Advancing Science and Practice at the Seven Mile Island Innovation Lab in New Jersey's Back Bays

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Seven Mile Island Innovation Laboratory

- A Proving Ground Using Natural and Nature-Based Features to Provide Ecological Uplift and Enhanced Resilience for Ecosystems and Coastal Communities
- A Test Bed to Advance and Improve Dredging Techniques and Marsh Restoration and Coastal Feature Creation Techniques in Coastal New Jersey
- Using a Landscape Approach and Adaptive Management to Move From Pilot Projects to Ecosystem Solutions
- Based on an International Concept Pioneered by the Dutch
- 24 sq mi Back Bay Marsh Dominated System with Shallow Bays, Sounds and Tidal Inlets Bisected by the NJ Intracoastal Waterway
- 50+ Member Working Group for Knowledge Sharing
- More than 30 Scientists Working in SMIIL

US Army Corps of Engineers

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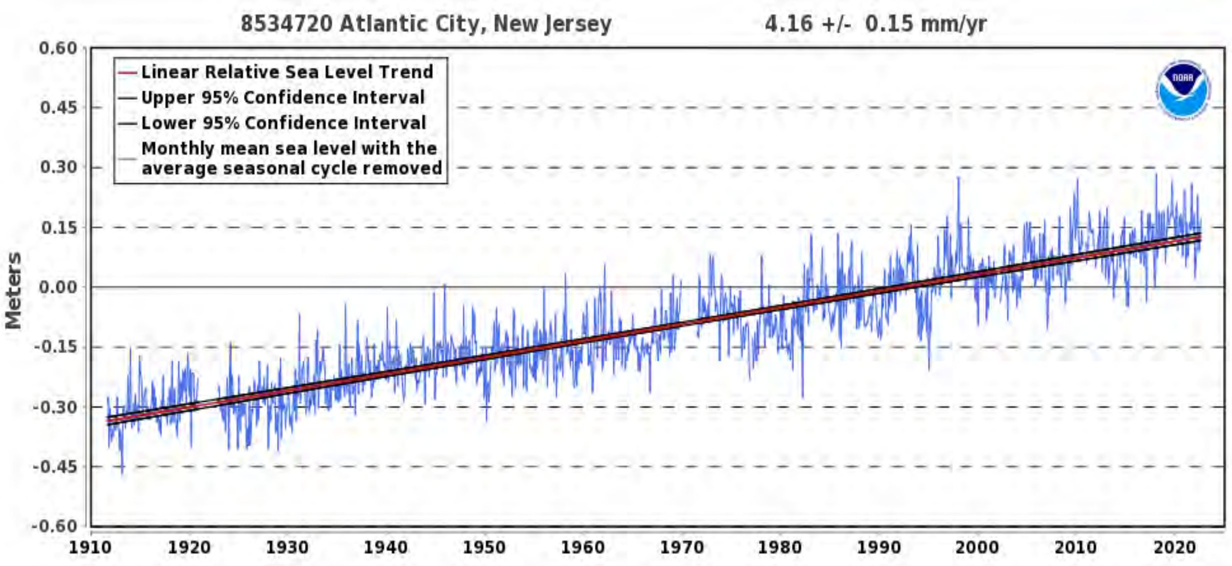
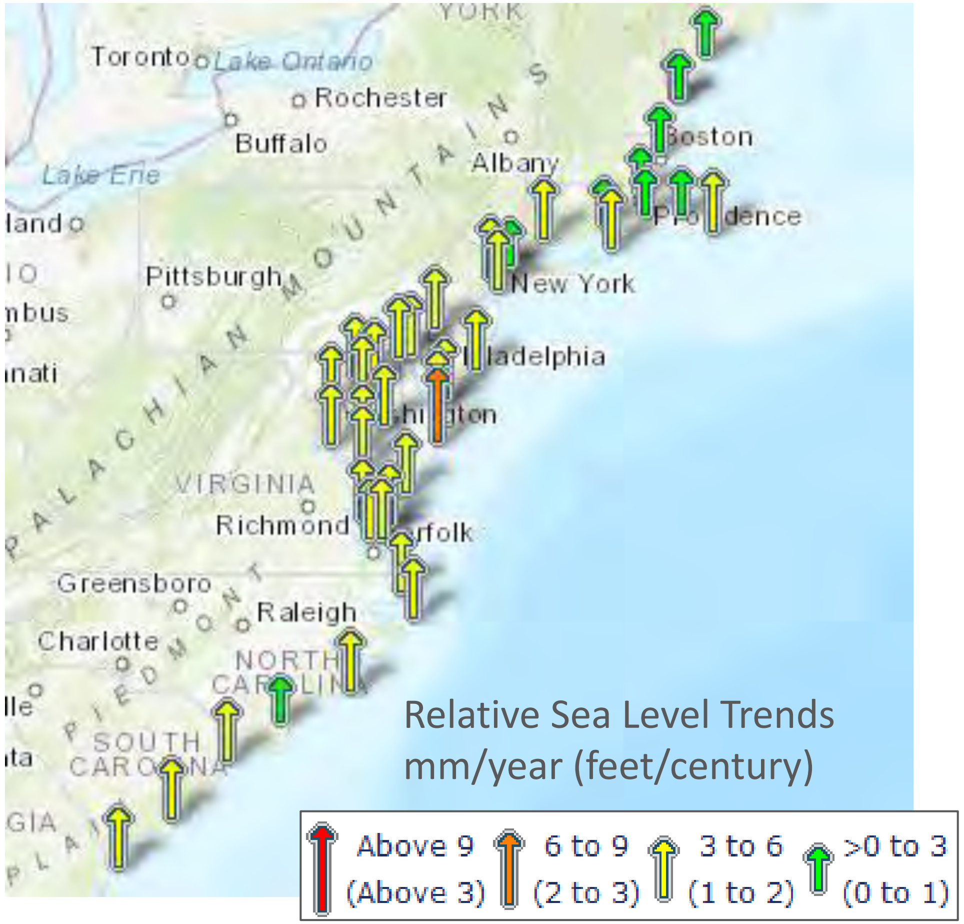
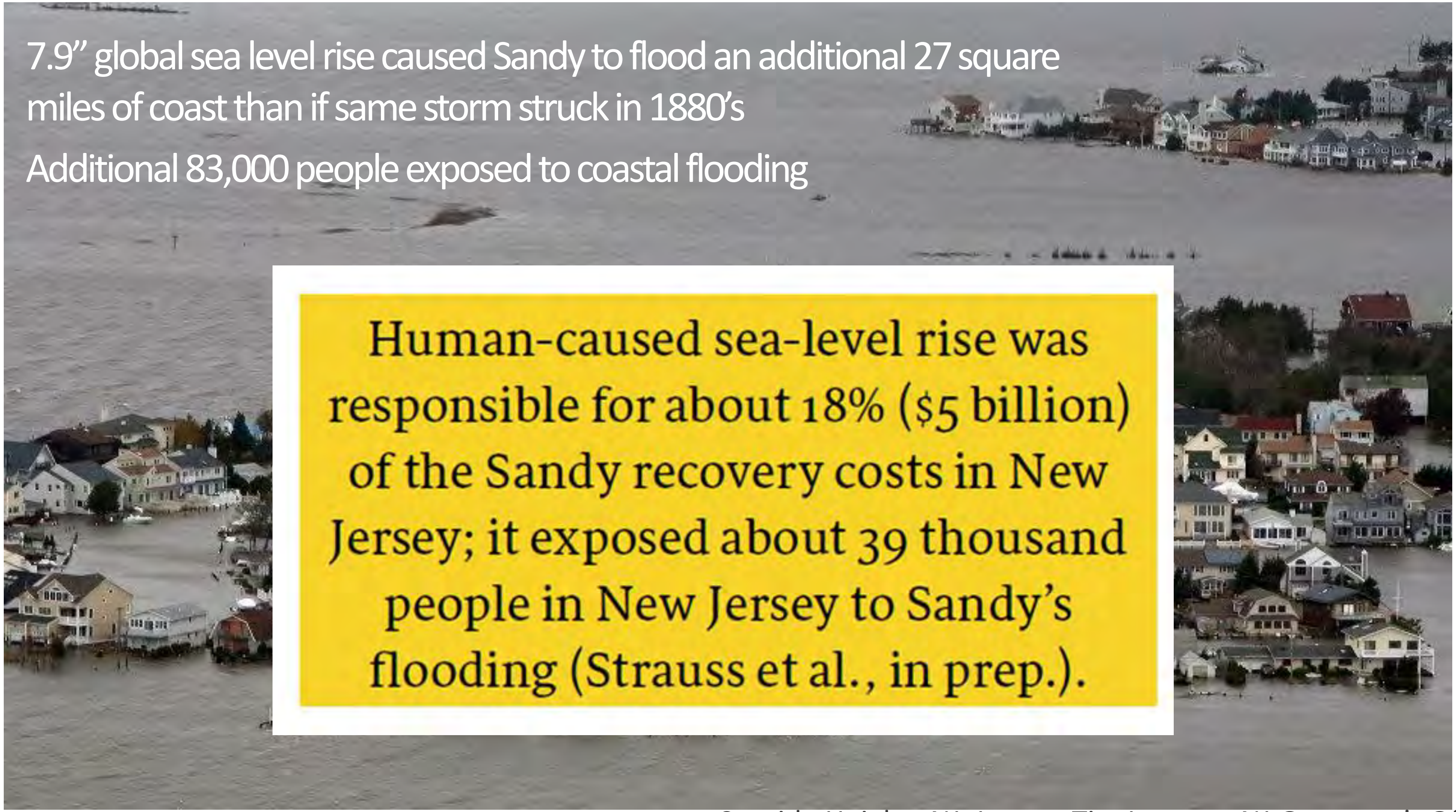
Relative Sea Level Trend





