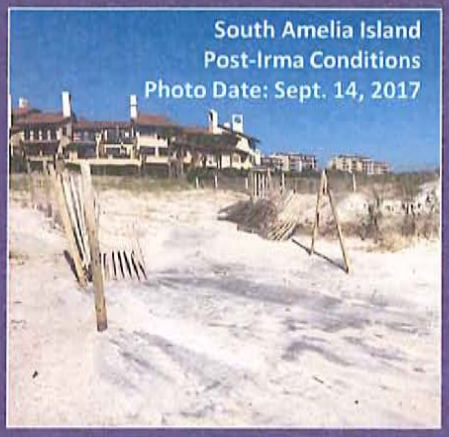

South Amelia Island Shore Stabilization Project

HURRICANE IRMA (FEMA DR-4337) POST-STORM DESIGN SURVEY & ANALYSIS

Prepared for:
Nassau County, FL,
Board of County Commissioners
South Amelia Island Shore
Stabilization Association (SAISSA)

Prepared by:
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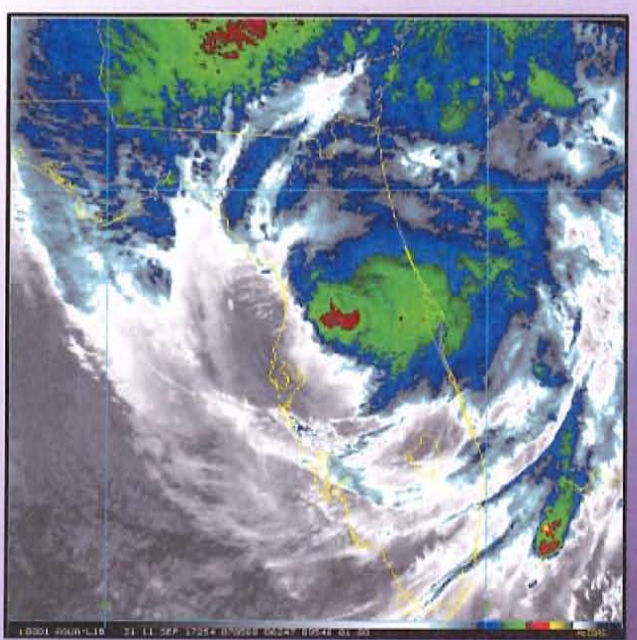


Enhanced infrared (IR) image of Hurricane Irma as the storm moved up the Florida Peninsula.
Image Source: NOAA – National Environmental Satellite, Data & Information Service.

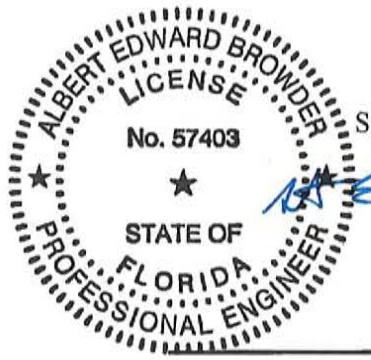
February 2018
(Revised August 2018)

olsen
associates, inc.

South Amelia Island Shore Stabilization Project

HURRICANE IRMA (FEMA DR-4337)
POST-STORM DESIGN SURVEY & ANALYSIS

February 2018 (revised August 2018)



07 Aug '18

Report Prepared for:
Nassau County, FL, Board of County Commissioners
South Amelia Island Shore Stabilization Association (SAISSA)

Report Prepared by:
Olsen Associates, Inc.
2618 Herschel Street
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EXECUTIVE SUMMARY

This report documents the impacts of Hurricane Irma upon the engineered beach nourishment project along the southern Atlantic Ocean shoreline of Amelia Island in Nassau County, FL. The engineered South Amelia Island Shore Stabilization Project was impacted by Irma from September 9-12, 2017. As part of the management of the engineered beach nourishment project, Nassau County and the South Amelia Island Shore Stabilization Association (SAISSA) authorized beach profile surveys and this report to determine the extent of damages to the beach and formulate the scope of any necessary repairs. The local- and State-funded engineered beach nourishment project qualifies for Category G post-disaster relief from the Federal Emergency Management Agency (FEMA) Public Assistance Program for impacts sustained by the beach from an event that is declared an emergency.

Hurricane Irma impacted the South Amelia Island Shore Stabilization Project between September 9th and September 12th, 2017, with elevated storm surge and damaging storm waves. Elevated surge levels, peaking over 6.34 ft-NAVD88 (~3.95 ft above the Mean High Water), impacted the shoreline for nearly 2 days and wave heights exceeding 20 ft occurred at the offshore edge of the project limits. The wave and tidal surge conditions combined to produce wave runup exceeding 10 to 11 ft-NAVD, based upon observation of wave overwash of sand and wrack debris.

Erosion damage to the engineered beach project was documented by comparison of the pre-storm project monitoring survey of March 2017 to the post-storm project design survey of September 2017. Both surveys include 31 beach profiles, each located at historical transect locations based upon the FDEP R-monument system. The survey transects were carried offshore beyond the typical depth of significant survey change. Based upon inspection of the historical beach profiles in this area, the closure depth is taken to be -20 ft-NAVD. After removing the average annual background erosion volume from the measured volume changes between March 2017 and September 2017, the calculated Hurricane Irma related-impact to the engineered beach nourishment project is a loss of -134,100 cy. Of that total, -126,050 cy occurred along the SAISSA shoreline segment of the project and -8,050 cy along the AISP shoreline segment. **It is thus determined that the replacement of 134,100 cubic yards of beach-compatible sand would be required to restore the engineered beach fill project to its pre-Hurricane Irma condition.**

South Amelia Island Shore Stabilization Project

HURRICANE IRMA (FEMA DR-4337) POST-STORM DESIGN SURVEY & ANALYSIS

February 2018 (revised August 2018)

Report Prepared for:
Nassau County, FL, Board of County Commissioners
South Amelia Island Shore Stabilization Association (SAISSA)

Report Prepared by:
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February 2018 (revised August 2018)

Report Prepared for:
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1.0 Introduction

1.1 Scope and Authorization of Study

This report documents the changes in shoreline position and beach volume along the south Amelia Island shoreline caused by the effects of Hurricane Irma in early September 2017. On September 10, 2017, Hurricane Irma was declared a major disaster by the Federal Government for portions of Florida, including Nassau County, FL. As part of the management of the engineered beach nourishment project, Nassau County and the South Amelia Island Shore Stabilization Association (SAISSA) authorized beach profile surveys and this report to determine the extent of damages to the beach and formulate the scope of any necessary repairs. The local- and State-funded engineered beach nourishment project qualifies for Category G post-disaster relief from the Federal Emergency Management Agency (FEMA) Public Assistance Program for impacts sustained by the beach from an event that is declared an emergency.

1.2 Project Location and Physical Setting

Amelia Island is a sandy barrier island located in Nassau County in Northeast Florida (**Figure 1.1**). The island has approximately 14.5 miles of sandy shoreline, bordered to the north by the entrance to the St. Mary's River, and to the south by Nassau Sound. Neighboring islands include Cumberland Island, GA, to the north, and Little Talbot Island to the south. The engineered beach project extends approximately 19,260 feet from Burney Park at FDEP R-monument R-59 southward to the rock terminal groin located at the southern tip of the island at R-monument R-79. The project includes approximately 3,420 feet of shoreline located along Amelia Island State Park (AISP) at the southern end of the island, from a point approximately 250 feet south of R-monument R-75 at the rock breakwater extending southward to R-79 at the rock terminal groin.

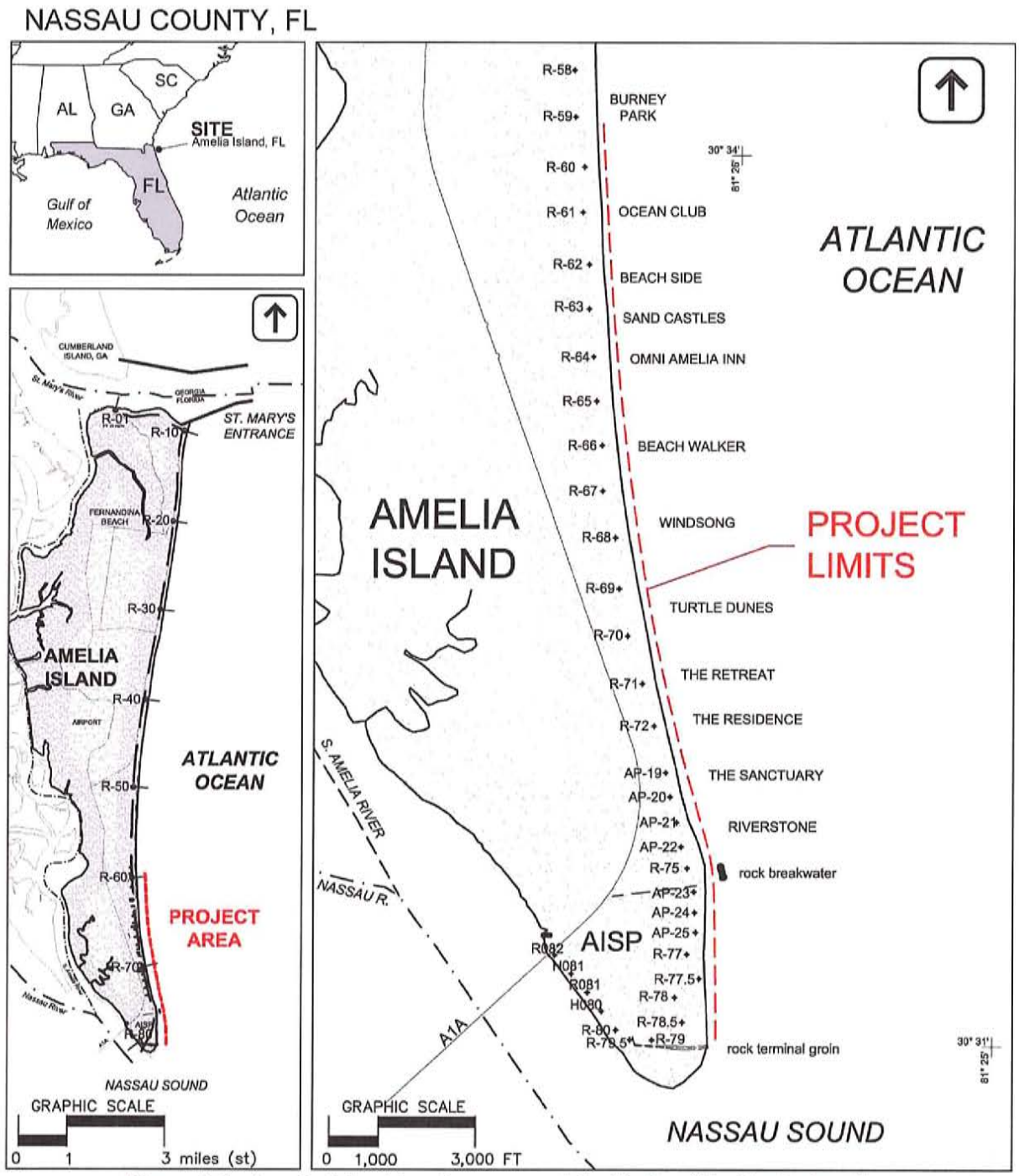

Figure 1.1: Amelia Island location map and the limits of the South Amelia Island Shore Stabilization Project.

The astronomical tides in the vicinity of the project area are semi-diurnal and have average mean and spring ranges of approximately 5.2 ft and 5.9 ft, respectively. Tidal datums at the south end of Amelia Island are listed in **Table 1.1**.

Table 1.1: Tidal datums at the south end of Amelia Island[1].

Vertical Datum	Elevation (ft-NAVD 88[2])
Mean High Water (MHW)	+2.0
NAVD 1988	0.0
Mean Tide Level (MTL)	-0.5
NGVD 1929	-1.2
Mean Low Water (MLW)	-3.1

1.3 Project Area Background (pre-Hurricane Irma)

Over the last 50 years, numerous actions have been implemented to offset the effects of erosional stress along the southern end of Amelia Island. Major engineering activities since 1964 are summarized in **Table 1.1** (updated from OAI 2011). Since 1984, over 10.2 Mcy of sand have been placed as beach fill or dune enhancement along the south end of the island alone (R-48 to R-79).

In 1993, The Nassau County, FL, Board of County Commissioners established the South Amelia Island Shore Stabilization – Municipal Services Benefit Unit (SAISS-MSBU) and formed a group of property owners into the South Amelia Island Shore Stabilization Association, Inc. (SAISSA) to assist in project management for the purpose of combatting the severe erosion that threatened the south Amelia Island shorefront. Ultimately, the County and SAISSA sponsored the design and construction of a 2.6 Mcy beach restoration project along a 3.2 mile reach of the southernmost shoreline (R-59 to R-78). This project was designed and permitted by Olsen Associates, Inc. and constructed in the summer of 1994.

In 2002, a 1.8 Mcy renourishment of the 1994 project was constructed between R-60 and R-79.5. The 2002 beach fill constituted Phase I of the SAISSA project, which was co-sponsored by the Florida Park Service (FPS). As a result, the project limits were extended to include the Amelia Island State Park as well as privately owned properties located north of the park. In August 2003, permits for a Phase II Structural Stabilization project were issued by the FDEP. Three rock structures were permitted with the intention of a.) stabilizing the severely eroded Park oceanfront shoreline at a more seaward position for purposes of restoring recreational beach and protecting a unique maritime forest and related Sea Island ecosystem; b.) increasing the overall performance (*i.e.* longevity) of the 3.5 mile beach

[1] Approximations based upon NOS Tidal Station 8720135, Nassau River Entrance, Nassau River.
[2] NAVD 88: North American Vertical Datum of 1988. **All elevations in this report are referenced in FEET relative to NAVD 88 unless otherwise noted.**

restoration project and in particular the Park shoreline segment lying in close proximity to Nassau Sound; and c.) to assist in fostering the stability of the Park east-west shoreline which borders a relatively deep Nassau Sound marginal tidal channel. Construction of the three structures was initiated in July 2004 with substantial completion of the project in December 2004.

The 2011 project was the second scheduled maintenance of the SAISS Project (1994 & 2002) and the first maintenance nourishment following completion of the Phase II structural stabilization project (2004). The project placed approximately 2,100,630 cubic yards of beach quality sand (Contractor's estimated placed volume) from roughly R-59.5 southward to R-77, approximately 1,900 feet north of the existing rock terminal groin. This project is discussed in greater detail in *Post-Construction Documentation Report* (OAI 2011).

During the summer of 2013, the Florida Inland Navigation District (FIND) sponsored the placement by the U.S. Army Corps of Engineers of approximately ±581,000 CY of material from the Atlantic Intracoastal Waterway (AIWW) onto the south Amelia Island beaches between the detached breakwater and the terminal groin (R-76 to R-79). This project is discussed in greater detail in *Year-Three Post-Construction Report* (OAI 2014).

Table 1.1a: Historical shoreline protection efforts, South Amelia Island, 1964-2013.

DATE	ACTION
1964	In response to erosion damage suffered during Hurricane Dora in 1964, emergency Federal funds were appropriated for the construction of granite stone revetments along approximately 1.1 miles of American Beach. This revetment is currently buried by both beach fill and natural dunes.
1970's	Amelia Island Plantation (AIP) conducted beach scraping along its shoreline. The effort consisted of seasonal scraping of sand from the intertidal beach zone and subsequent placement at the dune toe.
1980	Permitted beach scraping of approximately 32,000 cy of material was conducted between monuments R-64 and R-68. The project was undertaken by the AIP and constructed in a manner consistent with previous scraping efforts.
1984	Between January and March, AIP placed approximately 76,000 cy of material via truck haul from the Atlantic Intracoastal Waterway (AIWW) dredge spoil disposal site within the Amelia Island State Recreation Area (AISRA) located at the southern end of Amelia Island. The material was placed as dune enhancement along 7,200 feet of AIP shoreline. As an emergency response to the Thanksgiving Day Storm of 1984, an additional 5,500 cy of sand were trucked in from the aforementioned spoil pile and placed at various locations where breaching of the AIP dune system was considered to be imminent.
1987	As part of a larger island-wide 1.42 Mcy beach fill project, 515,000 cy of material were placed by the USACE along a 1.3-mile reach of shoreline between R-48 and R-55. The material was obtained from new-work dredging of the St. Mary's Entrance required to provide navigational access for the U.S. Navy's Trident-class submarines. The disposal project was undertaken as a result of a 1986 Memorandum of Understanding (MOU) between the U.S. Navy and the State of Florida.
1987	USACE placed 2.13 Mcy of material in a nearshore disposal site located between R-33 and R-55. The material placed at this site was obtained from the aforementioned new work dredging of the St. Mary's Entrance. The material was placed seaward of the –18 ft (MLW) contour, and primarily in deeper water (-20 to –35 ft, MLW).
1988	Under the conditions of the 1986 State/Navy MOU, USACE reportedly placed 750,000 cy of material along approximately 1 mile of shoreline between R-55 and R-60. The material was originally placed in the USACE nearshore disposal site by hopper dredge and later moved onshore by means of a cutterhead dredge. The volume actually placed on the beach is a matter of dispute. The dredging contractor was paid for the placement of 1.083 Mcy of fill, intended to extend over the 12,000-ft reach of shoreline between R-54 and R-65. Actual placement of material occurred along approximately 5,000 ft of shoreline between R-55 and R-60. This resulted in an approximate 60% shortfall in project length relative to the original design. Anecdotal visual inspection indicated that much of the material was fine sands and clay, which in all probability resulted from over-dredging of the specified nearshore rehandling site.
1989	AIP placed about 50,000 cy of beach fill material along its shoreline. The material was trucked in from an AIWW dredge spoil disposal site located west of the Amelia River.
1991	AIP placed approximately 12,000 cy of beach fill, from an upland source, along its shoreline as a part of a continuing dune protection effort.
1993	USACE beach fill along South American Beach~300,000 cy extending south to about R-62.
1994	SAISS-MSBU funded the design and construction of a comprehensive beach restoration project along the southernmost 17,000 feet of Amelia Island's shoreline. The project placed approximately 2.6 Mcy of fill between monuments R-59 and R-78. The borrow area for the site was 800-ft wide by 7,500-ft long and located between 3,000 and 3,900 feet offshore of the southern end of the island on the margins of the Nassau Sound ebb shoal platform.

(table continued on next page)

Table 1.1b: Historical shoreline protection efforts, South Amelia Island, 1964-2013.

(table continued from previous page)

DATE	ACTION
1995	A temporary terminal groin field was constructed between August and November consisting of four groins placed perpendicular to the shoreline, spaced about 500 ft apart in a tapered configuration. The groins were constructed of 70-inch diameter, sand-filled geotextile tubes (LONGARD™) and numerous smaller support tubes. The landward terminus of each groin was installed below grade within the 1994 beach fill.
1996	The southernmost groin, G-4, was first vandalized in October, resulting in deflation of a 50-ft section of the geotextile groin. The gap was closed through the placement of several small tube sections.
1997	Between May and September, FIND sponsored and USACE placed about 300,000 cy of sand along 4,500 ft of shoreline between monuments R-73.5 and R-77.5. The sand was obtained from maintenance dredging of the AIWW through Nassau Sound. Fill was placed within the groin field as well as along the beach 1,000 ft to the north and 2,000 ft to the south of the structures.
2000	All four of the geotextile groins have been routinely vandalized resulting in substantial structural damage and sand loss. The seaward terminus of each groin required major reconstruction during which the decision was made by SAISS-MSBU to truncate each structure. Additional stabilizing bags were also added to groin G-4 at this time. In October, groin G-3 essentially was rendered ineffective.
2000	In November/December, approximately 2,000 ft of shore-parallel sand-filled geotextile tubes were placed along segments of the AISRA to reduce flooding of the maritime forest in areas where the dune had been lost to chronic erosion. During the same time period, the FIND sponsored and USACE initiated a second beach disposal project derived from material maintenance-dredged from the AIWW. With participation from FDEP, the total volume is expected to reach as much 300,000 cy, to be placed at the southern terminus of the island.
2001	Between May and September, FIND sponsored and USACE placed about 300,000 cy of sand along 4,500 ft of shoreline between monuments R-73.5 and R-77.5. The sand was obtained from maintenance dredging of the AIWW through Nassau Sound. Fill was placed within the groin field as well as along the beach 1,000 ft to the north and 2,000 ft to the south of the structures.
2002	Phase I of the South Amelia Island Shore Stabilization Project was constructed between monuments R-60 and R-79 along Amelia Island State Park and northward thereof; approximately 1.8 million cubic yards of sand were placed. Prior to construction, all shore-parallel and shore-perpendicular geotextile structures were removed.
2004/05	Phase II of the South Amelia Island Shore Stabilization Project was constructed. The project consisted of three engineered rubble mound erosion control structures, a detached breakwater and two groins, including a "leaky" terminal groin at the south end of the island in an east-west orientation
2006	Approximately 400,000 cy of material from the AIWW was hydraulically placed by U.S. Army Corps of Engineers, sponsored by FIND, onto the south Amelia Island beaches between the detached breakwater and the terminal groin, or between monuments R-76 to R-79
2011	The 2011 renourishment of the South Amelia Island Shore Stabilization Project was constructed between R-59.5 and R-77 along the southern 3.2 miles of the Atlantic Ocean shoreline of Amelia Island, FL. Approximately 2.1 million cubic yards of sand were placed.
2013	Approximately ±581,000 cy of material from the AIWW was hydraulically placed by U.S. Army Corps of Engineers, sponsored by FIND onto the south Amelia Island beaches between the detached breakwater and the terminal groin, or between monuments R-76 to R-79
2016	Project area impacted by Hurricane Matthew (October)
2017	Project area impacted by Hurricane Irma (September)

1.4 Post-Construction Monitoring Program

The current physical monitoring plan was instituted in 2011, prior to construction of the most recent renourishment. This plan is summarized in the document, the *South Amelia Island Shoreline Stabilization Project Beach Renourishment – Physical Monitoring Plan with Structure Remediation Contingency*, revised March 1, 2011. The standards for all relevant data acquisition and submission requirements are published by the Florida Department of Environmental Protection (FDEP). The schedule of data collection and analysis for the first five years following project completion is provided in the Plan documentation referenced above and summarized in **Figure 1.2**.

The plan consists of numerous components that track the performance of the beach restoration project including:

- Beach profile surveys between R-55 to R-82 (41 beach profiles)
- Bathymetric surveys of the borrow site
- Bathymetric surveys of the Nassau Sound Ebb Shoal
- Orthorectified aerial photography
- Oblique aerial photography
- Beach sand sampling

While post-storm surveys are not specifically included in the scope of the physical monitoring program, the data collection and reporting contained in this report follows the form of the plan. Following Hurricane Irma, a beach profile survey was performed by ARC Surveying and Mapping, Inc. of Jacksonville, FL[3] in order to document storm damage. This survey was initiated in September 2017, approximately 2 weeks following the impacts of Hurricane Irma, at 31 beach profiles (R-55 to R-79D) historically included as part of the monitoring program.

For purposes of analysis and discussion, the south Amelia Island monitoring shoreline is qualitatively broken into four shoreline segments (or zones of interest, each with significantly varying physiographic characteristics. The four zones are as follows:

- **"North of Project Area" (5,220 ft):** R-55 to R-59
- **"SAISSA Engineered Beach" (14,820 ft):** R-59 to Detached Breakwater
- **"AISP Engineered Beach" (3,420 ft):** Detached Breakwater to Terminal Groin
- **"AISP Sound Shoreline" (4,750 ft):** Terminal Groin to R-82

The AISP Sound Shoreline (Terminal Groin to R-82) was not surveyed during the September 2017, post-Irma survey and was not included in the analysis contained herein.

[3] Arc Surveying & Mapping, Inc.; 5202 San Juan Avenue; Jacksonville, FL 32210

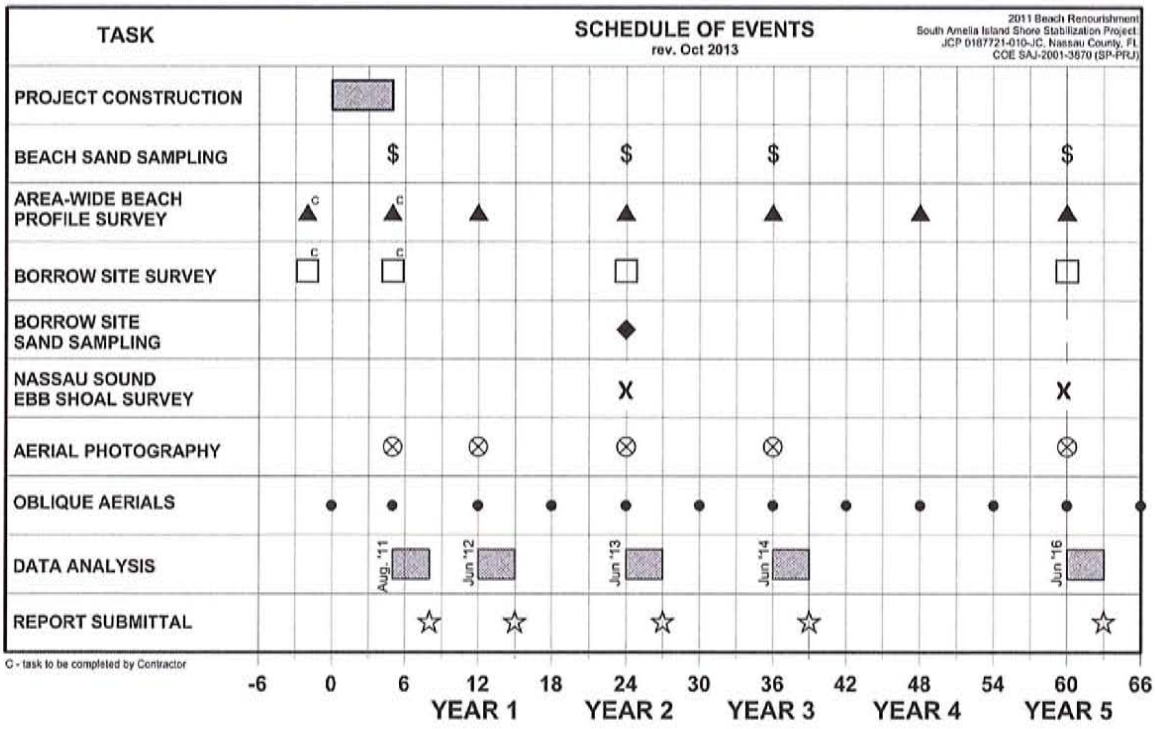

Figure 1.2: Schedule of monitoring events for the first five years following construction of the 2011 SAISS Project.

2.0 Storm Description: Hurricane Irma, September 2017

The large storm system developed from a tropical wave that formed near Cape Verde on August 30, 2017. Within 24 hours, Irma intensified into a Category 3 hurricane. After several days of fluctuating intensity, Irma intensified further to a Category 5 hurricane while located approximately 250 miles east of Barbuda. On September 5, Irma made landfall at Barbuda with maximum sustained winds peaking at 185 mph. Hurricane Irma continued its destructive path, making landfalls as a Category 5 hurricane on Saint Martin, Ginger Island and Tortola on September 6. On September 7, Irma's eye passes just *north* of Puerto Rico and the Dominican Republic and *south* of the Turks and Caicos before making landfall on the Bahamian Island of Little Inagua on September 8, all while at near peak strength. As Irma neared Cuba, it weakened to a Category 3 storm but reintensified as it crossed the Straits of Florida, making its initial US landfall in Cudjoe Key as a Category 4 storm with 130 mph sustained winds on September 10. Irma weakened further, to a Category 3 storm prior to making another landfall on Marco Island, FL.

Figure 2.1 plots the track of Hurricane Irma as the storm traversed Florida. The storm proceeded to travel northward along the I-75 corridor, up the State of Florida. On the morning of September 11, the center of Hurricane Irma passed about 100 miles west of Amelia Island, as a strong tropical storm, bringing wind gusts of up 88 mph in the vicinity of the project area. As Hurricane Irma moved north out of Florida, it weakened to a tropical depression near the Georgia-Alabama border.

