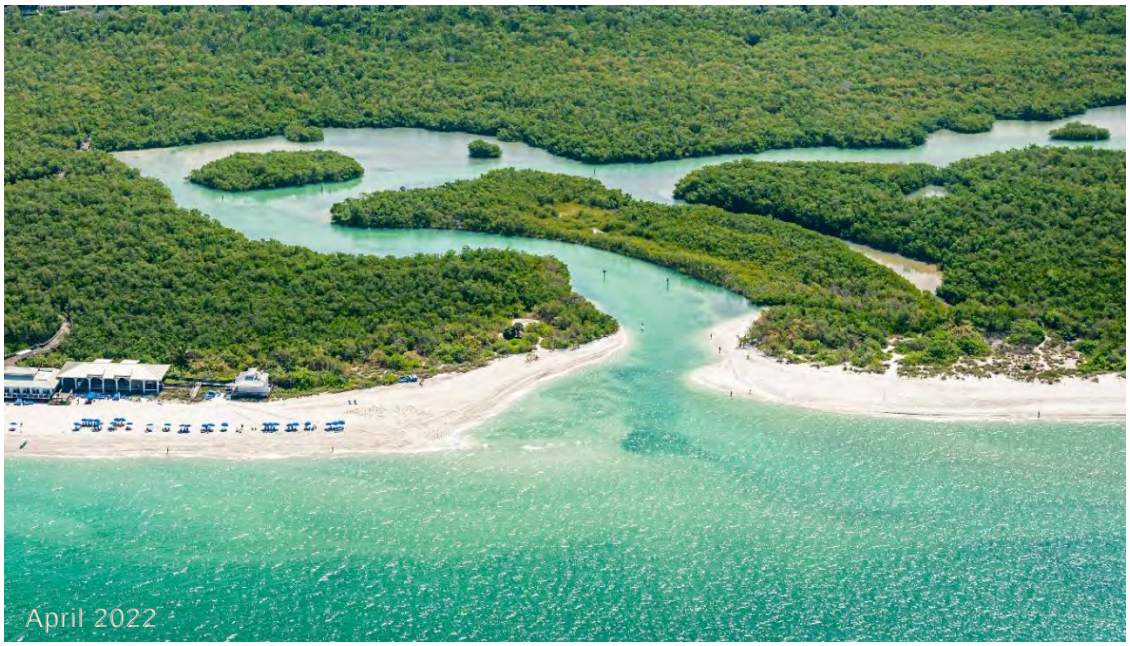
Clam Pass
Physical and Tidal Monitoring Report 2021
and Post Construction Summary 2022



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Prepared for
Pelican Bay Services Division

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1. BACKGROUND

This report provides the 2021 annual assessment of the bathymetric and hydrologic conditions of Clam Pass, and a post construction report of the 2022 dredging project. Clam Pass is a small wave dominated inlet on the southwest coast of Florida that provides a tidal connection to 560 acres of nature preserve including 420 acres of mangroves. The relatively small tidal prism of Clam Bay provides a critical balance between tidal flow and littoral processes moving to the inlet. This affects the inlet hydraulic efficiency over time, especially when littoral transport rates are high due to periods of high wave energy. Clam Pass requires maintenance dredging to remain an open and viable inlet and bay system. This annual report provides a summary of the physical and tidal monitoring metrics incorporated in the 2015 Clam Bay NRPA Management Plan. Physical monitoring is based upon surveys and mapping of the inlet system. Hydraulic monitoring of the bay system includes continuous water level and tidal data collection at four locations within the bay system.

The pass and wetland preserve have been managed according to a Natural Resource Protection Area (NRPA) Management Plan first adopted in 1999. An updated NRPA Management Plan was developed in 2014 and adopted by Collier County in 2015. Following the implementation of the Clam Bay NRPA Management Plan, maintenance dredging occurred in 1999, 2002, 2007, 2013, 2016, 2018 and most recently in 2022. The 2015 Management Plan incorporated grading areas at the sandy inlet banks to allow construction to mimic natural bank conditions. Grading is typically conducted from uplands using excavators and has been included in every dredge event beginning with 2016. Maintenance grading has also been conducted in response to the passage of tropical storms and other sand bypassing events that shoal the inlet mouth but do not contribute to accumulation in the interior part of the flood shoals of the inlet. Maintenance grading was completed in August 2017 in response to tropical storms, and in April and December of 2020 in response to bypassing of sediment from south to north after the truck haul placement at Clam Pass Park completed in early 2020.

Sand migration toward the north continued into 2021, resulting in low and declining tide range ratios in the first half of 2021, which led to authorization for a maintenance dredging ahead of the tropical season in the summer of 2021. With no tropical storms affecting southwest Florida in 2021, the inlet stability improved during the summer months with relatively calm wave conditions. The construction project was postponed until required in early 2022, following impacts due to winter cold fronts. Maintenance dredging of the entire dredging template was scheduled, and construction began in March of 2022 and was completed April 22, 2022. The 2022 event was the first full dredging of Clam Pass template since 2018

2. PHYSICAL MONITORING

2.1. INTRODUCTION TO INLET GEOMORPHOLOGY

An inlet channel is one part of a larger tidal inlet system where the inlet connects a bay system to open waters such as the Gulf of Mexico. The tidal flow through flood and ebb tides interacts with active beach wave and sediment transport processes that influence the stability of a tidal inlet. The morphologic features of a tidal inlet include the ebb shoal, flood shoal and inlet channel. **Figure 1** illustrates these three main morphologic features of an inlet system. The flood shoal includes the sand shoals on the bay side of the inlet channel. The flood shoal is less dynamic than the gulf side of the inlet as it is influenced mainly by tidal flow and sheltered from the varying wave conditions on the open coast side. The ebb shoal features can be explained as sand bar features forming a delta on the open coast side of the inlet. The ebb shoal delta shields the inlet channel from waves and provides pathways for sand transport along the coast to bypass the channel without shoaling the inlet closed. A stable inlet system requires an ebb shoal feature that prevents rapid shoaling at the inlet mouth. The inlet channel maintains its flow cross section through tidal flow that scours the channel to required flow area while the waves are moving large amounts of sand along the coast. The magnitude and direction of wave energy plays a significant role in the shape and dynamics of the inlet features.

The stability and dynamics of a tidal inlet is based on the balance of the tidal jet and wave driven sand transport long the coast. The location and size of the shoal is determined by the balance of outgoing tidal currents pushing sand seaward and the incoming wave energy driving sediment along the coast and back toward the coastline from the shoal. An increase or change in wave energy and sediment can upset the balance. Depending on the severity and duration of the unbalance, the inlet may recover naturally, with the forces returning to their natural balance. If the inlet does not recover naturally, the tidal jet becomes insufficient to scour the incoming sediment, which progressively shoals the inlet closed. As the inlet closes, the volume of water passing in and out with each tide cycle is reduced. Tide levels within a lagoon can provide an indicator of shoaling at the inlet.

2.2. AERIAL PHOTOS

Perspective aerial views are taken on monthly basis and provided to document the channel alignment and the overall condition of the inlet. Aerial photos are included in **Appendix A**. These illustrate the condition of the pass during 2021 and the construction during 2022. The aerials indicate the shoaling of the inlet mouth as sand continued to be transported from the south adjacent beaches on to the inlet until the maintenance dredging in April 2022. The aerials also show post construction conditions in May and June of 2022.

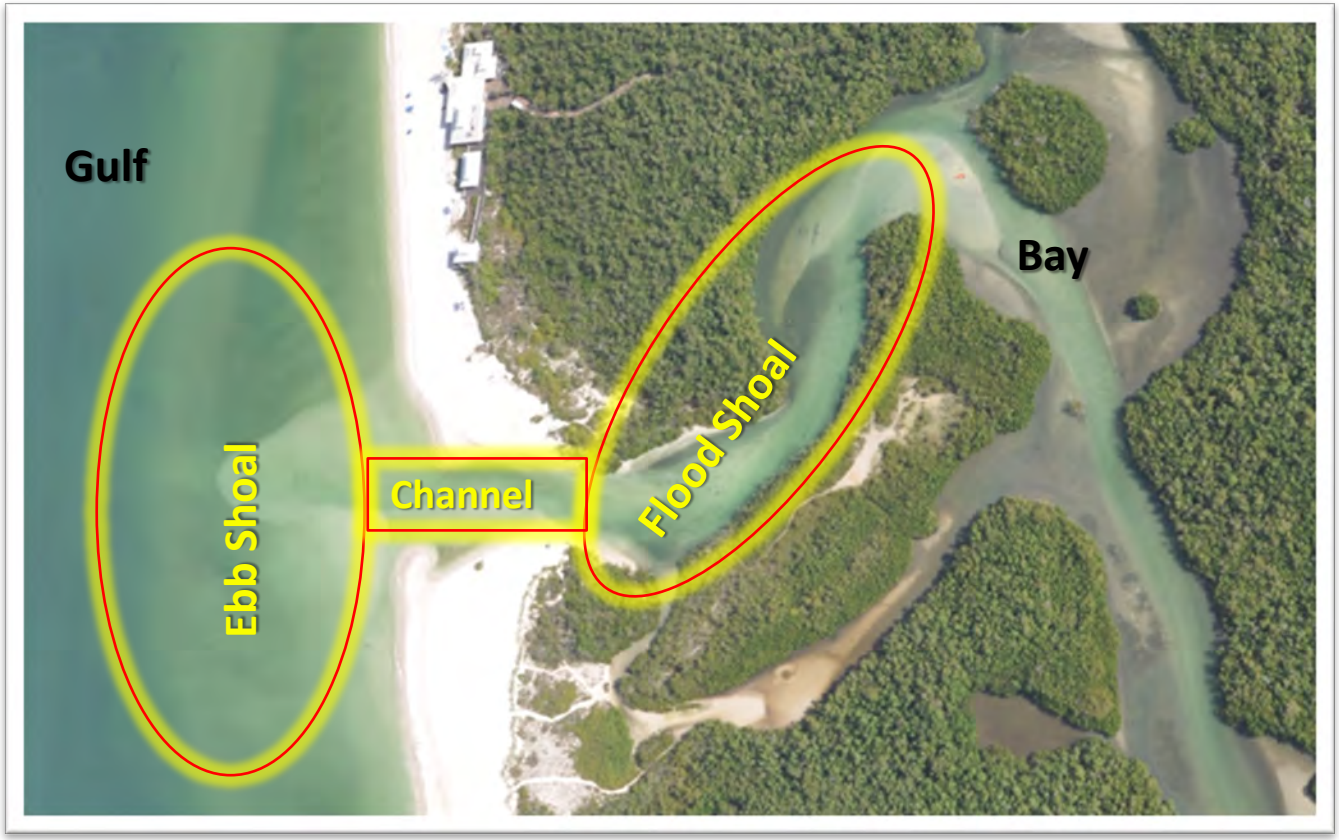


Figure 1. Clam Pass Morphologic Feature Definitions

2.3. HYDROGRAPHIC AND BEACH SURVEY

Physical monitoring data is used to characterize the flow areas and shoaling within the channel and flood shoal areas. Physical monitoring data includes bathymetric surveys of the inlet channel, flood shoal and ebb shoal features. The data analysis includes evaluation of the flow cross-section areas in three main sections of the dredging template, Sections A, B and C. **Figure 2** shows the three monitoring segments. Section A represents the inlet channel, Section B represents the seaward part of the flood shoal and Section C represents the bay side part of the flood shoal. The analysis included an evaluation of the cross section of flow below mean high water and volume of sand within each segment. The cross section of flow was computed at each survey station spaced approximately 50 feet apart. The average and minimum cross section areas were used as indicators of the physical condition of the flow area through each of the three segments. The scope of the survey and comparative profile plots with previous survey data are included in **Appendix B**. Each of these segments, along with the channel length and ebb shoal parameters were discussed in detail in the Review of Inlet Management compiled for PBSD and Collier County in 2019. A summary table including the data referenced above is provided in Section 5 of this report.

3. TIDAL MONITORING

3.1. INTRODUCTION AND BACKGROUND

Prior to the commencement of the March 1999 dredging, water level recording gauges were installed at selected locations within the Clam Bay estuarine system and Gulf of Mexico to measure tidal ranges. Tides along the southwest Florida coast are mixed, meaning that they exhibit either diurnal (one tide per day) or semidiurnal (two tides per day) characteristics at different times during each month, primarily dependent on the phase of the lunar cycle. There are seasonal variations as well. The locations of the gauges are illustrated in **Figure 3**.

Understanding the mixed tide characteristics of this area is important for the tidal data analysis. Part of the month, during neap tide, when tidal currents are not particularly strong, the inlet may take on wave dominant characteristics and appear to be shoaling near the entrance. This is particularly true when neap tide coincides with high wave energy events. During the ensuing spring tide roughly two weeks later, however, tidal currents become considerably stronger and may efficiently scour out shoals that formed during the neap tide interval. Short term channel shoaling and scouring that occurs in this manner causes short term variations in phase lag and tidal range data. This process therefore explains much of what appears as scatter in the phase lag and tide range data. When shoals are scoured out of the inlet channel, some of that sand is deposited on the ebb shoal, seaward of the beaches, restoring it to the littoral system. This is part of the sand supply for adjacent beaches; however, some of that sand scoured from the inlet channel becomes redistributed as net accumulation onto the broader interior flood shoals. It is this net accumulation on the flood shoals, usually over a period of several years, which eventually leads to the need for maintenance dredging.

The purpose of the monitoring program is to evaluate inlet characteristics on a comprehensive long term basis, with less emphasis on day to day, week to week changes, or even month to month and seasonal changes. Because of the dynamics of this system, the findings of this report provide a comprehensive evaluation of project performance which, at times, may not seem consistent with visual observation of inlet conditions over relatively short time intervals, particularly conditions that may be observed during or immediately after a storm.

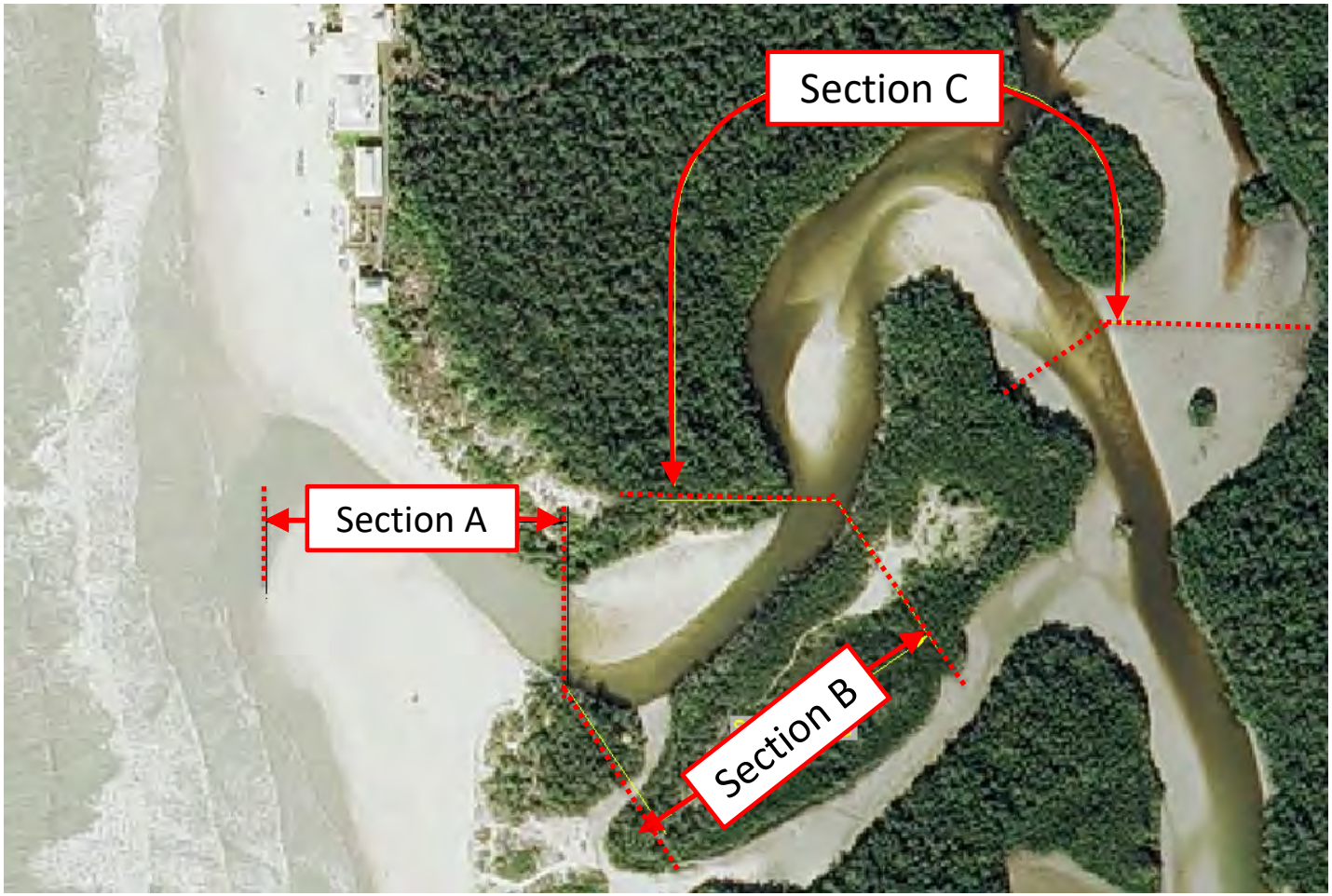


Figure 2. Clam Pass Monitoring Segments

CLAM PASS TIDE GAUGE LOCATIONS

Legend:

- Old Gauge Locations (1998 – 2015)
- New Gauge Location s (2016)

Figure 3 - Clam Pass Tide Gauge Locations

3.2. GAUGES

During 2015, PBSD initiated the purchase and installation new tidal gauges with solar recharging, onsite data logging and remote access capabilities. Installation and initiation of the new gauges was completed in January 2016. The new gauges were installed at marker locations near the previous gauges. Gauges are now installed at the following marker locations, their respective old gauge location is also shown (**Figure 3**):

- Marker 4: Registry (Hotel/County) Boardwalk
- Marker 14: South beach Facility Boardwalk
- Marker 26: North Beach Facility Boardwalk
- Marker 32: Upper Clam Bay

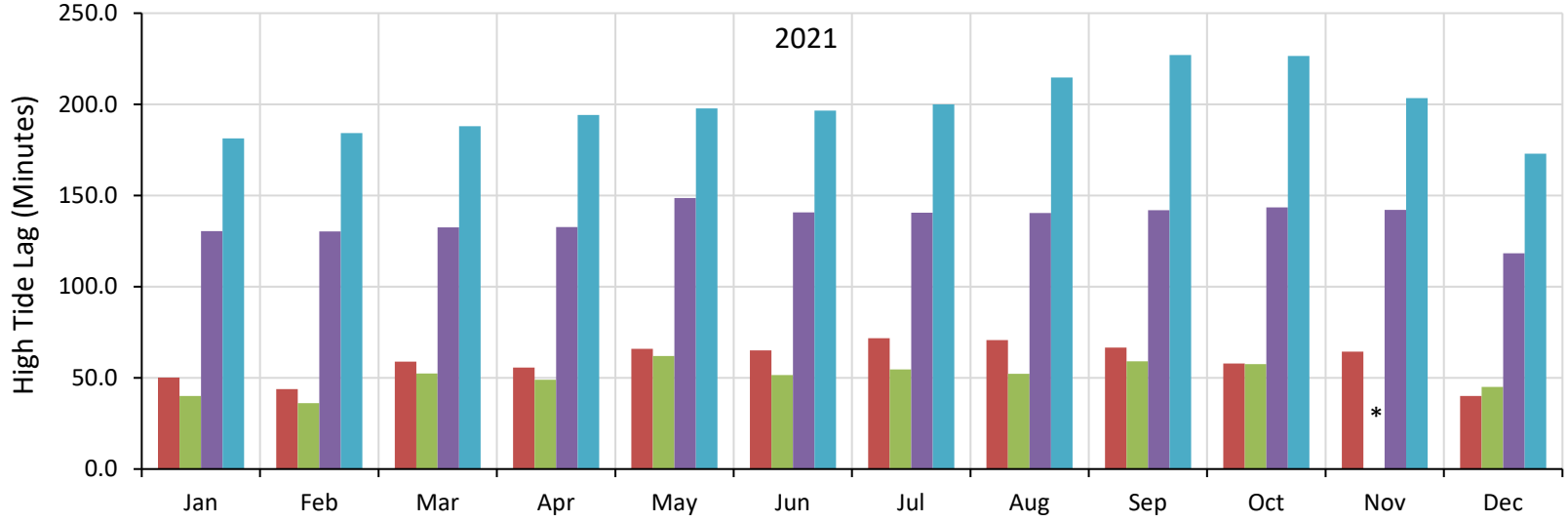
Remote access provides the ability to access the data at any time without interrupting data collection. Problems with data recording can be identified as they occur. Monthly data records can be accessed as soon as the month is completed, allowing for monthly updates to be posted on the web. The water elevation time series for each gauge are presented in **Appendix C** for each month of the 2021/2022 monitoring period. During this time period, the gauge at Marker 14 location malfunctioned and had to be replaced.

3.3. TIDE PHASE LAG

One of the parameters monitored is tidal phase lag. This is the time difference between the high or low tide in the Gulf of Mexico and the corresponding high or low tide in the bay. The magnitude of this phase lag is an important indicator of inlet dynamics, because shoaling in an inlet that obstructs tidal flow will cause the phase lag to increase. Short time lags indicate good flushing and scouring ability, long time lags indicate potentially limited flushing and shoaling.

Figures 4 & 5 present a monthly average of the low tide and high phase lags over the monitoring period of 2021/2022. Marker 4 and 14 are located near the inlet and provide a good indication of inlet condition. Monthly high and low tide lags were very low in January 2021 immediately following the maintenance grading completed in early January. The lags then increased to peak in July before declining during the second half of 2021. In January 2022, tide lag increased to the range of the July peak and the dredge project was scheduled to proceed. Following completion of dredging in April 2022, tide lags have been generally low, except for Marker 4 in April of 2022, which recorded only the initial week after reopening. Monthly time lags at Markers 26 and 32 remained the same suggesting no shoaling of the connector channels.

Figure 6 shows the annual averages of low tide and high tide phase lags from 2008 to 2021. The data indicates that the annual time lags for 2021 were slightly higher at Marker 4 and 14, but did not require the intervention that was needed during 2020. The spreading of sand from Clam Pass Park beach toward the north appears to be slowing. The high and low tide time lag at Markers 26 and 32 have declined since 2018, which may represent an improvement of flow conditions to these areas.



