



U.S. ARMY

Identifying Collaborative Opportunities for Natural Infrastructure and Nature Based Features

Safra Altman, Lauren Dunkin, Rose Dopsovic

US Army Engineer Research and Development Center
USACE Mobile District



US Army Corps
of Engineers



Importance of Natural Infrastructure

- Natural and hybrid approaches provide important coastal risk reduction.
- Now is the time to incorporate natural and hybrid approaches into coastal planning.
- These approaches are key to increasing coastal resilience to climate change.

Sutton-Grier et al 2015

ENVIRONMENTAL SCIENCE & POLICY 51 (2015) 137–148

Available online at www.sciencedirect.com
ScienceDirect
 journal homepage: www.elsevier.com/locate/envsci

Review

Future of our coasts: The potential for natural and hybrid infrastructure to enhance the resilience of our coastal communities, economies and ecosystems

Ariana E. Sutton-Grier^{a,b,*}, Kateryna Wowk^{a,c}, Holly Bamford^{a,***}

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... sea wall to protect defense is an option barrier island

ARTICLE INFO

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Available online 28

Keywords:
Ecosystem services
Storm protection
Coastal flooding
Storm surge

REVIEWS REVIEWS REVIEWS

82 Marine urbanization: an ecological framework for designing multifunctional artificial structures

Katherine A. Duffren^a, Tim M. Glasby^b, Laura Ainsdill^a, Natalie K. Riveno^c, Mariana Mayer-Pinto^d, and Emma L. Johnston^e

Underwater cities have long been the subject of science fiction novels and movies, but the “urban sprawl” of artificial structures being developed in marine environments has widespread ecological consequences. The practice of combining ecological principles with the planning, design, and operation of marine artificial structures is gaining in popularity, and examples of successful engineering applications are accumulating. Here we use case studies to describe the design, construction, and operation of marine artificial structures. We discuss the benefits and costs of these structures, and provide a framework for their design and operation. We also discuss the need for interdisciplinary research and collaboration between engineers, ecologists, and social scientists to ensure that these structures are designed and operated in a way that is both ecologically sound and socially beneficial.

Journal of Environmental Economics and Management
Volume 85, September 2017, Pages 62–80

Benefits and ancillary costs of natural infrastructure: Evidence from the New Jersey coast ☆

Steven J. Dundas

Show more

<https://doi.org/10.1016/j.jeem.2017.04.008>

Get rights and content

Evaluation of Natural Infrastructure

- Environmental Defense Fund, 2015
- Summary of risk reduction performance and engineering guidance, costs, and factors relevant to climate change.
 - Risk Reduction Performance
 - Design/O&M Criteria
 - Costs
 - Other Factors

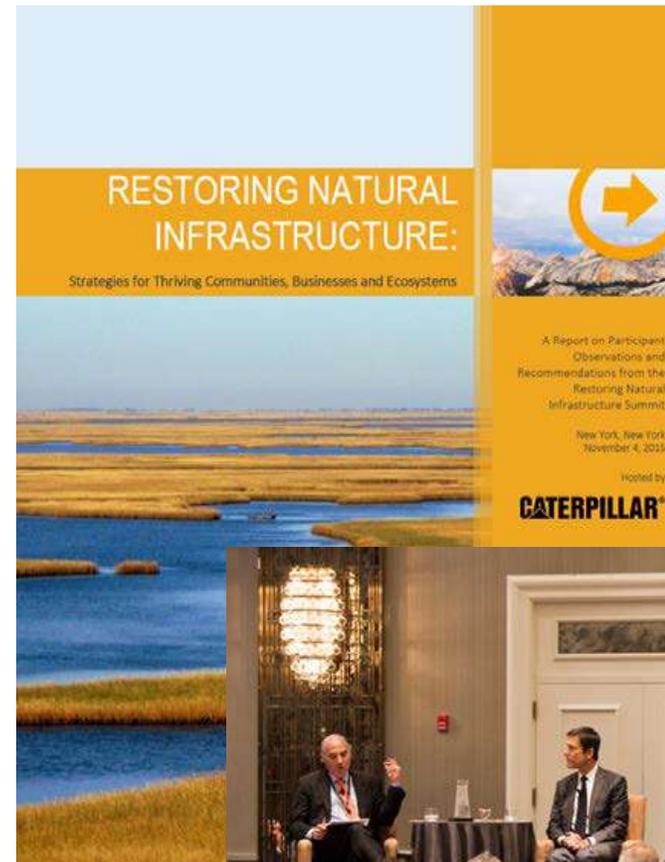
Table 1: Natural Infrastructure and Nature-based Measures: Summary of risk reduction performance and engineering guidance, costs, and factors relevant to climate change.

		Risk Reduction Performance ¹					Design/O&M Criteria (for performance areas specific to feature)	Costs ² per linear foot		Other Factors	
		Reduce coastal erosion/ Shoreline Stabilization	Nuisance floods (high tides with sea level rise)	Short wave (<2') attenuation (Stabilize Sediment)	Reduce force & height of med. waves (2'-3')	Storm Surge (low frequency extreme events)		Construction	Annual O&M ³	Mitigates climate change (CO ₂ sequestration)	Adaptability to sea level rise & changing community needs
Structural	Groins	+ ⁴	-	+			+	\$2-5k	\$1-5k	No	
	Breakwaters	+ ⁴	-	+	+		+	\$5-10k	>\$5k	No	Variable
	Seawall/ Revetments/ Bulkheads	+ ⁴	+		+	+	+	\$3-10k \$5-10k \$2-5k	>\$5k \$1-5k \$1-5k	No	
	Surge Barriers	-			+	+	+	>\$10k ⁵		No	
Existing Natural	Wetlands	+		+	~	~	N/A	N/A		Yes	Yes
	Mangroves/ coastal forest	+		+	+	+	N/A	N/A		Yes	Yes
	Vegetated Dunes	+		+	+	+	N/A	N/A		~	Yes
Strategy	Beach Nourishment	+	+	+	+		+	\$2k-5k ⁶	\$1k-5k		Yes
	Vegetated Dune creation	+	+	+	+	+	+	\$0.03k-5k ⁶	\$1k-5k	~	Yes
	Barrier Island Restoration	+	+	+	+	+	+	\$0.76k- \$1.1k ⁷			Yes
	Small scale edging and silts (living shorelines)	+	~	+				\$1k-2k	<\$1k	Variable	Yes
	Restored Oyster/Shell-fish Reefs	+		+	~	~	Possible, akin to low breakwaters	\$23k-24k ⁸		Yes	Yes
	Restored/ Created Coral Reefs	+		+	~	~	Possible, akin to low breakwaters	\$2k-50k ⁸		~	
	Restored Maritime Forests (including Mangroves)	+	+	+	+	+		\$23k-216k ⁹ /ha (mangroves)		Yes	Yes
Restored Wetlands¹⁰	+	+	+	~		-	\$0.81k-36.4k/ha ¹¹		Yes	Yes	

Cunniff and Schwartz 2015

Collaboration with the Private Sector

- Caterpillar Inc.
 - ▶ Restoring Natural Infrastructure Summit; November 4th 2015; New York City
 - ▶ Natural Infrastructure Initiative – USACE Collaboration Work Streams
 1. NI Opportunity Evaluation Tool.
Capitalizing on enterprise-level capability:
CE Dredge Decision Support Tool
 2. Evaluation and Decision Making
 3. Field Application and Demonstration
- Western Dredging Association (WEDA)
 - ▶ Collaborative technical workshop on engineering and construction techniques for Engineering With Nature



<http://www.caterpillar.com/en/company/sustainability/natural-infrastructure.html>

Natural Infrastructure Initiative



Natural Infrastructure Initiative is an informal grouping of companies and organizations working to promote the use of natural infrastructure

High level objectives:

- Accelerate investment in water based natural infrastructure projects as part of a solution set for infrastructure needs
- Embed natural infrastructure as part of ongoing discussions about improving investment in water-based infrastructure. Promote the use of natural infrastructure in general

Vision:

The widespread acceptance of, and increased investment, in natural infrastructure projects as a means to advance the economic vitality, environmental health and security of our nation.

