



moffatt & nichol

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# Temporary Breakwater to support Cruise Pier Construction at Half Moon Cay, Bahamas

→ 2026 National Conference on Beach Technology

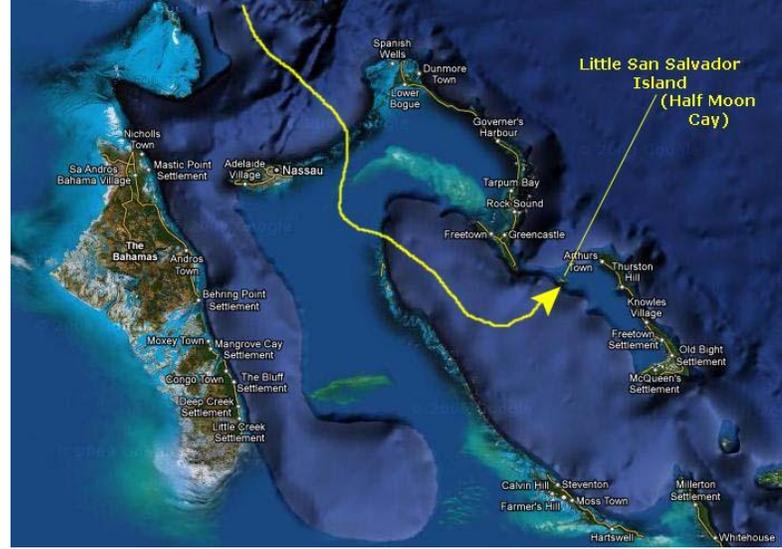




# Presentation Outline

- › Background on Project Site
- › Challenges for Marine Construction
- › Summary of Coastal Processes
- › Selection Process for Temporary Breakwater
- › Construction Sequencing
- › Breakwater Damage – Hurricane
- › Conclusions





## Background On Project

- › Half Moon Cay – private island cruise ship destination since 1990's
- › Located near Eleuthera, Bahamas – aka Little San Salvador
- › Rebranding as RelaxAway, Half Moon Cay
- › New Cruise Pier on North Side of island
- › Excel Class Ships – 6,500 pax
- › Remote island destination – presents challenges





**Originally Proposed Safe Harbour –**  
*Unightly Marine Equipment Near Guest Areas*

## Challenges for Marine Construction

- › **Remote Island Location:** 275 miles to US based export facility
- › **Heavy Marine Construction:** Up to 10 ABS Barges at Project Peak
- › **Exposure to open seas** and deep water
- › **Mixture of sandy and well cemented** limestone geological features
- › **Minimize construction downtime** – meet Project schedule

- › **Distance to nearest safe harbor** for Moderate to Severe Weather Conditions – 32 Miles (No Name Harbour – Photo to right)
- › 2-3 Day Process Both Ways, generally resulting in at least (1) week impact per safe harbour event
- › Crossing the “Bridge”, 12 mile open ocean crossing between Eleuthera and Half Moon Cay, oftentimes not passable for marine equipment for several days before and after storm events, further increasing risks of project impact
- › **Daily overhead and equipment costs** in excess of \$50,000 at peak construction make investment for temporary breakwater attractive
- › **Temporary Breakwater** – Allows for local storage for mild to moderate weather events



