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Final Report

Damage Assessment and Access Restoration of Old A1A and the Summer Haven Branch of the Matanzas River at Summer Haven, St. Johns County

Florida Department of Environmental Protection, Office of Resilience and Coastal Protection

June 2023

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Notice

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This document has 51 pages including the cover.

Document History

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Rev 2.0	Final Report	NE/WL	NE/CP/WL	MS	CP	6/22/2023

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1. Introduction and Purpose

The Summer Haven area, located in St. Johns County, Florida, has a history of experiencing severe erosion, especially during storm events such as hurricanes and nor'easters. This erosion has resulted in frequent damage to Old A1A, causing restricted access to adjacent properties, and the opening, closing, and shifting of inlets to the Summer Haven branch of the Matanzas River[1]. The Florida Department of Environmental Protection (FDEP) received funding and engaged Atkins to procure an assessment of damages, cost, and recommendations to restore access to Old A1A while continuing to protect the integrity of the Summer Haven branch of the Matanzas River. Figure 1 below shows the project location, between FDEP coastal range monuments R-200 and approximately R-208+400. The project area is located 3,400 feet south of the Matanzas Inlet to the north end of Marineland at the St. Johns/Flagler County border.

For this study, Atkins first developed a list of historical documents and other sources of information to be used as references throughout the project. Then, Atkins investigated and summarized the historical records of beach-dune erosion and remedial actions taken by St. Johns County and other agencies to restore the dune system and roadway. Additionally, the vulnerability of the dune and roadway to high frequency storm events, based on 15-year and 25-year storm parameters, and chronic erosion was evaluated. Once the baseline erosion for the two storm events was determined, Atkins assessed the cost of restoring and maintaining access to Old A1A over the next 30 and 50 years. These cost estimates were based on the cost to periodically restore a berm to support Old A1A, including the initial volume to construct this berm and volumes to remediate erosion caused by periodic impacts of the 15-year and 25-year storm events.

Atkins also assessed the cost of potential remediation alternatives to restore and maintain access to Old A1A. The remediation alternatives may minimize, but not prevent, damages to Old A1A and the Summer Haven branch of the Matanzas River from the impacts of 15-year and 25-year return interval storm events. The four basic conceptual alternatives considered include: (1) dune restoration with periodic maintenance and repair, (2) beach and dune restoration with periodic maintenance beach nourishment, (3) construction of a system of nearshore segmented breakwaters, and (4) construction of a seawall. For each of the four alternatives, Atkins developed conceptual plan views and typical cross-sections, as well as preliminary opinions of probable costs, including initial construction and assumed maintenance over a 25-year design life.

For the purposes of this study, the dual goals of restoring access to Old A1A and protecting the integrity of the Summer Haven branch of the Matanzas River are accomplished by establishing and maintaining a driving path in front of the existing homes (approximately along the Old A1A right of way). This solution would greatly reduce sand overwash into the Summer Haven branch of the Matanzas River and help maintain water circulation within the river. Adding other features (e.g., a large beach fill project, offshore breakwater, or seawall) to protect this driving path would further reduce overwash to the point where it would only be expected to occur during very large storm events. A more extensive analysis of the coastal and riverine processes in this area (e.g., sediment budget analysis, 2-D hydrodynamic modeling) and evaluation of more complex/costly options for protecting the integrity of the Summer Haven branch of the Matanzas River (e.g., larger beach fill projects or coastal structures) were considered to be outside the scope and time frame allotted for this study.

[1] In this report, the river that runs immediately behind (west) of the Summer Haven barrier beach is referred to as the "Summer Haven branch of the Matanzas River". This river is also referred to as the "Summer Haven River" in other documents.

Figure 1: Summer Haven Project Location (Google Earth, 2021)

2. Vulnerability and Historical Management Background

Summer Haven Beach is vulnerable to long-term erosion due to a variety of factors including: (1) the beach is very narrow and is a low barrier between the Summer Haven branch of the Matanzas River and the Atlantic Ocean, making it vulnerable to overwash and breaches during tropical storms and nor'easters, (2) the location of the area is south (downdrift) of the Matanzas Inlet, which traps significant sand quantities estimated to be about 71,000 cubic yards/year, and (3) it is located between two rock revetments at Marineland and Summer Haven North, which intensifies the erosion (Taylor Engineering, 2009), (St Johns County, 2022).

In 1986, FDEP identified beaches along the Florida coast that are critically eroding and was held responsible for developing and maintaining a comprehensive long-term plan to manage the restoration of these beaches. According to the Florida Administrative Code (F.A.C.) a "critically eroded shoreline" is described as "*a segment of the shoreline where natural processes or human activity have caused or contributed to erosion and recession of the beach or dune system to such a degree that upland development, recreational interests, wildlife habitat, or important cultural resources are threatened or lost. Critically eroded shorelines may also include peripheral segments or gaps between identified critically eroded areas which, although they may be stable or slightly erosional now, their inclusion is necessary for continuity of management of the coastal system or for the design integrity of adjacent beach management projects"* (FDEP, 2022a). In 1999, Summer Haven Beach was classified as a "critically eroded shoreline" from R-197 to R-209, totalling 2.4 miles of shoreline, as shown in Figure 2.

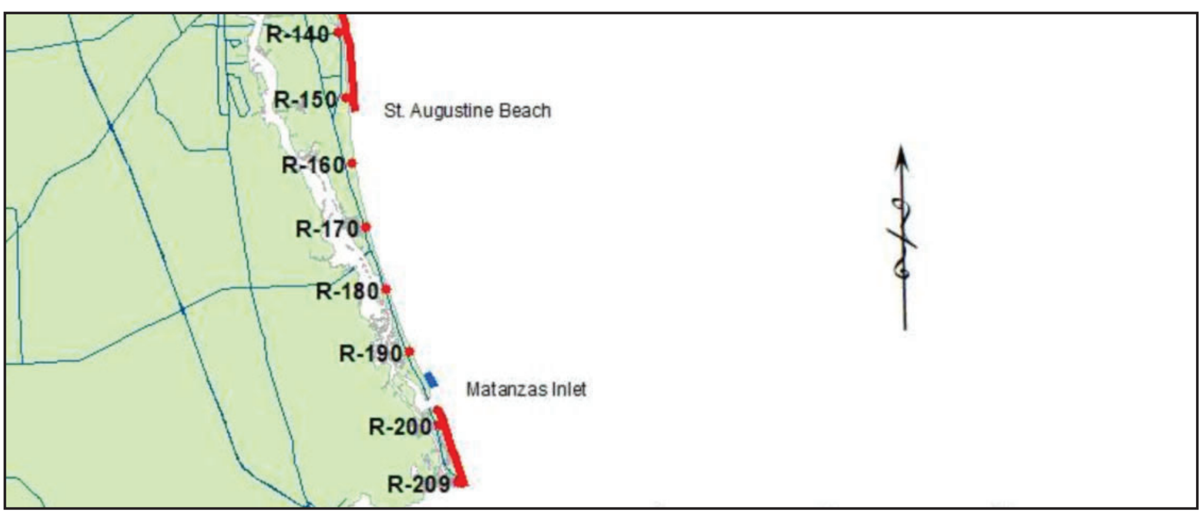

Figure 2: Critically eroded shoreline St. Johns County, project area R200-208 (FDEP, 2022a)

2.1. Hurricanes and Tropical Storms

On average, from 1830-present, one tropical storm has passed within fifty miles of the Summer Haven area every three years. Erosion and threats to the infrastructure along the coast have been occurring since before the mid-1990s. In response, several segments of protective rock revetments have been constructed and State Road (SR) A1A has been shifted inland (USACE, 2017). The right of way for Old A1A runs along the beach with houses adjacent to the road. Erosion, especially during storm events, has resulted in frequent damage to Old A1A, restricting access to the properties. Table 1 lists some of the more significant historical tropical storms and hurricanes, with their peak hurricane intensity, that have impacted the Summer Haven area since 1894. These storms have caused the project area to experience erosion, breaches, and damage to Old A1A, as shown in Figure 3.

Table 1: List of Significant Historical Summer Haven Storms

Name	Year
No Name (Cat 1)	1894
Hurricane Donna (Cat 3)	1960
Ash Wednesday Storm	1962
Hurricane Dora (Cat 2)	1964
Thanksgiving Storm	1984
Hurricane Gladys (Cat 1)	1988
Tropical Storm Gabrielle	1995
Hurricane Floyd (Cat 3)	1999
Hurricane Charlie (Cat 1)	2004
Hurricane Frances (Cat 2)	2004
Hurricane Jeanne (Cat 3)	2004
Tropical Storm Fay	2008
Hurricane Matthew (Cat 4)	2016
Hurricane Irma (Cat 5)	2017
Hurricane Dorian (Cat 5)	2019
Hurricane Ian (Cat 4)	2022
Hurricane Nicole (Cat 1)	2022

The most devasting storm to have impacted this area was Hurricane Dora, which made landfall in 1964 in St. Augustine as a Category 2 hurricane. The wind speeds of this storm were near 110 mph at the time of landfall, and it produced a 12-ft-high storm surge (Mehta and Jones, 1977). The extensive damage caused by this hurricane included the breaching of Rattlesnake Island. Following the hurricane, the revetment north of R-200 was expanded and State Road A1A was relocated in the 1970s to its present location.

The Thanksgiving Storm (1984) and Hurricane Floyd (1999) caused major dune erosion and storm surge breaches near the Matanzas Inlet and surrounding areas. Old A1A became buried with sand due to Hurricane Floyd. In 2004, Hurricanes Frances and Jeanne caused moderate dune erosion at Summer Haven with the narrow barrier breaching at R-201.2 and R-201.5. About 2,000 feet of Old A1A was undermined and collapsed between R-205.5 and R-207.5 due to the waves of Hurricane Jeanne (FDEP, 2004).

In 2008, Tropical Storm Fay created a breach at R-200 which caused over 300,000 cubic yards of sand to infill the Summer Haven branch of the Matanzas River (INTERA-GEC, 2022). Hurricane Matthew (2016) had the biggest impact to the Summer Haven area since Hurricane Dora by causing a major tidal breach across the barrier beach between R-204 to R-205 (Figure *3*), which had an emergency closure after the storm (ATM, 2021). After Hurricane Matthew, a beach and river restoration project began in

2017 which resulted in excavating overwashed sand from the Summer Haven branch of the Matanzas River and constructing a barrier dune and beach berm between R-200 and R-205 (FDEP, 2018).

When Hurricane Irma (2017) passed through this project area, approximately 90 percent of the fill from the 2017 beach and river restoration project was lost between R-200 and R-205 (FDEP, 2018). In 2019, Hurricane Dorian caused tidal over-topping between R-203.5 and R-204.5 (FDEP, 2020). Most recently, in 2022, Hurricane Ian and Hurricane Nicole impacted the Summer Haven area. Hurricane Ian brought major wind and storm surge resulting in dune and beach erosion, while Hurricane Nicole produced significant waves and further eroded the already severe beach and dune erosion in the area (INTERA-GEC, 2022). Due to Hurricane Ian, the Summer Haven branch of the Matanzas River received large washover deposits that blocked the flow in the lagoon at three different locations between R-200 and R-205. Additionally, a breach occurred beneath a single-family dwelling that was supported by piles. The impact of Hurricane Nicole exacerbated the overall beach erosion in St. Johns County due to lack of significant recovery after Hurricane Ian. At R-200, just south of the rock revetment, another breach was created. Furthermore, an approximately 2,000-foot-long rock revetment sustained major damaged with significant displacement of rocks (FDEP, 2022b).

Figure 3: Barrier island breach at Summer Haven post Hurricane Matthew (Photo: U.S. Geological Survey)

2.2. Remedial Actions

Each of the historical storms listed above have had a significant impact to the coast and infrastructure of Summer Haven and the surrounding area. Following several storm events, St. Johns County and the State implemented several types of remedial actions. These have included:

- Placement of sand dredged from the Intracoastal Waterway (ICWW). In 1989, FIND developed a long-term dredged material management plan for placing ICWW sediments along Summer Haven beach. This sand was generally placed between R-monuments R-200 and R-208. In 1991, a beach disposal area plan was put into place for the sediment that was being dredged near the

Matanzas Inlet. The beach disposal area, FIND SJ-MB, is located between R-200 and R-208, totalling approximately 7,800 linear feet. The USACE and FIND have dredged the ICWW approximately every three years to maintain navigation from 1958 to 2019, totalling approximately 4.3 million cubic yards (INTERA-GEC, 2023).

- Construction of emergency berms. Several storm events, such as Hurricane Frances, Hurricane Jeanne, and Tropical Storm Faye caused breaches at the Summer Haven area and resulted in the area being included in a federally declared disaster, making Federal Emergency Management Agency (FEMA) funds available for construction of emergency berms. These berms, which were typically on the order of 6 cubic yards per linear foot, were constructed by truck hauling sand from upland sources. In 2011, St. Johns County placed a significant amount of sand between R-202 and R-208 for the FEMA emergency berm project permitted under SJ-1074. The beach compatible material was excavated and trucked from the upland borrow area FIND DMMA SJ-1.

In 2014, FDEP issued a permit to the St. Augustine Port, Waterway and Beach District to excavate material from the Summer Haven branch of the Matanzas River that had been deposited from breaches of the beach and dune complex during storms. The dredged sand material would be placed back on the Summer Haven beach between R-200 and R-208 (FDEP, 2019). Modifications of this permit included dredging of the flood shoal located at the confluence of the river and Matanzas Inlet, placing additional material at R-205 to close a breach caused by Hurricane Matthew, levelling of shoals, planting vegetation on the dune, modifying the dune fill template, and extending the duration of the permit to all beach maintenance for future emergency events (FDEP, 2019).

Table 2 represents a summary of sand placement events that occurred in this project area, per permitting records, from 1992 to present. Since 1992, sand placement volumes from the ICWW have ranged from approximately 187,862 to 430,000 cubic yards, totalling approximately 2.4 million cubic yards of sand (St. Johns County, 2022).

Table 2: Summer Haven Sand Placement Events

Date	Location	Volume (CY)	Source	Agency
1992	R200-208	191,502	ICWW	FIND-USACE
1994	Unknown	197,370	ICWW	FIND-USACE
1999	R200-208	211,615	ICWW	FIND-USACE
1999	R198-209	844,311	SJ-1	FIND
2001	R200-208	218,000	ICWW	FIND-USACE
2002	R203-208	21,300	Upland	FEMA+SJC
2003	R200-208	29,300	Upland	FEMA+SJC
2004	R200-208	286,529	ICWW	FIND-USACE
2007	R200-208	187,862	ICWW	FIND-USACE
2011	R200-208	33,000	SJ-1	FEMA
2011	R205-208	250,000	ICWW	USACE
2017	R204-208	430,000	ICWW	FIND-USACE
2017	R200-205	390,000	Summer Haven branch of the Matanzas River	SAPWBD
2019	R200-203.5	47,100	Summer Haven branch of the Matanzas River	SAPWBD
2019	R200-208	394,028	ICWW	FIND-USACE
2019	R204-205	12,700	Summer Haven branch of the Matanzas River	SJC
2021	R202-208	103,000	Summer Haven branch of the Matanzas River	FEMA+SJC

2.3. Shoreline Recession Rate

Data available from FDEP's Mean High Water (MHW) database, which included the distances from the FDEP range monument to the MHW over time, was used to develop an estimate of the long-term recession rate of the MHW line for this area (FDEP Historic Shoreline Database, accessed 2023). The most recent beach survey in the project area, which was performed by WPT in October 2022 (post Hurricane Nicole), was also included in the analysis. Data was extracted from the FDEP database for the years 1872-2022 for each FDEP range monument from R-200 to R-208. A study done by Foster, et al (2000) calculated the recession rate of the project area from 1972-1999 to be between 1.5 and 2 feet/year.

To account for the most recent significant storms and sand placement projects, the shoreline recession analysis was calculated for the years of 2003-2022. Based on these years, the MHW shoreline for the Summer Haven beach project area is changing at an average rate of approximately -7 feet/year (indicating the beach is receding an average of approximately 7 feet per year). This recession rate was also obtained in an analysis done by Applied Technology & Management (ATM) staff (ATM, 2021). During the years 2003-2019, the impact of significant storms, such as Hurricane Matthew, Irma, and Dorian, nearly tripled the recession rates calculated by Foster et al (2000) for 1972-1999, even taking into account the sand placement projects listed in Table 2.

2.4. Water Levels

The nearest active NOAA tide gauge, Station 8720218, located in Mayport, Florida, was used to determine the tidal range for the project area. At this station, mean higher-high water (MHHW) elevation is approximately 1.96 feet relative to NAVD88 and mean high water (MHW) is approximately 1.70 feet relative to NAVD88, as shown Table 3 (NOAA, accessed 2023). The MHHW was used as a maximum water elevation for developing the roadway and beach berm elevation.

Table 3: Tidal Datum for NOAA Tide Gauge: Mayport Station 8720218 (NOAA, 2023)

Water Level	Description	Elevation (ft NAVD88)
MHHW	Mean Higher-High Water	1.96
MHW	Mean High Water	1.70
MSL	Mean Sea Level	-0.52
MTL	Mean Tide Level	-0.57
MLW	Mean Low Water	-2.84
MLLW	Mean Lower-Low Water	-2.99

The storm surge elevations for the 15-year and 25-year storm events are +6.8 feet NAVD88 and +8.0 feet NAVD88, respectively (FDEP, 2009). It should be noted that sea level rise was judged to have a relatively minor effect on the analysis of periodic storm events; it was therefore not included in the design water elevations for the conceptual alternatives analysis.

3. Storm Erosion Modeling

The SBEACH storm erosion model within the CEDAS software was used to simulate storm-induced erosion along three beach profiles for the 15-year and 25-year return interval storm events to help predict the frequency and magnitude of future damages in terms of beach-dune elevations and volumetric changes.

Most of the model input data for the storm event wave parameters and water level hydrographs were obtained from Appendix VI and Appendix VII of the June 2010 SBEACH Model Studies for the Florida Atlantic Coast for St. Johns County report, performed by FDEP (Leadon & Nguyen, 2011). The FDEP

SBEACH input storm surge hydrographs have peak elevations of +4.9 feet NAVD88 and +5.8 feet NAVD88 for the 15-year and 25-year storm events, respectively. It should be noted that the peak storm surges for the input hydrographs are not representative of the total storm surge elevation since they have been adapted for SBEACH. The wave parameters (wave height and wave period) and beach characteristics provided in the FDEP report correspond to the location of the R-monuments R-198 to R-209. Table 4 provides the input parameters utilized for the SBEACH erosion analysis including wave parameters, water level hydrographs and beach characteristics.

R-monuments R-201, R-204, and R-208, shown in Figure 4 below, were selected as the three input beach profiles to analyze along the project area. R-201 represents the northern section of the study area where the beach profile is relatively low and there are no structures or roadway; R-204 represents the middle section of the study area that has been overwashed by recent storms; R-208 represents the southern section of the study area that is somewhat higher and has some remnants of a vegetated dune system. These beach profiles are a composite of the 2016 (offshore region) and 2022 (nearshore region) LiDAR survey data obtained from the FDEP data archive.

Table 4: SBEACH Input Parameters for 15-year and 25-year storm simulations for St. Johns County

Grain Size	Water Temperature	Constant Wave Height	Constant Wave Period	Hydrograph Peak Elevation (NAVD88)	
				15-year	25-year
0.45 mm	27 °C	8 ft	8 s	4.9 ft	5.8 ft

Figure 4: SBEACH R-Monument Locations

The eroded beach profiles for the 15-year and 25-year return period events are shown in Figure 5 for a simulation duration of 36 hours. The location of the R-monument is represented by station zero. The left panel shows the total length of the beach profile; the right panel is focused on the nearshore area. Table 5 describes the volumetric changes and MHW shoreline change for each of the beach profiles due to a 15-year and 25- year storm event.

