SOUTHEAST FLORIDA SEDIMENT ASSESSMENT AND NEEDS DETERMINATION (SAND) STUDY

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ABSTRACT

The Southeast Florida Sediment Assessment and Needs Determination (SAND) study quantifies domestic sand resources to support placement of planned, full-sized beach nourishment projects through the next 50-years (year 2062) for St. Lucie, Martin, Palm Beach, Broward and Miami–Dade Counties. Sediment needs for each county were established based on project performance, accounting for storms, construction losses and sea level change. Sediment source volume calculations considered new and existing offshore sediment sources in State and Federal jurisdictional waters. Both recent and historical geotechnical and geophysical data from -8 feet NAVD88 to -90 feet NAVD88 towards the Florida-Hatteras continental shelf slope break were taken into account during sediment assessment. Offshore sediment sources were divided into four categories: Proven, Potential, Unverified (volume contributing and volume non-contributing) and Depleted, depending on density and quality of geological data. Confidence levels of 90%, 70% and 30% were applied in the volume assessment to the Proven, Potential and volume contributing Unverified categories, respectively. Contingencies were added to volume assessments for a vertical 2-foot buffer for all counties and for reef talus specific to Palm Beach County. Based on the needs determination with contingencies applied, it was found that 174,101,870 cubic yards of sediment are needed to support placement of planned, full-sized beach nourishment projects through 2062. With contingencies and confidence levels applied, it was found that 280,037,956 cubic yards exist offshore of Southeast Florida that meet the criteria for this study established for sand placement on Florida beaches. Therefore, currently known sediment resources for St. Lucie, Martin, Palm Beach, Broward and Miami–Dade Counties exceed sediment needs by 100,000,000 cubic yards.

FORWARD

The Southeast Florida Sediment Assessment and Needs Determination (SAND) Study was completed to improve upon sediment needs determinations and existing volume estimates of offshore sediment sources suitable for beach nourishment, storm damage reduction and hurricane protection projects. A separate site investigation report consisting of data from 199 vibracores collected in 2012 on the continental shelf offshore of St. Lucie, Martin and Palm Beach Counties, Florida contains geotechnical data completed for the SAND Study.

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http://ross.urs-tally.com/

1.0 INTRODUCTION

1.1 Background

Beach nourishment has been an ongoing practice in Southeast Florida since the late 1950s providing essential economic, environmental and recreational benefit to coastal communities. Berm, dune and nearshore structures serve as a vital buffer between coastal areas and the destructive forces of ocean waves and storm events. However, sediments suitable for beach restoration are limited, non-renewable resources consumed through beach nourishment practices. Heightened environmental concerns have led to tighter permitting restrictions on the types of sediments that are considered "compatible" with the native or existing beach further reducing volumes of available sand. In many coastal areas of Florida, regional sediment management (RSM) techniques have been implemented to ensure long-term sediment availability across political jurisdictions and between navigation and shore protection projects.

When considering the long term sustainability of a regional beach nourishment program, the volume of available sediment sources must be quantified. Earlier studies have made volume estimates of offshore sediment sources in the Southeast Florida region of St. Lucie, Martin, Palm Beach, Broward and Miami-Dade counties as seen in Table 2. Meisburger and Duane (1969, 1971) performed the first comprehensive study of offshore sources in Southeast Florida in “Geomorphology and Sediments of the Inner [Nearshore] Continental Shelf” series spanning from Miami to Cape Kennedy Florida which estimated approximately 646 million cubic yards (mcy) of material are available offshore of the study area. Hoenstine and Freedenberg (1995-2002) conducted “A Geologic Investigation of Sand Resources in the Offshore area Along Florida’s Central-East Coast” which estimated sediment source volumes from Brevard County south to Martin County. Hoenstine and Freedenberg’s volume estimates for sediment sources offshore of St. Lucie and Martin counties total approximately 501 mcy, but do not include estimates for Palm Beach, Broward or Miami-Dade counties. URS Corporation with Coastal Planning and Engineering, Inc. (CPE) completed Phase I and Phase II of the Reconnaissance Offshore Sand Search (ROSS) (2007) for the Florida Department of Environmental Protection, Bureau of Beaches and Coastal Systems which estimated approximately 14 billion cubic yards of sand resources on the continental shelf within the study area. Each of these studies used combinations of previous studies, geophysical, geotechnical, and geomorphic data sets in their analysis, primarily deviating from one another in controlling parameters and degrees of conservatism with sediment source area delineations.

Desk top study approaches for calculating sediment volumes were done in the 1996 Coast of Florida Feasibility Study by USACE and by Halcrow/GEC for USACE in 2008. The Coast of Florida Feasibility study (1996) estimated 685.9 mcy of material was available from Palm Beach to Miami-Dade County. The study by Halcrow/GEC for USACE (2008) estimated 61.5 mcy of material was available from Palm Beach to Miami-Dade County. The Coast of Florida Feasibility study and the study by Halcrow/GEC did not include analysis of St. Lucie or Martin County, but established the study criteria and methodology for the Southeast Atlantic Regional Sediment Management Plan for Florida (2009 RSM) prepared by Taylor Engineering, Inc. for the US Army Corps of Engineers (USACE), Jacksonville District. The 2009 RSM applied a desk top study approach to calculating sediment needs and volumes and estimated approximately 146 mcy of material were needed and 147 mcy of material were available in the study area. Volume estimates by county and category from the 2009 RSM are presented in Table 1. The 2009 RSM study utilized three different categories of sediment sources; proven, potential, and unverified. Moving through the categories from Unverified to Proven represents an increase in quality and quantity of data delineating the investigated sediment sources. The 2009 RSM study did not include additional geotechnical or geophysical data collection, but rather applied more detailed analysis of the quality of previously identified sediment sources prior to including source volume in the report, and included St. Lucie, Martin, Palm Beach, Broward and Miami-Dade Counties.

Table 1. Regional Sustainability Analysis for SE Florida from the 2009 SE Florida RSM (Taylor, 2009)

County	*50-Year Volume Need (cy)	Borrow Area Beach Quality Sand Volumes (cy)				Volume Balance (cy)
		Category 1 (Proven)	Category 2 (Potential)	Category 3 (Unverified)	**County Total	
St. Lucie	24,440,000	17,218,750	41,600,000	188,582,413	58,818,750	34,378,750
Martin	29,900,000	24,781,000	0	282,733,583	24,781,000	-5,119,000
Palm Beach	49,166,000	12,039,000	42,307,000	63,951,826	‡55,296,000	6,130,000
Broward	24,225,000	988,400	0	5,116,691	988,400	-23,236,600
Miami-Dade	18,274,000	900,000	2,009,713	14,771,984	‡‡7,009,713	-11,264,287
Totals	**146,005,000**	**55,927,150**	**85,916,713**	**1,079,656,497**	**146,893,863**	**888,863**

* Project 50-year volumes assume placement of scheduled full-sized project until the end of 2059
**County Totals ignore Category 3 contributions
‡ Includes 950,000 cubic yards of material that are renewable
‡‡ Includes 4,100,000 cubic yards of material that are renewable

As noted in Table 2, for the study area, the difference between sediment volume estimates among earlier studies is orders of magnitude apart. To make well informed decisions regarding allocation of Federal and State sediment resources, stakeholders, regulatory agencies and policy makers need to have the best scientific data on sediment needs and availability to ensure long-term sustainability of coastal Southeast Florida.

Table 2. Volume Estimates of available offshore sediment resources in SE Florida from historical studies.

STUDY	Volume estimate (cy)	*Difference (cy)
Meisburger and Duane, 1969-1971	646×10^6	472×10^6
USACE, Coast of Florida Study, 1996	*** 685.9×10^6	511.9×10^6
Hoenstine and Freedenberg, 1995-2002	** 501×10^6	327×10^6
URS, CPE 2007 for FDEP	$14{,}400 \times 10^6$	$14{,}226 \times 10^6$
Halcrow/GEC, 2008 for USACE	*** 61.5×10^6	-112.5×10^6
Taylor, 2009 RSM for USACE	147×10^6	-27×10^6

cy = cubic yards
* The estimated amount of sediment available in excess of the 2012 needs determination of 174×10^6 cy for the study area.
**only St. Lucie and Martin Counties
***only Palm Beach, Broward and Miami-Dade Counties

1.2 Scope

The Southeast Florida Sediment Assessment and Needs Determination (SAND) Study was designed to build on the Southeast Atlantic Regional Sediment Management Plan for Florida (RSM) prepared by Taylor Engineering, Inc (2009) covering a fifty year period of evaluation; fifty years being the maximum period of Federal participation in Coastal Storm Damage Reduction (CSDR) projects.

The SAND Study has two main purposes; updating sediment needs determinations using project performance and improving sediment volume estimates (Table 1) by adding geotechnical data, incorporating updated bathymetry and seismic data, and moving unverified sources into the potential and proven categories.

The scope of the sediment needs determination portion of the SAND Study was to evaluate each county's sediment requirements based on survey level estimates and documented past project performance. Additionally, the needs determination considered external contingencies that could increase or decrease sediment needs and apply them uniformly to all the counties in the study.

The scope of the sediment assessment portion of the SAND Study included three primary phases: a desktop study, geotechnical investigation, and sediment volume analysis. The desktop study began in October of 2011 when historic reports and geotechnical and geophysical data were located. National Oceanic and Atmospheric Administration contour data from 2010, bathymetry, fish haven locations, cable easements, offshore dredge material disposal sites, and cultural resources were identified and plotted for the study area. Existing seismic data and geotechnical boring data were incorporated with the sediment source boundaries from the 2009 RSM, and a core boring plan for the 2012 SAND Study was determined. The geotechnical investigation phase followed with vibracore drilling, logging and sediment sample laboratory analysis and was completed in June 2012. A total of 199 vibracores were collected offshore of St. Lucie, Martin and Palm Beach Counties. These vibracores were collected primarily in the 2009 RSM 'Unverified' source boundaries and in additional un-delineated locations with anecdotal evidence to suggest a possible sediment source. The geotechnical investigation results are found in the SAND Study Site Investigation Report which is available on the FDEP ROSS database server. The sediment source boundaries from the 2009 RSM study, previous geotechnical and geophysical studies and the SAND Study Site Investigation Report data represent the data set used for the sediment volume analysis.

A draft SAND Study report and findings were presented to the SAND Study Team, who requested a third-party peer review be conducted. Coastal Planning and Engineering, Inc., (CPE) was retained by the FDEP and conducted a peer review that was presented to the SAND Study Team. Based upon the recommendations of CPE and the advice for the SAND Study Team, the draft report was revised to include additional explanation of the data used in the study and the analysis applied to the data. Also the analysis of individual sand deposits were reviewed by USACE and FDEP geologists with the assistance of CPE geologists to apply the recommendations of CPE and the advice of the SAND Study Team.

The final report herein presents the sediment needs determinations, the sediment volume assessment, and compares the quantity of sediment available to the quantity of sediment needed over a 50-year time horizon beginning in 2012 through 2062 for St. Lucie, Martin, Palm Beach, Broward and Miami-Dade Counties (Plate 2).

1.3 Geological Setting

1.3.1 Stratigraphy

This section provides the geological context of the region. A representative stratigraphic column of the study area is shown in Table 3. The surficial geology of the eastern Florida continental shelf consists of Holocene age unconsolidated sediments associated with paleo-shore lines, beach ridges and troughs, paleo-ebb deltas, and sand waves. Pliocene to Cretaceous lithological formations indicate deposition during fluctuating sea levels over a large shallow marginal shelf of the Florida carbonate platform (Hoenstine et al. 2002). The Florida platform lies unconformably atop Mesozoic sedimentary and volcanic rocks that originated with the formation and separation of Pangaea (Scott et al, 2001).

Table 3. Stratigraphic Column; Mid-Mesozoic to Recent: Southeast Florida, Coastal Zone (modified/expanded from Meisburger and Duane, 1971; Randazzo and Jones, 1997; Reese and Wacker, 2009).