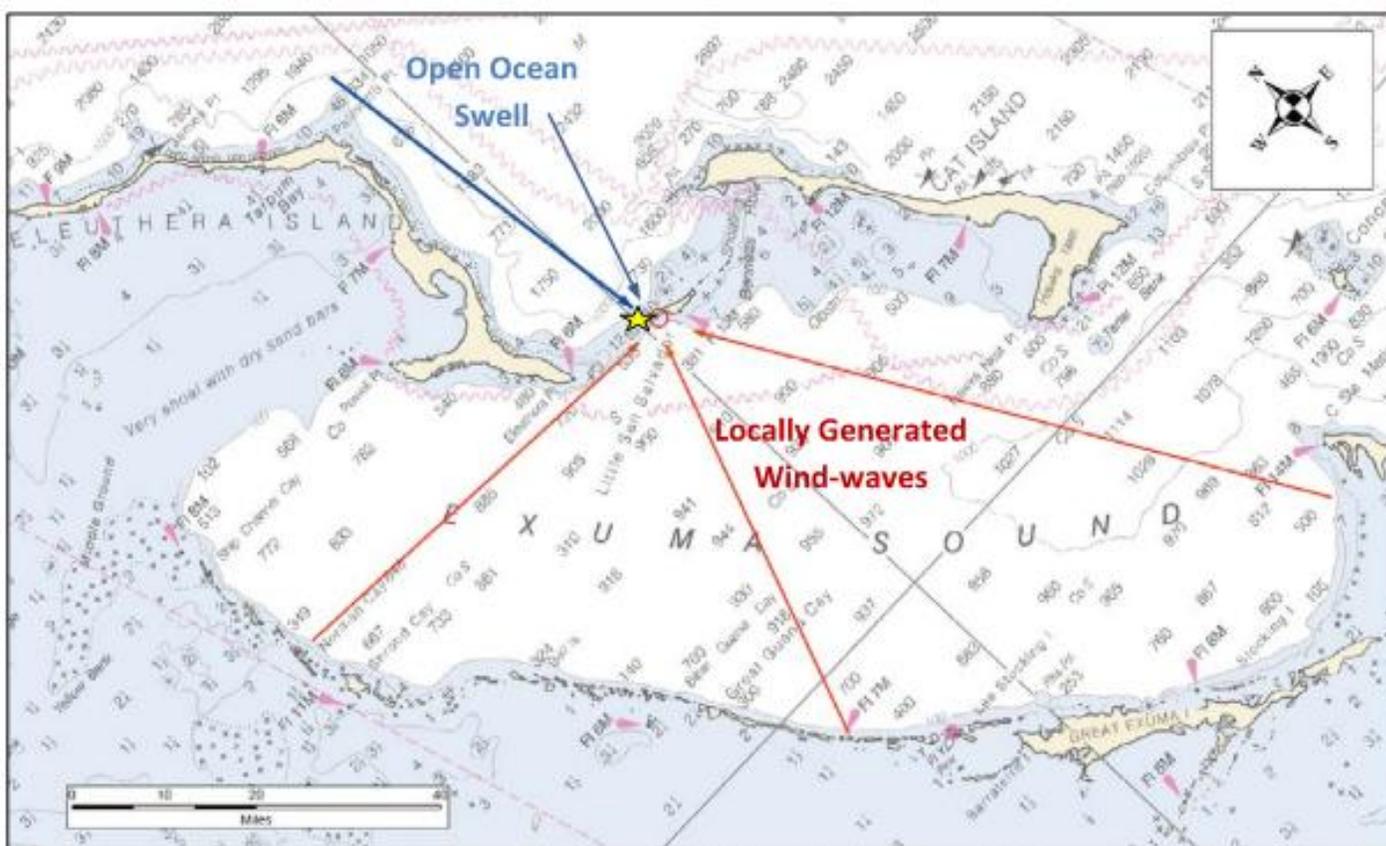


Figure 2. Project Location Exposure (source: NOAA Nautical Chart 11013, soundings in fathoms).

# Summary of Coastal Processes

1. Coastal Engineering Report - ATM
2. ADCP Measurements
3. Swells from NW
4. Wind-Generated Waves
5. Extreme Conditions – 3.5m waves at site

