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Coastal & Marine Engineering





Wave and Storm Surge Modeling of Island Breakwaters for Hurricane Protection of Florida's Largest Marina on the Southeast Coast

FSBPA 36th Annual National Conference on Beach Preservation Technology
February 2, 2023

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Background

- In September 2017 Hurricane Irma causes extensive damage to Dinner Key Marina.
- The City of Miami, with funding from FEMA and FIND, embarks on a multi-year restoration of the Marina.
- The City of Miami requests supplementary funding from FEMA to implement a comprehensive mitigation plan to protect the marina.

Location Map

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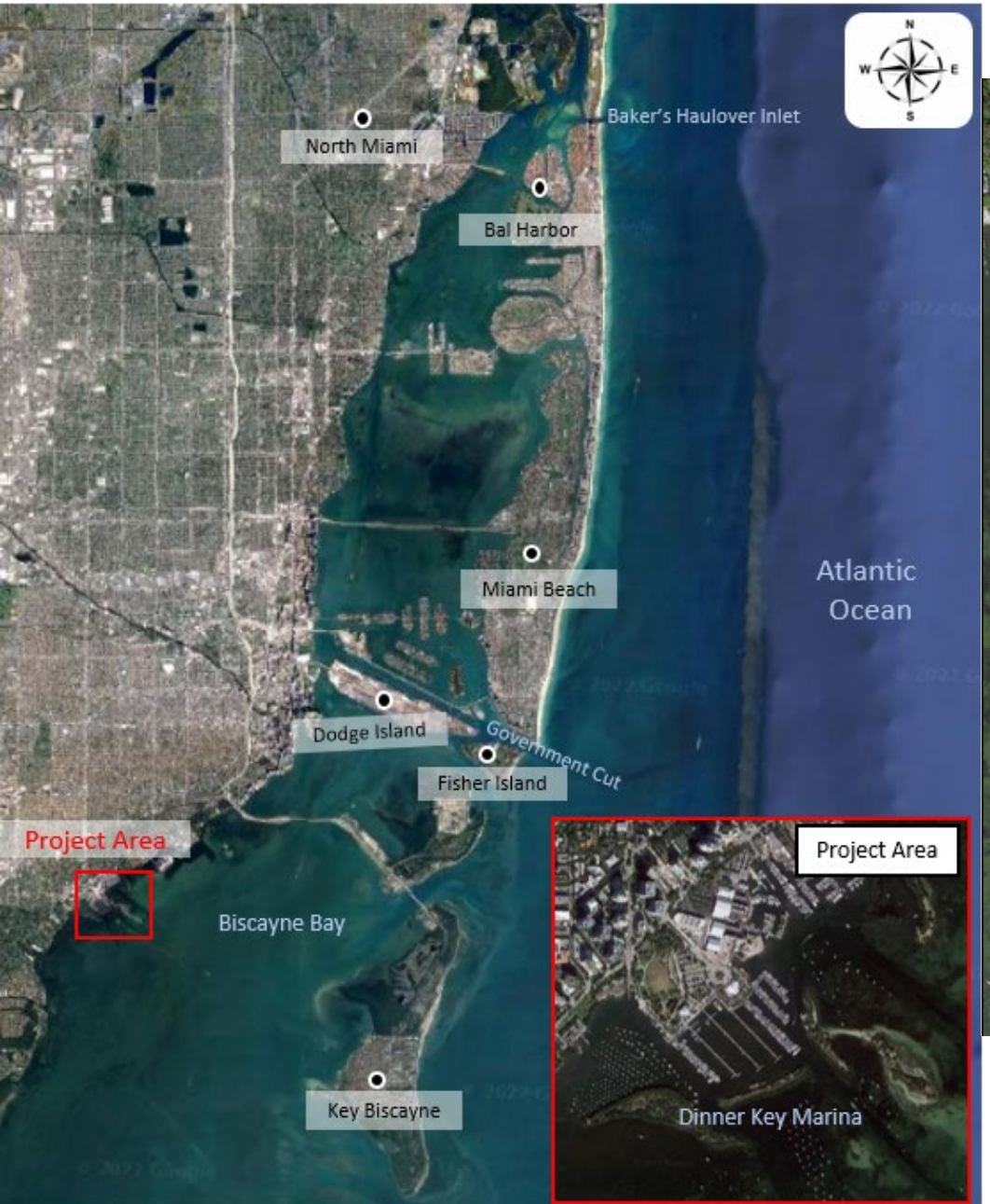

History

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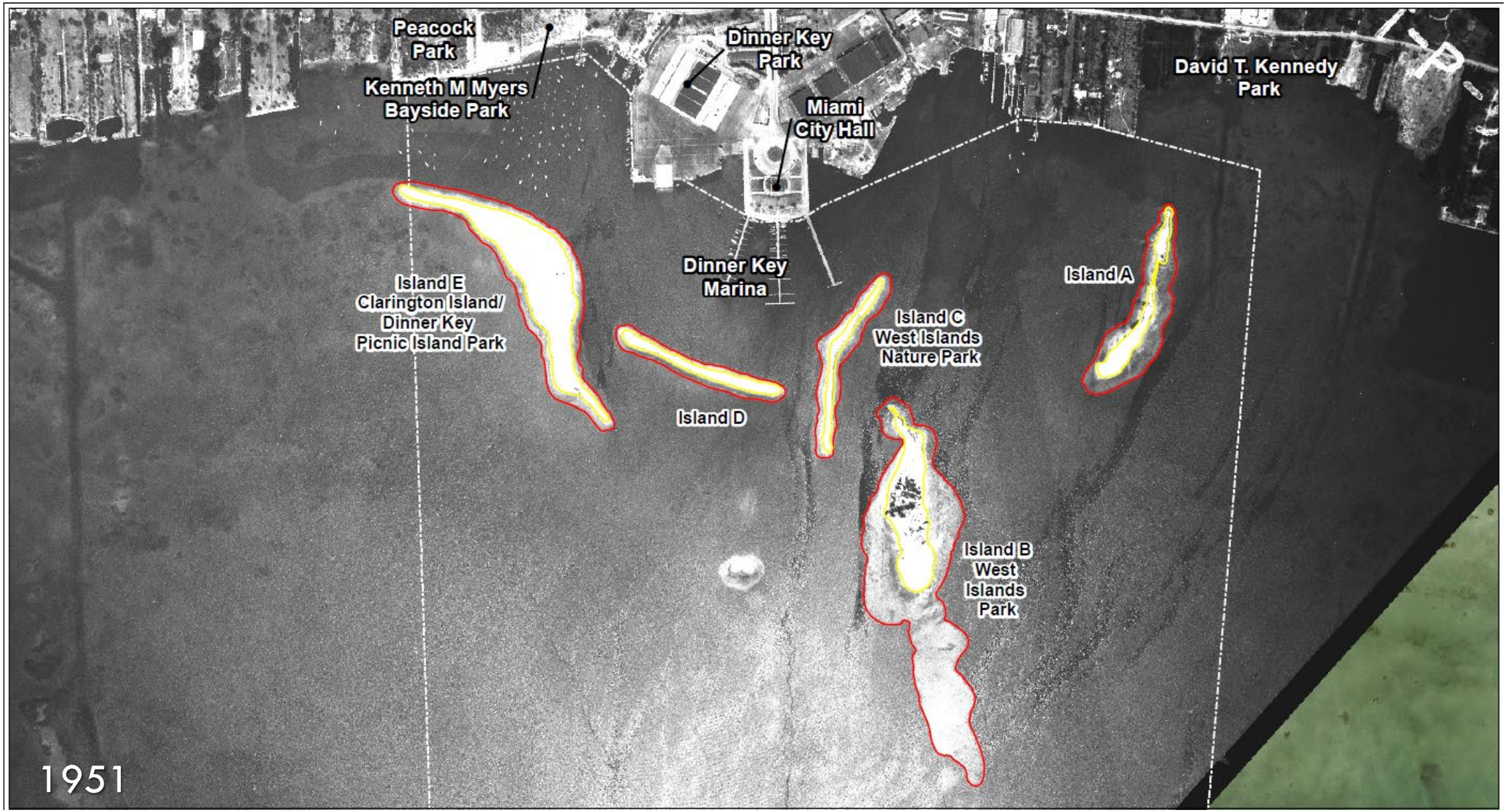
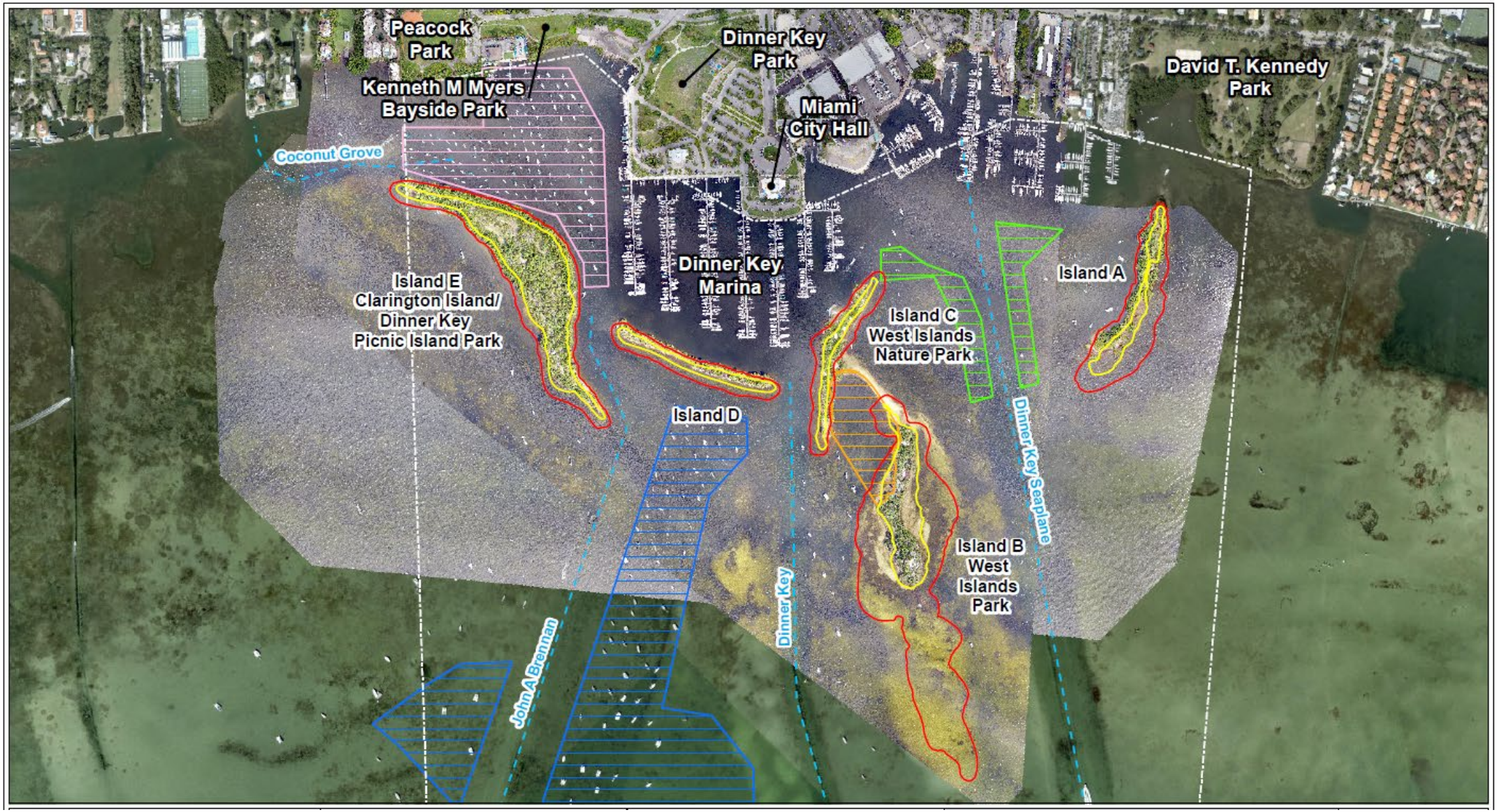

