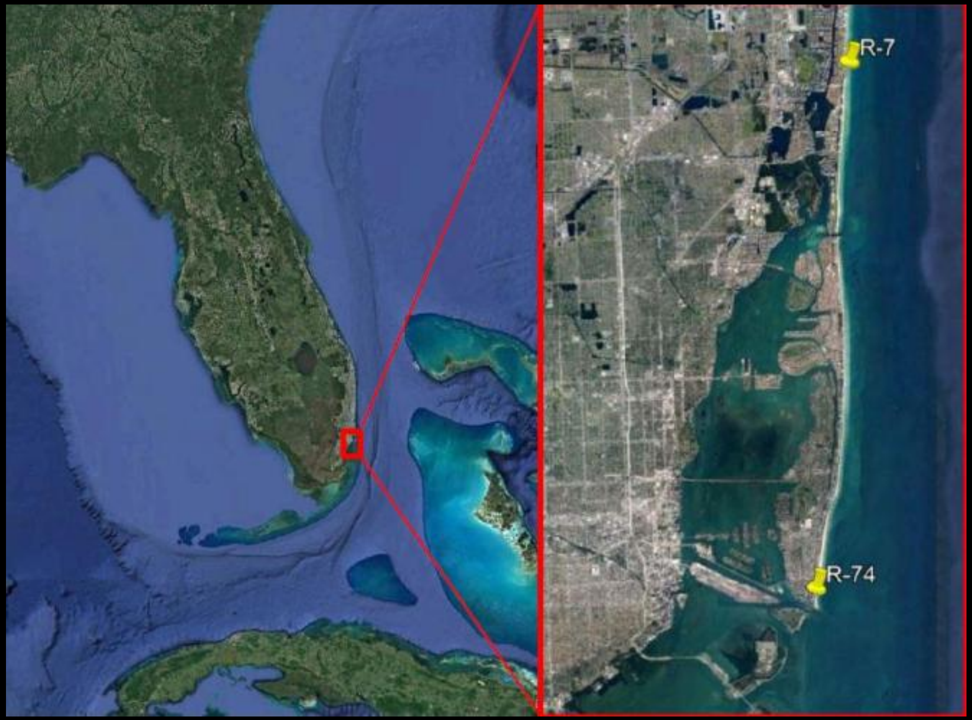
Developing Sustainable and Innovative Systems for Beach Erosion Control through Modeling and Design



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Project Goals & Objective

<u>Objective:</u>

An engineering solution to stabilize and reduce the downdrift erosive signal south of 32nd Street along the Miami Beach coastline.

- Least Disruption to Adjacent Shorelines
- Efficient and Adaptable Design for Future Hydrodynamic Conditions
- Environmentally Compatible and Sustainable Design

Background

- Previously identified erosional hot spots throughout the County's shorelines, indicating the maximum erosional signal occurring between R-61 to R-64 (GHD, 2021).
- The effect of nourishment events is captured in the survey data (Table 1) and not included in the LITPACK modeling (Table 2)
- This area is identified for a beach erosional control installation to improve shoreline stability.

