NNBF

International Guidelines on Natural and Nature-Based Features for Flood Risk Management

Enhancing Structural Measures for Environmental, Social, and Engineering Benefits

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Enhancing Structural Measures for Environmental, Social, and Engineering Benefits

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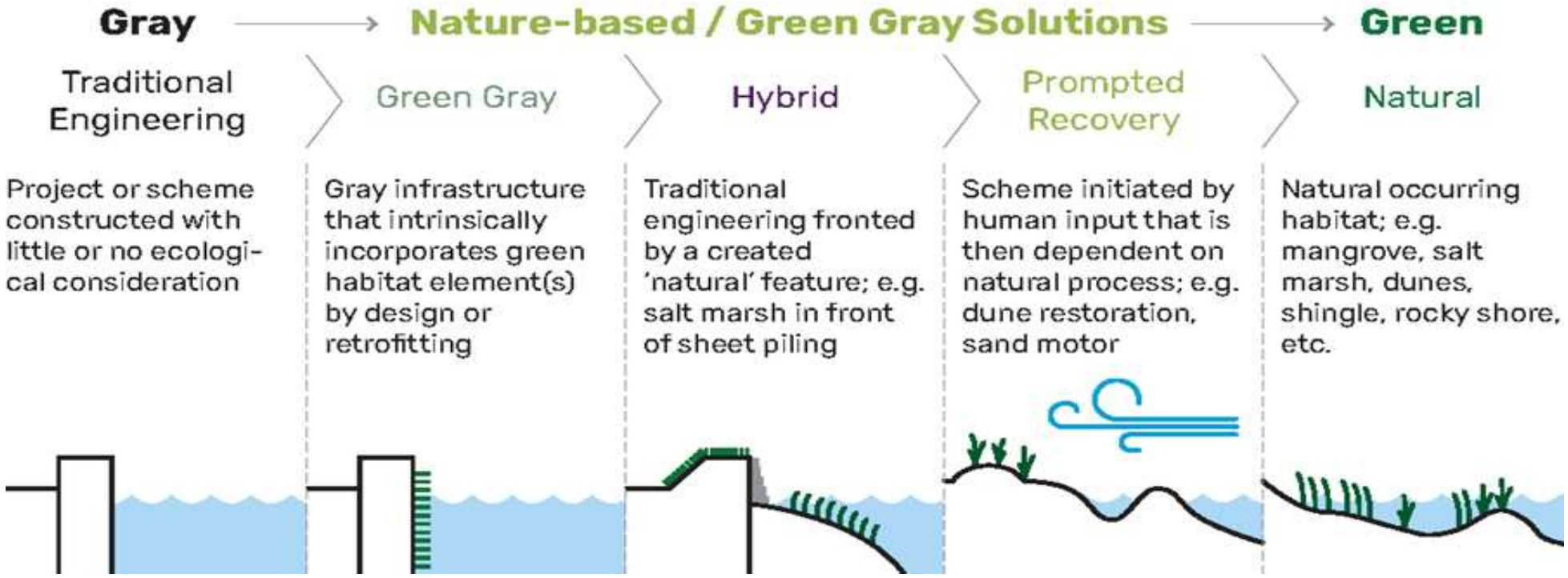
Introduction

- **Chapter Objective:** to illustrate how to approach expanding environmental and social value from existing conventional FRM structures by applying NNBF
- **NNBF includes** coastal, estuarine, and riverine landscapes that are naturally occurring or engineered to mimic some aspect of a natural condition while still providing flood risk reduction benefits
- **Applying NNBF** to existing infrastructure is characterized by a continuum across many forms and scales
- **Examples** of this continuum in coastal areas will be presented

Subtidal, intertidal, supratidal: Enhanced seawall material (wall fabric composition or surface texture) (Photos: Burton Suedel)

Key Message: Enhancing can take multiple forms

- Enhancing structures using natural and nature-based features can take multiple forms, serving as a continuum of measures over broad scales and structure types in both coastal and fluvial environments.