Peacock Park
Kenneth M Myers Bayside Park
Dinner Key Park
Miami City Hall
David T. Kennedy Park
Dinner Key Marina
Island E Clarington Island/ Dinner Key Picnic Island Park
Island D
Island C West Islands Nature Park
Island A
Island B West Islands Park
1951

Current Site



Hurricane Irma (2017)

- Hurricane Irma makes landfall in Monroe County as a Category 4 Hurricane.
- While the storm was almost 100 miles from the marina, impacts were still felt locally.
- The peak water elevation measure by the USGS gage at Dinner Key marina was 6.31 ft NAVD88

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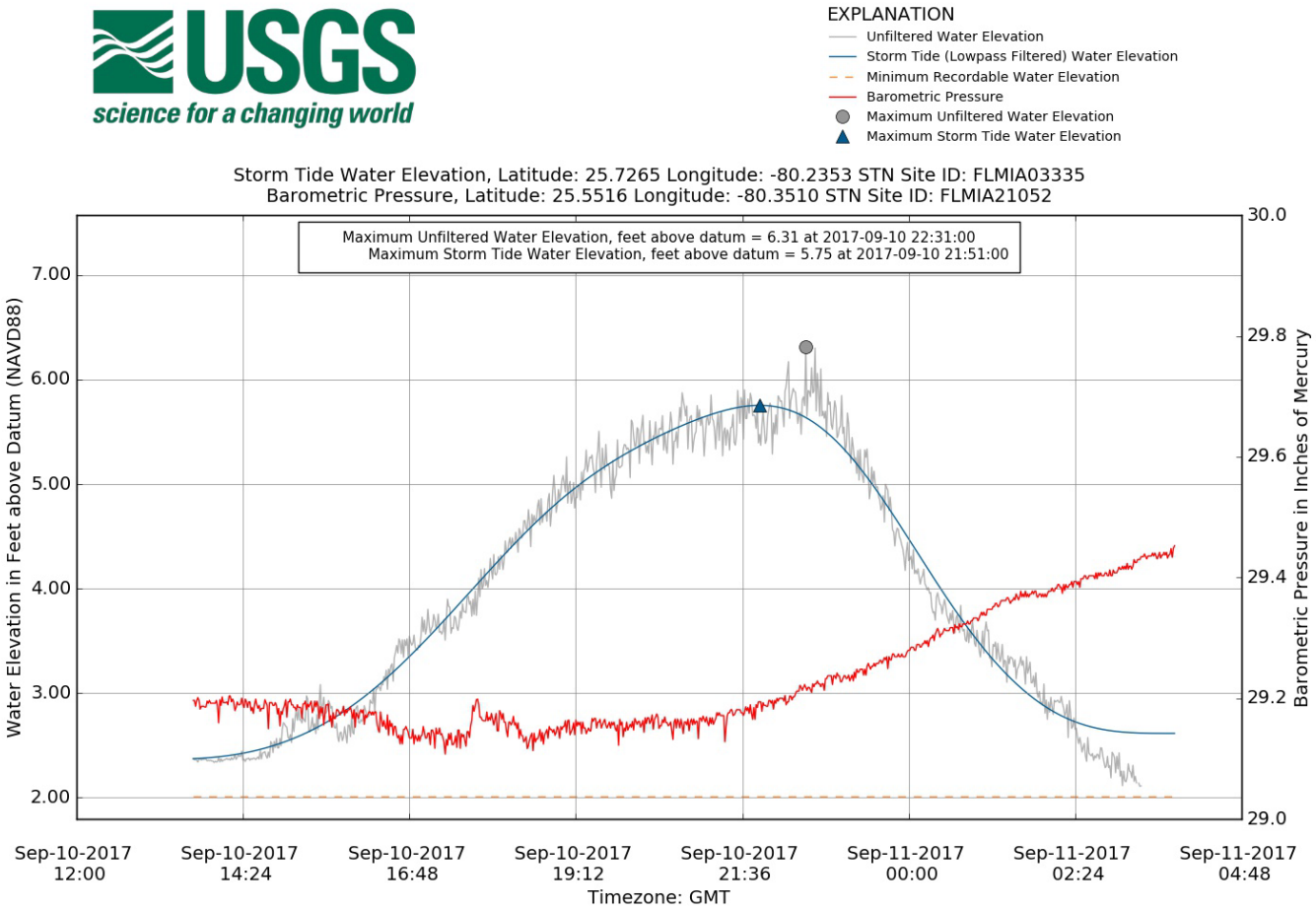

Hurricane Irma Damage

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Hurricane Irma Damage

Hurricane Irma Damage

Marina Rebuilding

- Repairs, replacements, and enhancements to the Marina culminate in 2021.
- More than $20M invested in the restoration, repair, and rebuild of Dinner Key Marina.
- An increased need to protect significant investment and a Critical Asset as defined in section 380.093, F.S.

FEMA Objectives and City Goals

- **FEMA Hazard Mitigation Proposal:** To lessen and/or prevent damages from future similar events, the City has requested supplementary 406 mitigation funding to implement a comprehensive mitigation plan to ***protect the marina and moorage***. This plan consists of ***strengthening and hardening of existing and repaired structures as well as comprehensive shoreline protection measures.***

- **City of Miami**: Prepare three conceptual plans, of varying levels of design, showing the ***layout of proposed improvements for all five islands*** and potential additional features such as islands or rock breakwaters. The plans will also ***include new design amenities*** for the islands, as well as ***innovative concepts to increase the overall resilience*** and protection the islands offer to the region.

Site Conditions - Spoil Island Elevations

- Spoil islands are relatively low in elevation, ranging from 0 to 3 ft NAVD88.
- MHHW approximately 0.2 ft NAVD88
- King Tide Elevations observed up to +2.2 ft NAVD88
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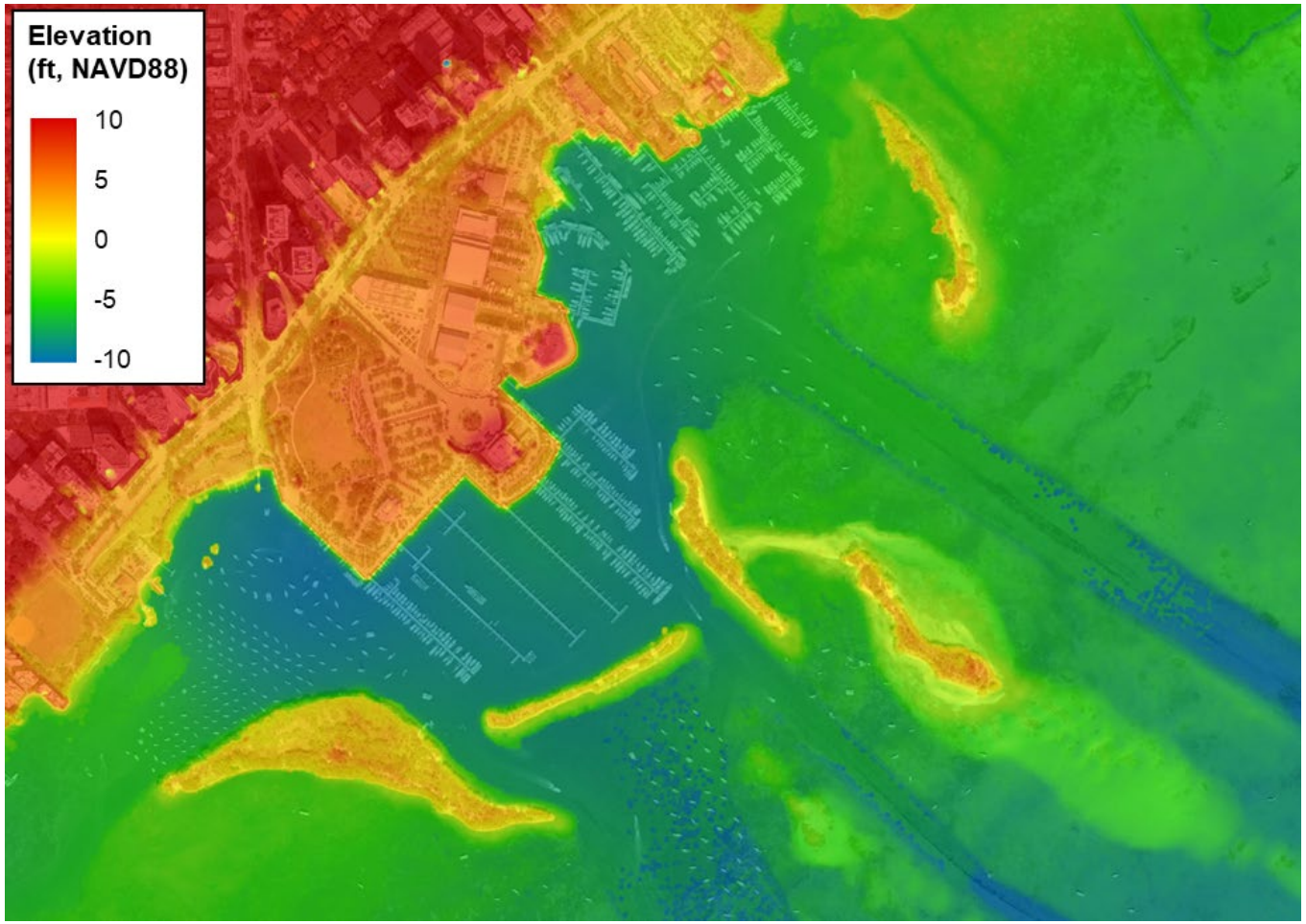
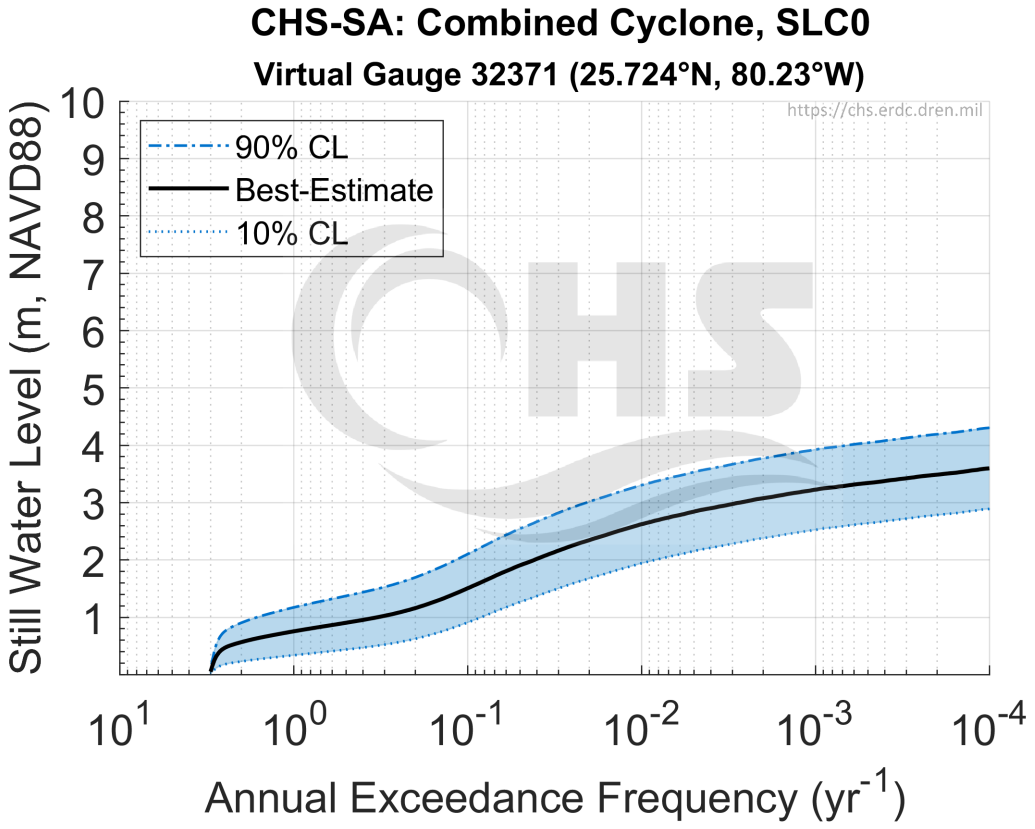


