Continuing Authorities Program (CAP)
Section 1135 Project

Engineering Appendix

for

Pahokee Restoration

Environmental Restoration Project

Continuing Authorities Program (CAP)

Section 1135

Integrated Feasibility Report and Environmental Assessment

Pahokee, Florida

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Prepared By:

US Army Corps of Engineers ®
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ATTACHMENTS

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List of Acronyms

ACE	Annual Chance Exceedance
ARI	Annual Recurrence Interval
CAP	Continuing Authorities Program
CE/ICA	Cost Effectiveness/Incremental Cost Analysis
CONUS	Continental United States
D&I	Design and Implementation
ER	Engineering Regulation
FIND	Florida Inland Navigation District
HHD	Herbert Hoover Dike
HS	Significant Wave Height
HUC	Hydrologic Unit Code
LIDAR	Light Detection and Ranging
LORS	Lake Okeechobee Regulation Schedule
MCRAM	Monty Carlo Risk Assessment Model
MRR	Modified Rehabilitation Report
NAVD 88	North Atlantic Vertical Datum, 1988
NESDIS	National Environmental Satellite, Data and Information Service
NOAA	National Oceanographic and Atmospheric Administration
PBC	Palm Beach County
pcf	Per cubic foot
SLC	Sea level change
SLR	Sea level rise
USACE	U.S. Army Corps of Engineers
WRDA	Water Resources Development Act
WSE	Water Surface Elevation
VA	Watershed Vulnerability Assessment

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Executive Summary

This appendix documents all engineering analyses and design tasks that were performed for the Pahokee Restoration Project (1135) Final Integrated Feasibility Report. The Continuing Authorities Program (CAP) Project is authorized by Section 1135 of the Water Resources Development Act (WRDA) of 1986, as amended; Project Modifications for Improvement of the Environment. This engineering appendix includes alternatives evaluated, engineering analysis summaries, and the preliminary design. The Cost Appendix is provided as a separate appendix. This document meets all requirements in Appendix C of ER 1110-2-1150.

1.0 Background

1.1 Location

The City of Pahokee, Florida is located on the southeastern shoreline of Lake Okeechobee, as shown in Figure 1-1. The study area is 4,000 feet wide, spanning approximately 31,000 feet of shoreline along Lake Okeechobee within the City of Pahokee, as shown in Figure 1-2.

Figure 1-1 – Location Map.

Figure 1-2 – Location Map Inset.

1.2 Problem Statement

Herbert Hoover Dike (HHD), which surrounds Lake Okeechobee, has altered the historic ecosystem of the shoreline in the project area. Before HHD was constructed, the southeastern shore of Lake Okeechobee contained a gentle slope into deeper waters, resulting in a shallow area along the shoreline. This shallow area provided the optimum depth to support littoral zone vegetation, and served as a natural breakwater, allowing vegetation to take root. The vegetation provided critical feeding and breeding habitat for aquatic and terrestrial species. The natural wind and wave break also minimized sediment re-suspension. Construction of HHD resulted in a shoreline with scarce vegetation, and a deeper nearshore zone that is more susceptible to intense wind and wave forcing and not hospitable to the re-establishment of vegetation. As a result, the southeast shore where Pahokee is located is now characterized by a steep slope into deep water, sparse upland and aquatic vegetation, limited littoral zone or animal habitat, and turbid water.

1.3 Objectives

The following study objectives have been developed based on problems, opportunities, goals, and Federal and state objectives and regulations.

1. Reduce the effects of wind during tropical storms and storm events in order to shelter a portion of the shoreline in lower Lake Okeechobee
2. Create an area suitable for vegetation, with associated habitat, of at least 1 acre

3. Create habitat for fisheries and birds within 5 years
4. Maintain or improve ecotourism
5. Improve natural lake bottom conditions in the project or adjacent area within 5 years

2.0 Alternatives

As presented in detail in the Main Report, the team developed management measures, a preliminary array of alternatives, and the engineering analysis led to a final array of six alternatives (in addition to the "no-action" alternative) that would create favorable conditions for an aquatic ecosystem within the project area.

2.1 Alternative 1.

Alternative 1, *Low Profile Island*. This includes construction of an island with an elevation of 11.0 feet NAVD 88. The island would be constructed of a mix of sand and finer silt sediment, surrounded by a 100-foot sand berm for stability. This would enable improvement of turbidity in the project area by dredging and sequestering some of the fine silt sediments. The slopes on only one side, the lake-ward side, would be armored with 250-lb limestone riprap (stone). The east-west profile is shown in Figure 2-1, with the west/lakeward side on the left.

2.2 Alternative 2.

Alternative 2, *Low Profile Littoral Shelf.* This includes construction of a littoral shelf with an elevation of 11.0 feet NAVD 88. The shelf would be constructed of a mix of sand and finer silt sediment, surrounded on three sides by a 100-foot sand berm for stability and armored on the lake-ward side only with 500-lb limestone riprap (rock). The fourth side would tie into the shore. The east-west profile is shown in Figure 2-2.

2.3 Alternative 3.

Alternative 3, *High Profile Island.* This includes construction of a terraced island with a lower elevation of 11.0 feet NAVD 88 and a higher elevation of 13.0 feet NAVD 88. The island would be constructed of a mix of sand and finer silt sediment, surrounded by a 200-foot sand berm for stability. The east-west profile is shown in Figure 2-3.

2.4 Alternative 4.

Alternative 4, *High Profile Littoral Shelf.* This includes construction of a terraced littoral shelf with a lower elevation of 11.0 feet NAVD 88 and a higher elevation of 13.0 feet NAVD 88. The shelf would be constructed of a mix of sand and finer silt sediment, surrounded on three sides by a 200-foot sand berm for stability. The fourth side would tie into the shore. The east-west profile is shown in Figure 2-4.

2.5 Alternative 5 – Selected Plan.

Alternative 5, *Low Profile Island and High Profile Island*. This includes construction of two structures; a low profile island and a high profile island. The low-profile island would be constructed of a mix of sand and finer silt sediment, surrounded by a 100-foot sand berm for stability and armored on one side only,

the lake-ward side, with 500-lb limestone riprap (rock). The high-profile island would be a terraced island with a lower elevation of 11.0 feet NAVD 88 and a higher elevation of 13.0 feet NAVD 88. The terraced island would be constructed of a mix of sand and finer silt sediment, surrounded by a 100-foot sand berm for stability and armored on one side only, the lake-ward side, with 250-lb limestone riprap (stone). The east-west profile is shown in Figure 2-5.

2.6 Alternative 6.

Alternative 6, *Low Profile Island and Low Profile Littoral Shelf*. This includes construction of two structures; a low profile island and a low profile littoral shelf. The low-profile island would be constructed of a mix of sand and finer silt sediment, surrounded by a 100-foot sand berm for stability and armored with 500-lb limestone riprap (rock) on one side only, the lake-ward side. The low profile shelf would be constructed of a mix of sand and finer silt sediment, surrounded on the three lake-ward sides by a 100-foot sand berm for stability and armored on the lake-ward side only with 500-lb limestone riprap (rock). The fourth side would tie into the shore. The east-west profile is shown in Figure 2-6.

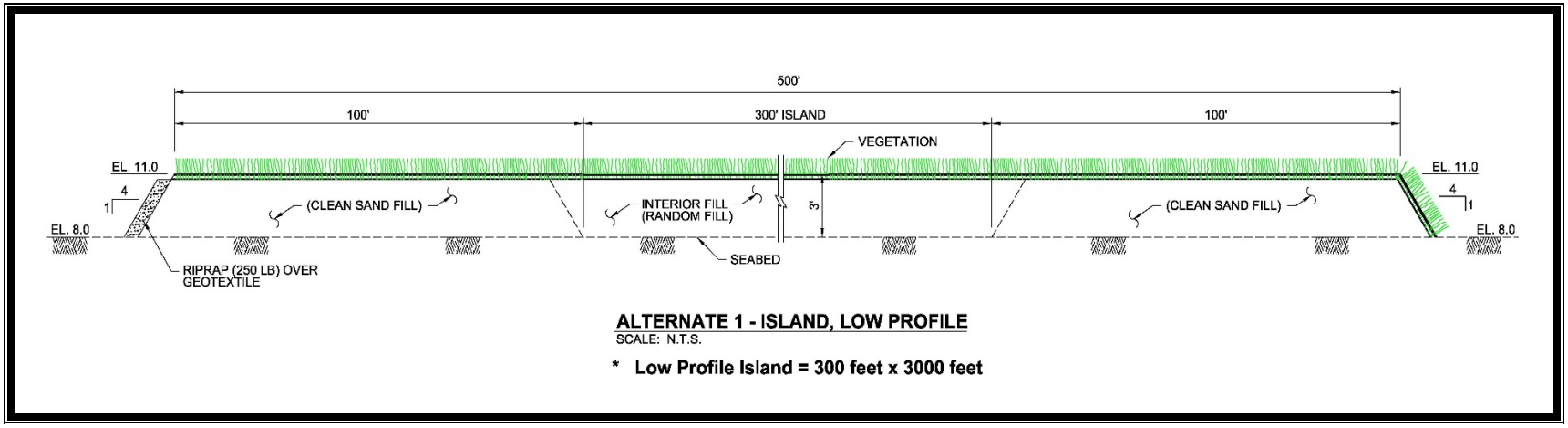


Figure 2-1 – Alternative 1 Profile, Looking North.

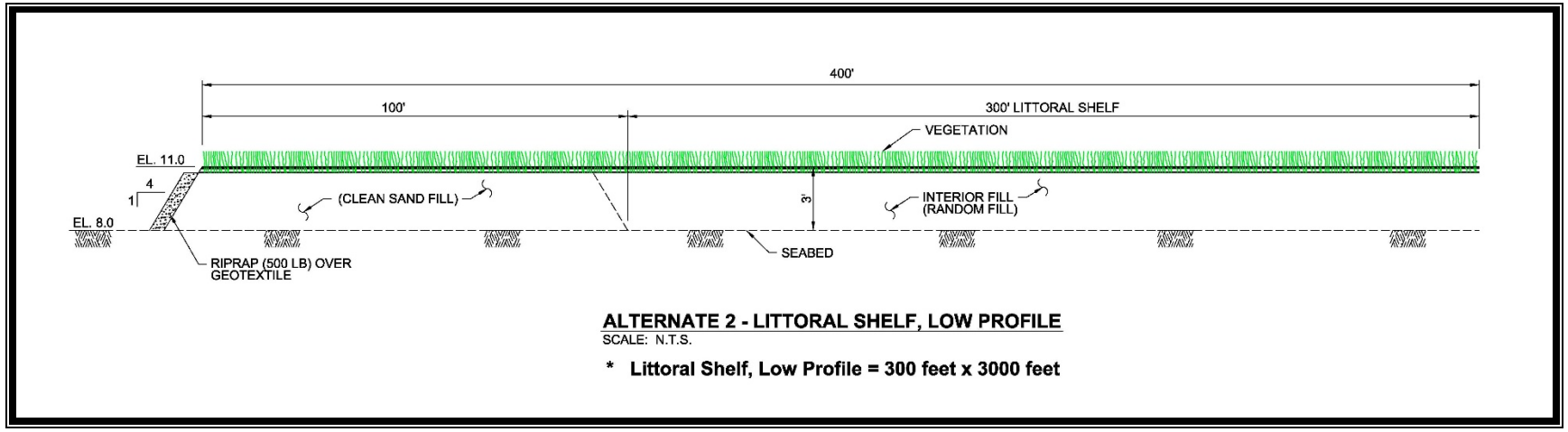


Figure 2-2 – Alternative 2 Profile, Looking North.

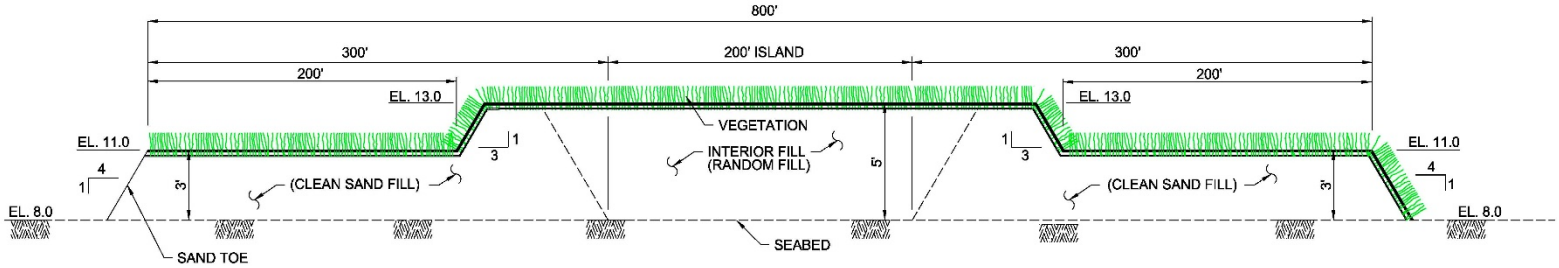
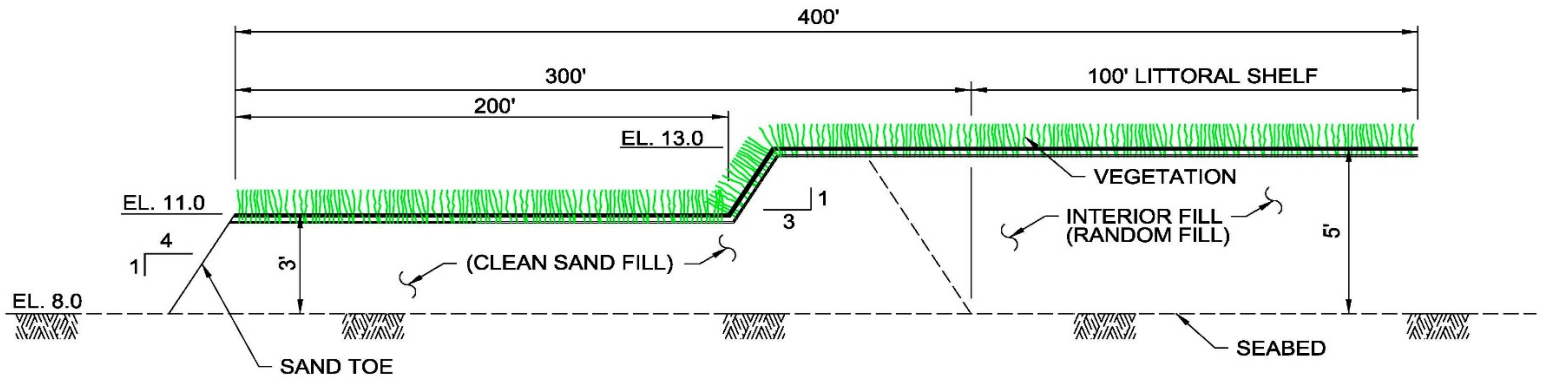


Figure 2-3 – Alternative 3 Profile, Looking North.

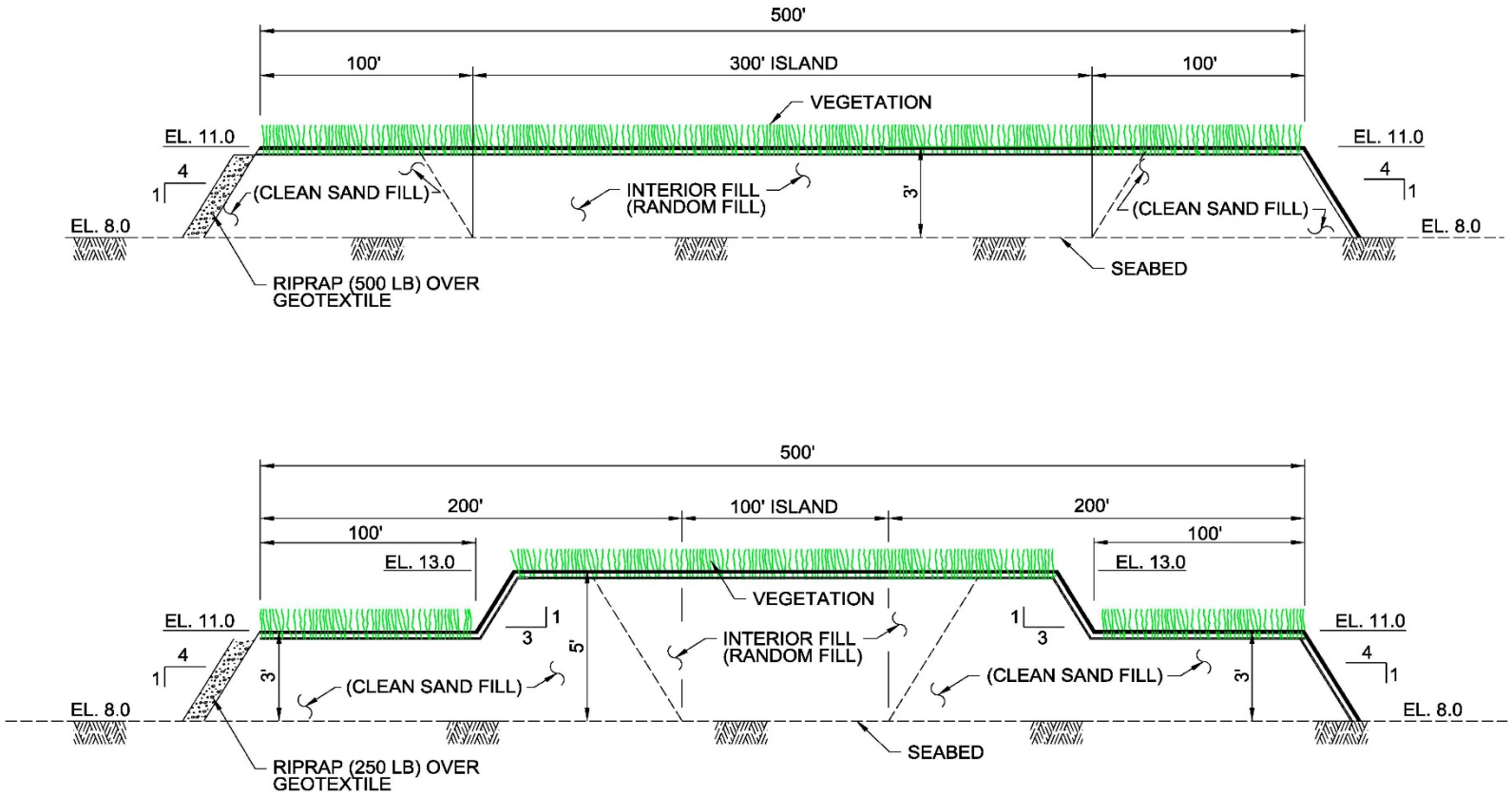


ALTERNATE 4 - LITTORAL SHELF, HIGH PROFILE

SCALE: N.T.S.

* **Littoral Shelf, High Profile = 100 feet x 3000 feet**

Figure 2-4 – Alternative 4 Profile, Looking North.

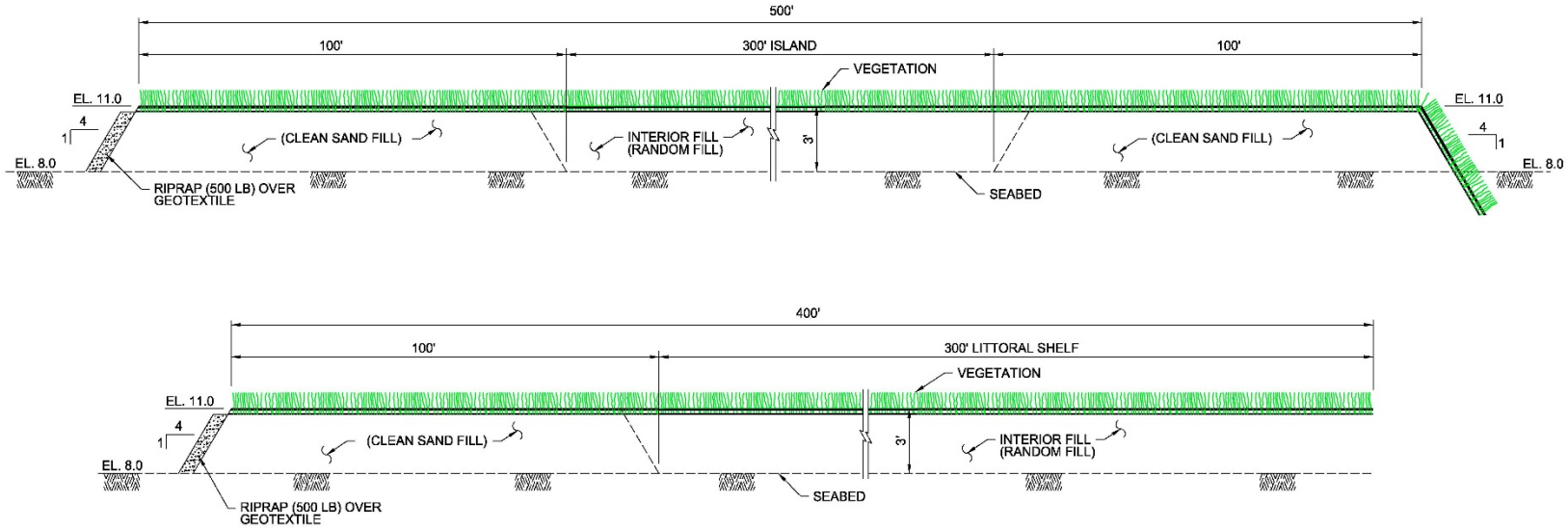


ISLAND (LOW PROFILE) + ISLAND (HIGH PROFILE)

SCALE: N.T.S.

* **Low Profile Island = 300 feet x 1500 feet**
* **High Profile Island = 100 feet x 1000 feet**

Figure 2-5 – Alternative 5 Profile, Looking North.



ISLAND (LOW PROFILE) + LITTORAL SHELF (LOW PROFILE)
SCALE: N.T.S.

* **Low Profile Island = 300 feet x 1500 feet**
* **Low Profile Littoral Shelf = 300 feet x 1500 feet**

Figure 2-6 – Alternative 6 Profile, Looking North.

2.7 Selected Plan

Following economic and benefits analyses, Alternative 5 was determined to be the selected plan. The economic and benefits analyses that determined the selected alternative are presented in the main report. The location of the selected plan is shown in Figure 2-7. Discussion of location selection is presented in Section 4.2 of this appendix. For additional clarity and detail, the north-south profiles are shown for the selected plan in Figure 2-8 and Figure 2-9.

Figure 2-7 – Location of Selected Alternative 5.

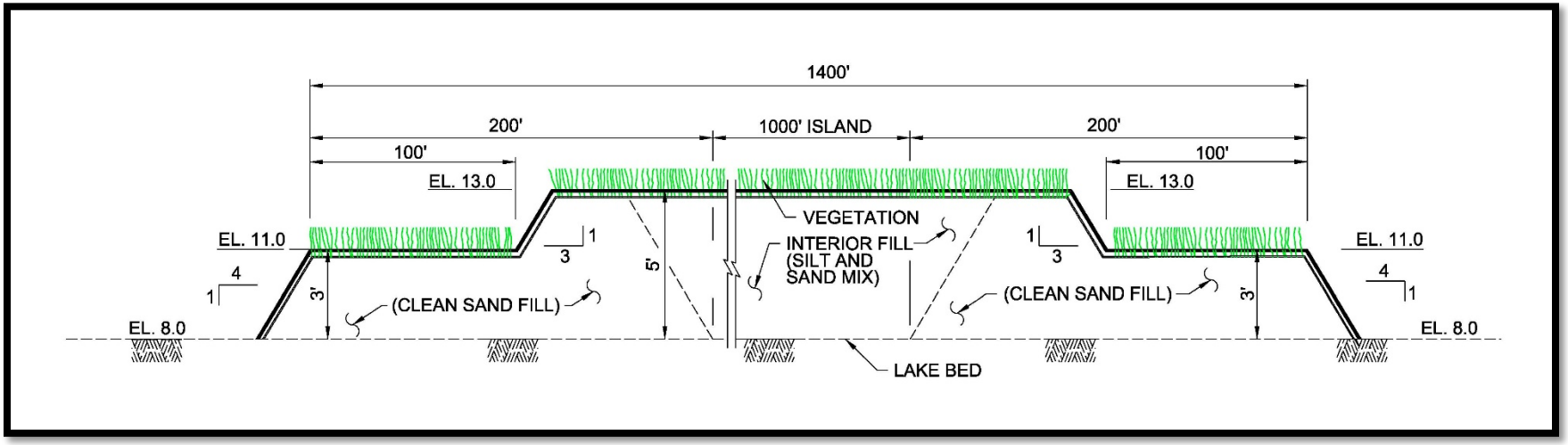


Figure 2-8 – Alternative 5 High Profile – Looking West

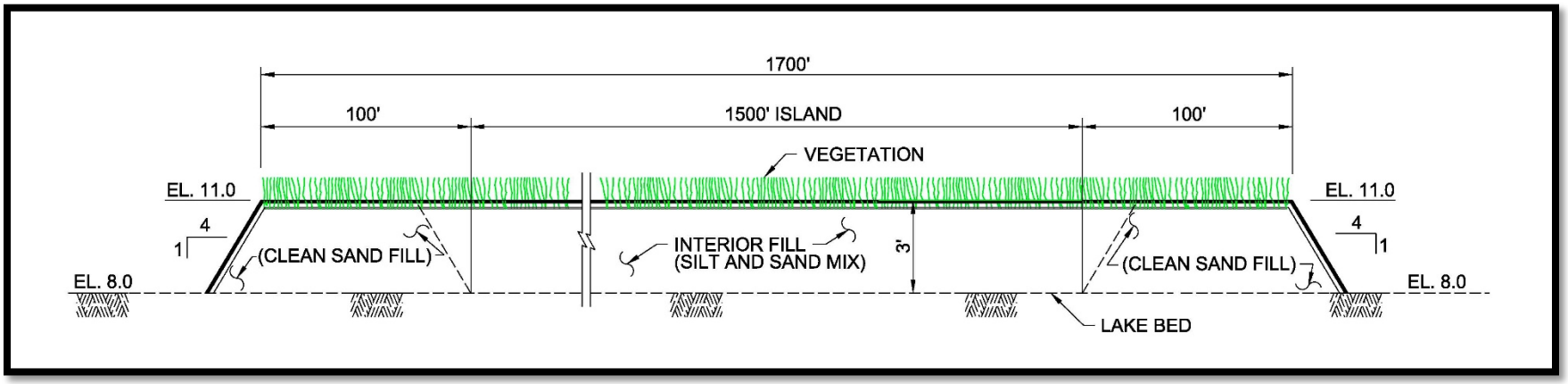


Figure 2-9 – Alternative 5 Low Profile – Looking West

3.0 Pertinent Data

Four sources of hydrographic survey data were used for this study. Data from the 2014 Herbert Hoover Dike Water Resources report (USACE 2014) was referenced to determine the approximate lake bottom elevations in the project area. Light Detection and Ranging (LIDAR) data collected by the U.S. Army Corps of Engineers (USACE) in 2016 was referenced to determine existing island elevations (USACE 2016[3]). Hydrographic survey data of Routes 1 and 2 collected by the USACE Operations Division in April and May 2017 (USACE 2017) was used to determine exact location, elevation, and areas of silt shoaling. Hydrographic survey data collected in the project area by the Sponsor in September 2017 (PBC 2017) was used to determine the final project location, based upon the shallowest areas. The results from the Sponsor's survey are presented in **Plates 1-7** in **ATTACHMENT 1**. The vertical datum in all data collected was converted to NAVD 88 (if necessary) for consistency in the analysis and design. A more current and comprehensive topographic survey will be acquired at the outset of the Design and Implementation (D&I) phase to develop plans and specifications.