Figure 2.2 plots the track of the storm in the vicinity of Amelia Island. The figure also displays the location of NOAA Buoy 41112, located roughly 8 miles offshore of Fernandina Beach, FL, approximately 16 miles northeast of the project. The buoy was deployed in February 2006 in roughly 50 feet of water and been collecting data nearly continuously for 12+ years. The data collected by the buoy include significant wave height (average of the highest one-third of all waves in a 20-minute sampling period), wave period, wave direction, water temperature and other standard meteorological data.

Additionally, **Figure 2.2** shows the locations of the Mayport (NOS 8720218) and Fernandina Beach (NOS 8720030) tidal stations, owned and maintained by NOAA's National Ocean Service (NOS) Water Level Observation Network. The Mayport station is located within the mouth of the St. John's River approximately 8 miles south of the project area. The Fernandina Beach station is located on the Amelia River, approximately 10 miles north of the project area. Both stations typically collect readings of water level, wind speed, gust speed, atmospheric pressure, and other meteorological data. It is noted that both tide gages are not located on the open coast but in sheltered areas. As such, water levels reported here are likely to be somewhat lower than those experienced along the open coastline of Amelia Island.

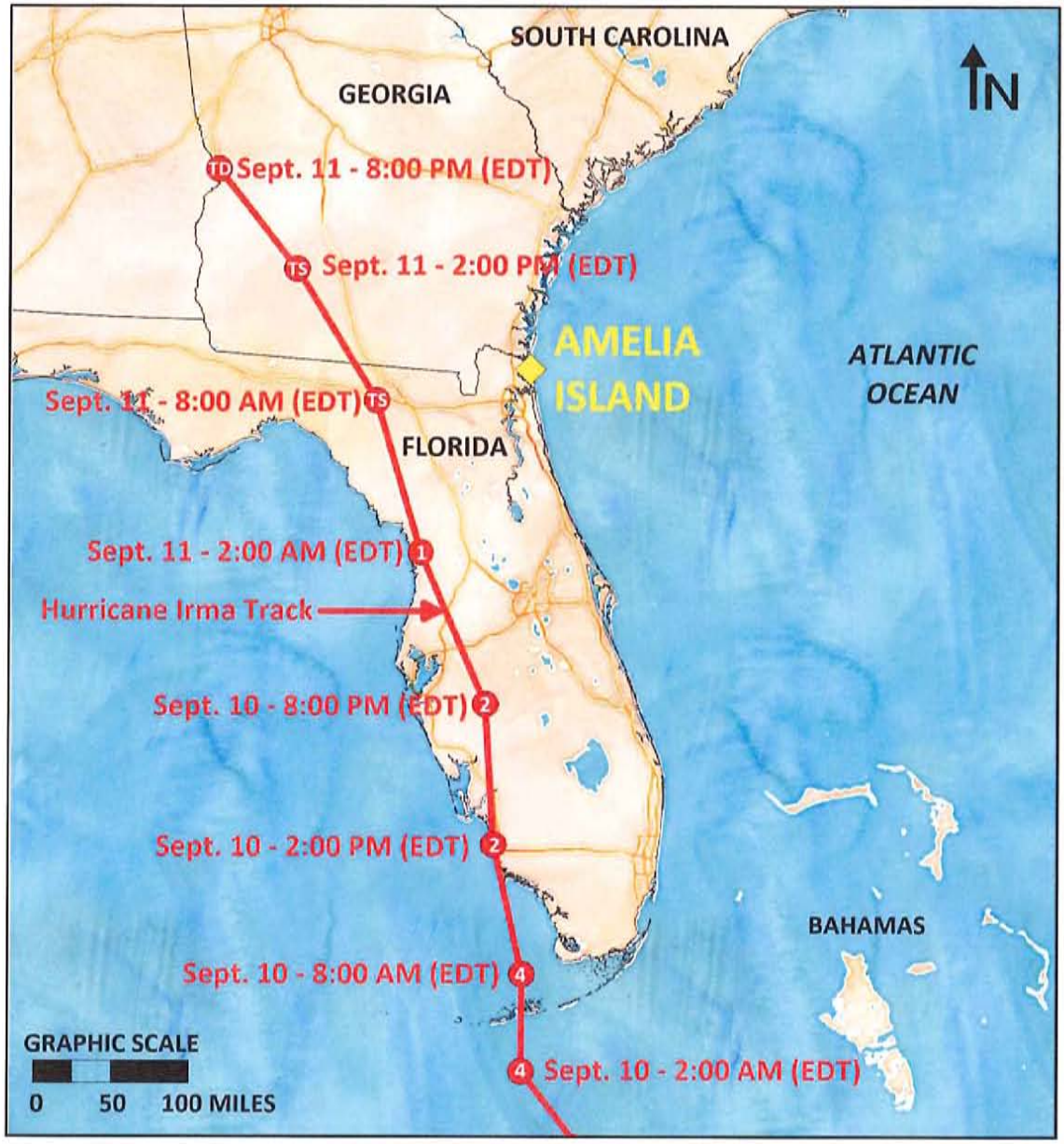

Figure 2.1: Storm track of Hurricane Irma in the vicinity of the southeast US. (Track available from the National Hurricane Center)

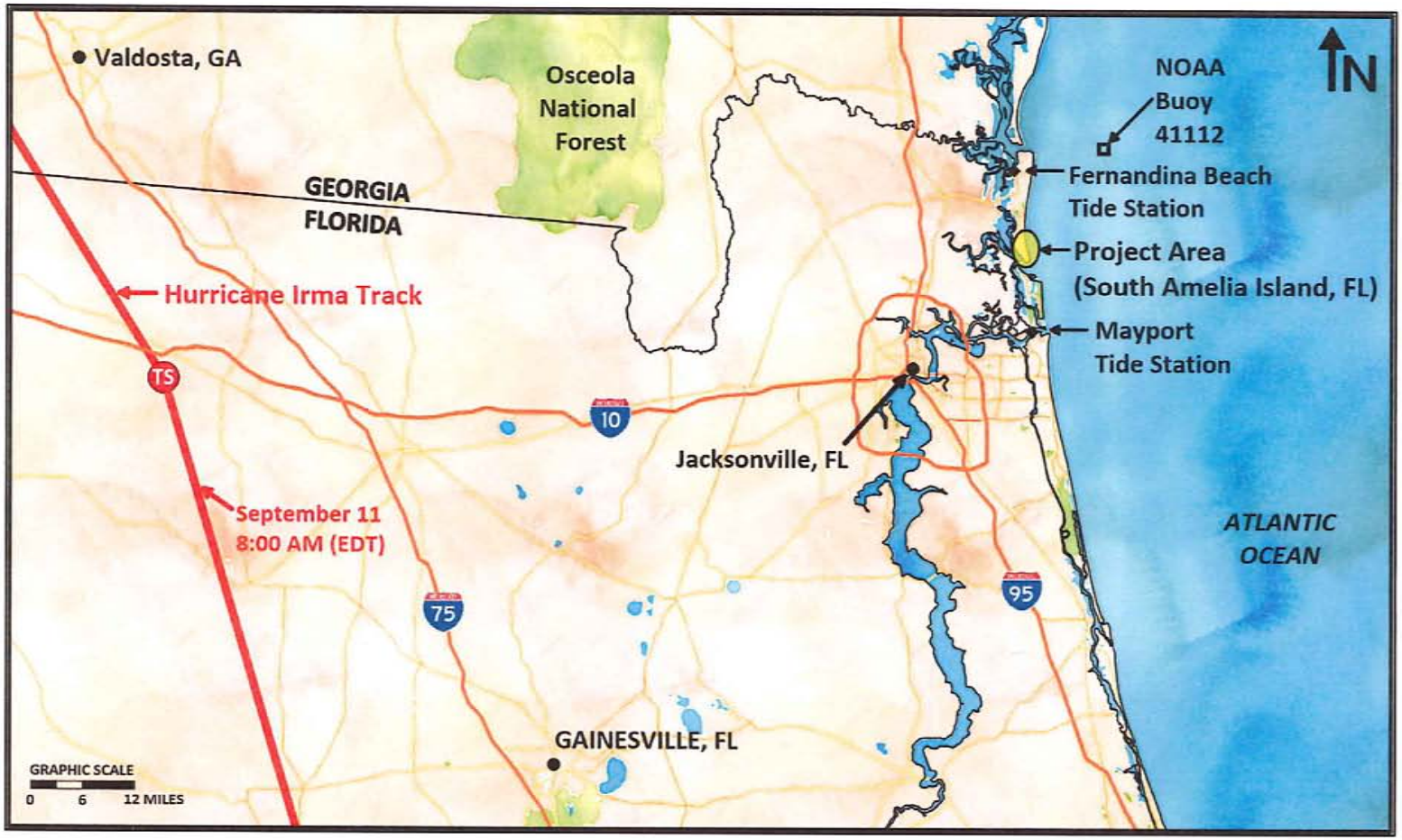

Figure 2.2: Storm track of Hurricane Irma in the vicinity of Amelia Island showing the location of NOAA Buoy 41112 and nearby tide stations. (Track available from the National Hurricane Center).

Wave Heights **Figure 2.3** displays the time series of significant wave heights measured at NOAA Buoy 41112 as Hurricane Irma approached and passed Amelia Island. While the buoy is located offshore in unprotected waters, the wave conditions measured can generally be related to nearshore conditions along the project limits. All wave statistics mentioned in this section will be from measurements at Buoy 41112.

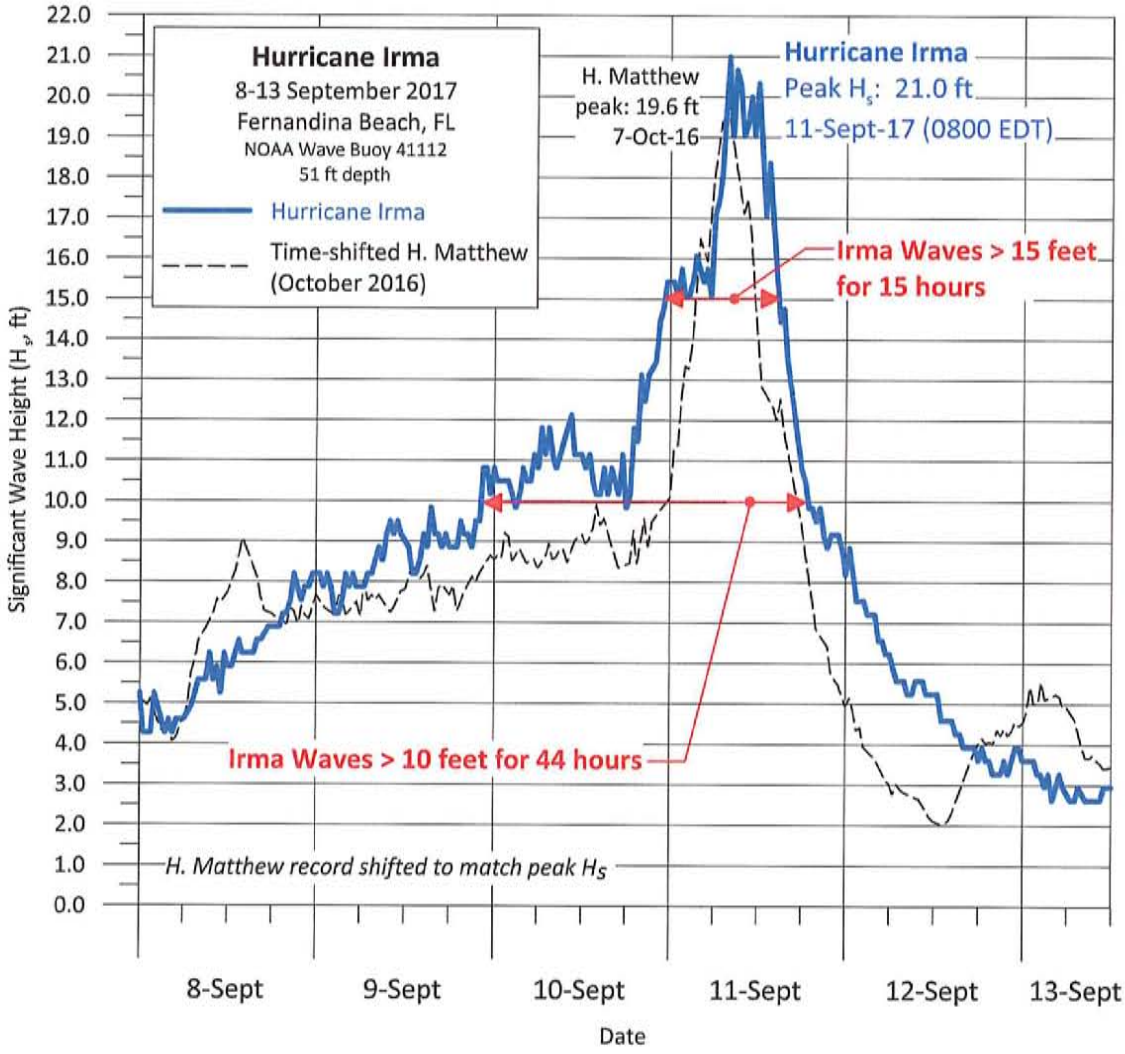

Figure 2.3: Time series of significant wave heights measured at NOAA Buoy 41112 during the passage of Hurricane Irma in September 2017. The buoy is located approximately 16 miles northeast of the south Amelia Island shoreline in 51 feet of water.

The largest recorded significant wave height[4] in Irma was measured to be 21.0 ft. The dominant wave period peaked at about 13 seconds during this time. Waves exceeding 10 ft persisted for over 44 hours, and waves exceeding 15 ft persisted for more than 15 hours. For comparison, the time series of Hurricane Matthew in October 2016 is plotted in time-shifted fashion in **Figure 2.3**. While the peak wave height in Matthew was similar at 19.6 ft, the duration of large waves, and hence the total energy striking the beach in the storm, was noticeably greater in Irma. In Matthew, waves exceeding 10 ft in height only persisted for 18 hours (versus 44 hours for Irma).

Water Levels/Surge **Figure 2.4** displays the time series of water levels measured at the Fernandina Beach (bay-side) and Mayport (inlet interior) tide gages as Hurricane Irma passed. Water levels peaked at +6.34 ft-NAVD at the Fernandina Beach gage, which is 3.95 ft above the Mean High Water at this gage. For comparison, during Hurricane Matthew, in October 2016, the water level at this gage peaked at +6.90 ft-NAVD, 0.56 ft *higher* than during Irma. At the Mayport station, the water level peaked at +5.58 ft, which is 3.89 ft above the Mean High Water at this gage. For comparison, during Hurricane Matthew, the water level at this gage peaked at +5.20 ft-NAVD, 0.38 ft lower than Irma. Based upon these gage data for wave heights and water levels, and observations of beach erosion wrack debris and sand overwash, the wave and tidal surge conditions combined to produce wave action and wave runup exceeding 10 to 11 ft NAVD88 (approx.).

Wind Speeds **Figure 2.5** displays the time series of wind speed measured at the Fernandina Beach and Mayport stations during the passage of Hurricane Irma. Wind speed measurements in the area are highly affected by their specific locations and the level of sheltering received by the individual instruments from winds from givens directions. As measured at the Mayport bar pilots dock near the St. Johns River entrance (NOAA station MYPF1), sustained wind speeds in Hurricane Irma reached over 61 mph (strong tropical storm force) early in the morning on September 11th, 2017. At the same time, roughly 3:30am EDT, the Mayport gage reported wind gusts of 73.7 mph (nearly Category 1 hurricane force) and 88.7 mpg (mid-Category 1 hurricane force) in two individual sampling periods. At the Fernandina dock on the Amelia River (NOAA station FRDF1), the measured sustained wind speeds in the storm only reached just over 33 mph (below tropical storm force), also in the morning on September 11th, 2017. The highest measured wind gusts at the

[4] The significant wave height (H_s) is the average of the highest 1/3 of all the wave heights measured by the buoy instrument in a 20-minute sampling period. For that reason, individual waves in that 20-minute period may be much higher than the reported significant wave height, perhaps by a factor of up to two times. The gage lies in 51 ft of water, eight miles offshore. At that depth, depth-limited waves would break at a height of roughly 40 ft. It is not known specifically what was the highest wave height in that record.

Fernandina gage was 55.3 mph (tropical storm force). The Fernandina gage is much more sheltered from winds from the east and southeast.

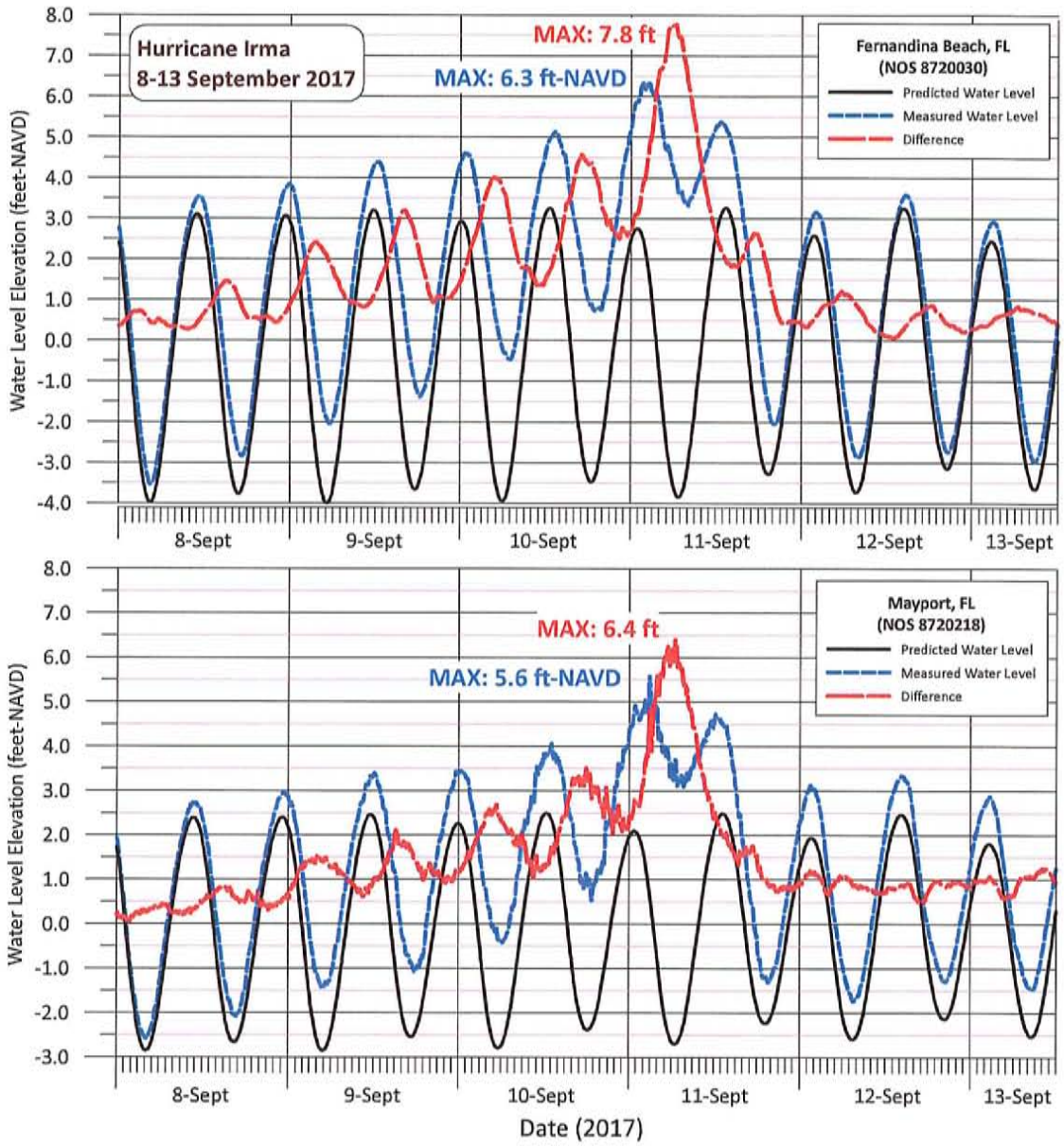

Figure 2.4: Time series of water levels measured at two nearby tide gages located along the northeast Florida coast during the passage of Hurricane Irma. The two stations, Fernandina Beach (NOS: 8720030) and Mayport (NOS: 8720218) are both maintained by NOAA and are within 10 miles of the project area. Neither gage specifically indicates the water levels along the open coast of south Amelia Island.

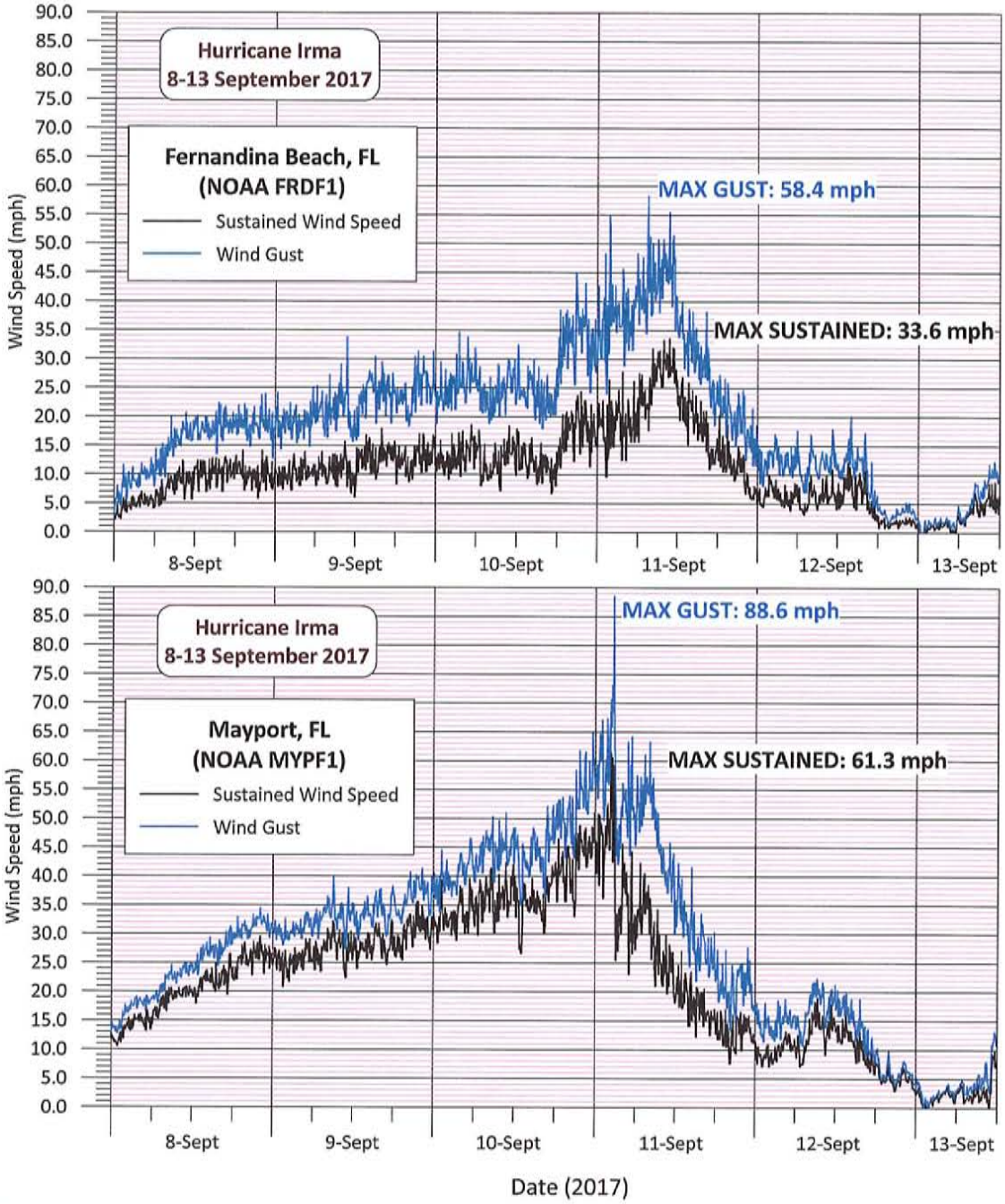

Figure 2.5: Time series of wind speed measured at the Fernandina Beach (FRDF1) and Mayport (MYPF1) stations during the passage of Hurricane Irma.

3.0 Hurricane Irma Shoreline Position and Volume Changes

3.1 Survey Data

To measure the storm impacts to the design beach profile, a post-Irma beach profile survey was authorized and funded by the County SAISS-MSBU. During this survey, 31 beach profiles, only those located along the engineered beach and typically included in the monitoring program, were surveyed beyond the typical depth of significant survey change (-20 ft-NAVD is typically used for the lower limit of volume change calculations in the project monitoring program).

The onshore/wading portion of the survey was completed in late September 2017, roughly 2 weeks following passage of the storm effects. The offshore portion of the survey was not completed until early November 2017 due to rough sea conditions. Additional survey work was performed in December 2017 to close gaps between the wading and offshore data along several of the profiles. Despite the gap closing work, several gaps (>30 ft between survey points) remain. However, with the exception of two relatively large gaps at R-61 and R-75, the survey appears to accurately depict the post-Irma conditions. In the volume change analysis, the changes at R-61 and R-75, above the typical wading survey elevation (-3.1 ft-NAVD) were included but below that elevation the changes at these profiles were omitted due to the 200+ ft gaps in the survey data at these profiles. Instead, the volume changes measured at the adjacent monitoring stations, below -3.1 ft-NAVD, were utilized using an average end-area method.

Beach profile plots of the post-Irma survey (nominally dated September 2017) are provided in **Appendix A**. In addition, relevant surveys from the monitoring program database are also plotted, including the March 2017 survey, the most recent pre-Irma survey. **For purposes of the present analysis, the March 2017 survey is assumed to represent the pre-storm condition.** A summary of the available monitoring surveys conducted to date is provided in Appendix A.

3.2 Methodology

Alongshore **volume changes** were calculated using an average end-area method, where the cross-sectional areas are determined by comparing pre- and post-storm beach profiles at each beach monitoring station above several different vertical datums. This approach allows evaluation of beach changes at different elevations along the project in addition to the total profile. For this analysis volume changes were calculated in 0.5 ft vertical increments from +15.0 ft-NAVD to -30 ft-NAVD. Volume changes above the MHWL (+2.0 ft-NAVD) and 20 ft-NAVD contour are summarized in tabular form in **Appendix B**.

Shoreline position changes were computed at the berm (+6.5 ft-NAVD) and MHWL (+2.0 ft-NAVD). The average shoreline changes along given reaches were calculated by spatially weighting the changes at individual monuments based upon the distance due to the non-uniform alongshore spacing of survey monuments.

3.3 Pre- to Post-Irma Shoreline and Volume Changes

Figures 3.1 and **3.2** graphically depict the berm and MHWL changes, respectively at 31 R-monuments during the March 2017 to September 2017 period. Within the full engineered beach project limits (R-59 to the terminal groin), the berm receded by an average of 28 feet and the MHWL advanced by 10 feet between March 2017 and September 2017. At the berm, 24 of the 27 profiles within the project limits reported recession. At the MHWL, 11 of the 27 profiles reported recession. In many instances the profiles suggest that sand eroded from the upper beach was transported and deposited in the intertidal zone, thus resulting in the advance of the lower contours. **Figure 3.3** illustrates the typical changes in beach profile shape and areas of volume losses and gains along the engineered beach profile. Along the length of the engineered fill berm the upper (landward) portions of the berm deflated by one to two feet or more in many areas.

Figures 3.4 through **3.8** depict pre- and post-storm ground photos of the beach conditions associates with Hurricane Irma. The photos illustrate the impacts of the storm upon the upper portions of the engineered fill berm, which suffered damage and erosion during the storm. Notable in **Figures 3.7** and **3.8** is the deflation of the beach berm, evidenced by the loss of pioneer vegetation at the seaward edge of the berm.

