



Engineering with Nature: Using Living Shorelines to Strengthen our Infrastructure

Feb. 3, 2023

ASCE Florida Section

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Go to www.menti.com and use the code 6623 4453

The code lets your audience join the presentation and expires in 2 days.

What do you want to get out of this training?

 Mentimeter

- 1st | Design criteria
- 2nd | Applicability/suitability to your project
- 3rd | Benefits of a living shoreline
- 4th | Pitfalls with living shoreline strategies
- 5th | I am not interested in living shorelines



Go to www.menti.com and use the code 6623 4453

What do you think of when you hear the term, "living shoreline"?

 Mentimeter

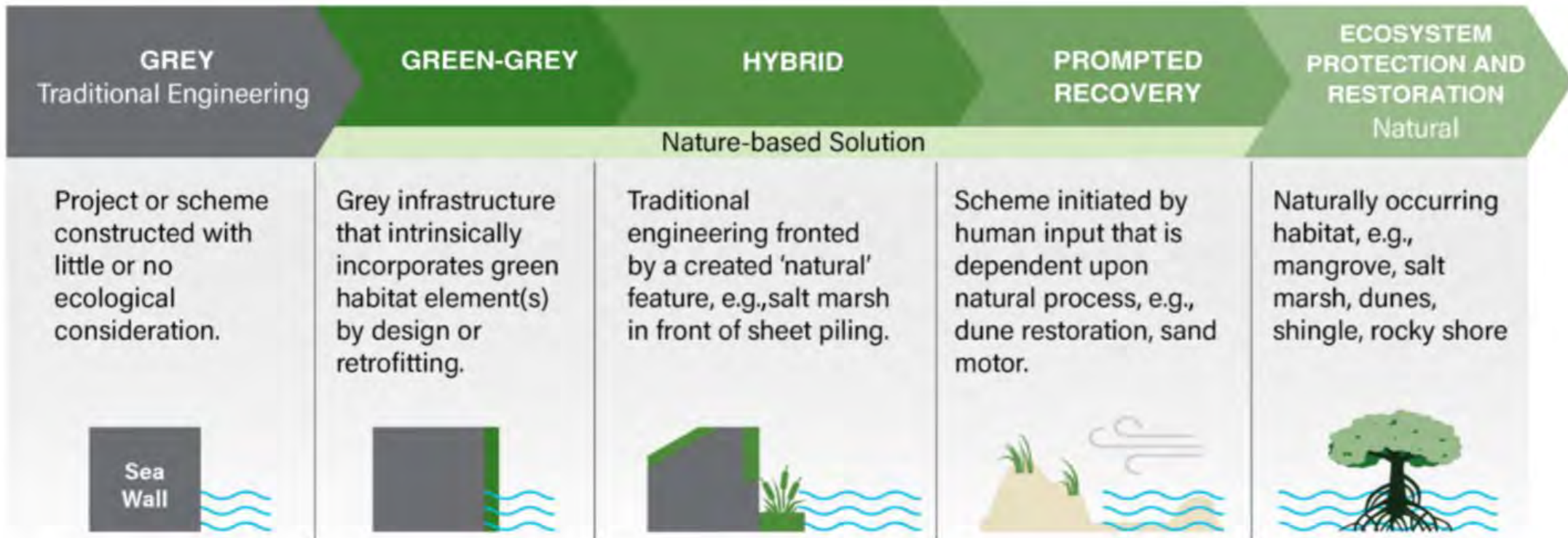


Living shorelines makes me think of...

oysters mangrove
innovate
maintenance footprint
engineering
barrier
drawdown reef tidal riprap
shores high waves
green intensive
natives land infrastructure
carbon revetment
saltmarsh resilience
energy armoring
nature-based
access habitat
erosion

Shorelines must adapt to future conditions.

- Our future will be wet and stormy...shorelines are first line of defense
 - Back bays more at risk than ocean front
 - Balance resilience, ecology, and access
- Competitive funding sources available, especially for nature-based solutions

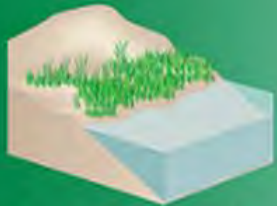


HOW GREEN OR GRAY SHOULD YOUR SHORELINE SOLUTION BE?

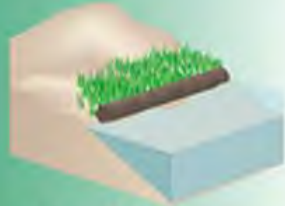
GREEN - SOFTER TECHNIQUES

GRAY - HARDER TECHNIQUES

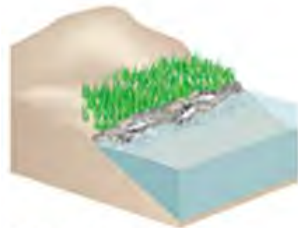
Living Shorelines



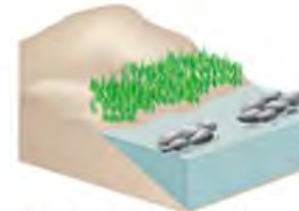
VEGETATION ONLY -
Provides a buffer to upland areas and breaks small waves. Suitable for low wave energy environments.



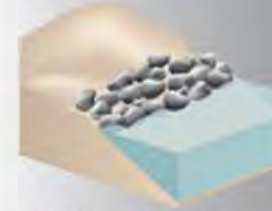
EDGING -
Added structure holds the toe of existing or vegetated slope in place. Suitable for most areas except high wave energy environments.



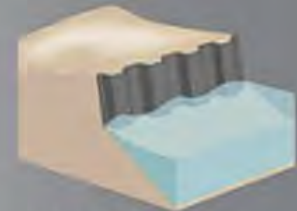
SILLS -
Parallel to vegetated shoreline, reduces wave energy, and prevents erosion. Suitable for most areas except high wave energy environments.



BREAKWATER -
(vegetation optional) - Offshore structures intended to break waves, reducing the force of wave action, and encourage sediment accretion. Suitable for most areas.



REVETMENT -
Lays over the slope of the shoreline and protects it from erosion and waves. Suitable for sites with existing hardened shoreline structures.



BULKHEAD -
Vertical wall parallel to the shoreline intended to hold soil in place. Suitable for high energy settings and sites with existing hard shoreline structures.

Image credit: NOAA

Traditional Approaches

- Seawalls / bulkheads
- Protect against:
 - Dissipate wave energy
 - Shoreline erosion
 - Flood Protection
 - Storm Surge buffer
- Upside:
 - Easy to permit
 - Known installation practices
 - Contractor knowledge
 - Low maintenance

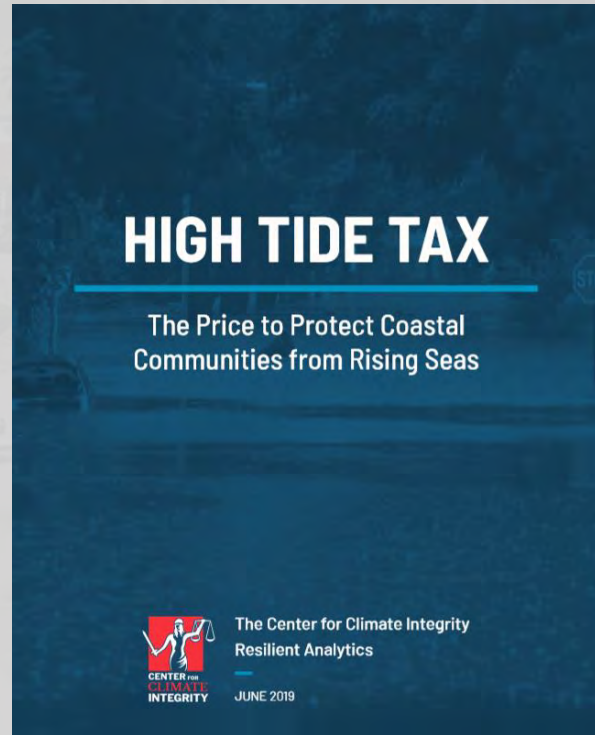




Disadvantages of Seawalls

- Expensive to build and maintain
- Reflect wave energy rather than dissipate it
- Cause scour, offsite erosion
- Can be unattractive
- Disturb habitat
- Alter sediment flow

- 50,000 miles of seawalls in 22 states by 2040
- **Protect critical infrastructure** includes schools, hospitals, medical facilities, government buildings, airports, and all public horizontal infrastructure (roads, railways, and runways).
- 10-15% of total seawall costs born by local/state governments



State Rankings

Download Rankings

1	Florida	\$75,898,048,000
2	Louisiana	\$38,431,868,000
3	North Carolina	\$34,838,128,000
4	Virginia	\$31,207,175,000
5	Maryland	\$27,414,762,000
6	New Jersey	\$24,985,408,000
7	Washington	\$23,892,865,000
8	California	\$21,999,799,000
9	South Carolina	\$20,061,030,000
10	Texas	\$19,279,011,000



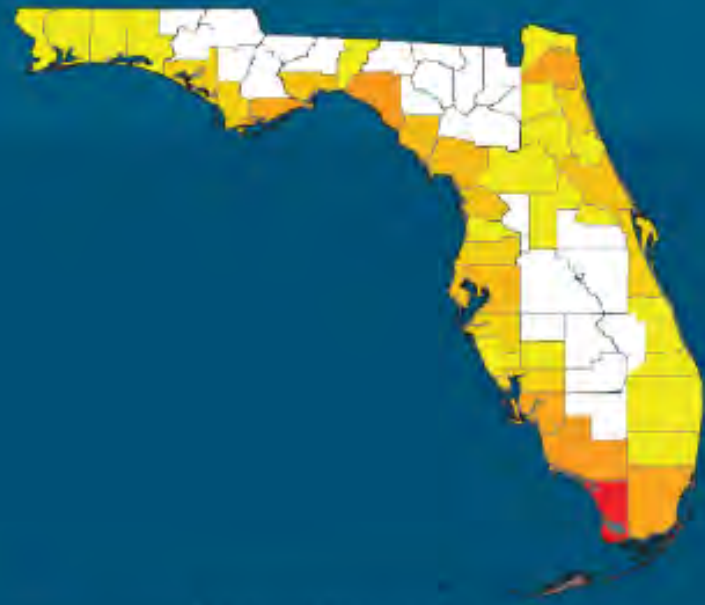
Florida In 2040

RELATED DATA

Most costly Florida counties

- #1 **Monroe County** (\$11.1 Billion for seawalls) [SEE COST](#)
- #2 **Taylor County** (\$4 Billion for seawalls) [SEE COST](#)
- #3 **Collier County** (\$3.8 Billion for seawalls) [SEE COST](#)
- #4 **Franklin County** (\$3.8 Billion for seawalls) [SEE COST](#)
- #5 **Lee County** (\$3.5 Billion for seawalls) [SEE COST](#)

[SEE ALL](#)



\$75.9
BILLION
FOR SEAWALLS
#1 most costly state

9,243
MILES
OF SEAWALLS
#1 most miles of seawalls

Benefits of Living Shorelines

- Provides/protects nearshore habitat
- Improve water quality
- Provide carbon storage & sequestration
- Elongate the life of a seawall
- Improve human health & well-being
- Provide food & livelihood by supporting fisheries
- Dissipate wave energy**
- Shoreline erosion**
- Funding availability (public projects)

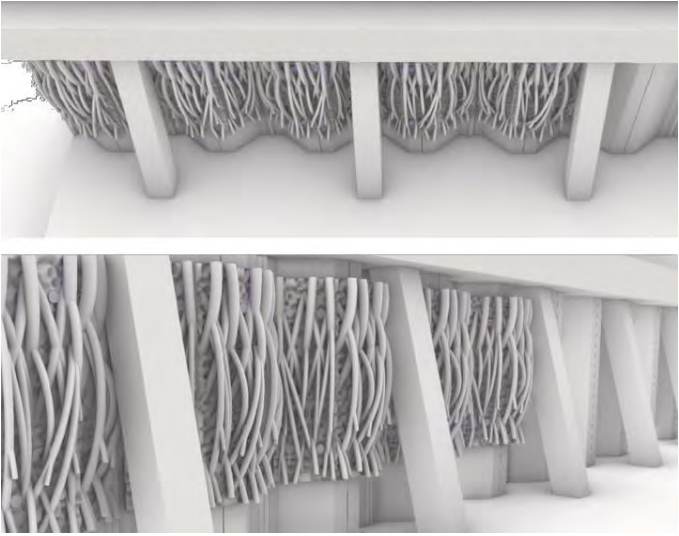


Nature-Based Solutions

- Living Seawalls
 - Texturing
 - Concrete selection
 - Mangrove reef wall panels
- Pilings
 - Oyster ring attenuators
 - Oyster wrap
- Revetments
 - Limestones
 - Tidal pools
 - Mangrove / marsh planters
- Oyster Reefs
 - Bags, domes, prisms, castles, rastas, tabletops, lollipops
- Reef balls

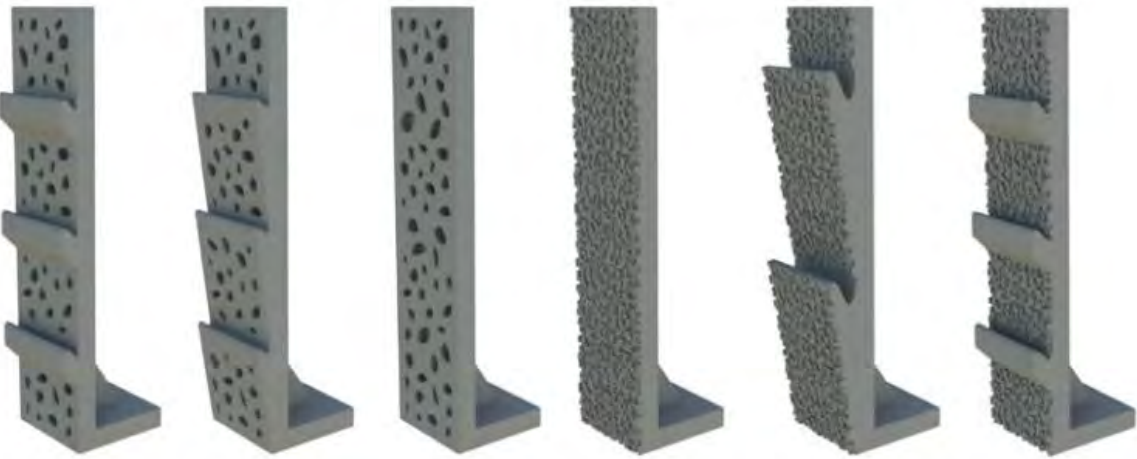


Living Seawalls



Ecological Enhanced Seawall

Reef Wall Paneling



Franklin 98 Oyster Reef Breakwater Project



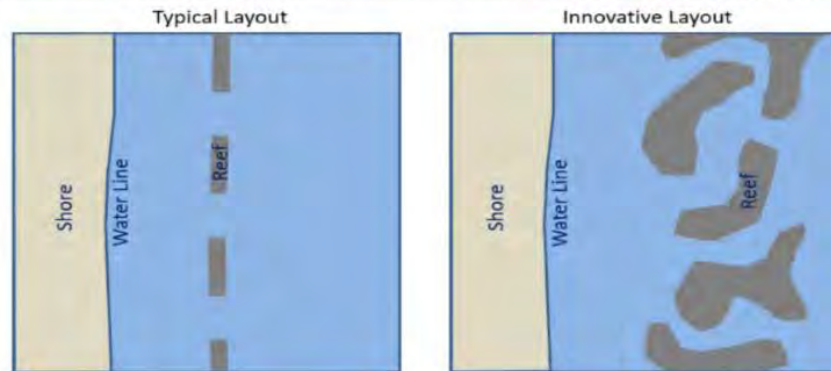
Goals/Vision

Specific Restoration Goals:

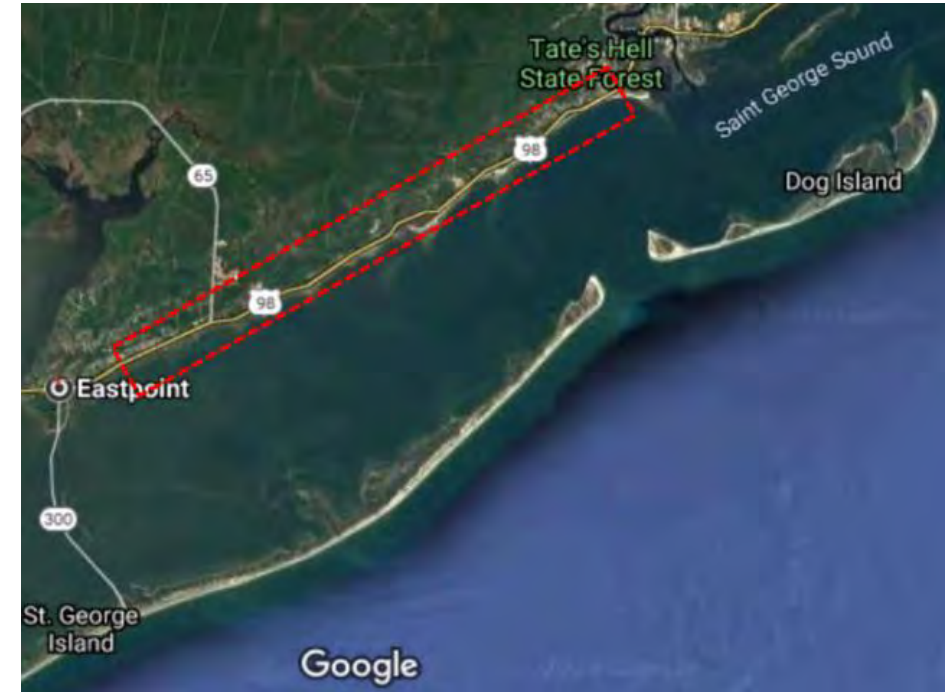
- 20 acres of new reef
- 30 acres of new marsh

Project Benefits:

- Increased ecosystem productivity/diversity
- Shoreline stabilization
- Community resiliency
- Community education & cooperation
- Economic development



Our innovative design approach will maximize habitat and coastal resiliency, while achieving better aesthetics through natural design.