Series	Formation	Depth to Top of Formation (Below NAVD88)	Lithological Character
Holocene		0 to +30	Unconsolidated quartzose sand, calcareous sand, silty sand, silt, clay, shell
Pleistocene	Pamlico	Around 30+	Unconsolidated quartzose sand with some shell beds, sandstone and limestone
	*Miami Limestone	0 to 80 feet	Oolitic limestone, quartz sand and sandstone
	Anastasia	0 to 100 feet	Sand, shell beds, marl, calcareous sandstone (coquina/calcarenite)
	Fort Thompson	0 to 80 feet	Silty limestone, silty sand, clayey marl, shell marl
	Caloosahatchee Marl	230 to 330 feet	Sandy marl, clay, silt with interbedded sand and shell beds
Pliocene	Tamiami	230 to 400 feet	silty limestone, silty sand, clayey marl, shell marl
	**Hawthorn Group	400 to 890 feet	Undifferentiated clays, marls, sands, limestone, and fine grained dolomites and phosphorites
Miocene			

* Miami Limestone grades laterally northward into the Anastasia Formation.
** The Hawthorn is a Group not a Formation.

1.3.2 Geomorphology

Generally, the east coast Florida margin is characterized as a gently eastward dipping shelf-slope system sitting atop the older Floridian carbonate platform. The latitudinal geomorphology of the study area extends from the southern end of the Canaveral cuspate foreland taper in St. Lucie County to the shore parallel linear paleo-reef ridge and trough features of Palm Beach County (Hine, 1997). Meisburger and Duane (1971) categorize geomorphic features of the continental shelf north of latitude N26º 40' (geographically around the upland location of Lake Worth Inlet, Florida) by cross shore morphology; the shoreface zone, the inner shelf plain, and the outer shelf zone as seen in Figure 1. The shelf narrows in the portion of the study area south of latitude N26º 40' and step-like linear flats separated by rocky irregular modern and paleo-reef ridges predominate as seen in Figure 2. A general depiction of the regional geomorphology is presented in Plate 1, which was revised using 2012 NOAA bathymetry, recent borings and historical seismic data to delineate shoal, flat, rock exposure and other geomorphic boundaries. The geomorphology presented in Plate 1 for Palm Beach County was unaltered and incorporated from the ROSS database (URS 2007).

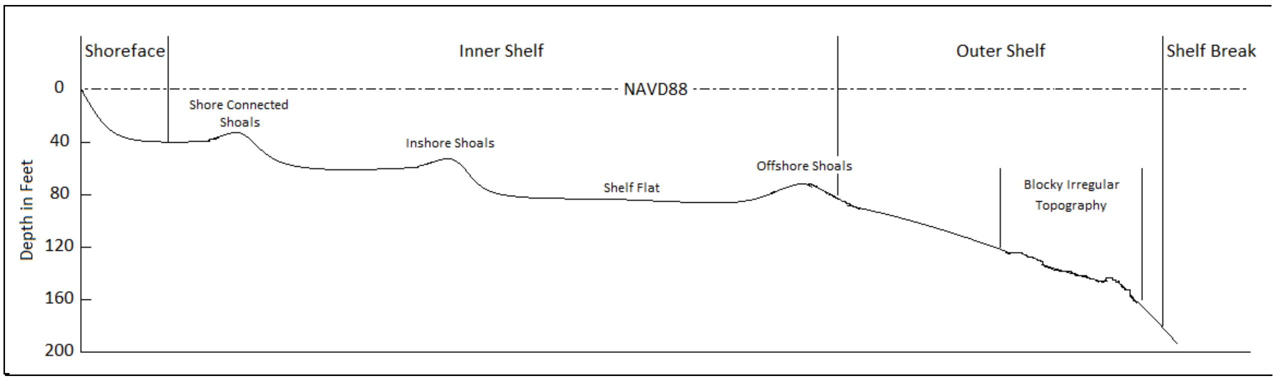

Figure 1. Schematic Profile of Shelf Morphology Typical of the Study Area off St. Lucie and Martin Counties with Descriptive Terminology (After Meisburger and Duane, 1971)

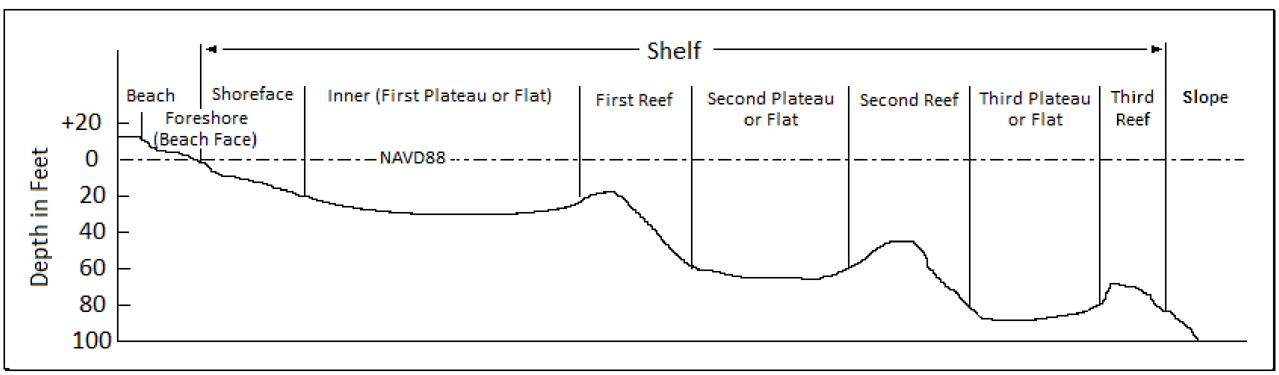

Figure 2. Schematic Profile of Shelf Morphology Typical of the Study Area off Palm Beach, Broward and Miami-Dade Counties with Descriptive Terminology (After Meisburger and Duane, 1969.) Note: different scale than Figure 1.

1.3.2.1 Shoreface Zone

The shoreface zone north of latitude N26º 40' (approximately Lake Worth Inlet, Florida) consists of a terrace like feature with a 1 on 80 slope extending to elevations near -43 ft NAVD88 and varying between approximately 500 ft and 3,000 feet in width. Offshore linear shoals that occur on the Inner Shelf Plain commonly extend into and attach to the coast in the shoreface zone (Duane et al. 1972). Coquina outcrops are observed in the shoreface and are correlated to the semi-consolidated to consolidated stratigraphy of the Anastasia formation. Historical borings in the shoreface zone indicate that unconsolidated sediments extend 5-10 feet below the sediment-water interface before encountering consolidated materials (Meisburger and Duane, 1971; URS, 2007).

1.3.2.2 Inner Shelf Plain

The inner shelf plain north of latitude N26º 40', from approximately -43 to -78 ft NAVD88, consists of gently dipping plateaus with minimal change in depth range. Northeasterly trending symmetric and asymmetric shore connected linear shoals are interspersed with flats of minimal bathymetric relief (±5 ft). Asymmetric shoals generally have seaward facing lee slopes. Ankona Shoal in the northern portion of the study area connects the Capron Shoal to the St. Lucie Shoal (Plate 1). Like Thomas Shoal to the north and outside the study area, the Ankona shoal trends to the northwest and is thought to differ from the northeasterly trending shoals in deposition time or process of formation. Seismic reflection studies indicate that inner shelf plain shoals are superposed on the surface of the flats (Meisburger and Duane, 1971; URS, 2007). Shore connected linear shoals show cross-bedding and hydraulic evidence that they are actively impacted by storm currents and deep water wave action from hydrodynamic processes that operate on regional scales. Additionally, shoreface connected linear shoals are thought to originate in the nearshore, elongate, detach and isolate in time associated with landward coastal retreat (Duane et al. 1972).

Shore-parallel, relic Holocene reefs and lithified sand ridges that formed during back-stepping of the reefs in response to changes in sea level emerge as the Inner Shelf Plain transitions to the south (Banks, 2007). Between latitude N27º 00' and N26º 40', only the shoreface zone, a relic Holocene reef structure and a second 1.5-mile wide flat, approximately 2-3 miles off shore, occur landward of the continental shelf slope break.

1.3.2.3 Outer Shelf Zone

The outer shelf zone north of latitude N26º 40'is a discontinuous, broken topography of generally low relief (Meisburger and Duane, 1971). Geomorphic features of this zone include rocky or coral reef patches, ridges, ledges, cliffs or depressions. While characterized as discontinuous, there is indication that some linear sedimentary ridges continue as deep as -95 ft NAVD88. Areas of the outer shelf zone that do not stand in relief as ridges are considered flats. However, unlike the flats in the inner shelf zone, those in the outer shelf zone have a more irregular or hummocky surface (Meisburger and Duane, 1971; URS, 2007). Flats of the outer self zone decrease in lateral width until distinct zones are no longer observed south of latitude N26º 40'.

1.3.2.4 South of Latitude N26º 40'

The sandy shoreface south of latitude N26º 40' is periodically interrupted by step-like rocky ridges that are likely local exposures of the consolidated Anastasia formation, which supports modern hardbottom habitat. At the seaward boundary of the shoreface slope, the cross-shore profile flattens and transitions into the first flat. The first flat ranges from approximately 1,050 feet to 5,100 feet wide and is bounded by a seaward, shore-parallel, relic Holocene reef and lithified sand ridge (Banks, 2007). In the southernmost portion of the study area, the first flat is bifurcated by a relic Holocene reef structure that delineates the first and second flat to the south. Banks (2007) and Walker (2012) provide a more detailed analysis of the reef-ridge structure in the southern portion of the study area.

2.0 SEDIMENT DISTRIBUTION

Sediments encountered in the study area are predominately poorly-sorted, fine to medium sand-sized quartz and sand-sized to fine gravel-sized carbonate, with varying amounts of silt, clay and whole and broken shell. Other materials encountered include coarse sand-sized to fine-gravel sized shell, calcarenite (cemented carbonate sand), highly to moderately weathered quartzose sandstone, and highly weathered (saprolitic) to moderately weathered hard limestone.

North-south and northeast-southwest trending shoals have been the traditional sources for beach compatible sediments offshore St. Lucie and Martin Counties. However, borings collected during this study indicate shelf flats may also contain beach compatible sediments with sufficient thickness to be economically feasible for beach nourishment. Carbonate content testing of vibracore samples (2012 SAND vibracores and historic data when available) indicated the sediments in the shoals and flats contain between 37 to 96% carbonate, averaging 79%. Typically, sediments are poorly-sorted due to the range of grain sizes represented by carbonate fractions. Borings recovered in the Ankona Shoal spanning between the Capron Shoal and St. Lucie Shoal, indicate it consists primarily of fine gravel sized shell with fine to coarse sand sized carbonate and quartz that is not beach compatible (Plate 1).

Mean grain sizes become finer with increasing quartz content moving southward in the study area. Potential sediment resources in the southern portion of Martin County and the entire length of Palm Beach County are primarily located in the first flat between the shoreface and the first seaward Holocene paleo-reef ridge. Sediments tend to be thicker on the seaward edge of the flat and generally contain coarser sand-sized sediments as the deposit approaches the confining seaward paleo-reef structure. Typically the materials encountered are unconsolidated fine to medium grained sand sized quartz with a range of carbonate content. The flats between relic Holocene reef ridges contain talus, possibly as much as 25%, as observed in previous project constructions, for example the 2009/2010 Juno Beach construction (personal communication with FDEP). Unconsolidated flat deposits exist between smaller shore parallel reef ridge structures; however, they are not laterally continuous enough to be economically or environmentally feasible at the time of this study.

3.0 SEDIMENT NEEDS DETERMINATION

The sediment needs determination portion of this study included St. Lucie, Martin, Palm Beach, Broward and Miami-Dade Counties. Full needs determination reports are in Section 9.0. Sediment needs were based on survey level assessments made by county representatives and/or project engineers with institutional project knowledge. Needs determinations were based on project performance and updated planning reports over a time span capturing all Federal and non-Federal beach nourishment projects using offshore sediment sources. “Renewable” sand sources such as ebb shoals used for sustaining specific projects through inlet sand bypassing are incorporated in this study by reducing the needs determination and are not listed as project needs or available sediment sources.