In addition, wind data, lake stage frequencies, storm surge data, and significant wave height data were all collected for the analysis. The references and use of this data is discussed in Section 4.1.

4.0 Coastal and Aquatic Structure Analysis

4.1 Primary Analysis Strategy

A detailed discussion of the initial management measure development and screening is provided in Section 3 of the Main Report. To ascertain the component size range on which to begin analysis, the team referenced the Lake Worth Lagoon CAP project (USACE 2016[1]), which is similar to Pahokee in scope and objective. Table 4-1 shows the main design parameter questions that needed to be addressed to refine the design, as well as the evaluation methods and data referenced/applied.

Table 4-1 – Initial Analysis Strategy.

Step	Design Parameter Questions	Evaluation Method	Data Source
1	What Volume of sediment is necessary?	Calculated as a function of (fn) island size, elevation, and lake bathymetry.	Existing hydrographic data from HHD report (USACE 2014)
2	What material?	Wind and wave data from STWAVE model was used to determine wave climate under different storm conditions (USACE 2014).	LO operation levels and storm surges (USACE 2014)
3	Armor stone?		
4	What elevation? Multi-elevation?	Studied existing littoral shelves and islands near project area to get an idea of elevations that sustain vegetation, as well as vegetation species (Torry Island).	Site visit to Torry Island to determine species. Existing LiDAR data (USACE 2016[3]) was referenced to determine approximate elevations that will sustain vegetation seen on site.
5	What are the target restoration flora and fauna species?		
6	Which target flora species can both support the target fauna species AND withstand the variable lake stages, storm surge, and wave climate?		
7	Location along the shoreline?	Referenced hydrographic survey elevations to ascertain the shallowest locations in the study area.	Hydrographic survey data from Sponsor (PBC 2017).

The evaluations presented in Table 4-1 were executed in an iterative procedure, as represented in Figure 4-1. Discussions of the steps presented in Table 4-1 and Figure 4-1 are provided in the sections following.

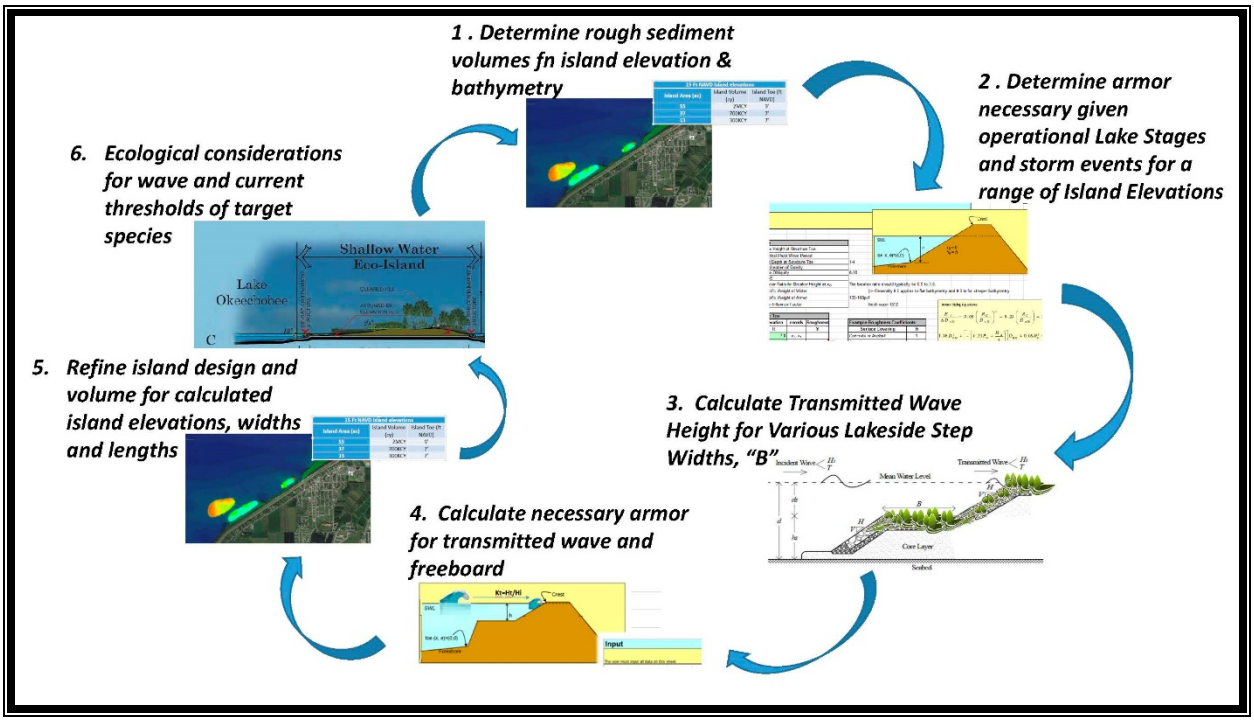


Figure 4-1 – Analysis and Design Process.

4.1.1 Natural Forces

There are a number of contributing factors controlling the processes within Lake Okeechobee. The role of each of these factors and their contribution to water level elevations are typically weather dependent. During calm weather, the operational Water Level Schedule will govern the water levels for the lake. During storm events, storm surge and wave climate must be taken into account in addition to operational water level variation.

4.1.2 Lake Okeechobee Hydrology

Lake Okeechobee is part of a massive flood control system known as the Central & Southern Florida Project, which stretches from just south of Orlando to Florida Bay and serves 8.1 million people. The U.S. Army Corps of Engineers (USACE) manages Lake Okeechobee water levels with the goal of balancing flood control, public safety, navigation, water supply and ecological health. USACE bases operational decisions – whether to retain or release water in the massive lake – on its regulation schedule and the best available science and data. Under its revised Lake Okeechobee Regulation Schedule, USACE strives to maintain Lake Okeechobee's water level in part to protect the integrity of the aging Herbert Hoover Dike, the hydraulic-fill earthen embankment dam that surrounds the lake.

In 2014, USACE performed a detailed analysis on the stage, wind, and wave climate in Lake Okeechobee (USACE 2014), as part of a larger study to replace a culvert structure on the lake (USACE 2015). The 2014 analysis included the following methodology:

- Calculate stage frequency in Lake Okeechobee to determine storm surge elevations;
- Compile wind data for Lake Okeechobee;
- Use wind and storm surge data to generate significant wave heights using the STWAVE modeling program.

Wind and wave conditions were modeled in 2014. This project uses the design wave that was the highest possible wave condition (as a function of lake stage). The 2014 analysis results were used in this study, and are presented in the following graphics. Table 4-2 shows two sets of stage frequencies for the lake, the 2000 Modified Rehabilitation Report (MRR) stages and the 2015 MCRAM updated stages. The stages used in the 2014 study were the 2000 MRR stages, and are therefore the only stages for which wind and wave data has been calculated. As presented in the following sections, the wave climate is analyzed to determine the level of erosion protection necessary. The island or shelf top elevation range of between 11.0 to 13.0 falls below the 10-year frequency lake stage, which means the island or shelf, and therefore the erosion protection, will be submerged for all less frequent (higher) lake stages and not subjected to wave impacts. In addition, the difference between the MRR and MCRAM 10-year lake stages is 0.14 feet, which is below the confidence level of the model used to calculate the wind and wave climate. Therefore, to maintain the intent of CAP, the existing wind and wave data for the MRR stage frequencies were used. The resulting storm surge elevations for multiple storms are shown in Figure 4-2 (USACE 2014). Wind data is shown in Table 4-3 (USACE 2014). The resulting significant wave heights for each storm event are shown graphically in Figure 4-3, and tabulated in Table 4-4 (USACE 2014).

Table 4-2 – Lake Okeechobee Stage Frequency.

Lake Okeechobee, Stage-Frequency				
	2000 MRR		2015 SPF Update (MCRAM)	
ACE (ARI)*	ft, NGVD29	ft, NAVD88	ft, NGVD29	ft, NAVD88
0.99 (1-yr)	12.8	11.5	11.95	10.65
0.10 (10-yr)	17.2	15.9	17.06	15.76
0.05 (20-yr)	17.8	16.5	17.54	16.24
0.04 (30-yr)	18.1	16.8	17.82	16.52
0.03 (40-yr)	19.3	18.0	17.99	16.69
0.02 (50-yr)	20.1	18.8	18.11	16.81
0.01 (100-yr)	21.3	20.0	18.66	17.36
0.005 (200-yr)			19.35	18.05
0.004 (250-yr)			19.58	18.28
0.003 (333-yr)			19.87	18.57
0.002 (500-yr)			20.32	19.02
0.001 (1,000-yr)			21.08	19.78
0.0009 (1,111-yr)			21.19	19.89
SPF	26.0	24.7	22.80	21.50

*ACE = Annual Chance Exceedance

*ARI = Annual Recurrence Interval

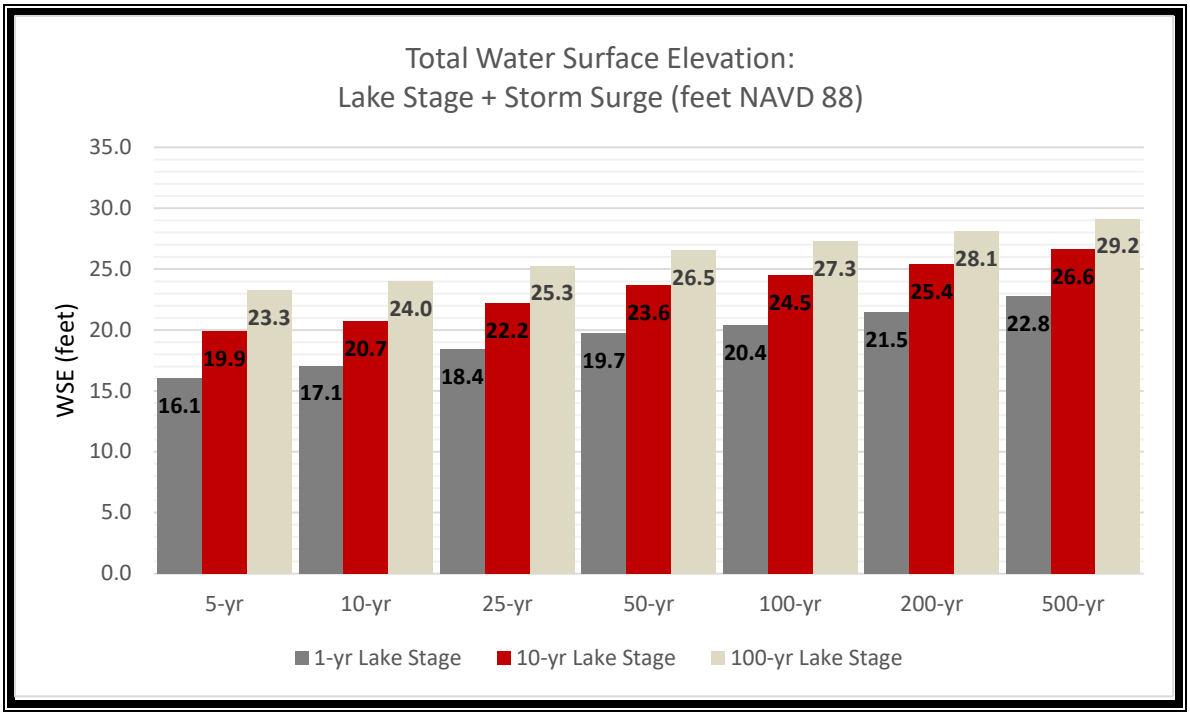


Figure 4-2 – Total Water Level for Combined Lake Stage and Storm Surge.

Table 4-3 – Design Wind Speeds.

Storm Event	50-yr, 3-sec gust (mph)	100-yr, 3-sec gust (mph)	100-yr, 1-hour gust (mph)	1-hour over water (mph)	**Fetch-limited (mph)**
5-yr	122	80.5	53.3	48.0	**42.9**
10-yr	122	90.3	59.8	53.8	**48.3**
25-yr	122	107.4	71.1	64.0	**57.7**
50-yr	122	122.0	80.8	72.7	**65.7**
100-yr	122	130.5	86.5	77.8	**70.4**
200-yr	122	139.1	92.1	82.9	**75.2**
500yr	122	150.1	99.4	89.4	**81.3**

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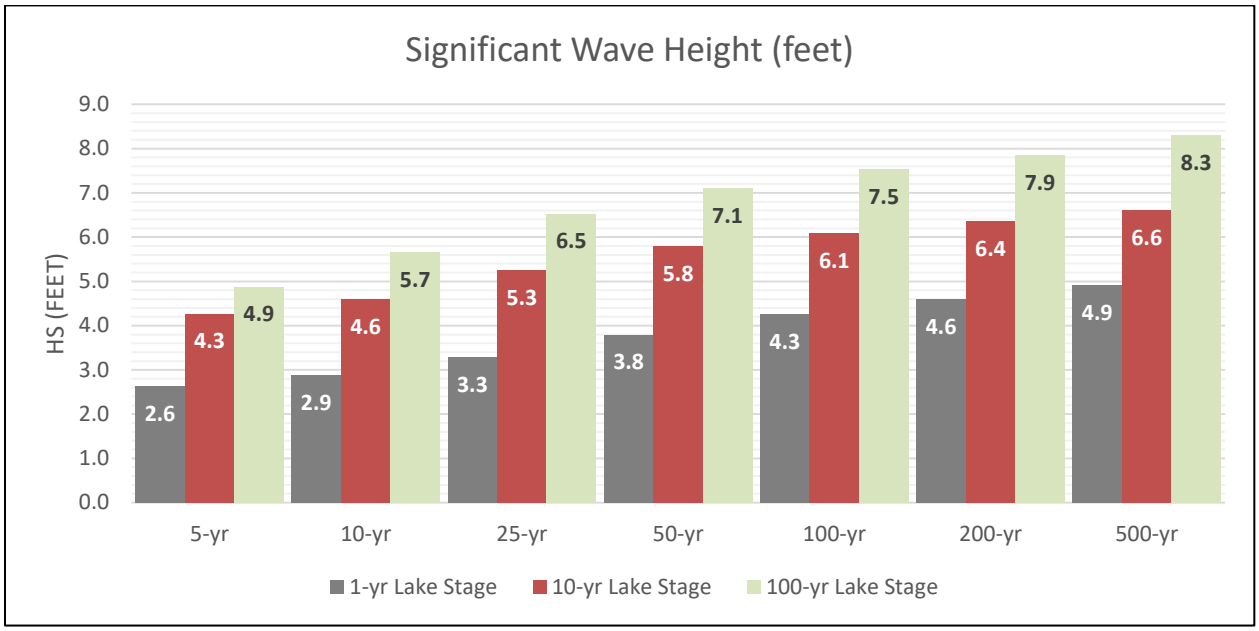

Figure 4-3 – Lake Okeechobee Wave Climate under Various Operational + Storm Scenarios.

Table 4-4 – Wind, Storm Surge, Lake Stage and Wave Heights for Lake Okeechobee.

	0.99 (1-yr) LAKE STAGE 11.5feet feet, NAVD 88 11.5				0.10 (10-yr) LAKE STAGE 15.9feet feet, NAVD 88 15.9				0.01 (100-yr) LAKE STAGE 20.0feet feet, NAVD 88 20.0			
STORM EVENT	WIND SPEED m/s	SURGE (m)	STAGE + SURGE ELEV (m) NAVD 88	WAVE HT (m)	WIND SPEED m/s	SURGE (m)	STAGE + SURGE ELEV (m) NAVD 88	WAVE HT (m)	WIND SPEED m/s	SURGE (m)	STAGE + SURGE ELEV (m) NAVD 88	WAVE HT (m)
5-yr	19.2	1.4	4.9	0.8	19.2	1.2	6.1	1.3	19.2	1.0	7.1	1.5
10-yr	21.6	1.7	5.2	0.9	21.6	1.5	6.3	1.4	21.6	1.2	7.3	1.7
25-yr	25.8	2.1	5.6	1.0	25.8	1.9	6.8	1.6	25.8	1.6	7.7	2.0
50-yr	29.4	2.5	6.0	1.2	29.4	2.4	7.2	1.8	29.4	2.0	8.1	2.2
100-yr	31.5	2.7	6.2	1.3	31.5	2.6	7.5	1.9	31.5	2.2	8.3	2.3
200-yr	33.6	3.0	6.5	1.4	33.6	2.9	7.7	1.9	33.6	2.5	8.6	2.4
500-yr	36.3	3.4	6.9	1.5	36.3	3.3	8.1	2.0	36.3	2.8	8.9	2.5
STORM EVENT	WIND SPEED mph	SURGE (feet)	STAGE + SURGE ELEV (feet) NAVD 88	WAVE HT (feet)	WIND SPEED mph	SURGE (feet)	STAGE + SURGE ELEV (feet) NAVD 88	WAVE HT (feet)	WIND SPEED mph	SURGE (feet)	STAGE + SURGE ELEV (feet) NAVD 88	WAVE HT (feet)
5-yr	42.9	4.6	16.1	2.6	42.9	4.01	19.9	4.3	42.9	3.3	23.3	4.9
10-yr	48.3	5.6	17.1	2.9	48.3	4.83	20.7	4.6	48.3	4.0	24.0	5.7
25-yr	57.7	6.9	18.4	3.3	57.7	6.29	22.2	5.3	57.7	5.3	25.3	6.5
50-yr	65.7	8.2	19.7	3.8	65.7	7.74	23.6	5.8	65.7	6.5	26.5	7.1
100-yr	70.4	8.9	20.4	4.3	70.4	8.59	24.5	6.1	70.4	7.3	27.3	7.5
200-yr	75.2	10.0	21.5	4.6	75.2	9.52	25.4	6.4	75.2	8.1	28.1	7.9
500-yr	81.3	11.3	22.8	4.9	81.3	10.71	26.6	6.6	81.3	9.2	29.2	8.3

Table 4-5 – Wind, Storm Surge, Lake Stage and Wave Heights for Lake Okeechobee (continued).

STORM EVENT	WIND SPEED feet/s	SURGE (feet)	STAGE + SURGE ELEV (feet) NAVD 88	WAVE HT (feet)	WIND SPEED feet/s	SURGE (feet)	STAGE + SURGE ELEV (feet) NAVD 88	WAVE HT (feet)	WIND SPEED feet/s	SURGE (feet)	STAGE + SURGE ELEV (feet) NAVD 88	WAVE HT (feet)
5-yr	62.6	4.6	16.1	2.6	62.6	4.01	19.9	4.3	62.6	3.3	23.3	4.9
10-yr	70.5	5.6	17.1	2.9	70.5	4.83	20.7	4.6	70.5	4.0	24.0	5.7
25-yr	84.2	6.9	18.4	3.3	84.2	6.29	22.2	5.3	84.2	5.3	25.3	6.5
50-yr	95.9	8.2	19.7	3.8	95.9	7.74	23.6	5.8	95.9	6.5	26.5	7.1
100-yr	102.8	8.9	20.4	4.3	102.8	8.59	24.5	6.1	102.8	7.3	27.3	7.5
200-yr	109.8	10.0	21.5	4.6	109.8	9.52	25.4	6.4	109.8	8.1	28.1	7.9
500-yr	118.7	11.3	22.8	4.9	118.7	10.71	26.6	6.6	118.7	9.2	29.2	8.3

Lake Okeechobee is deepest in the eastern portions of the lake, allowing it to support larger waves. For depth limited waves, a good rule of thumb is that the wave height is equal to 80% of the water depth. In addition, the highest prevalence of muds and unconsolidated silts are in that region as well. The impact of the energetic wave climate on consolidated fine silt sediment results in turbid water that attenuates light from reaching subaqueous plants. Figure 4-4 shows the wave height distribution in Lake Okeechobee as a function of a west wind (USACE 2014).

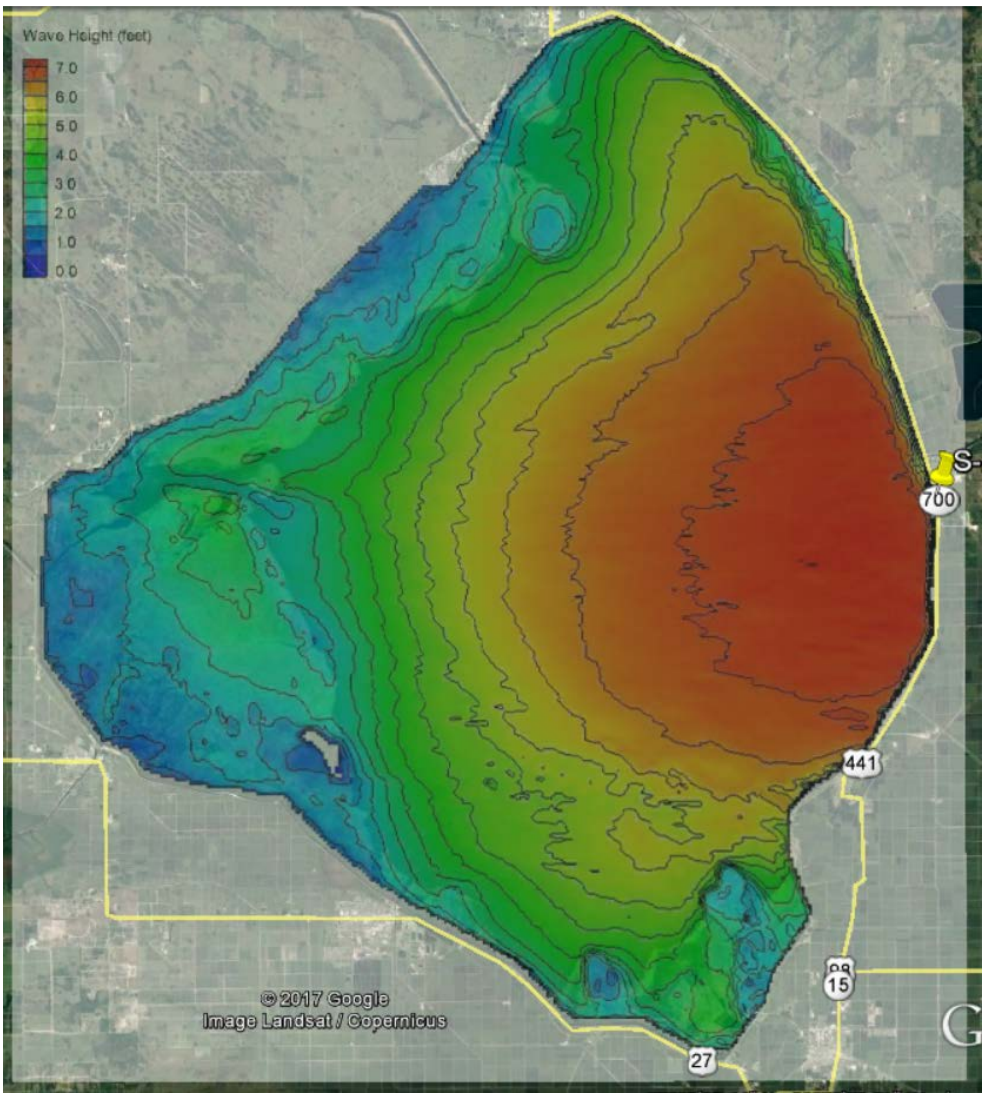

Figure 4-4 – Wave Height Distribution from West Wind.