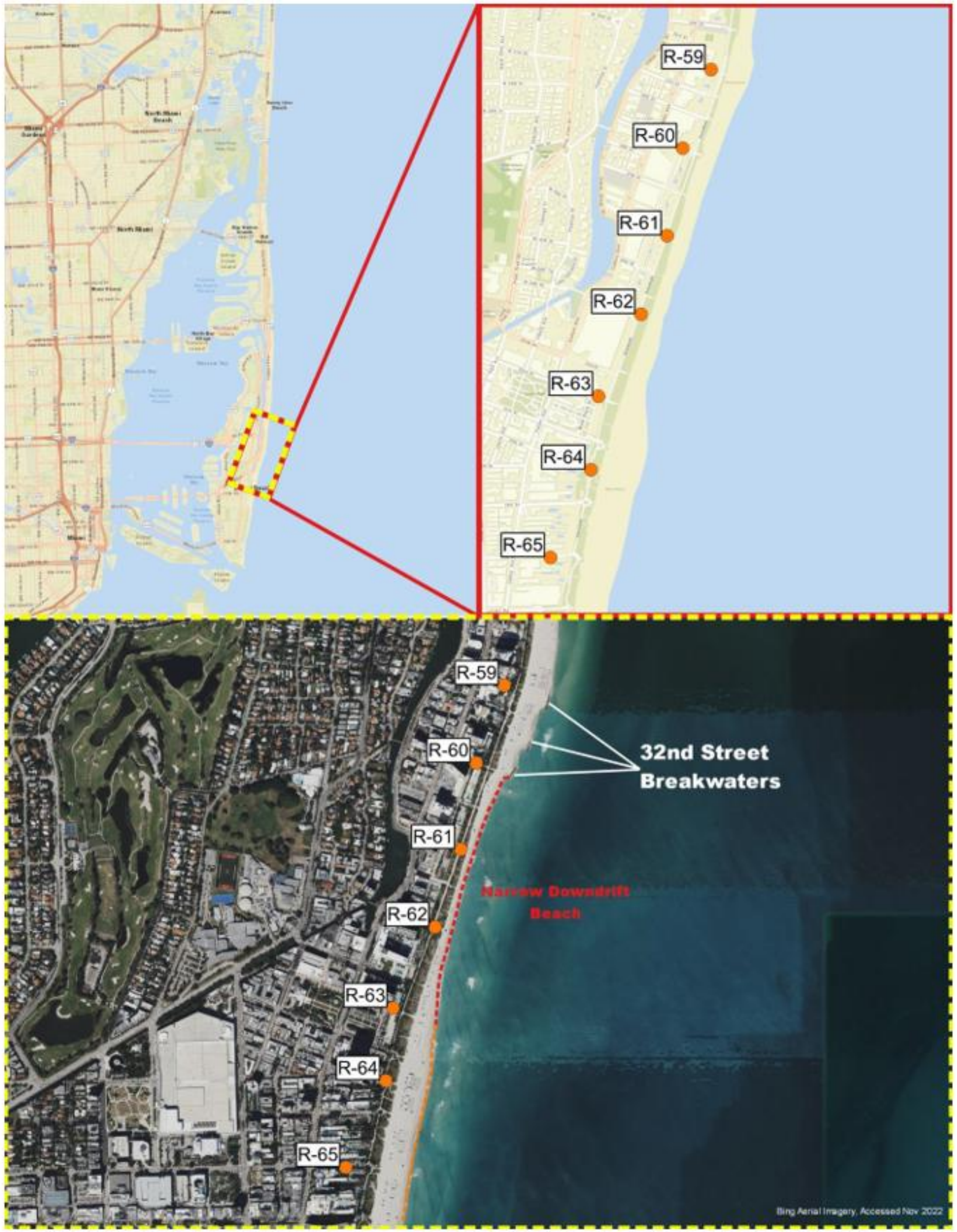


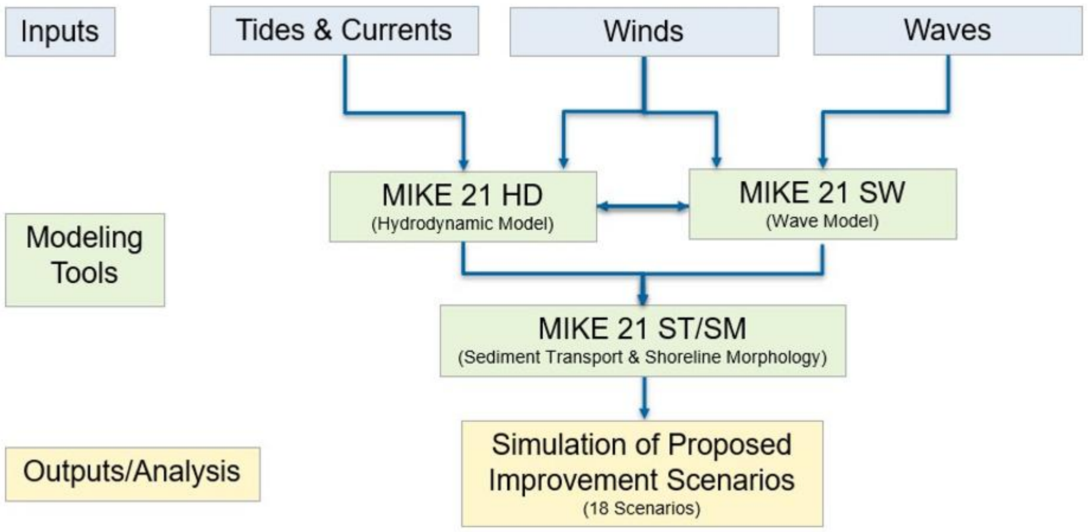
Table 1 *Erosional Hotspots from Survey Data, 2003 - 2016*

#	Erosional Hotspot	Average Annual Shoreline Movement (ft/yr)
1	R-1 to R-3	-1.7
2	R-7 to R-11	-3.2
3	R-14 to R-21	-3.2
4	R-27 to R-40	-1.7
5	R-42 to R-47	-2.0
6	R-50 to R-54	-2.4
7	**R-61 to R-64**	**-3.3**

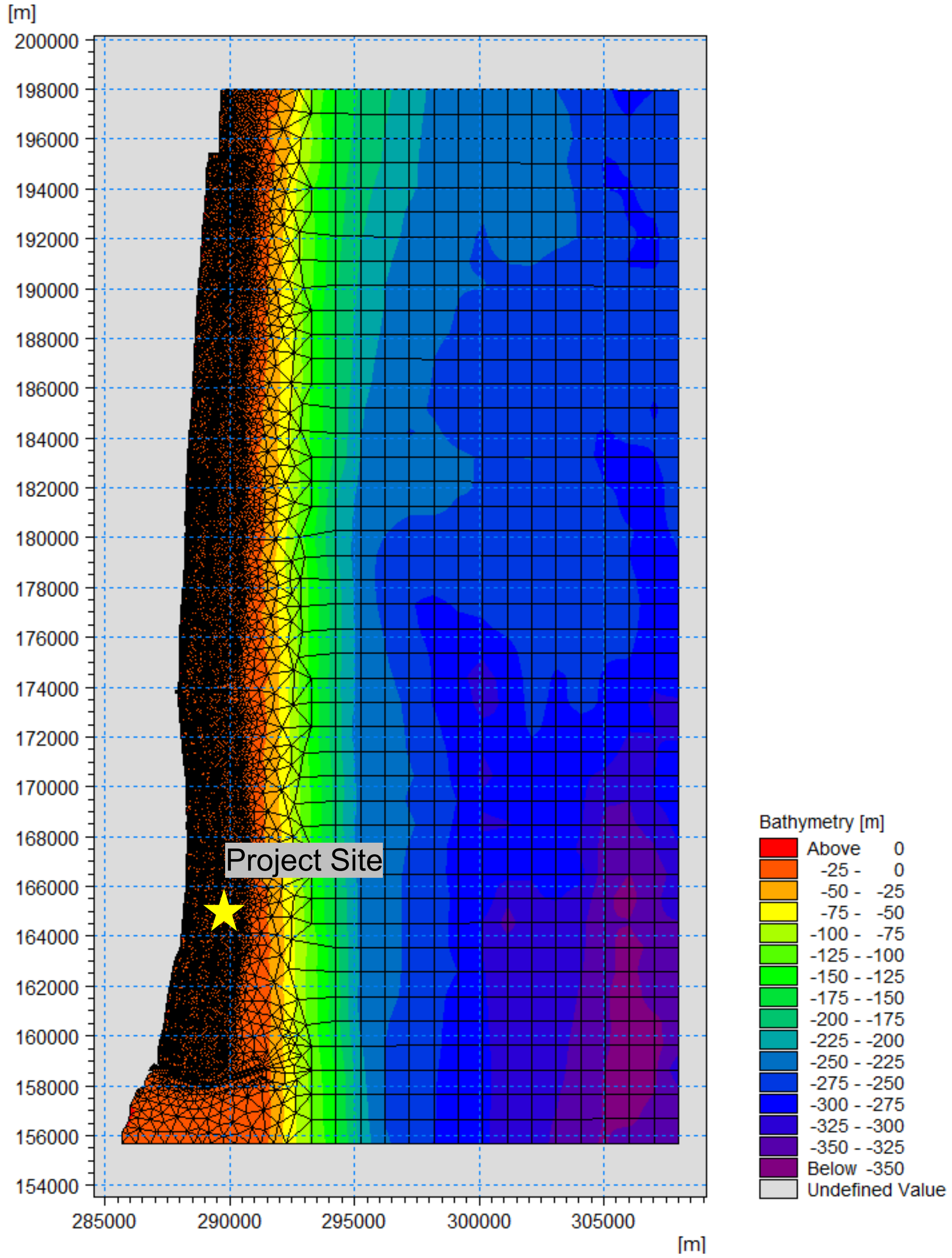
Table 2 *Erosional Hotspots from LITPACK Evaluated Under Average Annual Conditions*

#	Erosional Hotspot	Average Annual Shoreline Movement (ft/yr)
1	T-5 to R-7	-0.4
2	R-9 to R-14	-1.2
3	R-22 to R-25	-1.2
4	R-27 to R-30	-4.8
5	R-32 to R-33	-0.03
6	R-36 to R-54	-0.9
7	**R-61 to R-62**	**-8.3**
8	R-68 to R-70	-1.1

