Protecting Military Readiness through Integrative Numerical Modeling for the US Marine Corps – Parris Island, South Carolina

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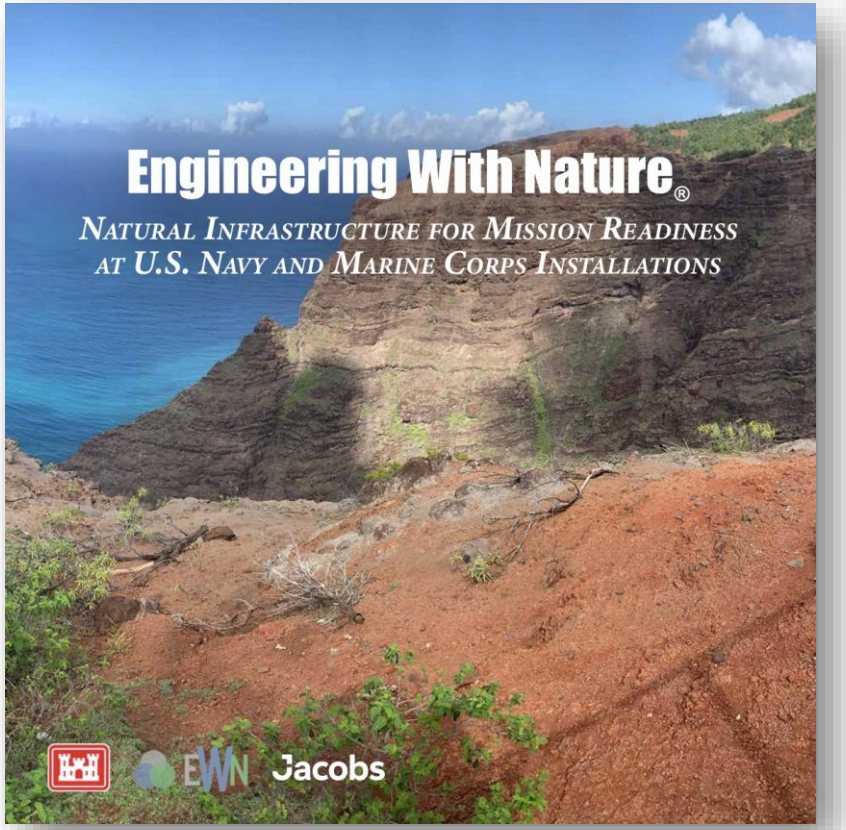
[2] ATM / Geosyntec

[3] U.S. Marine Corps Recruit Depot - Parris Island

September 26, 2025

Engineering with Nature – Dept. of Defense



https://erdc-library.erdc.dren.mil/items/626b9db0-1450-4138-93ed-bf588e7ffc38

Engineering With Nature

Mission-Ready, Multi-Benefit Solutions For The Department Of Defense

Operating across more than 25 million acres and nearly 5,000 sites worldwide, the U.S. Department of Defense (DoD) faces the challenge of maintaining mission-critical infrastructure in diverse and demanding environments. Engineering With Nature (EWN) meets this need by integrating natural processes with engineered systems, delivering innovative, resilient, and efficient solutions to ensure mission success.

EWN is guided by four foundational principles when supporting military installations:

1. **Mission Assurance**: Using science and engineering to produce operational efficiencies supporting delivery of resilient project benefits and mission.
2. **Using Natural Processes**: Leveraging natural systems to reduce resource demands and minimize landscape impacts.
3. **Broadening Benefits**: Designing projects to incorporate social, ecological, and economic value.
4. **Promoting Collaboration**: Aligning stakeholders, interests, and partners through science-based collaboration to achieve shared goals.

Marine Corps Recruit Depot (MCRD) – Parris Island

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- **The US Marines are the maritime land force service branch of the US Military**
- **Essential National Security Asset** responsible for the recruitment and training of approximately 20,000 new Marines each year (out of a total force of approximately 170,000)
- **MCRD PI Mission: *We make Marines*** by recruiting quality young men and women and transforming them through the foundations of rigorous basic training, our shared legacy, and a commitment to our Core Values, **preparing them to win our Nation's battles** in service to the country.
- MCRD PI trains approximately **20,000** recruits each year through a thirteen-week Recruit Training period of instruction along with serving as the headquarters for the **Marine Corps Eastern Recruiting Region, responsible for all recruiting efforts east of the Mississippi River**.
- The recruit depot encompasses **8,270 acres**, approximately 3,262 of which are habitable, the remaining **~5,000 acres of wetlands, tidal marsh and creeks.**

Orientation to MCRD Parris Island

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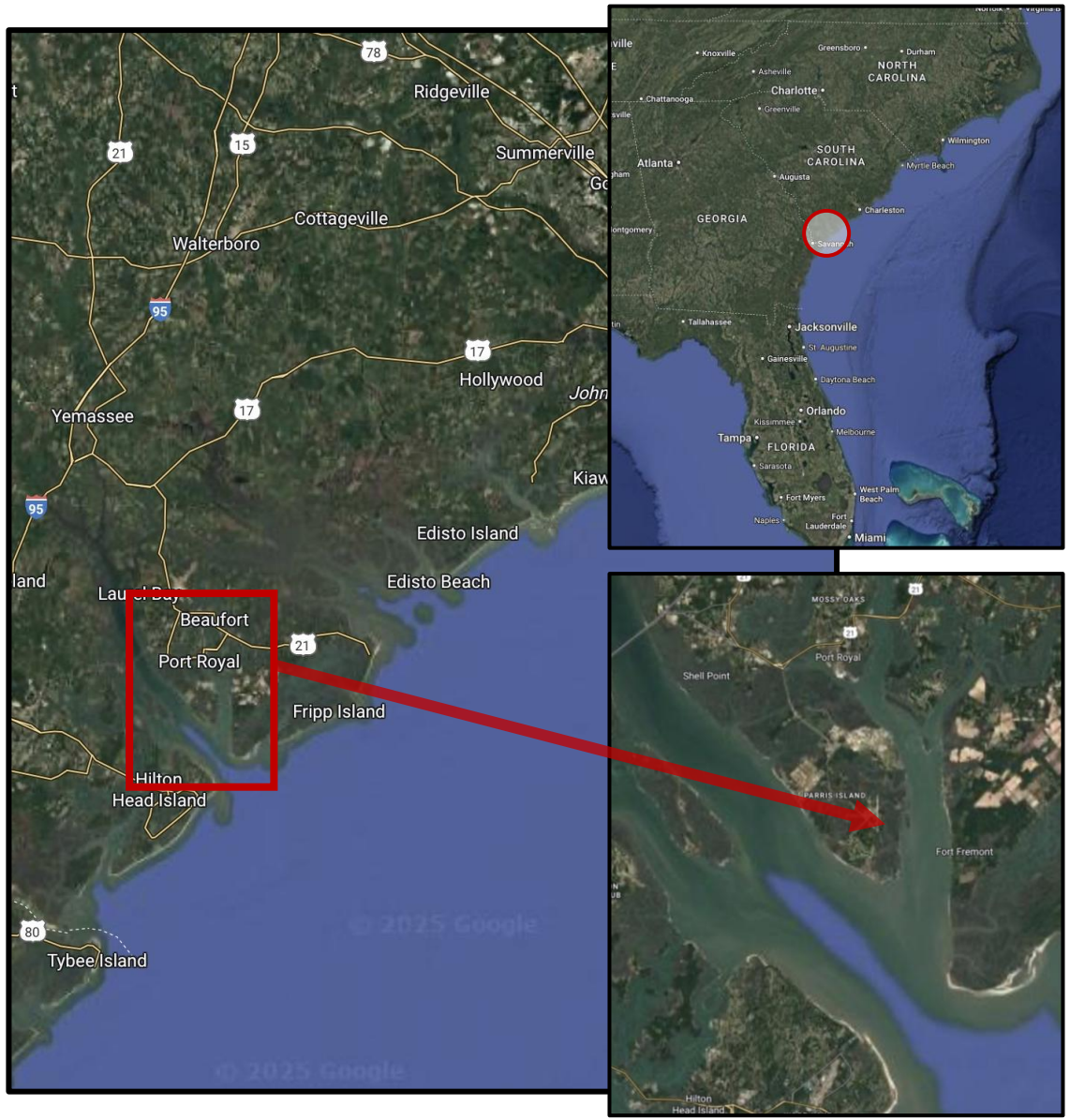
- Located at the confluence of the Broad River and Beaufort River
  - 8,270 acres: 3,262 acres are habitable/ ~250 facilities 20 years or older.
- Series of islands separated by marshes and creeks.
  - Boundary perimeter – 21.5 miles
  - Effective shoreline perimeter – 51.5 miles
- One causeway that permits ingress and egress from the installation.
- Average elevation main side -11ft., WFTBn – 9ft., Main Causeway – 8ft.
- Storm water drainage dependent on tides – occasional flooding at highest tides.



Study Motivation – Broad River Shoreline

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- **Determine the cause of shoreline erosion.**
- **Design, permit, and construct shoreline stabilization using nature-based features.**
- **Short- and long-term monitoring.**

Methods Overview

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Numerical Modeling

Sensor Networks

AI / ML

Engineering Design

Permitting & Regulation

Construction (Core and Full-scale Prototype)

Methods Overview

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 Sensor Networks

~~AI / ML~~ 

 Engineering Design

~~Permitting & Regulation~~ 

 ~~Construction (Core and Full-scale Prototype)~~

In-Situ Sensor Network Deployment

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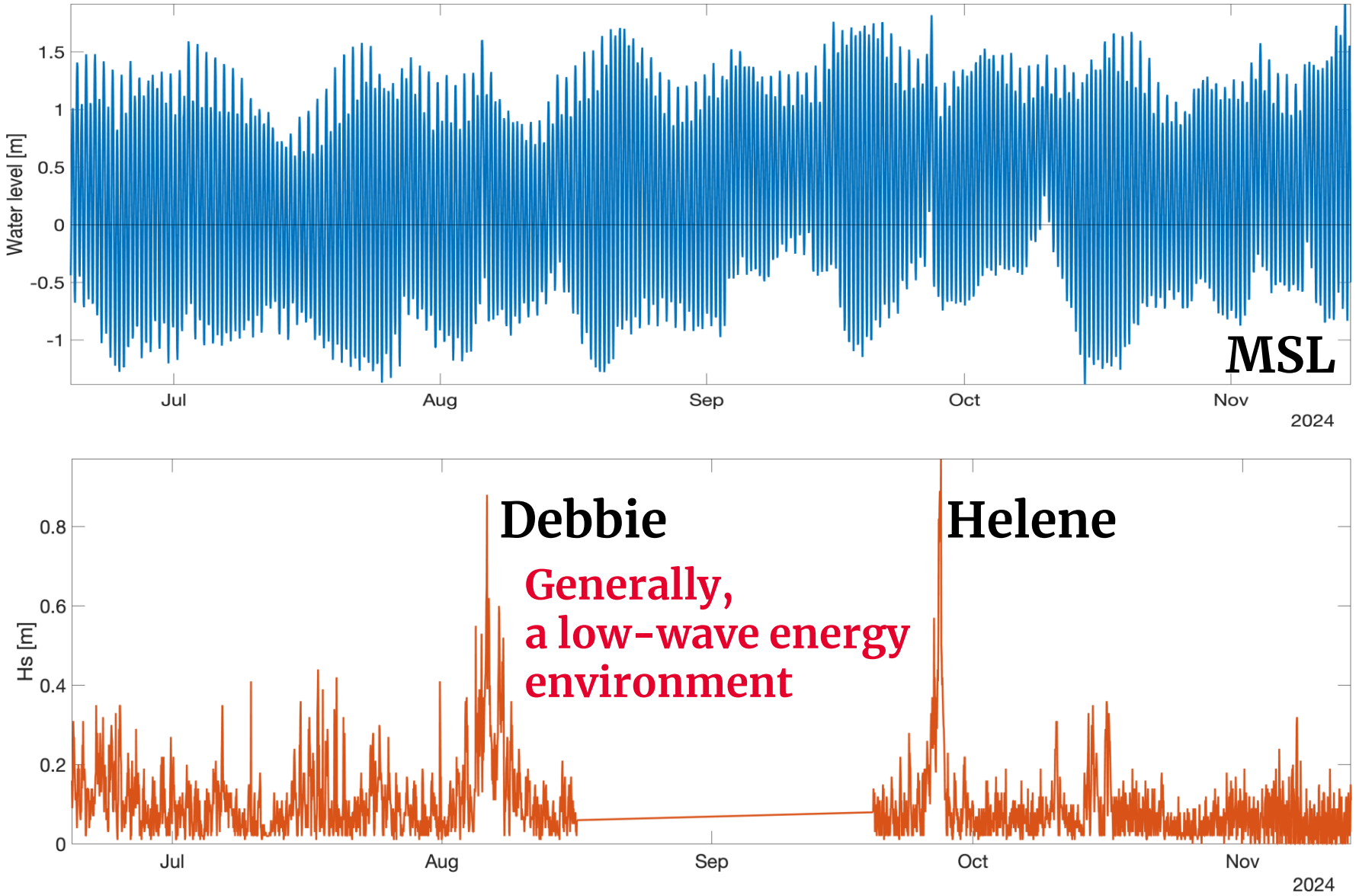
Pressure (RBR) and velocity profilers (ADCP)