Natural *AND* Built Infrastructure, not *OR*



The Nature Conservancy



INTREXON

AECOM



Brown & Root



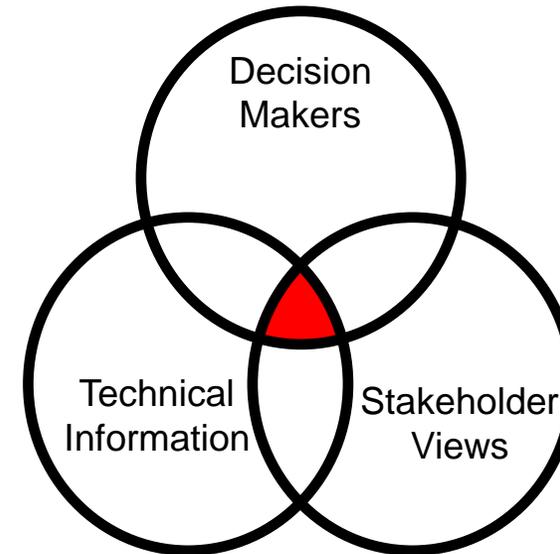
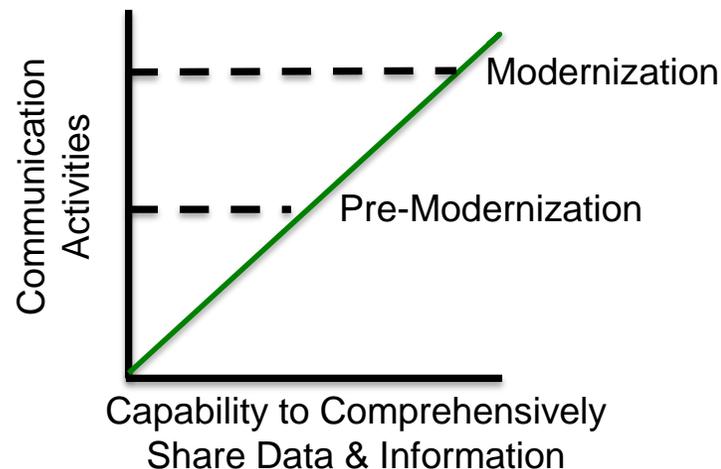
DUCKS
UNLIMITED



US Army Corps of Engineers • Engineer Research and Development Center

Increase integration of information through a connected data network

- Consistent access to authoritative data
- Simplified & expedited dredging analyses
- Multi-objective systems optimization
- Dynamic visualization
- Enhances communications
 - Within USACE
 - With non federal sponsors and partners
 - With environmental agencies



**Improved Communication,
Shared Visioning, and
Alignment of Mutual Objectives**

Tool Development: Natural Infrastructure Opportunities Tool

- The public facing *N/OT* web-viewer, developed in collaboration with the Natural Infrastructure Initiative, focuses on identifying beneficial use an natural infrastructure opportunities.
- The initial version of viewer developed to address a number of questions identified by NII group including:

Where are the sediment sources?

Where are the current placement areas?

Where are the restoration, shore protection, and nearshore placement projects?

What volume of material was (or is planned to be) placed?

Where are potential placement sites?

What capacity is available?

What are the upcoming dredging/navigation needs?

What are the opportunities for new beneficial use?

Are there opportunities to link multiple projects?



The Nature Conservancy

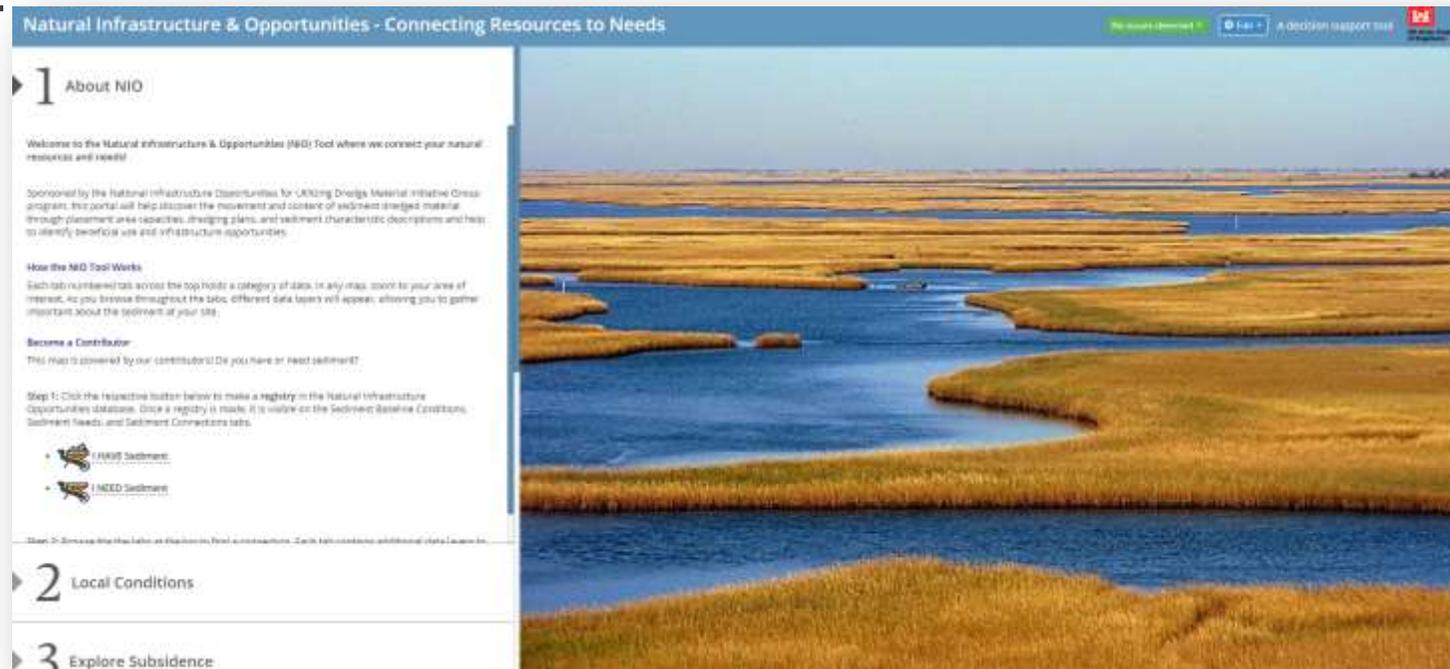


AECOM



What is the Natural Infrastructure Opportunities Tool?

By using map based visualizations of environmental, geomorphic and sediment conditions, as well as upcoming USACE projects, and an interface for users to add their resource needs and resource availability, this portal will help discover natural infrastructure connections and inspire innovative opportunities.



NIO - Resource

Please fill out the form below to register your resource in the Natural Infrastructure and Opportunity (NIO) database.

Location of Resource*
Where is the resource located?!

Loc: 400 10328
Lat: 1.42611 Lon: 0

Submission Date*
9/14/16

Resource Status*
Is this a planned, under contract, or

NIO - Need

Please fill out the form below to register your resource in the Natural Infrastructure and Opportunity (NIO) database.

