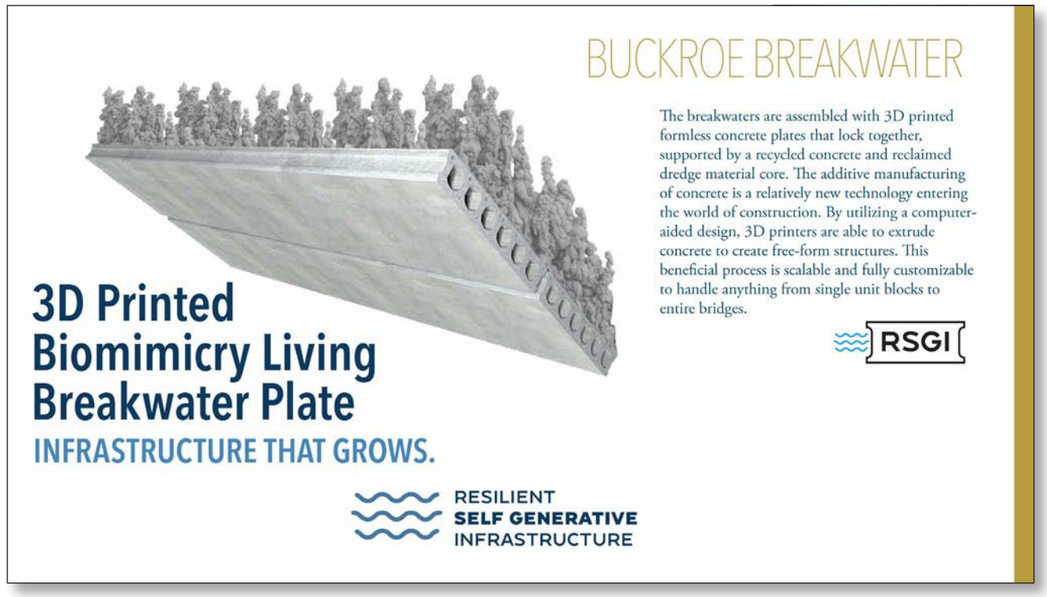
We propose four treatments along a 5.2 mile portion of Hampton's coastline. These resilient self-generative infrastructure treatments rely on ecological processes to protect the urban environment, sequester carbon, clean water, and generate carbon credits for the benefit of Hampton through the year 2100.

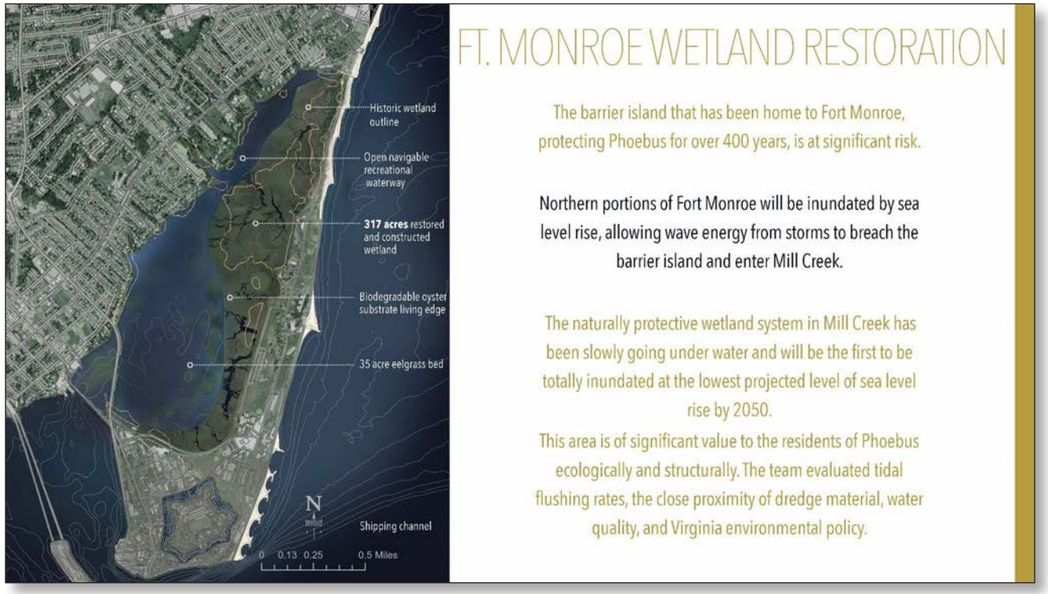
- *600 Acre Protective Barrier Island*
- *37 Living Oyster Reef Breakwaters and Seagrass Beds*
- *Restored and Constructed Wetland*
- *Citizen Driven Carbon Sequestration Program*


GRANDVIEW BARRIER ISLAND
29,044,444
cubic yards
Dredge Spoils
Reuse
Shoreline Restoration
200-300
million cubic yards dredged annually
20-30%
is reused for beneficial purposes
(NDT, 2003).
$40,081,333
in dredge storage savings
(Craney Island Dredged Material Management Area).
Phalacrocorax auritus
Haematopus palliatus
Pelecanus occidentalis
Ardea alba
Ardea herodias
Sand Dune
Littoral Zone
Coastal Shallows
Oyster Reef Breakwater
Forested Wetland
Grassed Wetland
Open Bay
Zostera marina
Centropristis striata
Crassostrea virginica
Cirripedia
Brevoortia tyrannus
Alosa aestivalis
Diadumene luecolena
Pogonias cromis
Micropogonius undulatus
541.35 tonnes C
Average Annual Carbon Sequestration Potential of Barrier Island


GRANDVIEW BARRIER ISLAND
BUCKROE BREAKWATER
0 0.25 0.5 1 Miles


BUCKROE BREAKWATER
SAV Habitat potential
588 acres
Eelgrass planting zones along the coast are defined by qualifying dissolved oxygen content from the 2020 Virginia DEQ water quality report and expanded based on ecological mutualism between eelgrass and oysters.
968,657
cubic yards
Dredge Spoils
Reuse
Oyster Habitat potential
95.3 acres
Oysters living on the breakwater below MHHW cover approximately 25 ft of each sloped side
Oyster Reef filters 2.3 Billion gallons water per day
28.6 tonnes C
SAV Sequestration
50.5 tonnes C
Oyster Sequestration


BUCKROE BREAKWATER
The breakwaters are assembled with 3D printed formless concrete plates that lock together, supported by a recycled concrete and reclaimed dredge material core. The additive manufacturing of concrete is a relatively new technology entering the world of construction. By utilizing a computer-aided design, 3D printers are able to extrude concrete to create free-form structures. This beneficial process is scalable and fully customizable to handle anything from single unit blocks to entire bridges.
RSGI
3D Printed
Biomimicry Living
Breakwater Plate
INFRASTRUCTURE THAT GROWS.
RESILIENT
SELF GENERATIVE
INFRASTRUCTURE



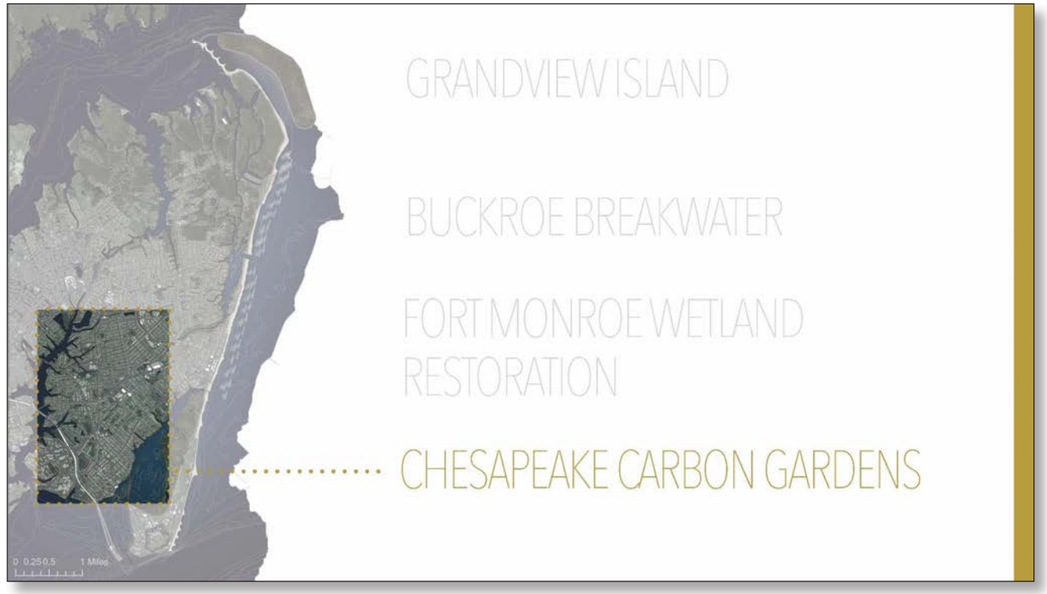
FT. MONROE WETLAND RESTORATION

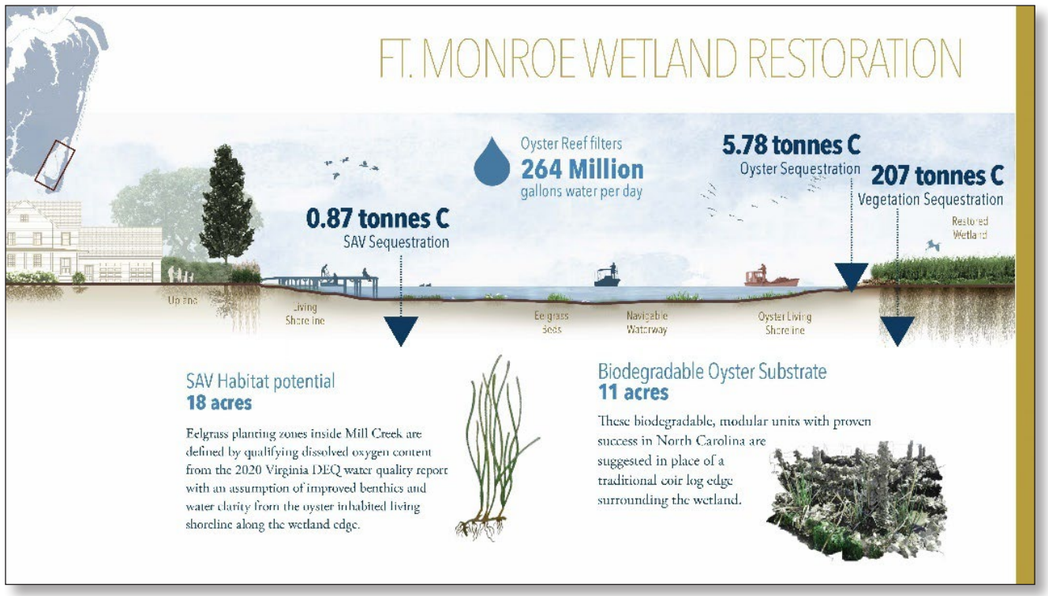
The barrier island that has been home to Fort Monroe, protecting Phoebus for over 400 years, is at significant risk.

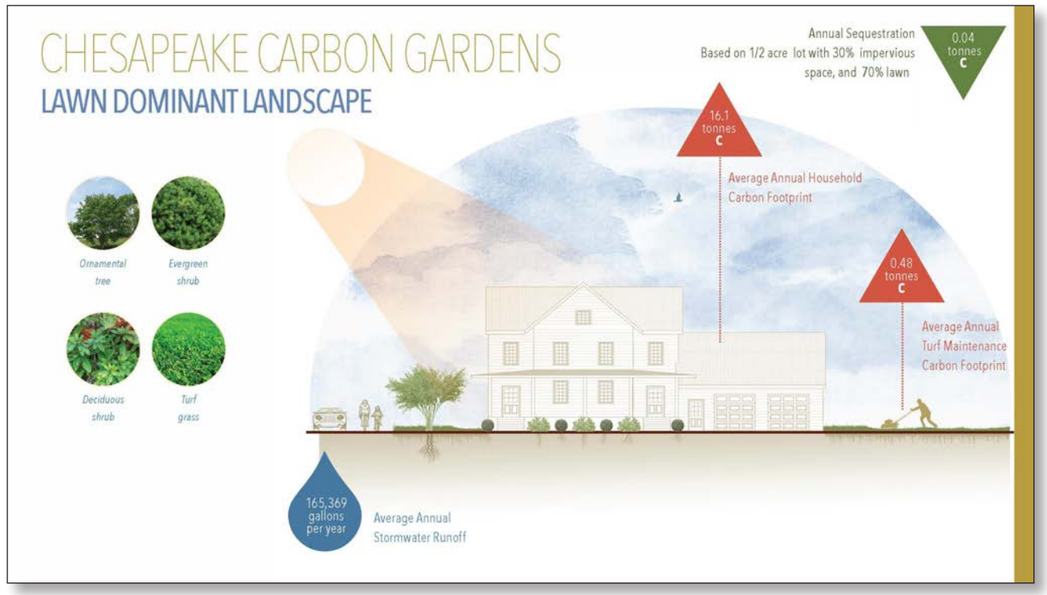
Northern portions of Fort Monroe will be inundated by sea level rise, allowing wave energy from storms to breach the barrier island and enter Mill Creek.

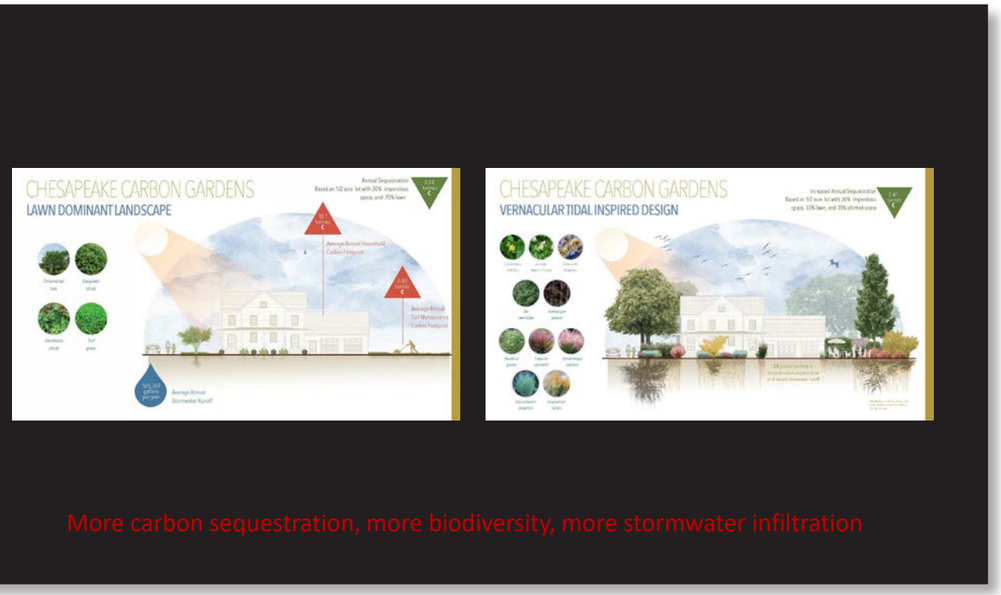
The naturally protective wetland system in Mill Creek has been slowly going under water and will be the first to be totally inundated at the lowest projected level of sea level rise by 2050.

This area is of significant value to the residents of Phoebus ecologically and structurally. The team evaluated tidal flushing rates, the close proximity of dredge material, water quality, and Virginia environmental policy.









More carbon sequestration, more biodiversity, more stormwater infiltration

CARBON SEQUESTRATION

1395 tonnes C

$.43\ tC \bullet ha^{-1} \bullet yr^{-1} \times (588\ ac / 247)ha = 102.34\ tC \bullet yr^{-1}$

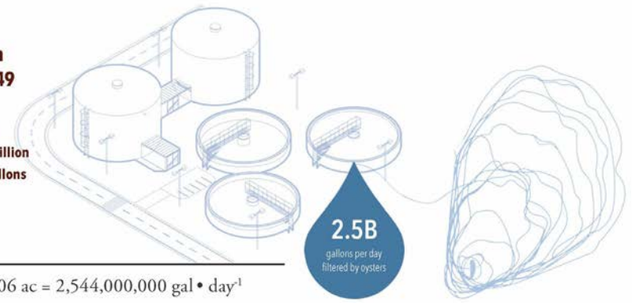
Intervention	Sequestration Rate	Area (acres)	Total Carbon Sequestered
Oysters - Breakwaters	131 gC m^{-2} yr^{-1}	95	50.53 tC yr^{-1}
Oysters - Ft. Monroe	131 gC m^{-2} yr^{-1}	11	5.78 tC yr^{-1}
Eelgrass - Coastal	0.12 gC m^{-2} yr^{-1}	588	28.60 tC yr^{-1}
Eelgrass - Ft. Monroe	0.12 gC m^{-2} yr^{-1}	18	0.87 tC yr^{-1}
Wetland - Ft. Monroe	161.8 gC m^{-2} yr^{-1}	317	207.64 tC
Wetland - Grandview	161.8 gC m^{-2} yr^{-1}	677	443.45 tC
C4 Veg - Barrier Island	2.66 tC ha^{-1} yr^{-1}	390	419.82 tC
Trees - Barrier Island	1.43 tC ha^{-1} yr^{-1}	210	121.53 tC
C4 Veg - C Gardens	2.66 tC ha^{-1} yr^{-1}	73.45	79.07 tC
C4 Veg - C Gardens	1.43 tC ha^{-1} yr^{-1}	39.55	22.89 tC yr^{-1}

Coastline protection that is regenerative and adaptive and harnesses the global carbon market as a financing tool.

WATER FILTRATION

The Hampton Roads Sanitation district has a total capacity of 249 million gallons per day, serving 1.7 million people.

The oyster reef breakwater design, with 4.15 million square feet of oysters, each one filtering 50 gallons per day, has the potential to clean 9.5 times more water.



24,000,000 gal • ac $^{-1}$ • day $^{-1}$ x 106 ac = 2,544,000,000 gal • day^{-1}

Project Zone	Area (acres)	Water Filtration Capacity	Total Water Filtration	
Breakwaters	95.00	24,000,000 gal ac $^{-1}$ day $^{-1}$	2,280,000,000 gal/day	832,200,000,000 gal/year
Ft. Monroe	11.00	24,000,000 gal ac $^{-1}$ day $^{-1}$	264,000,000 gal/day	93,360,000,000 gal/year

Exploring the Potential of Self-Generative Infrastructure for Coastal Resilience in the Hampton Roads Region and at Joint Base Langley-Eustis

A multi-faceted project that will:

- study nature-based coastal defense solutions,
- measure and model current conditions, and
- perform site analysis and community engagement

to better understand innovative materials and deliver a comprehensive resilience master plan for Joint Base Langley-Eustis and surrounding areas.

Student Awards – *Carbon in the Tidewater*

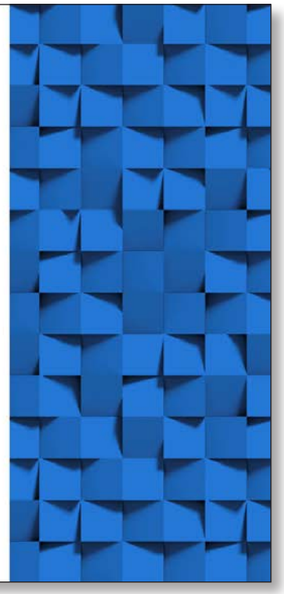
2021: Coastal and Estuarine Research Federation (CERF) First Place in Student Design Competition

2022: ASLA PA/DE Honor Award in Collaboration

2022: ASLA Award of Excellence in Collaboration

Year 1 – Summer 2023

- Complete a thorough analysis of prior plans and existing conditions to identify which sub-regions around JBLE and adjacent areas are most appropriate for various types of NBS.
- Develop a resilience baseline and metrics to determine success above the baseline.
- Define threats and opportunities at JBLE and adjacent communities and engage in stakeholder engagement processes to verify assumptions.