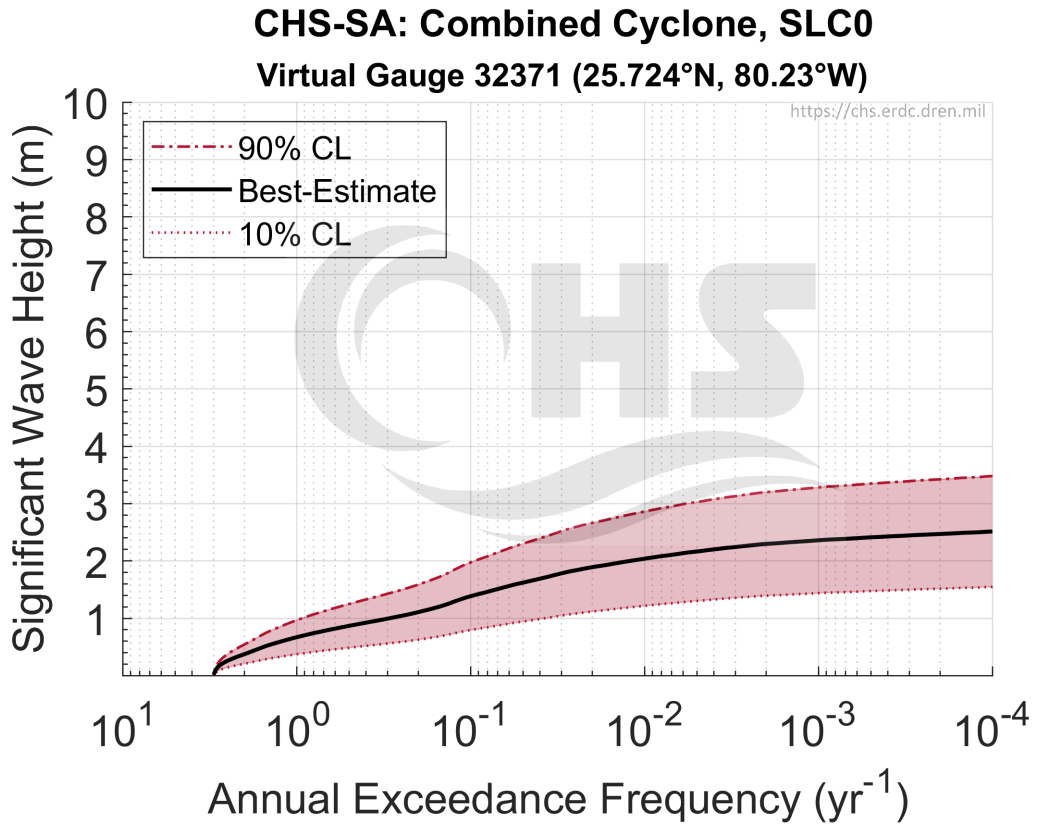
Site Conditions – Environmental Resources

- Spoil Islands contain different vegetation types
  - Red, Black, and White Mangroves.
  - Buttonwoods, Seagraves
- Seagrass beds located nearshore of the spoil islands
- Marina located within the Biscayne Bay Aquatic Preserve
- Site is subject to regulatory criteria from USACE, FDEP, and Miami-Dade DERM

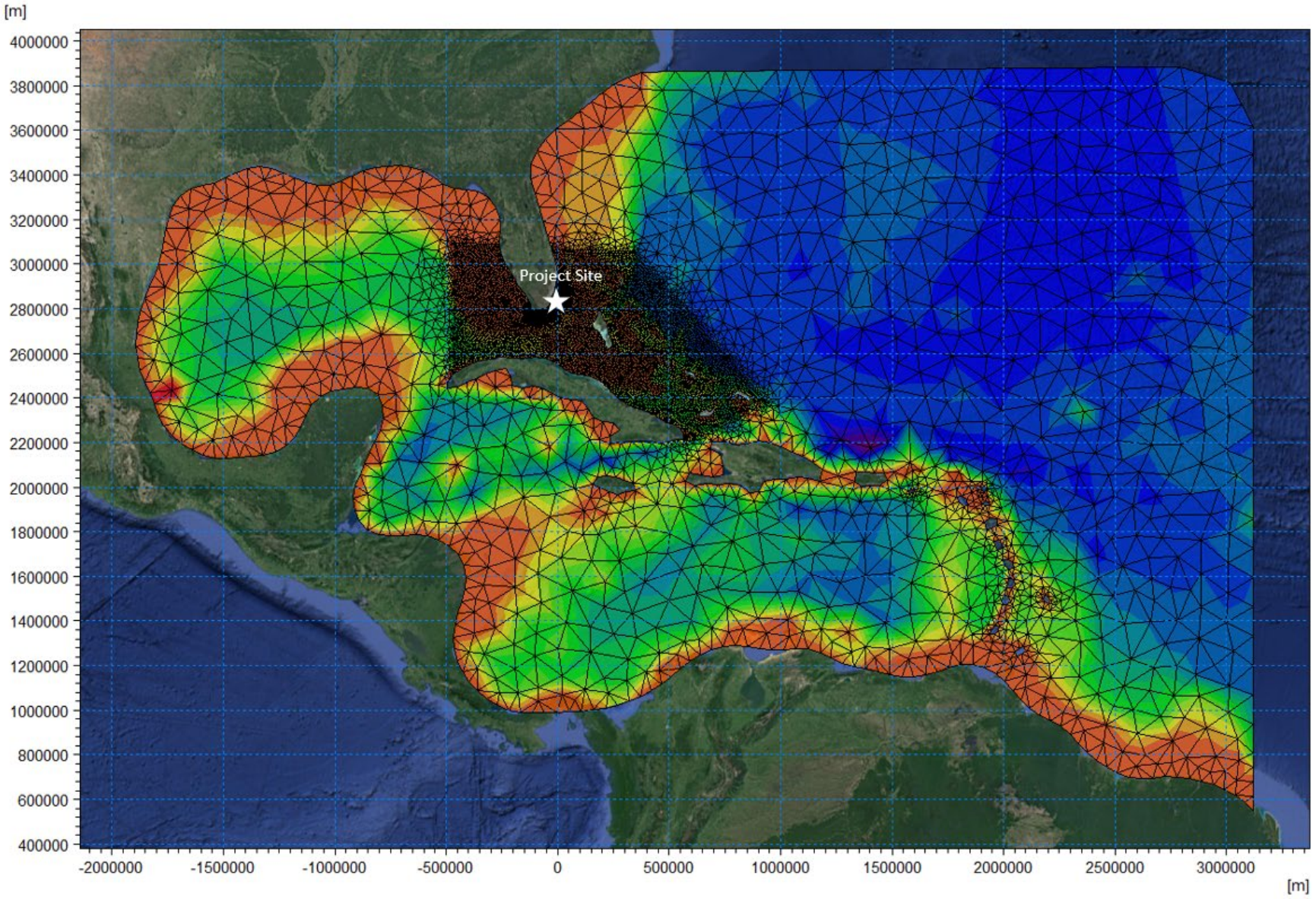
Return Period Storm Values

Flood Source	Coastal Transect	Starting Wave Conditions for the 1% Annual Chance		Starting Stillwater Elevations (ft NAVD88) Range of Stillwater Elevations (ft NAVD88)				
		Significant Wave Height H_s (ft)	Peak Wave Period T_p (sec)	10% Annual Chance	4% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Biscayne Bay	177	6.4	4.4	3.3 3.3-3.5	3.8 3.8-3.9	7.9 7.8-8.2	9.4 8.9-9.6	12.4 11.8-12.4

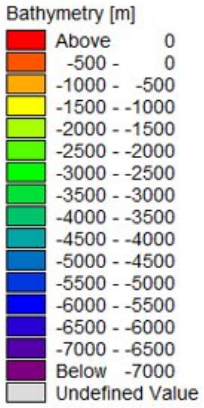




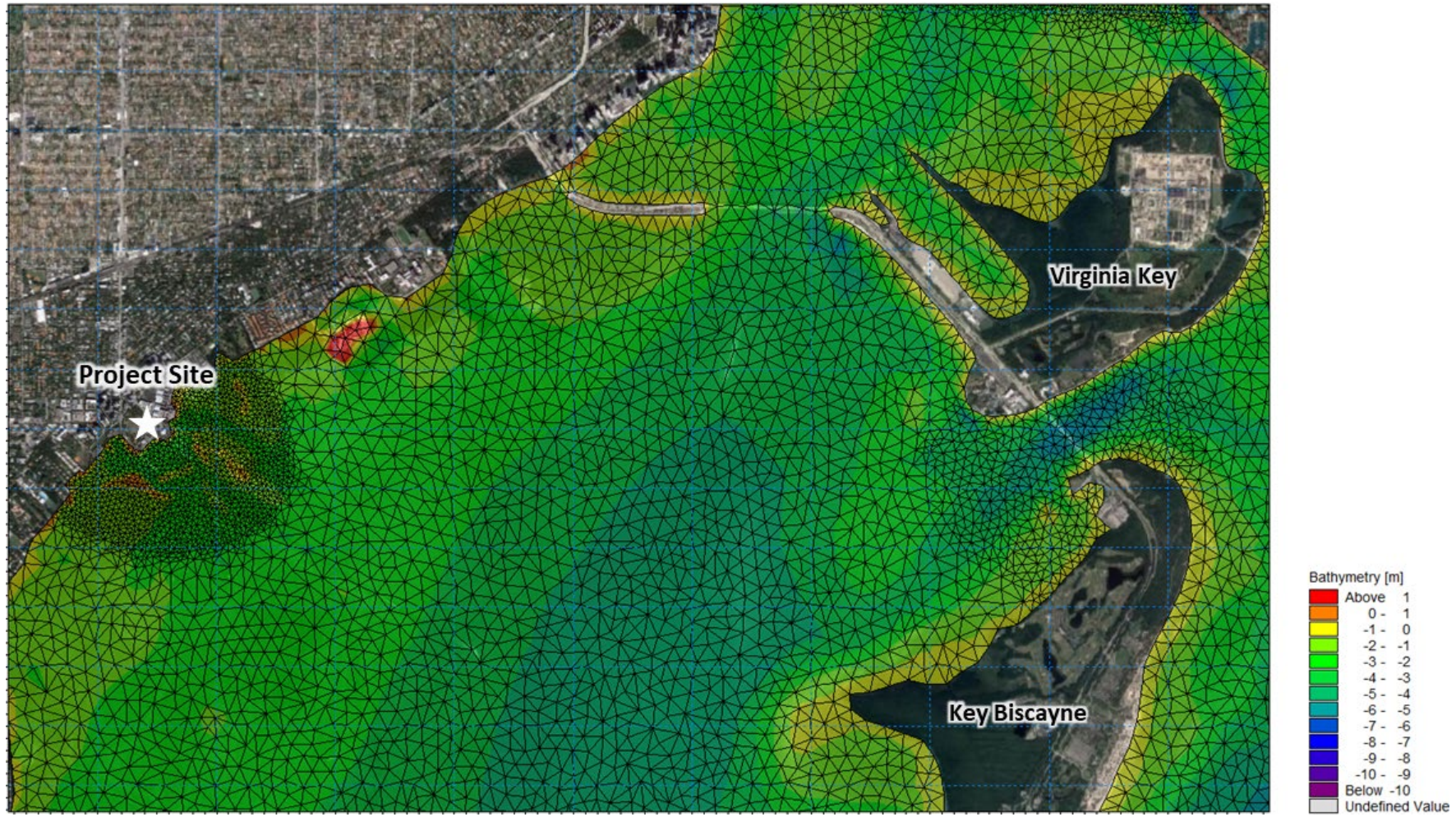
Storm Surge Modeling – Regional Mesh



- Atlantic, Gulf And Caribbean
- Numerical Model Mesh
- Fine resolution in areas of interest to resolve hurricane wind speeds
- Calibrated to historical storms