Submission Date*
9/14/16

Location of Need*
Where is the need/make it?

Loc: 041, NCAR
Lat: 1.40451 Lon: 0

Area of Interest Buffer*
Even, in feet, the appropriate width of the area of interest.

How the NIOT Works

- The NIOT brings together datasets from multiple sources all in one place
- Data is organized in a map. The map will change based on what links are clicked – either the category number or any hyperlinks in the category description
- There are 11 tabs. Each tab holds a subset of data organized for that category. Interested in seeing all data together? Tab 10 provides access to all data layers in the NIO tool.

Interested in finding contacts who are also exploring natural infrastructure opportunities? Tab 11 provides contact offices for users of the NIOT.

- ▶ 1 About NIO
- ▶ 2 Local Conditions
- ▶ 3 Explore Subsidence
- ▶ 4 Shoreline Rate Change
- ▶ 5 Sediment Baseline Conditions
- ▶ 6 Resource Needs
- ▶ 7 Resource Connections
- ▶ 8 Environmental Considerations
- ▶ 9 Environmental Impact
- ▶ 10 All Data
- ▶ 11 Connections & Contacts

Open, Online Application

Natural Infrastructure Opportunities Tool - Connecting Resources to Needs

A decision support tool



▶ 1 About NIOT

Welcome to the Natural Infrastructure Opportunities Tool (NIOT) where we connect your natural resources and natural infrastructure needs!

This portal will help discover available resources for natural infrastructure projects including the movement and content of dredged material through placement area capacities, dredging plans, and sediment characteristic descriptions and help to identify beneficial use and infrastructure opportunities.

How the NIOT Works

Each numbered tab down the left holds a category of data. In any map, zoom to your area of interest. As you browse throughout the tabs, different data layers will appear, allowing you to gather important information about your site of interest.

Become a Contributor

This map is powered by our contributors! Do you have or need resources for natural infrastructure (e.g., sediment, equipment, etc.)?

Step 1: Click the respective button below to make a registry in the Natural Infrastructure Opportunities database. Once a registry is made, it is visible on the Sediment Baseline Conditions, Resource Needs, and Resource Connections tabs.

-  [I HAVE Resources](#)
-  [I NEED Resources](#)

▶ 2 Local Conditions



Supported by Arc Story Maps

Local Conditions

Natural Infrastructure & Opportunities - Connecting Resources to Needs

A decision support tool



1 About NIO

2 Local Conditions

How to use this map:

- The National Wetlands Inventory are provided by FWS. This data set represents the extent, approximate location and type of wetlands and deepwater habitats in the United States and its Territories. These data delineate the areal extent of wetlands and surface waters as defined by Cowardin et al. (1979).

3 Explore Subsidence

4 Shoreline Rate Change

5 Sediment Baseline Conditions

6 Resource Needs

7 Resource Connections

8 Environmental Considerations

9 Environmental Impact

10 All Data

Data Layers:

Wetlands

Shoaling Rate

Volume change – with different storms

Shoreline change – with different storms

Elevation change

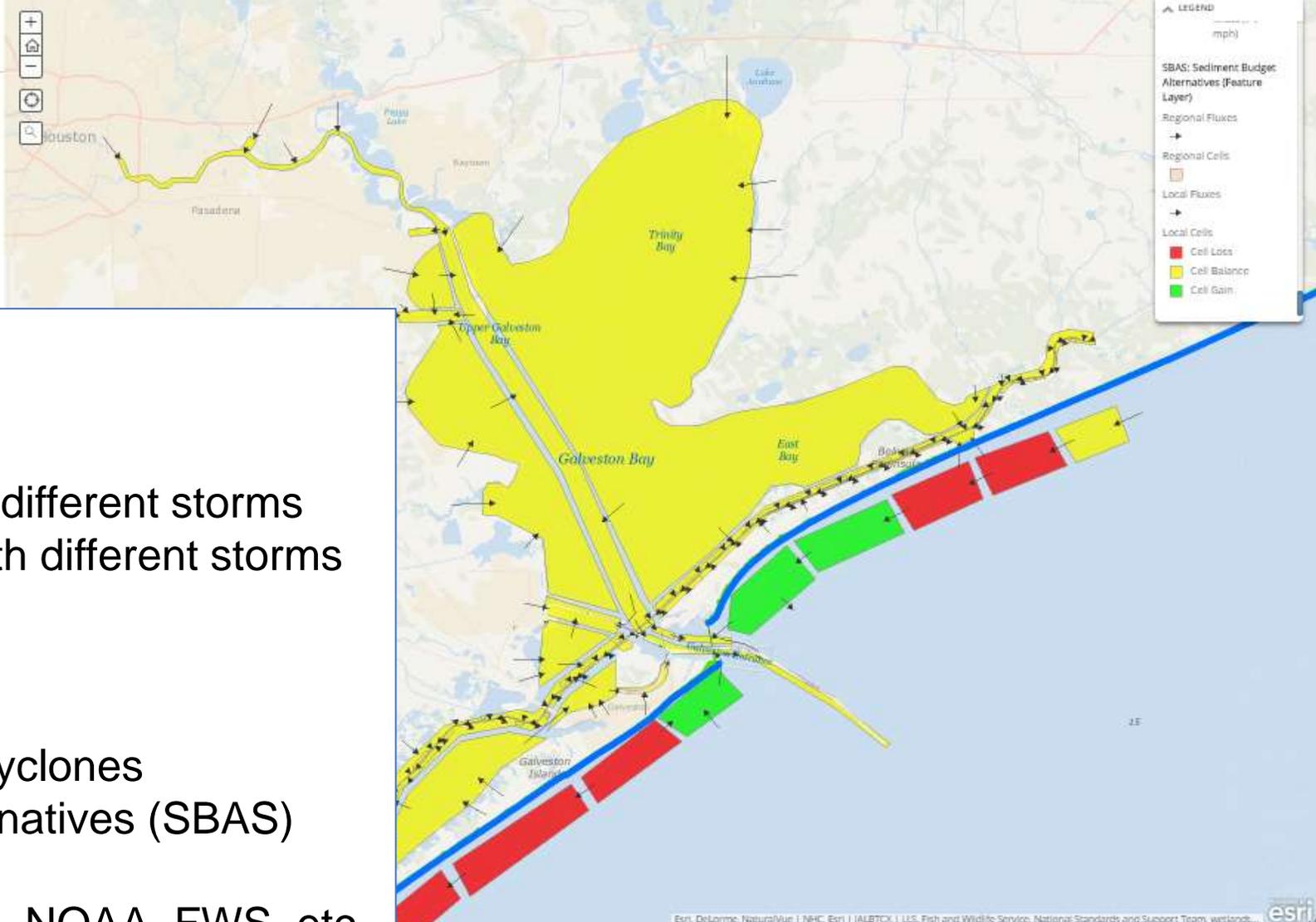
Geomorphic features

Dune Features

Tropical Storms and Cyclones

Sediment Budget Alternatives (SBAS)

Data Sources: USACE, NOAA, FWS, etc.



Subsidence

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A decision support tool



1 About NIO

2 Local Conditions

3 Explore Subsidence

Explore Groundwater-Level and Compaction Data in the Chicot, Evangeline and Jasper Aquifers

- The map to your right shows the 2018 water levels for the Jasper aquifer.
- Open USGS's Subsidence Viewer.

USGS measures water groundwater levels in over 700 wells in an 11-step region of groundwater levels. The cumulative compaction in the study area.