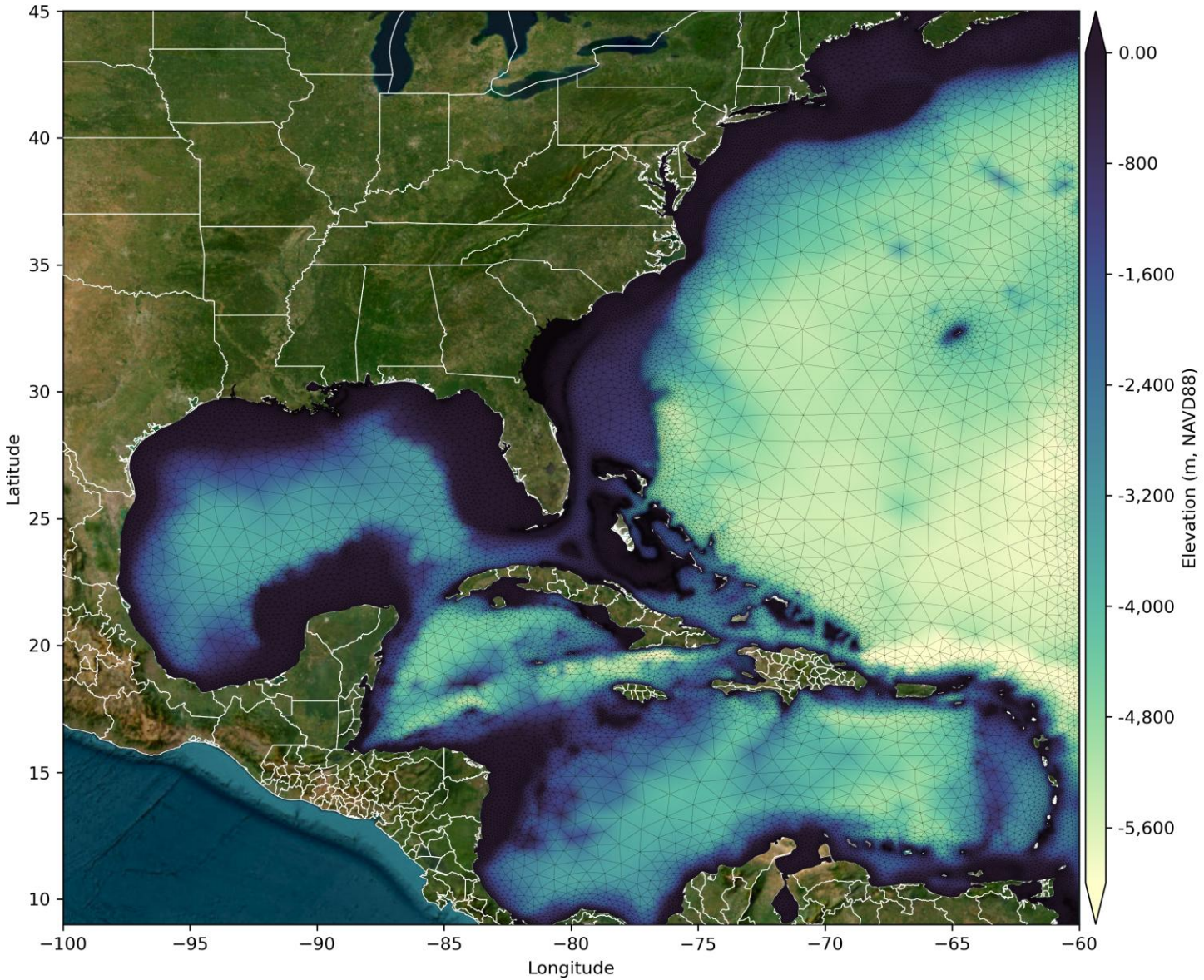

IF800 TomCat UAV
TrueView 535 LiDAR sensor

Water Levels and Waves (2024)



Data courtesy of Paul Gayes, Coastal Carolina Univ.

ADCIRC + SWAN



- **1.7M Nodes**
  - Aquaveo SMS
  - OceanMesh 2D
- **Resolution down to 20 m**
- **1-sec time-step**
- **Vertical feature integration**
  - Bilskie et al. (2018) Adv. Water Resources
  - Gao et al. (2022) Env. Modelling & Software
- **Advection enabled**
- **Wetting/Drying enabled**

ADCIRC + SWAN

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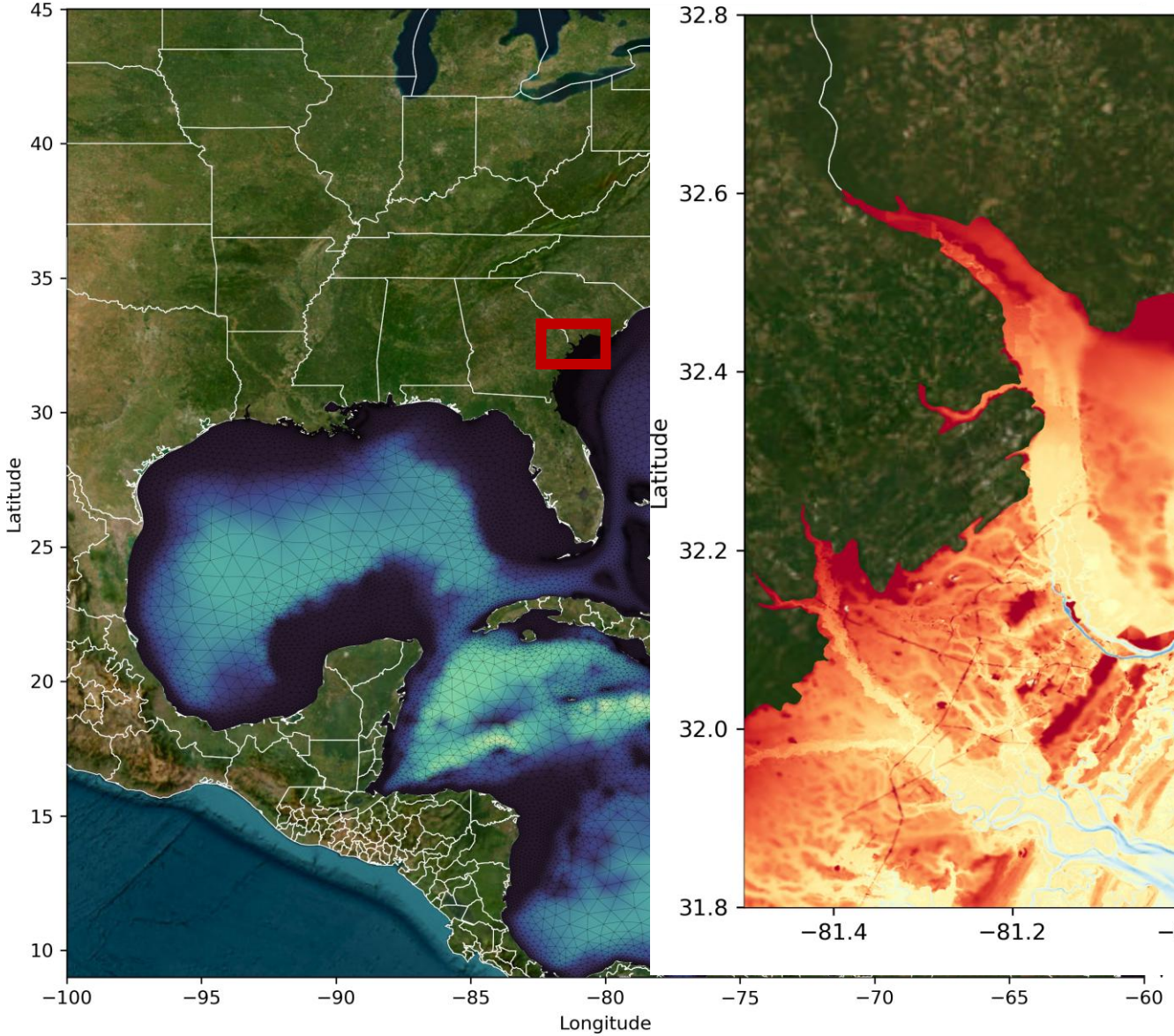

