Regional Planning of Nature-Based Strategies for Coastal Hazard Reduction for Crisfield, MD

CBP Wetlands Workgroup Meeting (09/16/2025)

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Agenda

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- Quick Project Recap
- Modeling Approach
- Candidate Nature-Based Solutions
- Conclusion & Next Steps
- Q&A

Quick Project Recap

NBS Feasibility and Alternatives

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Review Coastal NBS & ID Success Criteria

Reviewed ***>1,000 coastal NBS projects*** yielding ***28 unique NBS*** approaches across ***4 categories***

Study yielded ***"key environmental conditions"*** important to NBS feasibility

Delineate Project Area into Unique Regions

Identified ***16 unique geographical regions*** based on similar soil, land cover, and coastal oceanographic conditions

Evaluate NBS Against Local Environmental Conditions

Determined values for each key environmental condition across unique geographies

Developed algorithmic approach to ***identify suitable NBS for each unique geography***

Recommend Region-Specific NBS

Narrowed focus to critical areas for addressing surge, wave, and water level impacts at Crisfield

Suggested 3 suites of NBS across Janes Island, Cedar Island Marsh complex, and Little Annemessex

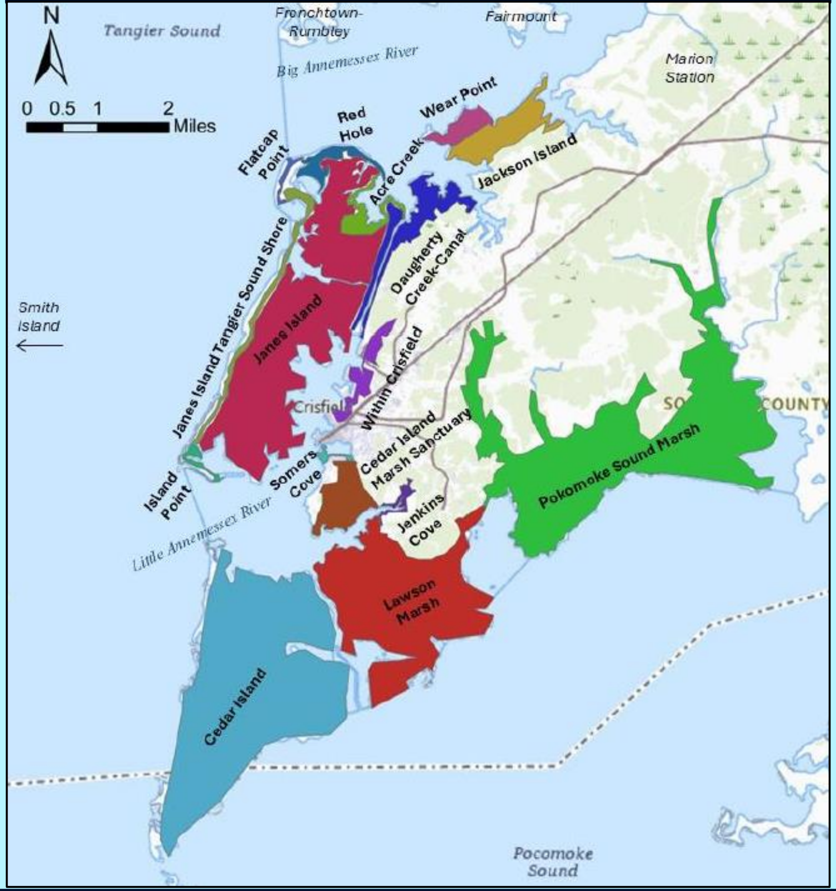
Key Environmental Conditions

Water Depths/SLR	Inundation Projection	Upland Slope/Setbacks	Hard Infrastructure
Fetch	Storm Surge Depths	LULC/Marsh Condition	Habitat Suitability
Wind-Wave Energy	Vessel Impacts	Benthic Substrate	
Erosion Potential			

Broad NBS Categorization

Marsh Restoration	Living Shorelines
Artificial Reefs	Dune Restoration

Geographic Delineation



Integration with Upland Infra.

Proposed Coastal NBS Around Crisfield

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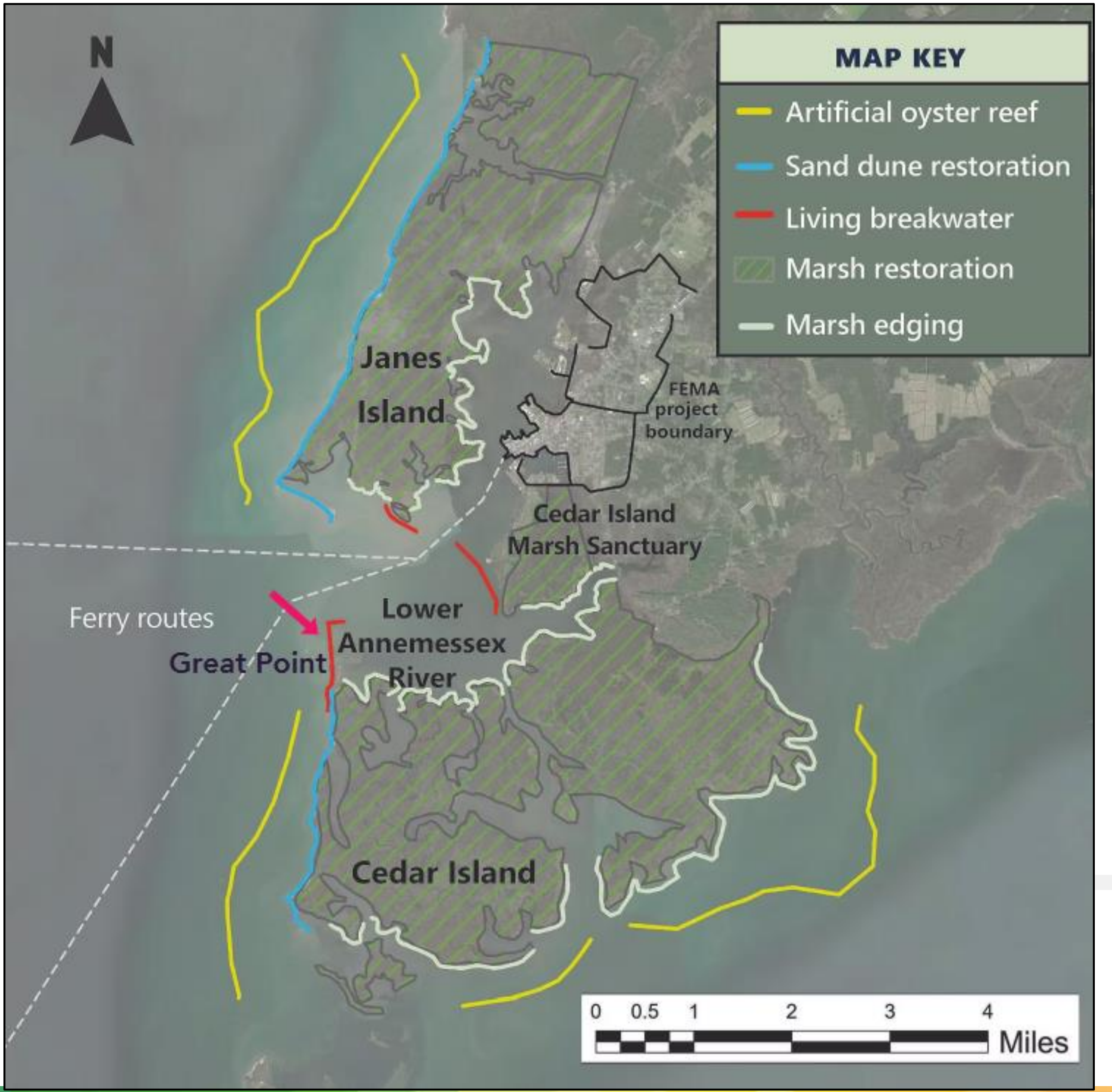
Location	Solution	Notes
Janes and Cedar Island Marsh and Dune Complexes	***Marsh Restoration*** by sediment placement in existing marsh and open water areas; strategic runneling	Existing, degraded marsh system with large open water areas necessitates material placement and runneling for hydrologic connectivity
	Sand Dune Restoration by vegetation planning and stone revetement core	High fetch exposure necessitates dune stabilization; dunes current first line of defense for marsh complex and ultimately Crisfield
	Oyster Reef Creation by reef balls or similar	High erosion rate and moderate wind-wave energy; dissipates energy prior to dune/marsh system
Lower Annemessex	***Living Coastal Breakwaters***	Extreme erosion of sandy cape requires breakwater to protect against longshore drift; primary surge/wave exposure for Crisfield