Examples of Different Sills:



Photo credit: J. Bradshaw



Photo credit: North Carolina Coastal Federation



Photo: Sandbar Oyster Co., Niels Lindquist

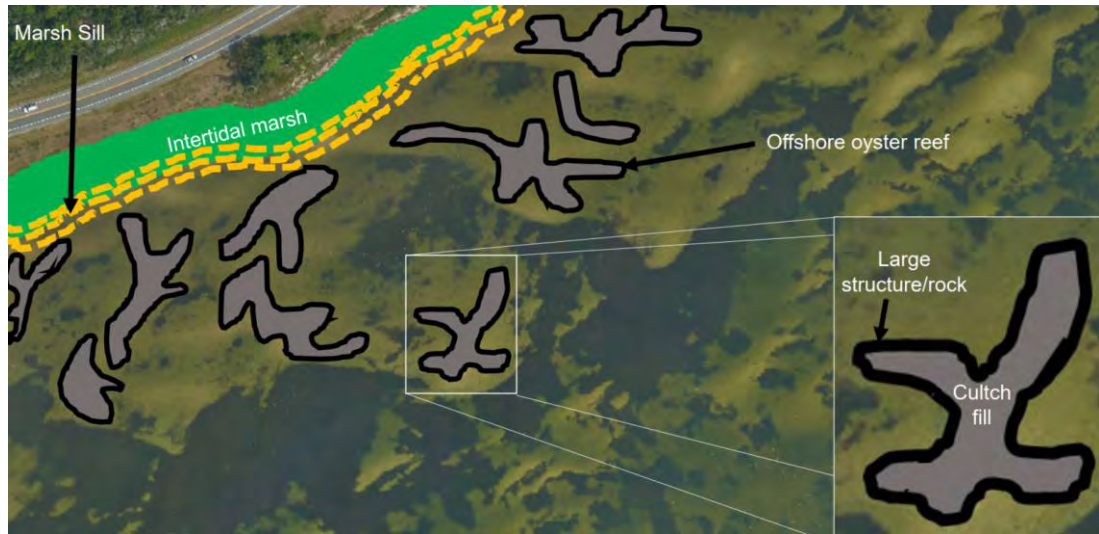


Rastas deployed
Jan. 2020

Tabletops
deployed 9/10/20

Lollipops deployed
Jan. 2020

Apalachee Regional Planning Council 12-Mile Project



Perimeter of larger objects

Riprap/recycled concrete

Oyster Castles

Interior filled with loose cultch (rock/rubble/shell)

Reef balls

Oyster Catcher Tabletops



Oyster Castle

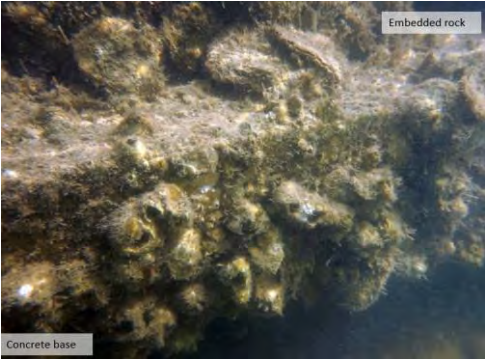
Riprap/recycled concrete

Reef balls

Tabletops

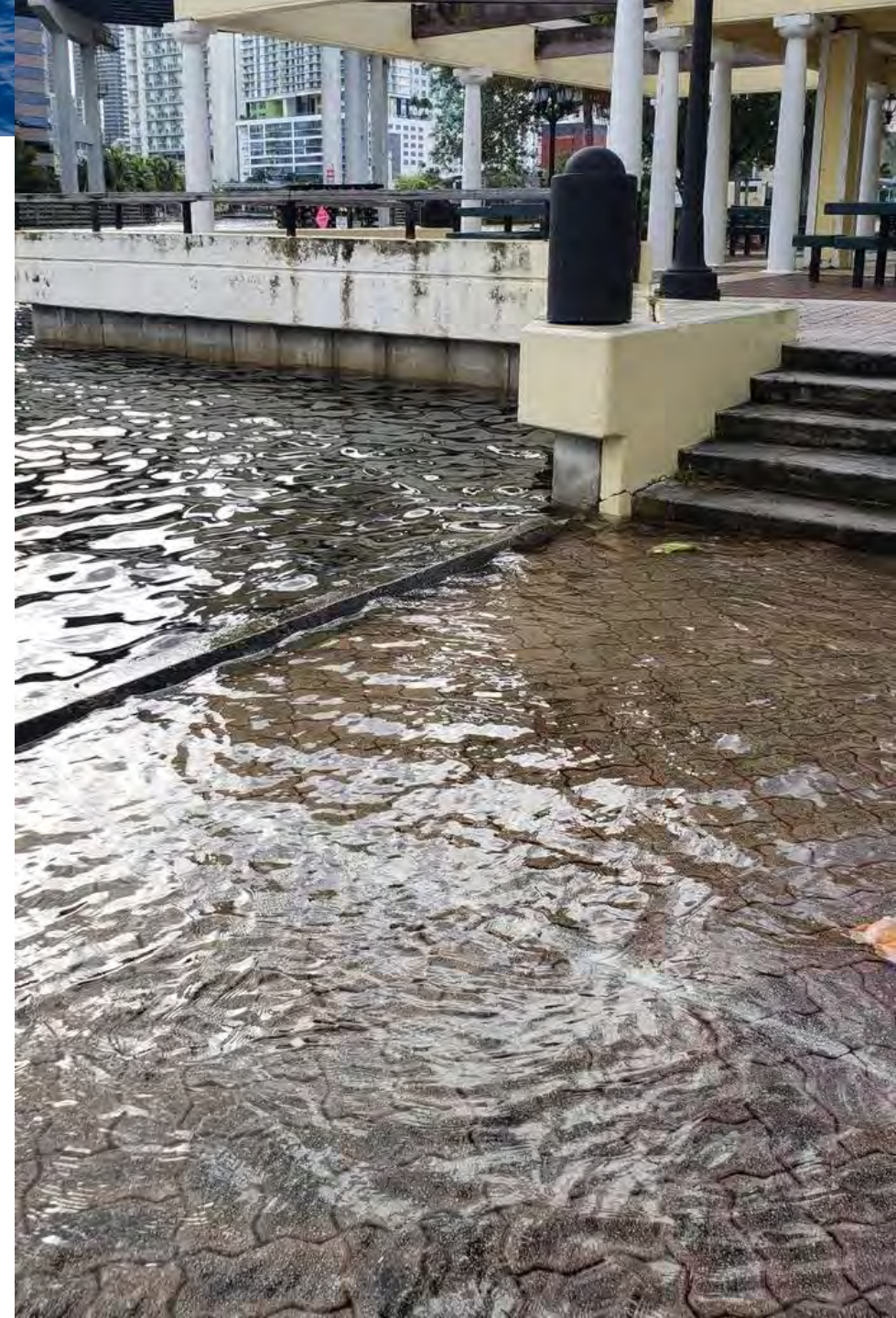
Stacked Oyster Prism

*Could involve one or more structure types



Site evaluation

- Site selection
- Shoreline physical conditions
- Shoreline habitat conditions
- Wave climate
- Water levels
- Design constraints
- Project goals steer design!!

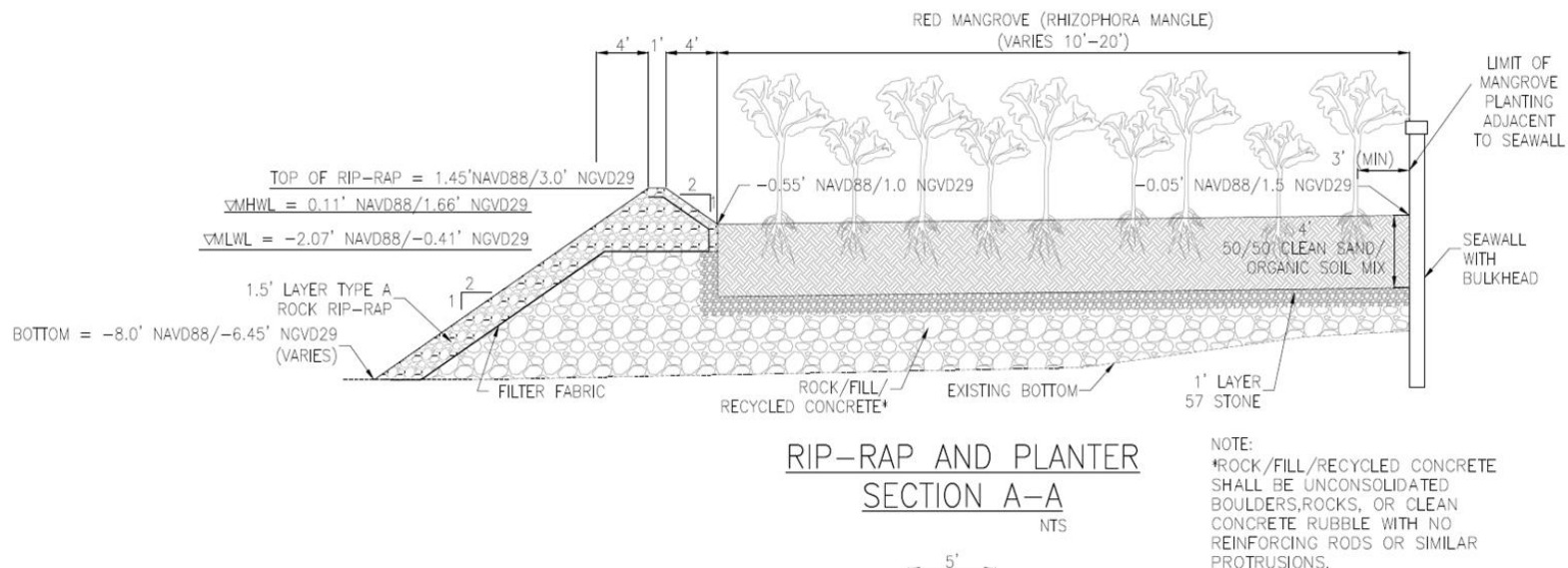
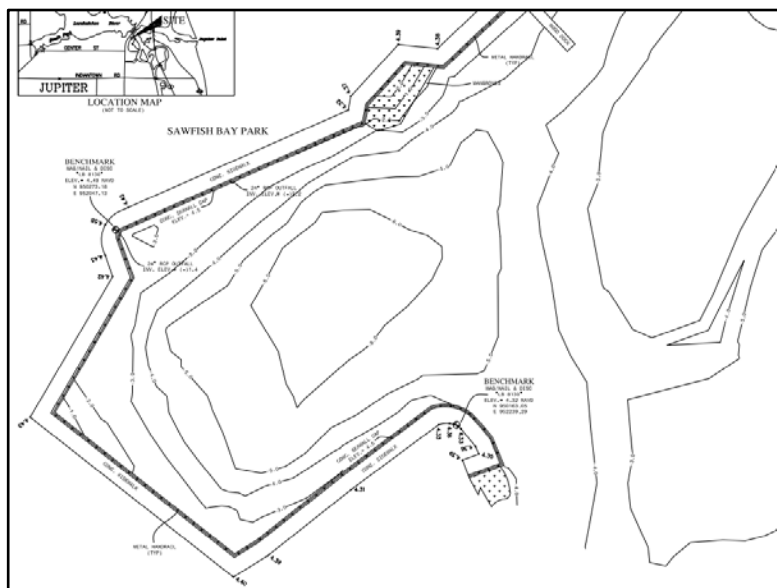


- Ownership
 - Private vs public upland
 - Sovereign or non-sovereign submerged land
- Upland vs waterfront uses
- Infrastructure/utilities
- Owner's willingness, ability to maintain
- Space limitations