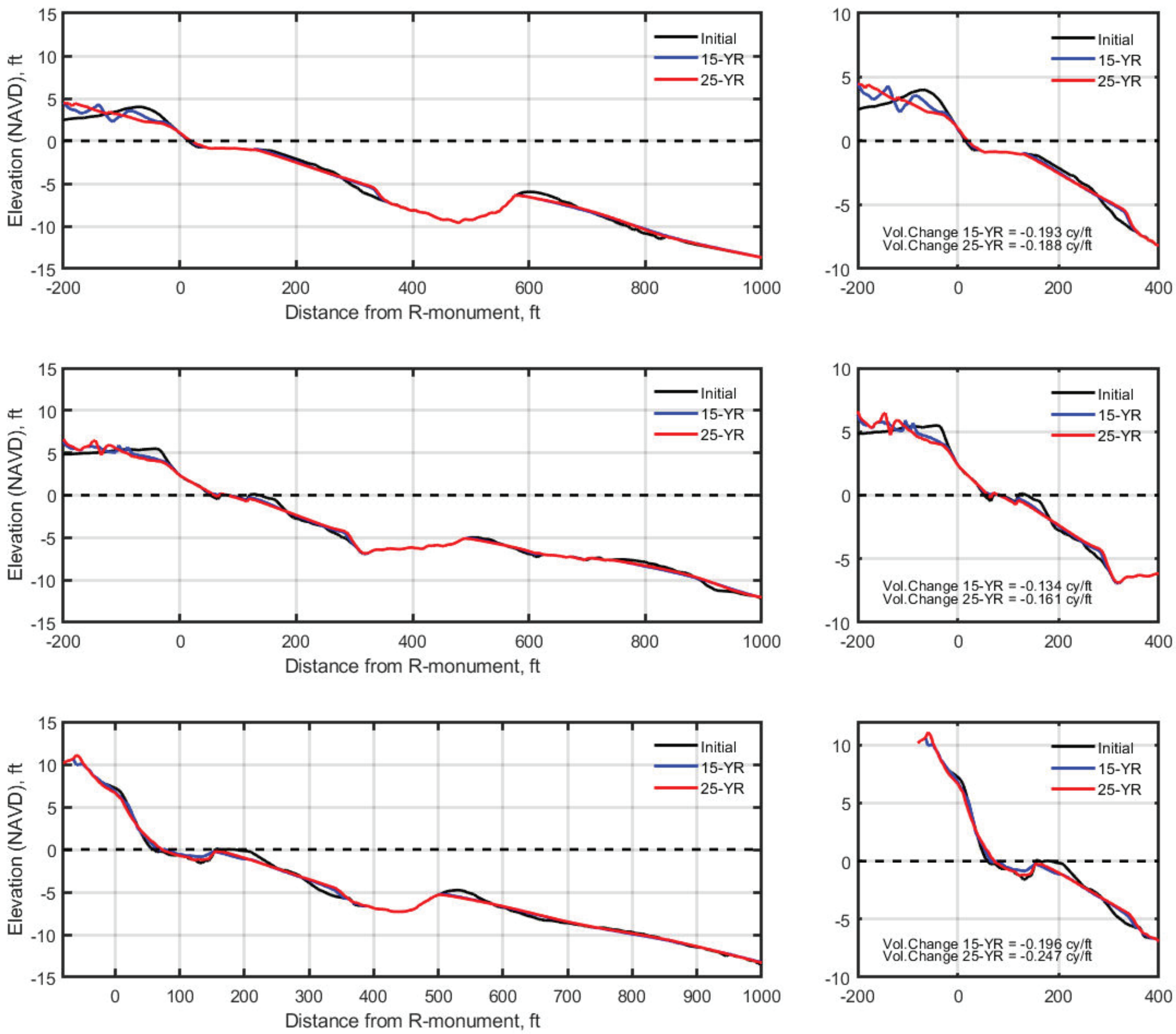

Figure 5: Simulated eroded profiles for the 15-year (blue) and 25-year (red) return period events along (top) R-201, (middle) R-204 and (bottom) R-208

Table 5: Calculated volumetric sand loss and shoreline change analysis based on the 15-year and 25-year storm simulations for beach profiles R-201, R-204, and R-208

Beach Profile	**Volumetric Sand Loss (cy/ft)**		**Shoreline Change (ft)**	
	Storm Event		Storm Event	
	15-year	25-year	15-year	25-year
R-201	0.19	0.19	-0.08	-0.19
R-204	0.13	0.16	0.07	0.04
R-208	0.20	0.25	0.17	0.18

For all return period events at R-201 and R-204, the eroded profiles show major volumetric changes in the existing dune and beach berm area (between 50 and 350 feet seaward of the R-monument), possibly due to their low elevation relative to R-208. A total volumetric sand loss was calculated to be between 0.13 and 0.19 cubic yards per linear foot extending from the landward limit of the profile to 400 feet seaward from the R-monument. At R-208, a volumetric loss between 0.20 and 0.25 cubic yards per linear foot was calculated extending from the landward limit of the profile to 400 feet seaward from the R-monument. Based on the representative shoreline reaches defined in Section 5.3 below, this would result in total volumetric losses from the landward limit of the profile to 400 feet seaward from the R-monument across the project area of 1,448 cubic yards and 1,718 cubic yards for the 15-year and 25-year storm events, respectively. It should be noted that there is some mass balance within this active section of the beach and the dune erosion experienced is more significant than these total erosion values reflect.

A MHW shoreline change calculation was performed using the existing conditions compared to the 15-year and 25-year return period storm events. The shoreline changes from the 15-year return period event at R-201 and R-204 are -0.08 feet and 0.07 feet, respectively. The shoreline changes from the 25-year return period event at R-201 and R-204 are -0.19 feet and 0.04 feet, respectively. The shoreline changes modeled at R-208 are 0.17 feet and 0.18 feet for the 15-year and 25-year storm event, respectively. Although, a slight MHW shoreline advancement is observed for R-204 and R-208 in response to each storm event, it should be noted that the majority of the erosion occurs in the dune system, landward of the MHW line. These results are not surprising given the limitations in the analysis approach employed by the SBEACH model due to the geometry and nature of the barrier beach immediately seaward of the Summer Haven branch of the Matanzas River.

4. Baseline Beach Profiles

One of the main goals of this study is to provide estimated costs for various options to restore and maintain access to Old A1A and protect the integrity of the Summer Haven branch of the Matanzas River. While past remedial actions (Table 2) have added sand to the beach, the goals of these actions have ranged from providing short-term storm protection (FEMA emergency berms) to helping periodically restore an access path to the existing homes, to making beneficial use of sand dredged from the ICWW. None of these actions were designed or intended to provide a long-term solution to the ongoing erosion in this area or be constructed on a regular basis. In addition, the beach profiles have varied significantly for each of the past projects. Since past remedial actions have varied greatly in key aspects, it is not possible to define a “typical” set of conditions or remedial actions to examine.

With this in mind, a “baseline” condition was established for each profile. This “baseline” or “starting” condition was developed to provide a beach berm that was high enough and wide enough to allow driving along the same basic historical alignment of Old A1A. Options and associated costs for establishing, protecting, and maintaining this cross section were evaluated as part of this study.

The following approach was used to develop the “baseline” condition cross-sections for the profiles located along R-201, R-204, and R-208, shown in Figures 6 through 8:

- The composite existing ground elevation profile was used to determine current elevations near the location of the roadway.
- The roadway and berm crest elevation, shown in Table 6, was determined based on the tidal elevations and the existing ground conditions at each R-monument.
  - The elevation of the roadway/berm for each profile was set to be at least one foot above MHHW, so as to minimize inundation of the roadway during high tide events.
  - The elevation of the roadway/berm was set to be approximately equal to (or above for R-208) the anticipated daily wave runup elevation. For daily conditions, a wave height of 3 feet and a wave period of 8 seconds were used to compute runup on the natural

existing beach face slope of 20H:1V (estimated based on the profiles at R-201 and R-204), which resulted in a 2% wave runup of approximately 1.4 feet. This value was added to the MHW elevation of 1.7 feet NAVD88 to ensure minimal overtopping due to wave runup during the daily conditions. The roadway berm elevation was selected as a balance between initial construction costs and associated ongoing maintenance costs.

  - The approximate existing ground elevation from R-204 was used for the beach berm elevation at R-201 since there is no existing road in that area; therefore, the elevation of the roadway was the same for R-201 and R-204.

- The distance from the R-monument, represented by station 0 in the figures below, to the seaward edge of the Old A1A was measured based on historical aerial imagery, with the resulting distances shown in Table 6.
- The roadway width was set to 10 feet, wide enough for a single driving lane.
- A 10-foot buffer was added seaward of the historical seaward edge of Old A1A to determine the seaward edge of the beach berm.
- The beach berm was extended landward to where it intersects the existing ground.
- The seaward edge of the berm was tied into a 10H:1V slope to existing ground in the nearshore.

Table 6: Baseline Cross-Section Parameters

R-monument	Roadway Berm Elevation (ft NAVD88)	Seaward Edge of Old A1A (Distance from R-mon, ft)	Seaward Edge of Beach Berm (Distance from R-mon, ft)
R – 201	3.0	N/A	-13.0
R – 204	3.0	+18.0	+28.0
R – 208	8.0	-14.0	- 4.0

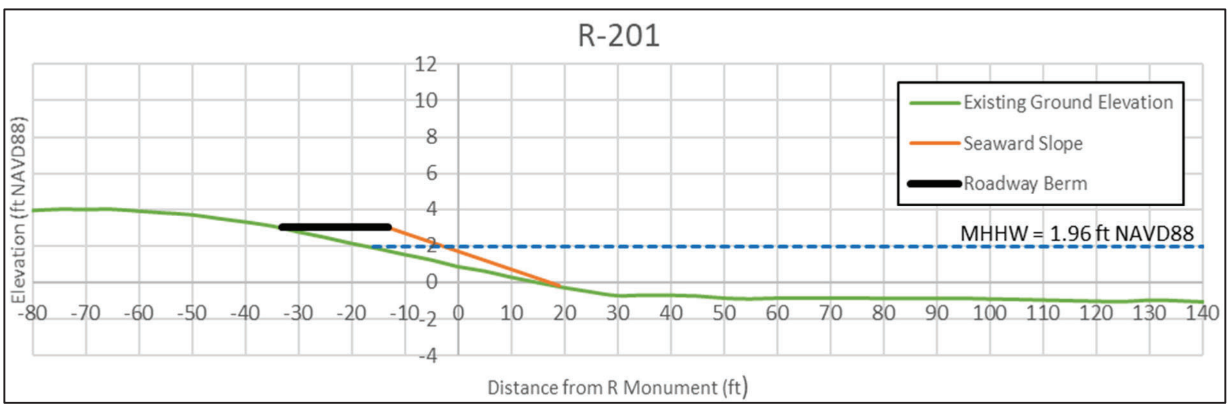

Figure 6: R-201 Baseline Cross-Section

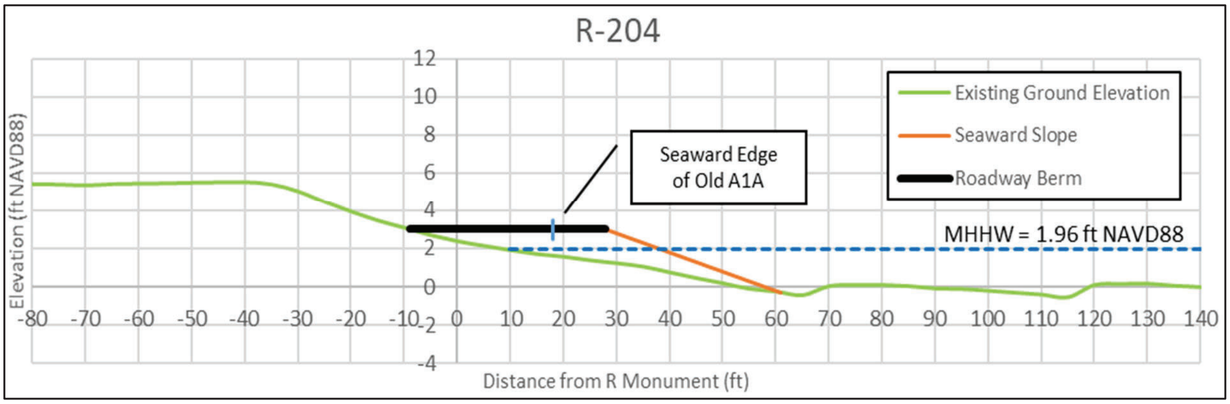

Figure 7: R-204 Baseline Cross-Section

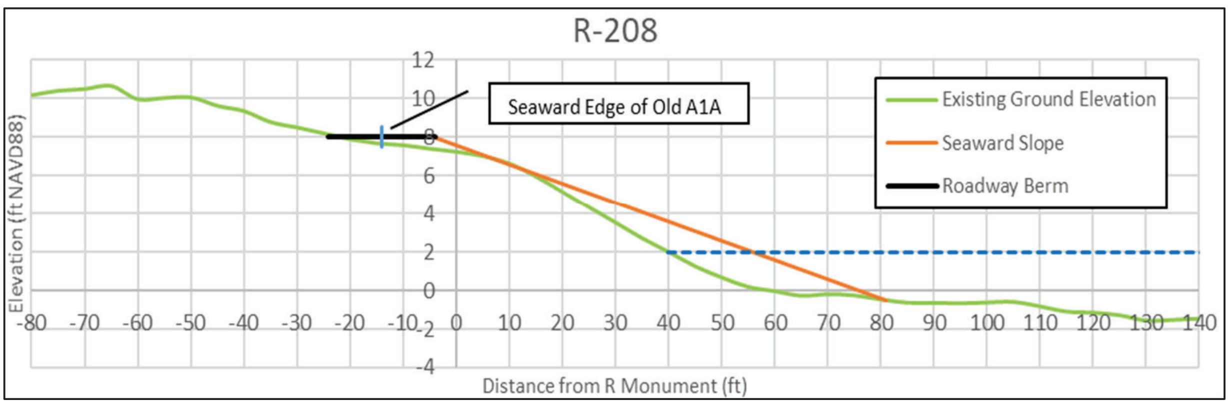

Figure 8: R-208 Baseline Cross-Section

5. Baseline Roadway Berm Volume Assessment

The volume assessment for actions to restore and maintain access via Old A1A over the next 30 and 50 years focused on two major components. The first was the initial beach fill volume to construct a berm to support the driving surface for Old A1A and the second was the beach fill volumes needed to remediate erosion caused by periodic impacts of the 15-year and 25-year return period storm events.

5.1. Initial Beach Fill Volumes

The initial beach fill volumes required to construct a berm to support the driving surface for Old A1A were determined utilizing the baseline cross-sections that were developed previously at FDEP monuments R-201, R-204, and R-208. These were developed using historical imagery, composite survey data, and tidal datum elevations. At each monument, the fill volume per linear foot needed to achieve the baseline cross-section from the existing ground conditions was calculated, as shown in Figure 9 through Figure 11. The initial beach fill volumes calculated at R-201, R-204, and R-208 are 1.3, 2.5, and 3.3 cubic yards per linear foot, respectively, and are summarized in Table 7 below.

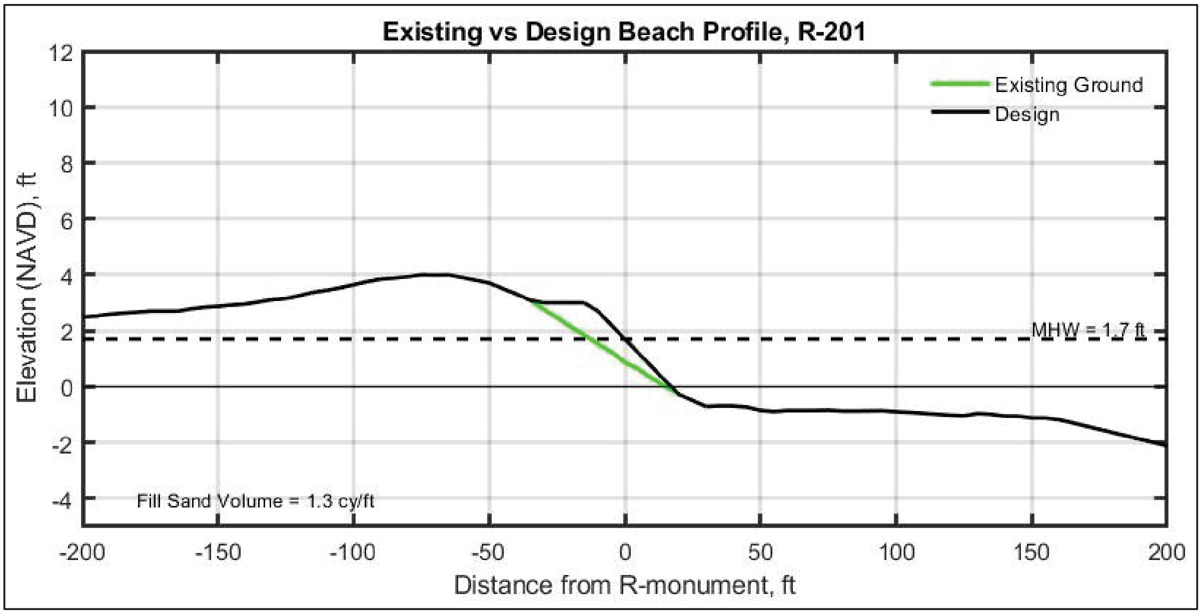

Figure 9: Initial Beach Fill Volume at Profile R-201

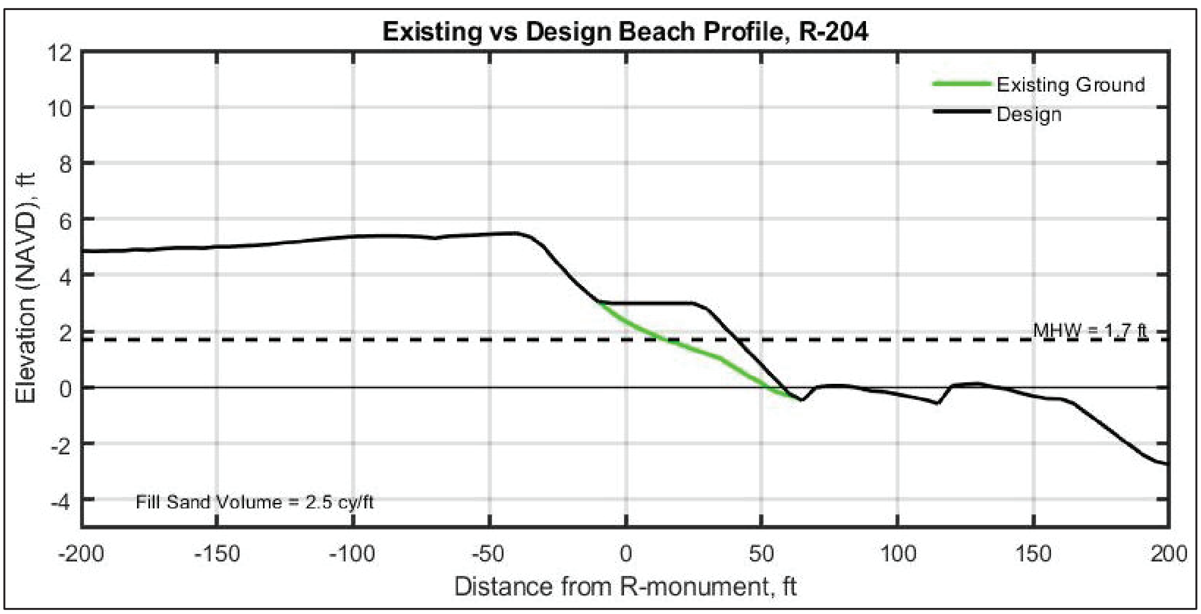

Figure 10: Initial Beach Fill Volume at Profile R-204

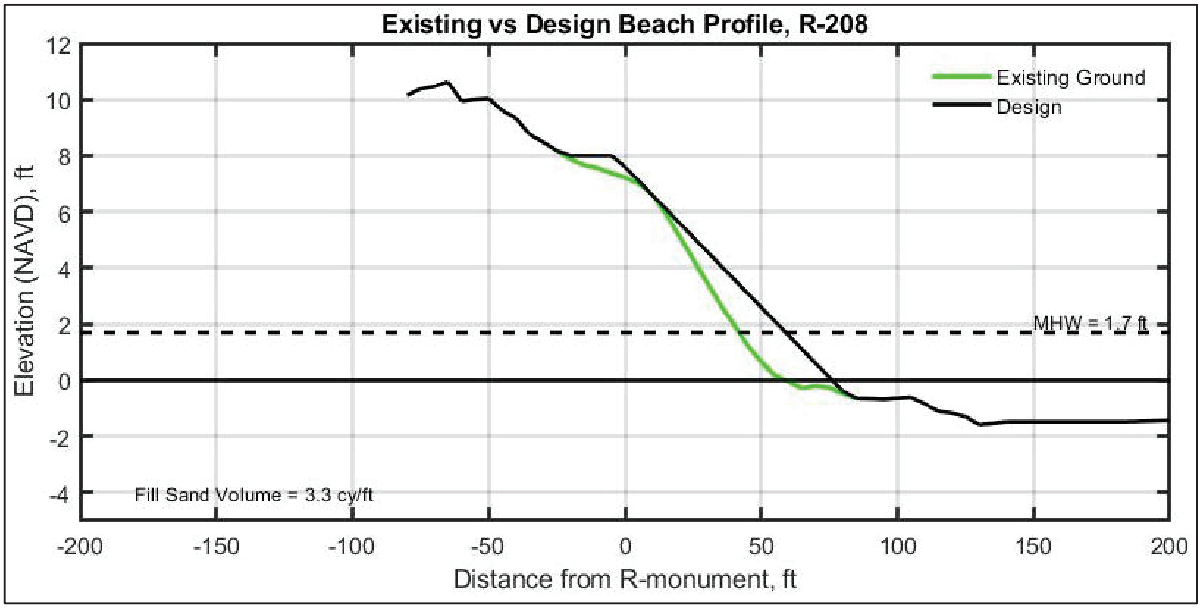

Figure 11: Initial Beach Fill Volume at Profile R-208

Table 7: Initial Beach Fill Volumes per Linear Foot at Each Profile

Profile	Required Initial Beach Fill Volume (CY/LF)
R-201	1.3
R-204	2.5
R-208	3.3

5.2. Remediation Beach Fill Volumes

The SBEACH storm erosion model within the CEDAS software was used to determine the beach fill volumes needed to remediate erosion caused by the 15-year and 25-year events. Utilizing the baseline cross-sections developed previously as the starting profile conditions, SBEACH was used to simulate storm-induced erosion for the 15-year and 25-year return interval storm events. Most of the model input data for the storm event wave parameters and water level hydrographs were obtained from Appendix VI and Appendix VII of the June 2010 SBEACH Model Studies for the Florida Atlantic Coast for St. Johns County report, performed by FDEP. The eroded profiles for the 15-year and 25-year return period events at each beach profile are shown in Figure 12 through Figure 14 for a simulation duration of 36 hours, where the location of the R-monument is represented by station zero.