- New Jersey SLR is 2x Global Average
- 1911 – 2021 rose 1.36 feet in 100 years
- Rate has increased from 2010 of 4.04 mm/year to 4.16
- Has risen 4” since 2000
- Typical marsh accretion rates in the area can be 4 mm/year
- Regional subsidence rates are ~2 mm/year

Sea Level Rise Contributed Substantially to Sandy's Impact



Seaside Heights NJ; Image: Tim Lawson, NJ Governor's Office

Evidence of Marsh Drowning

- Conversion to mudflat
- Swiss cheese and expanding panne margins

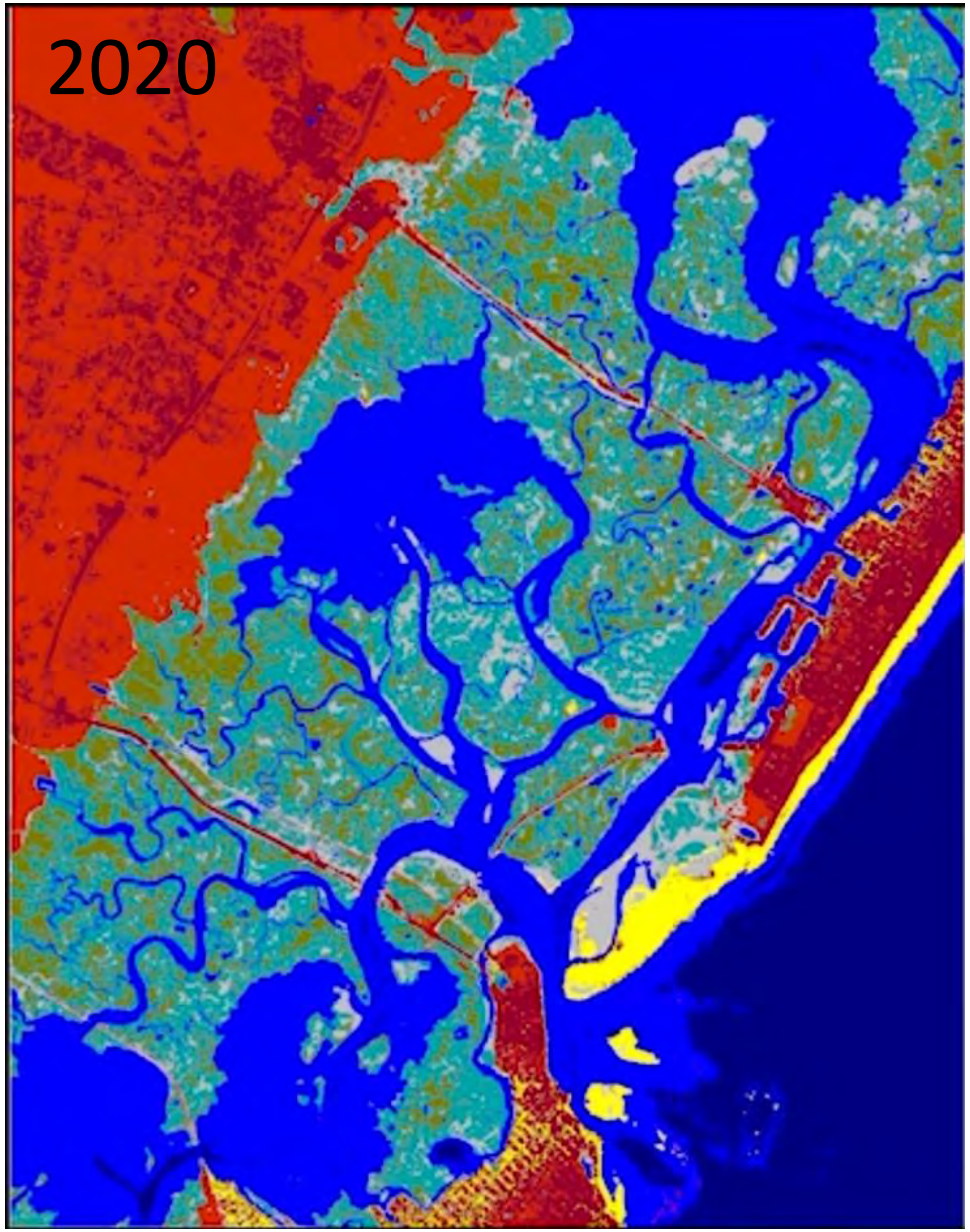
Marsh Edge Erosion Contribution to Wetland Loss