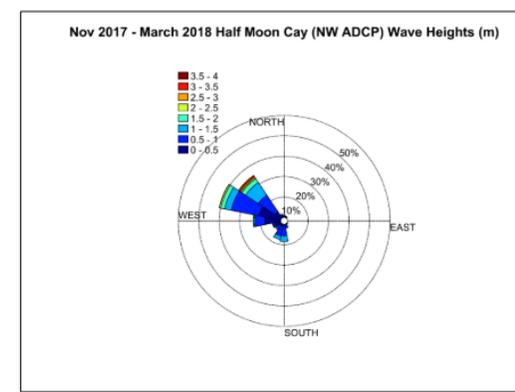


Figure 5. NW ADCP Location Significant Wave Heights (Hs, meters) by Direction

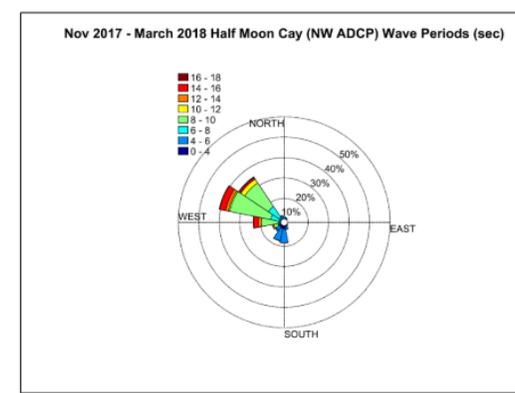


Figure 6. NW ADCP Location Peak Wave Periods (Tp, seconds) by Direction

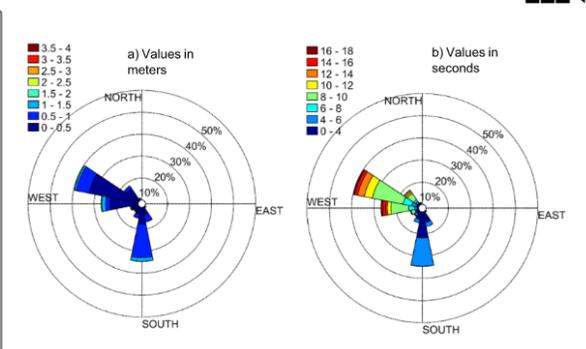


Figure 4-1: Wave Height Rose (a) and Wave Period Rose (b) at the Center Pier Location (Source: ATM)

Table 4-4: Percentage of Occurrence for Wave Heights (a) and Wave Periods (s)

Table 3. Center Pier ADCP Wave Height Occurrences by Direction

Incident Wave Direction (Degrees North)	Wave Heights, m									
	0-0.5	0.5-1	1-1.5	1.5-2	2-2.5	2.5-3	3-3.5	3.5-4	4-6	6-8
N	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
NNE	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
NE	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
ENE	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
E	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
ESE	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SE	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SSE	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
S	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SSW	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SW	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
WSW	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
W	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
WNW	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
NW	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
NNW	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 4. Center Pier ADCP Wave Period Occurrences by Direction

Incident Wave Direction (Degrees North)	Wave Periods, sec							
	0-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18
N	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
NNE	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
NE	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
ENE	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
E	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
ESE	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SE	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SSE	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
S	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SSW	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SW	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
WSW	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
W	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
WNW	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
NW	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
NNW	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%



# Wave Design Assumptions

1. Selected PZC13 Sheet Piles
2. Approximately 15 ft. Embedment Requirement
3. Approximately 15 ft. average water depth
4. Short duration events assumed
5. Simple cantilever wall developed in SAP2000 Wave Load Generator to generate demands into each load case
6. Nearby Marine Borings used for design assumptions

CMS-Wave Model Output Station Significant Wave Heights (meters)															
Case	Return Period	Input Water Level (m, MSL)	Incident Wave Direction	Incident Hs (m)	Incident Tp (sec)	Hs (m) Station 1	Hs (m) Station 2	Hs (m) Station 3	Hs (m) Station 4	Hs (m) Station 5	Hs (m) Station 6	Hs (m) Station 7	Hs (m) Station 8	Hs (m) Station 9	Hs (m) Station 10
1	25-Yr	2.22	SW (220°)	4.17	7.5	3.45	4.06	4.20	3.63	3.76	3.91	3.56	3.80	3.84	3.55
2			W (270°)	4.17	7.5	3.49	3.85	3.55	3.39	3.34	3.24	3.14	3.22	3.13	3.00
3			NW (300°)	4.47	8.0	3.02	3.35	3.00	2.87	2.76	2.62	2.76	2.66	2.60	2.55
4	50-Yr	2.86	SW (220°)	4.74	8.5	3.94	4.59	4.60	4.11	4.33	4.39	4.08	4.41	4.40	3.95
5			W (270°)	4.74	8.5	3.88	4.24	3.91	3.81	3.75	3.58	3.59	3.69	3.58	3.47
6			NW (300°)	5.19	8.5	3.43	3.78	3.38	3.27	3.15	2.94	3.21	3.05	3.00	2.94
7	100-Yr	3.73	SW (220°)	5.32	8.5	4.42	5.11	5.05	4.59	4.77	4.86	4.45	4.82	4.87	4.36
8			W (270°)	5.32	8.5	4.37	4.76	4.39	4.26	4.20	4.02	4.00	4.10	3.98	3.84
9			NW (300°)	5.97	8.5	3.97	4.33	3.89	3.76	3.63	3.40	3.65	3.48	3.44	3.32