Countywide Numerical Model

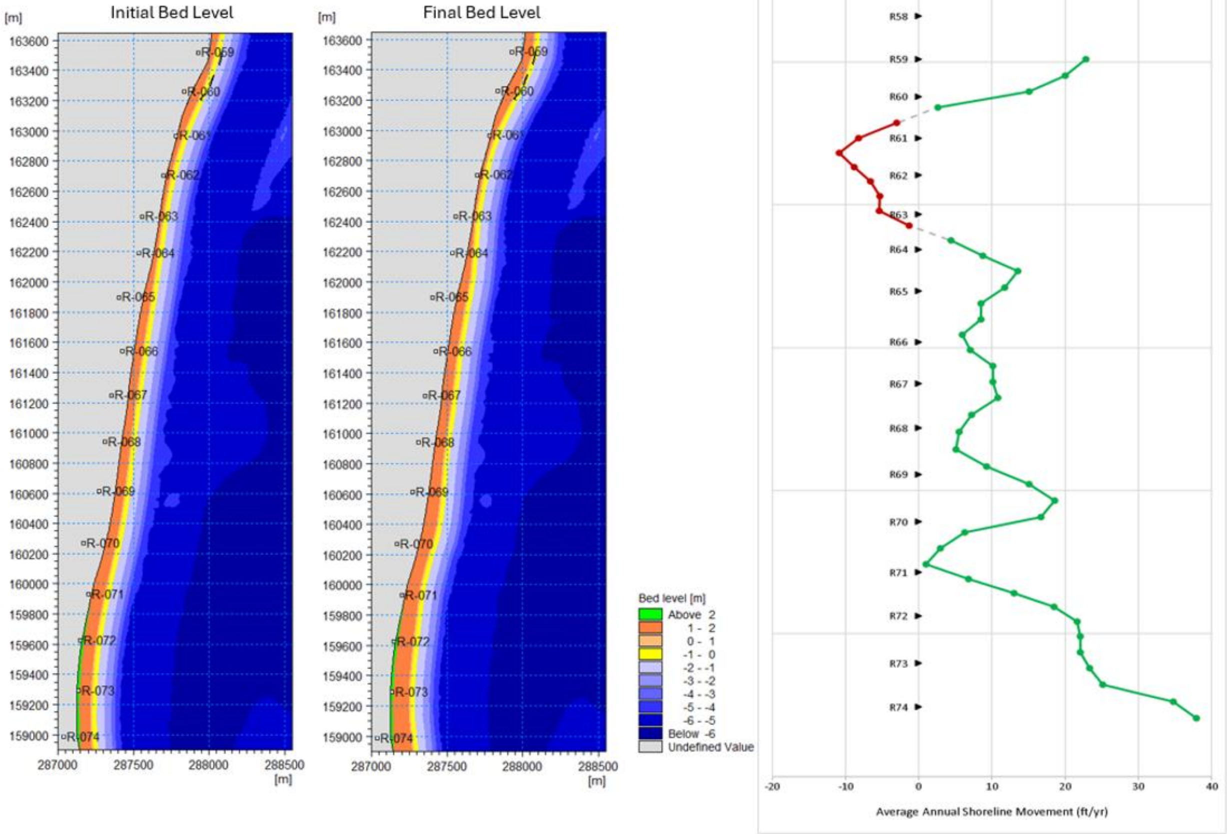


Scenario #	Max. Erosion Rate (ft/yr.)	Max. Erosional Signal Length (ft)	Average Erosion Rate within Max. Erosional Signal (ft/yr.)
1 (Baseline)	-15	2297	-9
2	-46	2297	-29
3	-75	2953	-43
4	-57	3937	-26
5	-49	3937	-24
6	-47	3937	-26
7	-27	3281	-18
8	-29	2297	-20
9	-22	2953	-15
10	-6	2297	-5
11	-6	2297	-4
12	-6	2297	-3
13	-3	1312	-2
14	-3	1312	-1
15	-3	984	-1
16	-5	1640	-3
17	-3	1312	-1
18	-10	1640	-8