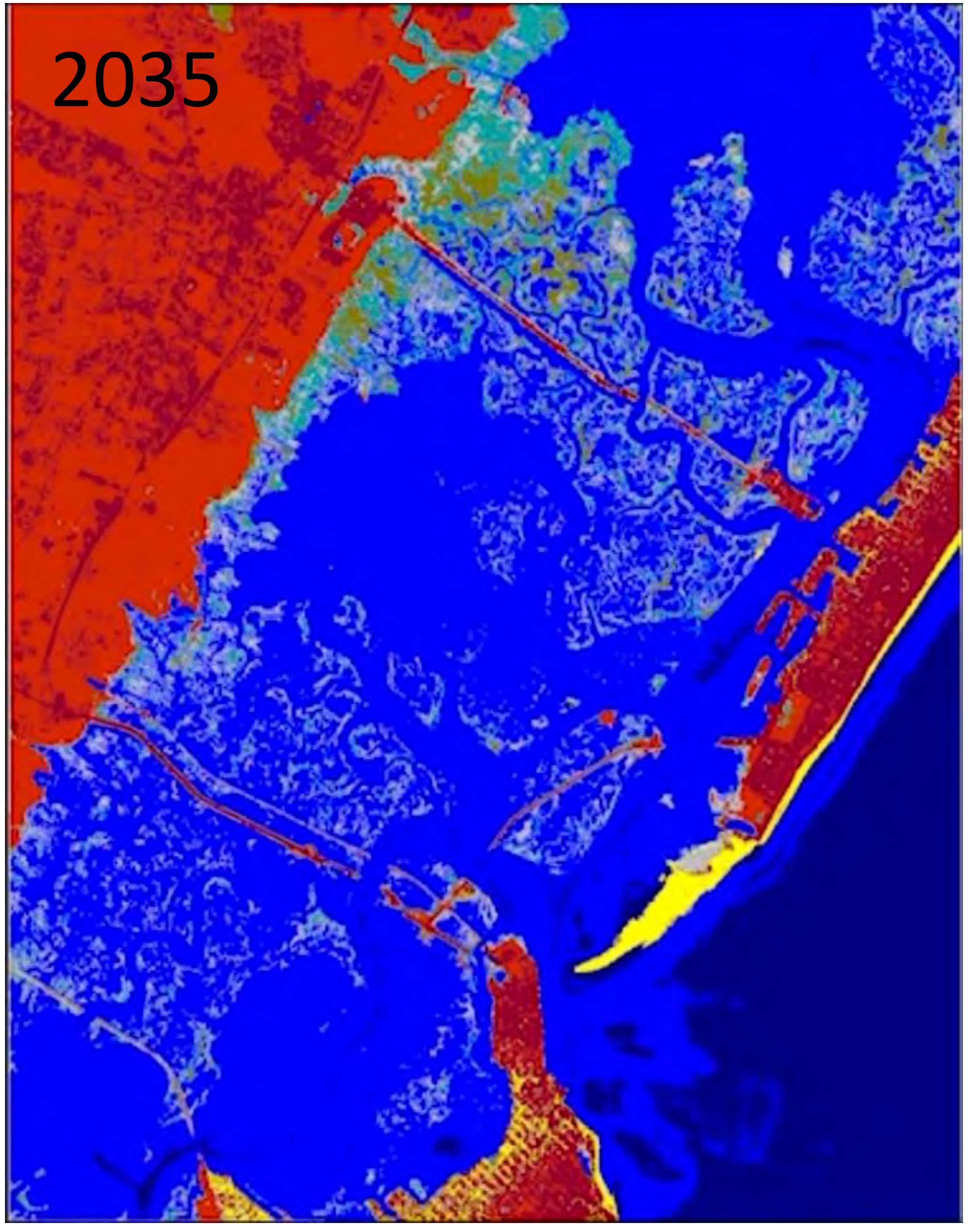
Along open fetch areas from storms

Boat wake induced erosion

Other causes?

USFWS Sea Level Affecting Marshes Model





High Tide Flooding (MHW SLAMM) and Coastal Resilience

Getting BU Projects on Ground

Step 1

Project Impetus & Location Considerations:
- Navigational Dredging Needs of NJ Intracoastal Waterway
- Shoaled Areas and Transport Distance

Step 2

Project Partners
- Project Area Land Owners
- Permitting Agencies
- Ecological Experts
- Navigation Managers and Engineers

Step 3

Project Selection
- Ecological Condition Assessments
- Habitat and Wildlife Needs
- Sediment Suitability, Type and Volumes

Step 4

Project Design, Construction, Monitoring
- Ecological and Construction Goals
- Construction Planning and Implementation
- Permitting and Construction
- Monitoring and Adaptive Management

- SMIIL Projects to Date Are Driven by USACE NJIWW Maintenance Dredging
- SMIIL Goals Include Advancing Dredging Technology and Beneficial Use Innovation

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SMIIL Beneficial Use Projects

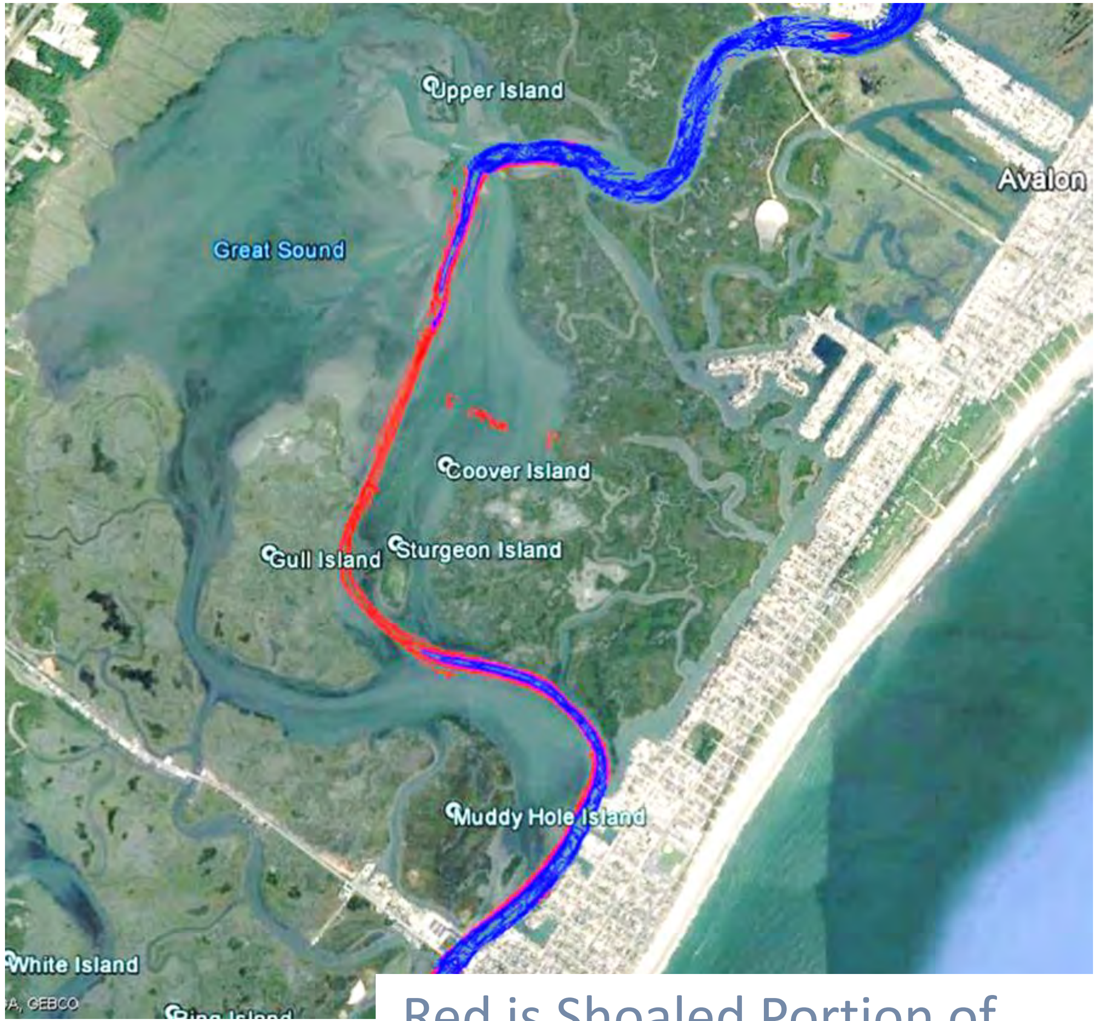
- Marsh Elevation Enhancement/Wading Bird Nesting Habitat
- Sandy Marsh Edge Protection
- Intertidal Shallows and Tidal Delta Enhancement
- Edge Protection and Tidal Flat Enhancement
- Marsh Elevation Enhancement
- Elevated Nesting Habitat

Sediment Type Mixed Fine Sand and Mud
Maintenance Dredging NJIWW
Hydraulic Dredging and Transport

Sediment Type: Fine to Medium Sand
Maintenance Dredging NJIWW
Hydraulic Dredging and Transport

Site Selection

- Key drivers of many BUDM projects:
  - Composition, volume, and location of available material
    - Transport distance is a major limiting factor
- Navigational dredging needs of USACE and state transportation networks are the largest “sediment brokers” nationally.
  - They often need partners and partner sites to complete navigation channel maintenance dredging.
- Marsh condition alone is unlikely to drive site selection.
  - Exceptions may be dredging specifically to source material for marsh restoration