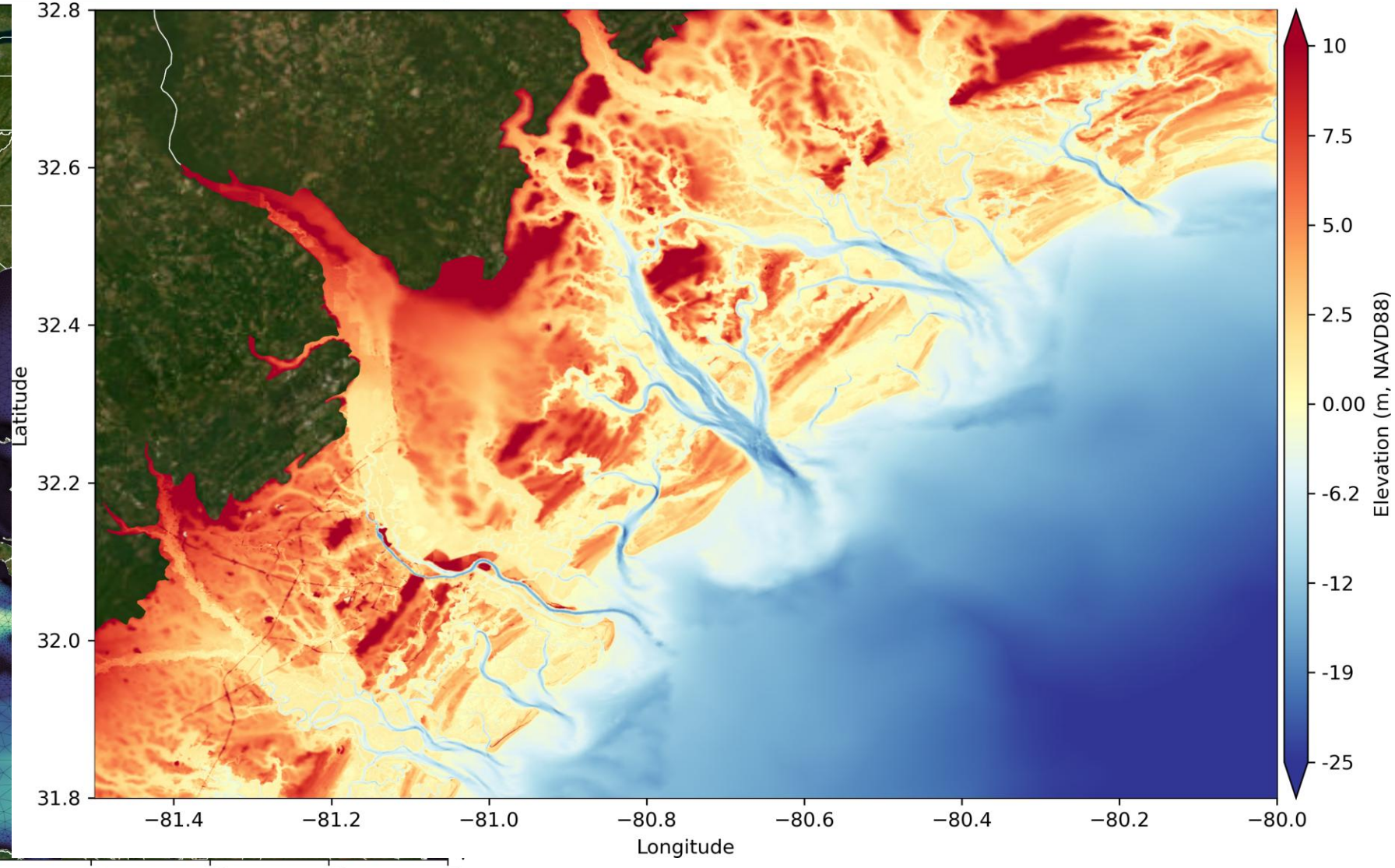

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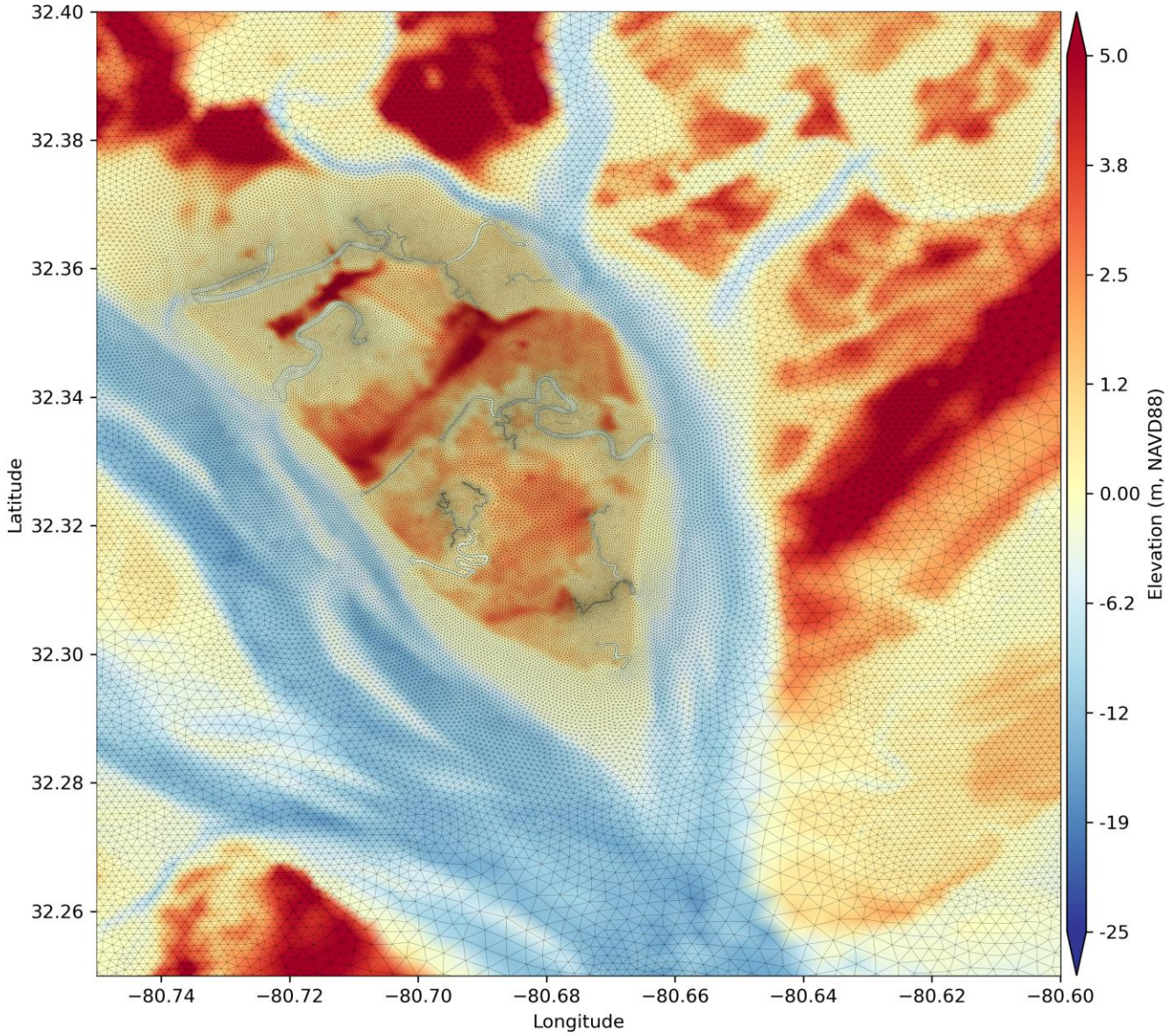
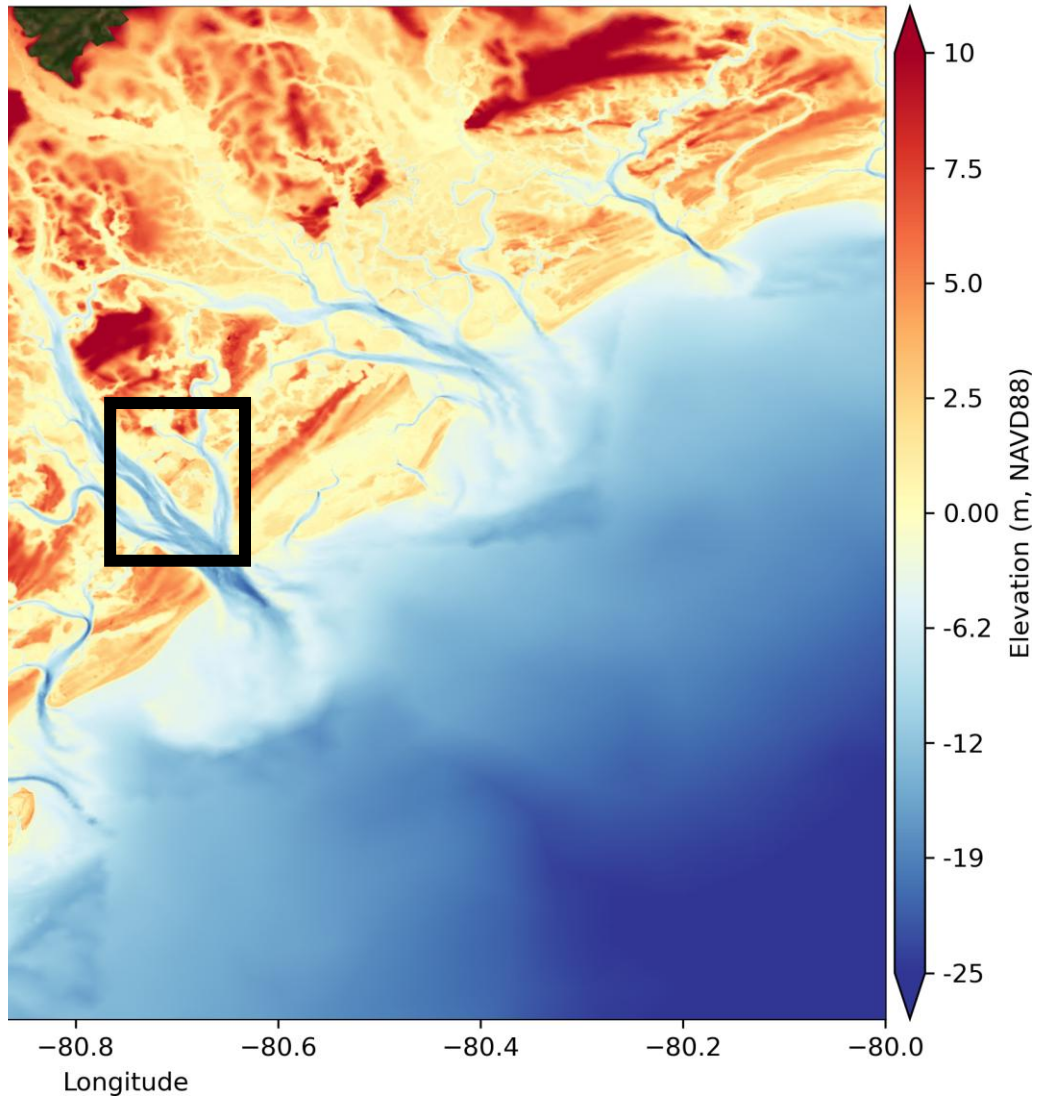

32.40
32.38
32.36
32.34
32.32
32.30
32.28
32.26
Latitude
−80.74
−80.72
−80.70
−80.68
−80.66
−80.64
−80.62
−80.60
Longitude
5.0
3.8
2.5
1.2
0.00
-6.2
-12
-19
-25
Elevation (m, NAVD88)


−80.8
−80.6
−80.4
−80.2
−80.0
Longitude
10
7.5
5.0
2.5
0.00
-6.2
-12
-19
-25
Elevation (m, NAVD88)