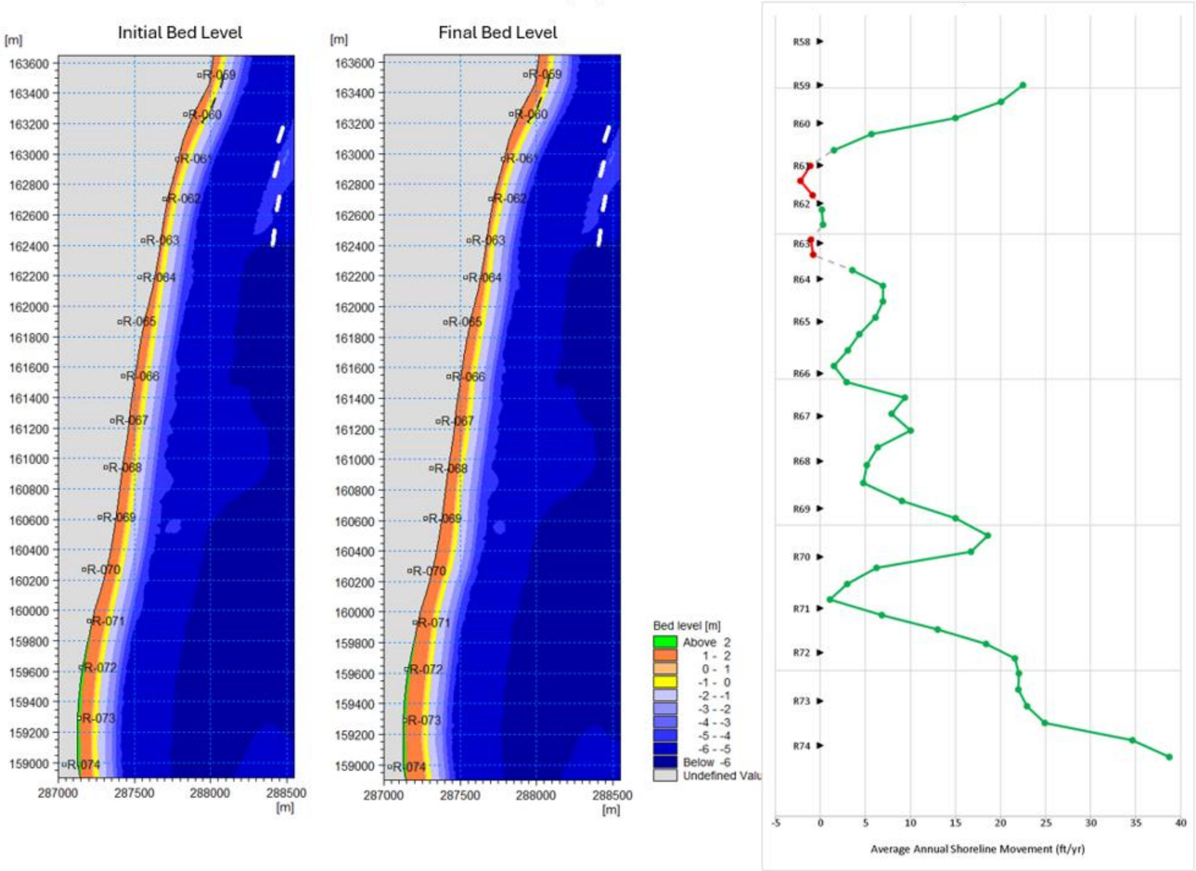


Numerical Modeling Results

Baseline



Scenario 15



- Number of Structures: **4**
- Length of Structures: **300 ft**
- Gap Width: **450 ft**
- 2000 Feet Offshore
- Crest Elevation: Submerged, -4.0 ft, NAVD88 = **-2 ft, MLLW**

SEAHIVE® System

A collaborative study between the University of Miami and GHD evaluating the use of SEAHIVE® as a submerged breakwater system.

Aim to design and develop an efficient, cost-effective, and sustainable shore protection system with high potential for natural habitat creation.

Image courtesy of the University of Miami

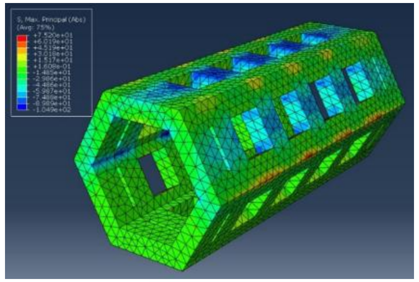
SEAHIVE® System

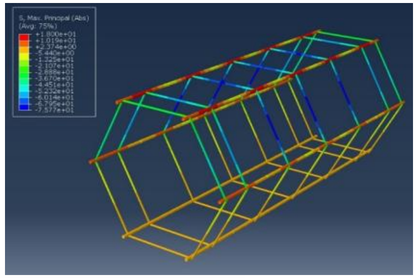
Efficient:
Shape adapted for stability as well as to increase wave-energy dissipation

Adaptive:
Modular system with adaptability to future sea-level rise, stacked in a tight configuration

Environmentally friendly:
Structural complexity provides great hospitably for marine organisms.

Cost-effective:
Equivalent hydrodynamic performance with a smaller footprint and less material, thereby reducing material costs.





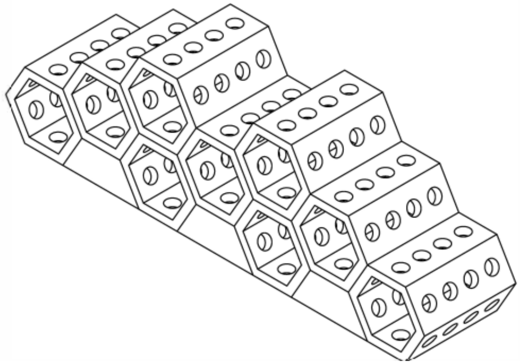
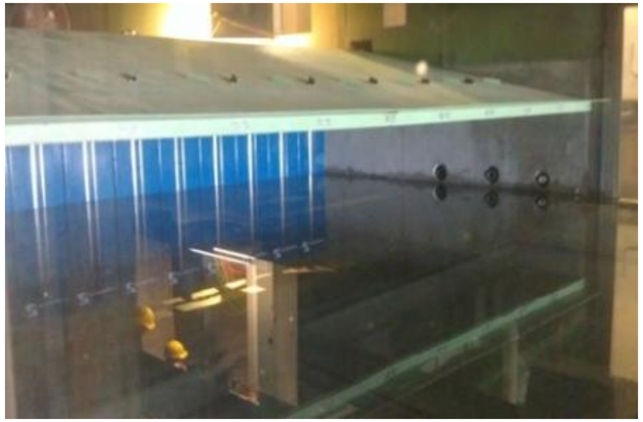
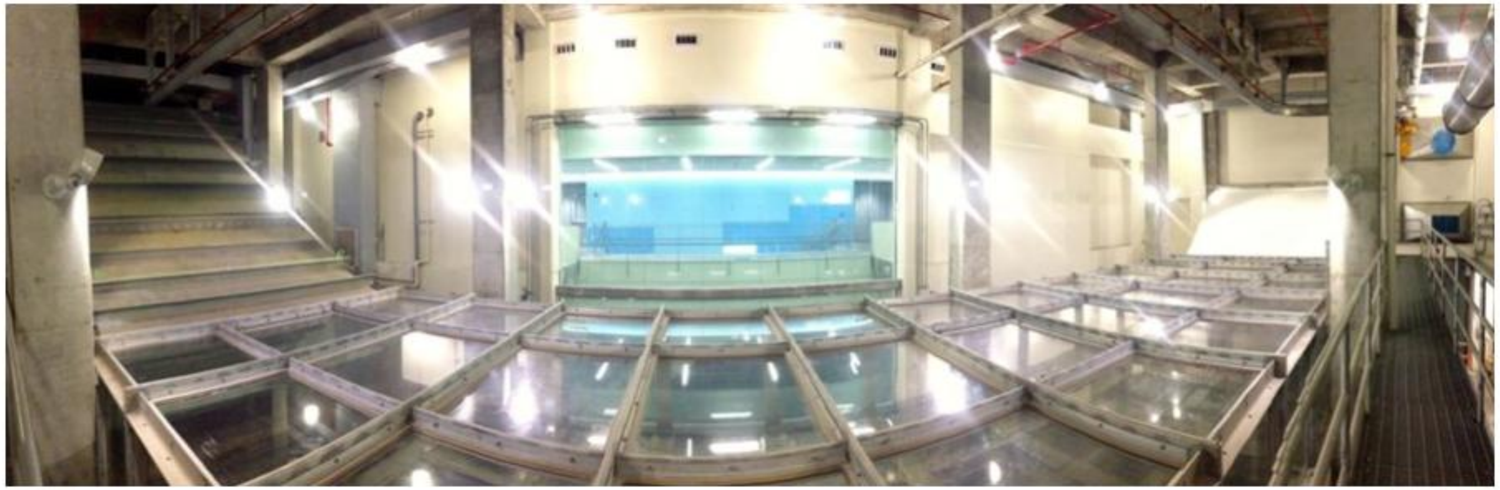


Image courtesy of Wahoo Bay

Physical Modeling: SEAHIVE®

- Evaluated by the University of Miami, who conducted physical testing in the Alfred C. Glassell, Jr. SUrge-STructure-Atmosphere Interaction (SUSTAIN) Facility.