All needs determinations in this report underwent review by the stakeholders (FDEP, Counties, USACE) through the USACE Dr. Checks system allowing comment and full disclosure of each county’s needs determination process. Following stakeholder acceptance of each County’s base sediment needs, contingencies were established by the SAND Study team and applied uniformly to all needs determinations. Contingencies, for a total of 55%, are as follows:

- 30% borrow area waste (sand left in the borrow area)
- 15% other dredging losses (dig-to-place loss)
- 10% future project performance including sea level rise impacts

The 30% contingency for borrow area waste and the 15% contingency for other dredging losses are based on region-wide past project performance. The contingency of 10% future project performance including sea level rise impacts is based on project observations and average increased erosion calculations for the region using the Bruun Rule method and the intermediate sea level rises scenario from the US Army Corps of Engineers sea level change guidance (EC-1165-2-212).

Individual project needs are presented in Table 4. Final needs determinations by county are presented in Table 5. It is currently atypical to develop construction work orders where borrow area use is dictated to maximize removal of available sediment. It is possible that through the development and implementation of borrow area construction plans dictating material removal to the extent practicable in sub-areas prior to moving to other sub-areas, borrow area waste contingencies may be significantly reduced. Such borrow area construction plans have been successfully implemented in the Florida panhandle and along St. John’s County in northeast Florida.

Table 4. Individual Project Needs Determinations

County	Project Name	Monument Range	Estimated 50-yr Sand Requirement (cy)	County total (cy)
St. Lucie	Ft. Pierce Shore Protection Project	from Ft. Pierce Inlet (200 feet north of R34 - T41)	13,000,000	
	South County Beach Project		5,017,487	18,017,487
Martin	Martin County Hurricane and Storm Damage Reduction Project	R1 - R25	8,186,000	
	Bathtub Beach/Sailfish Point	R34.2 - R40.5	1,425,000	
	Town of Jupiter Island	R76A - R84, R88 - R112	12,500,000	22,111,000
Palm Beach	Jupiter/Carlin	R13.5 - R19	5,467,000	
	Juno Beach	R26 - R38	6,300,000	
	Mid-Town	R90 - R101	7,250,000	
	Phipps Ocean Park	R119 - R126	7,250,000	
Palm Beach	Ocean Ridge	R153 - R159	3,410,000	
	Delray Beach	R180 - R188.5	7,200,000	
	North Boca Raton	R205 - R212	4,550,000	
	Central Boca Raton	R216 - H222	4,150,000	45,577,000
Broward	Segment I	R6 - R14	2,000,000	
	Segment II	R25 - R72	2,750,000	
	Segment III (John U. Lloyd)	R85.7 - R93	2,910,000	
	Segment III (Hollywood/Hallandale/Dania)	R99 - R128	3,990,000	11,650,000
Miami-Dade	Sunny Isles	R7 - R19.3	2,965,500	
	"Main Segment": Government Cut through Haulover Park	R19.3 - R74	11,551,800	
	Fisher Island	R75 - R78	26,000	
	Virginia Key	R79 - R88	0	
	Key Biscayne	R89 - R110	425,000	14,968,300
			Total	**112,323,787**

Table 5. Southeast Florida Needs Determinations by County

County	50-Year Volume Need (cubic yards)	50-Year Need with Contingencies included (cubic yards)
St. Lucie	18,017,487	27,927,105
Martin	22,111,000	34,272,050
Palm Beach	45,577,000	70,644,350
Broward	11,650,000	18,057,500
Miami-Dade	14,968,300	23,200,865
Total	112,323,787	**174,101,870**

4.0 SEDIMENT SUITABILTIY

Beach nourishment projects in the State of Florida are constructed to protect upland property from storm damage, promote environmental sustainability and temporarily increase the recreational areas along the coast. Therefore, sediment placed in the coastal system (dune, berm, nearshore) must be compatible to insure the same function to meet the purposes stated above. Beach compatible fill is material that maintains the general character and functionality of the material occurring on the beach and in the adjacent dune and coastal system. In terms of functionality, sediment grain size is the most important consideration for design. Ideally, beach compatible fill will have a composition, mean and median grain size, grain size distribution, sorting, skewness, silt content, color, carbonate content and organic content matching that of the native or existing beach (CEM, 2002). When the sediment distribution of the fill material is equal or nearly equal (+/- .02mm) to the native or existing beach the equilibrated beach will adequately maintain a similar beach profile (Dean, 1991). Beach fill design aims to compensate for the differences between the fill material and the native or existing sand, usually by overfilling and assuming preferential loss of the fine fractions. One feature of beach fill technology is the loss of the fine fraction during dredging and handling between the borrow source and the beach. There have been many cases where such handling losses have produced sand fill on the beach that is coarser than the borrow sand from which the fill was derived (CEM, 2002). Composite grain size statistics for sediment sources and constructed beach fills are shown in Table 6. Post-construction sampling of the fill material occurred within two weeks of project completion for the examples presented in Table 6.

Table 6. Compatibility data for projects showing the borrow source and post-fill composite statistics.

Project/Year	Fill Volume	Sediment source	Source composite stats			Post-fill beach composite stats		
			Mean mm	Sorting phi	% passing #230	Mean mm	Sorting phi	% passing #230
Duval SPP, 2005	710,000 cy	Duval B/A “Area A”	0.25	1.15	3.4	0.25	0.85	0.70
Tampa Harbor O&M, Egmont Key, 2005	1.3 mcy	Egmont Channel and Mullet Key Cut	0.35	1.58	25	0.27	1.21	2.5
Ft. Pierce SPP, 2007	517,000 cy	Capron Shoal	0.43	0.97	1.6	0.60	1.34	0.10
IWW O&M, St. Augustine Inlet, 2008	122,648 cy	IWW, St. Augustine Inlet	0.28	1.94	2.57	0.28	0.84	0.41
Lee Co. SPP, Captiva Island, 2008	98,270 cy	Borrow Site VI	0.40	1.04	0.87	0.51	1.34	0.53
IWW, Matanzas Inlet, 2009	288,647 cy	IWW, Matanzas Inlet	0.16	0.64	3.15	0.24	0.42	0.29
John’s Pass O&M, 2010	250,000 cy	John’s Pass Entrance Channel, Shoal east of channel	0.24, 0.16	0.73, 0.56	0.86, 1.69	0.22	1.07	0.21
Treasure Is./Long Key SPP, 2010	160,000 cy	Blind Pass Entrance Channel	0.24	1.59	1.71	0.18	0.89	0.21
Duval SPP, 2011	689,015 cy	Duval B/A “A + A2”	0.17-0.26	-	1.70	0.25	0.87	1.18
IWW O&M, Bakers Haulover Inlet, 2011	33,000 cy	IWW, Bakers Haulover Inlet	0.26	1.30	6.48	0.67	0.72	0.20
Sand Key SPP, 2012	1.2 mcy	Borrow Area L	0.18	0.96	3.04	0.28	1.37	0.58
SPP: Shore Protection Project, O&M: Operation and Maintenance, IWW: Intracoastal Waterway, cy: cubic yards, mcy: million cubic yards								

Where beach fill finer than the native or existing beach sediment is placed the resultant beach profile will have a gentler slope and a greater volume of sand is needed to maintain the design width of the dry beach. Furthermore, while the correlation between finer material and turbidity (or total suspended solids) in the coastal system are not currently fully understood, finer sediments in beach fill can increase potential for turbidity issues. Hardbottom and coral reef resources increase moving into the southern portion of the study area. Turbidity and sedimentation from both borrow sites and fill placement are important environmental considerations in designing a borrow site (Erftemeijer, et. al. 2012). Despite this, gentler beach profiles still provide shore protection by allowing a greater cross-shore area for wave energy dissipation (CEM, 2002).

Alternatively, if the sediment used for beach nourishment is coarser than the native or existing beach, the equilibrated beach will have a steeper cross shore profile and recreational value may be reduced (CEM, 2002). For example, the berm and foreshore may hold a steep slope impeding the view from the berm to the swash zone creating potential recreational safety issues. Additionally, the recreational value of a beach may decrease if the material in the fill that coarsens the mean grain size is shell or rock.

Other sediment properties considered for beach nourishment include sediment color and odor. Sediment color, from a recreational standpoint is a matter of aesthetics and preference, but is more significant from an environmental perspective. Studies show that fill material darker in Munsell color value with respect to the native or existing beach can create a change in ambient sea turtle nest temperature impacting the sex ratio of hatchlings (Georges, 1994). Altering the sex ratio of hatchlings could result in a shift of the overall sea turtle population sex ratio, and thus in the reproductive success of impacted sea turtle species (USACE, 2011). However, it is important to note that the color of sediment placed in the active coastal environment will lighten, typically one value lighter, when exposed to the sun and wave action. Native or existing beaches in the region have Munsell color value ranges between 4 (darkest) and 8(lightest) (data from permit applications submitted to FDEP). Therefore, the darkest Munsell color value accepted for this study is a value of 4 based on moist Munsell color analysis. Typically, odor will only have a temporary impact on a beach, potentially affecting recreation for a short time.

Constructing a beach nourishment project with analogous properties between offshore sediment and native or existing beach sediment is often difficult because such material does not exist in adequate volume at a reasonable cost (CEM, 2002). Here, compatible sand constitutes the parameter range (mean grain size, carbonate content, Munsell color range, etc.) acceptable within the State of Florida's "Sand Rule", F.A.C. 62B-41.007(2) (j) as observed on native or existing beaches in Southeast Florida and further constrained by the parameters in Table 7.

Table 7. Acceptable Ranges of Sediment Parameters for Beach Placement used for the SAND Study

Sediment Parameter	Acceptable Parameter Range
Composite mean grain size	Composite between 0.13 mm and 0.80 mm
Silt content, passing the #230 Sieve	No more than 5% by weight in composite
Gravel content, retained on the #4 Sieve	No more than 5% by weight in composite
Construction debris, toxic material, foreign matter	None in any sample
Material resulting in beach cementation	None in any sample
Moist Munsell color	Value between 4 and 8, any hue and chroma

The “Sand Rule”, F.A.C. 62B41-007(2)(j), specifies beach compatible fill as material with a particle size distribution ranging between 0.062 mm and 4.76 mm and does not specify a specific range for acceptable mean grain size. However, mean grain size is frequently used to characterize both sediment sources and beach nourishment areas. Therefore, mean grain size ranges were used to constrain sediment sources in this study between 0.13 mm to 0.80 mm. This range captures acceptable material in the fine sand- to coarse sand-size range. This does not mean that all identified sediment source material falls within the specified range, but the mean grain size falls within this range. The lower limit of 0.13 mm mean grain size was established using the boundary between very fine and fine sand using the Wentworth Grain Size Classification. The upper limit of 0.80 mm mean grain size was constrained using data from Phelps et al (2009) which provided a sedimentological and granulometric analysis of existing beaches along Florida’s east coast.

Sieve analysis was run on all SAND Site Investigation Study samples prior to carbonate digestion following the method outlined by Twenhofel and Tyler (1941). Following carbonate content analysis, the samples were re-sieved. Figure 3 shows the distribution of sample means from the original and post carbonate digestion sieve analysis. Through the analysis it was found that the majority of carbonate content in the study area is medium sand-sized to fine gravel sized. Finer sediments in the study area are comprised of quartz, heavy minerals, and other minor silicates. For beach nourishment, coarser and more durable carbonate will not increase turbidity or cause cementation (Molenaar and Venmans, 1993).