4.1.3 Similar Environment Analysis

To select a target elevation for the planned habitat, elevations of nearby islands with healthy native vegetation were examined using 2016 LIDAR (USACE 2016[3]). The location and elevation of one of the islands, Torry Island, are shown in Figure 4-5. The most elevated portions of Torry Island were previously

elevated for agriculture use. These elevations were deemed inappropriate for the designed type of semi-aquatic vegetation, which typically occur in shallow regions of Lake Okeechobee. However, the lower elevations of the island were deemed suitable. Target elevations for constructed habitat, based upon portions of Torry Island, were identified to be between 11 feet and 13 feet NAVD 88. A discussion of the vegetation noted on Torry Island is covered in Section 4 of the Main Report.

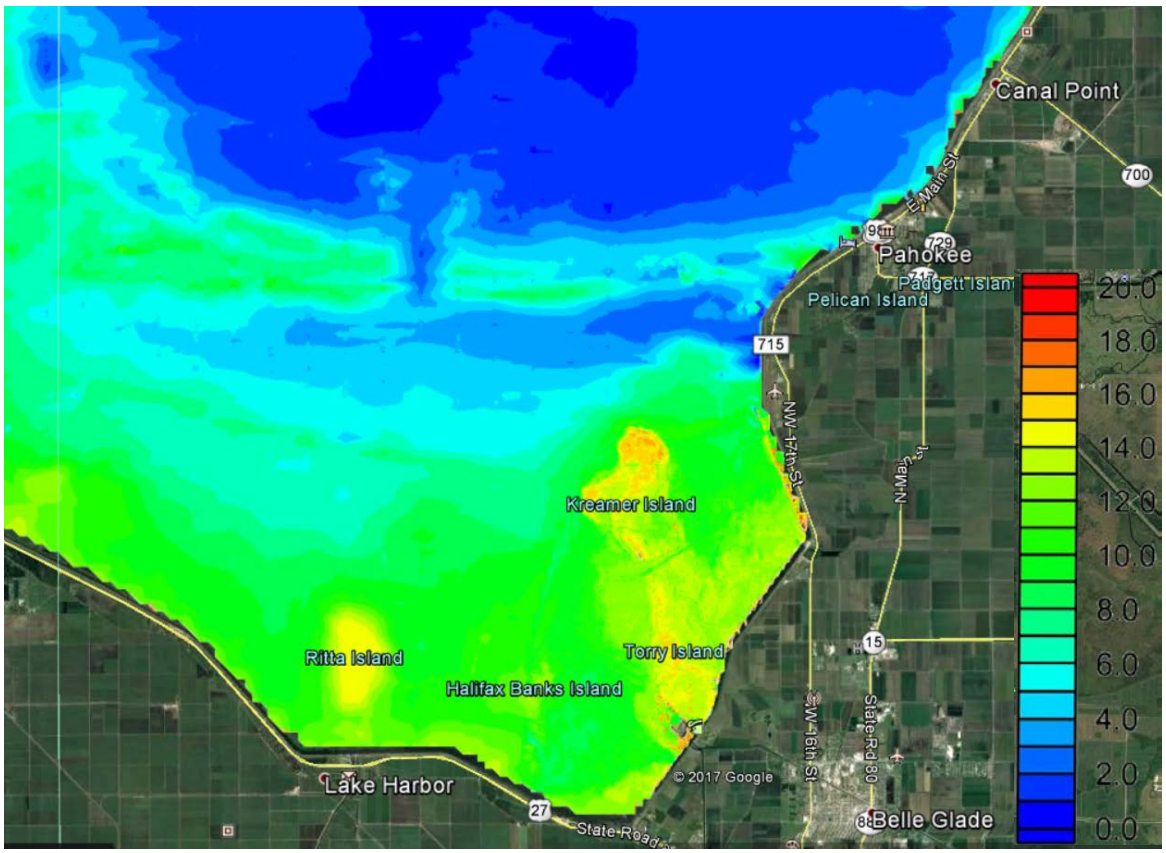

Figure 4-5 – 2016 LIDAR elevations Torry Island, FL.

4.1.4 Armor Analysis

Armor requirements to protect the habitat against erosion were determined based on operational lake stages and storm events for a range of proposed habitat elevations. The EuroTop equations (EuroTop 2007) were used to calculate necessary armor for habitat construction. Spreadsheets developed by ERDC (Melby 2015) were used for calculations of armor stone.

4.1.4.1 Maximum Expected Armor

Armor stone is based on wave climate. It was found that an island or shelf with a top elevation at or below 15 feet NAVD 88 will be submerged for all lake stages with a return frequency (x-year) greater than the 10-year event. Therefore, the wave climate with the highest energy waves that would impact the island

or shelf is the 10-year lake stage combined with storm surge between the 5-yr and 25-yr storm. The island or shelf would be submerged for all other higher energy wave climates, and not subjected to the erosive wave forces. Figure 4-6 shows an illustration of this. The maximum expected armor weight for 135 pcf stone (typical of Florida limestone) was in excess of 300 lbs.

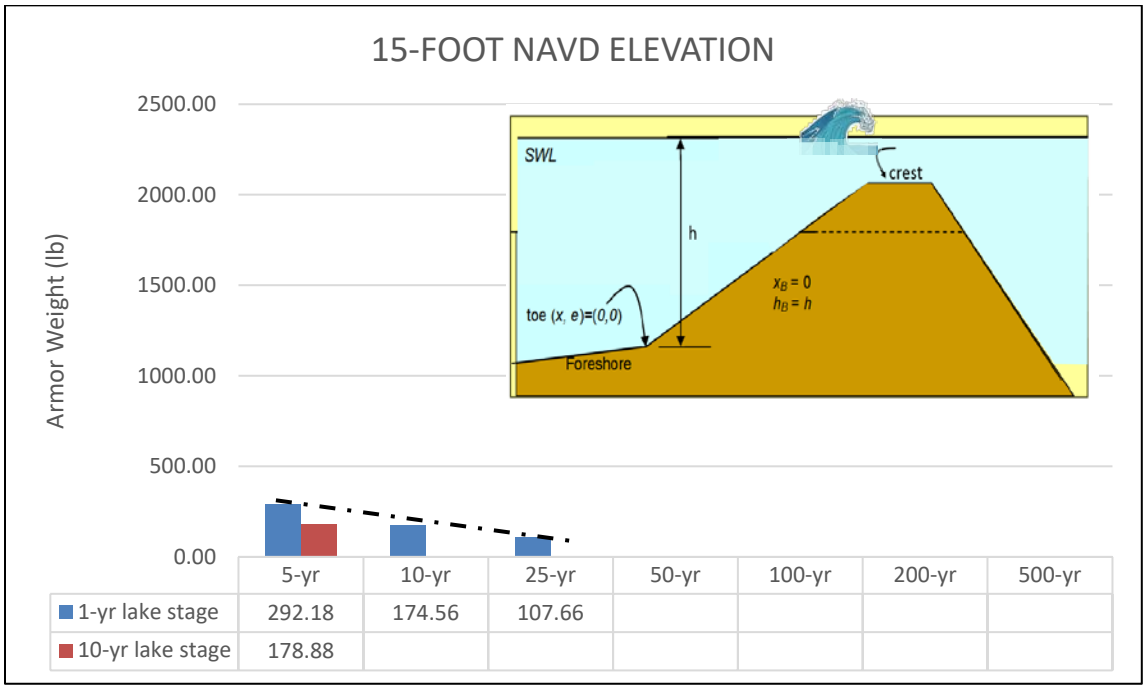

Figure 4-6 – Maximum Expected Armor Weight for Constructed Habitat.

4.1.4.2 Armor for 11-Foot Habitat

Armor stone was sized using the EuroTop equations in the spreadsheet tool provided by ERDC (Melby, 2015). The 5-year storm, with a Significant Wave Height (Hs) of 2.6 feet and a Peak Spectral Wave Period (Tp) of 3.9 seconds (USACE 2014) was analyzed for 11-foot, 12-foot, and 13-foot surface water elevations (WSE). The maximum required stone has a median armoring weight (W 50) of 202 lbs and a median armor stone size (D 50) of 1.12-feet, as shown in Table 4-6. Figure 4-7 shows an illustration of the location of the armor stone for the 5-year storm.

Table 4-6– Armor Stone Calculation for WSE 11-13 feet NAVD 88.

5-Yr storm Hs=2.6 ft Tp = 3.9s

Stone Armor - 11' NAVD Base ledge on 8' NAVD toe	Armor Weight W_{50} lb	Armor Stone Size D_{n50} ft	Armor layer thickness t_a ft	Underlayer Weight $W_{u,50}$ lb	Underlayer Stone Size $D_{u,n50}$ ft	t_u ft
11 ft surge	142.51	0.99	1.99	14.25	0.46	0.92
12 ft surge	202.11	1.12	2.23	20.21	0.52	1.04
13 ft surge	106.53	0.90	1.80	10.65	0.42	0.84

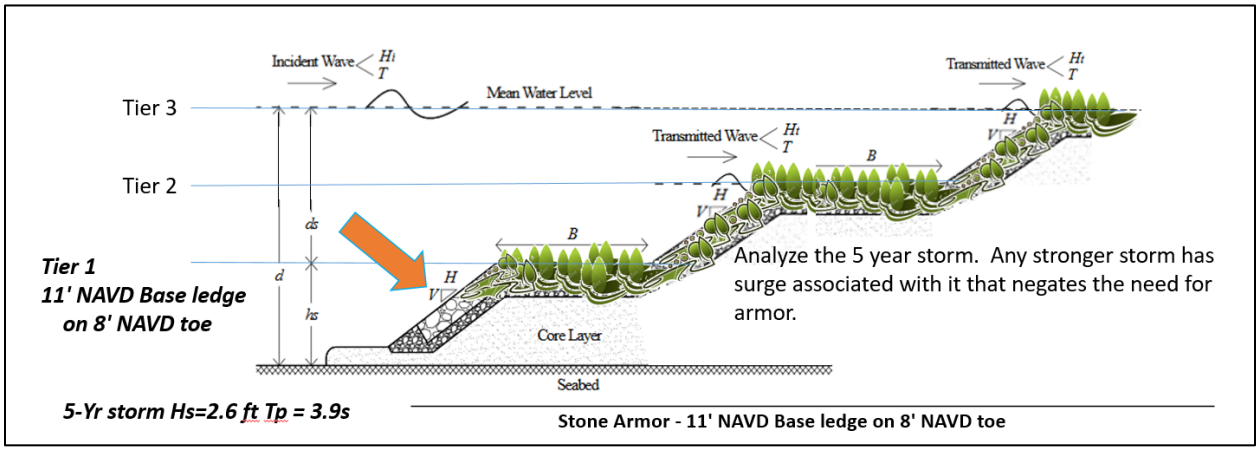

Figure 4-7 – Reference Illustration Armor and Wave Dissipation for 11 feet Elevation Habitat.

In order to size the armor needed for the slope up to the 13-foot elevation, the wave dissipation and width of the 11-foot elevation berm (B) first needs to be determined to accurately characterize the wave climate.

4.1.4.3 Minimum 11-Foot Elevation Habitat Width

Wave dissipation was calculated to determine the minimum habitat width (B) necessary such that no wave energy would be transmitted to the leeward side of the constructed habitat (Harris and Friebel 1998). Results are shown in Table 4-7. For the 5-Year storm and a total water surface elevation of 12 feet NAVD 88, wave transmission is zero for B = 20 meters (65.6-feet). For a total water surface elevation of 13 feet NAVD 88, the habitat width of 30 meters (98.4-feet) will dissipate all wave energy.

5-Yr storm Hs=2.6 ft Tp = 3.9s

Calculating TIER 1 Step Width for Wave Height Reduction								H_t (ft)			
Kt	Surge							Surge			
B (m)	11	12	13	14	15	16	17	13	14	15	17
10	0	0.21	0.43	0.58	0.69	0.76	0.82	1.1	1.5	1.8	2.1
15		0.06	0.31	0.48	0.6	0.68	0.74	0.8	1.2	1.6	1.9
20			0.2	0.38	0.51	0.61	0.67	0.5	1.0	1.3	1.7
25			0.09	0.29	0.43	0.53	0.61	0.2	0.8	1.1	1.6
30				0.2	0.35	0.46	0.54	0.0	**0.5**	0.9	**1.4**
35				0.11	0.27	0.39	0.48		0.3	0.7	1.2
40				0.02	0.19	0.32	0.42		0.1	0.5	1.1
45					0.12	0.25	0.36			0.3	0.9

Table 4-7 - Wave Energy Transmission for Various Habitat Widths and Surges.

4.1.4.4 Armor for 13-Foot Habitat

Armor stone necessary for the 5-year storm wave, transmitted across a 30 meters (98.4-feet) ledge at 11 feet NAVD 88, was sized using the EuroTop equations in the spreadsheet tool provided by ERDC (Melby 2015). The results are presented in Table 4-8 and illustrated in Figure 4-8.

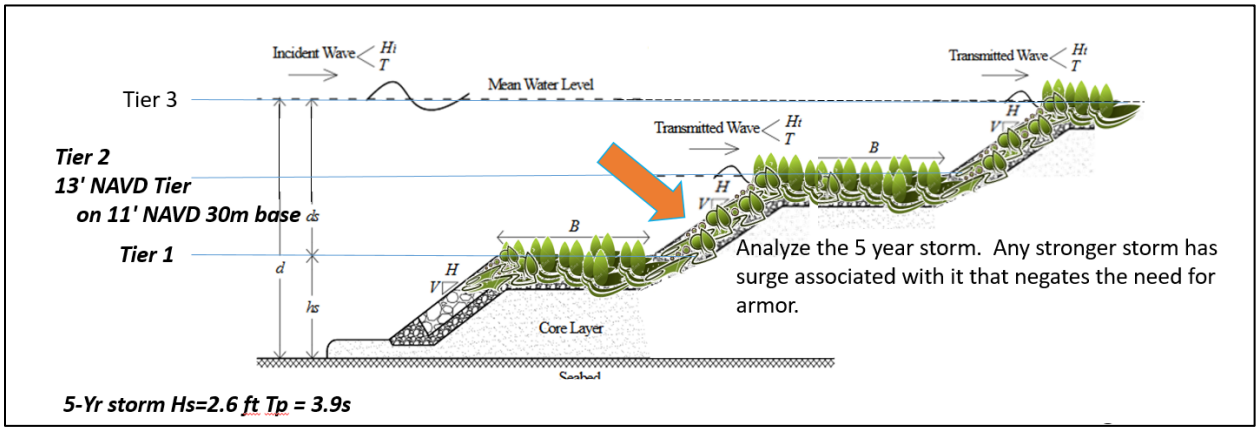

Figure 4-8 – Reference Illustration Armor and Wave Dissipation for 13 feet Elevation Habitat.

Table 4-8 - Armor Stone Calculation for WSEs 13 and 14 feet NAVD 88.

5-Yr storm Hs=2.6 ft Tp = 3.9s

Stone Armor - 13' NAVD Second Tier on 11' NAVD Base Ledge B=30m *Ht = 0.5 ft, Tp = 3.9s, Surge = 14 ft NAVD*						
	Armor Weight	Armor Stone Size	Armor layer thickness	Underlayer Weight	Underlayer Stone Size	
	W_{50} lb	D_{n50} ft	t_a ft	$W_{u,50}$ lb	$D_{u,n50}$ ft	t_u ft
13 ft surge	**3.05**	0.28	0.55	0.31	0.13	0.26
14 ft surge	0.00	0.00	0.00	0.00	0.00	0.00

4.1.4.5 Minimum 13-Foot Elevation Habitat Width

Wave dissipation was calculated to determine the minimum habitat width (B) necessary such that no wave energy would be transmitted to the leeward side of the constructed habitat (Friebel and Harris 1998). For the 5-Year storm and a total water surface elevation of 13 feet NAVD 88, wave transmission is zero for B = 30m (98.4-feet), as shown in Table 4-9.

Table 4-9 - Wave Energy Transmission for Various Habitat Widths and Surges.

5-Yr storm Hs=1.4 ft Tp = 3.9s

Calculating TIER 1 Step Width for Wave Height Reduction								H_t (ft)		
Kt			Surge					*Surge*		
B (m)	**13**	**14**	**15**	**16**	**17**	**18**		**15**	**16**	**17**
10	0	0.25	0.53	0.69	0.78	0.84		0.7	1.0	1.1
15		0.06	0.39	0.57	0.68	0.75		0.5	0.8	1.0
20			0.25	0.45	0.58	0.66		0.4	0.6	0.8
25			0.11	0.34	0.49	0.58		0.2	0.5	0.7
30			-0.02	0.24	0.39	0.5		0.0	0.3	0.5
35			0	0.13	0.3	0.42			**0.2**	***0.4***
40			0	0.02	0.22	0.35			0.0	0.3
45			0	0	0.13	0.27				0.2

4.2 Secondary Analysis

The initial screening of the parameters resulted in an initial array of 587 alternatives that included high and low profile islands, high and low profile littoral shelves, and a living shoreline. The variables applied in the initial screening are provided in Table 4-10.

Table 4-10 – Design Variables.

Variable	Range	General Results
Component	Islands, littoral shelves, and living shorelines	Living shorelines were all screened out due to construction costs
Toe Elevation	6-feet NAVD 88 and 8-feet NAVD 88	All 6 feet toe elevations were screened out due to higher cost/acre than 8 feet toe design of same acreage
Top Elevation	11-feet NAVD 88 and 13.0-feet NAVD 88*	No noticeable trends
Cross-Shore Length	100, 150, 200, and 300 feet	The longer lengths tended to be more cost-effective
Long-Shore Length	500, 1000, 1500, 2000, 2500, and 3000 feet	The longer lengths tended to be more cost-effective
Toe Material	Sand, 250-lb stone, and 500-lb rock	No noticeable trends

*11-foot elevation is considered “low profile”, and 13-foot elevation is considered “high profile”.

A discussion of the 250-lb limestone stone (with a median diameter of approximately 15 inches) and 500-lb limestone rock (with a median diameter of approximately 20 inches) is presented in Section 5.3.3 of this appendix. Preliminary unit costs were used to calculate the approximate construction cost for all 587 preliminary alternatives. The criteria used to screen the alternatives included total construction cost and cost per acre. Since the maximum cost for this CAP project is $13.3 Million, design costs over $12 Million were screened out. Those designs below $6 Million were paired up to create combination alternatives. The parameters of the six final most cost-effective array of alternatives are presented in Table 4-11.

Table 4-11 – Final Alternative Parameters.

Alt #	Description	Surface Elevation	Toe Elevation	Toe Material	Cross-shore Length	Long-shore Length	Total Acres	Cost/Acre
1	Low-profile Island	11-feet NAVD 88	8-feet NAVD 88	250-lb stone	300 feet	3000 feet	34.4	$286,335
2	Low-profile Shelf	11-feet NAVD 88	8-feet NAVD 88	500-lb rock	300 feet	3000 feet	27.5	$367,357
3	High-profile Island	13-feet NAVD 88	8-feet NAVD 88	Sand	200 feet	1500 feet	27.5	$417,451
4	High-profile Shelf	13-feet NAVD 88	8-feet NAVD 88	Sand	100 feet	3000 feet	27.5	$413,821
5	Low-profile Island[1] and high-profile Island[2]	11-feet[1] 13-feet[2] NAVD 88	Both 8-feet NAVD 88	500-lb rock[1], 250-lb stone[2]	300 feet[1], 100 feet[2]	1500 feet[1], 1000 feet[2]	29	$384,026
6	Low-profile Island[1] and Low-profile Shelf[2]	Both 11-feet NAVD 88	Both 8-feet NAVD 88	Both 500-lb rock	300 feet[1], 300 feet[2]	1500 feet[1], 1500 feet[2]	31	$346,867

*The superscripts 1 and 2 in the parameters columns refer to the like-numbered components in the Descriptions column.

After the final alternative parameters were determined, the team received updated hydrographic survey data. These data were used to narrow down the most cost-effective location for each alternative, based on actual depths.

Figure 4-9 through Figure 4-14 show the locations analyzed for each alternative. The shallowest locations abutting the shore were chosen for all the littoral shelves, and the shallowest locations for the islands were chosen, which are all located on the lake-side of the Route 2 navigation channel. The very shallow area (shown in yellow and orange hues in Figure 4-9) is an exposed limestone outcrop within the lakebed.

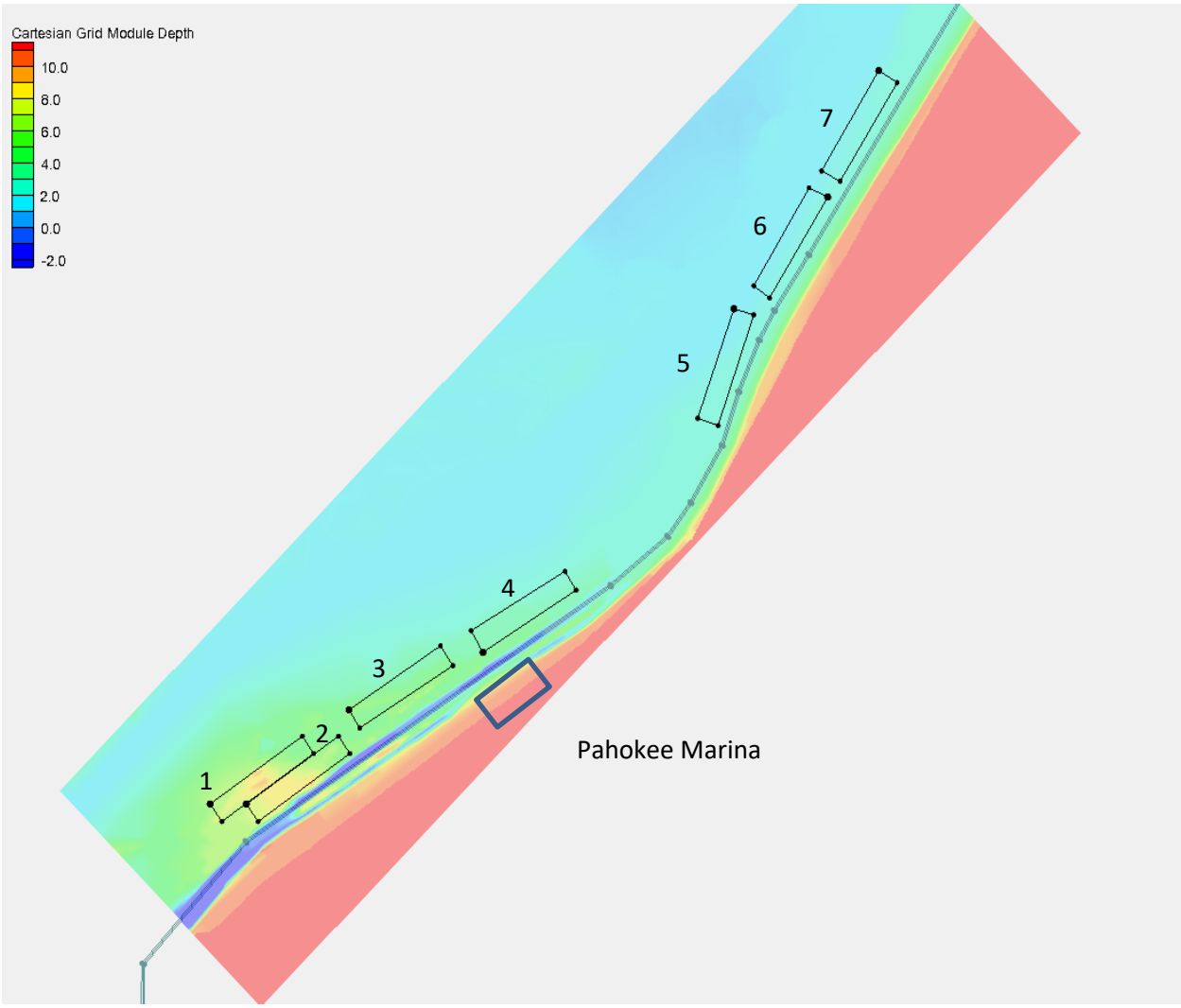

Figure 4-9 – Alternative 1 Locations Analyzed.