SUSTAIN Wind-Wave Laboratory at the University of Miami

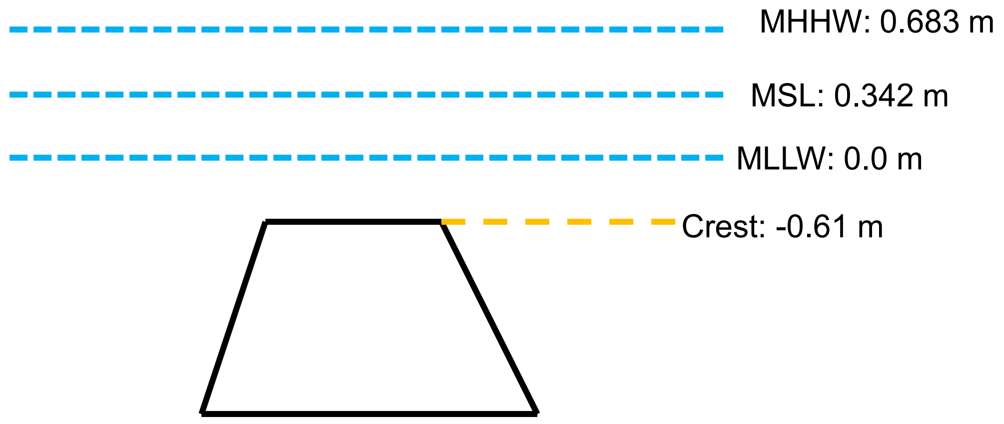
Tidal Datums

Station: 8723214, Virginia Key, FL

Units: Meters

Datum: MLLW

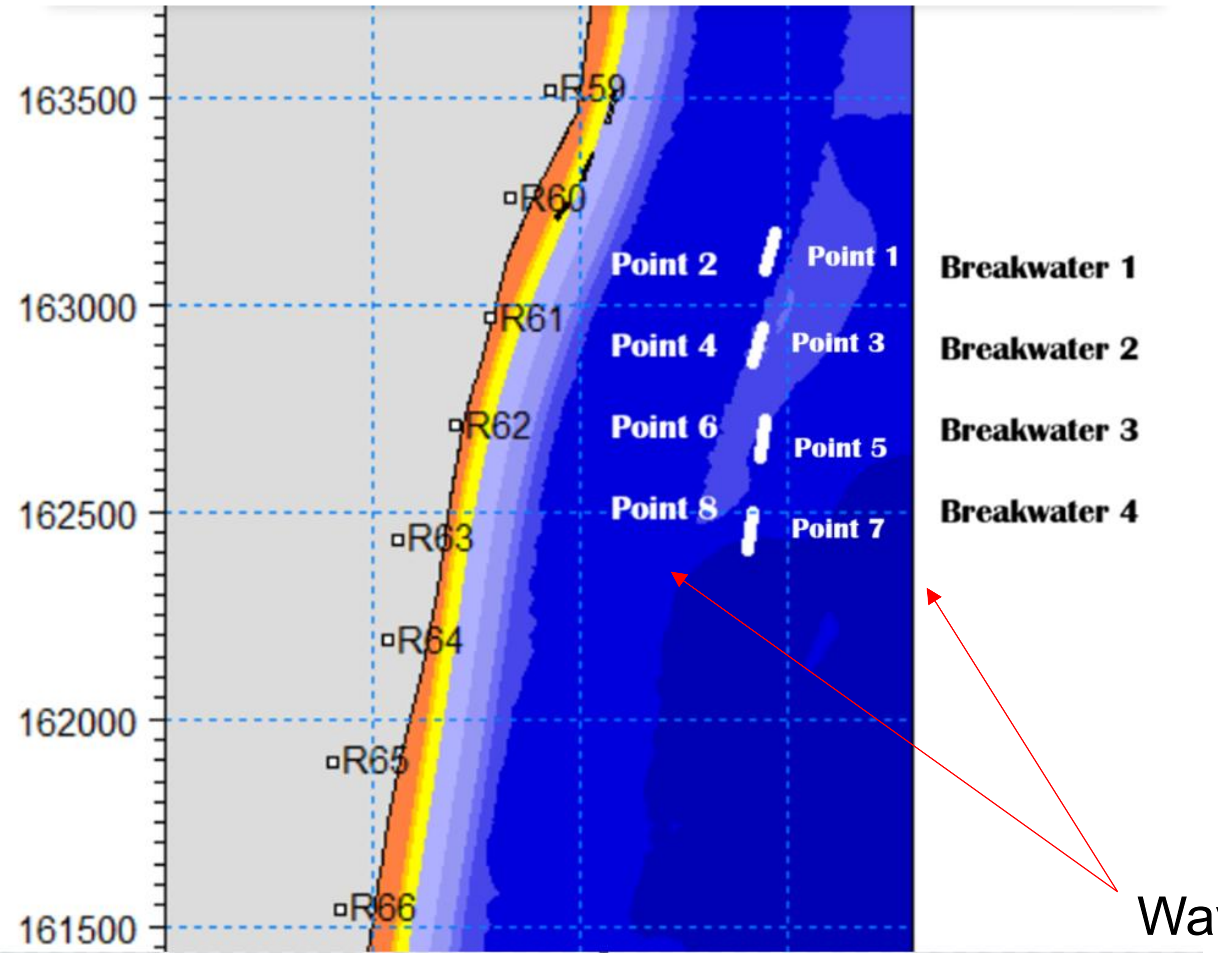
MHHW	**0.683**	**Mean Higher-High Water**
MHW	0.661	Mean High Water
MTL	0.351	Mean Tide Level
MSL	**0.342**	**Mean Sea Level**
DTL	0.342	Mean Diurnal Tide Level
MLW	0.040	Mean Low Water
MLLW	**0.000**	**Mean Lower-Low Water**
NAVD88	0.614	North American Vertical Datum of 1988
STND	-3.089	Station Datum
GT	1.296	Great Diurnal Range
MN	1.236	Mean Range of Tide
DHQ	0.635	Mean Diurnal High Water Inequality
DLQ	0.653	Mean Diurnal Low Water Inequality
HWI	2.214	Greenwich High Water Interval (in hours)
LWI	8.434	Greenwich Low Water Interval (in hours)
Max Tide	1.771	Highest Observed Tide
Max Tide Date & Time	9/10/2017 17:00	Highest Observed Tide Date & Time
Min Tide	-0.392	Lowest Observed Tide
Min Tide Date & Time	3/29/1994 21:42	Lowest Observed Tide Date & Time
HAT	0.981	Highest Astronomical Tide
HAT Date & Time	10/9/2033 14:18	HAT Date and Time
LAT	-0.220	Lowest Astronomical Tide
LAT Date & Time	1/31/2014 7:48	LAT Date and Time