Water-level altitude contours, wells, and compaction data have been collected from 1977 through the present, water-level changes over

Data Layers:
USGS Subsidence Viewer

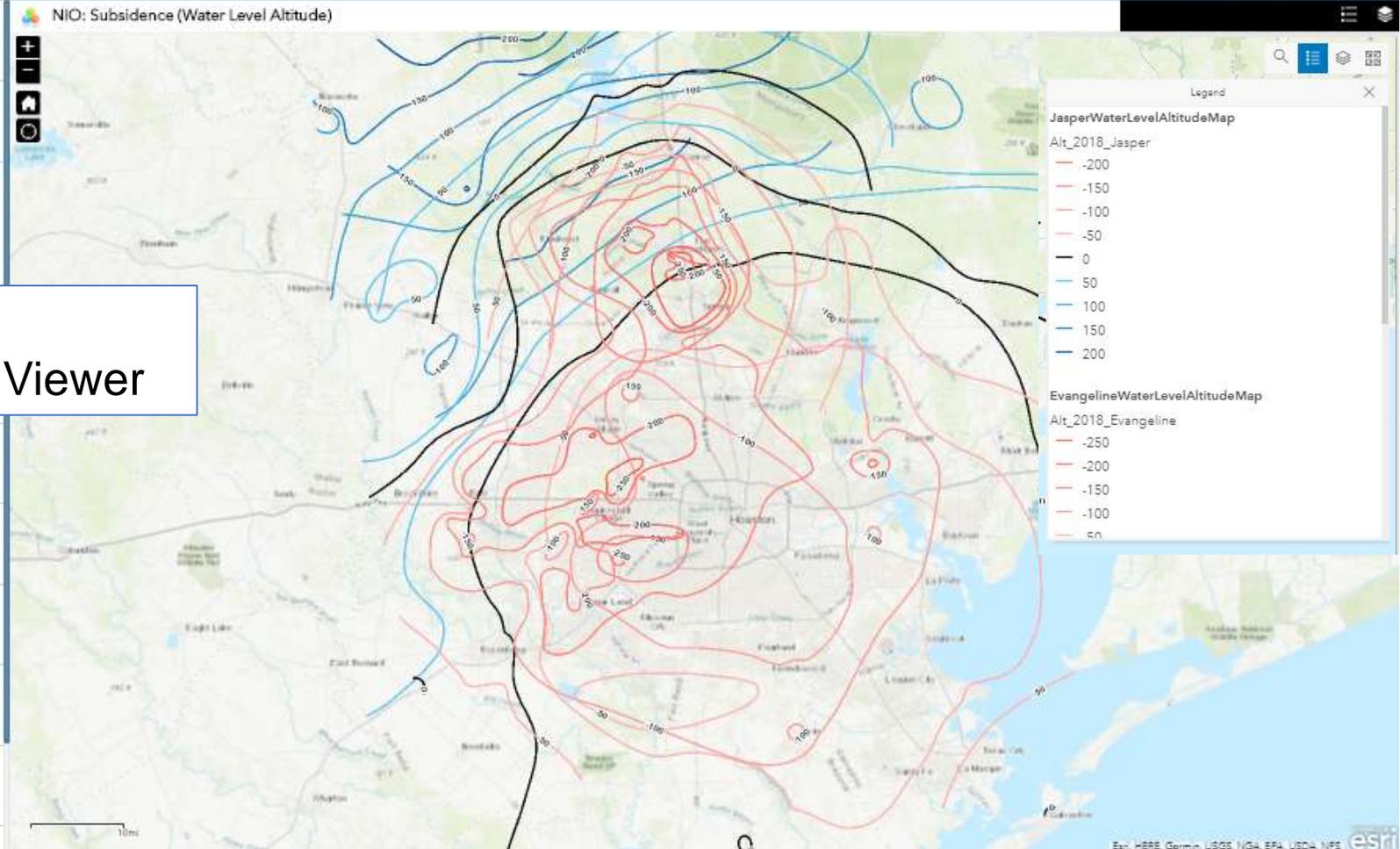
4 Shoreline Rate Change

5 Sediment Baseline Conditions

6 Resource Needs

7 Resource Connections

8 Environmental Considerations



Shoreline Change

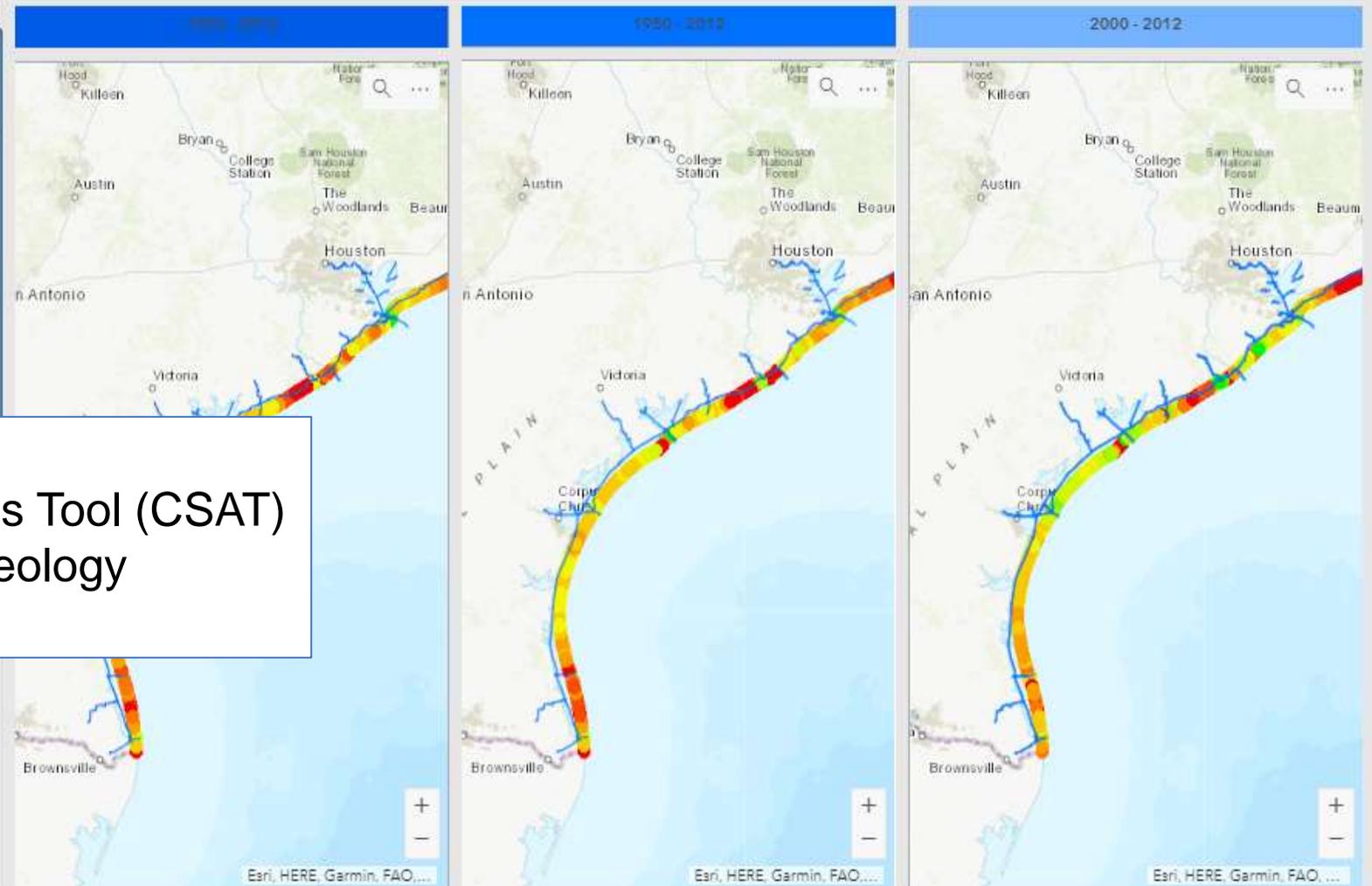
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A decision support tool