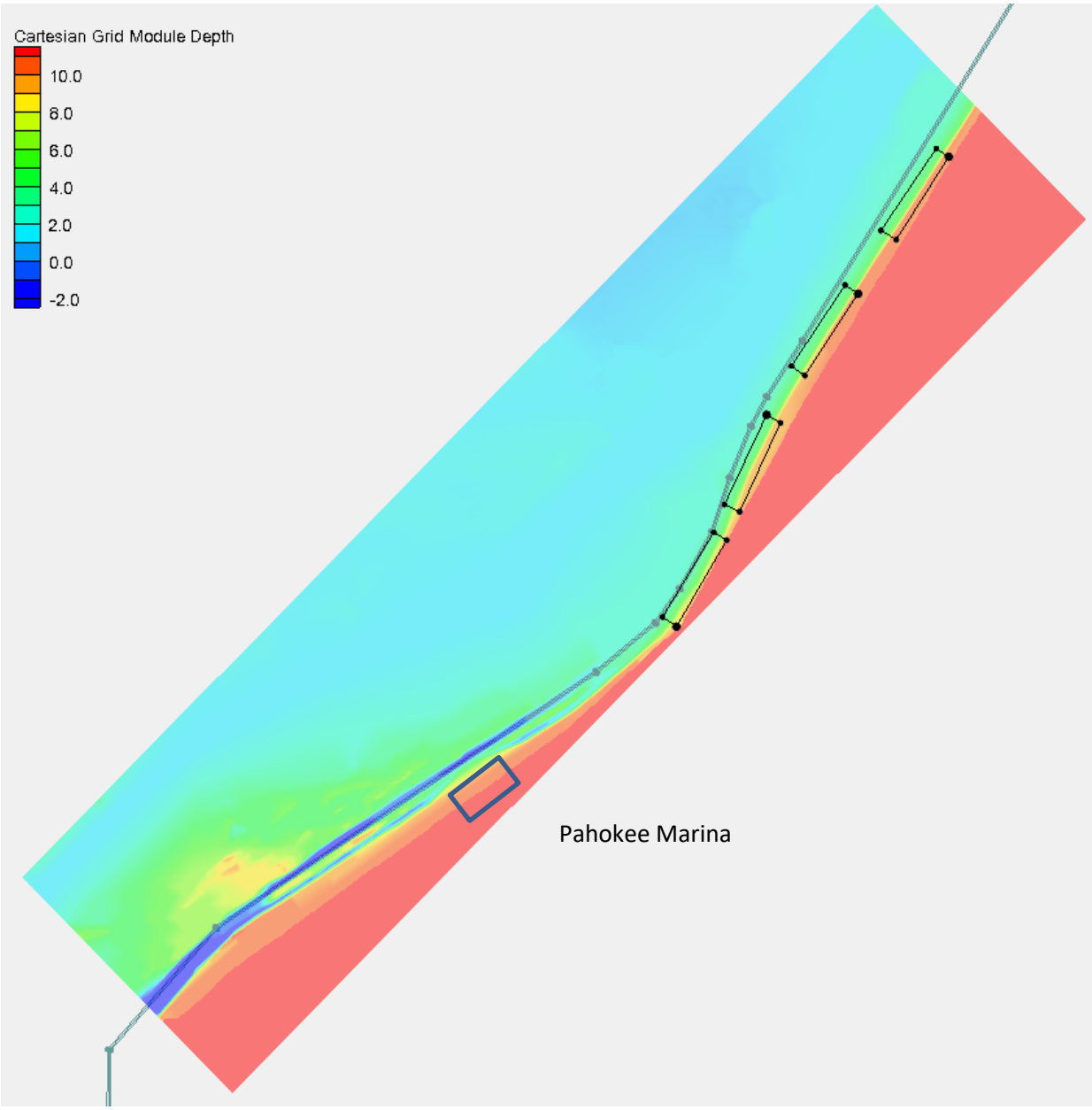

Figure 4-10 – Alternative 2 Locations Analyzed.

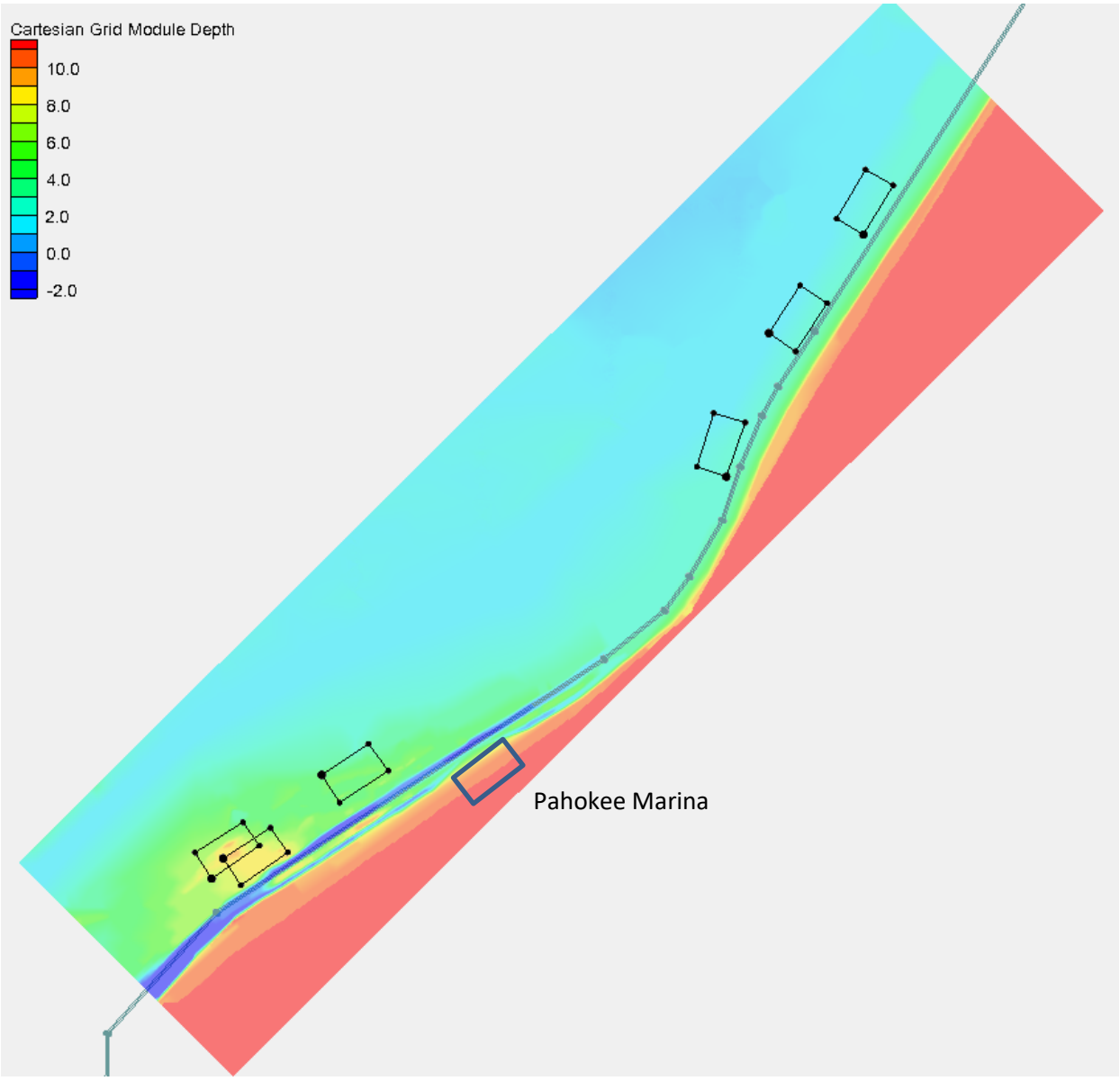

Figure 4-11 – Alternative 3 Locations Analyzed.

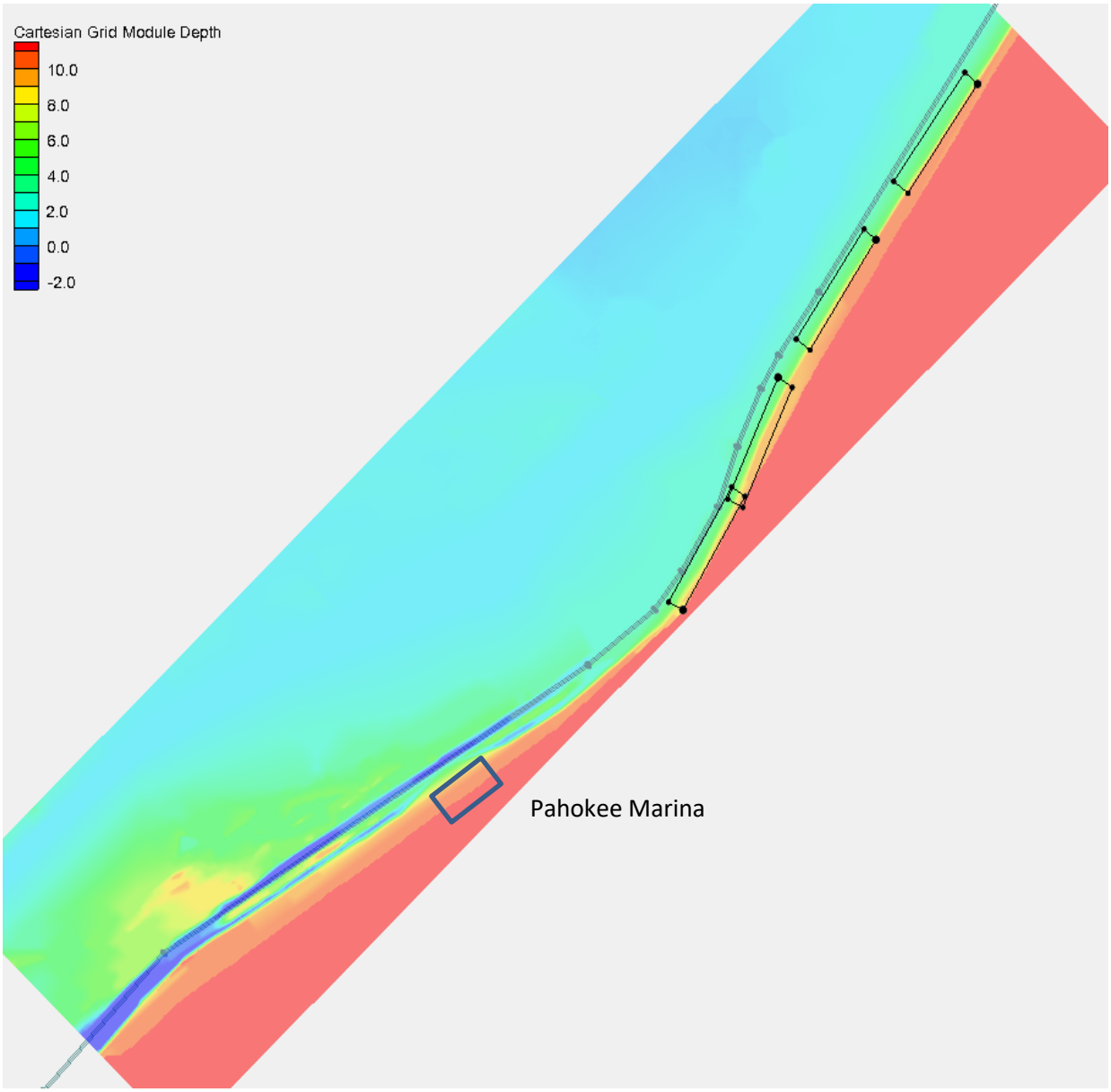

Figure 4-12 – Alternative 4 Locations Analyzed.

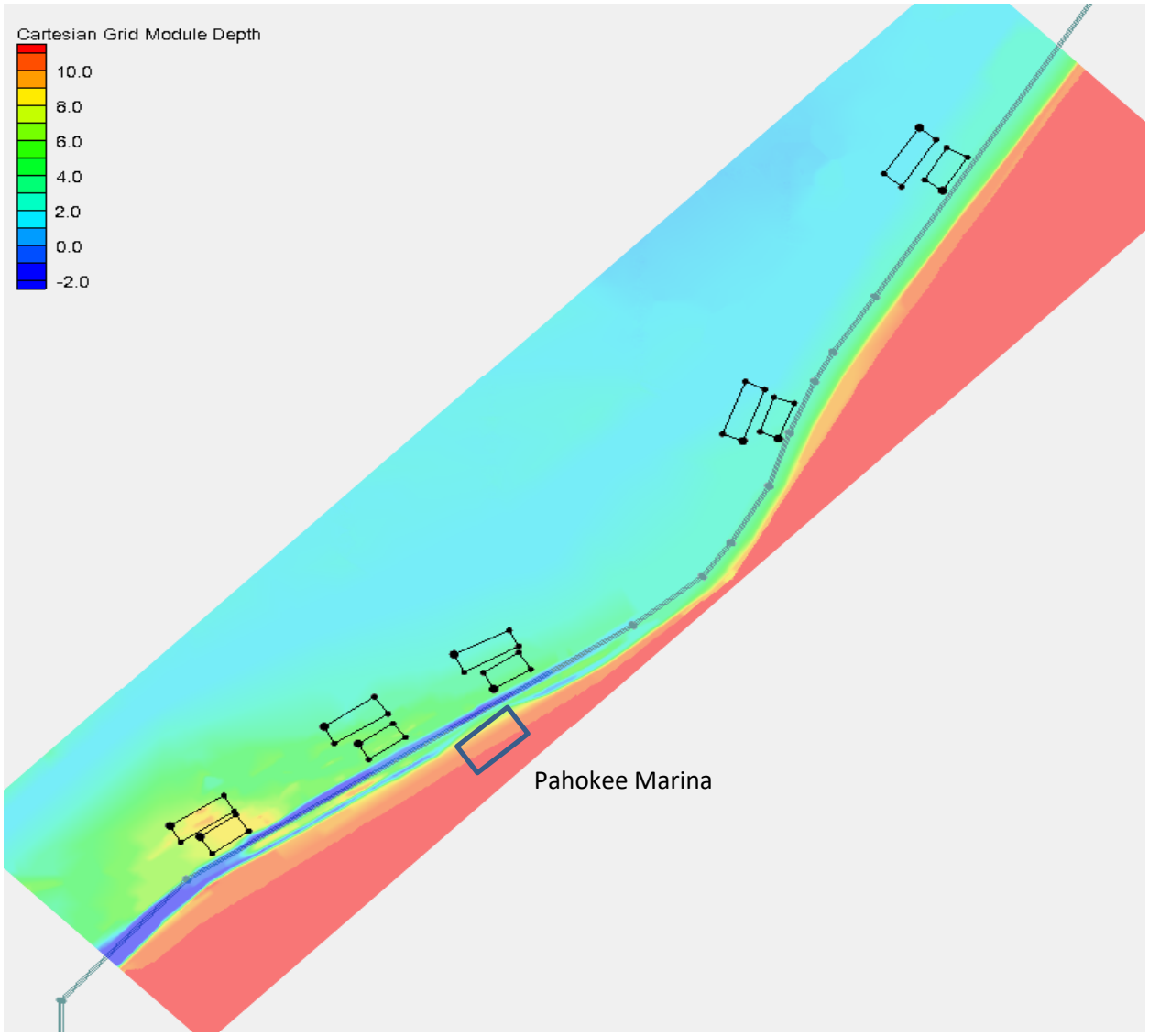

Figure 4-13 – Alternative 5 Locations Analyzed.

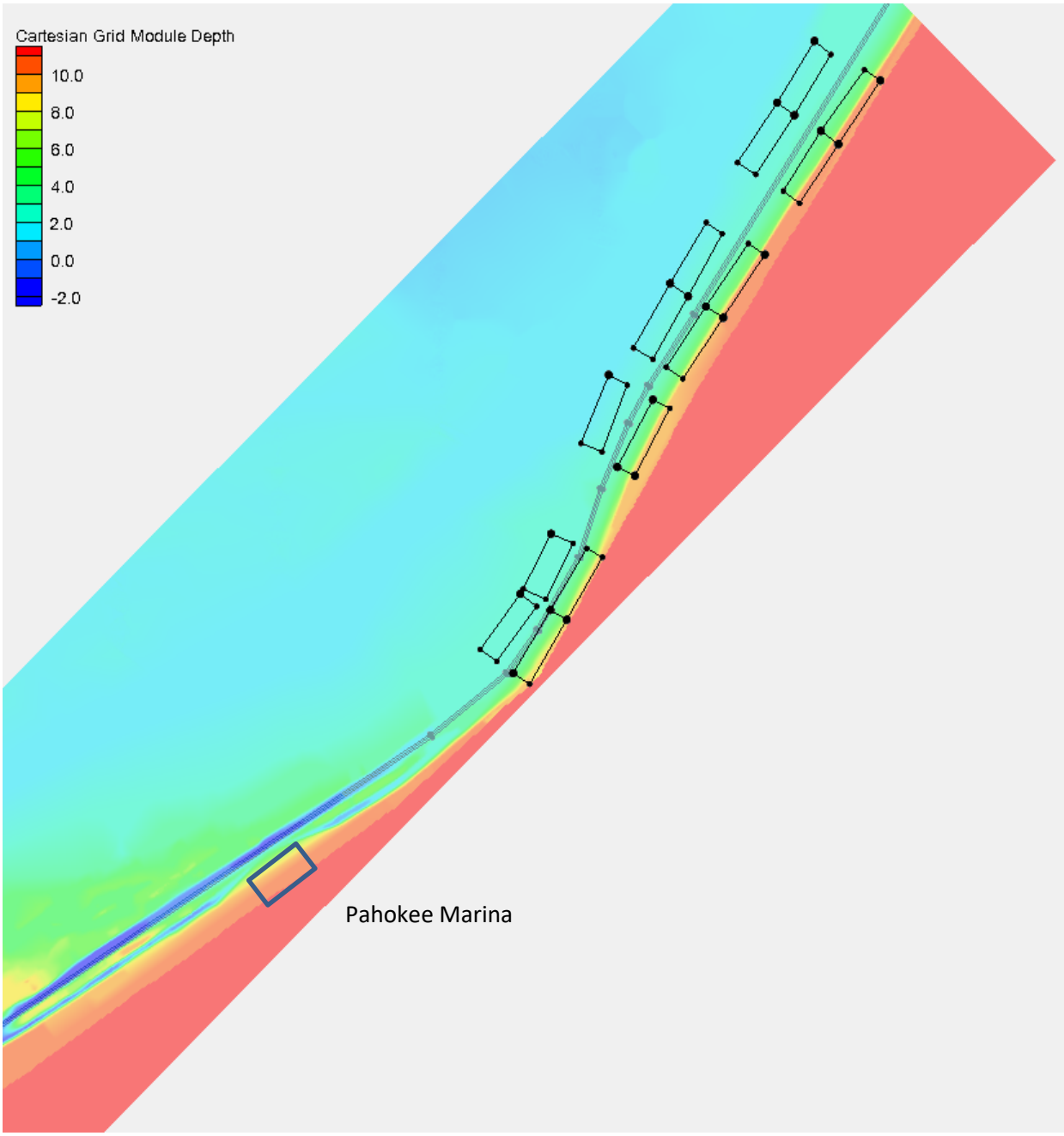

Figure 4-14 – Alternative 6 Locations Analyzed.

Once location options were determined for each alternative, the one location requiring the least material was selected for each alternative based on fill volumes. The Cost Effectiveness/Incremental Cost Analysis (CE/ICA) process, which is discussed in the Main Report, was then used to determine the selected alternative. Briefly:

- the updated costs of each alternative resulted in Alternatives 1, 2, and 6 exceeding the CAP cost limit, leaving only Alternatives 3, 4, and 5 as viable alternatives.

- After further consideration of the wave climate, the sand toe design of Alternative 4 was changed to stone.
- At the request of the sponsor, the sand toe design of Alternative 3 was also changed to include stone, resulting in Alternative 3a.
- The CE/ICA results showed that Alternative 5 is the most cost-effective and therefore the selected alternative. The most cost-effective location for the Alternative 5 is shown in Figure 4-15, with respect to Pahokee and Route 2. The two islands will be parallel to shore, positioned as shown, with the lakeward island being the low-profile island, and the leeward island being the high-profile island. The leeward island is 200 feet from Route 2, the navigation channel, meeting offset requirements of the Florida Inland Navigation District (FIND) and the Miami Waterways sector of the U.S. Coast Guard. The island location was verified to not have any obvious dam safety concerns, as long as it was off the lakeside toe of Herbert Hoover Dike. Bringing fill from outside the lake was also verified to not cause any dam safety concerns; adding material to the lake in the quantities analyzed is not expected to increase the stages since the lake stages are regulated.

Figure 4-15 – Location of Selected Alternative.

4.3 Sea Level Change

ER 1100-2-8162, Incorporating Sea Level Change (SLC) in Civil Works Programs, provides regulations and guidance for incorporating direct and indirect physical effects of projected future sea level change to USACE Civil Works projects. These regulations apply to all USACE Civil Works activities and projects, both

existing and proposed, across the project life cycle in managing, planning, engineering, designing, constructing, operating, and maintaining USACE projects and systems of projects. Consideration of potential relative sea level change is required in every USACE coastal activity as far inland as the estimated tidal influence, including studies that calculate backwater profiling with the ocean as the downstream boundary condition. Lake Okeechobee is an inland water body with a controlled stage that is not calculated using backwater profiles from the ocean; therefore, the standard SLC analysis covered in this guidance does not apply. Figure 4-16 shows the locations vulnerable to sea level rise (SLC) are along the coast and do not include Lake Okeechobee (USACE Climate Change Vulnerability Assessment Tool 2017).

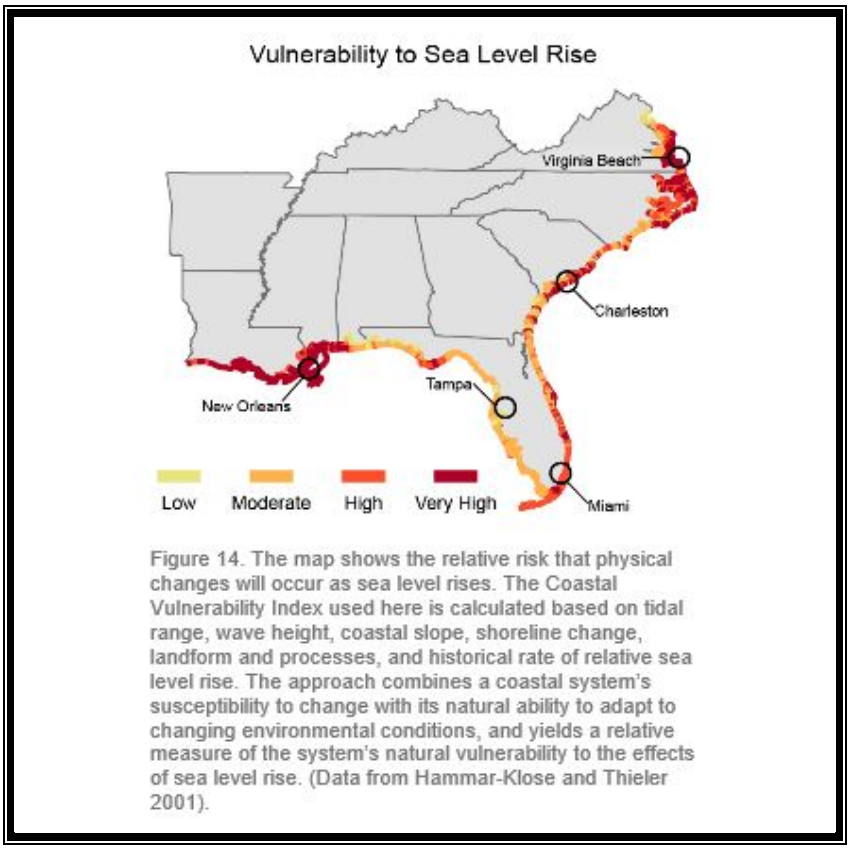

Figure 4-16 – SLR Vulnerability Map.

However, the impacts of higher lake levels would have similar impacts to the project. In the event that the Lake Okeechobee Regulation Schedule (LORS) lake stages are increased, this can be addressed similar to the adaptive management process and measures. The health of the vegetation should be monitored. If vegetation thriving levels decrease, the elevation of the component(s) can be increased by placing additional silt sediment from the surrounding lake bed on the component.

4.4 Climate Change Analysis

The overarching USACE climate change policy document, *USACE Climate Preparedness and Resilience Policy Statement* (June 2014[1]), requires consideration of climate change at every step in the project life cycle for all existing and planned USACE projects to reduce vulnerabilities and enhance the resilience of our water-resource infrastructure. Guidance for incorporating climate change and hydrologic analyses is provided in Engineering And Construction Bulletin (ECB) No. 2016-25 (16 Sept 2016), Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs, and Projects. This applies to all current and future studies and any completed projects for which Federal funds are being used to rehabilitate a project, but does not apply to short-term water management decisions. The analysis provides for consideration of specific climate change projections in the project area and potential impacts to the particular hydrologic analysis.

The required qualitative analysis involves two phases. Current climate change trends are analyzed during Phase I, and projected future changes to hydrology are analyzed during Phase II. Phase I consists of literature review and investigation of annual maximum stream flow trends using the USACE Climate Hydrology Assessment and USACE Nonstationarity Detection Tools. Phase II consists of investigating projected future trends in annual maximum stream flows using the same two USACE tools mentioned previously, and performing a vulnerability assessment using the USACE Watershed Vulnerability Assessment Tool. The Climate Change assessment for this project are presented in the following sections.

4.4.1 Phase I: Relevant Current Climate and Climate Change

4.4.1.1 Pahokee, Florida

Pahokee, Florida has a mild, and generally warm and temperate climate characterized by an annual average temperature of 73°F and approximately 75% humidity. The warmest month is August, with an average maximum temperature of 91.2°F; and the coolest month is January, with an average maximum temperature of 74.1°F. The rainy season spans from May through October. June is the wettest month with an average monthly precipitation of over 7.6 inches, and December is the driest month with an average monthly precipitation of approximately 2 inches (https://en.climate-data.org). The HUC for this watershed is 03090201.

4.4.1.2 Observed Changes

The NOAA National Environmental Satellite, Data and Information Service (NESDIS) released a report in January 2013 assessing climate trends and scenarios into the next 50–100 years for the Southeast CONUS region (NOAA 2013). The report indicates that over the period of hydroclimatological record for the Southeastern United States, both temperature and precipitation have shown either a statistically insignificant trend or no trend in change. The only trend noted was a slight increase in precipitation in the Gulf region.

The USACE Climate Hydrology Assessment Tool (https://maps.crrel.usace.army.mil/apex/f?p=313:2:0::NO) was experiencing technical difficulties and was not available for use for this project.

The Nonstationarity Detection Tool (https://maps.crrel.usace.army.mil/apex/f?p=257:2:0::NO:::) was experiencing technical difficulties and was not available for use for this project.

4.4.1.3 Projected Changes in Climate.

To account for climate change, the projected meteorological conditions in the region considers the past temperature and precipitation records, as well as the modeled future conditions in the area through 2099. According to the NESDIS report (NOAA 2013), a warming trend of approximately 2-5°F and no discernable precipitation trend can be expected over the next 50 years, although these estimates have significant uncertainty.