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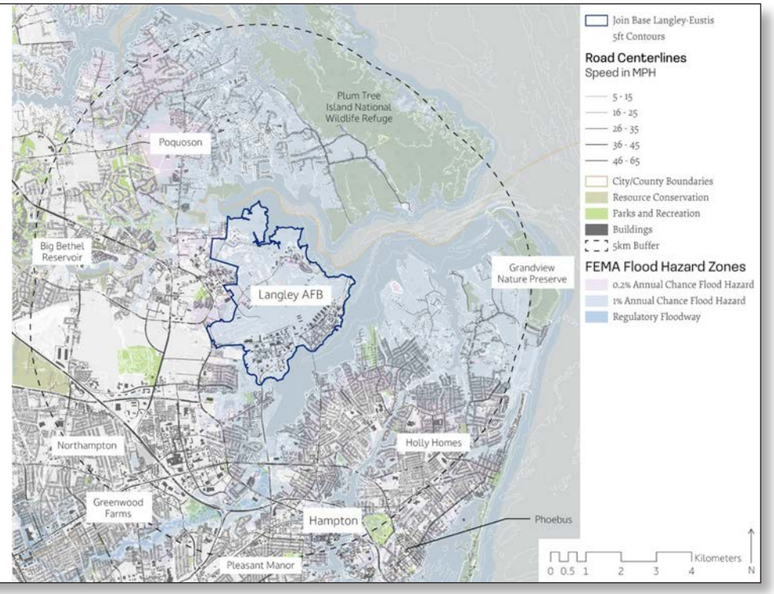
Site Overview

- Analyzing a 5km buffer from Langley Air Force Base
- **Many** homes are located within the 100-year FEMA flood zone
- The **majority** of Langley AFB is within the 100-year flood zone



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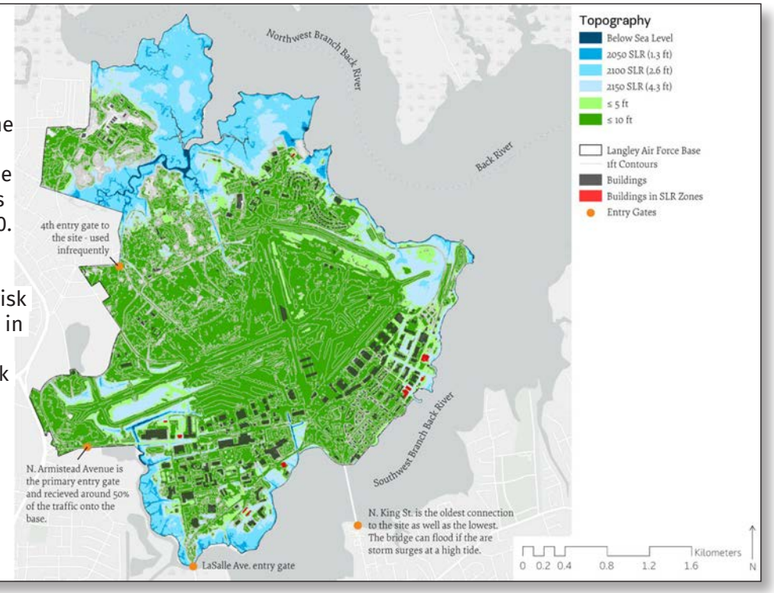
Topography on the Base

- The blue areas show the areas of the site at or below sea level, and the sea level rise estimates for 2050, 2100, and 2150.
- The green shows the areas ≤ 5 ft and ≤ 10 ft.
- Sea level rise poses a risk to the buildings shown in red.
- The orange circles mark the entry gates to the base.



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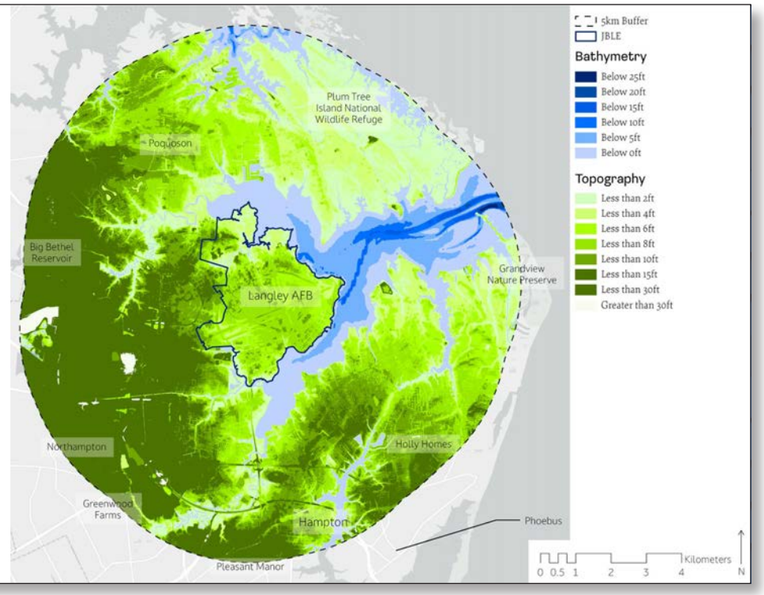
Topography and Bathymetry

- Majority of JBLE is less than 8 ft above sea level, leaving the site exposed to sea level rise and storm surge.
- Many of the adjacent communities are also at high risk of sea level rise and storm surge.



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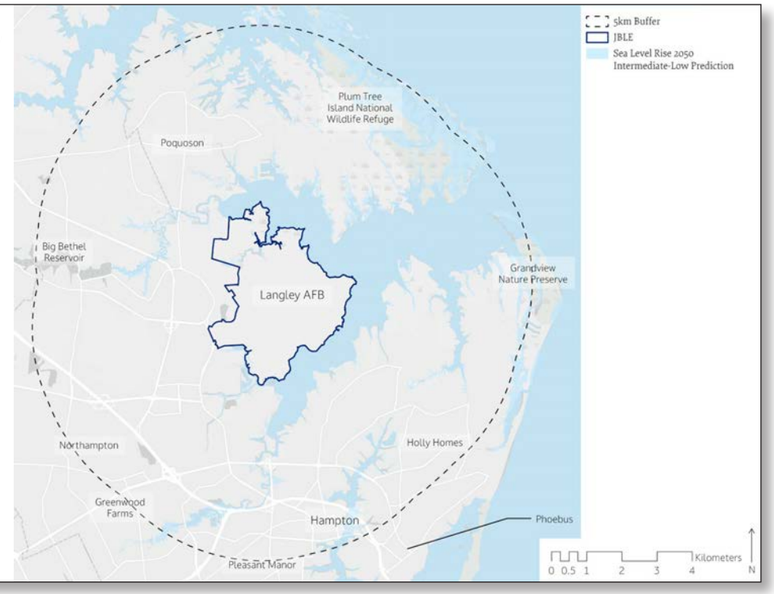
Sea Level Rise

2050 Intermediate-Low Prediction

The intermediate-low SLR prediction for 2050 is 0.4m.
Around 33 structures are within 0.4m of SLR - most appear to be on the water.

The relative sea level rise rate in the Hampton Roads region is 4.7mm/year. More than half of this is estimated to be from vertical land movement, with a rate of around 2.9mm/year (NOAA 2022 Sea Level Rise Report).



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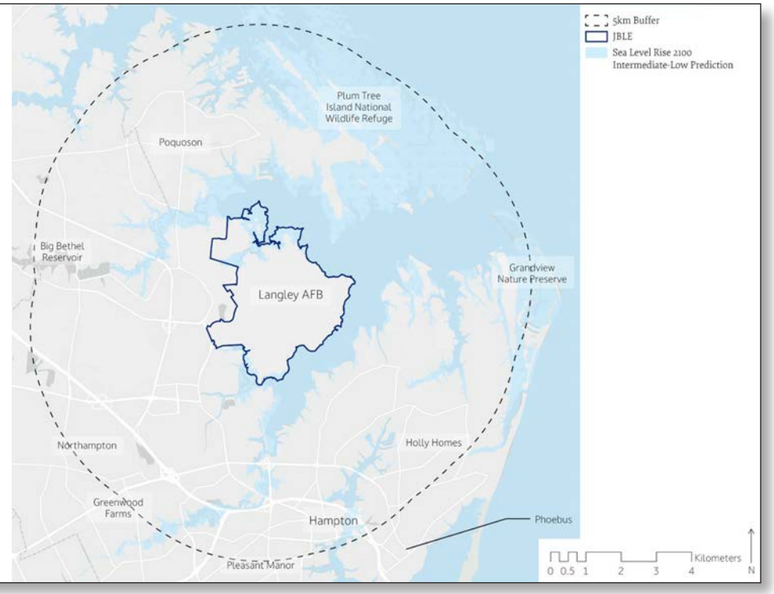
Sea Level Rise

2100 Intermediate-Low Prediction

The intermediate-low SLR prediction for 2100 is 0.8m. Around 44 structures are within 0.8m of SLR - as with the 2050 SLR estimate, most of the structures appear to be on the water.

Hampton Roads is second only to New Orleans as the country's largest population center at risk from SLR (Virginia's Sea Level Is Rising).



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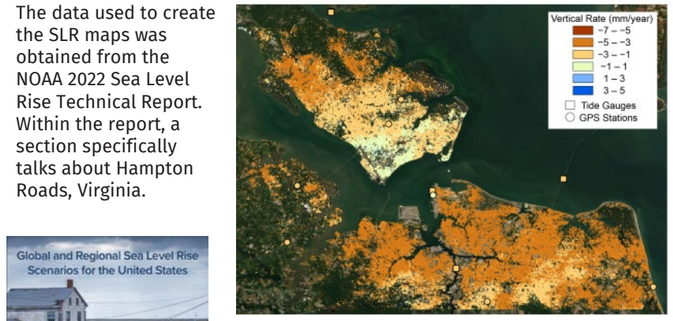
NOAA 2022 Sea Level Rise Technical Report

The data used to create the SLR maps was obtained from the NOAA 2022 Sea Level Rise Technical Report. Within the report, a section specifically talks about Hampton Roads, Virginia.



Hampton Roads, Virginia

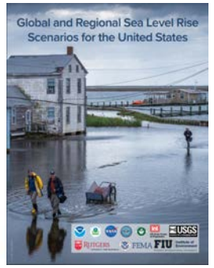
The historical long-term linear RSL rise rate at the Sewells Point, Virginia, tide gauge[44] is about 4.7 mm/year. More than half of this rate is estimated to be from downward VLM or subsidence with a rate of about 2.9 mm/year, which is close to previous estimates (Zervas, 2013; Kopp et al., 2014; Sweet et al., 2017). This subsidence is driven by both GIA and more localized groundwater withdrawal. If assumed to be linear and persistent into the future, VLM will contribute about 0.29 m to projections of RSL over the next 100 years. For example, by 2050 under the Intermediate-Low and Intermediate scenarios, the amount of RSL rise is projected to be between about 0.4 m and 0.45 m, respectively, with about 35% and 30% of that rise amount respectively, from VLM.

However, VLM rates across the Hampton Roads region are not uniform. A past study (Eggleston and Pope, 2013) leveraged a variety of in situ observations to find a spatially varying pattern of subsidence ranging from 1.8 to 4.4 mm/year in the region from 1940 to 1971. The variations were connected to groundwater withdrawal in the region, which was captured via this assessment even with an effective spatial resolution on the order of tens of kilometers. More recently, InSAR rate maps have shown a range of subsidence from

[44] https://tidesandcurrents.noaa.gov/stationhome.html?id=8638610

Global and Regional Sea Level Rise Scenarios for the United States | 57

about 1 mm to 5 mm/year in the region over the time period from 2014 to present, with locally higher rates (Figure 4.9; Buzzanga et al., 2020). Importantly, the satellite-based assessment revealed spatial variations on sub-kilometer scales, with some of the most prominent features in the spatial map connected to specific construction projects and land-use changes. With an average rate of subsidence around 3 mm/year over the course of the 21st century, VLM could contribute about 0.3 m to projected RSL, with locally higher amounts elsewhere in the region. Furthermore, comparing the InSAR-derived spatial pattern of VLM to that in either Eggleston and Pope (2013) or the gridded rates in this report provides important information about the linearity of VLM and the timescales on which VLM varies. There are considerable differences between the different assessments, indicating a shift in rates over the time periods considered. While it is necessary to consider the uncertainty in the VLM rate estimates and differences in measurement type, users of VLM information should assess land-use changes over the time periods considered along with the relevant processes driving VLM in the region. InSAR-derived VLM maps will play an increasingly key role in this assessment due to the spatial coverage and resolution provided by the satellites.



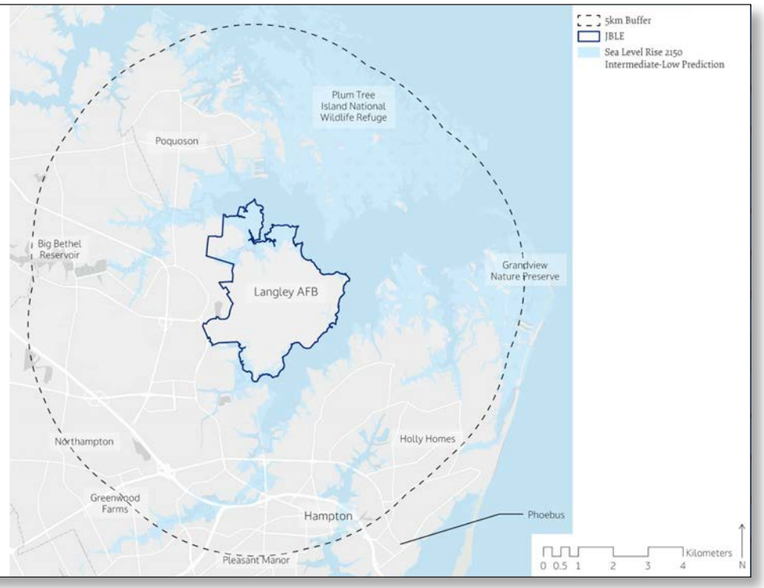
This map shows the rate of vertical land movement each year. An area on the base is experiencing around 3-5 mm of downward movement each year.

Link to Report

Sea Level Rise

2150 Intermediate-Low Prediction

The intermediate-low SLR prediction for 2150 is 1.3m.
Around 775 structures are within the 2150 prediction for SLR.
Between 2100 and 2150, SLR will start severely impacting the region.



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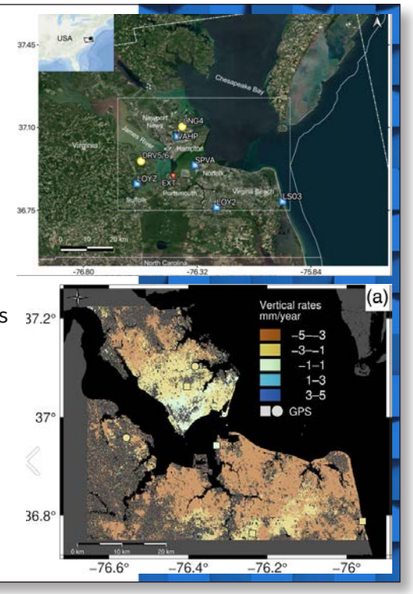
Toward Sustained Monitoring of Subsidence at the Coast using InSAR and GPS: An application in Hampton Roads, Virginia

- Hampton Roads region is experiencing high rates of relative sea level rise (RSLR) due to land subsidence.
- Groundwater extraction of ~150 million gallons per day leads to aquifer compaction and regional subsidence.
- Glacial isostatic adjustment (GIA) is also contributing to subsidence.
- Anthropogenic activities cause spatial variability in land subsidence, impacting RSLR.



Library Paper

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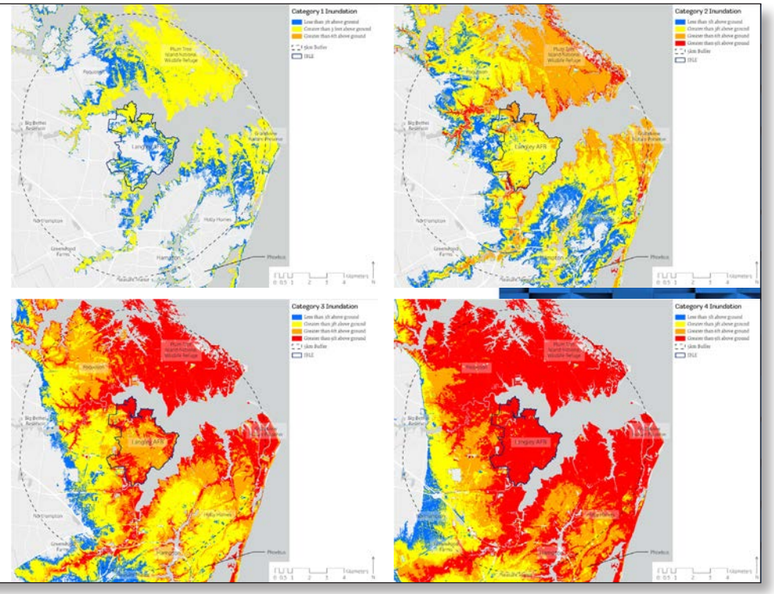
Storm Surge

One of our goals is to establish a Resilience Baseline, and we are currently researching existing tools that assess coastal community resilience and looking at LEED and SITES rating systems.
The main goal of our site analysis will be to identify the threats to the area and then calculate the probability of the events associated with these threats occurring.



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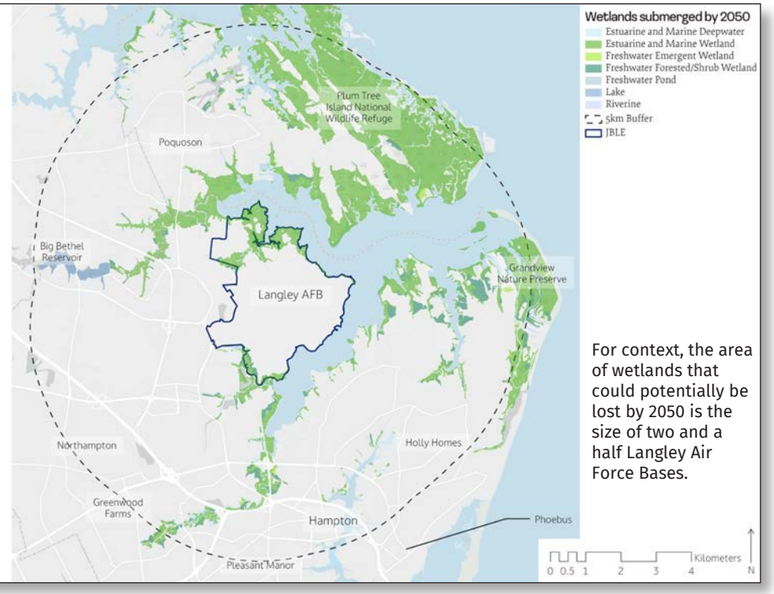
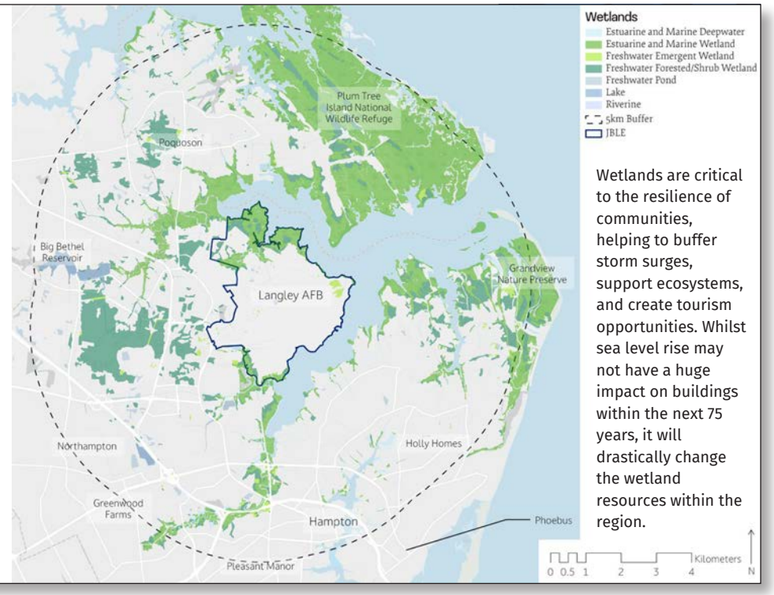
Wetlands Submerged by 2050



For context, the area of wetlands that could potentially be lost by 2050 is the size of two and a half Langley Air Force Bases.

Wetlands



Wetlands are critical to the resilience of communities, helping to buffer storm surges, support ecosystems, and create tourism opportunities. Whilst sea level rise may not have a huge impact on buildings within the next 75 years, it will drastically change the wetland resources within the region.