- ▶ 1 About NIO
- ▶ 2 Local Conditions
- ▶ 3 Explore Subsidence
- ▶ 4 Shoreline Rate Change

Shoreline Rate Change: 1930 - 2012



Data Layers:
 Corps Shoaling Analysis Tool (CSAT)
 Bureau of Economic Geology
 Shoreline Change

How to use this map:

- [Click to show Corps Shoaling Analysis Tool \(CSAT\)](#)
- [Click to show change rate \(Bureau of Economic Geology\)](#)
- [Click to show change rate \(Shoreline Change\)](#)
- [Click to show change rate \(Shoreline Change\)](#)

Other options to explore:

- [Bureau of Economic Geology](#)
- [CSAT mapping application](#)
- [CSAT data sources](#)

Note:

Data for this change rate (1930s - 2012) application are taken from Paine, Caudle, and Andrews (2014), where the methods, data sources, and results are discussed. The individual data points (shoreline movement rates at 11,497 points along the 2012 Texas Gulf coast shoreline) can be downloaded from the Bureau's coastal studies download page. Project sponsored by the General Land Office of Texas under CEPR contract no. 09-074-000.

Sponsoring and Participating Organizations

Baseline Conditions

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4 Shoreline Rate Change

5 Sediment Baseline Conditions

How to use this map:

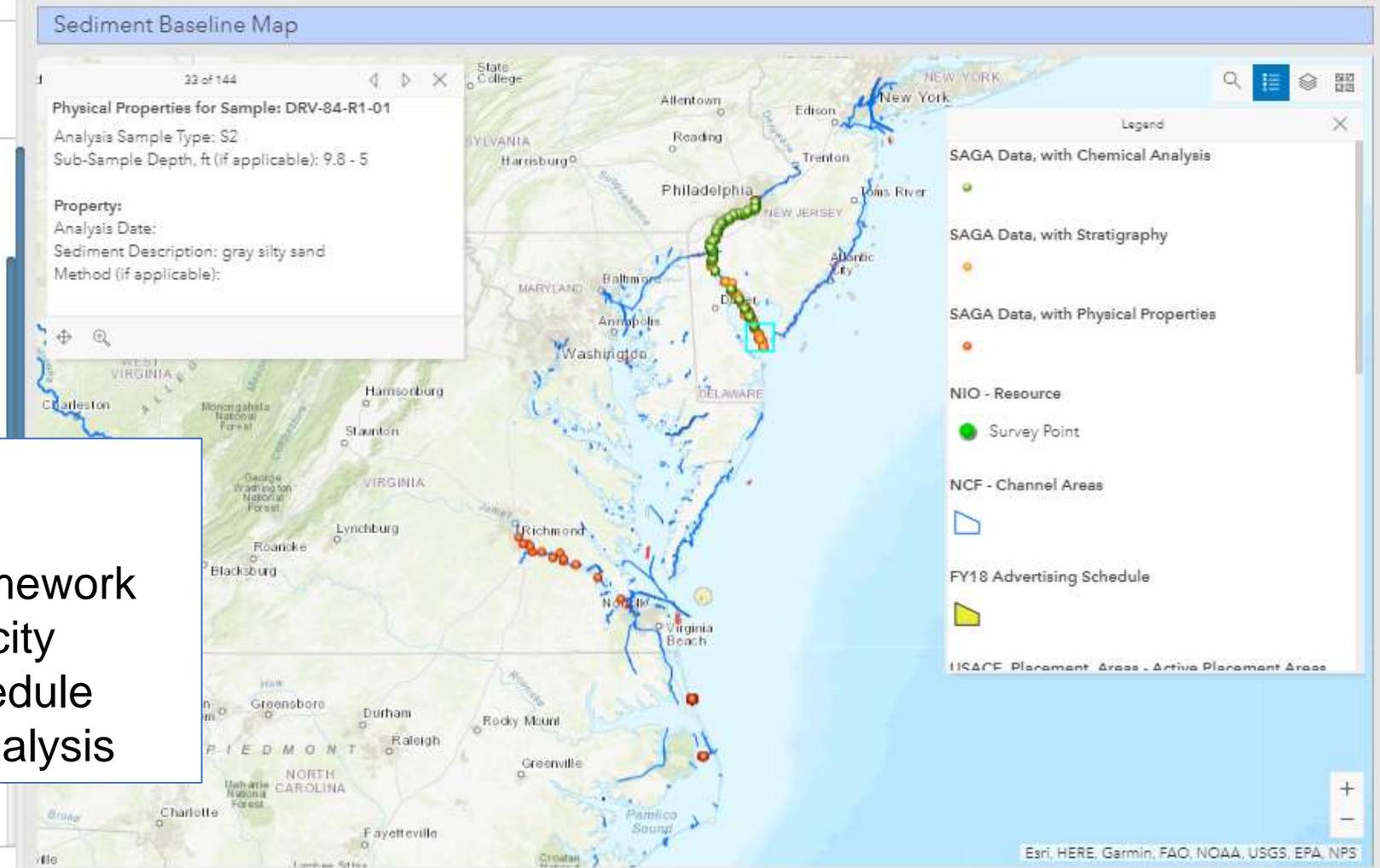
- This map shows sediment RESOURCES known in the US Army Corps of Engineers through sediment sampling activities and analyses, based on FY 18 [Dredging Advertising Schedule](#).
 - You can see if a location have Physical, Chemical, or Biologic analyses available.
 - You can view Placement Area Capacity
- This map also shows National Channel Framework
- Click on features in the map to view details.
- Available Map Layers:
 - NIO - Resource
 - Placement area Capacity
 - FY19 Advertising Schedule
 - Available Sediment Analysis

Become a Contributor

This map is powered by our contributors.

Step 1: Click the button below to contribute.

- I HAVE Resources



Data layers:
 NIO – Resource
 National Channel Framework
 Placement area Capacity
 FY19 Advertising Schedule
 Available Sediment Analysis

NI Resource Need

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6 Resource Needs

How to use this map:

- This map also shows contribution from our *NIO User Community* identifying resource NEEDS.
- Click on features in the map to uncover additional attribution per each site or polygon

- NIO Resource Needs
- Regional Sediment Management (RSM) Projects, FY17
- Pre-Construction Engineering and Design (CSRMS)
- Partial Construction Funds Received (CSRMS)
- Awaiting Initial Construction (CSRMS)
- National Channel Framework