Red is Shoaled Portion of NJIWW (Markers 386-397)

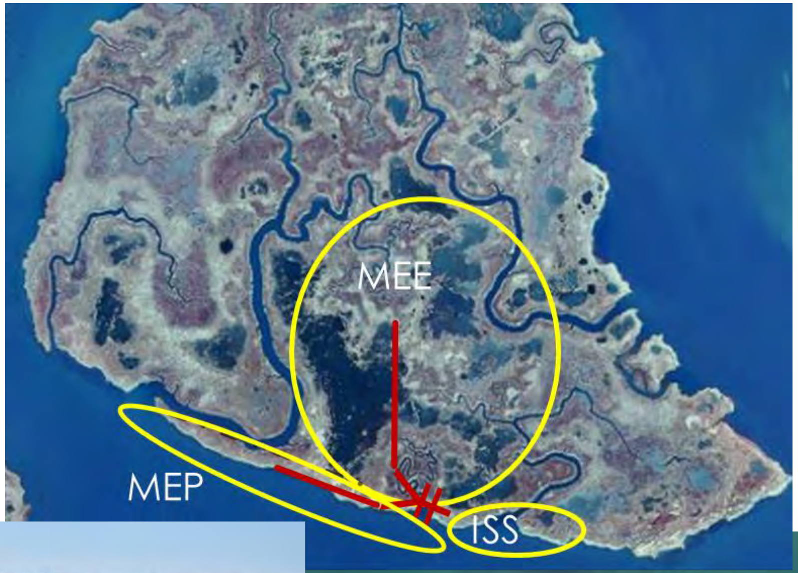
Marrying Site Selection with Dredging

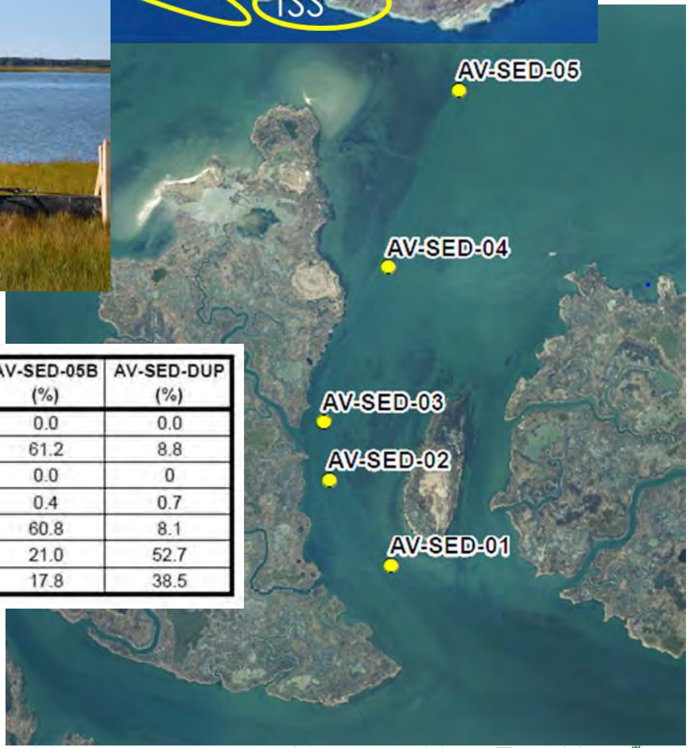
- Once Source Sediments and Dredging Need is Identified Ecological Aspects Take Center Stage
- Marsh Condition Assessments, Habitat and Sensitive Species Status and Concerns Identified, Connections to Community Resilience and Benefits
- Develop Set of Projects to Address Ecosystem and Community Resiliency Needs Utilizing Available Sediment to Address Navigational Dredging Needs

- Sturgeon and Gull Islands are drowning low lying marsh islands
- Historic dredge material placement sites created important wading bird habitat
  - Nesting areas account for nesting for 35% of all colonial wading birds in NJ
- Habitat degrading with elevation loss
- Island drowning destabilizing marshes

Create a System of Solutions

- Raise Elevations of Marsh Platform Across a Gradient of Elevations (MEE)
  - Target Wading Bird Nesting Elevations - Transitional Upland Shrub Habitat (>3.5' NAVD88)
  - Target High Marsh Elevations for Salt Marsh Sparrow (2.7' – 3.1' NAVD88)
  - Target Low Marsh Elevation for Fish Habitat (2.0 – 2.7' NAVD88) and Shorebird and Wader Foraging
- Create Marsh Edge Protection Zone (MEP)
  - More Natural Marsh Edge Slope and Wave Energy Buffer
  - Strategic Placement for Marsh Nourishment
  - Intertidal Shoal to Marsh Edge Elevation (2.0' NAVD88)
- Enhance Intertidal and Subtidal Shallows (ISS)
  - Target Elevations to MLLW Where Macroalgal Flats Transition from Sparse to Densely Vegetated (-1.0 MLLW – 0' MLLW)

