



# **INTEGRATING NATURE INTO ADAPTED SHORELINES**

Pippa Brashear,  
Resilience Principal, SCAPE Landscape Architecture

**What are natural and  
nature-based solutions (NNBS) or  
natural and nature-based  
features (NNBF)?**

## WHAT ARE NATURAL AND NATURE-BASED FEATURES (NNBF)?

**Natural and Nature-Based Features (NNBF)** refers to **the use of landscape features to produce flood risk management (FRM) benefits**. NNBF projects may also produce **other economic, environmental, and social benefits known as co-benefits**. These landscape features may be natural or nature based and include such features as beaches, dunes, wetlands, reefs, and islands..

*US Army Corps of Engineers ERDC (2021). "Overview: International Guidelines on Natural and Nature-Based Features for Flood Risk Management"*

<https://ewn.erdcdren.mil/>



# WHAT ARE NNBF?

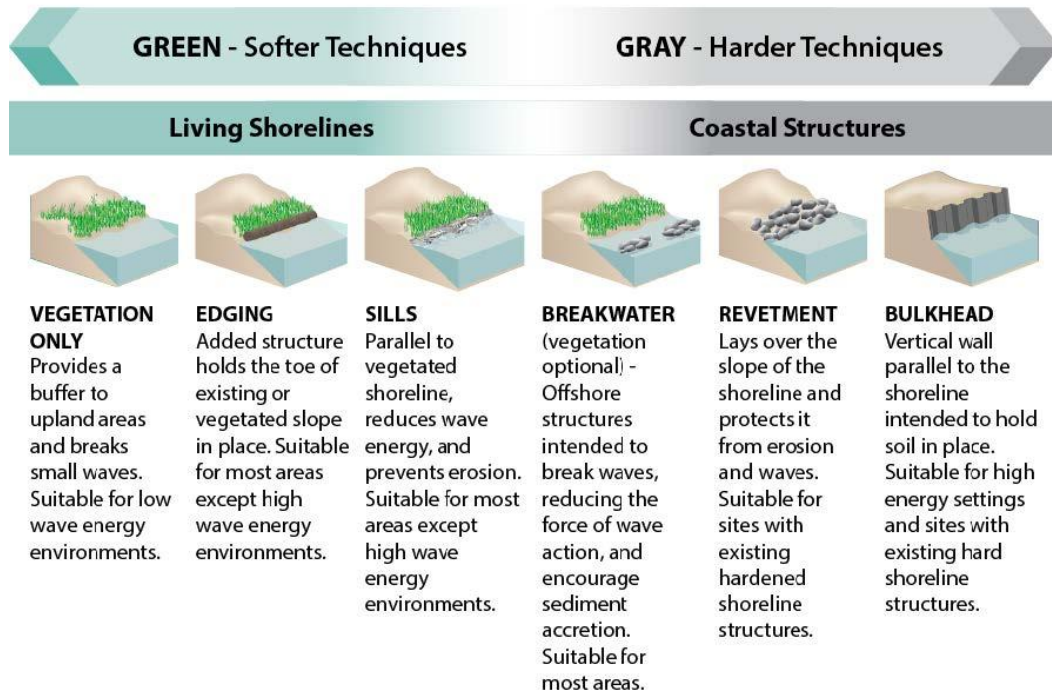
## US ARMY CORPS

“**Natural and nature-based features (NNBF)** refers coastal and fluvial landscape features, either natural or nature-based, that produce flood risk management and other benefits.

**Natural features** are those created by nature;

**nature-based features** are engineered by people to mimic natural conditions. NNBF projects provide multi-purpose functions related to flood and storm damage reduction and ecosystem restoration. They are designed to simultaneously deliver economic/engineering, social and environmental benefits.”

<https://ewn.erdc.dren.mil/>



Source: USACE Engineering With Nature (EWN)

# What are NNBF?

## US ARMY CORPS

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## NOAA

NOAA defines **natural infrastructure** as “healthy ecosystems, including forests, wetlands, floodplains, dune systems, and reefs, which provide multiple benefits to communities, including storm protection through wave attenuation or flood storage capacity and enhanced water services and security.”

NOAA Administrative Order (NAO)  
216-117: National Habitat Policy

## FEMA

**“Nature-based solutions** are sustainable planning, design, environmental management and engineering practices that weave natural features or processes into the built environment to promote adaptation and resilience.”

<https://www.fema.gov/emergency-managers/risk-management/nature-based-solutions>

# A RANGE OF SHORELINE TYPES FROM NATURAL TO HARDENED



salt marsh/emergent wetland



rip-rap sill shoreline



bio enhanced concrete unit



bulkhead



salt marsh/emergent wetland



constructed dune



reef balls



revetment



shellfish bed/reef



living shoreline



bio enhanced concrete units



groin/jetty

Natural  
Features

Nature-Based  
Features

Ecologically  
Enhanced Hard  
Structural Features

Hard Structural  
Features

**To what extent can nature be  
used to help build flood  
protection in the region?  
(Extent that nature can help  
build protection)**

**What types of nature-based  
solutions are feasible for our  
community?**

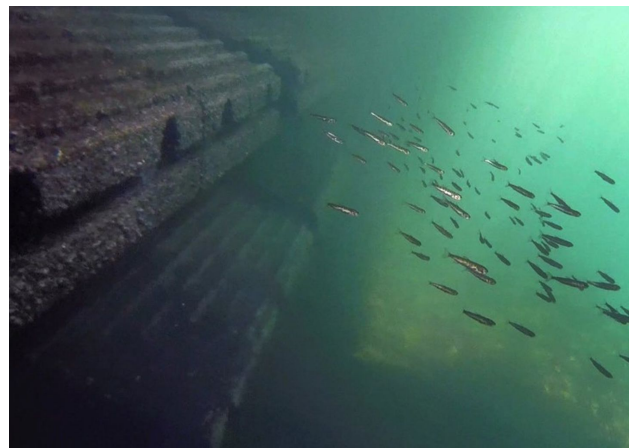
**How might natural &  
nature-based features be  
integrated into the HATS  
proposals?**

## ENHANCE EXISTING MEASURES

Enhance the hard shore-based measures, storm barriers, and risk reduction features with habitat/ecosystem enhancing features

- + Create habitat & Support biodiversity
- + Help offset environmental impacts hard structures
- + Restore/provide a range of ecosystem functions

# ECOLOGICALLY ENHANCED BULKHEADS



# ECOLOGICALLY ENHANCED REVETMENTS



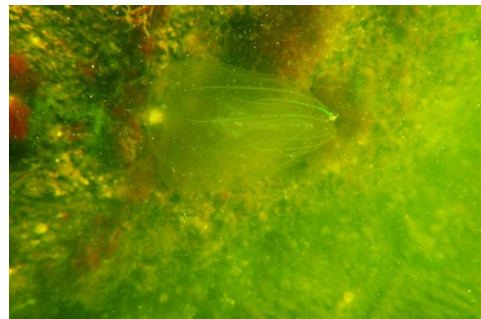
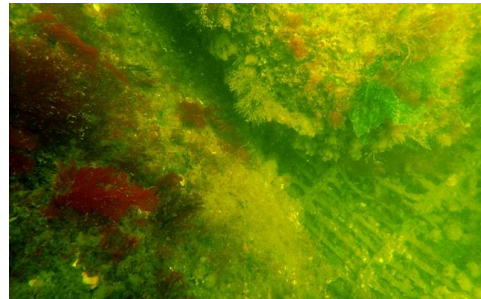
Photo: SCAPE

1 Huron Street, Brooklyn  
photo: Scape

# ECOLOGICALLY ENHANCED BREAKWATERS



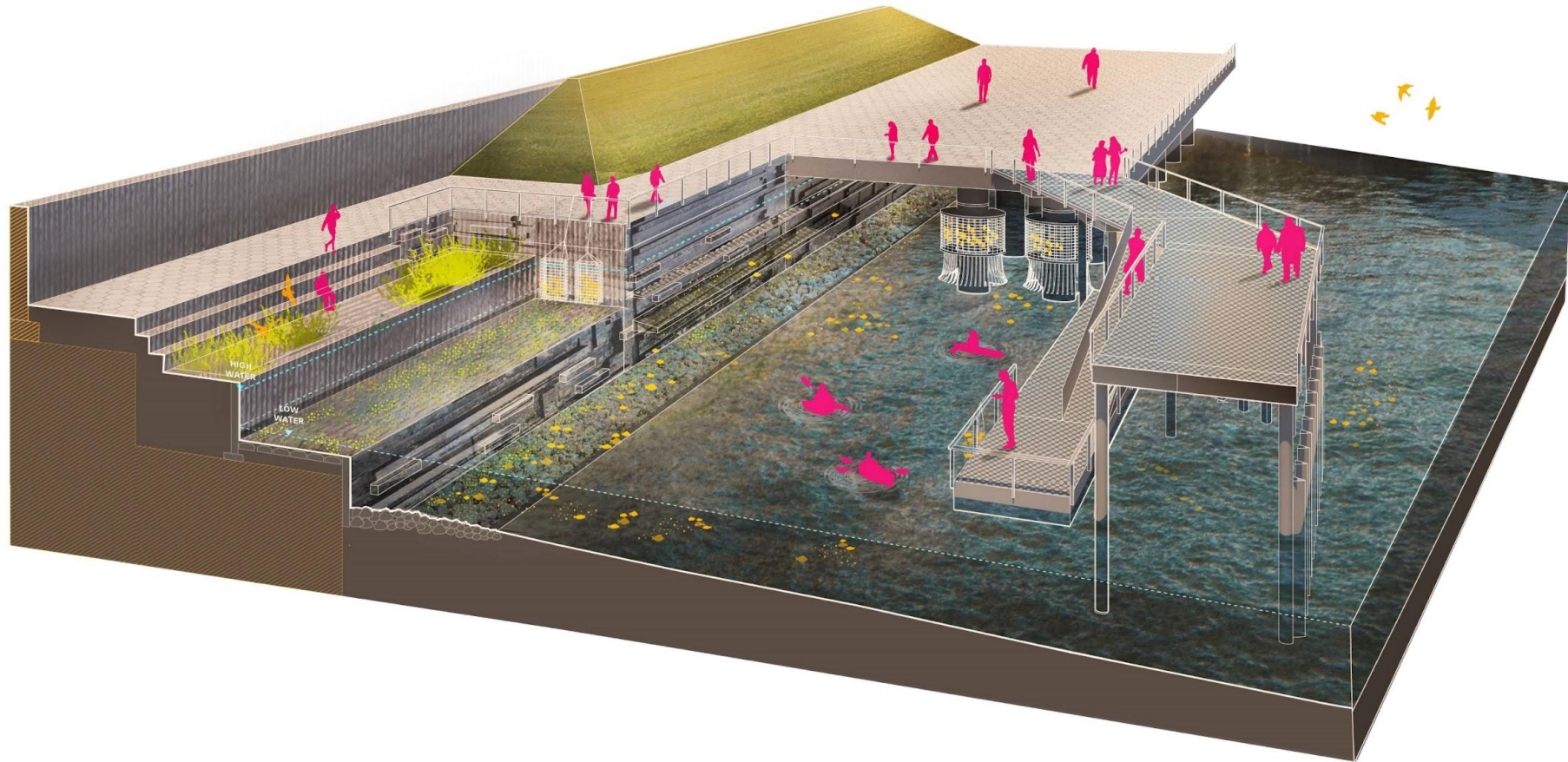
photos: SCAPE + COWI



Living Breakwaters (NY GOSR)