Conceptual Breakwater Crest Elevation

(Schematic Not to Scale)

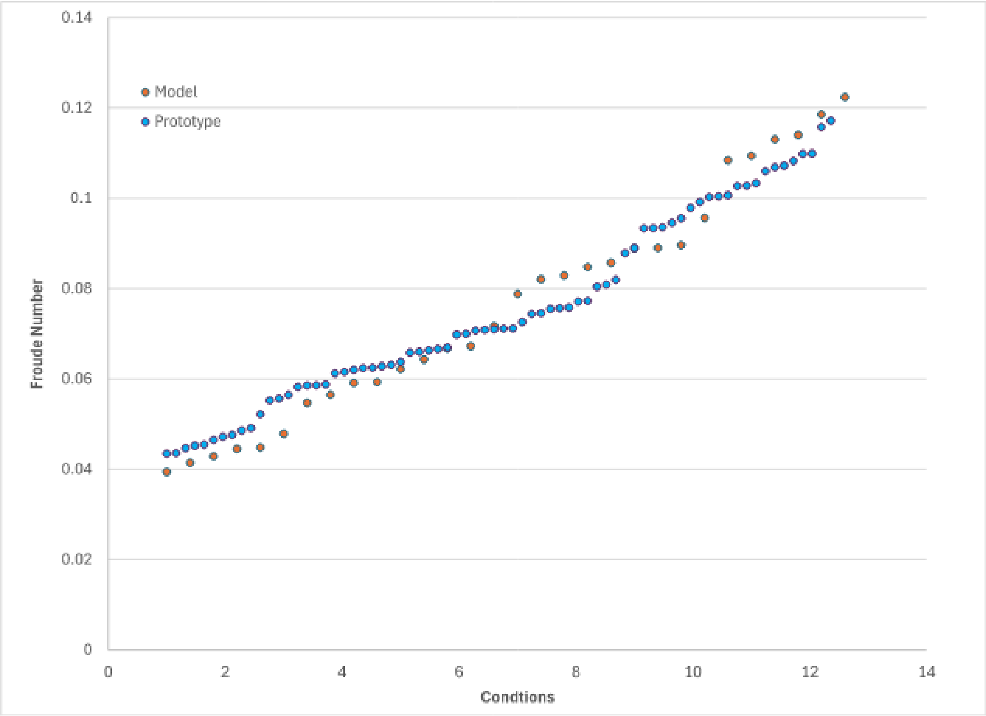
Breakwater and Point Extract Locations



Wave height time series extracted for 5 m before and after each breakwater.

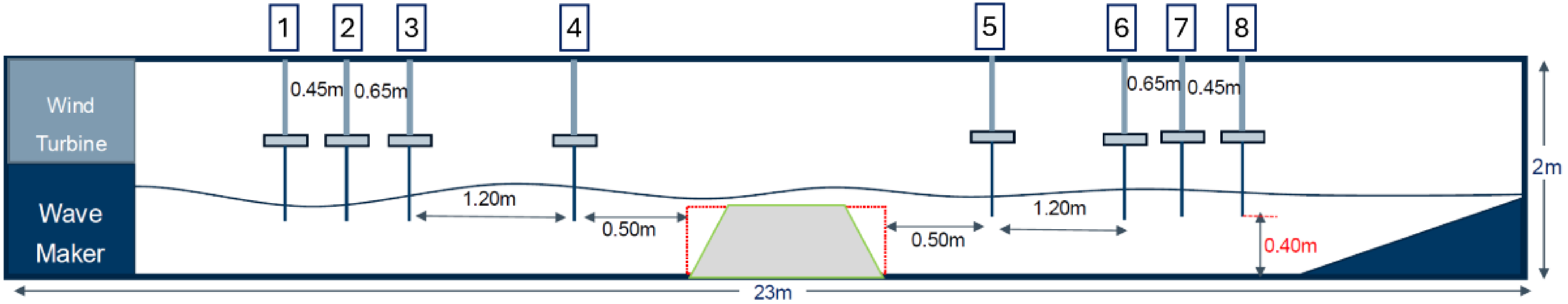
Physical Modeling: SEAHIVE®

Froude number similarity was employed to simulate the hydrodynamic conditions of prototype structures offshore of Miami Beach for the physical experiments in SUSTAIN.



The water and wave conditions were determined based on the capabilities of the wavemaker and a 1:10 geometrical scale. The SEAHIVE® system was thus tested under 30 different hydrodynamic scenarios