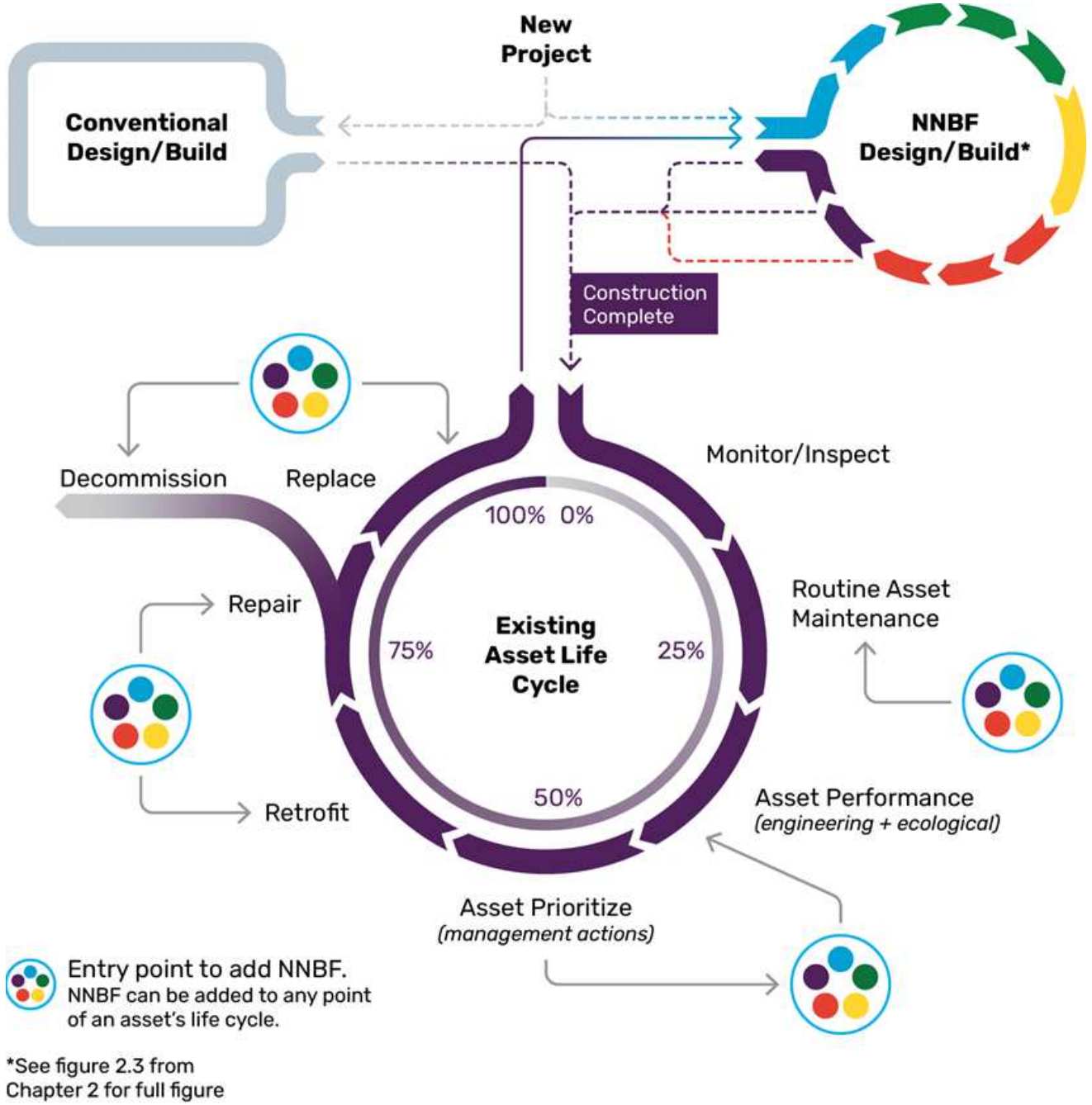
Key Message: Multiple benefits can be gained from enhancing existing infrastructure

- Ecological enhancements can offer multiple benefits:
  - **Structural** - increased engineering design life and flood risk reduction,
  - **Environmental** – ecological habitat,
  - **Societal** - recreational opportunities and improved well-being.

Infrastructure types	Enhancement	Often improves	Sometimes improves
Breakwater 	**Offshore:** Rock rubble, bioenhanced concrete (adding holes and pools)	· Fish and shellfish habitat · Habitat biodiversity · Amenity value · Social cohesion · Recreational activities	· Structure design life · Bird feeding or roosting habitat · Sediment transport · Commercial fish and shellfish
Groin or jetty 			

Key Message: We can enhance across the design life

- Enhancement can occur at any stage of the design life of the structure, including during new construction and repair, maintenance, or modification of the structure.