## CREATING A MULTI-LAYER SYSTEM

Strategies for Ecosystem Enhancement



## LAYER NATURAL AND NATURE-BASED FEATURES

Layer nature-based strategies (e.g. living shorelines) and natural systems restoration (e.g. saltmarsh, eelgrass)

- + Create habitat & Support biodiversity
- + Help offset environmental impacts hard structures
- + Restore/provide a range of ecosystem functions
- + Reduce erosion and wave impacts
- + Help preserve existing natural shorelines
- + Can help reduce the height and cost of shore-based structures

# LIVING SHORELINES + SHORE-BASED MEASURES



In construction



In construction

Ohio Creek Neighborhood Resilience Project (City of Norfolk, VA)

# LIVING BREAKWATERS + SHORE-BASED MEASURES



In construction



Living Breakwaters (NYS GOSR)

SCAPE Team for NYS GOSR

# Overview of the Final Design

## ADJACENT SHELL HALO

Reef ridges were design at a maximum 1:10 slope and incorporate artificial tide pools that retain water between tides, introducing interstitial habitat communities.

## EMERGENT HABITAT AND LEE SIDE

Above MHW the breakwater side slopes and crest create opportunities for perching birds as well as haul out areas for harbor seals.

## WIDENED BEACHES

Reversal of shoreline erosion and accretion of sediment over time will create wider beaches. These beaches will act as an energy buffer and allow for the establishment of dune grasses

## SHALLOW SLOPING INTERTIDAL HABITAT

Reef ridges were design at a maximum 1:10 slope and incorporate artificial tide pools that retain water between tides, introducing interstitial habitat communities.

## STEEP SUBTIDAL HABITAT

Vertical and steeply inclined surfaces are placed within the subtidal zone and incorporate both bio-enhancing concrete armor units and stone armor units. The unit complexity, along with low sedimentation and light levels create prime opportunities for the colonization various aquatic organisms.

## REEF STREETS CREATE COMPLEX HABITAT

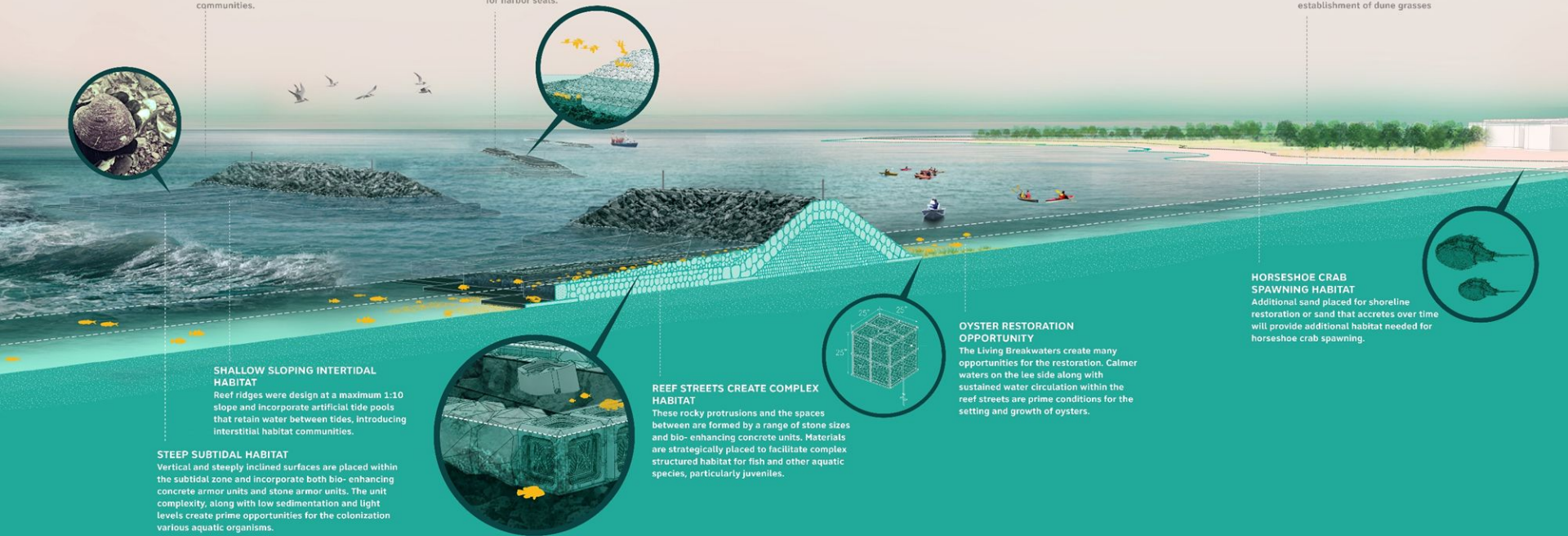
These rocky protrusions and the spaces between are formed by a range of stone sizes and bio-enhancing concrete units. Materials are strategically placed to facilitate complex structured habitat for fish and other aquatic species, particularly juveniles.

## OYSTER RESTORATION OPPORTUNITY

The Living Breakwaters create many opportunities for the restoration. Calmer waters on the lee side along with sustained water circulation within the reef streets are prime conditions for the setting and growth of oysters.

## HORSESHOE CRAB SPAWNING HABITAT

Additional sand placed for shoreline restoration or sand that accretes over time will provide additional habitat needed for horseshoe crab spawning.



Living Breakwaters, Staten Island

# HABITAT BREAKWATERS



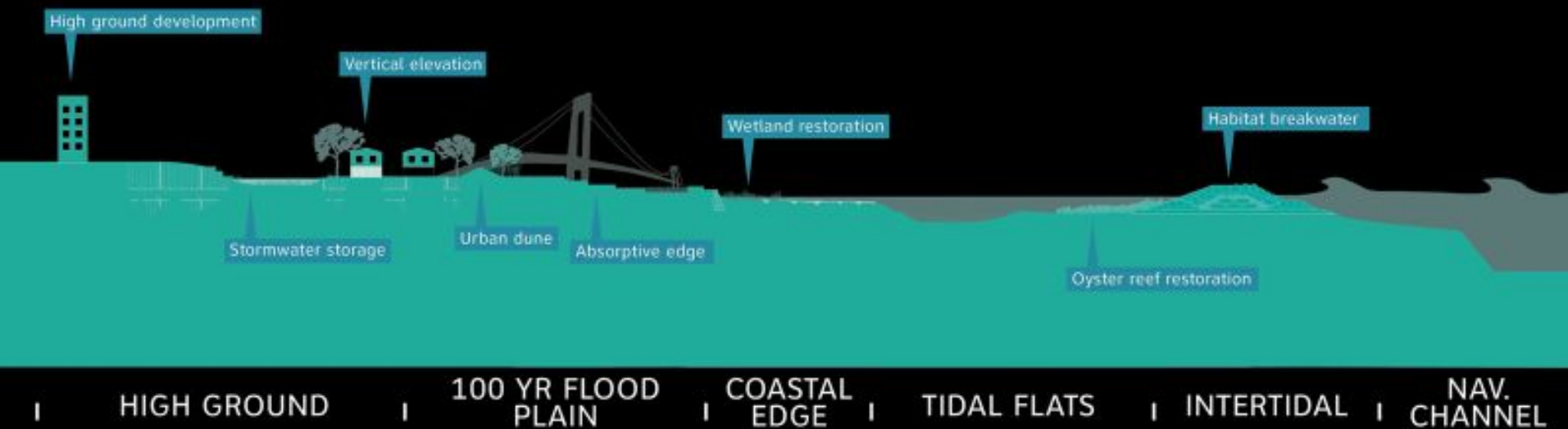
## DO:

- REDUCE EROSION
- LESSEN WAVE IMPACTS
- PROVIDE HABITAT
- ENCOURAGE  
RECREATIONAL  
FISHERIES
- BUILD BEACHES

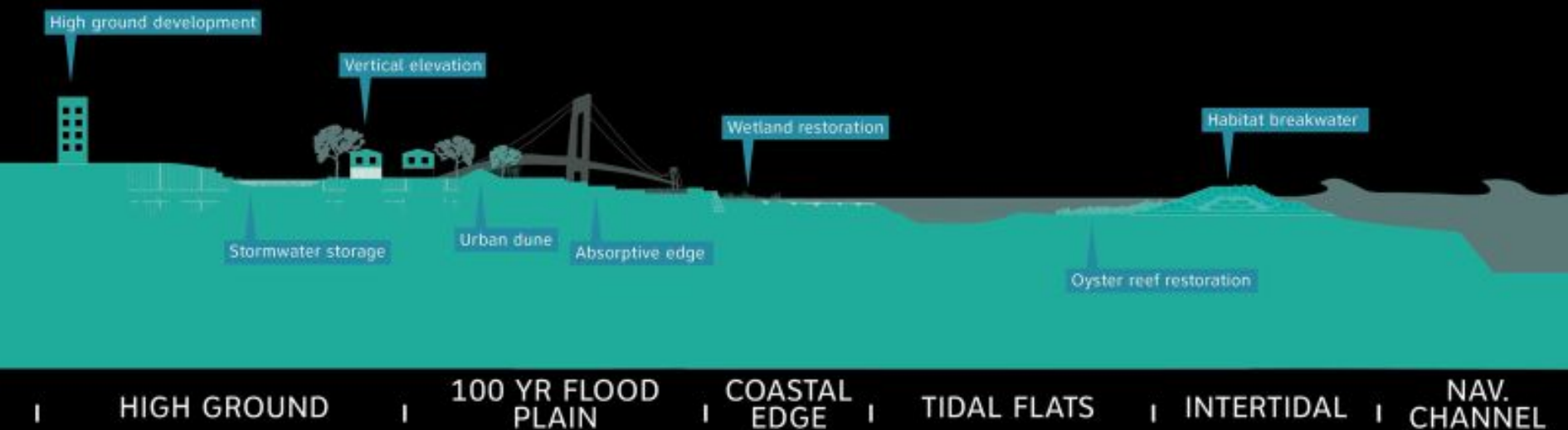
## DO NOT:

- KEEP OUT FLOOD  
WATER

# ITS NOT JUST A LIVING BREAKWATER IT IS A LAYERED APPROACH



# ITS NOT JUST A LIVING BREAKWATER IT IS A LAYERED APPROACH



# LIVING SHORELINE



SOURCE: NYC Water

Jamaica Bay Living Shoreline Project , Queens

# LIVING SHORELINE



SOURCE: Brooklyn Bridge Park Conservancy

Brooklyn Bridge Park, Brooklyn

# CONSTRUCTED WETLANDS



Hunters Point South Park, Queens

# [NARROW, URBAN] LIVING SHORELINE



NYC Parks Natural Resources Group



Harlem River Park, Manhattan

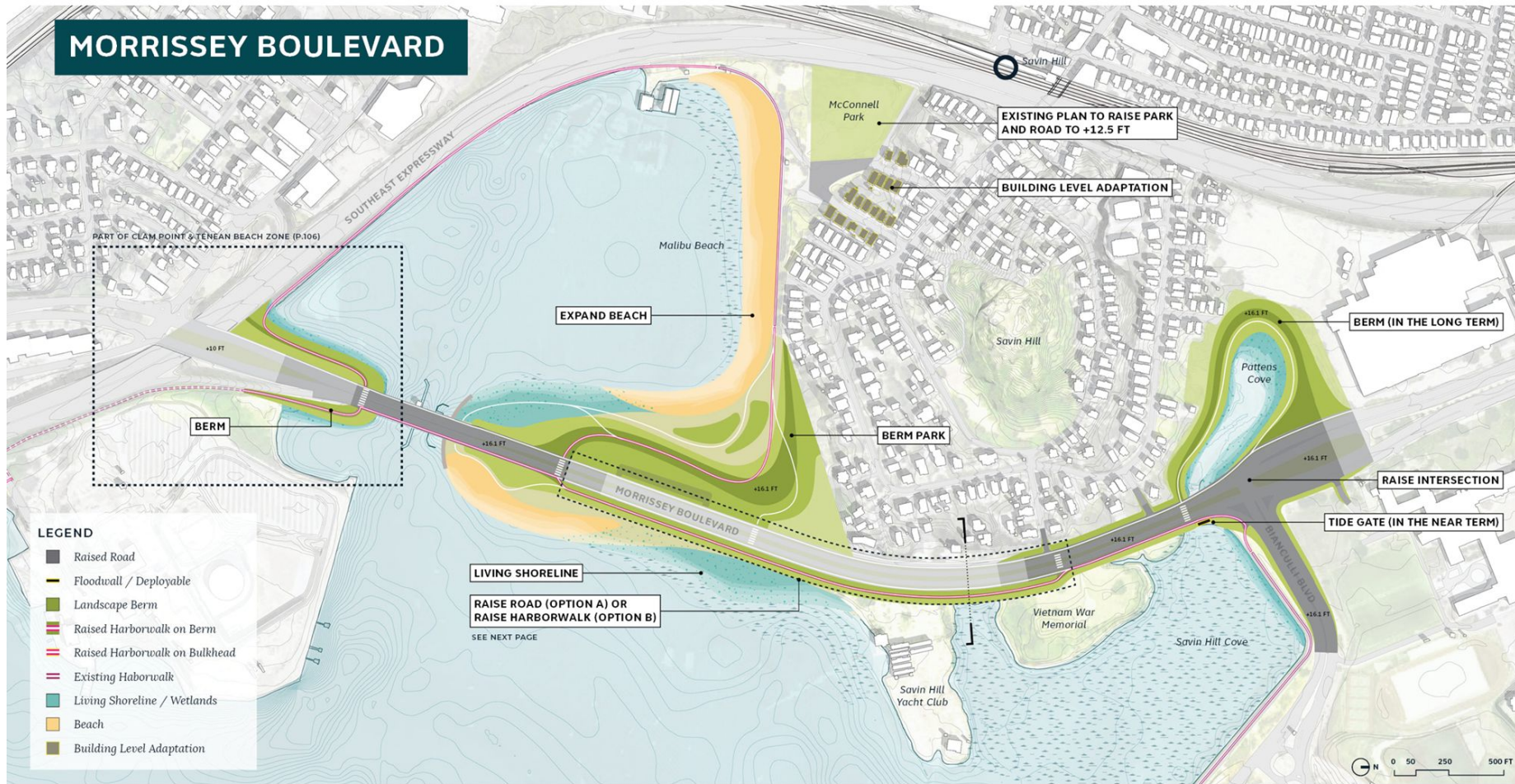
# [NARROW, URBAN] LIVING SHORELINE



Ganesvoort Peninsula Park, Manhattan

James Corner Field Operations, courtesy of the Hudson River Park Trust

# MORRISSEY BOULEVARD



Climate Ready Dorchester, Boston, MA

SCAPE + Woods Hole Group + Tetratech for City of Boston

# PERFORMANCE: FLOOD MODELING

## MORRISSEY BOULEVARD WAVE MODELING TRANSECT



1% Annual Chance Flood with 9 in of SLR (2030s) with near-term coastal resilience solutions in place



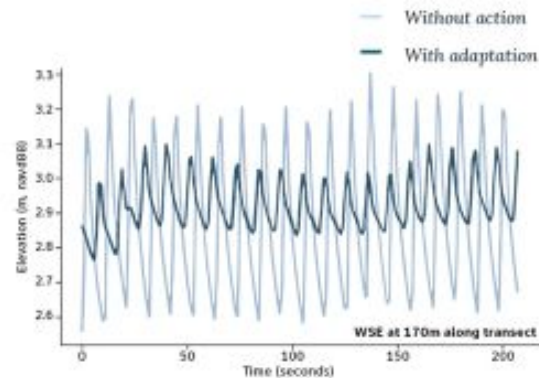
1% Annual Chance Flood with 40 in of SLR (2070s) with near-term and long-term coastal resilience solutions in place

Reduction in waves at Morrissey Boulevard occurring during a 10% annual chance storm with 9 in of SLR due to the proposed beach and living shoreline elements. The results show a 66% reduction in wave height and energy that would reduce erosion and damage to Morrissey Boulevard. The light blue line shows results with no living shoreline or beach restoration in place, while the darker blue line shows the results with the living shoreline and beach nourishment implemented.

### LEGEND

- Coastal Flood Risk Area without action
- Coastal Flood Risk Area with coastal resilience solutions
- Coastal Resilience Solution (Flood Risk Reduction)
- Coastal Resilience Solution (Access, Ecology & Equity)

FLOOD SCENARIO	WAVE HEIGHT REDUCTION
10% Annual Chance Flood with 9 in of SLR	66%
1% Annual Chance Flood with 9 in of SLR	47%
10% Annual Chance Flood with 40 in of SLR	27%
1% Annual Chance Flood with 40 in of SLR	15%



Reduction in waves at Morrissey Boulevard occurring during a 10% annual chance storm with 9 in of SLR due to the proposed beach and living shoreline elements. The results show a 66% reduction in wave height and energy that would reduce erosion and damage to Morrissey Boulevard. The light blue line shows results with no living shoreline or beach restoration in place, while the darker blue line shows the results with the living shoreline and beach nourishment implemented.

## REVIVE ECOSYSTEM-SCALE SYSTEMS

### Revive estuary-scale nature-based systems

- + Create habitat & Support biodiversity
- + Help preserve or restore natural shoreline and nearshore habitats, and ecosystem functions
- + Reduce erosion and wave impacts
- + In the right location and at the right scale can reduce surge heights/extents
- + Can help reduce the height and cost of shore-based structures

## Jamaica Bay Marsh Islands Restoration



BUILDING STRONG®

Jamaica Bay Marsh Island Restoration, Queens + Brooklyn, NY

USACE New York District



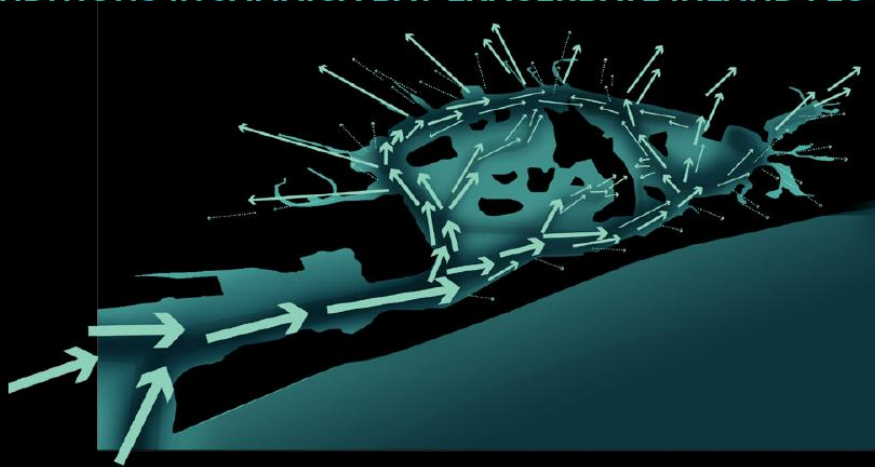
Dredging + Marsh Restoration, Stone Harbor, NJ