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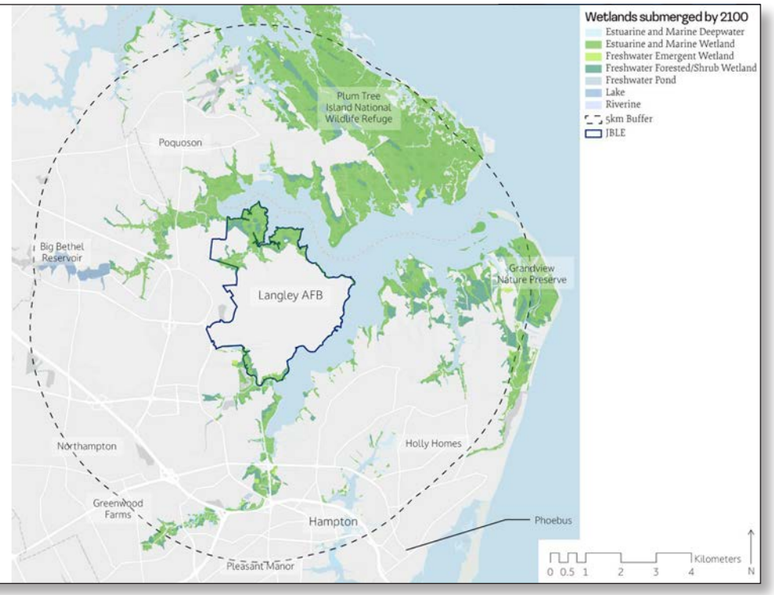
Wetlands Submerged by 2100



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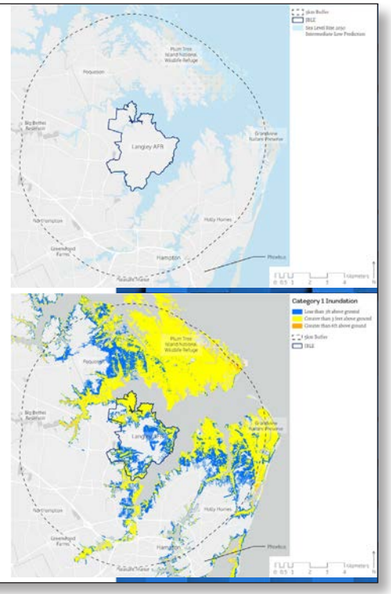
Climate Related Threats to the Site and the Adjacent Community

To establish a Resilience Baseline we first need to understand the threats to the site.
Current Threats

- SLR
- Flooding
- Storm Surge
- Drought
- Heat Island Effect
- Pollution (Air and Water)

We would then estimate the likelihood of each threat occurring.

The purpose of developing a Resilience Baseline is so monitoring and assessment can be done to quantify how any work implemented improves the area's resilience.
It would also be beneficial to compile environmental and socioeconomic data that can help assess improved community resilience.

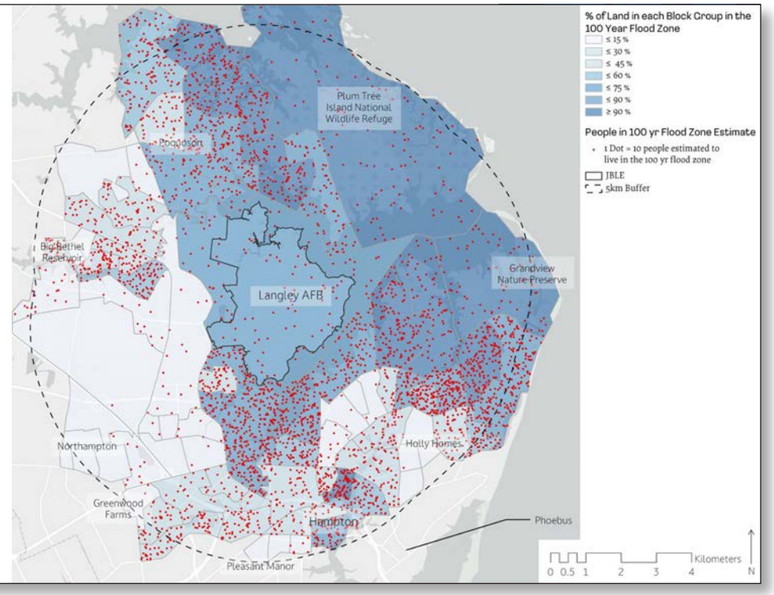


Priority
Restoration
Areas

This graphic was developed after the October 2021 stakeholder meeting. It shows the six priority restoration areas for future consideration.
With our site analysis, we aim to identify adjacent communities that could benefit from the addition of NbS that could also benefit Langley AFB.

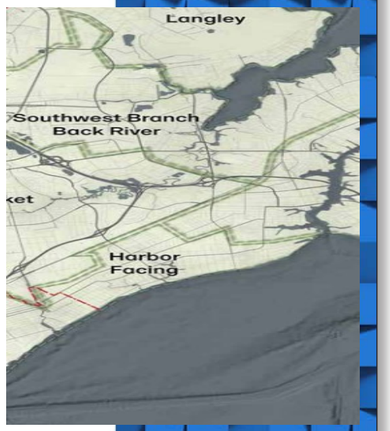
Threats to
Social Factors

We need to understand how the threats to this area could impact social, economic, and environmental factors.
This map uses Census Block Groups to calculate the percentage of land within each block group within the 100-year flood zone.
The red dots estimate the number of people per block group living within the 100-year flood zone (1 dot = 10 people).



Living with Water Hampton: A Holistic Approach to Addressing Sea Level Rise and Resiliency - Phase 1

Understanding the interaction between different layered systems is crucial for effective planning and design.
Extensive research and mapping are required to comprehend the site's current and future water interactions, along with knowledge of the soils.
Most soils in the Hampton area are hydric, leading to quick flooding during rainy periods, necessitating the design of water storage solutions.
Designing for periodic and permanent inundation is important, suggesting the need for water storage options like retention basins or constructed wetlands.
Community resilience should be prioritized by considering the unique characteristics of each neighborhood in the design process.
Collaboration and coordination with surrounding communities are essential to develop cohesive solutions and avoid mismatched systems.
The heat island effect is a concern, and increasing the tree canopy in the area is recommended to mitigate its impact.
Considering the long-term effects of global warming, addressing the heat island effect should be a part of the proposed master plan.

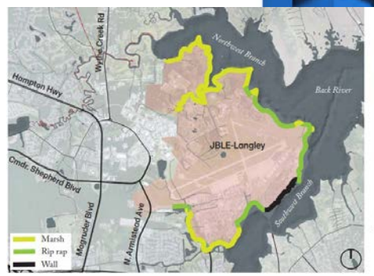


Link to Report

Hampton-Langley Air Force Base Joint Land Use Study Addendum: Resiliency and Adaptation

Snow and freezing currently threaten access points at JBLE, leading to closures, but future threats from sea level rise, land subsidence, and storm surge will be more significant.
Historic buildings on the site are at risk from flooding, but measures such as door dams and elevation of vulnerable elements have been implemented successfully.
Developing a stormwater management plan is essential and should be a vital component of the master plan.
Sea level rise threatens two access points, and relocation of the most used access point and underground utilities are being considered.
Ferry access to the site is also suggested in the report, with a potential route indicated on a map.
Establishing a resilient transportation network around the base is crucial, and promoting alternative transportation methods could reduce traffic congestion and CO2 emissions.
Restoration of tidal wetlands and strengthening ecological edges are essential considerations in the master plan.

- Further mapping should be conducted to assess the condition of the edges of the base.
- Analysis is needed to determine possibilities for aquaculture in the river and assess water quality in the area.
- Rezoning parcels and acquiring available ones for JBLE-Langley ownership is recommended, especially in potential accident zones, as shown on the maps in the report.



Above:
NASA's campus occupies the remainder of the peninsula that is shared with JBLE-Langley. The boundary of NASA has more roadway frontage, but only two primary entry gates, represented as green circles.

Left:
The range of edge conditions where JBLE-Langley meets the water varies, from concrete walls and marinas to rip rap to marsh and open wetlands. These edge types will help identify where to locate future projects.

Link to Report

Initial Design Thoughts

- Need to aim to increase green space in the area (pervious land cover)
- Many homes are within the 100 year flood zone - our focus needs to be on reducing the number of people at risk
- Large areas of wetlands are a risk of being lost by 2050 - work needs to be done to elevate the wetlands or look at pathways for wetland retreat
- The adjacent communities along the Southwest and Northwest Branch Back River have a high number of people potentially living in the 100 year flood zone
  - Focusing our analysis in these areas could see solutions implemented that benefit Langley AFB and the adjacent communities along the river.

UF College of Design, Construction and Planning

Developing Engineering practices using Ecosystem Design Solutions for Future Army

DEEDS

Building Coastal Community Resilience with Nature-based Shoreline Solutions

YEAR 1/4

LSU ERDC

OUR TEAM

Jules Bruck (PI, UF)
Chair & Professor of Landscape Architecture

Jack Puleo (PI, UD)
Chair and Professor, Civil & Environmental Engineering

Amy Slocum, UD
Project Manager
Delaware Environmental Institute

Ecological Connectivity

Ed Hale
(Co-PI, UD)
Assistant Professor of Marine Science and Policy

Danielle Kreeger
(Co-PI, PDE)
Senior Science Director
Shellfish & Wetland Ecologist

Josh Moody
(Co-PI, PDE)
Restoration Manager
Ecology and Geospatial Sciences, Environmental Sciences

Coastal Forcing

Manoj Gangadharan
(UD)
Civil Engineering

Infrastructure Systems

Monique Head
(Co-PI, UD)
Associate Professor, Civil and Environmental Engineering

Eric Bardenhagen
(Co-PI, UD)
Director & Associate Professor of Landscape Architecture

Yao Hu (Co-PI, UD)
Assistant Professor
Geography and Spatial Sciences

Purpose

- To collaboratively explore coastline suitability for enhanced living shoreline technologies while also addressing the associated physical and social infrastructure and land use patterns that may threaten natural and restored ecosystems.

Goal

- To determine appropriate wetland locations for shellfish enhanced nature-based (NB) living shorelines (LS) along the coast in the Delaware and Inland Bays Estuaries as well as one site in the northern Chesapeake Bay.

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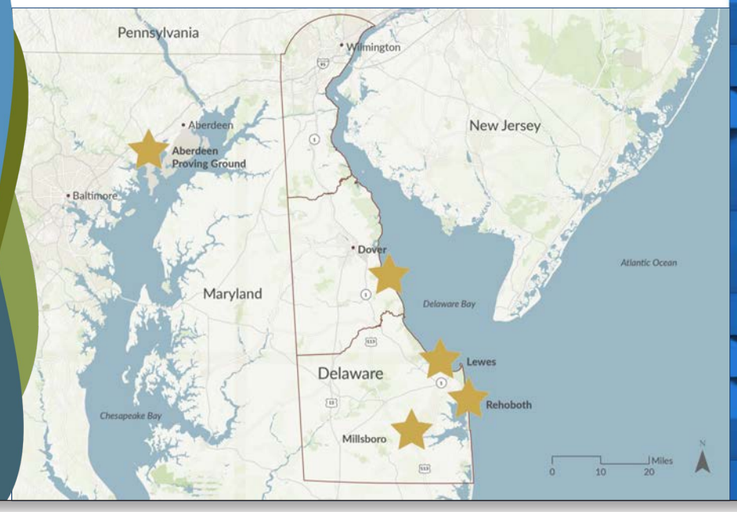
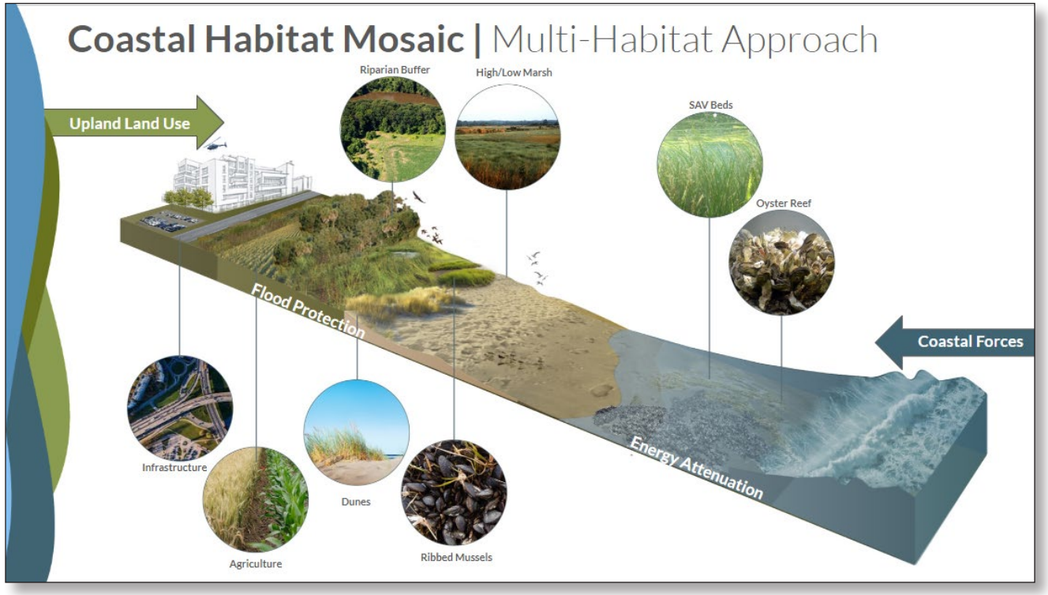
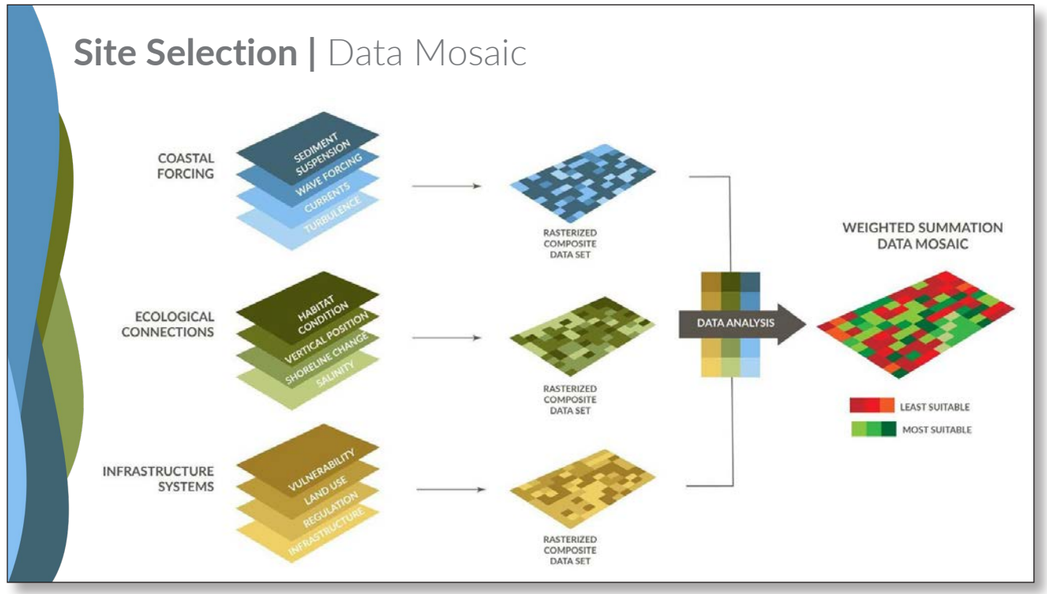
Initial Areas of Interest | Coastal Communities

Initial Areas of Interest | Coastal Defense + Vulnerability



Initial Areas of Interest | Aberdeen Proving Ground





Infrastructural Systems | Social+ Natural

Leads

Jules Bruck, (UF)

Eric Bardenhagen (UD)

Yao Hu (UD)

Zachary Hammaker, (UD)

Martha Ryan, PhD Student

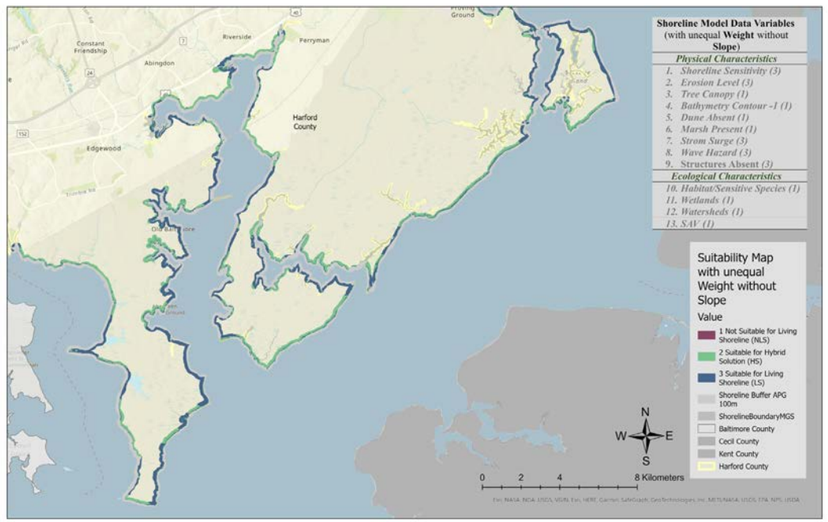
Leigh Muldrow, PhD Student

Research Questions

- What design and planning tools will enable communities to implement NNBF adaptation strategies informed by future land-use and agent-based modeling?
- What ecosystem services and benefits are provided by mosaic shellfish-enhanced living shorelines that will encourage social and political adoption of nature-based coastal resilience design?
- How can NNBF be designed to provide social, cultural and economic value to nearby communities?

Transdisciplinary approach to considering coastal edge conditions and future scenarios. Increase utility of proposed plans and models by following a participatory approach with involvement from stakeholders to verify assumptions.

Stakeholder engagement, assessment of risk and vulnerability, and future scenario planning



Site Suitability Map for Living Shoreline at Aberdeen Proven Ground Maryland - DEED Project

Research question

How can living shoreline solutions be modeled in land cover forecasts to better assess their impacts on future water quality at DEEDs study sites?

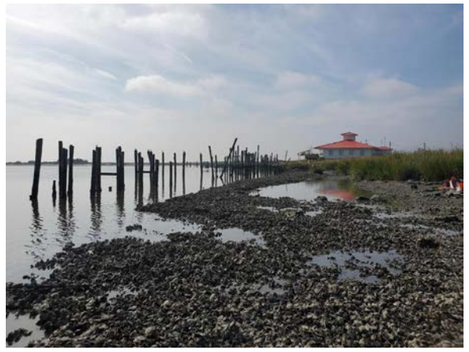


Photo of living shoreline with oyster beds at Mispillion in southeastern Delaware in 2021.

Additional Modeling of Ecosystem Services includes:

InVEST Blue Carbon model quantifies the value of carbon storage and sequestration services provided by coastal ecosystems.

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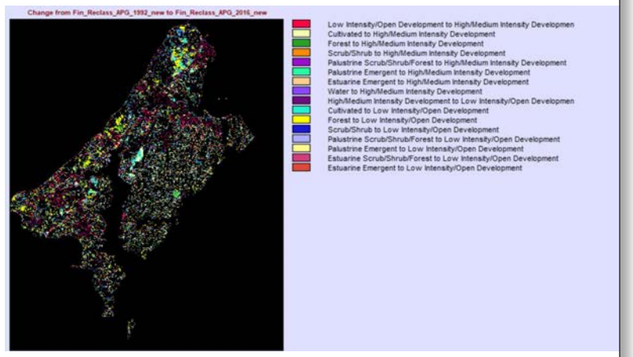
Preliminary Results APG: Analysis of Land Cover Change over time

- Expansion of urban development
  - Forest loss
  - Palustrine wetland loss
- Palustrine emergent to scrub
- Estuarine forest to emergent



All land cover transitions that occurred at APG between 1992 and 2016.