Figure 3.9 depicts the changes in beach sand volume over the March 2017 to September 2017 survey period. The lower frame of **Figure 3.9** depicts the volume density change, in bar chart form, at each transect in cubic yards per foot (cy/ft). The stacked bars indicate the changes above the MHWL (red bars) and between the MHWL and -20 ft-NAVD (blue bars). The upper frame of **Figure 3.9** plots the cumulative volume changes along the project shoreline beginning at R-59. This plot illustrates the different areas of shoreline behavior as evidenced by changes in slope of the cumulative curves. Each curve represents the total volume change measured to the specified elevation. Individual volume changes computed between profile transects are tabulated in **Appendix B**. Based upon inspection of the historical beach profiles in this area, the closure depth is taken to be -20 ft-NAVD.

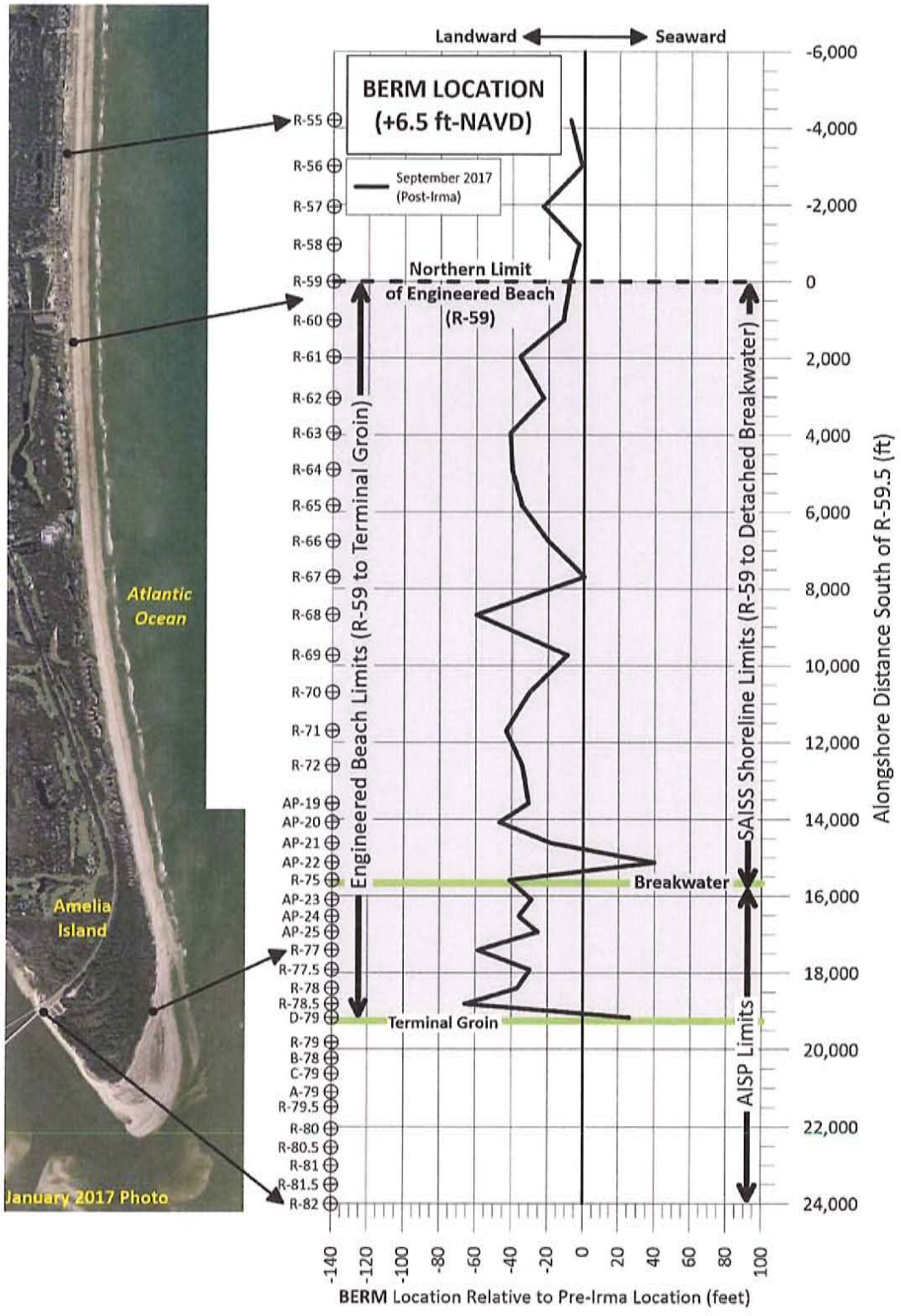

Figure 3.1: Pre- to Post-Irma BERM (+6.5 ft-NAVD) changes (March 2017 to September 2017).

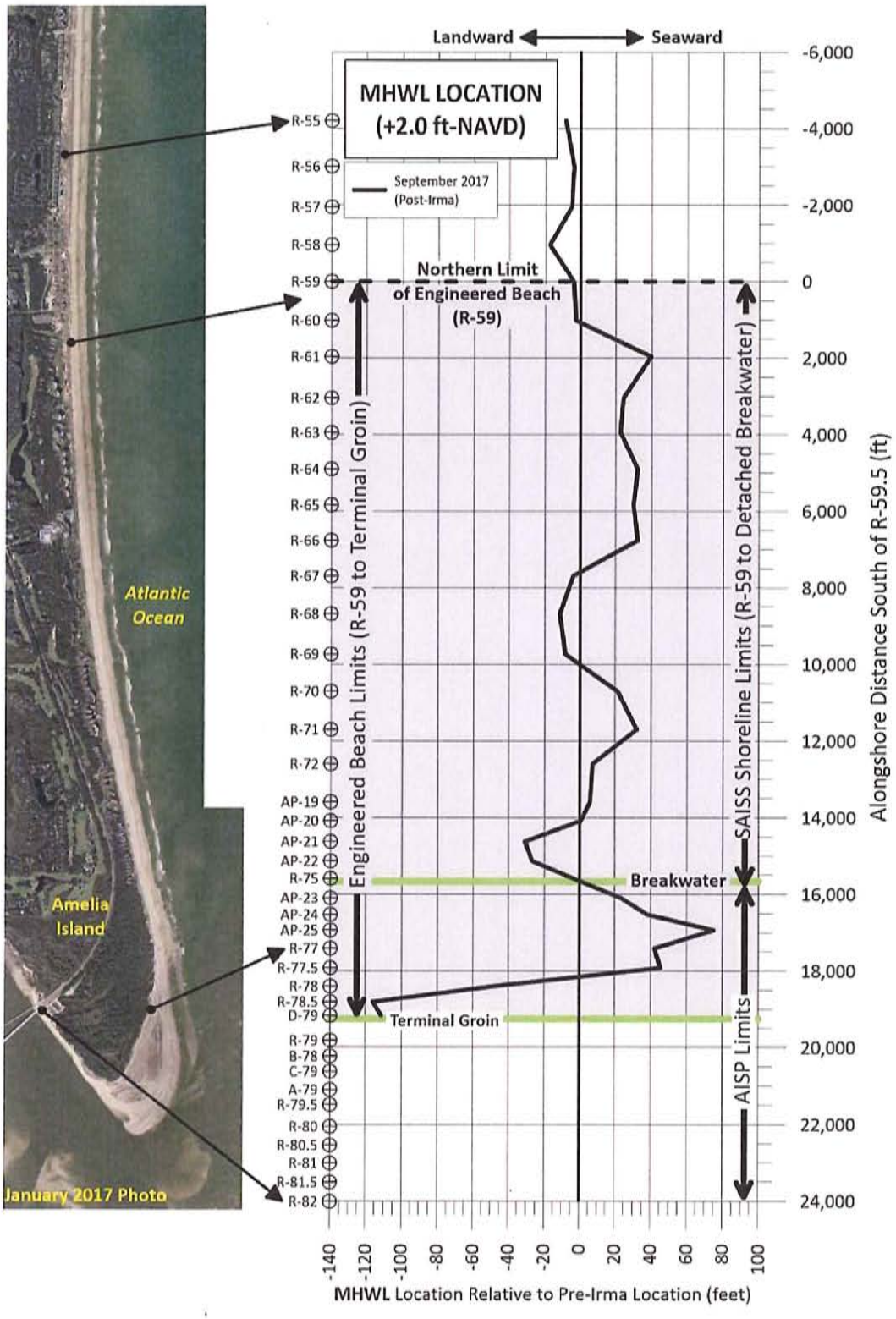

Figure 3.2: Pre- to Post-Irma MHWL (+2.0 ft-NAVD) changes (March 2017 to September 2017).

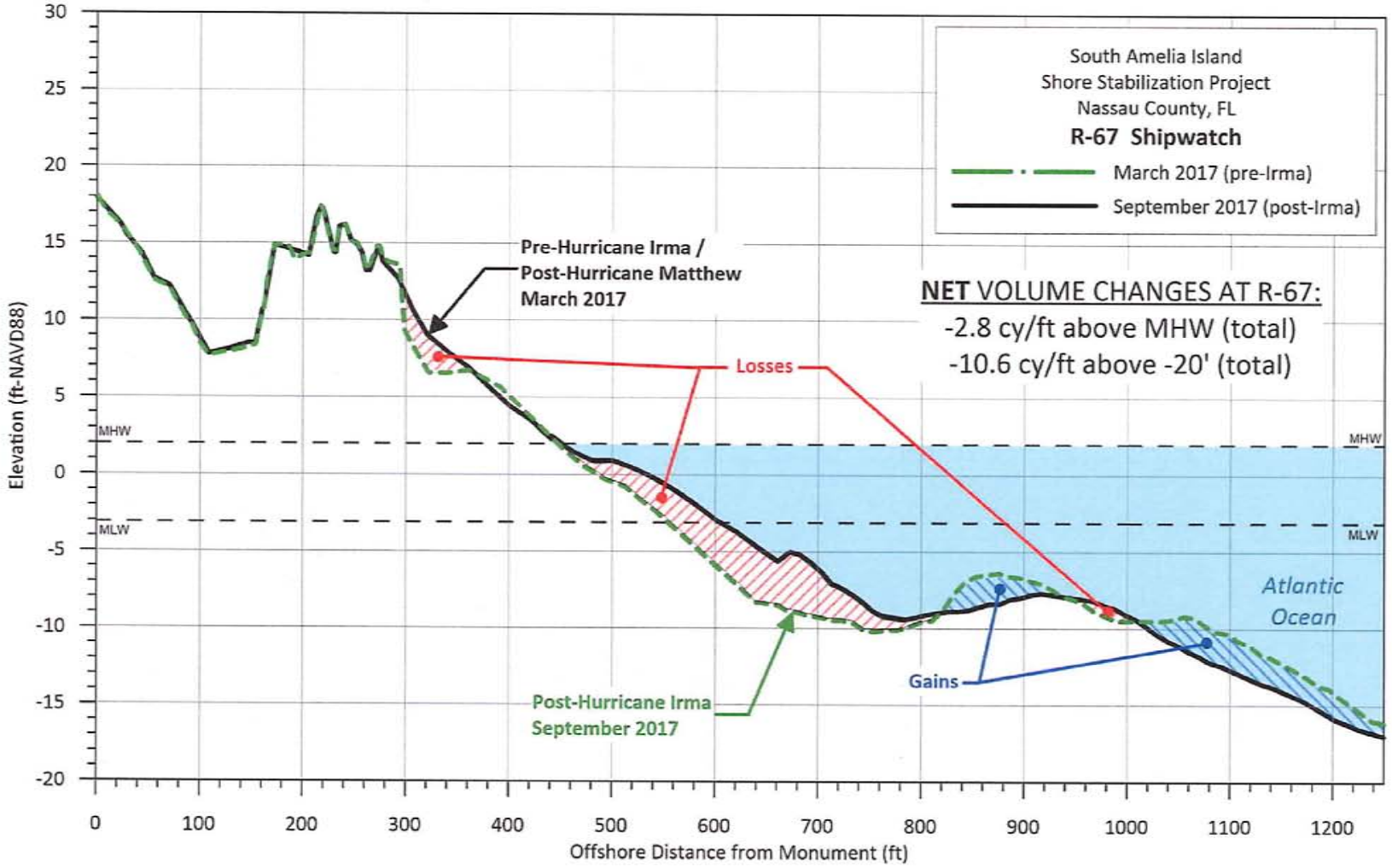

Figure 3.3: Changes in bach profile shape and volume density at R-67 (Shipwatch) associated with the impacts of Hurricane Irma in September 2017.

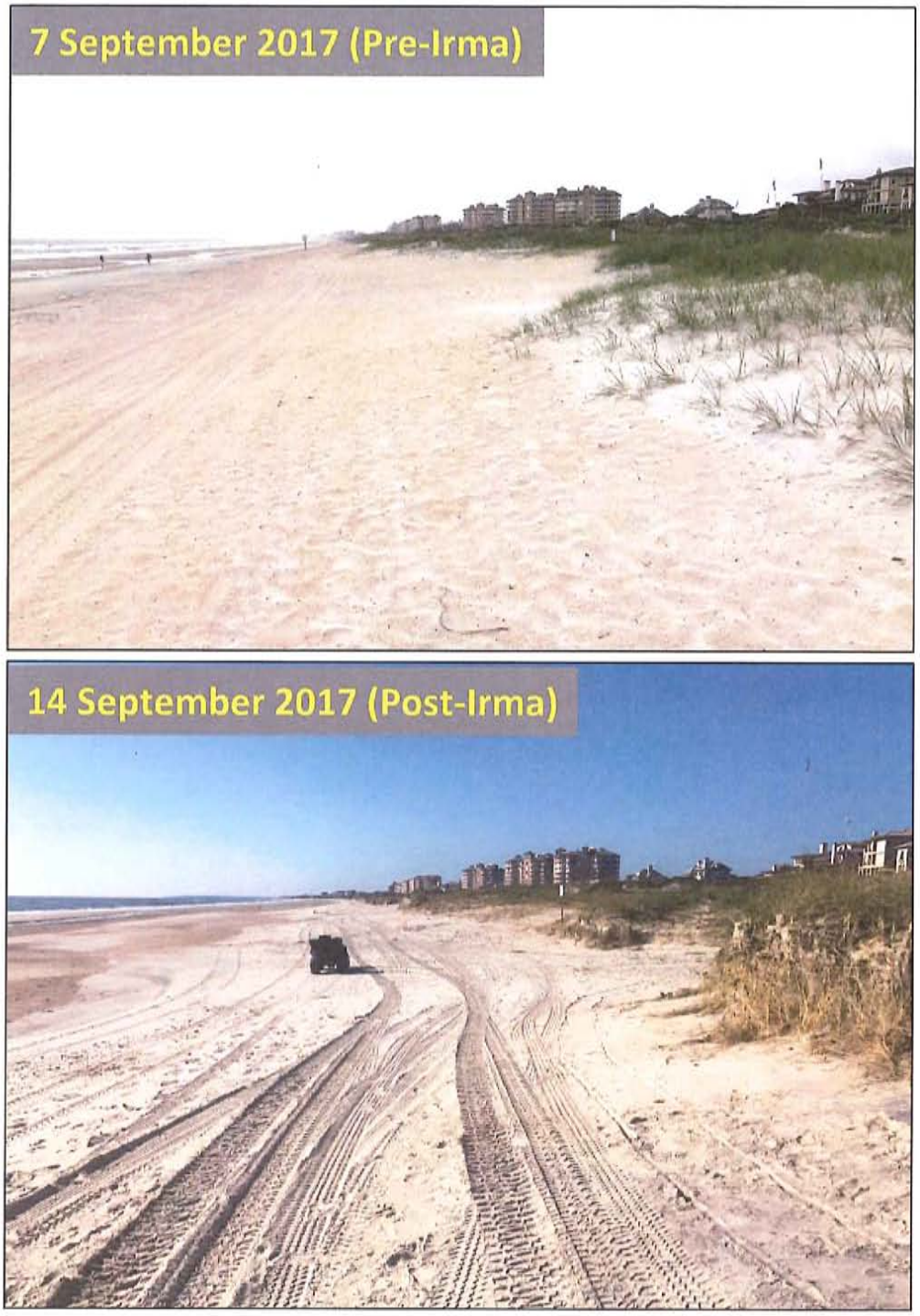

Figure 3.4: Pre- and post-Hurricane Irma SAISSP shoreline at the 15th green, looking southward down the 16th fairway toward FDEP survey monument R-60.

Figure 3.5: Pre- and post-Hurricane Irma SAISSP shoreline at the Ocean Club, looking northward at FDEP survey monument R-61.

Figure 3.6: Pre- and post-Hurricane Irma SAISSP shoreline at Beach Walker, looking northward at FDEP survey monument R-66.

Figure 3.7: Pre- and post-Hurricane Irma SAISSP shoreline at Windsong looking northward at FDEP survey monument R-68. Note the deflation of the beach berm, evidenced by the loss of pioneer vegetation at the seaward edge of the berm.

Figure 3.8: Pre- and post-Hurricane Irma SAISSP shoreline at the South County Access on Amelia Island, looking northward toward FDEP survey monument R-70. Note the deflation of the beach berm, evidenced by the loss of pioneer vegetation

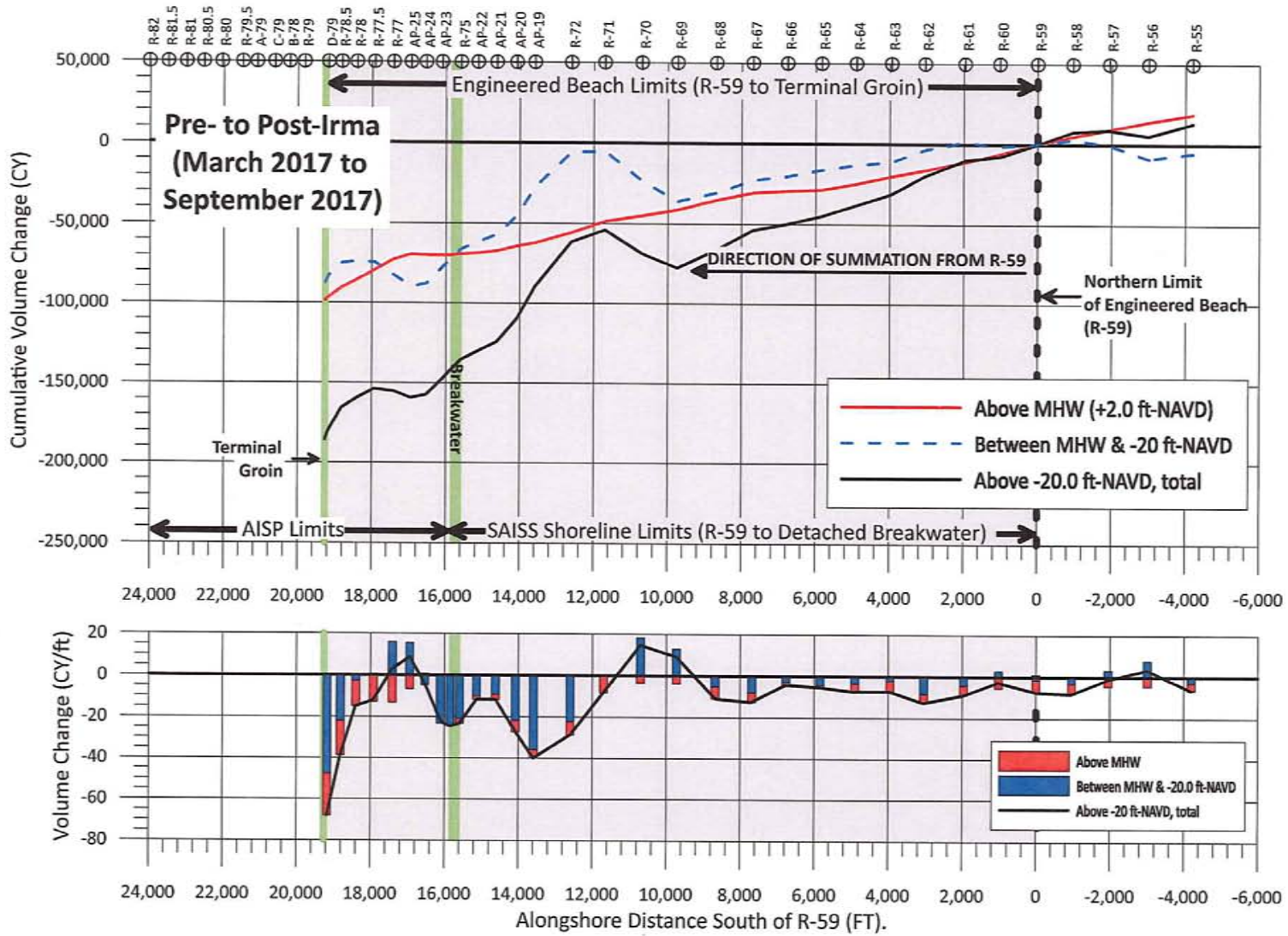

Figure 3.9: Pre- to Post-Irma beach volume changes (March 2017 to September 2017), South Amelia Island, FL.

Between March 2017 (pre-Irma) and September 2017 (post-Irma), the entire surveyed shoreline (R-55 to the terminal Groin) lost approximately -117,100 cy above the MHWL and an additional -81,900 cy below the MHWL to -20 ft-NAVD for a net loss of -199,000 cy. Above the MHWL, 29 of the 31 profiles surveyed experienced a net loss. Above -20 ft-NAVD, 23 of the 29[5] profiles surveyed experienced a net loss.

Table 3.1 summarizes the volume changes by subreach above the MHWL, MLWL and -20 ft-NAVD elevations between March 2017 and September 2017. Within the full engineered beach project limits (R-59 to the terminal groin), the shoreline lost roughly -185,900 cy above -20 ft-NAVD (-9.9 cy/ft). Of that total, -141,400 cy occurred along the SAISSA shoreline (R-59 to the detached breakwater) and -44,500 cy along the AISP shoreline (detached breakwater to the terminal groin).

Table 3.1: Volume changes along the entire monitored shoreline by subreach, pre- to post-Irma (May 2017 to September 2017)

Reach	Above MHWL (+2.0 ft-NAVD)	Above MLWL (-3.1 ft-NAVD)	Above -20 ft-NAVD
North of Project Area (R-55 to R-59)	-18,600	-34,900	-13,100
SAISSA Project Area (R-59 to Detached Breakwater)	-69,900	-128,700	-141,400
AISP Atlantic Shoreline (Detached Breakwater to Terminal Groin)	-28,600	-13,800	-44,500
Total Engineered Project Area (R-59 to Terminal Groin)	**-117,100**	**-177,400**	**-199,000**

[5] In the volume change analysis, the changes at R-61 and R-75, above the typical wading survey elevation (-3.1 ft-NAVD) were included but below that elevation the changes at these profiles were omitted due to the 200+ ft gaps in the survey data at these profiles.

3.4 Background Erosion Rate

As described in Section 3.3, the volume changes along the SAISSA and AISP portions of the engineered beach fill project between March 2017 and September 2017, including the impacts of Hurricane Irma, were computed along the entire project length out to a depth below -20 ft NAVD88, historically taken to be the typical depth of significant survey change reported in the monitoring program (OAI, 2016a, see also beach profile plots in Appendix A). The resultant volume change was determined to be -141,400 cubic yards along the SAISSA project area and -44,500 cubic yards along the AISP project area.

To account for natural background erosion along the length of the engineered beach occurring between March 2017 and September 2017, the annual monitoring survey data for the five-year period prior to Hurricane Matthew, August 2011 to May 2016 (4.8 years), was analyzed to determine a least-squares fit for the average annual volume change, measured from the dunes to -20 ft-NAVD. **Figure 3.10** presents the volume changes along the SAISSA and AISP engineered beach shoreline segments. In the figure the least squares fit trend line is also plotted. The average annual background volume change rates were determined to be -30,700 (SAISSA segment) and -72,900 (AISP segment) cubic yards per year, measured to -20 ft NAVD (OAI, 2016a).

Table 3.2 summarizes the calculation of the background erosion occurring between March 2017 and September 2017. Applying the computed average annual background rate as a deduct to the measured volume change over this 6-month period yields an expected background erosion volume of -15,400 cy (SAISSA segment) and -36,500 cy (AISP segment).

After removing the background erosion from the measured changes, the calculated Hurricane Irma related-impact to the engineered beach nourishment project is a loss of -133,800 cy. Of that total, -126,050 cy occurred along the SAISSA shoreline segment and -8,050 cy along the AISP shoreline segment.

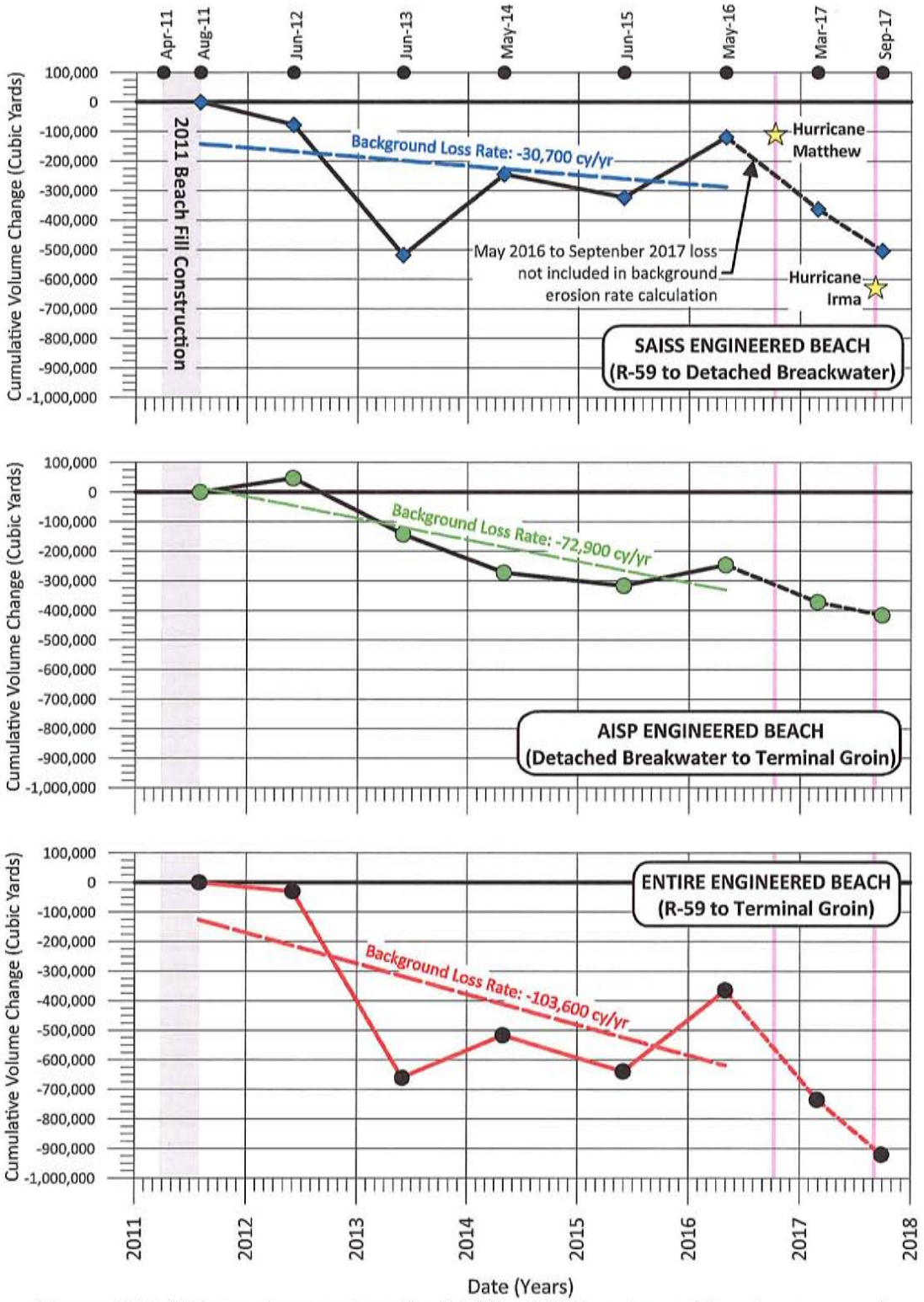

Figure 3.10: Volume changes along the SAISSA/AISP engineered beaches measured above -20 ft-NAVD since completion of the 2011 Beach Renourishment Project.