Key Message: Valuing NNBF

- The **implementability** of enhancements can be increased by identifying and quantifying the value NNBF provides
- The costs and benefits associated with them can be compared effectively against conventional structural measures.

Business-As-Usual Mowing Regime at Canvey Island

Changed Mowing Regime at Canvey Island

Source: Tim Gardiner, Environment Agency (United Kingdom)

Changed Mowing Regime Attracts Native Pollinators

Case Studies

Environmental enhancements to existing coastal and fluvial infrastructure cay be achieved many ways.

Case studies presented illustrate the ways in which these enhancements have been achieved.

These case studies show enhancement during maintenance, repairs, and modifications to existing flood alleviation schemes.

These case studies share lessons learned to promote future NNBF project enhancements.

Breakwater structure at Milwaukee Harbor repaired after decades of exposure to Lake Michigan waves and storms.

Smaller stones placed underwater to repair the breakwater structure at Milwaukee Harbor.

EWN Research

Milwaukee Harbor Breakwater Repair

- Modify design of rubble mound breakwater during maintenance
- Extend beyond indirect and unplanned habitat creation
- Provide features creating habitat opportunities for fish and other aquatic life
- Examine creation of habitat surfaces using rubble mound
  - Stone size
  - Gentler sloping shelf
- Create habitat for fish such as walleye and lake trout
- Approach widely applicable

In: EWN Atlas Volume 1 (pages 220-223) (top)

Rendering of living jetty (bottom)

EWN Research

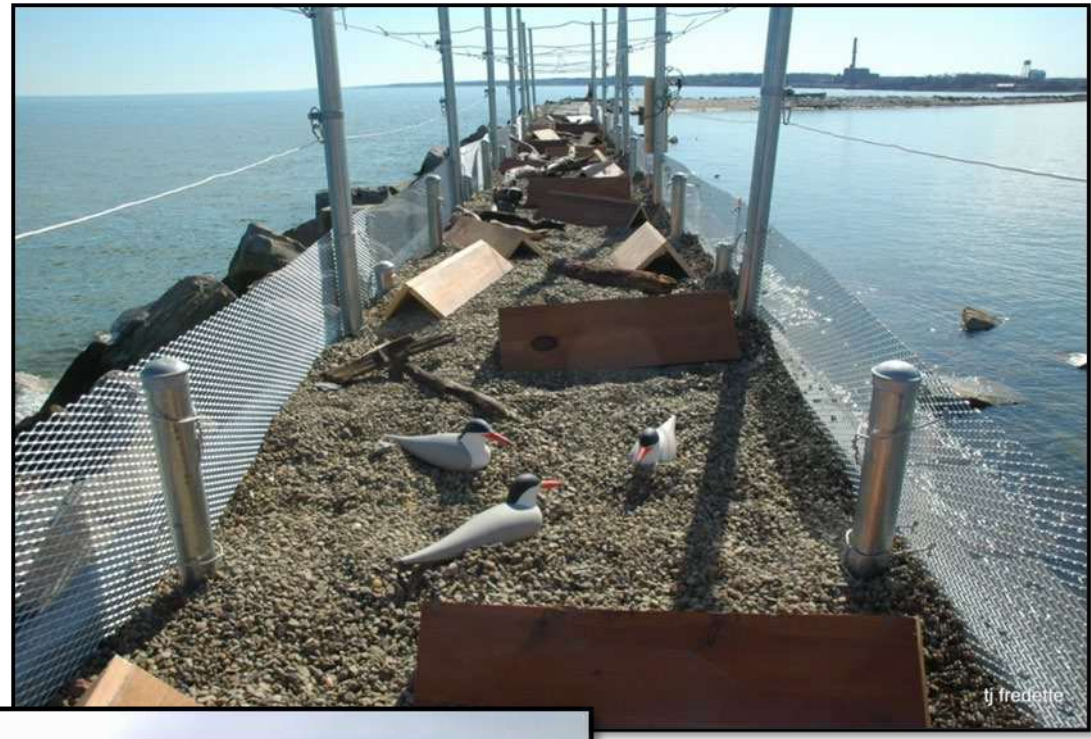
Cleveland Harbor Breakwater Repair

- Beyond indirect and unplanned habitat creation
- Modify design of featureless toe blocks used for breakwater maintenance
- Provide features creating habitat opportunities for fish and other aquatic life
- Created habitat features on toe blocks
  - Protected indented shelf
  - Dimpled block surface
  - Grooved block surface

EWN Research

Ashtabula Harbor Breakwater Repair

- Modify design of breakwater to create bird habitat features during routine maintenance
- Examines creation of tern nesting features using modified toe blocks
  - Nesting pea gravel
  - Predator/competitor exclusion grid
  - Side fencing
  - Chick shelters – TNC collaboration
- Challenges
  - Winter ice
  - Site discovery not immediate
  - Predators in the vicinity
  - Storm wave damage



Completed features (top) included nest and call boxes, tern decoys, and gravel substrate. Slope blocks (left) grooved to provide additional habitat.