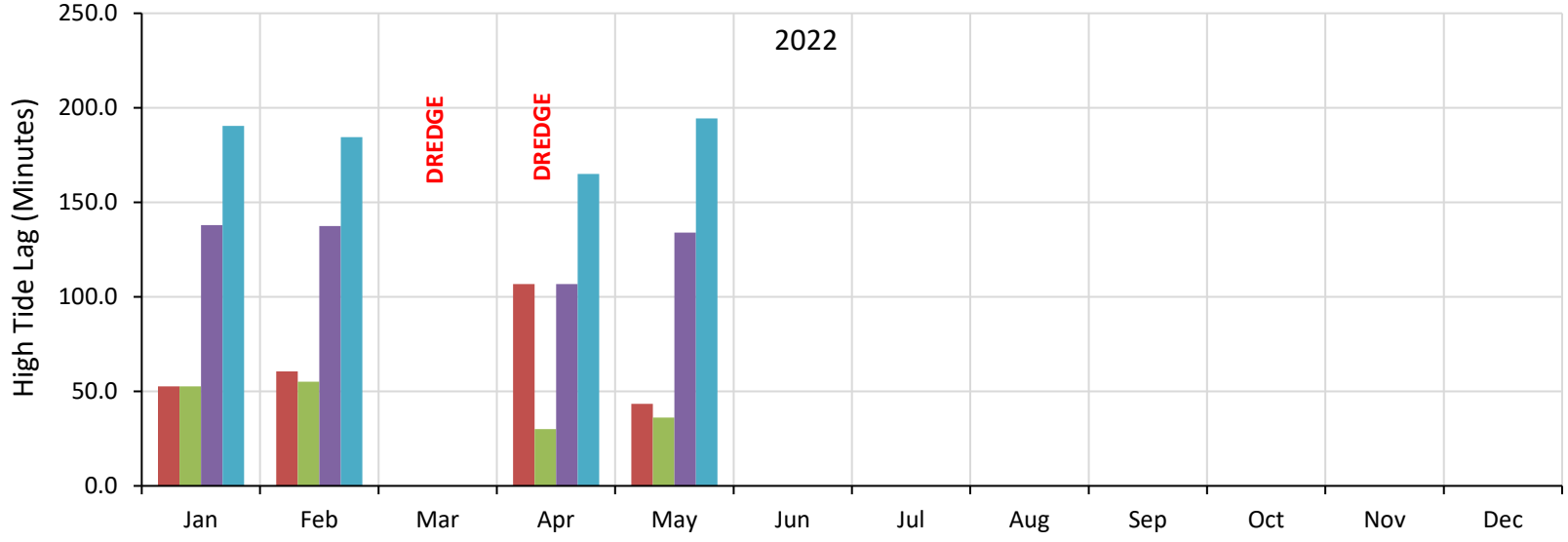


Figure 4 – Monthly High Tide Time Lag Averages – 2021/2022

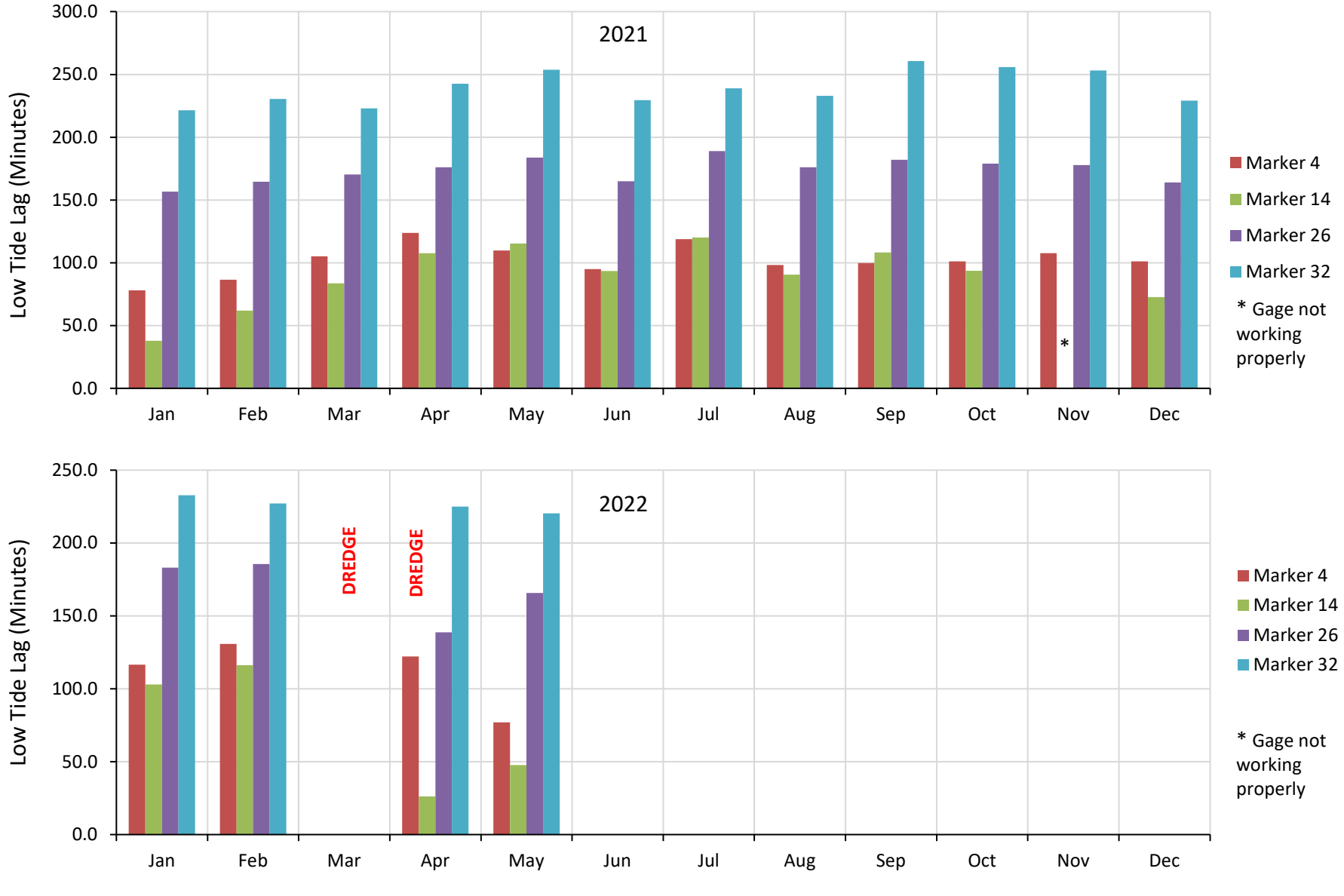


Figure 5 – Monthly Low Tide Time Lag Averages – 2021/2022

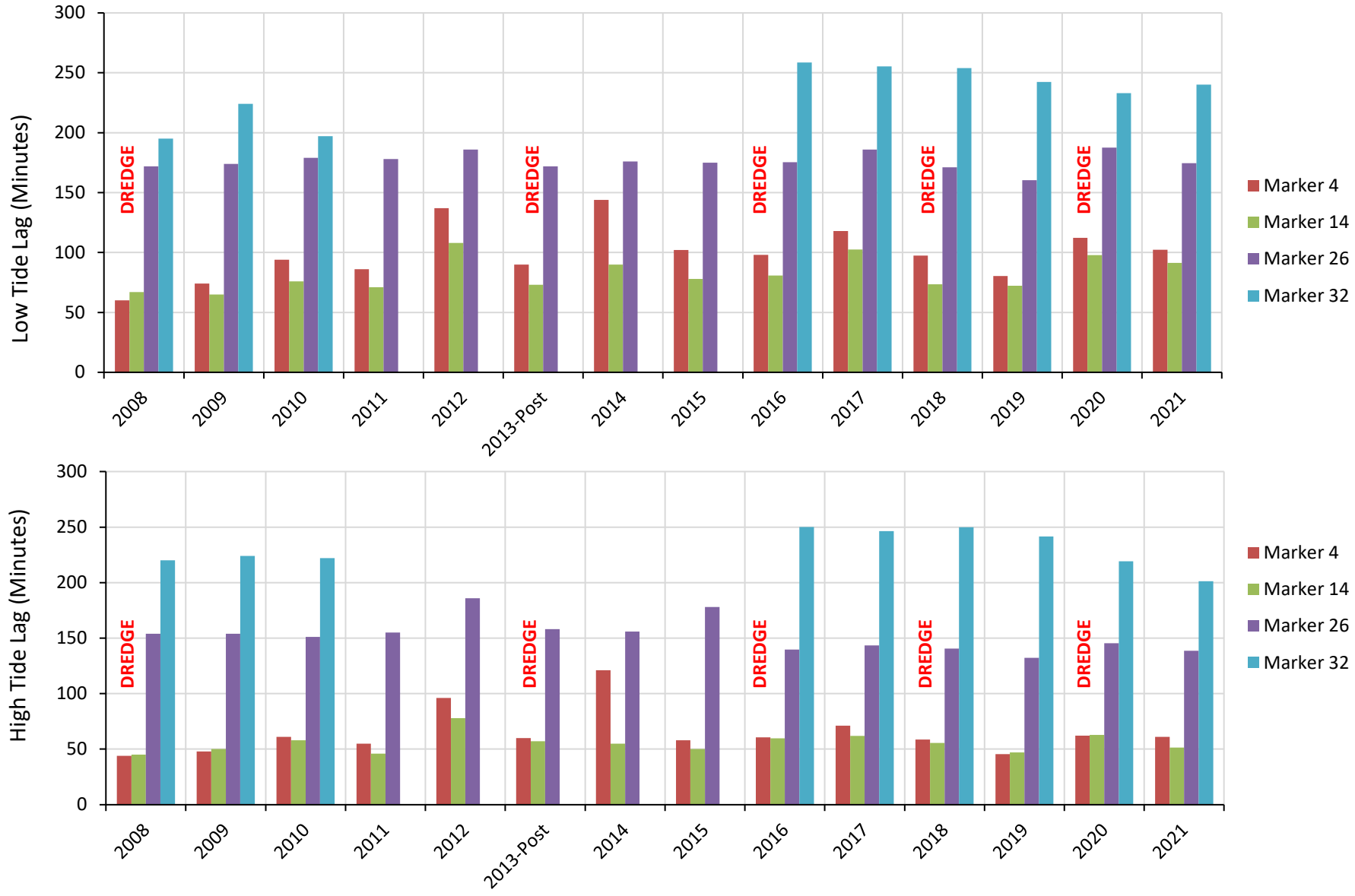


Figure 6 – Yearly Low & High Tide Time Lag Averages – 2008 to 2021

3.4. TIDE RANGE

The tide range is also an important indicator of the flushing of Clam Bay and shoaling within the inlet. The tide range is the difference in elevation between high water and low water for a given tidal cycle which is an indicator of the tidal prism or volume of water flowing through the inlet at each tidal cycle. The bay tide range will always be smaller than the gulf tide range, however, a reduced bay tide range is an indicator of flow restriction through the inlet channel and shoal features (**Figure 7**).

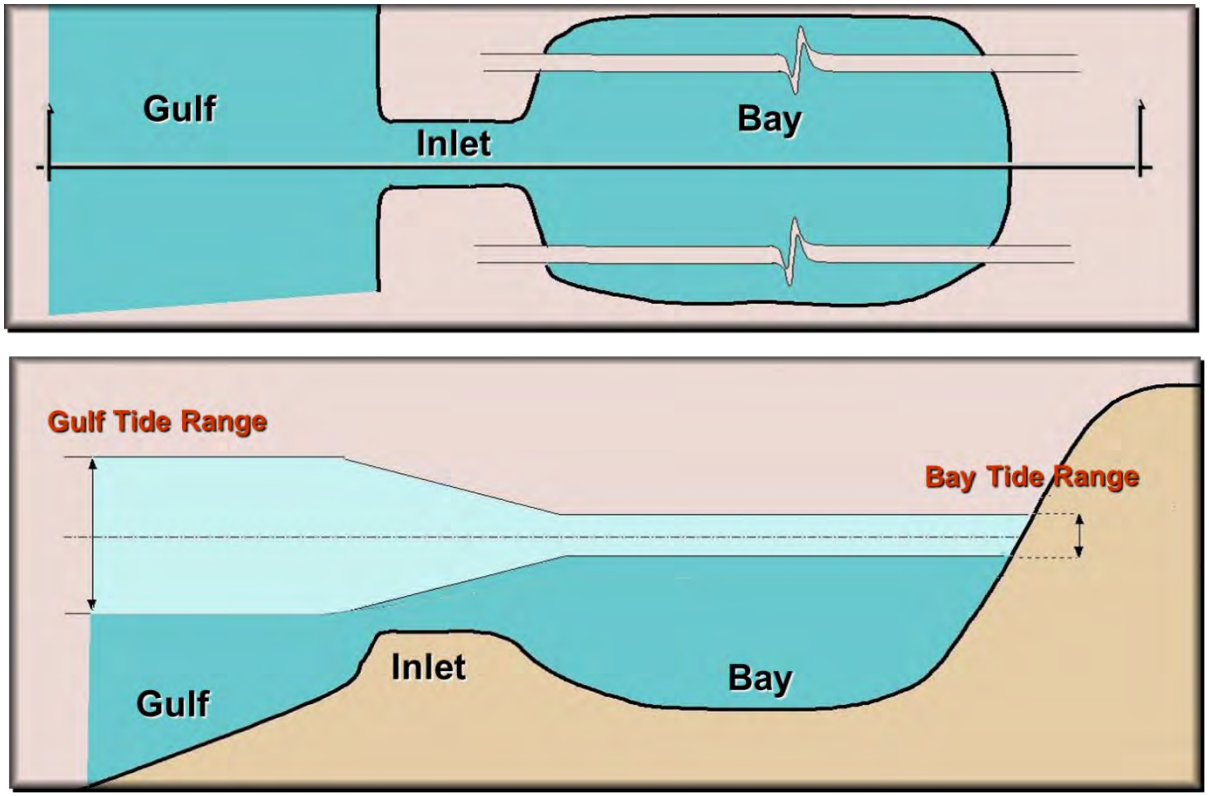
A review of ratios of the tidal range at each monitoring station to that of the gulf tide is used as the monitoring indicator for the flow through the inlet. The annual ratios of bay to Gulf tide from 1998 to date were used to establish a design tidal range ratio for Clam Bay. The available data indicates that when the inlet was hydraulically stable the ratio between the bay (Marker 4 & 14) and Gulf tide was between 0.6 and 0.7 over 90% of the time. The data also showed that this ratio was below 0.5 prior to 1999 dredging when the inlet was unstable and in 2012 prior to the inlet closure. The 2015 NRPA Management Plan set the critical ratio at 0.5, with additional monitoring conducted when the ratio drops below 0.6. The 2015 updated management plan uses the relative tidal range at the Marker 4 and Marker 14 gauges as indicators of hydraulic efficiency.

Figure 8 shows the monthly average tidal ranges for the monitoring period of 2021/2022. The Gulf tide range was around 2 feet, while the Marker 4 & 14 gauges (near the pass) tide ranges began 2021 near 1.5 feet, then fell to around 1 foot during the summer months. Near the end of 2021, tide ranges began to increase, but again returned to just over 1 foot in early 2022. At this point the decision was made to proceed with the dredging project. The tidal ranges at Marker 26 and 32 showed a similar pattern, beginning the year high, then declining, recovering slightly, and again declining prior to the 2022 dredging.

Figure 9 shows the monthly average tide ratios for the monitoring period of 2021/2022. Tide ratios at Marker 4 & 14 entered the critical stability range in April but remained generally stable through October when they began to improve. The ratios again entered the critical stability range in January and the dredge project was scheduled. The dredge project resulted in much higher ratios, indicating improved tidal exchange in the bays.

Average annual tidal ranges and ratios for Clam Pass are presented in **Figure 10** for the time period between 2008 and 2021. The average annual tidal ranges remain within the range of typical values. The average ratios for 2021 at Marker 4 and 14 were in the range of 0.6. This represents an improvement from 2020. The dredging completed in early 2022 is anticipated to produce an even higher tide range ratio for 2022 if similar conditions persist.

Overall, monthly and annual tide ranges and range ratios indicated a critically stable inlet requiring observation thoughout much of 2021. A dredge project was bid in the first half of 2021 for which construction occurred in early 2022. Construction restored tide ratios to the stable range. However, continued monitoring is required for inlet management.



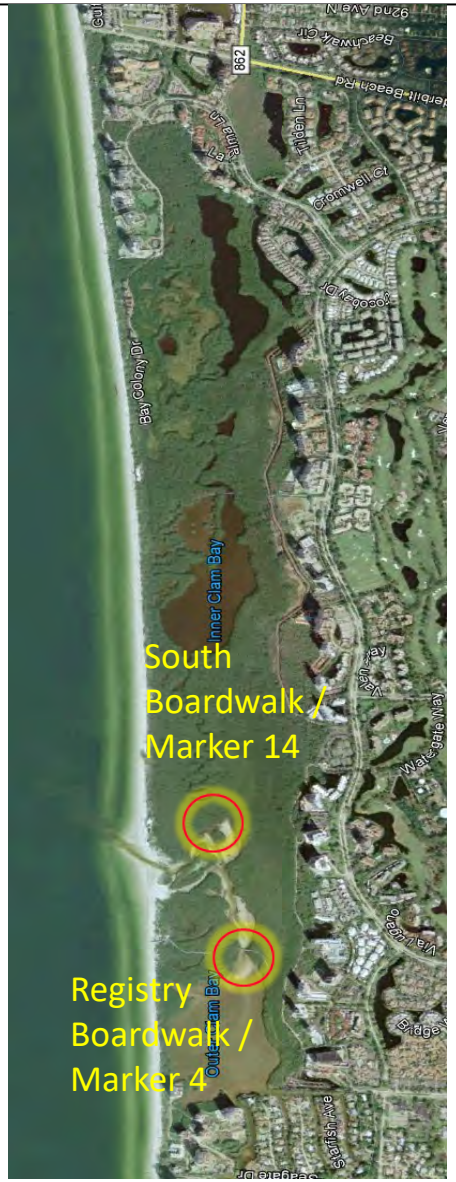
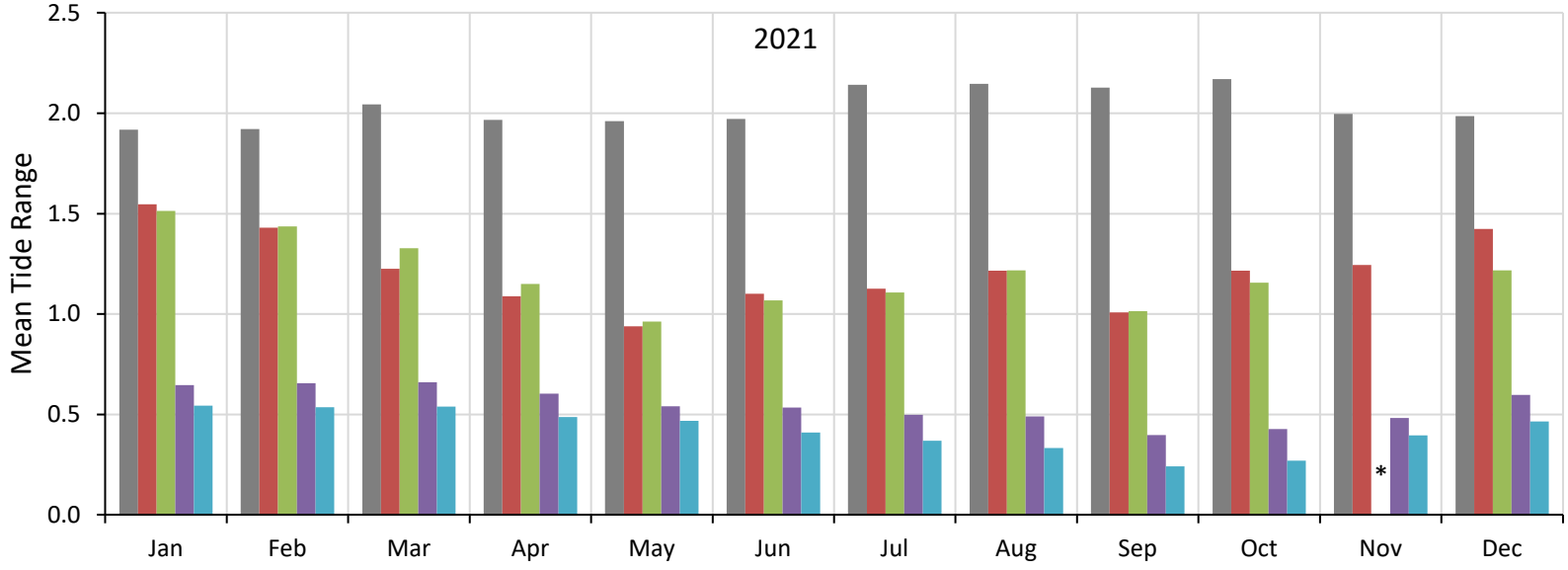


Figure 7. Gulf and Bay Tide Range Illustration



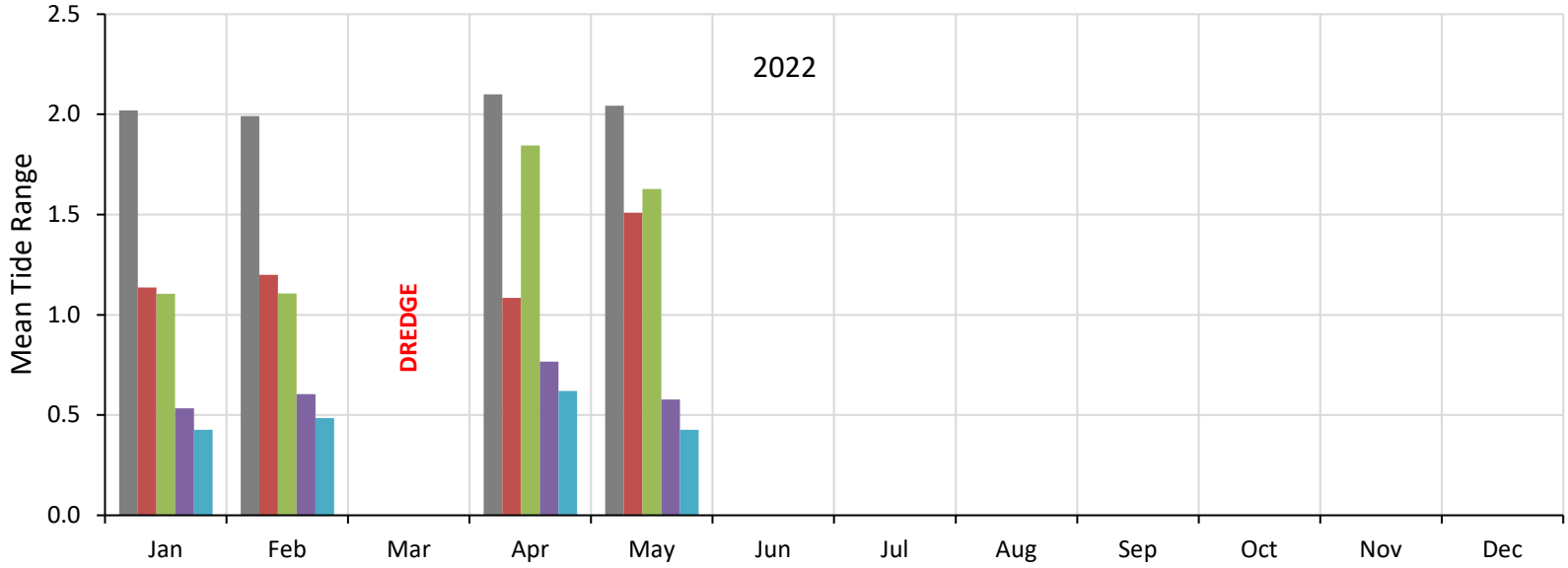
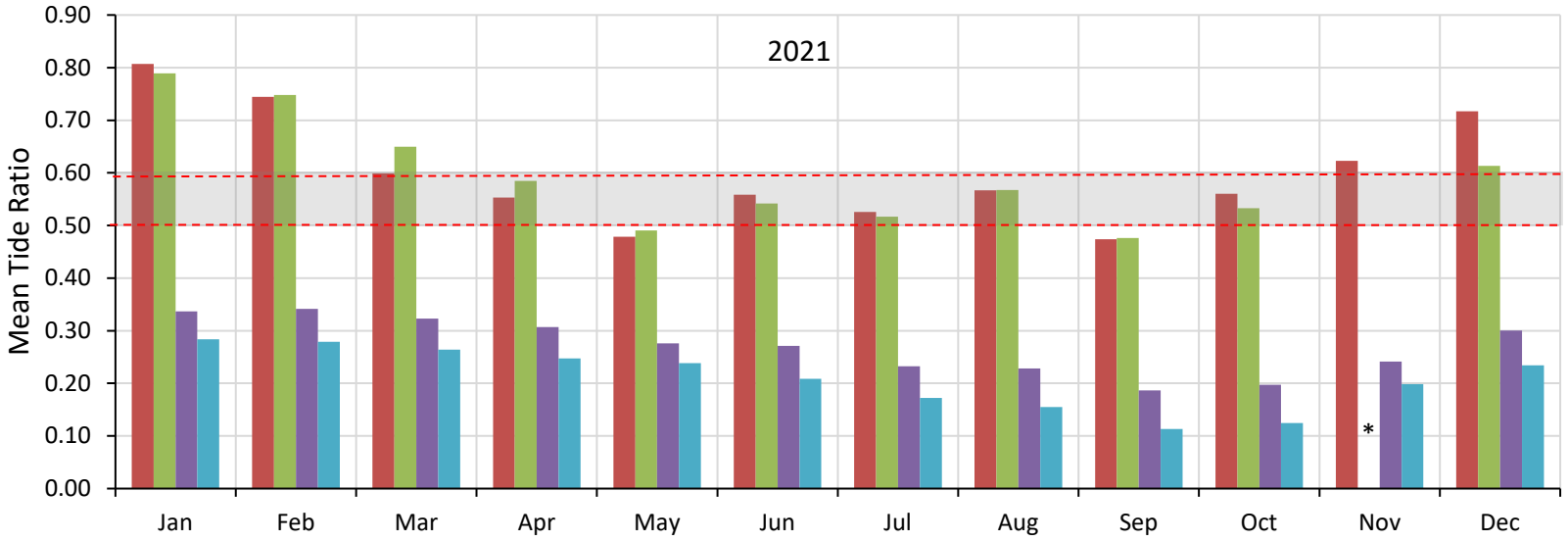