Based on the eroded profiles for each storm event, the amount of beach fill needed to remediate the storm erosion and return the upland profile to the baseline condition was calculated for each storm event at each monument. Since the focus of this study is to restore and maintain access to Old A1A, the remediation volumes were calculated above the MHW elevation identified as +1.70 feet NAVD88. The calculated volumes needed for restoration of the baseline profile assumes that:

- New material will be brought in via truck haul to replace any upland losses (above MHW) from each storm event.
- Material that is pushed landward within the profile will be considered lost and will not be manipulated to rebuild the baseline road template after each storm event.

- Sand that may have been shifted to the portion of each profile below MHW is assumed to be unrecoverable.

The remediation beach fill volumes calculated at R-201, R-204, and R-208 for the 15-year return period event are 3.04, 2.80, and 0.49 cubic yards per linear foot, respectively. The remediation beach fill volumes calculated at R-201, R-204, and R-208 for the 25-year return period event are 4.04, 2.67, and 1.01 cubic yards per linear foot, respectively. These results are summarized in Table 8 below.

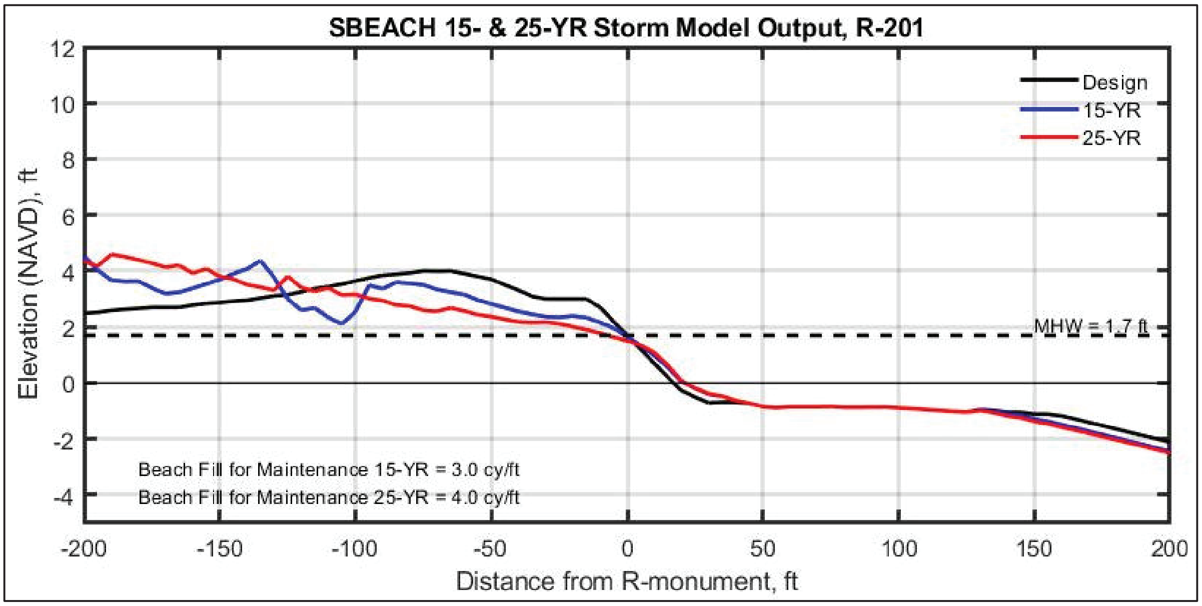

Figure 12: Eroded Profiles for the 15- and 25-year events at Profile R-201

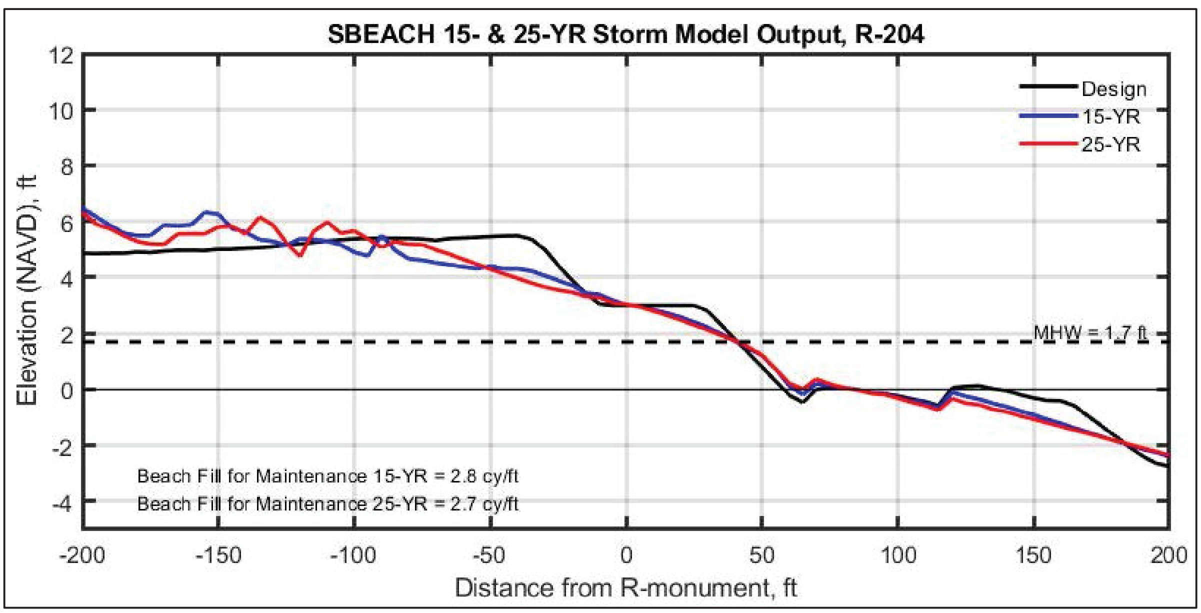

Figure 13: Eroded Profiles for the 15- and 25-year events at Profile R-204

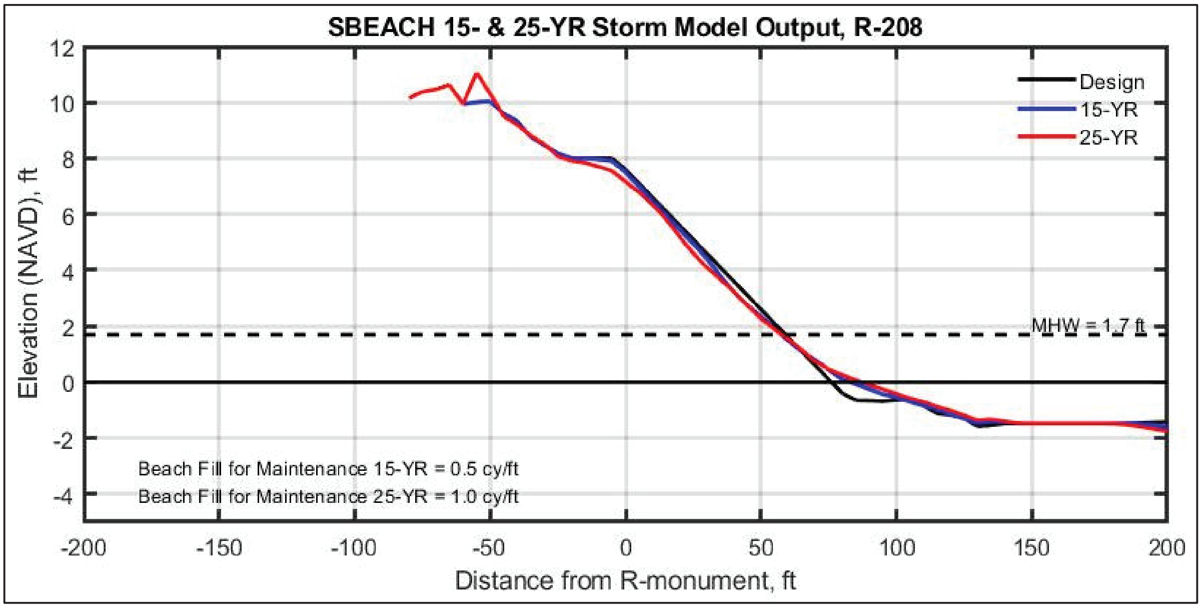

Figure 14: Eroded Profiles for the 15- and 25-year events at Profile R-208

Table 8: Remediation Beach Fill Volumes per Linear Foot at Each Profile

Profile	Required 15-Year Storm Event Remediation Beach Fill Volume (CY/LF)	Required 25-Year Storm Event Remediation Beach Fill Volume (CY/LF)
R-201	3.0	4.0
R-204	2.8	2.7
R-208	0.5	1.0

5.3. Representative Shoreline Segments

Once the volumes per linear foot were calculated at each of the three profile lines, representative beach reaches for each profile were defined. This was accomplished using aerial imagery and recent survey data to determine the length of shoreline each profile would characterize, as shown in Figure 15. The shoreline lengths represented by R-201, R-204, and R-208 are 1,764 linear feet, 3,348 linear feet, and 3,388 linear feet, respectively. These shoreline segments were also used for the restoration alternatives.

Figure 15: Representative Beach Profile Reaches

5.4. Beach Fill Volume Summary

The required fill volume at each profile was then applied along its representative shoreline reach to determine the total beach fill volume. The initial fill volume was calculated to be approximately 21,630 cubic yards. The total remediation beach fill volumes were determined to be approximately 16,420 cubic yards for the 15-year return period event and 19,500 cubic yards for the 25-year return period event.

Table 9 below summarizes the required initial and remediation beach fill volumes for each representative profile reach. As noted previously, the calculated volumes needed for remediation of the baseline profile assumes that new material will be brought in via truck haul to replace any upland losses (above MHW) from each storm event.

Table 9: Beach Fill Volume Summary

Profile Reach	Representative Shoreline Length (LF)	Required Initial Beach Fill Volume (CY)	Required Remediation Beach Fill Volume for 15-Year Event (CY)	Required Remediation Beach Fill Volume for 25-Year Event (CY)
R-201	1,764	2,300	5,370	7,130
R-204	3,348	8,310	9,380	8,940
R-208	3,388	11,020	1,670	3,430
Total	**8,500**	**21,630**	**16,420**	**19,500**

5.5. Baseline Roadway Berm Cost Estimate

The cost assessments for continuing remediation actions to restore and maintain access to Old A1A over the next 30 and 50 years focused on two major components: (1) the initial beach fill volume needed to construct a berm to support the driving surface for Old A1A in its approximate historical location and (2) the beach fill volumes needed to remediate erosion caused by periodic impacts of the 15-year and 25-year storm events. Due to the long duration of the continued remediation, inflation was included for remediation of future storm events.

Cost estimates are provided for the 30-year and 50-year time periods in Table 10 and Table 11, respectively. The approximate total costs to restore and maintain Old A1A over the next 30 and 50 years were calculated to be approximately $9,940,000 and $20,891,000, respectively.

The following assumptions were made in developing these cost estimates:

- New material will be brought in via truck haul to replace any upland losses from the storm events. Material that is pushed landward within the profile will be considered lost and will not be manipulated to rebuild the baseline road template after each storm event.
- Cost for placing crushed shell or other material to create a solid driving surface was not included since this type of work has not been done by St. Johns County for many years and it would have a relatively minimal contribution to the overall cost.
- Costs do not include any dredging of the Summer Haven branch of the Matanzas River, including removal of any sand overwashed into the river during storm events.
- Costs assume truck hauling beach fill material at a unit cost of $95 per cubic yard based on recent bids received by St. Johns County for truck hauling sand to the beaches of northern St. Johns County. While pumping material dredged from nearby waterways could be done at a significantly lower unit cost, this material is not available on a regular basis and was therefore not used for determining sand placement costs.
- Opportunities for sand placement due to dredging sand from the ICWW could result in cost savings; however, these alternative unit costs were not included in this study.
- Cost estimates assume 4% inflation per year for the first five (5) years, then 3% inflation per year for the remainder of each time period. These estimates are based on Atkins' ongoing efforts to research and stay up to date with construction cost trends.
- The 30-year cost assumes two (2) 15-year return period storm events (estimated to occur in Year 5 and Year 20) and one (1) 25-year storm event (estimated to occur in Year 15) will occur within this time period.

- The 50-year cost assumes three (3) 15-year return period storm events (estimated to occur in Year 5, Year 20, and Year 35) and two (2) 25-year storm events (estimated to occur in Year 15 and Year 40) will occur within this time period.
- It is anticipated that periodic maintenance due to routine wave effects will be needed twice annually for the beach reaches represented by R-201 and R-204. It is estimated that the fill volume required for each maintenance event is on the order of 3,100 cubic yards based on the volume necessary to replenish the buffer seaward of the roadway, for an approximate total annual cost of $590,000 based on the current unit price of $95 per cubic yard. In years with more active wave climates, this cost could be considerably higher. This cost has not been included in the project costs shown below.

Table 10: 30-Year Continued Remediation Cost Estimate for Baseline Roadway Berm

Reach	Event	Required Fill Volume per Event (CY)	Unit Cost ($/CY)	Total Cost ($)
R-201	Initial	2,300	$95.00	$219,000
	15-year Storm Event (Year 5)	5,370	$115.58	$621,000
	15-year Storm Event (Year 20)	5,370	$180.07	$967,000
	25-year Storm Event (Year 15)	7,130	$155.33	$1,108,000
	Subtotal			$2,915,000
R-204	Initial	8,310	$95.00	$789,000
	15-year Storm Event (Year 5)	9,380	$115.58	$1,084,000
	15-year Storm Event (Year 20)	9,380	$180.07	$1,689,000
	25-year Storm Event (Year 15)	8,940	$155.33	$1,389,000
	Subtotal			$4,951,000
R-208	Initial	11,020	$95.00	$1,047,000
	15-year Storm Event (Year 5)	1,670	$115.58	$193,000
	15-year Storm Event (Year 20)	1,670	$180.07	$301,000
	25-year Storm Event (Year 15)	3,430	$155.33	$533,000
	Subtotal			$2,074,000
Total				**$9,940,000**

Table 11: 50-Year Continued Remediation Cost Estimate for Baseline Roadway Berm

Reach	Event	Required Fill Volume per Event (CY)	Unit Cost ($/CY)	Total Cost ($)
R-201	Initial	2,300	$95.00	$219,000
	15-year Storm Event (Year 5)	5,370	$115.58	$621,000
	15-year Storm Event (Year 20)	5,370	$180.07	$967,000
	15-year Storm Event (Year 35)	5,370	$280.55	$1,507,000
	25-year Storm Event (Year 15)	7,130	$155.33	$1,108,000
	25-year Storm Event (Year 40)	7,130	$325.23	$2,319,000
	Subtotal			$6,741,000
R-204	Initial	8,310	$95.00	$789,000
	15-year Storm Event (Year 5)	9,380	$115.58	$1,084,000
	15-year Storm Event (Year 20)	9,380	$180.07	$1,689,000
	15-year Storm Event (Year 35)	9,380	$280.55	$2,632,000
	25-year Storm Event (Year 15)	8,940	$155.33	$1,389,000
	25-year Storm Event (Year 40)	8,940	$325.23	$2,908,000
	Subtotal			$10,491,000
R-208	Initial	11,020	$95.00	$1,047,000
	15-year Storm Event (Year 5)	1,670	$115.58	$193,000
	15-year Storm Event (Year 20)	1,670	$180.07	$301,000
	15-year Storm Event (Year 35)	1,670	$280.55	$469,000
	25-year Storm Event (Year 15)	3,430	$155.33	$533,000
	25-year Storm Event (Year 40)	3,430	$325.23	$1,116,000
	Subtotal			$3,659,000
Total				**$20,891,000**

6. Restoration Alternatives Design Parameters

Four (4) basic alternatives to restore and maintain access to Old A1A are being considered under this study, including: (1) dune restoration with periodic maintenance and repair, (2) beach and dune restoration with periodic maintenance beach nourishment, (3) construction of a nearshore segmented breakwater, and (4) construction of a seawall. It should be noted that these restoration alternatives are conceptual in nature and are intended to present preliminary concepts and designs. Additional refinement of these designs would be required prior to implementation.

The daily water elevations utilized for conceptual design are consistent with those provided above, where the mean higher-high water (MHHW) elevation is approximately 1.96 feet relative to NAVD88 and the mean high water (MHW) elevation is approximately 1.70 feet relative to NAVD88. As stated previously, the surge elevations (and water level hydrographs, where applicable) for the 15-year and 25-year storm events were obtained from Appendix VI and Appendix VII of the June 2010 SBEACH Model Studies for the Florida Atlantic Coast for St. Johns County report, performed by FDEP. As noted above, sea level rise was not included in the design water elevations for the conceptual alternatives analysis. Long term shoreline recession rates were also not included in the design of the conceptual alternatives due to inlet sand bypassing in the project area. Additionally, including this would increase estimated costs for the dune restoration and beach and dune restoration alternatives (Alternatives 1 and 2).

6.1. Alternative 1 – Dune Restoration

The dune restoration with periodic maintenance and repair alternative builds upon the baseline roadway cross-sections developed previously for R-201, R-204, and R-208. The proposed dune is placed landward of the baseline roadway berm to help limit overwash during storm events into the Summer Haven branch of the Matanzas River; placing the dune on the seaward side of the roadway was judged to be impractical given the narrow beach width. For this alternative, the volume analysis included the initial beach fill volume, as well as the beach fill volumes needed to remediate erosion caused by periodic impacts of the 15-year and 25-year return period storm events. Due to the narrow beach width, construction of this dune (which is also proposed in Alternative 2) will need to extend onto private properties.

The dune parameters to be incorporated into the baseline profiles are summarized as follows:

- Dune crest elevation of +10 feet NAVD88
- Dune crest width of 15 feet
- Side slope of 4H:1V to tie into existing ground on the landward side
- Side slope of 4H:1V to tie into the roadway berm at the landward side of the proposed Old A1A footprint (leaving a 20-foot-wide berm for the roadway and buffer) on the seaward side

The proposed profiles at R-201, R-204, and R-208 for the dune restoration alternative can be seen in Figure 16 through Figure 18 in Section 6.1.1. The conceptual plan view and typical cross-sections are provided in Appendix A.

6.1.1. Initial Beach Fill Placement Volumes

The initial beach fill volumes were determined for the dune alternative at FDEP monuments R-201, R-204, and R-208 using the combined baseline and dune profile, as well as the composite existing ground survey data. At each monument, the fill volume per linear foot to achieve the proposed dune alternative cross-section from the contemporary existing ground conditions was calculated, as shown in Figure 16 through Figure 18. The initial beach fill volumes calculated at R-201, R-204, and R-208 are 10.3, 10.3, and 3.9 cubic yards per linear foot, respectively, and are summarized in Table 12 below.