EWN Best Practice

Fowl River Private Living Shorelines (AL)

- Living shorelines constructed by TNC for private landowners with river-adjacent property
- Replaced failing bulkheads experiencing erosion caused from boat wakes
- Stabilized existing bulkhead using tiered gabion baskets filled with dredged sediment, then planted with native marsh grass
- 40 ft of natural shoreline and an existing marsh island were protected by two gabion-basket breakwaters utilizing sediment dredged from nearby canal
- Protected 200 ft of shoreline and enhanced 720 ft^2 of marsh
- Design leaves failing bulkhead in place and stabilizes the structure, saving cost of removal

In: EWN Atlas Volume 1 (pages 232-235)

EWN Best Practice

Mangroves & Recreation Infrastructure (FL)

Nature-based Solutions

- Ecological Functions
- Amenities / recreational values
- Cost reduction (e.g., vs. seawall)
- Adaptability to sea level rise

Potential Environmental Design Features

- Living shorelines
- Mangrove islands
- Boardwalks & kayak trails

Mangrove Shoreline (Harborside, Jupiter, FL)

Mangrove Shoreline (Admiral's Cove, Jupiter, FL)

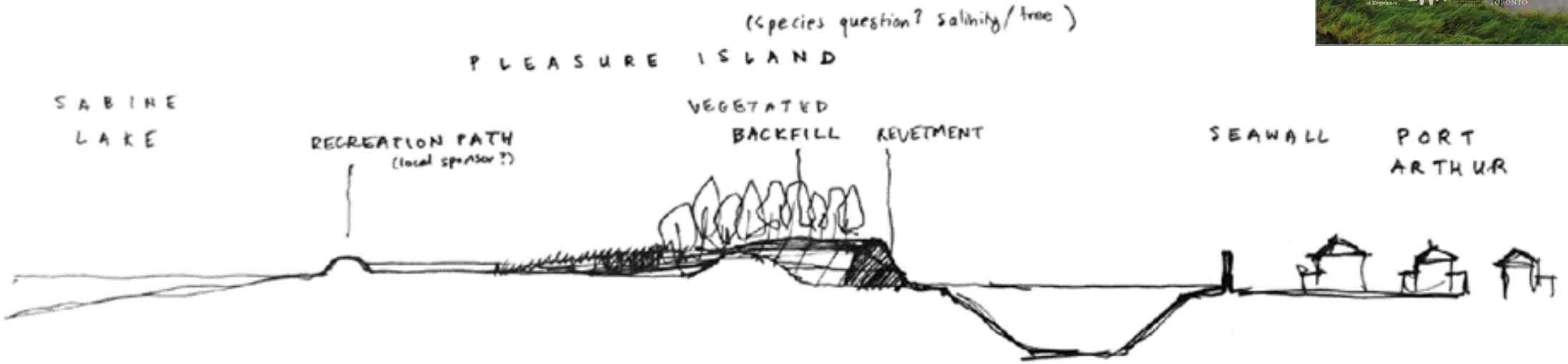
Mangrove Marina Edge (Jupiter Yacht Club, FL)

Courtesy: Esteban Biondi (ATM)

Leveraging EWN + Landscape Architecture to Promote GI-LID

- Collaborations amongst science, engineering, and landscape architects jointly contribute to EWN implementation through best management practices and scientific research
- CSRM projects are being implemented that incorporate EWN+LA practices to achieve additional environmental and social benefits maintaining intended engineering project functions