4.4.2 Phase II: Projected Changes to Watershed Hydrology and Assessment of Vulnerability to Climate Change.

The USACE Climate Hydrology Assessment Tool was used to examine observed and projected trends in watershed hydrology to support the qualitative assessment. However, the Climate Hydrology Assessment Tool was experiencing technical difficulties and was not available for use.

The USACE Watershed Vulnerability Assessment (VA) Tools, which include the Climate Hydrology and Nonstationarity Detection tools, (https://maps.crrel.usace.army.mil/projects/rcc/portal.html) was used to examine the vulnerability of the project area to future flood risk. The Regional Overview for the Southeast United States discusses threats to three key topics; increased sea level rise threats, increasing temperatures, and decreased water availability. For total precipitation trends predicted between the years 2071 and 2099 (as compared to 1970-1999), this tool predicts that Pahokee will experience over a 10% increase in precipitation in the fall and over a 20% decrease in during the summer with continued emissions increase (see Figure 4-17). For 2081-2100, the tool predicts a future change multiplier of over 2 for extreme daily precipitation events. The tool also reports a modeled prediction of an increase between 10% and 20% in consecutive dry days in Pahokee for the years 2070-2099 (as compared to the years between 1971-2000), given continued increase in emissions (Figure 4-18).

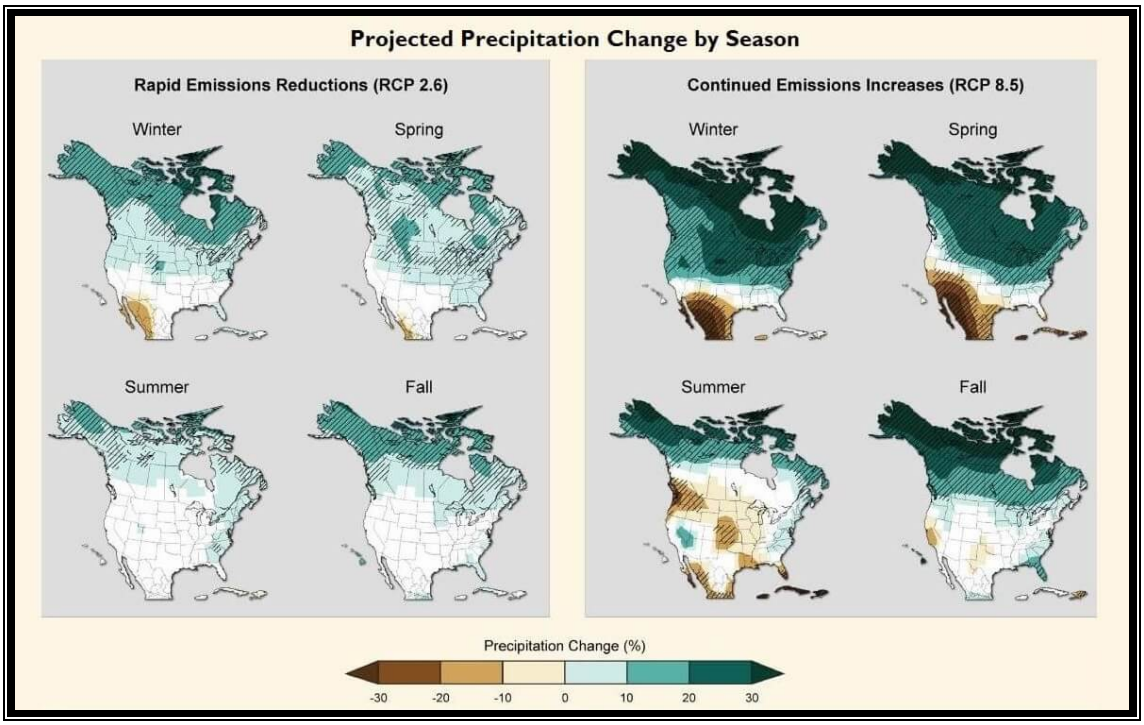

Figure 4-17 – Projected Precipitation Change by Season.

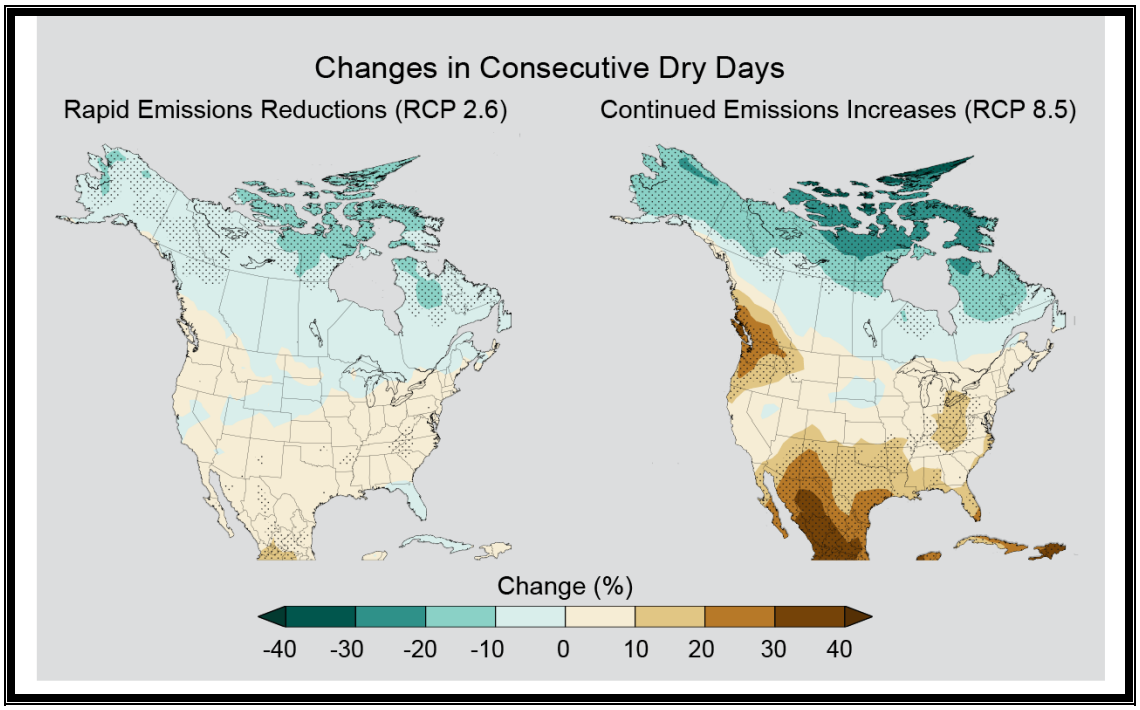

Figure 4-18 – Projected Change in Consecutive Dry Days.

Regarding temperature trends, the VA Tool shows an average increase in the annual number of days over 95°F in the Southeastern US as emissions continue to increase, as shown in Figure 4-19.

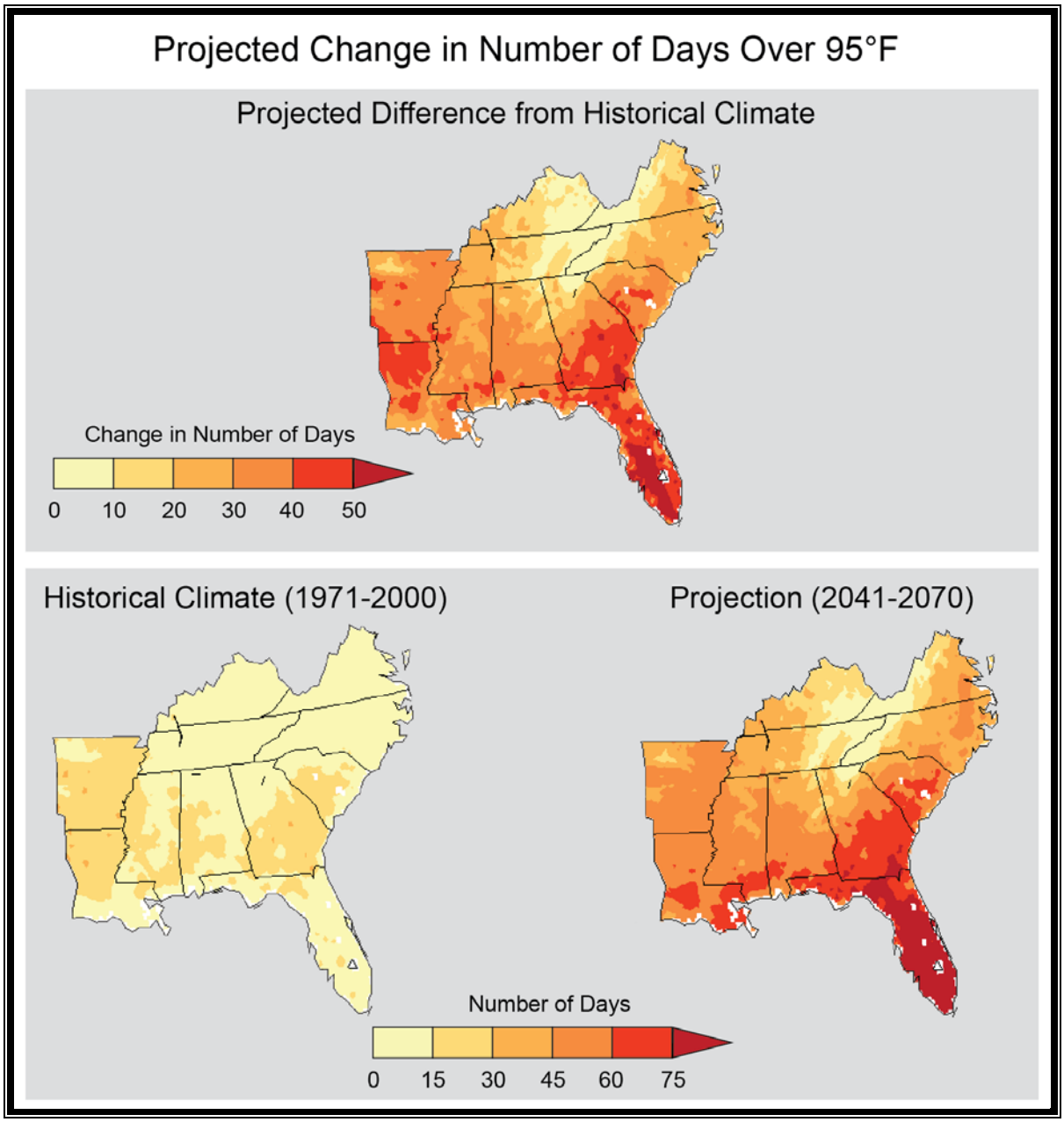

Figure 4-19 – Projected Increase in Annual Number of Hot Days.

The increased number of consecutive dry days combined with the higher temperatures and increased severity in large rainfall events has significant implications for Pahokee flora and fauna, increased soil erosion, and human health. However, with a continued Lake Okeechobee regulation schedule, the project area may not experience as great a change. The actions that can be taken in the context of the current study to make the community more resilient to higher future runoff flows, overall wetter conditions, and

higher temperatures can include continuing to operate Lake Okeechobee at the current regulation schedule, or placing additional silt to increase the component elevation if the Lake Okeechobee stages increase.

5.0 Geotechnical Analysis

This portion of the report addresses the materials encountered, geotechnical design and considerations with respect to the littoral shelf / island alternative of the Pahokee Restoration Project.

5.1 Geology

5.1.1 Regional Geology

The Florida Peninsula occupies a portion of the much larger geologic unit called the Florida Plateau. Deep water in the Gulf of Mexico is separated from deep water of the Atlantic Ocean by this partially submerged platform nearly 500 miles long and 450 miles wide. Since the Mesozoic Era, approximately 200 million years BP (before present), the plateau has been alternately dry land or covered by shallow seas. During that time up to 20,000 feet of carbonate and marine sediments were deposited in central and southern Florida. Either following or concurrent with one of the later periods of emergence, there appears to have been a tilting of the Florida Plateau about its longitudinal axis. The west coast was partially submerged, as indicated by the wide estuaries and offshore channels, while the east coast was correspondingly elevated, showing the characteristics of an emergent coastline (Randazzo and Jones, 1997).

During the last two million years, sea levels rose and fell in response to retreat or advance of polar glaciers. As a result of these sea level fluctuations, the Florida Plateau was successively inundated and uncovered by shallow seas. The penultimate interglacial maximum sea level occurred approximately 120,000 years ago, with sea levels approximately 20 feet higher than those levels today. Sea levels then declined, with lowest sea levels (and maximum glacial coverage) occurring approximately 25,000 years ago. Sea levels were as great as -300 feet (or more) lower than those of today (Balsillie and Donoghue, 2004). Figure 5-1 shows the present Florida coastline with selected sea level stands, and the extent of the carbonate platform.

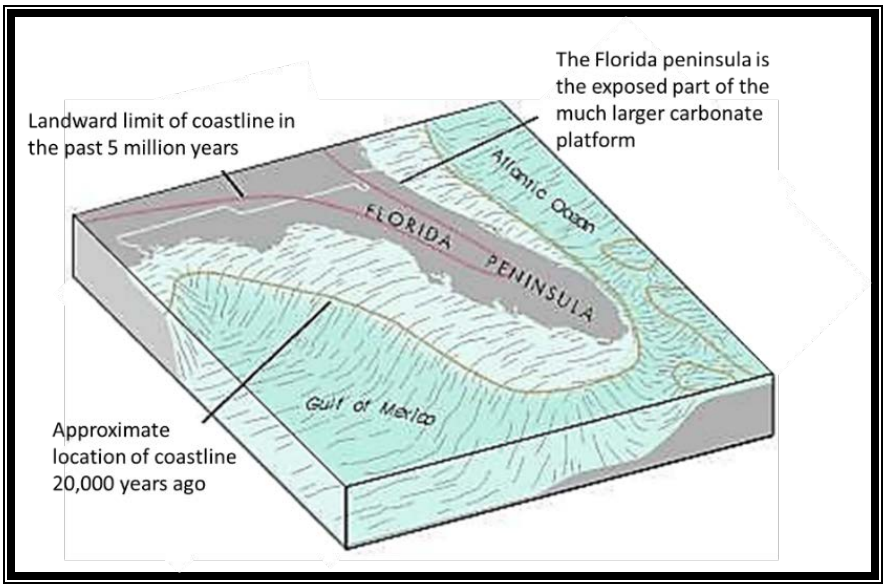

Figure 5-1 – Carbonate Platform Extent.

About 100,000 years ago, the last glacial period began. Sea level fell to 300 feet below its present level and the Florida Plateau emerged as dry land. Approximately 15,000 years ago, sea level began its most recent rise towards present sea level. Sea level rose at an average rate of 30 feet per 1,000 years. About 7,000 years ago, the rate of sea level rise slowed when the sea level was about 30 feet below its present level. It was at this most recent slowing of sea level rise that the modern barrier islands of southeast peninsular Florida formed.

5.1.2 Local Geology

Palm Beach County is made up of three physiographic areas: The Atlantic Coastal Ridge, the Sandy Flatlands, and the Everglades. The formations exposed at the surface include sand, coquina, and limestone deposited during the glacial epochs starting 10,000 to 2 million years ago.

With the exception of the Everglades and the Loxahatchee Marsh area, where organic soils cover the surface, a layer of surface sand overlies most of Palm Beach County. On the sandy flatlands between the Everglades and the coastal ridge, this sand is one to two feet thick, increasing to 10 feet along the ridge and adjacent barrier islands.

The Anastasia Formation immediately underlies the surficial sands along the Atlantic Coast, and can occur in deposits ranging from 40 feet to more than 200 feet thick. This formation is composed of sand, coquina, sandstone, limestone and shell beds. The Anastasia Formation grades laterally into the Fort Thompson formation. The Everglades are underlain by the Fort Thompson Formation, which consists of marine sands, shell beds, sandstone, limestone and freshwater marl; the deposit ranges from approximately 50 to more than 100 feet thick within the study area.

A 1973 USGS study (McKenzie) describes the subsurface material of the southeastern shore of Lake Okeechobee to contain silty, organic soil and sand. This organic soil, a supersaturated silt locally referred to as "muck," overlays gravel, limestone, and marl. Additional borings reported by the FGS in 1976 confirm the presence of supersaturated silt overlaying sandy sediments, limestone, and marl (Schneider 1976). A study from 1994 (Kirby et al.) showed that "beach rock," or limestone, outcrops in the lake, just south of the Pahokee marina. This material has been reported to be a part of the Fort Thompson Formation outcrops on the bottom of Lake Okeechobee which form a double row of "reefs" across the southern portion of the lake (Brooks 1984, Kirby et al. 1994).

The project area, located within Lake Okeechobee, adjacent to the city of Pahokee, Florida, has typical substrates ranging from supersaturated silt/clay with some organics to sand and shell; instances of outcropping limestone may be encountered south of Pahokee during low water levels of Lake Okeechobee.

5.2 Field Exploration and Laboratory Testing

Historical data was reviewed and a field investigation was conducted by Palm Beach County in order to determine the subsurface conditions of the project area.

5.2.1 Encountered Materials

A field investigation was performed by Palm Beach County as part of this Section 1135 study. At the time of this report, the results from the field investigation had not been completed. Existing field data from previous USACE, FIND, FGS, and USGS projects in the study area were utilized to evaluate site conditions. Twelve (12) previously drilled vibracores collected by FIND for a separate project (2006), but located within the study area, are shown on **Plate 8** in **ATTACHMENT 1** and summarized in Table 5-1.

Table 5-1 – Existing Vibracore Data Available for the Study Area.

Sample Designation	Northing (Y)	Easting (X)	Location
R101	962005	775908	Route 1
R102	897012	709134	
R103	897060	706960	
SLC1	1010150	888626	St. Lucie Canal
SLC2	976410	838206	
SLC3	964406	782197	
RC01	962018	780504	Route 2 / Rim Canal
RC02	957500	782236	
RC03	908477	767729	
RC04	868202	752015	
RC05	855921	735680	
RC06	874675	697422	

Fourteen (14) previously drilled Standard Penetration Test (SPT) borings conducted by the non-federal sponsor for a separate project (1989 and 1992), but located within the study area, are shown in **Plate 9** in **ATTACHMENT 1** and summarized in Table 5-2.

Table 5-2 – Existing Core Boring Data Available in Study Area.

Sample Designation	Northing (Y)	Easting (X)	Location
B-1 (1989)	906353	765125	Pahokee Marina Breakwater
B-2 (1989)	906253	765130	
B-3 (1989)	906286	765016	
B-4 (1989)	905844	764285	Pahokee Marina
B-5 (1989)	905972	764482	
B-6 (1989)	906092	764680	
B-7 (1989)	906481	764847	Proposed Pahokee Pier / OWW Routes
B-8 (1989)	906551	764806	
B-9 (1989)	906605	764767	
B-10 (1989)	906349	764951	
B-1 (1992)	905676	764534	Pahokee Marina Boat Storage and Pier
B-2 (1992)	905595	764383	
B-3 (1992)	905591	764311	
B-4 (1992)	905875	764795	

Forty five (45) jet probes were collected in October 2017 by Palm Beach County, as shown on **Plate 10** in **ATTACHMENT 1**. The samples were collected using a 2" trash pump with a 2" discharge reduced to a 1/2" pipe used to penetrate sediment. These data are summarized in Table 5-3.

Table 5-3 – Summary of Jet Probe Data from Lake Okeechobee Within the Study Area.

Sample Designation	SPC FL East, NAD 83 (feet)		Elevation (Feet NAVD 88)			Probe Length (ft)	Thickness (ft)		Probe Description
	Nothing (Y)	Easting (X)	Mudline	Top of Sand	Bottom of Sample		Silt Layer	Sand Layer	
100	905,571	749,518	1.9	1.8	-5.2	7.1	0.1	7.0	Rock
101	904,231	750,998	2.6	2.5	-5.6	8.2	0.1	8.1	Limit of Probe (20 feet)
102	902,895	752,502	1.7	1.5	-4.9	6.6	0.2	6.4	Rock
103	901,541	753,976	5.9	5.8	-3.2	9.1	0.1	9.0	Refusal
104	900,030	755,667	-1.2	-1.7	-5.2	4.0	0.5	3.5	Limit of Probe (20 feet)
105	899,655	756,082	-4.1	-4.6	-10.7	6.6	0.5	6.1	Rock
106	911,741	753,339	-0.4	-0.5	-6.3	5.9	0.1	5.8	Limit of Probe (20 feet)
107	910,069	754,451	0.3	0.2	-5.9	6.2	0.1	6.1	Rock

Sample Designation	SPC FL East, NAD 83 (feet)		Elevation (Feet NAVD 88)			Probe Length (ft)	Thickness (ft)		Probe Description
	Nothing (Y)	Easting (X)	Mudline	Top of Sand	Bottom of Sample		Silt Layer	Sand Layer	
108	908,386	755,535	0.8	0.7	-6.2	7.0	0.1	6.9	Rock
109	906,719	756,634	1.1	1.0	-6.1	7.2	0.1	7.1	Limit of Probe (20 feet)
110	905,048	757,728	3.2	3.1	-3.1	6.3	0.1	6.2	Refusal
111	903,090	759,027	8.2	8.1	6.4	1.8	0.1	1.7	Rock
112	902,607	759,341	0.4	0.4	-5.4	5.8	0.0	5.8	Rock
113	912,523	758,208	0.3	0.3	-5.6	5.9	0.0	5.9	Limit of Probe (20 feet)
114	910,852	759,304	0.6	0.6	-6.4	7.0	0.0	7.0	Limit of Probe (20 feet)
115	909,201	760,395	0.9	0.9	-6.4	7.3	0.0	7.3	Limit of Probe (20 feet)
116	907,525	761,493	1.6	1.5	0.4	1.2	0.1	1.1	Rock
117	905,551	762,791	4.0	4.0	-5.6	9.6	0.0	9.6	Refusal
118	905,074	763,097	-0.1	-1.1	-5.7	5.6	1.0	4.6	Refusal
119	916,652	760,882	0.5	0.5	-5.6	6.1	0.0	6.1	Limit of Probe (20 feet)
120	914,988	761,981	0.8	0.8	-5.9	6.7	0.0	6.7	Limit of Probe (20 feet)
121	913,305	763,077	1.0	1.0	-5.6	6.6	0.0	6.6	Limit of Probe (20 feet)
122	911,637	764,174	0.7	0.7	-3.3	4.0	0.0	4.0	Refusal
123	909,970	765,273	1.0	1.0	-3.1	4.1	0.0	4.1	Refusal
124	908,017	766,552	3.3	3.2	1.8	1.5	0.1	1.4	Rock
125	907,537	766,865	5.4	5.4	5.4	0.0	0.0	0.0	Rock
126	919,058	764,218	0.0	-0.1	-5.2	5.2	0.1	5.1	Refusal
127	918,091	765,971	0.1	-0.1	-4.4	4.5	0.2	4.3	Refusal
128	917,127	767,717	0.6	0.3	-4.9	5.5	0.3	5.2	Refusal
129	916,157	769,478	0.9	0.7	-4.7	5.6	0.2	5.4	Rock
130	915,029	771,539	2.2	1.5	-3.1	5.3	0.7	4.6	Refusal
131	914,760	772,031	4.0	3.5	-5.6	9.6	0.5	9.1	Refusal – Gravel
132	924,541	765,306	0.0	-0.3	-2.9	2.9	0.3	2.6	Refusal
133	923,446	766,968	0.3	0.1	-2.5	2.8	0.2	2.6	Refusal
134	922,348	768,647	0.4	0.1	-2.1	2.5	0.3	2.2	Refusal
135	921,245	770,312	0.5	0.3	-3.3	3.8	0.2	3.6	Refusal
136	920,133	771,986	0.8	0.3	-4.1	4.9	0.5	4.4	Refusal
137	918,848	773,958	2.3	1.9	-3.5	5.8	0.4	5.4	Refusal
138	918,534	774,443	4.0	3.2	-4.1	8.1	0.8	7.3	Refusal – Gravel/Rock
139	927,145	769,347	0.2	0.1	-3.1	3.3	0.1	3.2	Refusal
140	926,080	771,024	0.5	0.2	-2.1	2.6	0.3	2.3	Refusal
141	925,010	772,715	0.7	0.1	-2.1	2.8	0.6	2.2	Refusal
142	923,933	774,406	1.1	0.5	-2.1	3.2	0.6	2.6	Refusal

Sample Designation	SPC FL East, NAD 83 (feet)		Elevation (Feet NAVD 88)			Probe Length (ft)	Thickness (ft)		Probe Description
	Nothing (Y)	Easting (X)	Mudline	Top of Sand	Bottom of Sample		Silt Layer	Sand Layer	
143	922,652	776,375	2.3	1.6	-0.6	2.9	0.7	2.2	Refusal
144	922,334	776,862	4.0	2.9	-4.1	8.1	1.1	7.0	Refusal – Gravel/Rock

The materials encountered within Lake Okeechobee near Pahokee, Florida consist of sands and silts, peat, and limestone rock fragments; however the surficial sediments are primarily supersaturated silts, silty sands, and sand. Sands are characterized as poorly graded to silty sands, with some pebble-sized rock, and shell fragments. Silty material also contains shell fragments. Some clay is also found occurring with silt. While the visual classification of the soils show large deposits of clay material, laboratory testing indicate that this material is predominantly silt and organic material.

5.2.2 Laboratory Testing

Index testing will be performed by Palm Beach County on samples from the lake bottom of Lake Okeechobee prior to construction of the project. Sample locations will be chosen based on the reconnaissance jet probe data collected and presented in Table 5-3.

Historic data for this are include sieve analysis performed in 2006 on select samples from the Okeechobee Waterway, including Route 1, Route 2, and the St. Lucie Canal, in preparation for maintenance dredging. A summary of the index testing results is shown in Table 5-4.