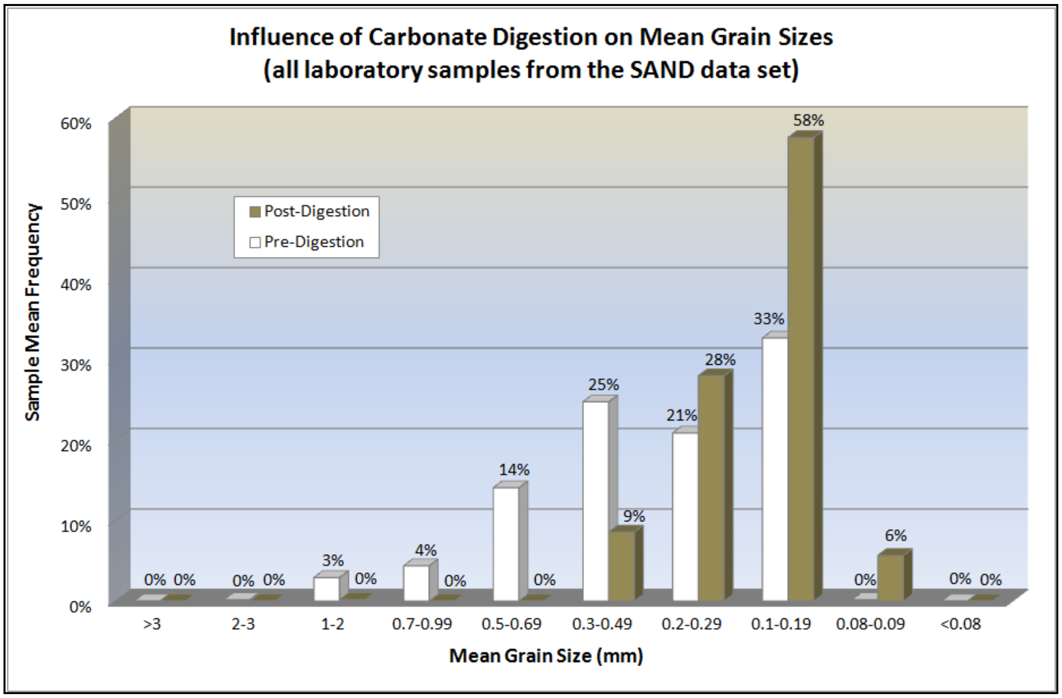

Figure 3. Sample Means (mm) frequency pre and post-carbonate digestion. The shift in the skewness and kurtosis of the frequency of mean distributions indicates that the carbonate content in the data set occurred in the coarser fractions of the samples.

5.0 METHODS AND ASSUMPTIONS

5.1 Sediment Source Delineation

This study considers offshore sediment sources that lie in State and Federal jurisdictional waters. Both recent and historical bathymetric, seismic, geomorphologic and geotechnical data taken from -8’ NAVD88 to -90’ NAVD88 towards the Florida-Hatteras continental shelf slope break were taken into account. Historical data collected during the desktop study and the geotechnical data from the cores collected as part of this study were used in the analysis to delineate offshore sand sources meeting the criteria outlined in Table 7. Previously delineated sediment source boundaries were modified to reflect data collected since their delineation using available borings and jet probes, seismic data, bathymetry, and geomorphology. Additionally, new sediment source boundaries were defined using cores from the site investigation phase of this study. Sediment source boundaries were refined and are spatially referenced to State Plane Florida East, NAD83 and are listed in Table 8.

Table 8. Sediment Source Summary

County	Sediment Source	Category	Centroid State Plane FL East Easting	Centroid State Plane FL East Northing	Previous Nomenclature
St. Lucie County	SL2-R9	Proven	892386	1163952	Ft. Pierce SPP AREA AB
	SL4-R10		898897	1162948	Ft. Pierce SPP AREA D
	SL1-R22		892352	1151784	Ft. Pierce SPP AREA E
	SL3-R33		906354	1141402	Ft. Pierce SPP AREA F
	SL3-R44		906909	1131686	Ft. Pierce SPP Area C
	SL2-R56		905772	1119672	Ft. Pierce SPP Area C
	SL6-R67		929596	1110162	Borrow Area D/ St. Lucie #4
	SL6-R73		935923	1104561	Borrow Area C/ St. Lucie #3/MMS BA A
	SL5-R84		931918	1095092	Borrow Area B/ MMS BA A
	SL1-R87		912854	1091767	CPE BA-2
	SL1-R92		914125	1087105	CPE BA-3
	SL0-R98		914628	1081609	CPE BA-4

County	Sediment Source	Category	Centroid State Plane FL East Easting	Centroid State Plane FL East Northing	Previous Nomenclature
St. Lucie County	SL4-R98	Proven	932245	1082187	Borrow Area A
St. Lucie County	SL7-R104	Proven	949446	1076701	Martin County Borrow Area B
St. Lucie County	SL3-R107	Proven	930680	1073543	CPE BA-5
St. Lucie County	SL3-R12	Potential	896983	1161819	Part of Shoal A and Unnamed Shoal #1
St. Lucie County	SL10-R16	Potential	935084	1157442	Previously Un-delineated
St. Lucie County	SL10-R27	Potential	937717	1147917	Previously Un-delineated
St. Lucie County	SL1-R35	Potential	892465	1139483	Part of Shoal A
St. Lucie County	SL10-T41	Potential	940750	1133950	Previously Un-delineated
St. Lucie County	SL2-R76	Potential	913277	1101706	Previously Un-delineated / CPE BA-1
St. Lucie County	SL7-R9	Unverified	920203	1163835	Previously Un-delineated
St. Lucie County	SL6-R10	Unverified	914540	1163140	Previously Un-delineated
St. Lucie County	SL7-R12	Unverified	927892	1164234	Previously Un-delineated
St. Lucie County	SL11-R16	Unverified	942273	1158041	Previously Un-delineated
St. Lucie County	SL4-R22	Unverified	906650	1152163	Previously Un-delineated
St. Lucie County	SL9-R22	Unverified	933589	1151886	Previously Un-delineated
St. Lucie County	SL5-R29	Unverified	914915	1145383	Previously Un-delineated
St. Lucie County	SL1-R32	Unverified	892380	1142795	Part of Shoal A
St. Lucie County	SL10-R35	Unverified	941005	1140075	Previously Un-delineated
St. Lucie County	SL4-R39	Unverified	909617	1135597	Previously Un-delineated
St. Lucie County	SL11-T41	Unverified	946325	1134416	Previously Un-delineated
St. Lucie County	SL8-R42	Unverified	932927	1133667	Part of MMS-6
St. Lucie County	SL11-R64	Unverified	955080	1112996	Previously Un-delineated
St. Lucie County	SL3-R66	Unverified	913152	1111241	Previously Un-delineated
St. Lucie County	SL3-R67	Unverified	916969	1110314	Previously Un-delineated
St. Lucie County	SL5-R70	Unverified	927605	1107274	Part of St. Lucie #4/ MMS-6
St. Lucie County	SL10-R77	Unverified	955078	1101301	Previously Un-delineated
St. Lucie County	SL3-R81	Unverified	920606	1097301	Previously Un-delineated
St. Lucie County	SL4-R90	Unverified	932371	1088903	Previously Un-delineated
St. Lucie County	SL6-R91	Unverified	943285	1088743	Previously Un-delineated/ MMS-7
St. Lucie County	SL8-R93	Unverified	951086	1086729	Previously Un-delineated/ MMS-7
St. Lucie County	SL8-R97A	Unverified	955770	1083298	Previously Un-delineated/ MMS-7
Martin County	M2-R83	Proven	955839	997339	Site A
Martin County	M2-R110	Proven	963640	974699	Site B
Martin County	M3-R125	Proven	972151	962054	Area 4
Martin County	M3-R45	Potential	950351	1030225	MI-6
Martin County	M2-R58	Potential	950176	1018119	MI-3
Martin County	M2-R66	Potential	948571	1010480	MI-3
Martin County	M3-R108	Potential	968822	976325	Previously Un-delineated
Martin County	M7-R2	Unverified	958409	1064810	Part of MMS-7
Martin County	M6-R5	Unverified	953397	1062354	Part of MMS-7
Martin County	M0-R36	Unverified	933487	1037265	Gilbert Shoal South
Martin County	M7-R45	Unverified	969337	1028856	Previously Un-delineated
Martin County	M2-R76A	Unverified	952342	1002589	Previously Un-delineated
Martin County	M3-R91	Unverified	961910	990488	Previously Un-delineated
Martin County	M1-R93	Unverified	953934	988985	Previously Un-delineated
Martin County	M1-R95	Unverified	956793	987133	Previously Un-delineated
Martin County	M2-R105	Unverified	961818	978858	Previously Un-delineated
Martin County	M4-R105	Unverified	974328	978840	Part of MMS-7
Martin County	M2-R117	Unverified	966753	968811	Previously Un-delineated
Palm Beach County	PB2-R2	Proven	967410	958473	Jupiter/Carlin A
Palm Beach County	PB3-R8	Proven	973128	954584	Jupiter/Carlin B
Palm Beach County	PB0-R59	Proven	973828	904694	Singer Island

County	Sediment Source	Category	Centroid State Plane FL East		Previous Nomenclature
			Easting	Northing	
Palm Beach County	PB0-R71	Proven	974459	892425	Singer Island /Lake Worth Inlet North
	PB0-R86		973953	876234	Lake Worth Inlet South/ ROSS Area-10/PB North
	PB0-R111		974186	847755	Palm Beach South
	PB0-R160		970289	796834	ROSS Proposed Area-12, 17 / Ocean Ridge
	PB0-R170		968484	785593	Briny Breezes
	PB0-R182		966669	772424	Delray Beach/ ROSS Proposed Area-44, 36
	PB0-R197		964893	756841	Highland Beach
	PB0-T205		964865	747883	ROSS Proposed Area - 54
	PB0-R212		964340	741188	Boca Raton/ ROSS Proposed Area-59
	PB0-R216		964122	736812	Previously Un-delineated
	PB0-R221		963636	731335	ROSS Proposed Area - 73
	PB0-R2	Potential	960021	958469	Part of ROSS Proposed Area-1
	PB0-R15		963213	947634	
	PB1-R21		966439	942212	Part of Palm Beach (Juno to Jupiter)
	PB0-R39		968801	923844	Part of ROSS Proposed Area-1
	PB0-R49		972254	913826	Part of Palm Beach (Juno to Jupiter)
	PB0-R127		973820	831087	Palm Beach Area III
	PB0-R142		972742	814799	PB-3
	PB0-R150		971730	806054	Previously Un-delineated
Palm Beach County	PB0-R52	Unverified	973381	910442	Previously Un-delineated
	PB0-R96		974655	864588	PB-2
	PB0-R183		965898	771994	Previously Un-delineated
	PB0-R226		963117	725057	ROSS Proposed Area-79

Initially, sand sources were categorized using the criteria established by the US Army Corps of Engineers in the 2008 Southeast Atlantic Regional Sediment Source Study for Florida and the 2009 RSM (Halcrow/GEC, 2007, Taylor, 2009). Following discussions with the SAND Study Team and using the professional judgment of the primary investigators, the categories from the 2009 RSM have been refined as: Proven, Potential, Unverified (volume contributing and non-volume contributing) and Depleted or Unusable. Each category's criterion has been defined as presented in Table 9. Additionally, each category has been assigned a confidence level based on the density of data available. Confidence levels for the Proven, Potential and Unverified (volume contributing) are 90%, 70% and 30% respectively.

Table 9. Sediment Source Categories (Adapted from the Southeast Atlantic RSM Plan for Florida, 2009)

Category	Confidence	Description
1: Proven	90%	Meets all the criteria of Potential sources. Contains permitted borrow areas that have not been dredged. Some areas have design level geotechnical and seismic coverage; any areas that are less than design level have high data density combined with professional judgment of the interpretation of bathymetry, seismic and geotechnical data.
2: Potential	70%	Meets all the criteria of Unverified sources. Also has geotechnical data with laboratory analysis. Cores indicate a minimum of 4' of compatible material, greater than 0.13 mm mean grain size, less than 5% silt content passing the #230 sieve, less than 5% retained on the #4 sieve, all Munsell values are 4 or greater. Areas all have some combination of data sets: vibracores, bathymetry, seismic, geomorphology combined with professional judgment used to define the sediment source.