Storm Surge Modeling - Mesh



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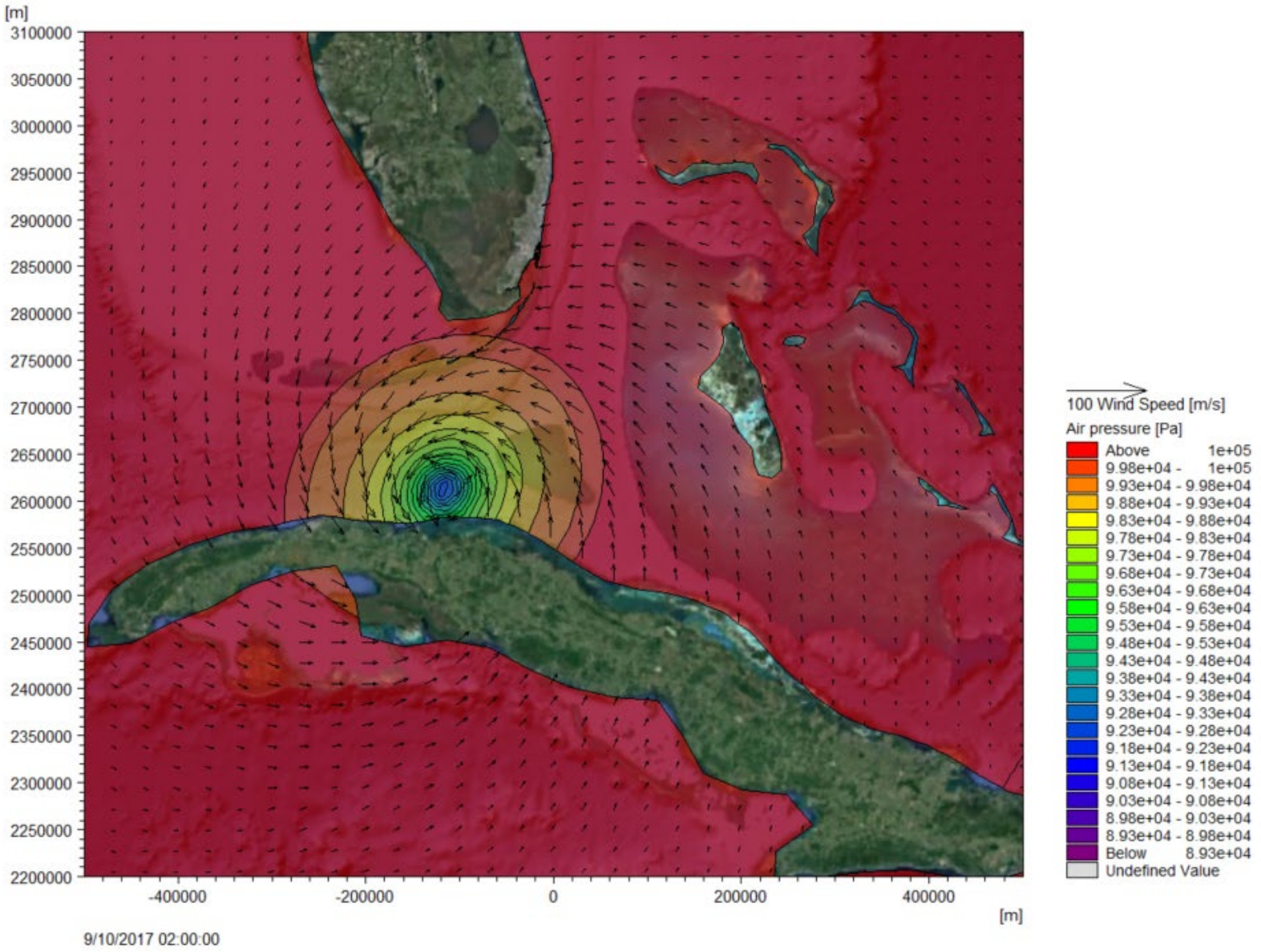
Storm Surge Modeling – Cyclone Generation



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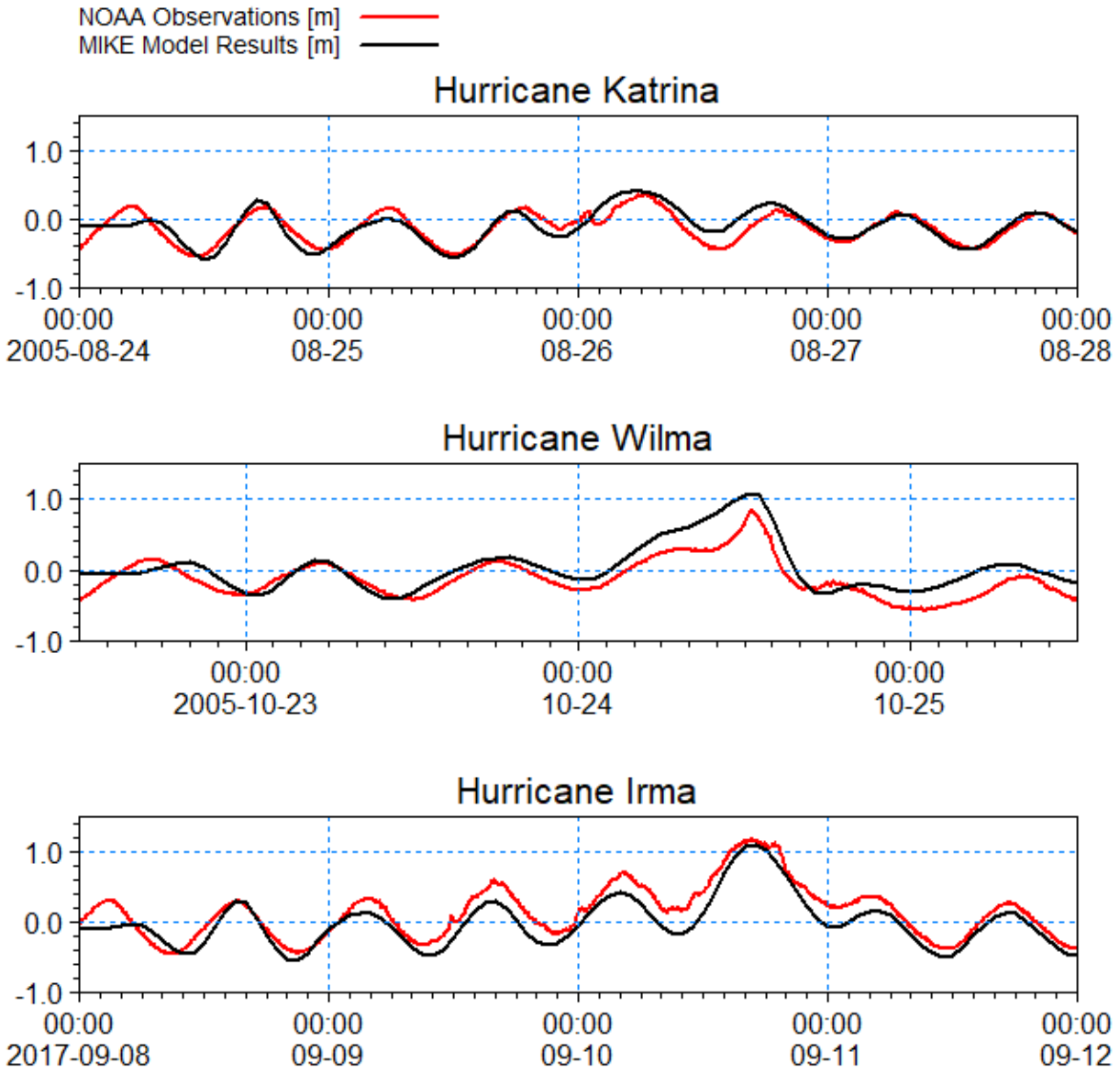
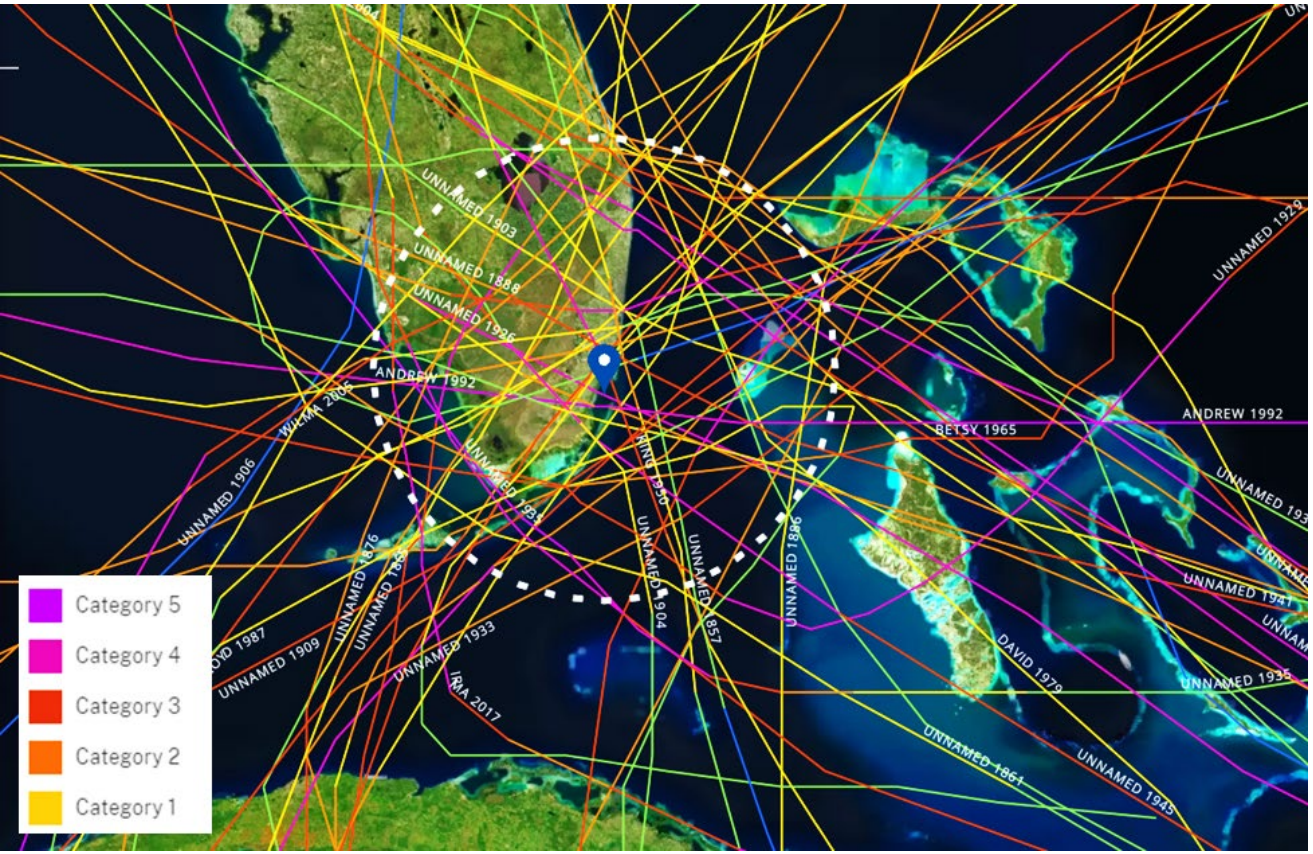
Storm Surge Modeling