Become a Contributor

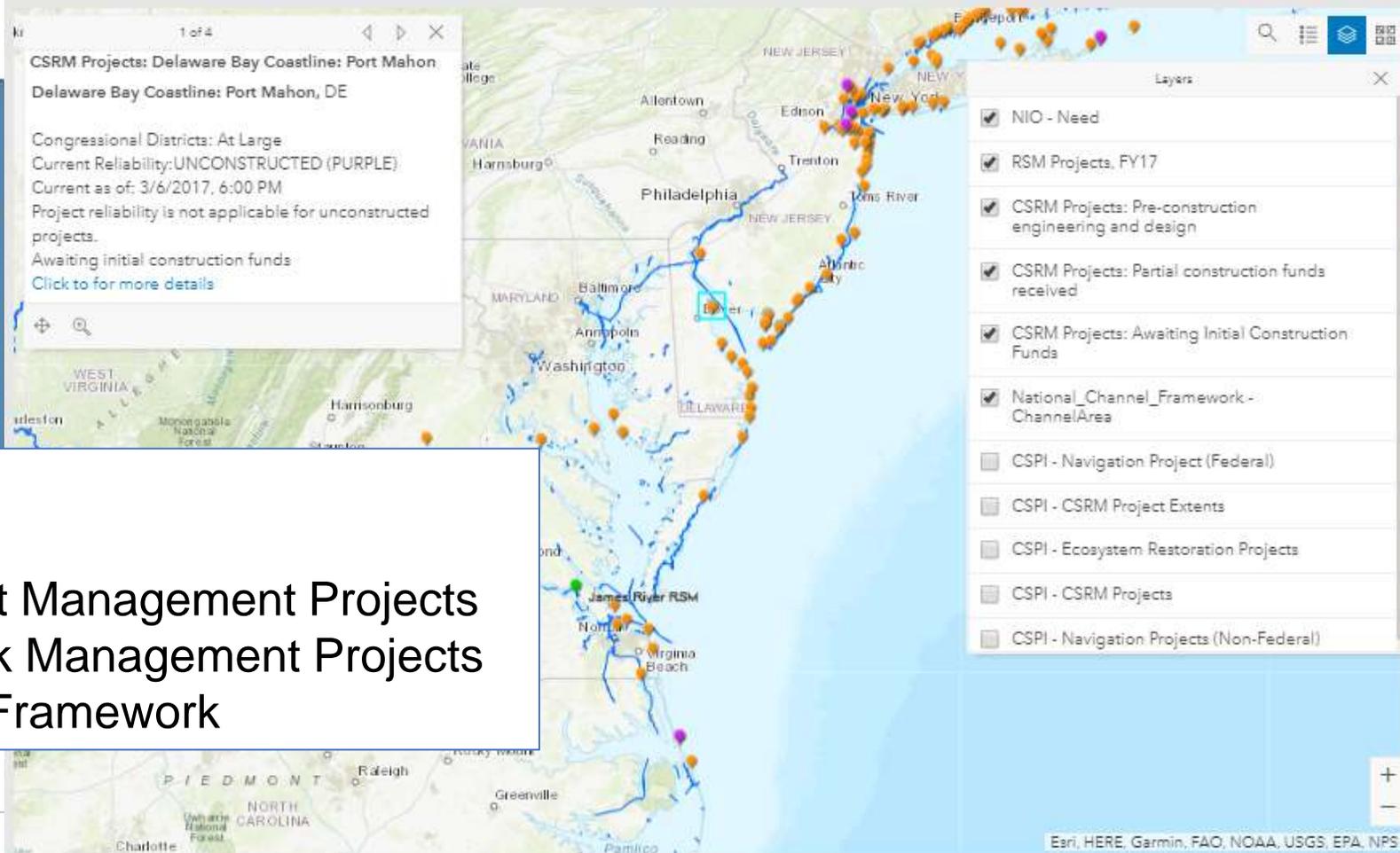
This map is powered by our contributors! D

Step 1: Click the NEED button below to mak

- I NEED Resources

Data Layers:
 NIO – Need
 Regional Sediment Management Projects
 Coastal Storm Risk Management Projects
 National Channel Framework

Resource Needs Map



NIO Contributors

- The mapping tools allows the community of users to submit “announcements” of resources or needs.
- Tabs 1, 5, and 6 have links to create a mapped “announcement” of Available Resources or Resource Needs.
- Click the respective link to open the online entry form
 - Users supply location and basic descriptions of resources that they need or have.

▶ 1 About NIO

▶ 2 Local Conditions

▶ 3 Explore Subsidence

▶ 4 Shoreline Rate Change

▶ 5 Sediment Baseline Conditions

▶ 6 Resource Needs

▶ 7 Resource Connections

Step 1: Click the respective button below to make a registry in the Natural Infrastructure Opportunities database. Once a registry is made, it is visible on the Sediment Baseline Conditions, Resource Needs, and Resource Connections tabs.

-  I HAVE Resources
-  I NEED Resources

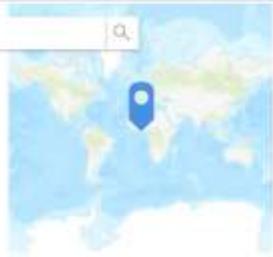
NIO Contributors | Forms

NIO - Resource

Please fill out the form below to register your resource in the Natural Infrastructure and Opportunity (NIO) database.

Submission Date*

Location of Resource*
Where is the resource located?


Powered by Esri

Lat: 1.40611 Lon: 0

Resource Status*
Is this a planned, under contract, or current availability?

Planned

Under Contract

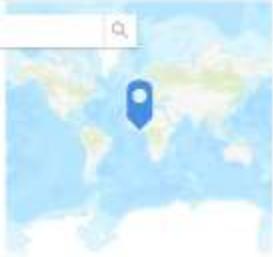
Currently Available

NIO - Need

Please fill out the form below to register your resource in the Natural Infrastructure and Opportunity (NIO) database.

Submission Date*

Location of Need*
Where is the need located?


Powered by Esri

Lat: 1.40611 Lon: 0

Area of Interest Buffer*
Enter, in feet, the approximate width of the area of interest.

Need Description*

NIO Resource Connections

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A decision support tool



7 Resource Connections

How to use this map:

- This map only shows contributions from our *NIO User Community* and Regional Sediment Management (RSM) Projects for the current fiscal year.
- Click on the Legend and Layers buttons at the bottom of the map to discover what data is available.
- Click on features in the map to uncover additional attribution per each site or polygon.