ADCIRC + SWAN

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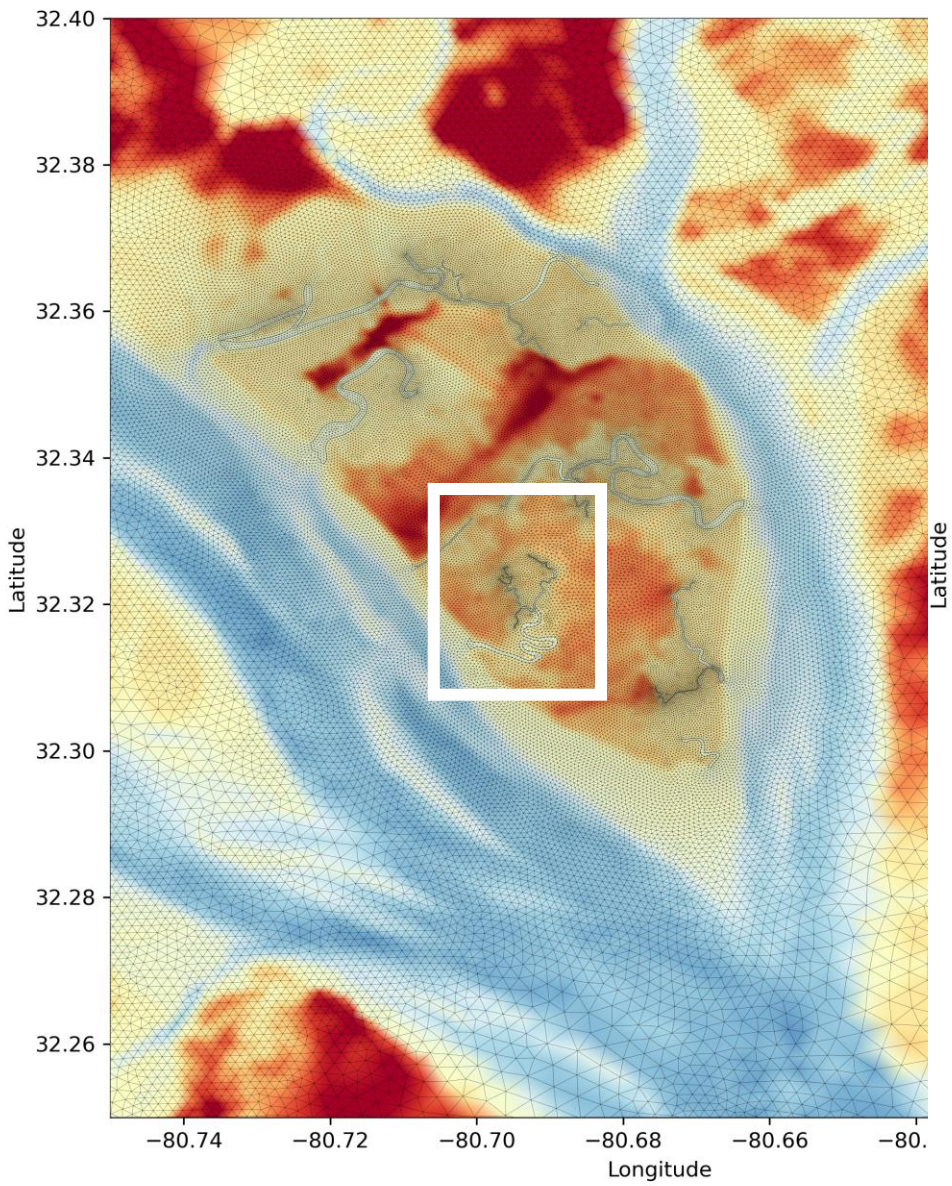

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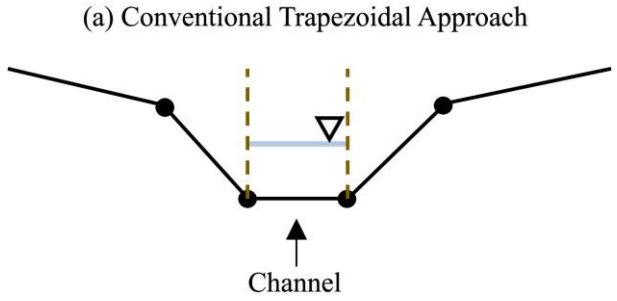

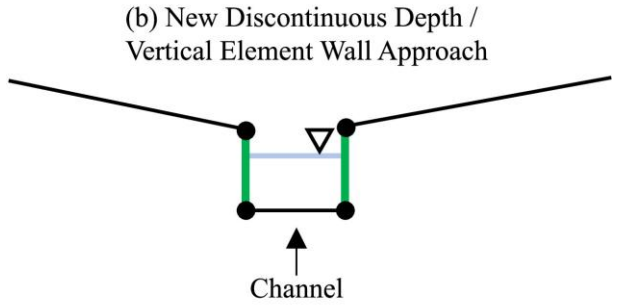

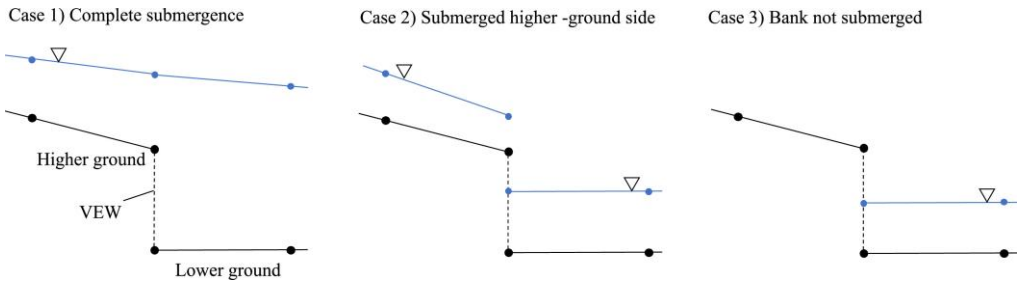

Bunya et al. (2023). *Advances in Engineering Software*

SACS JPM Storm Tracks for Study Area

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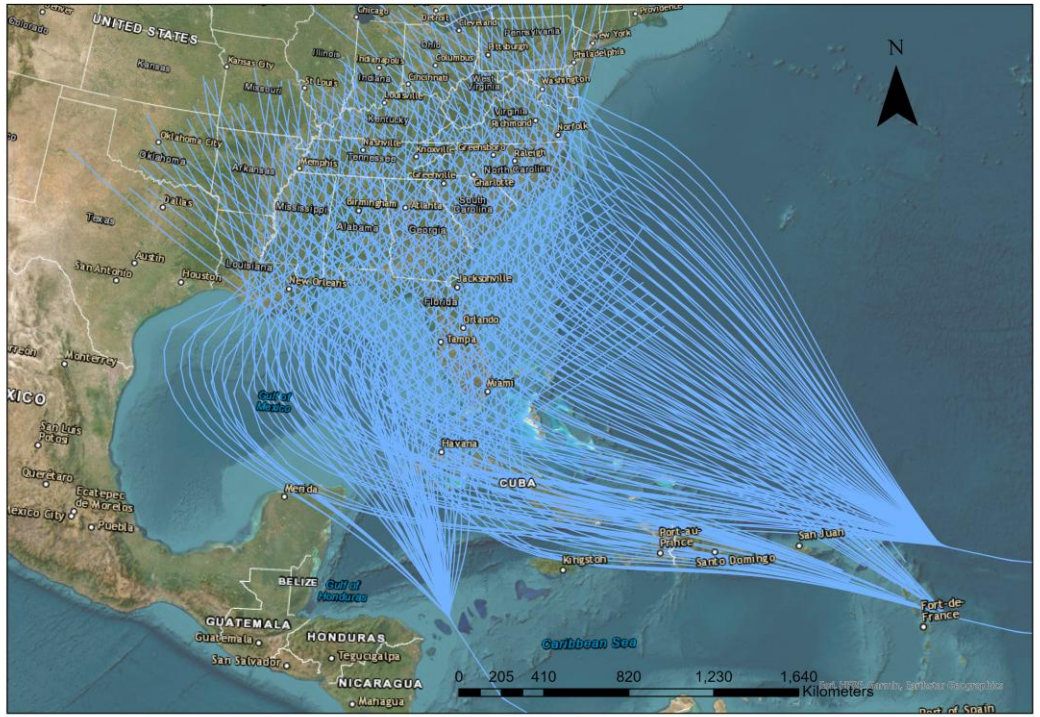
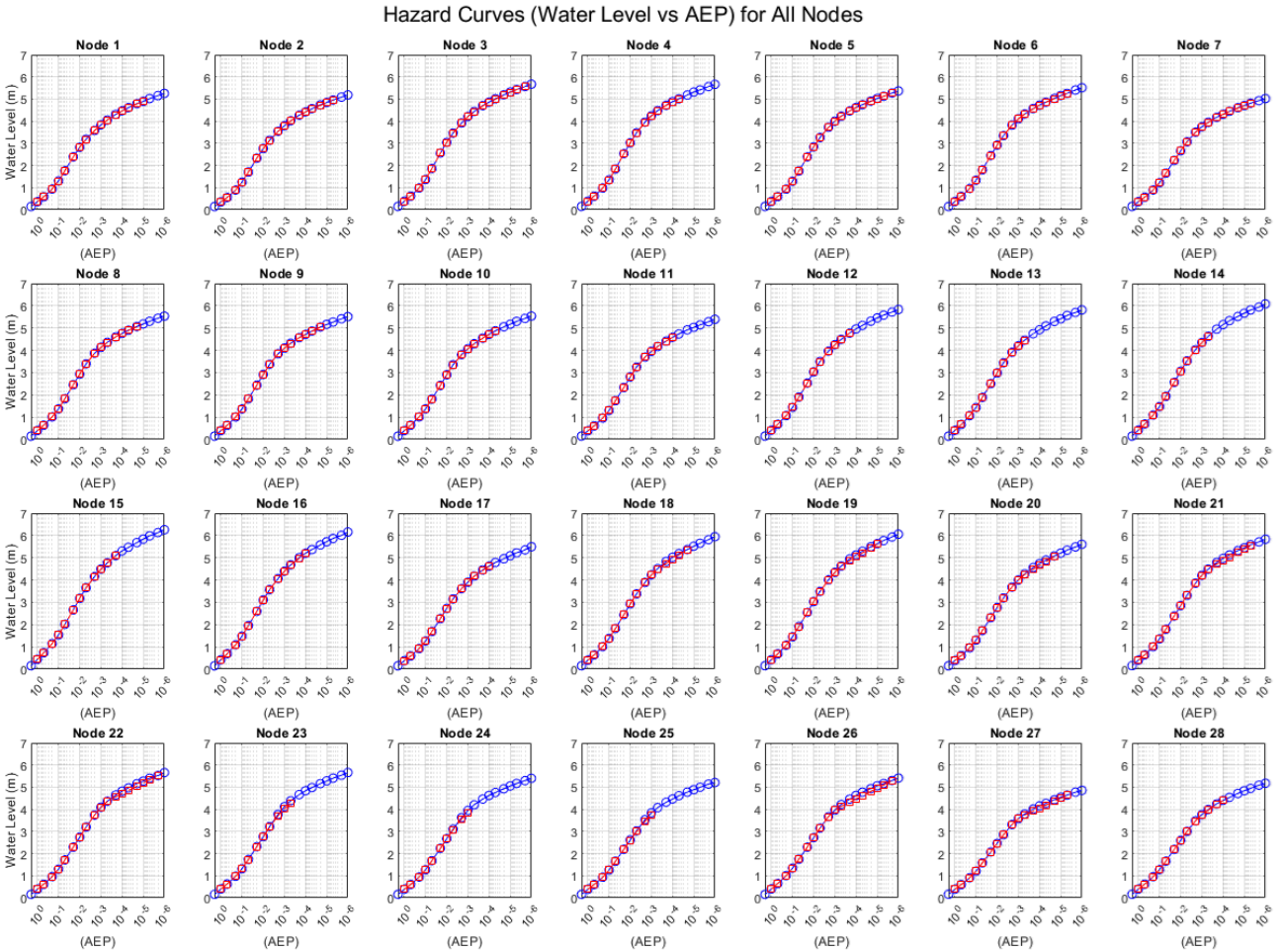
U.S. Army Corps of Engineers (USACE)
South Atlantic Coastal Study (SACS)
1600 Storm Tracks



Reduce the storm suite for the study area & re-weight the probability of occurrence based on the storm sub-set.