Modeling Coastal NBS

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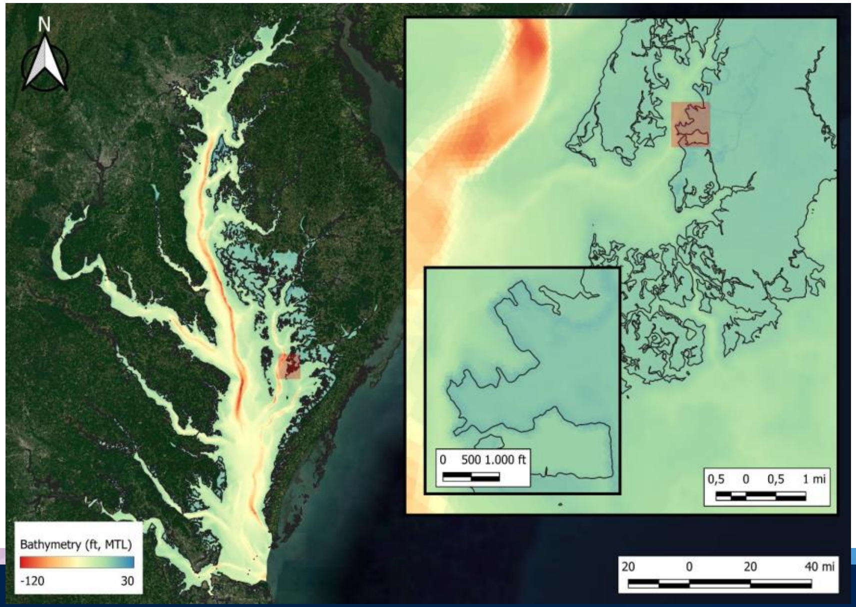
Goal:

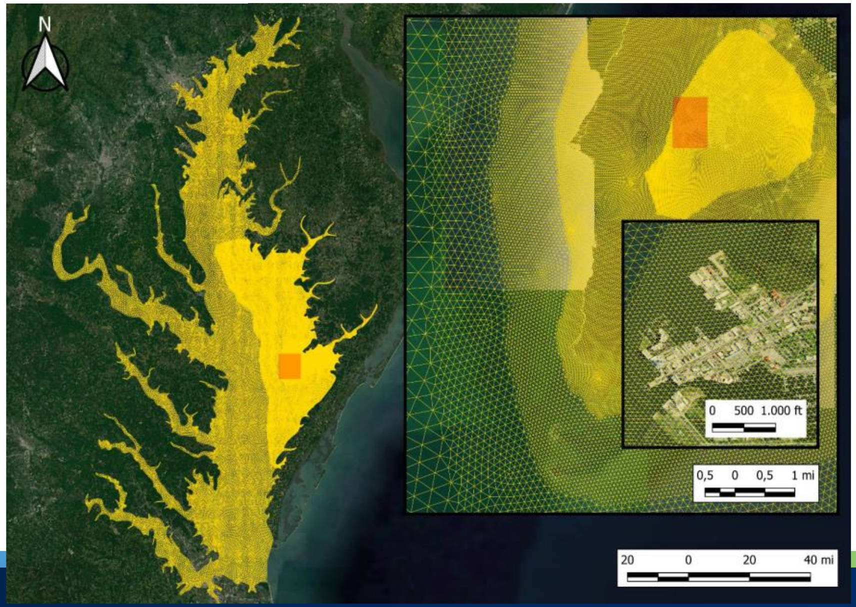
- Evaluate ***NBS effectiveness at attenuating waves and storm surge*** to inform ***NBS prioritization*** and future design projects

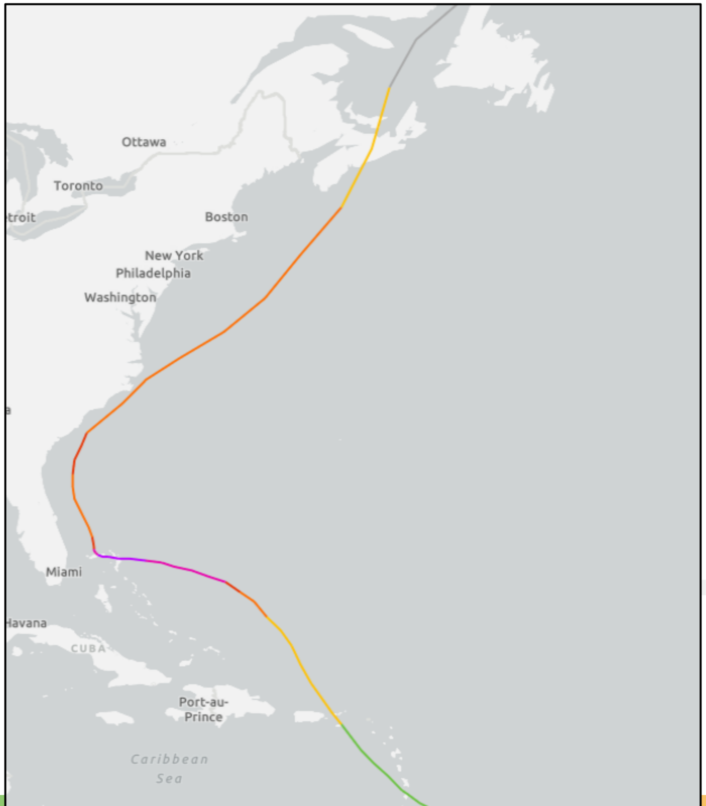
Approach:

- Perform ***Delft-3D flow and wave modeling*** under various NBS configurations, wind fields, climate scenarios, etc

Feature	
Number of triangular elements	254,044
Nodes	129,866
Lower Resolution	2.500 ft
Highest Resolution	150 ft







Hurricane Dorian (2019)

Model Setup, Calibration, Validation

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Domain:

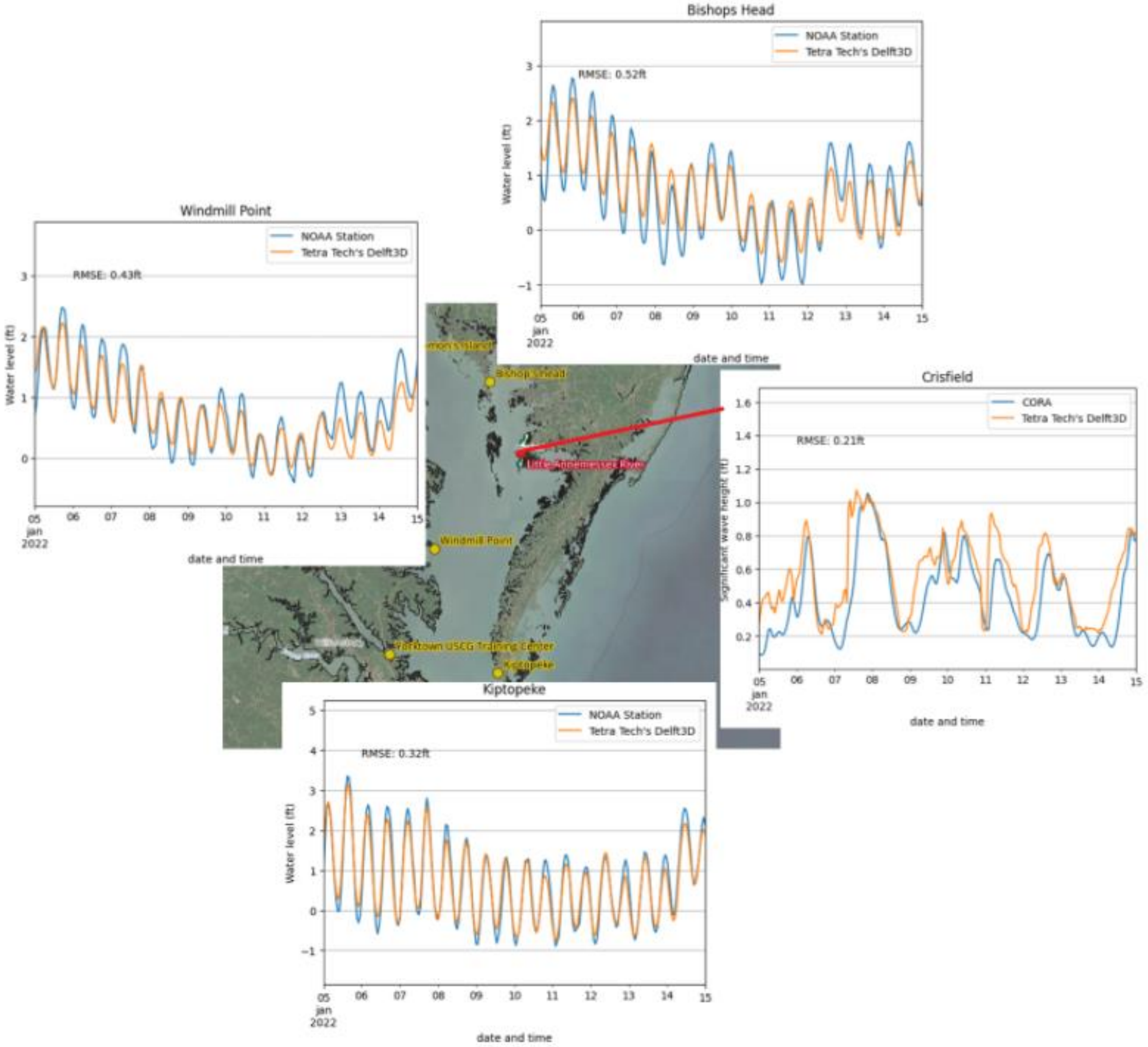
- Full Chesapeake Bay (up to 2,500 ft res.); Crisfield local mesh to 150 ft res.
- Water levels – NOAA gauges and CORA
- Wave heights – NOAA/NDBC buoys

Calibration/Validation:

- Period - 1/5/22 through 1/15/22
- Calibrated to “typical” WLs & Hs, plus Dorian surge
- Primary Tuners - Roughness & wind field parameterizations
- Comparison to Obs – WL (~10% err), Hs (~17% err), accurate tide and peak wave phasing

Overview:

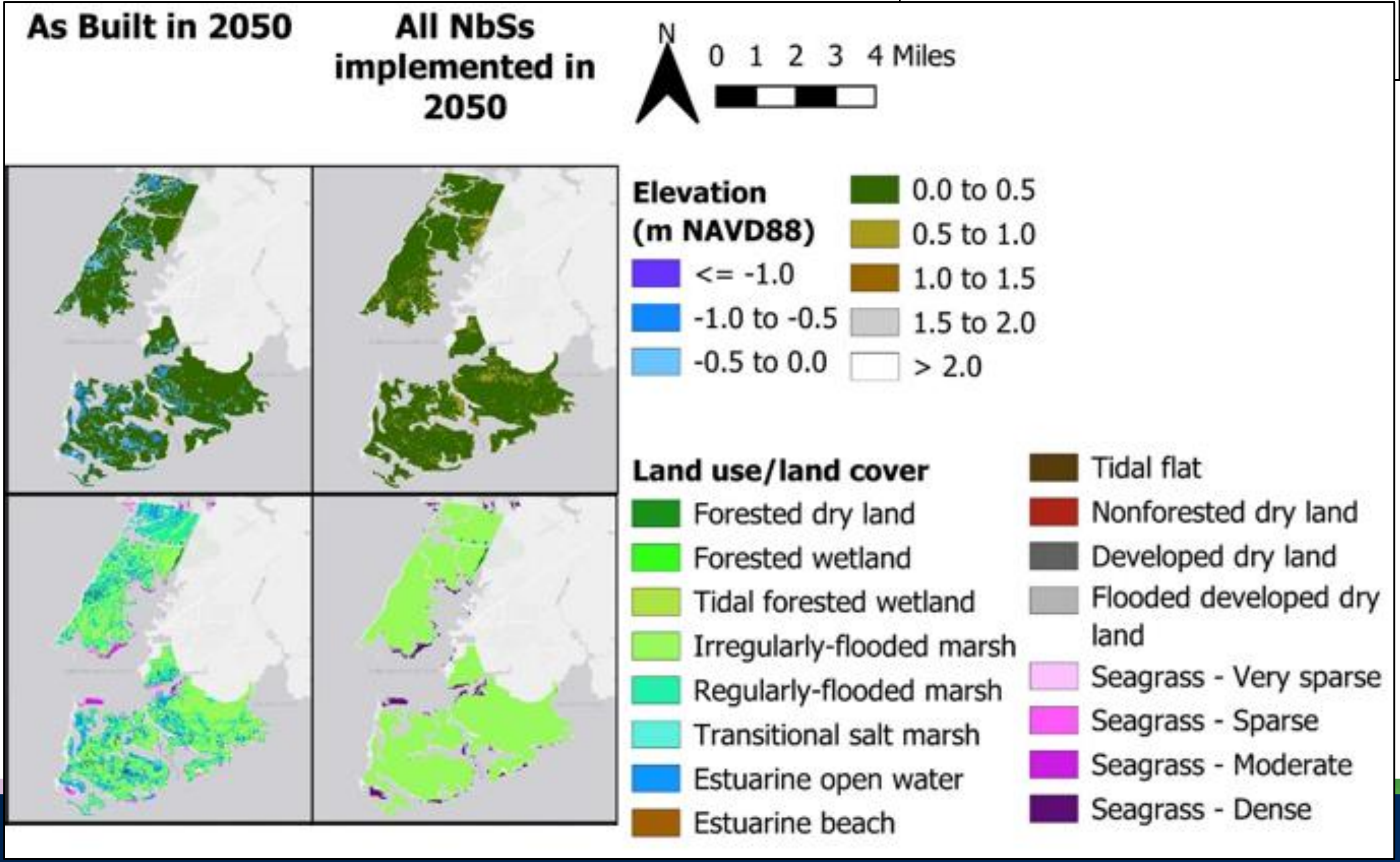
- Good agreement in magnitude and timing builds confidence in water level and wave dynamics under both typical and storm conditions.
- Could be improved with obs data near Crisfield.



NbS Rep. In Domain

Table 3-2. Summary of the NbS feature characteristics.