Figure 8 – Monthly Average Tide Range – 2021/2022



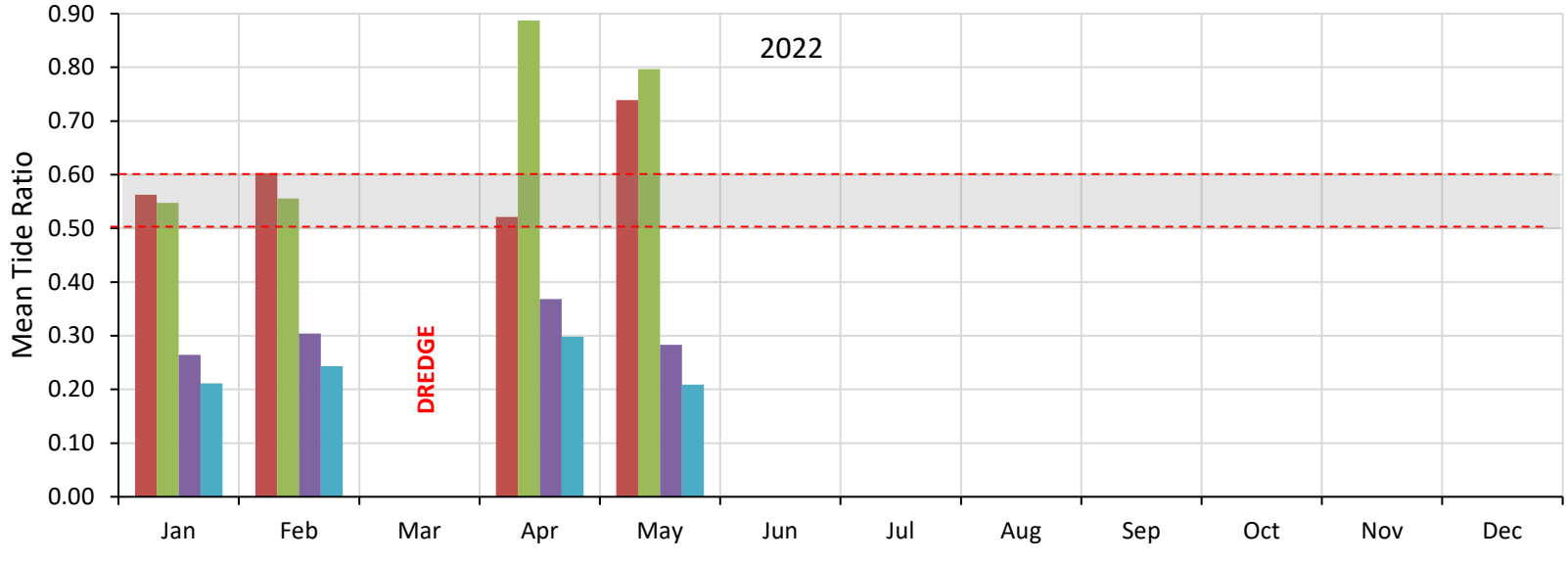


Figure 9 – Monthly Average Tide Range Ratio – 2021/2022

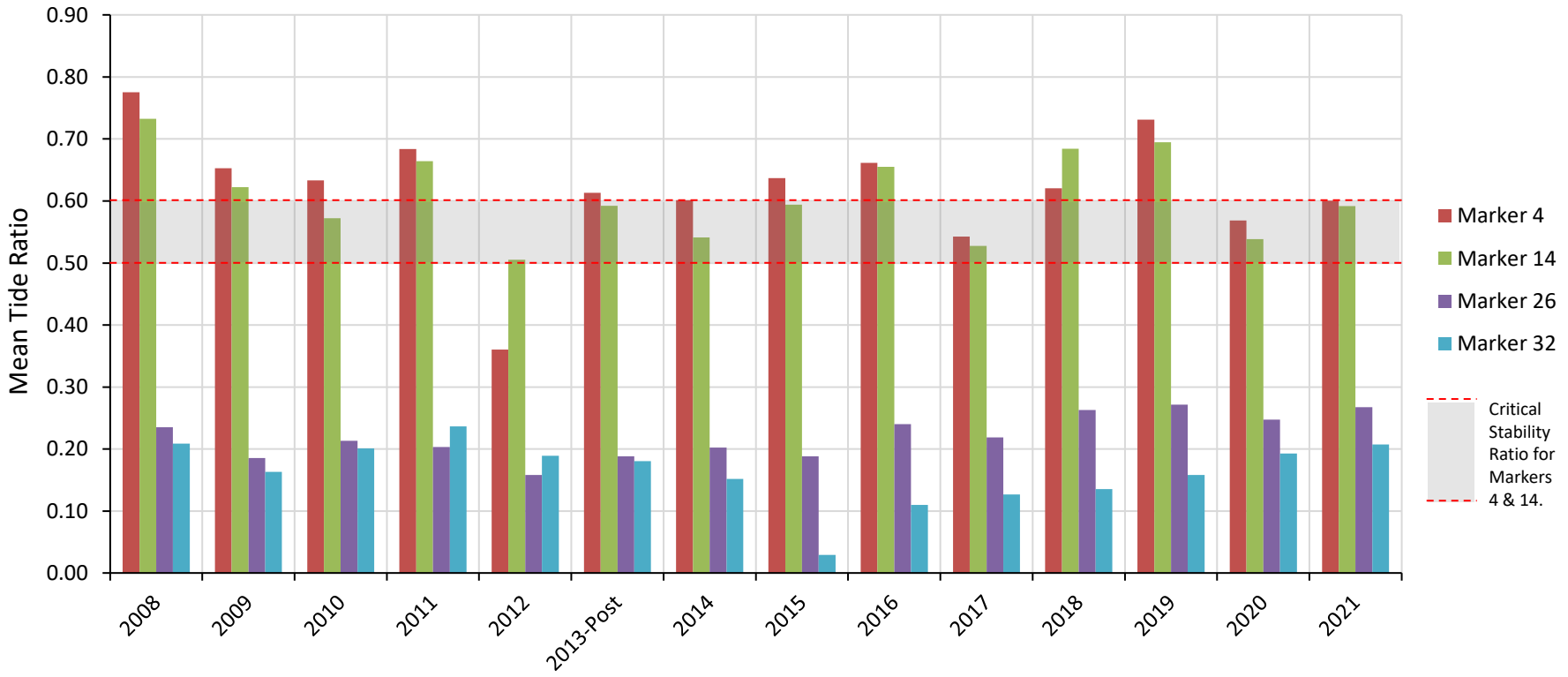


Figure 10 – Average Annual Tide Range Ratio – 2008 to 2021

4. 2022 INLET MAINTENANCE CONSTRUCTION SUMMARY

Maintenance grading was required to remove shoaling at the mouth of Clam Pass in April and December of 2020 following fill placement at Clam Pass Park in early 2020. The inlet twice migrated rapidly toward the north, as sand influx from the adjacent beaches south of the inlet continued to cause progressive shoaling. Shoaling again resumed following the January 2021 maintenance grading. Critical shoaling was documented in the summer of 2021 and a dredge project was bid with two options. One option was to provide only maintenance grading in Sections A and B as had been done twice in 2020 in anticipation of the 2021 tropical season. The second option would dredge the entire channel template, which had not been done since 2018.

In the absence of active tropical storms in 2021, conditions improved in the second half of 2021, leading to postponement of the potential limited dredging project. When conditions again deteriorated in the beginning of 2022 following a few winter storms, Full dredging of the inlet template was recommended and approved. Construction began in March of 2022 and was completed April 22, 2022. Construction was completed by TSI Disaster Recovery, Inc. of Melbourne, FL.

The 2022 maintenance dredging included grading of the inlet banks and dredging of the permitted template. The project timing was chosen based on inlet conditions and planned to occur outside of turtle nesting season with coordination with other coastal management efforts in Collier County. The last time the full template was dredged was 4 years ago in 2018 and dredging the full template was recommended to restore the inlet to design conditions. Pre-construction conditions indicated shallow water depths throughout the authorized template confirming the critical nature of the inlet hydraulic stability and the extent of shoaling. Under such conditions and due to the size and depth limitations the size and type of equipment that can dredge the pass is limited. Working under controlled environment by constructing a temporary dike at the entrance and turbidity curtains at interior limits of the template were designed to protect nearby seagrass bed. These measures allowed the contractor to dredge the entire template under controlled flow conditions and to protect seagrass beds near the end of the template from potential turbidity spreading by tidal currents. Construction observations and turbidity measurements were conducted regularly in compliance with permit authorizations. The project cut and fill areas were completed in approximately 6 weeks. The temporary sand dike was excavated at the final stages of construction to reopen the inlet and grade the adjacent beaches. In addition, this construction method also resulted in substantial cost savings compared to mobilizing a hydraulic dredge and was completed in a similar timeframe. In total, 17,442 cubic yards of sediment were dredged at a construction cost of $301,230.00, or $17.27 per cubic yard. **Appendix D** includes exhibits illustrating project construction from pre to post construction conditions. The exhibits show the project site plan with background aerials at preconstruction conditions and several progress stages to post construction conditions. The figure for pre-construction conditions shows the shoaling throughout the template and the intermediate stages show work progress of excavation of the template under controlled environment to restore the inlet to design conditions. The post construction exhibit shows the restored inlet conditions following the completion of the project.

5. SUMMARY & RECOMMENDATIONS

Clam Pass and Clam Bay include sensitive environmental habitat and several considerations are considered in maintenance events. The nature of a small inlet like Clam Pass requires rapid response to maintain the inlet open following significant shoaling events. The Inlet flow meanders significantly throughout the flood shoal and inlet mouth, as the narrow bay inlet at the entrance fills with sand between the mangrove shorelines. Without timely maintenance the shoaling overwhelms the inlet and inlet closure becomes imminent. Emergency dredging using mechanical equipment was used on several occasions where inlet shoaling following storms closed or threatened to close the inlet. Mechanical excavation to reopen the pass occurred in 2013, 2017 and 2020. The 2013 dredging event occurred following inlet closure due to the active tropical storm season in 2012 while the 2017 and 2020 dredging events were in response to excessive shoaling of the inlet and spit growth across the inlet mouth following beach nourishment of adjacent beaches.

Since placement of beach nourishment fill along beaches south of the inlet in early 2020 along Clam Pass Park and Park Shore beaches, there has been persistent flow of sand from the south side of the inlet. Limited maintenance excavations and grading projects were completed in April 2020 and December 2020 to reopen the inlet, mechanically bypass the sand accumulation at the south side of the inlet and restore the inlet channel to its design template. These maintenance events helped restore tidal flow, but the sand has continued to encroach upon the inlet channel from the south pushing the channel to the north.

The 2022 maintenance dredging included grading the inlet banks and dredging of the permitted template. The project timing was chosen based on inlet conditions and planned to occur outside of turtle nesting season with coordination with other coastal management efforts in Collier County. The last time the full template was dredged was 4 years ago in 2018 and dredging the full template was recommended to restore the inlet to design conditions. The condition of Clam Pass was documented by monthly oblique aerial photography, four complete bathymetric surveys, and tidal flow monitoring throughout 2021/2022. These datasets were processed to monitor the condition of the pass. **Table 1** summarizes the design criteria indicators based on the 2021/2022 survey and tidal data.

Tidal monitoring indicated that Clam Pass remained critically stable in the first half of 2021 until shoaling reached critical conditions. A temporary improvement in the fall of 2021 allowed delaying inlet restoration to early 2022. Construction was completed in April, 2022. The post construction data and analysis from April and May 2022 indicates that most inlet stability indicators are within the stable range. The ebb shoal shows a large seaward growth from April to May but still remains below historically stable conditions. Dredging and realignment of the channel typically results in ebb shoal changes where the shoal at the old channel alignment moves onshore and a new shoal is formed at the new channel alignment. Re-growth of the ebb shoal at the channel alignment post dredging is ongoing. Hydraulic monitoring indicates that the tidal exchanges are in a healthy range, above critical levels.

Table 1: Design Criteria and Present Conditions

Criteria	Target		Monitoring Condition			
			Jan '21	Feb '22	Apr '22	May '22
Section A – Average Cross Section (square feet)	>	300	631	381	581	485
Section A – Minimum Cross Section (square feet)	>	250	339	278	337	332
Section B – Average Cross Section (square feet)	>	450	636	390	581	--[4]
Section B – Minimum Cross Section (square feet)	>	350	372	286	385	--[4]
Section B – Volume in Template (cubic yards)	<	2,500	670	3,230	211	--[4]
Section C – Average Cross Section (square feet)	>	450	565	581	697	--[4]
Section C – Minimum Cross Section (square feet)	>	350	285	258	415	--[4]
Section C – Volume in Template (cubic yards)	<	4,000	3,728	2,711	464	--[4]
Annual Tide Ratio – Marker 4	>	0.5	0.78[1]	0.60[2]	--[3]	0.63[5]
Annual Tide Ratio – Marker 14	>	0.5	0.77[1]	0.59[2]	--[3]	0.84[5]
Monthly Tide Ratio – Marker 4	>	0.5	0.81	0.60	0.52	0.74
Monthly Tide Ratio – Marker 14	>	0.5	0.80	0.56	0.89	0.80
Seaward Extent of Ebb Shoal (feet)	>	250	230	210	155	205
Ebb Shoal Area (square feet)	>	200,000	205,000	162,000	153,000	150,000

1. Average January & February 2021.
2. Annual Average 2021
3. Immediately Post Construction
4. Survey of Section A only.
5. Average of April & May 2022.

The following recommendations for monitoring on a continuous basis are:

1. Tidal monitoring should continue to be collected and studied on a monthly basis as it has been shown to indicate the state of hydraulic efficiency in the pass.
2. Continue physical monitoring by conducting an annual hydrographic survey and possibly an interim survey to identify shoaling if tidal monitoring indicate critical conditions. This report documents the annual monitoring of 2021 through post construction of the inlet dredging project in early 2022. A monitoring survey can be conducted towards the end of 2022 to document the post construction adjustments and physical condition of the pass following the 2022 tropical season. This survey can be reported as a 2022 physical conditions update and annual report in early 2023.

REFERENCES

Humiston & Moore Engineers (2018) Clam Pass Physical and Tidal Monitoring Report. Prepared for Pelican Bay Services Division, Collier County, Florida. December 2018.

Humiston & Moore Engineers (2019) Review of Inlet Management. Prepared for Pelican Bay Services Division, Collier County, Florida. August 2019.

Turrell, Hall & Associates, Inc.(2014) Clam Bay NRPA Management Plan. Prepared for Pelican Bay Services Division, Collier County, Florida. November 2014.

APPENDIX A

Clam Pass

Monthly Aerial Photos 2021/2022

Figure A1 - Clam Pass Aerial Photograph (Photo Taken by Aerial Innovations)

Figure A2 - Clam Pass Aerial Photograph (Photo Taken by Aerial Innovations)

Figure A3 - Clam Pass Aerial Photograph (Photo Taken by Aerial Innovations)

Figure A4 - Clam Pass Aerial Photograph (Photo Taken by Aerial Innovations)

Figure A5 - Clam Pass Aerial Photograph (Photo Taken by Aerial Innovations)

Figure A6 - Clam Pass Aerial Photograph (Photo Taken by Aerial Innovations)

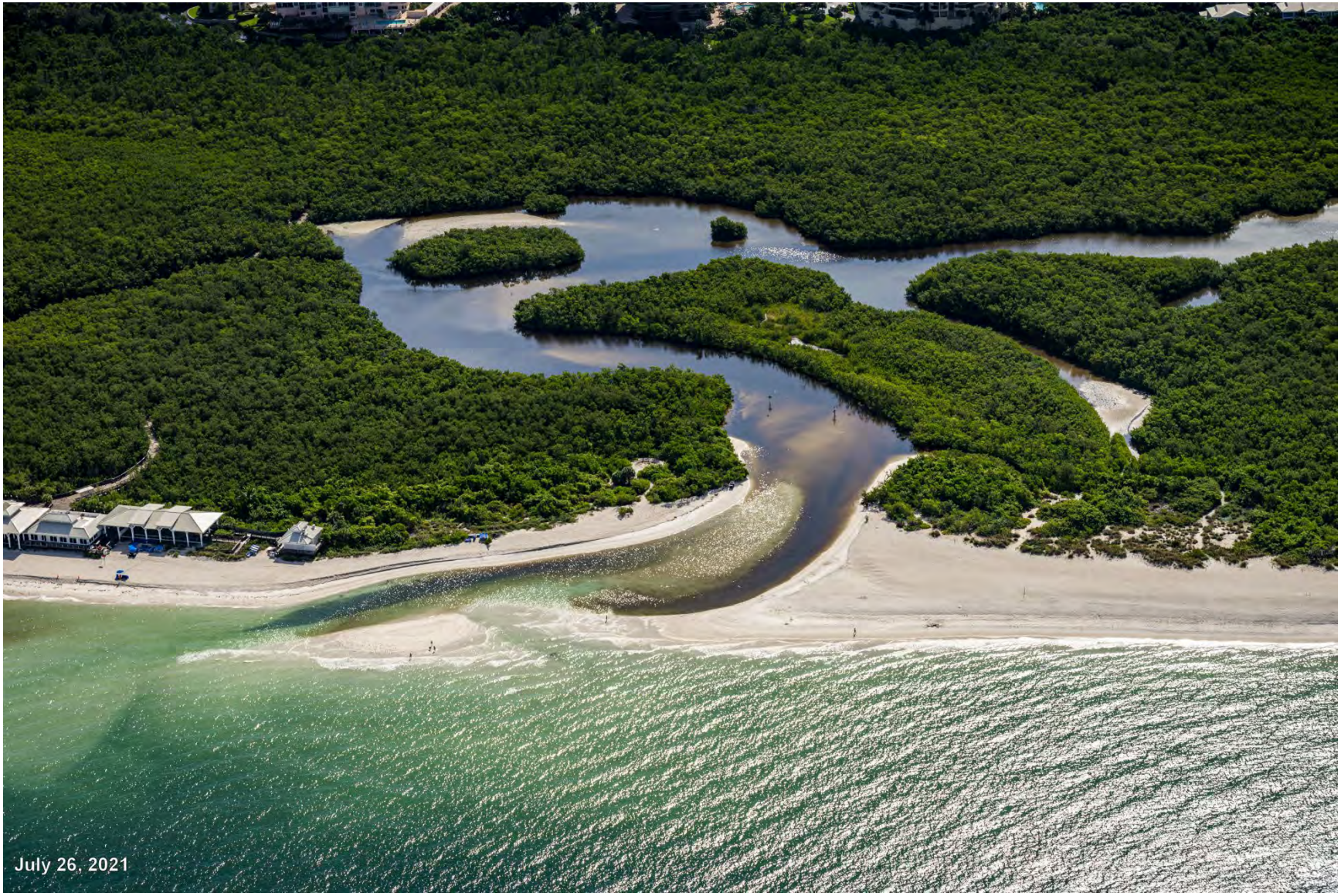


Figure A7 - Clam Pass Aerial Photograph (Photo Taken by Aerial Innovations)

Figure A8 - Clam Pass Aerial Photograph (Photo Taken by Aerial Innovations)

Figure A9 - Clam Pass Aerial Photograph (Photo Taken by Aerial Innovations)

Figure A10 - Clam Pass Aerial Photograph (Photo Taken by Aerial Innovations)

Figure A11 - Clam Pass Aerial Photograph (Photo Taken by Aerial Innovations)

Figure A12 - Clam Pass Aerial Photograph (Photo Taken by Aerial Innovations)

Figure A13 - Clam Pass Aerial Photograph (Photo Taken by Aerial Innovations)

Figure A14 - Clam Pass Aerial Photograph (Photo Taken by Aerial Innovations)

Figure A15 - Clam Pass Aerial Photograph (Photo Taken by Aerial Innovations)

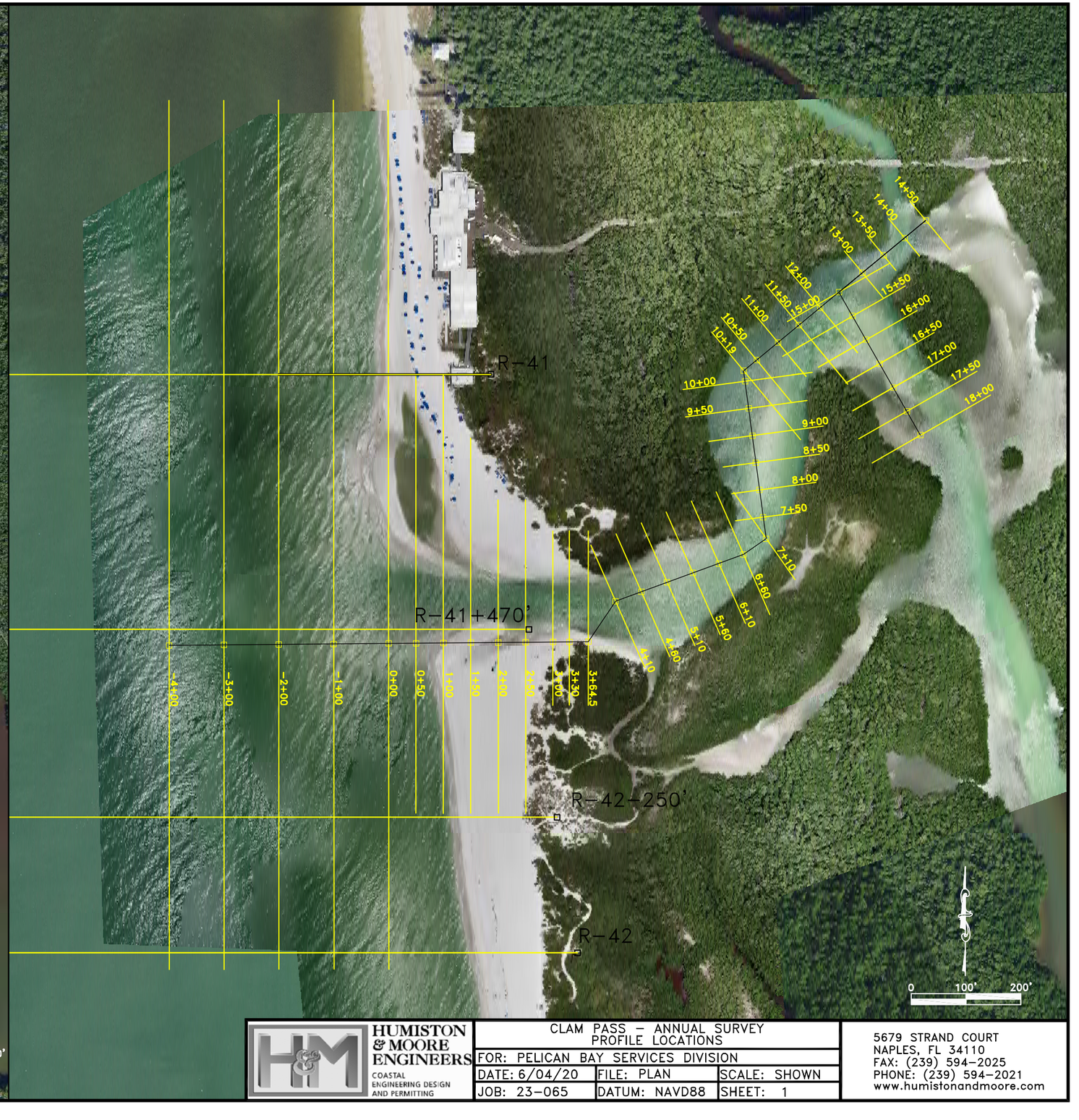
Figure A16 - Clam Pass Aerial Photograph (Photo Taken by Aerial Innovations)

Figure A17 - Clam Pass Aerial Photograph (Photo Taken by Aerial Innovations)

APPENDIX B

Clam Pass Surveys
Profile Cross Sections

January, 2021
February, 2022
April, 2022
May, 2022



NOTES:
1. BACKGROUND AERIAL IMAGE NOV. 2019 COURTESY OF COLLIER COUNTY TAX COLLECTOR.
2. CLAM PASS INSET COLLECTED MAY 2020 BY HUMISTON & MOORE ENGINEERS.