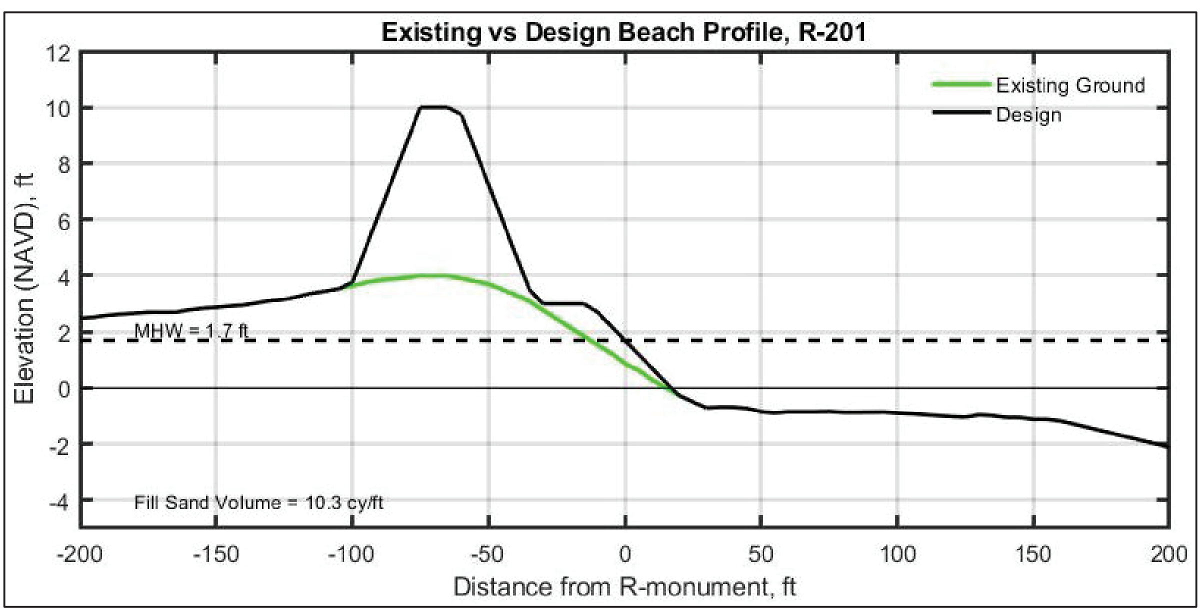

Figure 16: Initial Beach Fill Volume at Profile R-201 for Alternative 1 (Dune Restoration)

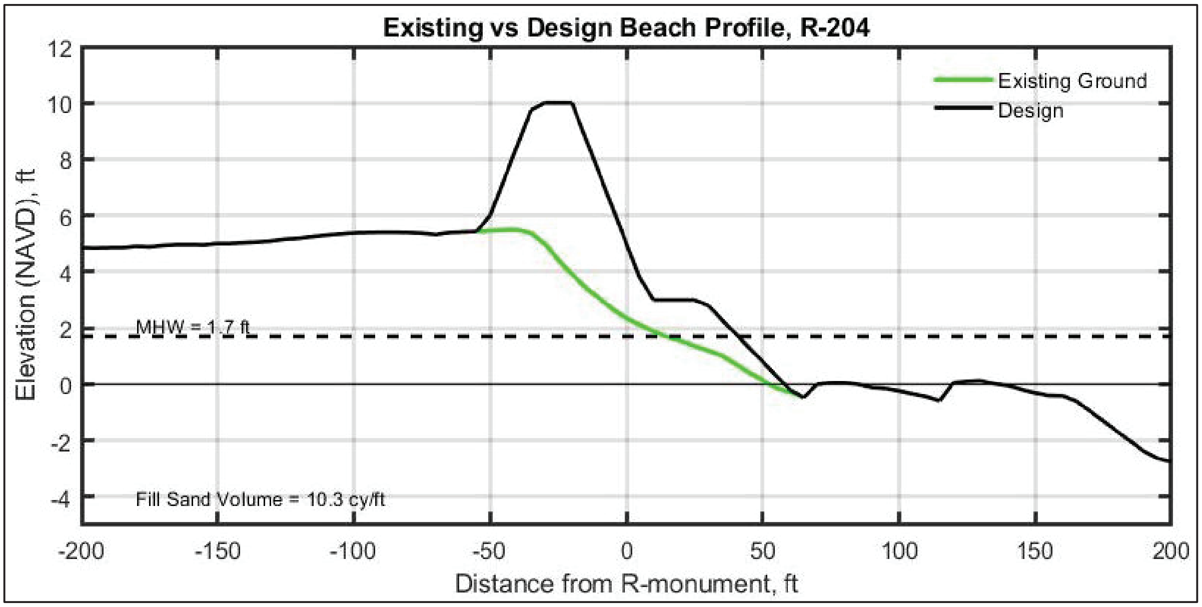

Figure 17: Initial Beach Fill Volume at Profile R-204 for Alternative 1 (Dune Restoration)

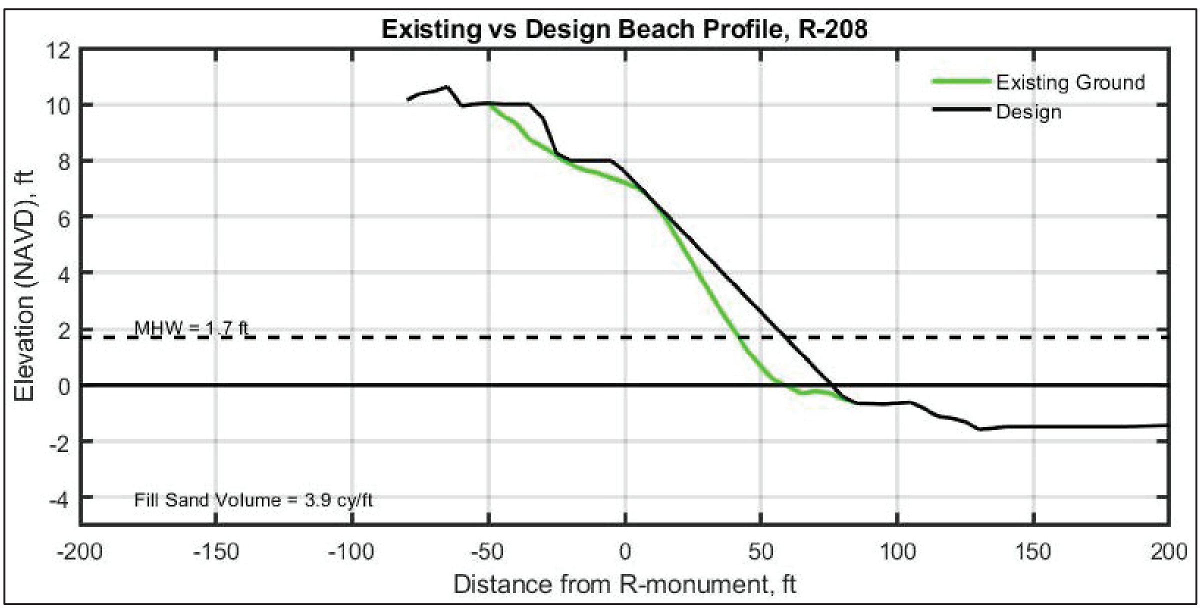

Figure 18: Initial Beach Fill Volume at Profile R-208 for Alternative 1 (Dune Restoration)

Table 12: Initial Beach Fill Volumes per Linear Foot at Each Profile for Alternative 1 (Dune Restoration)

Profile	Required Initial Beach Fill Volume (CY/LF)
R-201	10.3
R-204	10.3
R-208	3.9

6.1.2. Remediation Beach Fill Placement Volumes

The SBEACH storm erosion model within the CEDAS software was used to determine the beach fill volumes needed to remediate erosion caused by the 15-year and 25-year events utilizing the parameters defined above. The eroded profiles for the 15-year and 25-year return period events at each beach profile are shown in Figure 19 through Figure 21 for a simulation duration of 36 hours, where the location of the R-monument is represented by station zero.

Based on the eroded profiles for each storm event, the amount of beach fill needed to remediate the storm erosion and return the upland profile to the baseline condition was calculated for each storm event at each monument. Similar to the roadway berm analysis, it was assumed that all new material will be brought in to replace any losses within the template from the statistical storm events. Material that is displaced landward of the template will be left in place and not used to restore the template. The remediation beach fill volumes calculated at R-201, R-204, and R-208 for the 15-year return period event are all approximately 0.5 cubic yards per linear foot. The remediation beach fill volumes calculated at R-201, R-204, and R-208 for the 25-year return period event are 0.8, 7.2, and 0.8 cubic yards per linear foot, respectively.

It should be noted that the SBEACH results seem to underestimate the magnitude of dune erosion that would be expected during a major storm event for most profiles and events with this alternative; however, this seems to be a known complication with utilizing SBEACH to calculate erosion in some cases. Only the 25-year storm event at R-204 showed potential material overwash into the Summer Haven branch of the Matanzas River for this alternative; however, the potential amount of material is estimated to be relatively small (total of approximately 23,450 cubic yards across the representative shoreline length). The remediation beach fill volumes calculated at R-201, R-204, and R-208 are summarized in Table 13 below.

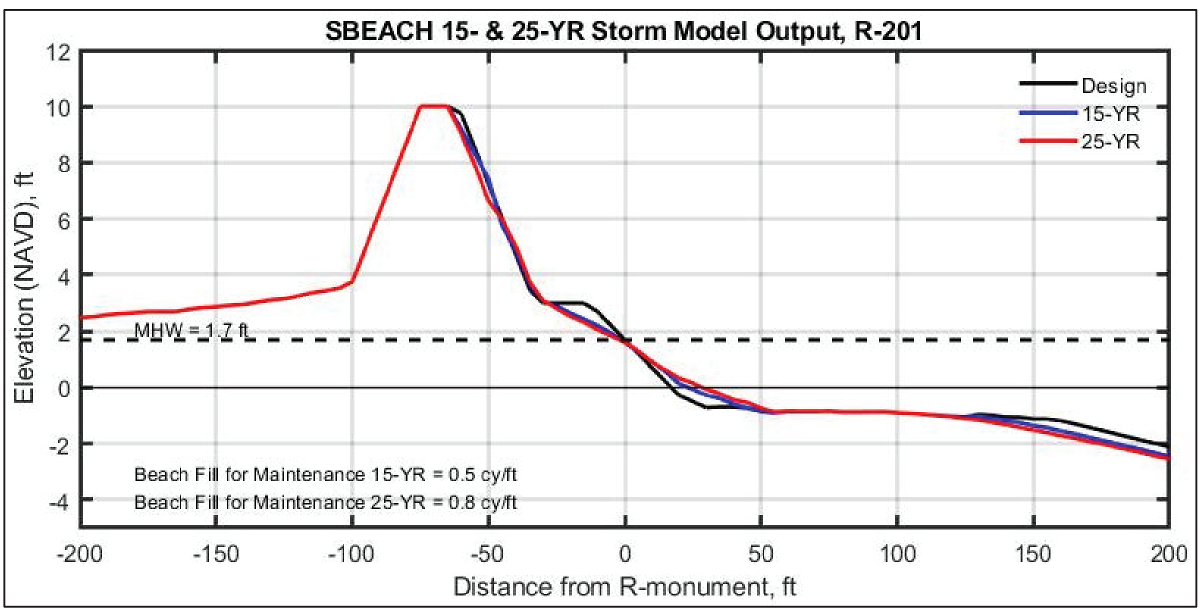

Figure 19: Remediation Beach Fill Volume at Profile R-201 for Alternative 1 (Dune Restoration)

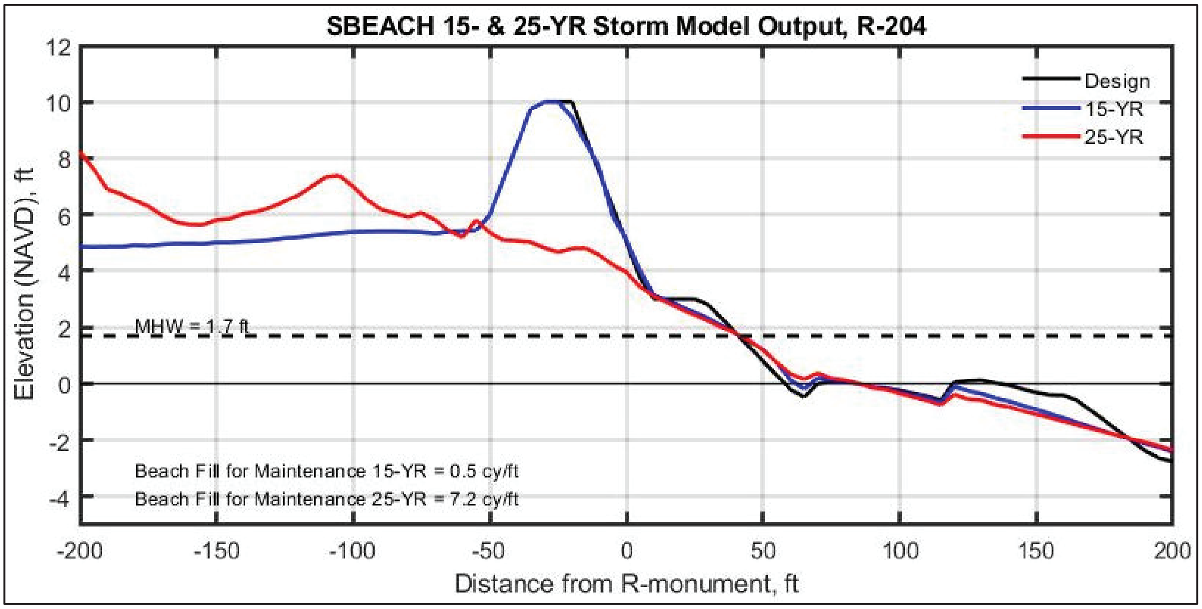

Figure 20: Remediation Beach Fill Volume at Profile R-204 for Alternative 1 (Dune Restoration)

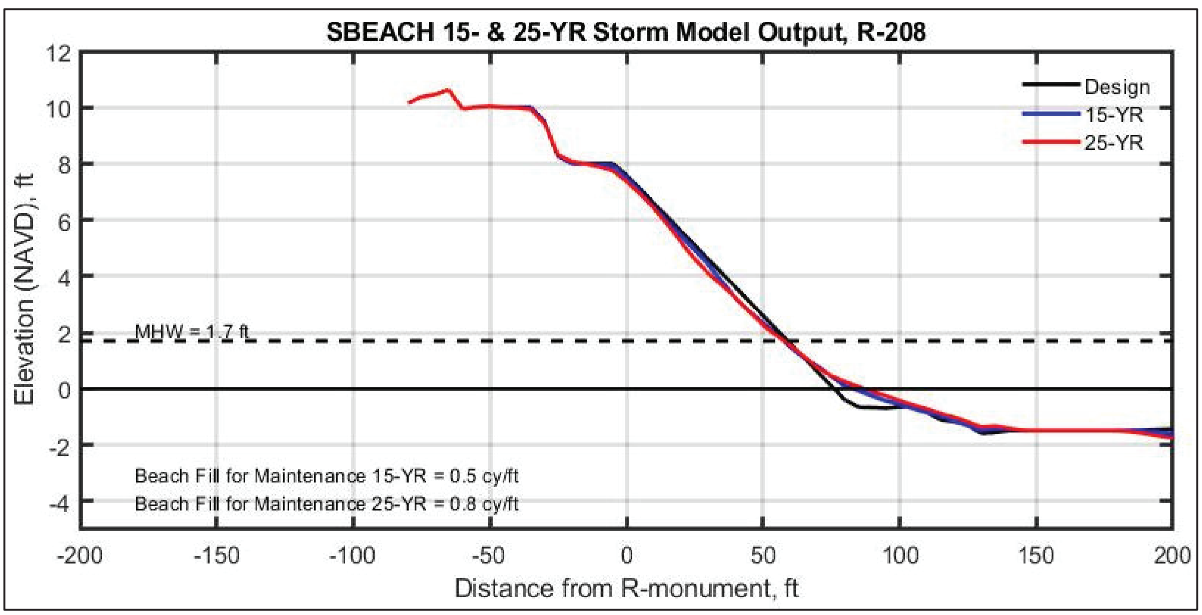

Figure 21: Remediation Beach Fill Volume at Profile R-208 for Alternative 1 (Dune Restoration)

Table 13: Remediation Beach Fill Volumes per Linear Foot at Each Profile for Alternative 1 (Dune Restoration)

Profile	Required 15-Year Storm Event Remediation Beach Fill Volume (CY/LF)	Required 25-Year Storm Event Remediation Beach Fill Volume (CY/LF)
R-201	0.5	0.8
R-204	0.5	7.2
R-208	0.5	0.8

6.1.3. Beach Fill Placement Volume Summary

The required fill volume at each profile was then applied along its representative shoreline reach as defined above to determine the total initial beach fill volume of approximately 65,880 cubic yards, as well as the total remediation beach fill volumes of approximately 4,270 cubic yards for the 15-year return period event and 28,250 cubic yards for the 25-year return period event. Table 14 summarizes the required initial and remediation beach fill volumes for each representative profile reach. As noted previously, the calculated volumes needed for remediation of the baseline profile assume that new material will be brought in via truck haul to account for any losses within the proposed template from the statistical storm events.

Table 14: Beach Fill Volume Summary for Alternative 1 (Dune Restoration)

Profile Reach	Representative Shoreline Length (LF)	Required Initial Beach Fill Volume (CY)	Required Remediation Beach Fill Volume for 15-Year Event (CY)	Required Remediation Beach Fill Volume for 25-Year Event (CY)
R-201	1,764	18,170	890	1,420
R-204	3,348	34,490	1,680	24,110
R-208	3,388	13,220	1,700	2,720
Total	**8,500**	**65,880**	**4,270**	**28,250**

6.2. Alternative 2 – Beach and Dune Restoration

The conventional beach and dune restoration with periodic maintenance and repair alternative builds upon the baseline roadway cross-sections developed previously for R-201, R-204, and R-208, as well as the dune restoration proposed as Alternative 1. For this alternative, the proposed beach berm is placed seaward of the roadway berm to help limit damage to Old A1A. The volume analysis included the initial beach fill volume, as well as the beach fill volumes needed to remediate erosion caused by periodic impacts of the 15-year and 25-year return period storm events.

The dune and beach parameters incorporated into the baseline profiles for this alternative are summarized as follows:

- Dune (same as defined for Alternative 1):
  - Crest elevation of +10 feet NAVD88
  - Crest width of 15 feet
  - Side slope of 4H:1V to tie into existing ground on the landward side
  - Side slope of 4H:1V to tie into the roadway berm at the landward side of the proposed Old A1A footprint (leaving a 20-foot-wide berm for the roadway and buffer) on the seaward side
- Beach berm:
  - Berm crest elevation of +3 feet NAVD88
  - Berm crest width of an additional 100 feet
    - R-201 and R-204 include the roadway berm crest width plus an additional 100 feet of berm for a total berm crest width of 120 feet
    - R-208 adds a secondary beach berm crest that is 100 feet wide at the specified beach berm crest elevation of +3 feet NAVD88
  - Seaward slope of 10H:1V to tie into existing ground in the nearshore

The proposed profiles at R-201, R-204, and R-208 for the beach and dune restoration alternative can be seen in Figure 22 through Figure 24 in Section 6.2.1. The conceptual plan view and typical cross-sections are provided in Appendix A.

6.2.1. Initial Beach Fill Placement Volumes

The initial beach fill volumes were determined for the beach and dune alternative at FDEP monuments R-201, R-204, and R-208 using the proposed profiles defined above, as well as the composite existing ground survey data. At each R-monument, the fill volume per linear foot to achieve the proposed beach and dune alternative cross-section from the contemporary existing ground conditions was calculated, as shown in Figure 22 through Figure 24. The initial beach fill volumes calculated at R-201, R-204, and R-208 are 24.5, 22.0, and 19.4 cubic yards per linear foot, respectively, and are summarized in Table 15 below.