Nature-based Solution (NbS) feature	Conceptual NbS characteristics	Model representation
Subtidal oyster reef	Total linear feet (lf): Janes Island [approximately (approx..) 29,000 lf], Ceder Island and Lawson Marsh Complexes (approx. 48,000 lf)	Linear representation along 6.6-9.8 ft (2-3 m) contour with constant width, height 0.8-3.3 ft (0.25-1 m) and trapezoidal profile, crest elevation at least 5 ft (1.5 m) below the water surface
Dune restoration	Total linear feet (lf): Janes Island (approx. 30,000 lf), Cedar Island and Lawson Marsh complex (approx. 15,000 lf) Crest Elevation: Approx. 5.7 ft (1.7 m) NAVD88 in 2050	Linear representation with constant width, height approx. 5.7 ft (1.7 m) NAVD88 in 2050
Living breakwaters	Total linear footage: ~12,000 lf Crest height: approx. 5ft (1.5 m) above mean lower low water (MLLW)	Linear representation with constant width, with constant height 5ft (1.5 m) above MLLW to allow for wave overtopping
Marsh restoration	Total marsh acreage: Janes Island [approx. 4,000 acres (ac)], Ceder Island and Lawson Marsh (approx. 6,000 ac)	Maintain primary channel representation; apply elevation changes consistently throughout marsh restoration areas; runneling and marsh edging are not explicitly simulated



Modeling Approach

Batch 1 & 2 Simulations

Batch 1:

- Understanding basic model performance
- Contribution of individual, combination, and regional NbS
- All Dorian, dynamic wind field

Batch 2:

- Simplify and target prevailing wind directions and peak surge
- Adjust linear NbS representation

	#	Type	Year	Scenario
BATCH 01	1	Baseline	2020	No NbS
	2			All NbS
	3	Treatment	2050	No NbS
	4			All NbS
	5	Standalone NbS	2020	Oyster reef only
	6			Dune only
	7			Marsh only
	8			Breakwater only
	9	NbS Combination		All but breakwater
	10			Marsh and dune
	11			Dune and oyster reef
	12	Large Scale Geographies		All NbS – Janes Island only
	13			All NbS – Cedar Island only
BATCH 02	14	Static Wind Field	2020	No NbS - NW wind
	15			No NbS - SW wind
	16			All NbS - NW wind
	17			All NbS - SW wind
	18			No NbS - NW wind / Maximum water level surge (max. surge)
	19			No NbS - SW wind / max. surge
	20			All NbS - NW wind / max. surge
	21			All NbS - SW wind / max. surge
	22	Wider NbS	2020	All NbS
	23		2050	All NbS
	24	Static Wind Field + Wider NbS	2050	No NbS - NW wind / max. surge
	25			All NbS - NW wind / max. surge
	26			No NbS - SW wind / max. surge
	27			All NbS - SW wind / max. surge

Batch 2 Info

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Scenarios:

- Steady, SW or NW winds at 20m/s (~40 kts) – prevailing wind directions, storm wind speeds, Dorian peak surge
- Dorian, SW to NE trajectory
- Parameters of interest – *Wave impact force, significant wave height, shear stress, tidal circulation*

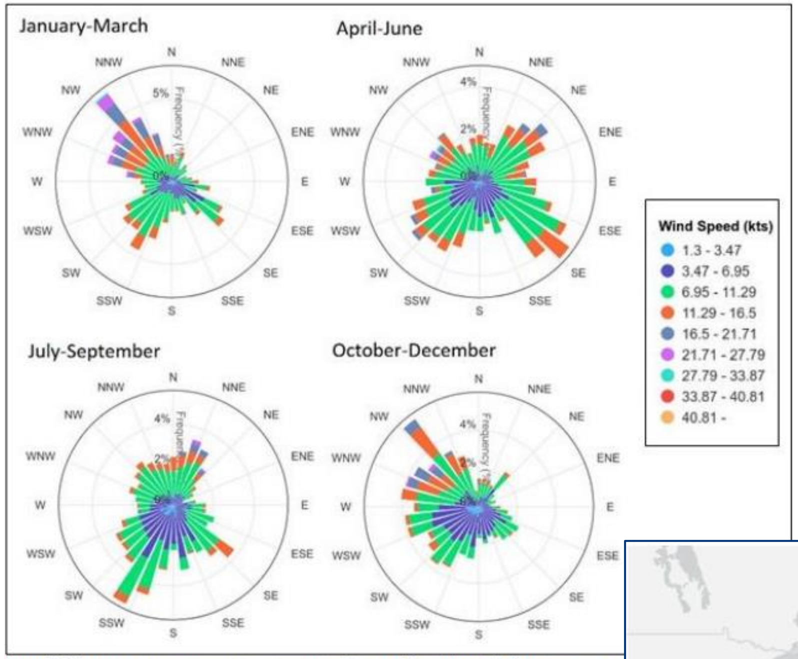
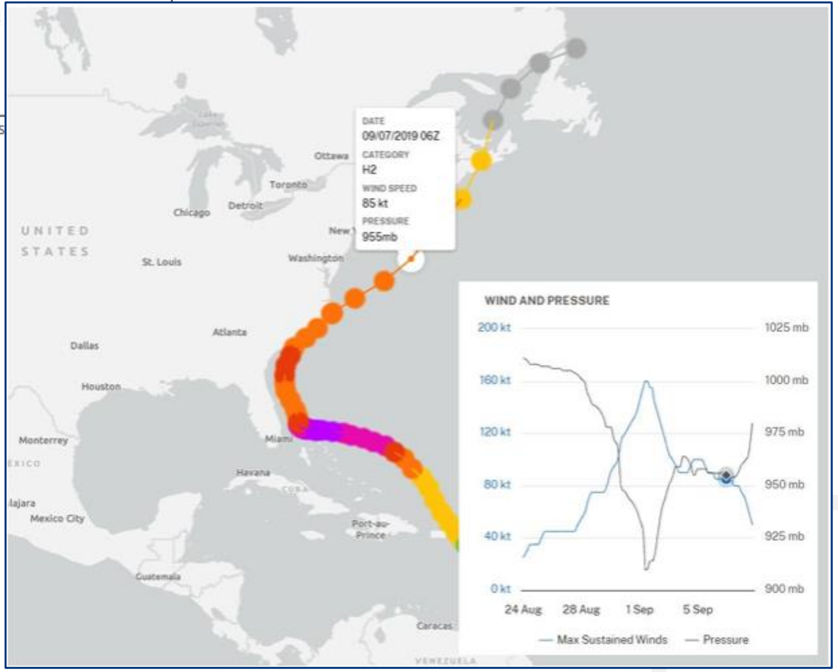


FIGURE D3. SEASONAL HOURLY WIND-ROSE DIAGRAMS FOR PATUXENT RIVER NAVAL AIR STATION WEATHER S
TO CRISFIELD) (SOURCE: MIDWESTERN REGIONAL CLIMATE CENTER 2023).



Candidate NbS

Candidate NbS Ranking Approach

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1. Prioritize based on ***protection*** afforded from coastal hazards
2. Prioritize NbS that are ***adaptive, independent, and additive***
3. Prioritize around estimated ***CapEx, O&M costs, and cobenefits***