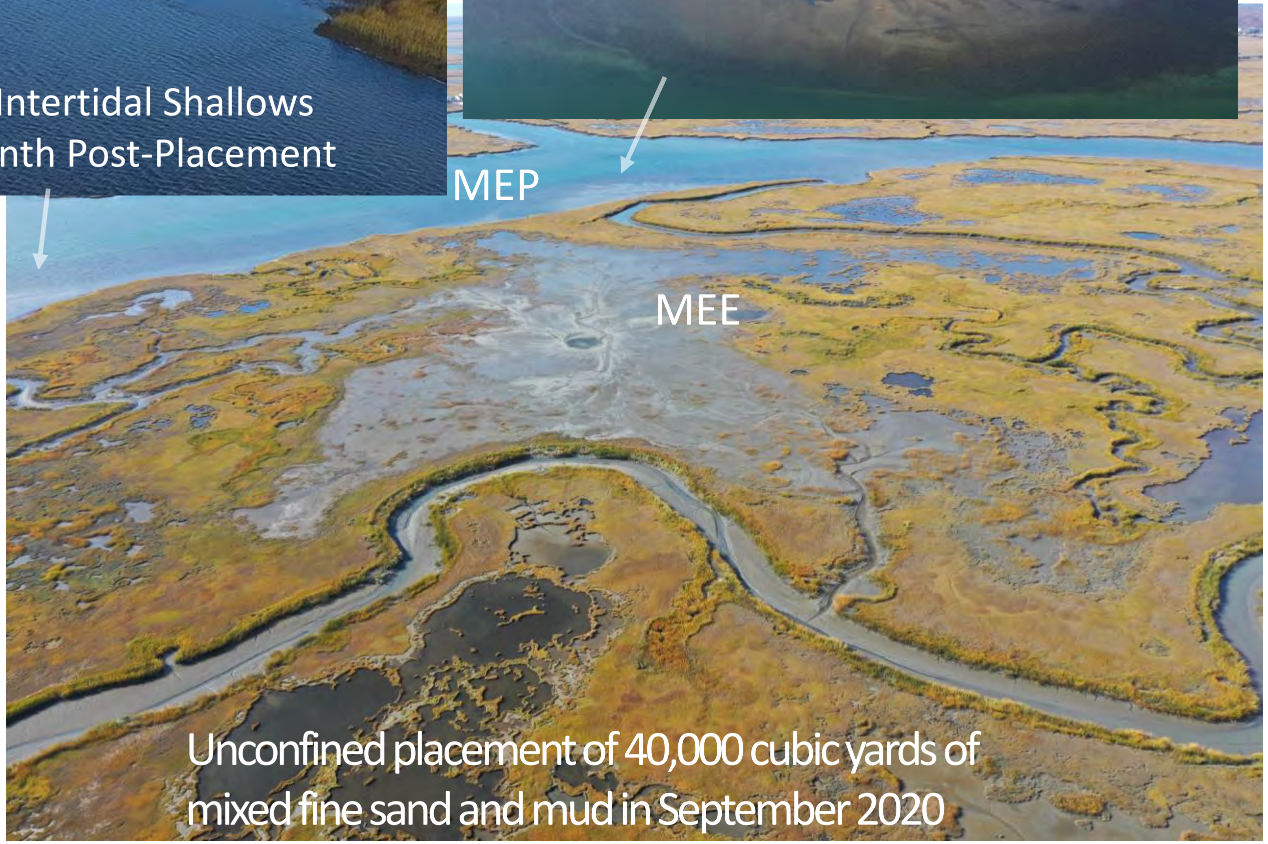




Sample ID Analyte	AV-SED-01 (%)	AV-SED-02/03 (%)	AV-SED-04 (%)	AV-SED-05A (%)	AV-SED-05B (%)	AV-SED-DUP (%)
Gravel	0.0	0.0	0.0	0.0	0.0	0.0
Sand	23.1	9.8	17.9	34.2	61.2	8.8
Coarse Sand	0.0	0.0	0	0.0	0.0	0
Medium Sand	1.2	1.5	1.3	0.5	0.4	0.7
Fine Sand	21.9	8.3	16.6	33.7	60.8	8.1
Silt	53.5	61.1	60.1	49.4	21.0	52.7
Clay	23.4	29.1	22	16.4	17.8	38.5

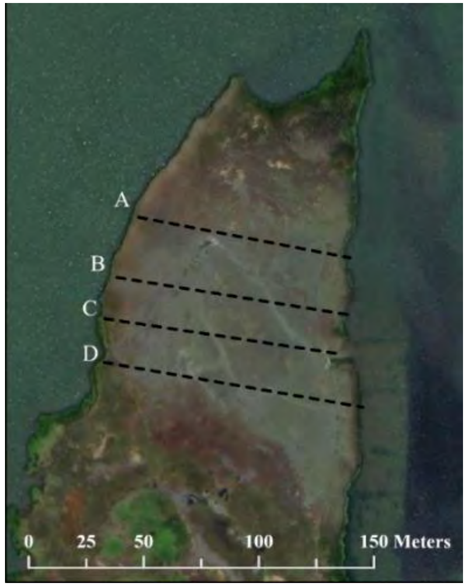
Outcomes Gull Island Projects

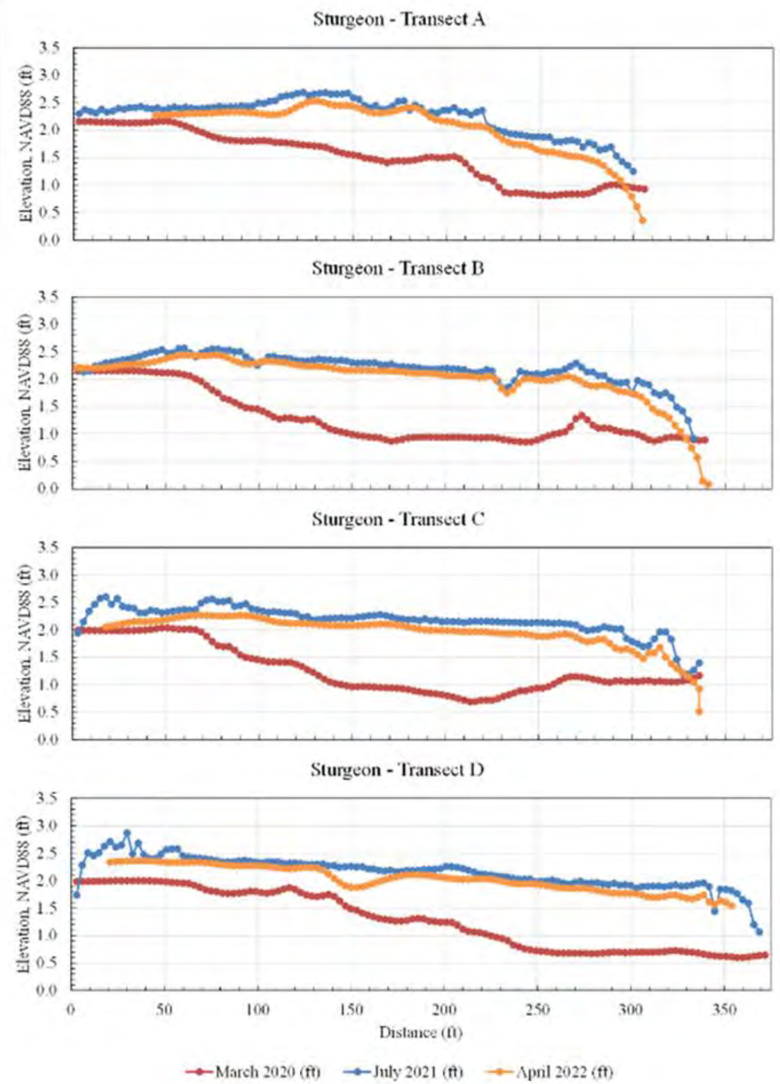
- Marsh Elevation Enhancement (MEE)
  - ~22 acres of elevation lift
  - 3.9' NAVD88 1.8' NAVD88
  - Excellent grass recovery
  - Migratory shorebird and sparrow use
- Marsh Edge Protection (MEP)
  - Built to marsh edge (2.0' NAVD88) down to MLLW
  - Placed ~9000 cy and gained 1 – 2.5' of elevation
  - 50% reduction in volume (~4700 cy) after 16 months and 1-1.5' of elevation gain
  - ~Measured wave height and energy reduction along marsh edge during May Nor'easter (Perkey et al.)
- Enhanced Intertidal Shallows (ISS)
  - Placed ~8700 cy and gained 1-2.5' of elevation gain and shallowed up to MLLW
  - Reduced to ~4100 cy after 16 months and 1-1.5' of elevation gain so ~50% reduction in volume
- Documented very low turbidity during and following placement on par with storm generated turbidity and in close proximity to placement (Fall et al., 2022)



Sturgeon Island Placements

- Placed in Two Phases in 2020
  - March 2020
    - 4,200 cubic yards
  - September 2020
    - 15,000 cubic yards
  - Mixed fine sand and mud
- Marsh Elevation Enhancement (MEE)
  - 3.5 acres of enhancement
  - 3.0’ NAVD88 grading down to 1.9’
- Marsh Edge Protection (MEP)
  - Placed small sand ridge along toe of erosional slope
- Enhanced Intertidal Shallows (ISS)
  - Shallowed above MLLW along eastern island to extend flats northward
- Returned in Fall 2022 for Phase 3





- 2020 unconfined placement achieved 1.5 – 2.5' of marsh elevation enhancement
- Vegetation recolonization is rapidly occurring naturally via seed bank in year 2

Courtesy of Harris et al.

Sturgeon Island Phase 3 – Fall 2022

- Placed 24,000 CY of fine sand to create sandy marsh edge protection features
  - Intercepting wave energy
- Used containment to elevate 0.4 acre for elevated bird nesting habitat
  - Placed more than 3' of material
  - Built to 4.0' NAVD88
- Employed Y-valve to switch between containment and subtidal features
  - Maintain dredging efficiency
  - Allow time for contained area to dewater
  - Slow and manage flow volumes and velocities

Nesting Habitat Clusters: Mimicking Nature and Managing Navigational Needs

Dredging Need

- Sandy Shoaled Portion of NJIWW
- Repetitive Availability of 4,000 – 7,000 CY
  96% Fine to Medium Sand
- 3 Year Return Cycle for Shoal Clearing