Table 3.2: Hurricane Irma storm impact background erosion adjustment calculations.

	SAISSA Project Area	**AISP Project Area**	**Total Project Area**
	R-59 to Detached Breakwater	**Detached Breakwater to Terminal Groin**	**R-59 to Terminal Groin**
Background loss rate:	-30,700 cy/yr	-72,900 cy/yr	-103,600 cy/yr
Adjusted background loss for March 2017 to September 2017: (background loss rate MULTIPLIED by 6/12 year)	-15,350 cy	-36,450 cy	-51,800 cy
Calculated Change: March 2017 to September 2017 (Above -20 ft-NAVD):	-141,400 cy	-44,500 cy	-185,900 cy
Claim Volume (cy): (Calculated change MINUS adjusted background loss)	**-126,050 cy**	**-8,050 cy**	**-134,100 cy**

4.0 Summary and Recommendations

This report documents the impacts of Hurricane Irma upon the engineered beach nourishment project along the southern Atlantic Ocean shoreline of Amelia Island in Nassau County, FL. The engineered South Amelia Island Shore Stabilization Project was impacted by Irma from September 9-12, 2017. As part of the management of the engineered beach nourishment project, Nassau County and the South Amelia Island Shore Stabilization Association (SAISSA) authorized beach profile surveys and this report to determine the extent of damages to the beach and formulate the scope of any necessary repairs. The local- and State-funded engineered beach nourishment project qualifies for Category G post-disaster relief from the Federal Emergency Management Agency (FEMA) Public Assistance Program for impacts sustained by the beach from an event that is declared an emergency.

Hurricane Irma impacted the South Amelia Island Shore Stabilization Project between September 9th and September 12th, 2017, with elevated storm surge and damaging storm waves. Elevated surge levels, peaking over 6.34 ft-NAVD88 (~3.95 ft above the Mean High Water), impacted the shoreline for nearly 2 days and wave heights exceeding 20 ft occurred at the offshore edge of the project limits. The wave and tidal surge conditions combined to produce wave runup exceeding 10 to 11 ft-NAVD, based upon observation of wave overwash of sand and wrack debris.

Erosion damage to the engineered beach project was documented by comparison of the pre-storm project monitoring survey of March 2017 to the post-storm project design survey of September 2017. Both surveys include 31 beach profiles, each located at historical transect locations based upon the FDEP R-monument system. The survey transects were carried offshore beyond the typical depth of significant survey change. Based upon inspection of the historical beach profiles in this area, the closure depth is taken to be -20 ft-NAVD. After removing the average annual background erosion volume from the measured volume changes between March 2017 and September 2017, the calculated Hurricane Irma related-impact to the engineered beach nourishment project is a loss of -134,100 cy. Of that total, -126,050 cy occurred along the SAISSA shoreline segment of the project and -8,050 cy along the AISP shoreline segment. **It is thus determined that the replacement of 134,100 cubic yards of beach-compatible sand would be required to restore the engineered beach fill project to its pre-Hurricane Irma condition.**

5.0 References

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APPENDIX A:
Beach Monitoring Profiles
(R-55 to R-79D)

This appendix contains plots of the May 1994 (pre-1994 project), August 1994 (post-1994 project), August 2011 (post-2011 project), March 2017 (pre-Hurricane Irma / 5 months post-Hurricane Matthew) and September 2017 (post-Hurricane Irma) beach profile surveys. The September 2017 survey only included monuments R-55 to R-79D and only those locations are plotted in this Appendix. **Table A.1** summarizes all of the monitoring surveys conducted since the 1994 project. The location of the survey monuments (R-55 to R-82) are listed in **Table A.2** and graphically depicted as **Figure A.1**. Monument coordinates are referenced to the Florida State Plane Coordinate System – East Zone, North American Datum of 1983 (NAD83). Elevations are referenced to the National American Vertical Datum of 1988 (NGVD88). Plots of the beach profiles are provided as **Figures A.2** through **A.32**.

Table A.1: South Amelia Island beach profile monument surveys conducted since 1994. (highlighted surveys are plotted in this appendix – R55 to R79D)

Survey Date	Comments
May 1994	Pre-1994 project. 29 profiles surveyed between R-55 & R-80
August 1994	Post-1994 project. 29 profiles surveyed between R-55 & R-80
August 1995	1 Year Post-1994 project. 29 profiles surveyed between R-55 & R-80
August 1996	2 Years Post-1994 project. 33 profiles surveyed between R-55 & R-80
August 1997	3 Years Post-1994 project. 34 profiles surveyed between R-55 & R-80
November 1999	5 Years Post-1994 project. 23 profiles surveyed between R-59 & R-80
October 2000	6 Years Post-1994 project. 16 profiles surveyed between R-59 & R-80
December 2001	7 Years Post-1994 project. 22 profiles surveyed between R-55 & R-80
June 2002	Pre-2002 project. 33 profiles surveyed between R-55 & R-82
August 2002	Post-2002 project. 33 profiles surveyed between R-55 & R-82
October 2003	1 year post-2002 project. 36 profiles surveyed between R-55 & R-82
March 2004	1.5 years post-2002 project. 36 profiles surveyed between R-55 & R-82
March 2005	2.5 years post-2002 project. 36 profiles surveyed between R-55 & R-82
September 2005	3 years post-2002 project. 38 profiles surveyed between R-55 & R-82
July 2006	4 years post-2002 project. 38 profiles surveyed between R-55 & R-82
June 2007	5 years post-2002 project. 40 profiles surveyed between R-55 & R-82
July 2008	6 years post-2002 project. 40 profiles surveyed between R-55 & R-82
July 2009	7 years post-2002 project. 29 profiles surveyed between R-55 & R-82
June 2010	8 years post-2002 project. 41 profiles surveyed between R-55 & R-82
April 2011	Pre-2011 project. 41 profiles surveyed between R-55 & R-82
August 2011	Post-2011 project. 41 profiles surveyed between R-55 & R-82
June 2012	1 years post-2011 project. 41 profiles surveyed between R-55 & R-82
June 2013	2 years post-2011 project. 41 profiles surveyed between R-55 & R-82
May 2014	3 years post-2011 project. 41 profiles surveyed between R-55 & R-82
June 2015	4 years post-2011 project. 41 profiles surveyed between R-55 & R-82
May 2016	5 years post-2011 project. 41 profiles surveyed between R-55 & R-82
October 2016	Post-Hurricane Matthew. 19 profiles surveyed between R-55 & R-82 (wading only)
March 2017	5 months post-Hurricane Matthew. 41 profiles surveyed between R-55 & R-82
September 2017	Post-Hurricane Irma. 31 profiles surveyed between R-55 and R-79D

Table A.2: Amelia Island beach profile monument locations, Nassau County, FL.[1]

Monument	Easting (FT-NAD83)	Northing (FT-NAD83)	Azimuth (GRID)
R-55	516,460.95	2,271,262.28	90
R-56	516,483.30	2,270,095.17	90
R-57	516,414.52	2,269,011.22	90
R-58	516,318.94	2,268,032.19	90
R-59	516,344.60	2,267,069.81	90
R-60	516,533.34	2,266,043.31	85
R-61	516,500.04	2,265,114.39	85
R-62	516,636.37	2,264,047.58	85
R-63	516,633.19	2,263,137.39	85
R-64	516,727.61	2,262,166.47	85
R-65	516,798.43	2,261,258.65	85
R-66	516,915.53	2,260,354.04	85
R-67	516,929.73	2,259,419.25	85
R-68	517,194.46	2,258,462.24	85
R-69	517,273.81	2,257,418.78	85
R-70	517,451.78	2,256,448.88	85
R-71	517,756.39	2,255,471.08	80
R-72A	518,005.90	2,254,607.56	80
AP-19 (R-73)	518,246.99	2,253,651.21	80
AP-20	518,339.25	2,253,167.93	78
AP-21 (R-74)	518,474.97	2,252,644.52	80
AP-22	518,568.40	2,252,149.07	80
R-75	518,691.29	2,251,709.72	80
AP-23	518,831.26	2,251,228.48	85
AP-24	518,850.77	2,250,804.95	87
AP-25	518,871.46	2,250,399.82	88
R-77	518,694.42	2,249,947.24	90
R-77.5	518,947.28	2,249,454.66	90
R-78	518,448.49	2,249,070.95	90
R-78.5	518,601.91	2,248,564.09	90
R-79D	517,978.22	2,248,204.80	90
R-79			130
R-79B			155
R-79C			180
R-79A			210
R-79.5	517,526.25	2,248,206.96	210
R-80	517,233.65	2,248,409.46	210
R-80.5	516,936.91	2,248,793.50	220
R-81A	516,643.65	2,249,174.18	220
R-81.5	516,302.60	2,249,553.11	220
R-82	515,961.50	2,249,931.91	220

[1] Only profiles R-55 through R-79D are plotted in this Appendix.

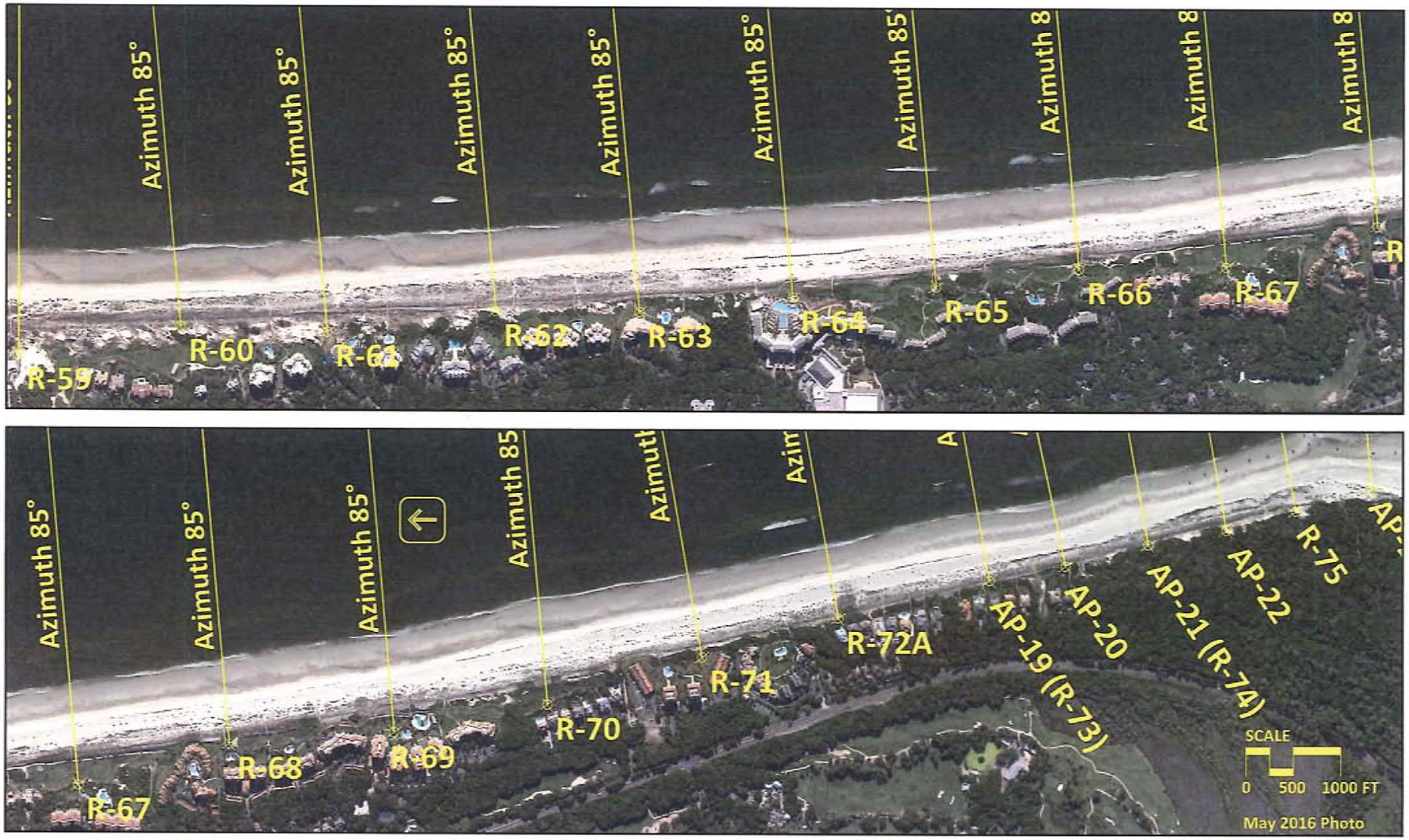

Figure A.1: Amelia Island beach profile monument locations.

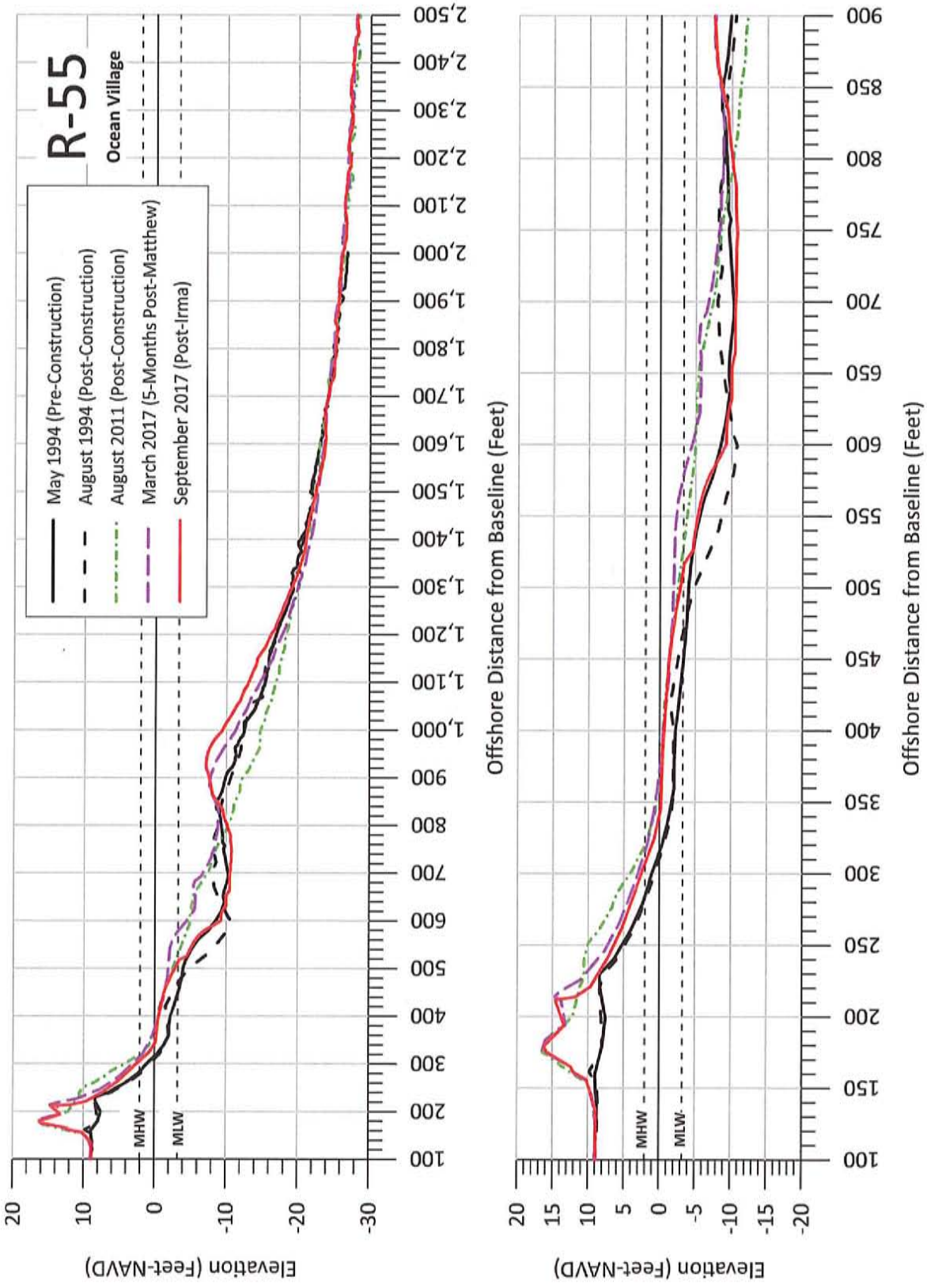

Figure A.02: Measured beach profiles at monument R-55 Amelia Island, Florida.

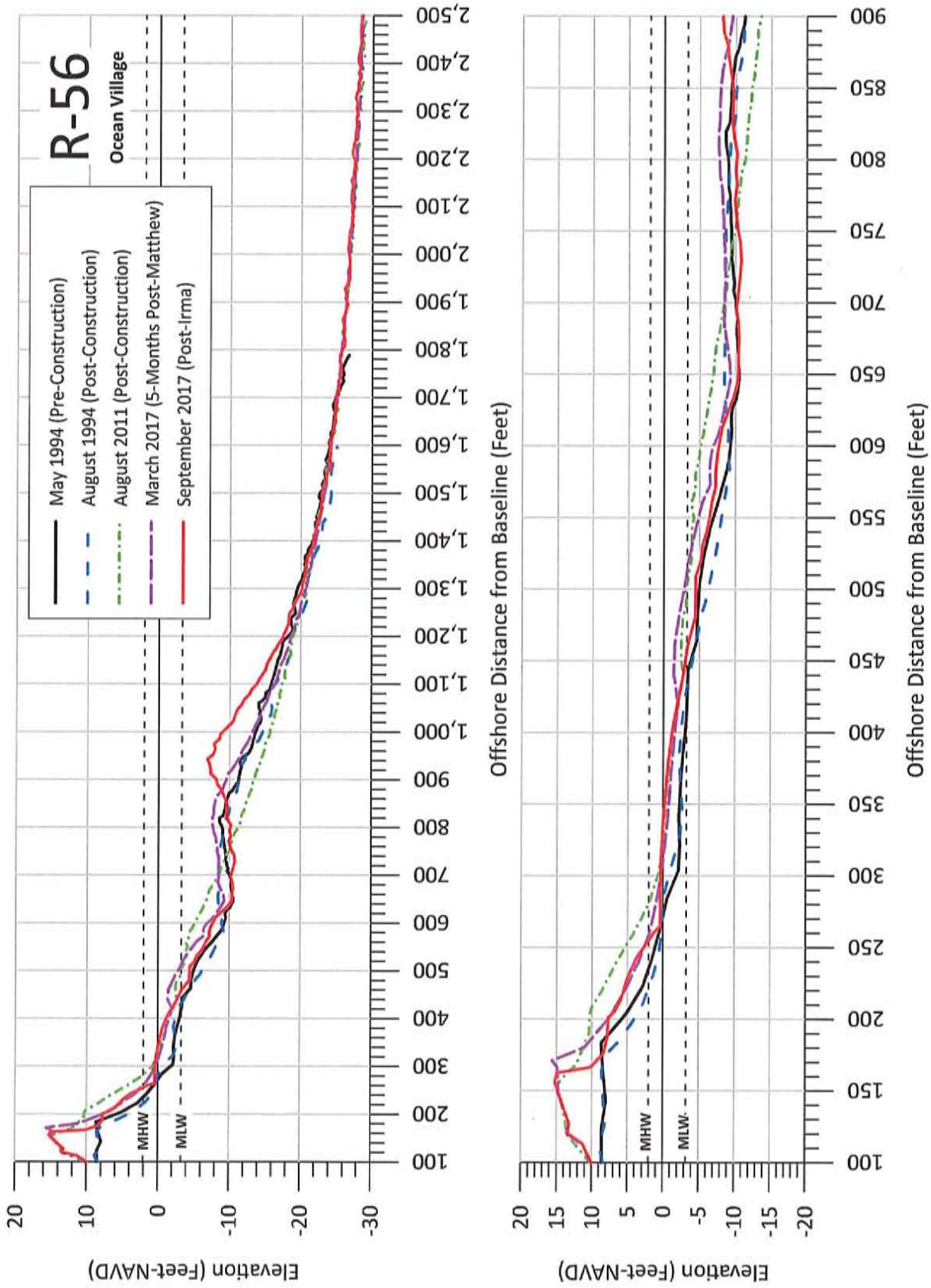

Figure A.03: Measured beach profiles at monument R-56 Amelia Island, Florida.

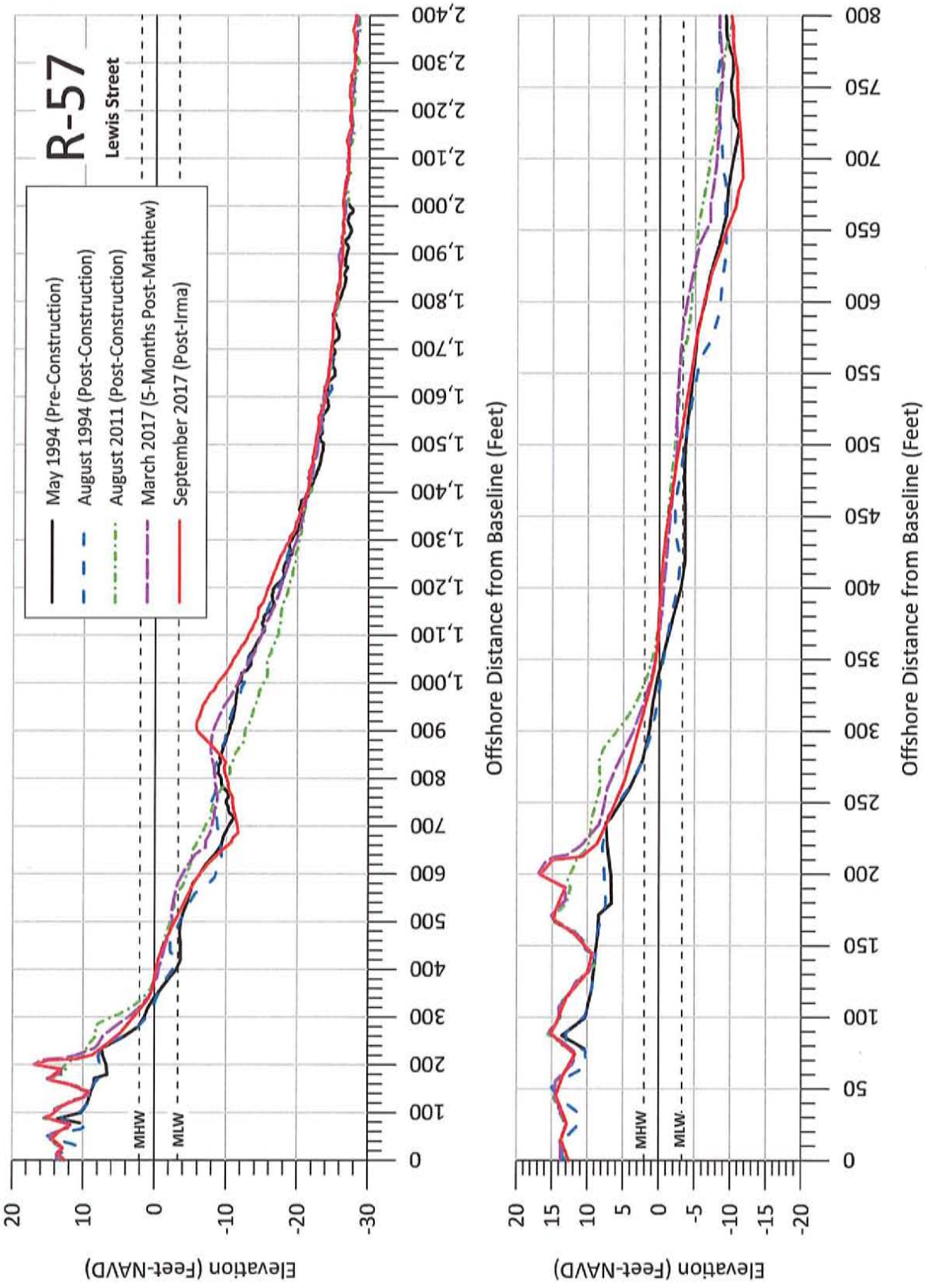

Figure A.04: Measured beach profiles at monument R-57 Amelia Island, Florida.

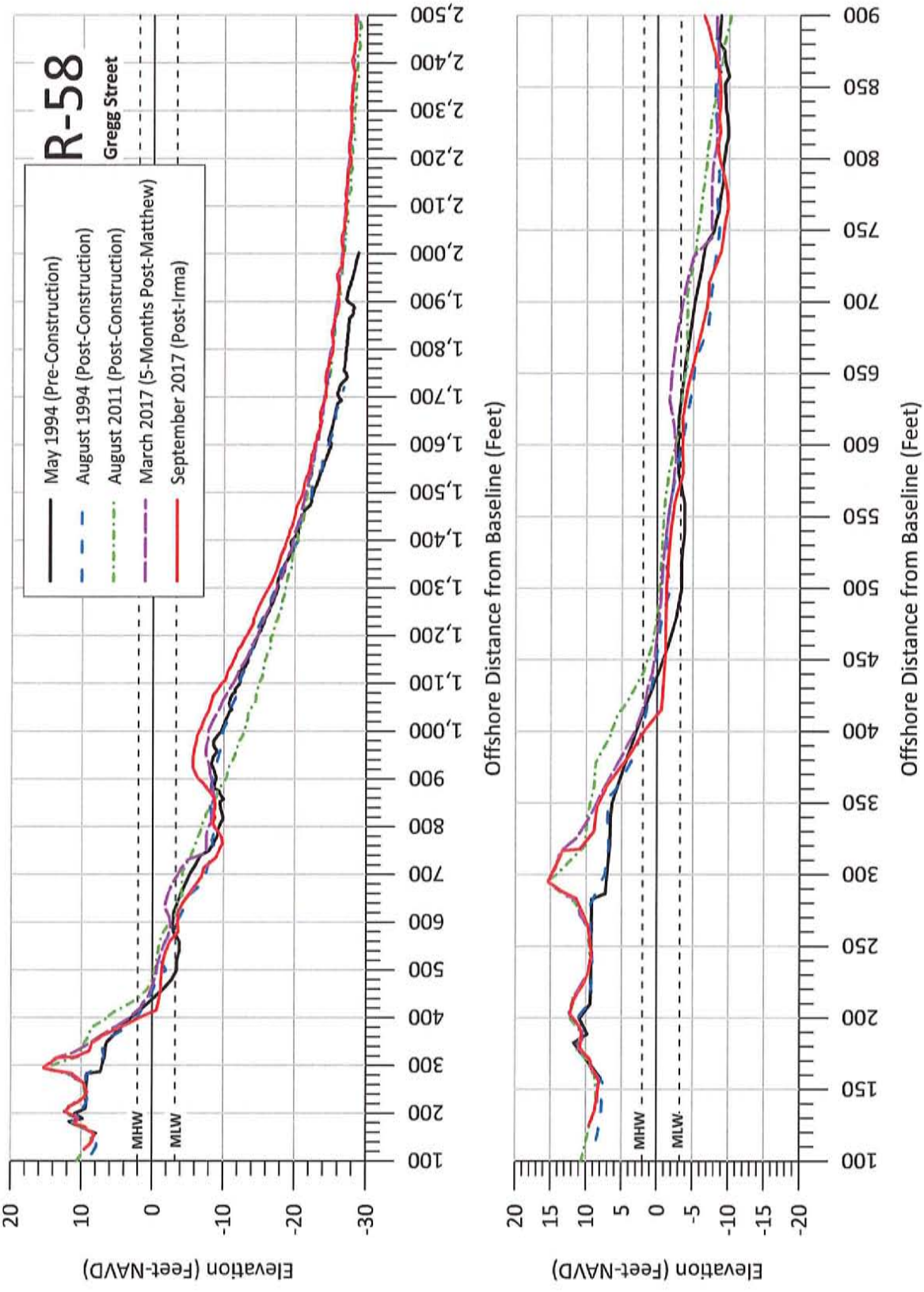

Figure A.05: Measured beach profiles at monument R-58 Amelia Island, Florida.