NbS Effects - Wave Impact Force at Crisfield

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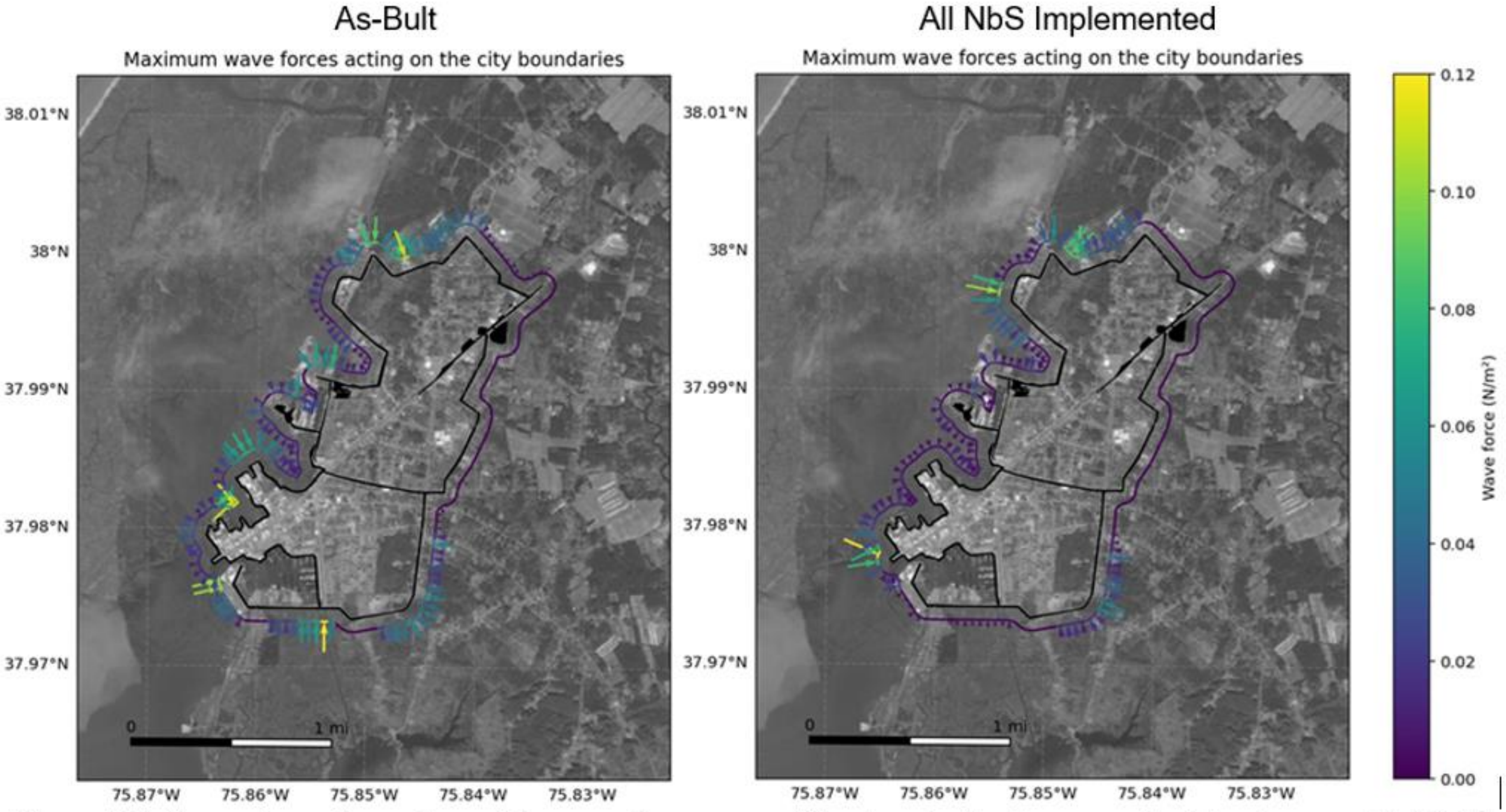

Figure 3-2. Comparison of wave impact forces on the proposed flood protection levees and bulkheads around Crisfield averaged over the course of a Hurricane Dorian-like storm event, were it to occur in 2050.

H_s Attenuation

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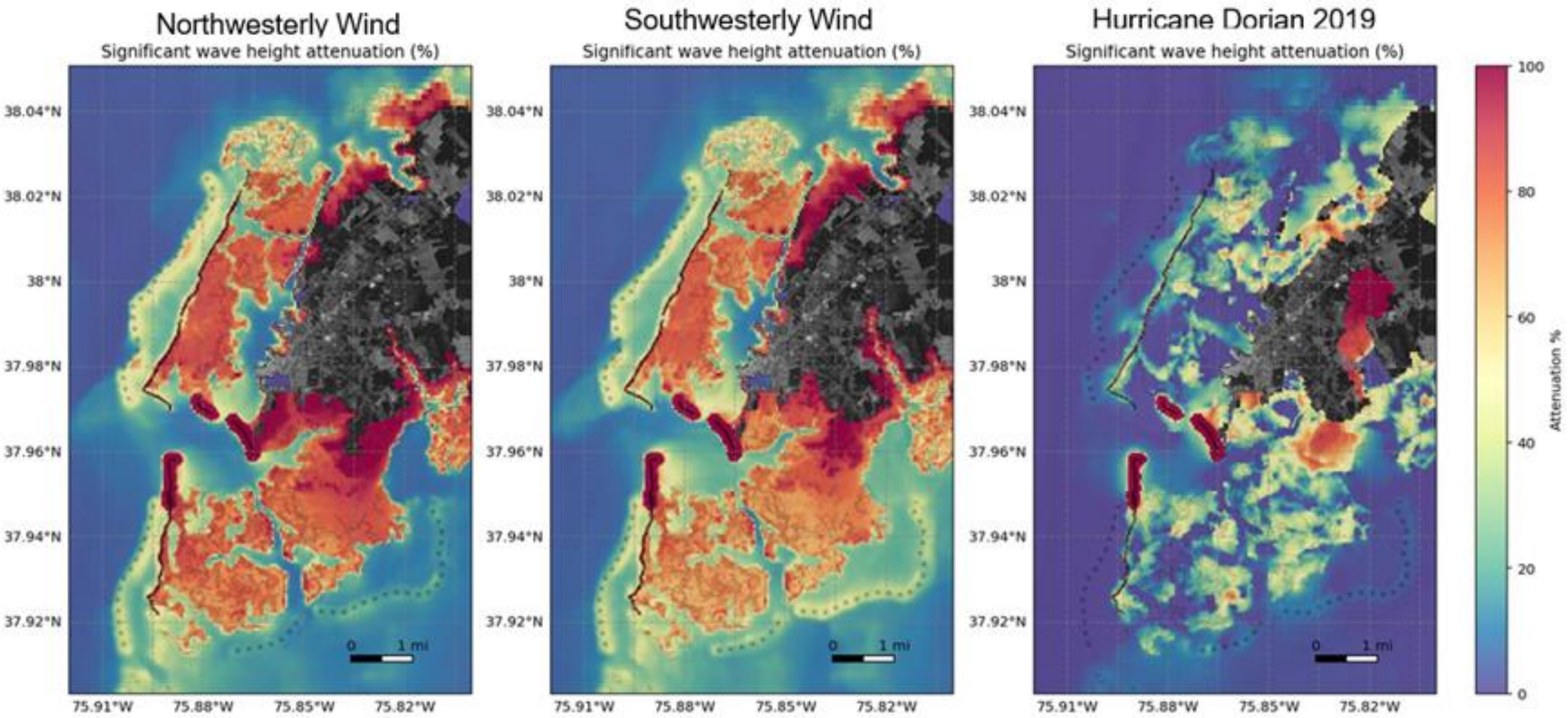
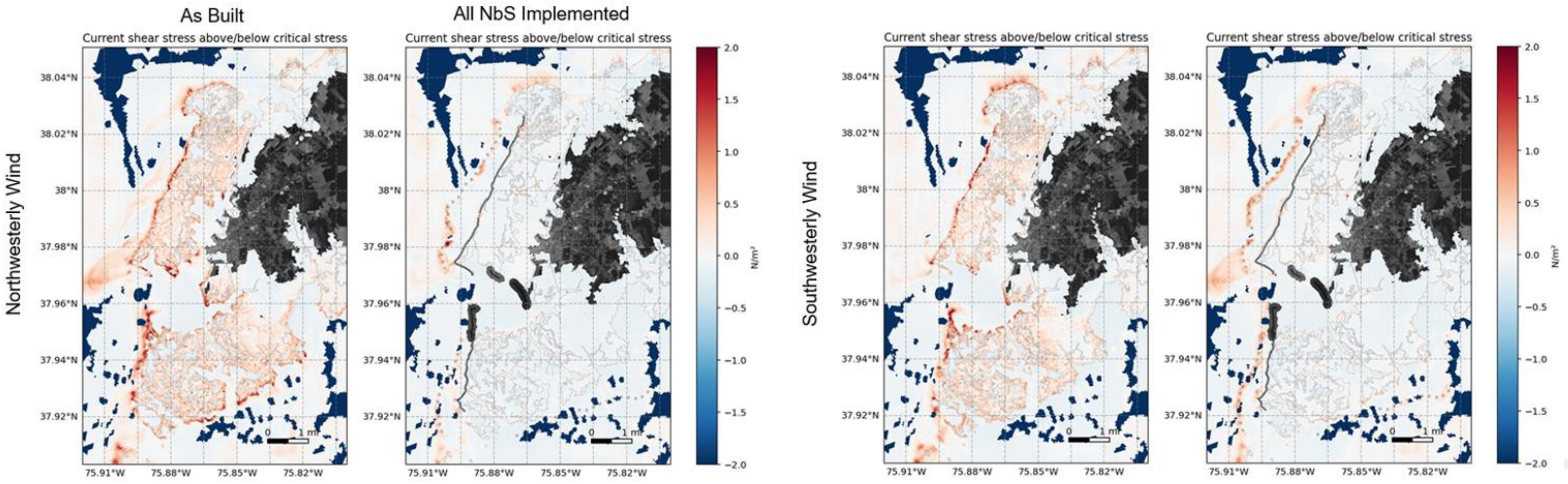


Figure 4-2. Wave height attenuation maps for all NbS implemented in 2050 compared to as built conditions.