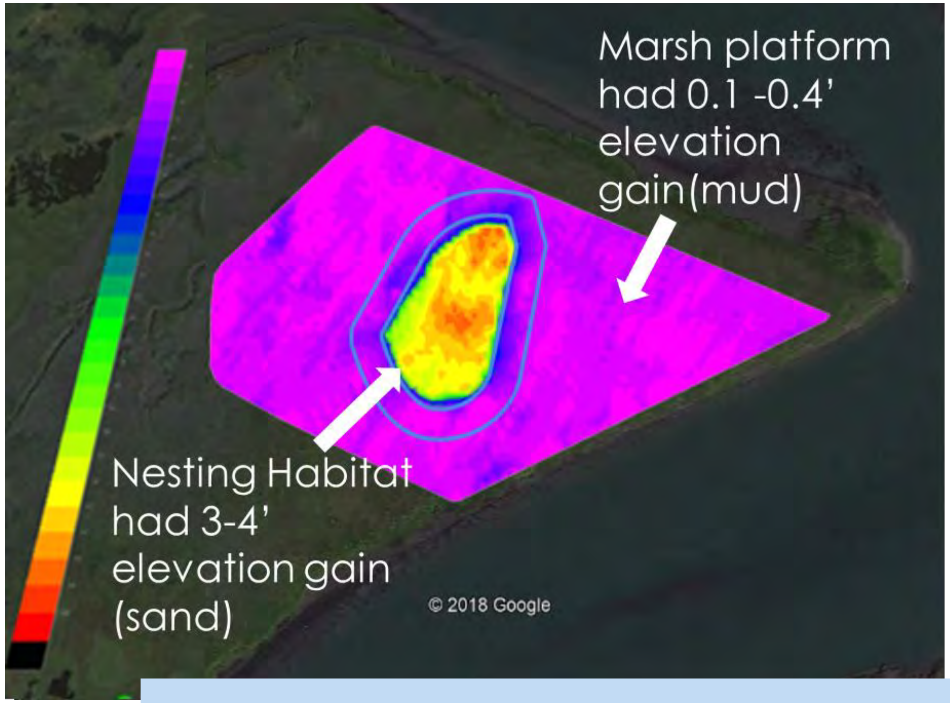
Ecologic Need and Solutions

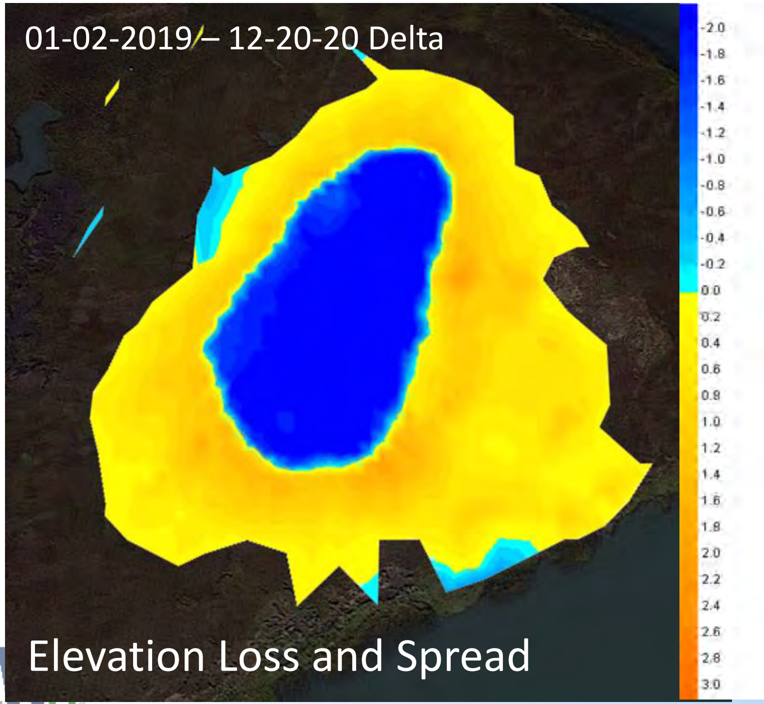
- Declining and Stressed Populations of Beach-Nesting Species
- Create Network of Nesting Sites at Different Stages of Succession
- Separate Populations for Resilience
- Dredging Return Frequency as Adaptive Management Tool
- Ecological Value During Site Evolution Trajectory

Dredging Value

- Provides for Repetitive Placement Cyc
- Matches Ecological Goals with Dredg Goals
- Minimizes Permitting and Reduces Cos

2018 Placement





Elevation Loss and Spread

2021 Placement

Construction then Repetitive Adaptive Management

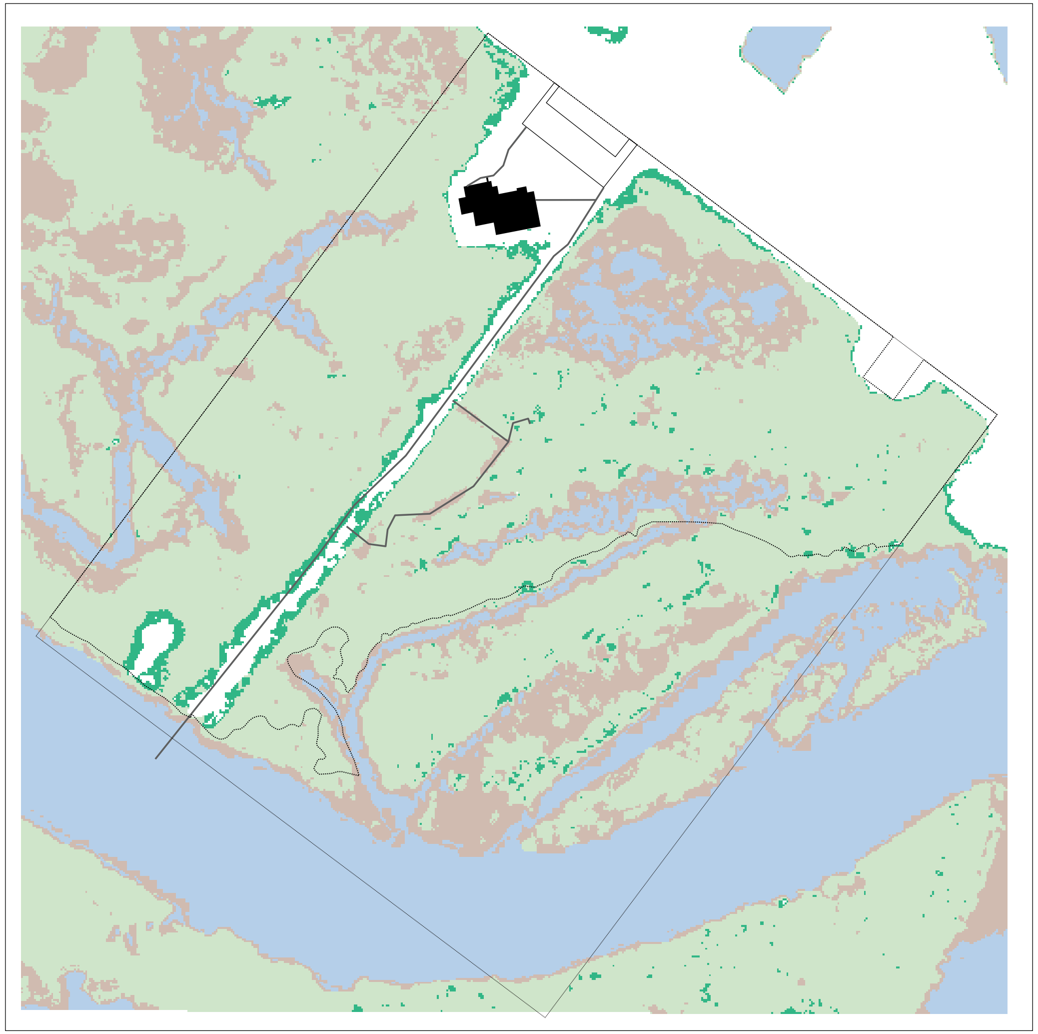
- 1 acre sites – 6,000 CY initial placement
- 3 year return cycle refurbished with 4,000 CY each time
- Free pump until enough material to create containment berms
- Match maintenance dredging of small sandy shoals with ecological goals for at risk species