Return Period (Years)	Regional Assessment Surge Value Range (meters, MSL)	Half Moon Cay Project Site Estimated Surge (meters, MSL)
25	0.98 - 2.41	1.68
50	1.37 - 2.77	2.32
100	1.79 - 3.38	3.19

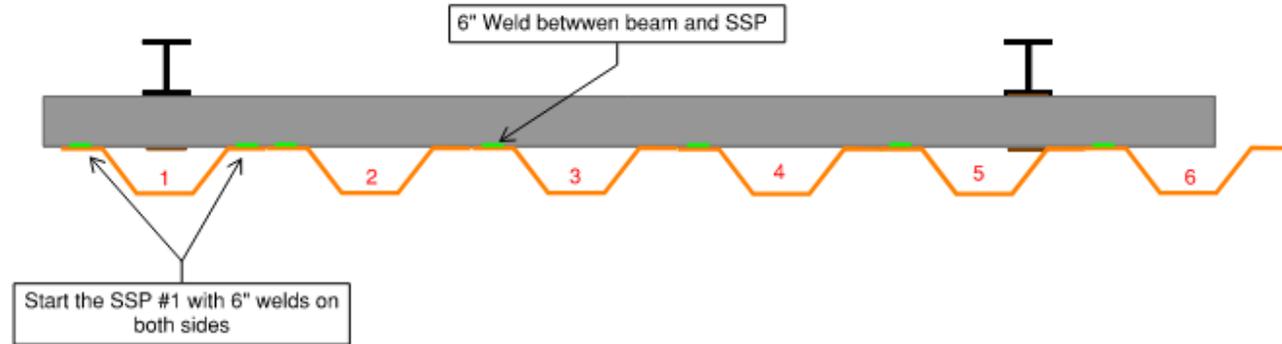
**Multitude of Criteria – these are the main criteria driving the marine structural configuration**

With Storm Surge

Load Case	Return Period Years	Period s	Wave Input				Wave Demands SAP2000				DCR		
			Wind ft/s	Current ft/s	Surge ft	Height ft	V kips	M kip ft	V kip/ft	M kip in/ft	V	M Elastic	M Plastic
1	25	7.5	50.64	2.13	5.51	12.60	935.7	23329.3	1.87	559.9	0.01	0.77	0.65
2	25	7.5	50.64	2.13	5.51	10.27	649.1	15851.3	1.30	380.4	0.01	0.53	0.44
3	25	8.0	50.64	2.13	5.51	8.53	263.8	6575.1	0.53	157.8	0.00	0.22	0.18
4	50	8.5	50.64	2.13	7.61	14.44	1179.3	30853.8	2.36	740.5	0.02	1.02	0.86
5	50	8.5	50.64	2.13	7.61	11.75	807.2	20579.4	1.61	493.9	0.01	0.68	0.57
6	50	8.5	50.64	2.13	7.61	9.84	596.6	14968.2	1.19	359.2	0.01	0.50	0.42
7	100	8.5	50.64	2.13	10.47	15.98	1386.3	38872.7	2.77	932.9	0.02	1.29	1.08
8	100	8.5	50.64	2.13	10.47	13.06	949.4	25832.8	1.90	620.0	0.01	0.86	0.72
9	100	8.5	50.64	2.13	10.47	11.29	734.3	19634.9	1.47	471.2	0.01	0.65	0.55