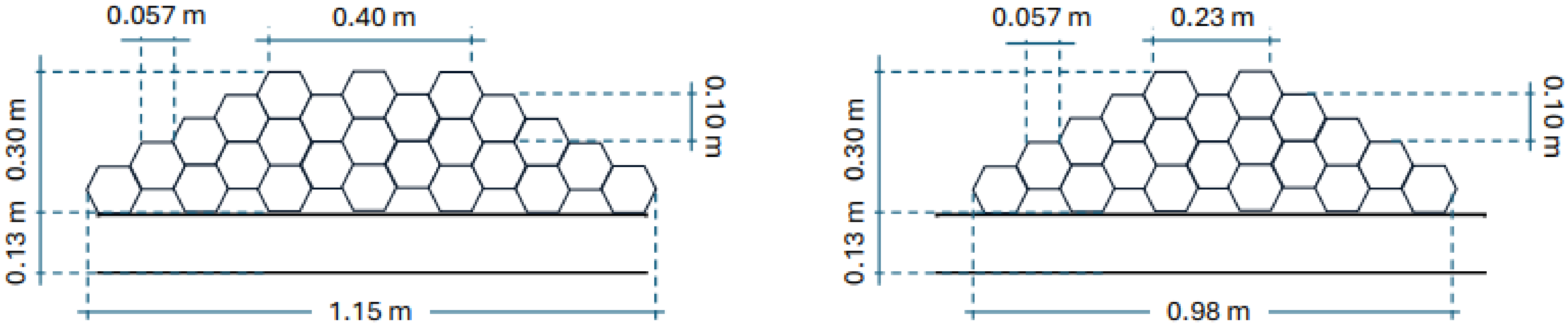
Physical Modeling: SEAHIVE®



Experimental setup for the GHD Miami-Dade SEAHIVE® breakwater testing in SUSTAIN

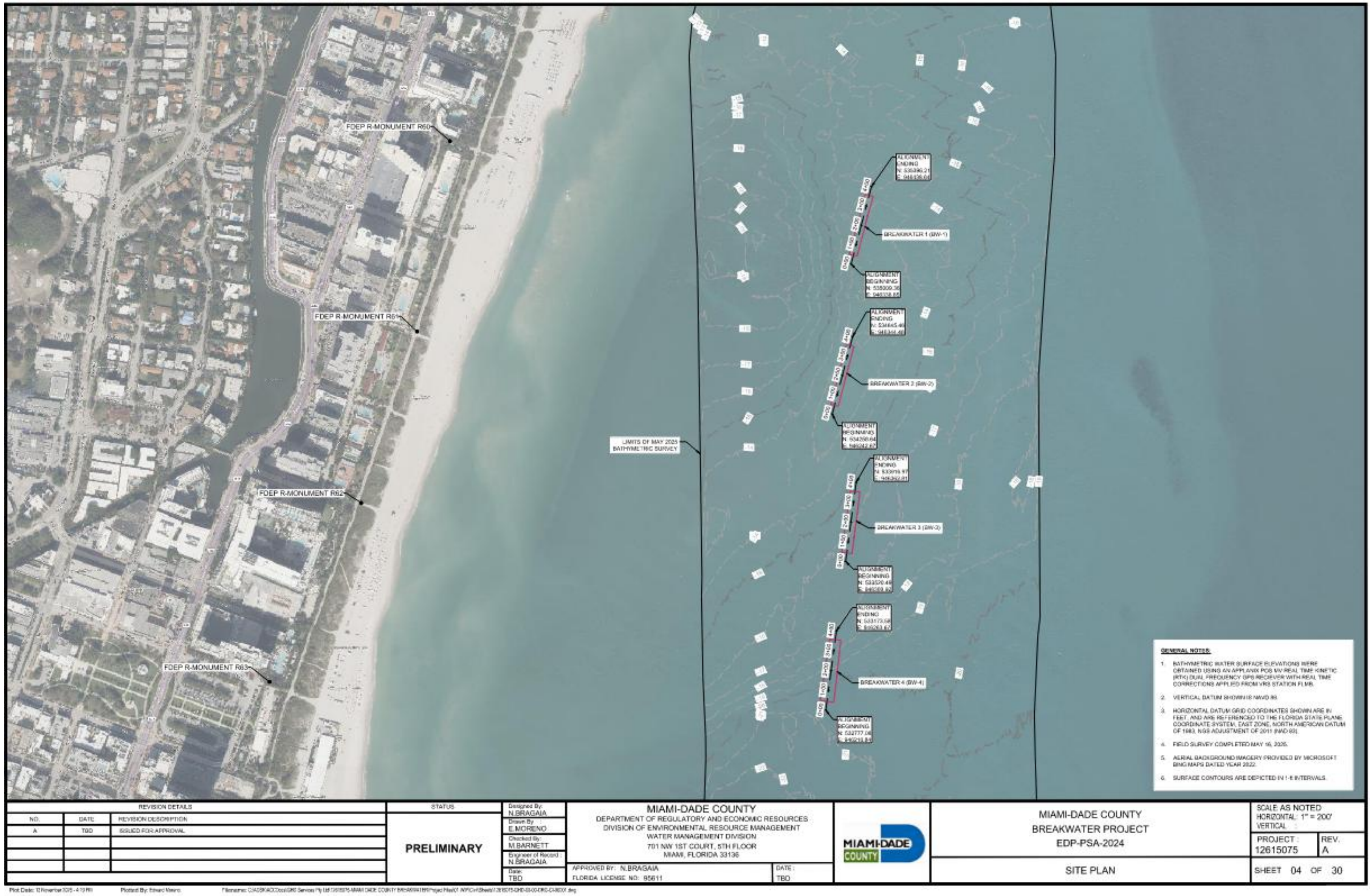
Physical Modeling Results

- Transmission coefficient, Kt (ratio between transmitted wave height and incident wave height) - is the KPI for this study. Desired values range from 0.8-0.9.
- Reduced model variant successfully achieved the desired transmission coefficient of 0.8-0.9 under most conditions, confirming its viability as a potential erosion control solution.

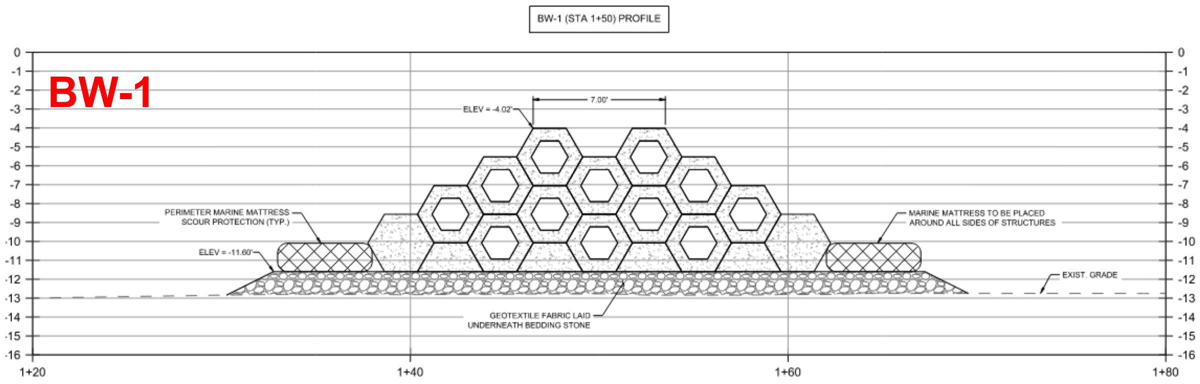


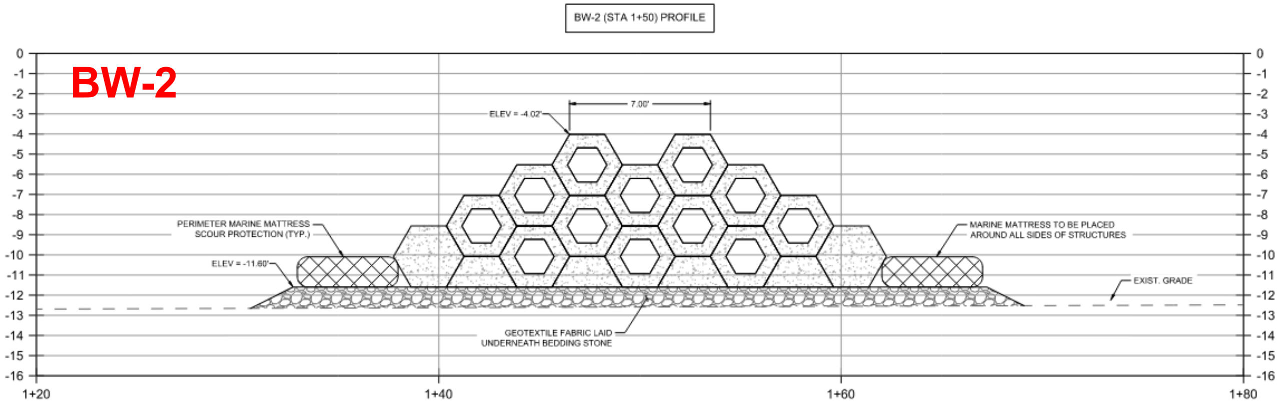
SEAHIVE® breakwater model geometry. (left) SEAHIVE® variant based on the GHD breakwater design; (right) adapted geometry for desired performance.