Shear Stress Anomoly



Residual and Tidal Circulation

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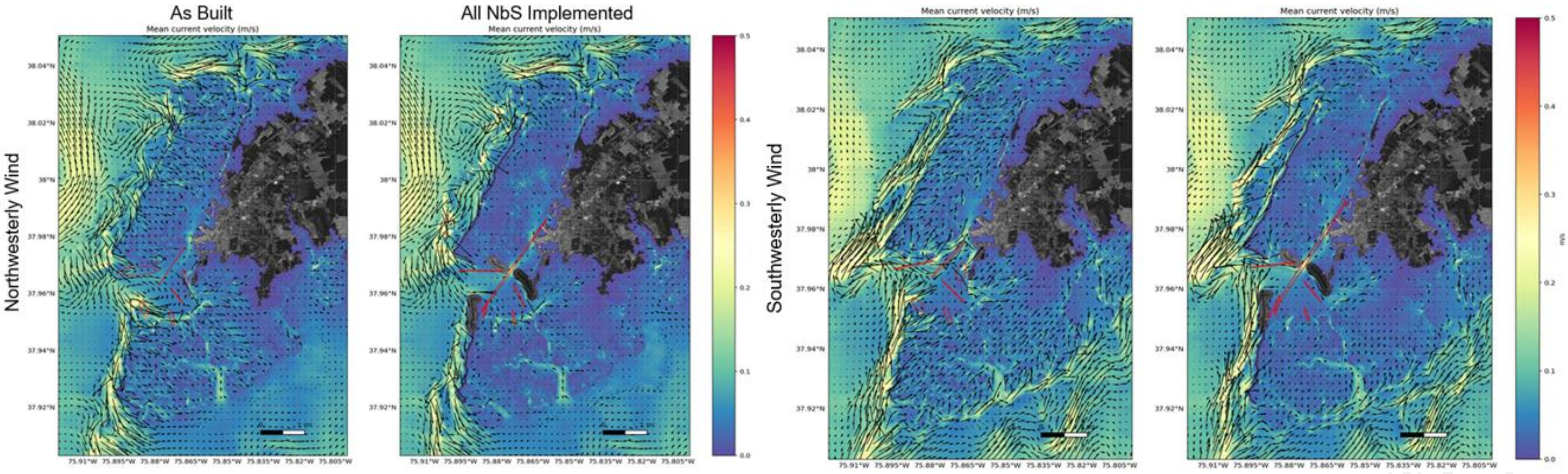

Residual and Tidal Circulation

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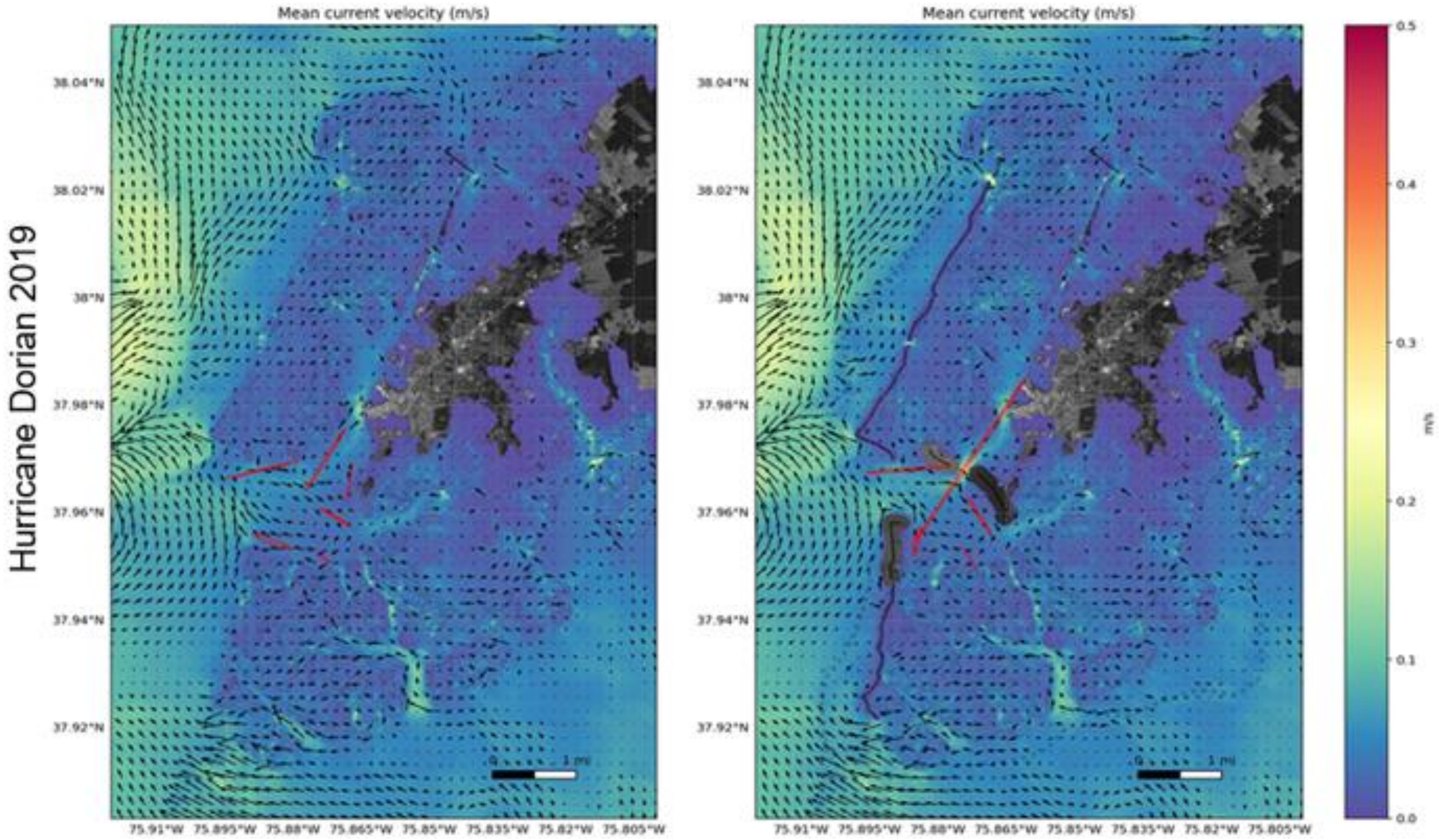