No Storm Surge

Load Case	Return Period Years	Period s	Wave Input				Wave Demands SAP2000				DCR		
			Wind ft/s	Current ft/s	Surge ft	Height ft	V kips	M kip ft	V kip/ft	M kip in/ft	V	M Elastic	M Plastic
1	25	7.5	50.63	2.13	0.00	12.60	1036.3	23178.4	2.07	556.3	0.02	0.77	0.64
2	25	7.5	50.63	2.13	0.00	10.27	706.9	15559.8	1.41	373.4	0.01	0.52	0.43
3	25	8.0	50.63	2.13	0.00	8.53	312.5	7056.3	0.63	169.4	0.00	0.23	0.20
4	50	8.5	50.63	2.13	0.00	14.44	1349.2	30467.9	2.70	731.2	0.02	1.01	0.85
5	50	8.5	50.63	2.13	0.00	11.75	902.8	19956.3	1.81	479.0	0.01	0.66	0.56
6	50	8.5	50.63	2.13	0.00	9.84	655.2	14330.3	1.31	343.9	0.01	0.47	0.40
7	100	8.5	50.63	2.13	0.00	15.98	1661.6	38060.5	3.32	913.5	0.03	1.26	1.06
8	100	8.5	50.63	2.13	0.00	13.06	1105.6	24678.5	2.21	592.3	0.02	0.82	0.69
9	100	8.5	50.63	2.13	0.00	11.29	838.2	18472.3	1.68	443.3	0.01	0.61	0.51



II) Install Kicker Plate once every 3 piles, along the whole length of the wall.



# Selection Process for Temporary Breakwater



Temporary Breakwater at HMC

## **Local Permitting** – breakwater not originally contemplated

- › *Able to include with Project Marine Structures Permit as a Temp Structure*

## **Other Alternatives** - Local Moderate Weather Safe Harbour (Near Tender Cut)

- › *Close to guest areas and Operator's Ro-Ro facility*
- › *Possible eye sore for guests with large marine fleet*

## **Selection of design wave conditions** – minimize cost for temporary structure

### **Balance the risk with cost**

- › *Breakwater not intended to store barges for major event over 7 ft. wave height*

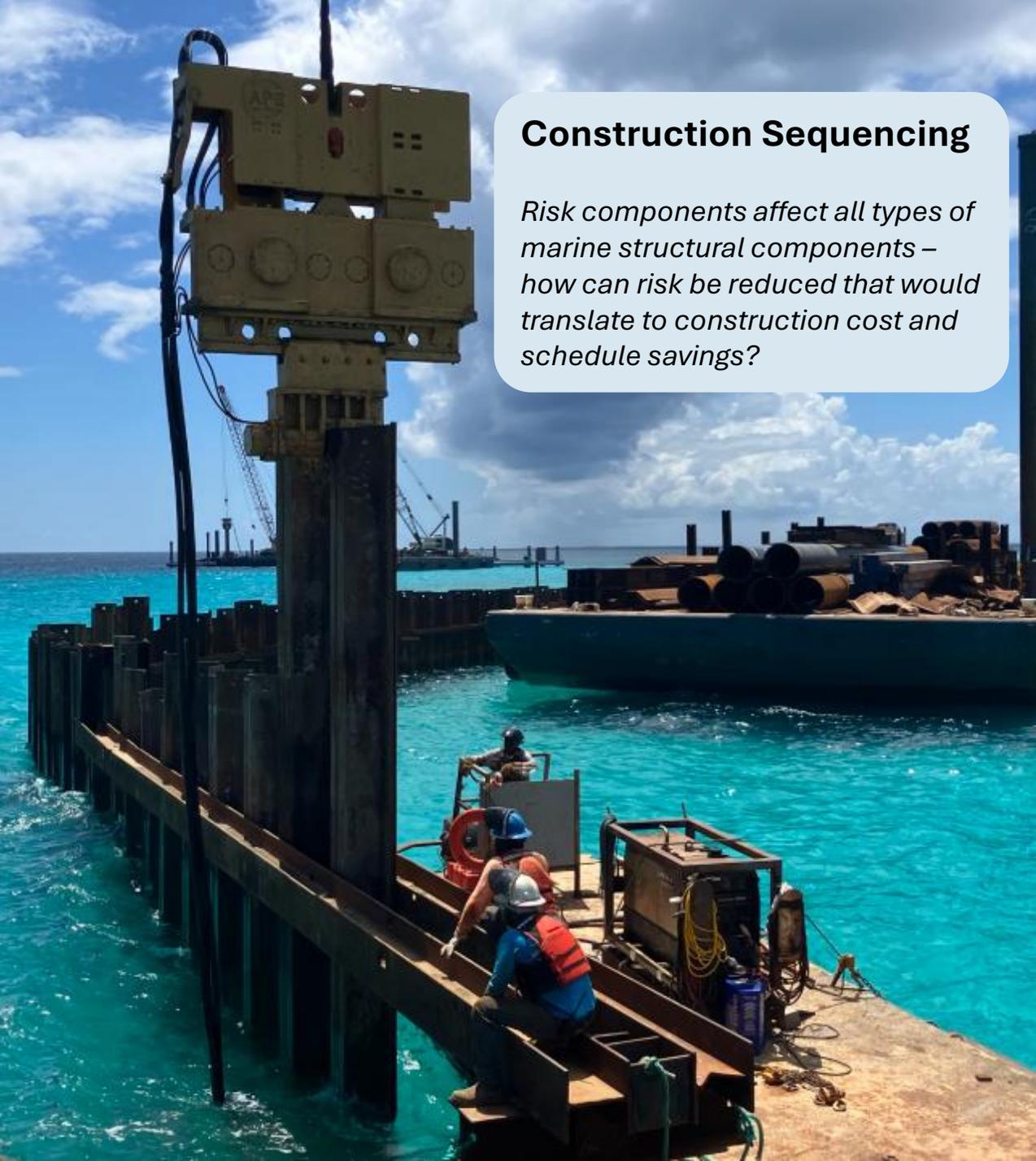
### **Equipment profile** – same as used for the pier