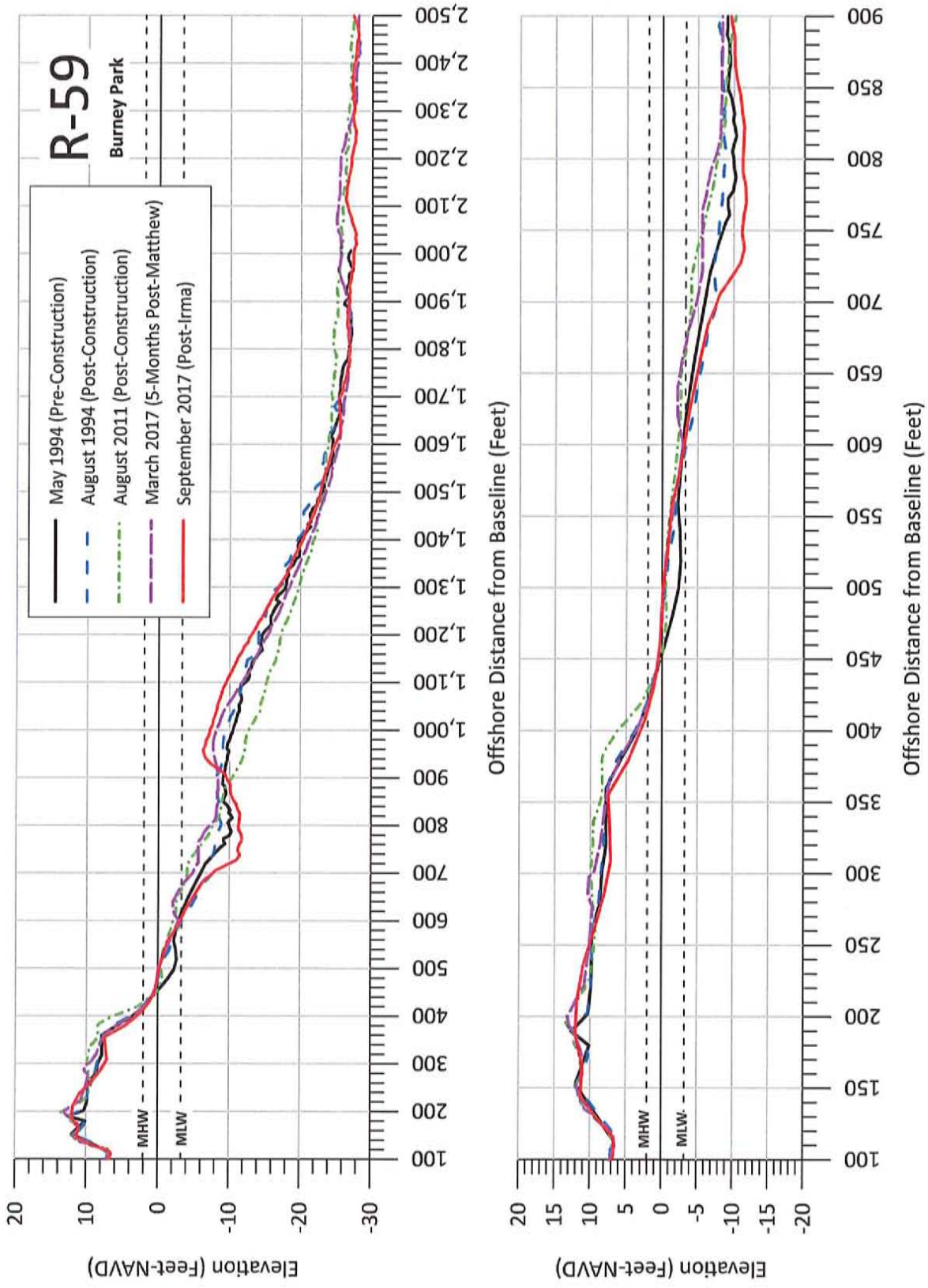

Figure A.06: Measured beach profiles at monument R-59 Amelia Island, Florida.

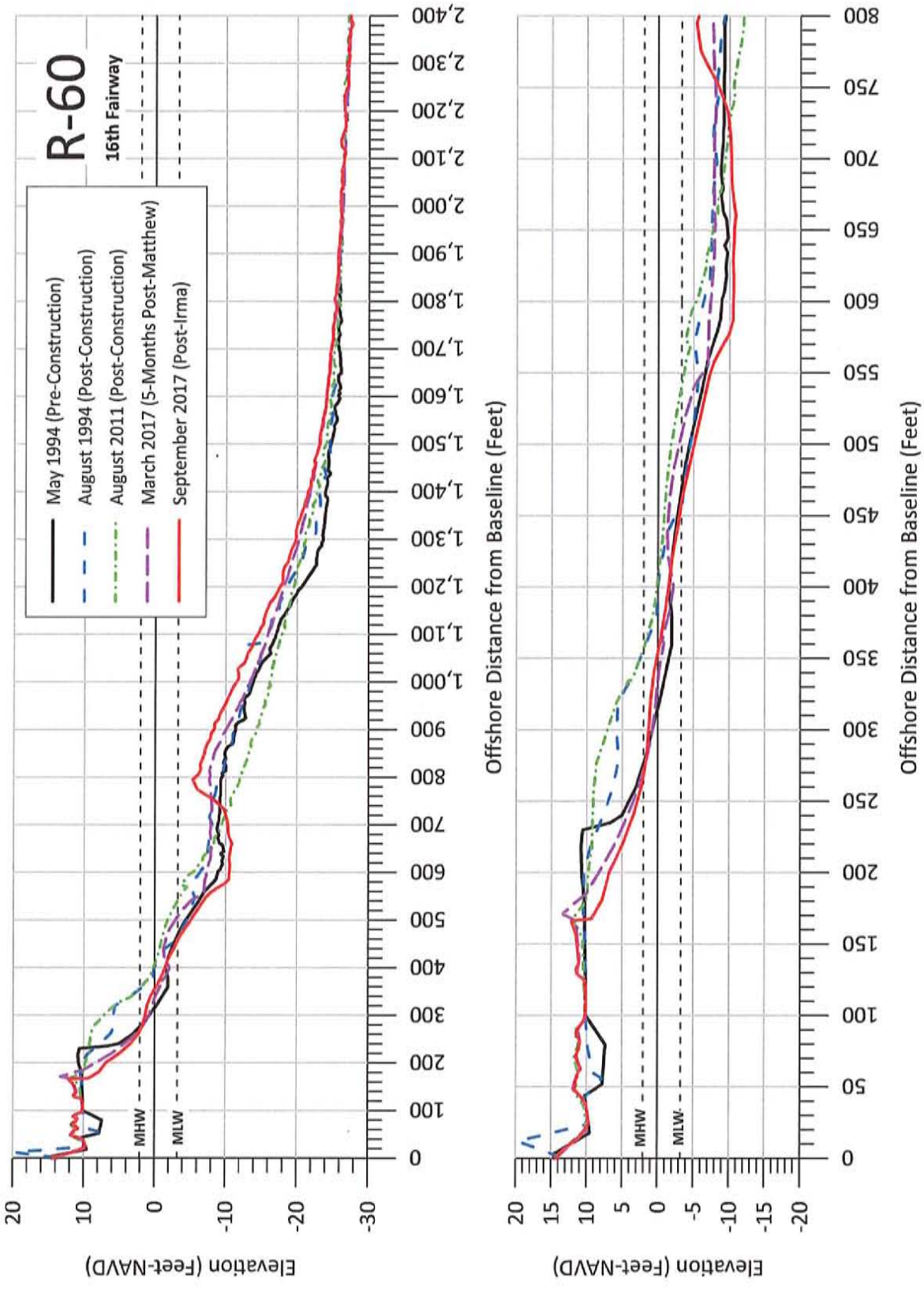

Figure A.07: Measured beach profiles at monument R-60 Amelia Island, Florida.

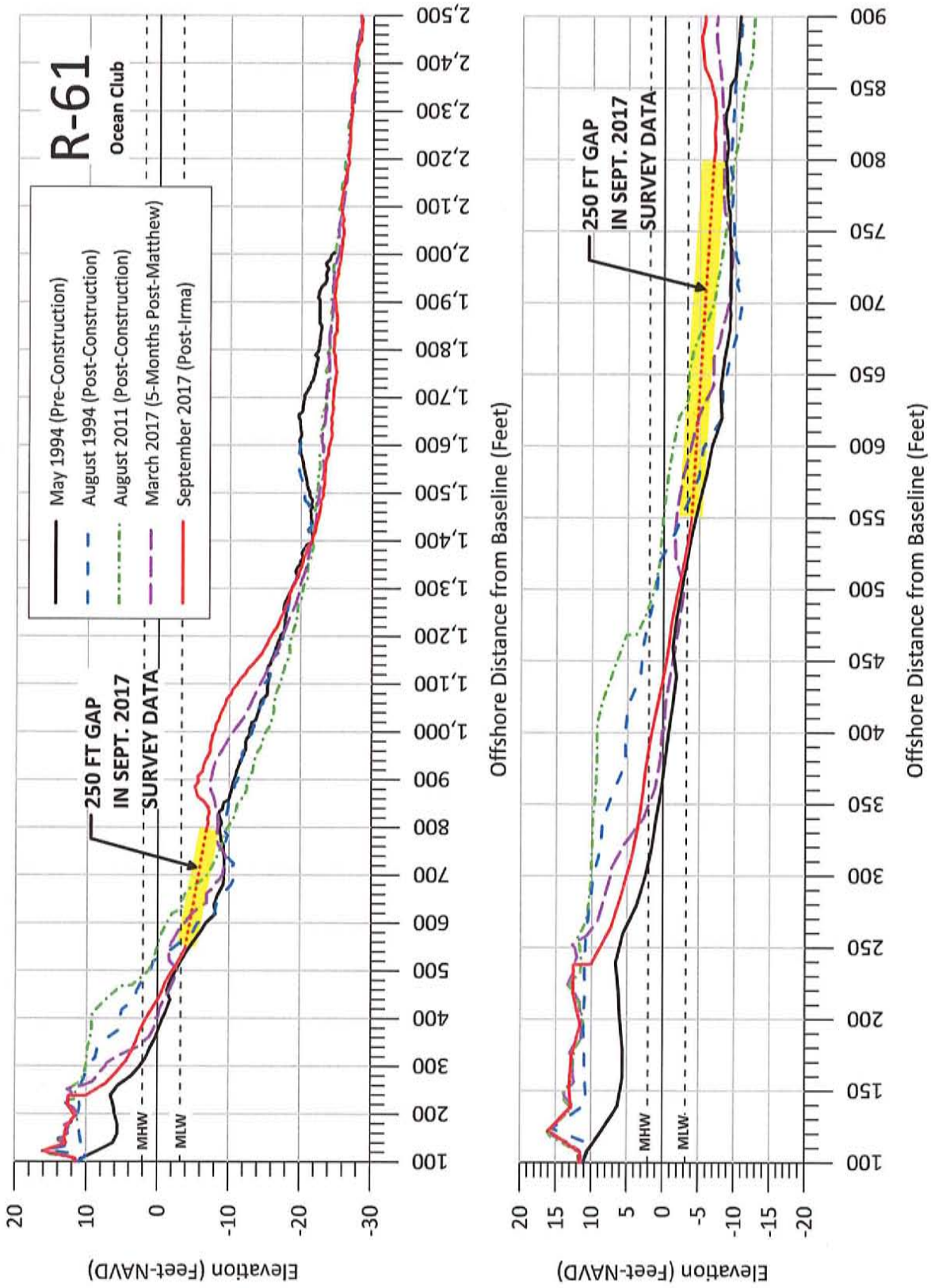

Figure A.08: Measured beach profiles at monument R-61 Amelia Island, Florida.

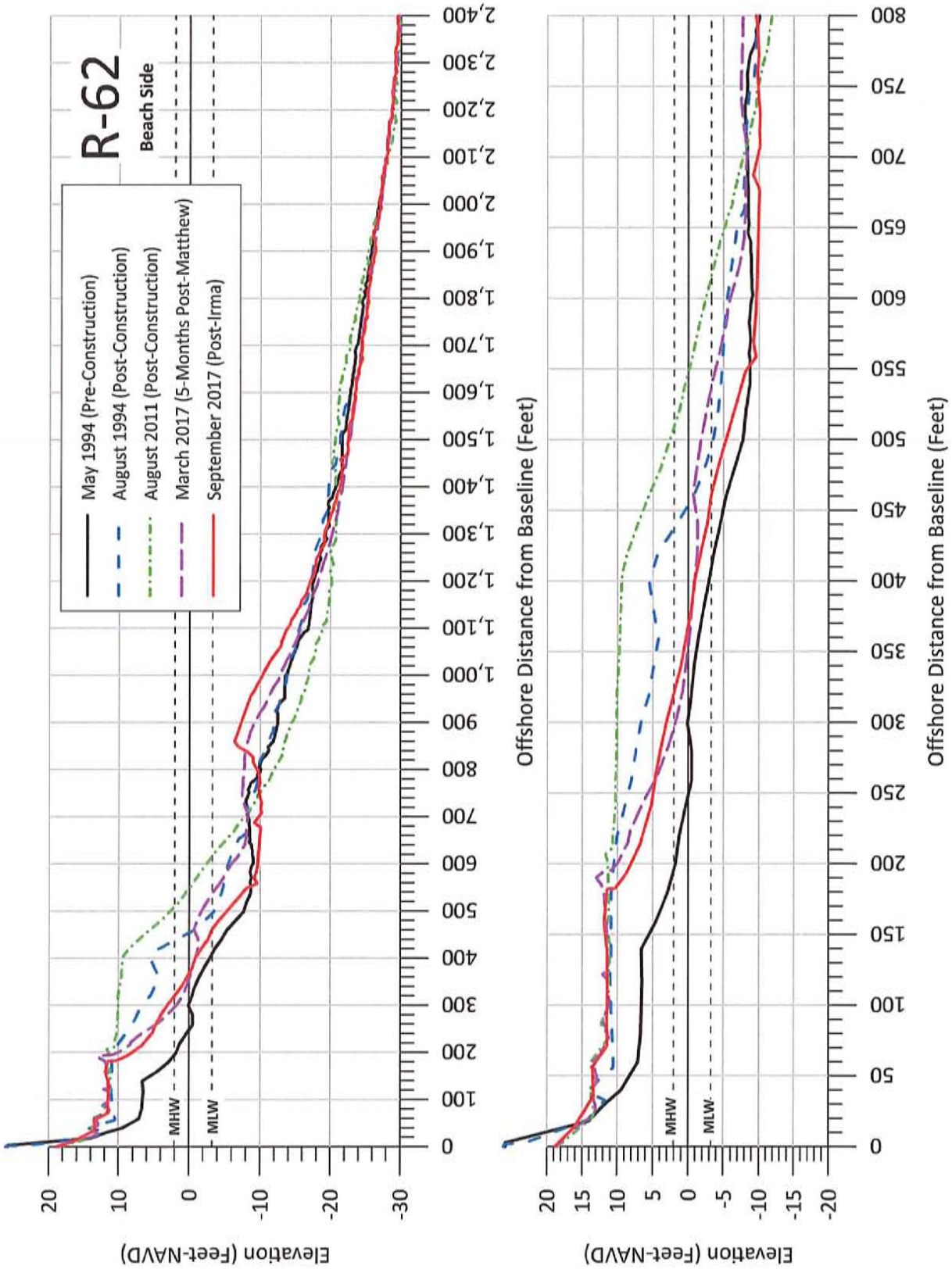

Figure A.09: Measured beach profiles at monument R-62 Amelia Island, Florida.

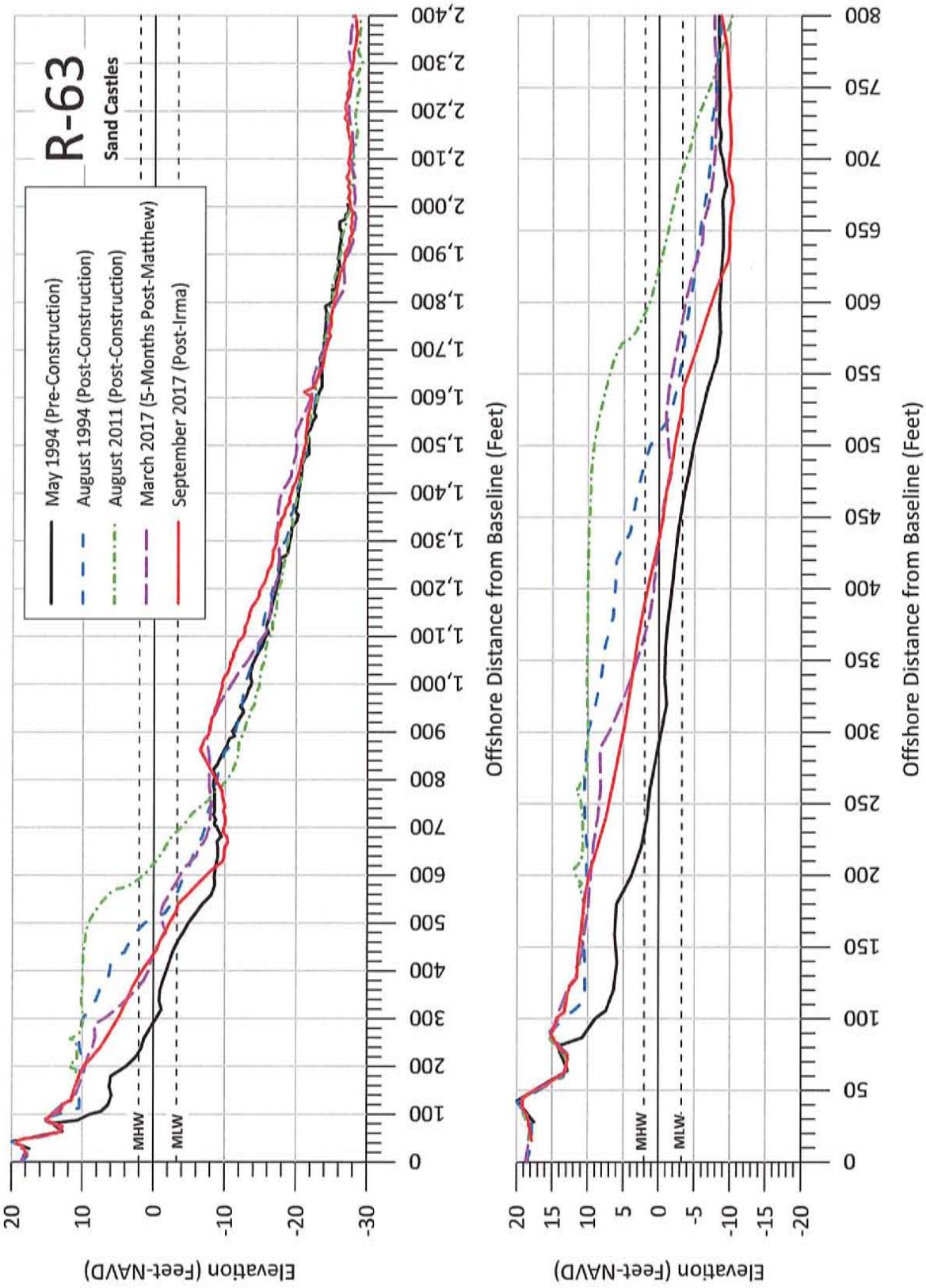

Figure A.10: Measured beach profiles at monument R-63 Amelia Island, Florida.

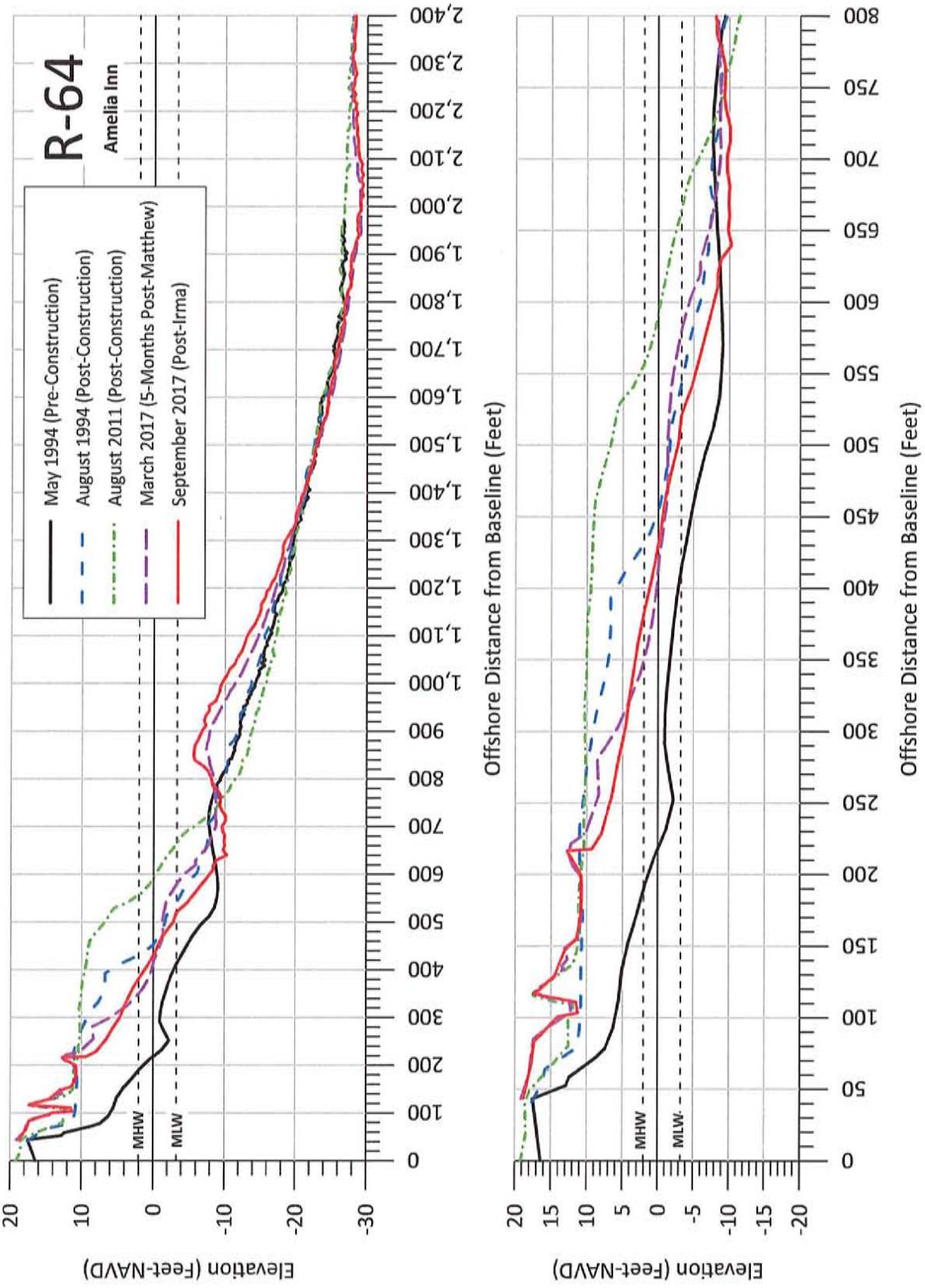

Figure A.11: Measured beach profiles at monument R-64 Amelia Island, Florida.

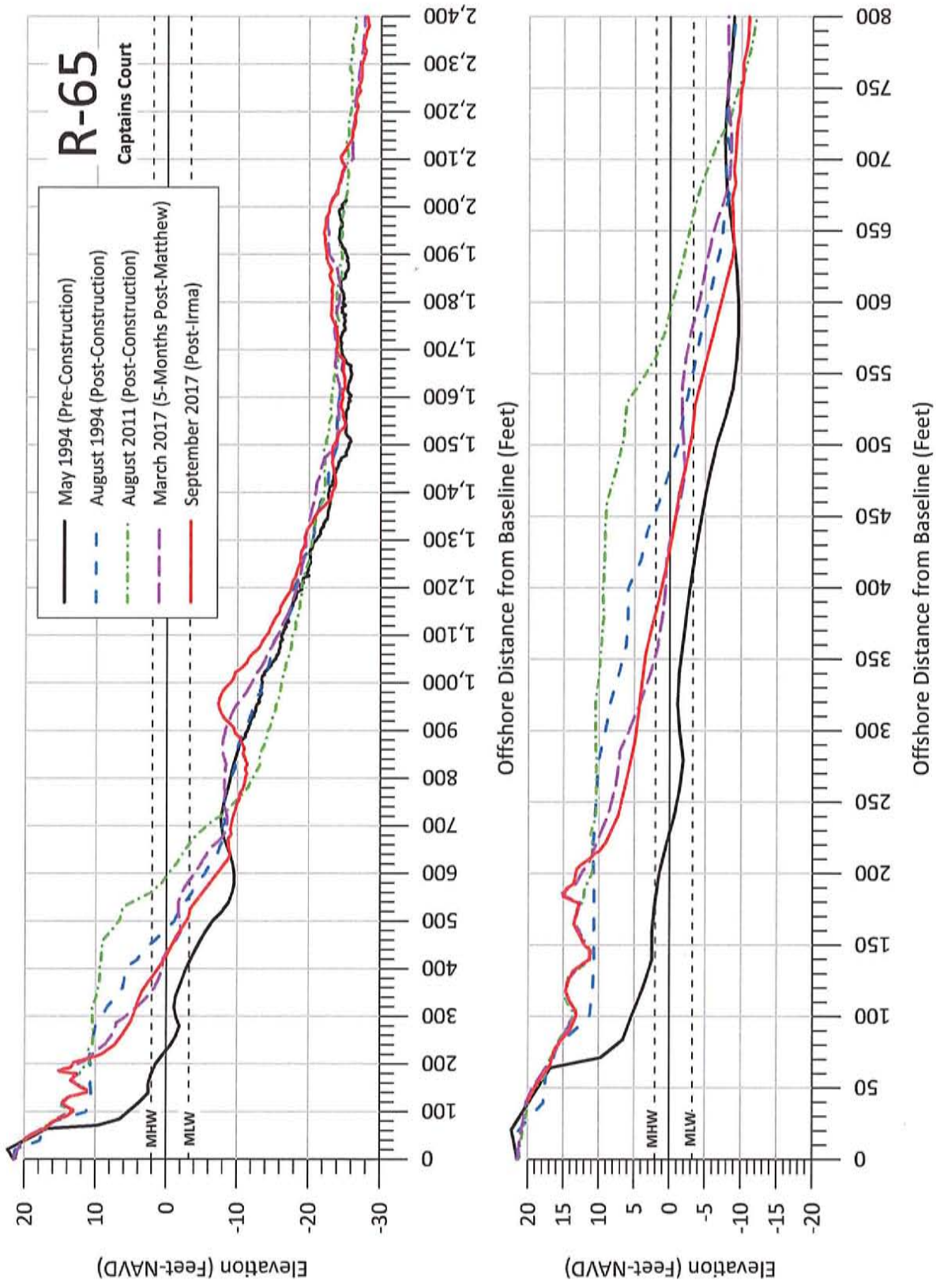

Figure A.12: Measured beach profiles at monument R-65 Amelia Island, Florida.