EWN website designs page: https://ewn.el.erdc.dren.mil/designs.html

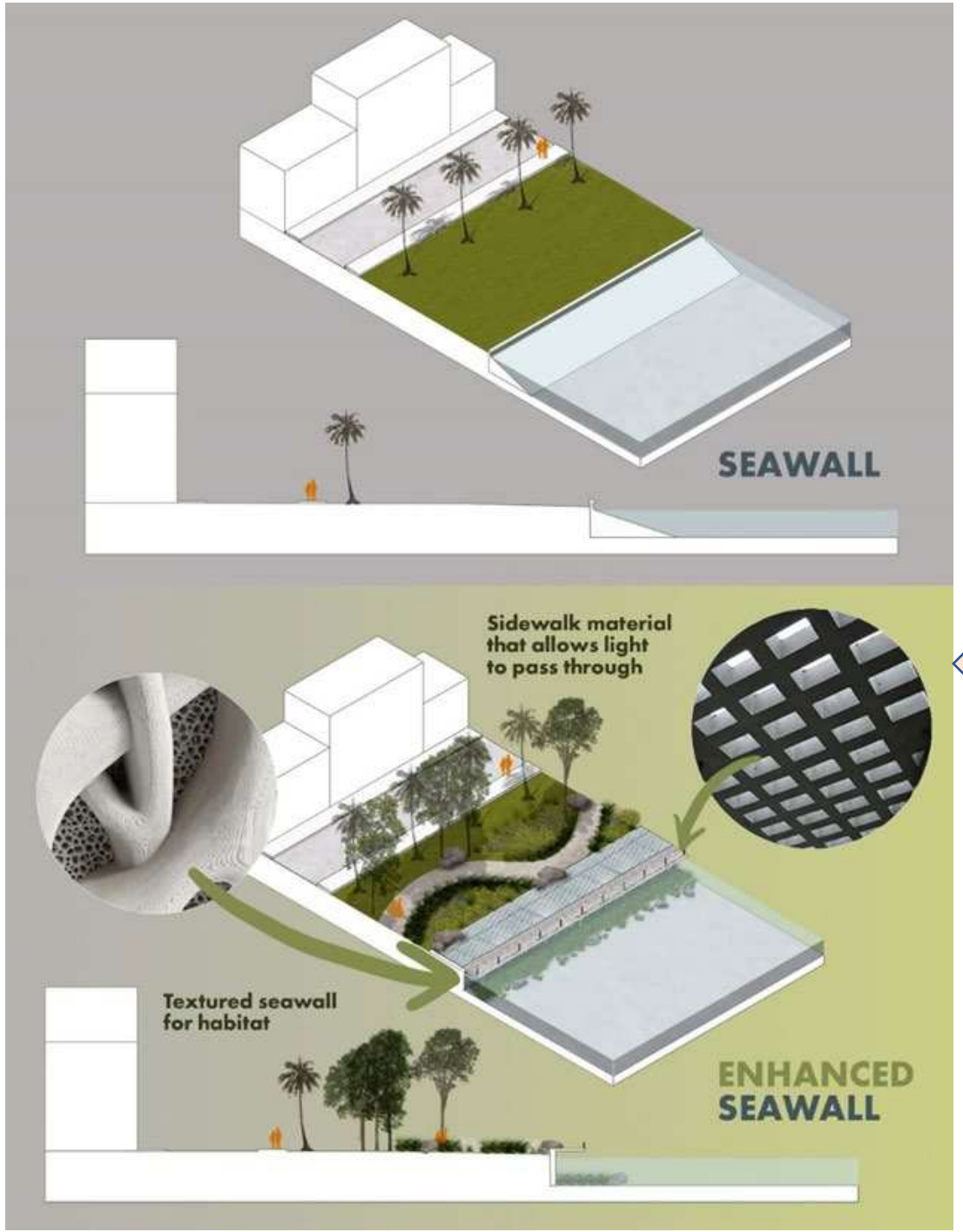


Drawing showing a potential augmentation to an existing coastal flood protection system (King et al. 2021)

Detailed Renderings Aid GI-LID Decision-making

Common coastal infrastructure types that can be enhanced for biodiversity:

- Thin layer placement
- Living shoreline
- Seawall
- Revetment
- Bulkhead
- Detached breakwater and jetty
- Sill
- Tidal control structure
- Groin