HUMISTON & MOORE ENGINEERS
COASTAL ENGINEERING DESIGN AND PERMITTING

CLAM PASS – ANNUAL SURVEY
PROFILE LOCATIONS

FOR: PELICAN BAY SERVICES DIVISION		
DATE: 6/04/20	FILE: PLAN	SCALE: SHOWN
JOB: 23-065	DATUM: NAVD88	SHEET: 1

5679 STRAND COURT
NAPLES, FL 34110
FAX: (239) 594-2025
PHONE: (239) 594-2021
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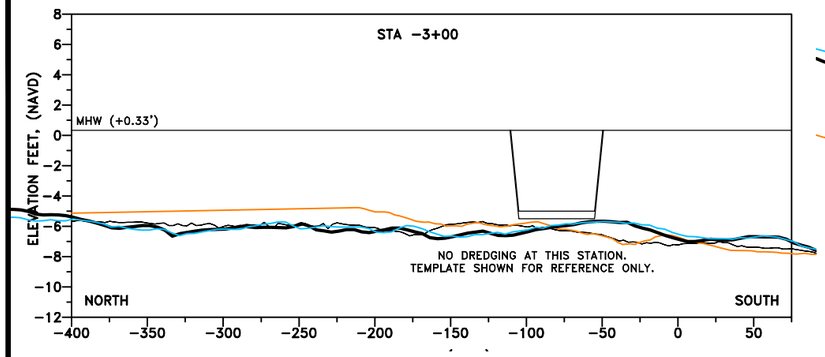

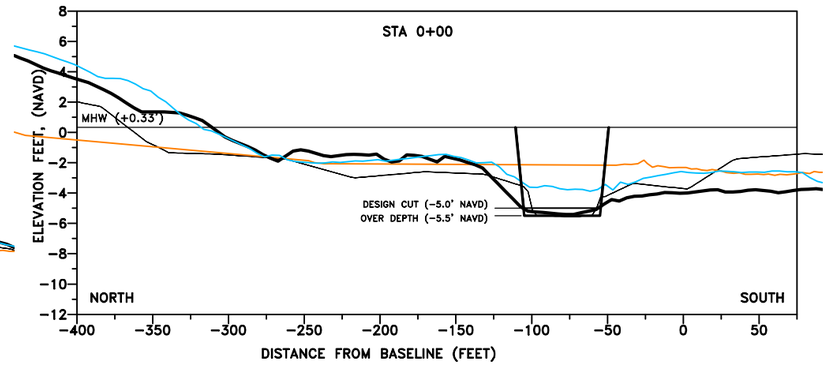

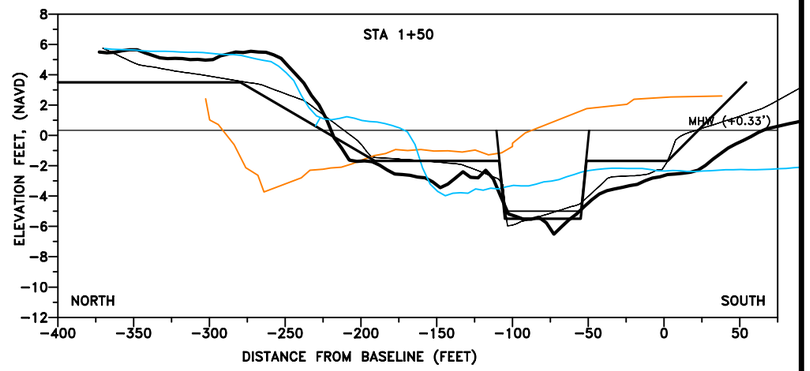

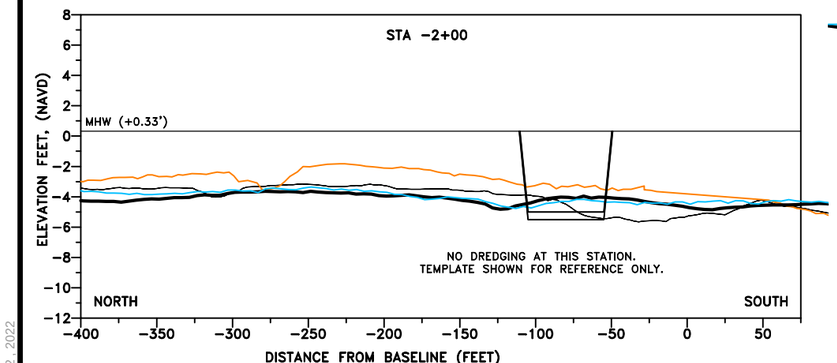

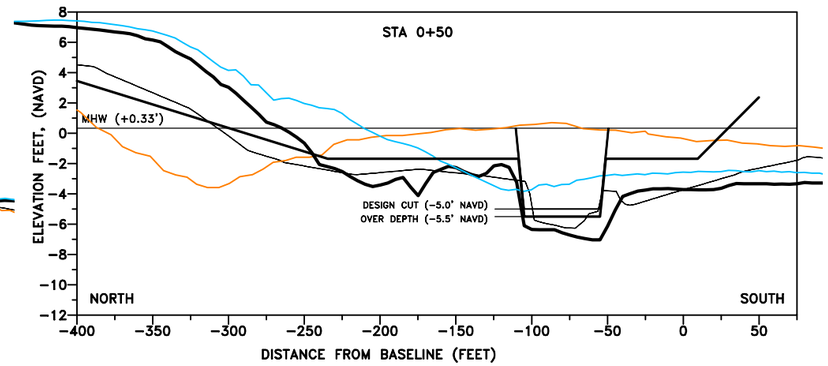

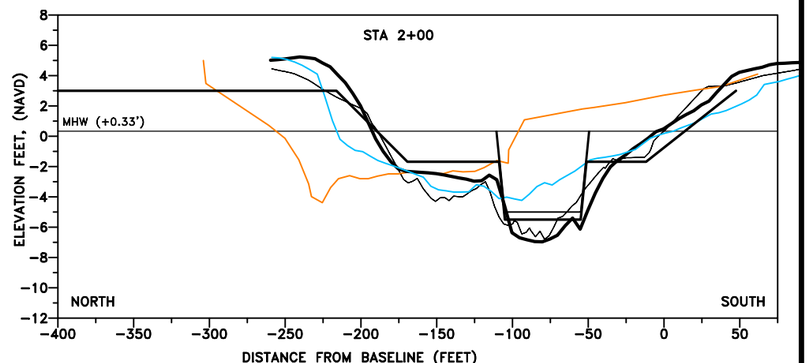

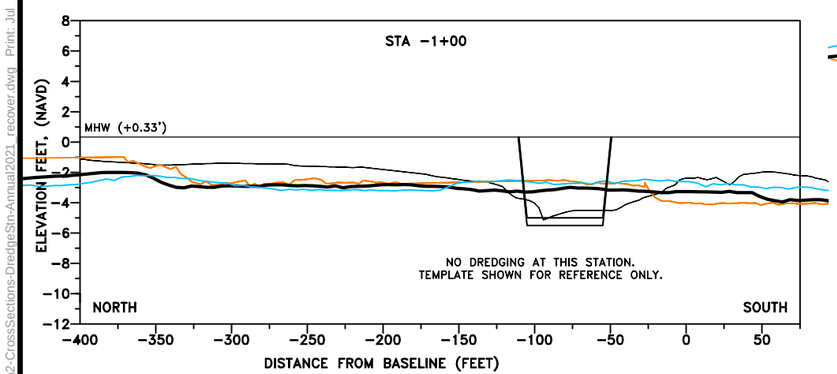

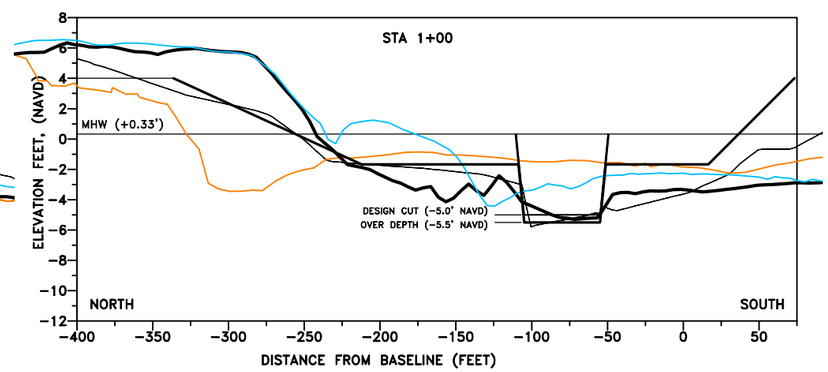

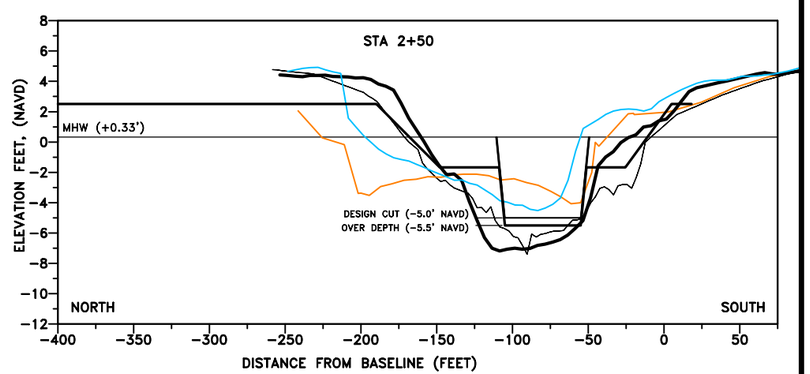

LEGEND

- JANUARY 2021 POST CON
- FEBRUARY 2022 PRE−CON
- APRIL 2022 POST CONSTRUCTION
- MAY 2022 ONE MONTH POST−CON

NOTES:

1. ELEVATIONS SHOWN ARE IN FEET BASED ON THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88).
2. DISTANCES SHOWN IN FEET.
3. STATIONS −1+00 THROUGH −3+00 SHOWN FOR REFERENCE ONLY
4. PROFILES BASED ON SURVEYS CONDUCTED BY PARK COASTAL SURVEYING.

HUMISTON & MOORE ENGINEERS
COASTAL ENGINEERING DESIGN AND PERMITTING

CLAM PASS − ANNUAL SURVEY
INLET CROSS SECTIONS

FOR: PELICAN BAY SERVICES DIVISION

DATE: 7/12/22	FILE: PLAN	SCALE: SHOWN
JOB: 29−018	DATUM: NAVD88	SHEET: 2

5679 STRAND COURT
NAPLES, FL 34110
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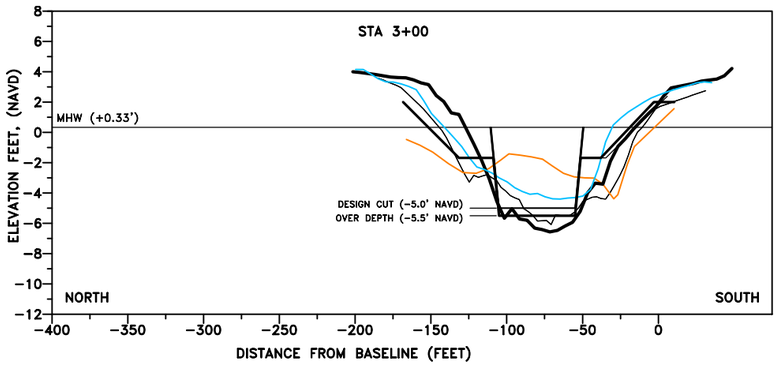

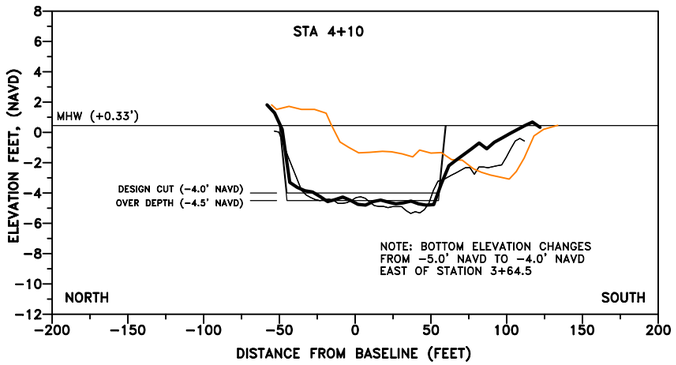

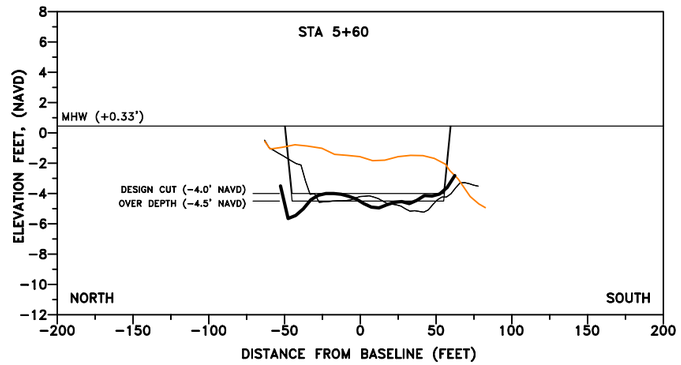

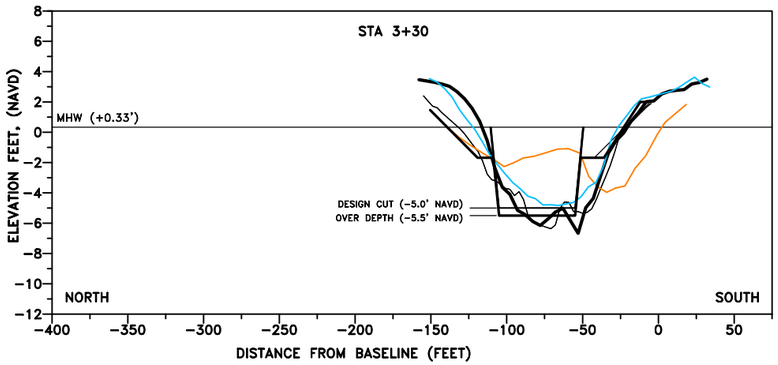

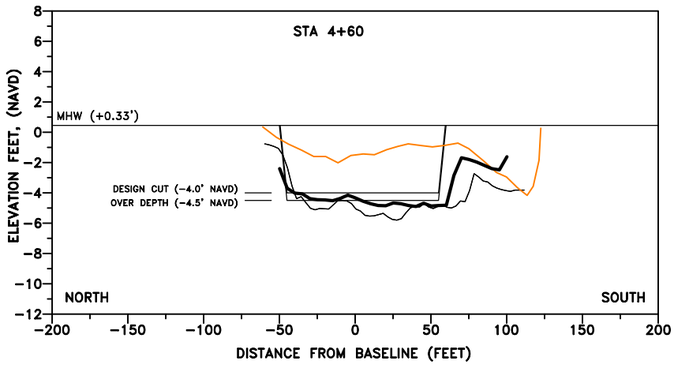

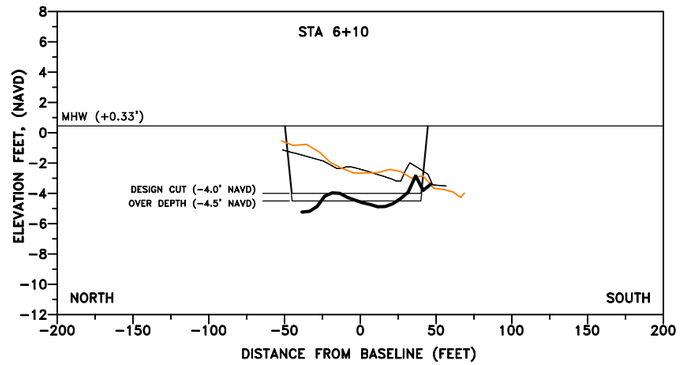

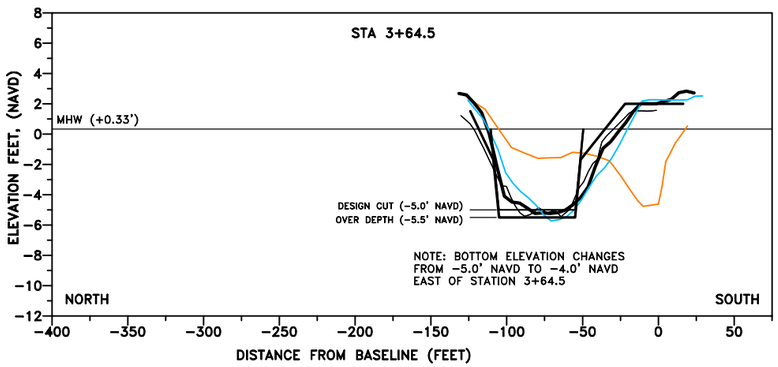

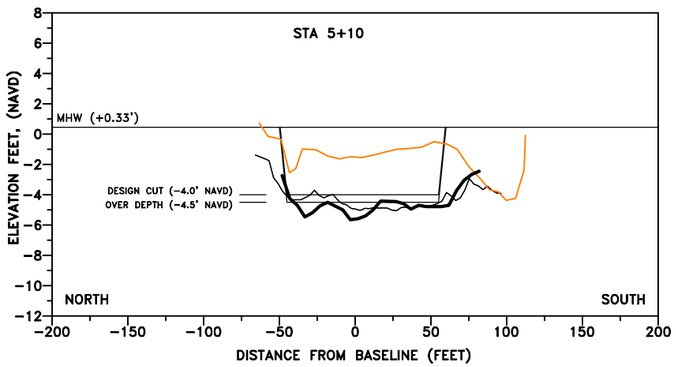

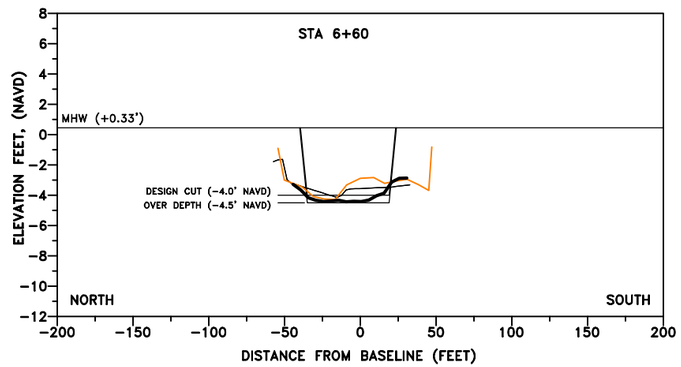

LEGEND

- JANUARY 2021 POST CON
- FEBRUARY 2022 PRE−CON
- APRIL 2022 POST CONSTRUCTION
- MAY 2022 ONE MONTH POST−CON

NOTES:

1. ELEVATIONS SHOWN ARE IN FEET BASED ON THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88).
2. DISTANCES SHOWN IN FEET.
3. PROFILES BASED ON SURVEYS CONDUCTED BY PARK COASTAL SURVEYING.

HUMISTON & MOORE ENGINEERS
COASTAL ENGINEERING DESIGN AND PERMITTING

CLAM PASS − ANNUAL SURVEY
INLET CROSS SECTIONS

FOR: PELICAN BAY SEVICES DIVISION		
DATE: 07/12/22	FILE: PLAN	SCALE: SHOWN
JOB: 29−018	DATUM: NAVD88	SHEET: 3

5679 STRAND COURT
NAPLES, FL 34110
FAX: (239) 594−2025
PHONE: (239) 594−2021
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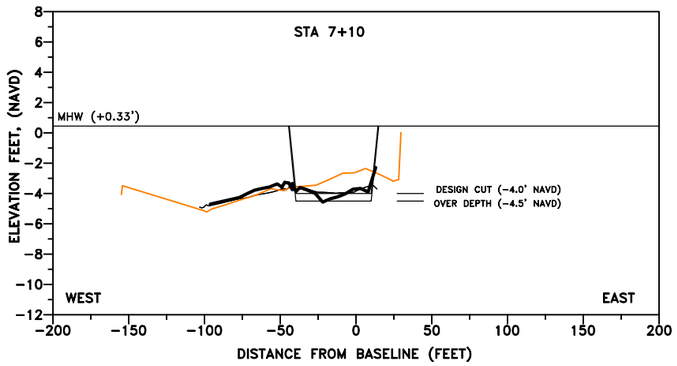

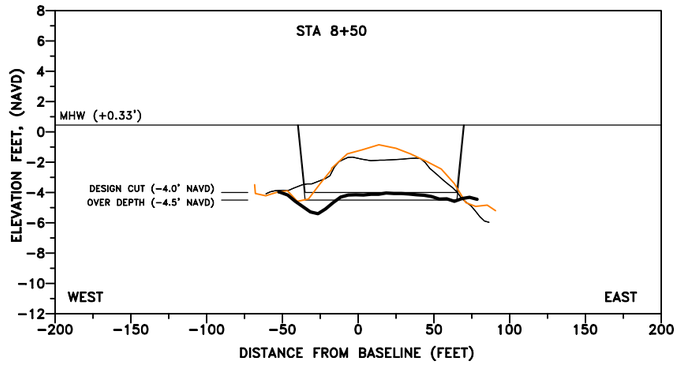

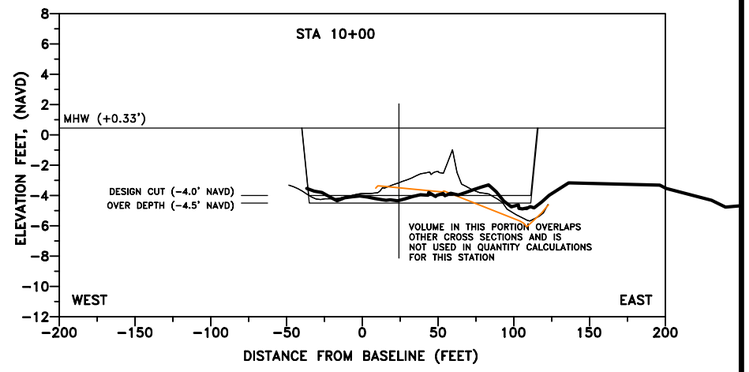

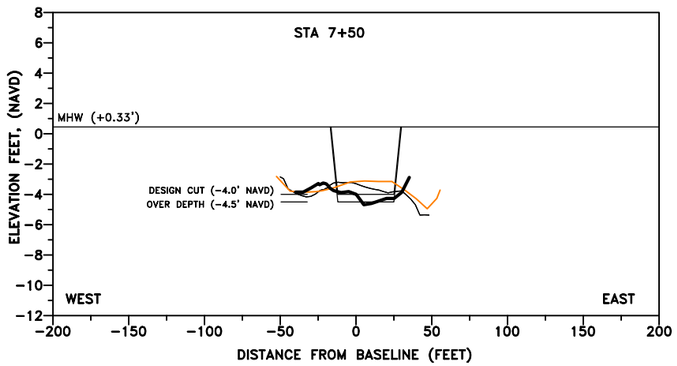

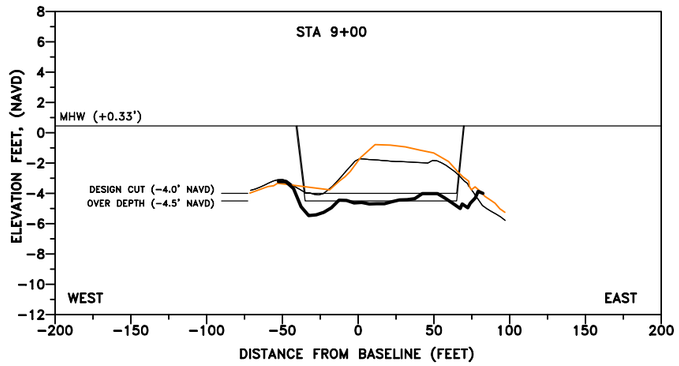

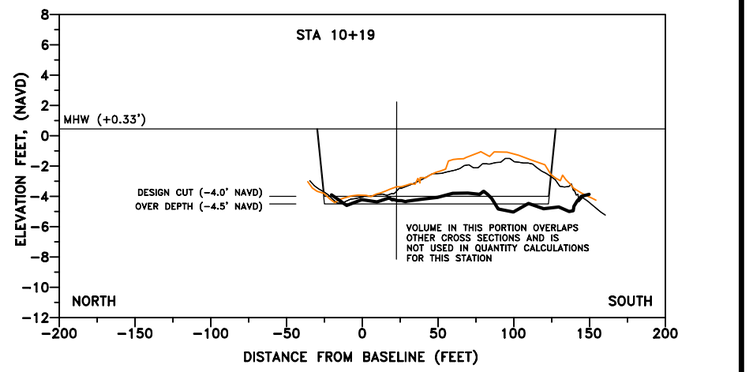

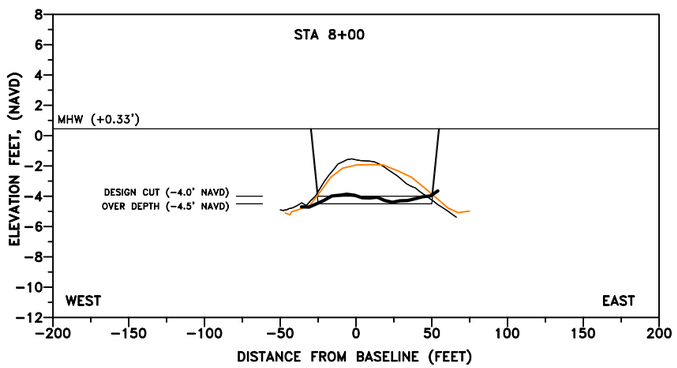

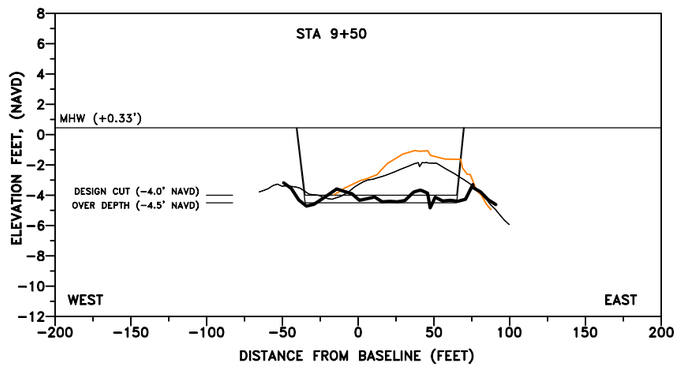

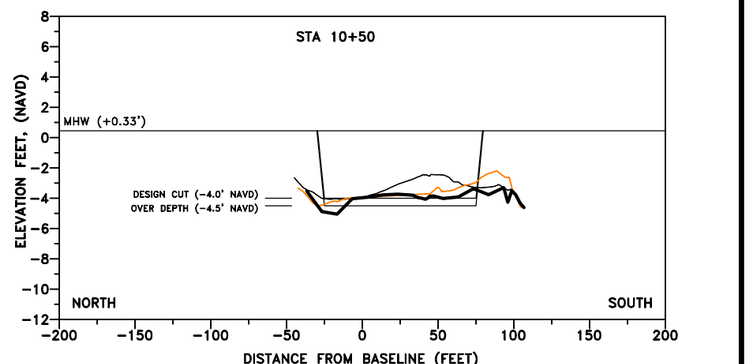

LEGEND

- JANUARY 2021 POST CON
- FEBRUARY 2022 PRE-CON
- APRIL 2022 POST CONSTRUCTION
- MAY 2022 ONE MONTH POST-CON

NOTES:

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HUMISTON & MOORE ENGINEERS
COASTAL ENGINEERING DESIGN AND PERMITTING

CLAM PASS - ANNUAL SURVEY
INLET CROSS SECTIONS

FOR: PELICAN BAY SEVICES DIVISION

DATE: 07/12/22	FILE: PLAN	SCALE: SHOWN
JOB: 29-018	DATUM: NAVD88	SHEET: 4

5679 STRAND COURT
NAPLES, FL 34110
FAX: (239) 594-2025
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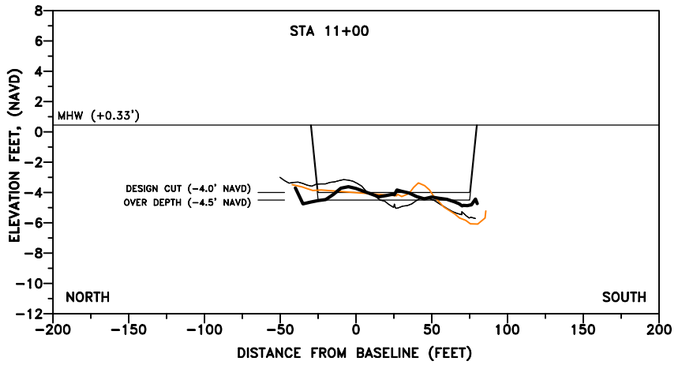