Table 5-4 – Summary of Index Testing for Select Samples.

Sample Designation	USCS	% Fines (Passing #200 sieve)	Description
R102	GP-GW	0.15	Limerock and shell fragments
R103	GP-GW	0.05	Limerock and shell fragments
SLC1	CL-ML	46.7	Dark brown sandy silt with traces of shell
SLC2-top	SP	1.8	Lt brown sand with shell
SLC2-bottom	SP	1.99	Lt brown sand with shell
SLC3	CL-ML	35.97	Dark brown sandy silt with traces of shell
RC01	SC-SM	21.08	Dark brown silty sand with traces of shell
RC02	SC-SM	40.97	Dark brown silty sand with traces of shell
RC03	SP	0.86	M-F lt brown sand with shell fragments
RC04	CL-ML	60.29	Dark brown sandy silt with traces of shell
RC05	SP-SM	13.39	Dark brown silty sand with traces of shell
RC06	SP-SM	16.46	Dark brown silty sand with traces of shell
USCS: Unified Soil Classification System			

5.2.3 Potential Rock and Sand Sources

Potential sand sources for the Pahokee Restoration project were determined through existing data. Data collected by Palm Beach County will be used to supplement existing data presented in this appendix.

5.2.3.1 Lake Okeechobee

There are no potential sand sources easily accessible for mining rock or sand within Lake Okeechobee. No sandy material or rock will be removed from the Lake.

Available organic silty material within the project area will be dredged from the lake bottom and added to the interior of the island to supply nutrients and organic matter to support vegetation growth on the island.

5.2.3.2 Upland Rock and Sand Sources

There are many upland mines near Pahokee, Florida, that are capable of supplying suitable sand and rock for this project. These upland mines are located within the Okeechobee Plain, providing quartz sand and limestone rock for beach nourishment and various types of construction projects within Florida; other upland mines in Florida are found in the Duval Uplands and the Lake Wales Ridge (Figure 5-2).

The mines within a 50 mile radius of Lake Okeechobee that are capable of supplying rock and sand suitable for this project may include, but are not limited to, the following:

- Bluegoose Sand Mine - sand
- Cemex Immokalee – sand
- Cemex Palmdale – sand
- Cemex South Bay Quarry – limestone
- E.R. Jahna Sand Mine (Haines City and Moore Haven) – sand
- Five Smooth Stones – limestone
- Florida Ranch Quarry – limestone
- Florida Rock Industries (Ft Myers) – limestone
- Florida Rock Industries (Sunland Mine) – limestone
- Florida Rock Industries (Witherspoon) – sand
- Lost Grove Quarry – limestone/sand
- Mayaca Materials – limestone/sand
- Palm Beach Aggregates – limestone/sand
- Seminole Tribe of FL, Inc. (Lakeport) - sand
- Star Ranch Mine – limestone
- Stewart Sand Mine (Immokalee/Ft Pierce/Jupiter) – limestone/sand
- US Sugar Lake Harbor Quarry – limestone

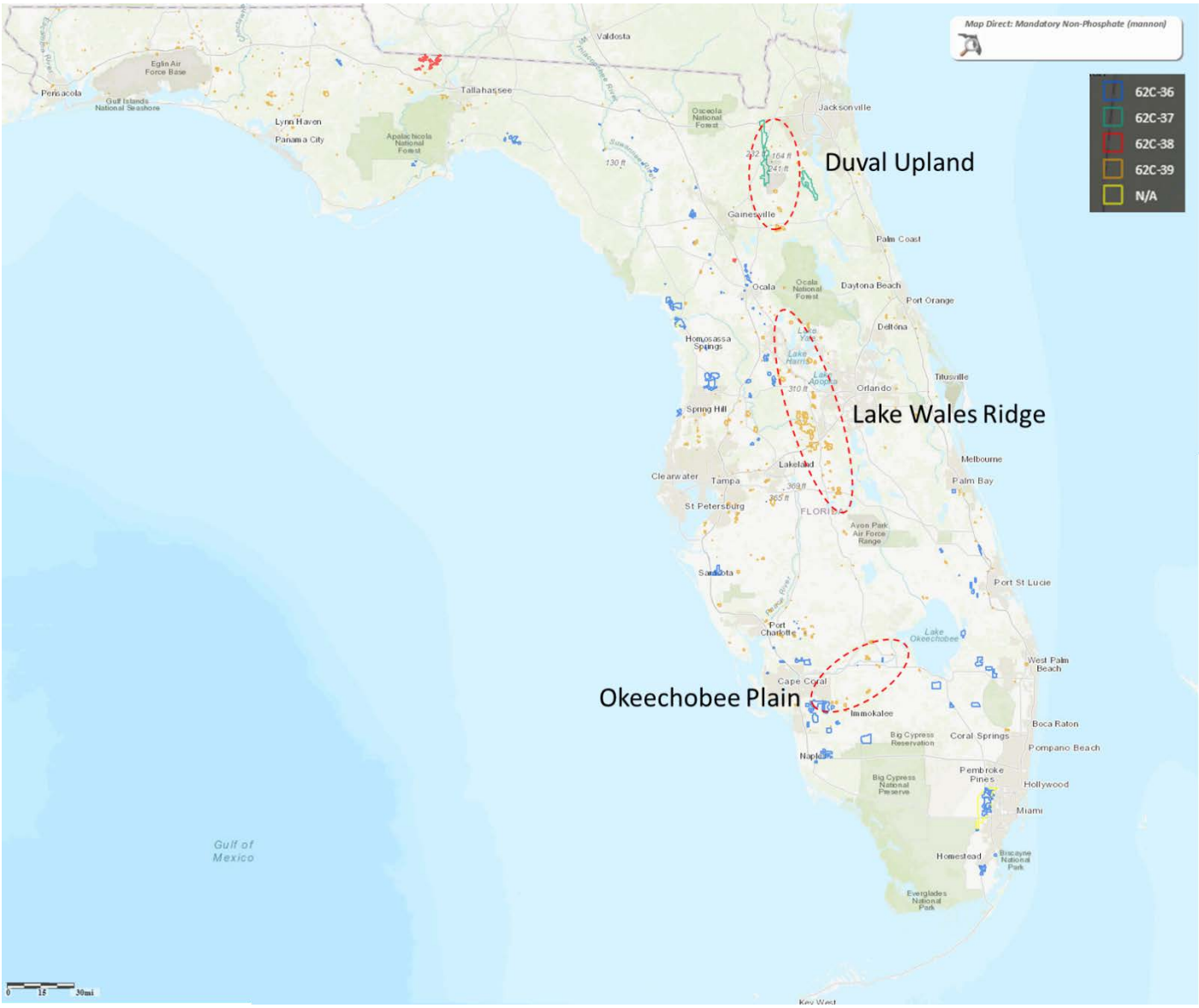

Figure 5-2 – Location of existing upland mines and large deposits of sand within Florida.

5.3 Geotechnical Evaluation

Geotechnical analyses for this project included a general assessment of the stability of the proposed "perimeter" sand berm embankments for the selected alternatives, based on the proposed construction and anticipated subsurface conditions. See Figure 5-3 below.

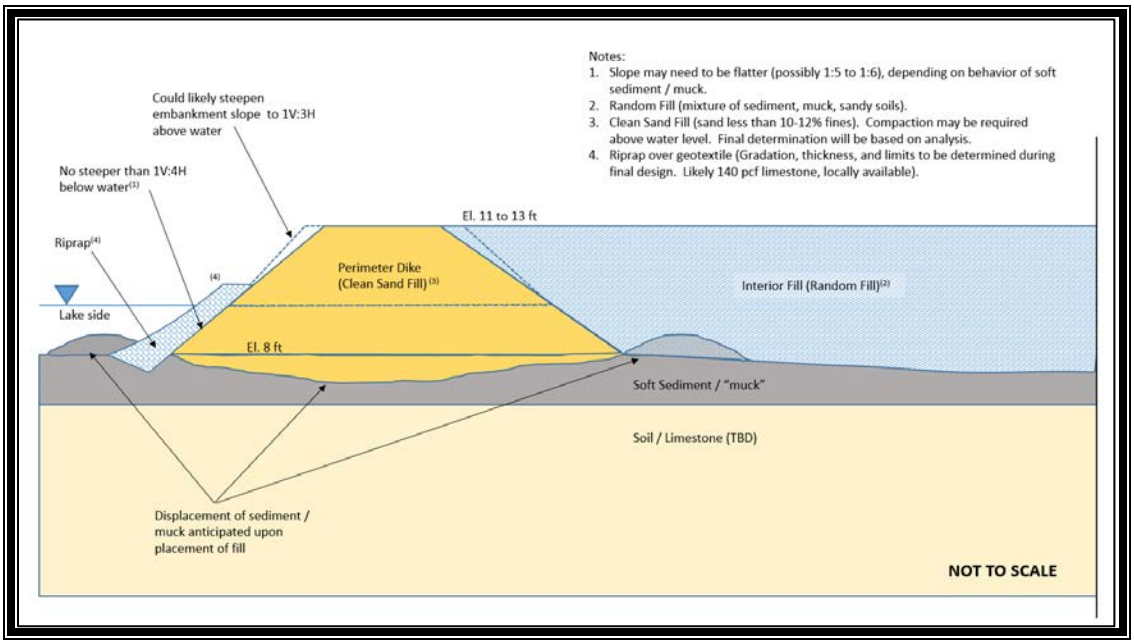

Figure 5-3 – Conceptual Construction Layout.

The geotechnical assessment for stability of the proposed embankment, considers that the construction features will likely consist of a sand berm, placed to retain fill that will compose the bulk of the island/shelf. The material recommended for the berm should consist of sand (SP, SP-SM) containing less than 10 to 12% fines (material passing the #200 sieve). The berm material should be placed by end-dumping and advancing the fill with a V-shaped leading edge such that the center of the fill is most advanced, thereby displacing much of any surficial soft sediment materials, anticipated to exist along the lake bottom. Sand berm materials placed into the lake waters (in-the-wet), will be placed without compaction. The embankment side slopes for the portion of the berm placed in-the-wet should be no steeper than 1 vertical (V):4 horizontal (H), but side slopes of 1V:5H to 1V:6H may be needed based on the actual behavior of the soft bottom materials. Once filling operations reach a height of approximately one foot to 2 feet above the lake water level, the fill soils should be compacted, and the embankment side slopes could likely be steepened to a slope of 1V:3H. The crest width of the sand berm is currently assumed to be 10 feet wide.

Once the sand berm is constructed, the interior fill materials can be placed. It is anticipated that the interior fill materials will consist of "random fill" (to be composed of a mixed combination of available sediment/silt from within the lake and the imported sandy soils used to construct the berm). The soil parameters for "random fill" (discussed below) anticipate that the materials will be generally mixed or blended by the excavation and placement processes. It is assumed that the ratio of materials used to make up the interior fill will be based on availability of material, and the required strength of the material (assumed to only be required to sustain vegetation within the island footprint). Preliminary global stability analyses was performed using the Spencer's method of slices and the circular search routine of the

SLOPE/W computer program. The SLOPE/W program was also developed by Geo-Slope International Ltd. Details of the geotechnical analyses performed are detailed below.

5.3.1 Soil Parameters

Although detailed data was not available for the subsurface conditions within the project area, the estimated soil parameters for the proposed sand berm had to be assumed to represent the anticipated soil conditions within the project area. Soil conditions could vary given that site specific data is collected in the future.

Table 5-5 – Design Sediment Parameters.

Elevation NAVD88	Zone	USCS Soil Type	γ_{sat} (pcf)	ø (deg)
13 to 11	Dike Fill	SP, SP-SM (compacted)	112	34
11 to 5(1)	Dike Fill	SP, SP-SM (uncompacted)	100	30
5(1) to 3	Sediment	ML (soft)	90	15
3 to (-)40	Lake Base soil	SP-SM, SM (loose)	105	28

Note: (1) Elevation and Depth of Soft Sediment will vary based on displacement caused by placement of overlying dike fill.

Random fill was also included in the analyses with the following parameters:

Table 5-6 – Random Fill Soil Parameters.

Elevation NAVD88	Zone	USCS Soil Type	γ_{sat} (pcf)	ø (deg)
13 to 8(1)	Radom Fill	SP, SP-SM, SM, ML (uncompacted)	100	28

Note: (1) Elevation and Depth of Random Fill at interface with Soft Sediment will vary based on displacement caused by placement of overlying fill.

5.3.2 Stability Analyses

Slope/W software (Geostudio, 2012, version 8.12.3.7901) was used to analyze the loading case discussed above with regard to slope stability (deep-seated failure / bearing capacity failure). Considerations to evaluate the stability of the proposed sand berm include global stability. The analysis considered a sand berm with the following dimensions:

- Side slope (above water table): 1V:3H
- Side slope (below water table): 1V:4H

- Crest width: 10 feet

A static water level condition was considered, with a lake level at El. 11 feet NAVD 88. Any additional buttress effects from the proposed armor stone were not considered at this stage of the analysis. Results of the stability analysis are as follows:

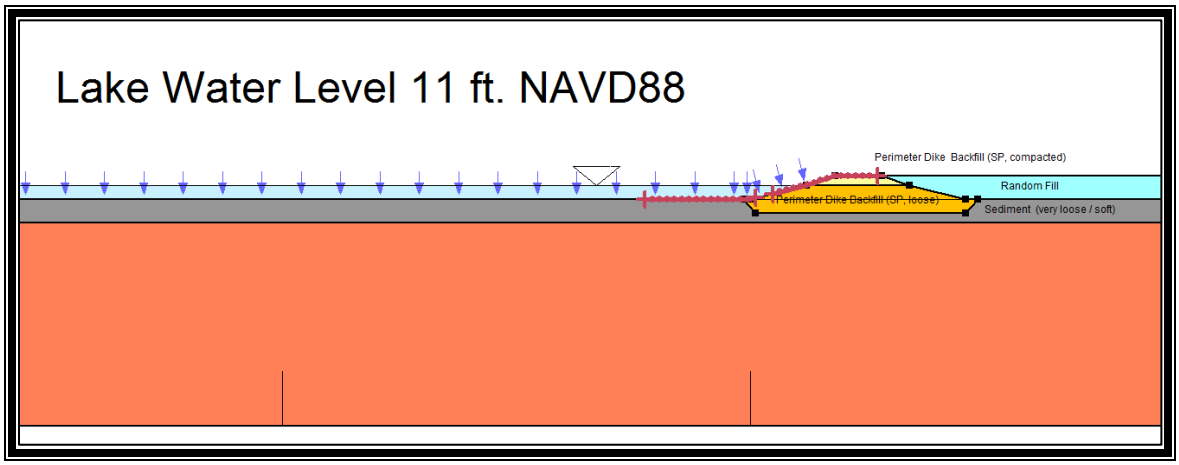

Figure 5-4 – Slope Stability.

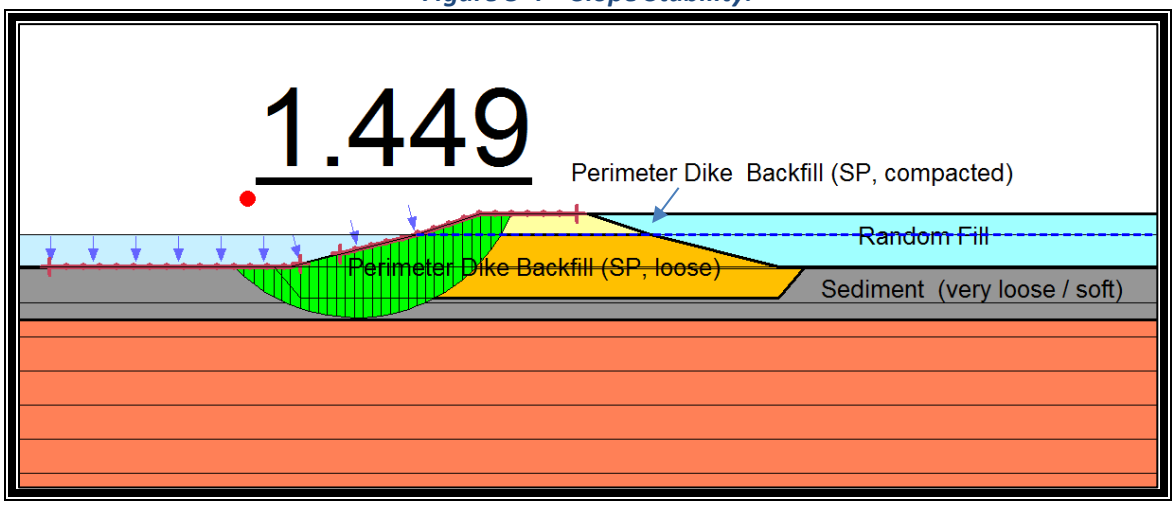

Figure 5-5 – Slope Stability Results.

Based on the preliminary results summarized above, the slope stability Factor of Safety is over 1.4. Therefore, there are no concerns related to slope stability of the sand berm. However, the estimated parameters and actual behavior of the soft sediment are expected to vary. Therefore, adjustments to the slope stability model are expected during final design. Furthermore, additional adjustments may also be needed to the side slopes during construction in order to maintain stability during backfill operations. It is expected that the slope face will be vegetated and armored, providing stabilization of the surface soils against erosion. Therefore, significant erosion of the lakeside face of the berm, is not anticipated.

5.3.3 Embankment Armoring Design

The embankment armoring design will be included as part of the final design. At this time, preliminary assessments estimate that armoring of the sand berm exteriors will be needed to protect the embankment soils against wave attack from the lake side. The protection measures will likely include a graded stone (riprap) over geotextile fabric. The riprap will likely be composed of locally available limestone (unit weight of 135 to 140 pcf), with a layer thickness of approximately 28 to 36 inches (normal to the embankment slope). The final layer thickness will be determined as a function of the final gradation, and must account for placement in-the-wet. Based on discussions with the Coastal Design Engineer, a stone gradation with a minimum W_{50} weight of approximately 200 pounds (D_{50} size of approximately 15 inches) is currently being considered. Based on gradation design criteria outlined in EM 1110-2-1601, Hydraulic Design of Flood Control Channels (1994), and considering an average unit weight of 140 pcf, the following design gradation is anticipated:

Table 5-7 – Design Gradation.

	Weight (lb)			Diameter (in)	
$W_{\#}$	Max	Min	$D_{\#}$	Max	Min
W_{100}	1000	400	D_{100}	26	19
W_{50}	300	200	D_{50}	17	15
W_{15}	---	60	D_{15}	---	10
Note: diameter consider stone shape to be 1/2 way between a sphere and a cube					

A standardized gradation (i.e., FDOT or ASTM D6092 standard) will likely be used. The closest standard gradation that would likely meet the design requirements would be FDOT Bank and Shore Protection (Standard Specifications for Road and Bridge Construction, January 2016, section 530-2.1.3.1 Rubble (Bank and Shore Protection)).

Based on the estimated size and weight of the riprap, a bedding stone layer is not anticipated. The geotextile will be a non-woven fabric. Geotextile will be required as a separator at the interface of the stone revetment sections and the supporting soils. The following requirements are anticipated for the geotextile:

- Apparent Opening Size (AOS): ≤0.27 mm
- Permeability (k): ≥ 0.131 cm/sec
- Permittivity (ψ): ≥ 0.7 sec^{-1}
- Porosity (n): 70%

A non-woven geotextile with the following properties is currently considered for use on this project:

Table 5-8 – Geotextile Properties.

Property	Units	Acceptable Values	Test Method
Grab Strength	lbs	320	ASTM D4632
Grab Elongation	%	50	ASTM D4632

Property	Units	Acceptable Values	Test Method
CBR Puncture	lbs	650	ASTM D6241
Trapezoid Tear	lbs	100	ASTM D4633
Seam Strength	lbs	290	ASTM D4632
AOS (no larger than)	U.S. Sieve	50	ASTM D4751
Permittivity (no less than)	sec^{-1}	1	ASTM D4491
Flow Rate (no less than)	$gpm/feet^2$	75	ASTM D4491
Ultraviolet Degradation	%	70 at 500 hours	ASTM D4355

5.3.4 Seismic Evaluation

The project is not located within a seismic zone; therefore, seismicity will not be evaluated in the design.

5.4 Design Phase Recommendations

This section describes the considerations to be taken into account for the design and implementation phase of the project.

Subsurface Investigations

Soils information used for this feasibility study was from investigations taken in the prior Section 205 project in the vicinity of the current project site. In order to obtain site specific conditions and narrow soil parameters of the area, it is recommended that site specific investigations are performed.

6.0 Civil Design

The site fill volumes were determined by estimating quantities based on Lake Okeechobee bottom elevations and island sizes, as described in Section 4.1 of this appendix. The volumes used for cost estimation are provided in **ATTACHMENT 2** of this appendix.

Coastal design and geotechnical analyses determined the optimal side slopes for the design of the islands. Side slopes of 1V on 3H above the water provide the most optimal slopes for wave energy dissipation. Side slopes of 1V on 4H below the water were determined to be the most stable. Additional information is provided in Section 5.3 of this appendix.

7.0 Real Estate

This project will require the acquisition of real estate in order to obtain access for construction equipment. Figure 7-1 shows the location of the selected alternative. This map is drawn to scale, and the leeward island is 200 feet lake-ward of the Route 2 navigation channel.

Figure 7-1 – Selected Alternative Location.

Real estate acquisition will also be required for staging/lay down areas, borrow areas, and access roads, which were selected to be in close proximity to the construction. The locations are shown in Figure 7-2. This project is located in the lake adjacent the City of Pahokee, and use the existing public city streets for transportation of construction equipment and material will be feasible.

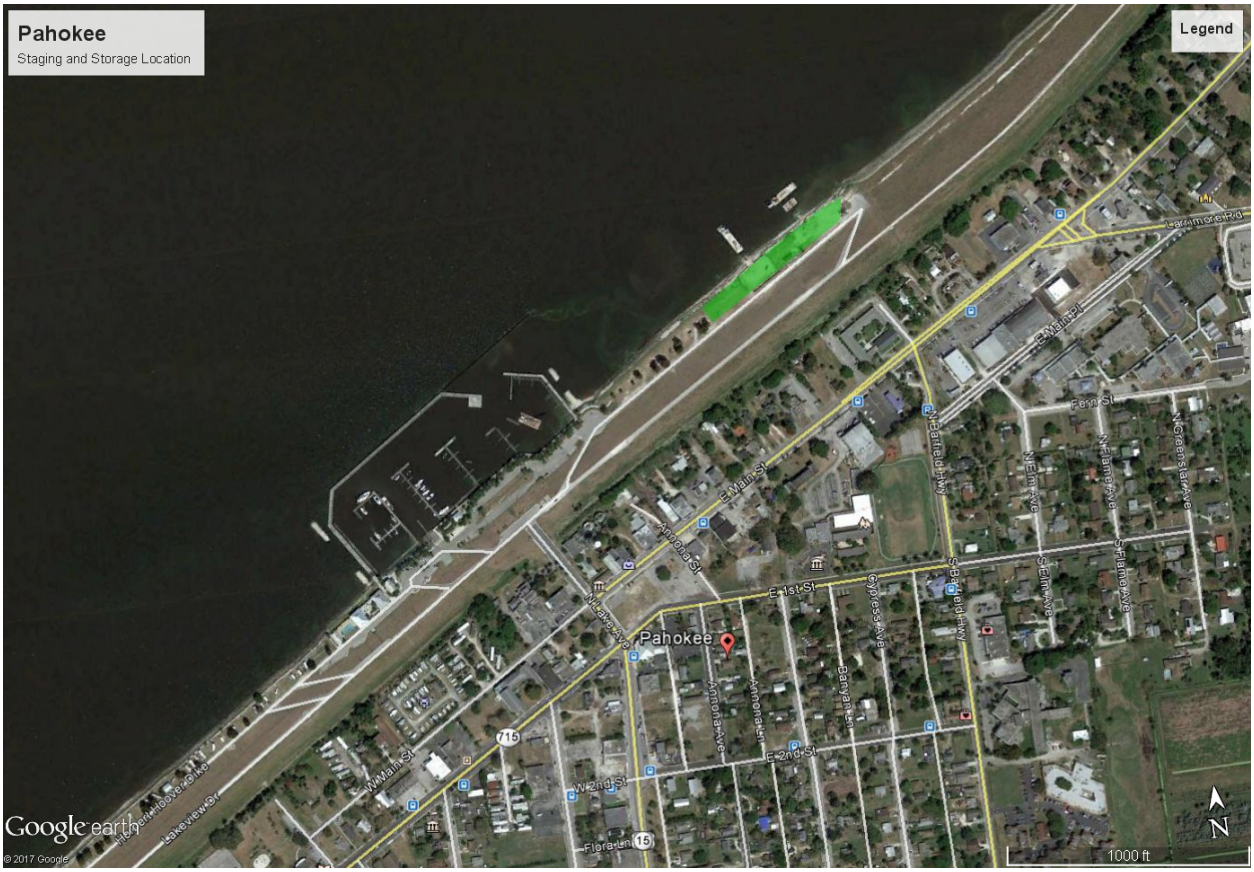

Figure 7-2 – Staging and Borrow Areas Locations.

8.0 Relocations

No utilities located in the vicinity of the project would be impacted during construction activities.

9.0 Structural Requirements

There are no structural elements in this design.

10.0 Electrical and Mechanical Requirements

There are no electrical or mechanical elements in this design.