THANK YOU

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Accelerating Science & Technology Innovation to Improve Coastal Health and Resilience, Christine Angelini, PhD, Director, Center for Coastal Solutions and Associate Professor in Environmental

Overview

Mission: Advance science & technologies that support more effective, efficient decision-making to improve coastal health and human well-being

Programmatic Areas:

1. Nature-Based Solutions for Coastal Resilience*
2. Integrated Watershed-to-Ocean Solutions for Coastal Water Quality Challenges
3. Coastal Policy Lab

Specialized Expertise:

Oceanography, hydrology, ecology, biogeochemistry, geotechnical engineering, numerical & physical modeling, computer science (AI, machine learning)

- 55+ Affiliate Faculty from 10 colleges
- >40 Current students associated with core projects
- 13 Full-time staff

2

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Capabilities: Field Lab & Technical Support Team

5 field techs + 8 research/support staff
Truck & Watercraft Fleet
Scientific divers + dive gear

Hydrodynamics

- ADCP/ADV/CTDs/DO sensor/etc
- Long-term to transect experiments

Ecology & Biogeochemistry

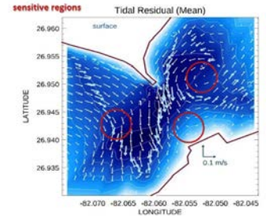
- Sub-tidal – corals/seagrass
- Intertidal – marshes, mangroves, oysters, dune

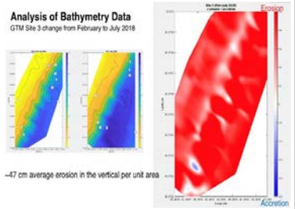
Geospatial Monitoring

- LiDAR, UAVs, RTK GPS, Bathydrone

Geotechnical Engineering

Earth System Models/ AI/ Data Science





3

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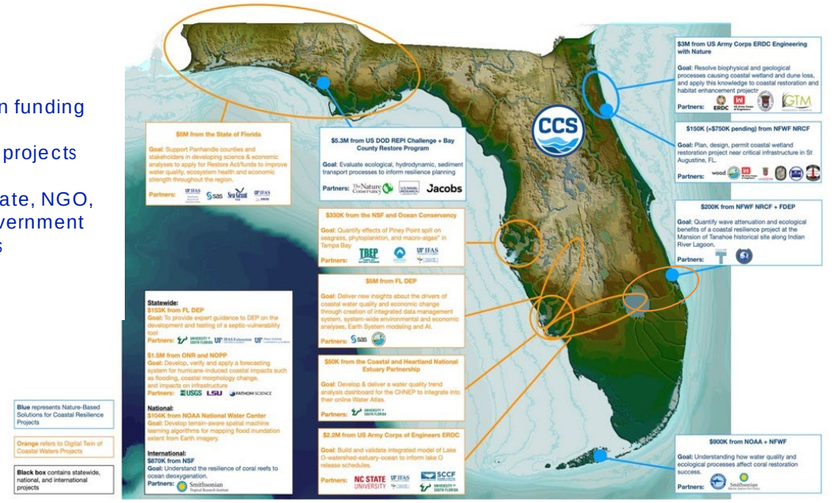
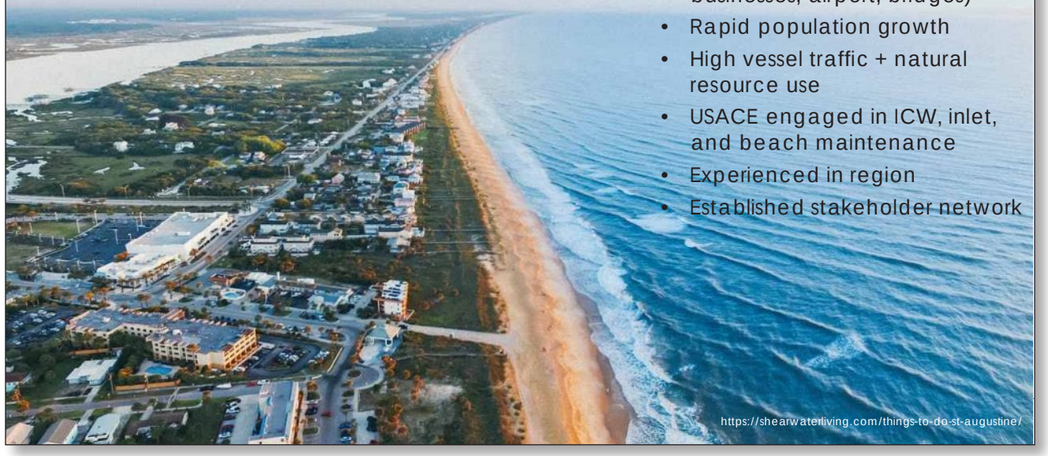
CCS Projects: 2021 to Present

- >$23M in funding
- 15 core projects
- 30+ private, NGO, and government partners

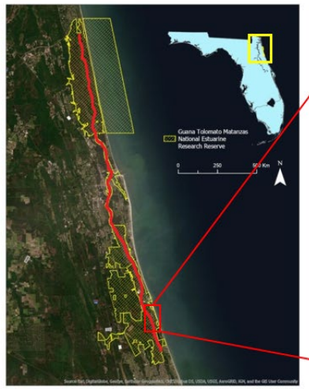


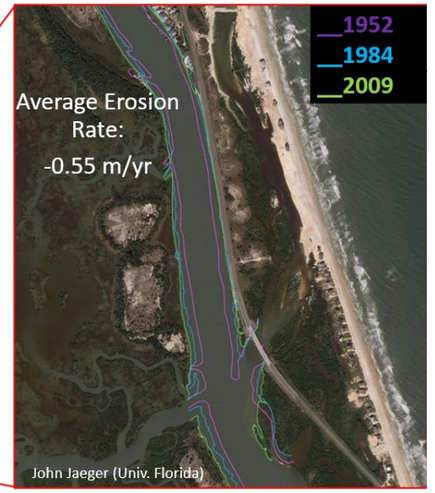
Focal EWN Project Region: Northeast Florida



- Significant dune and wetland erosion challenges
- High infrastructure vulnerability to SLR and storms (roads, homes, businesses, airport, bridges)
- Rapid population growth
- High vessel traffic + natural resource use
- USACE engaged in ICW, inlet, and beach maintenance
- Experienced in region
- Established stakeholder network

Shoreline Change in Northeast Florida





7

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6

Many living shoreline designs fail

8

Research & Management Collaboration

NERR Science Collaborative

FWC MEHRMA

9

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Dutch help us build brush-field groins along Florida's Intracoastal Waterway

11

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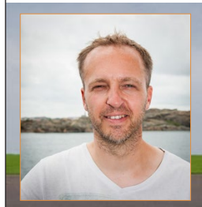
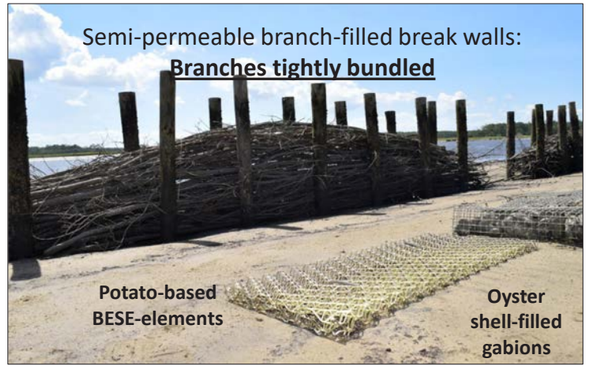


Tjisse Van Der Heide
University of Groningen
NIOZ

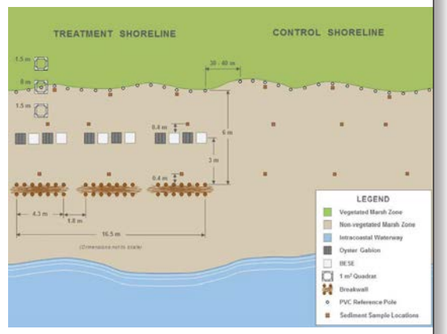
Groins have been used for hundreds of years to build marshes along high energy Dutch coastlines, protecting levees and supporting land reclamation

https://www.dutchwatersector.com/news/coastal-salt-marshes-as-flood-fighters

GTM NERR project



Safak et al 2020, Ecological Engineering



Paired living shoreline & unmanipulated controls at **6 sites** (1 pilot) of varying channel width
1 year pre-treatment + 2 year of post-treatment monitoring

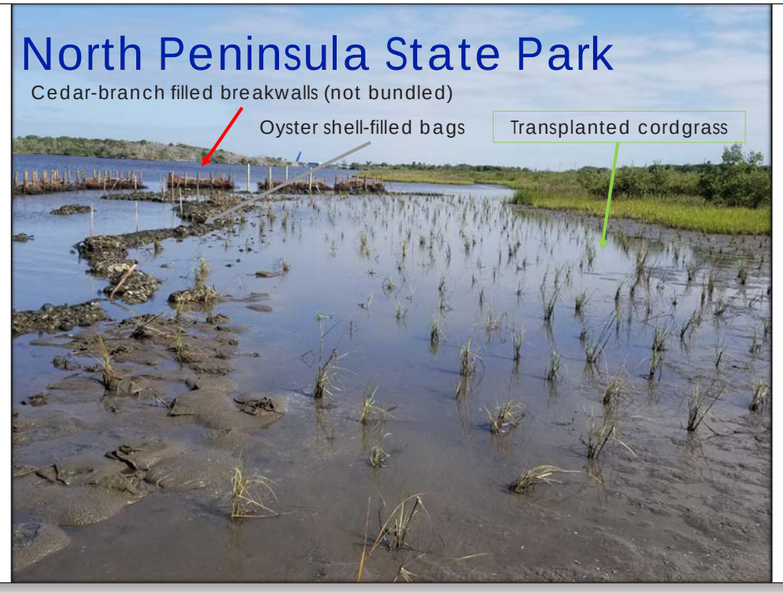
12

North Peninsula State Park

Cedar-branch filled breakwalls (not bundled)

Oyster shell-filled bags

Transplanted cordgrass



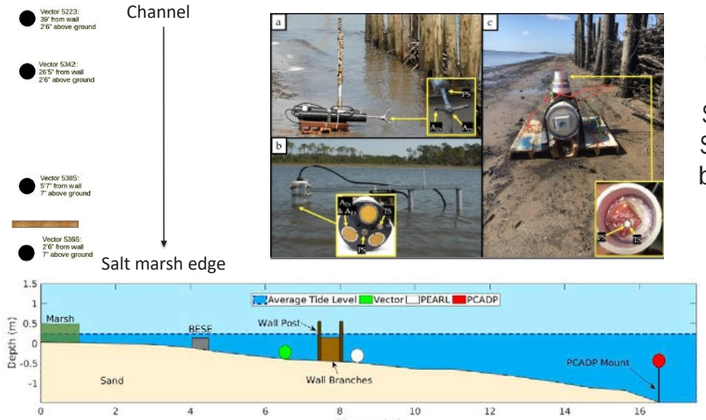
North Peninsula State Park

GTM breakwall	NP breakwall
- tree branches bundled	- tree branches not bundled
- porosity estimate of ~0.7	- porosity estimate of ~0.9

Are these features actually dissipating wakes and supporting marsh and oyster recovery?

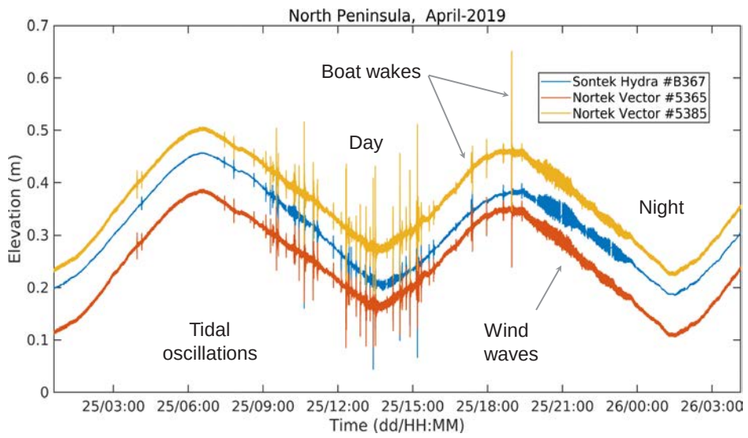
Assess Boat Wake Climate & Breakwall Dissipation

Offshore to onshore array of high frequency sensors deployed to: (1) capture wake propagation and shoaling, and (2) assess general hydrodynamics (e.g. currents, tides)



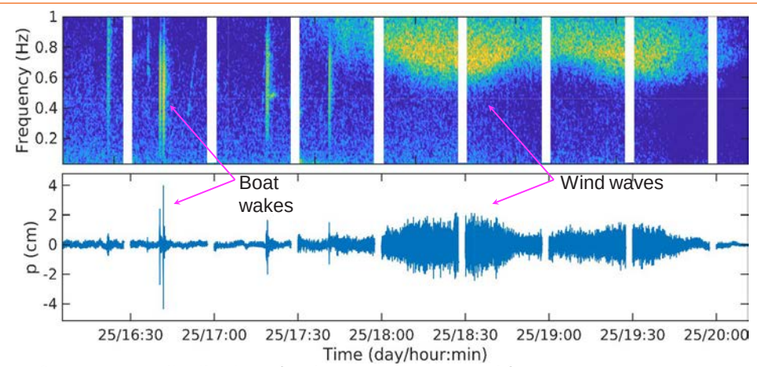
Research led by Dr. Alex Sheremet & Ilgar Safak, supported by FWC,SJRWMD, FDEP APs, GTM NERR

What do we see in the data? LOTS of boat wakes



18

Time-frequency analysis (spectrogram) of pressure records



Spectrogram: distribution of wake energy in time and frequency;
Wind waves energy is distributed in a relatively narrow frequency band;
Wakes are chirps: frequency increases in time, from 0.07 Hz < f < 1 Hz

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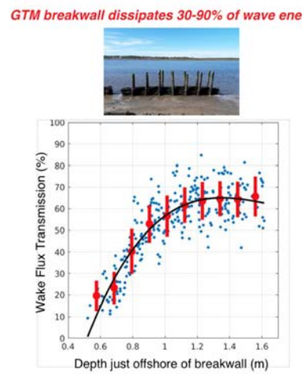
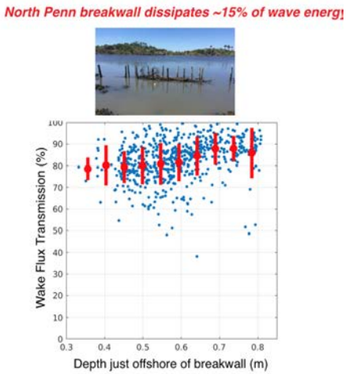
Breakwall Dissipate More Energy at GTMNERR and Are Less Effective at High Tide

GTM breakwall dissipates 30-90% of wave energy



North Penn breakwall dissipates ~15% of wave energy



** Findings are summarized in Safak, I., Angelini, C., Sheremet, A., Norby, P., Dix, N., Rodenberry, A., Herbert, D., Astrom, E., Wave transmission through living shorelines (in prep. For Ecologocial Engineering)*

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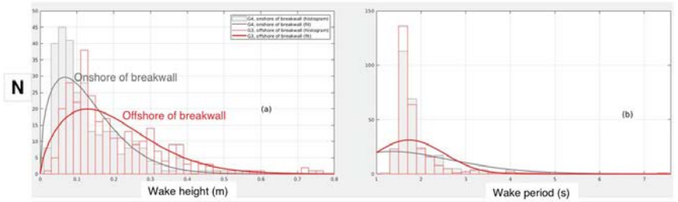
Breakwalls reduce wake height and lengthen wake period

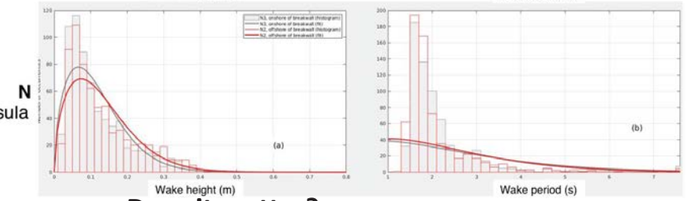
GTM (3/29–4/10 2019):
290 wakes, ~23 w/10 hr

GTM



N. Pen. (4/23–5/9 2019):
673 wakes, ~40 w/10 hr

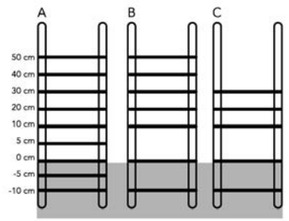
North Peninsula



Does it matter?

Conclusions

- Industrial entities must build breakwalls – *students + volunteers can't make sturdy structures*
- Shipworms can be prolific and undermine structural integrity/durability
- Modest wake dissipation can stabilize sediment & stimulate plant & oyster re-establishment
- Field observations provide powerful insights to wave/wake climate that can guide navigation channel & shoreline management



Berzosa et al. 2019 Ecological Engineering

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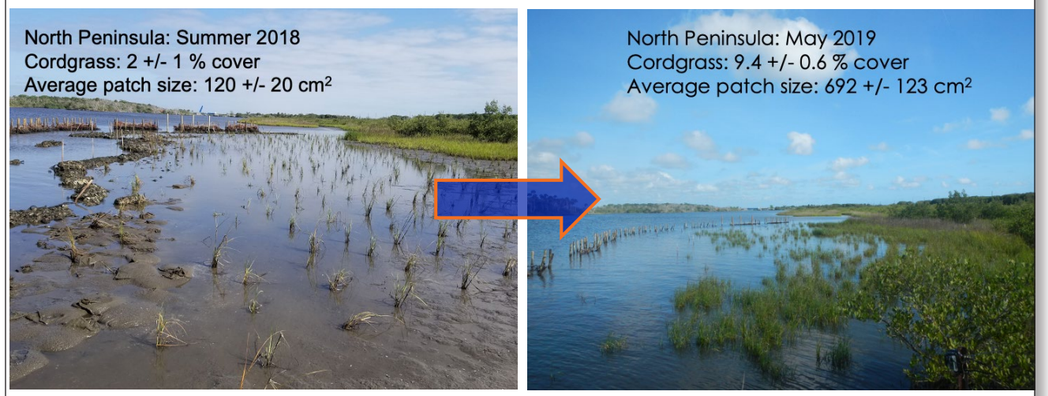
Plants Grow Well Behind Breakwalls; Sediment Accumulates; Oysters settle



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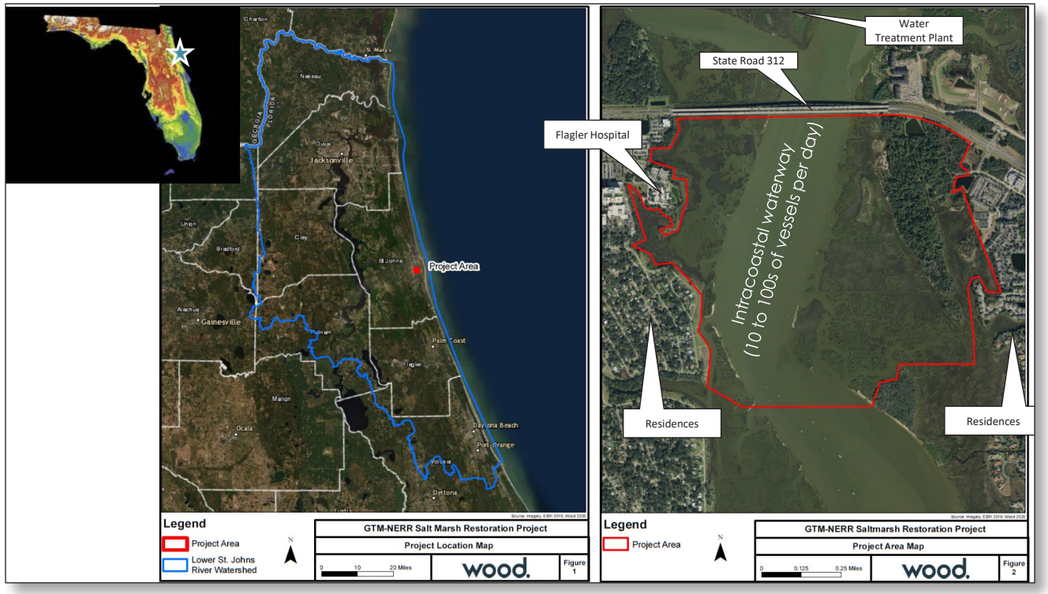
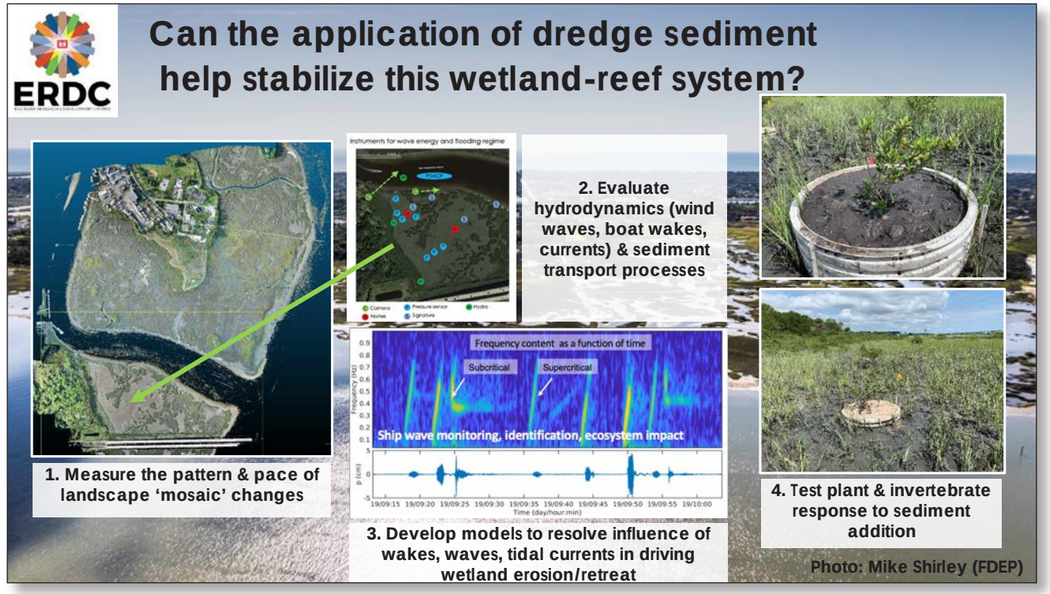
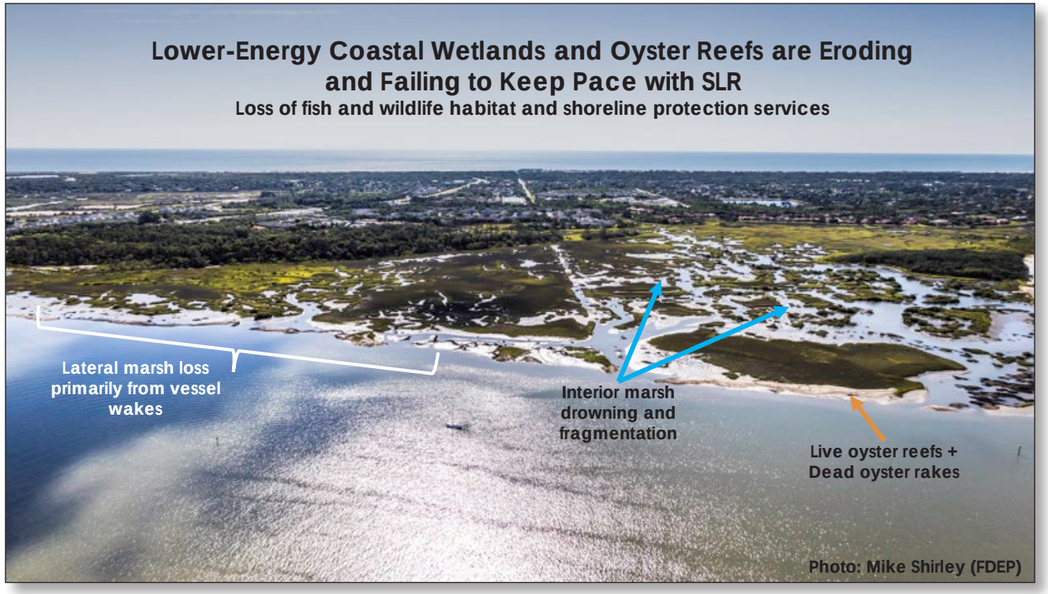
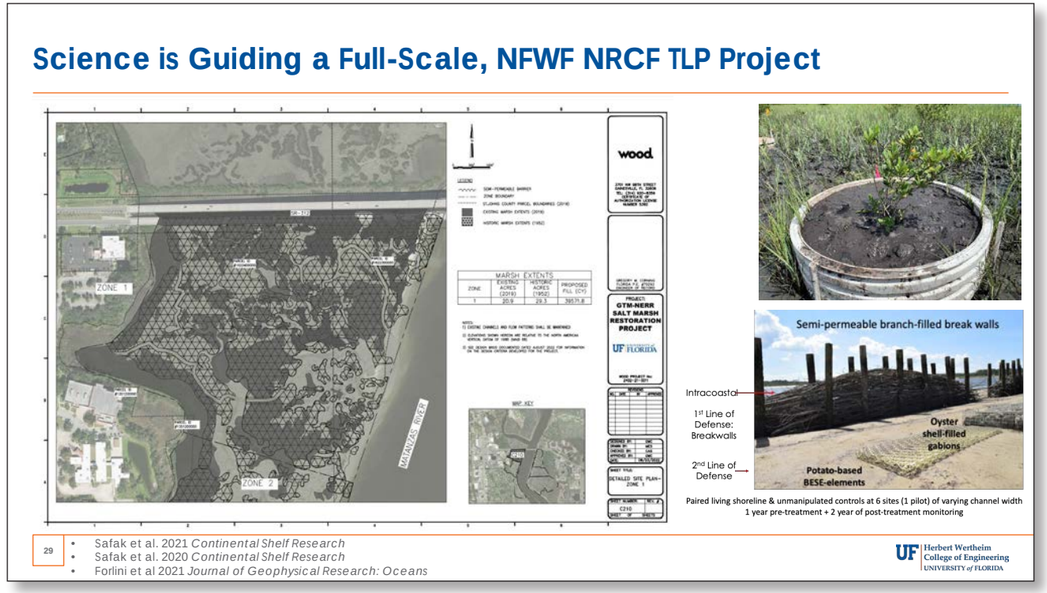