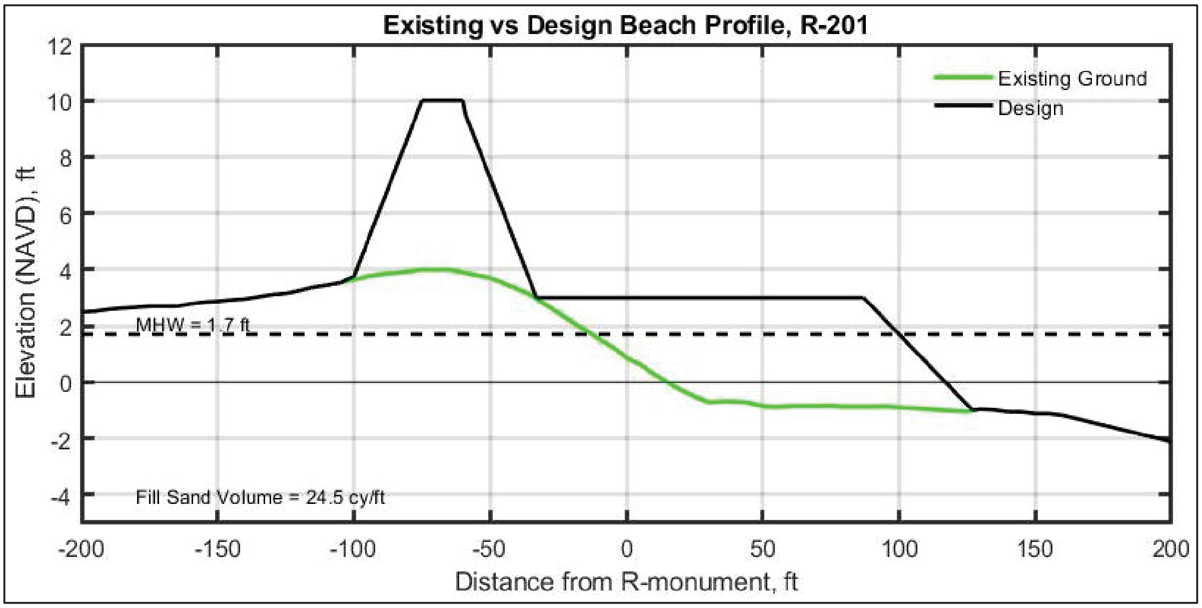

Figure 22: Initial Beach Fill Volume at Profile R-201 for Alternative 2 (Beach and Dune Restoration)

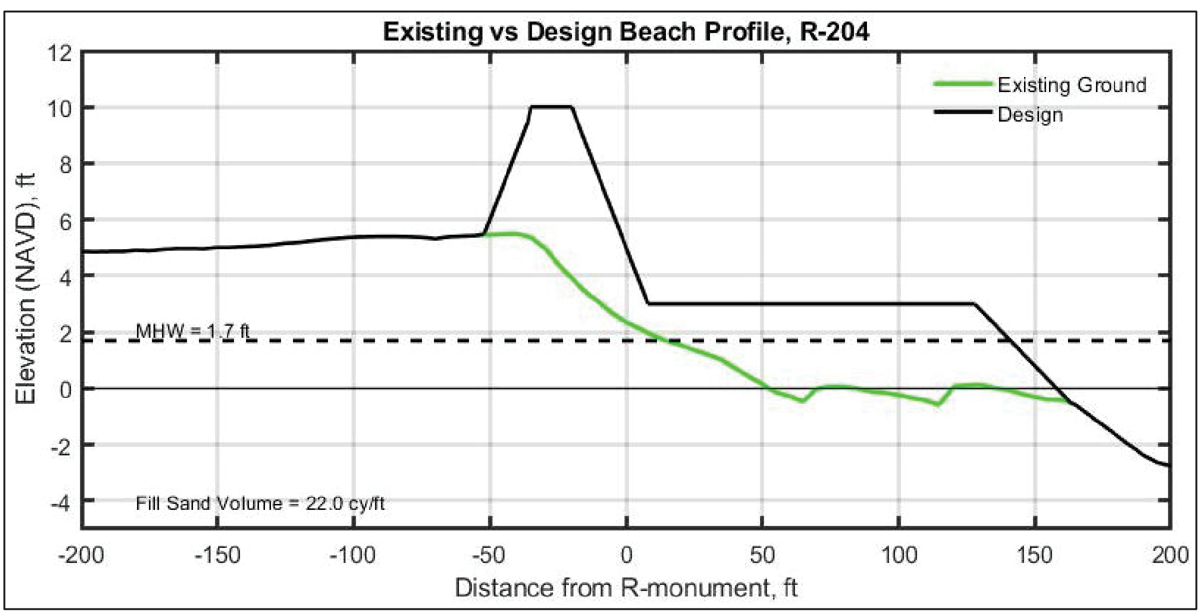

Figure 23: Initial Beach Fill Volume at Profile R-204 for Alternative 2 (Beach and Dune Restoration)

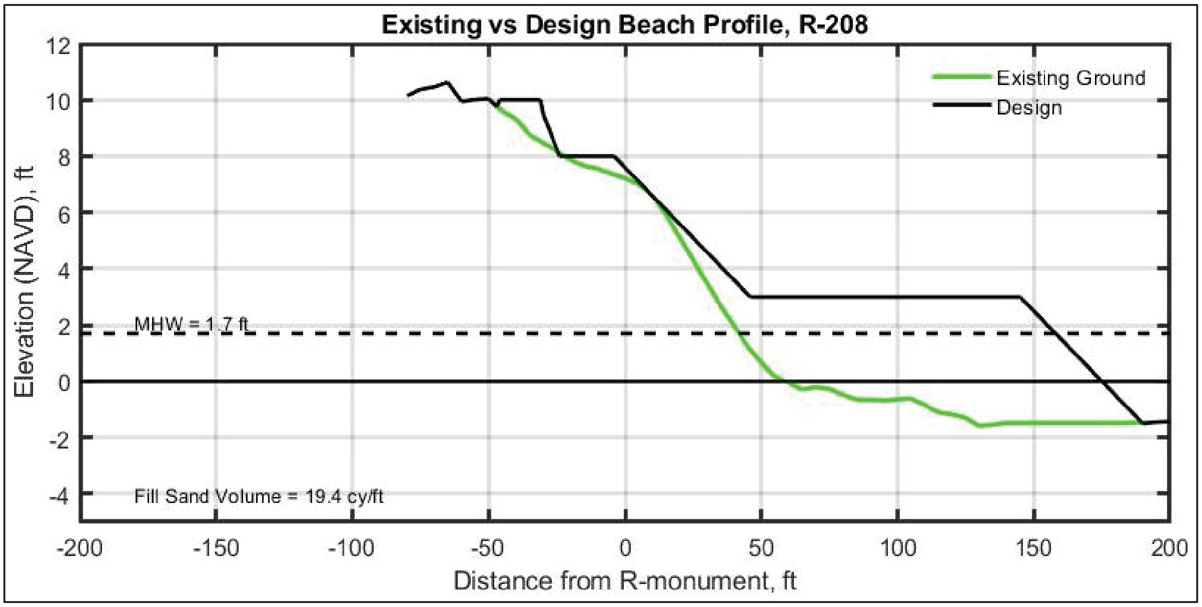

Figure 24: Initial Beach Fill Volume at Profile R-208 for Alternative 2 (Beach and Dune Restoration)

Table 15: Initial Beach Fill Volumes per Linear Foot at Each Profile for Alternative 2 (Beach and Dune Restoration)

Profile	Required Initial Beach Fill Volume (CY/LF)
R-201	24.5
R-204	22.0
R-208	19.4

6.2.2. Remediation Beach Fill Placement Volumes

The SBEACH storm erosion model within the CEDAS software was used to determine the beach fill volumes needed to remediate erosion caused by the 15-year and 25-year events utilizing the parameters defined above. The eroded profiles for the 15-year and 25-year return period events at each beach profile are shown in Figure 25 through Figure 27 for a simulation duration of 36 hours, where the location of the R-monument is represented by station zero.

Based on the eroded profiles for each storm event, the amount of beach fill needed to remediate the storm erosion and return the upland profile to the baseline condition was calculated for each storm event at each monument. Similar to the roadway berm analysis, it was assumed that all new material will be brought in to replace any losses within the template from the statistical storm events. Material that is shifted landward to the base of the dune will be left in place and not used to restore the berm template. The remediation beach fill volumes calculated at R-201, R-204, and R-208 for the 15-year return period event are 2.9, 5.0, and 3.5 cubic yards per linear foot, respectively. The remediation beach fill volumes calculated at R-201, R-204, and R-208 for the 25-year return period event are 3.4, 5.6, and 4.1 cubic yards per linear foot, respectively. The remediation beach fill volumes calculated at R-201, R-204, and R-208 are summarized in Table 16 below.

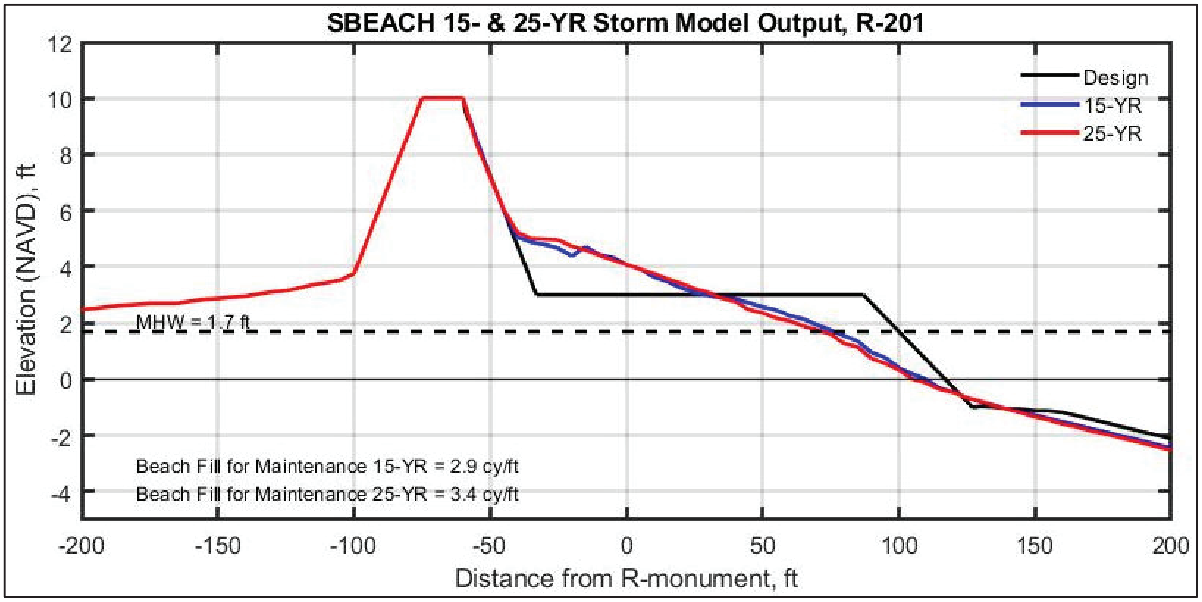

Figure 25: Remediation Beach Fill Volume at Profile R-201 for Alternative 2 (Beach and Dune Restoration)

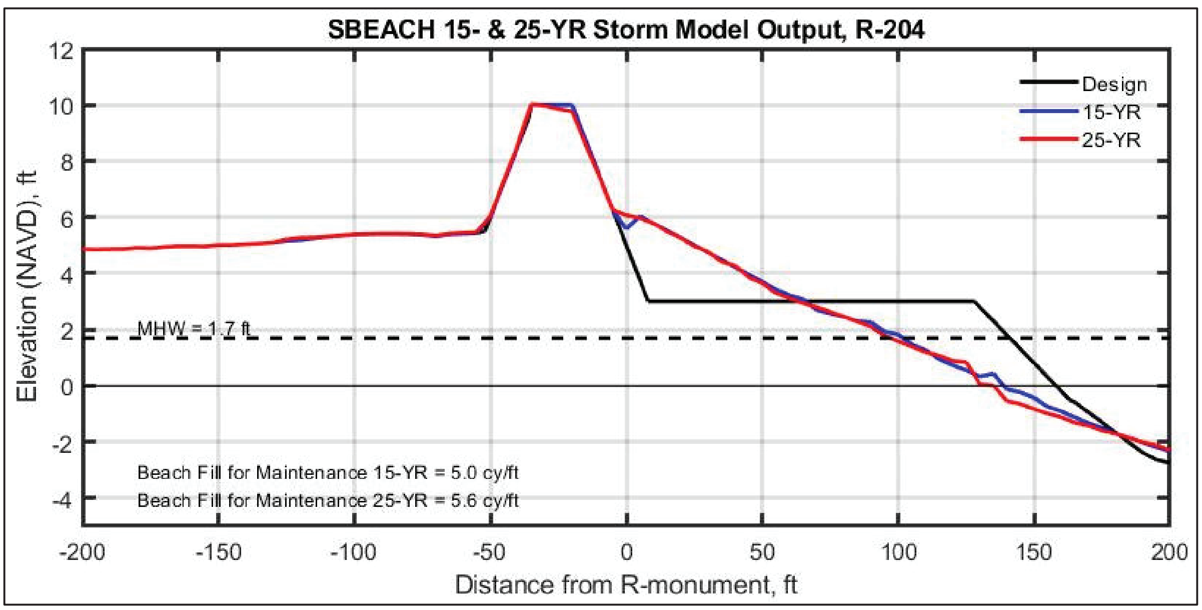

Figure 26: Remediation Beach Fill Volume at Profile R-204 for Alternative 2 (Beach and Dune Restoration)

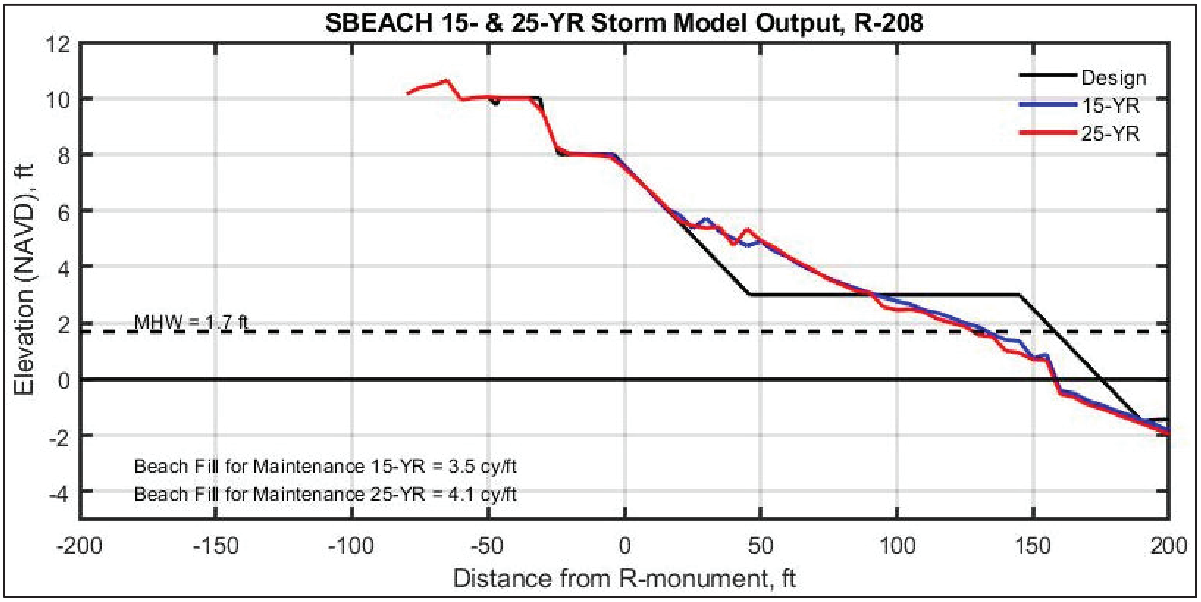

Figure 27: Remediation Beach Fill Volume at Profile R-208 for Alternative 2 (Beach and Dune Restoration)

Table 16: Remediation Beach Fill Volumes per Linear Foot at Each Profile for Alternative 2 (Beach and Dune Restoration)

Profile	Required 15-Year Storm Event Remediation Beach Fill Volume (CY/LF)	Required 25-Year Storm Event Remediation Beach Fill Volume (CY/LF)
R-201	2.9	3.4
R-204	5.0	5.6
R-208	3.5	4.1

6.2.3. Beach Fill Placement Volume Summary

The required fill volume at each profile was then applied along its representative shoreline reach as defined above to determine the total initial beach fill volume of approximately 182,610 cubic yards, as well as the total remediation beach fill volumes of approximately 33,720 cubic yards for the 15-year return period event and 38,650 cubic yards for the 25-year return period event. Table 17 below summarizes the required initial and remediation beach fill volumes for each representative profile reach. As noted previously, the calculated volumes needed for remediation of the baseline profile assumes that new material will be brought in via truck haul to account for any losses within the proposed template from the statistical storm events.

Table 17: Beach Fill Volume Summary for Alternative 2 (Beach and Dune Restoration)

Profile Reach	Representative Shoreline Length (LF)	Required Initial Beach Fill Volume (CY)	Required Remediation Beach Fill Volume for 15-Year Event (CY)	Required Remediation Beach Fill Volume for 25-Year Event (CY)
R-201	1,764	43,220	5,120	6,000
R-204	3,348	73,660	16,740	18,750
R-208	3,388	65,730	11,860	13,900
Total	**8,500**	**182,610**	**33,720**	**38,650**

6.3. Alternative 3 – Nearshore Segmented Breakwaters

The nearshore segmented breakwaters alternative builds upon the baseline roadway cross-sections developed previously for R-201, R-204, and R-208. The proposed conceptual nearshore segmented breakwaters are placed approximately 400 feet to 600 feet seaward of the shoreline to limit wave action on the erodible beach shoreline. For this alternative, the nearshore segmented breakwaters would be constructed along with the baseline roadway berm. The beach volume analysis for this alternative only includes the initial beach fill volume to construct the roadway berm, as it is assumed that the breakwaters would provide substantial protection to minimize erosion caused by the 15-year and 25-year return period storm events.

The nearshore segmented breakwater parameters are summarized as follows:

- Approximate existing ground elevation at centerline = -6.0 feet NAVD88 (approximately 400 to 600 feet offshore)
- Crest elevation = +4.0 feet NAVD88
- Side slopes = 3H:1V
- Unit weight of rock = 165 pounds per cubic foot
- Crest width = 10.5 feet
- Breakwater width = 60 feet
- Crest length = 400 feet

The conceptual breakwater geometry details can be seen in Figure 28 in Section 6.3.2 below. The conceptual plan view and typical cross-section, along with breakwater details, are provided in Appendix A.

6.3.1. Initial Beach Fill Placement Volumes

The initial beach fill volumes for the baseline roadway berm were determined previously utilizing the baseline cross-sections that were developed at FDEP monuments R-201, R-204, and R-208. At each monument, the fill volume per linear foot to achieve the baseline cross-section from the contemporary existing ground conditions was calculated, as shown previously. The initial beach fill volumes calculated at R-201, R-204, and R-208 are 1.3, 2.5, and 3.3 cubic yards per linear foot, respectively, and are reiterated in Table 18 below.

Table 18: Initial Beach Fill Volumes per Linear Foot at Each Profile for Alternative 3 (Baseline Roadway Berm)

Profile	Required Initial Beach Fill Volume (CY/LF)
R-201	1.3
R-204	2.5
R-208	3.3

6.3.2. Breakwater Design

The conceptual nearshore segmented breakwater design parameters for this study were determined utilizing the tidal elevations from NOAA and the peak surge elevations from the SBEACH hydrographs for the 15-year and 25-year storm events described in Section 3.0 above. Using the known peak surge elevation for the 25-year storm event, the minimum and maximum water depths at the structure location were determined. The varying water depths were used to calculate the maximum wave height that can be sustained, also known as the breaking wave height or depth-limited wave height.

The required breakwater stone sizes were determined using the peak surge elevation and associated depth-limited wave heights for the 25-year storm event. The median armor stone diameter for the breakwaters, utilizing a unit weight of 165 pounds per cubic foot, was determined to be approximately 3.5 feet. Utilizing the known median armor stone diameter, the median bedding stone diameter was selected as 0.6 feet. The minimum layer thicknesses for the armor stone and bedding stone were determined to be 7.0 feet and 1.75 feet, respectively.

The design crest elevation of the breakwater structures was determined based on multiple factors, including maximum allowable wave height able to travel over the breakwater, surge elevations, constructability, cost, and design life. One of the main considerations was the height of the wave that could pass unobstructed over the structure with the 15-year and 25-year return periods. As previously defined, the MHW elevation is +1.7 feet NAVD88 and the peak storm surge elevations for the 15-year and 25-year storm events are +6.8 feet NAVD88 and +8.0 feet NAVD88, respectively. Based on these elevations, the crest elevation of +4.0 feet NAVD88 was selected as it would protect against waves in the daily conditions and limit waves that could be transmitted over the structure in the 15-year and 25-year storm events to approximately 3 feet or less.