Legend

- USACE Projects
- NIO Resource
- NIO Need

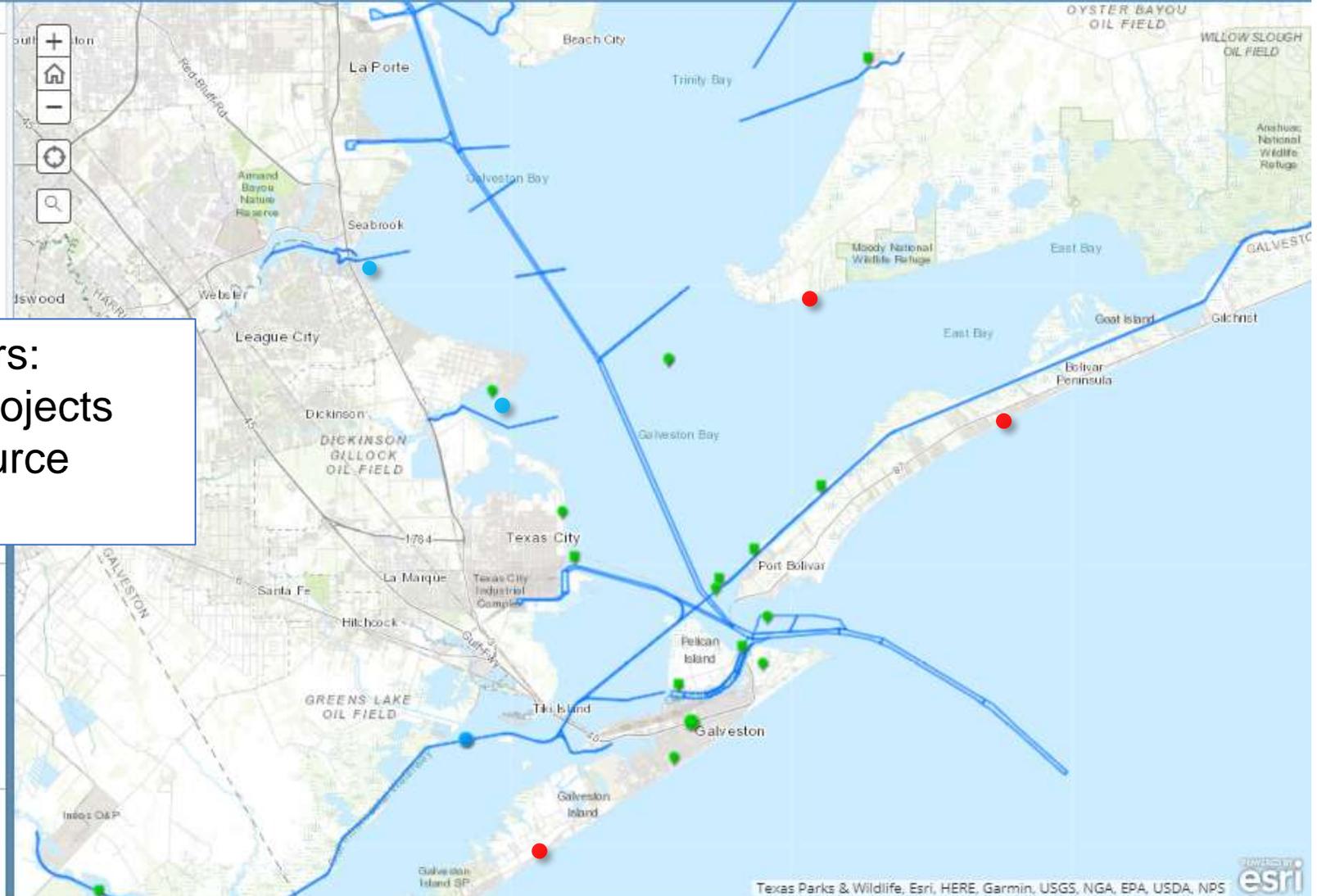
Sources: NIO, RSM

Data Layers:
USACE Projects
NIO Resource
NIO Need

8 Environmental Considerations

9 Environmental Impact

10 All Data



Texas Parks & Wildlife, Esri, HERE, Garmin, USGS, NGA, EPA, USDA, NPS



Environmental

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A decision support tool



▶ 5 Sediment Baseline Conditions

▶ 6 Resource Needs

▶ 7 Resource Connections

▶ 8 Environmental Considerations

▶ 9 Environmental Impact

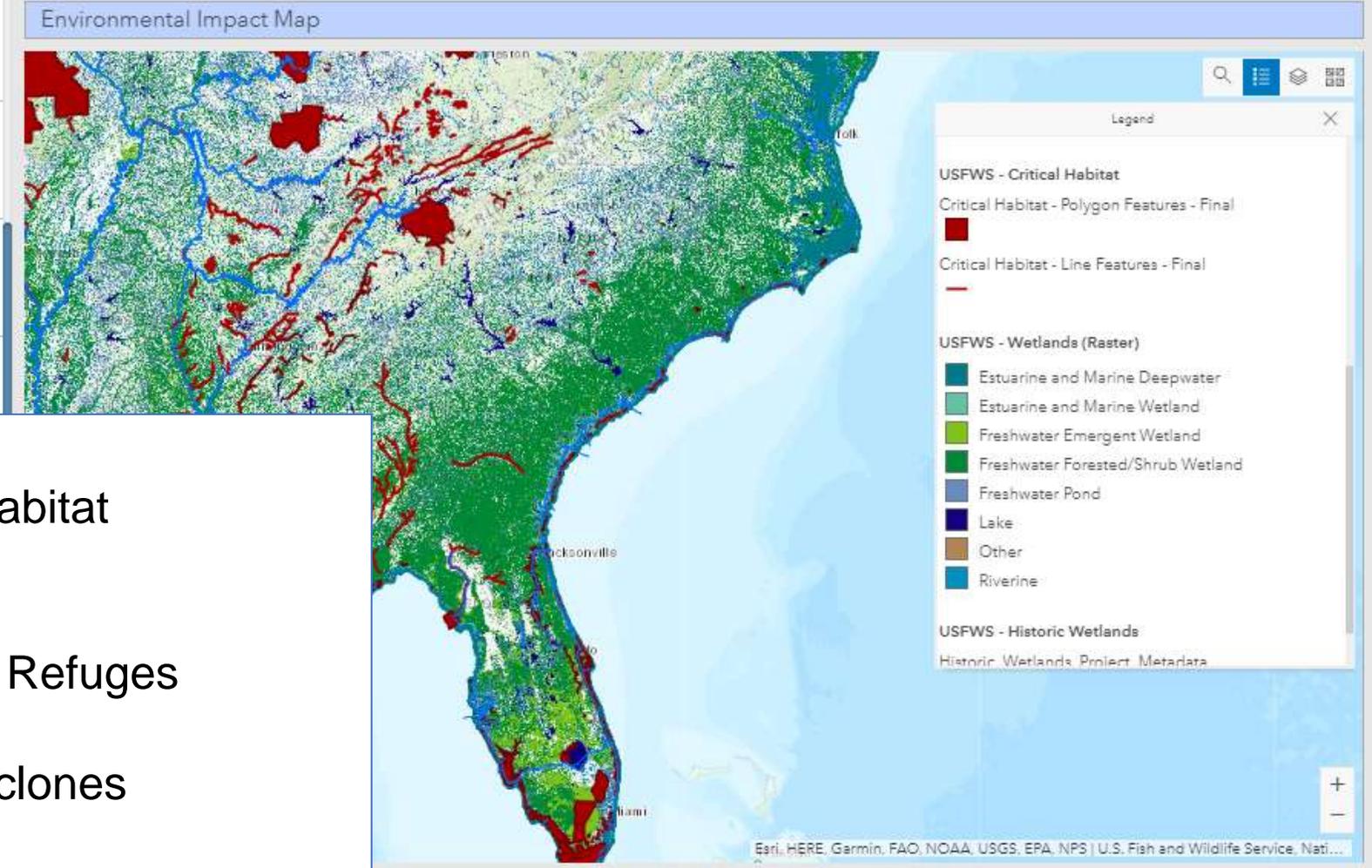
How to use this map:

- View the [NIO Environmental Impact Map](#)

- Zoom to your area of interest and display the map layers and environmental considerations.
- Click on the Legend button in the upper right corner of the map to view the legend.
- Click on features in the map to uncover more information.
- Use the map tools in the upper right corner of the map.