### **Geotechnical**

- › *Well cemented limestone layer made drivability and embedment of sheets in certain locations along the wall challenging*

### **Avoidance of marine resources**

- › *Location of temporary wall selected away from marine resources (coral, fish habitats, etc.)*



## Construction Sequencing

*Risk components affect all types of marine structural components – how can risk be reduced that would translate to construction cost and schedule savings?*

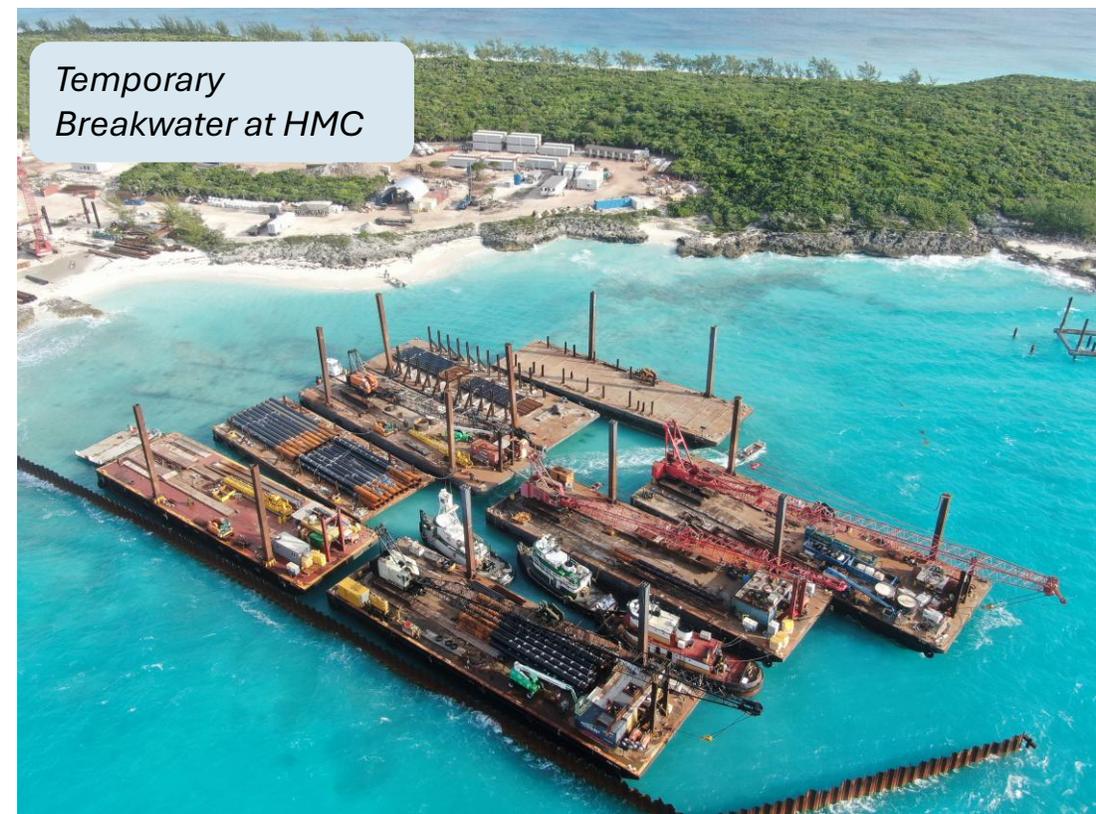
# Plan and Section of Proposed Breakwater