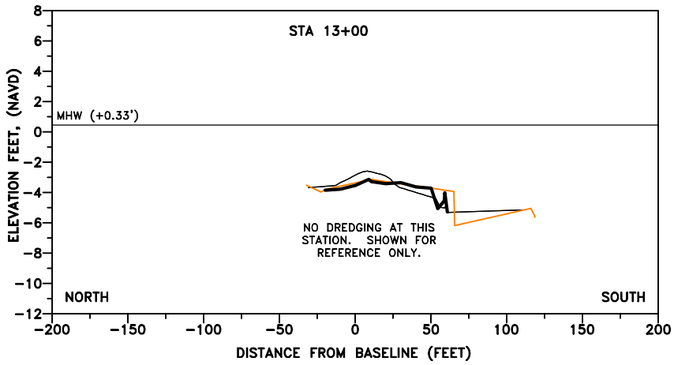

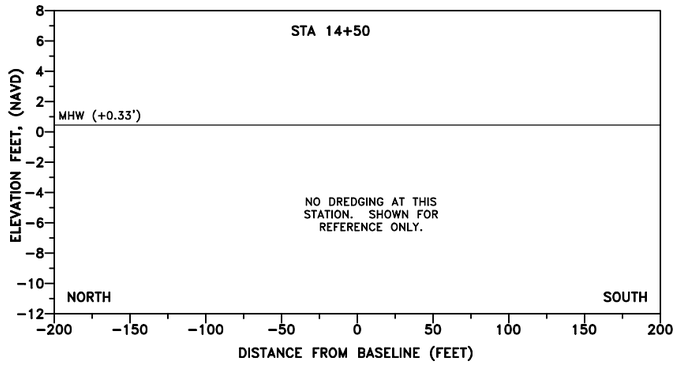

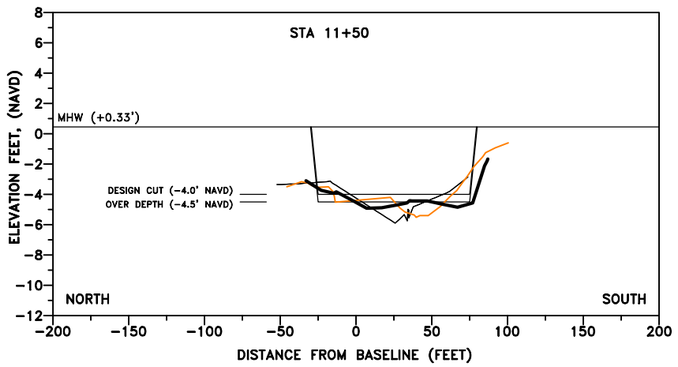

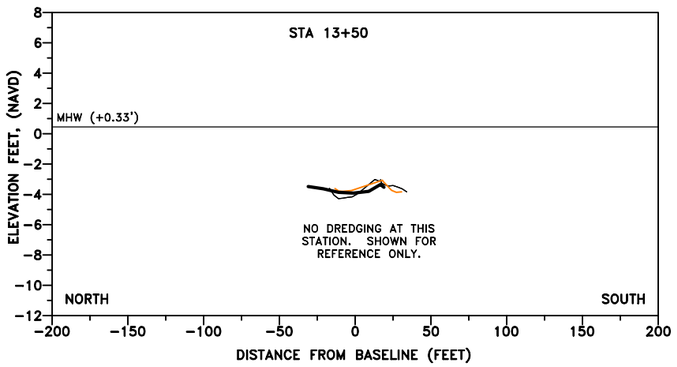

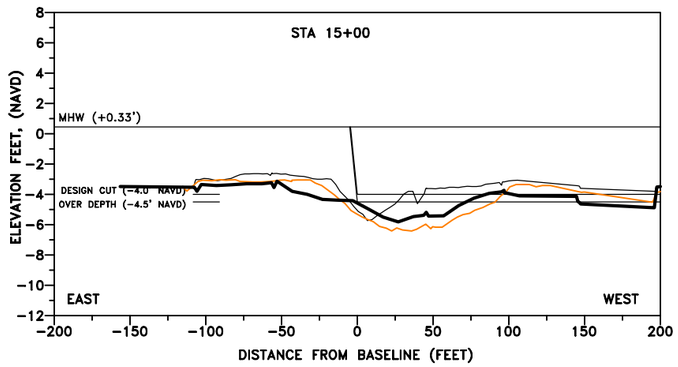

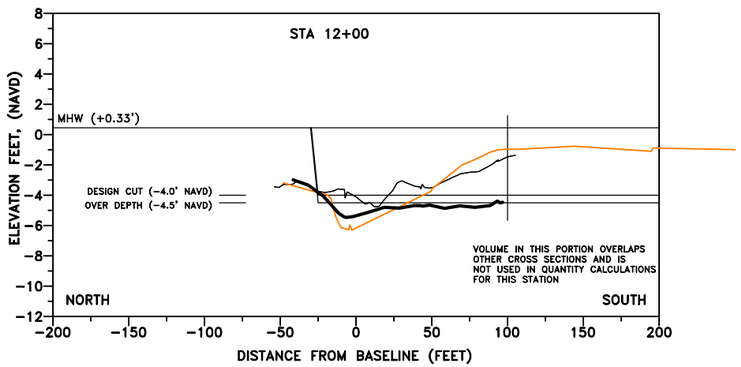

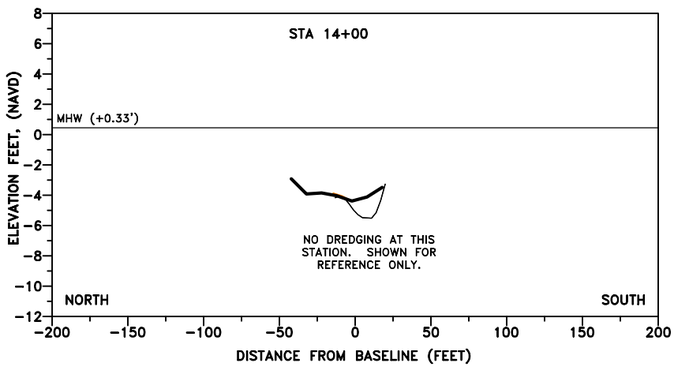

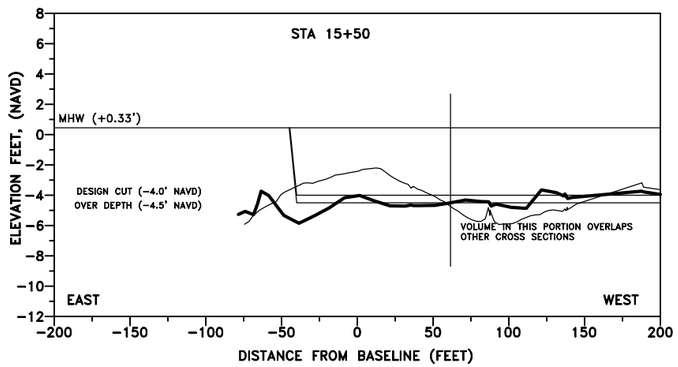

NOTES:

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HUMISTON & MOORE ENGINEERS
COASTAL ENGINEERING DESIGN AND PERMITTING

CLAM PASS - ANNUAL SURVEY
INLET CROSS SECTIONS
FOR: PELICAN BAY SERVICES DIVISION

DATE: 07/12/22	FILE: PLAN	SCALE: SHOWN
JOB: 29-018	DATUM: NAVD88	SHEET: 5

5679 STRAND COURT
NAPLES, FL 34110
FAX: (239) 594-2025
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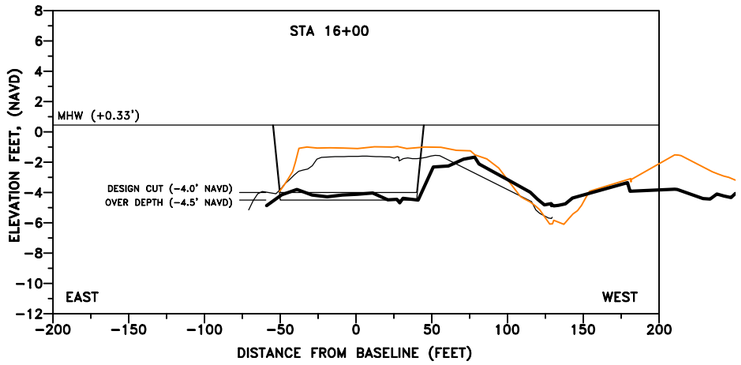
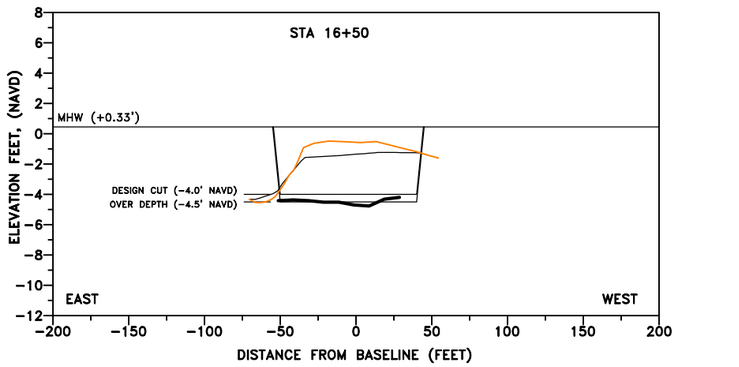
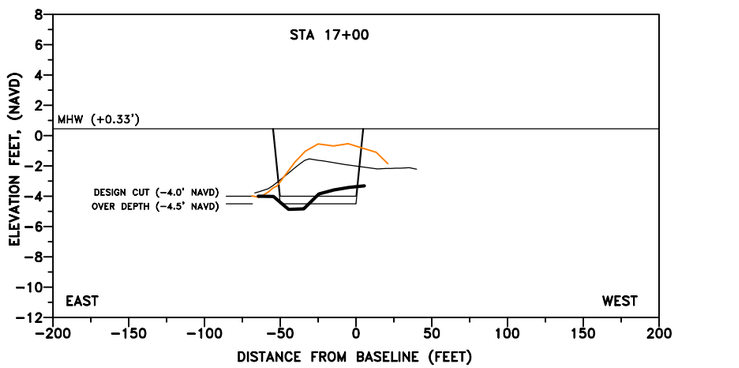






CUT TEMPLATE INFORMATION						1/5/2021		2/17/2022		4/19/2022		5/25/2022	
		Easting	Northing	Azimuth	Effective Distance	Measured Volumetric Rate (CY/FT)	Total Volume (CY)	Measured Volumetric Rate (CY/FT)	Total Volume (CY)	Measured Volumetric Rate (CY/FT)	Total Volume (CY)	Measured Volumetric Rate (CY/FT)	Total Volume (CY)
Shoal	-4+00	387,464.97	686,291.39	180	100.0	--	--	--	--	--	--	--	--
	-3+00	387,564.96	686,292.28	180	100.0	--	--	--	--	--	--	--	--
	-2+00	387,664.95	686,293.18	180	100.0	1.7	166.7	4.2	423.3	2.6	263.0	--	--
	-1+00	387,764.95	686,294.08	180	150.0	1.9	277.8	5.7	850.0	4.6	694.4	--	--
Section A	0+00	387,864.94	686,294.98	180	12.5	0.5	12.0	6.6	165.8	0.4	10.8	3.5	88.1
	0+50	387,914.94	686,295.42	180	50.0	0.6	29.6	23.8	1190.5	0.0	0.0	4.2	211.7
	1+00	387,964.94	686,295.87	180	50.0	0.6	29.6	10.5	524.0	1.0	49.8	15.2	758.7
	1+50	388,014.94	686,296.32	180	50.0	0.7	35.2	25.2	1261.8	0.2	9.8	9.3	466.2
	2+00	388,064.94	686,296.77	180	50.0	0.4	22.2	23.9	1194.4	0.0	0.0	4.4	217.4
	2+50	388,114.94	686,297.22	180	50.0	0.1	5.6	8.0	402.0	0.0	0.0	4.3	213.5
	3+00	388,164.94	686,297.67	180	40.0	1.0	26.5	6.9	190.6	0.0	0.0	2.9	80.9
	3+30	388,194.94	686,297.94	180	32.3	1.3	41.8	7.9	253.2	0.9	29.3	2.7	88.6
	3+64.5	388,229.44	686,298.25	180	42.3	1.4	59.5	9.0	380.3	1.5	64.2	2.5	106.1
Section B	4+10	388,279.10	686,372.13	156	50.0	1.3	64.8	15.8	789.0	1.0	50.6	--	--
	4+60	388,326.17	686,389.30	156	50.1	0.4	20.4	12.5	625.3	0.4	20.8	--	--
	5+10	388,373.24	686,406.47	156	50.1	0.5	24.1	12.5	625.3	0.0	0.0	--	--
	5+60	388,420.31	686,423.64	156	50.1	1.3	64.9	11.7	584.7	0.7	32.8	--	--
	6+10	388,467.38	686,440.81	156	49.0	7.3	355.7	7.7	379.2	0.7	36.3	--	--
	6+60	388,512.37	686,457.21	156	49.1	1.7	81.9	2.0	98.3	0.5	24.9	--	--
	7+10	388,553.62	686,486.14	145	45.0	1.3	58.3	2.9	128.2	1.0	45.7	--	--
Section C	7+50	388,548.38	686,525.38	82	44.8	2.7	121.1	1.8	81.1	0.4	17.8	--	--
	8+00	388,541.76	686,574.94	82	50.0	5.6	279.6	5.6	279.5	1.0	52.2	--	--
	8+50	388,535.14	686,624.50	82	50.0	8.0	401.9	9.3	465.0	0.9	43.7	--	--
	9+00	388,528.52	686,674.06	82	50.0	7.8	390.7	9.6	478.0	0.4	17.6	--	--
	9+50	388,521.91	686,723.62	82	50.0	5.9	294.4	7.4	370.5	1.2	62.4	--	--
	10+00	388,515.29	686,773.18	82	34.5	1.3	44.8	0.0	0.0	0.9	30.6	--	--
	10+19	388,512.76	686,792.09	140	25.0	0.8	20.4	0.0	0.0	0.5	12.5	--	--
	10+50	388,536.63	686,811.79	140	40.5	4.6	185.9	0.0	0.0	2.0	81.7	--	--
	11+00	388,575.19	686,843.61	140	50.0	6.1	303.7	0.0	0.0	1.2	60.4	--	--
	11+50	388,613.75	686,875.44	140	50.0	1.8	90.7	0.0	0.0	0.5	24.1	--	--
	12+00	388,652.32	686,907.26	140	101.0	7.5	755.6	0.0	0.0	0.0	0.0	--	--
	16+00	388,736.07	686,848.63	240	25.0	8.6	215.7	11.0	274.0	1.0	24.7	--	--
	16+50	388,760.89	686,805.22	240	50.0	10.0	500.0	12.0	598.0	0.3	13.0	--	--
	17+00	388,785.72	686,761.82	240	25	4.9	123.1	6.6	164.8	1.0	23.8	--	--
Section A							**262**		**5,563**		**164**		**2,231**
Section B							**670**		**3,230**		**211**		
Section C							**3,728**		**2,711**		**464**		
Totals							**4,660**		**11,503**		**839**		

NOTES:

1. ELEVATIONS SHOWN ARE IN FEET BASED ON THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88).
2. DISTANCES SHOWN IN FEET.
3. PROFILES BASED ON SURVEYS CONDUCTED BY PARK COASTAL SURVEYING.

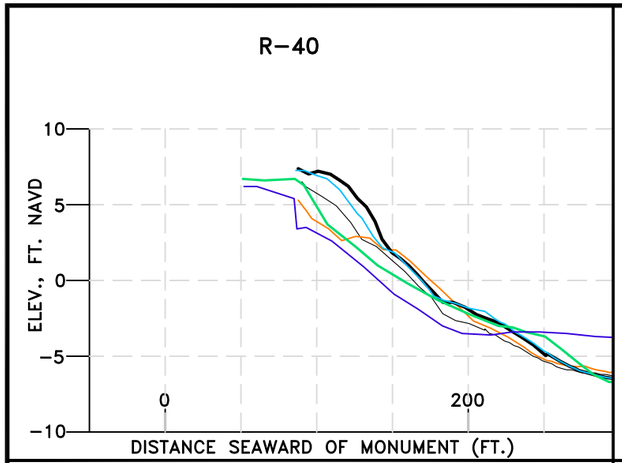
LEGEND

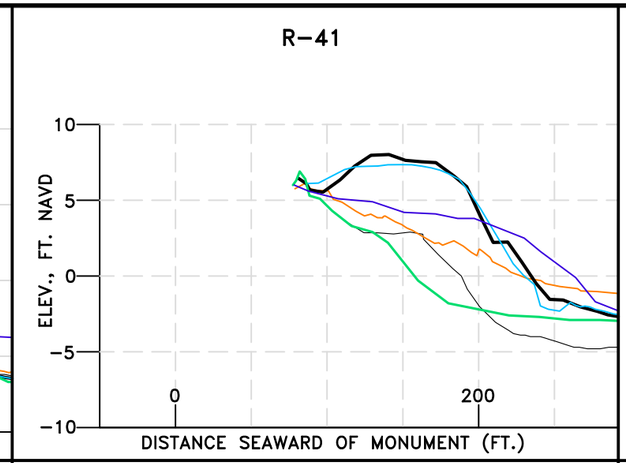
- JANUARY 2021 POST CON
- FEBRUARY 2022 PRE-CON
- APRIL 2022 POST CONSTRUCTION
- MAY 2022 ONE MONTH POST-CON

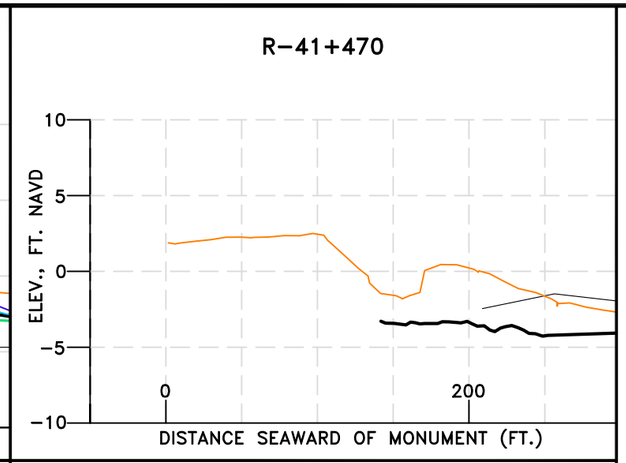
HUMISTON & MOORE ENGINEERS
COASTAL ENGINEERING DESIGN AND PERMITTING

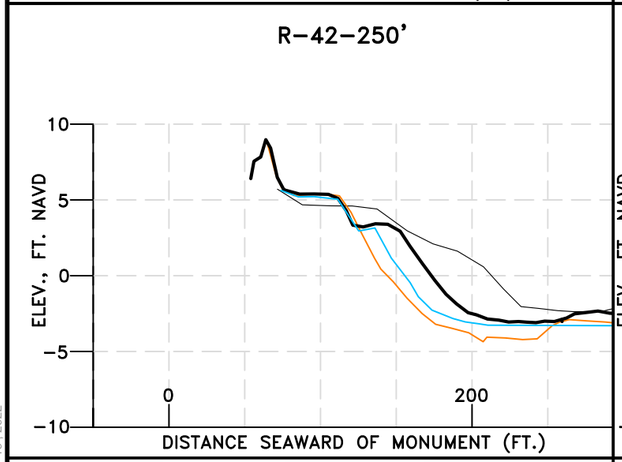
CLAM PASS - ANNUAL SURVEY
INLET CROSS SECTIONS
FOR: PELICAN BAY SERVICES DIVISION
DATE: 07/12/22 | FILE: PLAN | SCALE: SHOWN
JOB: 29-018 | DATUM: NAVD88 | SHEET: 6

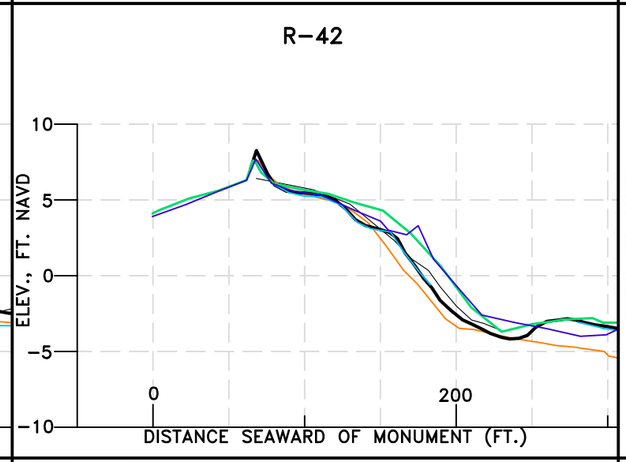
5679 STRAND COURT
NAPLES, FL 34110
FAX: (239) 594-2025
PHONE: (239) 594-2021
www.humistonandmoore.com

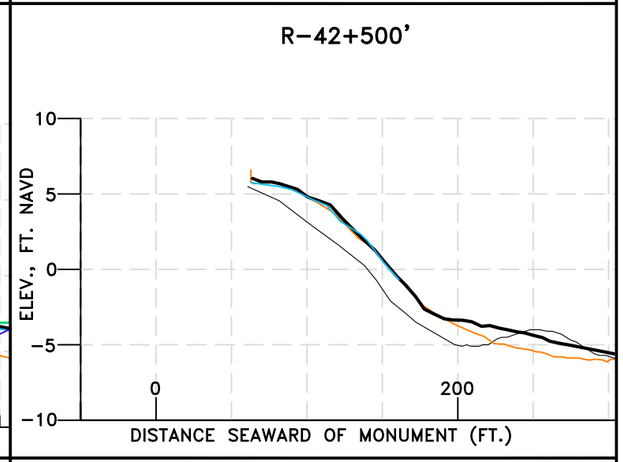


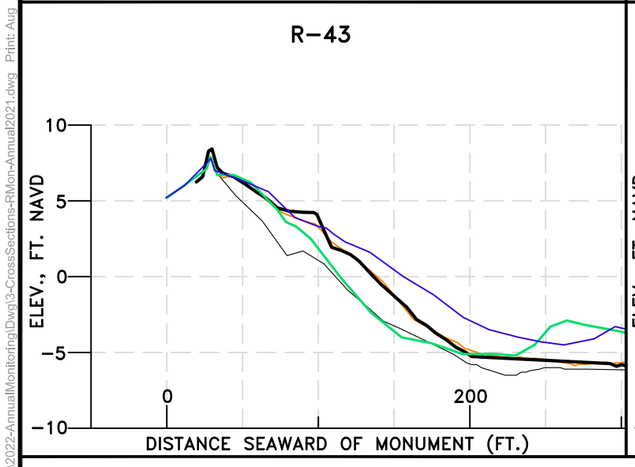


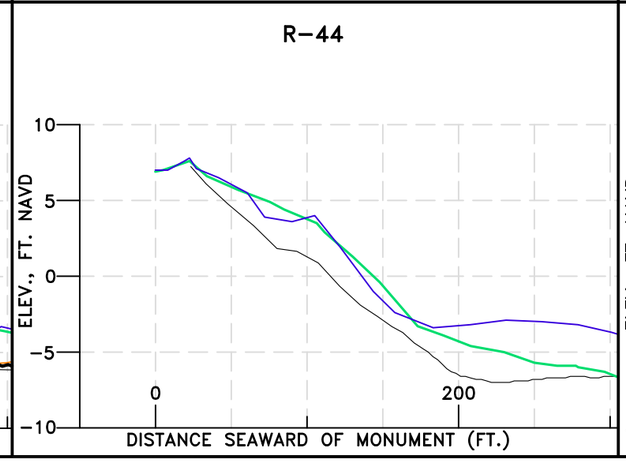


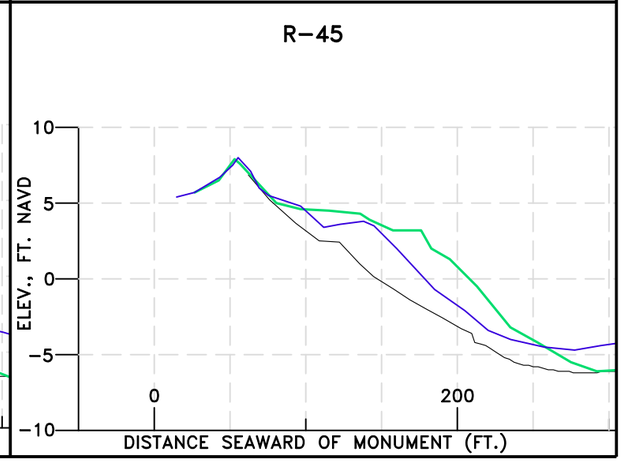




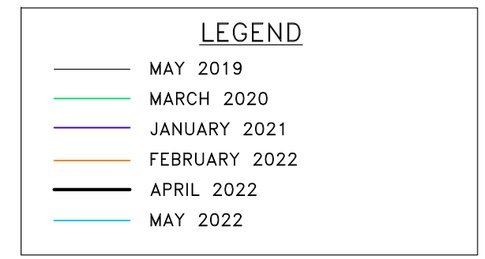








	Easting	Northing	Azimuth
R-40	387,963.80	687,793.80	270
R-41	388,051.60	686,785.60	270
R-41+470'	388,121.15	686,320.77	270
R-42-250'	388,172.39	685,978.25	270
R-42+500'	388,228.21	685,231.35	270
R-42	388,209.40	685,731.00	270
R-43	388,248.50	684,692.30	270
R-44	388,359.10	683,701.50	270
R-45	388,478.90	682,660.00	270



NOTES:
1. PROFILES BASED ON SURVEYS CONDUCTED BY SEA DIVERSIFIED MARCH 2020, AND JANUARY 2021 COURTESY OF COLLIER COUNTY. REMAINDER BY PARK COASTAL SURVEYING.
2. COORDINATES SHOWN ARE IN FEET BASED ON THE NORTH AMERICAN DATUM OF 1983, EAST ZONE (NAD83).
3. ELEVATIONS SHOWN ARE IN FEET BASED ON THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88).