ADCIRC+SWAN Results (Preliminary)

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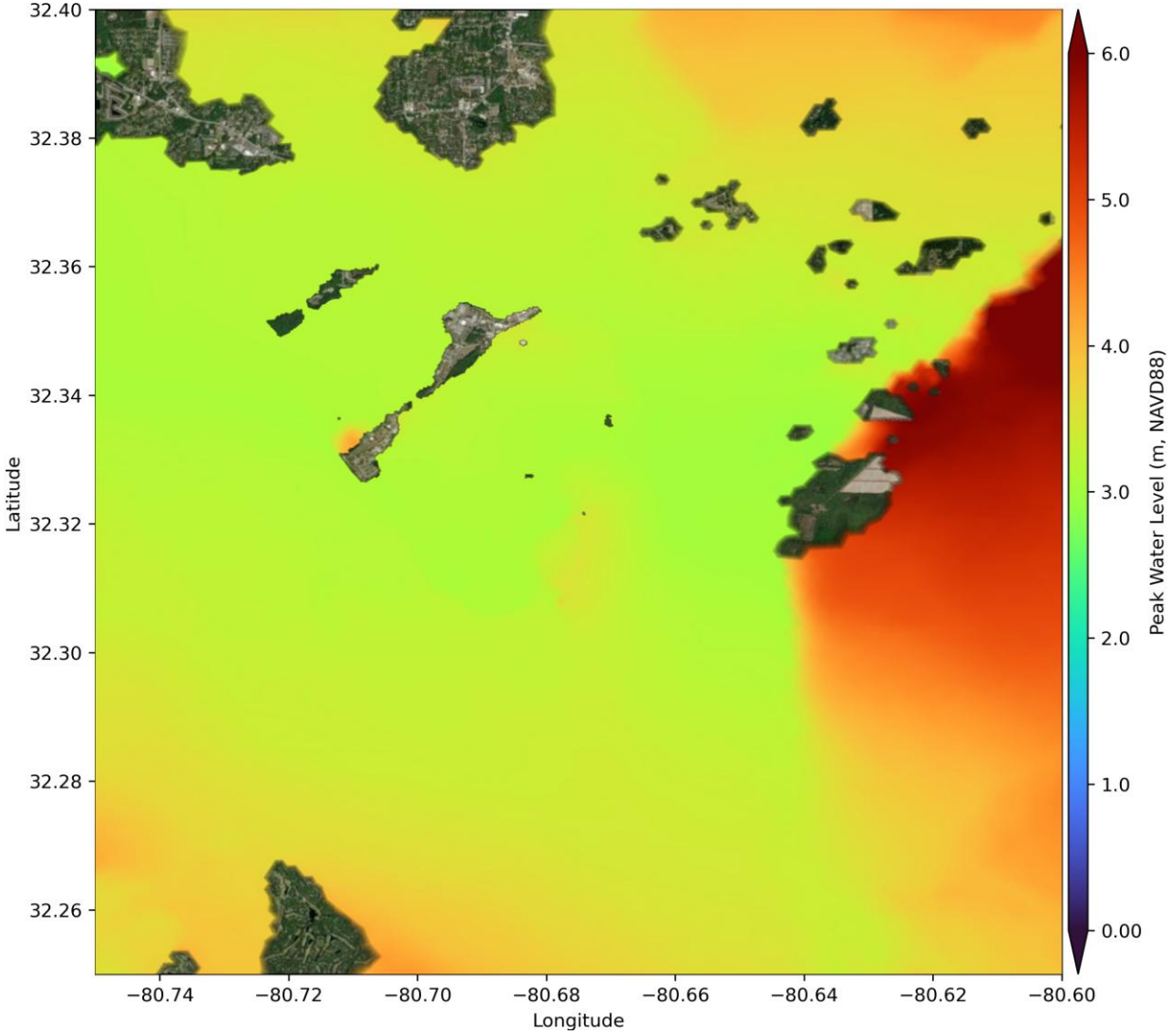
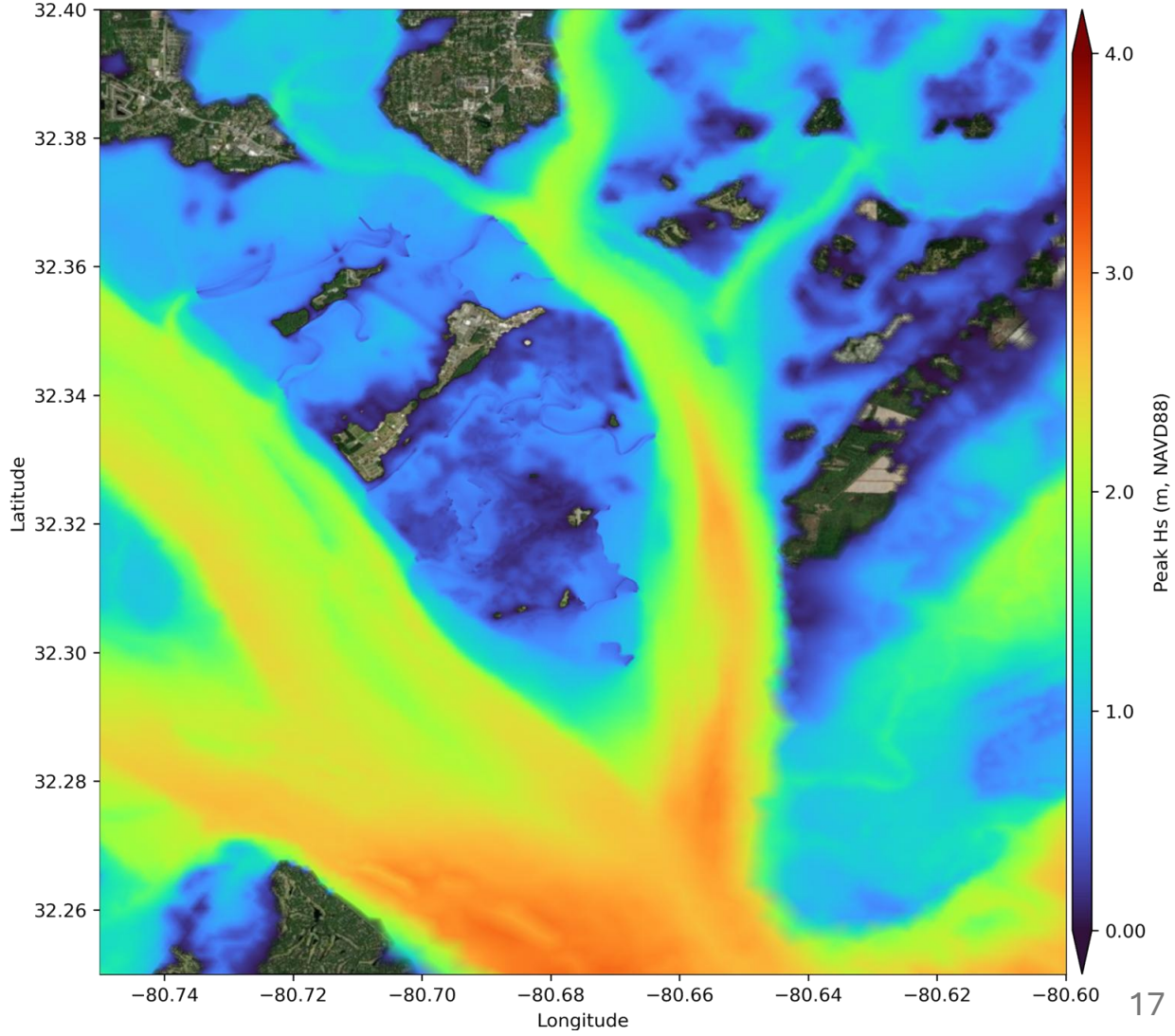
1% AEP Peak Water Level