Wave induced scour protection was another design consideration for the breakwater structures. In order to account for scour, the bedding layer and half of the first armor stone layer (3.5 feet total) are embedded into the existing ground at the toe. To provide structural stability, the sides of the breakwater were designed to have of slope of 3H:1V, which will apply from the edge of the breakwater crest to the beginning of the toe berm. The breakwaters are proposed to be placed at an elevation of approximately -6.0 feet NAVD88, which is the average bottom elevation approximately 500 feet from the shoreline of Summer Haven. The crest length of a single breakwater is approximately 400 feet and the gap between structure crests is 550 feet. The structure to gap ratio would be further refined based on numerical modeling if this alternative was selected for detailed design. A typical cross-section of the breakwater can be seen in Figure 28 below.

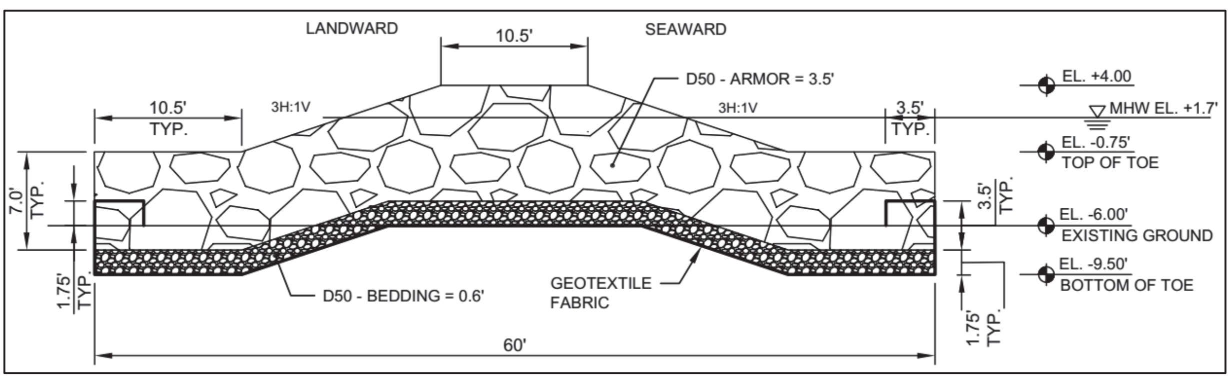

Figure 28: Conceptual Breakwater Typical Section for Alternative 3

6.4. Alternative 4 – Seawall

The seawall alternative builds upon the baseline roadway cross-sections developed above for R-201, R-204, and R-208. For this alternative, a steel sheet pile seawall would be constructed along with the baseline roadway berm. The proposed conceptual seawall is designed to be a retaining wall for the Old A1A roadway berm and is located at the seaward edge of the berm to stabilize the material placed for construction of the roadway berm. The beach volume analysis for this alternative only includes the initial beach fill volume to construct the roadway berm, as it is assumed that the seawall will provide substantial protection to minimize erosion of the roadway berm caused by the 15-year and 25-year return period storm events.

The seawall parameters are summarized as follows:

- Steel sheet pile wall with concrete cap
- Located at the seaward edge of the baseline roadway berm
- Steel sheet pile length = 30 feet
- Crest elevation (top of cap)
  - +3.0 feet NAVD88 for R-201 and R-204
  - +8.0 feet NAVD88 for R-208
- Concrete Cap = 3-foot by 3-foot

The conceptual seawall details can be seen in Figure 29 in Section 6.4.2 below. The conceptual plan view and typical cross-section are provided in Appendix A.

6.4.1. Initial Beach Fill Placement Volumes

The initial beach fill volumes for the baseline roadway berm were determined previously utilizing the baseline cross-sections that were developed at FDEP monuments R-201, R-204, and R-208. As described for Alternative 3 (nearshore segmented breakwaters), the initial beach fill volumes calculated at R-201, R-204, and R-208 are 1.3, 2.5, and 3.3 cubic yards per linear foot, respectively.

6.4.2. Seawall Design

As with the breakwater alternative, the conceptual seawall design was determined based on surge elevations from FDEP and the associated depth-limited wave heights at the structure toe. As stated previously, the seawall was designed to be a steel sheet pile retaining wall to stabilize and protect the material placed on the roadway berm to re-establish Old A1A. As such, the seawall will be located at the seaward edge of the baseline roadway berm and the crest elevations (top of cap) will be level with the baseline roadway berm crest elevations of +3.0 feet NAVD88 for R-201 and R-204 and +8.0 feet NAVD88 for R-208. While the seawall crest elevation at R-201 and R-204 will not fully protect the beach during the peak storm surge elevations, erosion landward of the seawall will be limited by the structure. Based on the crest elevations, wave conditions, and anticipated scour, the conceptual seawall design utilizes 30-foot-long steel sheet piles to provide adequate embedment. A typical cross-section of the seawall can be seen in Figure 29 below.

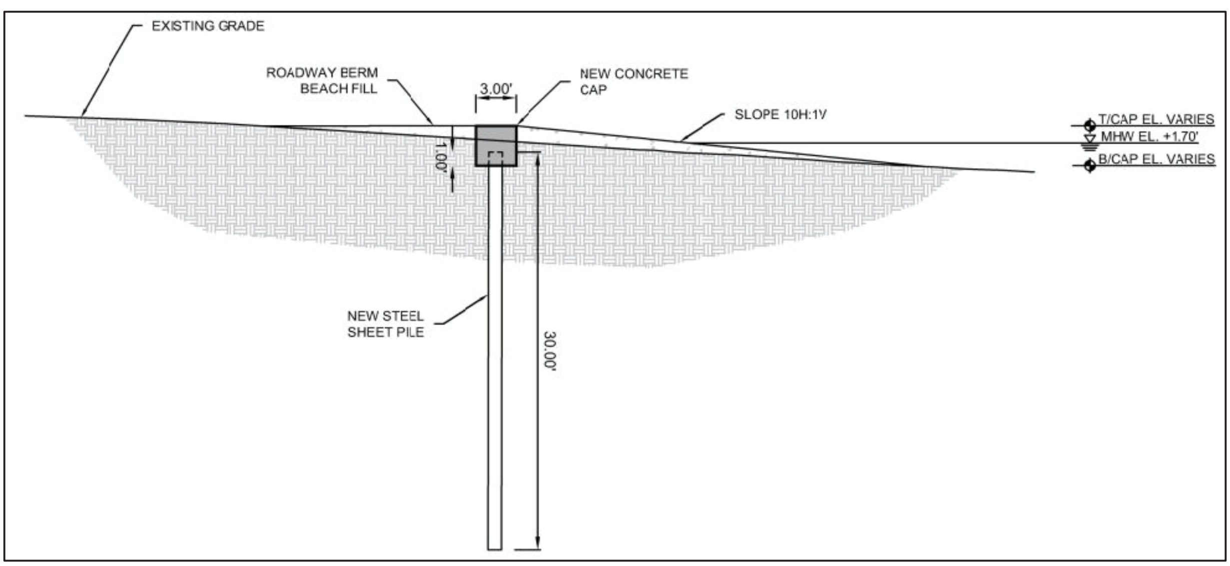

Figure 29: Conceptual Seawall Typical Section for Alternative 4

7. Permitting Considerations

Constructing each of the above alternatives will require processing permit applications involving the following agencies:

- FDEP
- Florida Fish and Wildlife Conservation Commission
- U.S. Army Corps of Engineers
- U.S. Fish and Wildlife Service

Preparing these permit applications will require additional data collection and studies, refinement of the conceptual designs, preparation of preliminary design plans, assessment of environmental impacts, and development of measures to address impacts. Of the four alternatives discussed above, obtaining a permit for Alternative 4 (seawall) will be the most challenging given the requirements of FDEP's current coastal armoring policy.

8. Restoration Alternatives Cost Estimates

The conceptual cost assessments were developed for the four alternatives described in the preceding sections of this report. Due to the long duration of the continued remediation for the two beach fill projects (Alternatives 1 and 2), inflation was included for remediation of future storm events. Remediation volumes are not included for the structural alternatives (Alternatives 3 and 4), as it is anticipated that the structures will minimize the erosion of the baseline roadway berm. Cost estimates are provided for the anticipated 25-year design life for each alternative in Table 19 through Table 22. The approximate conceptual costs range from $12,262,000 for Alternative 1 to $33,321,000 for Alternative 2. The structural alternatives have conceptual costs of $30,651,000 for Alternative 3 (breakwater with roadway berm) and $26,371,000 for Alternative 4 (seawall with roadway berm).

The following assumptions were made in developing the conceptual cost estimates:

- All alternatives:
  - Costs assume truck hauling beach fill material at a unit cost of $95 per cubic yard based on recent project estimates obtained by St. Johns County.
  - Costs are in-place (installed) costs for all materials.
- Beach Fill Alternatives (Alternatives 1 and 2):
  - New material will be brought in via truck haul to remediate any upland losses from storm events. Material that is pushed landward within the profile will be considered lost and will not be manipulated to rebuild the template after each storm event.
  - Cost of removal of sand overwashed into the Summer Haven branch of the Matanzas River (only experienced for 25-year storm event at R-204 for Alternative 1) during storm events determined by recent costs provided by St. Johns County.
  - Cost estimates assume 4% inflation per year for the first five (5) years, then 3% inflation per year for the remainder of each time period.
  - The 25-year cost assumes two (2) 15-year return period storm events (estimated to occur in Year 5 and Year 20) and one (1) 25-year storm event (estimated to occur in Year 15) will occur within this time period.
- Breakwater (Alternative 3):
  - Cost includes a 10% decrease in armor stone quantities to account for voids.
  - Cost includes a 5% decrease in bedding stone quantities to account for voids.
  - Cost includes 15% increase in geotextile fabric to account for overlap.
  - Stone unit weight was assumed to be 165 pounds per cubic foot.
  - Stone unit costs were obtained from the Florida Department of Transportation's Historical Item Average Costs Report (Statewide 12-month Moving Average dated 4/24/2023).

- No remediation for roadway berm since breakwater is anticipated to minimize wave action on the roadway berm.

- Seawall (Alternative 4):
  - Steel sheet pile seawall is installed from land.
  - No remediation for roadway berm since seawall is anticipated to minimize erosion to the roadway berm.

Table 19: Conceptual Cost Estimate for Alternative 1 (Dune Restoration)

Reach	Beach Fill Event	Required Fill Volume per Event (CY)	Unit Cost ($/CY)	Total Cost ($)
R-201	Initial	18,170	$95.00	$1,726,000
	15-year Storm Event	890	$115.58	$103,000
	15-year Storm Event	890	$180.07	$160,000
	25-year Storm Event	1,420	$155.33	$221,000
	Subtotal			$2,210,000
R-204	Initial	34,490	$95.00	$3,277,000
	15-year Storm Event	1,680	$115.58	$194,000
	15-year Storm Event	1,680	$180.07	$303,000
	25-year Storm Event	24,110	$155.33	$3,745,000
	Overwash Material Removal	23,450	$15.00	$352,000
	Subtotal			$7,871,000
R-208	Initial	13,220	$95.00	$1,256,000
	15-year Storm Event	1,700	$115.58	$196,000
	15-year Storm Event	1,700	$180.07	$306,000
	25-year Storm Event	2,720	$155.33	$423,000
	Subtotal			$2,181,000
Total				**$12,262,000**

Table 20: Conceptual Cost Estimate for Alternative 2 (Beach and Dune Restoration)

Reach	Beach Fill Event	Required Fill Volume per Event (CY)	Unit Cost ($/CY)	Total Cost ($)
R-201	Initial	43,220	$95.00	$4,106,000
	15-year Storm Event	5,120	$115.58	$592,000
	15-year Storm Event	5,120	$180.07	$922,000
	25-year Storm Event	6,000	$155.33	$932,000
	Subtotal			$6,552,000
R-204	Initial	73,660	$95.00	$6,998,000
	15-year Storm Event	16,740	$115.58	$1,935,000
	15-year Storm Event	16,740	$180.07	$3,014,000
	25-year Storm Event	18,750	$155.33	$2,912,000
	Subtotal			$14,859,000
R-208	Initial	65,730	$95.00	$6,244,000
	15-year Storm Event	11,860	$115.58	$1,371,000
	15-year Storm Event	11,860	$180.07	$2,136,000
	25-year Storm Event	13,900	$155.33	$2,159,000
	Subtotal			$11,910,000
Total				**$33,321,000**

Table 21: Conceptual Cost Estimate for Alternative 3 (Breakwater and Roadway Berm)

Reach	Material	Quantity	Unit	Unit Cost	Total Cost ($)
All	Armor Stone	146,190	TN	$150.00	$21,929,000
	Bedding Stone	37,000	TN	$170.00	$6,290,000
	Woven Geotextile Fabric	47,100	SY	$8.00	$377,000
R-201	Initial Roadway Berm Beach Fill	2,300	CY	$95.00	$219,000
R-204	Initial Roadway Berm Beach Fill	8,310	CY	$95.00	$789,000
R-208	Initial Roadway Berm Beach Fill	11,020	CY	$95.00	$1,047,000
Total					**$30,651,000**

Table 22: Conceptual Cost Estimate for Alternative 4 (Seawall and Roadway Berm)

Reach	Material	Quantity	Unit	Unit Cost	Total Cost ($)
R-201	Steel Sheet Piles (30' Long)	1,764	LF	$2,250.00	$3,969,000
	Concrete Cap (3'x3')	1,764	LF	$400.00	$706,000
	Seawall Coatings	105,840	SF	$3.50	$370,000
	Initial Roadway Berm Beach Fill	2,300	CY	$95.00	$219,000
	Subtotal				$5,264,000
R-204	Steel Sheet Piles (30' Long)	3,348	LF	$2,250.00	$7,533,000
	Concrete Cap (3'x3')	3,348	LF	$400.00	$1,339,000
	Seawall Coatings	200,880	SF	$3.50	$703,000
	Initial Roadway Berm Beach Fill	8,310	CY	$95.00	$789,000
	Subtotal				$10,364,000
R-208	Steel Sheet Piles (30' Long)	3,390	LF	$2,250.00	$7,628,000
	Concrete Cap (3'x3')	3,390	LF	$400.00	$1,356,000
	Seawall Coatings	203,400	SF	$3.50	$712,000
	Initial Roadway Berm Beach Fill	11,020	CY	$95.00	$1,047,000
	Subtotal				$10,743,000
Total					**$26,371,000**

9. Summary

A vulnerability assessment of Old A1A and the Summer Haven branch of the Matanzas River along the project shoreline of Summer Haven beach was performed for the 15-year and 25-year return interval storm events. A collection of historical storm events, beach placement events, and linear regression was used in conjunction with SBEACH to predict the frequency and magnitude of future damages in terms of beach-dune elevations and volumetric changes.

Three representative transects were identified at FDEP range monuments R-201, R-204, and R-208. R-201 represents the northern section of the study area where the beach profile is relatively low and there are no structures or roadway; R-204 represents the middle section of the study area that has been overwashed by recent storms; R-208 represents the southern section of the study area that is somewhat higher and has some remnants of a vegetated dune system. For these three profiles, SBEACH erosion analysis for the 15-year and 25-year return period events were completed. For R-201 and R-204 a total volumetric sand loss was calculated to be between 0.13 and 0.19 cubic yards per linear foot extending from the landward limit to 400 feet seaward. For R-208 a volumetric loss between 0.20 and 0.25 cubic yards per linear foot was calculated extending from the landward limit to 400 feet seaward from R-monument. The shoreline changes for a 15-year storm event for R-201, R-204, and R-208 were -0.08, 0.07, and 0.17 feet respectively. The shoreline changes for a 25-year storm event for R-201, R-204, and R-208 were -0.19, 0.04, and 0.18 feet respectively. Additionally, baseline roadway cross-sections were developed for each of the representative beach profiles. These templates were created using historical imagery, composite survey data, and tidal datum elevations for this area.

Atkins also assessed the cost of remediation to restore and maintain access to Old A1A over the next 30 and 50 years. These cost estimates are based on the cost to periodically restore the berm that supports Old A1A, including the initial volume to construct the berm and volumes to remediate erosion caused by periodic impacts of the 15-year and 25-year storm events. Based on the volume calculations and assumptions listed herein, the estimated costs to restore and maintain access to Old A1A over the next 30 and 50 years are approximately $9,940,000 and $20,891,000, respectively.

Finally, Atkins assessed the cost of potential remediation alternatives to restore and maintain access to Old A1A and protect the integrity of the Summer Haven branch of the Matanzas River. The four basic conceptual alternatives that were considered include: (1) dune restoration with periodic maintenance and repair, (2) beach and dune restoration with periodic maintenance beach nourishment, (3) construction of a system of nearshore segmented breakwaters, and (4) construction of a seawall. Conceptual plan views and typical cross-sections (provided in Appendix A), as well as preliminary opinions of probable costs, including initial construction and assumed maintenance over a 25-year design life were developed for each alternative. Based on the volume calculations and assumptions listed herein, the estimated costs of the beach fill alternatives range from approximately $12,262,000 for Alternative 1 to $33,321,000 for Alternative 2. The structural alternatives have estimated costs of $30,651,000 for Alternative 3 (breakwater with roadway berm) and $26,371,000 for Alternative 4 (seawall with roadway berm).

It should be noted that these restoration alternatives are conceptual in nature and are intended to present preliminary concepts and designs. As such, all costs provided within this study are intended to evaluate the relative costs of various options. Additional refinement of these designs would be required prior to final budgeting and implementation.

ATKINS
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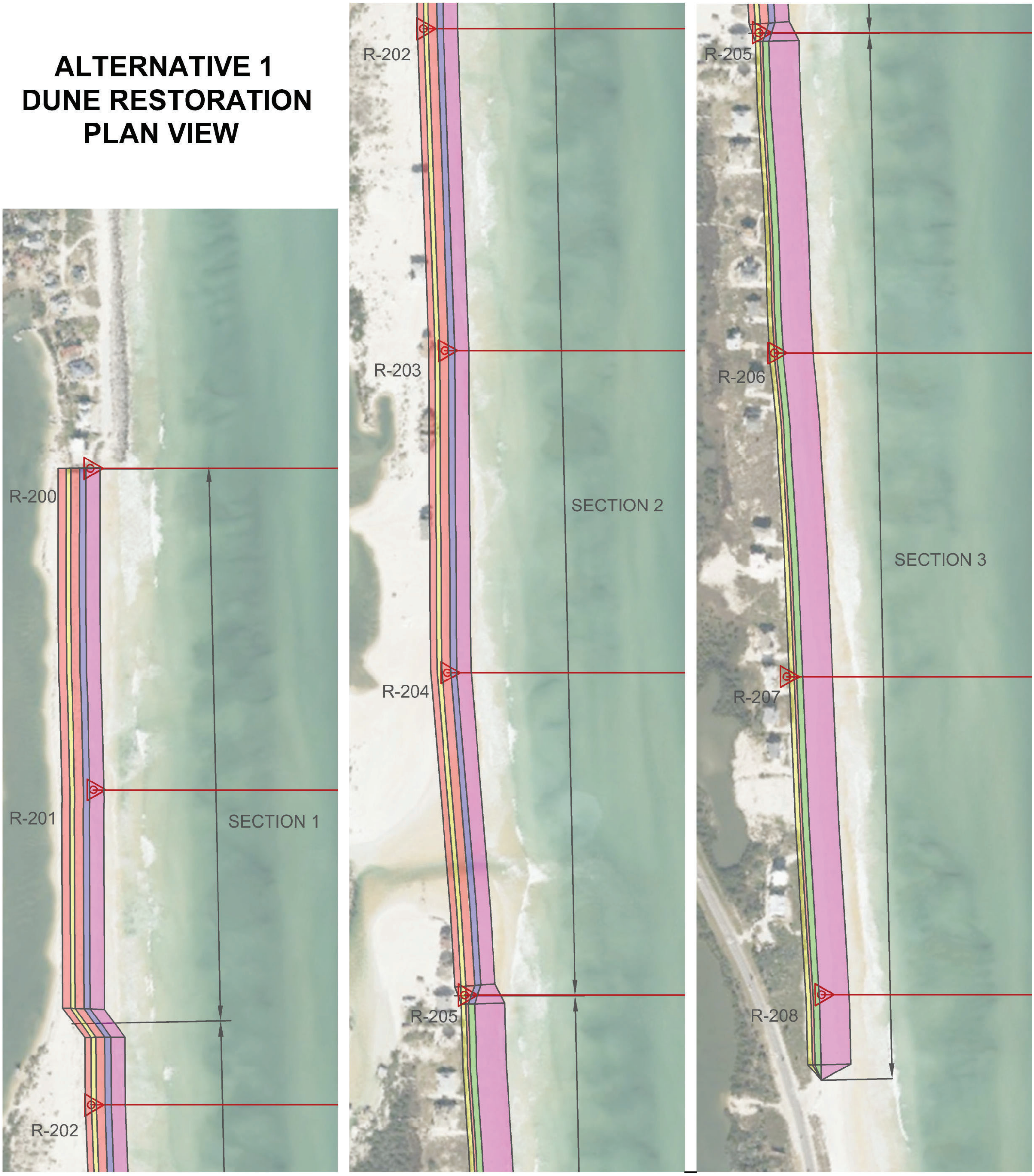
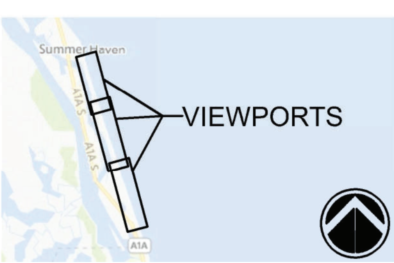
Appendix A: Conceptual Alternatives Plan Sheets and Typical Sections