Category	Confidence	Description
3a: Unverified	30%	Volume contributing. Some evidence to suggest a beach-quality sand source such as geomorphic, bathymetric, seismic, or other form of remotely sensed feature and at least one geotechnical core that meets the sediment criteria herein. Does not include depleted or unusable areas.
3b: Unverified	0%	Non-volume contributing. Some evidence to suggest a beach-quality sand source such as geomorphic, bathymetric, seismic, or other form of remotely sensed feature. Does not contain geotechnical data yielding information on the character of the material. Does not include depleted or unusable areas.
0: Depleted or Unusable	0%	Depleted: beach compatible material has been removed from the area for beach nourishment prior to the SAND Study. Unusable: Area is within 400' of hardbottom, near a cultural or historical resource, or is within submerged utility buffer. Fish havens and Offshore Dredge Material Disposal Sites (ODMDS) are also included in this category.

5.2 Horizontal Sediment Source Delineation

Any areas not identified as avoidance areas and not included as identified sediment source boundaries in this report are either areas that do not meet the criteria established for this study (Table 7) or are areas that lack sufficient data to warrant demarcation as a possible sediment source.

Horizontal sediment source delineation included six primary considerations:

- Previously delineated sediment source boundaries
- Bathymetric evidence
- Removal of depleted areas, avoidance areas, and hardbottom buffers
- Depth of closure
- Geotechnical boring influence
- Geophysical (seismic) evidence

Maps of previously delineated sediment source boundaries from the 2009 RSM were updated with new bathymetry and boring data. Depleted sediment source areas were then excluded from the sediment source boundaries. NOAA National Ocean Service (NOA) maps 11466 and 11474 were used to identify avoidance areas such as offshore dredge material disposal areas, fish havens, cable passages and culturally significant features. Identified avoidance areas were removed from the sediment source boundaries. In a few instances avoidance areas fell in the middle of a sediment source boundary. When this occurred the sediment source boundary was redrawn to subtract the avoidance area (for example SL3-R107) or the interior avoidance area was removed from the total area during the volume calculation (for example M3-R108).

Known hardbottom areas from the 2009 RSM and FDEP ROSS database and hardbottom delineations provided by and for Palm Beach County were considered when delineating the horizontal extent of sediment sources and given a 400 foot buffer. It should be noted that as of 2012, the dredging industry can successfully dredge within 10 feet of a structure such as a dock, bulkhead or jetty with no impact to the structure. Therefore, the horizontal and vertical constraints placed on sediment sources are not considered to be the result of dredging industry capability (personal communication during an industry meeting, USACE-Jacksonville District, 25-Oct-12). Sediment source buffer zones are then necessitated by environmental regulations on turbidity, where the extent, impact and mitigation needs are not fully understood. While 400 feet was used as the hardbottom buffer for the purposes of this study, 400 ft is not a regulatory standard for hardbottom buffers. There are many variables such as the quality of the hardbottom community, benthic density, and background water quality that are taken into consideration when determining what buffer will be applied during permitting.

The Depth of Closure (DoC) was taken into account as an important coastal engineering and management consideration when delineating the landward horizontal constraint on sediment sources. The depth of closure for this effort is defined as the most landward depth, seaward of which there is no significant change in bottom elevation and no significant net sediment transport between the nearshore and the offshore for a given or characteristic time interval (Kraus, Larson and Wise, 1998). Borrow areas excavated shallower than the depth of closure can act as a sink to long shore and cross shore sediment transport, creating erosional hotspots on the adjacent beach. This study includes DoC considerations as a landward limitation for potential sediment sources. Figure 4 from Dean and Malakar (2002) was used to obtain the DoC that was taken to be -28 feet in St. Lucie and Martin Counties and -25 feet in Palm Beach County. Ebb shoals that are shallower than the DoC were included in the Sediment Assessment portion of the SAND Study if they were not excluded during the Needs Determination as part of an existing inlet by-passing project.

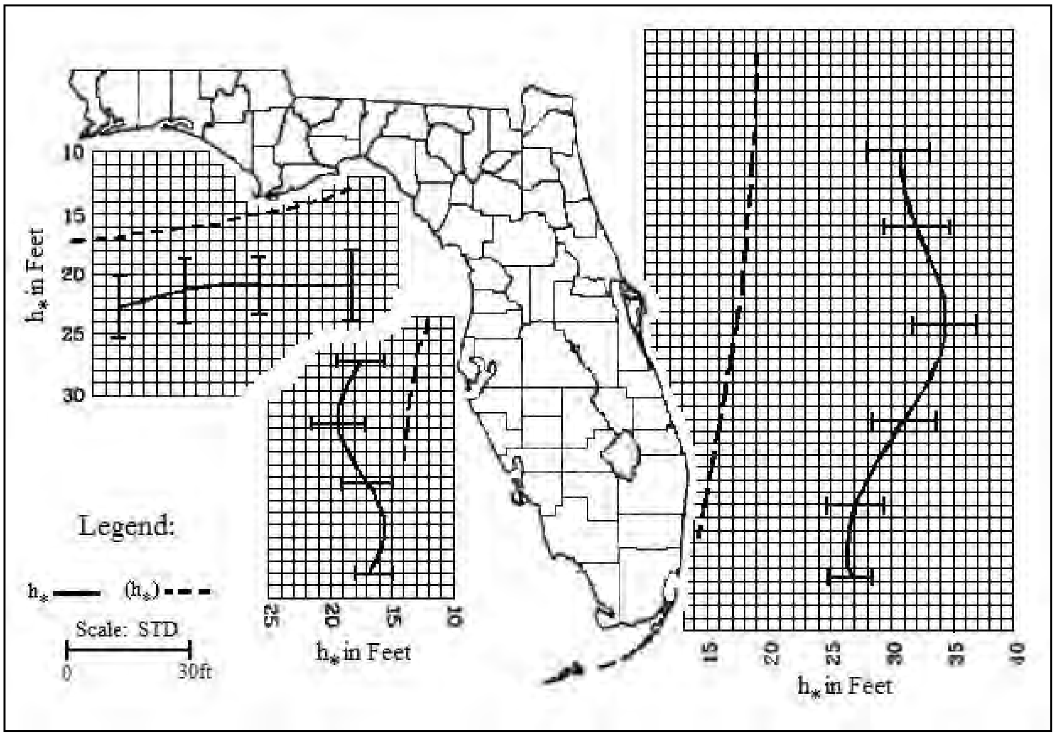

Figure 4. Depth of closure was selected for the study areas from Dean and Malakar (2002). Depth of closure calculated from Dean and Malakar (2002) are represented by h_* with a solid line compared with depth of closure determined by Dean and Grant (1989). The vertical bars represent ± one standard deviation about the averages of the depth of closure values.

All core borings or vibracores were considered to have a 500 foot radius circle of influence to assist in the delineation of sediment source boundaries. If a boring contained material meeting the criteria in Table 7, the boring and the 500 foot influence were included in the sediment source boundary. If a boring contained material that did not meet the criteria for this study, the sediment source boundaries excluded the boring and the 500 foot radius circle of influence. Additionally, when applicable, borings were plotted on seismic lines and used to establish which seismic reflector represented the depth of the sediment source (Figure 5). Seismic lines were used to outline the extent of sediment source boundaries laterally to a thickness of 4 feet as discussed in Section 5.3.

5.3 Vertical Sediment Source Delineation

Vertical sediment source delineation included three primary considerations:

- 4 foot thickness of suitable material
- Triangular source geometry seen in seismic and application of a source area edge thickness
- Re-evaluation of all available geotechnical data, historical and recent

This study required that a sediment source must contain a minimum of 4 feet of suitable material to be included for volume contribution. It is currently regulatory practice to leave a 2 foot vertical buffer between the maximum design dredge depth and the upper most layer of poor quality material as indicated in the core borings and seismic lines. This buffer allows for the disturbance of the 2 feet below the maximum dredge depth without disturbing or entraining poor quality material in the beach fill.

Seismic evidence indicates sediment sources in St. Lucie and Martin Counties are frequently shoals with a triangular geomorphic shape in cross section. Seismic evidence also indicates a triangular cross sectional geometry to sediment sources occurring in the first flat of Palm Beach County. Therefore, to better capture the source geometry, a 4 foot edge boundary thickness was added when finding the average thickness of a sediment source where appropriate (Figure 5).

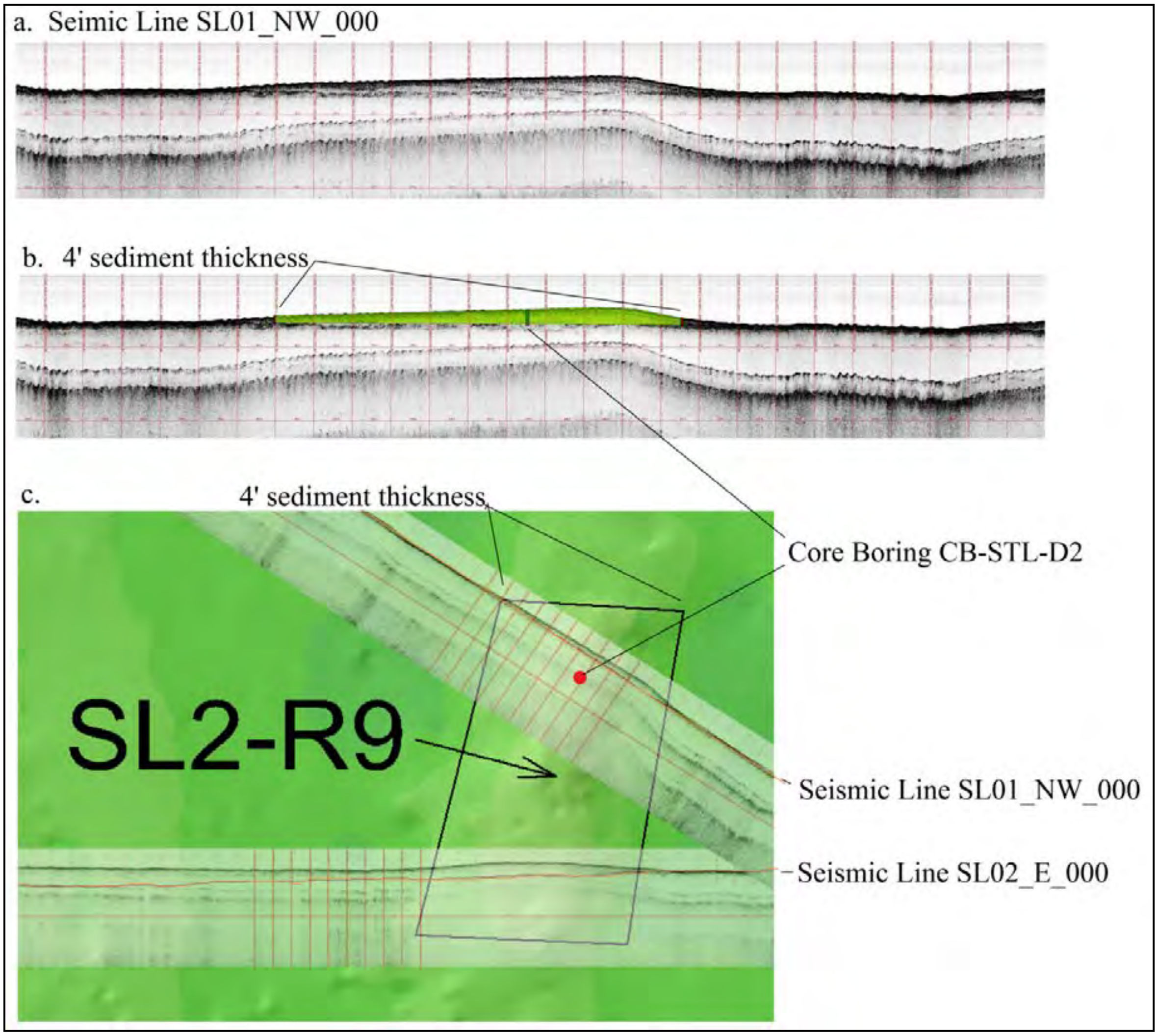

Figure 5. a. Seismic line SL01_NW_000 showing a surficial shoal offshore of St. Lucie County elucidating the triangular nature of the source. b. Boring CB-STL-D2 is projected on the seismic line along with the extents of the source horizontally to a 4 foot thickness. c. The planer extent of the source is outlined as identified using the seismic and bathymetric data.