Peak Sig. Wave Height



XBeach 2D – Grid & Model Setup

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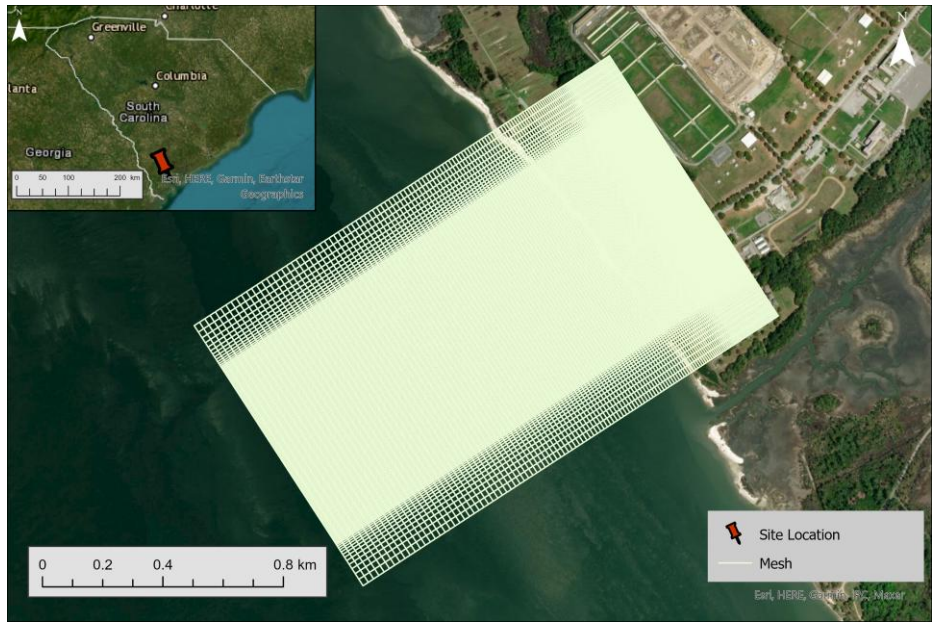
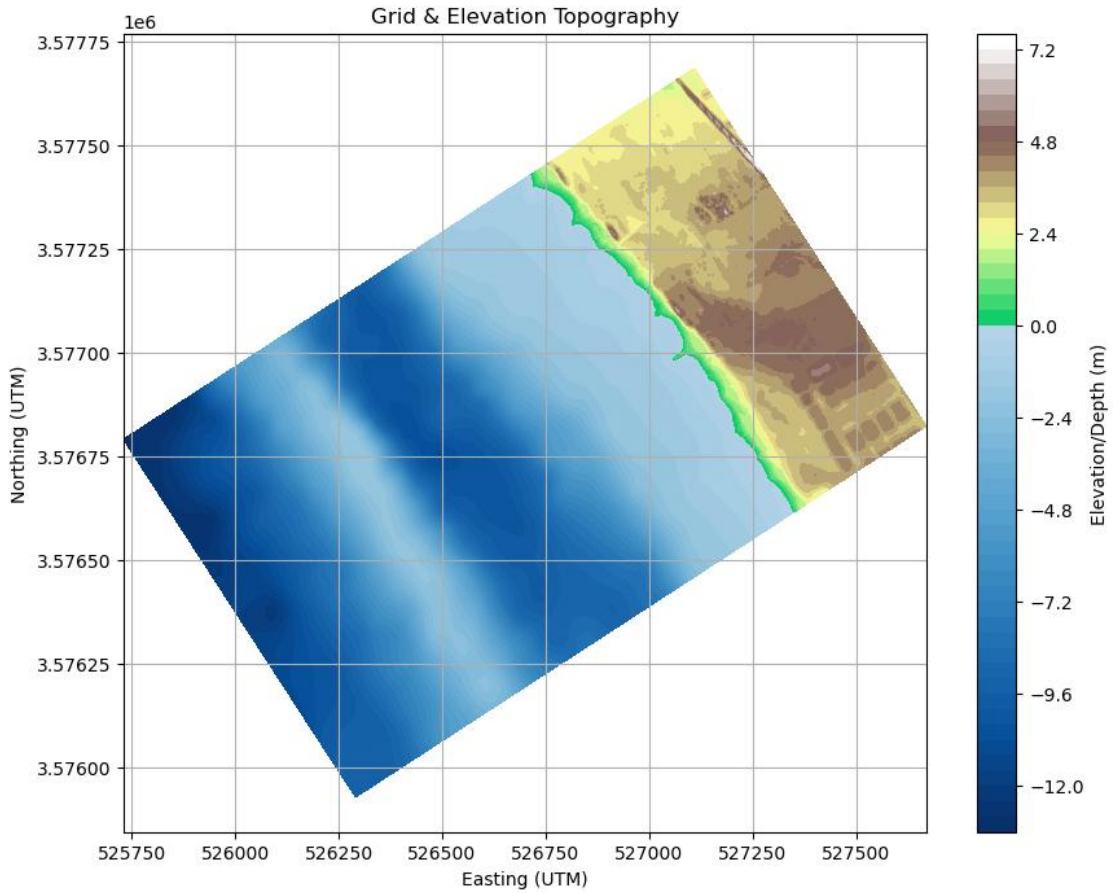
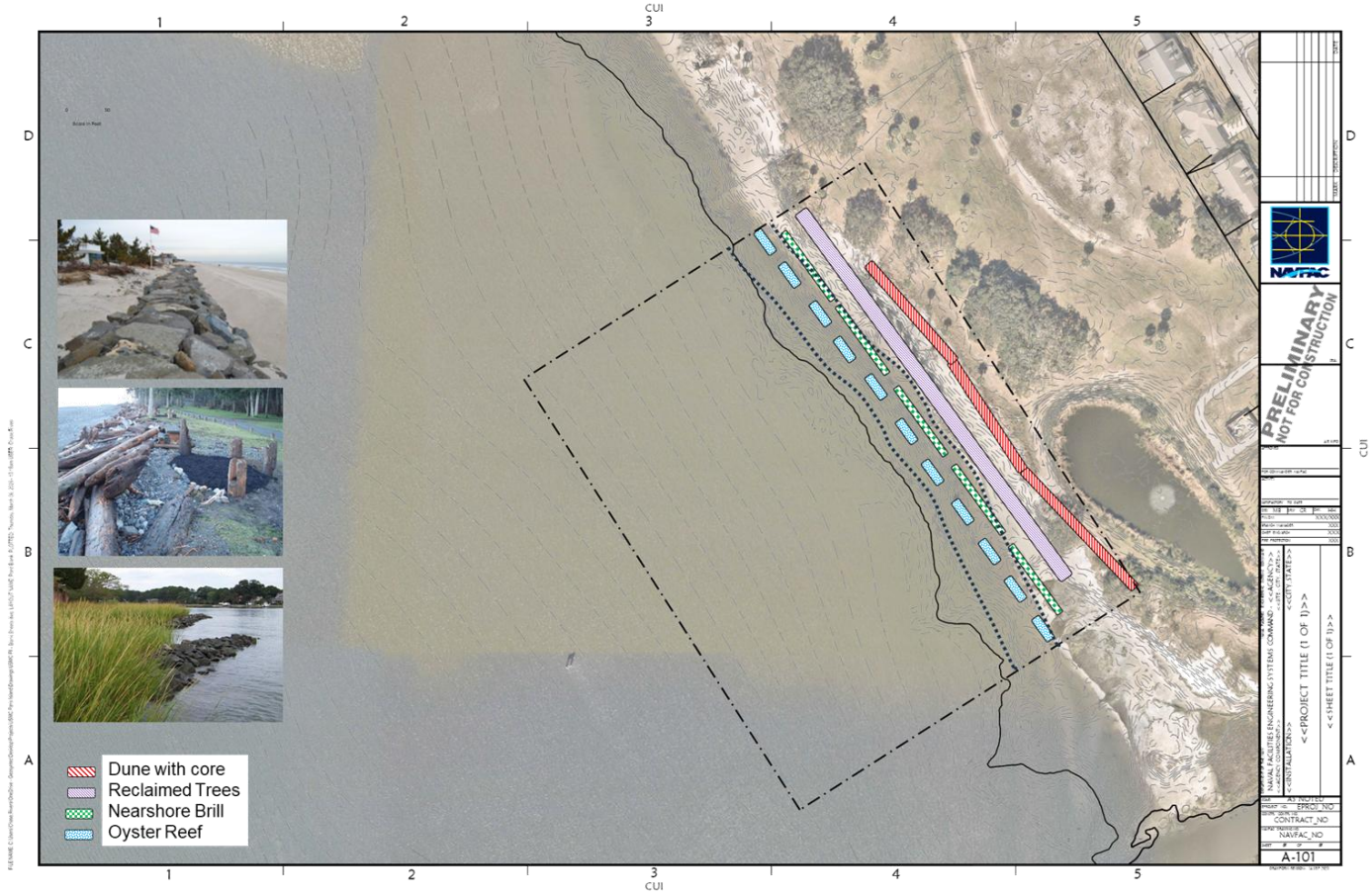
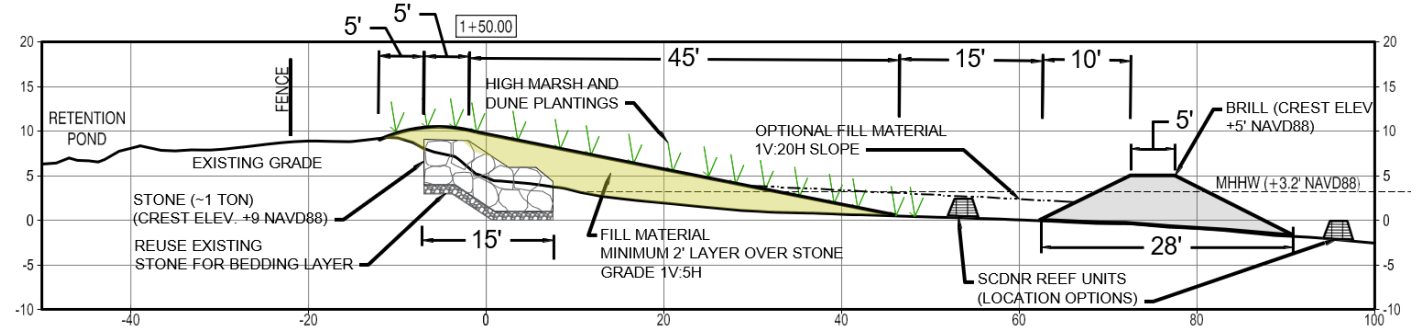
- Mesh Resolution: 5-30 m resolution
- Elevation Data: USGS Coastal National Elevation Database (CoNED) + UAV-lidar survey
- Surfbeat mode - waves phase-averaged
- Bed Friction: Manning's n from USGS NLCD
- Boundary Condition: From ADCIRC+SWAN Simulations