- › **General Working Conditions**
  - › Temporary breakwater utilized in forecasted seas up to 7 feet
  - › Work onsite with maximum wave height of 3-3.5 ft, depending on activity
- › **Selection of design wave conditions** – minimize cost for temporary structure
- › Balance the risk with cost
- › **Equipment profile** – same for temporary sheet pile installation as used for the pier
- › **Geotechnical**
  - › Well cemented limestone layer made drivability and embedment of sheets in certain locations along the wall challenging
- › **Avoidance of marine resources**
  - › Location of temporary wall selected away from marine resources (coral, fish habitats, etc.)



# After Installation – Breakwater Use

- › Contractor design and layout to allow for intended marine fleet
- › Upfront investment of schedule duration for installation
  - › 3 Weeks of Installation
  - › Approx. \$850K-1M in construction costs
- › Reduced Impacts For Demobilizations
  - › Likely eliminated 10-12 local demobilizations over the duration of the project related to severe weather events, saving 10-12 weeks of schedule overall
  - › Reduced wear and tear on marine equipment, with ability to store in protected area during minor to moderate wind/wave events
- › Continuous construction – avoid phasing that may be required for calmer Summer conditions without temporary breakwater
- › Conventional Construction Techniques – equipment, labor and materials



Date	Wind Direction	Wind Speed [mph]	Wave Hmax [ft]	Workable?
10/20/2024	E	10-15	2-3	Yes
10/21/2024	E	10-15	2-3	Yes
10/22/2024	E	10-15	2-3	Yes
10/23/2024	N	5-10	1-2	Yes
10/24/2024	E	10-15	1-2	Yes
10/25/2024	E	10-15	1-2	Yes
10/26/2024	E	10-15	1-2	Yes
10/27/2024	E	10-15	1-2	Yes
10/28/2024	E	15-20	2-3	No
10/29/2024	E	15-20	2-3	No
10/30/2024	E	15-20	3-4	No
10/31/2024	E	>20	3-4	No
11/1/2024	E	15-20	4-5	No
11/2/2024	E	15-20	4-5	No
11/3/2024	E	15-20	2-3	No
11/4/2024	E	>20	2-3	No
11/5/2024	SE	>20	3-4	No
11/6/2024	SE	>20	4-5	No
11/7/2024	SE	>20	3-4	No

*Sample Data sets by time periods for local weather*

Days Workable	158
Days Nonworkable	99
Total Days Tracked	257
% of Days Workable	61%
% of Days Nonworkable	39%



# Use During Construction

## Weather Buoy Data

- › After installation, weather monitored with Fondriest Weather Buoy
- › Weather data locally aligned over six months with anticipated wind and swell directions to plan work and demobilization go/no-go decisions
- › Ability to accurately anticipated condition through iterative observation process between this project and nearby project with similar exposure over a (3) year period
- › Modified CPM schedule to take advantage of calmer months for activities with higher weather dependency (i.e. placement of rock sockets, cast-in-place concrete work, rock socket drilling)





# Hurricane Damage

Several Significant Storms impacted the project site during construction most notably:

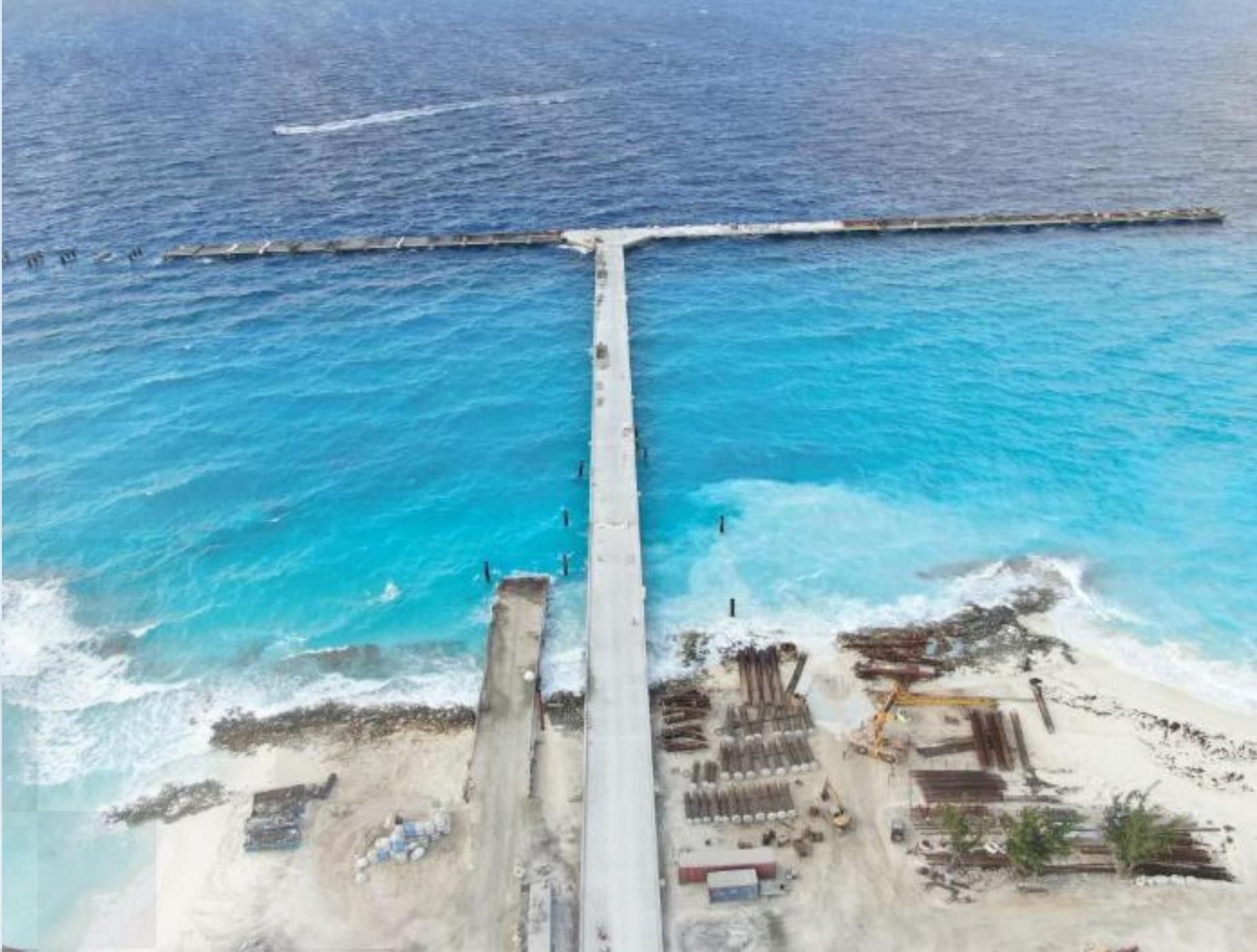
- › **Hurricane Milton**
  - › Minor Damage Occurred
- › **Tropical Storm Imelda**
  - › Waves over 12 ft Hmax prior to monitoring buoy becoming damaged
  - › 8 ft+ waves and winds in excess of 45 knots impacted wall for over (3) day duration
  - › Significantly damaged wall, with damage becoming worse over the long duration and seas likely in excess of the design wave / return period (approximately 14 ft Hmax), although not able to be verified.



# Team Effort



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# Thank you