- Available Map Layers:

Data Layers:
 Essential Fish Habitat
 Oyster Beds
 Seagrasses
 National Wildlife Refuges
 Wetlands
 Major Global Cyclones
 Hurricanes
 NCF-Channel area



Research and Development Center

Contacts and Connections

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▶ 8 Environmental Considerations

▶ 9 Environmental Impact

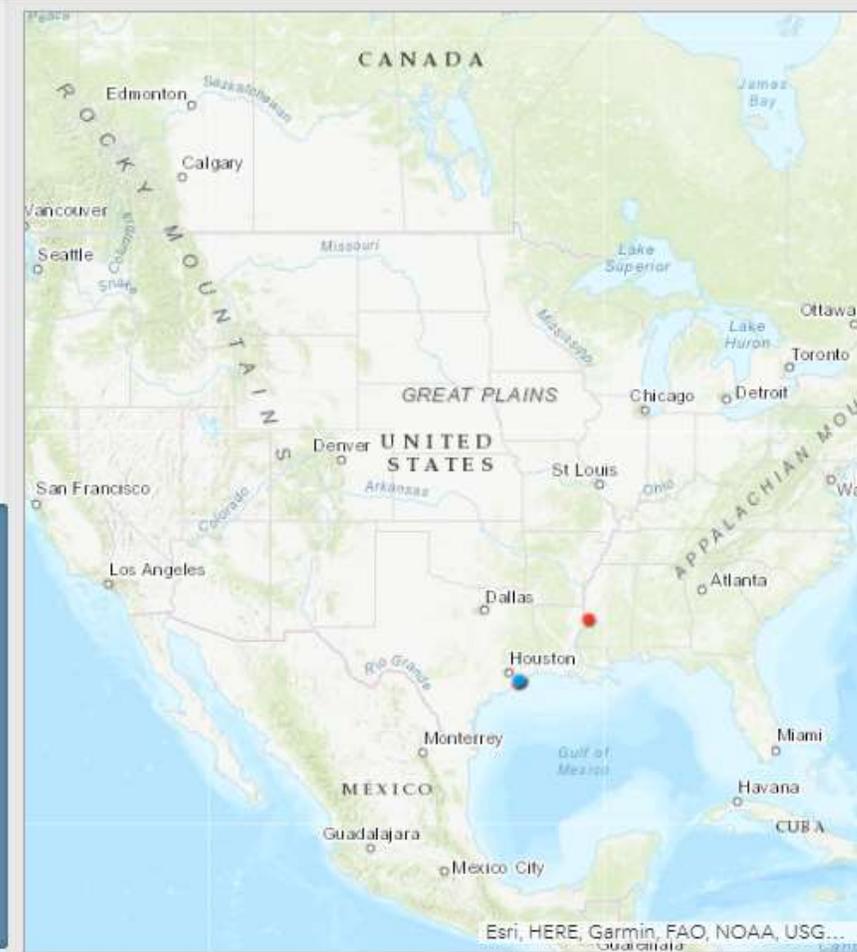
▶ 10 All Data

▶ 11 Connections & Contacts

The Natural Infrastructure Initiative membership includes: Caterpillar, AECOM, Great Lakes Dredge & Dock, The Nature Conservancy, Ducks Unlimited, University of Georgia - Institute for Resilient Infrastructure Systems, Brown & Root, and Dawson & Associates.

The NIOT was developed in collaboration with the Natural Infrastructure Initiative, US Army Corps of Engineers Engineer Research and Development Center (ERDC), and US Army Corps of Engineers Mobile District.

Use the lists on the right to view each of the Have/Need Resources submitted by



Need Resources	Have Resources
Vicksburg, MS Wetlands and Coastal Ecology ERDC TEST https://www.erd.c.usace.army.mil/Locations/EL/Demo	Title of Resource Here Your Agency Name Here Your Office Name Here Your Website Here Amount of Resource: 10000 cy
Name of Need Here USACE ERDC-RDE-EL-MS www.usace.army.mil A description of your resource need goes here	
Name of Need Here Organization name Here Office Name Here yourwebsite.com I need sandy material	
<p style="text-align: right; font-size: small;">Last update: 2 hours ago</p>	<p style="text-align: right; font-size: small;">Last update: 2 hours ago</p>

Where to find NIOT: <https://ewn.el.erdc.dren.mil/> <http://engineeringwithnature.org>

EWN
Engineering With Nature

EWN Initiative + Proving Grounds Projects + Resources + NNBF +

EWN News

August 8, 2019
The U.S. Army
Nature Initiative
Nature Resource
Achievement
With
ble
ing

August 7, 2019
Natural Infrastr
Developed in
Infrastructure
identifying natural infrastructure and beneficial use opportunities. (internal link)

June 18, 2019
Dr. David Pittman delivers ERDC briefing to the Army Science Board as part of the USACE Civil Works mission. EWN was included in the video on Civil Works R&D: Value to the Nation, linked here. (external link)

May 16-17, 2019
NNBF Symposium at Edinburgh's Centre for Carbon Innovation, Edinburgh (internal link)

May 13-15, 2019
Sixth, In-Person Technical Meeting of International Working Group Developing Guidelines for Use of Natural and Nature-Based Features (internal link)

May 2019
Corps researchers investigate how to create resilient

Run-off attenuation features, Belford Burn stream, Northumberland, England (Photo by Nicolas Barber).

Engineering With Nature An Atlas [Read more >](#)

October 2018 - This atlas is a collection of 56 projects that illustrate a diverse portfolio of contexts, motivations, and successful outcomes. These projects are presented and considered in this atlas using an Engineering With Nature lens as a means of revealing the use of nature-based approaches and the range of benefits that can be achieved.

Call for Project Nominations for the EWN, An Atlas Volume 2 [Read more >](#)

Due to the strong, positive response to the EWN Atlas, we are now

<https://ewn.el.erdc.dren.mil/tools.html>


[EWN Initiative +](#)
[Proving Grounds](#)
[Projects +](#)
[Resources +](#)
[NNBF +](#)

Tools

Natural Infrastructure Opportunities Tool

The public facing *Natural Infrastructure Opportunities Tool (NIOT)*, developed in collaboration with the Natural Infrastructure Initiative, focuses on identifying natural infrastructure and beneficial use opportunities. Through map-based visualizations of environmental, geomorphic, and sediment conditions, as well as upcoming USACE projects, and an interface for users to add their resource needs and resource availability, this portal will help discover natural infrastructure connections and inspire innovative opportunities.

The aim of the viewer is to provide a data informed perspective for multiple stakeholders with the goal of finding mutually beneficial strategies to improve and increase investment in the use and creation of natural infrastructure. The viewer is intended to be used in collaboration, as a platform to generate new ideas about natural infrastructure projects during the planning stages.

The NIOT viewer was developed through iterative collaboration with representatives from Caterpillar Inc., The Nature Conservancy, Great Lakes Dredge and Dock, AECOM, USACE ERDC and USACE Mobile District. The viewer brings together datasets from multiple sources in one place and also allows users to identify current infrastructure projects, and directly add resource or project needs. Resource connections, as well as points of contact, are integrated into supporting databases and appear on the viewer map. The viewer includes national and regional datasets, and also provides users the option to request the addition of user-identified geospatial data layers, allowing NIOT to be adapted for regional use and fine tuned for local application.

Type: Web application

User: Public and USACE

POC: Safra.Altman@usace.army.mil

[NIOT Tool User Guide \(PDF\)](#)

[Visit Natural Infrastructure Opportunities Tool web application](#)

Engineering With Nature Project Mapper (ProMap)

ProMap is a geography-based data viewer for projects that fit within the EWN context. The aim of the mapper is to allow users to explore information that can be helpful in developing EWN ideas during the planning of their own projects. Projects can be viewed based upon infrastructure type (e.g., dredging project, breakwater, lock & dam) or by their intended environmental or social benefits. (see [User's Guide](#))

Type: Web Application

User: Public and USACE

[ProMap Platform Presentation \(PDF\)](#)

[ProMap Poster Presentation \(PDF\)](#)

[ProMap ERDC Technical Note](#)

Concluding Thoughts

- USACE ERDC, Mobile and Galveston Districts have developed an extensible framework that uses available Corps enterprise databases and integrates data collection and analysis tools.
- Database capabilities, tools, and methods are extendable to other projects, USACE Districts, and infrastructure opportunities.
- In collaboration with the Natural Infrastructure Initiative the public facing *N/OT* web-viewer focuses on identifying beneficial use and infrastructure opportunities.
- We are looking forward to user additions and feedback to revise and improve the viewer.