USACE Philadelphia District

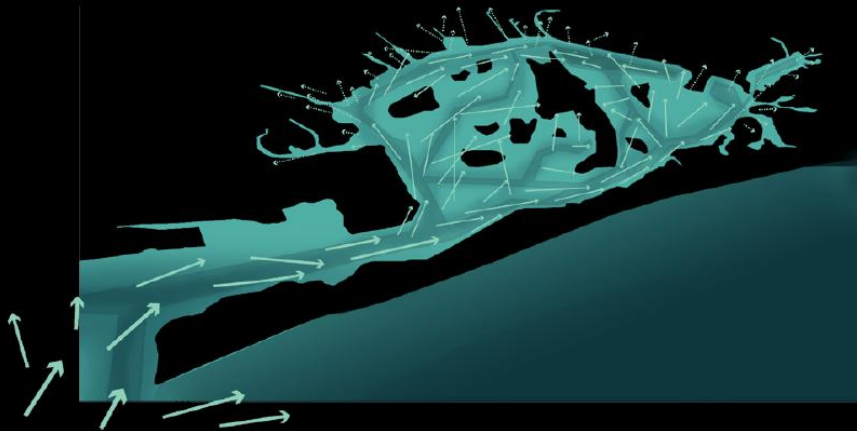
# EXTREME SHALLOWING SCENARIO



## CURRENT CONDITIONS IN JAMAICA BAY EXACERBATE INLAND FLOODING

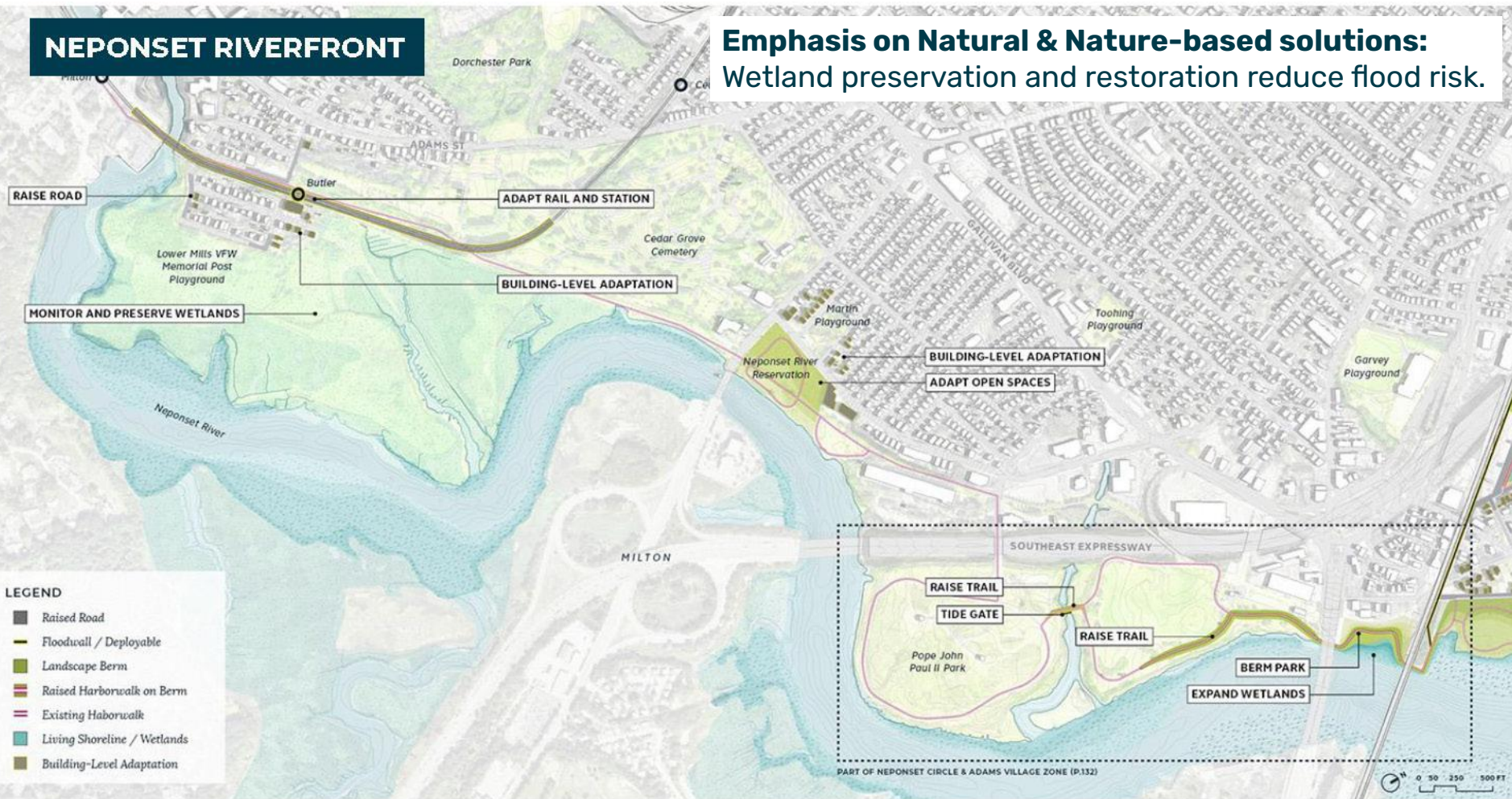


## PROPOSED SHALLOWING REDUCES INFLOW TO BAY SUBSTANTIALLY



## NEPONSET RIVERFRONT

**Emphasis on Natural & Nature-based solutions:**  
Wetland preservation and restoration reduce flood risk.



## Benefits

## Costs

### MONETIZED

#### BUILDINGS

- Avoided Damages to buildings and their contents, and associated functions (displacement and relocation costs, mental stress and anxiety, loss of productivity)

#### BUILDING-LEVEL ADAPTATION

- Building-Level Adaptation for residential buildings in Lower Mills

### NOT MONETIZED

#### INFRASTRUCTURE

- Avoided damages to transportation and utility infrastructure such the Mattapan Trolley, and the Neponset Greenway
- Avoided loss of service in transportation (emergency egress, travel detours and delays)
- Avoided loss of service in utilities

#### ECOLOGY

- Monitor closely critical environmental assets along the Neponset wetlands, to develop adaptation strategy for the long term

#### TRANSPORTATION INFRASTRUCTURE UPGRADES

- Adapted MBTA rail line and Butler Station\*
- Raised roadways\*

#### ECOLOGY

- Wetlands monitoring and preservation program
- Open Space improvements at Neponset River Reservation Park\*\*

## FLOOD MODELING

Results from flood modeling show that natural restoration and adaptation measures along the Neponset River can reduce the extent of fringe flooding impacting neighborhoods and infrastructure both in the near-term and the long-term.

Modeling results show that Neponset River Marsh restoration, adaptation, and management measures that enable marshes to adapt to and elevate with sea-level rise, can significantly reduce the flooding extents at some of the most critical locations impacted by the upper edge of fringe flooding, including the MBTA Butler Station, and the Cedar Grove Cemetery.

Flood model results indicate that maintaining the salt marsh elevation relative to sea-level would delay or postpone the need for flood protection or mitigation measures at Butler station, adjacent streets and homes in this area. Natural restoration and adaptation measures at this location, essentially provide more time to monitor actual sea-level rise trends and plan accordingly.



1% Annual Chance Flood with 9 in of SLR (2030s) with near-term coastal resilience solutions in place



1% Annual Chance Flood with 40 in of SLR (2070s) with near-term and long-term coastal resilience solutions in place

### LEGEND

- Coastal Flood Risk Area without action
- Coastal Flood Risk Area with coastal resilience solutions
- Coastal Resilience Solution (Flood Risk Reduction)
- Coastal Resilience Solution (Access, Ecology & Equity)

## PRESERVE & RESTORE NATURAL FEATURES

Preserve the healthy ecosystems we do have and restore ecosystems.

- + Sustain or improve habitats & biodiversity
- + Help preserve or restore natural shoreline and nearshore habitats, and ecosystem functions
- + Protect against erosion and wave impacts
- + May also keep surge heights/extents
- + Can help reduce the height and cost of shore-based structures

# WETLAND MANAGEMENT FRAMEWORK FOR NYC

FIGURE 4

## NYC's Streams and Wetlands

Approximately 4,020 acres of tidal wetlands, 1,630 acres of freshwater wetlands, and 110 miles of streams remain in NYC today, approximately half of which are on NYC Parks property. Tidal wetlands, which include salt marshes, are found where the land meets the sea, and are flooded by tides. Many of the lower extents of beaches along the coastline are technically tidal wetlands under today's regulatory definitions. The majority of freshwater wetlands and streams are found on Staten Island.

- Streams
- Freshwater Wetlands
- Lakes and Ponds
- Tidal Wetlands
- NYC Parks Property

Prepared by Forestry, Horticulture and Natural Resources  
Data Source: NYC Parks and Natural Wetlands Inventory  
Copyright 2020, NYC Parks

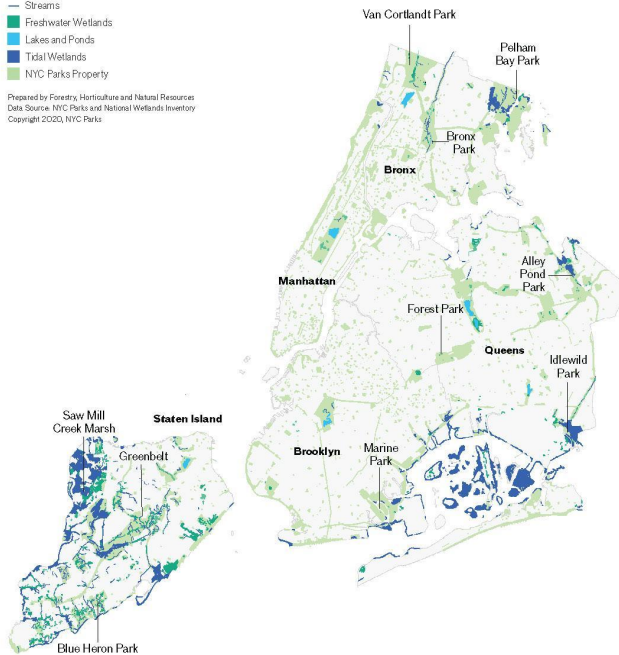


FIGURE 1

## NYC's Land Cover: 41% of NYC Is Green



Source: Natural Areas Conservancy Ecological Covertype Map, 2014.