Rough NbS Cost Estimation

Nature-based solution feature	Unit dimension at median cost	Unit cost (low end)[1]	Unit cost (high end)[1]	Estimated Cost Low	Estimate Median Cost	Estimated Cost High	Notes on cost coverage
Oyster reef	***~33,950 square feet (ft^2) [implemented as a series of ten parallel staggered broken lines spaced 3 ft apart]***	$203/lf	$386/lf	$4,208,000.00	**$9,994,000.00**	$15,780,000.00	Ecological baseline assessment, design, permitting, restoration materials (oyster substrate), labor, monitoring, and maintenance
Dune restoration	***~2,855 linear feet (ft)***	$2,000/lf	$5,000/lf	$5,710,000.00	**$9,992,500.00**	$14,275,000.00	Ecological baseline assessment, design, engineering, permitting, materials (e.g. plants), equipment for purchase or lease, and monitoring
Marsh restoration	***~263 acres (ac)***	$16,000/ac	$60,000/ac	$6,891,850.00	**$9,998,275.00**	$13,104,700.00	Ecological baseline assessment, design, engineering, permitting, materials, equipment for purchase or lease, monitoring, labor and maintenance
Living breakwater	Preliminary dimensions and costs of these breakwaters are evaluated in a United States Army Corps of Engineers feasibility study (USACE 2012). The following are the breakwater lengths as modeled: Great Point (~5,700 lf), Interior Breakwaters (~6,700 lf). Costs for breakwaters can greatly **exceed $1,000/lf**.			**Alternative 1, Option B** of the USACE study includes breakwaters at Great Point and Long Point/Cedar Island Marsh Sanctuary for a total cost of **$9.2M.** Due to its age, this estimate is included only for demonstration purposes only. Based on a $2,000/lf cost: Great Point (**~$11.4M**) and Interior Breakwaters (**~$13.4M**)			USACE Cost for Great Point, Long Point, and Cedar Island Marsh Sanctuary Breakwaters[2].

Conclusions & Next Steps

Candidate NbS Prioritization - Scoring

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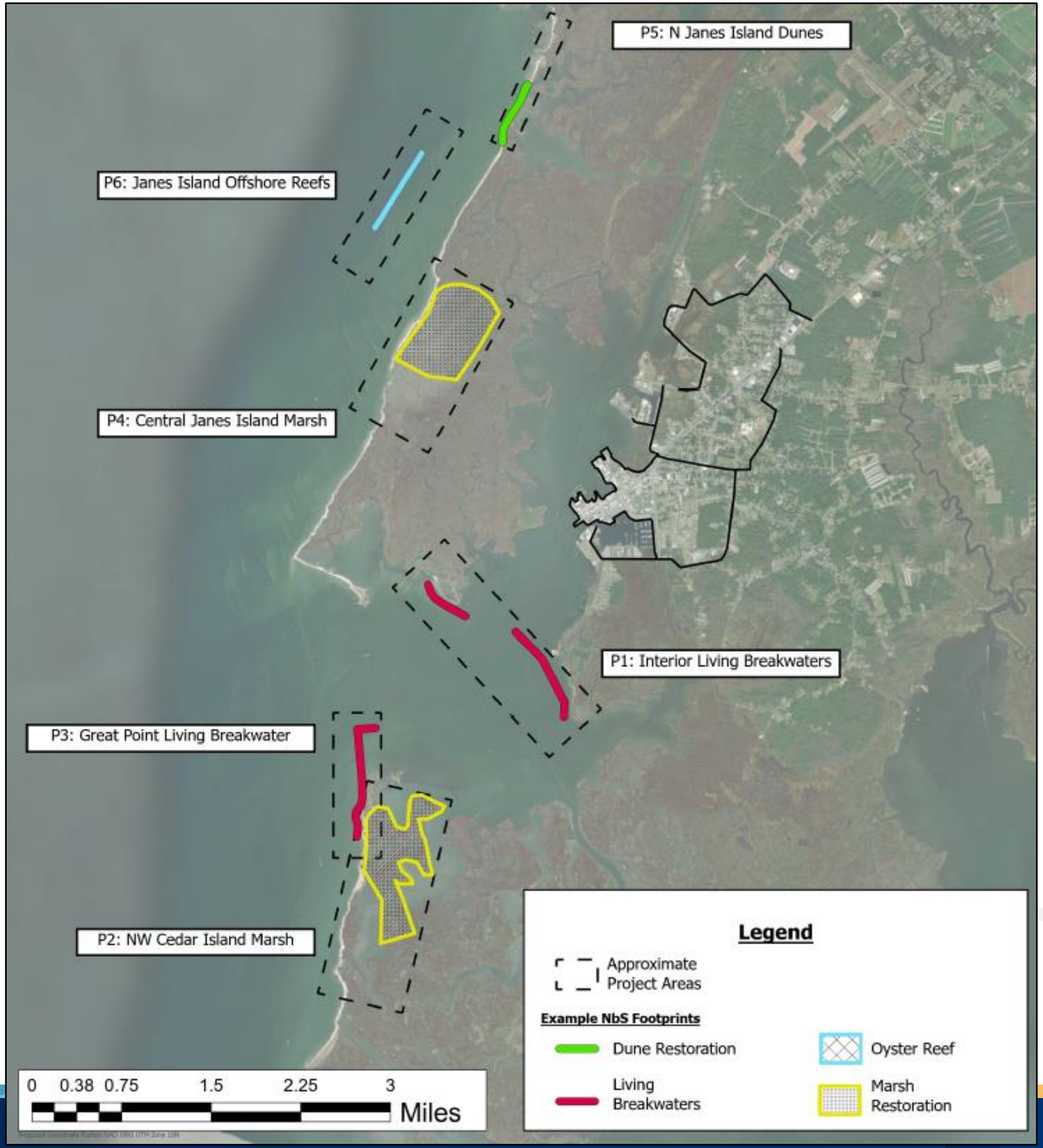
Project Rank & Name	Project Description	Protection for Crisfield prioritization	"Adaptive, Independent, and Additive" prioritization	Benefit-cost prioritization	Total Score	Justification
P1: Interior Living Breakwaters (13)	Long Point and Cedar Island Marsh Sanctuary living breakwaters	5	5	3	13	Offers high protection potential, can be implemented as a standalone project, and provides some co-benefits
P2: NW Cedar Island Marsh (11)	Marsh creation, restoration, runelling, and edging along the Tangier Sound shoreline of Cedar Island	4	3	4	11	Offers high protection potential, can be implemented as a standalone project but would benefit from edge protection, and provides many co-benefits
P3: Great Point Living Breakwater (11)	Living breakwater at Great Point with marsh edging along northern shore of Cedar Island	3	5	3	11	Offers some protection potential, can be implemented as a standalone project, and provides some co-benefits
P4: Central Janes Island Marsh (10)	Marsh creation, restoration, runneling, and edging along Tangier Sound shoreline of central Janes Island	3	3	4	10	Offers some protection potential, can be implemented as a standalone project within an adaptive restoration plan, and provides many co-benefits
P5: N Janes Island Dunes (9)	Dune restoration along Tangier Sound shoreline of north Janes Island near green kayak trail tidal inlet	2	4	3	9	Offers some protection potential, can be implemented as a standalone project within an adaptive restoration plan, and provides some co-benefits
P6: Janes Island Offshore Reefs (8)	Subtidal oyster reefs along Janes Island bayward of green kayak trail tidal inlet	1	2	5	8	Offers minimal protection potential, can be implemented as a standalone project within an adaptive restoration plan, and provides some co-benefits at a reasonable expense

Candidate NbS Prioritization - Map

- Black Dashed Box is general area of interest
- Projects P1-P6 given approximate footprints matching ~$10M cost estimate