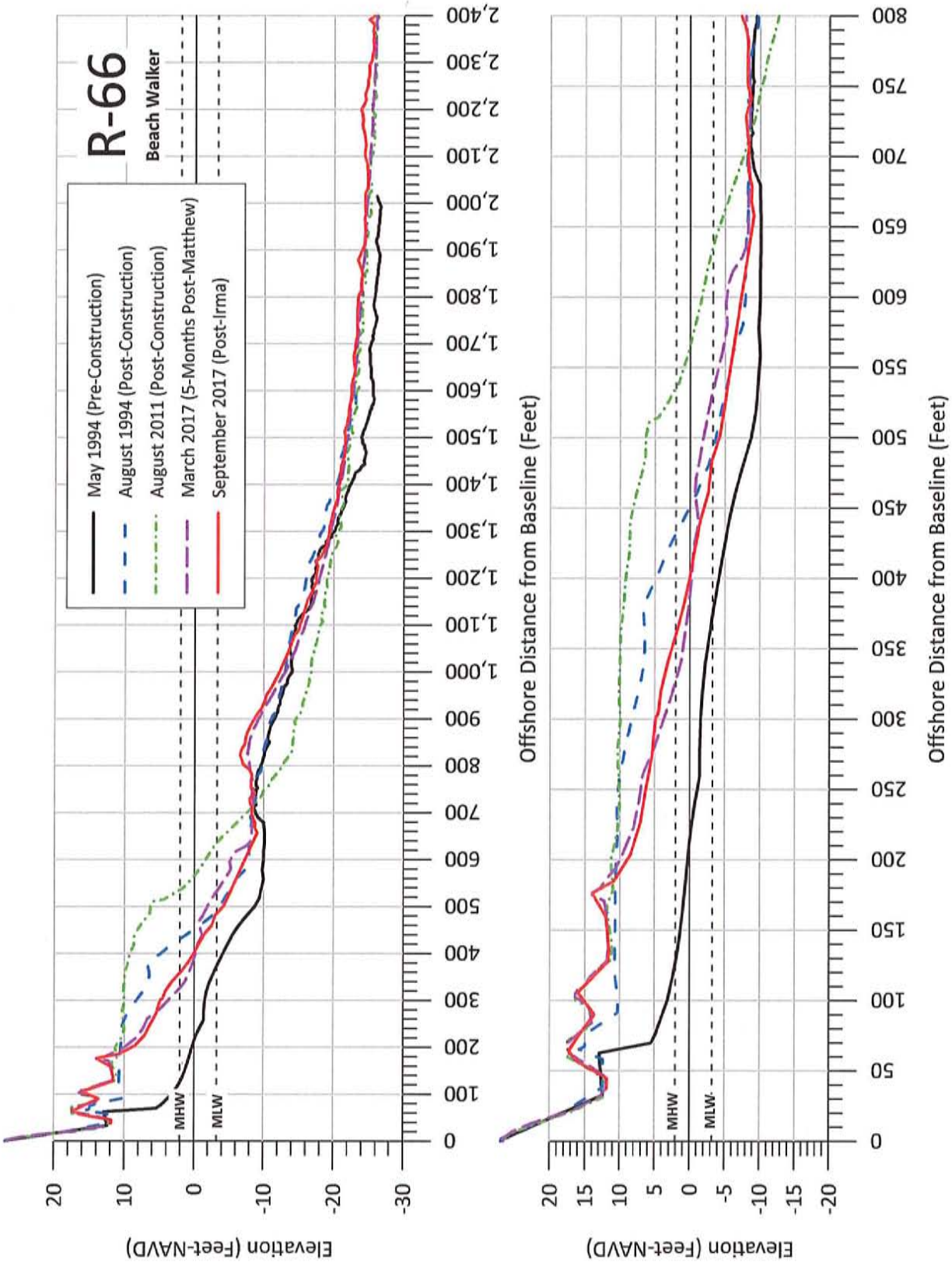

Figure A.13: Measured beach profiles at monument R-66 Amelia Island, Florida.

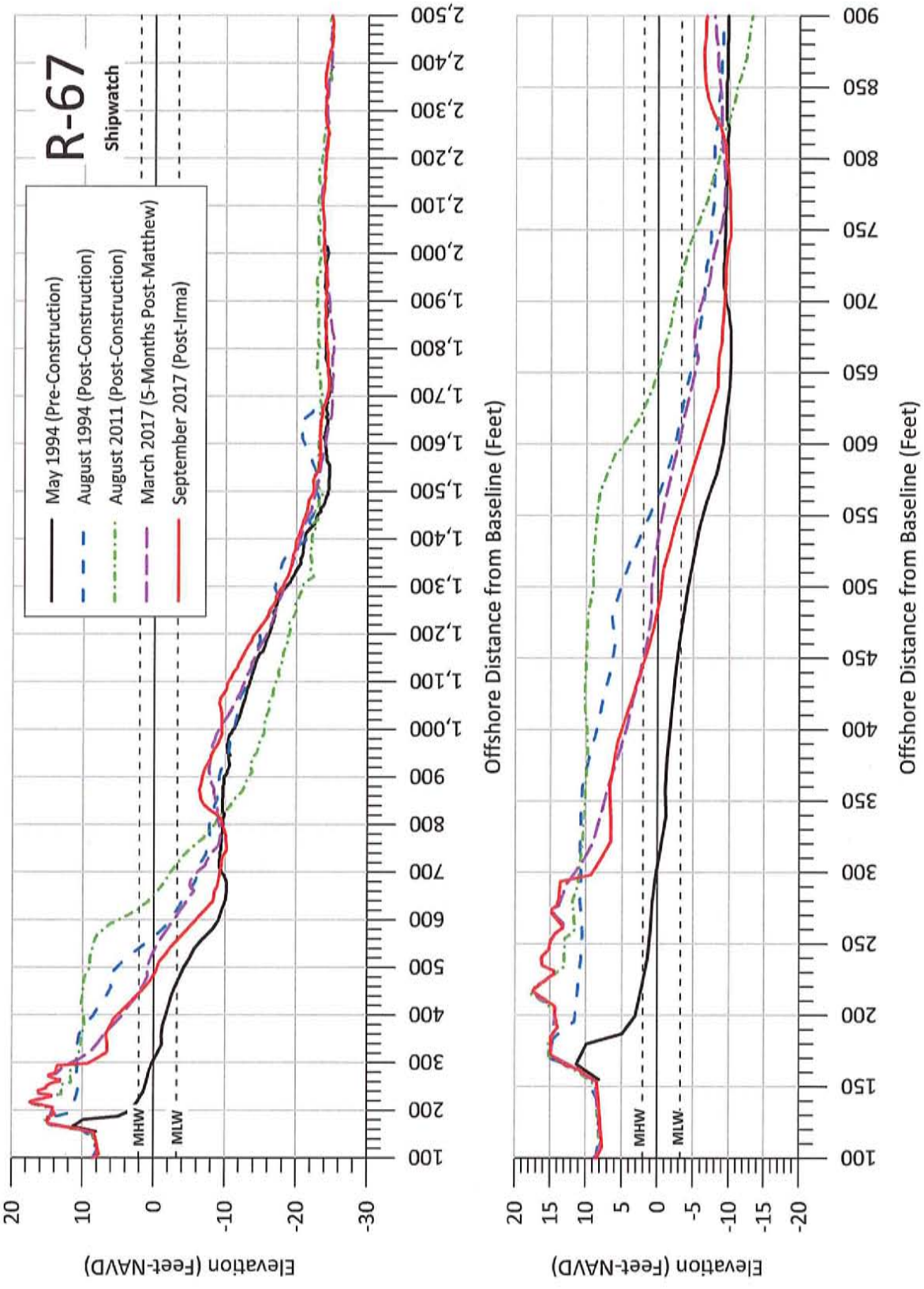

Figure A.14: Measured beach profiles at monument R-67 Amelia Island, Florida.

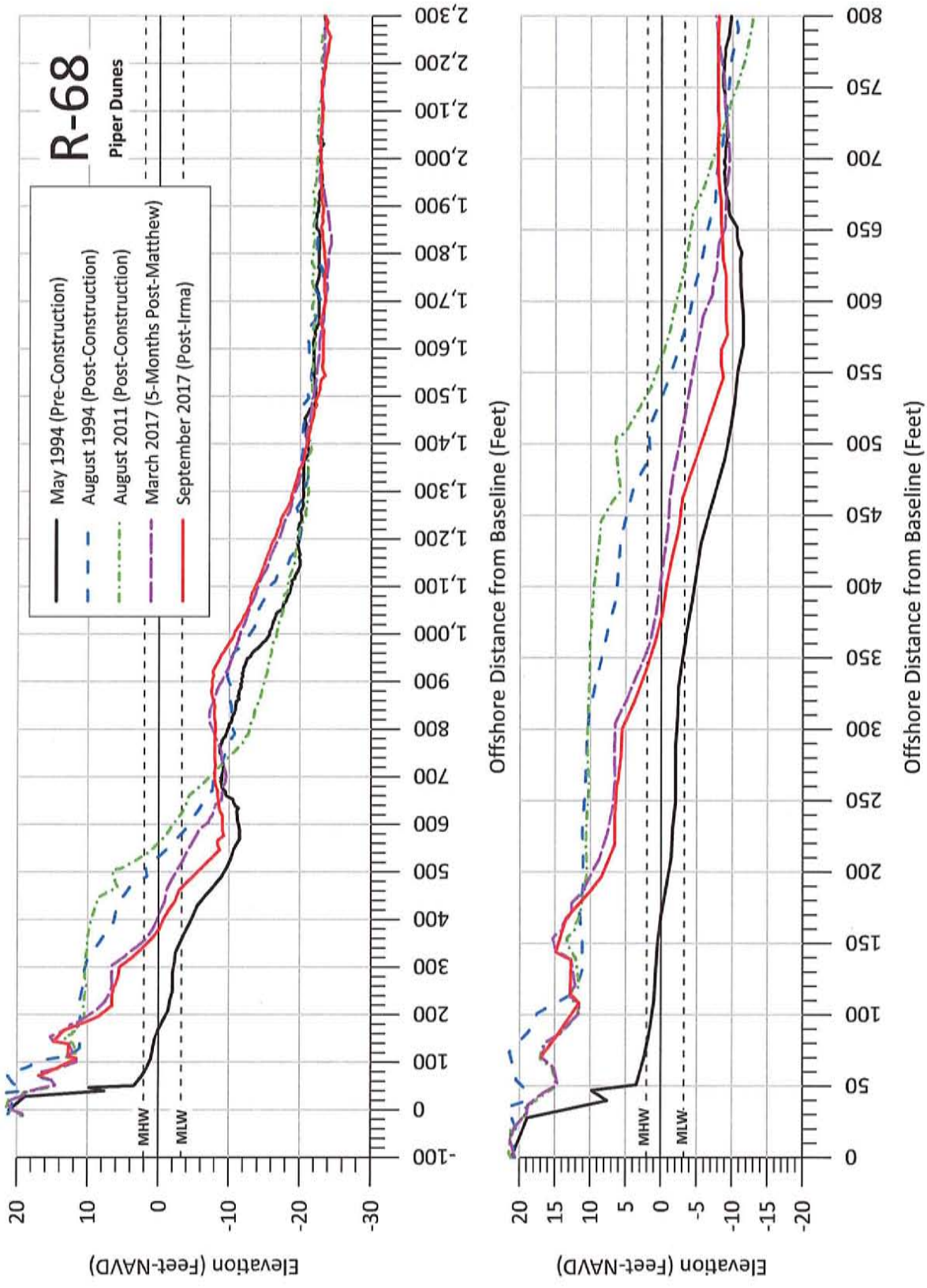

Figure A.15: Measured beach profiles at monument R-68 Amelia Island, Florida.

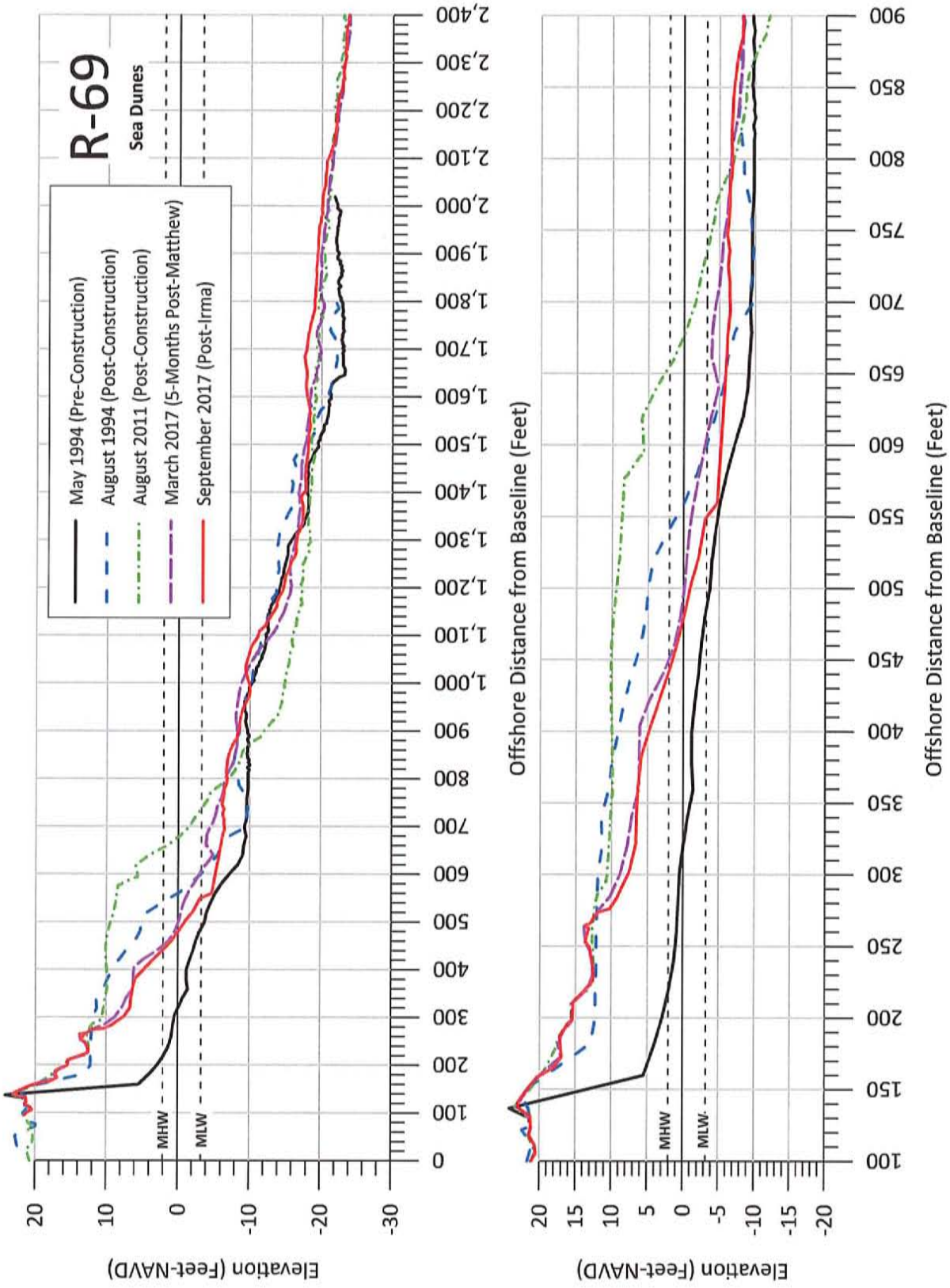

Figure A.16: Measured beach profiles at monument R-69 Amelia Island, Florida.

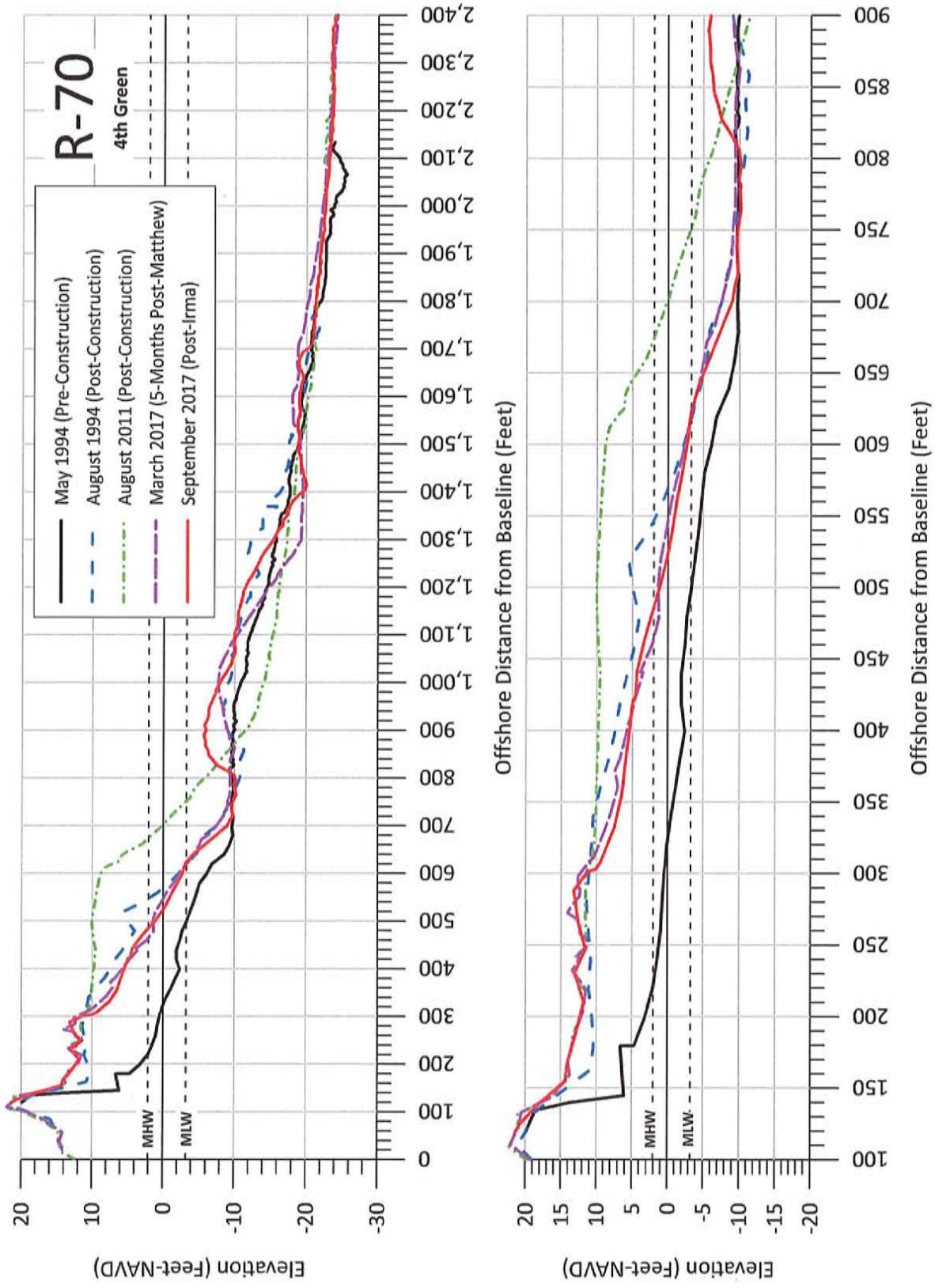

Figure A.17: Measured beach profiles at monument R-70 Amelia Island, Florida.

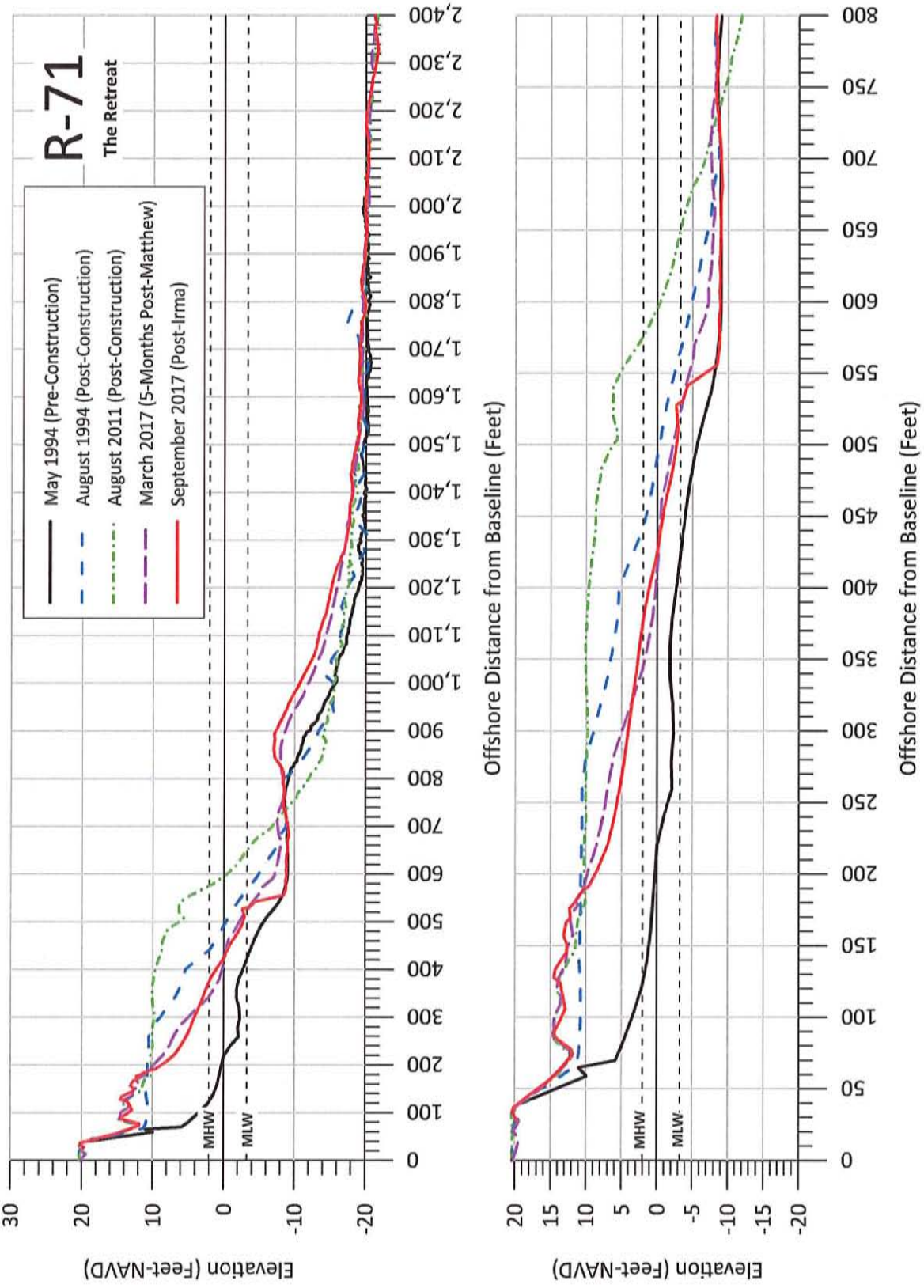

Figure A.18: Measured beach profiles at monument R-71 Amelia Island, Florida.

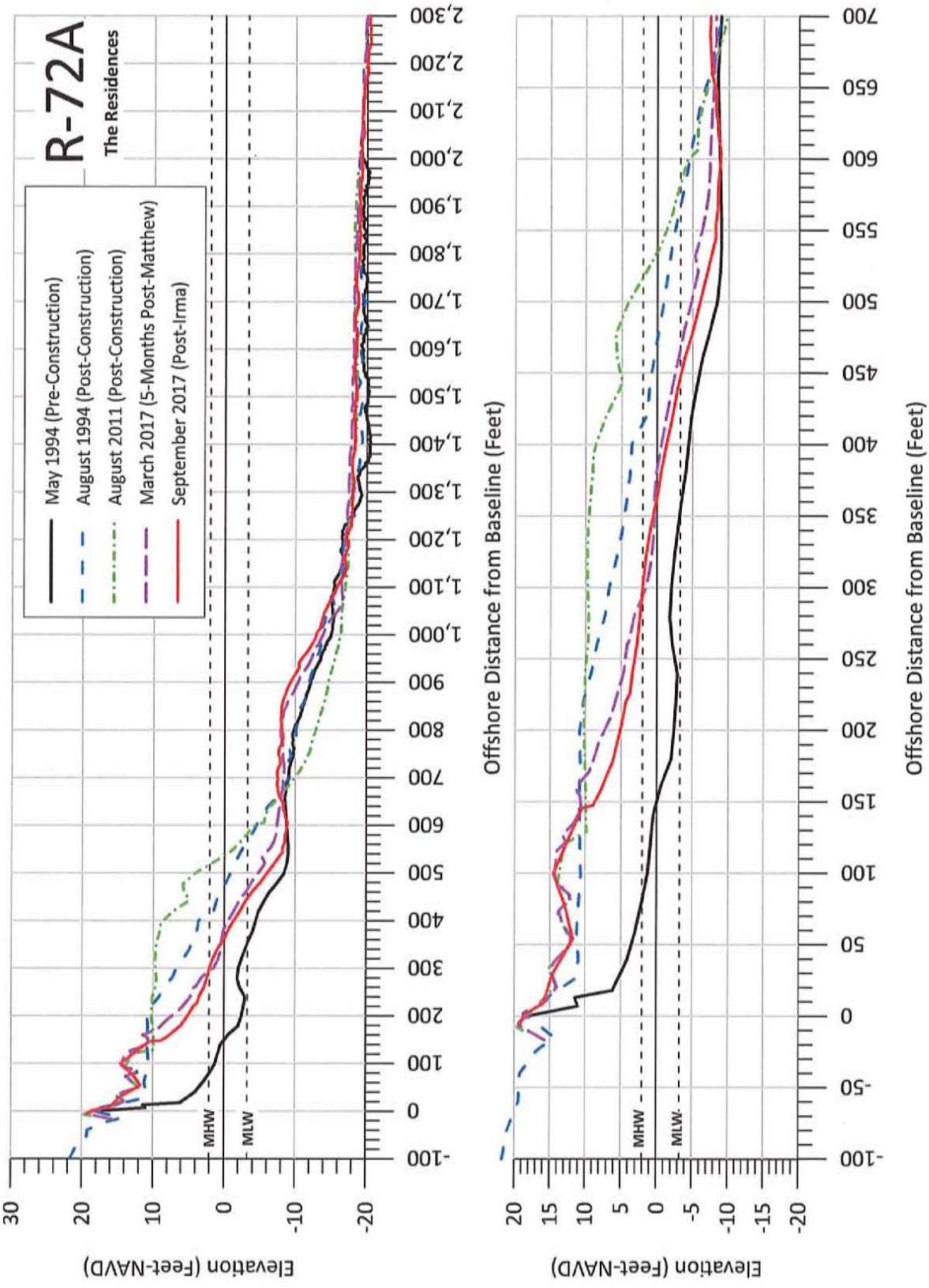

Figure A.19: Measured beach profiles at monument R-72A Amelia Island, Florida.