TWI 2.0 Building Resilience for The Wetlands Institute

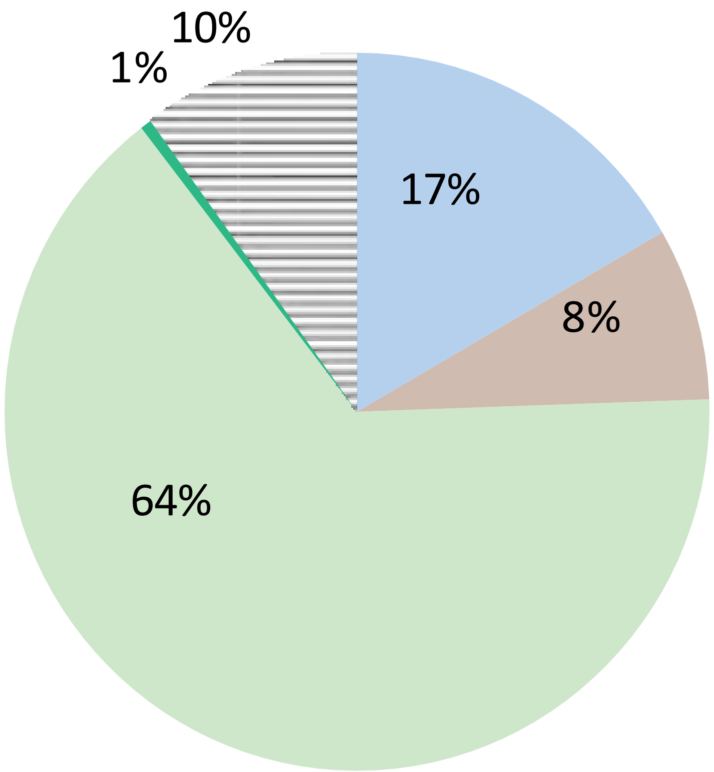
Wetland Ecosystem and Ecological Landscape

- Sea Level Rise Rates Altering Marsh Ecosystem
- Increasing Storm Risk Impacts and Uncertainties

TWI Existing Landcover



UPenn SLAMM Model Built via TWI Multispectral Drone Imagery and Survey Transect Elevations



UPLAND (UP)
HIGH MARSH (HM)
LOW MARSH (LM)
MUD FLAT (MF)
OPEN WATER (OW)
EXISTING PATH

High Marsh – Above Mean Tide and Less Flooded

Low Marsh – Mean Sea Level to Mean High Water; Flooded Daily By Tides

Mudflat (Tidal Flat) – Unvegetated Intertidal Area Flooded and Exposed by Tides Daily

Sea Level Rise Framework

Sea level rise predictions by Rutgers University:

		2030	2050	2070		
				Emissions		
	Chance SLR Exceeds			Low	Mod.	High
Low End	>95% Chance	0.3	0.7	0.9	1.0	1.1
Likely Range	>83% Chance	0.5	0.9	1.3	1.4	1.5
	~50% Chance	0.8	1.4	1.9	2.2	2.4
	<17% Chance	1.1	2.1	2.7	3.1	3.5
High End	<5% Chance	1.3	2.6	3.2	3.8	4.4

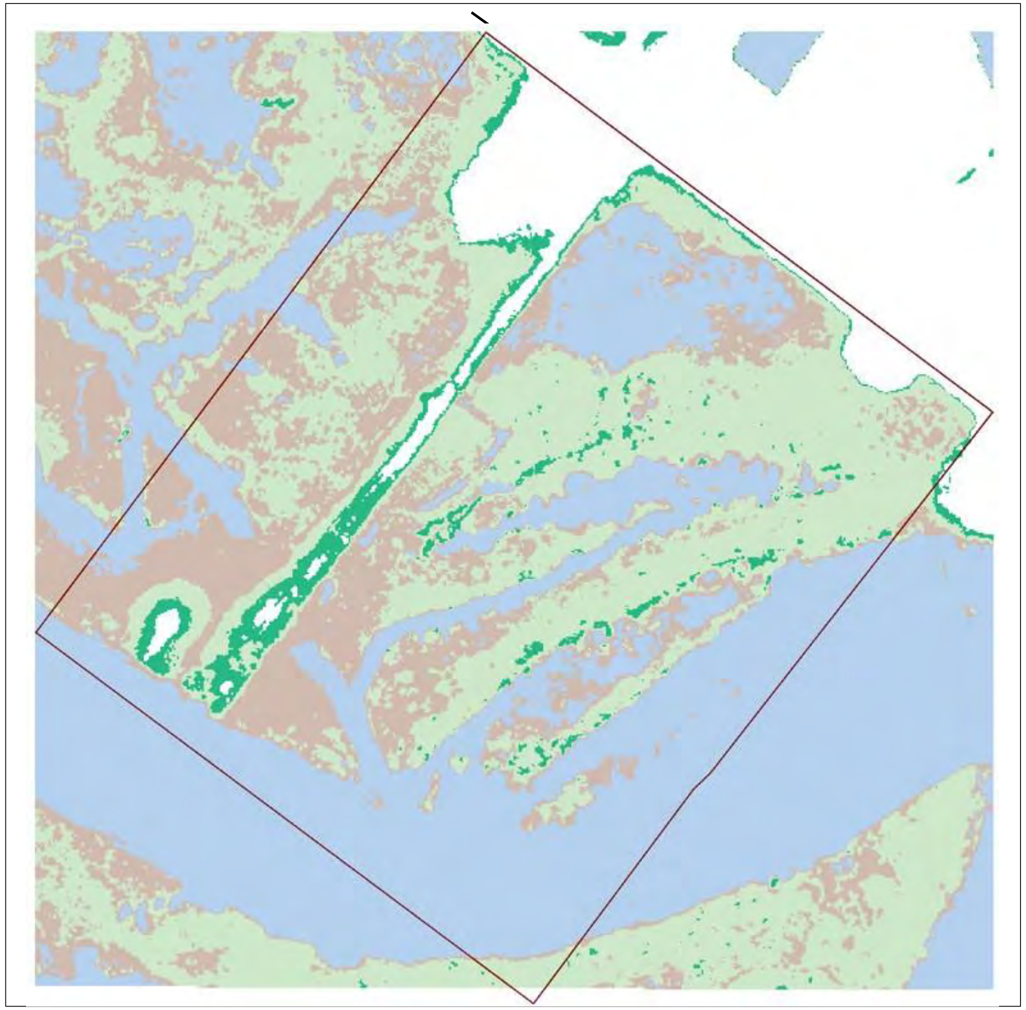
*"Sea Level Rise in New Jersey." Values chosen for design are highlighted in orange.

- SLR Projections are above year 2000 (1991-2009 average) baseline
  - 2000 - 2022 (2001 – 2019 average) observed 4" (0.03')
- Selected exceedance chance <17% based on selection being utilized by State of NJ for Planning and Regulatory Policy
- Focused on 2030 and 2050 Timelines

TWI Site Conditions Under Adopted Sea Level Rise Scenario (<17%)