FIGURE 2

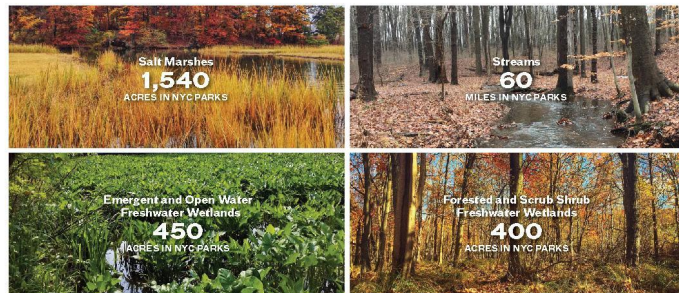
## NYC's Natural Areas Make Up 12% of the City



Source: Natural Areas Conservancy Ecological Covertype Map, 2014.

FIGURE 3

## Half of NYC's Wetlands and Streams Are in NYC Parks



NYC Parks wetlands extent is based on National Wetlands Inventory (NWI), 2004 and NYC Parks Freshwater Streams Hydrography, 2016. NWI data has been edited to reflect known conditions. Note: Citywide totals are: 4,020 acres of tidal wetlands (predominantly salt marshes), NYC Wetlands Strategy, 2012; 1,630 acres of freshwater wetlands (NWI, 2004), and 110 miles of streams (NYC Parks Freshwater Streams Hydrography, 2016). 1"=1

<https://naturalareasnyc.org/wetlands>

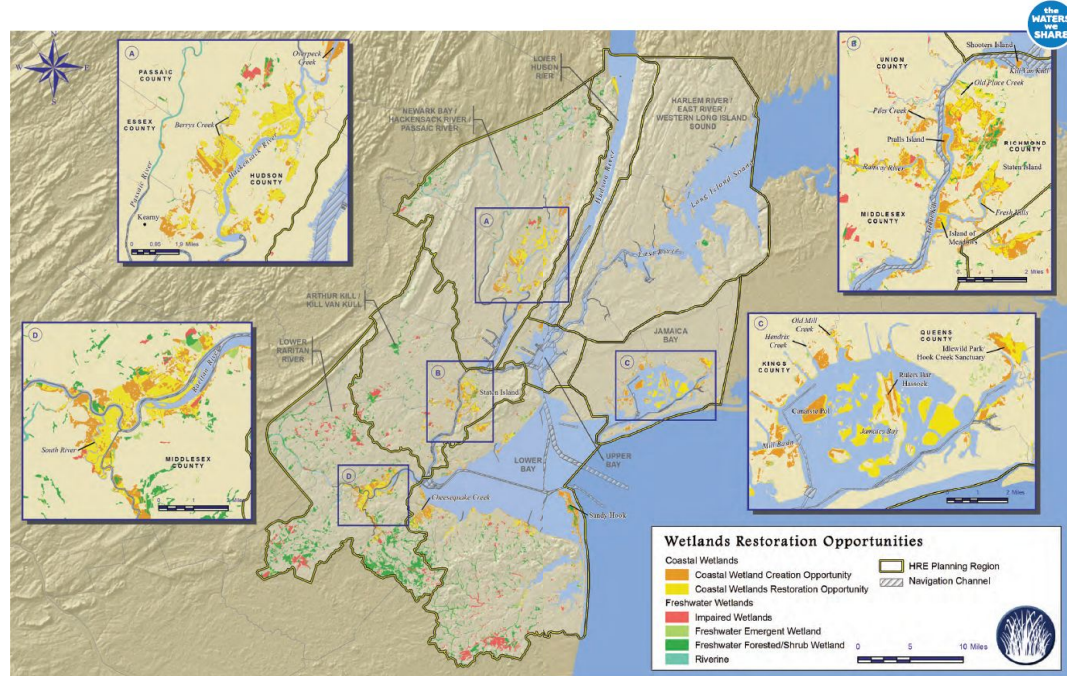
NYC Parks NRG + Natural Areas Conservancy

# Hudson Raritan Estuary Comprehensive Restoration Plan (2016)

- The Plan identified substantial **coastal and freshwater wetland restoration opportunities** within the HRE study area. Restoration opportunities were based on land elevation, bathymetry, and fetch distance as well as land use constraints in the estuary
- A. Meadowlands, Hackensack and Passaic Rivers (east of Kearny and along Berrys Creek)
- B. Islands of the Arthur Kill, Staten Island (Old Place Creek, Saw Mill Creek and branches of the Fresh Kills) and NJ side of Arthur Kill (Piles Creek and the Rahway River)
- C. Jamaica Bay (including Bayswater State Park, Fresh Creek, Brant Point, Dubos Point, Dead Horse Bay, and Hawtree Basin)
- D. Raritan River and its main tributary, the South River

<https://www.hudsonriver.org/article/hrecrp>

<https://www.hudsonriver.org/estuary-program>



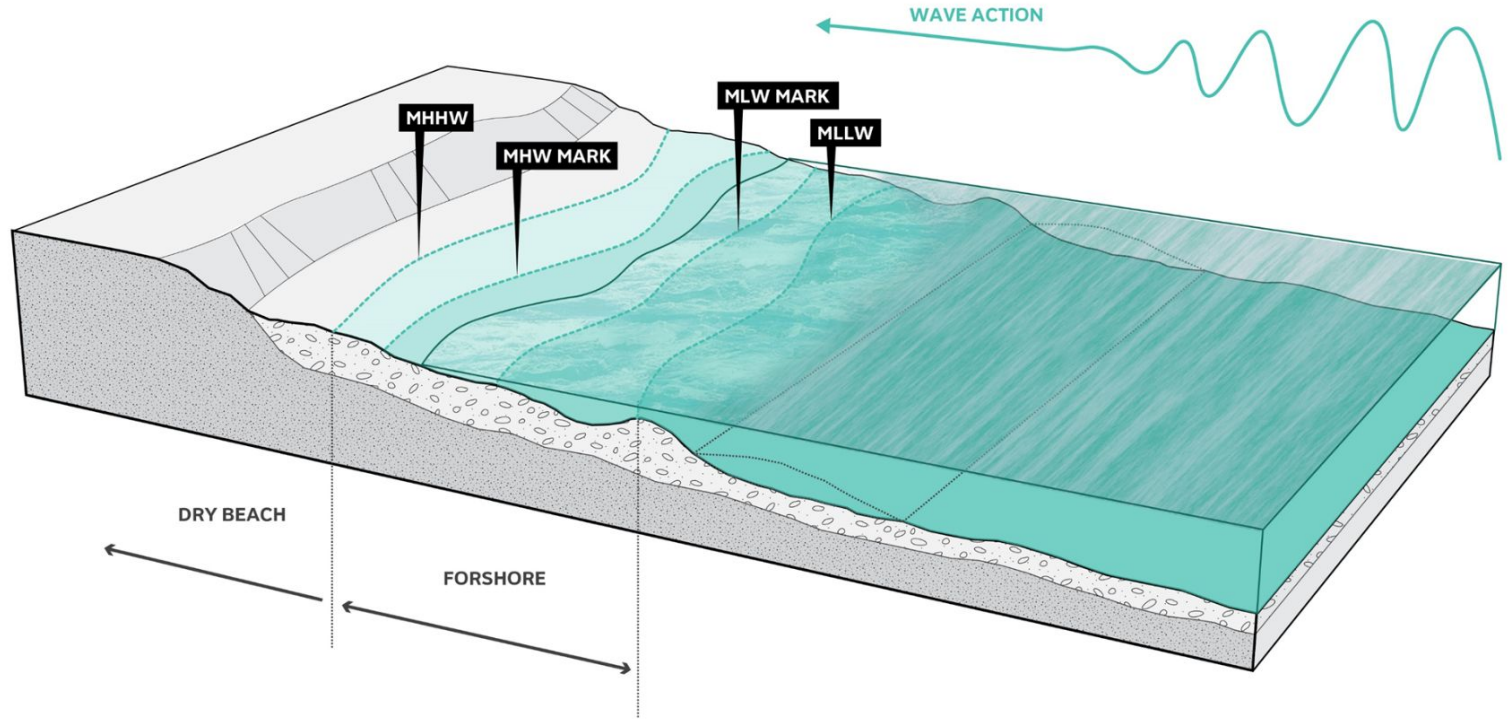
Resilient New Jersey -  
Raritan River and Bay Communities