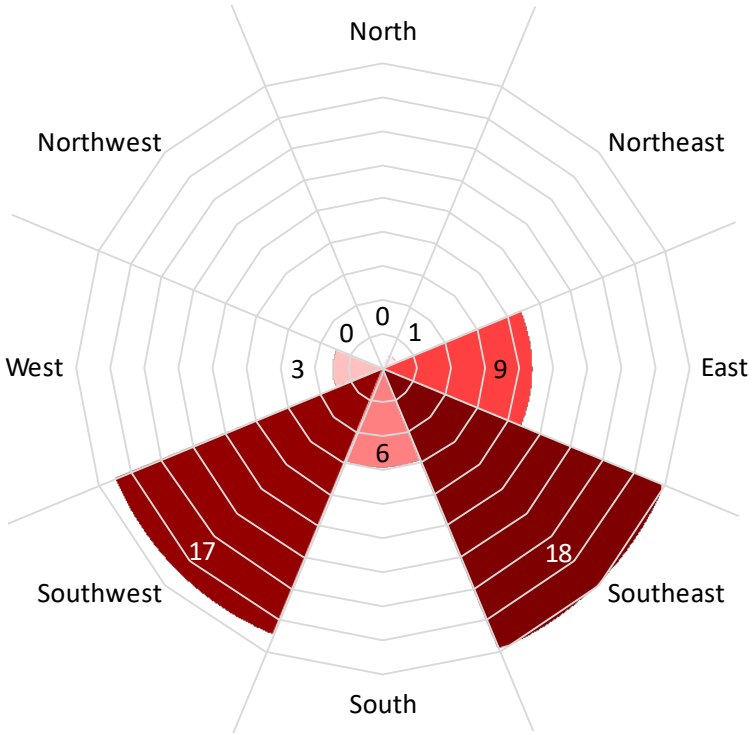
- Atlantic, Gulf And Caribbean
- Numerical Model Mesh
- Fine resolution in areas of interest to resolve hurricane wind speeds
- Calibrated to historical storms, Katrina, Wilma, and Irma

Directionality Considerations



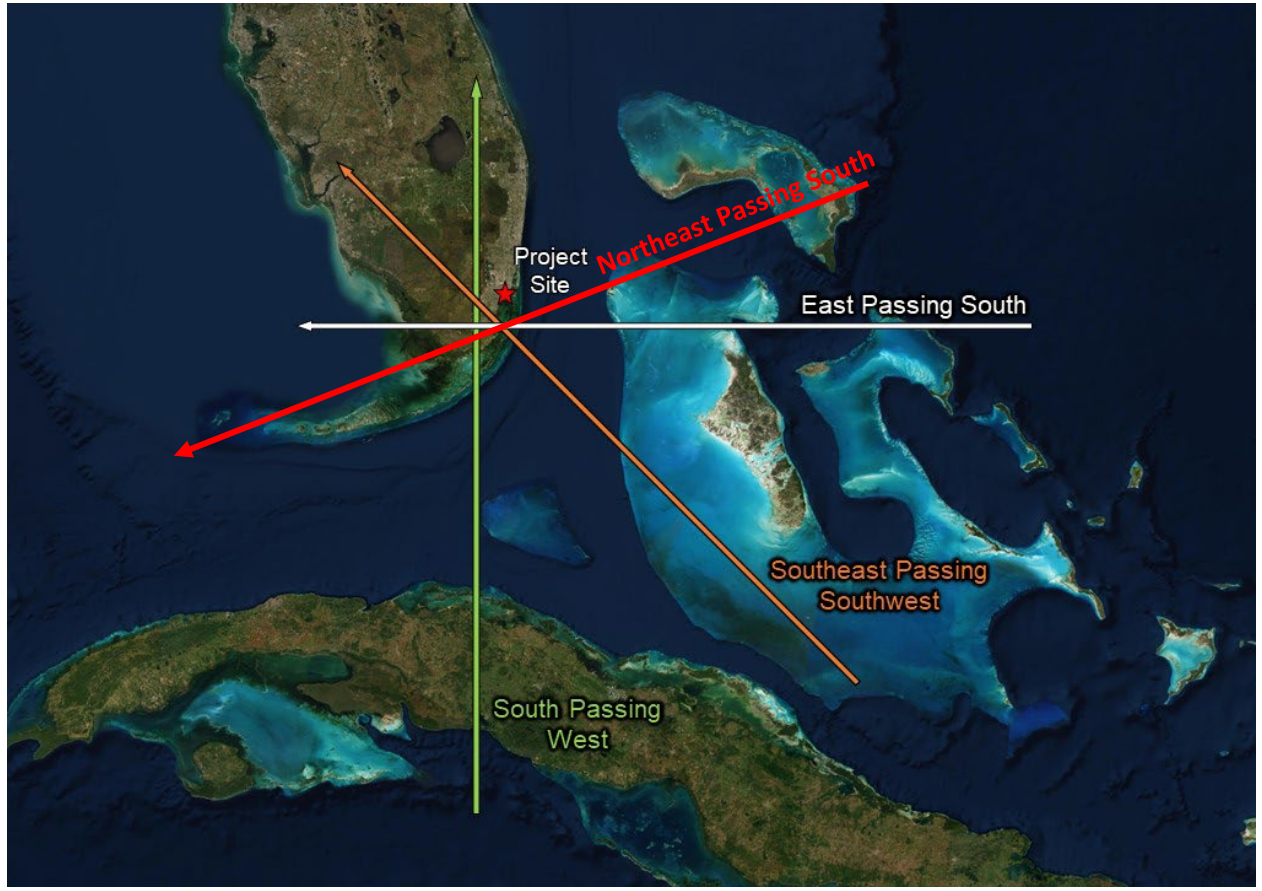
- Hurricane approach and direction has a significant effect on the impacts of the storm.
- The shape of the water body impacted by the hurricane is also sensitive to the path or direction of the hurricane winds

Directionality Considerations



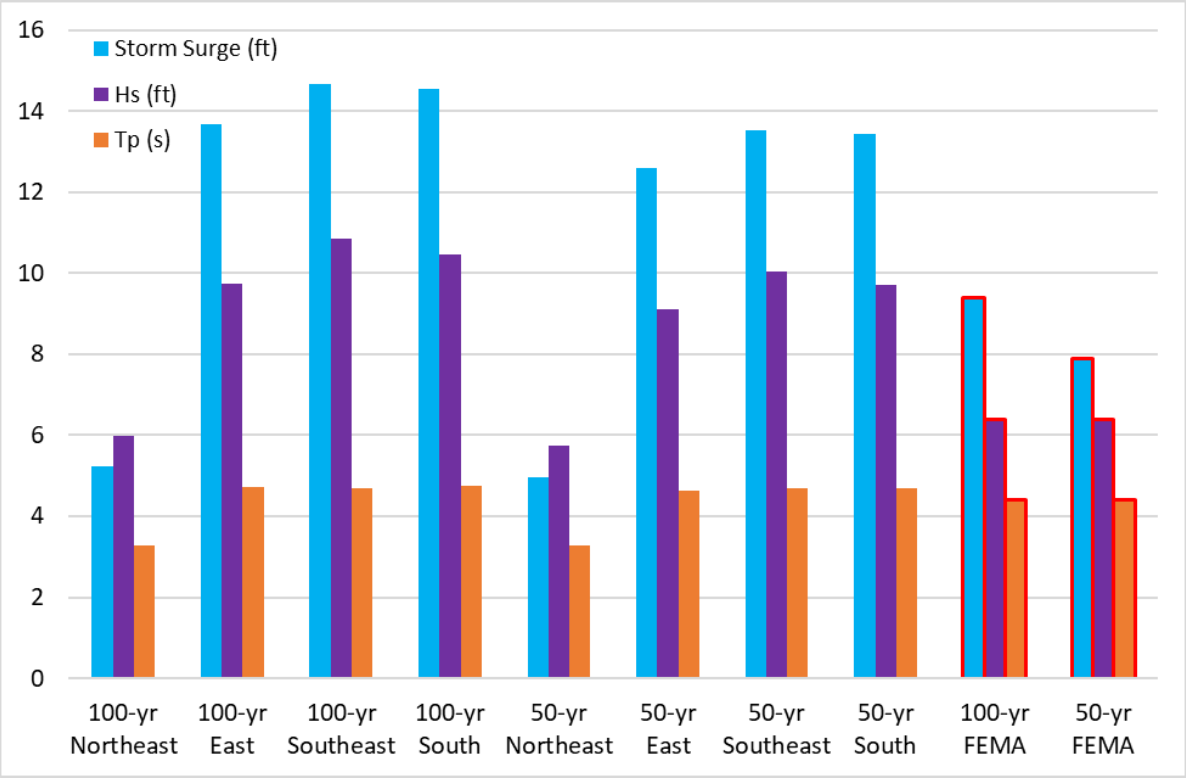
- Analysis of direction of 54 hurricanes within a 100-mile radius.
- Most frequent directions are southwest and southeast.

Synthetic Cyclone Tracks



- Three hurricane tracks were selected to model synthetic cyclone tracks.
- The tracks evaluate a worst case scenario approach, with the synthetic storms approaching the site with the maximum wind speeds.
- Return period winds determined with statistical analyses of historical storms within 100-mi radius

Storm Surge and Wave Modeling Results



- Synthetic return periods are relative to statistical winds; directions assume a worst-case approach at the marina.
- Directionality trends are identified for storms; northeast approaches not of primary concern.