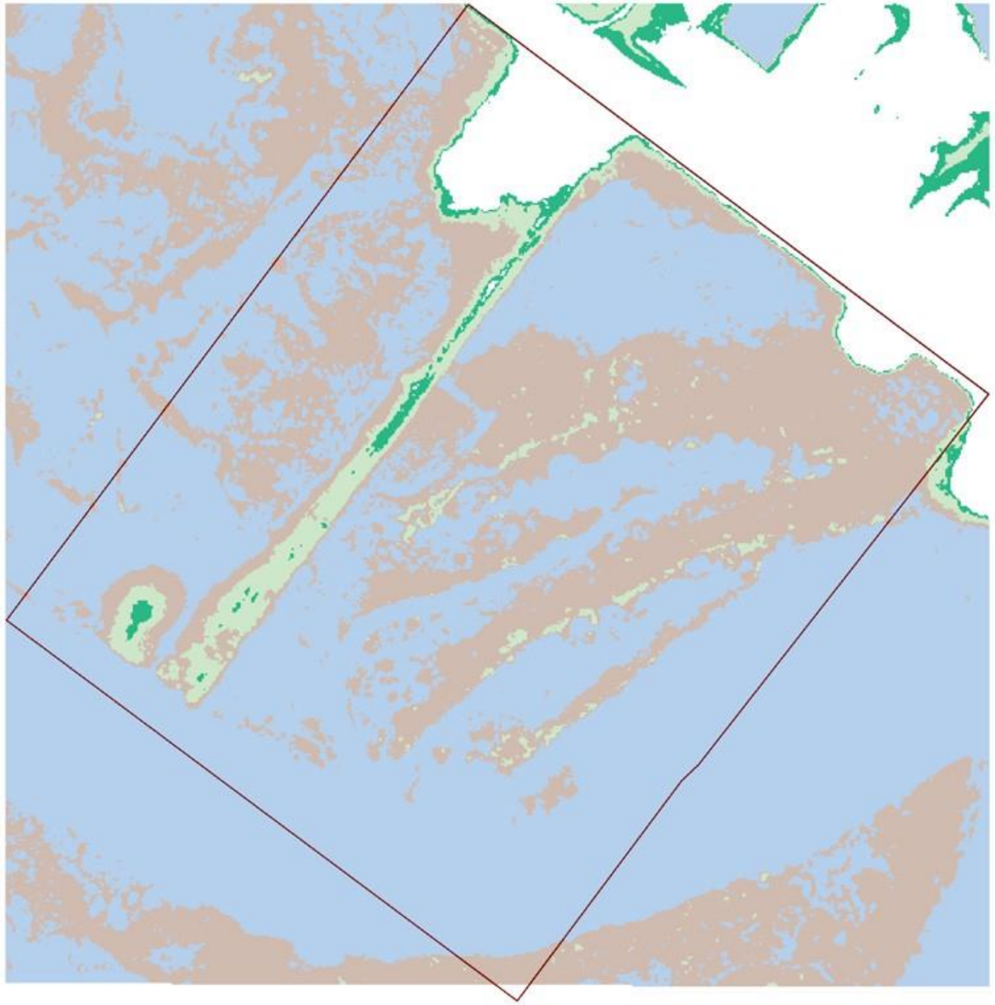
The Do Nothing Scenario

2030



UPLAND
HIGH MARSH
LOW MARSH
MUD FLAT
OPEN WATER

2050



Evolution of Habitat Elevation Ranges/Establishing Target Ecological Elevations

	2019 TWI		2030 Rutgers		2050 Rutgers	
SLR	n/a		1.1		2.1	
	Elevation Range (Ft NAVD88)					
Habitat	Low	High	Low	High	Low	High
UP	3.281	-	3.937	-	5.249	-
HM	2.953	3.281	3.281	3.937	4.265	5.249
LM	2.297	2.953	2.625	3.281	3.281	4.265
MF	0.64	2.297	1.969	2.625	2.625	3.281
OW	-	0.656	-	1.969	-	2.625

- Habitat maintenance over time requires increasing elevations
- Presumes salt marsh habitat is primarily guided by elevation related to sea level
- TWI elevations determined via direct elevation measurements and USACE 2017 DEM via LIDAR
- Future habitat elevation ranges are via SLAMM (Sea Level Affecting Marsh Model) to account for sea level rise, accretion, and subsidence via published resources

Constructed Habitat Design #2: Marsh Plateaus

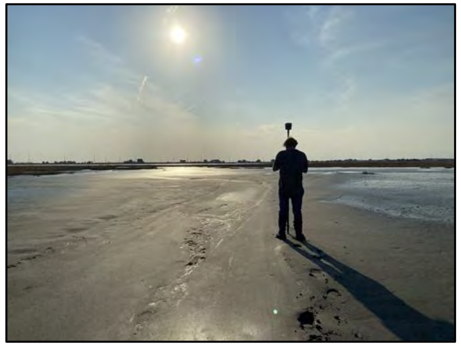
2030

2050

Lessons Learned And Some Guiding Thoughts

- Don’t over engineer projects
  - Sediment containment is challenging, expensive, and often creates its own negative feedback loops
  - Unconfined placement allows material to spread over wide areas and for maintenance/development of tidal flushing
  - Building elevation may require multiple lifts or partial containment
  - BUDM projects are water management projects (Flow velocities from 24” dredge pipe are 22,000 gals/min and 80% water)

- Dredging efficiency and effectiveness of placements enhanced by:
  - Using Y-valves and other tools to allow placement in multiple sites easily and switching between sites/location s at a site
  - Can help control flow velocities and provide resting and settling times for placed material
  - Adaptive management during dredging and placement is nearly impossible



- Plan for placement at multiple sites to manage changing dredge material composition
- Understanding progress towards construction/ecological goals during placement difficult
- Vegetation recovery takes ~two growing seasons to initiate
  - Recovery has been almost entirely by new seeding from the seedbank
  - Planting should be delayed for at least two growing seasons if needed at all
  - Balance placing in thin layers to preserve existing vegetation vs thicker placement for more ecological uplift

- Structure project goals to include habitat and species benefits during site evolution
- Consider role of monitoring and keep focused on adaptive management or to advance practices

Questions to Consider

Selecting Sites?

- Should marsh enhancement projects be focused on failing sites or those that have a trajectory toward failure?
- How do you balance rate of recovery vs longer term ecological uplift (thick or thin)?

Landscape Considerations

- Should projects provide uplift to higher elevation sites vs lower elevation site (maintain or restore elevation)?
- Marsh interior without suitable edge protection?

Defense or Creation?

- How do you think about blue carbon defense vs creation opportunities?

Relevant Publications

- Beardsley, Welp, Harris, McFall, Tyler, and Savant (2022): Sediment Distribution Pipe: Modeling Tool and field Application. WEDA Journal of Dredging, v. 20 (1) 16-37.
- Chasten, Goldberg, Pasquale, Piercy, Welp, and Golden (2016): Recent Experience with Channel Dredging and Placement to Restore Wetlands In New Jersey, WODCON XXI PROCEEDINGS.
- Collins, Ferguson, Morey, and Tedesco (2021): Cape May Wetlands Wildlife Management Area Habitat Restoration Monitoring and Evaluation, https://wetlandsinstitute.org/wp-content/uploads/2022/11/FG19-057_TWI_2019-2021_FINAL.pdf
- Ecoshape (2018): Living Lab for MUD Brochure, www.ecoshape.org.
- Fall, Perkey, Tyler, and Welp (2021): Field Measurement and Monitoring of Hydrodynamic and Suspended Sediment with the Seven Mile Innovation Laboratory, New Jersey, ERDC/CHL TR-21-9, https://permanent.fdlp.gov/gpo185925/ERDC-CHLTR-21-9(1).pdf
- Fall, Perkey, Tedesco and Chasten (2022): Impact of Strategic, Unconfined, Dredged Material Placement on Turbidity Within a Shallow Back Bay System: observations from Seven Mile Island Innovation Laboratory, NJ, WEDA Journal of Dredging, v. 20 (1) 38-49.
- Rochette, Chasten, Tedesco, and Kopkash (2019): Seven Mile Island Innovation Laboratory, Overview and Purpose Fact Sheet, www.nap.usace.army.mil.
- Sea Level Rise in New Jersey: Projections and Impacts – New Jersey Climate Change Resource Center," https://njclimateresourcecenter.rutgers.edu/climate_change_101/sea-level-rise-in-new-jersey-projections-and-impacts/.
- Tedesco, Chasten, Ferguson, Collins, and Davis (2021): Using Dredged Sediments to Uplift Marshes, Build Subtidal Shallows and Provide Marsh Edge Protection in the Seven Mile Island Innovation Lab, Delaware Estuary Science and Environmental Summit, https://delawareestuary.org/delaware-estuary-science-and-environmental-summit/
- The Nature Conservancy and New Jersey Department of Environmental Protection (2021).: Beneficial use of dredged material to enhance salt marsh habitat in New Jersey: Project summary and lessons learned.