11.0 Hazardous, Toxic, and Radioactive Waste (HTRW)

A desktop qualitative environmental analysis was performed on the silt in the project area, and is presented in the main report. The quality of the sand from the upland mine is known to be free of HTRW. Regarding the silt to be dredged, sediment is regulated under the Clean Water Act. HTRW testing is not required on sediment dredged from and placed within the same water body.

12.0 Construction Procedures and Water Control Plan

Construction of the revetment will be sequenced in order to minimize settling or displacement of the fill material. Runoff and erosion control measures will also be put in place during construction to minimize erosion of the slopes adjacent to the newly constructed component, as well as the fill material in the staging/access area.

12.1 Design and Implementation (D&I) Data

The following data and analyses will occur during the D&I Phase:

- Value Engineering Study;
- Design level hydrographic data;
- Reciprocal island position;
- Sediment probes to characterize the silt, including thickness and settle-ability;
- Construction access in shallow waters; and
- Sand placement technique to minimize silt displacement.

The team will conduct a Value Engineering Study at the beginning of the D&I Phase (see Value Management Plan in **ATTACHMENT 3**). During this study, the team will analyze and determine the most optimized design aspects, such as island position and placement relative to each other; as well as the most efficient methods of dredging and construction in the wet. Current uncertainties related to unknown silt settling rates, unknown location and quantity of silt, and barge access to the construction site were taken into account in the cost risk register.

12.2 Construction Techniques

The following construction equipment and techniques were assumed when calculating cost estimates:

- Sand will be excavated from an upland mine and transported to the Pahokee Marina staging area via truck.
- A scow barge with 3,000 CY capacity will be used to transport material from shore to site.
- Two hydraulic excavators and two clamshells will be used for loading and offloading the sand onto and from the barge.
- A dozer and a grader will be used for grading.
- One dredge will be used to dredge and place silt.

12.3 Construction Constraints

Material will not be excavated between the shore and the Route 2 navigation channel for dam safety reasons. In addition, the following potential construction constraints will be analyzed in greater detail during the D&I phase:

- Will all silt for the project be sources from Route 2? This is only possible in locations where the HHD cutoff wall has no gaps;

- If construction of sand berm sand berm occurs during high lake levels, will it be constructed to a higher elevation to contain the silt, and the sand berm sand elevation will slowly be reduced down to the design elevation by alternately pushing sand layers over the silt layers?
- How much time will be required to dewater the silt prior to placing the next layer of sand?
- Will the construction vessels be able to navigate around the exposed limestone ridge on the north to construct the lake-ward island from the west?

13.0 Operation and Maintenance

Operation and Maintenance (O&M) costs are 100% non-federal responsibility. USACE will be providing a Monitoring and Adaptive Management Plan instead of an O&M Plan. The Monitoring and Adaptive Management Plan details are discussed in Section 14.0 of this appendix.

14.0 Monitoring and Adaptive Management Plan

The Monitoring and Adaptive Management Plans for the project are combined into one document, **APPENDIX E**, and are also discussed in the main report. The differences between the two plans are covered in detail in **APPENDIX E**. In summary, the Monitoring Plan portion of the Monitoring and Adaptive Management Plan lasts for the first five years after construction completion, monitors the establishment of the vegetation, and is included as part of the cost estimate. The Adaptive Management Plan portion is meant to address functionality beyond the first five years post construction, and is not included in the cost estimate. Potential adaptive management measures could include replacement of approximately 80% of the riprap every ten years (depending on the performance of the proposed vegetation to resist erosion), and the placement of additional material to increase the island elevation. For example, if vegetation thriving levels decrease and low elevations are determined to be the cause of low success, then the elevation of the component(s) can be increased by placing additional silt sediment from the surrounding lake bed on the component. Costs associated with this can be found in the Cost Appendix.

15.0 Schedule for Design and Construction

The schedule for design and construction, as well as the cost risk register, is provided in the separate Cost Appendix.

16.0 References

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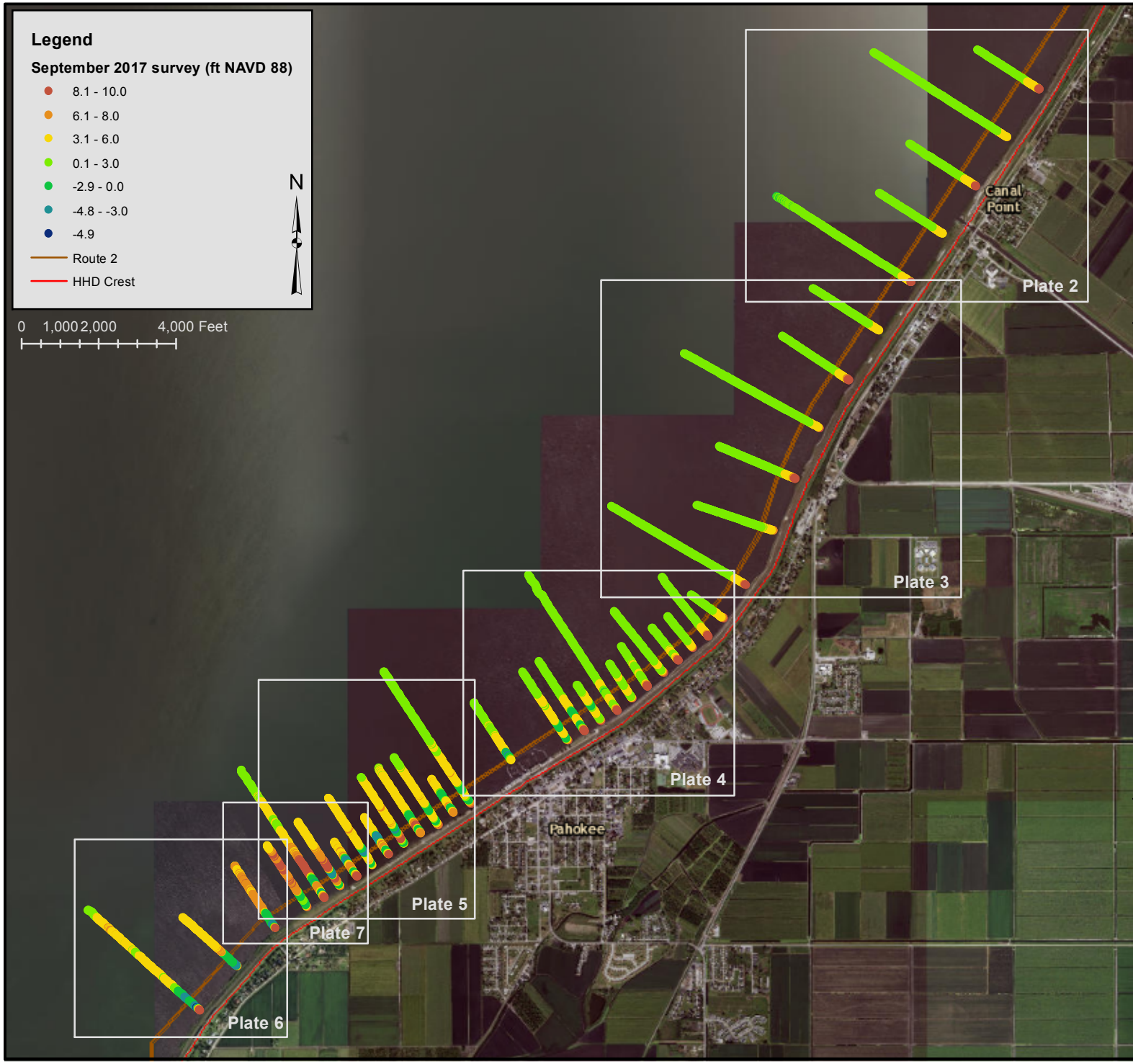
ATTACHMENT 1

ENGINEERING PLATES



US Army Corps of Engineers ®
Jacksonville District

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JACKSONVILLE DISTRICT
CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

GEOTECHNICAL DRAWINGS

NOT FOR CONSTRUCTION

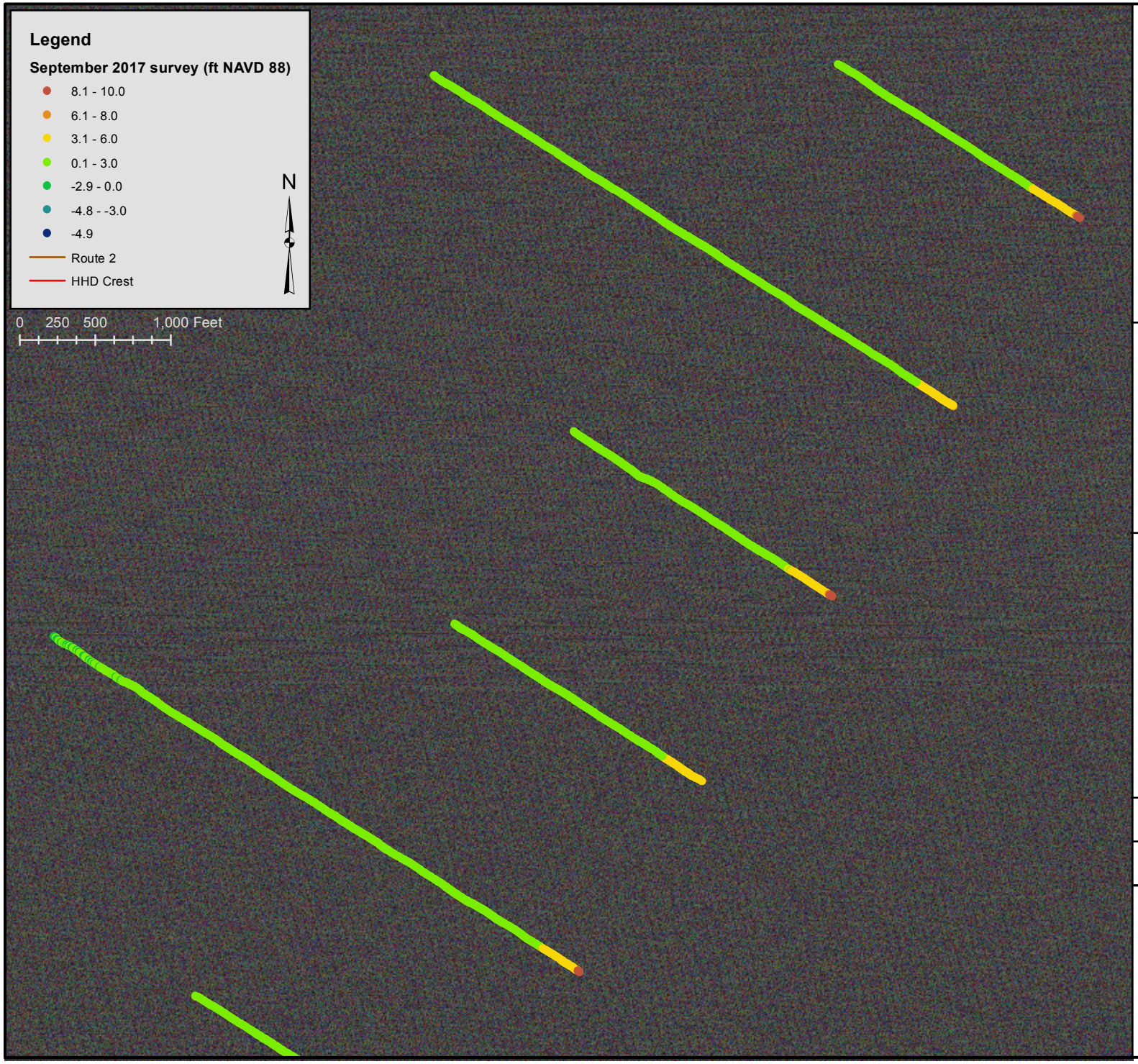
PAHOKEE ECORESTORATION PROJECT

SURVEY DATA

Dsn by: JLC	Ckd by: JLC
Dwn by: JLC	Dated: 04OCT2017

PLATE NO.

1



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PAHOKEE ECORESTORATION PROJECT SURVEY DATA

Gasparilla Shoal Sand Source

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Dwn by: JLC	Dated: 04OCT2017

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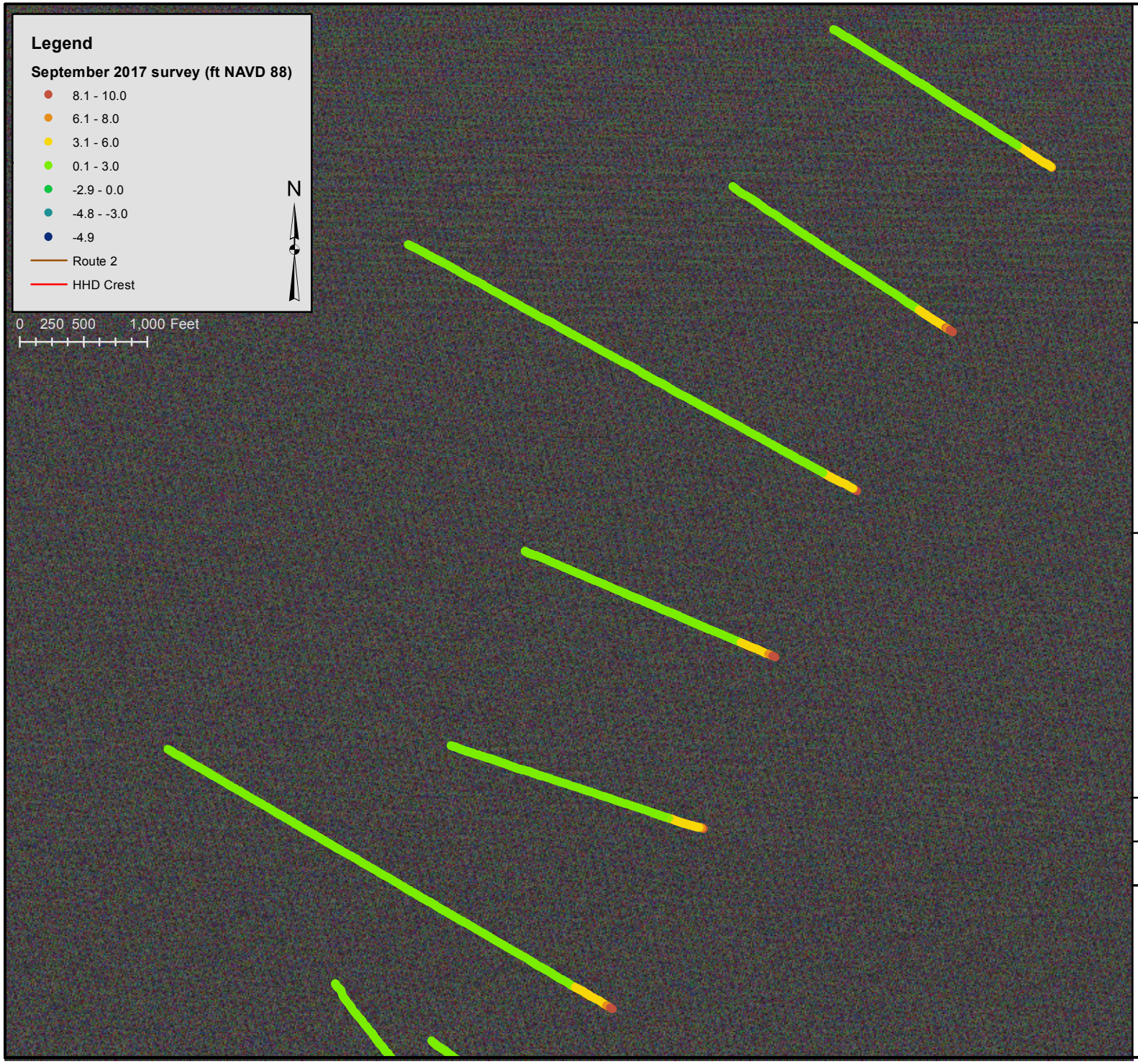

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Gasparilla Shoal Sand Source

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Dwn by: JLC	Dated: 04OCT2017

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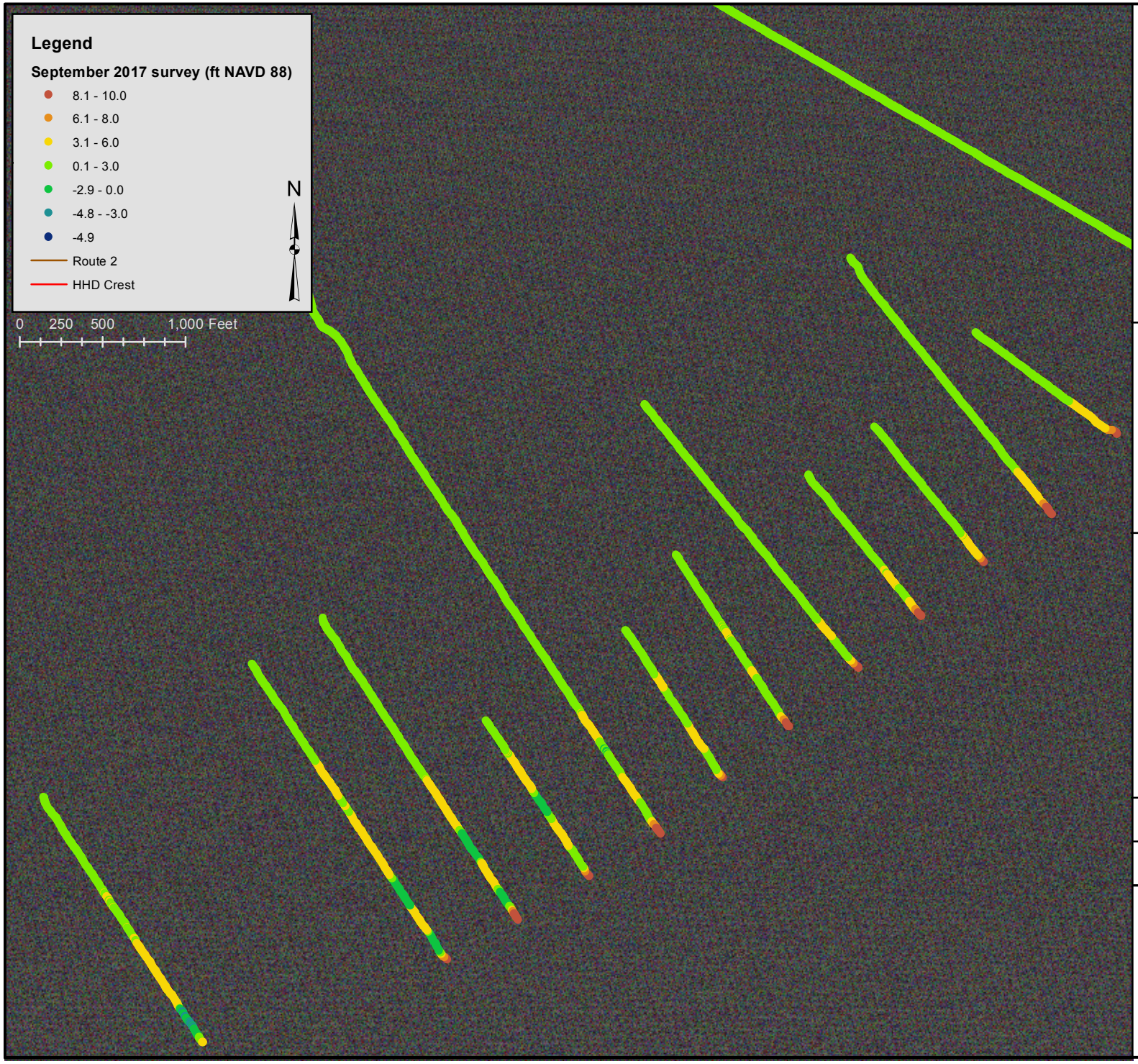

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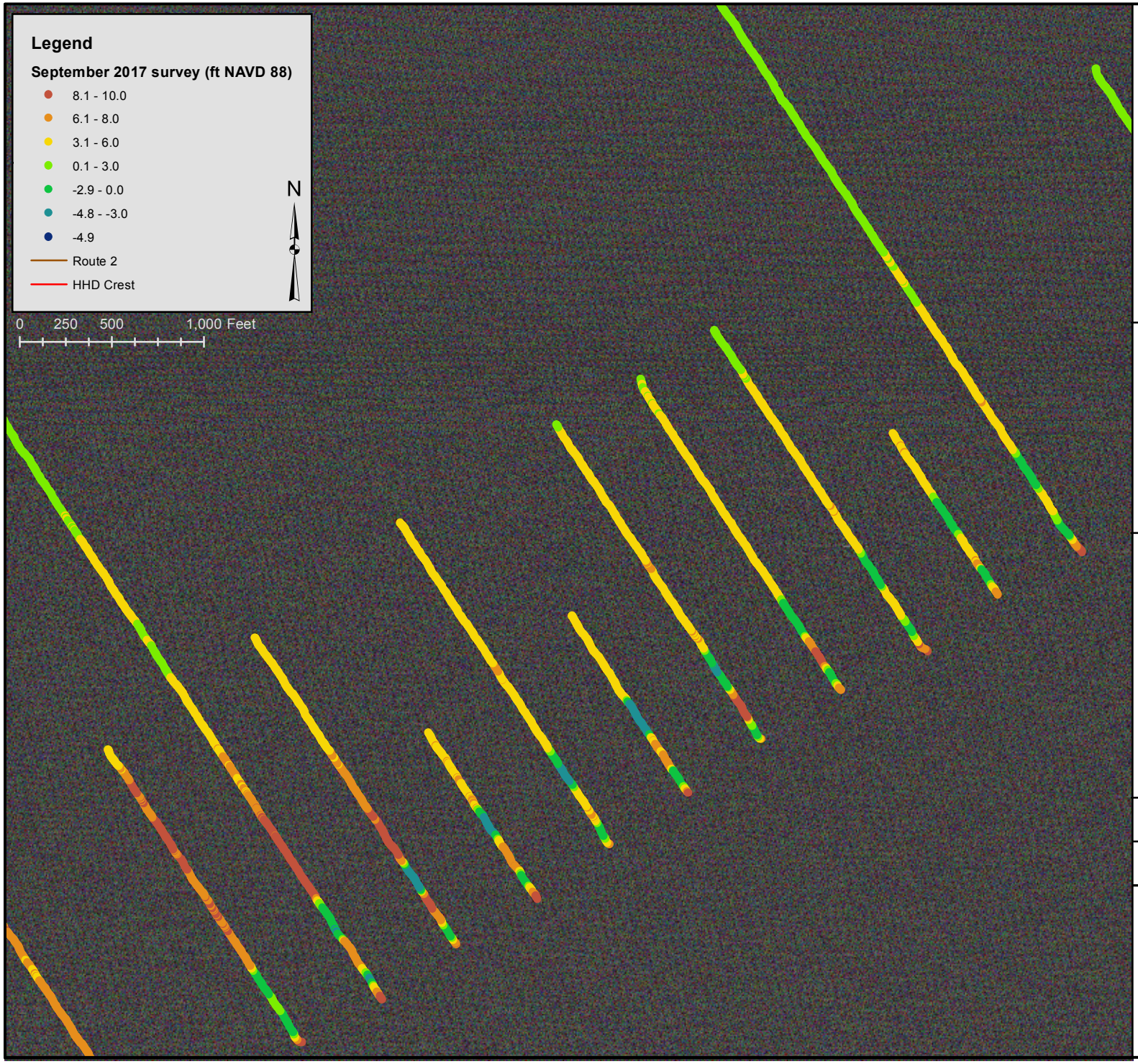

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Gasparilla Shoal Sand Source

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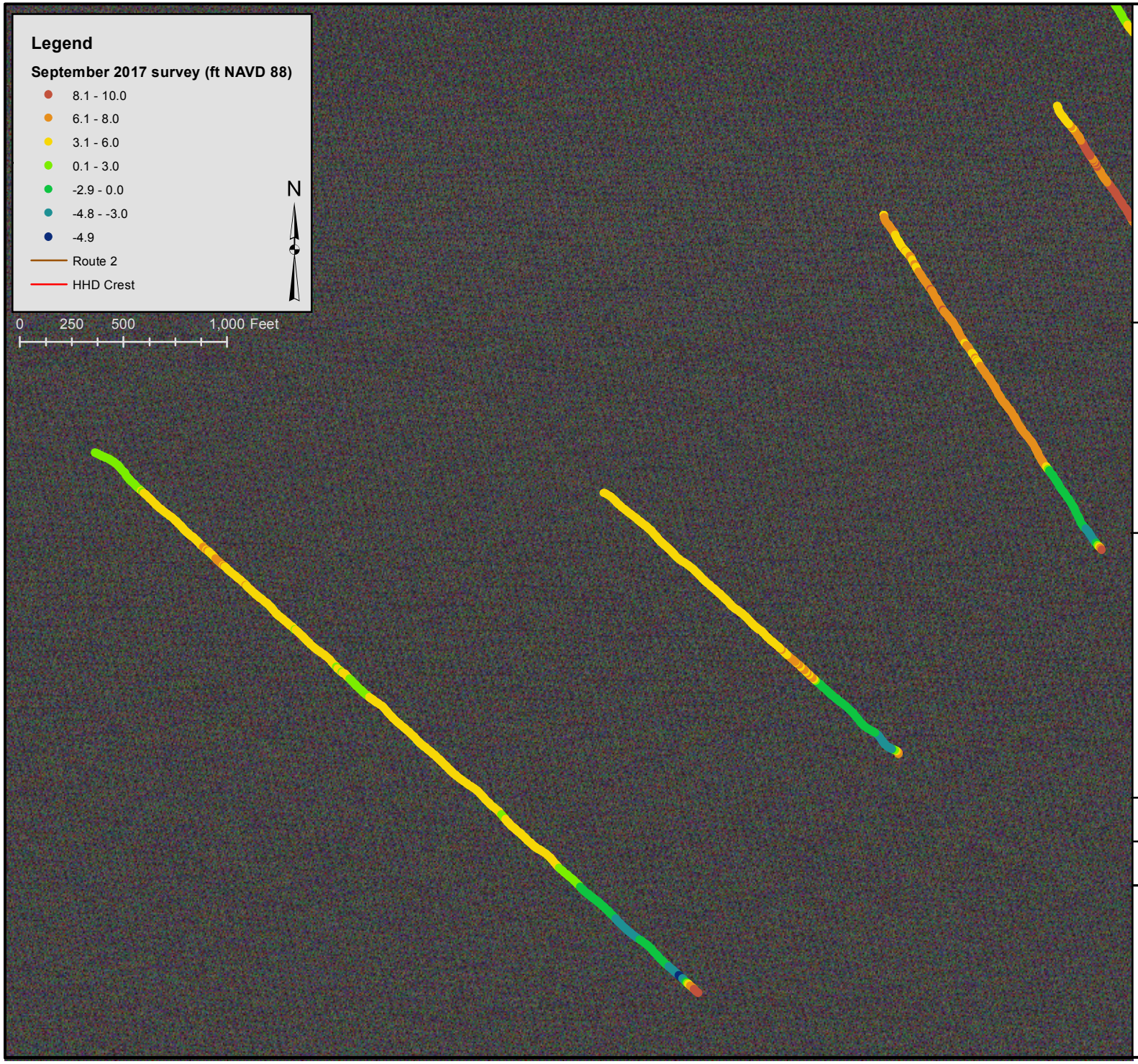