Legend
Project Area
Lower St. Johns River Watershed
GTM-NERR Salt Marsh Restoration Project
Project Location Map
wood.
Figure 1
Project Area
Flagler Hospital
State Road 312
Water Treatment Plant
Intracoastal waterway (10 to 100s of vessels per day)
Residences
Residences
Legend
Project Area
GTM-NERR Saltmarsh Restoration Project
Project Area Map
wood.
Figure 2


ERDC
Can the application of dredge sediment help stabilize this wetland-reef system?
1. Measure the pattern & pace of landscape 'mosaic' changes
2. Evaluate hydrodynamics (wind waves, boat wakes, currents) & sediment transport processes
3. Develop models to resolve influence of wakes, waves, tidal currents in driving wetland erosion/retreat
4. Test plant & invertebrate response to sediment addition
Frequency content as a function of time
Subcritical
Supercritical
Ship wave monitoring, identification, ecosystem impact
Photo: Mike Shirley (FDEP)


Lower-Energy Coastal Wetlands and Oyster Reefs are Eroding and Failing to Keep Pace with SLR
Loss of fish and wildlife habitat and shoreline protection services
Lateral marsh loss primarily from vessel wakes
Interior marsh drowning and fragmentation
Live oyster reefs + Dead oyster rakes
Photo: Mike Shirley (FDEP)


Science is Guiding a Full-Scale, NFWF NRCF TLP Project
ZONE 1
ZONE 2
MARSH EXTENTS
GTM-NERR SALT MARSH RESTORATION PROJECT
Semi-permeable branch-filled break walls
Intracoastal
1st Line of Defense: Breakwalls
2nd Line of Defense
Oyster shell-filled gabions
Potato-based BESE-elements
Paired living shoreline & unmanipulated controls at 6 sites (1 pilot) of varying channel width
1 year pre-treatment + 2 year of post-treatment monitoring
29
Safak et al. 2021 Continental Shelf Research
Safak et al. 2020 Continental Shelf Research
Forlini et al 2021 Journal of Geophysical Research: Oceans
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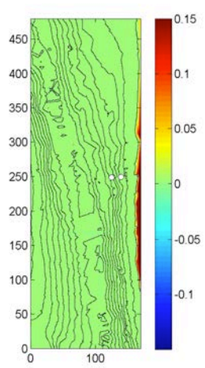
EWN Optimization: FUNWAVE TVD Modeling

FUNWAVE



FUNWAVE TVD Model
Boussinesq phase-resolving model

Prior work:
- Effects of boat 'traits' on wake signal
- Effects of wakes on sediment transport

Next Steps:
- Identify wake, wind wave, tidal current influences on whole wetland erosion in St Augustine
- Simulate effects of Jacobs-designed breakwalls on wave attenuation and sediment transport at Tyndall + validate with field data

Alex Sheremet + Carolina Forlini + Matt Malej + Marrisa Torres

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General introduction

Wind waves

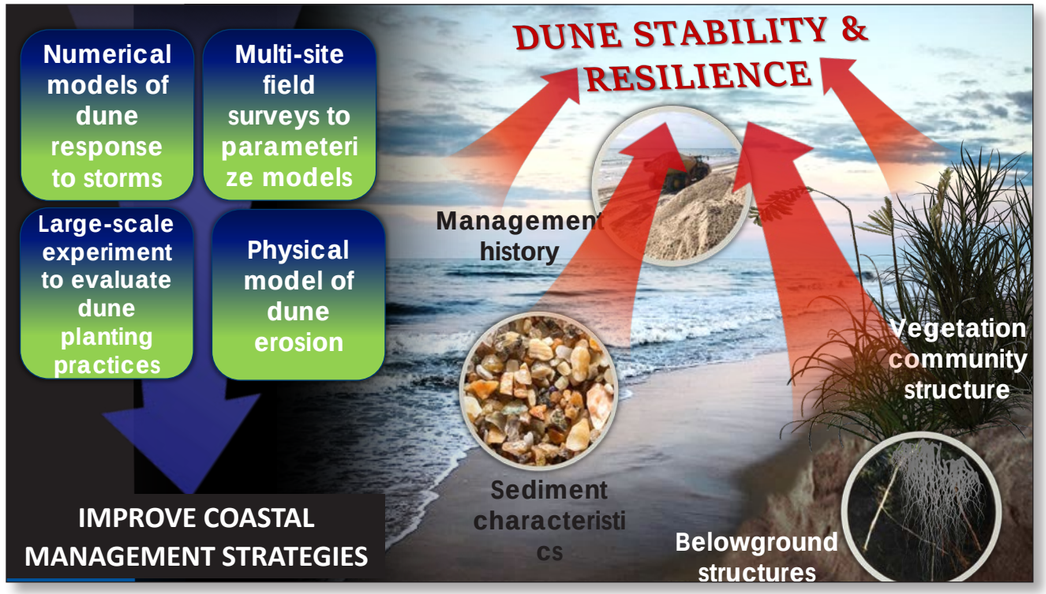
- Stationary;
- Homogeneous;
- Isotropic;
- Statistical analysis;
- Numerical modeling:
  - Phase-averaged: SWAN,WW3…
  - Phase-resolving: FUNWAVE-TVD…

Very well studied

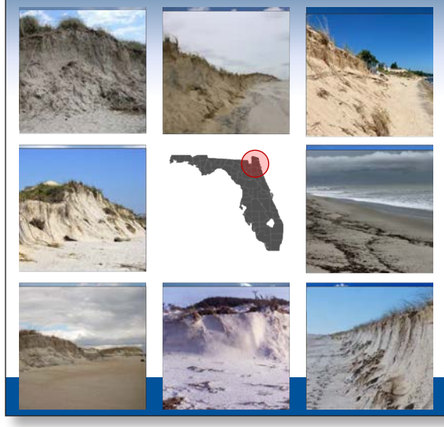
Ship waves

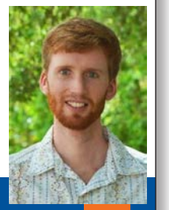
- Non-stationary;
- In-homogeneous;
- An-isotropic;
- Statistical analysis;
- Numerical modeling:
  - Phase-averaged: SWAN,WW3…
  - Phase-resolving: FUNWAVE-TVD…

Not very well studied



Approaches: (1) Quantifying belowground biomass of dune grasses and its impact on dune strength and erosion rates (Lead: Fischman), and (2) quantifying dune geotechnical and geologic properties (Leads: Shawler and Harris)





Method: Field surveys at 8 sites to identify how different plant species and restoration histories alter vegetation biomass, sediment properties, and response to disturbance.

Data gathered: Belowground biomass, sediment grain size, soil strength, dune angle of repose

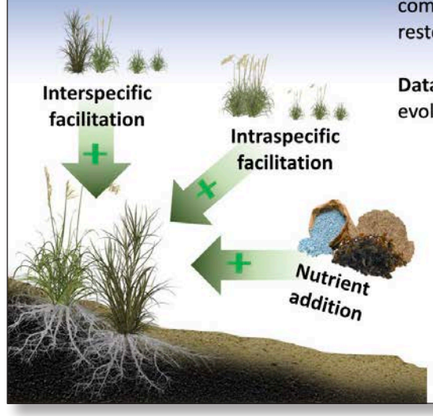
Timeline: April 2023 - May 2024

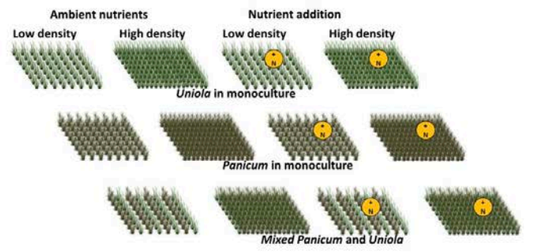
How can we harness positive species interactions to enhance plant growth following restoration?

Joe Morton

Method: Manipulative field experiment to determine what combinations of planting density, outplant species composition, and nutrient addition maximize dune restoration success

Data gathered: above- and belowground growth, geomorphic evolution, sediment chemistry, biodiversity metrics





Typical Approach to Restoring Vegetation in High Energy Dune Systems:

Multiple, multiple million dollar beach nourishment and dune creation projects to sustain beach-dependent tourism and protect critical infrastructure

Dune creation project in Ponte Vedra, Florida


Deepening ecological understanding to enhance dune restoration
Dune restoration substrate determines outplant vigor
(Frazier et al.– In prep, target: Ecological applications)
Atlantic ghost crabs facilitate dune grasses
(Morton et al.– In prep, target: Journal of Ecology)
GTM
RESEARCH RESERVE
ST. JOHNS COUNTY FLORIDA
US Army Corps of Engineers Jacksonville District
ENVIRONMENTAL HORTICULTURE
CCS
CENTER FOR COASTAL SOLUTIONS
UNIVERSITY OF FLORIDA
Sapelo Island
Change in aboveground biomass (g/m²/month)
Burrow area (cm²)
y = 0.2352x + 3.5788
R² = 0.1259

ADVANCING PRACTICE FOR COASTAL SYSTEM RESILIENCE

Monica Chasten
U.S. Army Corps of Engineers
Philadelphia District,
Operations Division

US Army Corps of Engineers

Organizational Perspective U.S. Army Corps Of Engineers Philadelphia District

- **Navigation Mission:** maintain federal channels in the Philadelphia District, largest is Delaware River
- **Flood/Coastal Storm Risk Management:** robust beach nourishment program in NJ & DE and 5 Reservoirs in PA
- **Ecosystem Restoration**
- **Regulatory Mission**

"A Partnership for our Planet"

- Persist, Innovate, Challenge, Advance, Evolve
- A Collaborative Approach Across USACE: *Working Together through the Regional Sediment Management and Engineering with Nature Programs*
- Illustrated Success: *Innovative Navigation Dredging and Placement Projects in New Jersey*
- Building Momentum: *Evolving the Practice for Dredging and Natural Infrastructure*

USACE Navigation Mission

- Nationally, USACE dredges 200 to 300 Million cubic yards annually. Over 5 Billion cubic yards over the last 25 years
- In order to dredge, USACE needs:
  - Authorization (law)
  - Appropriation ($$)
  - Placement Area (State)
- Cost of placement within *Federal Standard* (or cost-share needed) and need to implement per authorization and appropriation
- Navigation O&M is fast time scale!

Hopper Dredge McFARLAND
(USACE Minimum Fleet)

Survey Vessel H. R. SPIES

Philosophical Approach

▪ ***"Sediment is the currency of marsh ecosystems" ~*** Dr. Lenore Tedesco, The Wetlands Institute

▪ The US Army Corps of Engineers is perhaps the largest national "sediment broker" due to navigation mission and dredging (we have the currency!)

State endangered Black Skimmer at newly created habitat from dredged sediment, Ring Island, NJ

Challenge to Change

- Can we improve our stewardship of that sediment "currency" and optimize system resilience?
- Need to challenge our thinking and continue to evolve benefits in progression from caution and risk-aversed *to* cost-effective, proactive and innovative
- And improve Design, Permitting, Construction, Monitoring, Adaptive Management, Predictability(?)

A Sediment Progression: From Confinement To Natural Infrastructure

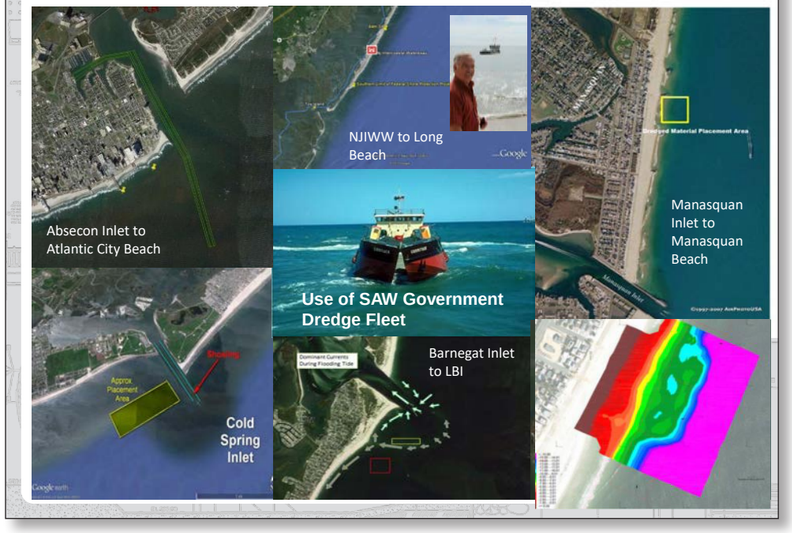
How Do We Construct the Projects?
(10K, 100k vs 10M Cubic Yards)

Dredge *TEXAS* working off of Stone Harbor, NJ for beach nourishment

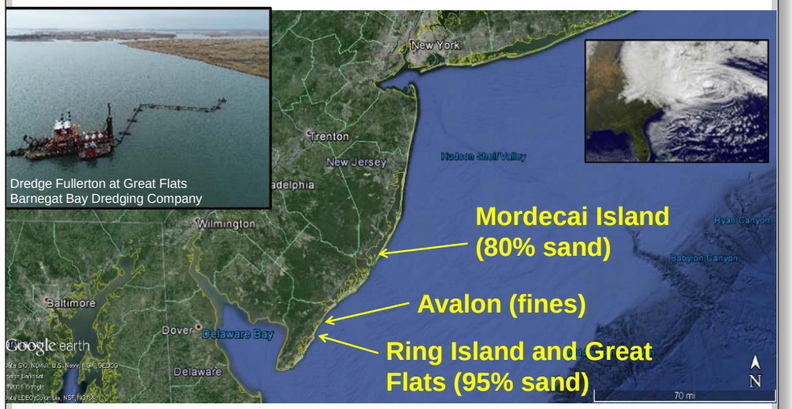
Dredge *Fullerton* working off of Mordecai Island, NJ for navigation and island restoration

US Army Corps of Engineers

Navigation Channels With Nearshore Nourishment



The Post-Sandy "Pilots"
Sediment Testing and Constructability Up Front!



The NJIWW is a 117-mile long federal channel that runs through the NJ Back Bays from Manasquan to Cape May

A Resilient Systems Approach
Mordecai Island Restoration, Beach Haven, NJ

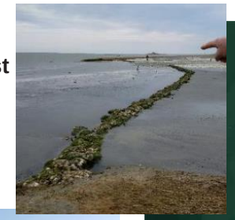
Mordecai Island During Construction

Adaptive Management: Thinking Through The Project Objectives

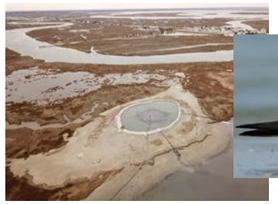
Build it and they will come….

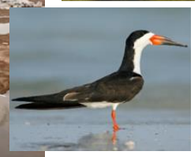
Monitoring & Partnering for Mordecai Island

- NOAA NCCOS
- ReClam the Bay
- Mordecai Land Trust
- NJDEP
- Rutgers University
- USFWS
- USACE ERDC



Ring Island, NJ: Habitat Creation and Thin-layer Placement





- Initial Placement: Aug 2014
- Placed on degraded land owned by the State instead of Confined Disposal Facility
- Success of habitat creation
  - Shorebird usage
  - Also used by horseshoe crabs & terrapins
- Included small thin layer placement demo with sand
- Adaptively managed habitat elevation in March 2018
- Precedent setting for regional approach with operational efficiencies

US Army Corps of Engineers, Philadelphia District · ERDC · GreenVest · Princeton Hydro · The Nature Conservancy · Wetlands Institute

NJ Intracoastal Waterway Avalon Pilot Project:
Dredging “The Football Field” and Thin-Layer Placement

- Constructed in two phases: Dec 2014 and Winter 2015/16
- Thin Layer Placement & filling pools
- Fine-grained material 55,000 cy on 50 acres
- Lessons learned document by NFWF Team and Thin Layer Placement Design Guidance by ERDC in preparation
- *Multiple ERDC work units support project*

Seven Mile Island Innovation Laboratory
Established 2019

ERDC
US Army Engineer Research and Development Center

US Army Corps of Engineers

NEW JERSEY DIVISION OF Fish and Wildlife

Wetlands INSTITUTE

BUILDING MOMENTUM: CHANGING PERSPECTIVES & EVOLVING THE PRACTICE

Inspired by the Dutch

EcoShape
building with nature

Fine sediment: from waste to resource

Throughout the world, different coasts, shores, lakes and rivers have to deal with excess sediment or sediment shortages. The natural balance between the removal and deposition of sediment is disrupted by human interventions such as dams in a river or ports in an estuary. As a result, sediment doesn't reach places where it is needed and too much accumulates in other locations. Ecosystems are affected and life becomes difficult for plants and animals. People are also pressured, for example in terms of food supplies, ports and leisure activities.