The evaluation and analysis of each sediment source included re-examination of all available core boring, vibracore and jet probe logs in the area. If available, grain size statistical data and grain size distributions, found in grain size distribution curves or sieve analysis tables were used to characterize individual layers shown in the boring logs. When considering sediment suitability in the context of an entire core, if a thin silt layer

<0.2' was encountered with several feet of clean sand above and below, it was assumed that the composite silt content would meet the criteria in Table 7 and the thickness for that boring was set at the base of the lower sand unit. Additionally, discrete pieces of coral and rock fragments were also accepted if they constituted <5% material that would be retained on the #4 sieve over the composite of suitable material in the core.

Each core was examined and a thickness of sediment meeting the criteria in Table 7 was established. Following agreement between the primary investigators regarding the thickness of suitable material for each core, the thickness of all borings representing given sediment source along with the 4 foot source edge thickness were averaged. The resultant average thickness was applied uniformly to the sediment source.

5.4 Sediment Source Nomenclature and Volume Calculation

Examinations of existing and proposed sediment sources made the need for a systematic nomenclature evident. A simple centroid method was devised where the centroid of each source is the geometric center of the planer polygon. The sediment source name is based on the location of the centroid and is established using statute mile offshore and established FDEP range monuments (R-monuments) by the following formula:

(County abbreviation)(Statute mile offshore)-(R-monument)

For example, the centroid for sediment source SL3-R33 is located in St. Lucie County, approximately three statute miles offshore of R-monument 33. This system works because all factors are unique across counties and the name of the sediment sources intuitively lead to location. The statute mileage offshore is done by bins. If the centroid lies between mile 0 and 1, the name uses mile 0, between 1 and 2 miles the name is mile 1, et cetera. So, if the centroid is 6.7 miles offshore the name would reflect the 6-mile bin.

Volume calculations were made by multiplication of the planar sediment source area as determined in Section 5.2 and the average suitable sediment thickness as found in Section 5.3. The data used for volume calculations for each sediment source are presented in Section 10.0. Also in Section 10.0, each delineated sediment source has a data sheet containing a map of the area showing the source, borings and seismic lines. A listing of borings used, thickness applied to each boring, average thickness of the sediment source, square footage of each sediment source, a brief description of the sediment encountered, mean grain sizes found in the area, average Munsell color values, and additional notes when necessary are also included.

6.0 DISCUSSION

Sand sources identified in this report have variations in the concentration of available data characterizing the nature of the sources. Some sand sources are permitted borrow areas for specific projects, some sources have been targeted by previous sand search investigations, and the remainder are sources identified and refined by the efforts of this study. For the majority of the sand sources, additional data will need to be collected to fully characterize the sources and increase the level of data concentration to provide reasonable assurance of the sediment source quality for permitting. Additional geotechnical and geophysical studies will also be necessary to identify sediment sources not yet delineated.

The sand sources identified in this study fall within the current limits of investigative and dredging technology. Geotechnical and geophysical sampling techniques and dredging technology used to investigate and recover offshore sediment sources will continue to evolve as demand for them increases. New innovations for the investigation, identification, and dredging of offshore sediment will allow for additional sediment sources not currently delineated to become available for use.

Occasionally, sediment sources were constrained vertically due to the length of available core borings which terminated in sediment suitable for beach placement. Therefore, as sediment sources are exhausted to the currently identified depth, additional investigation, seismic consideration or borings may be needed after removal of material to maximize the source.

7.0 CONCLUSIONS

Volume balances for the study area are presented in Table 10 and with expanded data in Plate 2 . A summary of the Sand Needs are shown with contingencies applied as discussed in Section 3.0. Proven, Potential and volume contributing Unverified sediment source volumes are shown by County with contingency and confidence applied in the Sand Assessments column. Contingencies are the application of a 2-foot vertical buffer above unsuitable material as described in Section 5.3 and a 25% loss applied to all categories in Palm Beach County to account for reef talus content observed in borings and as noted during previous project constructions. Confidence levels for the Proven, Potential, and volume contributing Unverified categories found in Section 5.1, are based on the density of data available and are 90%, 70%, and 30% respectively. Total Volume with Contingency/Confidence shows the total estimated sediment volume per county with the total for the region summed. The % State/Fed column shows the distribution of each County's total volume between State and Federal jurisdictional waters. Off of St. Lucie County, approximately 28% of the total sand source volumes identified fall in State jurisdictional waters. Off of Martin County, approximately 76% of the total sand source volumes identified fall in State jurisdictional waters. All sand source volumes identified in Palm Beach County fall in State jurisdictional waters. It is important to note that for sand sources in Federal waters, authorizations for geotechnical investigations and leases for use must be obtained from the US Department of Interior, Bureau of Ocean Energy Management. Finally, the Volume Balance column shows the volume balance for each County by subtracting the sand needs from the total volume. Previous data, projects constructed since 2009, and environmental restrictions (buffer zones) have reduced Miami-Dade and Broward Counties available sediments to zero cubic yards in all categories (USACE, 2012).

Table 10. Sediment Volume Balance for Southeast Florida

	Sand Needs (cy)	**Sand Assessments (cy)**					
County	50-Year Need + 55% Contingency	Proven with Contingency/ Confidence	Potential with Contingency/ Confidence	Unverified with Contingency/ Confidence	Total Volume with Contingency/ Confidence	% State/Fed	**Volume Balance**
St. Lucie	27,927,105	46,359,498	39,355,617	20,434,503	106,149,618	28/72	78,222,514
Martin	34,272,050	15,245,885	24,007,268	16,907,177	56,160,331	76/24	21,888,281
Palm Beach	70,644,350	107,435,942	48,582,048	-	156,017,990	100/0	46,919,949
Broward	18,057,500	-	-	-	-	0/0	-18,057,500
Miami-Dade	23,200,865	-	-	-	-	0/0	-23,200,865
Totals:	**174,101,870**	169,041,325	111,944,933	37,341,680	**280,037,956**		**105,936,086**
							100,000,000

Based on the needs determination with contingencies applied, it was found that 174,101,870 cubic yards of sediment are needed to support placement of planned, full-sized beach nourishment projects through 2062. With contingencies and confidence levels applied, it was found that 280,037,956 cubic yards exist offshore of Southeast Florida that meet the criteria for this study established for sand placement on Florida beaches. Therefore, currently known sediment resources for St. Lucie, Martin, Palm Beach, Broward and Miami–Dade Counties exceed sediment needs by 100,000,000 cubic yards representing an increase in sediment balance excess of 90 mcy from the 2009 RSM Study (Table 10, Table 1). This volume estimate will increase as potential and unverified sediment sources identified herein are further developed.

This study does not correlate specific offshore sediment sources to particular beach nourishment projects, but rather evaluates sediment sources for regional potential. A future study following this study could encompass comprehensive reporting of the native or existing beaches in the region identified in the needs determinations (Table 4) including a comparison to the sediment sources identified offshore through this study (Table 8). A compatibility analysis using all of the sediment parameters could be performed to delineate the offshore sediment sources most compatible with each beach project's specifications. This would assist stakeholders, Counties, and the State and Federal agencies with the allocation of sand resources on a regional level.

Additional steps moving forward could include creating a Regional Sediment Management Plan for all of the sand sources identified in this study and an effort between the Florida Department of Environmental Protection and the US Department of Interior, Bureau of Ocean Energy Management in creating a lease agreement for sediment sources that fall in Federal jurisdiction.

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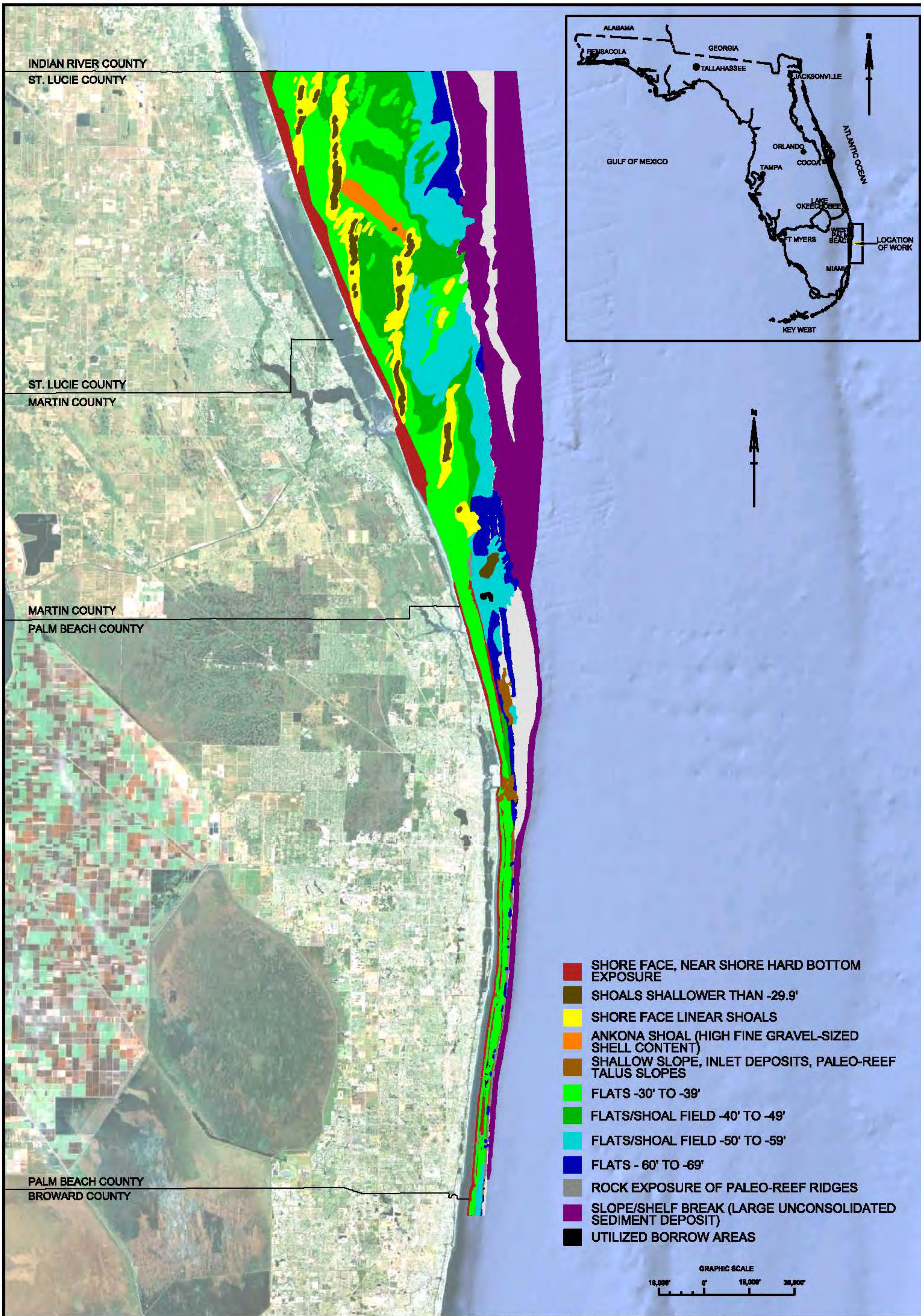


US Army Corps of Engineers Jacksonville District	GEOTECHNICAL DRAWINGS	Dsn by: JDO	MARTIN, ST. LUCIE AND PALM BEACH COUNTY, FLORIDA	PLATE
		Dwn by: CJB	SOUTHEAST FLORIDA SEDIMENT ASSESSMENT AND NEEDS DETERMINATION	
	DEPARTMENT OF THE ARMY JACKSONVILLE DISTRICT, CORPS OF ENGINEERS JACKSONVILLE, FLORIDA	Ckd by: JDO		B-1
		Dated: MAY 2013	MORPHOLOGY	