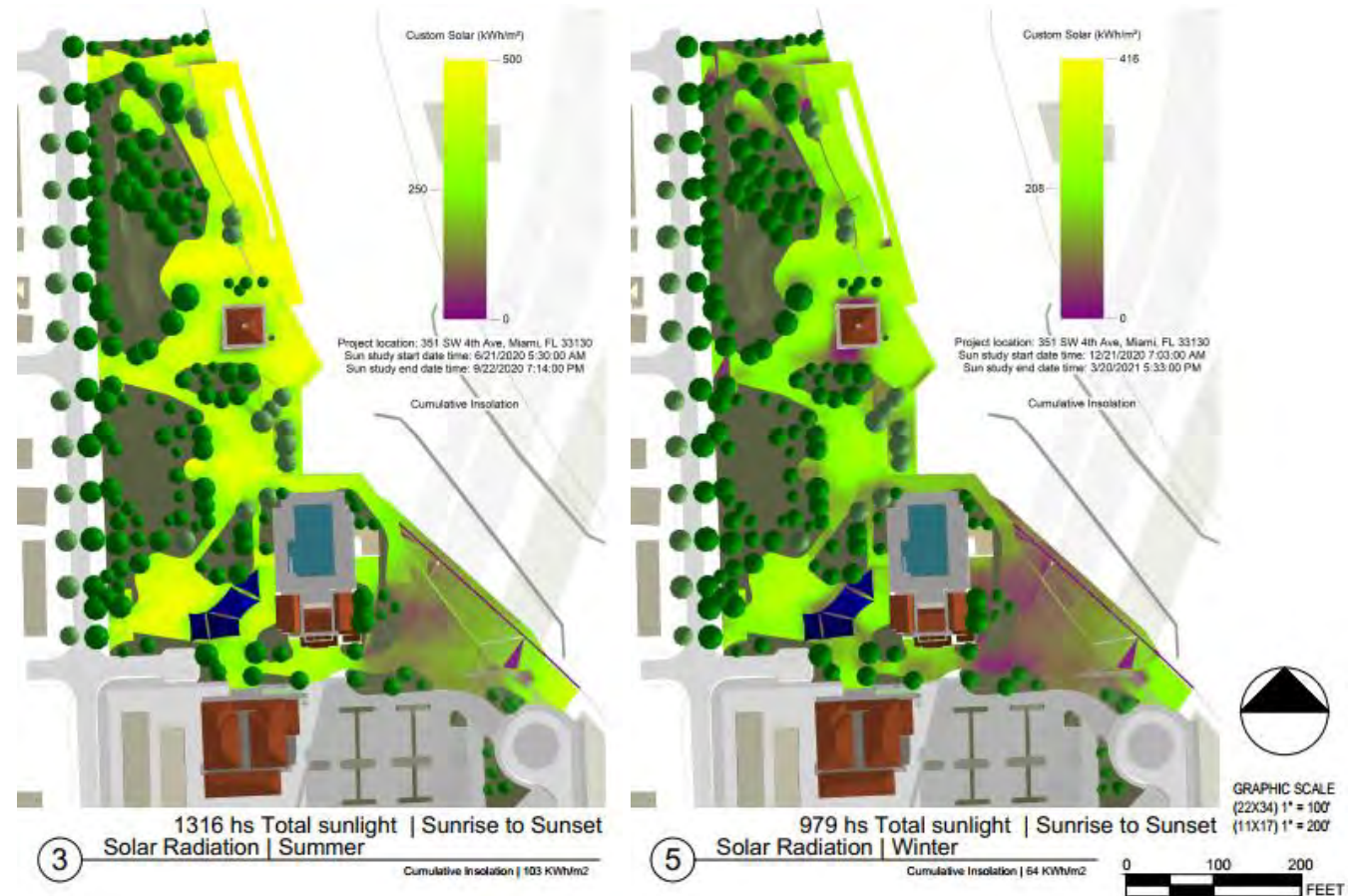
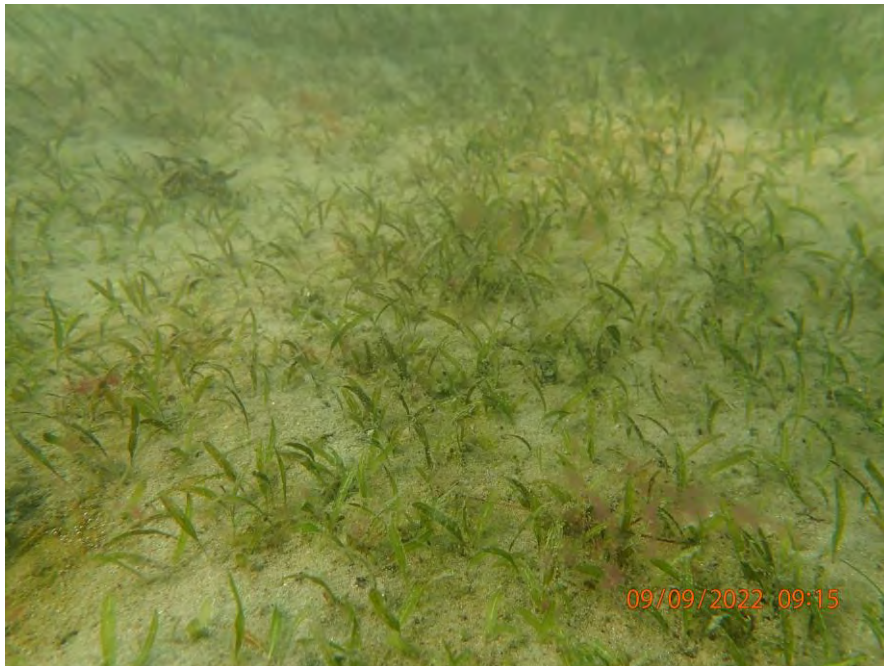
Shoreline Physical Conditions

- Natural or armored
 - onsite, adjacent, region
- Stable or eroding, known erosion rate
- Bathymetry/topography, orientation
- Sediment type & quality
 - Existing vs proposed
 - Dredge or fill (or both)



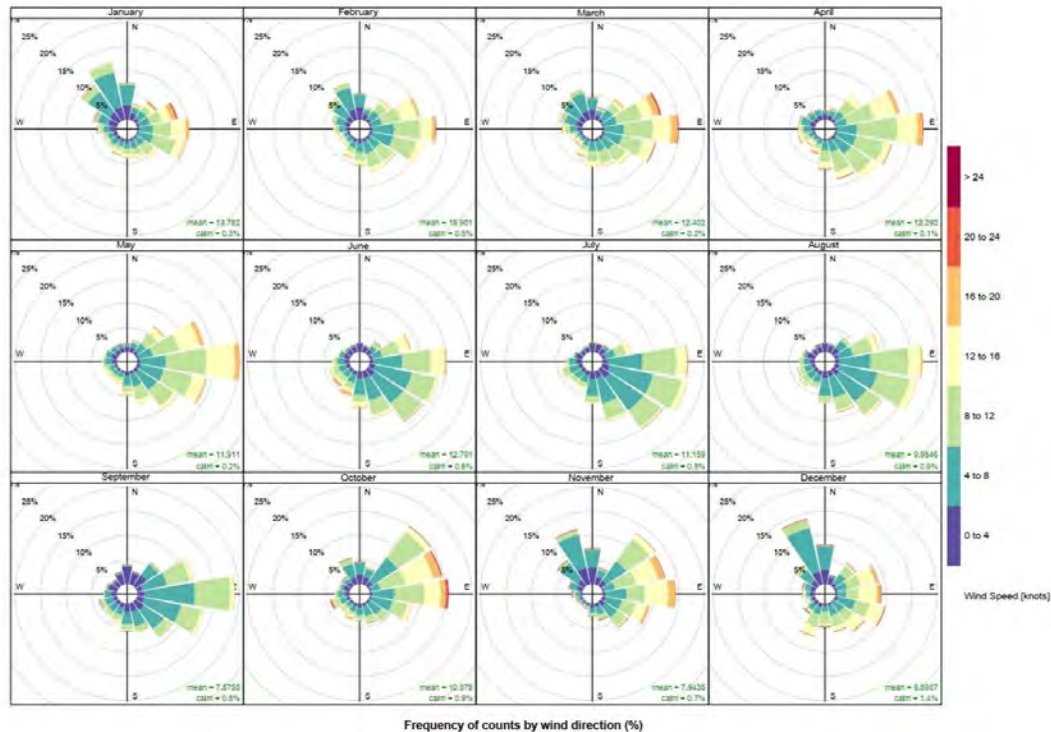
Shoreline Habitat Conditions

- Nearshore, intertidal, subtidal
 - Seagrass, coral, oysters, marsh, mangrove
 - Habitat mapping
- Existing, nearby, historical
- Sunlight exposure

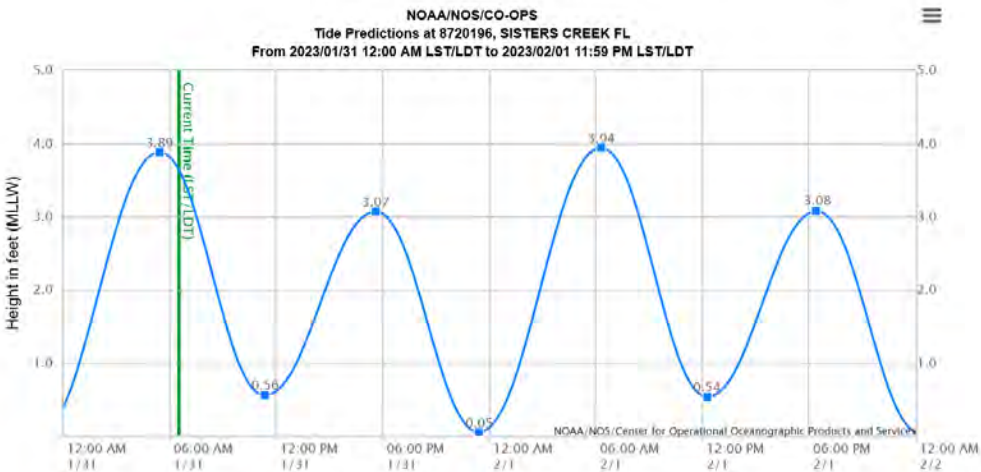
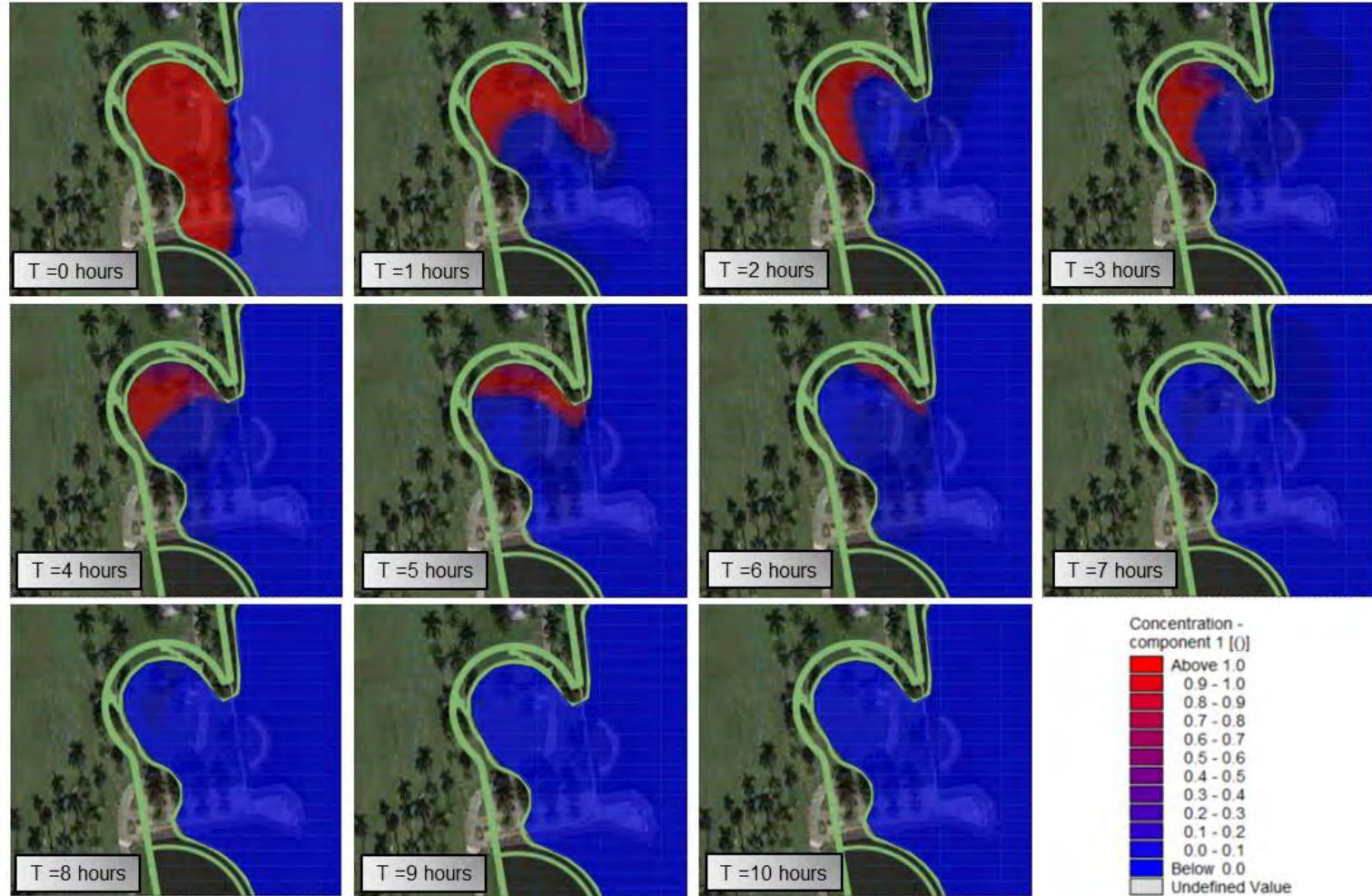


- Fetch, surge, runup, width of waterway
- Prevailing wind
- Speed zones
- Proximity to channel or inlet

FIGURE 5: MONTHLY WIND ROSE PLOT



- MHW, MLW, tide range
- King Tides
- SLR Projections
- Planning horizon
 - Today, 2040, 2070
- Design storm, flushing analysis, other modeling



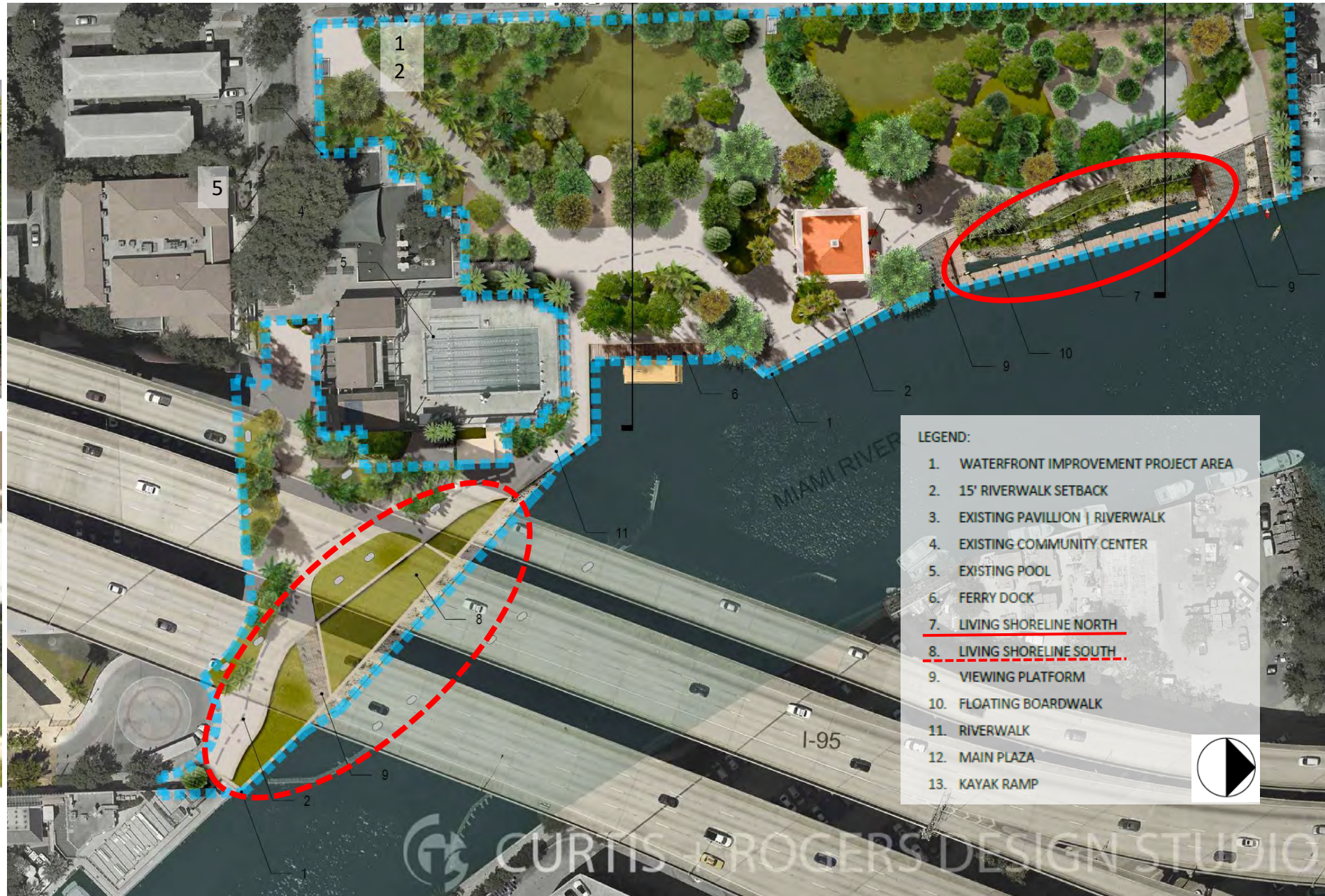


Year	NOAA Intermediate High Sea Level Rise* (ft)	MHHW*** (ft, NAVD 88)	King Tide** (ft, NAVD88)	King Tide + 1.5' Wake (ft, NAVD88)
2000	0.00	0.29	N/A	N/A
2010	0.30	0.58	N/A	N/A
2020	0.56	0.84	2.5	4.0
2030	0.98	1.27	2.9	4.4
2040	1.38	1.66	3.3	4.8
2050	1.94	2.22	3.9	5.4
2060	2.56	2.85	4.5	6.0
2070	3.31	3.60	5.3	6.8
2080	4.17	4.45	6.1	7.6
2090	5.12	5.40	7.1	8.6
2100	6.14	6.42	8.1	9.6