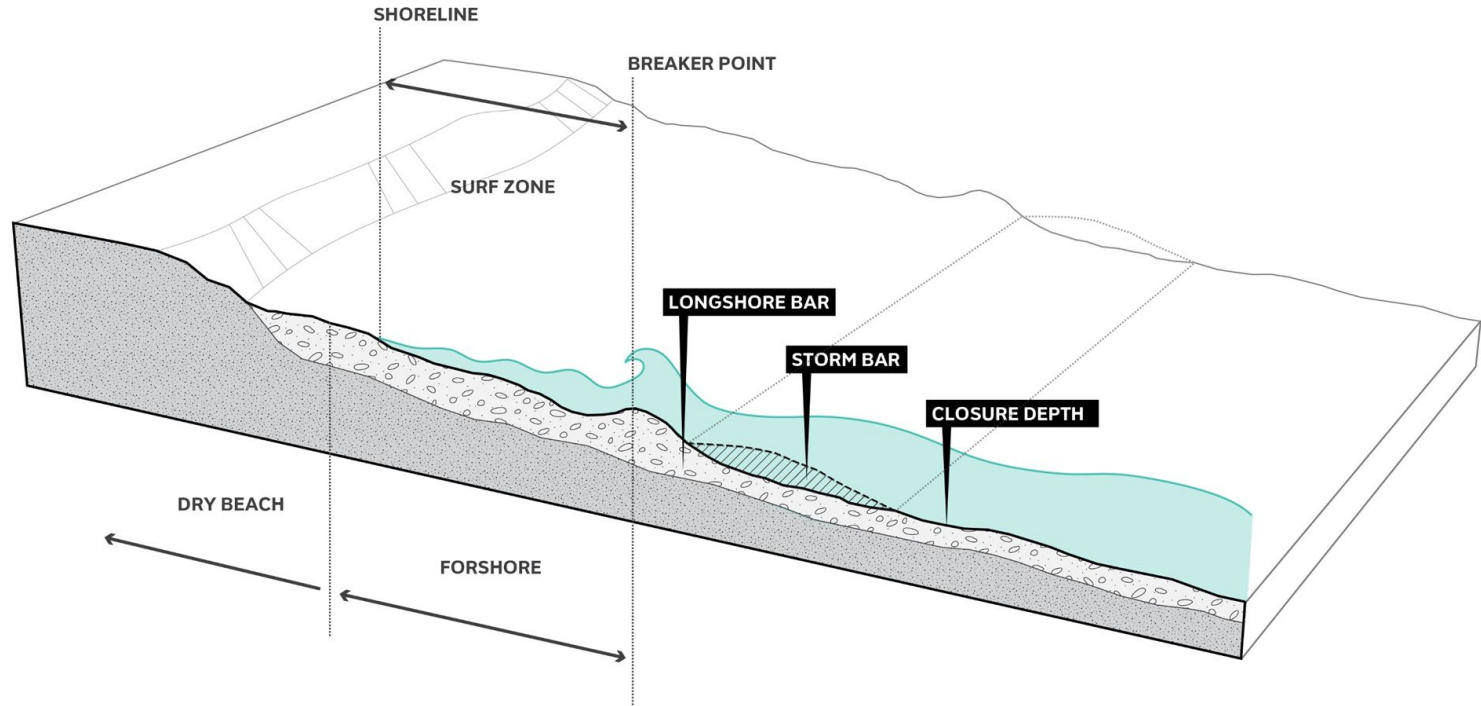
<https://resilientnewjersey.com/action-plan/>

**How do will gate closures and  
hardened shorelines impact  
erosion?**

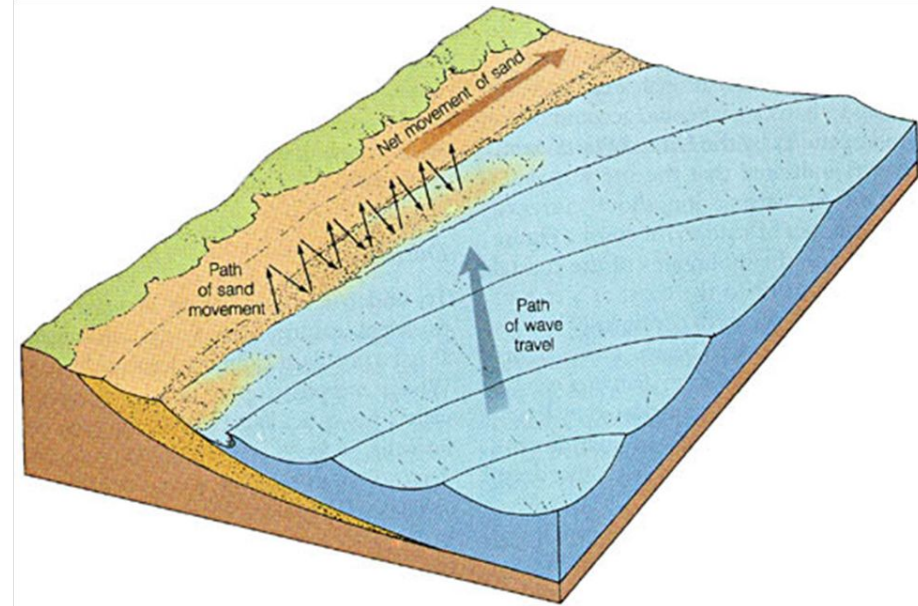
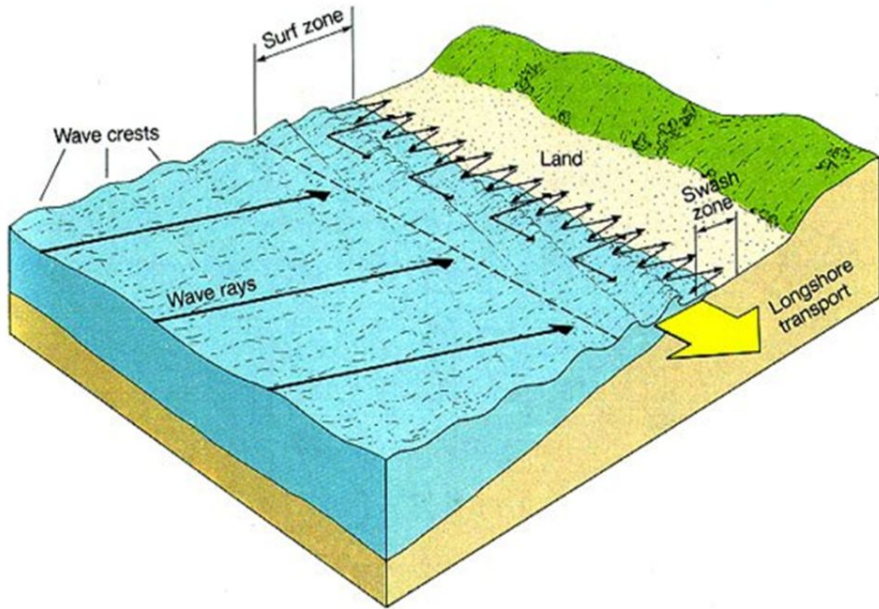
# A typical coastal shoreline (beach, non-hardened)



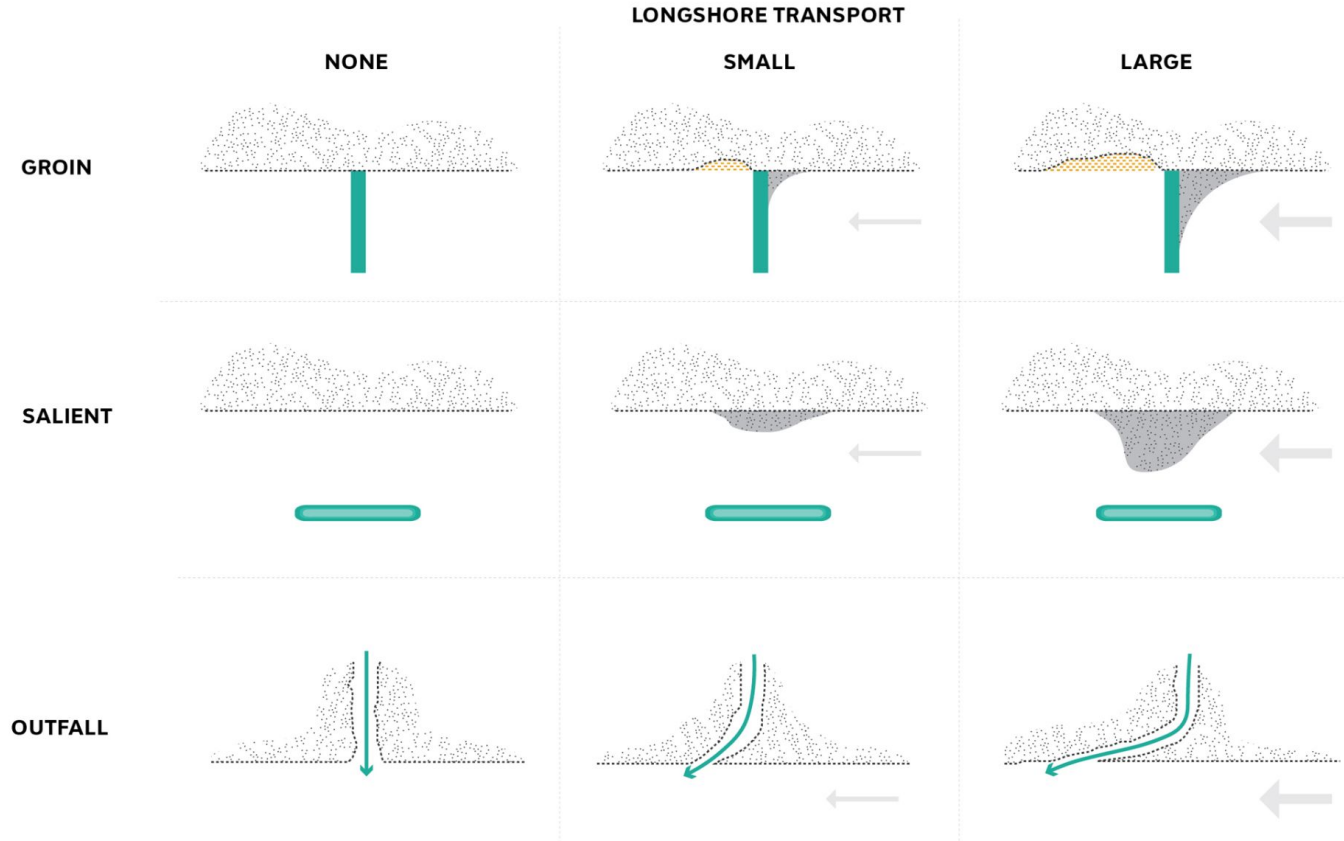
# A typical coastal shoreline (beach, non-hardened)