HUMISTON & MOORE ENGINEERS
COASTAL ENGINEERING DESIGN AND PERMITTING

CLAM PASS – ANNUAL MONITORING
BEACH CROSS SECTIONS

FOR: PELICAN BAY SERVICES DIVISION

DATE: 7/12/22	FILE: XSEC	SCALE: SHOWN
JOB: 29-018	DATUM: NAVD88	SHEET: 7

5679 STRAND COURT
NAPLES, FL 34110
FAX: (239) 594-2025
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APPENDIX C

Clam Pass Tidal Monitoring

Monthly Water Level Time Series

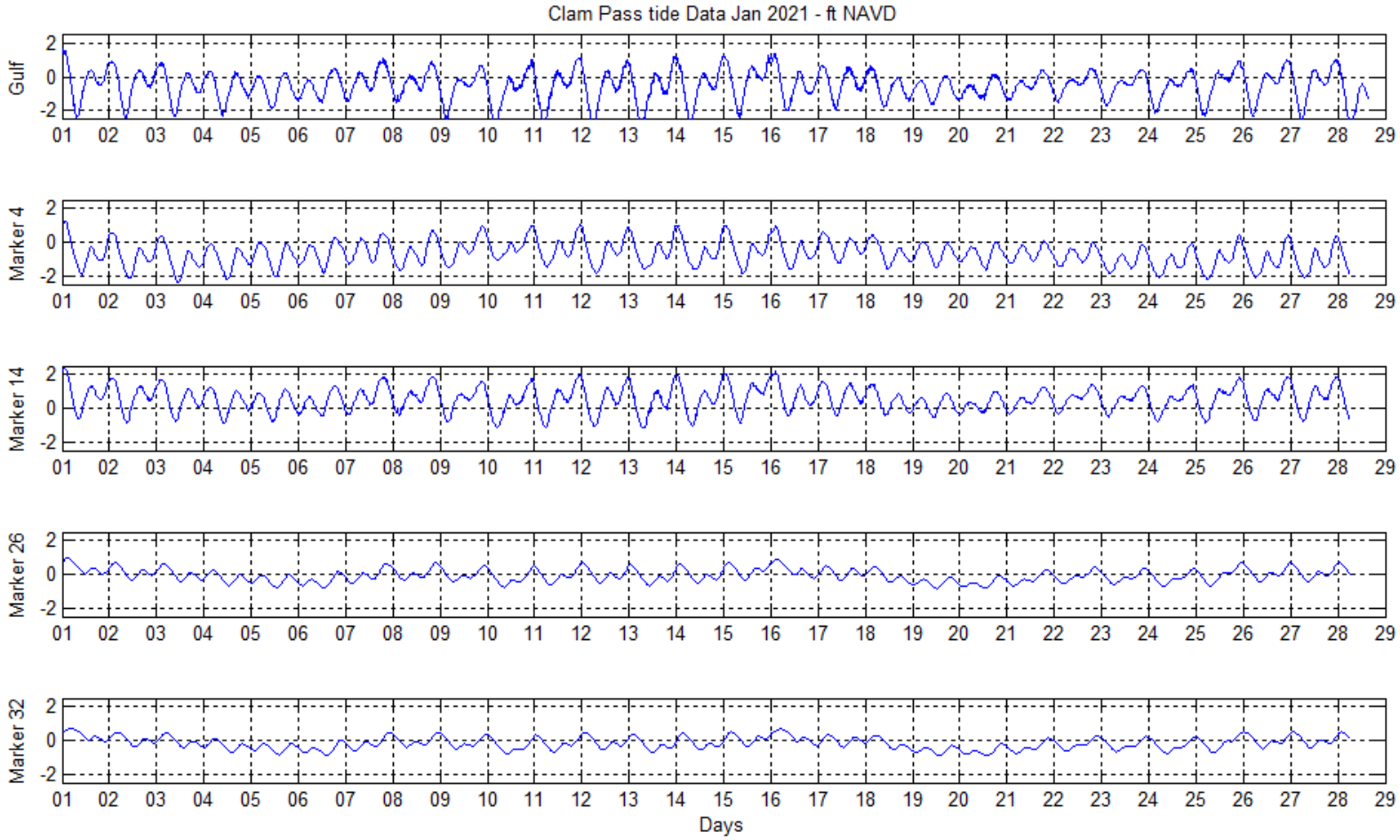


Figure C1 - Clam Pass Tide Gages Time Series – January 2021

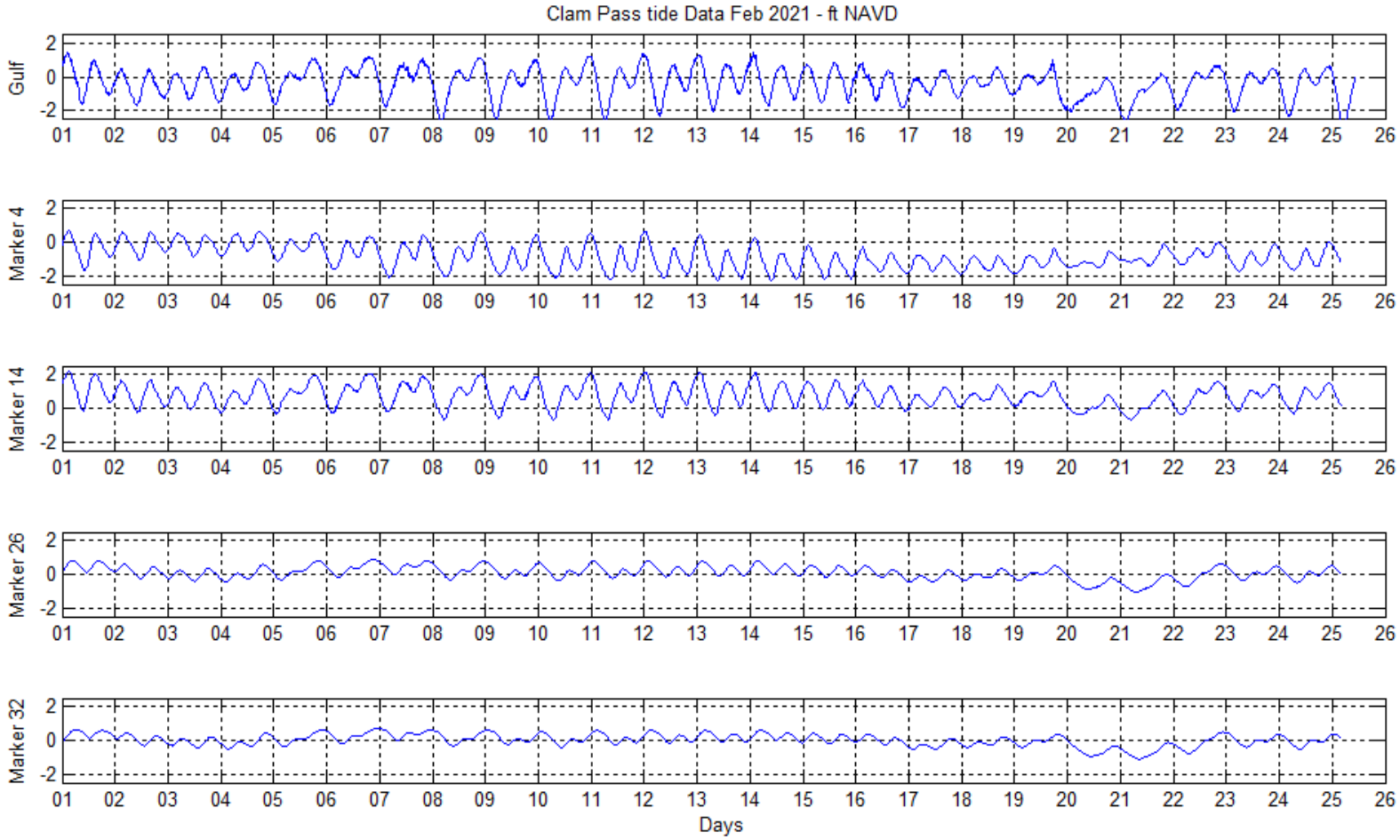


Figure C2 - Clam Pass Tide Gages Time Series – February 2021

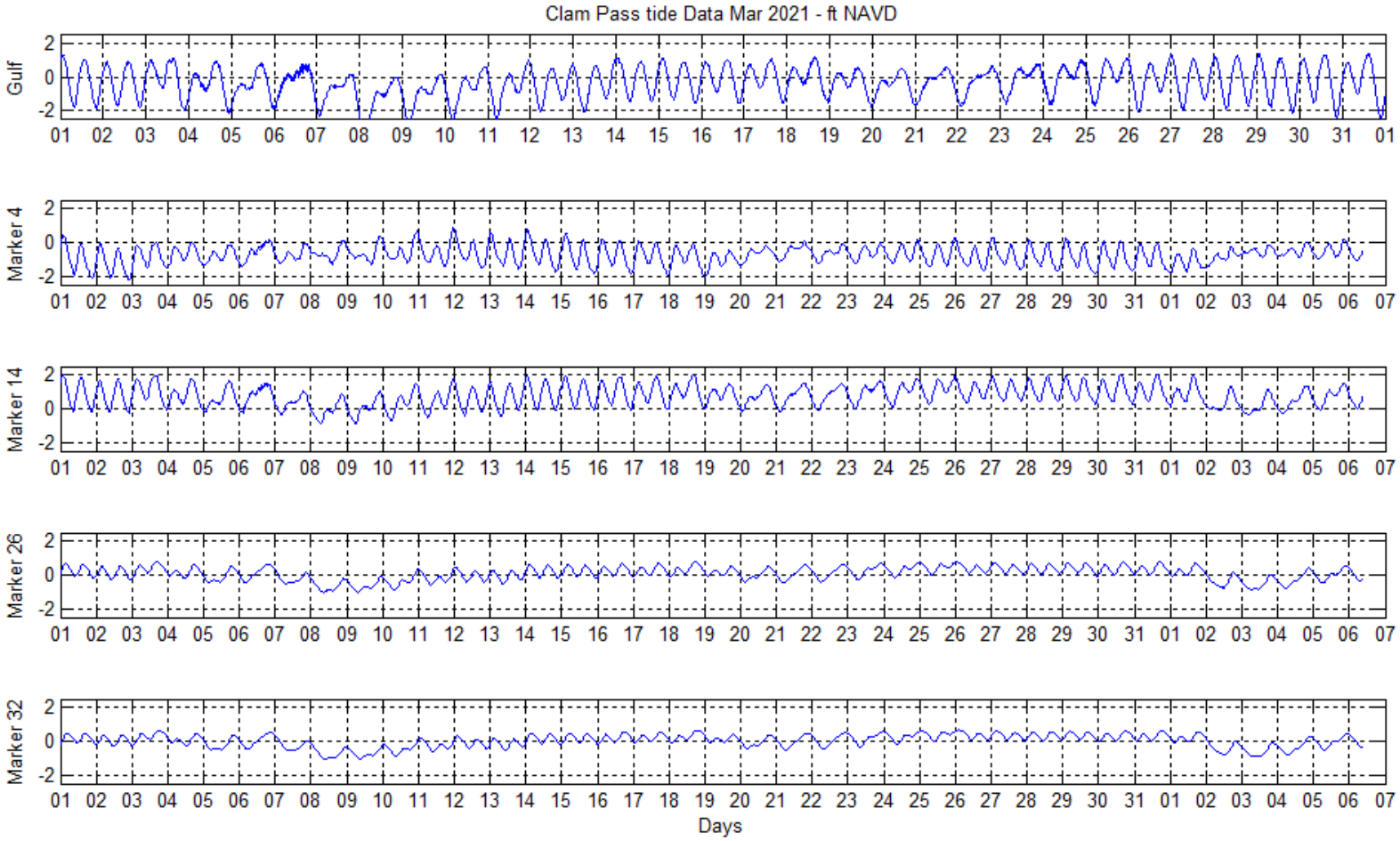


Figure C3 - Clam Pass Tide Gages Time Series – March 2021

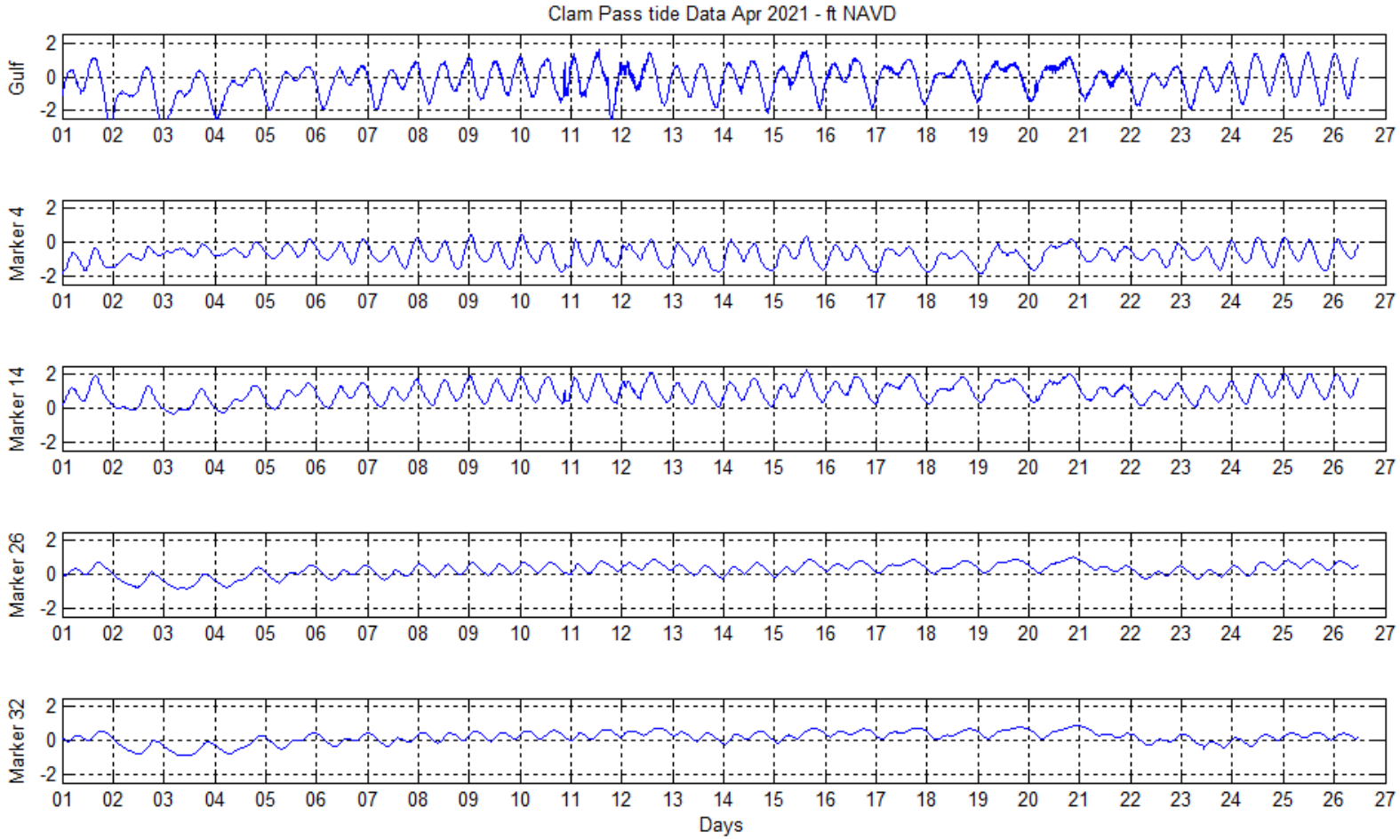


Figure C4 - Clam Pass Tide Gages Time Series – April 2021

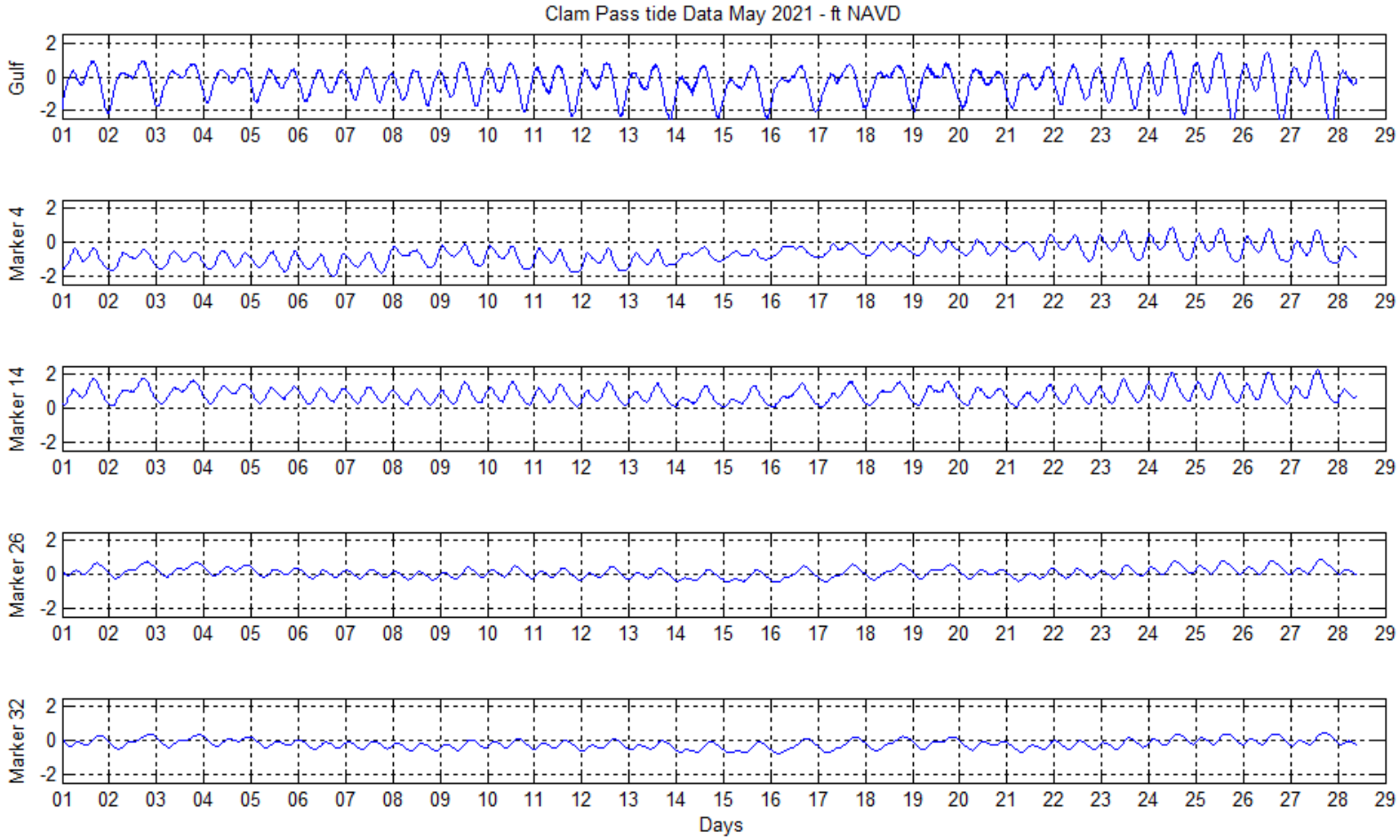


Figure C5 - Clam Pass Tide Gages Time Series – May 2021

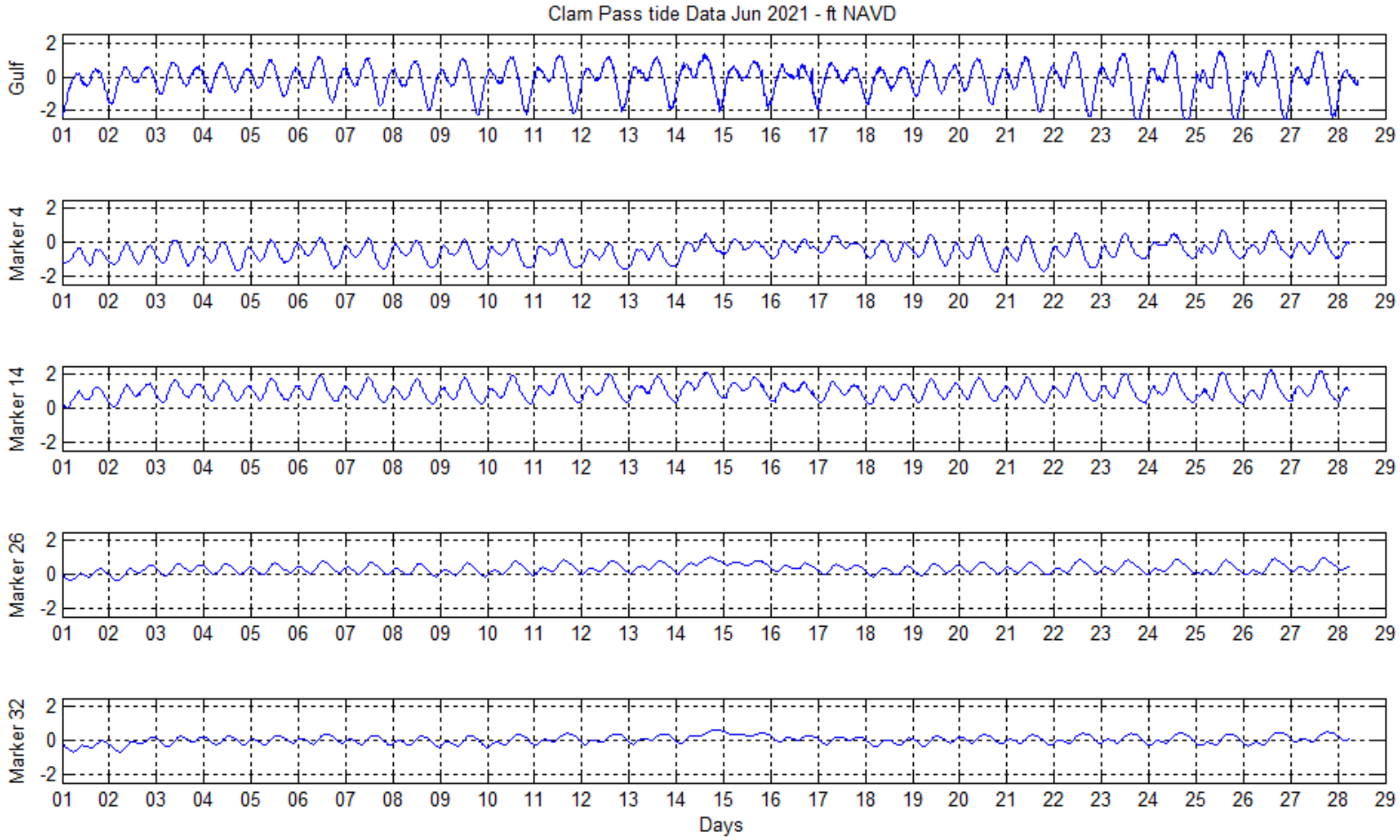


Figure C6 - Clam Pass Tide Gages Time Series – June 2021

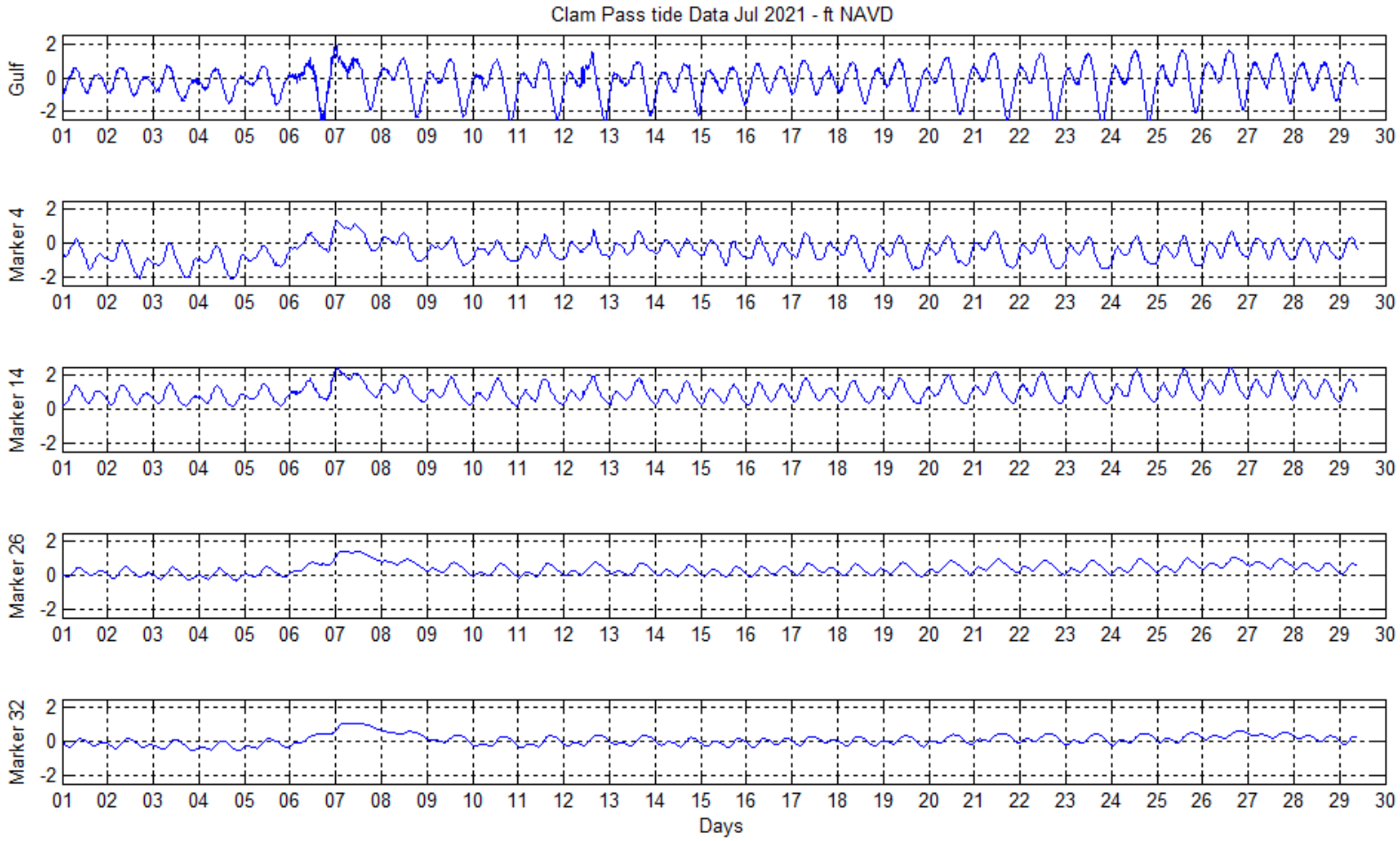


Figure C7 - Clam Pass Tide Gages Time Series – July 2021

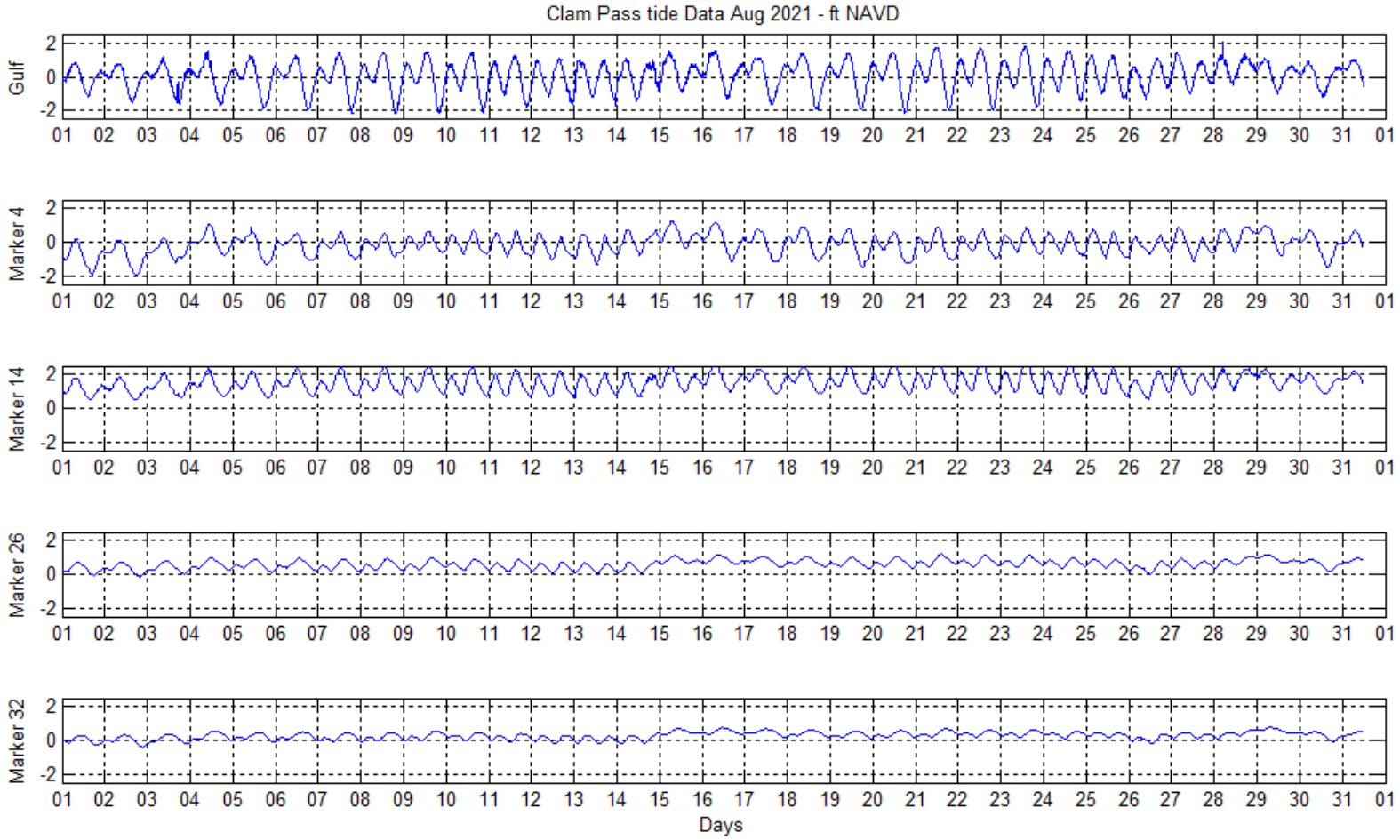


Figure C8 - Clam Pass Tide Gages Time Series – August 2021

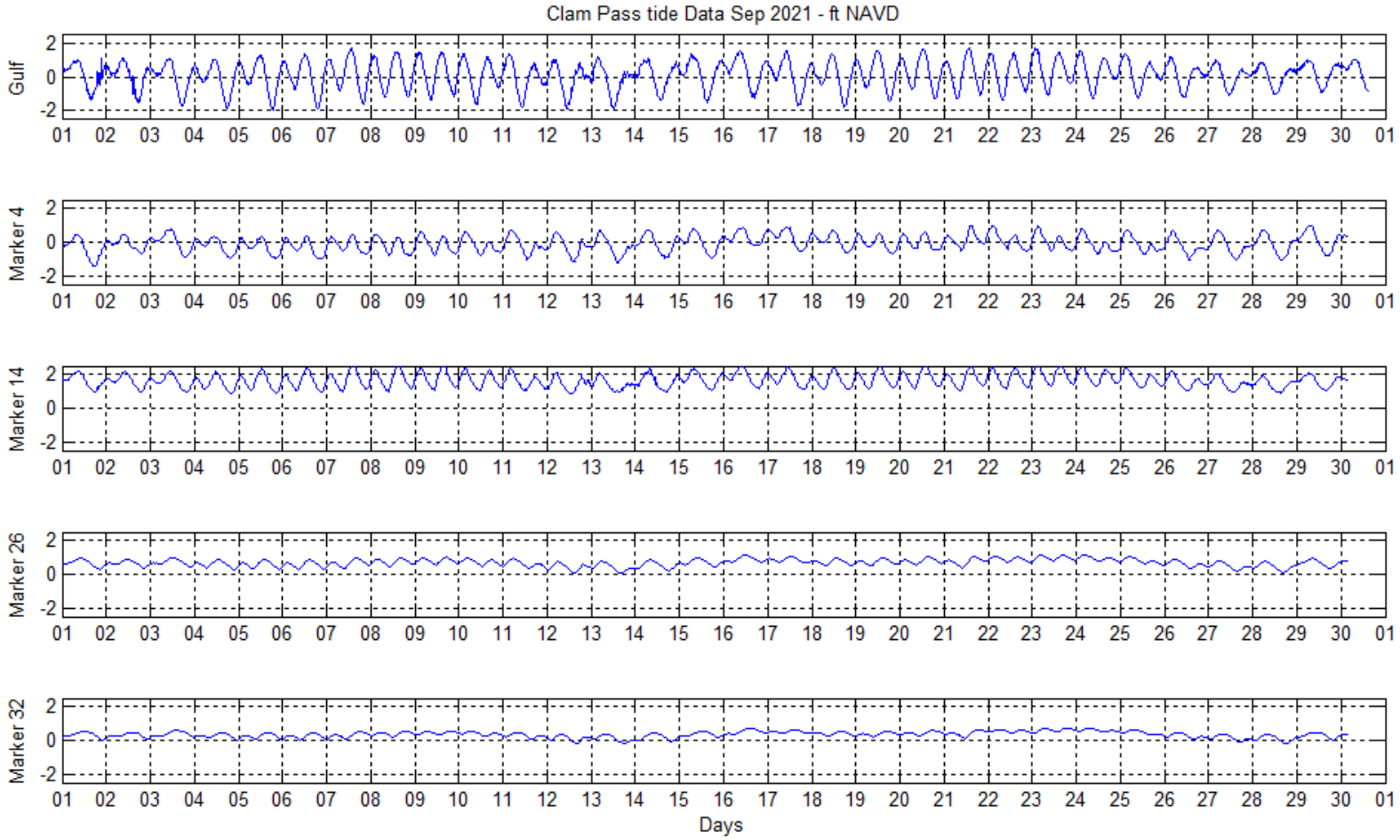


Figure C9 - Clam Pass Tide Gages Time Series – September 2021

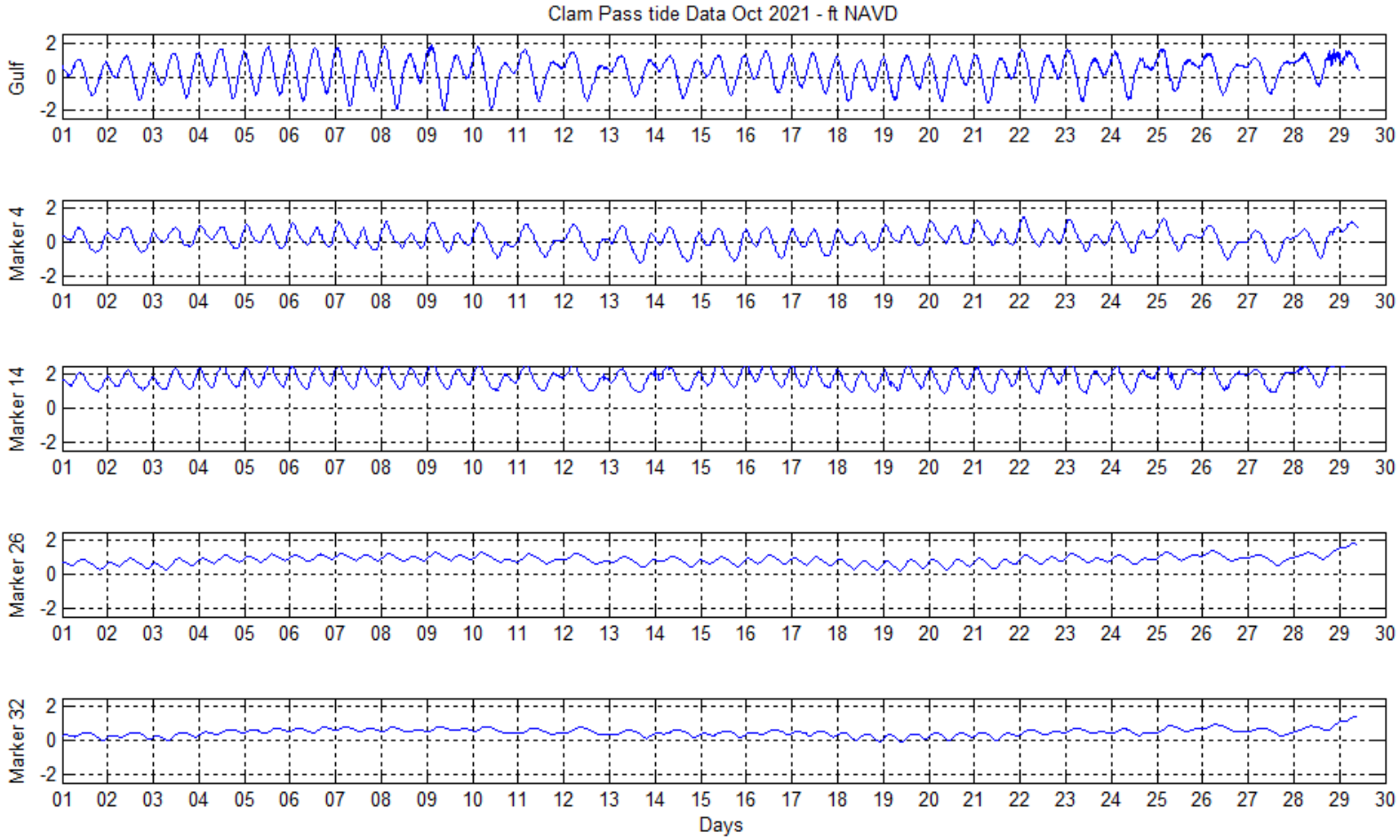


Figure C10 - Clam Pass Tide Gages Time Series –October 2021

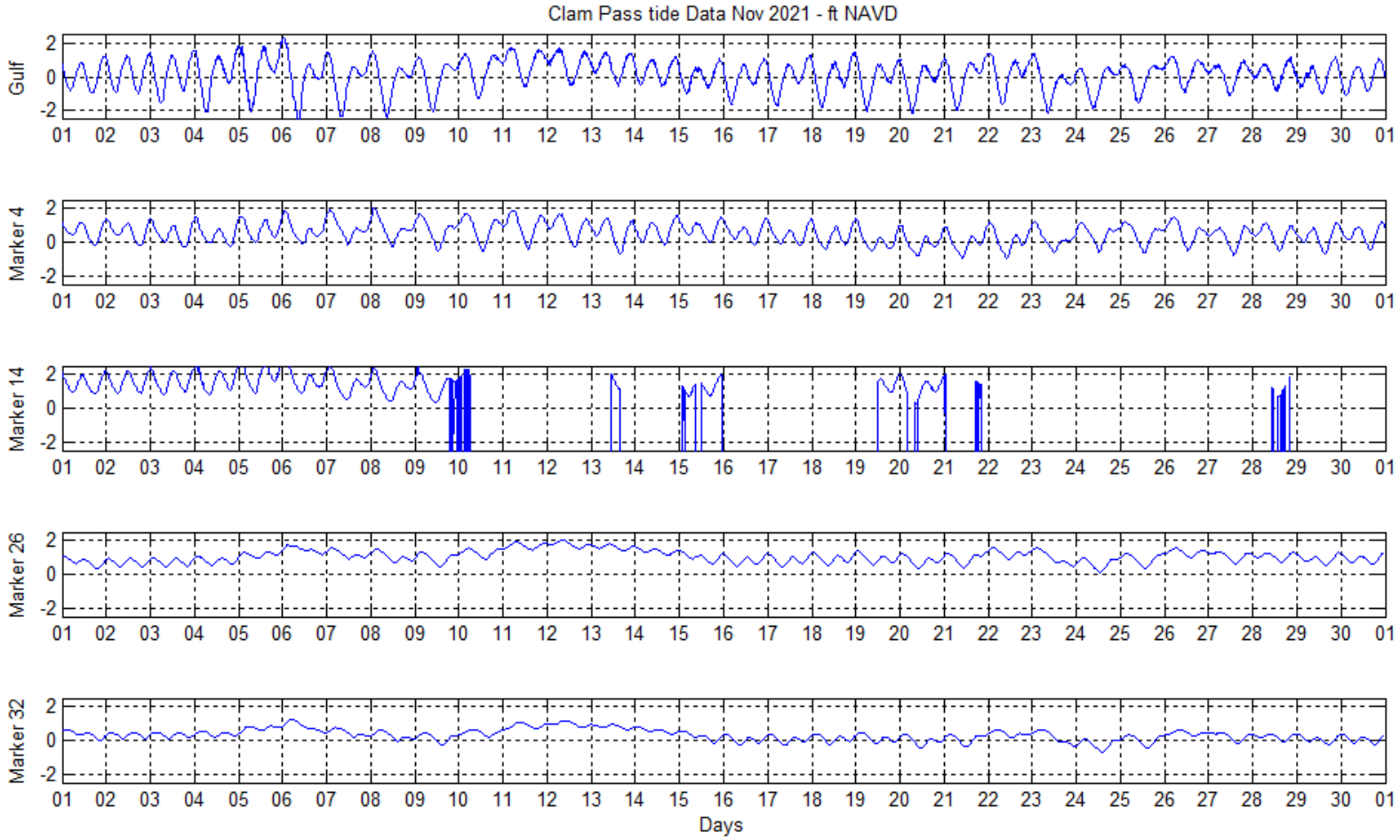


Figure C11 - Clam Pass Tide Gages Time Series –November 2021

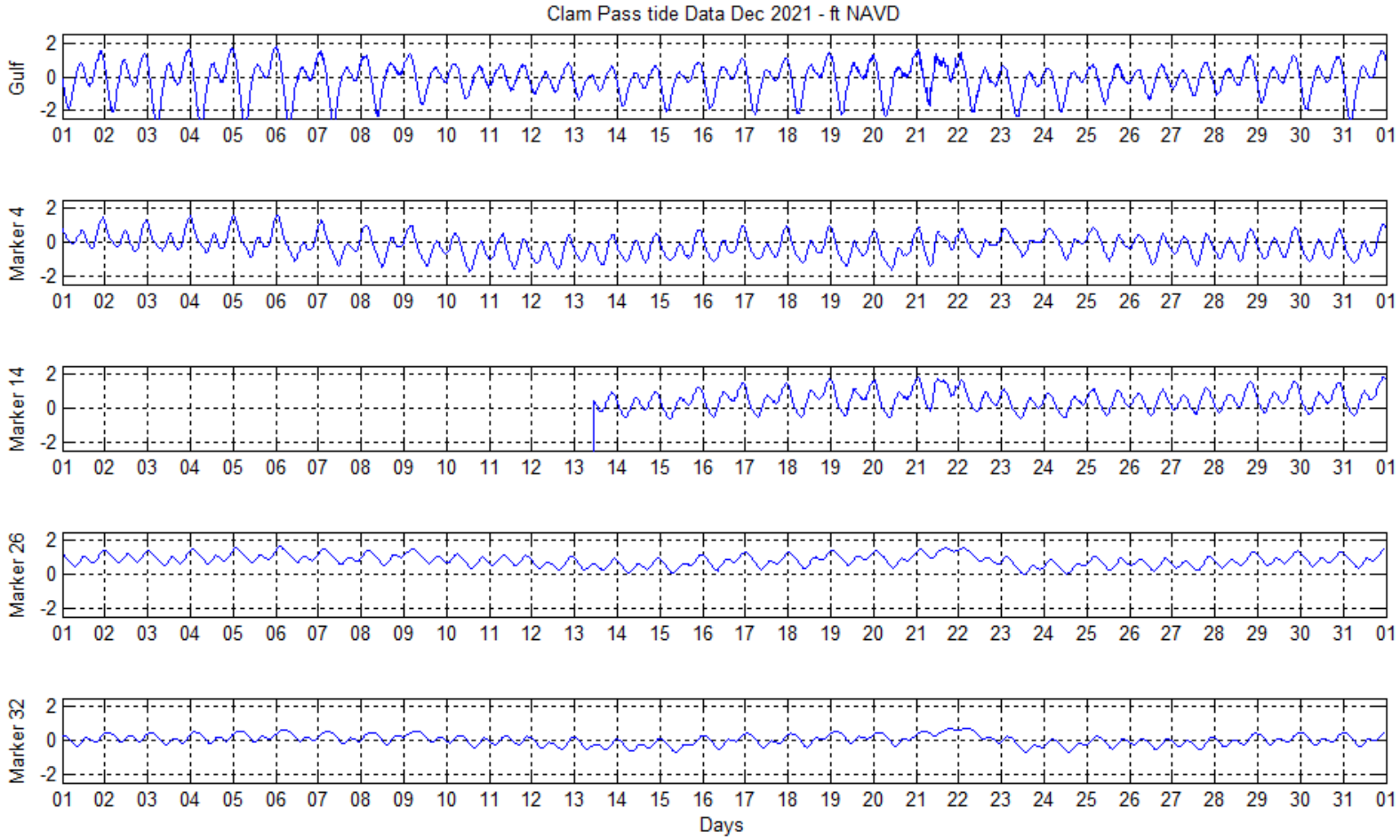


Figure C12 - Clam Pass Tide Gages Time Series –December 2020

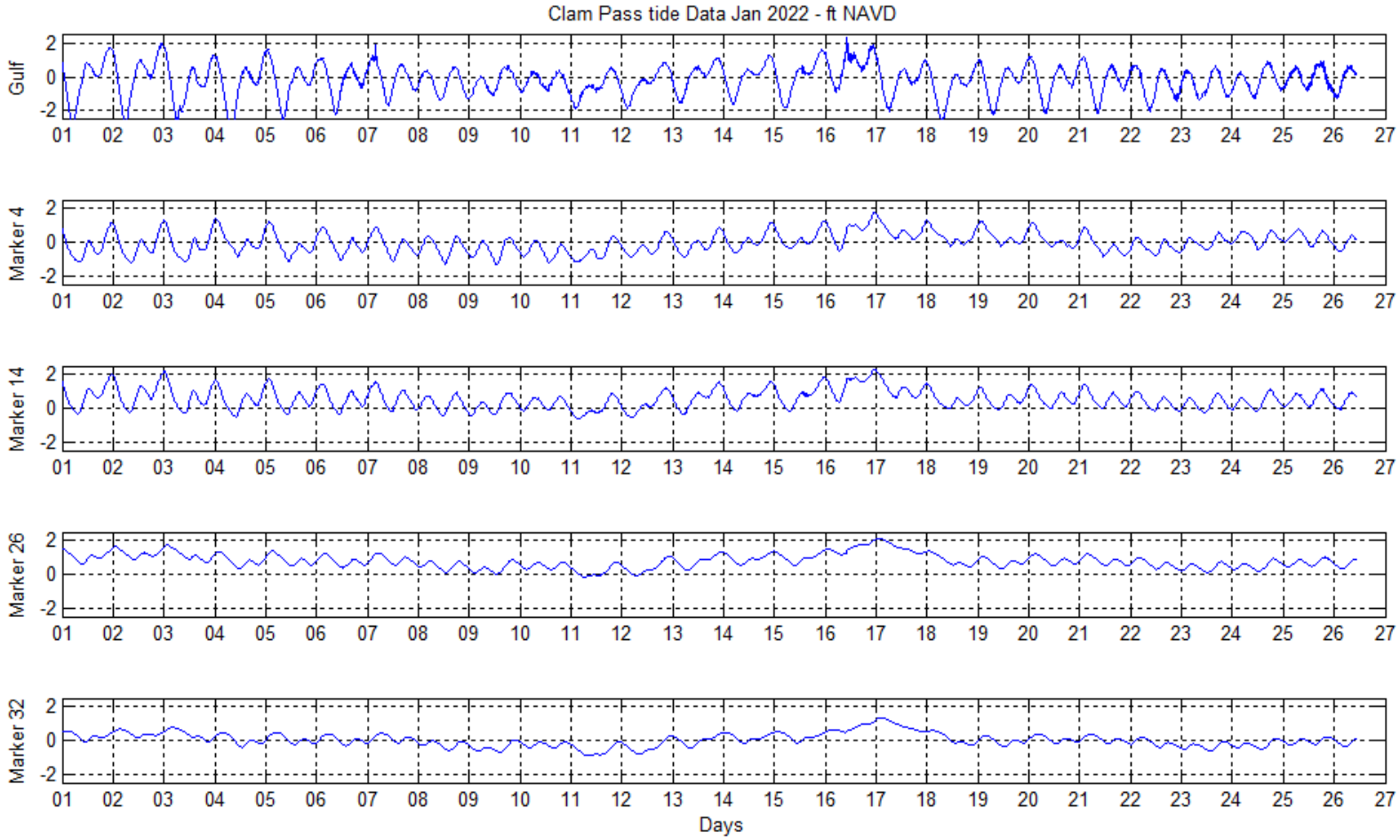


Figure C13 - Clam Pass Tide Gages Time Series – January 2022

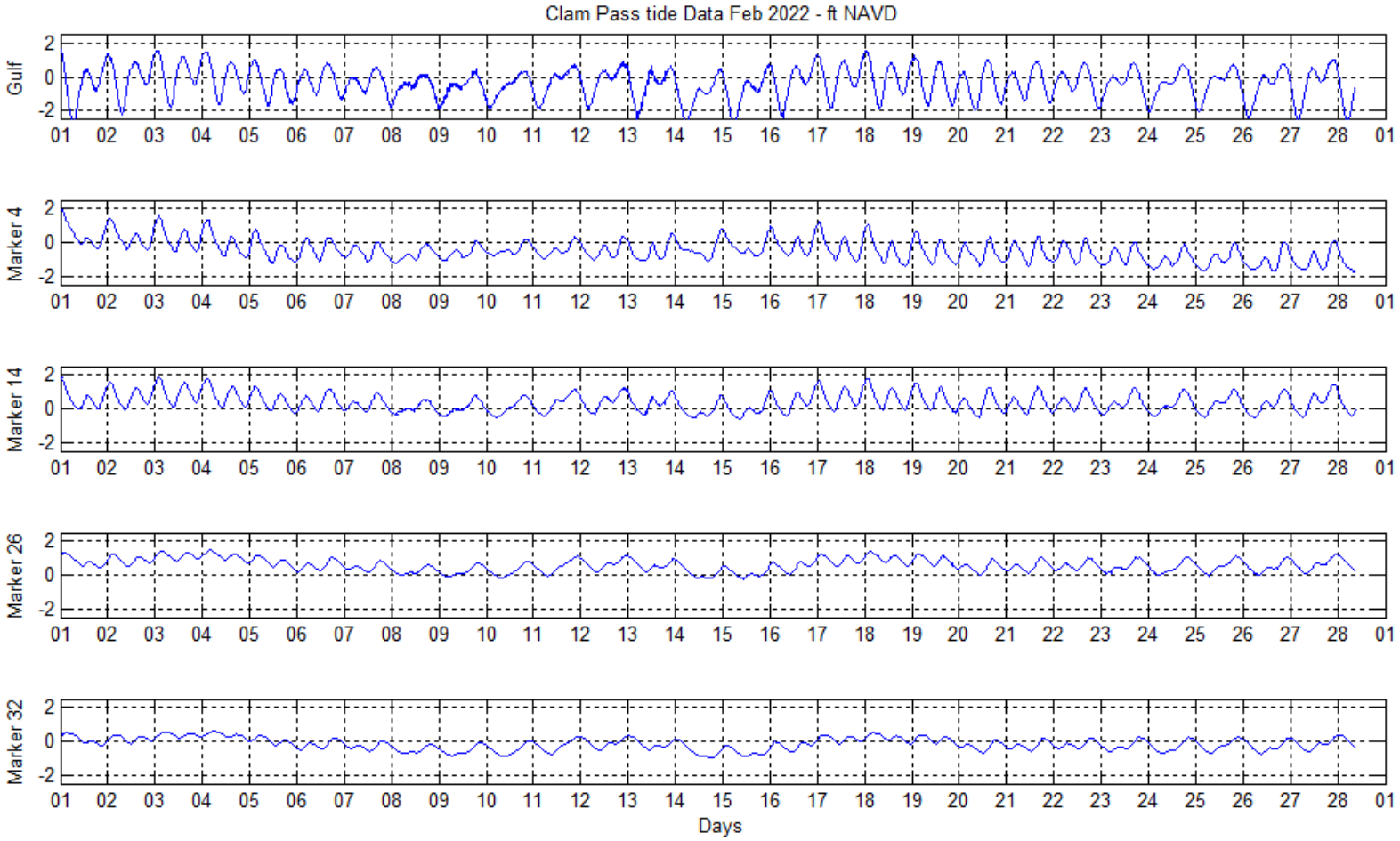


Figure C14 - Clam Pass Tide Gages Time Series – February 2022

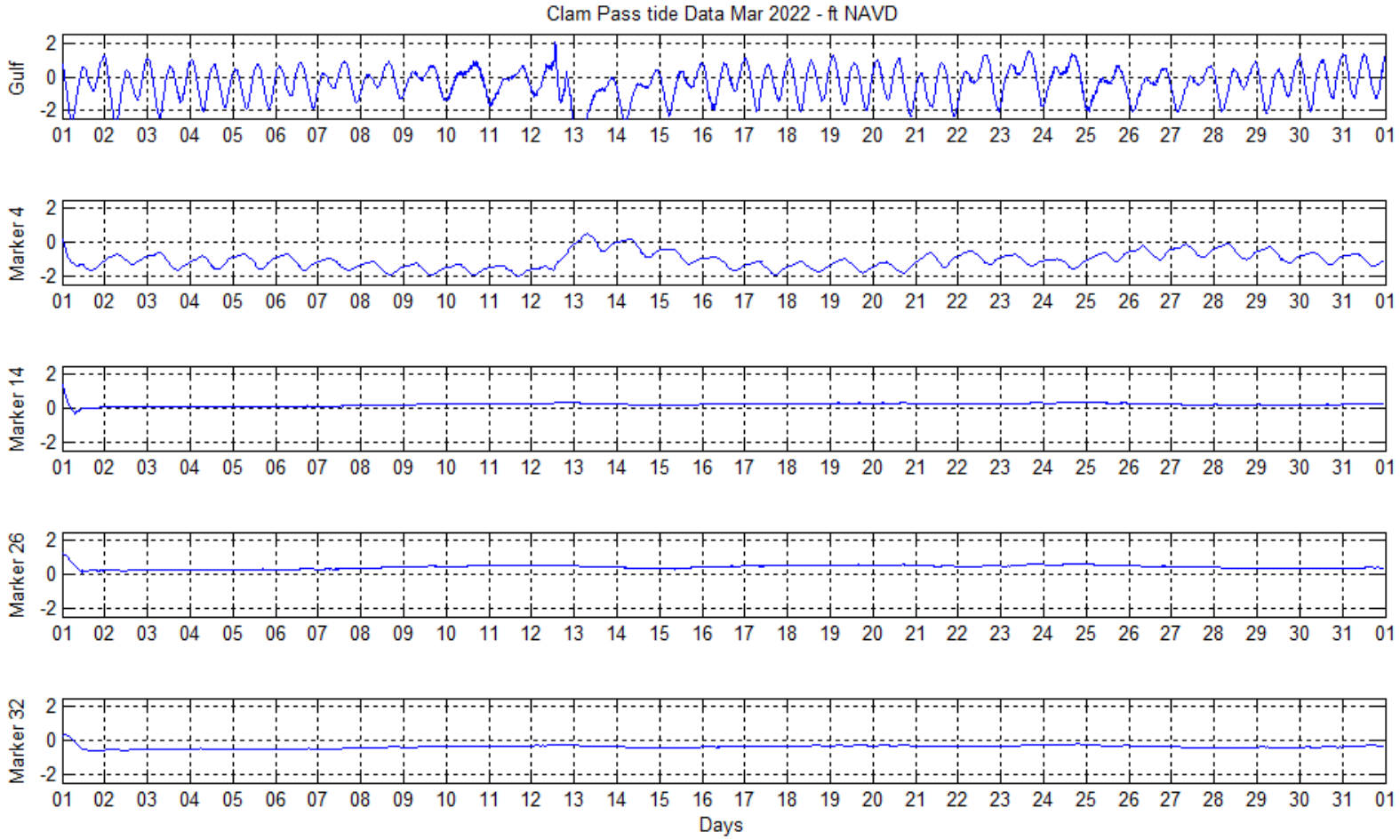


Figure C15 - Clam Pass Tide Gages Time Series – March 2022

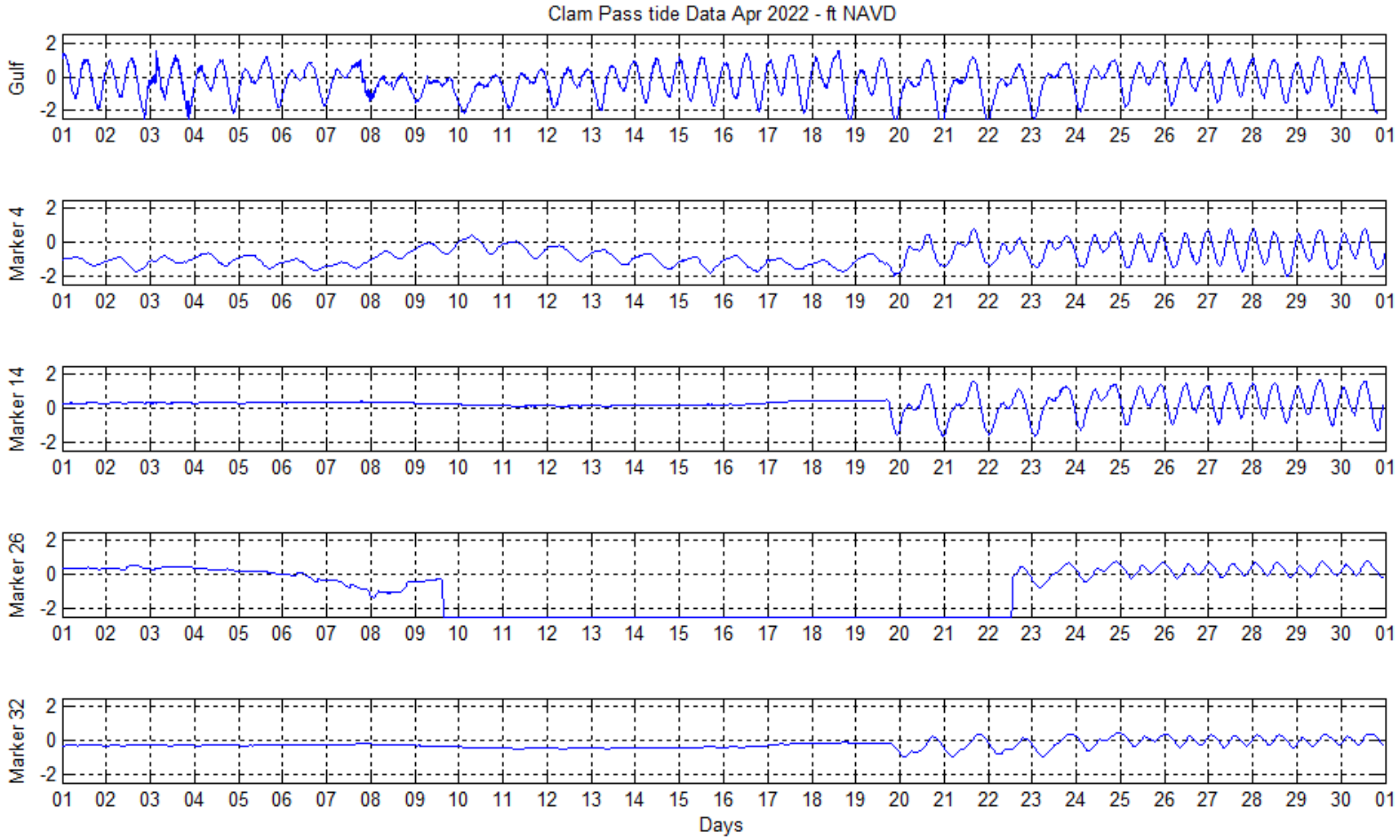


Figure C16 - Clam Pass Tide Gages Time Series – April 2022

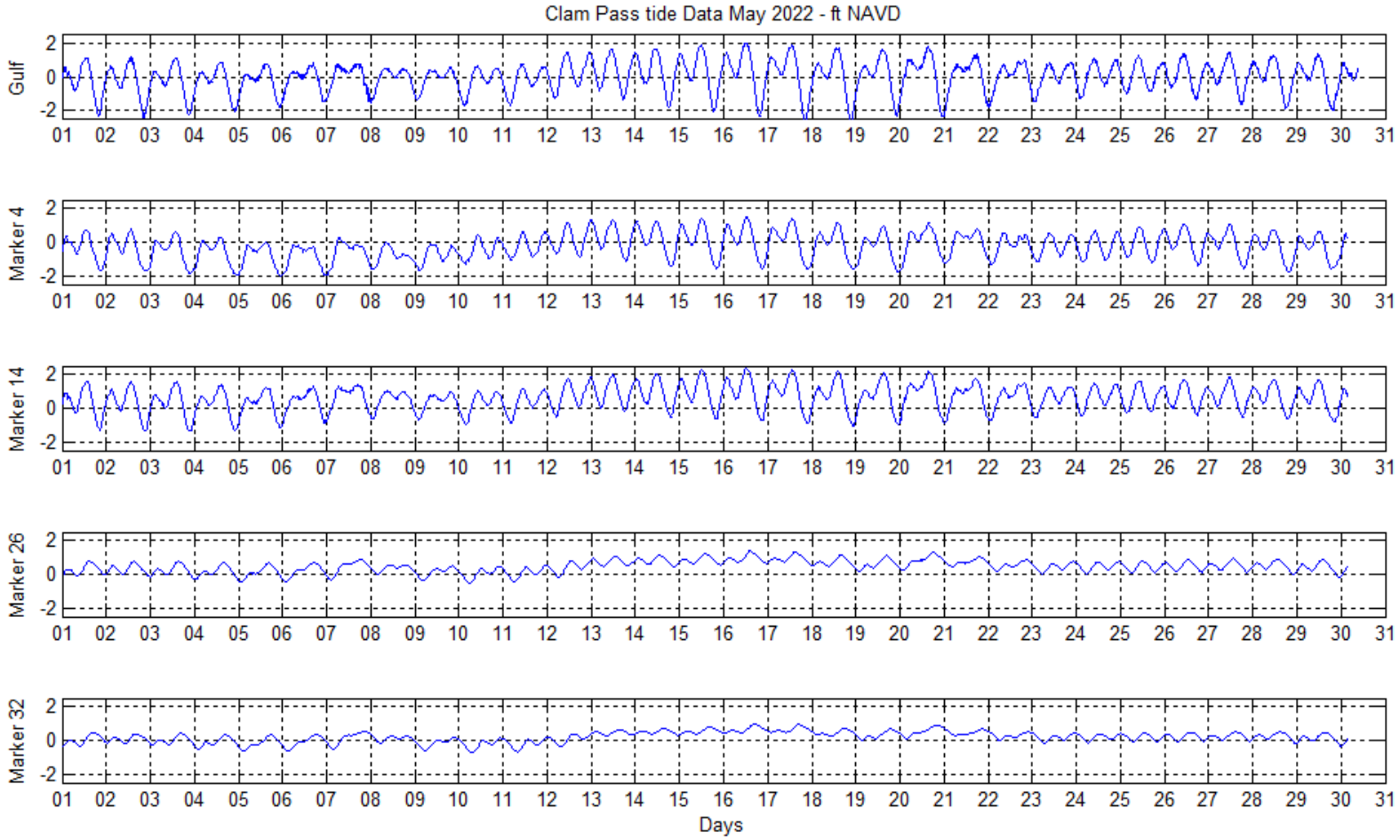
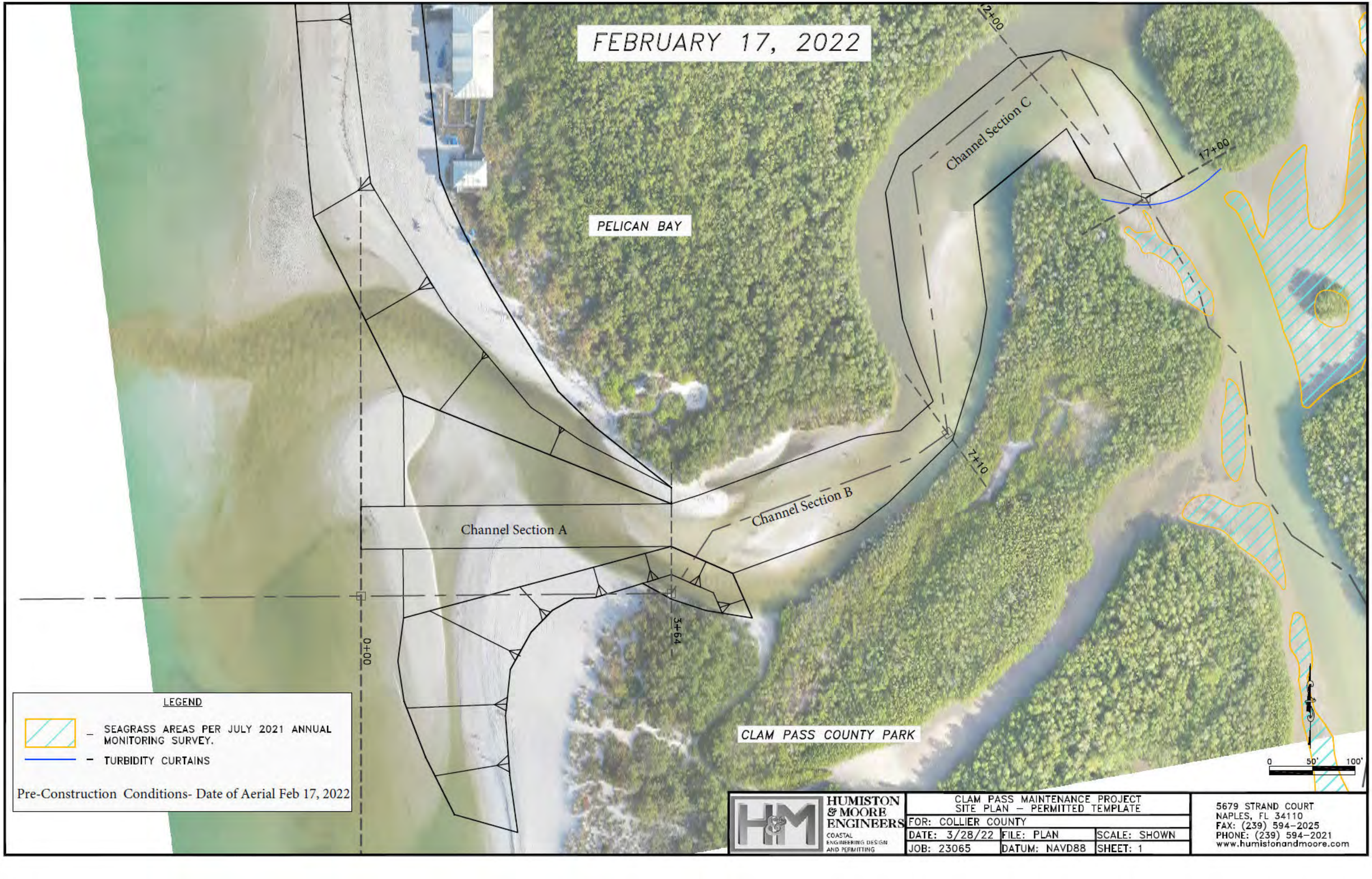


Figure C17 - Clam Pass Tide Gages Time Series – May 2022

APPENDIX D

2022 Maintenance Dredging
Project Progress Time Series



HUMISTON & MOORE ENGINEERS
COASTAL ENGINEERING DESIGN AND PERMITTING

CLAM PASS MAINTENANCE PROJECT
SITE PLAN – PERMITTED TEMPLATE

FOR: COLLIER COUNTY		
DATE: 3/28/22	FILE: PLAN	SCALE: SHOWN
JOB: 23065	DATUM: NAVD88	SHEET: 1

5679 STRAND COURT
NAPLES, FL 34110
FAX: (239) 594-2025
PHONE: (239) 594-2021
www.humistonandmoore.com

DREDGE TEMPLATE CONTROL INFORMATION		
STATION ID	EASTING (FEET)	NORTHING (FEET)
A	387,864.9	686,400.0
B	388,229.4	686,403.3
C	388,261.0	686,413.3