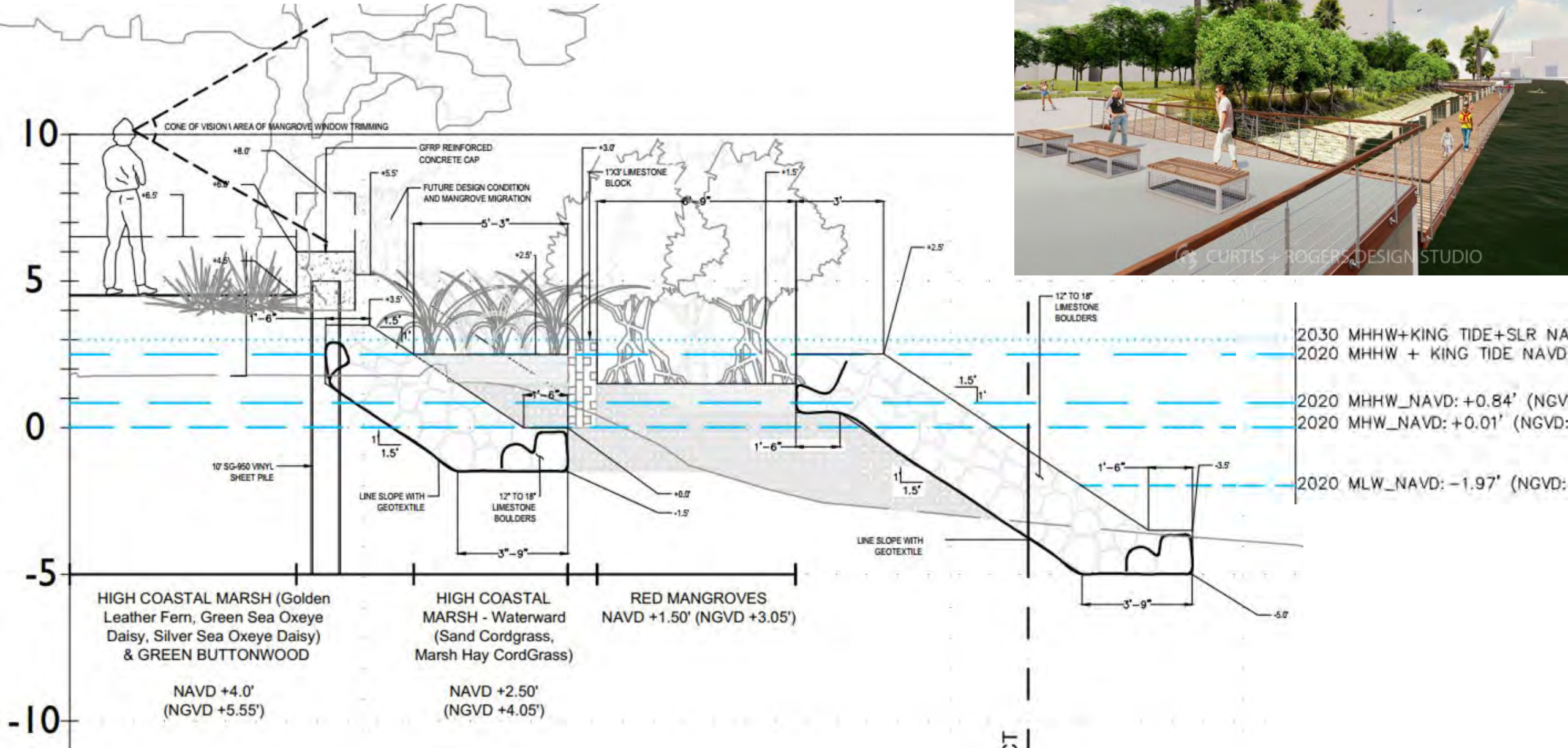
Jose Marti Park (City of Miami)

- Between Miami River & Little Havana
- Provides open space & social services
- Flooding due to sea level rise & king tide

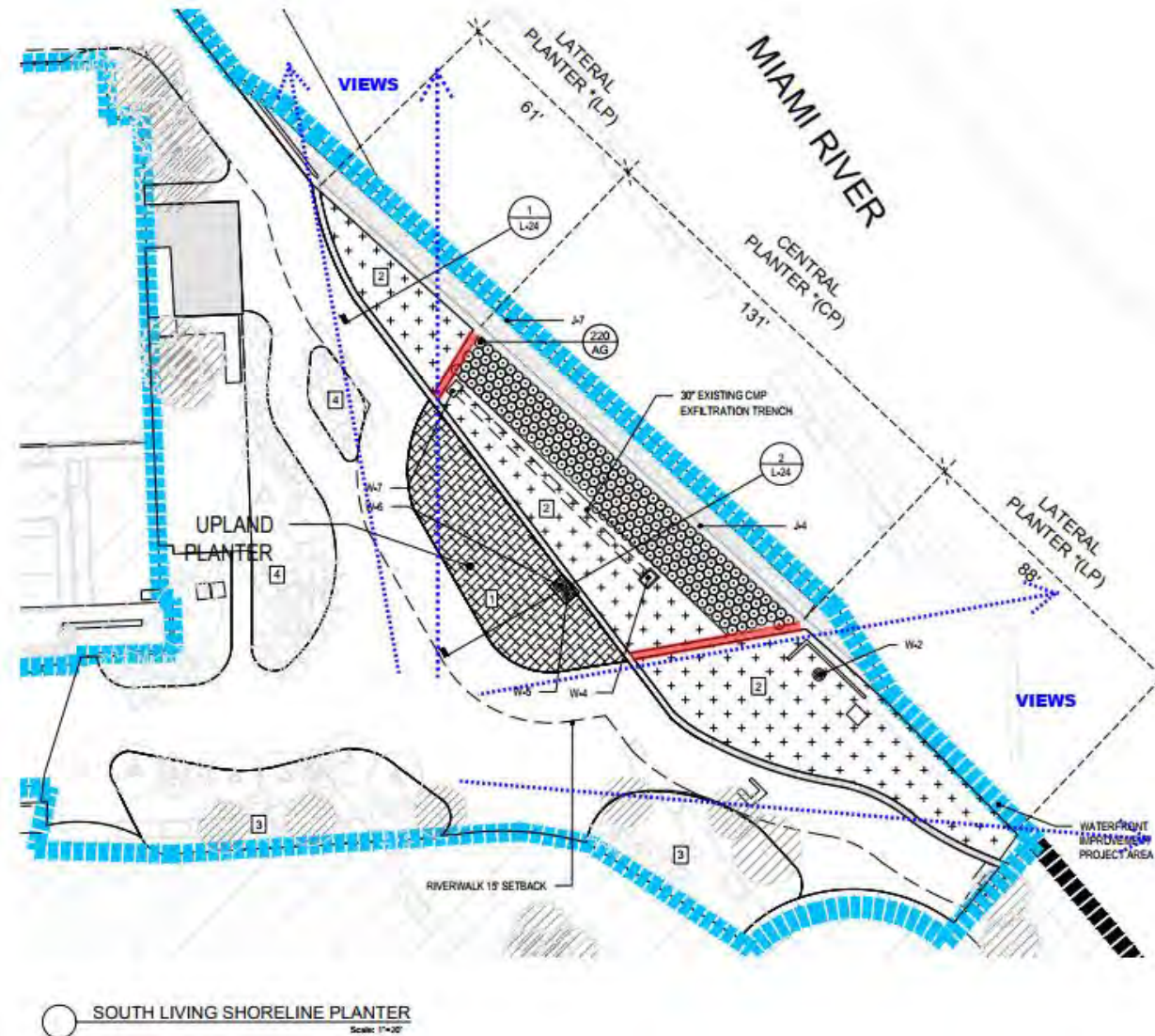
Jose Marti Park Project – 3 Shoreline Treatments



Jose Marti Park Tiered Planter



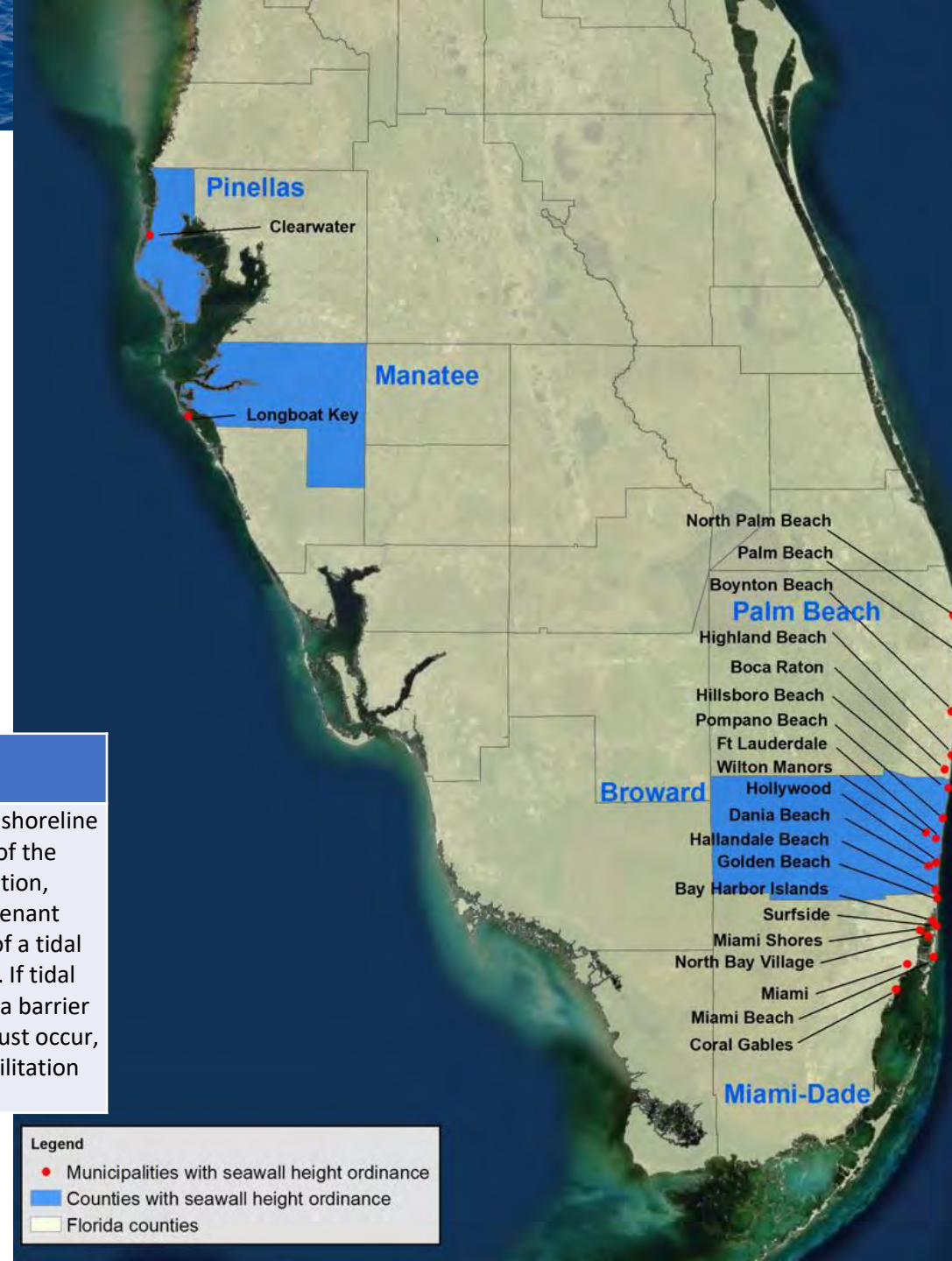
- Tidal flood barrier ordinance
- Green vs grey component
- Tolerance of plants to water levels
- Access considerations
 - Human or wildlife (manatee)
 - Boating – launching, mooring, active/passive
 - Viewing
 - Fishing