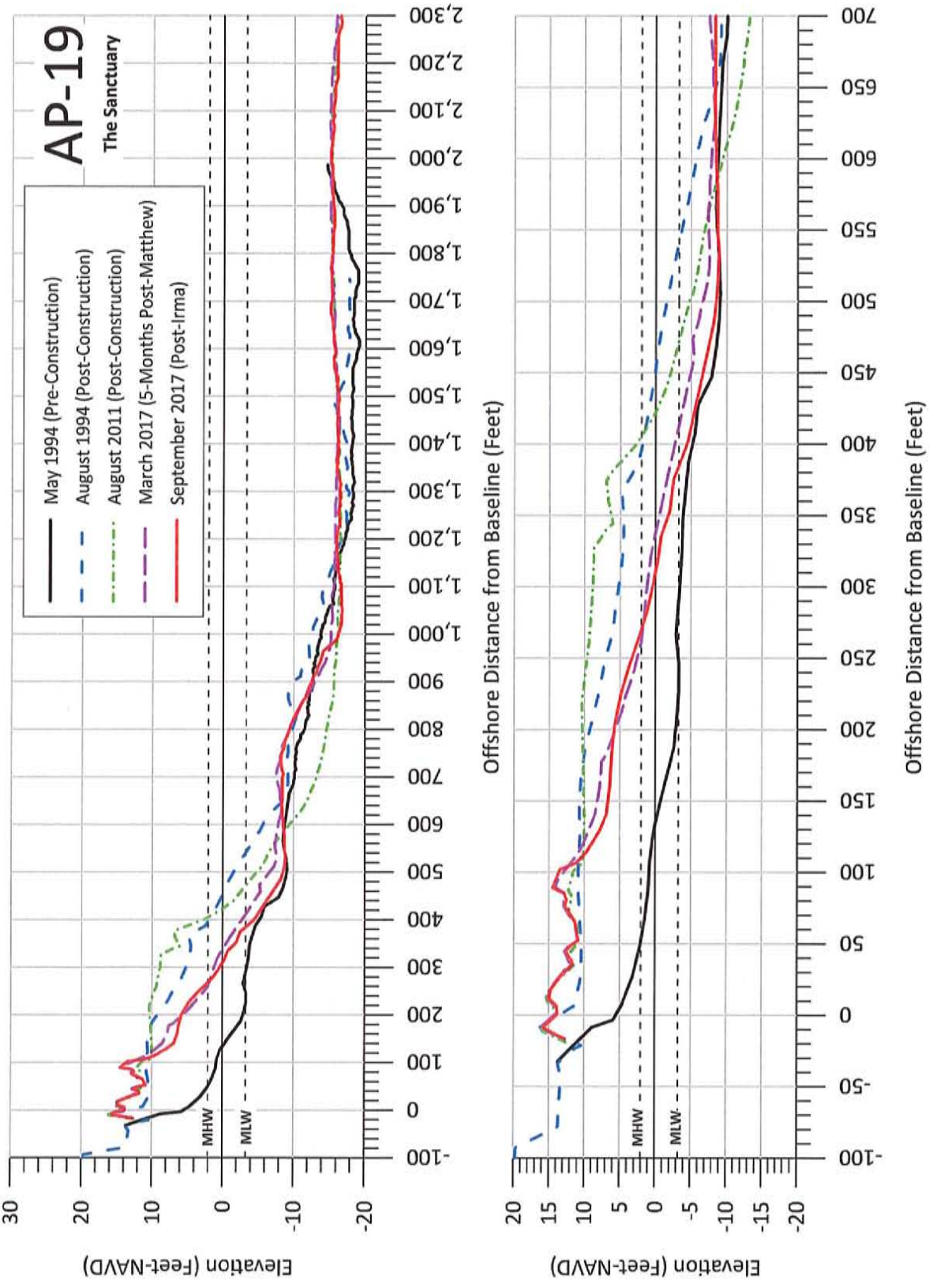

Figure A.20: Measured beach profiles at monument AP-19 Amelia Island, Florida.

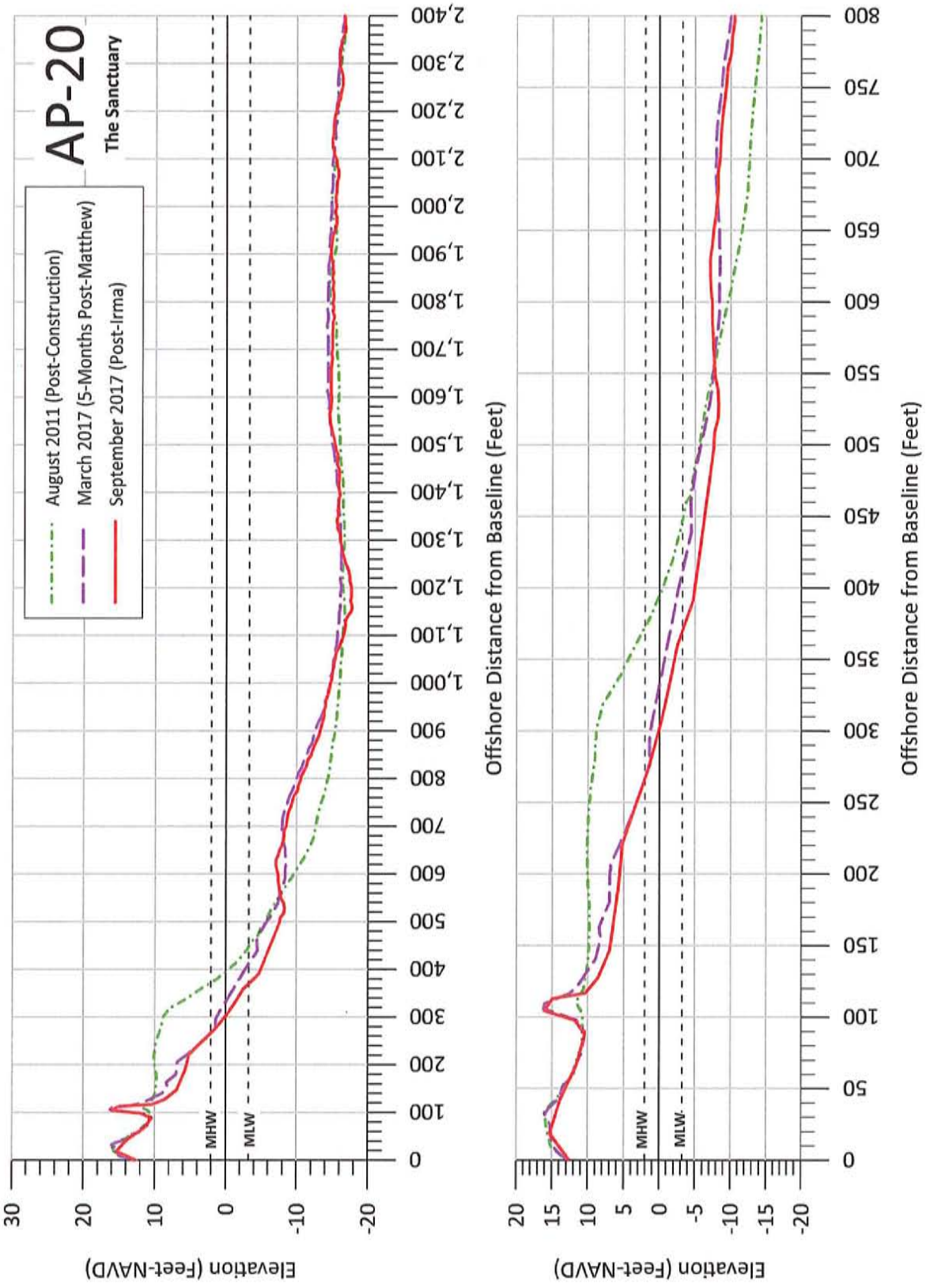

Figure A.21: Measured beach profiles at monument AP-20 Amelia Island, Florida.

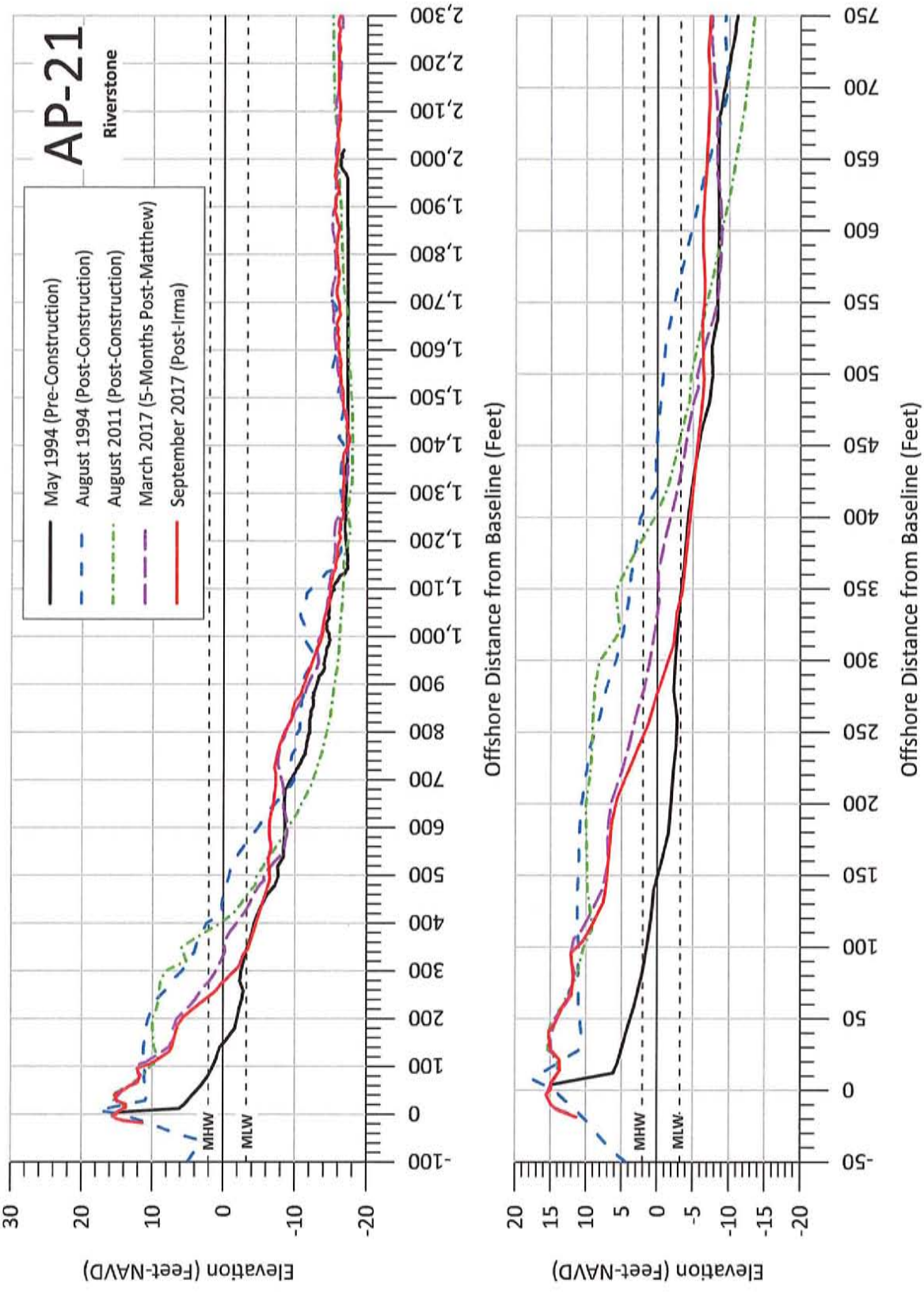

Figure A.22: Measured beach profiles at monument AP-21 Amelia Island, Florida.

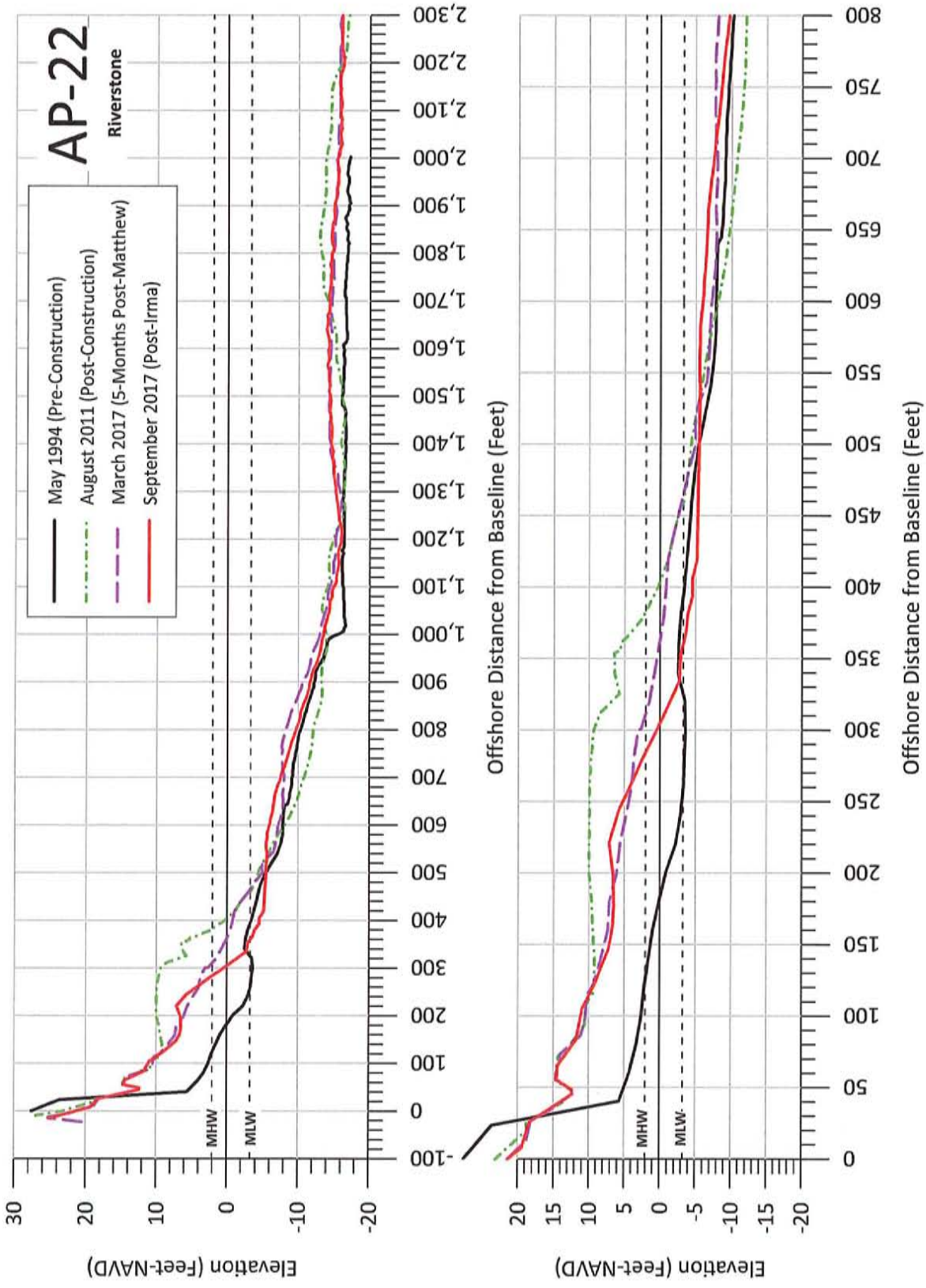

Figure A.23: Measured beach profiles at monument AP-22 Amelia Island, Florida.

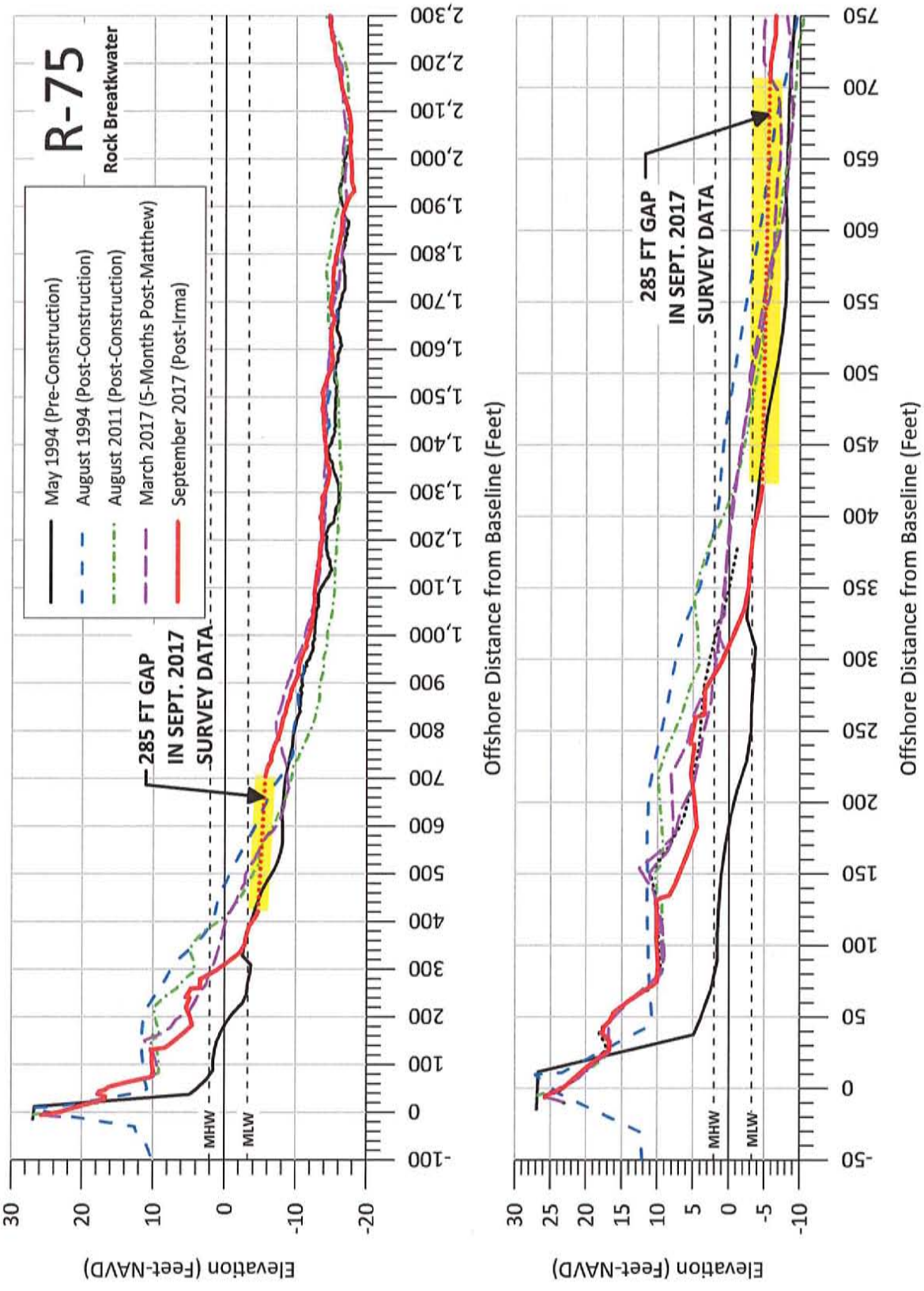

Figure A.24: Measured beach profiles at monument R-75 Amelia Island, Florida.

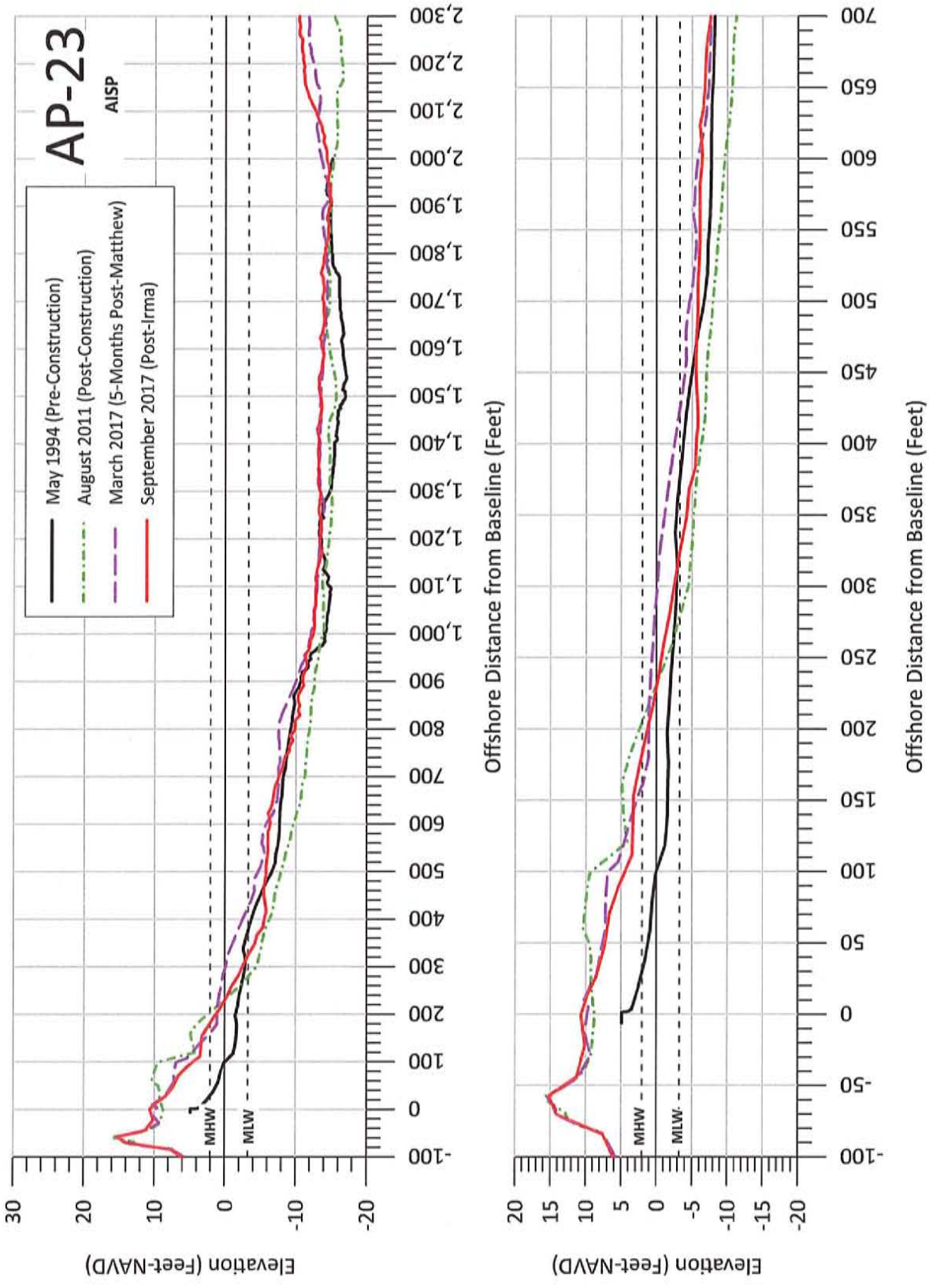

Figure A.25: Measured beach profiles at monument AP-23 Amelia Island, Florida.

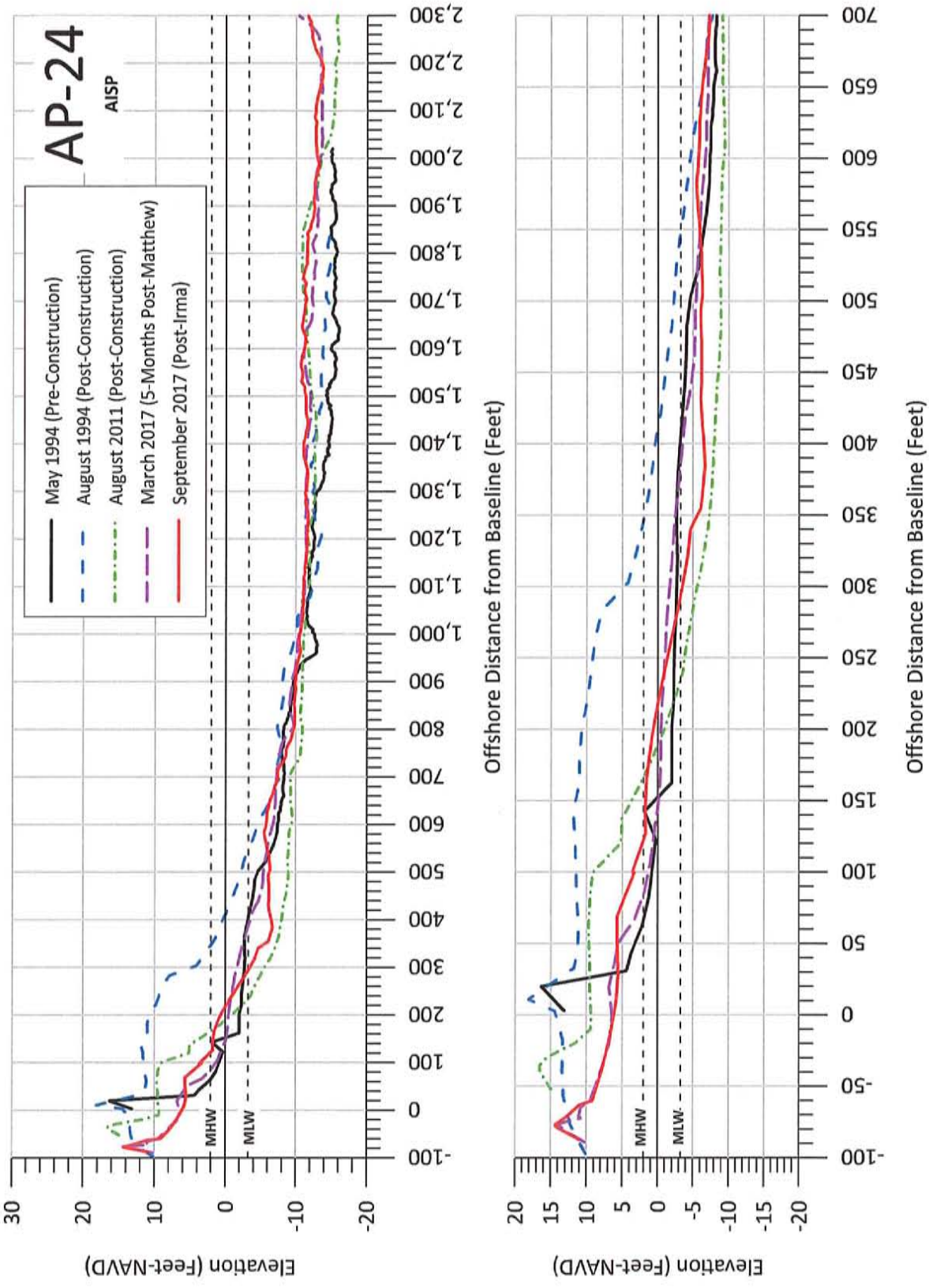

Figure A.26: Measured beach profiles at monument AP-24 Amelia Island, Florida.

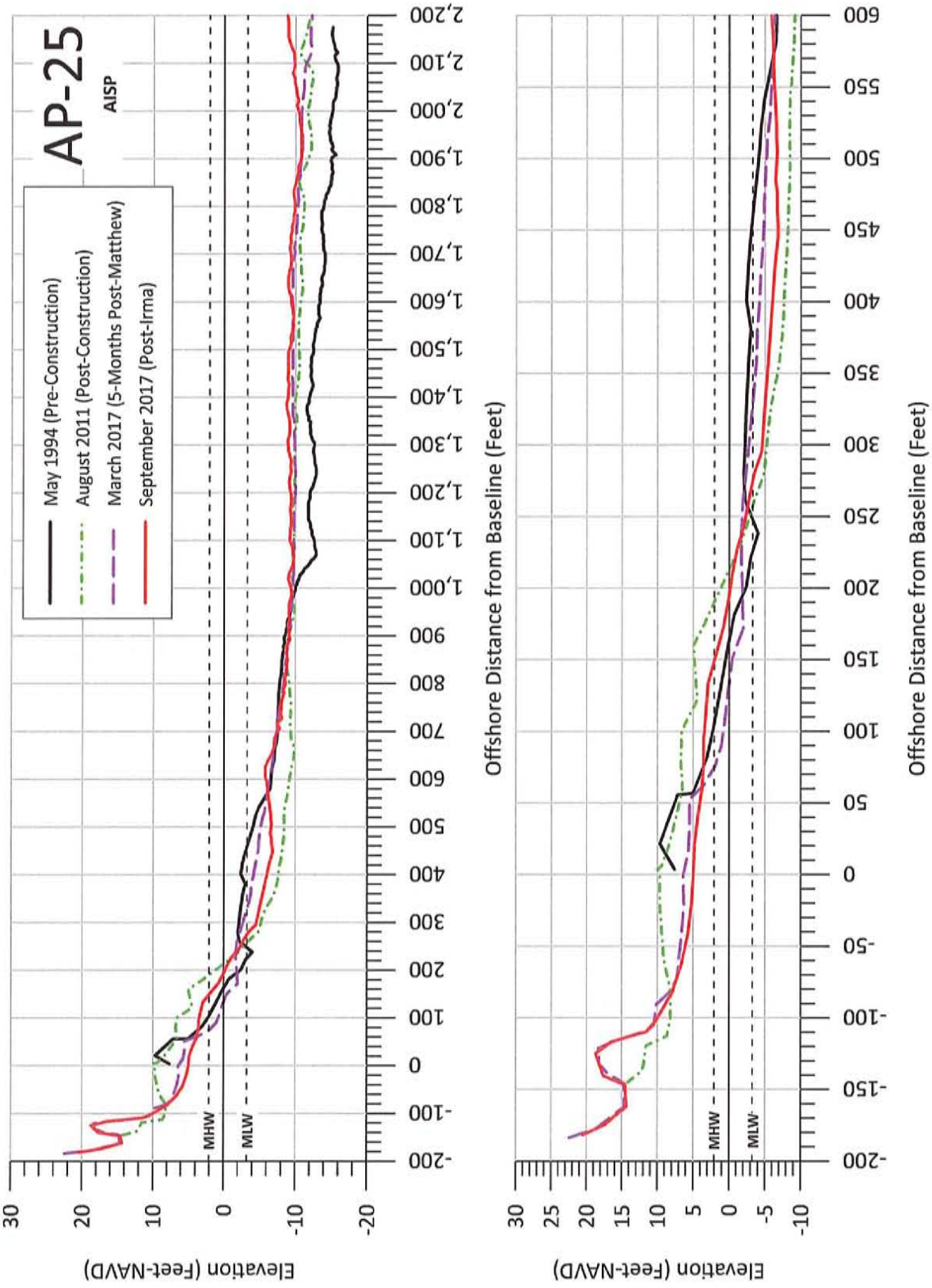

Figure A.27: Measured beach profiles at monument AP-25 Amelia Island, Florida.