D	388,449.3	686,482.0
E	388,498.3	686,489.3
F	388,536.6	686,523.6
G	388,517.0	686,571.6
H	388,500.5	686,619.9
I	388,480.6	686,768.5
J	388,496.9	686,811.4
K	388,636.4	686,926.6
L	388,686.5	686,935.5
M	388,746.0	686,911.9
N	388,779.5	686,873.5
O	388,829.1	686,786.7
P	388,785.7	686,761.8
Q	388,726.2	686,785.4
R	388,692.9	686,843.5
S	388,584.4	686,753.9
T	388,586.3	686,732.2
U	388,599.6	686,633.1
V	388,591.3	686,581.6
W	388,559.4	686,478.0
X	388,483.5	686,404.2
Y	388,442.5	686,373.3
Z	388,301.2	686,321.8
AA	388,228.9	686,353.2
BB	387,864.9	686,350.4

MARCH 23, 2022

R-41

12+00

17+00

7+10

3+64

0+00

CHANNEL SECTION C
EXCAVATION TO APPROX. -4.5' NAVD
INCLUDING OVERDEPTH
SIDE SLOPES AT 1:1

CHANNEL FLATS
FILL ABANDONED CHANNEL
TO -1.7' NAVD

CHANNEL SECTION A
BOTTOM -5.5' NAVD INCLUDING OVERDEPTH
SIDE SLOPES @ 1:1

50'

CHANNEL FLATS
CUT TO -1.7 NAVD
DO NOT PROVIDE FILL

CHANNEL SECTION B
EXCAVATION TO APPROX. -4.5' NAVD
INCLUDING OVERDEPTH
SIDE SLOPES AT 1:1

GULF OF MEXICO

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z AA BB

LEGEND

- SEAGRASS AREAS PER JULY 2021 ANNUAL MONITORING SURVEY.
- TURBIDITY CURTAINS

NOTES:
1. AERIAL PHOTOGRAPH TAKEN MARCH 23, 2022 BY HUMISTON & MOORE ENGINEERS.
2. COORDINATES SHOWN ARE IN FEET BASED ON THE NORTH AMERICAN DATUM OF 1983, EAST ZONE (NAD83).
3. ELEVATIONS SHOWN ARE IN FEET BASED ON THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88).

0 50' 100'

HUMISTON & MOORE ENGINEERS
COASTAL ENGINEERING DESIGN AND PERMITTING

CLAM PASS MAINTENANCE PROJECT
SITE PLAN – PROJECT STATIONS

FOR: PELICAN BAY SERVICES DIVISION

DATE: 03/23/22	FILE: PLAN	SCALE: SHOWN
JOB: 23-065	DATUM: NAVD88	SHEET: 2 OF 3

5679 STRAND COURT
NAPLES, FL 34110
FAX: (239) 594-2025
PHONE: (239) 594-2021
www.humistonandmoore.com

DREDGE TEMPLATE CONTROL INFORMATION		
STATION ID	EASTING (FEET)	NORTHING (FEET)
A	387,864.9	686,400.0
B	388,229.4	686,403.3
C	388,261.0	686,413.3
D	388,449.3	686,482.0
E	388,498.3	686,489.3
F	388,536.6	686,523.6
G	388,517.0	686,571.6
H	388,500.5	686,619.9
I	388,480.6	686,768.5
J	388,496.9	686,811.4
K	388,636.4	686,926.6
L	388,686.5	686,935.5
M	388,746.0	686,911.9
N	388,779.5	686,873.5
O	388,829.1	686,786.7
P	388,785.7	686,761.8
Q	388,726.2	686,785.4
R	388,692.9	686,843.5
S	388,584.4	686,753.9
T	388,586.3	686,732.2
U	388,599.6	686,633.1
V	388,591.3	686,581.6
W	388,559.4	686,478.0
X	388,483.5	686,404.2
Y	388,442.5	686,373.3
Z	388,301.2	686,321.8
AA	388,228.9	686,353.2
BB	387,864.9	686,350.4

APRIL 20, 2022

R-41

12+00

17+00

7+10

3+64

0+00

CHANNEL SECTION C
EXCAVATION TO APPROX. -4.5' NAVD
INCLUDING OVERDEPTH
SIDE SLOPES AT 1:1

CHANNEL FLATS
FILL ABANDONED CHANNEL
TO -1.7' NAVD

CHANNEL SECTION B
EXCAVATION TO APPROX. -4.5' NAVD
INCLUDING OVERDEPTH
SIDE SLOPES AT 1:1