Tidal Flood Barrier Ordinances

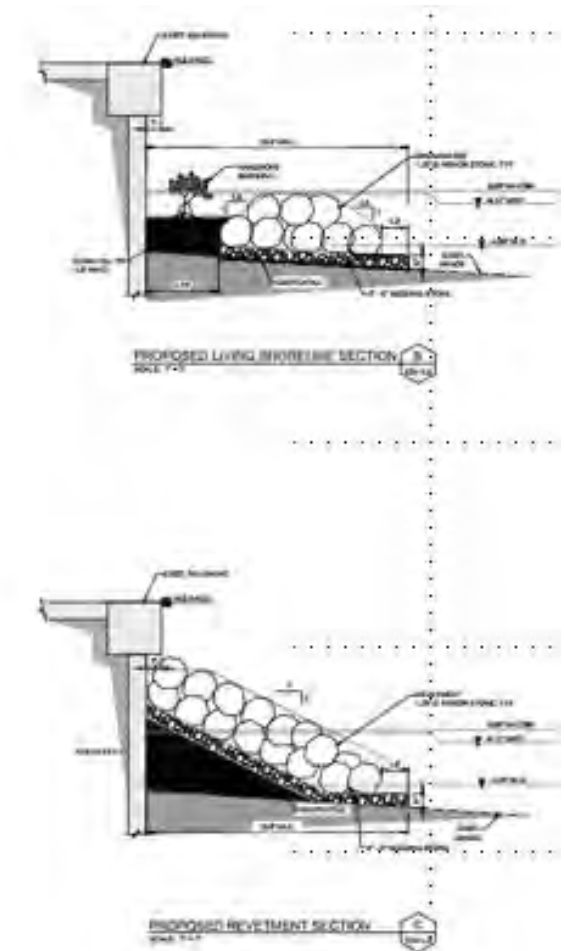
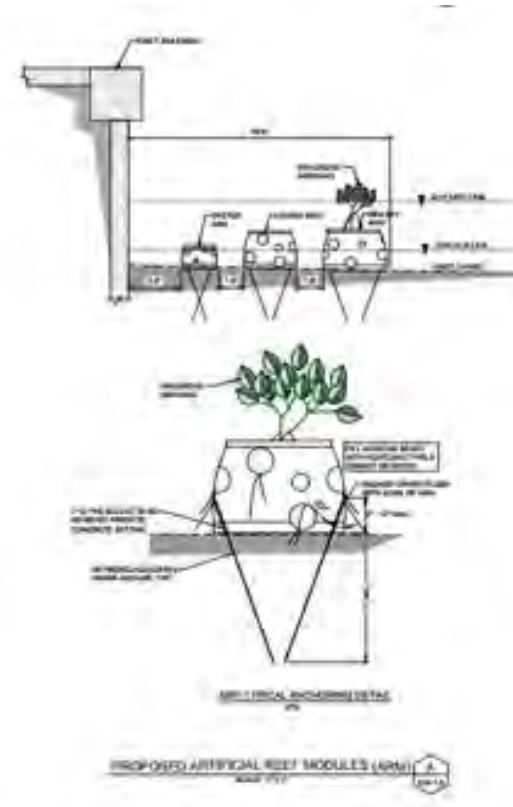
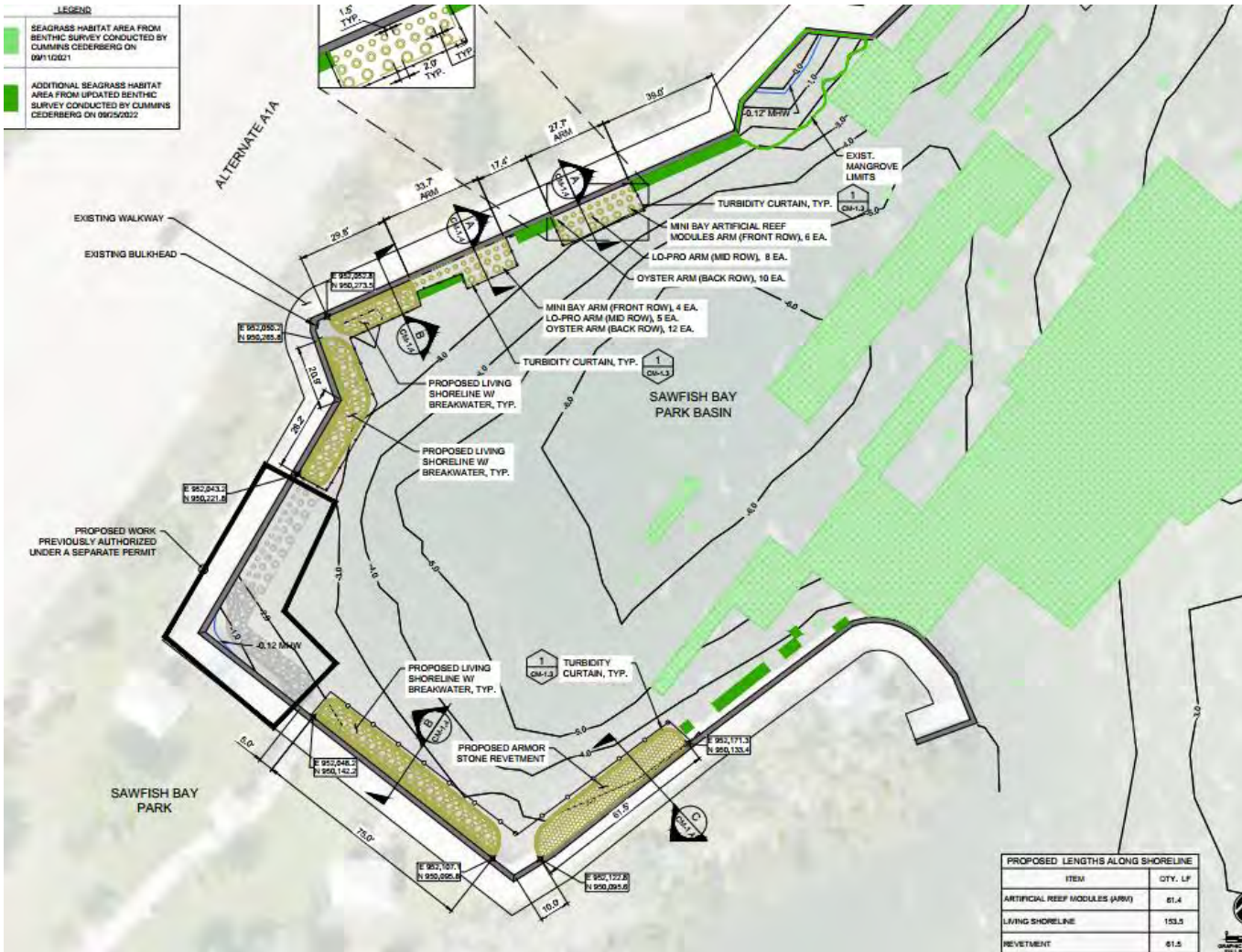
- Ordinances set minimum elevation for shoreline barriers (seawalls, berms, revetments)
 - Construction Trigger: New construction or >50% substantial repair of seawall
 - Trespass Trigger: Tidal waters flowing overland and leaving property
- Excludes groundwater seepage, parcels seaward of Coastal Construction Control Line

County	Ordinance #s	Minimum Elevation (ft)	Datum	Implementation Triggers
Broward	Ord. No. 2020- <u>11</u>	5 (Until 2035, 4' allowed if structure can be upgraded to 5' by 2050)	NAVD88	New tidal flood barriers, any shoreline or shoreline structures exceeding 50% the length of the property's shoreline, or any modification, alteration, or installation of an appurtenant structure that exceeds 50% of the cost of a tidal flood barrier <i>along property's shoreline</i> . If tidal waters flow unimpeded through or over a barrier onto adjacent property or ROW, repair must occur, and it meets substantial repair or rehabilitation threshold.



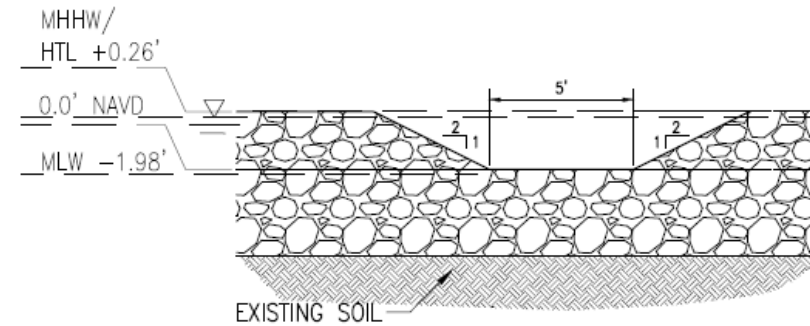
(8) Property owners are encouraged to consider approaches and materials that enhance the biological value of traditional (flat surface) seawalls and flood barriers with the incorporation of living shoreline features, use of hybrid green-grey materials, and the use of biological forms, where practicable. A living shoreline may have its waterside face consisting of plants and other natural elements to improve water quality, provide essential fish habitat, and foster increased biodiversity, provided the landside interface of a living shoreline is substantially impermeable and constructed to a finished elevation that meets the minimum elevation for tidal flood barriers set forth in this section. The landside interface may be located anywhere on an existing property fronting the living shoreline, as long as it is constructed in a manner and location that ensures any habitable structures on that property are protected from flooding from tidal waters and it prevents tidal flooding of adjacent properties and the public rights-of-way.

Choosing Engineered Features, Design Refinement



Currie Park's Mangrove Planters, Palm Beach County

COMMON NAME	SCIENTIFIC NAME	ELEVATION RANGE (FT NAVD)	AVERAGE SPACING (FT O.C.)	QTY	SIZE (MIN.)
SPARTINA GRASS	SPARTINA SP.	> 0.2' NAVD	2	945	1-GAL
RED MANGROVE	RHIZOPHORA MANGLE	-0.50' - +0.20' NAVD	5	150	3-GAL



MANATEE EGRESS AREA



Byrant Park's Marsh Planter, Palm Beach County



Safety Harbor's Shoreline Conversion, Pinellas County

Safety Harbor's Living Shoreline

Constructed in Spring 2019, Safety Harbor Waterfront Park Living Shoreline demonstrates stabilization techniques that contribute to the community's unique sense of place while also preserving the natural connections between land and water.

Safety Harbor Waterfront Park Living Shoreline will maintain continuity of the natural land-water interface and reduce erosion while providing habitat value, enhancing coastal resilience, and provide wildlife viewing along the beautiful shoreline.

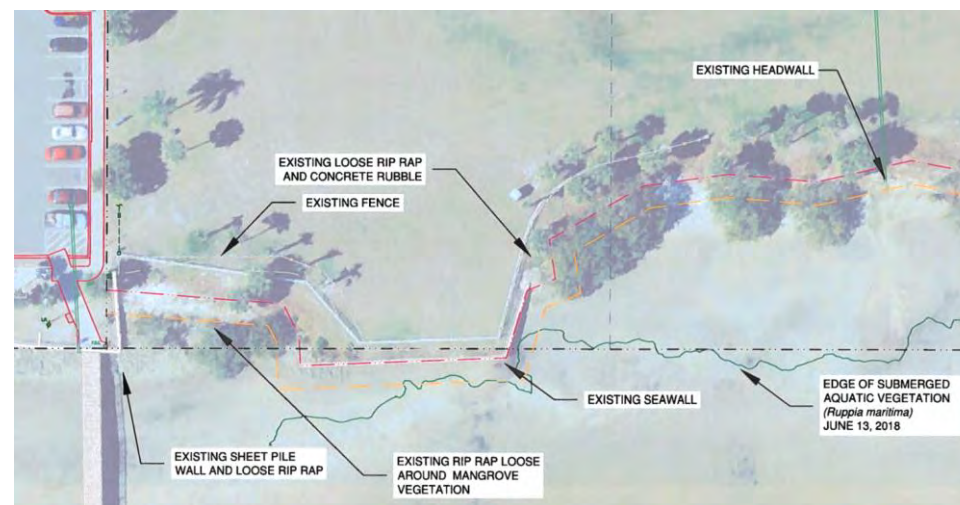
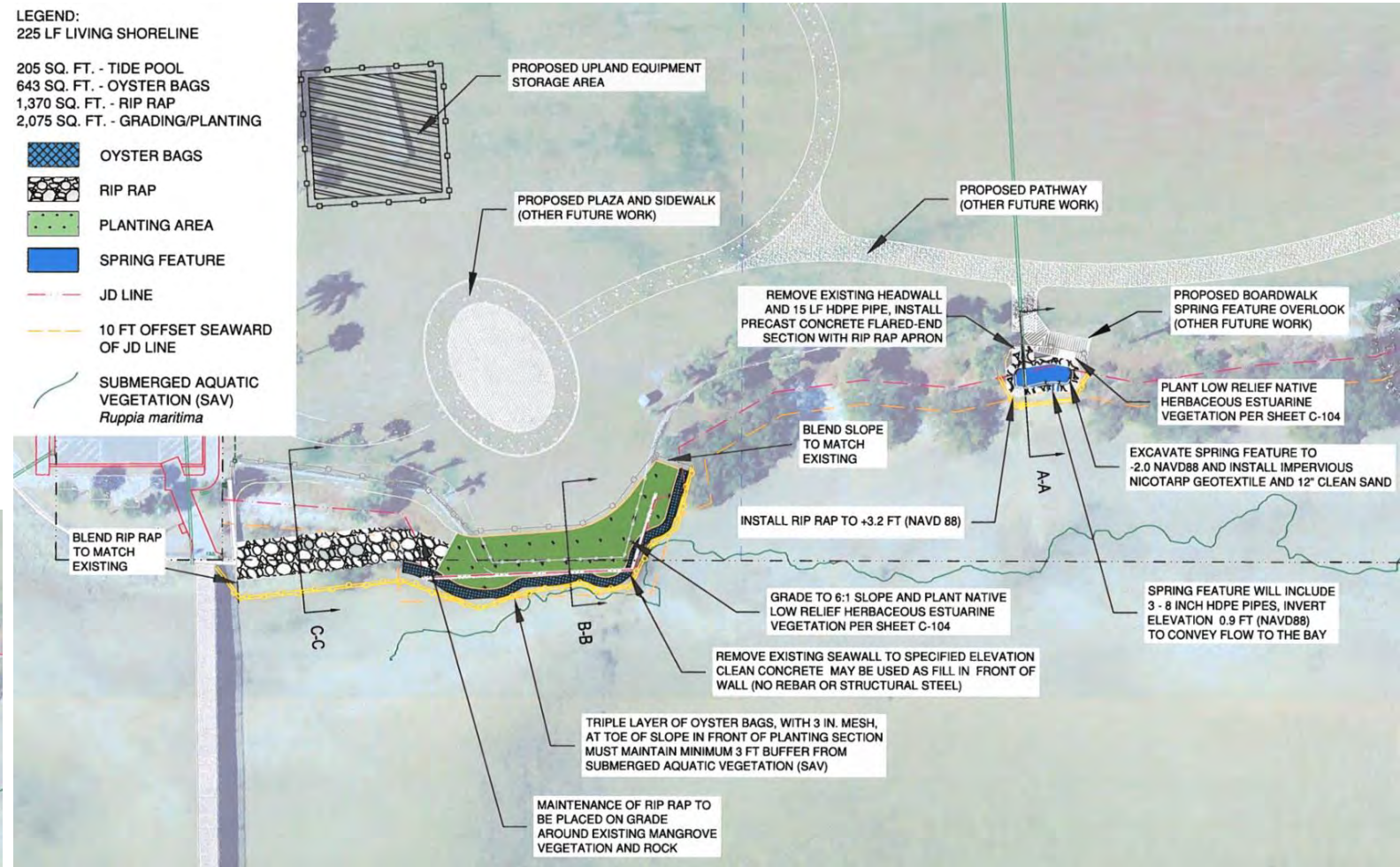
Living Shoreline Benefits:

- Improves water quality in Tampa Bay by trapping sediments and filtering pollutants.
- Ensures natural sediment movement along the shoreline.
- Reduces wave energy and associated shoreline erosion and minimizes property loss.
- Buffers the effects of storms, especially tropical storms and hurricanes.
- Creates and connects diverse animal habitats, provides migratory pathways for plants and animals, and supports valuable fisheries.

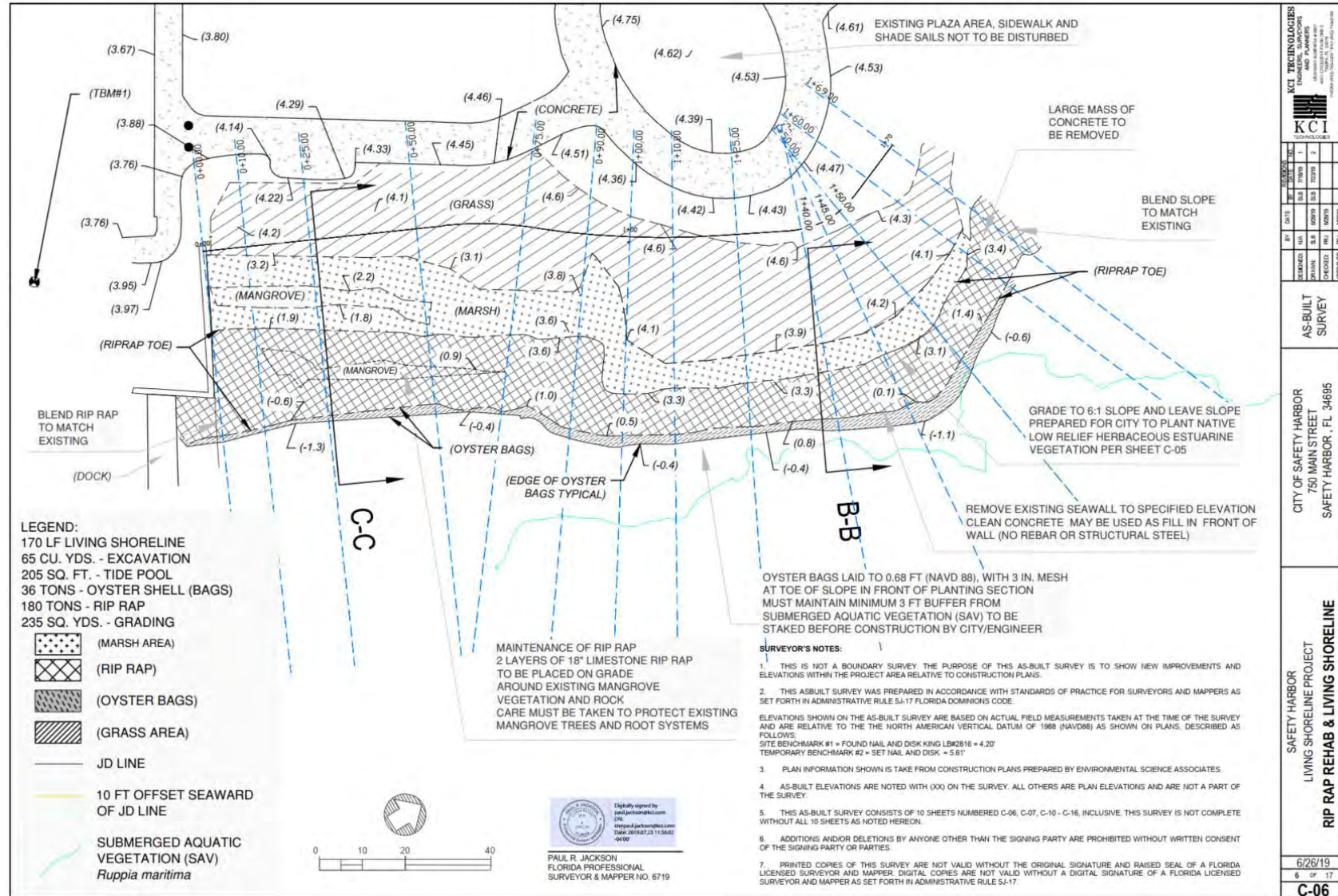
Waterfront Park Living Shoreline uses a sloped barrier of natural limestone rocks (or "rip rap"), native coastal plants, and an oyster reef to restore valuable habitats in Tampa Bay and enhance coastal resilience.