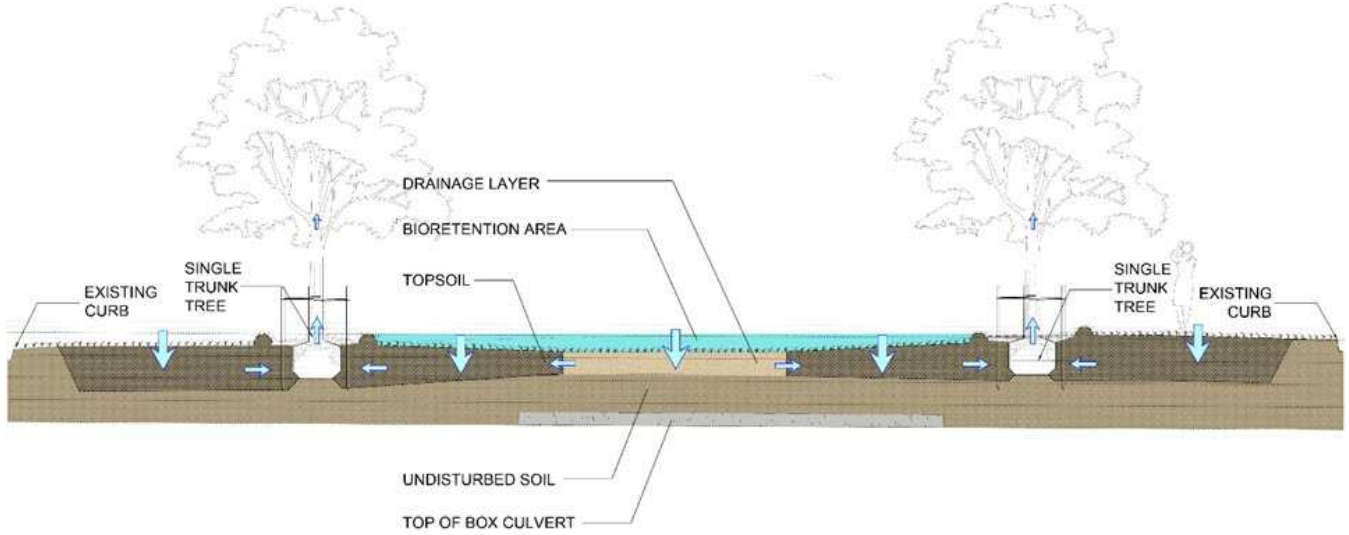
Renderings of a conventional seawall design (top) and an enhanced seawall design (bottom) that includes various NNBF for improving habitat quality of the structure, thereby promoting biodiversity and other benefits.

From Suedel et al. (In Review)

EWN+LA Best Practice

Southeast Louisiana Urban Flood Control Project (SELA) Project

- Responding to extensive flood damage in SE Louisiana in 1989 & 1995
- Providing flood risk reduction up to a level associated with a 10-year rainfall event
- Strengthening the City's neutral grounds as greenway connectors
- Reinforcing sustainable and resilient image through visual design
- Expanding New Orleans' urban forest
- Enhancing environmental value of urban green spaces
- Reducing burden on the storm drainage system
- Slowing land subsidence through groundwater recharge and infiltration
- Improving water quality



Cross-sectional rendering of the primary components of the bio-retention areas of the SELA project. Arrows mark surface and near surface water flow designed to reduce flood risk (Bourne et al. In Review).

Ground-level view of the bioretention component of the neutral ground. Bermuda grass was planted, consistent with Parks and Parkways maintenance standards, to foster biofiltration.

EWN Best Practices – Puerto Rico

Flood Risk Reduction using Natural Infrastructure Materials: Green Infrastructure-Low Impact Development (GI-LID)

Challenges

- Non-native species often growing along stream and riverbanks
- May choke waterways as debris following storms or floods
- Nuisance and hazard at bridges and other infrastructure

Opportunities

- Locally-available source of NI material for building check dams for erosion control
- Peak flow attenuation along the watershed

Bamboo thickets are abundant along sections of the Añasco River, Mayagüez. Photo: Burton Suedel.

Example bamboo check dam, Belford Natural Flood Management Scheme, England, UK. Image: Nicholas Barber, Newcastle University.