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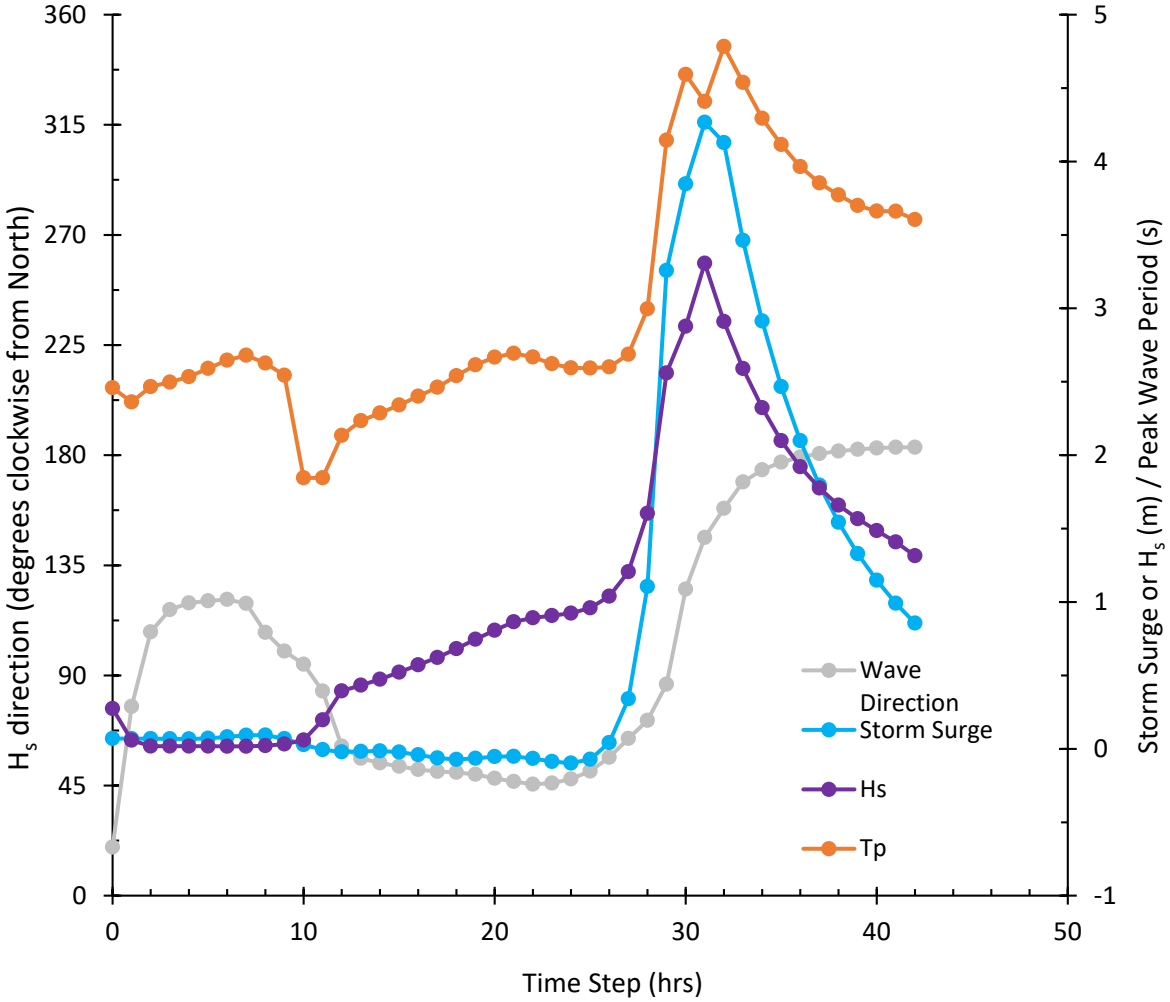
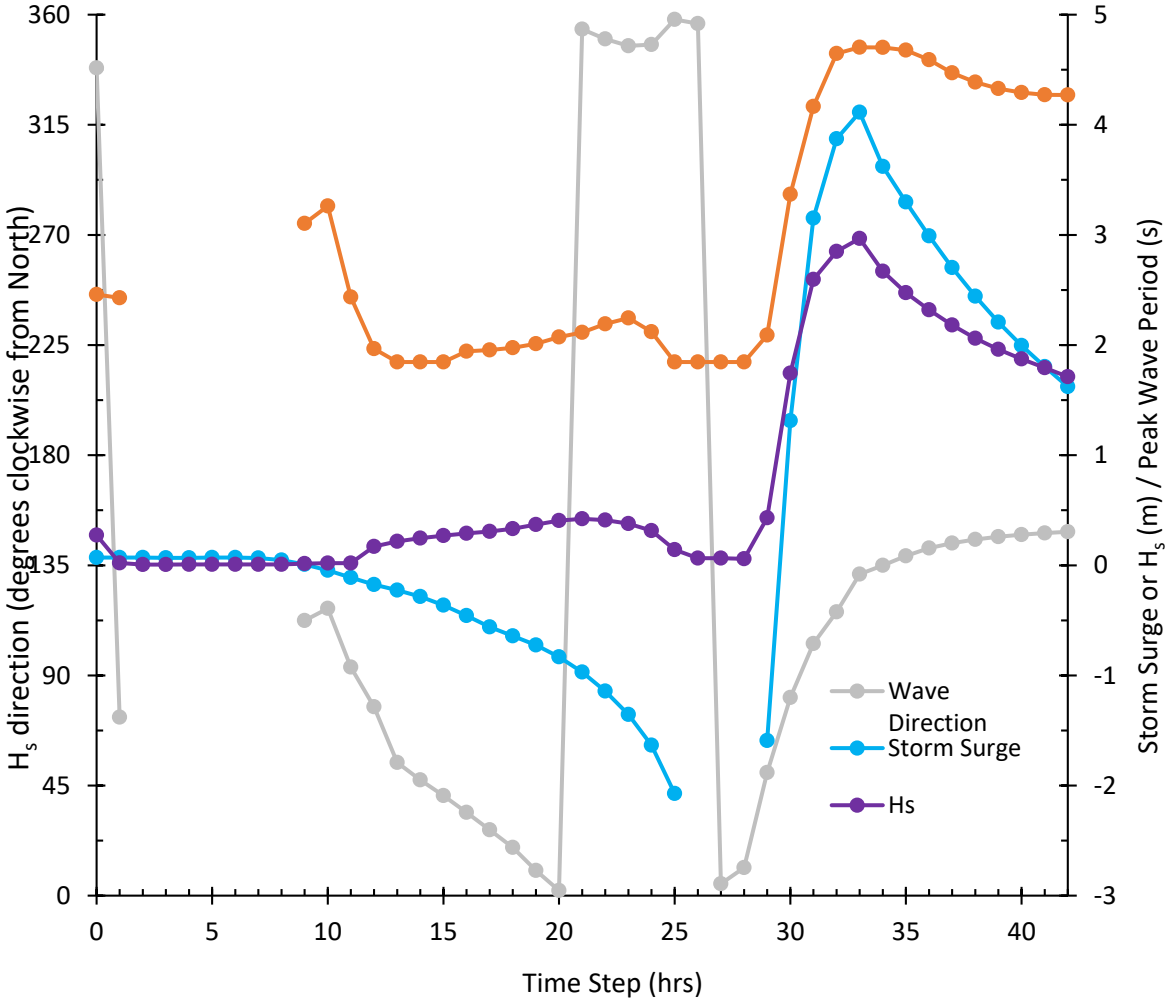


- 100-year southeast storm

- Timeseries results provide an output for how storm surge, wave direction, and period varies with the approach.
- Different wave conditions and directions were observed for different approaches

Storm Surge and Wave Modeling Results



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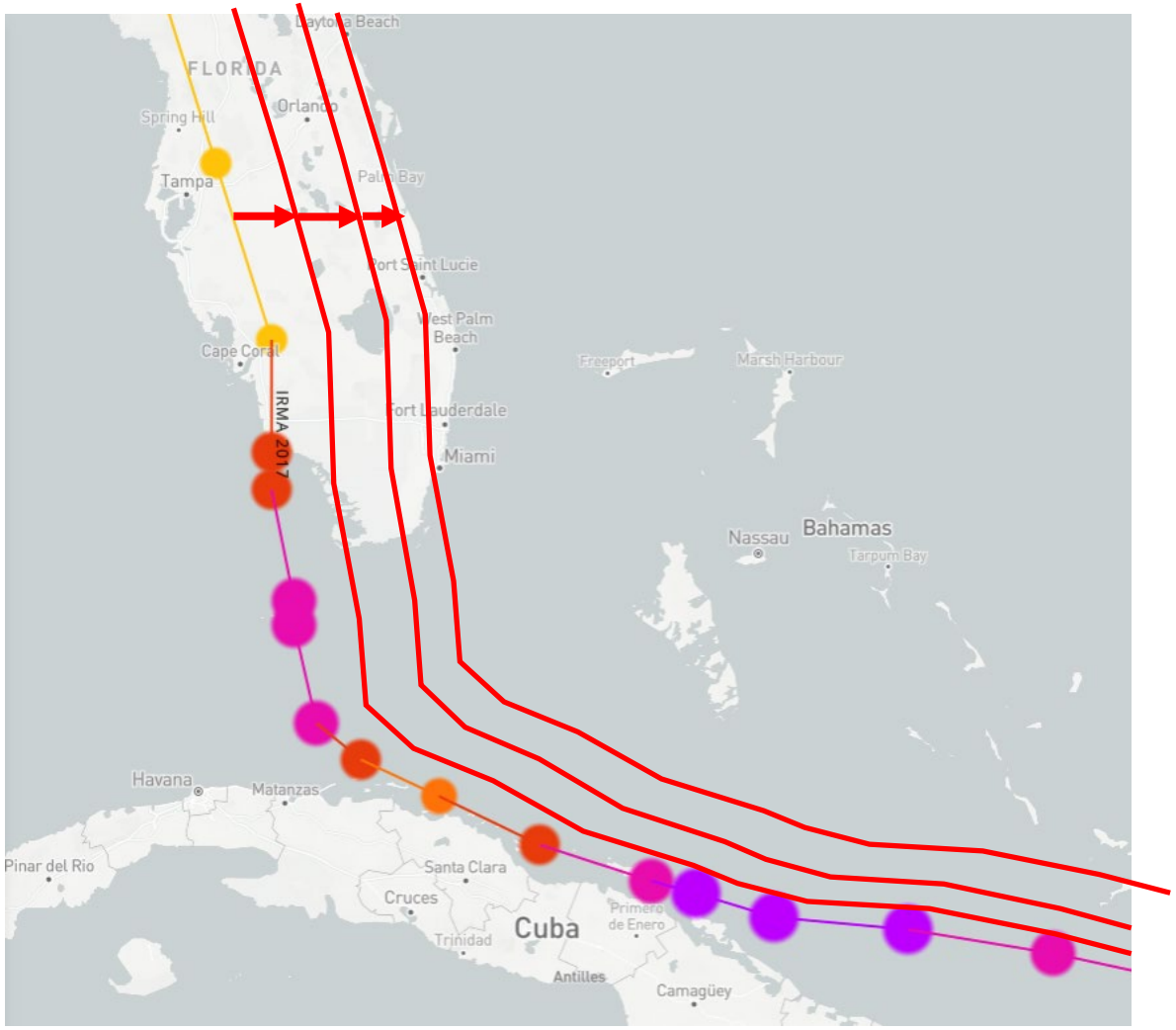
Storm Surge Variation – Proximity

- As a case study sample, Hurricane Irma was selected to evaluate the impact of proximity on storm surge values.