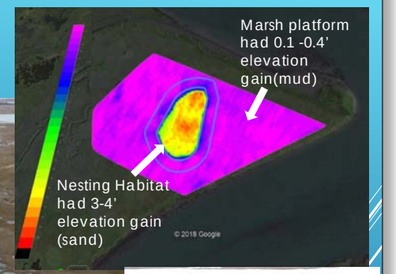
https://www.ecoshape.org/en/projects/living-lab-mud

Seven Mile Island Innovation Lab Background

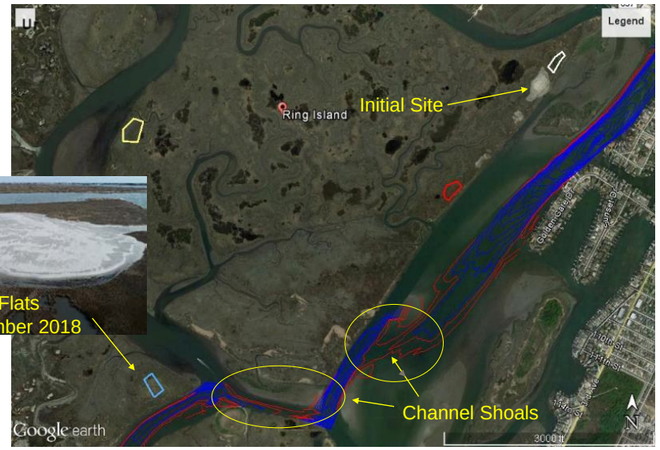
- Established in 2019 as partnership between USACE, NJDEP and TWI
- A Proving Ground using Natural and Nature-Based Features to provide ecological uplift and enhanced resilience for ecosystems and coastal communities
- A Test Bed to advance and improve dredging techniques and marsh restoration and coastal feature creation techniques in coastal New Jersey
- 24 sq mi Back Bay Marsh Dominated System with shallow bays, sounds and tidal inlets bisected by the NJ Intracoastal Waterway
- 50+ Member Working Group for knowledge sharing
- More than 30 Scientists Working in SMIIL
- Publications, presentations, fact sheets shared on TWI and USACE Websites

Great Flats Elevated Nesting Habitat

- Placed 6,000 yd^3 on 1 acre habitat
- Free Pump until Material to Create Containment
- Target Ecological Elevation 5.5'
  - Placement to 6.5' for Settling and Anticipated Wind Transport
  - 95%+ fine sand
- Had Thin Layer Placement of Mud on Surrounding Marsh Platform



Adaptive Management And Systems Approach
Moving Forward From Pilots To System Solutions



Taking It To The Next Level In SMIIL

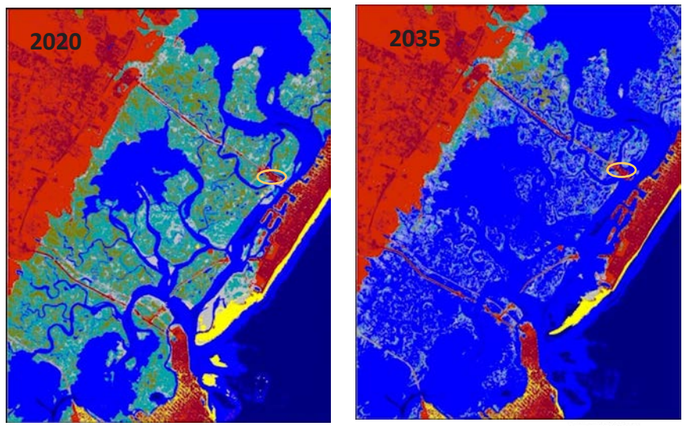
Gull Island
- Large portion of tidal marsh on southern Gull Island is projected to convert to mud flats and open water
- Southern margin experiencing marsh edge erosion and risk of breaching

Sturgeon Island
- Northern portions of island at low elevation and at risk of conversion to flats
- Northwestern island experiencing marsh edge erosion

Both Islands
- Low-vigor *Spartina* flats border directly to open water or function as low marsh and are transitioning to high-vigor *Spartina*
- Only stable portions of islands are historic dredged material placements

NJ Floodmapper

High Tide Flooding (MHW SLAMM) and Coastal Resilience

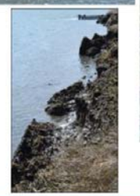


STURGEON ISLAND PLACEMENTS

- Placed in Two Phases in 2020
  - March & September 2020
  - Approx. 20,000 cu yds
  - Mixed fine sand and mud
- **Marsh Elevation Enhancement (MEE)**
  - 3.5 acres of enhancement
- **Marsh Edge Protection (MEP)**
  - Placed small sand ridge along toe of erosional slope
- **Enhanced Intertidal Shallows (ISS)**
  - Shallowed above MLLW along eastern island to extend flats northward
- Returned in Fall 2022 for Phase 3, additional 20,000 cy

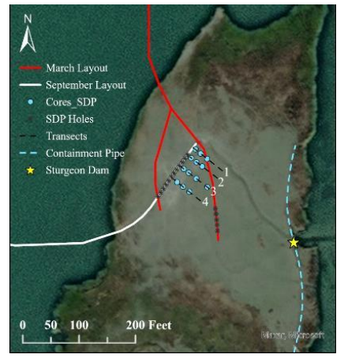
Marsh Edge Erosion Contribution to Wetland Loss

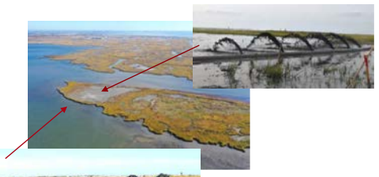
- Marsh losses also occur by edge erosion
  - Along open fetch areas from storms
  - Boat wake induced erosion



USFWS Sea Level Affecting Marshes Model

Partnering and Advancing Techniques
Sturgeon Island: Island Elevation Enhancement, Marsh Edge Protection, and Intertidal Shallows





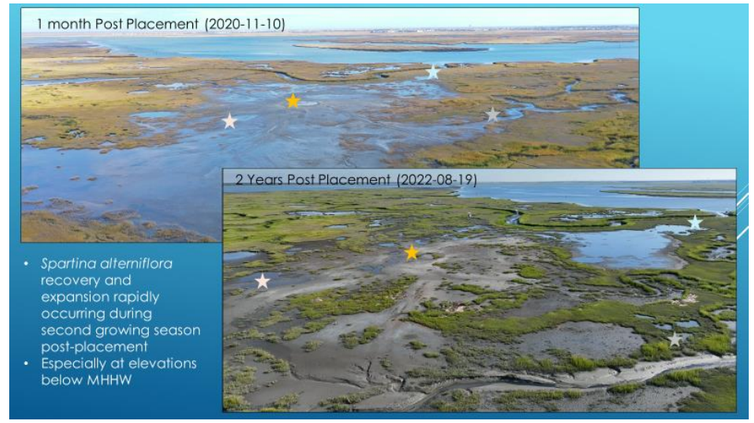
STURGEON ISLAND PHASE 3 – FALL 2022

Placed fine sand to create sandy marsh edge protection features

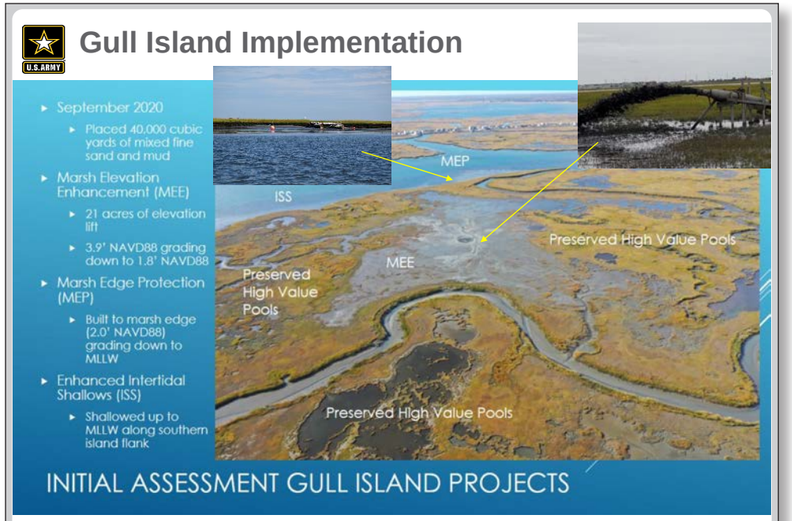
Used containment to elevate 0.4 acre for elevated bird nesting habitat
- Placed more than 3 ft of material
- Built to 4.0 ft NAVD88

Employed Y-valve to switch between containment and subtidal features
- Maintain dredging efficiency
- Allow time for contained area to dewater
- Slow and manage flow volumes and velocities

Gull Island Post-Placement
November 2020 and August 2022



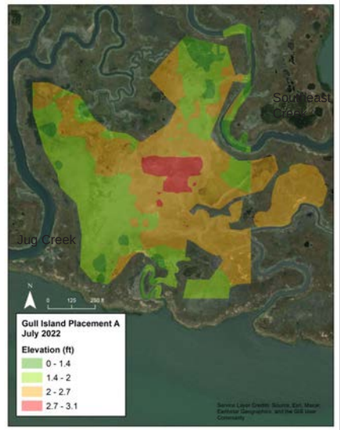
Gull Island Implementation



40,000 cu yd of mixed fine sand and silts from the NJIWW Mkrs 388 to 397 within State Wildlife Management Area (slide credits, G. Paul and The Wetlands Institute)

Gull Island Outcomes
2 Years Post Placement

- Below target elevations for transitional wading bird habitat and only small area of high marsh
- Acoustic monitoring detecting both Salt Marsh and Seaside Sparrows foraging on site
- Effectively created low marsh habitat and shallowed interior intertidal flats and pools
- Avian surveys documenting more than 25 species utilizing placement area for foraging including several surveys with 500-1000 Semipalmated Sandpipers
- Vegetation recolonization and expansion proceeding well at 2-yr post-placement
- Ecological benefits progressing along site evolutionary trajectory
- Return for additional uplift?



Monitoring & Research in the Seven Mile Island Innovation Lab

Marsh Vegetation Surveys	ERDC: Piercy/Russ
Hydrodynamic and Suspended Sediment within the SMIIL	ERDC: ERDC/CHL TR-21-9, Fall, Perkey, Tyler and Welp
Gull-Sturgeon Turbidity	ERDC: Fall, et al., 2022, WEDA Journal of Dredging, Volume 20, No. 1
Sediment Distribution Pipe: Sturgeon-Gull	ERDC: Beardsley, et al., WEDA Journal of Dredging, Volume 20, No. 1
Sturgeon/Gull Sediments/Consolidation	ERDC: Tyler/Harris
GCM Observations & Model Development	ERDC: Perkey/Fall
Sediment/Vegetation Interactions	ERDC: J. Smith/Ramirez
Vessel Wake Impacts on Marshes	ERDC: Priestas/Styles/Bain
Macroalgae/Benthic Surveys	ERDC: Altman/Balazik/Reine
Water Quality and Hydrodynamic Modeling	ERDC: Kim/Ding
Remote Sensing & EWN Landscape Architecture Applications	Univ of Pennsylvania: Burkholder & Van Der Sys
Monitoring and Adaptive Management of Elevated Nesting Habitats	The Wetlands Institute, NJ Fish & Wildlife
Monitoring and Adaptive Management of Gull and Sturgeon Islands	The Wetlands Institute, NJ Fish and Wildlife
Community Engagement Using Mental Modeling	ERDC: Thorne, et al., ERDC TR-22-12
Bathy/Topo/Currents/Sediments/Remote Sensing	USACE Philadelphia
Varied University Research	Univ of Penn, Boston College, Texas State, Louisiana State, Stevens, Univ of Washington, Stockton (Work Group)

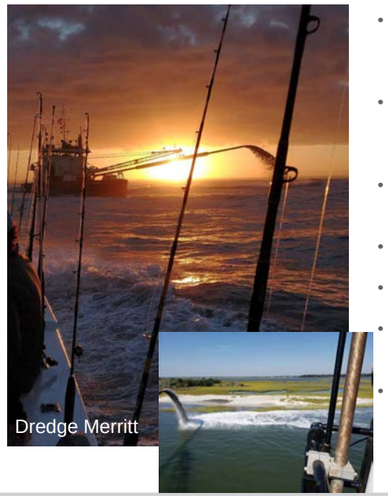
SMIIL Overview References

- American Shore and Beach Preservation Association National Conference, Sept 2022, Long Beach, Presentation, “Advancing Navigation Dredging and Innovative Placements to Support Coastal System Resilience in USACE's Philadelphia District” *(presentation only)*
- 37th International Conference on Coastal Engineering, December 2022, Sydney, Australia, Paper and Presentation, “Advancing Sediment Solutions in the Seven Mile Island Innovation Lab,” *in press*
- Coastal Sediments 2023, April 2023, New Orleans, Paper and Presentation, “Seven Mile Island Innovation Laboratory: Advancing Beneficial Use Practices to Support Coastal System Resilience,” *in press*
- *Additional Info and Fact Sheets:*

https://www.nap.usace.army.mil/Missions/Civil-Works/Coastal-Dredging-Beneficial-Use/

https://wetlandsinstitute.org/smiil/

What's Next for Nav in SMIIL?



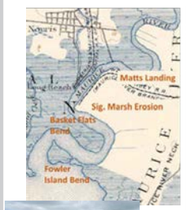
- Pilot to clear shoals with sidecast Government Dredge Merritt using "Fertilizing the Garden" approach (Sept 23)
- Track shoaling rates and patterns for long-term EWN strategies that are nature-based and less "big" construction efforts
- ***Risk acceptance and adaptive management, take "fail" out of language***
- Agricultural & dredging industry coordination
- Leverage SMIIL with communities
- Utilize techniques in remaining portions of NJIWW
- Sharing lessons learned with Maurice River & Salem Rivers, NJ

NJIWW Dredging & Scotch Bonnet Placement: 25,000 cy in Fall/Winter 2023

Restoring low marsh for avian and terrapin habitats, use of coir logs & Y-valve, permitted for multiple lifts over time, complements larger NJDEP/TWI grant project

SCALING UP & OVER

Maurice River NJ
Channel Dredging & Placement



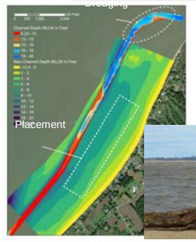
- Previous dredging in 1925 and 1996
- 1996 dredging DISPOSED of material in Cape May CDF while region is experiencing devastating erosion
- Advertised solicitation to dredge channel and beneficially place material in NJDEP's Heislerville Wildlife Management Area: anticipate Aug 2023 contract award

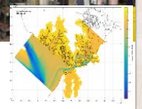
80,000 cy of fine-grained sediment to be dredged to support a struggling economy

Changing practice with a new twist in this Delaware Bay community: EWN, UPENN Landscape Architects and Lessons Learned from SMIIL

A Systems Approach to Beneficial Use of Fine and Coarse-grained Dredged Material at the Confluence of the Delaware and Salem Rivers

- Leveraging efforts of US Fish & Wildlife Service, Ducks Unlimited and EA Engineering to restore marsh in Supawna Meadows National Wildlife Refuge with 200,000 cy of fine-grained channel sediments in Fall/Winter 2023
- Using SMIIL lessons learned for use of fine-grained dredged material including use of Y-valve for adaptive management during construction
- Nearshore nourishment with sand using Dredge Murden

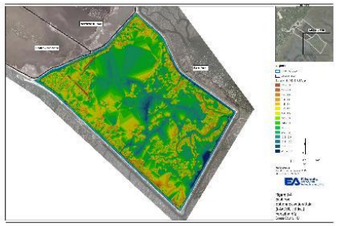




CMS Modeling

- Engineer Research and Development Center

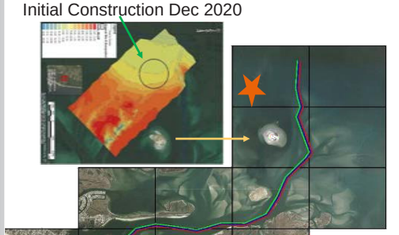
Partnering With USFWS RSM & EWN Opportunities



- MOUs signed between USACE & USFWS for Forsythe & Supawna Meadows National Wildlife Refuges
- Previous placements in CDFs
- Developed pilot project with Forsythe in Dec 2020 using NJIWW dredged sediments (2024?)
- Salem River Dredging & Supawna Meadows Placement in Fall 2023
- Short and long-term sediment management practices that will improve salt marsh restoration and coastal resilience efforts

Beneficial Use Placement Opportunities in NJ Using Navigation Channel Sediments: Barnegat Inlet

1122 “Intentional” Island Creation: Initial Construction Dec 2020

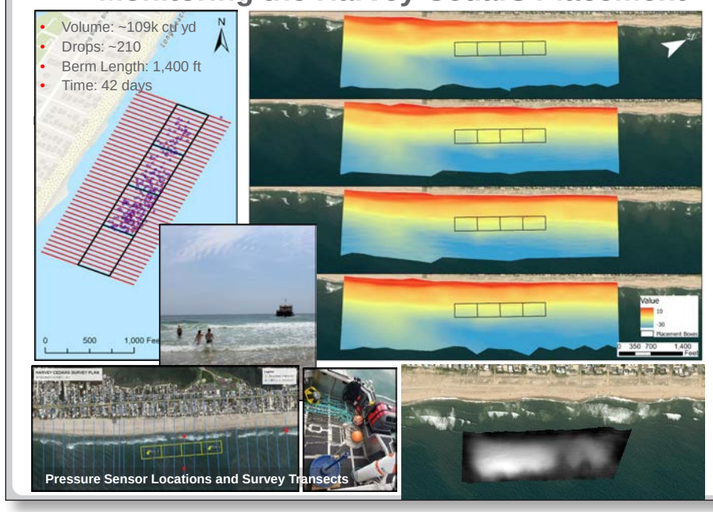


1122 Nearshore Placement: Constructed Aug 2021

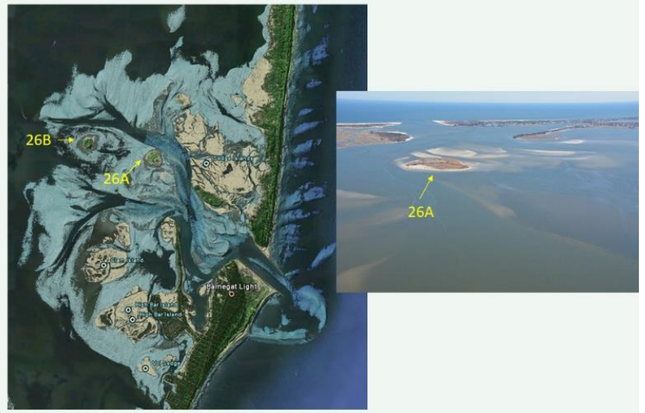
US Army Corps of Engineers

Regional Sediment Management: Monitoring the Harvey Cedars Placement

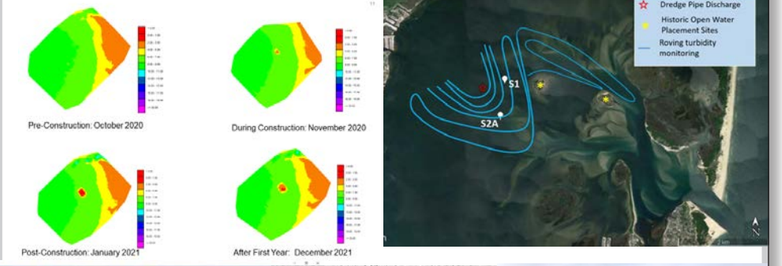
- Volume: ~109k cu yd
- Drops: ~210
- Berm Length: 1,400 ft
- Time: 42 days

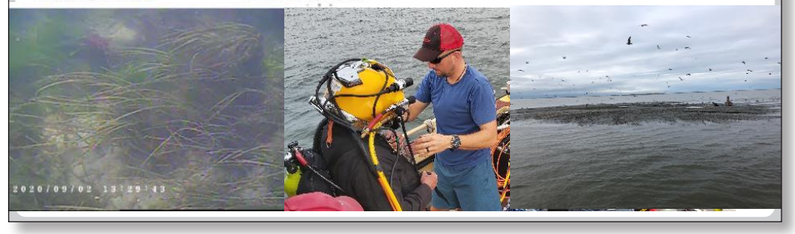


The Importance Of Monitoring & Tracking
BU Before It Was BU: The "Bernie Moore" Islands

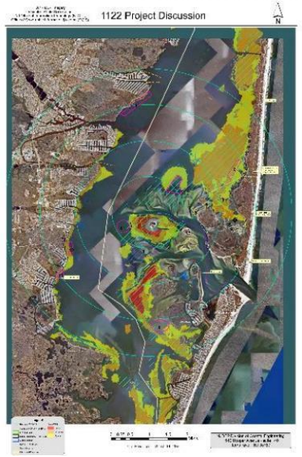


Monitoring the New Island in Barnegat Bay and Developing Lessons Learned





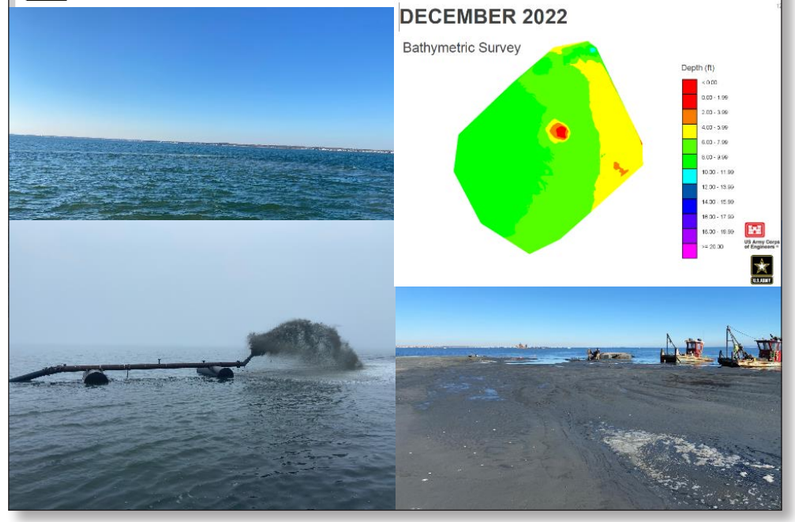
WRDA 2016 Section 1122 BU Pilot: Oyster Creek Dredging And Bay Placement Alternatives Analysis



- Coordination with NJDEP, agencies and Barnegat Bay Partnership
- 11 initial alternatives identified for various types of natural and nature-based features, narrowed to 5 sites
- Narrowed Federal Consistency request for Sites 6, 10 and 11
- Site 6 was moved forward for 1122 pilot placement with initial lift of new island constructed in Dec 2020; additional lifts Fall 2022 and 2023

US Army Corps of Engineers.