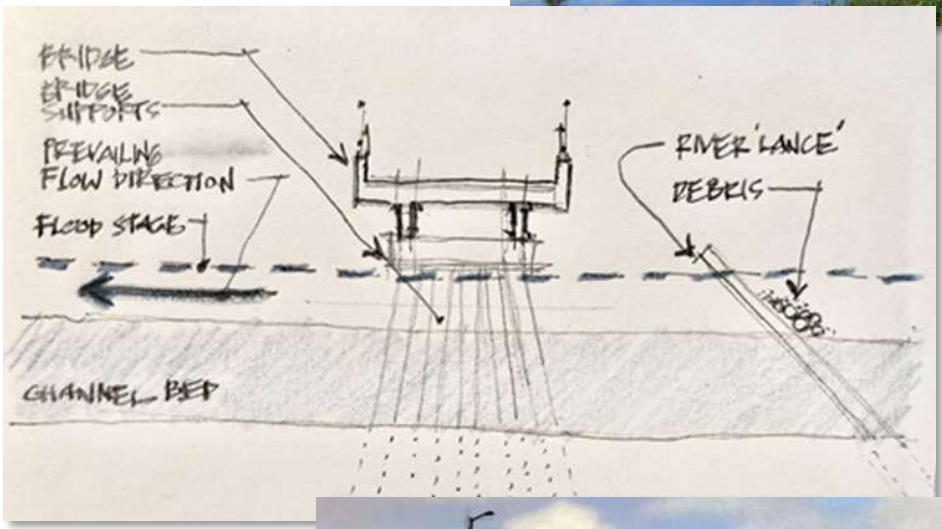
EWN GI-LID Best Practice

Flood Risk Reduction using Natural Infrastructure Materials

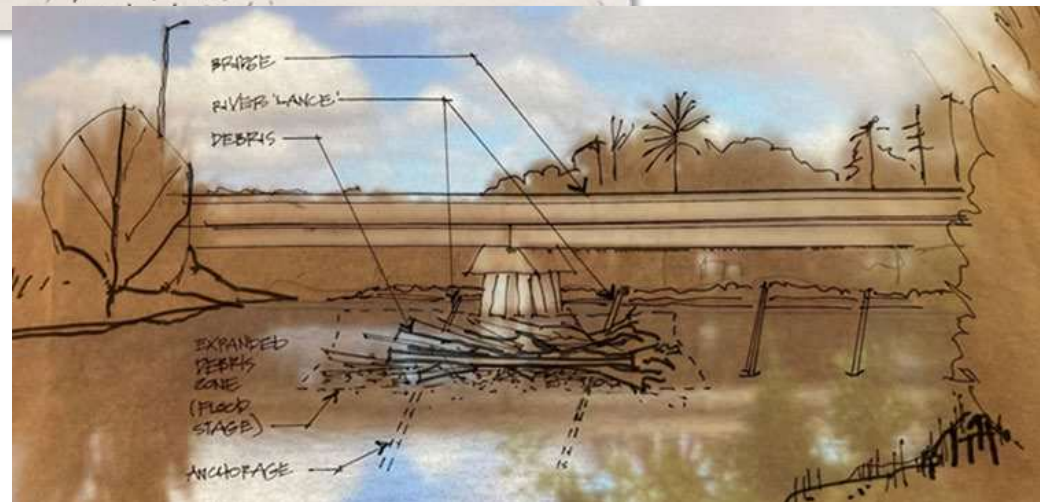
Opportunity

- Bridges as critical infrastructure subject to storm damage risk
- Cost effective relative to conventional infrastructure
- Optimal placement locations based on bridge span, location in river, bathymetry, streambed composition, water velocity, etc.
- Consider both short- and long-term impacts and climate change
- Integrate components that can adapt to changing climatic conditions
- Questions: design and construction materials; ownership; debris handling; material reuse, etc.

Bridge over the Lower Añasco River at Boquilla Village, Mayagüez. Image: Dave Hampton.



The 'river lance', longitudinal section. Image: Dave Hampton.



The 'river lance', perspective facing downstream. Image: Dave Hampton.

EWN GI-LID Best Practice

Enhancing Existing Flood Infrastructure – A Living Laboratory Concept for the Ajíes Dam

Opportunity

- Enhance flood risk management capability of the structure
- Promote other unrealized environmental, social, and economic benefits of the infrastructure
- Serve as test bed for other similar dams and infrastructure across multiple Puerto Rico watersheds
- Dam lies at the base of steep terrain and protects downstream development
- Natural infrastructure north of the dam can provide multiple opportunities to create human interactions with nature

Flowers on the current unmanaged Ajíes Dam and surrounding area.