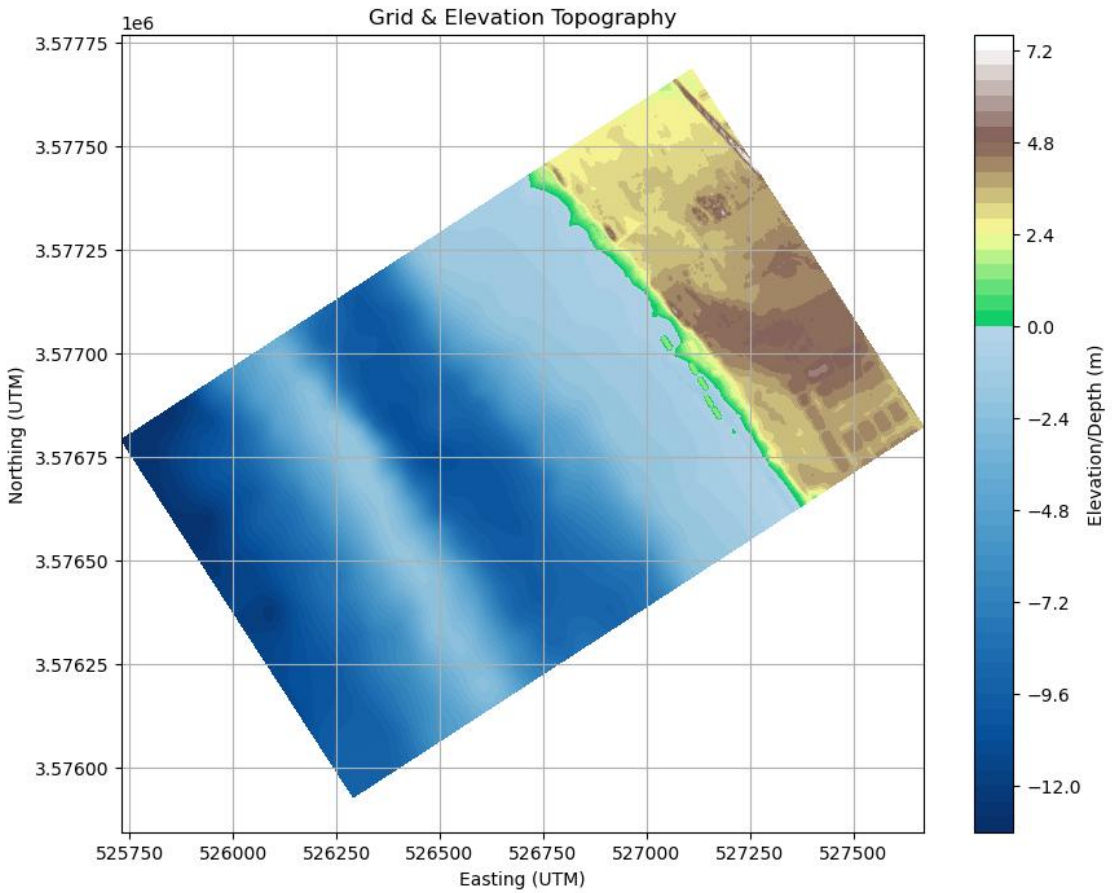




XBeach 2D – with Project Conditions







Wave Height Across the Brill - Preliminary

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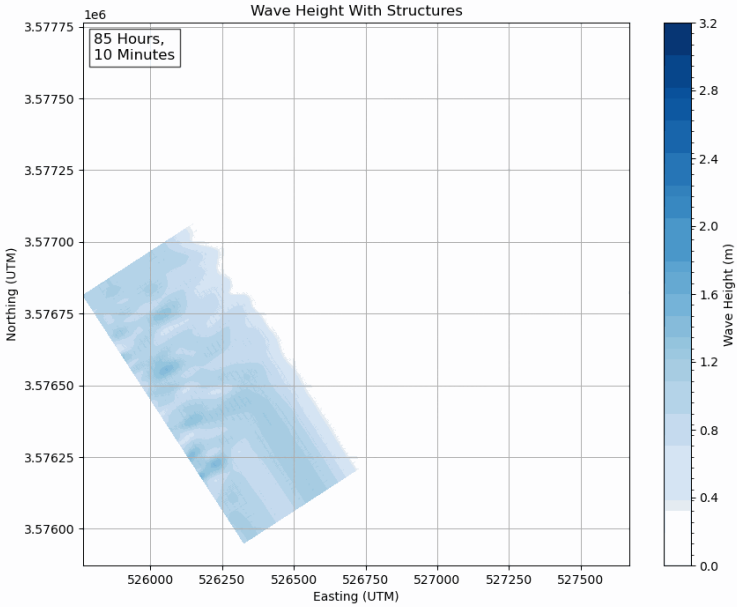
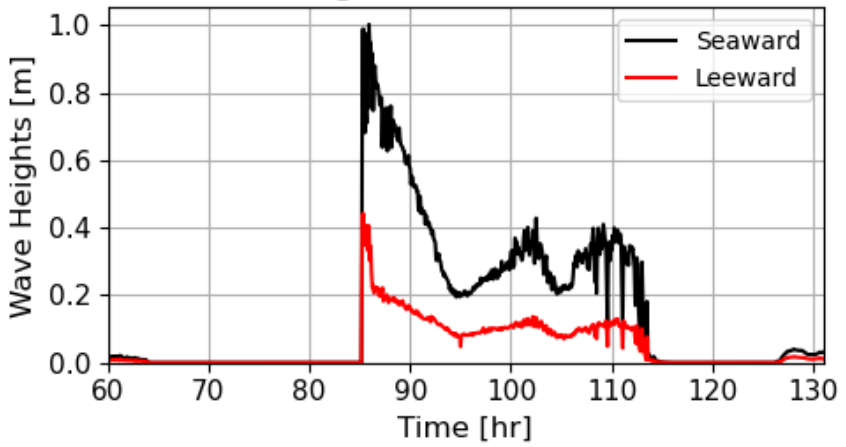
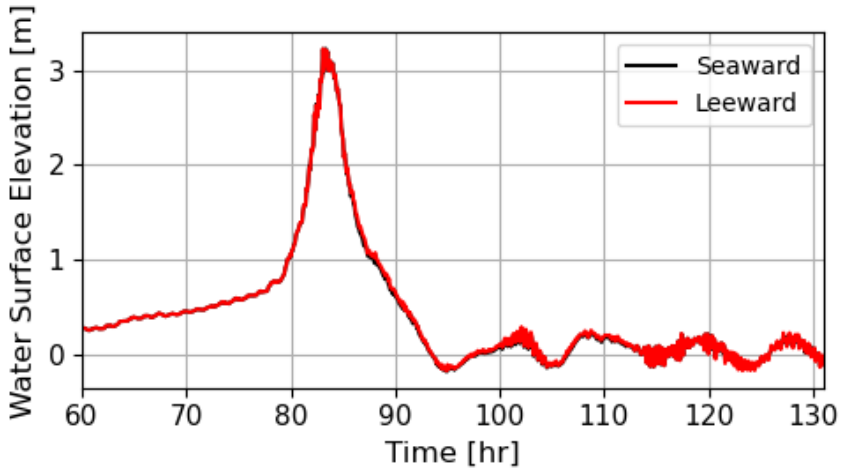
1% AEP Flood Event

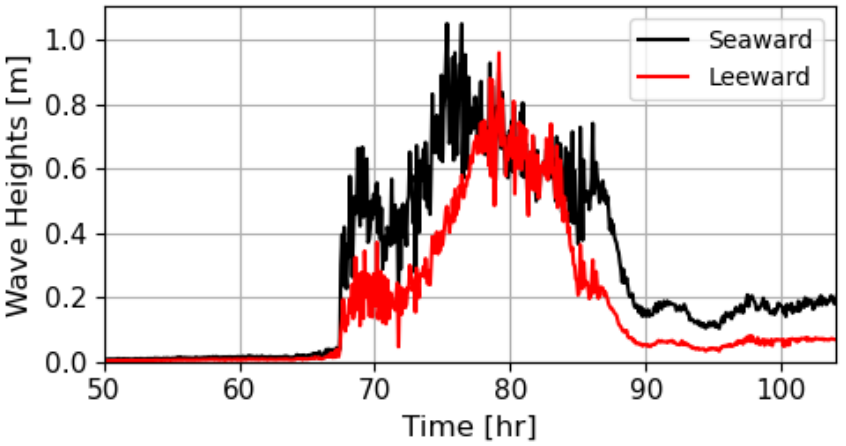


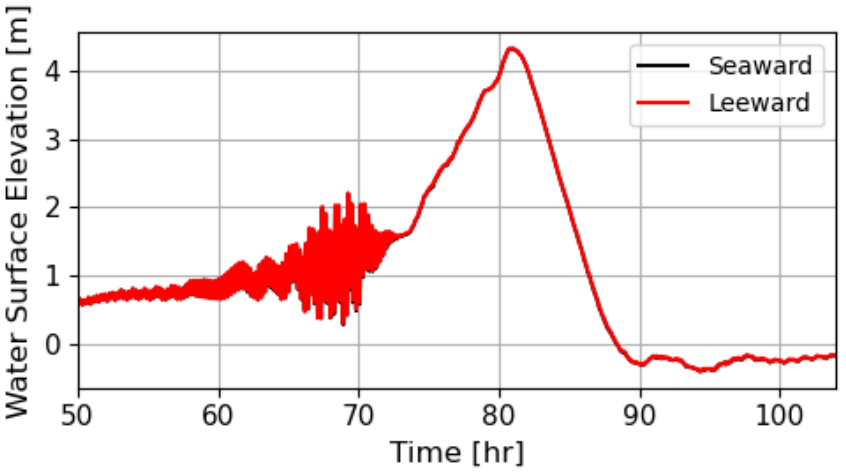
1% AEP Flood Event





0.2% AEP Flood Event





OpenFOAM 3D Simulation – In Progress!

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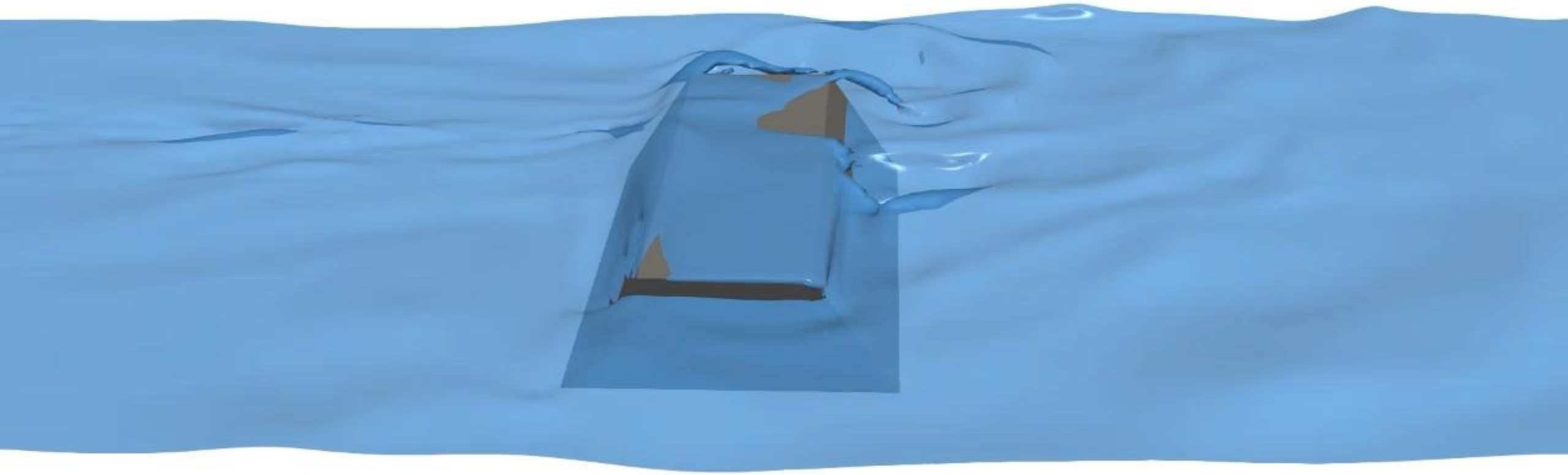

Broad River Core Prototype Initial Design

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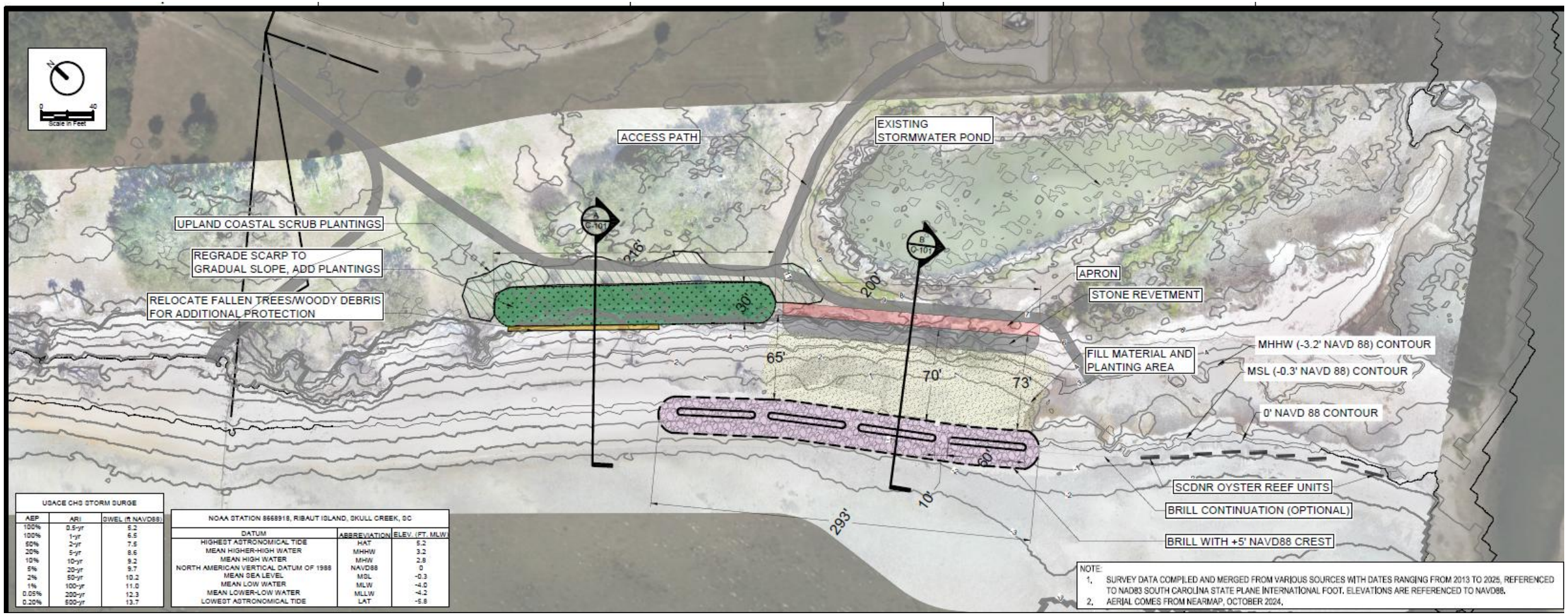

USACE CH3 STORM SURGE

AEP	ARI	SWEL (ft NAVD88)
100%	0.5-yr	5.2
100%	1-yr	6.5
50%	2-yr	7.5
20%	5-yr	8.6
10%	10-yr	9.2
5%	20-yr	9.7
2%	50-yr	10.2
1%	100-yr	11.0
0.05%	200-yr	12.3
0.20%	500-yr	13.7

NOAA STATION 8668918, RIBAUT ISLAND, SKULL CREEK, SC

DATUM	ABBREVIATION	ELEV. (FT. MLW)
HIGHEST ASTRONOMICAL TIDE	HAT	5.2
MEAN HIGHER-HIGH WATER	MHHW	3.2
MEAN HIGH WATER	MHW	2.8
NORTH AMERICAN VERTICAL DATUM OF 1988	NAVD88	0
MEAN SEA LEVEL	MSL	-0.3
MEAN LOW WATER	MLW	-4.0
MEAN LOWER-LOW WATER	MLLW	-4.2
LOWEST ASTRONOMICAL TIDE	LAT	-5.8

NOTE:
1. SURVEY DATA COMPILED AND MERGED FROM VARIOUS SOURCES WITH DATES RANGING FROM 2013 TO 2025. REFERENCED TO NAD83 SOUTH CAROLINA STATE PLANE INTERNATIONAL FOOT. ELEVATIONS ARE REFERENCED TO NAVD88.
2. AERIAL COMES FROM NEARMAP, OCTOBER 2024.