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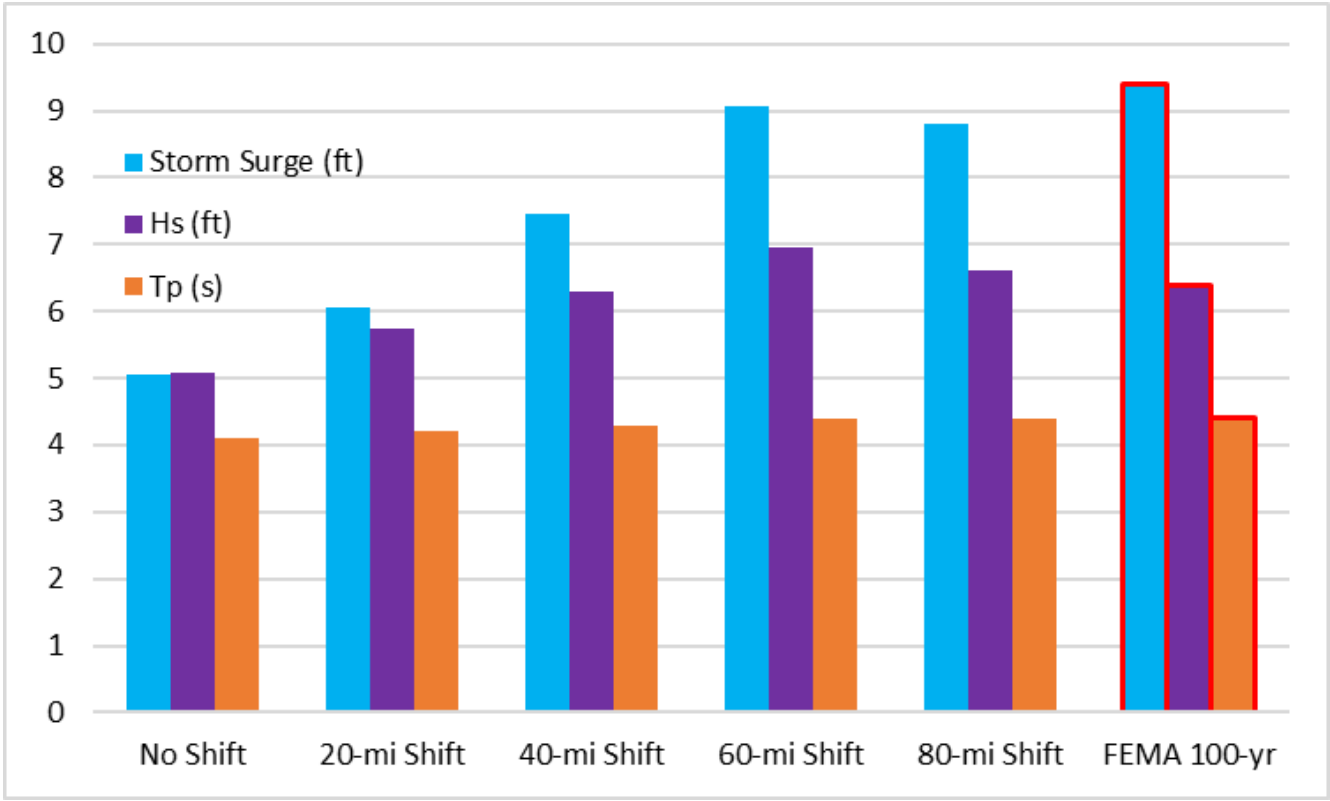

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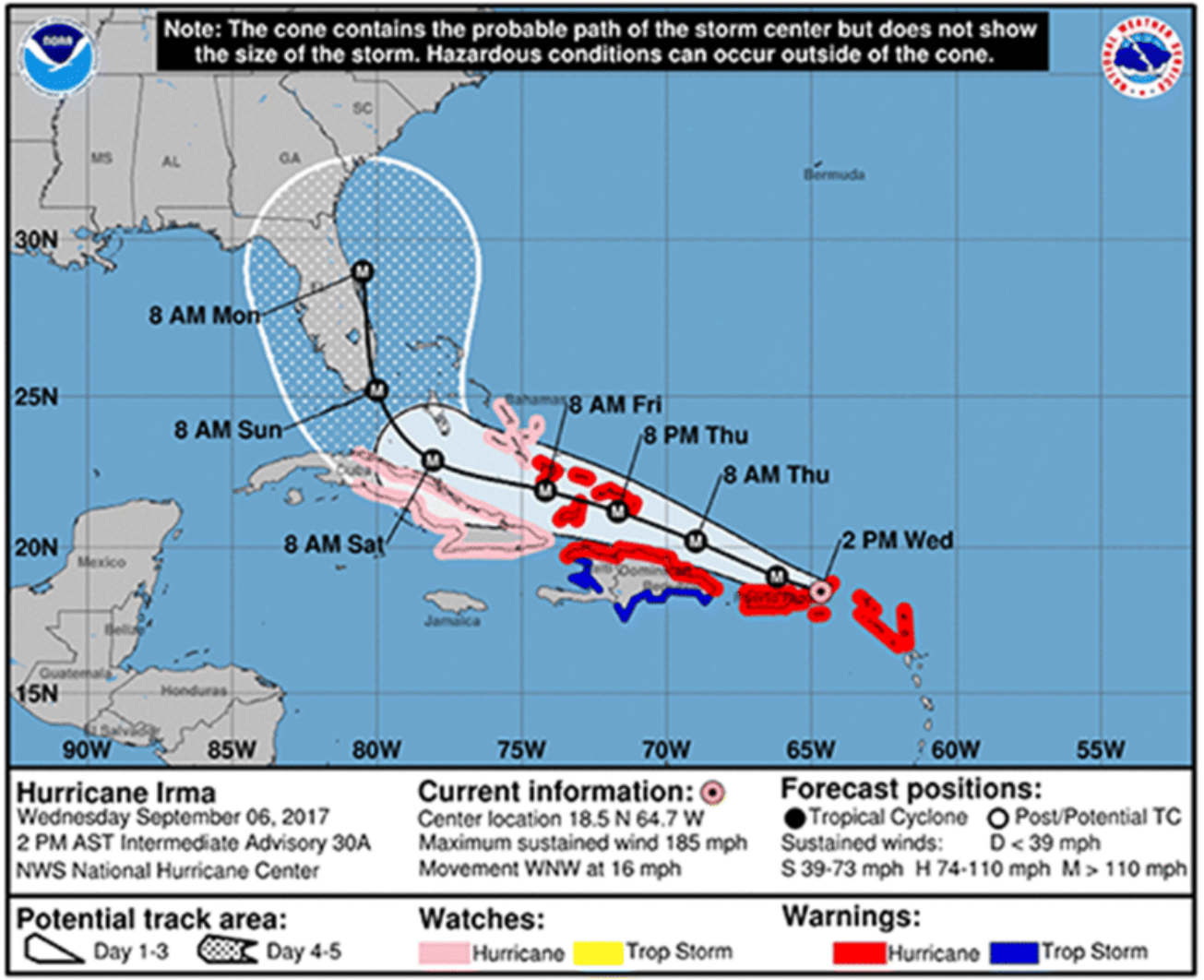
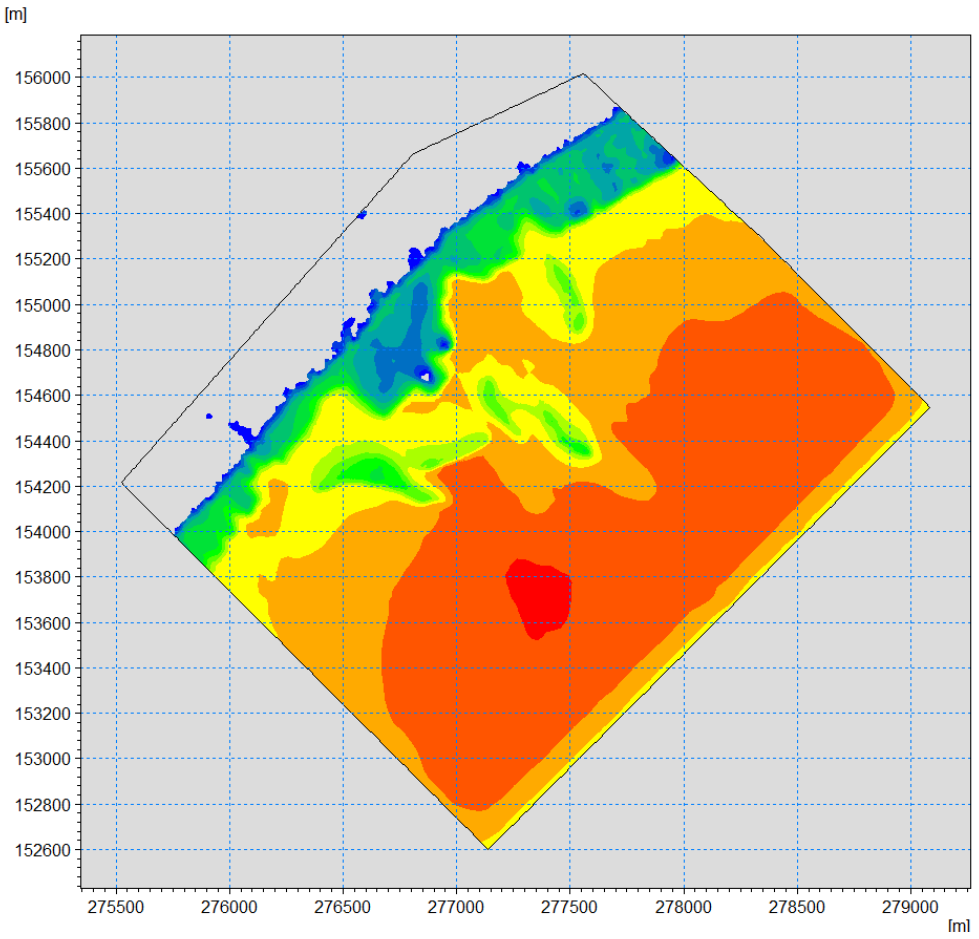
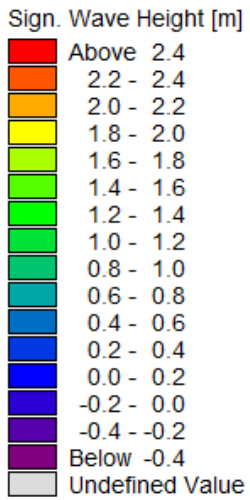
- The results of the shift indicate the proximity of the storm plays an important role in the storm surge values.
- This illustrates the significant risks associated with the uncertainty of the storms.