Plate 2. Sediment Assessment and Needs Determination Summary Sheet, 2012

	Sand Needs (cy)		Sand Availability (cy)									
				Proven[4]		Potential[5]		Unverified[6]				
County	50-Year Volume Need	50-Year Need + 55% Contingency	Jurisdiction	with 2' buffer	2' buffer w/ 90% confidence	with 2' buffer	2' buffer w/ 70% confidence	with 2' buffer	2' buffer w/ 30% confidence	2012 Total Volume per County	Volume + Contingency/ Confidence	**Volume after Needs met**
St. Lucie	18,017,487	27,927,105	State 28%	19,171,629	17,254,466	16,905,238	11,833,667	1,048,827	314,648	37,125,694	29,402,780	78,222,514
			Federal 72%	32,338,925	29,105,032	39,317,073	27,521,951	67,066,183	20,119,855	138,722,180	76,746,838	
Martin	22,111,000	34,272,050	State 76%	16,939,872	15,245,885	21,705,565	15,193,895	41,054,367	12,316,310	79,699,804	42,756,091	21,888,281
			Federal 24%	-	-	12,590,533	8,813,373	15,302,890	4,590,867	27,893,423	13,404,240	
Palm Beach[2]	45,577,000	70,644,350	State 100%	119,373,269	107,435,942	69,402,925	48,582,048	3,175,619	-	191,951,814	117,728,007	47,083,657
			Federal 0%	-	-	-	-	-	-	-	-	
Broward[3]	11,650,000	18,057,500	State 0%	-	-	-	-	-	-	-	-	-18,057,500
			Federal 0%	-	-	-	-	-	-	-	-	
Miami-Dade[3]	14,968,300	23,200,865	State 0%	-	-	-	-	-	-	-	-	-23,200,865
			Federal 0%	-	-	-	-	-	-	-	-	
	112,323,787	**174,101,870**		187,823,695	169,041,325	159,921,333	111,944,933	127,647,887	37,341,680	475,392,915	280,037,956	**105,936,086**
												100,000,000

NOTES:

1-Prior to adding contingency and confidence, there are 2 significant figures yielding the highlighted volume in the far right column. After contingencies/confidences are applied the significant figures are reduced to one.

2-All Palm Beach County categories have an additional 25% contingency removed for talus content applied in the 'Volume+Contingency/Confidence' column

3-Further investigation, project constructions and environmental constraints reduced volumes for Broward and Miami-Dade counties to 0cy

4-Category 1 (Proven) Meets all the criteria of Potential sources. Contains permitted borrow areas that have not been dredged. Some areas have design level geotechnical and seismic coverage; any areas that are less than design level have high data density combined with professional judgment of the interpretation of bathymetry, seismic and geotechnical data.

5-Category 2 (Potential) Meets all the criteria of Unverified sources. Also has geotechnical data with laboratory analysis. Cores indicate a minimum of 4' of compatible material, greater than 0.13 mm mean grain size, less than 5% silt content passing the #230 sieve, less than 5% retained on the #4 sieve, all Munsell values are 4 or greater. Areas all have some combination of data sets: vibracores, bathymetry, seismic, geomorphology combined with professional judgment used to define the sediment source.

6-Category 3 (Unverified) Volume contributing. Some evidence to suggest a beach-quality sand source such as geomorphic, bathymetric, seismic, or other form of remotely sensed feature and at least one geotechnical core that meets the sediment criteria for the study. Does not include depleted or unusable areas.

Project 50-year volumes assume placement of scheduled full-sized projects until the end of 2062.
Sand sources in this table include all known borrow areas in State and Federal waters.
"Renewable" sources such as sand dredged from ebb shoals are incorporated by reducing needs.

9.0 SAND NEEDS EVALUATION OF BEACH NOURISHMENT PER COUNTY

9.1 Needs Determination: St. Lucie County, FL

St. Lucie County, FL

Sand Needs Evaluation for Beach Nourishment

A component of the:

Southeast Florida Sediment Assessment and Needs Determination (SAND) Report

Submitted to:
Florida Department of Environmental Protection
Bureau of Beaches & Coastal Systems
Tallahassee, FL

Prepared by:
Author(s): Richard Bouchard, P.E. – St. Lucie County Erosion District
Michael Walther, P.E. – Coastal Tech

Date: March 2, 2012 (revised September 10, 2012)

Executive Summary

The purpose of this report is estimate the current and future demand for sand for beach nourishment in St. Lucie County. This estimate will be used in conjunction with similar estimates of the sand needs of the remaining southeast Florida counties (Martin, Palm Beach, Broward, & Dade) to determine a range of the amount of sand needed over the next 50 years to sustain southeast Florida's Federal and non-federal beach nourishment projects. Ultimately, the estimated needs of this region will be compared to the availability of sand for beach nourishment purposes. This comparison will be accomplished through the Southeast Florida Sediment Assessment and Needs Determination (SAND) Report, a joint effort led by the Florida Department of Environmental Protection and supported by the southeast Florida counties and the U.S. Army Corps of Engineers.

Accretion and erosion of St. Lucie County beaches are mostly attributable to the effects of Ft. Pierce Inlet. Dominant longshore transport is from north to south. Beaches north of the inlet are predominantly stable or accreting and have not required beach fill. Beaches south of the inlet are sand-starved by the inlet channel and jetties which constitute a total littoral barrier. Beach nourishment activities by the County have historically been focused on the 1.3 miles of beach immediately south of the inlet associated with the Ft. Pierce Shore Protection Project. Episodic erosion of beaches in the southernmost 3.4 miles of the County has prompted formulation of the proposed South County Beach Project.

The considered beach nourishment projects and projected 50-year renourishment requirements for St. Lucie County are summarized in Table 1. The table briefly describes the fundamental assumptions upon which the required sand volumes are based. Additional detail is provided in the following pages. The table, as shown, includes both Current Need (that is, for an ongoing construction project, or a pending initial project nourishment requirement) in addition to the anticipated future renourishment after the initial project 'burns off' its advance fill.

St. Lucie County											
Projected Sand Requirement over next 50 years (Current and Future)											
						Demand *not including current					
Name	Sponsor/Agency	Initial Construction Date	Monument Range	Length of Nourishment (ft)	"C" Estimated Current Requirement (cy)	"R" Estimated Rate (cy/yr)	"F"= R x 50 Estimated Future Demand Over 50 Years (cy)	"C + F" Estimated 50-yr Requirement (cy)	"(C + F)/50/ft" Estimated Requirement per Year per Linear Foot (cy/yr/ft)	Basis of Estimate	Comments
Ft. Pierce Shore Protection Project	St. Lucie County Erosion District, USACE, FDEP	1971	from Ft. Pierce Inlet (200 feet north of R-34) to T-41	6,864	0	260,000	13,000,000	13,000,000	37.9	maintenance requirements since March 1999 per 2009 monitoring report	The authorized Project extends over the 1.3 miles of shoreline south of Ft. Pierce Inlet. Prior to 1999, the Project was not regularly maintained.
South County Beach Project	St. Lucie County Erosion District, FDEP, USACE - pending Feasibility Study	2012-2013 (targeted)	R-98 to R-115	17,439	517,487	90,000	4,500,000	5,017,487	5.8	Historical South County Losses and advance fill projections	Historical Losses are less than projected volumes needed to maintain Project - per Martin County experience.
		Total	R-34 to R-115	24,303	517,487	350,000	17,500,000	18,017,487	14.8		

Main Report

Introduction and Project Status

Ft. Pierce Shore Protection Project: The following is from the report titled: "Ft. Pierce Shore Protection Project - 2011 Two-Year Post-Construction Monitoring Report" dated August 2011 by Taylor Engineering, Inc.:

> The River and Harbor Act of 1965 (PL 89-298, 79 Stat. 1089, 1092), in accordance with the recommendations of the Chief of Engineers in House Document (HD) 84, 89th Congress, authorized the Ft. Pierce SPP in St. Lucie County, Florida. The authorization provided for the restoration of 1.3 miles (mi) of shoreline south of Ft. Pierce Inlet and for periodic renourishment as needed for 10 years after initial project construction. The 1968 modification did not include the reimbursement authority originally provided; however, the non-federal sponsor, St. Lucie County, proceeded to construct the project with reimbursement of the federal share of the cost under the authority of Section 215 of the 1968 River and Harbor Act. The initial construction of the Ft. Pierce SPP, completed in 1971, placed 718,000 cubic yards (cy) of sand on the approximately 1.3 mi project shoreline (Figure 1.1). The project area extends south from the Ft. Pierce Inlet south jetty (approximately 200 feet [ft] north of FDEP reference monument R-34) through FDEP reference monument T-41. An unnourished, monitored control beach extends approximately 5,000 ft south of the project area (FDEP reference monuments T-41 – R-46A). In 1980, the first renourishment of the project placed 346,000 cy of sand from an offshore borrow area.
>
> Under the authority of Section 156 of the Water Resource Development Act (WRDA) of 1976 (PL 94-587), the Chief of Engineers extended federal participation to 15 years from initial construction. Federal participation then expired in 1986, 15 years after the initial construction fill in 1971. Data at that time indicated the project would require periodic renourishment at average intervals of about five years. Section 934 of WRDA of 1986 (PL 99-662) amended Section 156 of WRDA of 1976 to give the Secretary of the Army, acting through the Chief of Engineers, discretionary authority to extend federal participation to the fiftieth year after the date of initial construction of a shore protection project. A Section 934 Reevaluation Report completed in May 1995 deemed continued renourishment as economically and environmentally sound. Congress added Section 506(a)(2) of WRDA of 1996 (PL 104-303), which authorized the extension of federal participation in the periodic renourishment to 50 years, beginning on the date of initial project construction. With initial construction fill placed in 1971, Section 506(a)(2) of WRDA 1996 thus extends federal participation in periodic renourishment until 2020.
>
> Maintenance of the original 1971 Ft. Pierce SPP occurred when the first (1980) and second (1999) renourishment events added 346,000 cy and 830,000 cy of sand to the project area. Notably, 19 years passed between the first and the second

renourishment events. The third renourishment occurred in two phases over a two-year period. The first phase (2003) placed approximately 336,000 cy of sand from the Ft. Pierce Inlet south jetty to approximately 2,200 ft further south (FDEP reference monument T-36). The second phase (2004) placed approximately 406,000 cy of sand, including approximately 45,000 cy of upper beach advance fill (dune). The 2004 project area extended from the Ft. Pierce Inlet south jetty to approximately 2,700 ft further south (roughly halfway between FDEP reference monuments T-36 and T-37). An emergency renourishment project added approximately 616,000 cy of sand to the project area in 2005. A response to the erosive events of Hurricanes Frances and Jeanne during the 2004 hurricane season and several high-energy extratropical events during the winter of 2004 – 2005, this emergency renourishment restored the Ft. Pierce SPP project area to the 1999 renourishment design conditions. The 2007 renourishment project added approximately 503,800 cy of sand to the project area as the 2009 renourishment project added 189,600 cy of sand — 185,500 cy per the contractor's pay survey plus a natural variability volume — from the Ft. Pierce Inlet south jetty to approximately 1,400 ft further south (FDEP reference monument R-35). Most recently, the 2011 emergency renourishment project, constructed without federal participation or funding, placed 62,000 cy of material from the Ft. Pierce Inlet south jetty through R-35 by truck haul from an upland source (the Stewart Mining mine in St. Lucie County).

Capron Shoal, located approximately 3 mi southeast of the project area (Figure 1.1), served as the borrow area for each renourishment project excluding the first renourishment project of 1980. The borrow area limits for the sixth renourishment project of 2009 differ from the area dredged during the second renourishment project of 1999, from the area dredged in the third and fourth renourishment projects (2003/2004 (phase 1/2), and 2005), and from the area dredged in the fifth renourishment project (2007).