Broad River Core Prototype Initial Design

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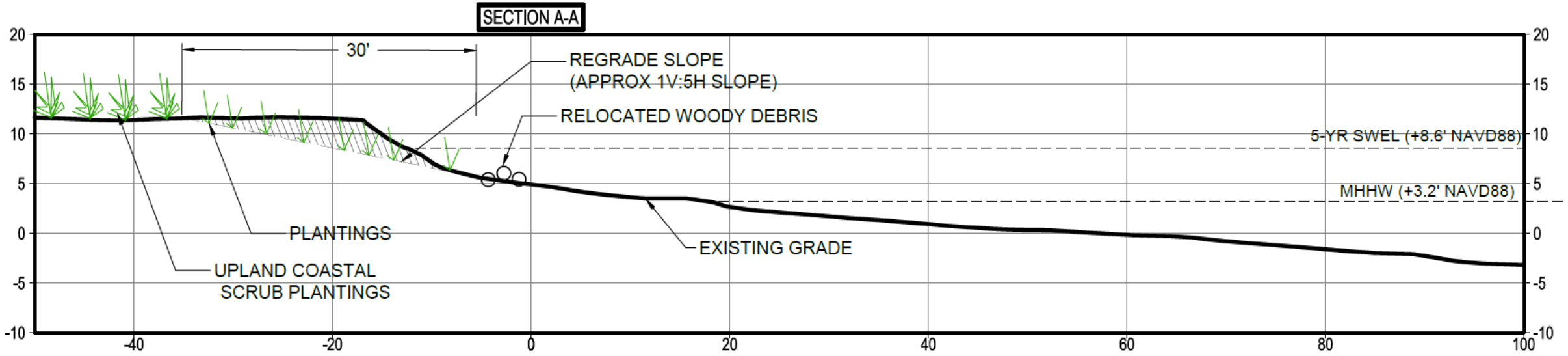

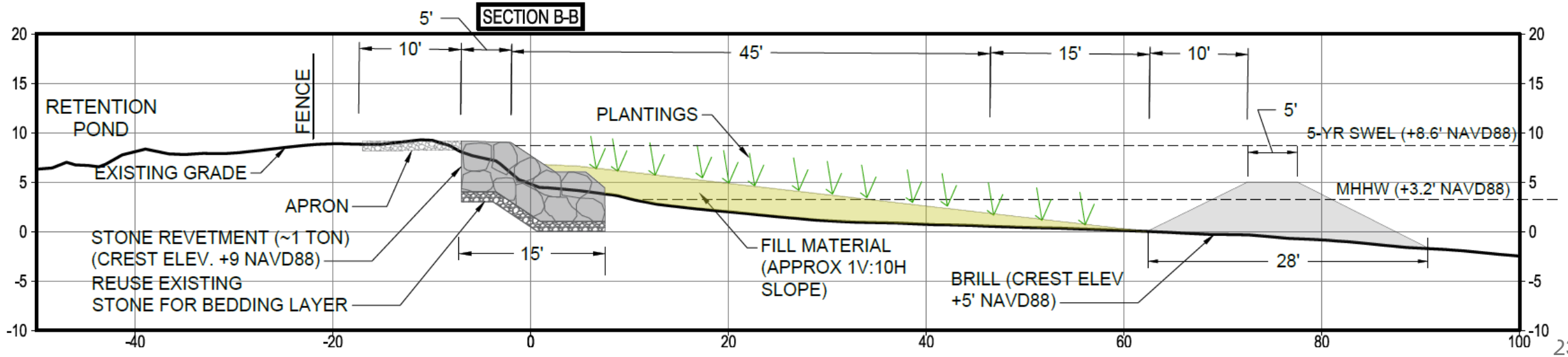

PARRIS ISLAND BROAD RIVER SHORELINE

Natural Infrastructure Core Prototype | Irregular Brill

All elevations shown in NAVD88

Rendered by Kelsey Broich, *UGA Carl Vinson Institute of Government*

PARRIS ISLAND BROAD RIVER SHORELINE

Natural Infrastructure Core Prototype | Irregular Brill

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Natural Infrastructure Core Prototype | Irregular Brill

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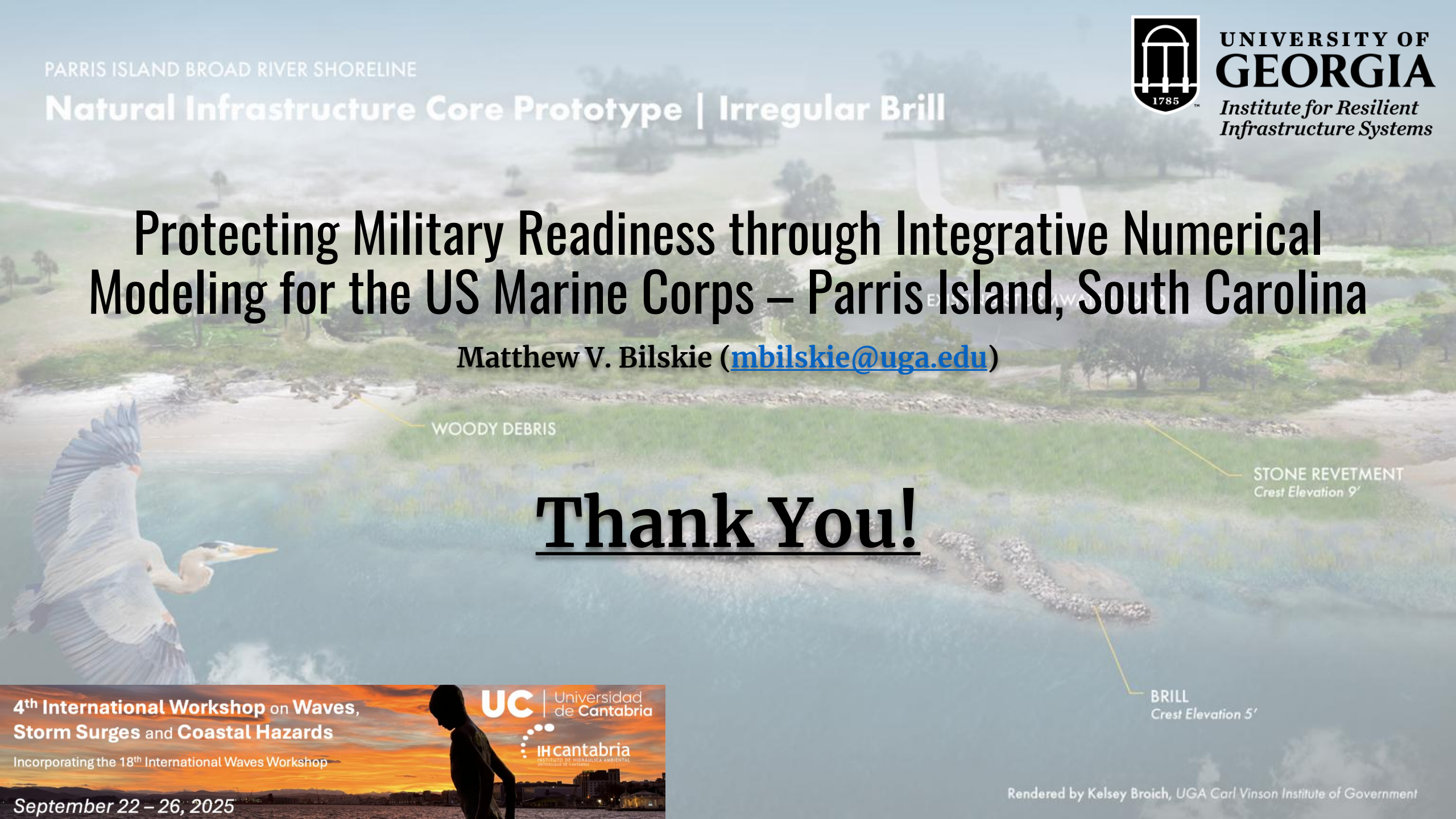

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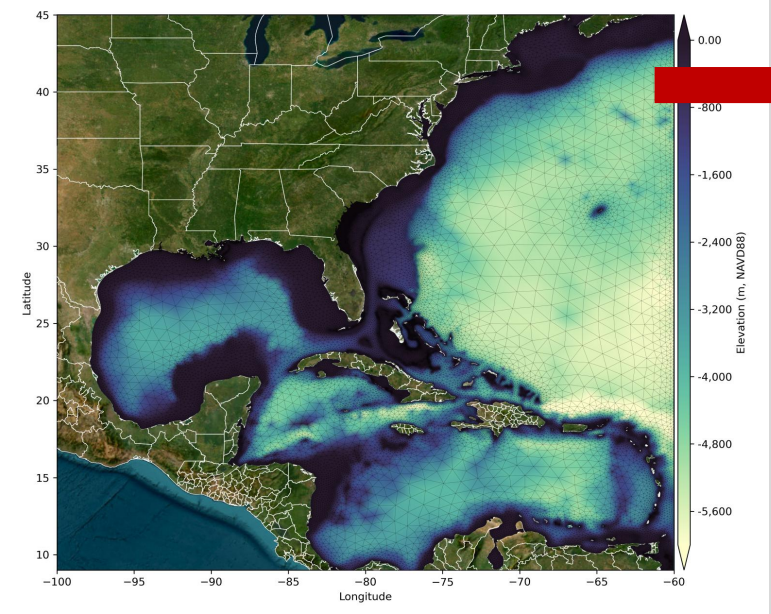
Matthew V. Bilskie (mbilskie@uga.edu)

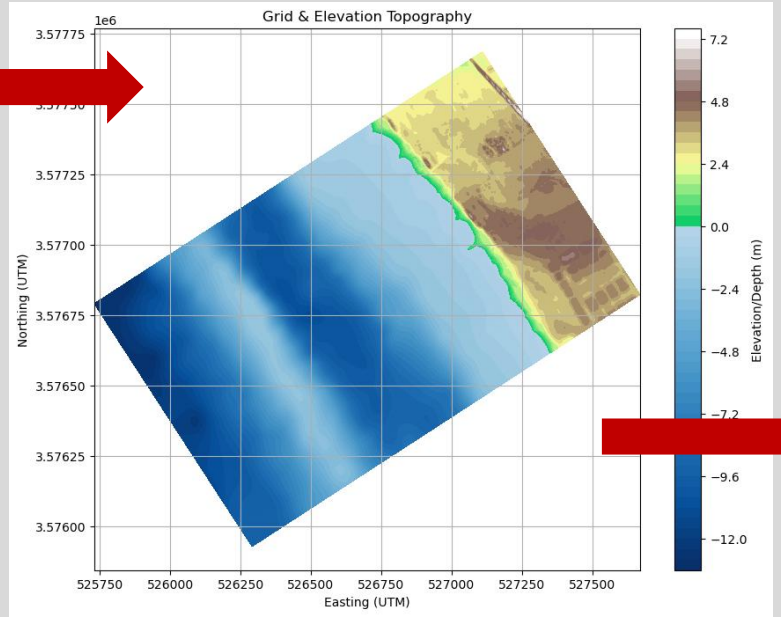
Thank You!

Numerical Modeling at Various Scales

ADCIRC+SWAN



XBeach 2D



OpenFOAM 3D