# EROSION: LONGSHORE TRANSPORT



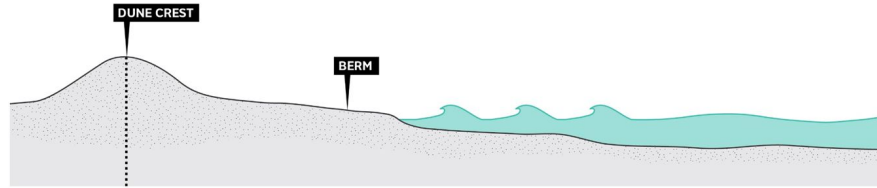
# EROSION: Longshore transport effects with hardened structures



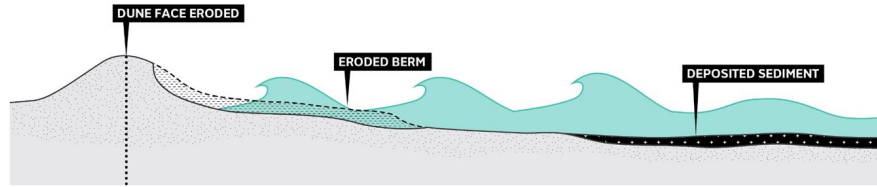


# EROSION: CROSS SHORE TRANSPORT

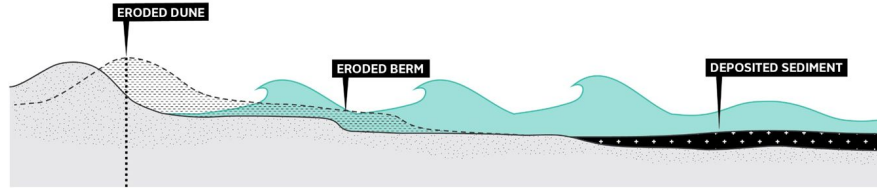
1. REGULAR WAVE ACTION



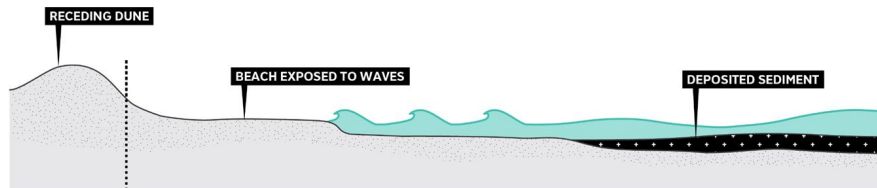
2. FIRST STORMS OF THE YEAR



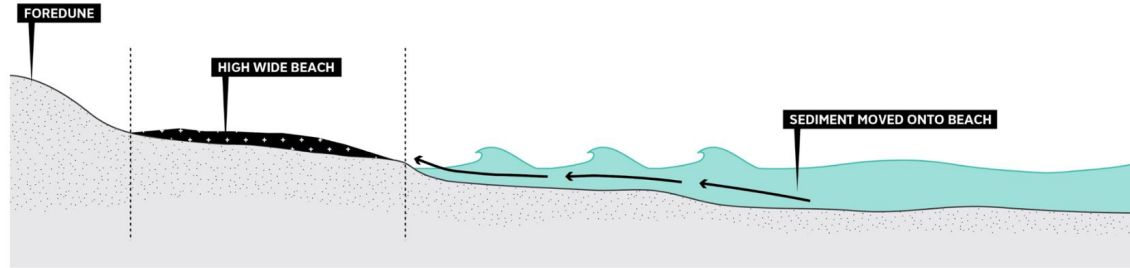
3. A STORM ERODES THE DUNE



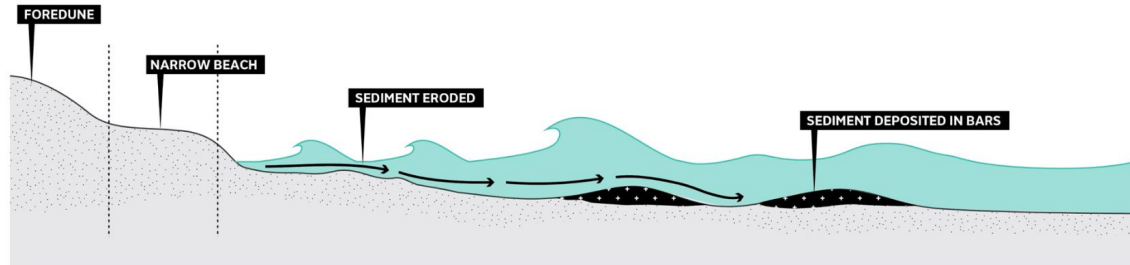
4. RESULTING PROFILE AFTER STORM



# EROSION: CROSS SHORE TRANSPORT

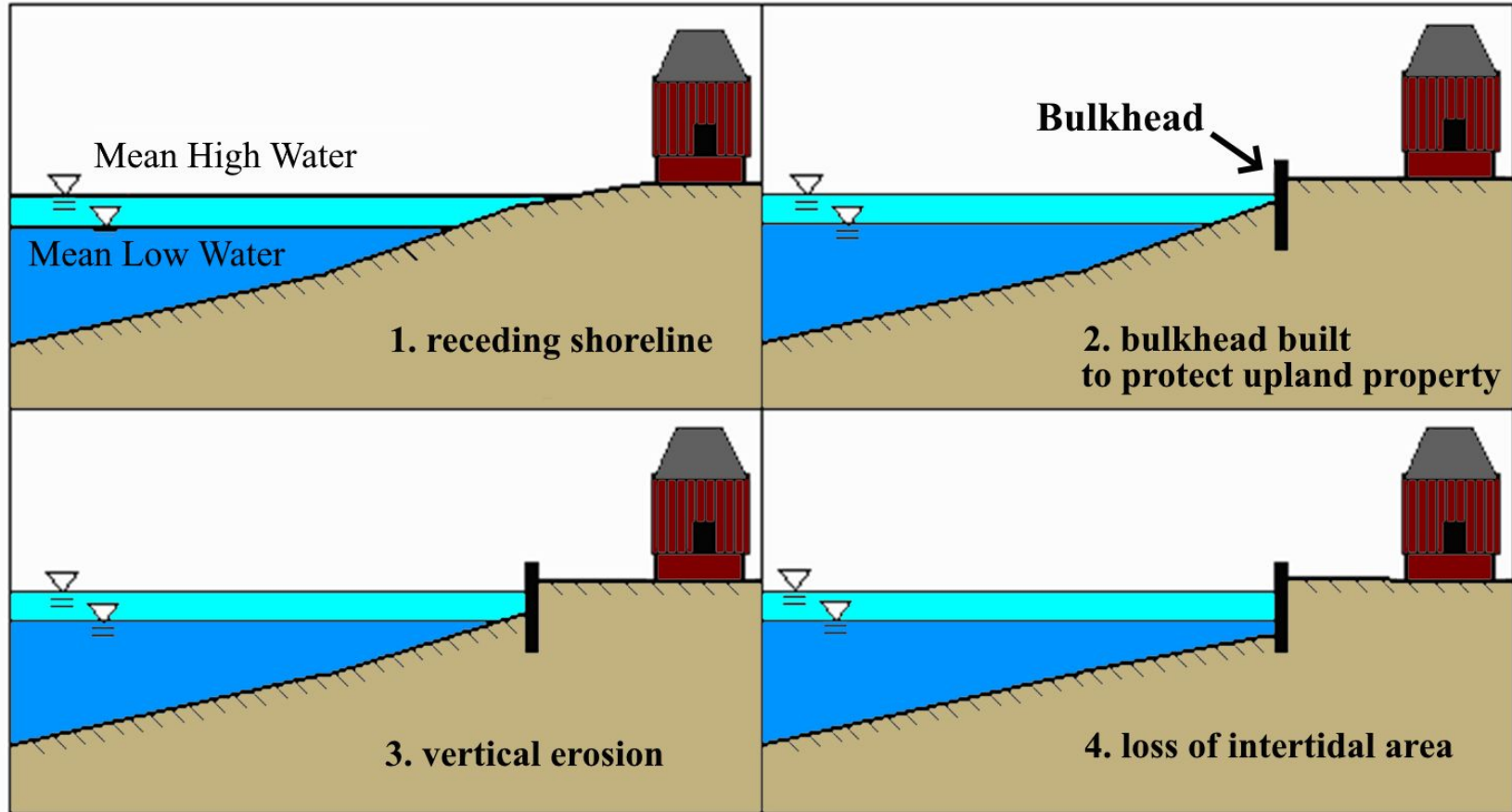


SUMMER CROSS SHORE TRANSPORT

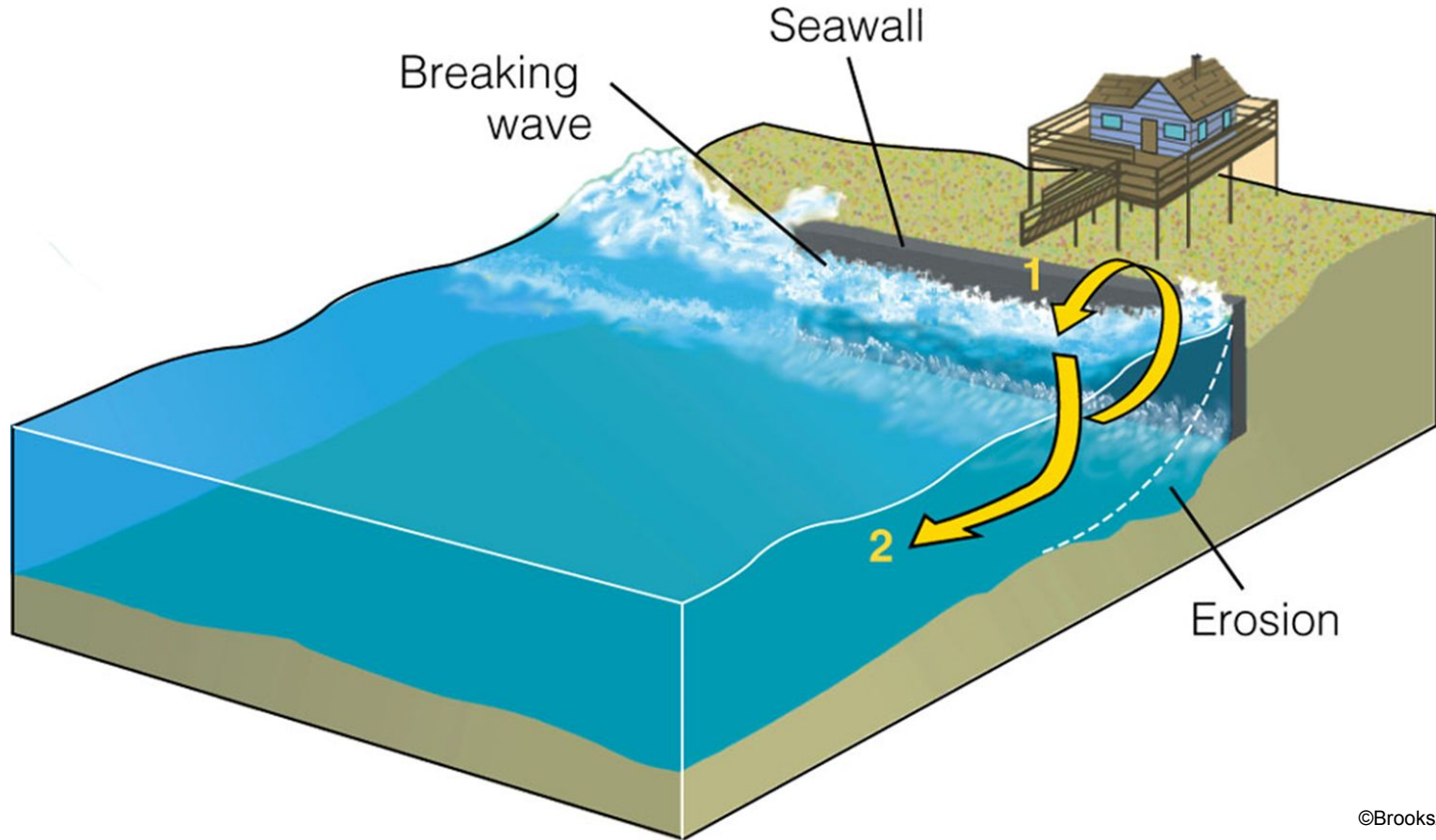


WINTER CROSS SHORE TRANSPORT

# EROSION: Cross shore effects with hardened structures



# PROBLEM OF TRADITIONAL SOLUTIONS





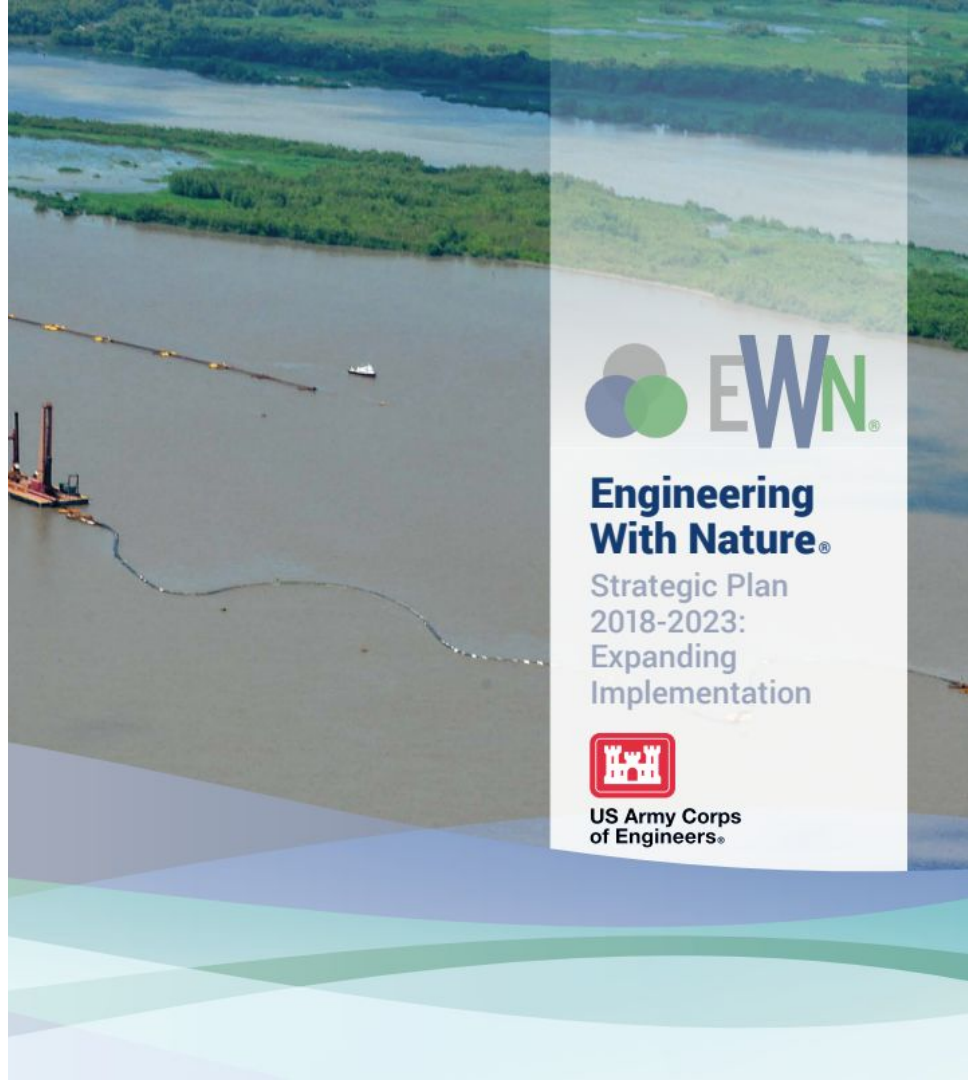
**Where/How can I learn more?  
Federal, State and Local  
Guidance on Nature-Based  
Solutions for Coastal  
Resilience**

# US Army Corps of Engineers

## Engineering with Nature (EWN) Initiative

- “Engineering With Nature is the intentional alignment of natural and engineering processes to efficiently and sustainably deliver economic, environmental, and social benefits through collaboration.”
- Uses science-based collaboration to organize and focus interests, stakeholders, and partners and produce more broadly acceptable projects
- use natural processes to minimize the environmental footprint of projects, enhance the quality of project benefits, and reduce demands on limited resources

<https://ewn.erdc.dren.mil/>



# NJ DEP

## Living Shorelines

- As defined in New Jersey's Coastal Zone Management Rules, a living shoreline is "a **shoreline management practice that addresses the loss of vegetated shorelines, beaches, and habitat in the littoral zone** by providing for the **protection, restoration or enhancement of these habitats.**"
- There are three types of living shorelines: natural, hybrid, and structural
  - **Natural living shorelines** include natural vegetation, submerged aquatic vegetation, fill, and biodegradable organic materials.