For more information on Living Shorelines, visit: floridalivingshorelines.com

- LEGEND:**
- 225 LF LIVING SHORELINE
 - 205 SQ. FT. - TIDE POOL
 - 643 SQ. FT. - OYSTER BAGS
 - 1,370 SQ. FT. - RIP RAP
 - 2,075 SQ. FT. - GRADING/PLANTING
 - OYSTER BAGS
 - RIP RAP
 - PLANTING AREA
 - SPRING FEATURE
 - JD LINE
 - 10 FT OFFSET SEAWARD OF JD LINE
 - SUBMERGED AQUATIC VEGETATION (SAV) *Ruppia maritima*



Safety Harbor's Living Shoreline Zones



62-330.051(12) – Other Shoreline Stabilization Exemption

- Should include mostly native wetland plants
- Can include oyster reefs, coir, rock sill/breakwater
- Cannot extend more than 10' from MHW
- Cannot exceed 500' along shore
- Minimum discharge of fill / size
- Requires maintenance, periodic repair
- Breakwater opening every 75' for flow of water & movement of fish/wildlife

All others get an Individual Permit.

62-330.631 – Gov't Entities, Limited Restoration/Enhancement

General Permit

- Cannot extend more than 15' from MHW
- Not in Aquatic Preserve or w/in 3' of SAV with 1% cover

62-330.632 – Low Profile Oyster Habitat General Permit

- Less than 0.25 acres total footprint,
- No work w/in 100 m of wading bird colonies, 180 m of tern / skimmer colonies, 100 ft from marked channel
- Clean, sediment free cultch, quarantined recycled shell, fossil shell, limerock w/20%+ calcium carbonate, concrete
- Fixed on substrate or bagged, Max ht. 18" from bottom, below MHW

- Effective Date: March 19, 2017;
Expiration Date: March 18, 2022
- Should include mostly native plants
- Can include oyster reefs, coir, rock sills
- Cannot extend more than 30' from MLW
- Cannot exceed 500' along shore
- Minimum discharge of fill / size
- Requires maintenance, periodic repair

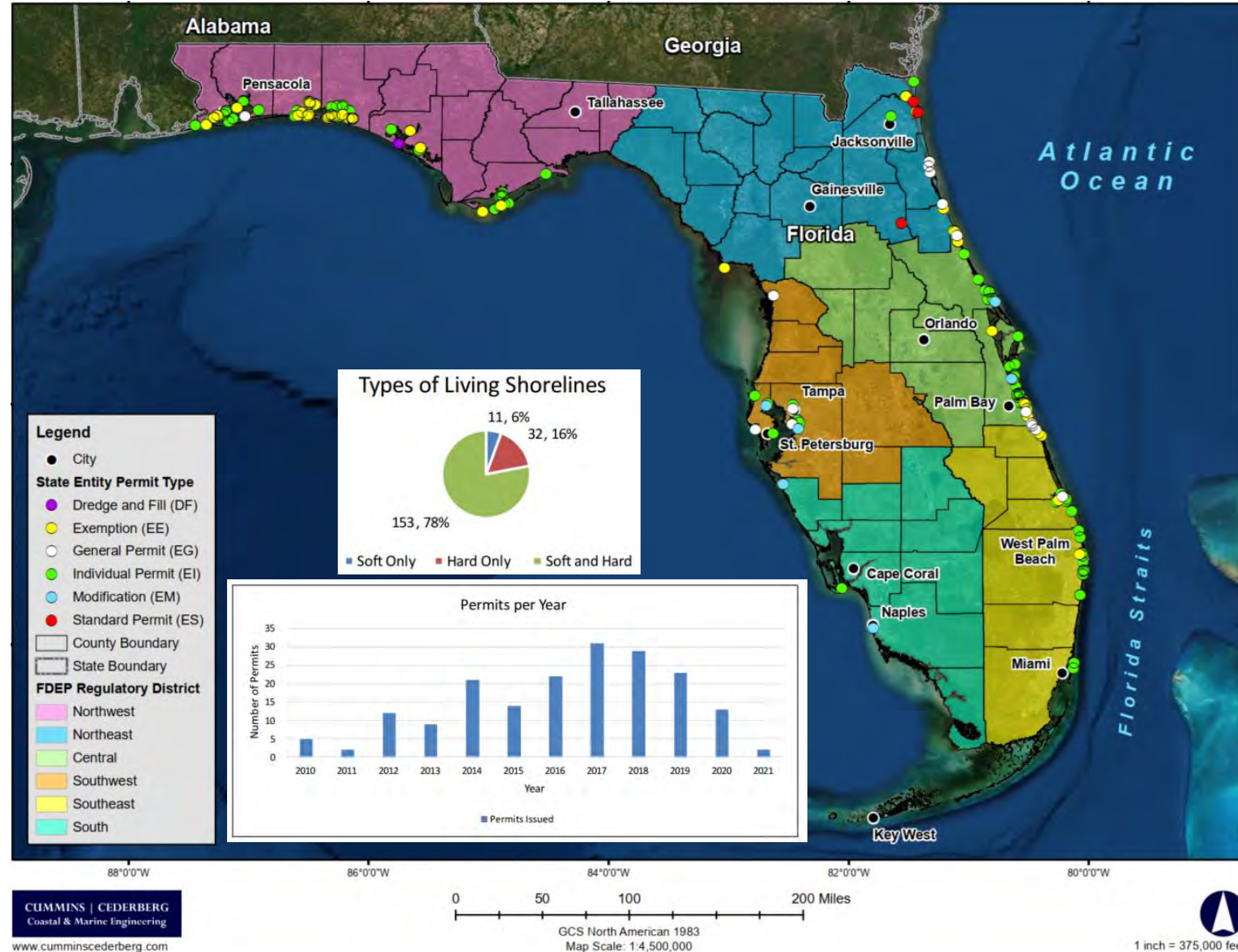
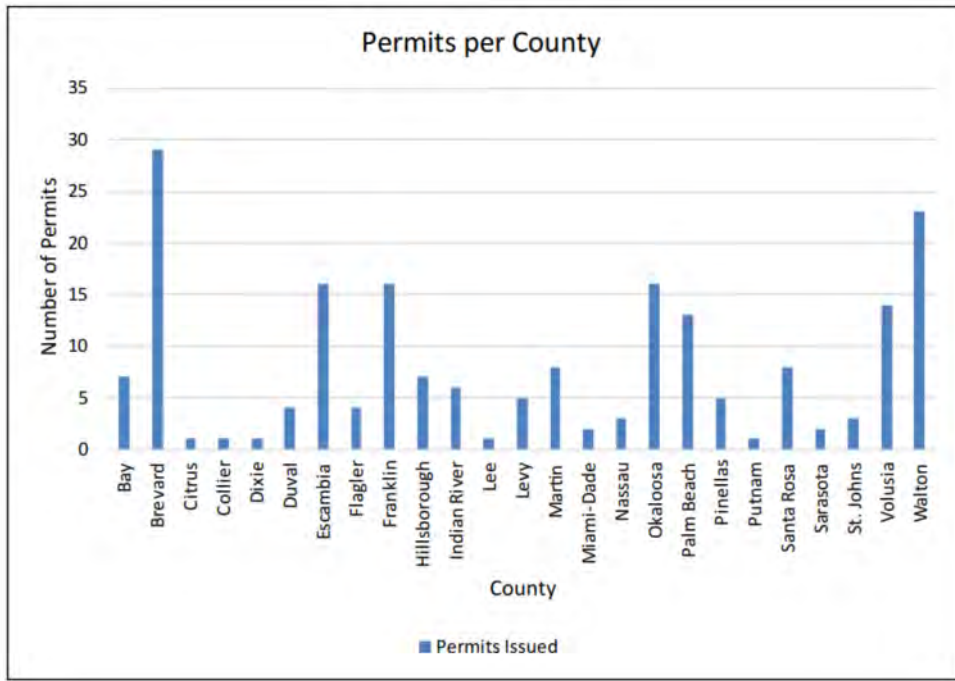


- **18-18.004 Definitions.**
- (12) "Fill" means materials deposited by any means onto submerged lands or transitional zones or submerged lands below mean high water within the preserve.
- **18-18.005 General Management Criteria.** Before the Board approves the sale, lease of transfer of interest in state lands or severance of materials therefrom, or the Secretary comments favorably concerning activities on private lands within the preserve, an applicant must affirmatively demonstrate, where applicable, that:
 - (1) Proposed dredging is the minimum necessary to accomplish the stated purpose and that the activity is designed to minimize the need for maintenance dredging;
 - (2) No new lands will be created by filling or spoiling unless no other alternative exists to accomplish the stated purposes, and project is designed to require the minimum filling to accomplish the stated purpose of the activity consistent with the protection of the preserve;
 - (3) Marina facilities over water are restricted to those water dependent activities necessary to service boats and allow for fishing or fish cleaning activities and are designed to allow the unimpeded flow of water and minimize bottom shading;
 - (4) Docks and piers are designed to allow the unimpeded flow of water and minimize bottom shading;
 - (5) Utility cables are placed within the bottom or laid on the bottom and located along a route in a manner which will cause minimum disturbance to the marine habitats;
 - (6) Dredged spoil materials are disposed of outside of the preserve unless the applicant affirmatively demonstrates that the spoil will not be harmful to or will benefit the quality or utility of the preserve.

Rulemaking Authority 258.397(4) FS. Law Implemented 258.397(3), (4) FS. History—New 3-20-80, Formerly 16Q-18.05, 16Q-18.005.

FDEP Permitted Living Shoreline Database

- 2010-2020 Time period
- 118 State/Federally Permitted Projects
- <https://floridadep.gov/rcp/resilient-florida-program/content/resilient-florida-program-living-shorelines>



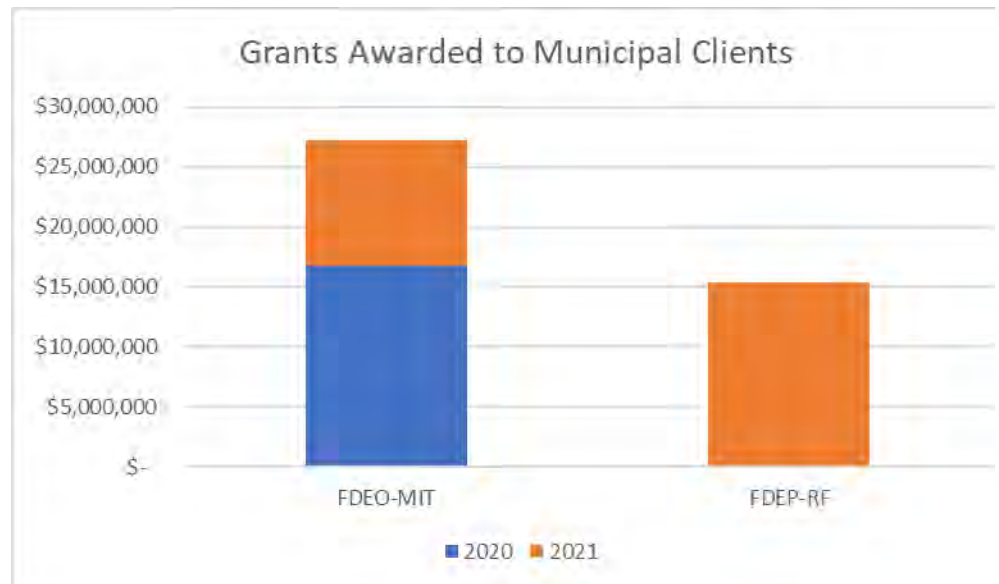
Funding Shoreline Adaptation

- Federal Funding Opportunities

- HUD Community Development Block Grant Program (FDEO)
- FEMA's Building Resilient Infrastructure & Communities (FDEM)
- NOAA's Community-Based Restoration Program
- NFWF National Coastal Resilience Fund
- FEMA Flood Mitigation Assistance
- FEMA Hazard Mitigation Grant Program
- FEMA Public Assistance

- State

- Resilient Florida
- FIND / WCIND



- Other Local/State

- Tax and Fee Revenues (sales tax, new development fees)
- Building NBSs into Capital Improvement Plan (CIP)
- Funding NBSs with Stormwater Utility Fees
- Clean Water State Revolving Fund
- General Funds
- Bond Proceeds
- LMS Project Priority Lists