ALTERNATIVE 1
DUNE RESTORATION
PLAN VIEW





LEGEND:

- LANDWARD/SEAWARD DUNE SLOPES 4:1 GRADE
- DUNE CREST EL. 10'
- BERM CREST EL. 3'
- BERM CREST EL 8'
- BERM SEAWARD SLOPES 10:1 GRADE
- R MONUMENT LOCATIONS

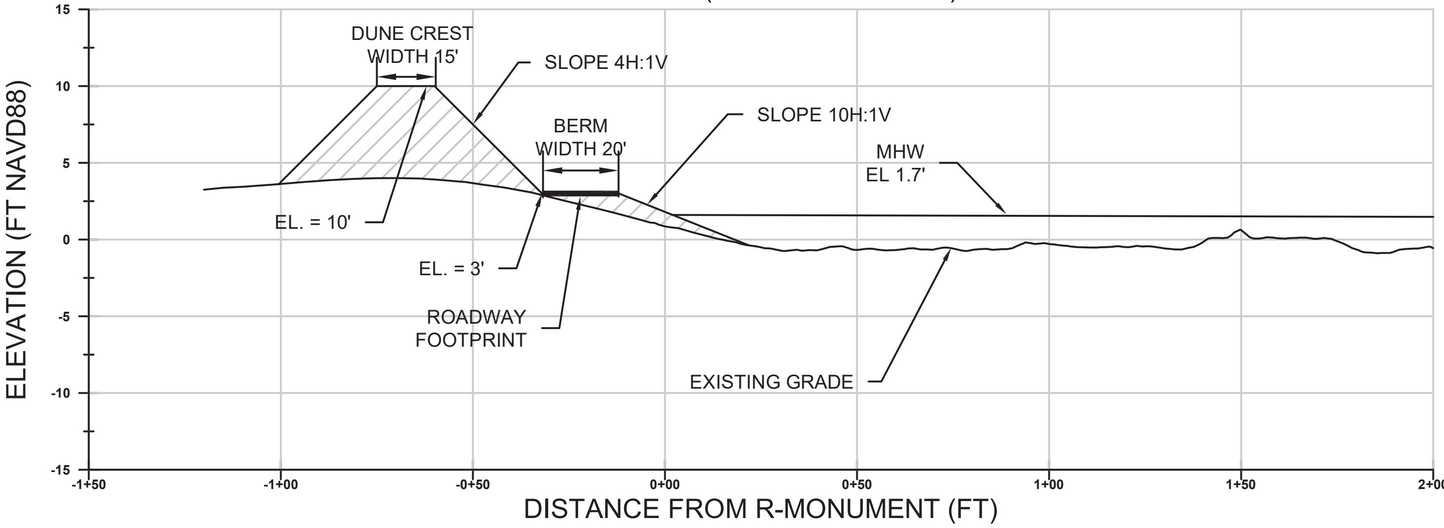
0 400 800 FEET

1"=400'

HORIZONTAL

ALTERNATIVE 1 - DUNE RESTORATION
TYPICAL CROSS-SECTIONS

SECTION 1 (R-MONUMENT 201)



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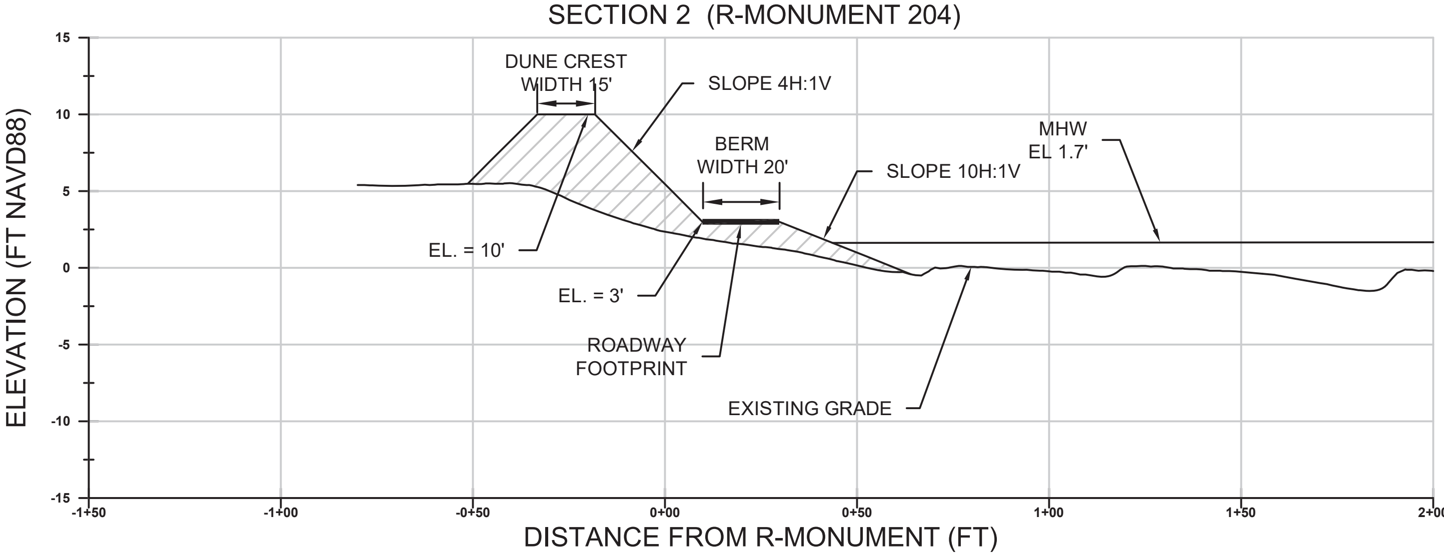
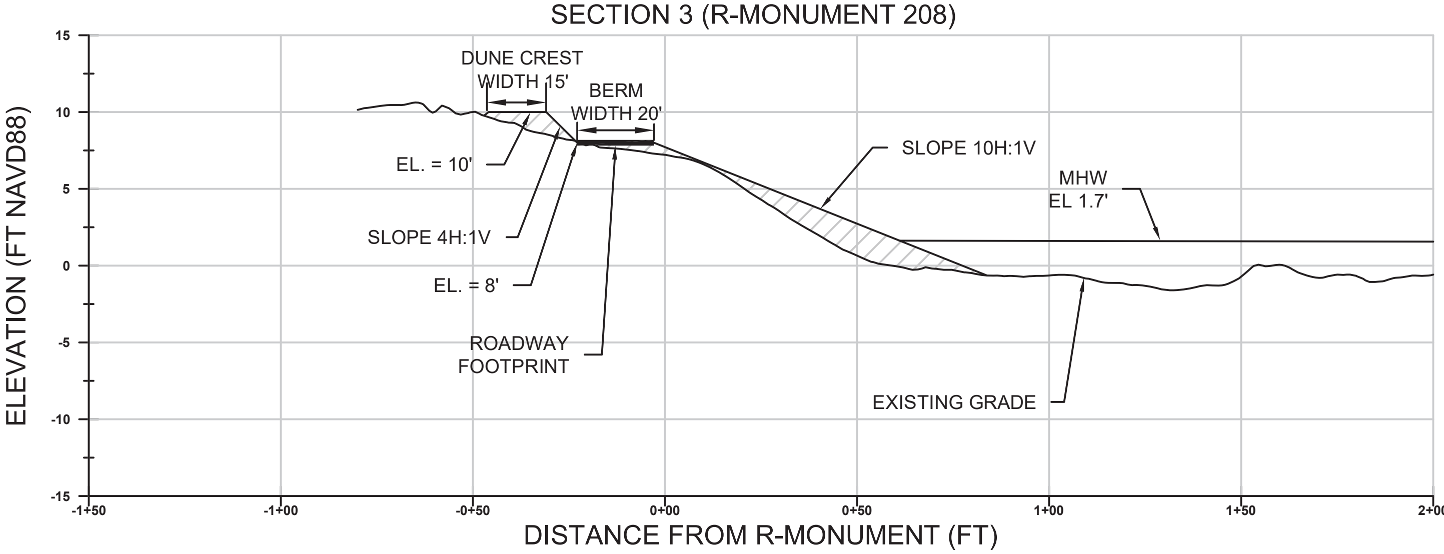
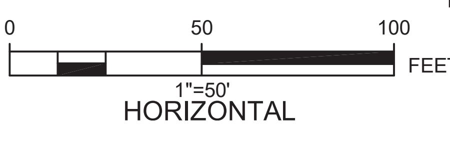
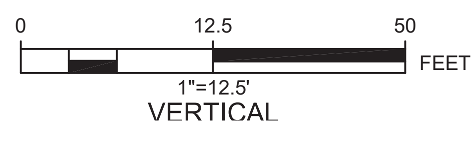


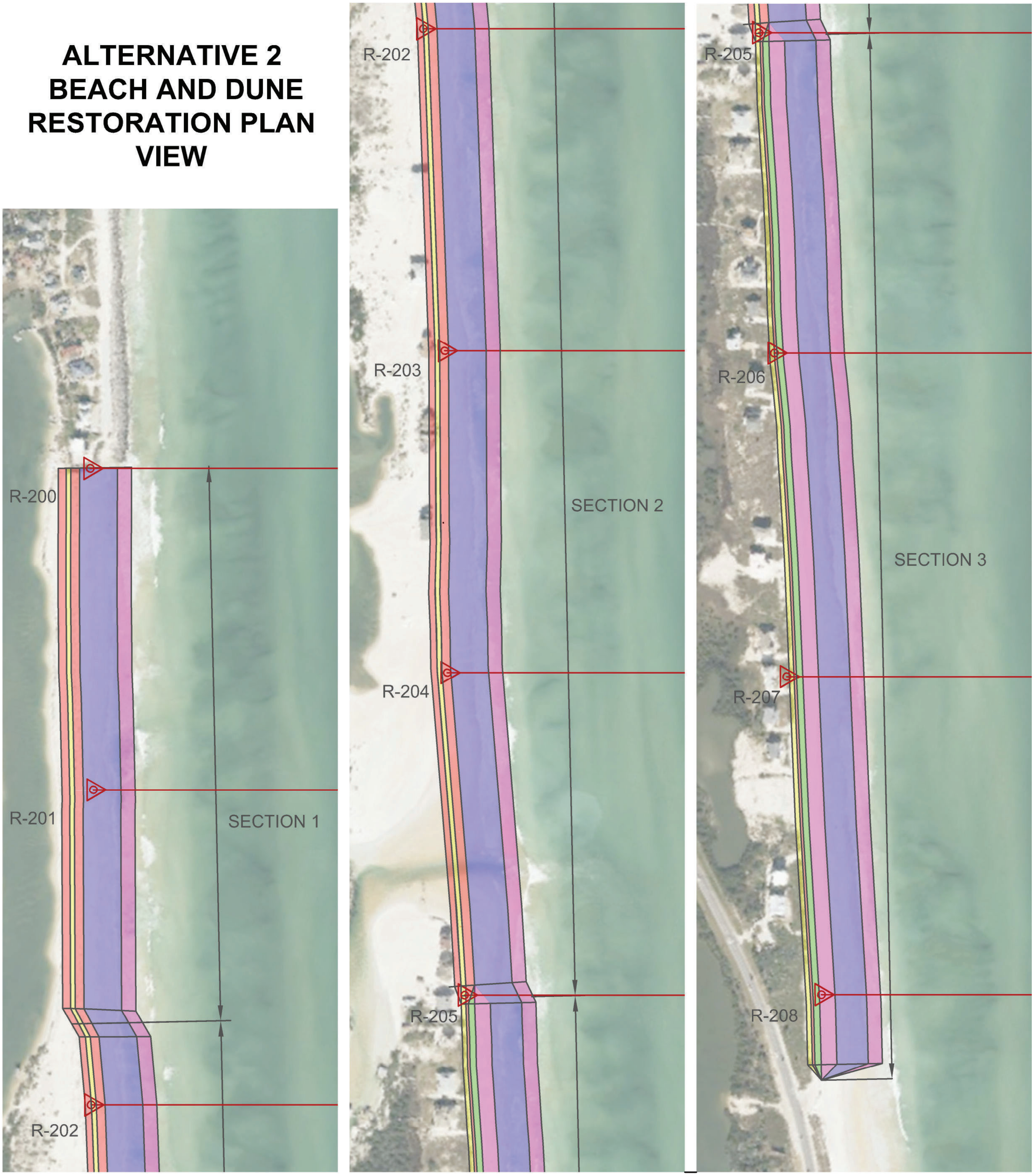
SECTION 3 (R-MONUMENT 208)

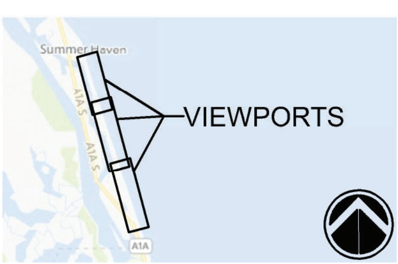






ALTERNATIVE 2 BEACH AND DUNE RESTORATION PLAN VIEW





LEGEND:

- LANDWARD/SEAWARD DUNE SLOPES 4:1 GRADE
- DUNE CREST EL. 10'
- BERM CREST EL. 3'
- BERM CREST EL 8'
- BERM SEAWARD SLOPES 10:1 GRADE
- R MONUMENT LOCATIONS

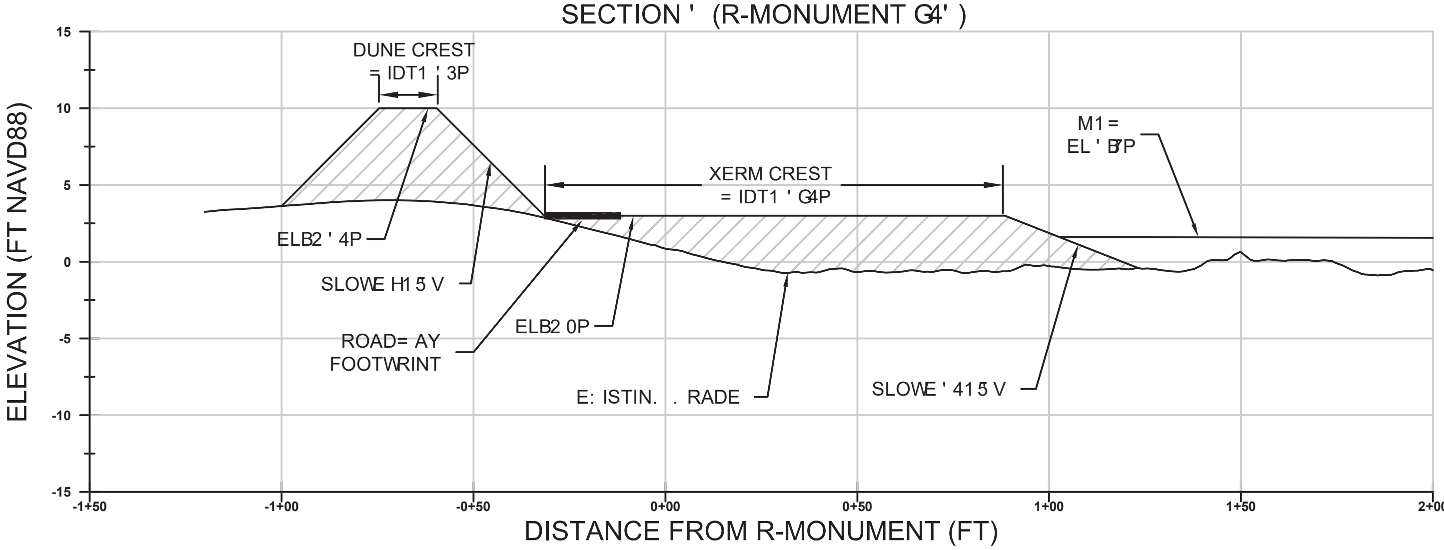
0 400 800 FEET

1"=400'

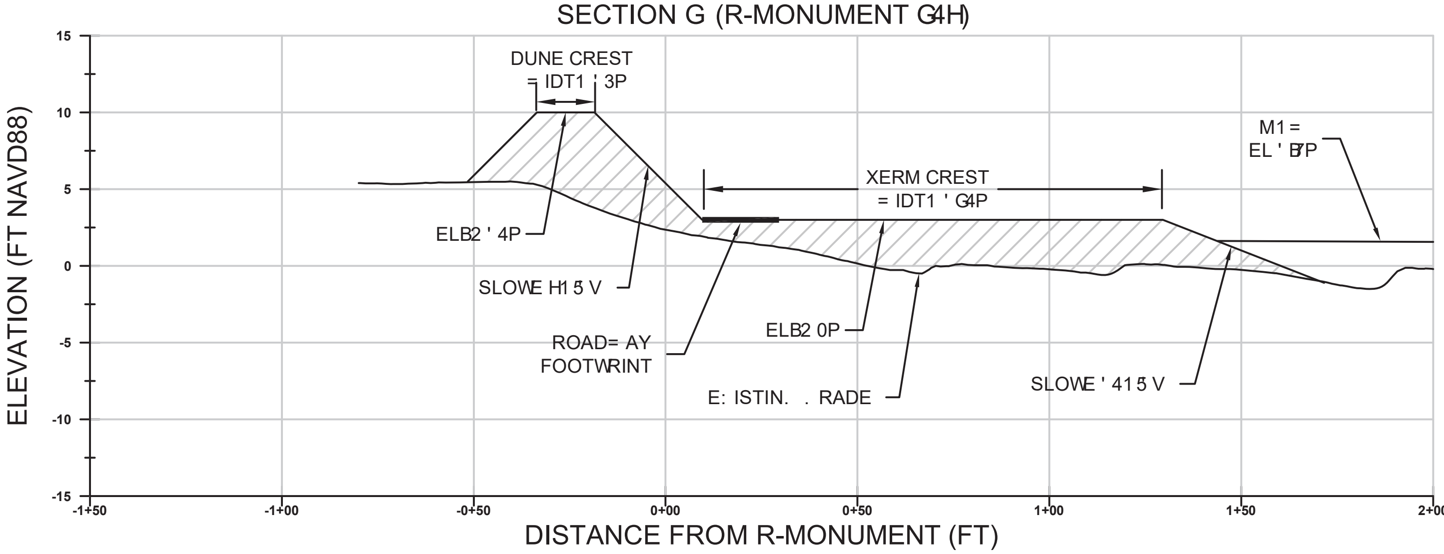
HORIZONTAL

ALTERNATIVE G- XEAC1 AND DUNE RESTORATION
TYWICAL CROSS-SECTIONS

SECTION ' (R-MONUMENT G4')



SECTION G (R-MONUMENT G4H)