Ajíes Dam and related flood control structure. The vegetation on the dam and surrounding area consists of volunteer species periodically maintained by mowing and bush-hogging (Photo: Burton Suedel)

EWN GI-LID Best Practice

Enhancing Existing Flood Infrastructure – A Living Laboratory Concept for the Ajíes Dam

- Develop living laboratory to maintain & enhance primary flood risk management mission
  - Environment (increase water levels to enhance aquatic habitat)
  - Engineering (enhance flood risk management; water recharge)
  - Education (school children; citizen scientists; universities)
  - Social/recreation (ecotourism; trail system; interpretive signs)
- Collaboratively engage stakeholders so that the concept can serve both community and environment

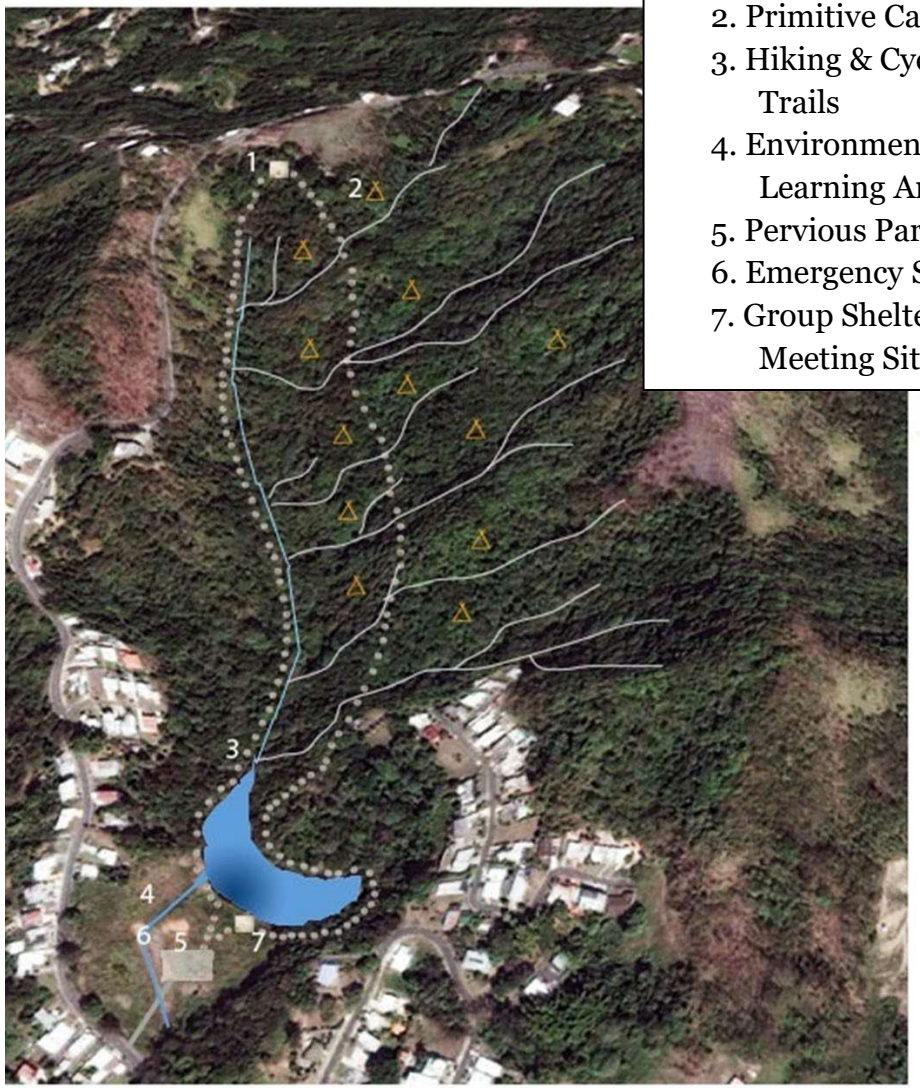
Left: Existing Ajíes Dam and related flood control structure. Right: Rendering showing possible environment/ human interactions through a trail, interpretative signage, floating dock to enhance fishing access, native wildflower plantings, increased bird and other wildlife usage, elevated water levels to promote boat access, and locally sourced building materials.

Concluding Thoughts

The practice of enhancing existing infrastructure for environmental, economic, social, and engineering benefits in both coastal and fluvial environments is progressing.

Elements of success to advance successful practice of long-term NNBF structural enhancement:

Early and often stakeholder communications	Meaningful community engagement	Partnering and collaborations among stakeholders to help monitor project success	Designing to achieve multiple benefit objectives	Developing monitoring programs that identify and quantify costs and short- and long-term benefits



Ajíes Dam Living Laboratory Conceptual Map (Image by Rhonda Fields).

Questions?

EngineeringWithNature.org

Download

- Executive Summary (70 pages)
- International Guidelines on NNBF for Flood Risk Management (1,000 pages)