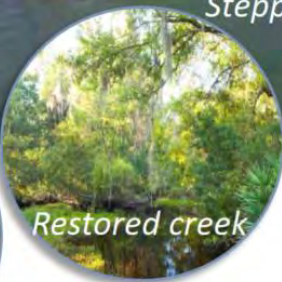


Currie Park Adaptive Redesign

\$ \$16.7M CDBG-MIT
FDEO/HUD



The Bay at Sarasota: Protect History & the Arts

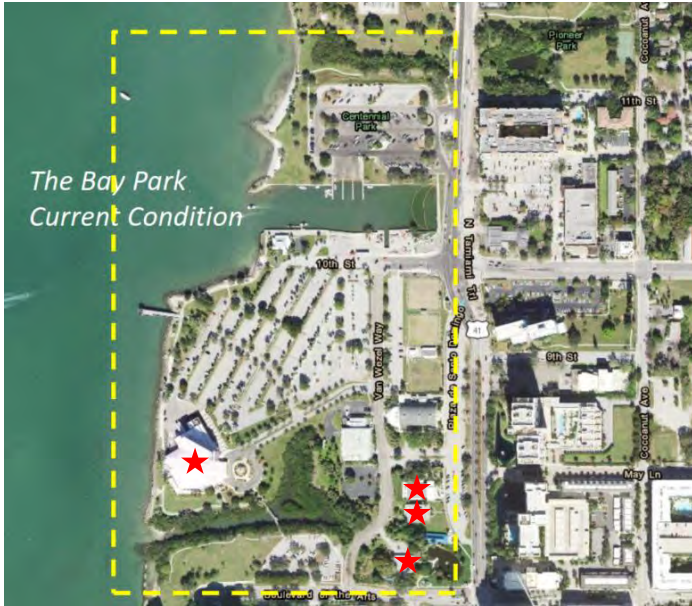


Restored creek

Living shoreline in Sarasota

Living shoreline

The Bay at Sarasota: Plan Out Funding Strategies











10.4M CDBG-MIT
FDEO/HUD

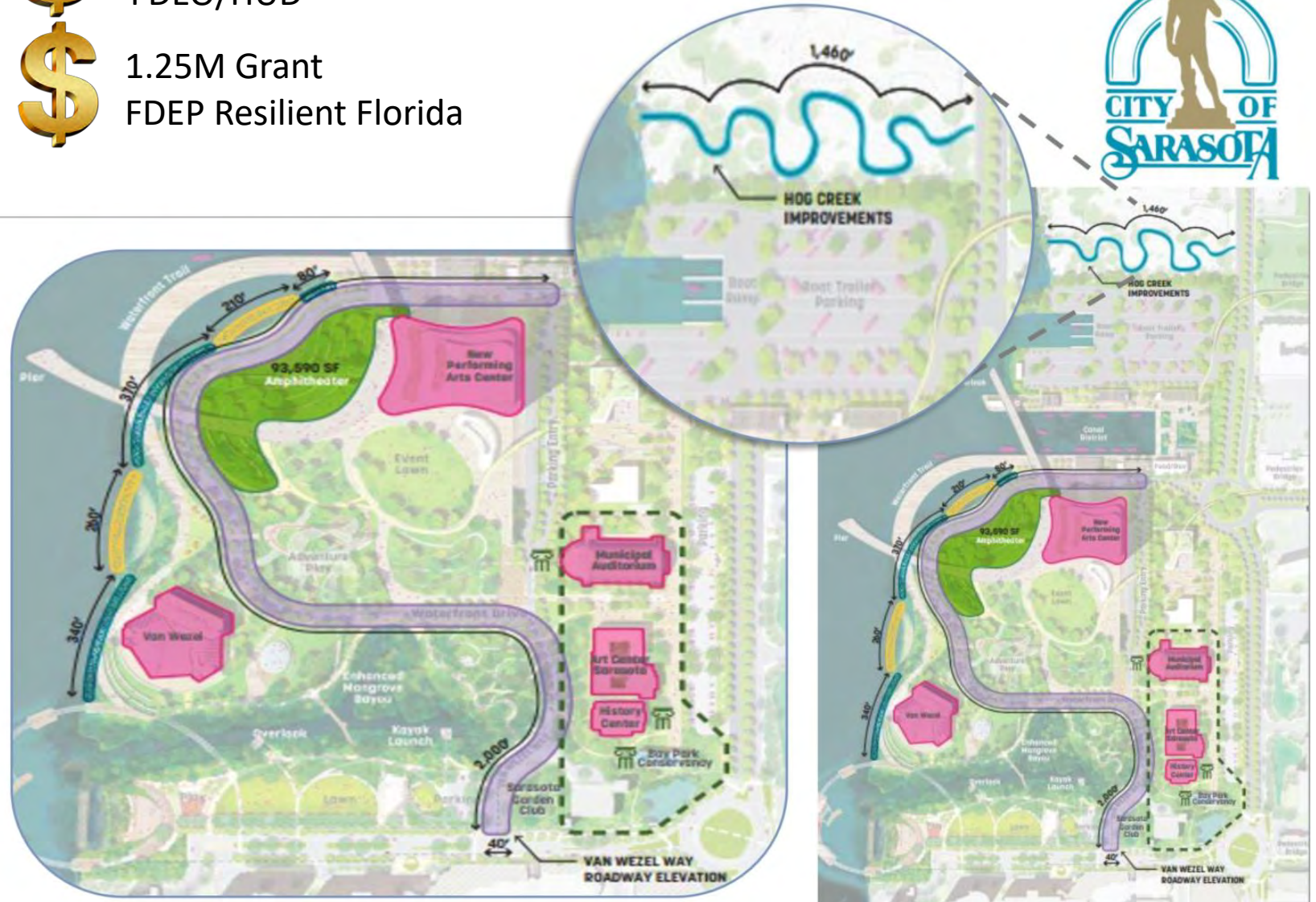
1.25M Grant
FDEP Resilient Florida

Agency
Landscape + Planning



LEGEND

-  Resilient 2:1 Slope Shoreline Riprap - 790 LF
-  Living Shoreline with Segmented Breakwater - 470 LF
-  Vegetated Floodable Stepped Flood Wall Revetment - 93,590 SF
-  Roadway Elevation - approximately 2,000 LF
-  Hog Creek Improvements - 1,460 LF
-  Buildings on Historic Register
-  Historic District
-  Cultural Facilities



Hollywood Tidal Flood Mitigation & Shoreline Protection

\$ 14M Grant
FDEP Resilient Florida



PROPOSED ADAPTATION DESIGN STRATEGIES



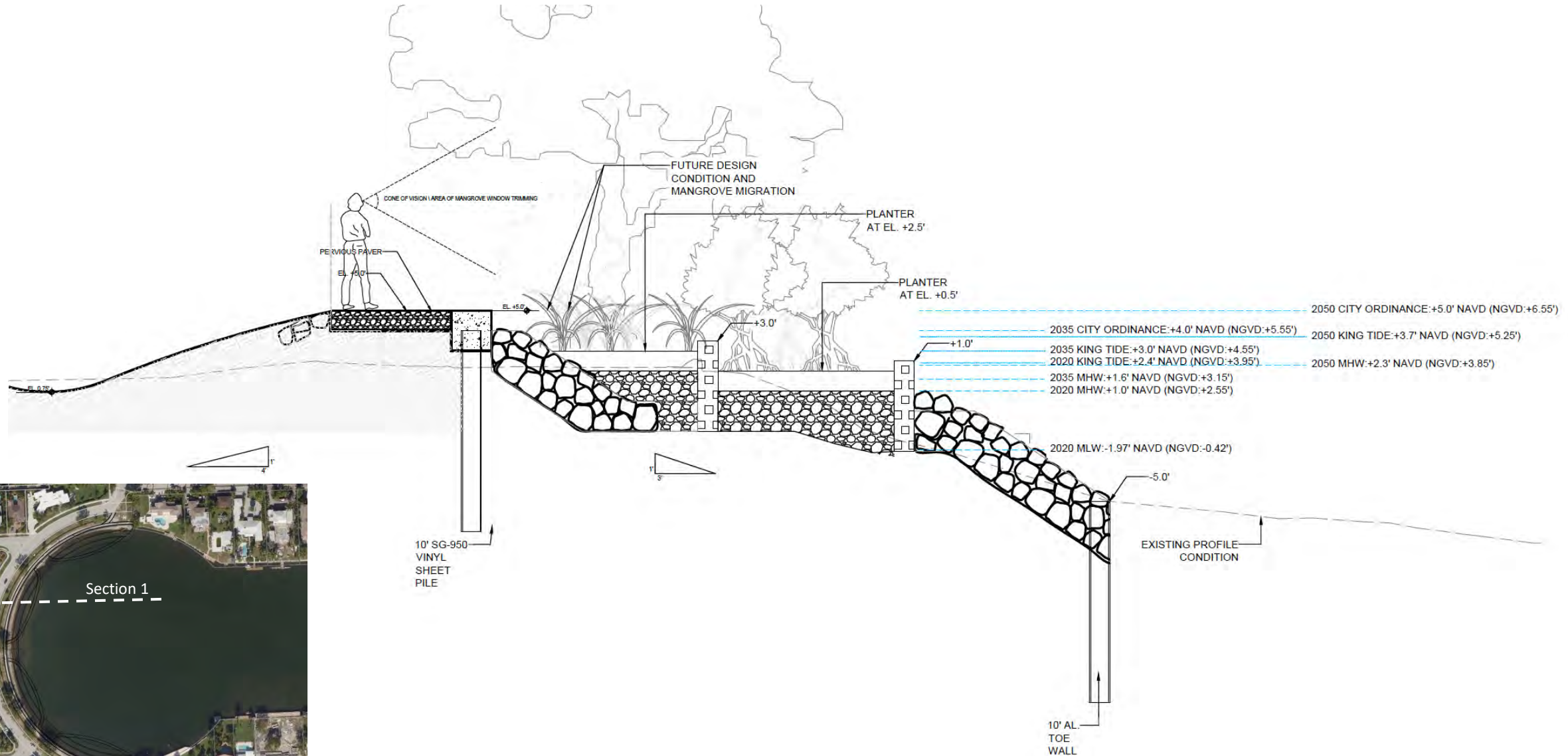
1. Seawall landward of mangrove planter
2. Mangrove planter (existing vegetation)

3. Raised end of road areas to +5:00 NAVD
4. Sloped Passive Pocket Park to meet road elevation

5. Kayak Access
6. Shade trees | landscape buffer with neighbors' properties.

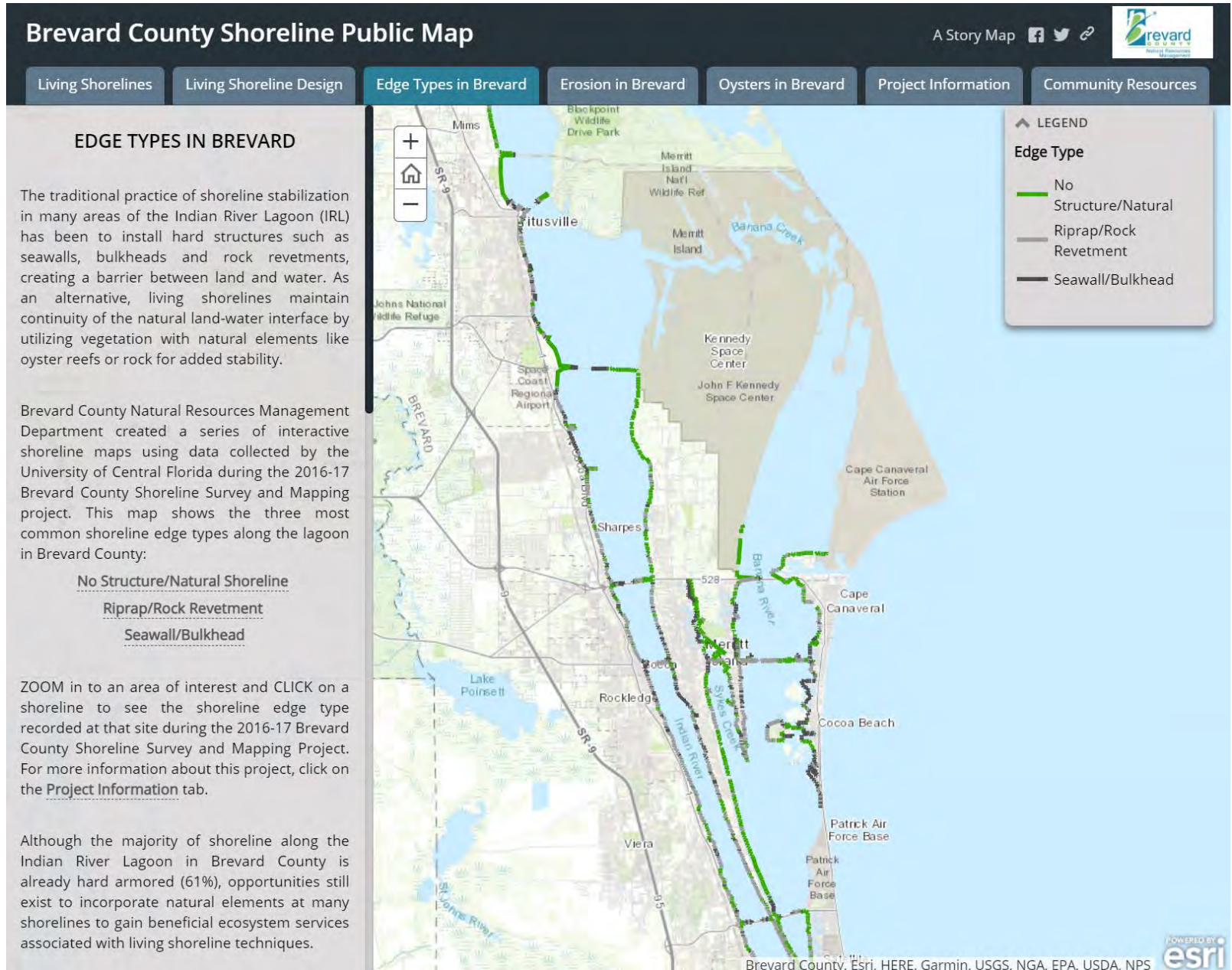


Hollywood's Hybrid Living Shoreline

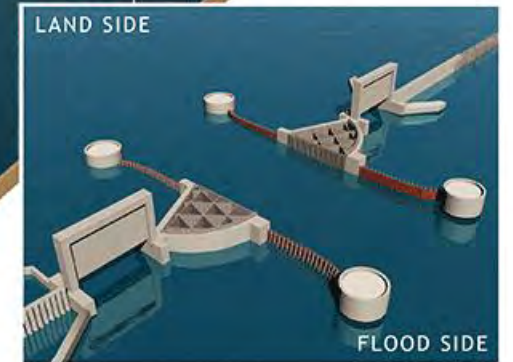


Brevard's "Save Our Indian River Lagoon"

- Project Plan funded by ½ Cent Sales Tax Referendum (2016)
- Focus on oysters
 - Denitrification
 - Filter feeding capacity
 - Erosion protection
- 20 miles new oyster reef
 - Reduce 21,120 lbs. TN
 - Reduce 7,181 lbs. TP
 - \$10M cost
- Shoreline Characterization (2016-17 UCF Data)



- Miami-Dade Back Bay Coastal Storm Risk Management (CSRM) Feasibility Study
 - Tentatively Selected Plan released Summer 2020
 - NBS preference came out in comments
 - Chief's report delayed
- Miami-Dade County is non-federal sponsor
 - 2.8M people, 34 municipalities
 - Avg elevation 5' NAVD88
- Solutions to reduce coastal storm impacts, considers SLR
 - Structural – flood walls & surge barriers, pump stations
 - Non-structural – elevating/floodproofing structures
 - Nature-based – mangroves, dredged spoil islands, SAV restoration