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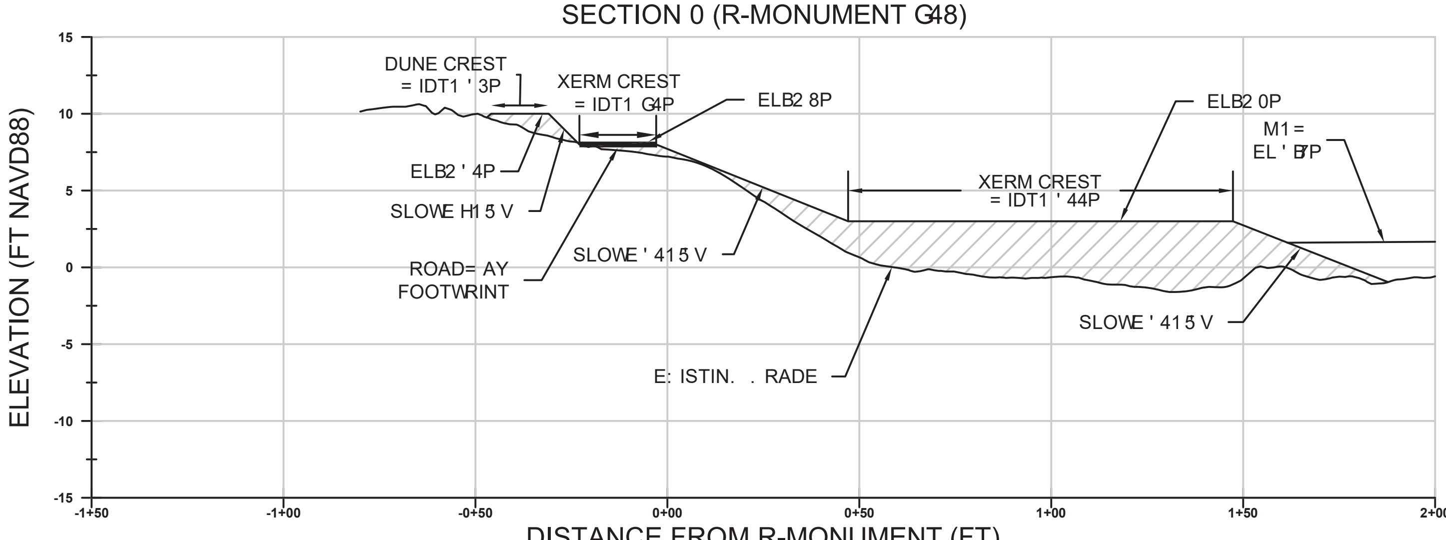
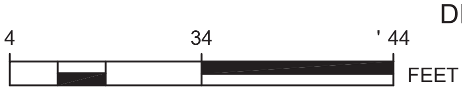
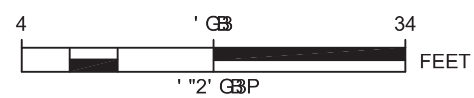


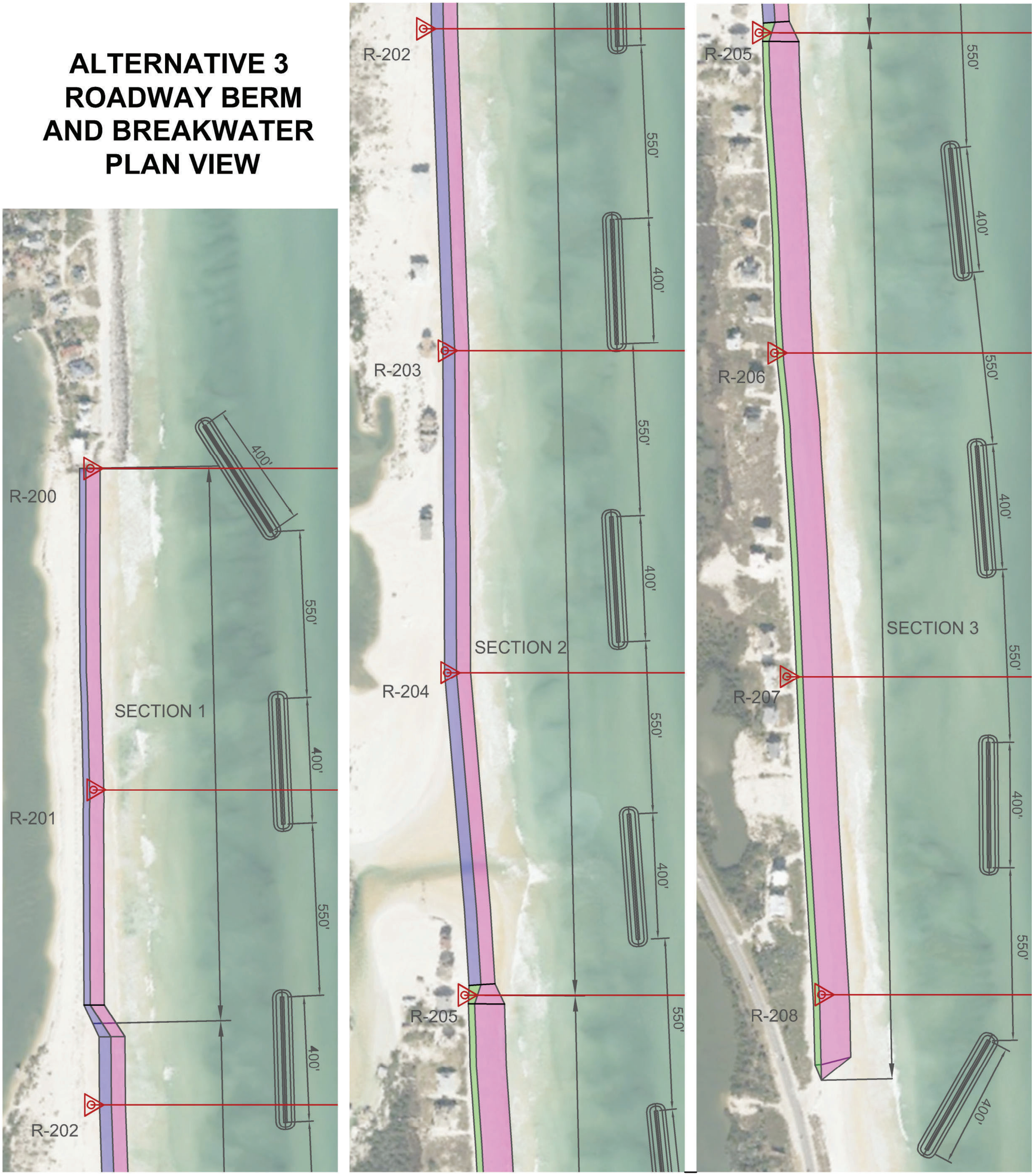


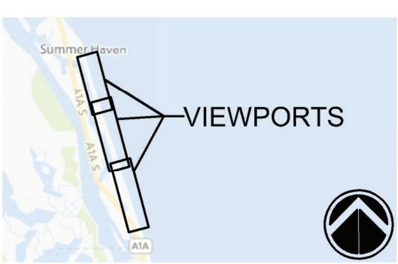
1 ORIZONTAL



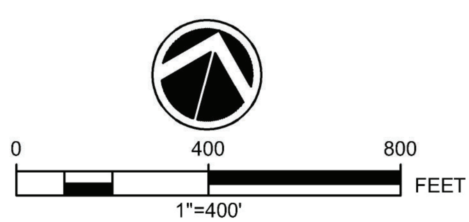
VERTICAL

ALTERNATIVE 3 ROADWAY BERM AND BREAKWATER PLAN VIEW

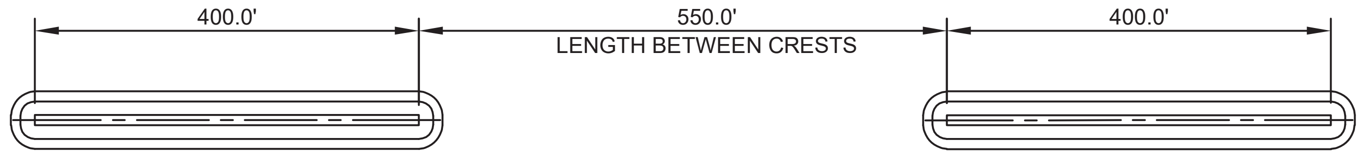




LEGEND:
- BERM CREST EL. 3'
- BERM CREST EL 8'
- BERM SEAWARD SLOPES 10:1 GRADE
- R MONUMENT LOCATIONS

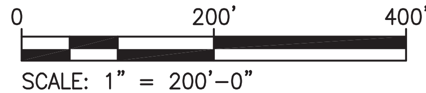


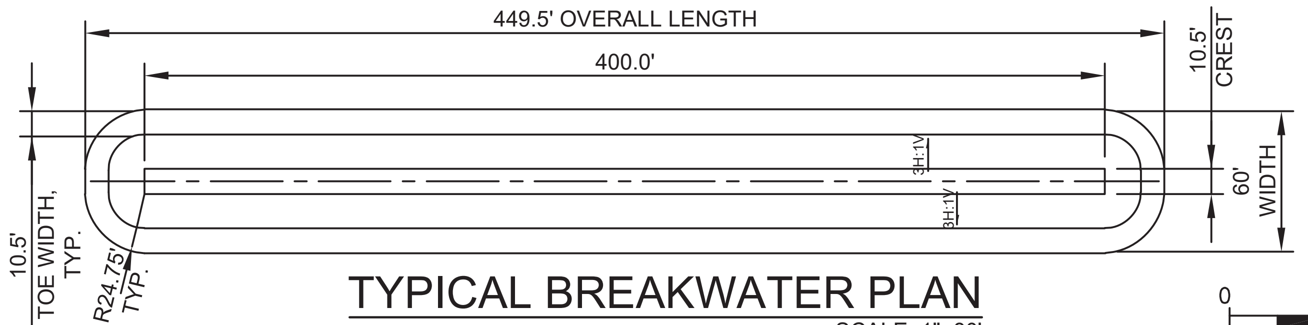
ALTERNATIVE 3 - NEARSHORE SEGMENTED BREAKWATER DETAILS



BREAKWATER SPACING PLAN

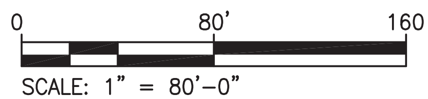
1"=200'

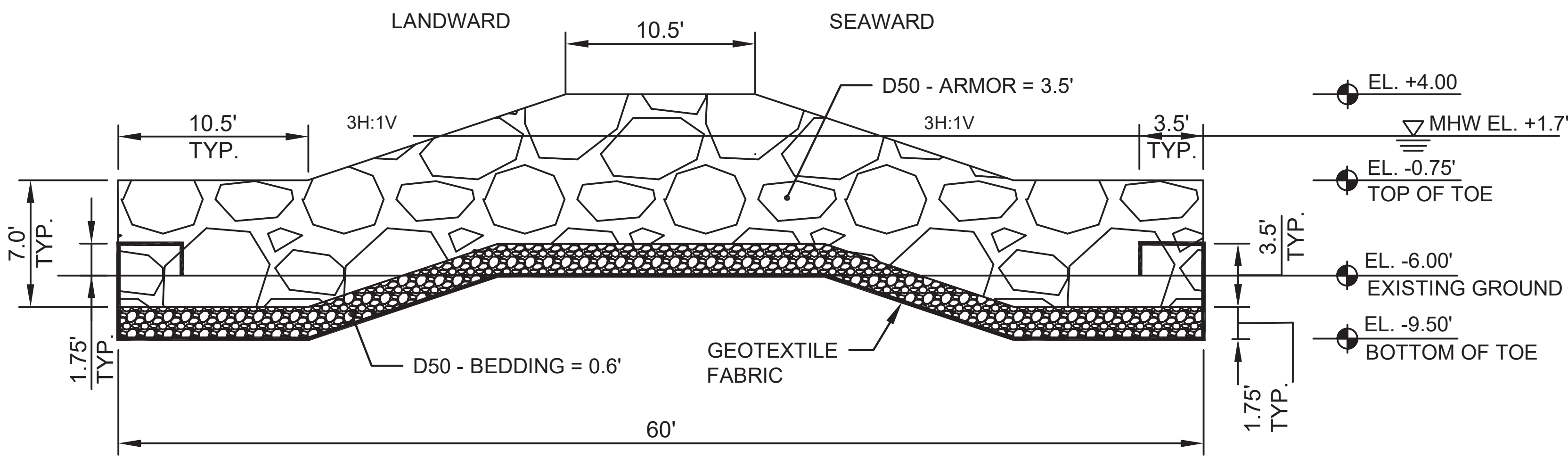




TYPICAL BREAKWATER PLAN

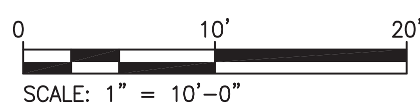
SCALE: 1"=80'





TYPICAL BREAKWATER STRUCTURE ELEVATION

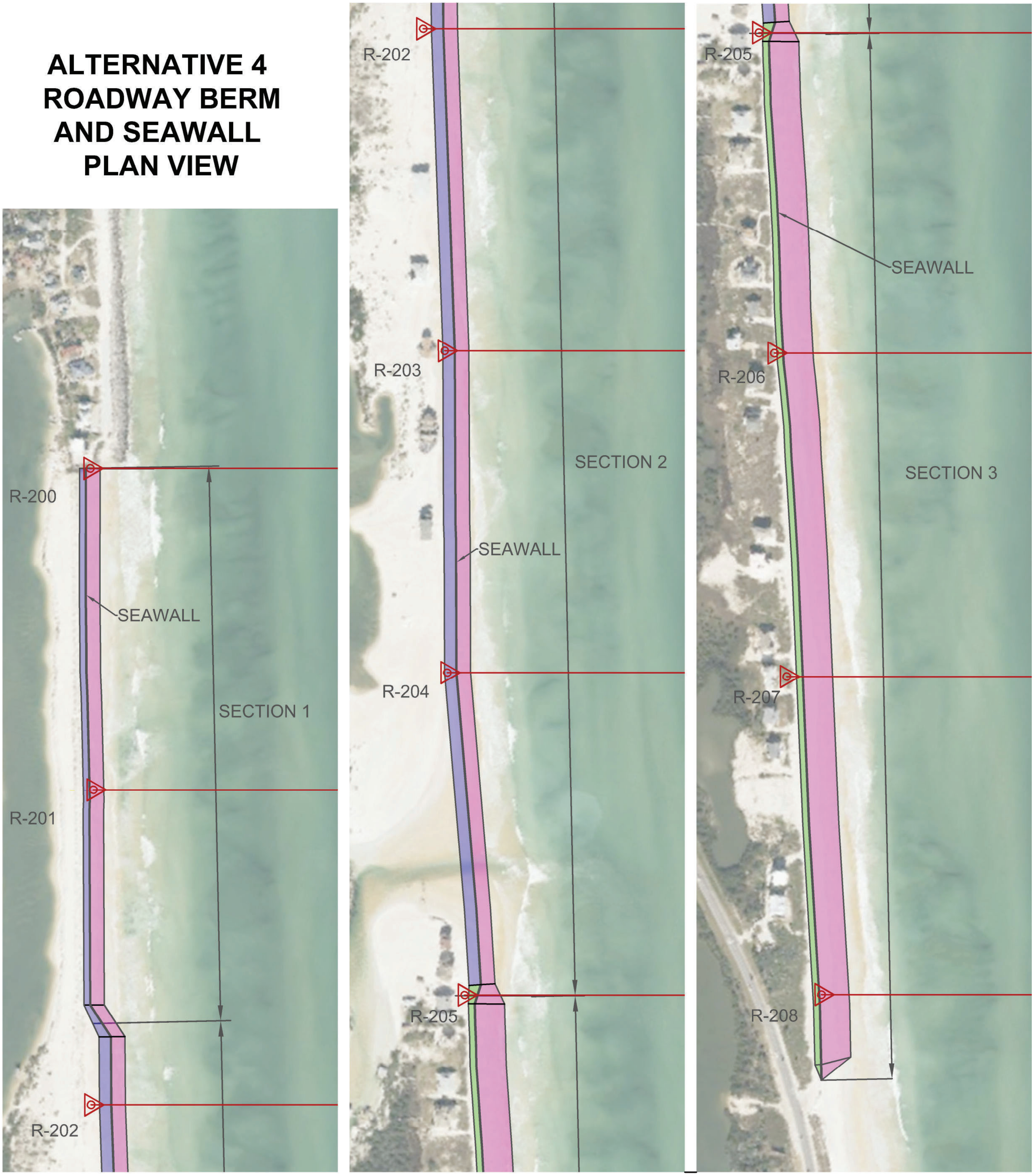
SCALE: 1" = 10'

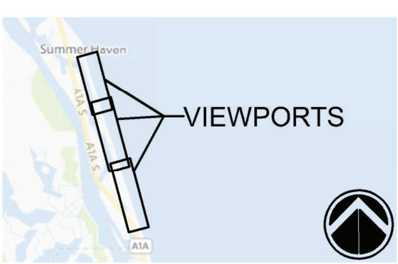


NOTE:

1. ALL ELEVATIONS ARE IN FEET AND REFERENCE NAVD88
2. STONE MATERIAL IS ASSUMED TO HAVE A MINIMUM UNIT WEIGHT OF 165 POUNDS PER CUBIC FOOT.

ALTERNATIVE 4 ROADWAY BERM AND SEAWALL PLAN VIEW





LEGEND:

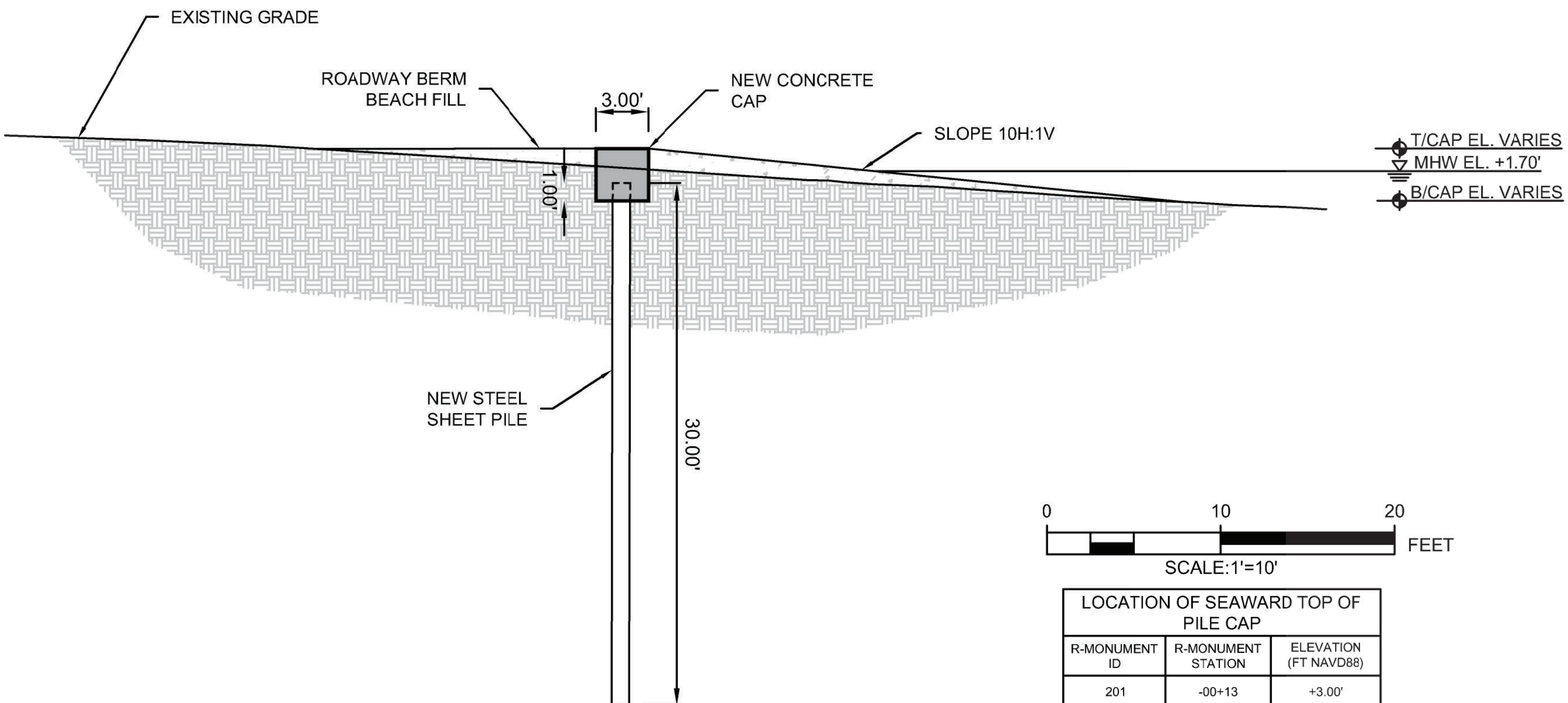
- BERM CREST EL. 3'
- BERM CREST EL 8'
- BERM SEAWARD SLOPES 10:1 GRADE
- CONCRETE CAP AND SEAWALL LOCATIONS
- R MONUMENT LOCATIONS

0 400 800 FEET

1"=400'

HORIZONTAL

ALTERNATIVE 4
ROADWAY BERM AND SEAWALL
TYPICAL DESIGN



LOCATION OF SEAWARD TOP OF PILE CAP		
R-MONUMENT ID	R-MONUMENT STATION	ELEVATION (FT NAVD88)
201	-00+13	+3.00'
204	00+28	+3.00'
208	-00+04	+8.00'