CHANNEL SECTION A
BOTTOM -5.5' NAVD INCLUDING OVERDEPTH
SIDE SLOPES @ 1:1

50'

CHANNEL FLATS
CUT TO -1.7 NAVD

GULF OF MEXICO

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z AA BB

LEGEND

- SEAGRASS AREAS PER JULY 2021 ANNUAL MONITORING SURVEY.
- TURBIDITY CURTAINS

NOTES:
1. AERIAL PHOTOGRAPH TAKEN APRIL 20, 2022 BY HUMISTON & MOORE ENGINEERS.
2. COORDINATES SHOWN ARE IN FEET BASED ON THE NORTH AMERICAN DATUM OF 1983, EAST ZONE (NAD83).
3. ELEVATIONS SHOWN ARE IN FEET BASED ON THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88).

0 50' 100'

HUMISTON & MOORE ENGINEERS
COASTAL ENGINEERING DESIGN AND PERMITTING

CLAM PASS MAINTENANCE PROJECT
SITE PLAN – PROJECT STATIONS

FOR: PELICAN BAY SERVICES DIVISION

DATE: 04/20/22 | FILE: PLAN | SCALE: SHOWN
JOB: 23-065 | DATUM: NAVD88 | SHEET: 2 OF 3

5679 STRAND COURT
NAPLES, FL 34110
FAX: (239) 594-2025
PHONE: (239) 594-2021
www.humistonandmoore.com

DREDGE TEMPLATE CONTROL INFORMATION		
STATION ID	EASTING (FEET)	NORTHING (FEET)
A	387,864.9	686,400.0
B	388,229.4	686,403.3
C	388,261.0	686,413.3
D	388,449.3	686,482.0
E	388,498.3	686,489.3
F	388,536.6	686,523.6
G	388,517.0	686,571.6
H	388,500.5	686,619.9
I	388,480.6	686,768.5
J	388,496.9	686,811.4
K	388,636.4	686,926.6
L	388,686.5	686,935.5
M	388,746.0	686,911.9
N	388,779.5	686,873.5
O	388,829.1	686,786.7
P	388,785.7	686,761.8
Q	388,726.2	686,785.4
R	388,692.9	686,843.5
S	388,584.4	686,753.9
T	388,586.3	686,732.2
U	388,599.6	686,633.1
V	388,591.3	686,581.6
W	388,559.4	686,478.0
X	388,483.5	686,404.2
Y	388,442.5	686,373.3
Z	388,301.2	686,321.8
AA	388,228.9	686,353.2
BB	387,864.9	686,350.4

APRIL 28, 2022

R-41

12+00

17+00

7+10

3+64

0+00

CHANNEL SECTION C
EXCAVATION TO APPROX. -4.5' NAVD
INCLUDING OVERDEPTH
SIDE SLOPES AT 1:1

CHANNEL FLATS
FILL ABANDONED CHANNEL
TO -1.7' NAVD

CHANNEL SECTION A
BOTTOM -5.5' NAVD INCLUDING OVERDEPTH
SIDE SLOPES @ 1:1

50'

CHANNEL FLATS
CUT TO -1.7 NAVD

CHANNEL SECTION B
EXCAVATION TO APPROX. -4.5' NAVD
INCLUDING OVERDEPTH
SIDE SLOPES AT 1:1

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z AA BB

LEGEND

- SEAGRASS AREAS PER JULY 2021 ANNUAL MONITORING SURVEY.
- TURBIDITY CURTAINS

NOTES:
1. AERIAL PHOTOGRAPH TAKEN APRIL 28, 2022 BY HUMISTON & MOORE ENGINEERS.
2. COORDINATES SHOWN ARE IN FEET BASED ON THE NORTH AMERICAN DATUM OF 1983, EAST ZONE (NAD83).
3. ELEVATIONS SHOWN ARE IN FEET BASED ON THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88).

0 50' 100'

HUMISTON & MOORE ENGINEERS
COASTAL ENGINEERING DESIGN AND PERMITTING

CLAM PASS MAINTENANCE PROJECT
SITE PLAN – PROJECT STATIONS

FOR: PELICAN BAY SERVICES DIVISION		
DATE: 04/29/22	FILE: PLAN	SCALE: SHOWN
JOB: 23-065	DATUM: NAVD88	SHEET: 2 OF 3

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