Second Lift of New Island in Barnegat Bay



Advancing Practice for Coastal Resilience

Rapid Progress in 10 Years! But more work to do…..

- **Momentum to embrace change; status quo no longer an option**
- Progression from 25% (pre-Sandy) to 60% (post-Sandy) to goal of 100% **beneficial use of clean channel sediments** in coastal NJ, setting bar high!
- Key **Partnerships** and Long-term Sustainability
- Work with cross-disciplinary teams and industry to **improve designs, constructability and cost efficiency**
- **Importance of monitoring** and leveraging with R&D to develop technologies, guidance, collaboration and knowledge/data management
- **Adaptive management** to manage risk are key in dynamic coastal system
- Projects must be reasonable and scalable; small successes lead to larger actions

https://www.nap.usace.army.mil/Missions/Civil-Works/Coastal-Dredging-Beneficial-Use/

Philadelphia District, Operations Division
Modelling Coastal Change Hazards, Nicholas Cohn, PhD, Research Oceanographer, Coastal and Hydraulics Laboratory, USACE ERDC

EWN/MacDill AFB Collaboration:
Modeling Coastal Change Hazards

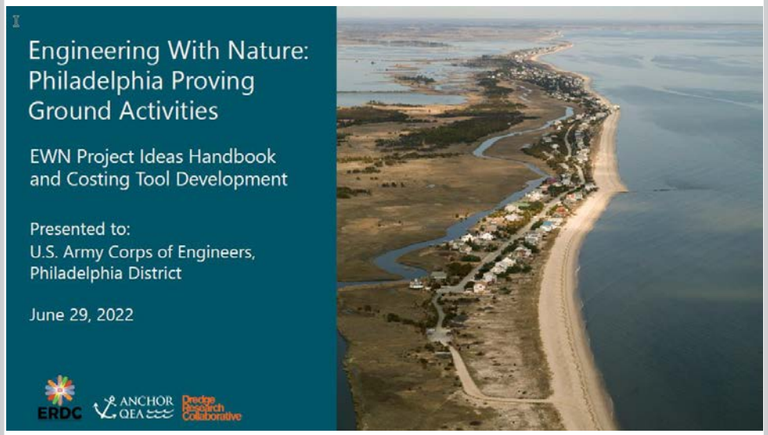
US ARMY CORPS OF ENGINEERS RESEARCH AND DEVELOPMENT CENTER COASTAL & HYDRAULICS LABORATORY
FIELD RESEARCH FACILITY: DUCK, NC

COASTAL & HYDRAULICS LABORATORY · ERDC · ENGINEER RESEARCH & DEVELOPMENT CENTER

EWN

NICK **COHN, PhD**
nicholas.t.cohn@usace.army.mil

Advancing Natural Infrastructure Approaches In The Philadelphia District



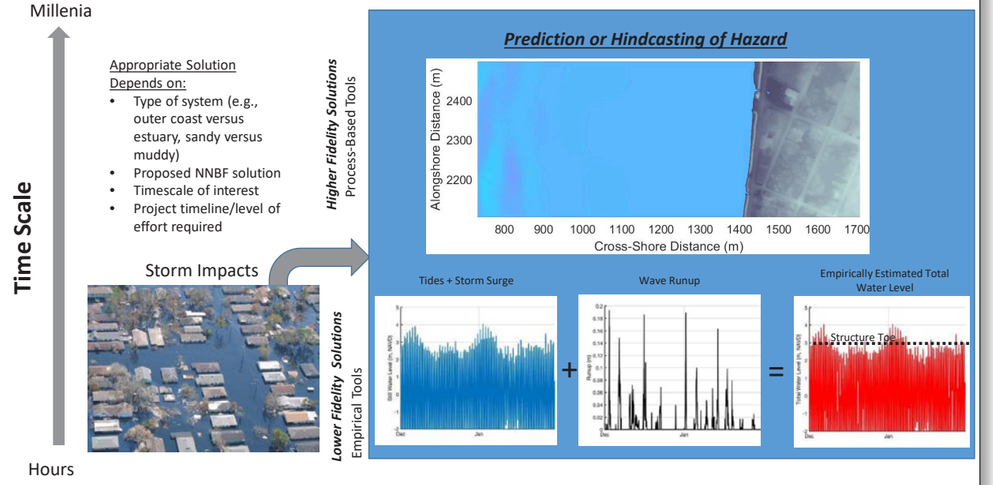
MODELING COASTAL CHANGE HAZARDS

Erosional Risks

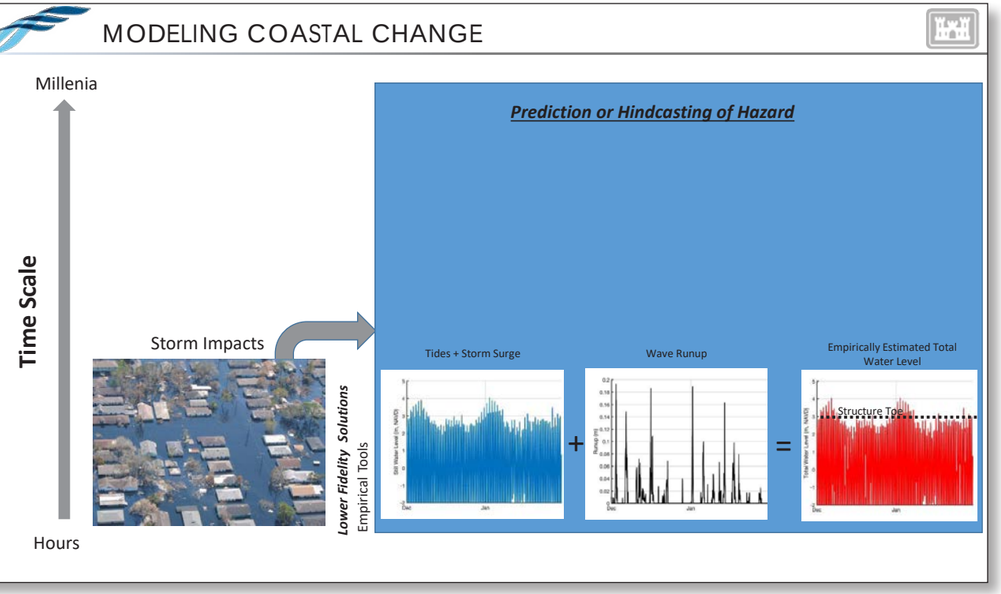
Flooding Risks

MODELING COASTAL CHANGE

MODELING COASTAL CHANGE



MODELING COASTAL CHANGE



MODELING COASTAL CHANGE

MODELING COASTAL CHANGE

MODELING COASTAL CHANGE HAZARDS

Mangroves

Nature-Based Solutions

Infrastructure

Coastal Foredunes

Salt Marsh

MODELING COASTAL CHANGE HAZARDS

Mangroves

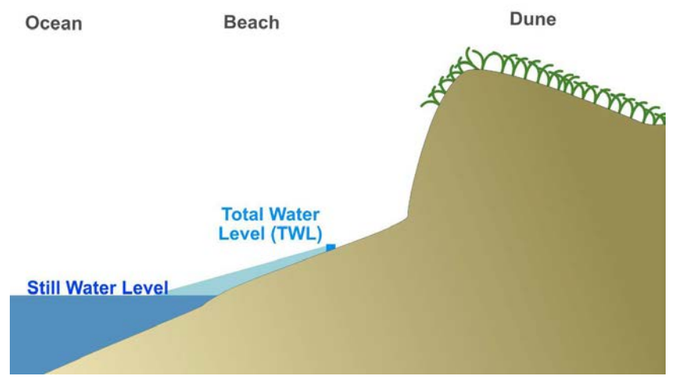
Nature-Based Solutions

Infrastructure

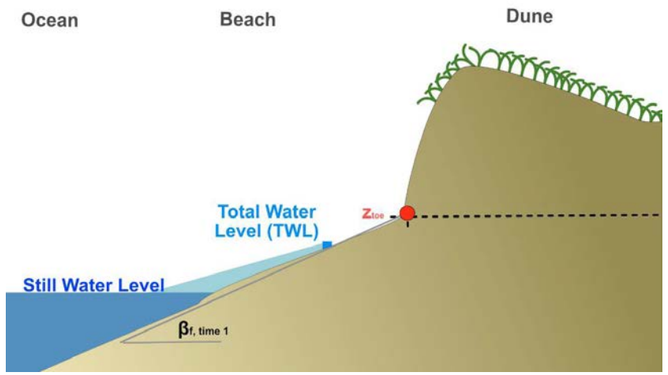
Coastal Foredunes

Salt Marsh

DUNE MODEL R&D



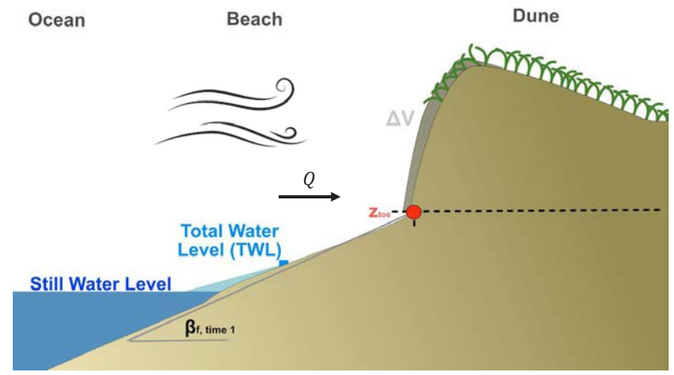
DUNE MODEL R&D



$$TWL = SWL + 1.1\left(0.35\,\beta_f (H_o L_o)^{1/2} + \frac{\left[H_o L_o \left(0.563\,\beta_f^2 + 0.004\right)\right]^{1/2}}{2}\right)$$

Following Stockdon et al. (2006)

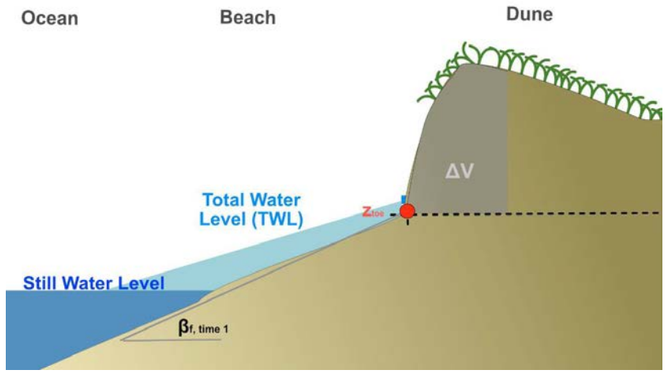
DUNE MODEL R&D



$$Q = C_k \frac{\rho_a}{g} (u_* - u_{th})(u_* + u_{th})^2$$

Following Kawamura (1951)

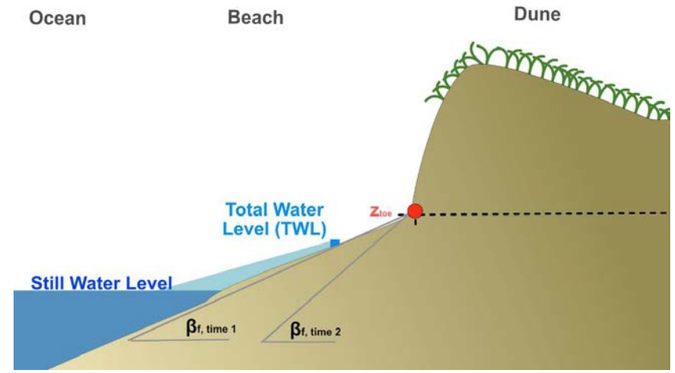
DUNE MODEL R&D



$$\Delta V = 4C_s (TWL - z_{toe})^2 \frac{t}{T}$$

Following Palmsten and Holman (2012)

DUNE MODEL R&D



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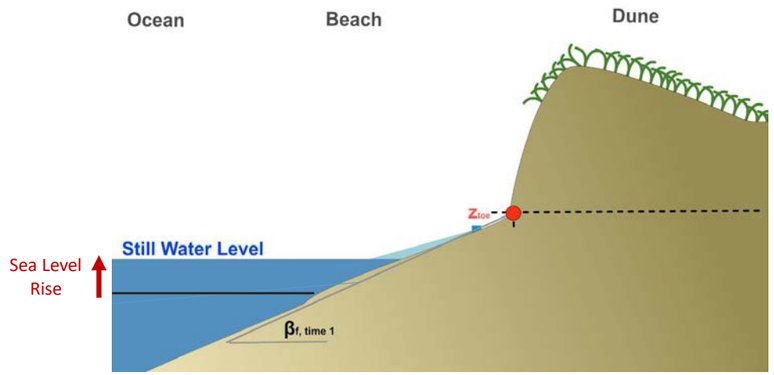
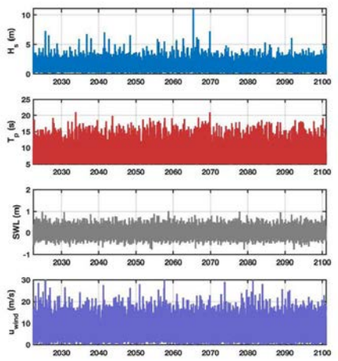


DUNE MODEL R&D

Modern Conditions (Outer Banks, NC)



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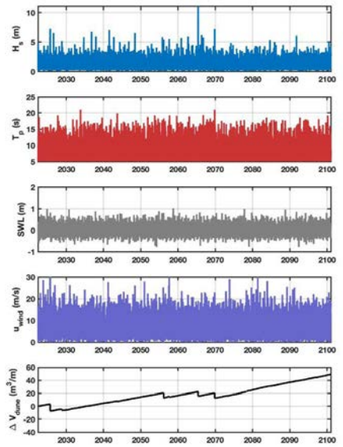

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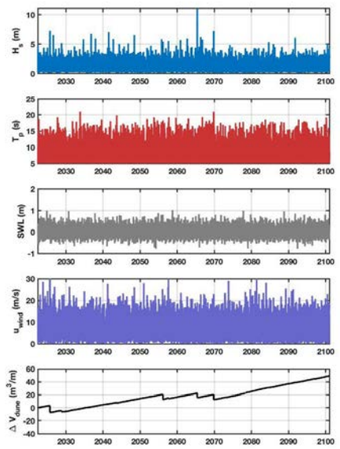
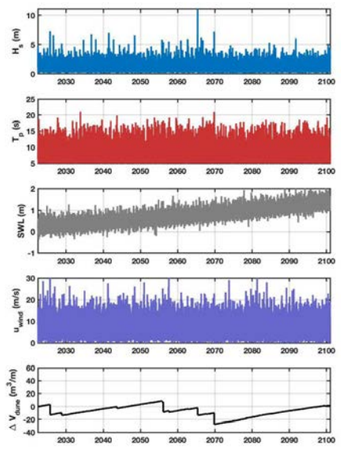


Intermediate Sea Level Rise Curve Added



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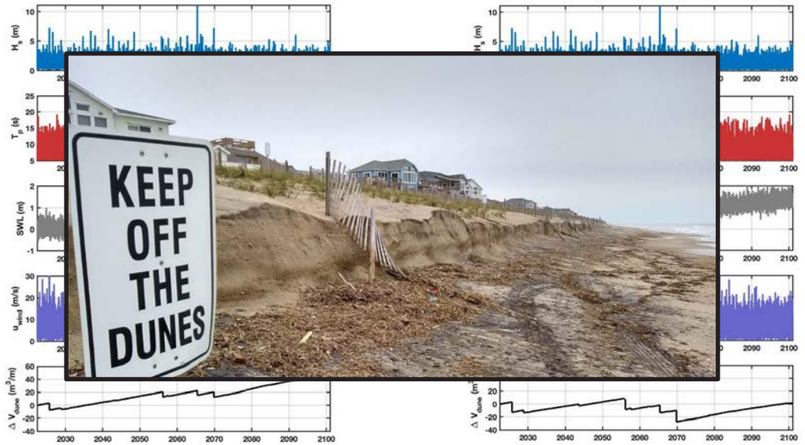


STOCHASTIC FORCING EMULATOR

Dune Lifecycle Projections

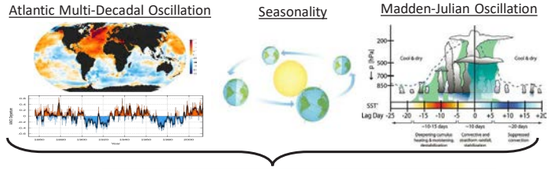
Stochastic Climate Generator

- Inter-annual sea surface temperature variability
- Intra-annual solar input
- Intra-seasonal outgoing longwave radiation

Atlantic Multi-Decadal Oscillation

Seasonality

Madden-Julian Oscillation



Stochastic Weather Generator

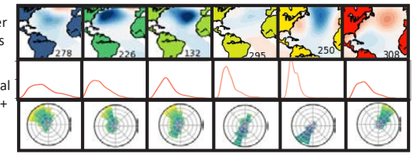
Synthetic daily weather predicted by ALR:

f(ENSO, MJO, seasonality, daily markov chain)

(Anderson et al. 2019, Time-varying Emulator.. JGRO)

Weather Patterns

Potential Waves + Winds



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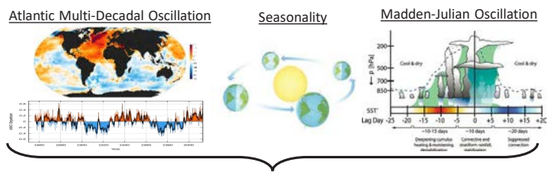

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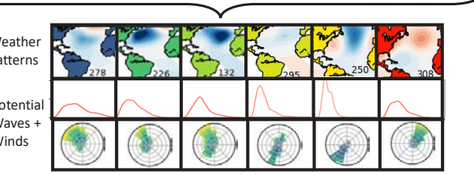
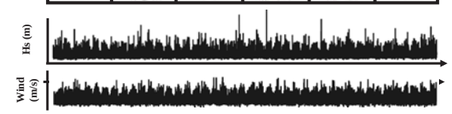


Downscaled Wave & Wind Conditions

Synthetic hourly time series of wave and water levels conditions

(Anderson et al. 2021, Hybrid Statistical Downscaling... Earth's Future)