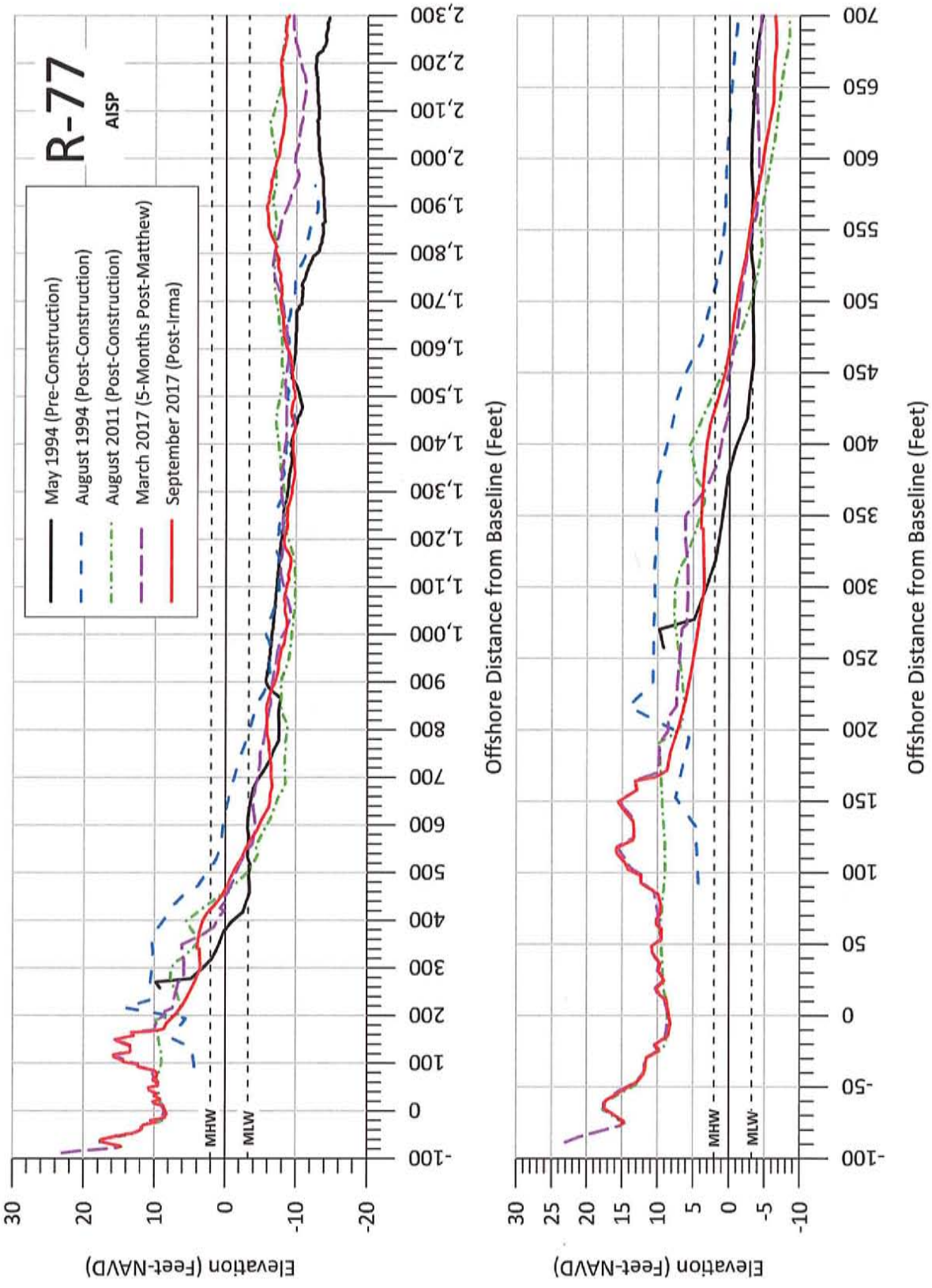

Figure A.28: Measured beach profiles at monument R-77 Amelia Island, Florida.

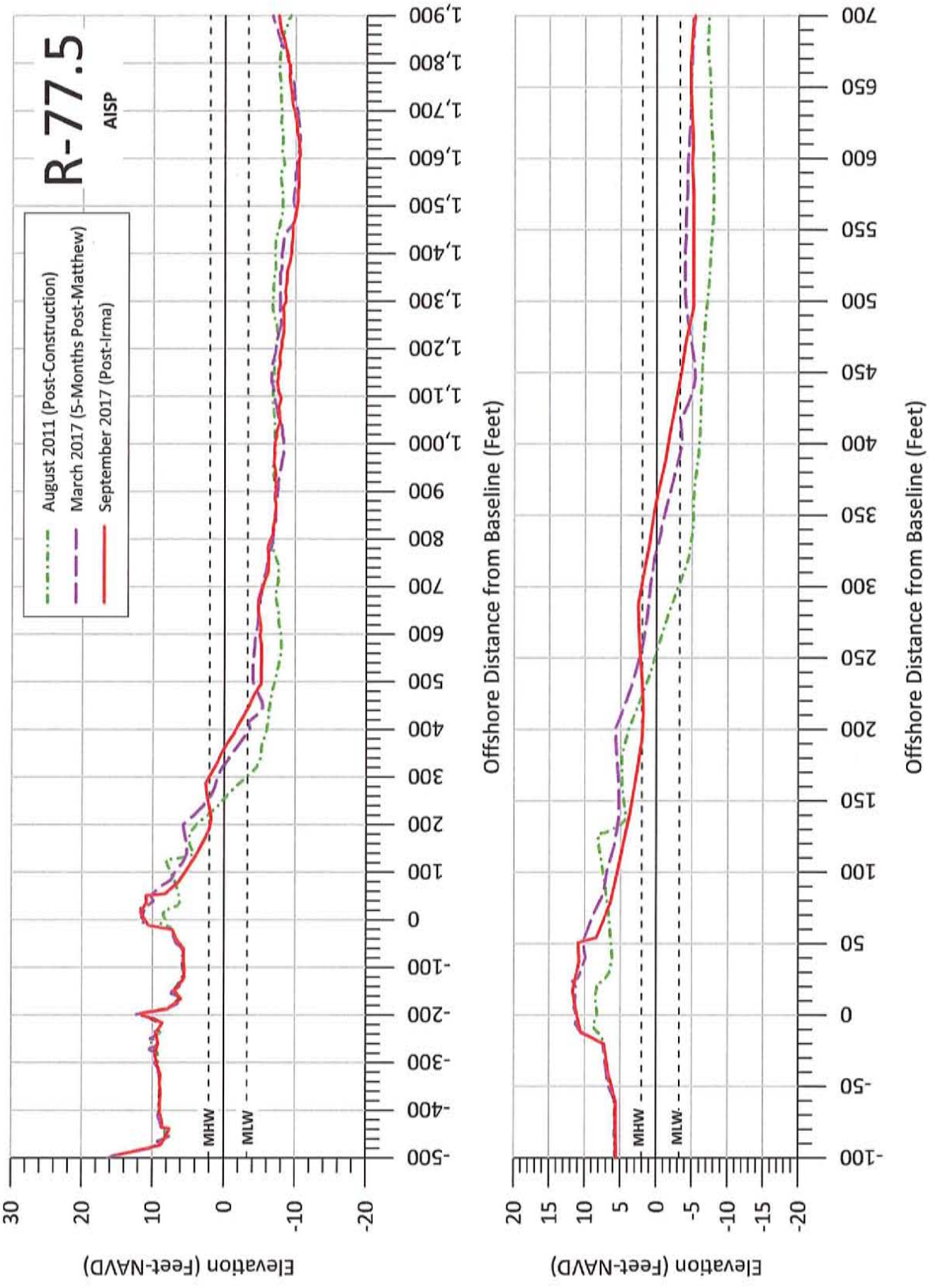

Figure A.29: Measured beach profiles at monument R-77.5 Amelia Island, Florida.

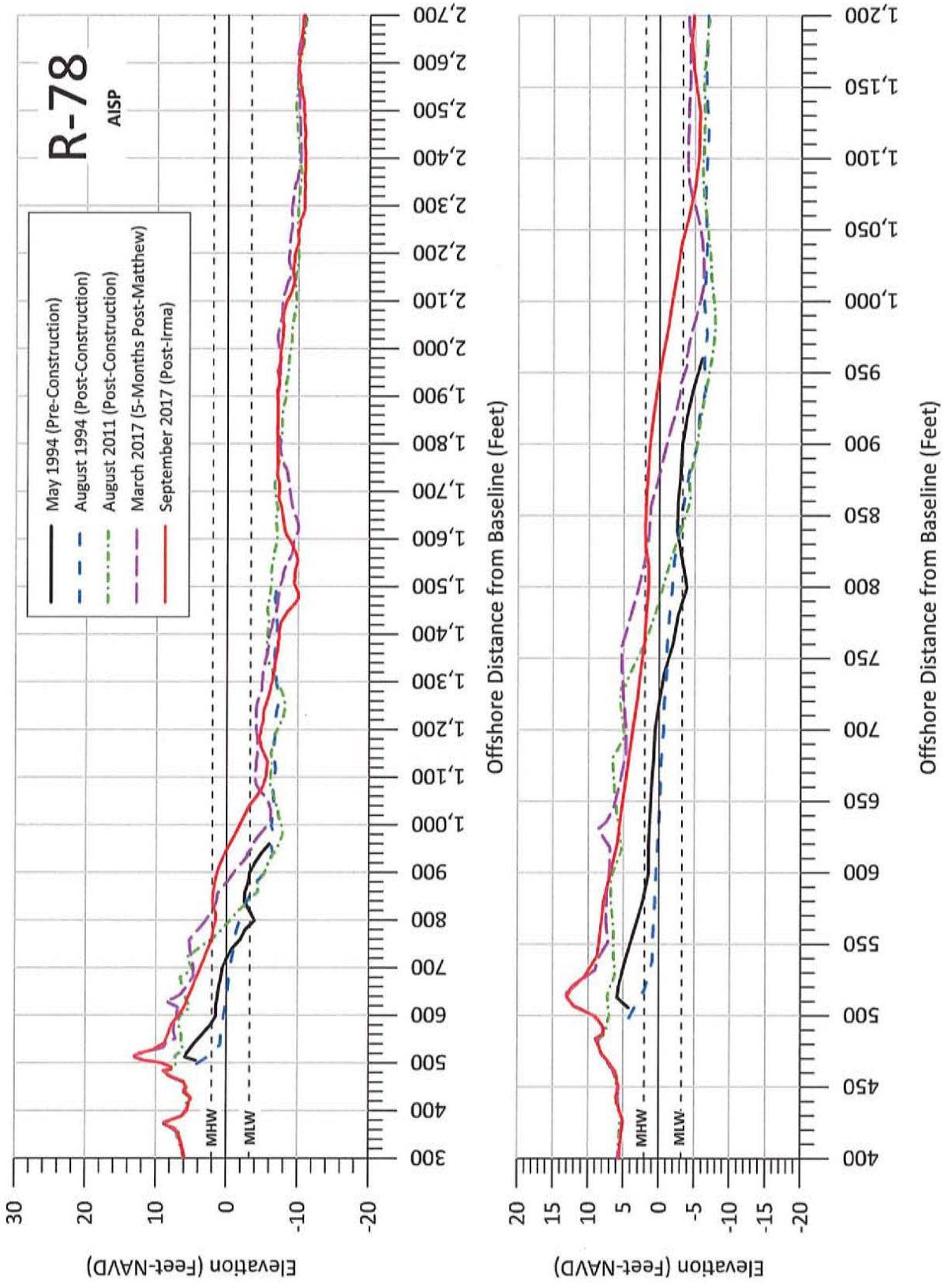

Figure A.30: Measured beach profiles at monument R-78 Amelia Island, Florida.

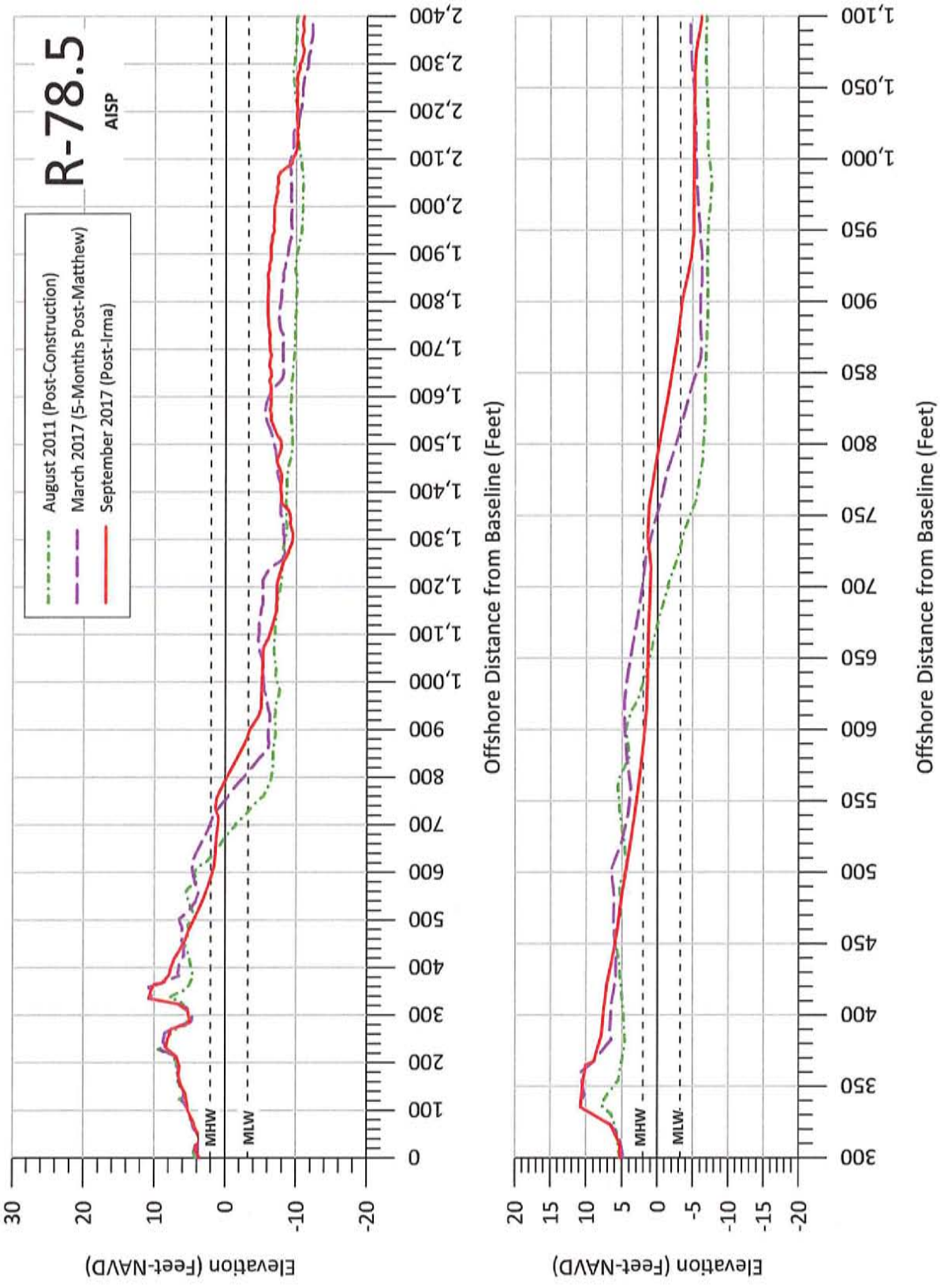

Figure A.31: Measured beach profiles at monument R-78.5 Amelia Island, Florida.

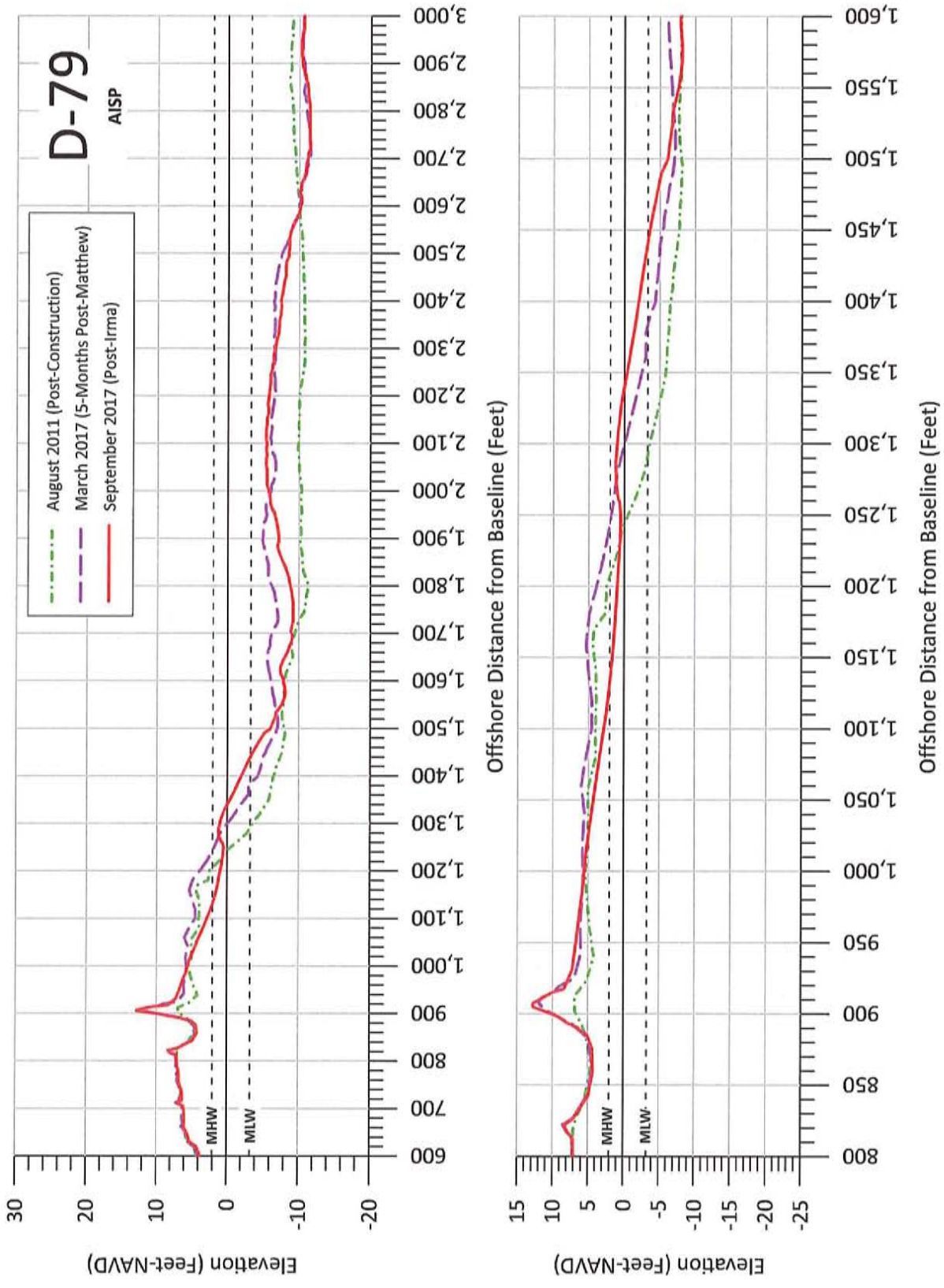

Figure A.32: Measured beach profiles at monument D-79 Amelia Island, Florida.

APPENDIX B:
Pre- to Post-Hurricane Irma
Volume & Shoreline Change Tables

This appendix contains the pre- to post-Hurricane Irma volume and shoreline change tables (March 2017 to September 2017). The tables and their contents are summarized in **Table B.1**. For purposes of analysis and discussion, the south Amelia Island monitoring shoreline is qualitatively broken into four shoreline segments (or zones of interest, each with significantly varying physiographic characteristics. The four zones are as follows:

- **"North of Project Area" (5,220 ft):** R-55 to R-59
- **"SAISSA Engineered Beach" (14,820 ft):** R-59 to Detached Breakwater
- **"AISP Engineered Beach" (3,420 ft):** Detached Breakwater to Terminal Groin
- **"AISP Sound Shoreline" (4,750 ft):** Terminal Groin to R-82

The AISP Sound Shoreline (Terminal Groin to R-82) was not surveyed during the September 2017, post-Irma survey and was not included in this analysis.

Volume changes between the monitoring surveys were computed above the MHWL (+2.0 ft-NAVD), the MLWL (3.1 ft-NAVD) and the presumed depth of closure (-20 ft-NAVD). Shoreline position changes were computed at the nominal fill berm elevation of +6.5 ft-NAVD, 2.0 feet below the seaward elevation of the construction berm and the MHWL (+2.0 ft-NAVD).

Table B.1: Listing of tables contained in Appendix B.

Table B.2: Pre- to post-Hurricane Irma (March 2017 to September 2017) volume changes *north of the engineered beach (R-55 to R-59).*

Monuments	Reach (FT)	Volume Change (CY) Pre- to Post-Irma (March 2017 to September 2017) MHWL	MLWL	Total Above -20 ft
R-55 to R-56	1,190	-4,400	-8,400	-7,700
R-56 to R-57	1,060	-4,800	-6,100	+3,600
R-57 to R-58	990	-4,500	-9,700	-1,200
R-58 to R-59	960	-4,900	-10,700	-7,800
Total (R-55 to R-59):	**4,200**	**-18,600**	**-34,900**	**-13,100**

Table B.3: BERM and MHWL position changes pre- to post-Hurricane Irma (March 2017 to September 2017) *north of the engineered beach (R-55 to R-59).*

R-Mon	Pre- to Post-Irma (March 2017 to September 2017) Shoreline Position Changes (feet) Berm (+6.5 ft-NAVD)	MHWL (+2.0 ft-NAVD)
R-55	-7.9	-8.5
R-56	-1.4	-3.8
R-57	-22.9	-5.1
R-58	-3.1	-17.5
R-59	-8.4	-3.9

Table B.4: Pre- to post-Hurricane Irma (March 2017 to September 2017) volume changes *along the **SAISSA engineered beach** from R-59 to the detached breakwater (R-75+250 feet).*

Monuments	Reach (FT)	Volume Change (CY) Pre- to Post-Irma (March 2017 to September 2017) MHWL	MLWL	Total Above -20 ft
R-59 to R-60	1,020	-6,000	-7,300	-7,500
R-60 to R-61	940	-5,200	-4,000	-2,500
R-61 to R-62	1,080	-5,100	-5,500	-9,700
R-62 to R-63	910	-3,700	-6,800	-11,400
R-63 to R-64	950	-4,900	-6,800	-6,900
R-64 to R-65	940	-3,700	-5,300	-6,900
R-65 to R-66	920	-900	-2,900	-4,900
R-66 to R-67	930	-1,200	-5,600	-3,800
R-67 to R-68	990	-4,500	-11,300	-12,400
R-68 to R-69	1,050	-6,100	-12,800	-11,500
R-69 to R-70	970	-3,700	-7,600	+9,000
R-70 to R-71	1,000	-3,500	-4,000	+14,700
R-71 to R-72	900	-7,100	-7,200	-7,500
R-72 to AP-19	990	-6,500	-9,200	-28,500
AP-19 to AP-20	490	-2,100	-4,400	-19,700
AP-20 to AP-21	540	-3,000	-8,100	-14,700
AP-21 to AP-22	510	-1,300	-8,300	-6,000
AP-22 to R-75	460	-800	-7,800	-5,400
R-75 to Detached Breakwater	250	-600	-3,800	-5,800
Total (R-59 to Detached Breakwater):	**15,840**	**-69,900**	**-128,700**	**-141,400**

Table B.5: BERM and MHWL position changes pre- to post-Hurricane Irma (March 2017 to September 2017) *along the **SAISSA engineered beach** from R-59 to the detached breakwater (R-75+250 feet).*

R-Mon	Pre- to Post-Irma (March 2017 to September 2017) Shoreline Position Changes (feet)	
	Berm (+6.5 ft-NAVD)	MHWL (+2.0 ft-NAVD)
R-60	-11.9	-2.6
R-61	-35.8	+39.7
R-62	-22.7	+24.3
R-63	-41.2	+22.8
R-64	-40.2	+32.3
R-65	-34.6	+30.0
R-66	-19.9	+32.4
R-67	+0.3	-4.0
R-68	-59.9	-11.5
R-69	-9.2	-8.3
R-70	-30.1	+21.3
R-71	-43.2	+32.0
R-72	-34.2	+7.3
AP-19	-30.5	+5.9
AP-20	-46.8	+0.7
AP-21	-18.0	-30.9
AP-22	+39.9	-26.9
R-75	-41.1	-3.3
DETACHED BREAKWATER		

Table B.6: Pre- to post-Hurricane Irma (March 2017 to September 2017) volume changes *along the **AISP engineered beach** south of the detached breakwater (R-75+250 feet) to the terminal groin.*

Monuments	Reach (FT)	Volume Change (CY) Pre- to Post-Irma (March 2017 to September 2017) MHWL	MLWL	Total Above -20 ft
Detached Breakwater to A-23	260	-100	-1,800	-6,400
A-23 to A-24	430	+200	-1,700	-9,700
A-24 to A-25	410	+300	+2,400	-1,700
A-25 to R-77	470	-3,200	-300	+4,100
R-77 to R-77.5	510	-6,800	-3,800	+1,400
R-77.5 to R-78	480	-6,200	-1,300	-5,900
R-78 to R-78.5	410	-5,000	-1,300	-6,200
R-78.5 to D-79	360	-6,000	-4,500	-14,000
D-79 to Terminal Groin	90	-1,800	-1,500	-6,100
Total (Detached Breakwater to Terminal Groin):	**3,420**	**-28,600**	**-13,800**	**-44,500**

Table B.7: BERM and MHWL position changes pre- to post-Hurricane Irma (March 2017 to September 2017) *along the **AISP engineered beach** south of the detached breakwater (R-75+250 feet) to the terminal groin.*

R-Mon	Pre- to Post-Irma (March 2017 to September 2017) Shoreline Position Changes (feet)	
	Berm (+6.5 ft-NAVD)	**MHWL (+2.0 ft-NAVD)**
DETACHED BREAKWATER		
AP-23	-28.8	+23.5
AP-24	-35.9	+38.0
AP-25	-25.2	+74.9
R-77	-58.6	+42.1
R-77.5	-29.6	+45.4
R-78	-36.6	-48.9
R-78.5	-65.6	-116.0
D-79	+26.2	-111.3
TERMINAL GROIN		