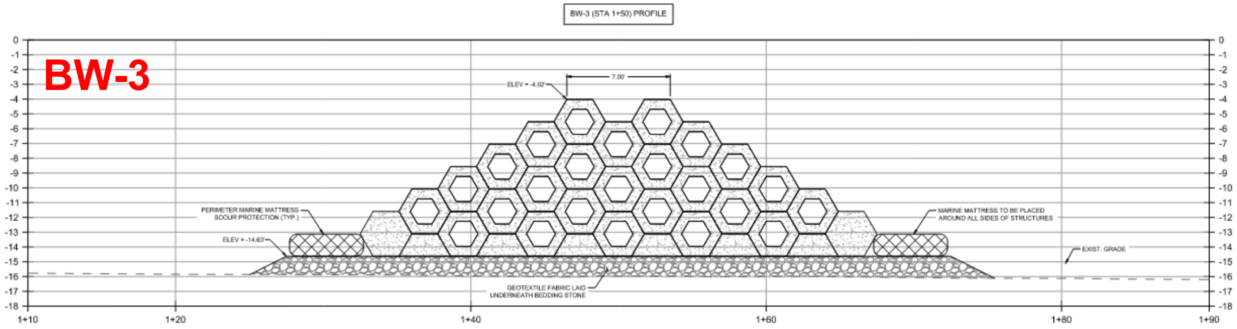
Design – Plan

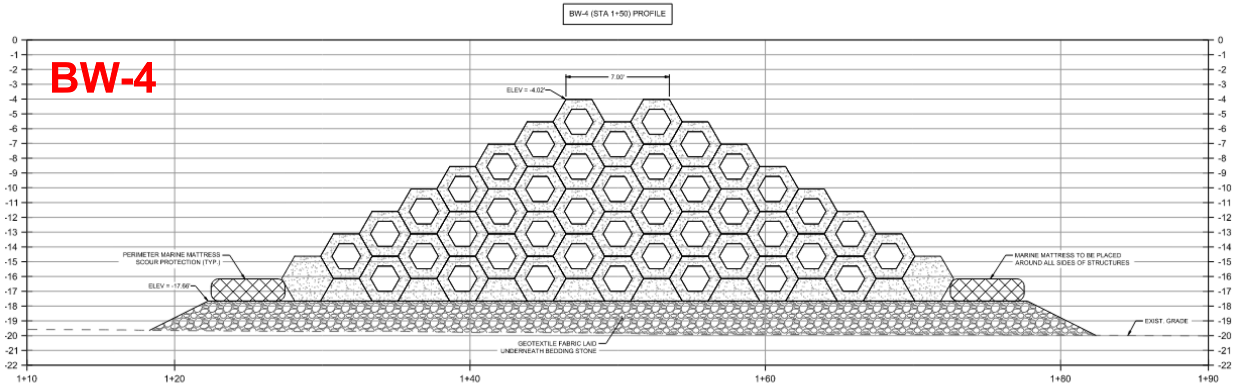

FDEP R-MONUMENT R60
FDEP R-MONUMENT R61
FDEP R-MONUMENT R62
FDEP R-MONUMENT R63
LIMITS OF MAY 2025 BATHYMETRIC SURVEY
BREAKWATER 1 (BW-1)
BREAKWATER 2 (BW-2)
BREAKWATER 3 (BW-3)
BREAKWATER 4 (BW-4)
GENERAL NOTES:
1. BATHYMETRIC WATER SURFACE ELEVATIONS WERE OBTAINED USING AN APPLANIX POS MV REAL TIME KINETIC (RTK) DUAL FREQUENCY GPS RECIEVER WITH REAL TIME CORRECTIONS APPLIED FROM VRS STATION FLMB.
2. VERTICAL DATUM SHOWN IS NAVD 88.
3. HORIZONTAL DATUM GRID COORDINATES SHOWN ARE IN FEET, AND ARE REFERENCED TO THE FLORIDA STATE PLANE COORDINATE SYSTEM, EAST ZONE, NORTH AMERICAN DATUM OF 1983, NGS ADJUSTMENT OF 2011 (NAD 83).
4. FIELD SURVEY COMPLETED MAY 16, 2025.
5. AERIAL BACKGROUND IMAGERY PROVIDED BY MICROSOFT BING MAPS DATED YEAR 2022.
6. SURFACE CONTOURS ARE DEPICTED IN 1-ft INTERVALS.
REVISION DETAILS
NO. DATE REVISION DESCRIPTION
A TBD ISSUED FOR APPROVAL
STATUS
PRELIMINARY
Designed By: N.BRAGAIA
Drawn By: E.MORENO
Checked By: M.BARNETT
Engineer of Record: N.BRAGAIA
Date: TBD
MIAMI-DADE COUNTY
DEPARTMENT OF REGULATORY AND ECONOMIC RESOURCES
DIVISION OF ENVIRONMENTAL RESOURCE MANAGEMENT
WATER MANAGEMENT DIVISION
701 NW 1ST COURT, 5TH FLOOR
MIAMI, FLORIDA 33136
APPROVED BY: N.BRAGAIA
FLORIDA LICENSE NO: 95611
DATE: TBD
MIAMI-DADE COUNTY
BREAKWATER PROJECT
EDP-PSA-2024
SITE PLAN
SCALE AS NOTED
HORIZONTAL: 1" = 200'
VERTICAL :
PROJECT : 12615075
REV. A
SHEET 04 OF 30

Design – Section









Summary and Future Work

- Numerical modeling guided the optimal breakwater system design, including layout, crest elevation, and spacing, to achieve target wave transmission and erosion-control performance.

- SEAHIVE® demonstrated a promising, innovative, and sustainable coastal protection solution with a reduced footprint.

- Results were validated through physical modeling.

- Future work will focus on full-scale structural and foundation design and securing regulatory permits.

* Thank You

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