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Gasparilla Shoal Sand Source

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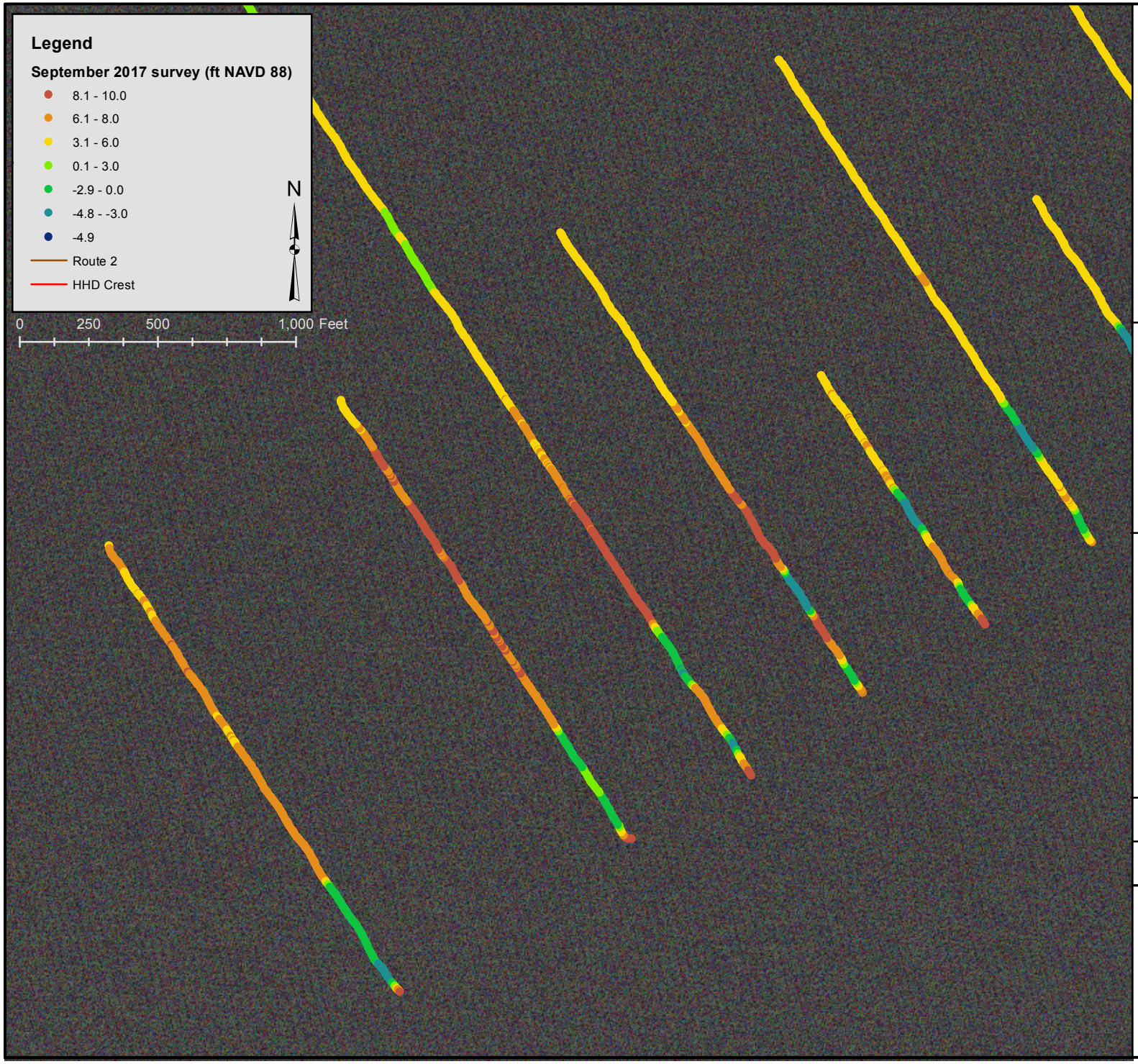

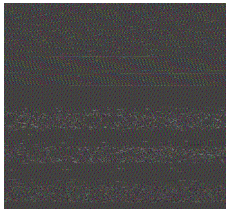

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Gasparilla Shoal Sand Source

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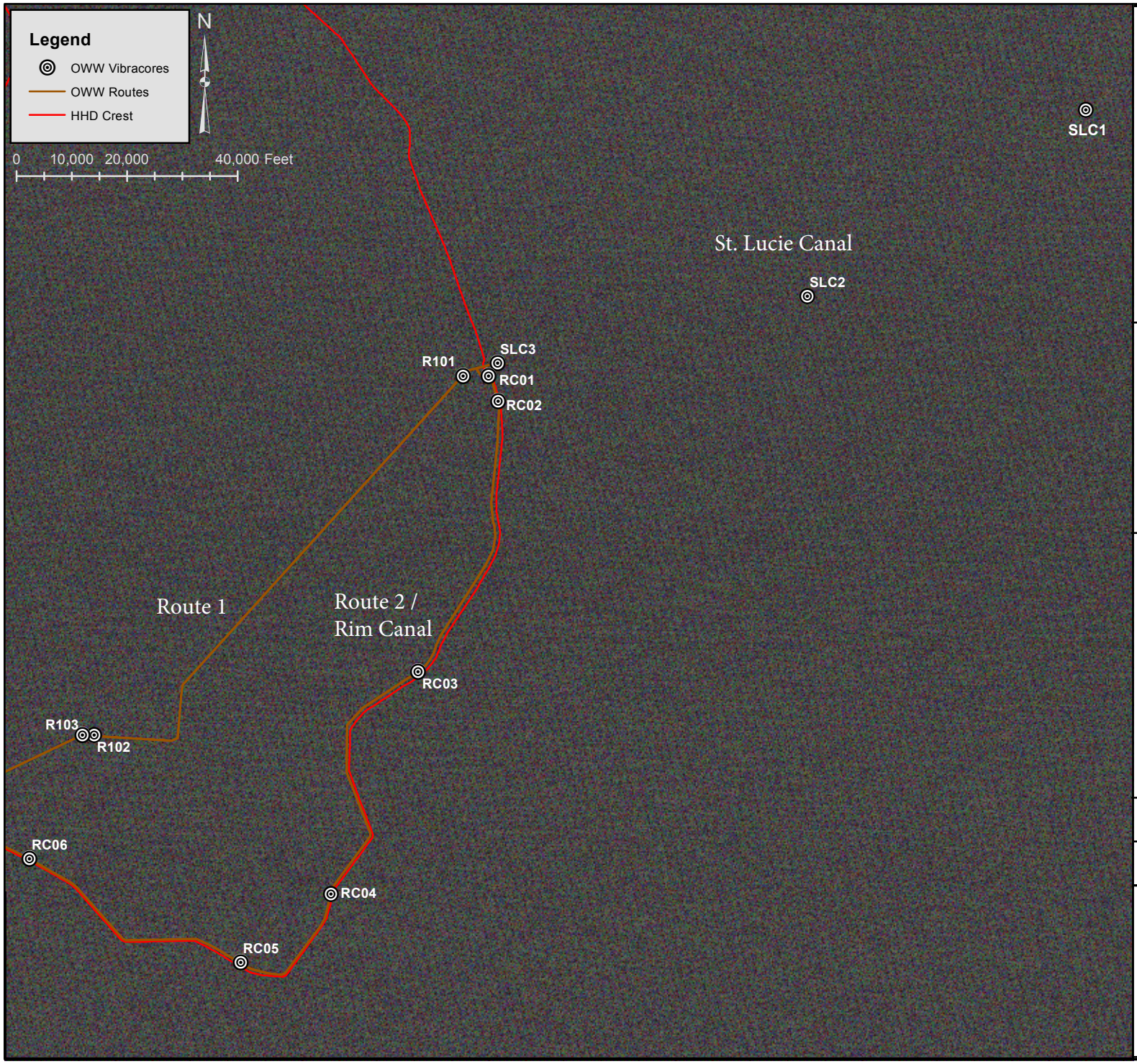

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PAHOKEE ECORESTORATION PROJECT

Okeechobee Waterway Vibracore Samples

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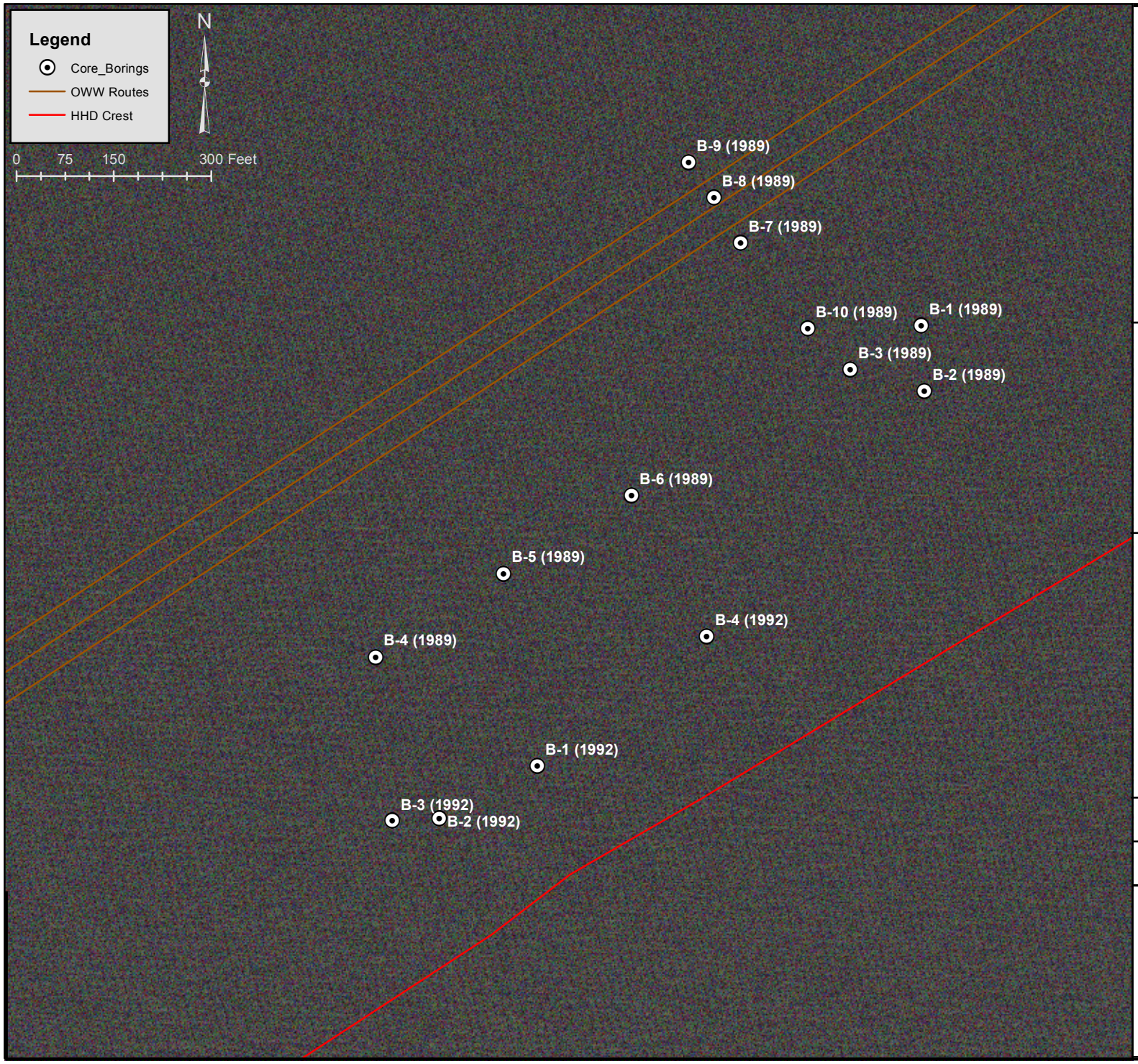

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PAHOKEE ECORESTORATION PROJECT

Pahokee Marina Core Borings

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PLATE NO.

9

ATTACHMENT 2

VOLUME TABLES

ALT #		Type	X' (ft)	Y' (ft)	Total Acres	Area (top) {ac} @ 13 ft tier	Area (top) @ 11 ft tier	Sand volume, cy	Sand volume, tons	Turbidity Curtain, lf	Silt volume, cy	Type B 500# Rock, tons	Type B 500# Rock, CY	Type A 250# Rock tons	Type A 250# Rock CY	Geotextile Fabric, sy	EAV Plants, Ac
1	low-profile island	Type1	300	3000	34.4	0.0	34.4	179,148	241,850	11,000	76,778	0	0	3,000	2,098	6,000	34
2	low-profile shelf	Type3	300	3000	27.5	0.0	27.5	140,231	189,312	11,000	72,240	12,000	8,392	0	0	10,000	28
3	high-profile island	Type2	200	1500	27.5	13.8	13.8	153,861	207,712	4,600	38,465	0	0	0	0	0	28
4	high-profile shelf	Type2	100	3000	27.5	13.8	13.8	179,429	242,229	3,800	44,857	0	0	0	0	0	28
5	submerged island TYPE 3 + emerged island TYPE 1	Type 3	300	1500	29	0.0	17.2	122,180	164,943	7,000	30,545	6,000	4,196	1,000	699	10,000	29
		Type 1	100	1000		6.9	4.6										
6	submerged island TYPE 3 + submerged shelf TYPE 3	Type3	300	1500	31	0.0	17.2	241,144	325,544	7,800	124,226	18,000	12,587	0	0	20,000	31
		Type3	300	1500		0.0	13.8										

ATTACHMENT 3

VALUE MANAGEMENT PLAN

Value Management Plan

(PMBP REF8023G)

Civil Works: ☑
Military: ☐

Project/Procurement Amount Cost = $13,300,000

Agency: USACE
District: SAJ

P2#: 455356
PN:
Project Title: Pahokee Restoration CAP Project (Section 1135)

Date: 12/20/2017
Filled Out By: Autumn Ziegler, PE, AVS
Project Manager: Jim Suggs

Goal: (Statement of overall goal of VM/E effort)

The Value Management Plan (VMP) is being prepared in compliance with ER-11-1-321, Change 1 dated Jan 2011. The VMP will document compliance with Value Engineering regulations by determining the best strategy based on the complexity and cost of the project. The overall goal of the VM/E effort will be to document that a VE study is required based on the oppontunity for the project to benefit from value analysis.

Objective: (Specific items of accomplishment that the VM/E effort will achieve as specific to the project)

A VE study is needed due to the opportunity for the project to benefit from a value analysis. The purpose of this Value Management Plan is to document concurrence with this selected VE strategy. Possible topics for the VE Team to consider during the workshop include refinements to the recommneded plan from the feasibility phase, sequence of construction, construction techniques, lessons learned from previous projects, design parameters, and testing and acceptance criteria.

Execution - VE Strategy & Level of Effort: (Document Decisions from Sections I & II)

Selected VE Strategy: (Select Only One Strategy)

Design Agent VE Compliance ☐ **Date of Compliance:**

No Further Action ☐ **Reason:**

Low Opportunity - VMP Only ☐
Low Opportunity - Bridge ☐
Low Opportunity - Scan ☐

Value Planning (Level 1) ☐
Abbreviated Study (Level 2) ☑
Standard Study (Level 3) ☐
Problem Resolution (Level 4) ☐
Programmatic (Level 5) ☐
Enterprise (Level 6) ☐

VE Activity Preliminary Schedule	
Overall VE Start (ML285, CW285, CW192)	TBD
VE Activity Start	TBD
VE Activity Finish	TBD
Overall VE Finish (ML290, CW290, CW195)	TBD

Level of Effort:
Single Effort ☑
Multiple Efforts ☐

VE Team:
Independent ☐
Integrated ☑
Blended ☐

Value Engineering Budget:

Cost Category	Cost	Remarks
VEO Labor	$15,000	VEO Labor for VE Coordination and Participation
Independent VE Team Member Labor		Labor for Non-CESAJ VE Team Members
In-House VE Team Labor	$25,000	Labor for CESAJ In-House VE Team Members
A-E Services Contract		Budget is an estimate. Actual contract cost to be determined.
Contracting		Fee for CESAJ Contracting to Award and Close-out Task Order
VEO Travel		For projects requiring site visits
Total Budget	$40,000	

Signature & Date of Project Manager (Required)

Signature & Date of VEO (Required)

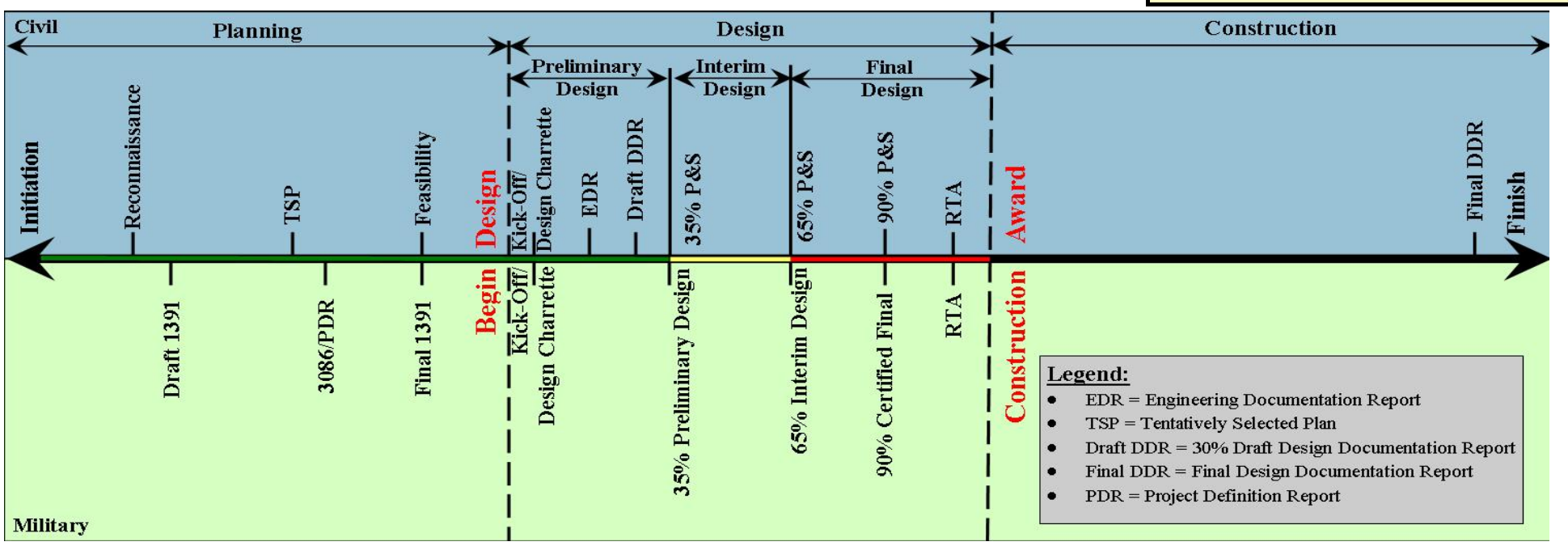
Screening Tool

P2#:	455356	**Date:**	12/20/2017
PN:		**Filled Out By:**	Autumn Ziegler, PE, AVS
Project Title:	Pahokee Restoration CAP Project (Section 1135)	**Project Manager:**	Jim Suggs

I. Initial Screening Process

Project Cost $ **$13,300,000**

Where is your project currently on the delivery time line below? **Planning**



A) Is the Project/Procurement federally funded?	Yes ☑	No ☐	If No, document as No Further Action.
B) Is the Corps the design agent?	Yes ☑	No ☐	If No, document design agent compliance.
C) Has a programmatic study been previously executed within the last 3 years? Allowed before 35% Design only. (Determines if a Bridge Strategy is an option)	Yes ☐	No ☑	If Yes, can select Bridge Strategy as long as design is below 35%.
D) Could this be a part of a programmatic study? (Automatically determines Programmatic Strategy)	Yes ☐	No ☑	If Yes, select Programmatic Strategy.
E) Are there at least 5 similar studies within the last 3-5 years in the same region? Allowed before 35% Design only . Applicable to projects in the $2-$10M range with MSC approval; projects over $10M require HQ Ch. OVE approval (Determines if Scan Strategy is an option)	Yes ☐	No ☑	If Yes, can select Scan Strategy as long as design is below 35%. If opportunity to change exists outside of past studies, do not select Yes.
F) Is the project/program/procurement over $10M?	Yes ☑	No ☐	If Yes, proceed to Strategy Screening Process in Section II below.
G) Is there a program specific screening tool?	Yes ☐	No ☑	If Yes and not pre-flagged as low opportunity, proceed to program specific screening tool.

II. VE Strategy Screening Process (work with PDT)

A) Project Specific				
1) Disciplines Involved	Couple (≤2) ☐	Few (2-4) ☐	Several (>4) ☑	
2) Scope – Simple/Complex	Simple ☐	Moderate ☑	Complex ☐	
3) New/Renovate/Addition	New ☑	Addition ☐	Renovation ☐	
4) Unique or Standard Type Design	Unique ☑	Repetitive ☐		
5) Constraints	Minimal ☐	Moderate ☑	Significant ☐	
6) Single Phase/Multi-Phase	Single ☑	Multiple ☐		
7) Single Facility/Multiple Facility	Single ☑	Multiple ☐		
8) Status of Design	Early ☑	35% ☐	65% or later ☐	
B) Stakeholders				
1) Level of PDT Experience	Limited ☐	Substantial ☑	Unknown ☐	
2) Applicability of Team Experience	Applicable ☑	N/A ☐	Unknown ☐	
3) Design Provided by Others	Yes ☐	No ☑		
C) Risk/Opportunity				
1) Confidence in Budget Estimate	Low ☐	Moderate ☑	High ☐	
2) Adequacy of Schedule – Design & Construction	Adequate ☑	Moderate ☐	Tight ☐	
3) Technical Risk – Design & Construction	Low ☑	Moderate ☐	High ☐	
4) Opportunity for Beneficial Change	Low ☐	Moderate ☑	High ☐	

Complexity Judgment - Assess complexity of overall circumstances (A-C) → Low ○ Moderate ◉ High ○

See Page 3 for Complexity Narrative and Explanation of Selected VE Strategy.

Screening Tool - Narrative

P2#:	455356	**Date:**	12/20/2017
PN:		**Filled Out By:**	Autumn Ziegler, PE, AVS
Project Title:	Pahokee Restoration CAP Project (Section 1135)	**Project Manager:**	Jim Suggs

Narrative: (Selected VE Strategy / Complexity)

Herbert Hoover Dike (HHD), which surrounds Lake Okeechobee, has altered the historic ecosystem of the shoreline in the project area. Before HHD was constructed, the southeastern shore of Lake Okeechobee contained a gentle slope into deeper waters, resulting in a shallow area along the shoreline. This shallow area provided the optimum depth to support littoral zone vegetation, and served as a natural breakwater, allowing vegetation to take root. The vegetation provided critical feeding and breeding habitat for aquatic and land species. The natural wind and wave break also minimized sediment re-suspension. Construction of HHD resulted in a shoreline with scarce vegetation, and a deeper shoreline more susceptible to intense wind and wave forcing that is not hospitable to the re-establishment of vegetation. As a result, the southeast shore where Pahokee is located is now characterized by a steep slope into deep water, sparse upland and aquatic vegetation, no littoral zone or animal habitat, and turbid water.

The selected design alternative includes construction of two structures; a low profile island and a high profile island. The Low Profile Island includes construction of an island with an elevation of 11.0-ft NAVD 88. The island would be constructed of a mix of sand and finer silt sediment, surrounded by a sand berm for stability. This would enable improvement of turbidity in the project area by dredging and sequestering some of the fine silt sediments. The outer slopes would be armored with riprap. The High Profile Island includes construction of a terraced island with a lower elevation of 11.0-ft NAVD 88 and a higher elevation of 13.0-ft NAVD 88. The island would be constructed of a mix of sand and finer silt sediment, surrounded by a sand berm for stability. The outer slopes would be armored with riprap.

Based on the level of complexity of the project and opportunity of the project to benefit from value analysis, a Level II Abbreviated VE Study will be conducted at the beginning of the design phase.