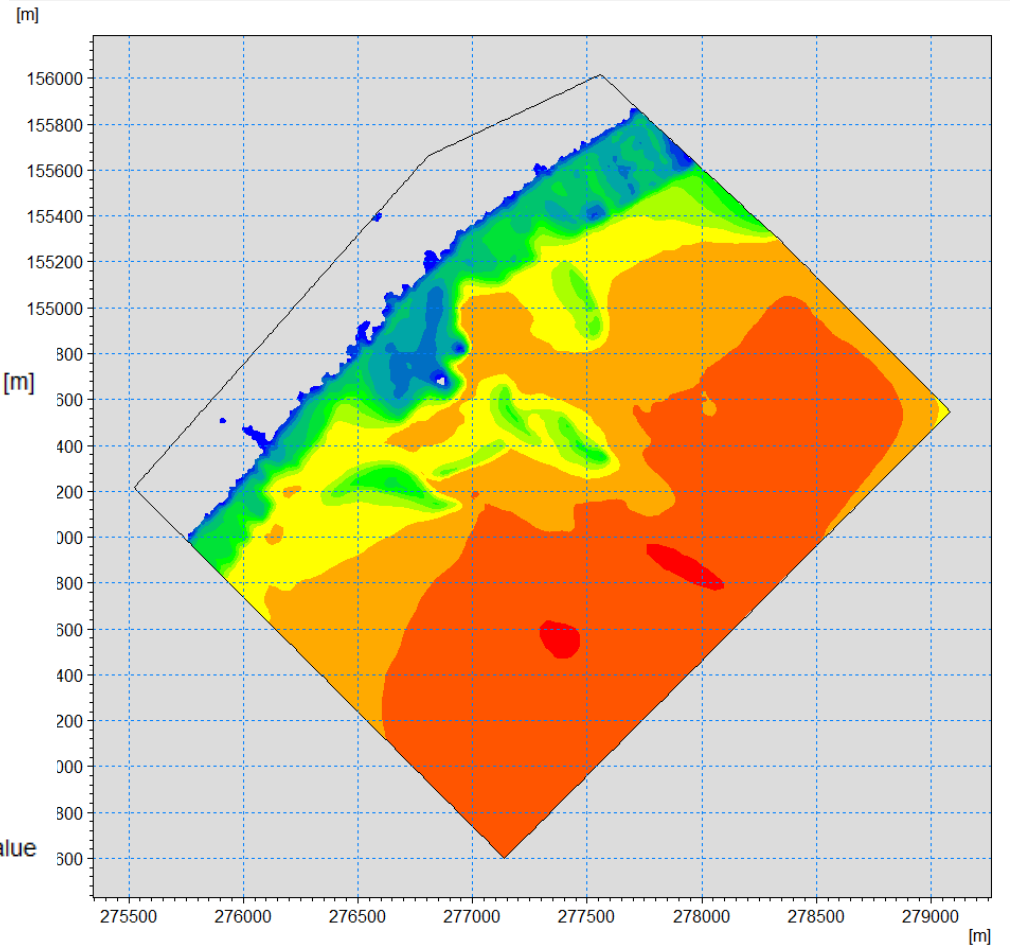
Waves Under Existing Conditions – Wave Height

100-year Southeast Conditions



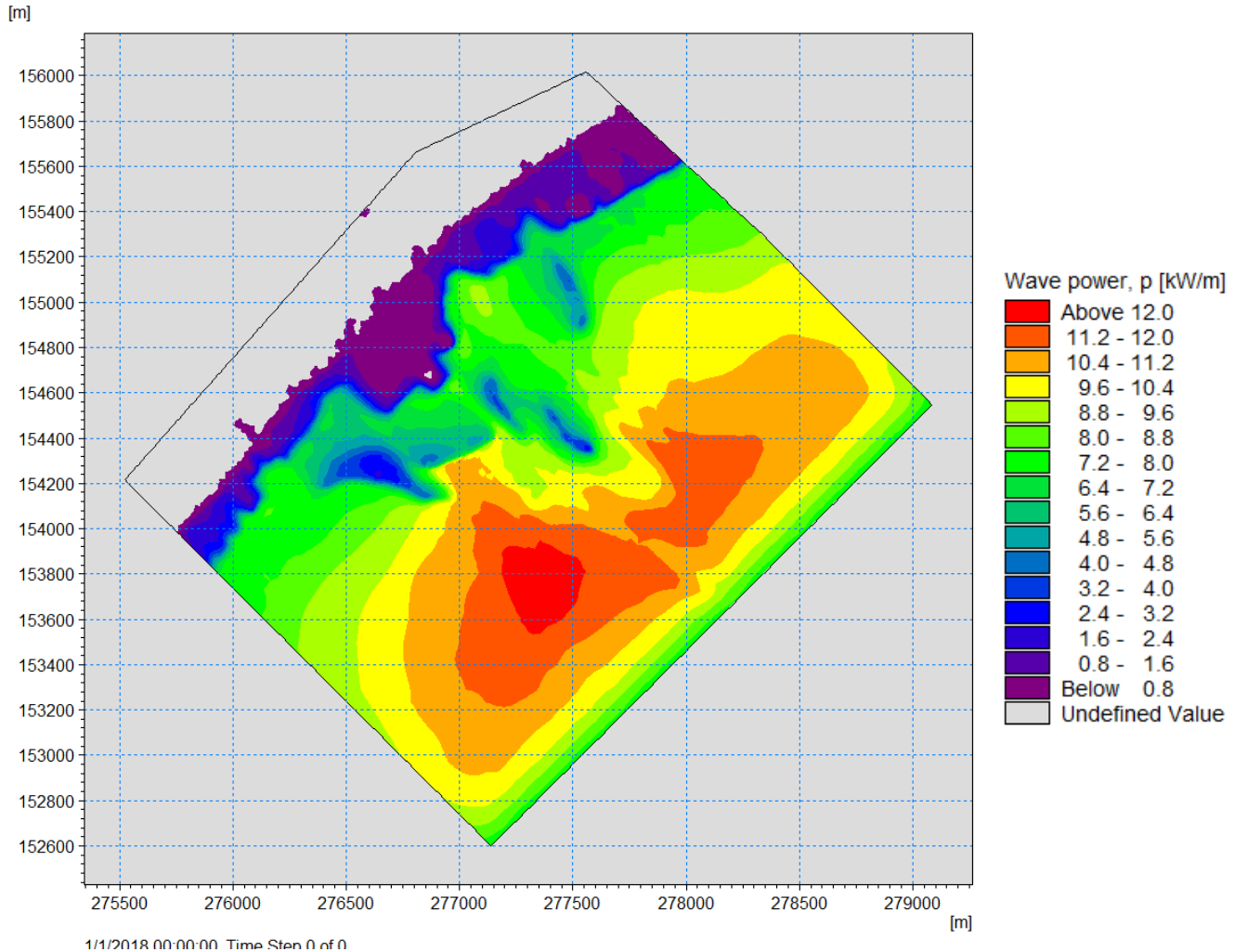


100-year East Conditions



Waves Under Existing Conditions – Wave Power

100-year Southeast Conditions



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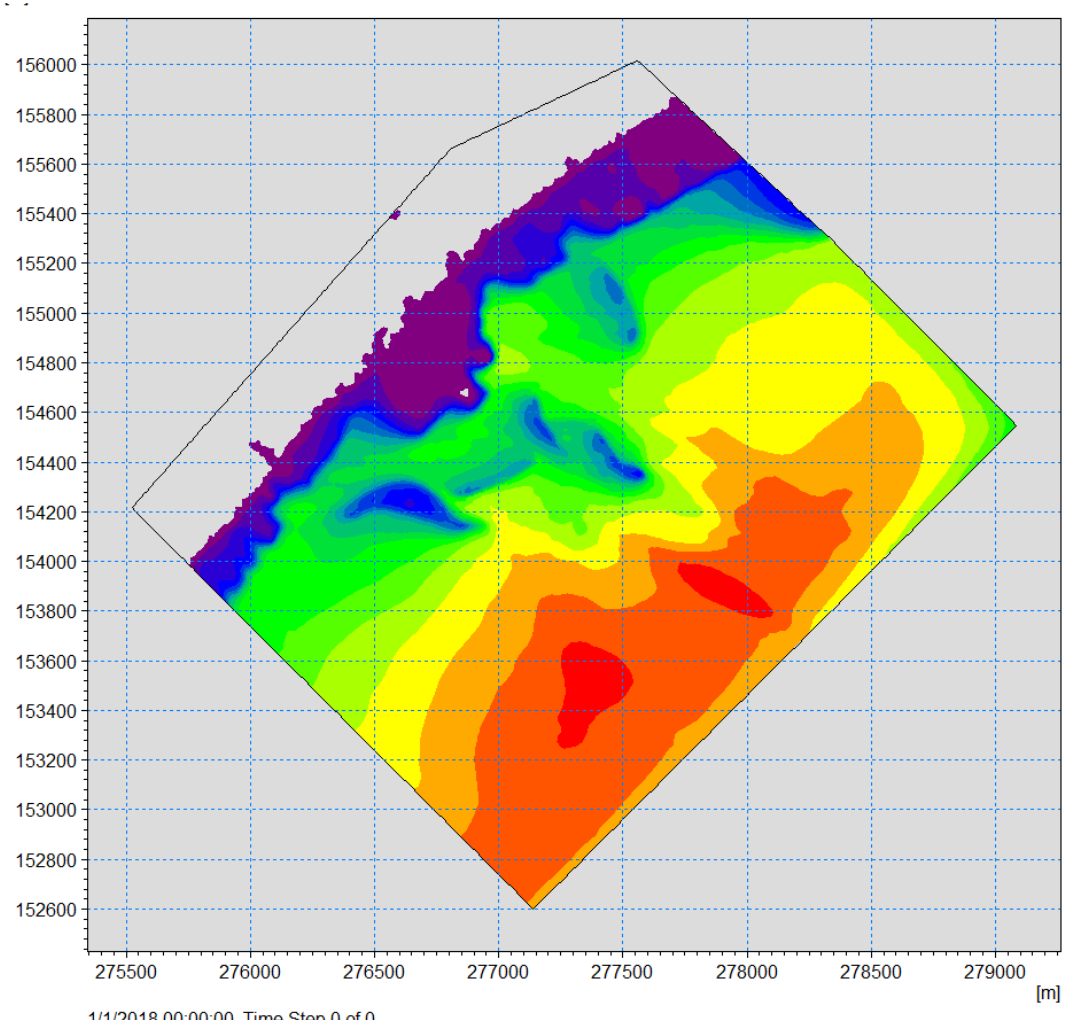

Next Steps

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    1. Data Collection and Analyses (July – December 2022) ☑
    2. Stakeholder Outreach (September - October 2022) ☑
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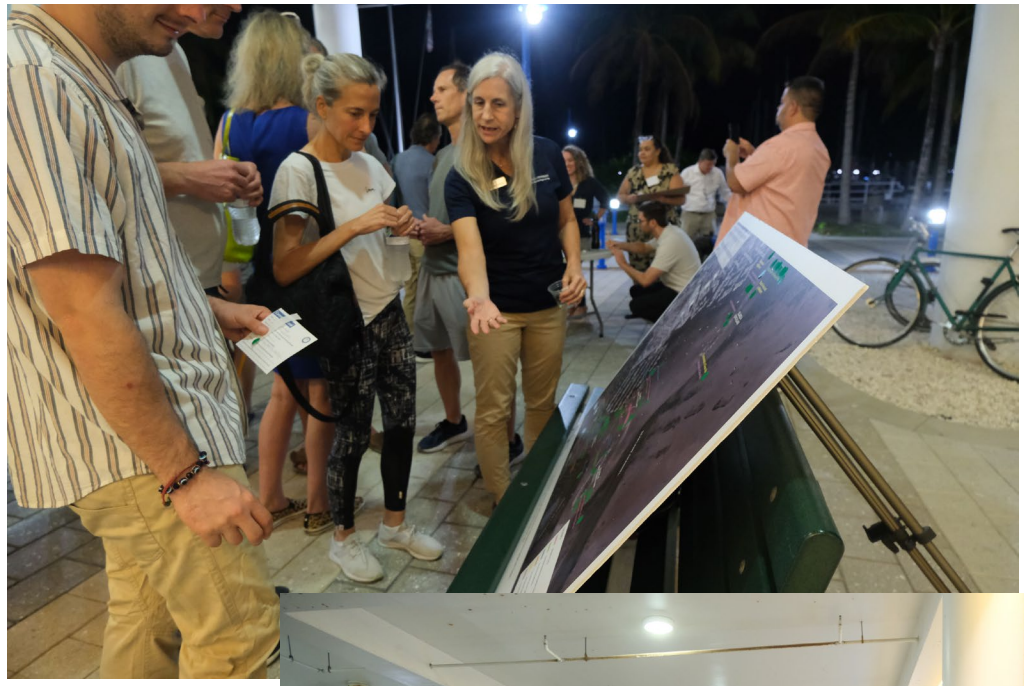

Thank you!

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