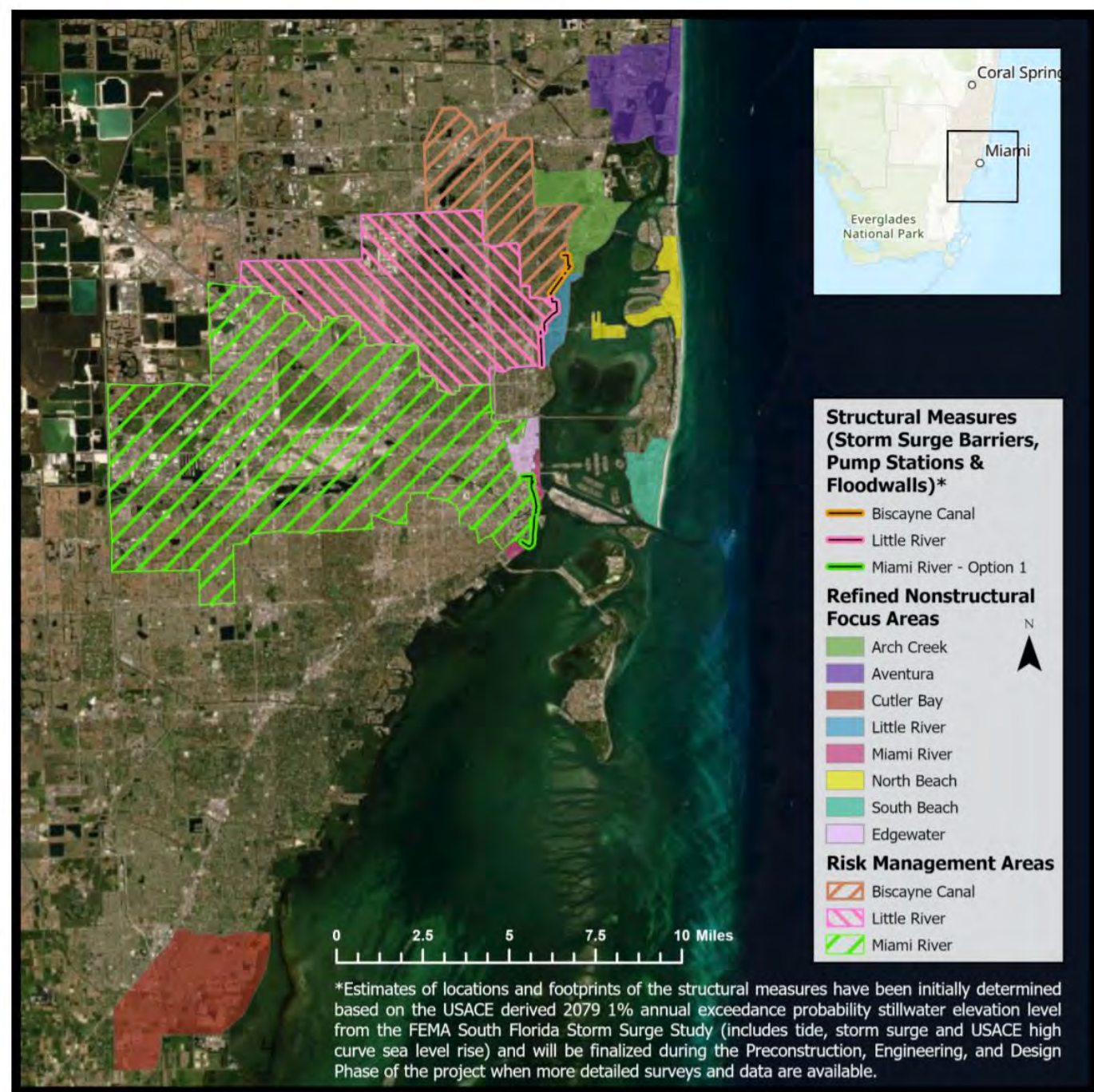
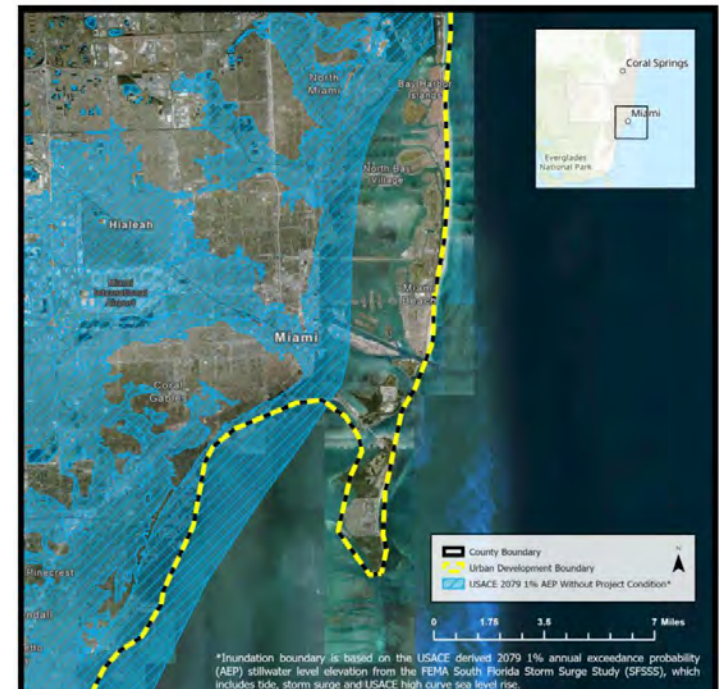


Figure 1. Tentatively Selected Plan

Without Project



With Project

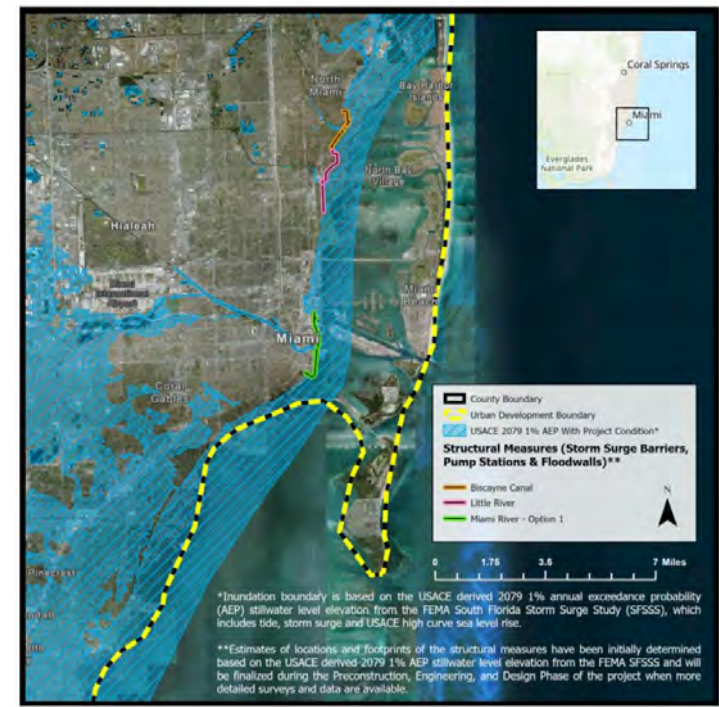


Figure 7-3. Future with Project Condition Inundation Boundary



Current Day



With Project



Alternative



Miami Herald

Miami-Dade said no to coastal wall. Feds agree to look at new hurricane protection options

BY ALEX HARRIS

UPDATED SEPTEMBER 06, 2022 4:19 PM



Media Contact:

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Miami-Dade County Mayor Daniella Levine Cava announces US Army Corps of Engineers extension of Miami-Dade Back Bay Coastal Storm Risk Management (CSRM) Feasibility Study

Secretary of the Army for Civil Works, Mr. Michael Connor, approved Miami-Dade County's request to extend the study.

MIAMI (September 06, 2022) — Mayor Daniella Levine Cava announced an extension for the Miami-Dade Back Bay Coastal Storm Risk Management (CSRM) Feasibility Study after making a formal request to Assistant Secretary Connor and the U.S. Army Corps of Engineers (USACE). The USCAE expressed support for the development and consideration of locally identified alternatives that enhance the natural environment and urban communities, in combination with other measures, to provide a level of risk reduction from storm surge.

“This is a huge win for Miami-Dade County and for resilient local governments across the US,” said Miami-Dade County Mayor Daniella Levine Cava. “With this extension, Miami-Dade can now better solicit community feedback and work to include nature-based solutions into this milestone project.”

In addition, Assistant Secretary Connor also encouraged coordination of the Back Bay Study with other water-related infrastructure projects and studies in the County and the Southeast Florida Region. As planning advances, new and enhanced collaboration will be led by the Coastal Storm Risk Management National Planning Center housed at the USACE North Atlantic Division (NAD). The USACE NAD and Norfolk District will continue managing the Back Bay Study

CLIMATE IMPACTS

FEMA ends policy favoring flood walls over green protections

Thomas Frank, E&E News reporter • Published: Thursday, October 15, 2020



FEMA

Ecosystem Service Benefits in Benefit-Cost
Analysis for FEMA's Mitigation Programs
Policy

FEMA Policy FP-108-024.02

BCA Valuation of Ecosystem Services for NBS

Quantified Benefits of Nature-Based Solutions

Benefit-Cost Analysis (BCA)

- Traditional benefits for the BCA
 - Avoided physical damage
 - Avoided loss-of-function costs
 - Avoided emergency management costs
- Additional benefits for NBS
 - Ecosystem Services

Ecosystem Services Valued in FEMA BCA Tool Kit

Ecosystem Service	Green Open Space (\$8,308/acre/year)	Riparian (\$39,545/acre/year)	Forest (\$554/acre/year)	Wetland (\$6,010/acre/year)	Marine & Estuary (\$1,799/acre/year)
Aesthetic Value	X	X	-	X	X
Air Quality	X	X	-	-	-
Biological Control	X	X	-	-	-
Climate Regulation	X	X	X	X	X
Erosion Control	-	X	-	-	-
Flood Hazard Reduction	-	X	X	-	-
Flood Provisioning	-	X	-	-	-
Habitat	-	X	-	-	X
Nutrient Cycling	-	-	-	X	X
Pollination	X	-	-	-	-
Recreation/Tourism	X	X	-	-	-
Stormwater Retention	X	-	-	-	-
Water Filtration	-	X	-	X	-
Water Supply	-	X	X	X	-

\$8,308/ acre/year)	\$39,545/ acre/year	\$554/acre/ year	\$6,010/ acre/year	\$1,799/ acre/year
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Jose Marti Park Carbon Footprint Analysis

30 Mangroves per 0.01 Hectares

1077 Ft² ≈ 0.01 Hectares

1 Mangrove Tree ≈ 12.3 kg CO₂ Scrubbed



≈ 370 kg/yr.

58 to 283 g of Carbon scrubbed/m² of Spartina Alterniflora per yr.

7612 Ft.² = 707.2 m²



≈ 41 to 200 kg/yr.

1 Acre of Algae scrubs 2.7 tons CO₂ per day

1215 Ft.² = 0.02789 Acres

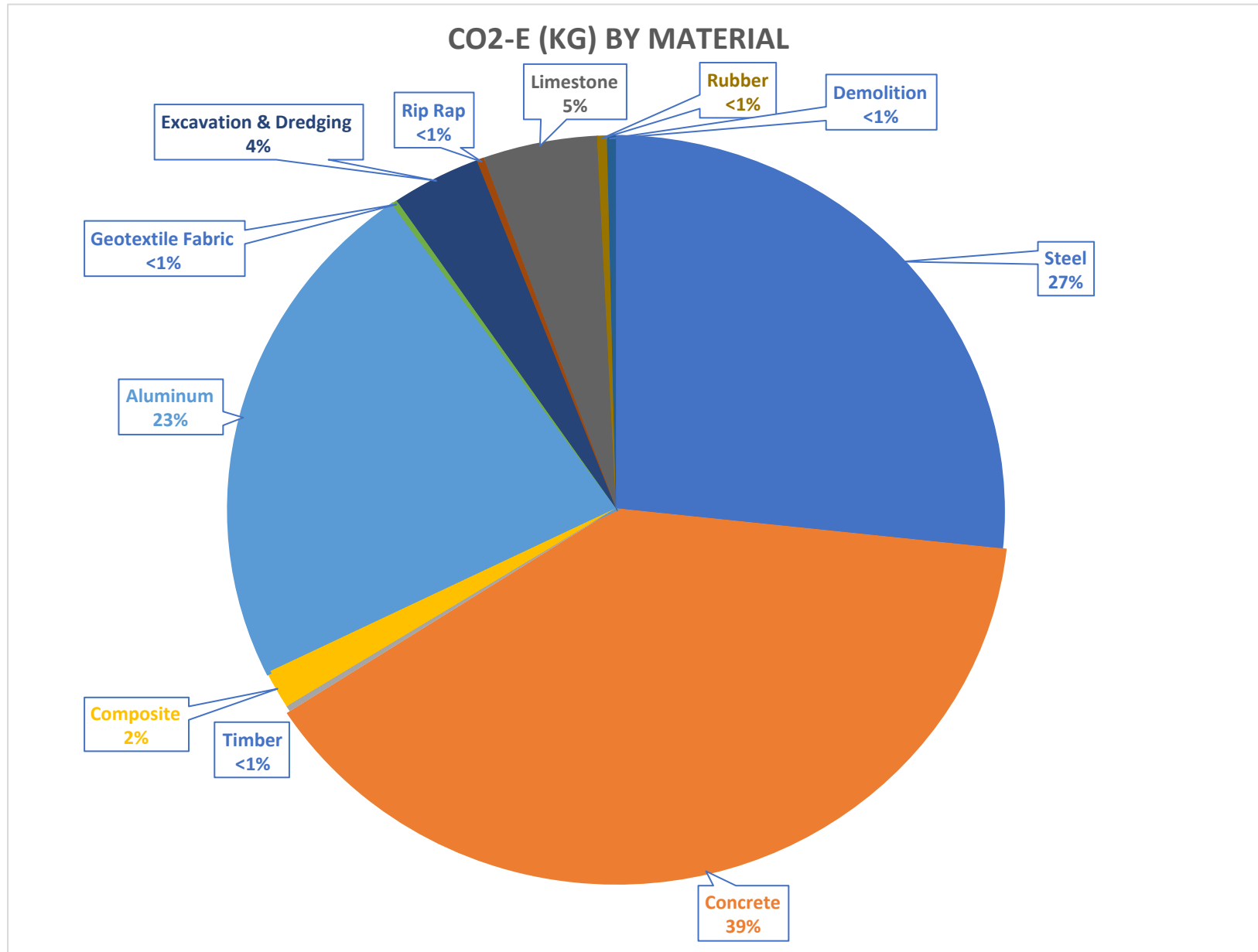


24,820 kg/yr.

= 25,315 kg/yr.

933964 kg / (25,315 kg/yr.) ≈ 37 years

Carbon Emissions by Material (Preliminary)



Florida's Biggest Impediments to Living Shorelines

- Space
- Maintenance burden
- Permitting, Submerged lands, riparian rights
- Public perception
- Lack of knowledge
 - Cost, protection level, design

Need for creative concepts blending engineering and ecology, flexible regulatory scaffolding.





LIVING SHORELINES SUPPORT RESILIENT COMMUNITIES

Living shorelines use plants or other natural elements—sometimes in combination with harder shoreline structures—to stabilize estuarine coasts, bays, and tributaries.



One square mile of salt marsh stores the carbon equivalent of **76,000 gal of gas** annually.



Marshes trap sediments from tidal waters, allowing them to **grow in elevation** as sea level rises.



Living shorelines improve **water quality**, provide fisheries **habitat**, increase **biodiversity**, and promote **recreation**.



Marshes and oyster reefs act as natural **barriers** to waves. **15 ft** of marsh can **absorb 50%** of incoming wave energy.



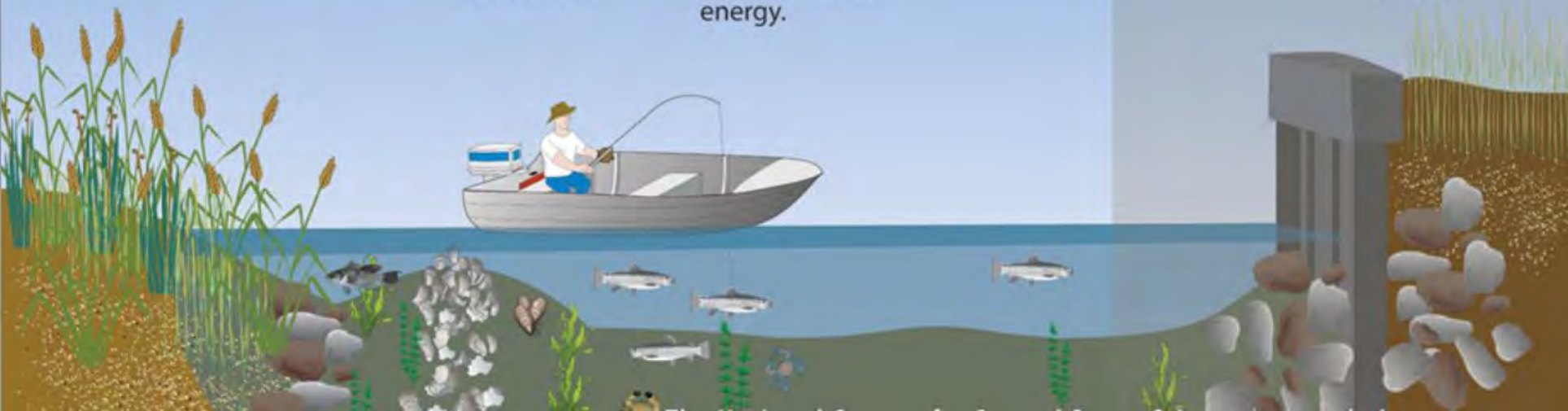
Living shorelines are **more resilient** against storms than bulkheads.



33% of shorelines in the U.S. will be **hardened** by **2100**, decreasing fisheries habitat and biodiversity.



Hard shoreline structures like **bulkheads** prevent natural marsh migration and may create seaward **erosion**.



- Where in FL?
 - Backbay areas
 - Easier on low to moderate energy shoreline
 - Easier on wider waterways
 - Tidal, non-tidal
 - Adjacent to bulkhead or natural shore
 - Urban or rural

Scan for a copy of
this presentation



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Coastal & Marine Engineering

“Be inspired and collaborate!”

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