Candidate NbS Prioritization: P1 – P3

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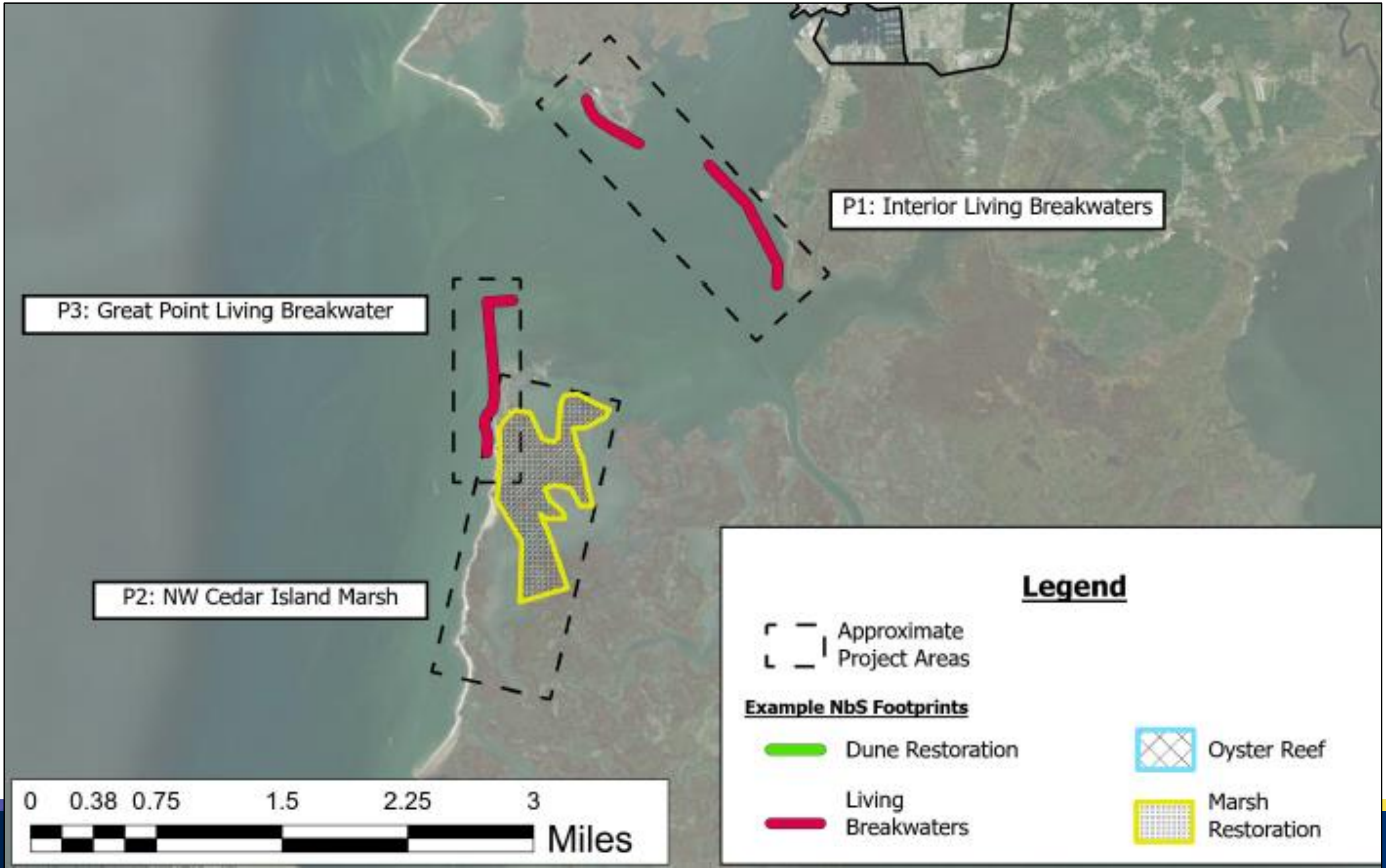

Candidate NbS Prioritizatio: P4 – P6

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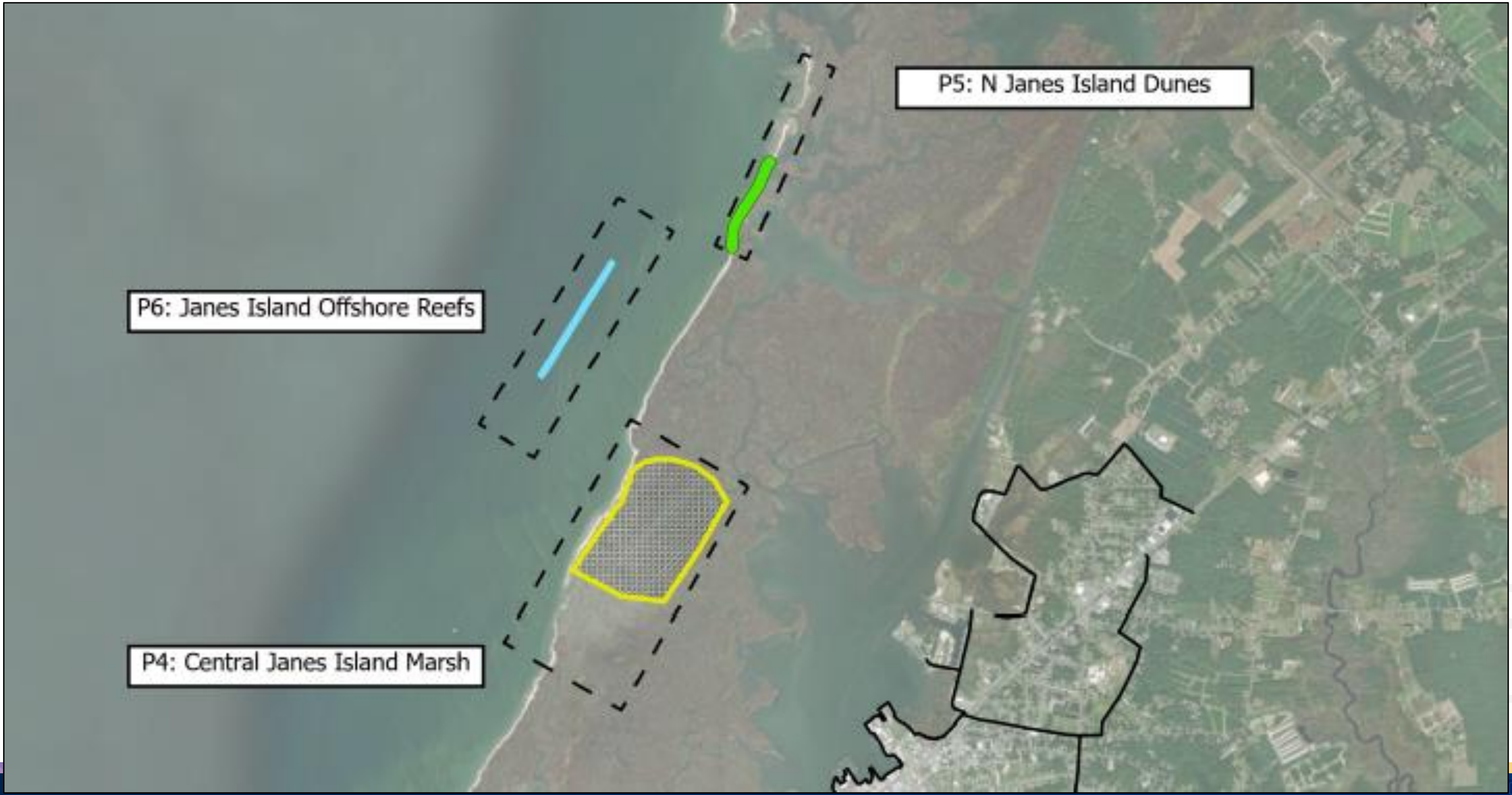

Select Limitations and Next Steps

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Limitations:

- ***Community feedback*** is needed and coming soon!
- Model is a ***2D approximation***, with ***resolution limits***, and ***no explicit representation of sediment transport***/morphologic change.
- Model would benefit from ***local field data*** collection
- Our ***BCA is highly generalized***, further analysis needed!
- Our study focuses on science and engineering; ***access, property rights, material needs, and permit feasability*** must also be evaluated!

Next Steps:

- Modeling: 1) collect ***field data***, 2) explicitely model ***sediment transport***, 3) dev nearshore wave models (i.e. Xbeach) and other ***supporting models*** in support of ***project level feasibility and design***