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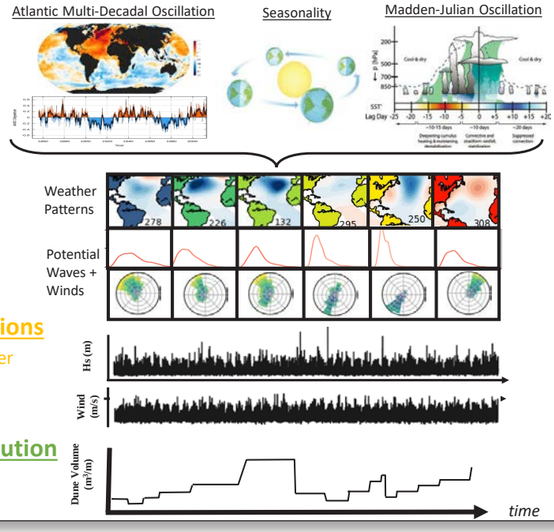
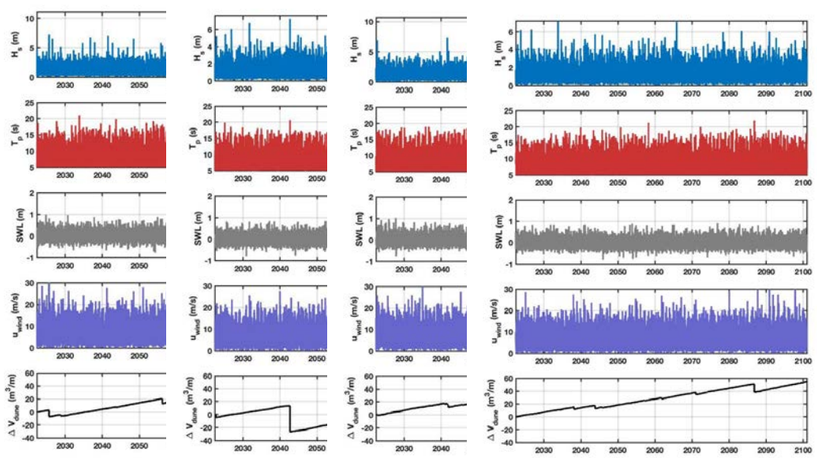
Monte Carlo of Dune Volume Evolution
- Erosion during high TWL events
- Accretion during wind events

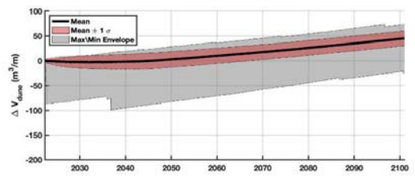


STOCHASTIC CLIMATE EMULATOR

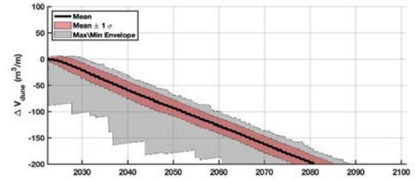


DUNE MODEL R&D

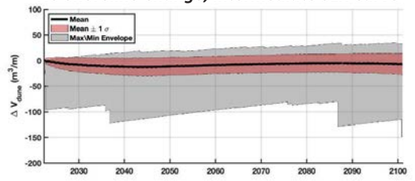
No Shoreline Change, No Sea Level Rise



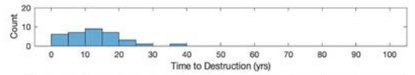
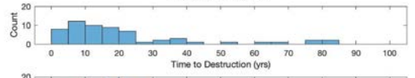
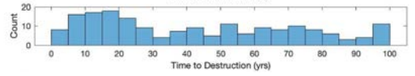
-1 m/yr Shoreline Change, No Sea Level Rise



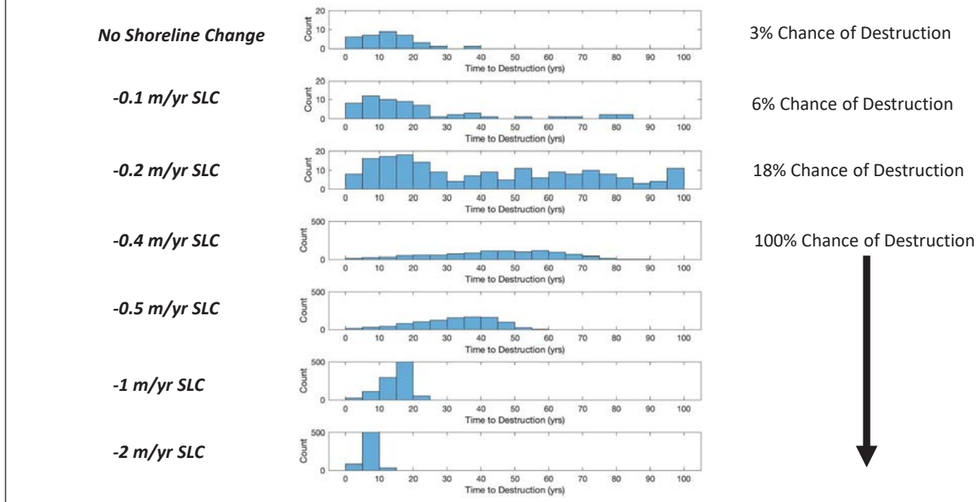
No Shoreline Change, Intermediate SLR Curve



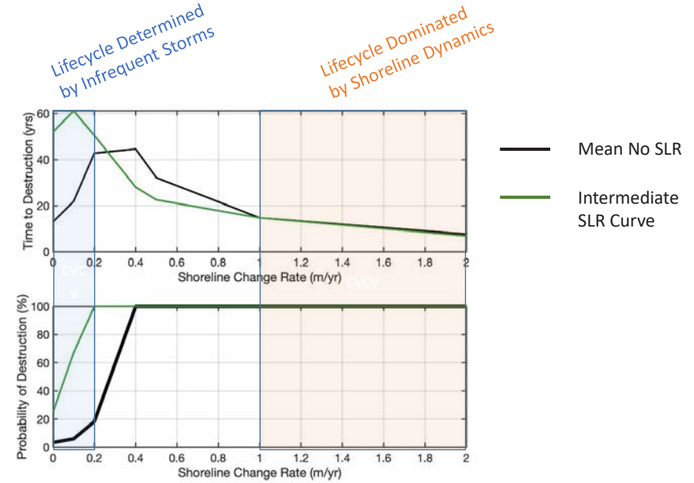
DUNE MODEL R&D

No Shoreline Change		3% Chance of Destruction
-0.1 m/yr SLC		6% Chance of Destruction
-0.2 m/yr SLC		18% Chance of Destruction

DUNE MODEL R&D



DUNE MODEL R&D



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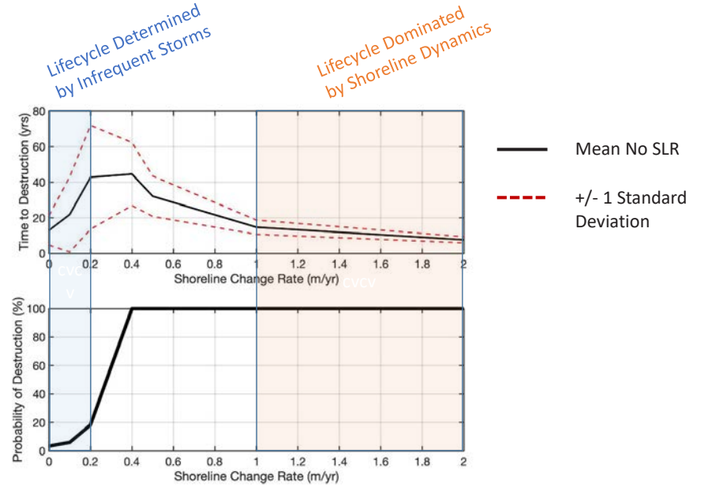

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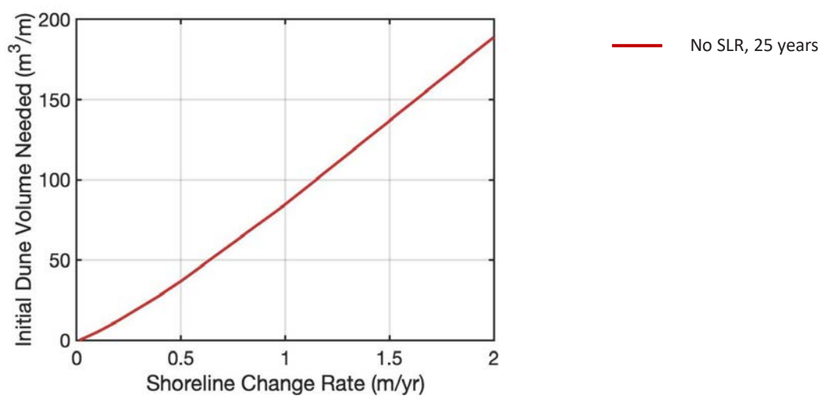
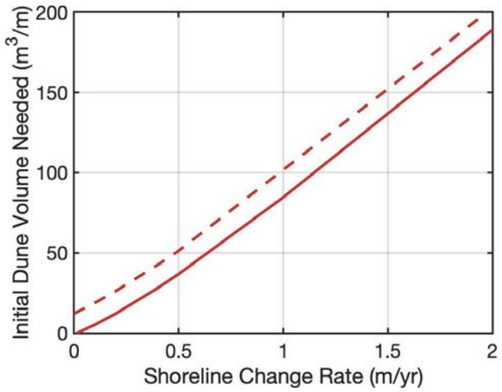


DUNE MODEL R&D



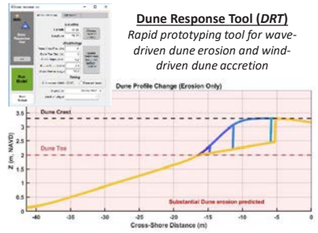
No SLR, 25 years

Int SLR, 25 years

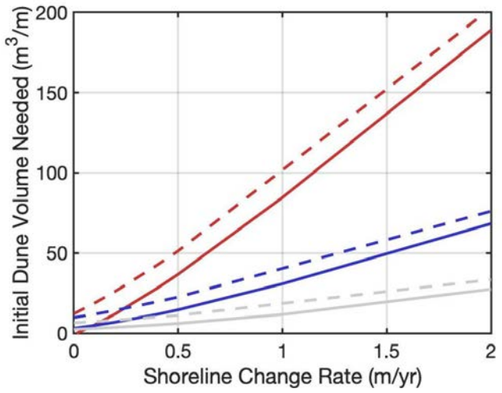
DUNE MODEL R&D

Dune Response Tool (*DRT*)

Rapid prototyping tool for wave-driven dune erosion and wind-driven dune accretion



DUNE MODEL R&D



No SLR, 25 years

Int SLR, 25 years

No SLR, 10 years

No SLR, 5 years

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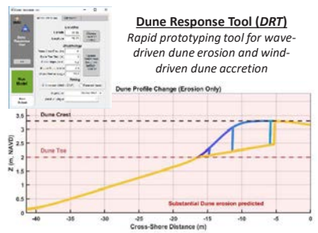
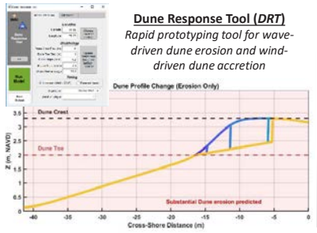


Short (hours to days)	**Time Scale of Interest**	*Long (months to years)*
Low (Limited Number of Processes Resolved)	**Model Fidelity**	*High*
High	**Tool Level of Maturity**	*Low*
Faster (Seconds to Minutes)	**Computational Speed**	*Slower (Minutes to Days)*

DUNE MODEL R&D



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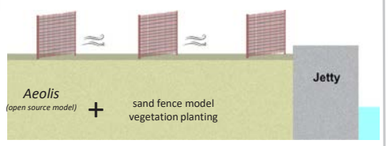
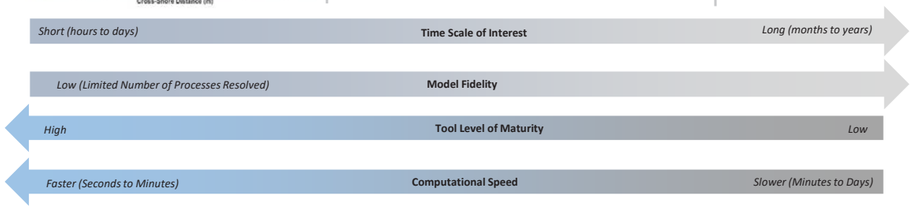
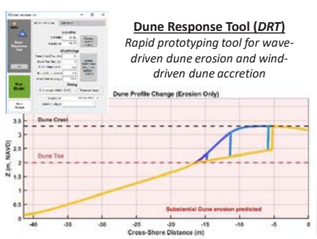
Aeolis *Process-based aeolian transport model with USACE management alternatives being added*



Aeolis+C2Shore: *Fully coupled subaqueous-subaerial model for simulating the co-evolution of coastal morphology from wind and waves*



DUNE MODEL R&D



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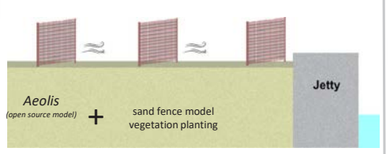

Aeolis+C2Shore: *Fully coupled subaqueous-subaerial model for simulating the co-evolution of coastal morphology from wind and waves*

Physics	• 1D processes, single grain size, highly empirical	• 1D and 2D processes, multifraction, intermediate physics	• 2D processes, multifraction, many processes resolved
Example NNBF	• Beach nourishment • Empirical vegetation effects	• Beach and dune nourishment • Multi-species interactions on aeolian transport • Sand fencing • Wrack effects (in development)	• Beach, dune, and nearshore placement • Spatial variability in bed type

DUNE MODEL R&D

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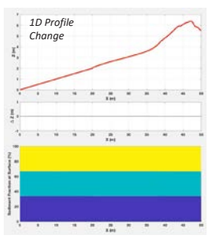

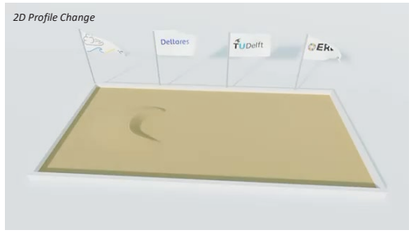

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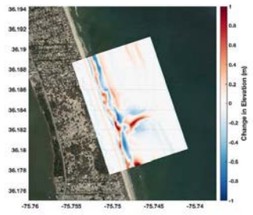

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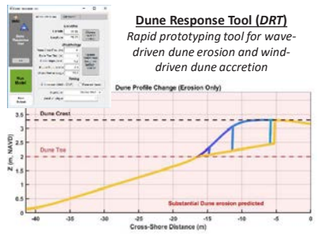


Dune Response Tool (*DRT*)
Rapid prototyping tool for wave-driven dune erosion and wind-driven dune accretion

TIKIGAQ
POINT HOPE ALASKA

EA Engineering, Science, and Technology, Inc., PBC

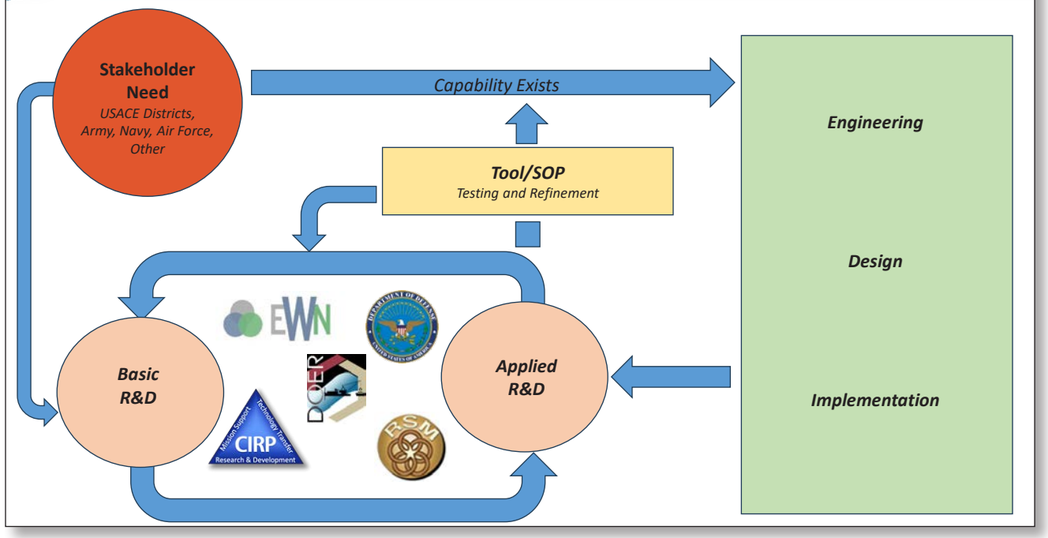
Arctic Tundra

NATIONAL PARK SERVICE

Island Bluff Dynamics

???

DUNE MODEL R&D



MODELING COASTAL CHANGE HAZARDS

Mangroves

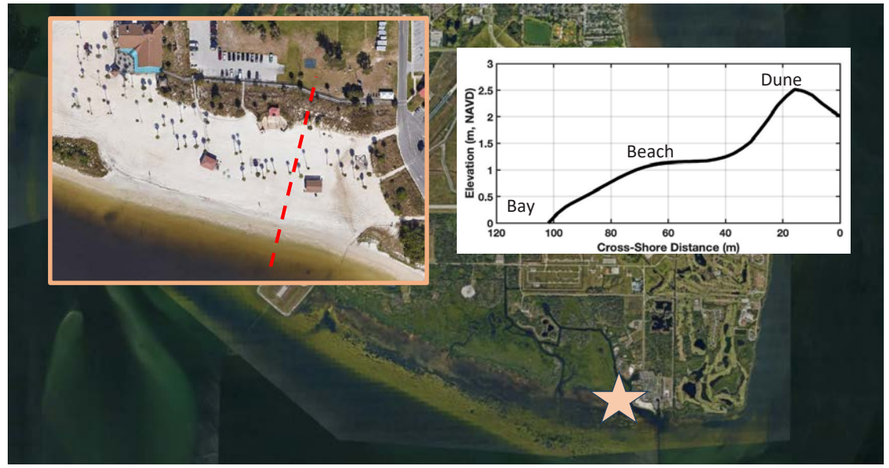
Nature-Based Solutions

Infrastructure

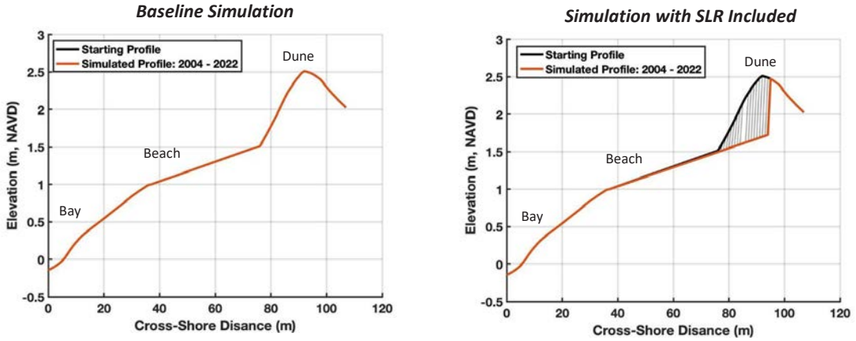
Coastal Foredunes

Salt Marsh

MODELING COASTAL CHANGE

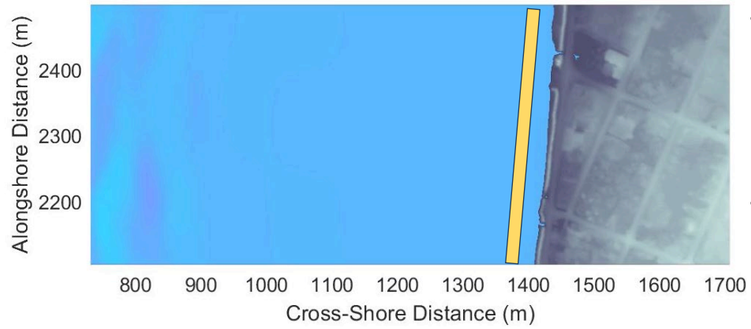


MODELING COASTAL CHANGE



MODELING COASTAL CHANGE HAZARDS

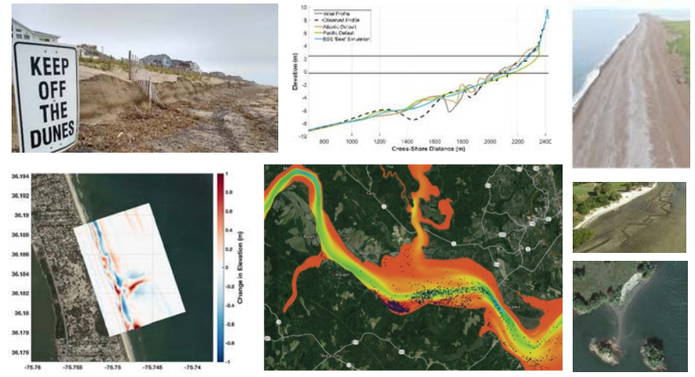
HIGHER FIDELITY MODELING CAPABILTIES



- Incorporate alternatives such as oyster reef balls, sediment placement, sea grass meadows, or dunes into numerical simulations
- Approaches for model integration informed by field and laboratory datasets

HIGHLIGHTS

- ERDC/USACE has broad expertise on quantifying coastal and estuarine hydrodynamics, sediment transport, and landscape changes
- Active R&D focused to developing state of the art hydrodynamic and morphologic tools
- Ability to assess many NNBF strategies in numerical tools to aid in understanding benefits and optimizing design across time and space scales



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EWN
Jacobs