  - **Hybrid living shorelines** incorporate natural vegetation, submerged aquatic vegetation, fill, biodegradable organic materials, and low-profile rock structures such as segmented sills, stone containment, and living breakwaters seeded with native shellfish.
  - **Structural living shorelines** include, but are not limited to, revetments, break-waters, and groins.

<https://www.nj.gov/dep/opi/living-shorelines.html>

# Building Ecological Solutions to Coastal Community Hazards

## A Guide for New Jersey Coastal Communities



# NYS DEC

## Using Natural Measures to Reduce the Risk of Flooding and Erosion

- Provides an overview of **natural resilience measures** and how they can reduce risk of flooding and erosion. Natural resilience measures are actions to conserve, restore or mimic natural landforms and processes that reduce risk from flooding and erosion.
- **The Community Risk and Resiliency Act (CRRA)** requires state agencies and applicants to consider future physical climate risks, including storm surge, sea-level rise and flooding and extreme weather events in certain permitting, funding and regulatory actions.

[https://www.dec.ny.gov/docs/administrative\\_pdf/crranaturalmeasuresgndc.pdf](https://www.dec.ny.gov/docs/administrative_pdf/crranaturalmeasuresgndc.pdf)



Department of  
Environmental  
Conservation

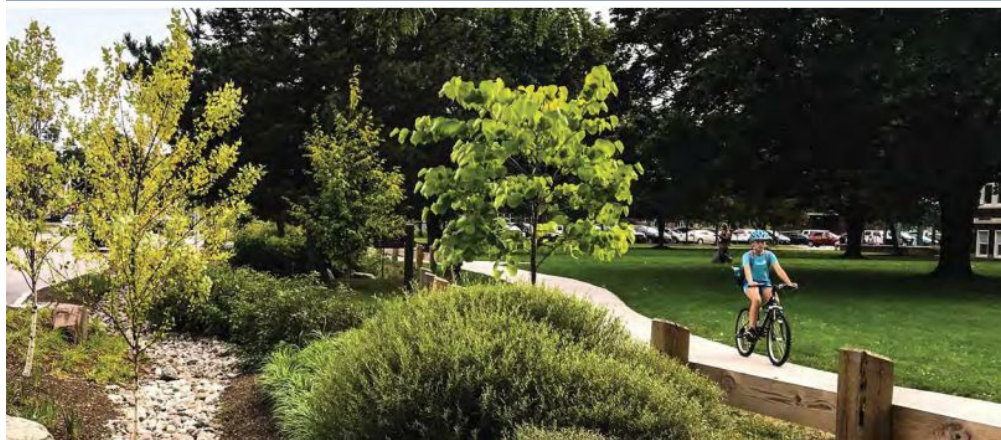
Department  
of State

## Using Natural Measures to Reduce the Risk of Flooding and Erosion

Guidance From New York State's  
Department of Environmental Conservation and Department of State

AUGUST 2020

Andrew M. Cuomo, Governor | Basil Seggos, Commissioner | Rossana Rosado, Secretary of State



# NYC Parks NRG

## NYC Wetlands Management Framework

- Provides a **30-year roadmap for the preservation, restoration, and management of all wetlands and streams in New York City** with particular focus on those under the care of NYC Parks.
- Identifies a variety of actions and dozens of potential projects that would **increase the footprint of wetlands in New York City**, and bring 7,000 acres of wetlands and surrounding area into active management.

<https://naturalareasnyc.org/wetlands>



# Wetlands Management Framework for New York City