In March 2012, a maintenance-renourishment of the Project was completed; approximately 482,000 cubic yards of sand were obtained from Capron Shoal to nourish the beach (personal communication, Richard Bouchard).

Figure 1 illustrates the fill area and borrow area at Capron Shoal.

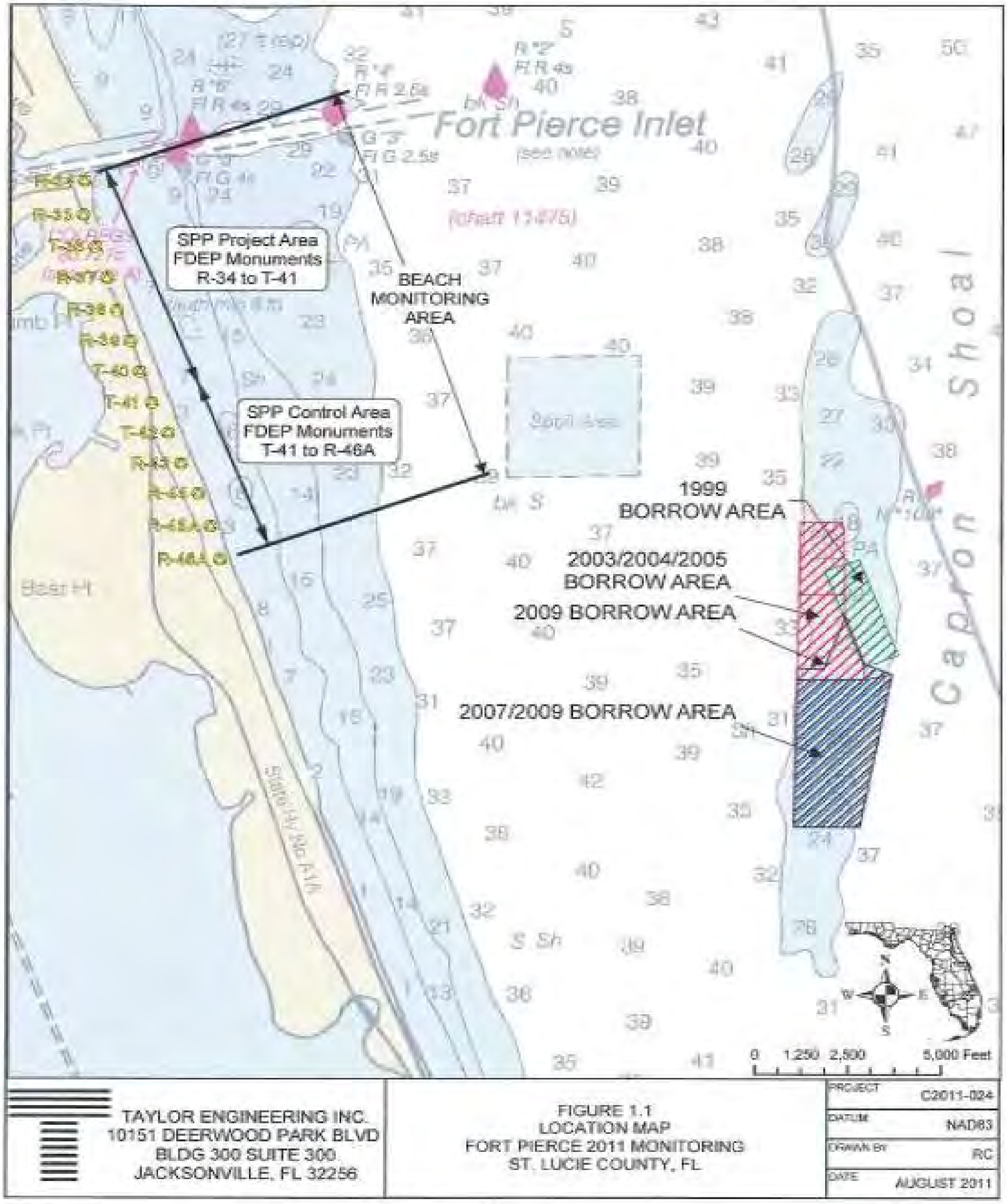


Figure 1: Map Showing Ft. Pierce Shore Protection Project

South County Beach Project: The Florida Department of Environmental Protection (FDEP) has classified much of the south St. Lucie County beaches as "critically eroded areas". The purpose of the proposed St. Lucie County *South County Beach and Dune Restoration Project* is to:

- offset the sediment deficit
- restore and maintain the recreational beach,
- restore/maintain habitat for marine turtle nesting, marine life and shore birds, and
- provide storm damage protection for property and infrastructure.

The County proposes a beach and dune restoration project to meet the project purpose. The proposed project entails placement of approximately 517,487 cubic yards of sand over about 3.4 miles of shoreline to partially restore the beach and dune along the South St. Lucie County beaches extending from FDEP reference monuments R98 to R115 + 1000 feet south (St. Lucie County/Martin County Line; see Figure 2).

In November 2002, the U.S. Army Corps of Engineers (USACE) completed a "Section 905(b)" analysis for a "St. Lucie County, Florida – Hurricane and Storm Damage Reduction Study" for the South St. Lucie County Beaches from R-77 to the Martin County Line (Study Area). In 2004, the USACE initiated a Federal Feasibility Study of the Study Area but, due to limited funding, it has only partially advanced. The USACE has conducted a historic and cultural resources survey of potential borrow areas for the proposed Project and has developed an inventory of existing buildings and structures fronting the shoreline in the Study Area. Because a Federal project is not expected to be undertaken prior to 2012, St. Lucie County is initiating effort to develop and construct an initial non-federal project to address the deteriorated shoreline and emergency conditions as soon as possible with parallel development of a Federal Shore Protection Project to provide for future renourishment of the beaches within the Study Area.

The Project is expected to be constructed employing an offshore sand source although St. Lucie County obtained USACE and FDEP permits to alternately employ either the offshore source or upland sources for the proposed Project as illustrated in Figure 3. The County received bids in early August 2012 whereas bids for use of upland sand sources were significantly higher than bids for use of the offshore sand source.

The proposed offshore sand source, identified as Area 5, located on the southern portion of St. Lucie Shoal which lies within State waters as identified by Coastal Planning & Engineering (CPE) in association with CPE's 2006 sand search and is described in the report entitled *South St. Lucie County Hurricane and Storm Damage Reduction Project – 2006 Offshore Geotechnical Investigations to Identify Sand Sources*. The proposed borrow area is located in a sand ridge from 3 to 6 miles offshore of FDEP monuments R-88 to R-115. The proposed offshore borrow area for the South County Project:

- contains approximately 1.3 million cubic yards of beach compatible material;
- is located in water depths of approximately -36' to -43' NAVD:
- will have a cut depth of approximately -49' NAVD.

The previously proposed upland sand sources were proposed to be excavated and processed to produce desirable beach-compatible sand for placement on the beach. Sand was specifically proposed to be produced from upland mines, transported by truck to upland staging areas adjacent to the beach fill area, and placed in the fill template using conventional upland earth moving equipment.

In general, it is assumed that sand for future renourishment will be obtained from offshore sources. It is expected that maintenance of the proposed Project will be performed under the auspices of a *Federal Shore Protection Project* currently under feasibility phase formulation by the U.S. Army Corps of Engineers (USACE) Jacksonville District. In keeping with conventional federal planning regulations, it is expected that the proposed Project will be maintained for a period of 50 years (Project Life). A conceptual “50-year borrow area” is depicted in Figures 4a through 4c including refuge patches - undisturbed portions of the borrow area intended to avoid and minimize impacts to environmental benthic resources. The proposed “50-year borrow area” was selected based on its proximity to the proposed Project Fill Area and the volume of beach compatible sediment – per results from the reconnaissance level geotechnical investigation (Coastal Tech, 2012).

For the proposed Project, the design renourishment interval is 10 years with an expected volume of about 200,000 cubic yards. A total of 5 renourishment events are expected over the Project life. The characteristics of sand in the “50-year borrow area” is comparable to that in the borrow area proposed for initial construction.

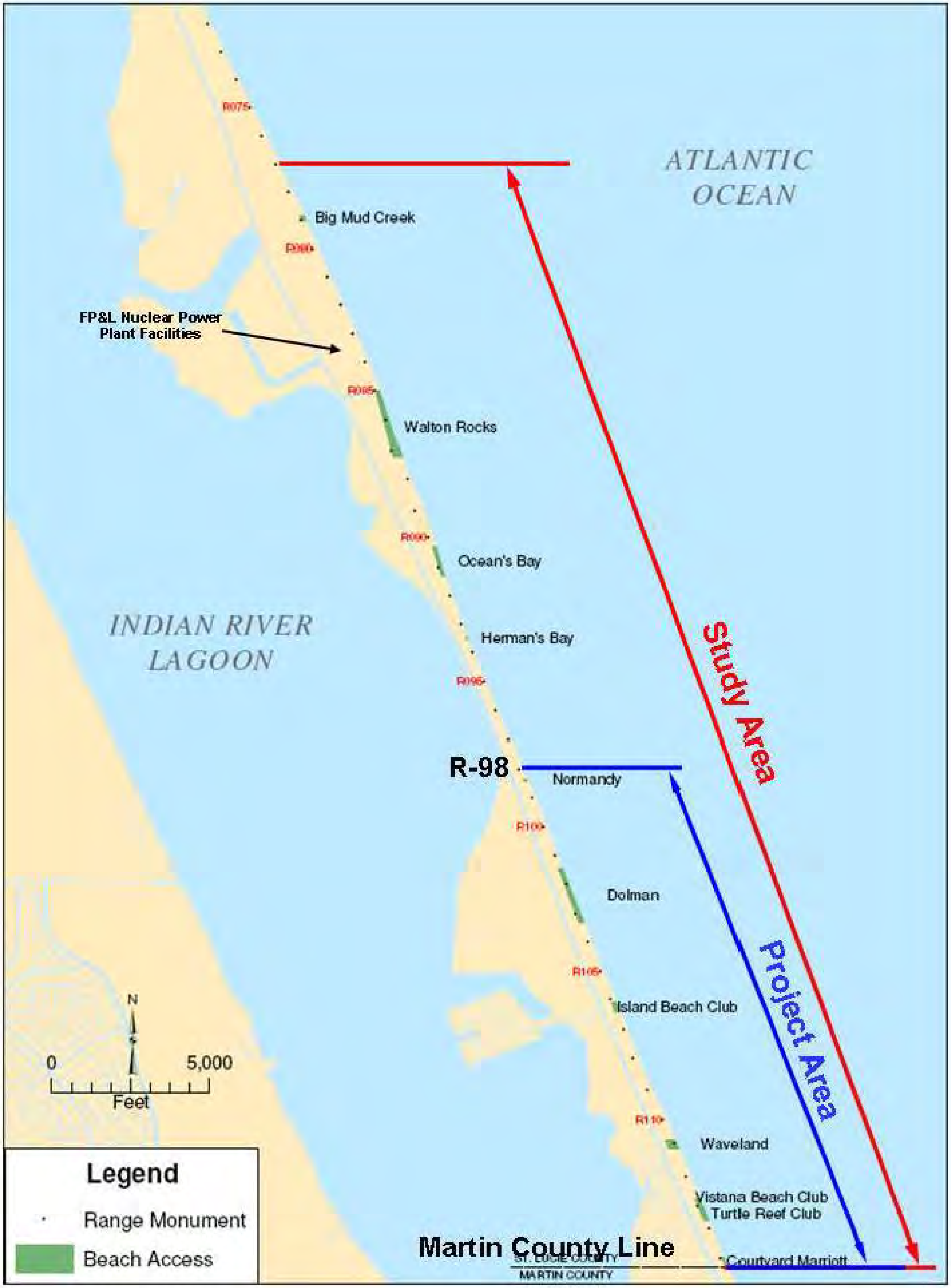


Figure 2: South County Beach Project

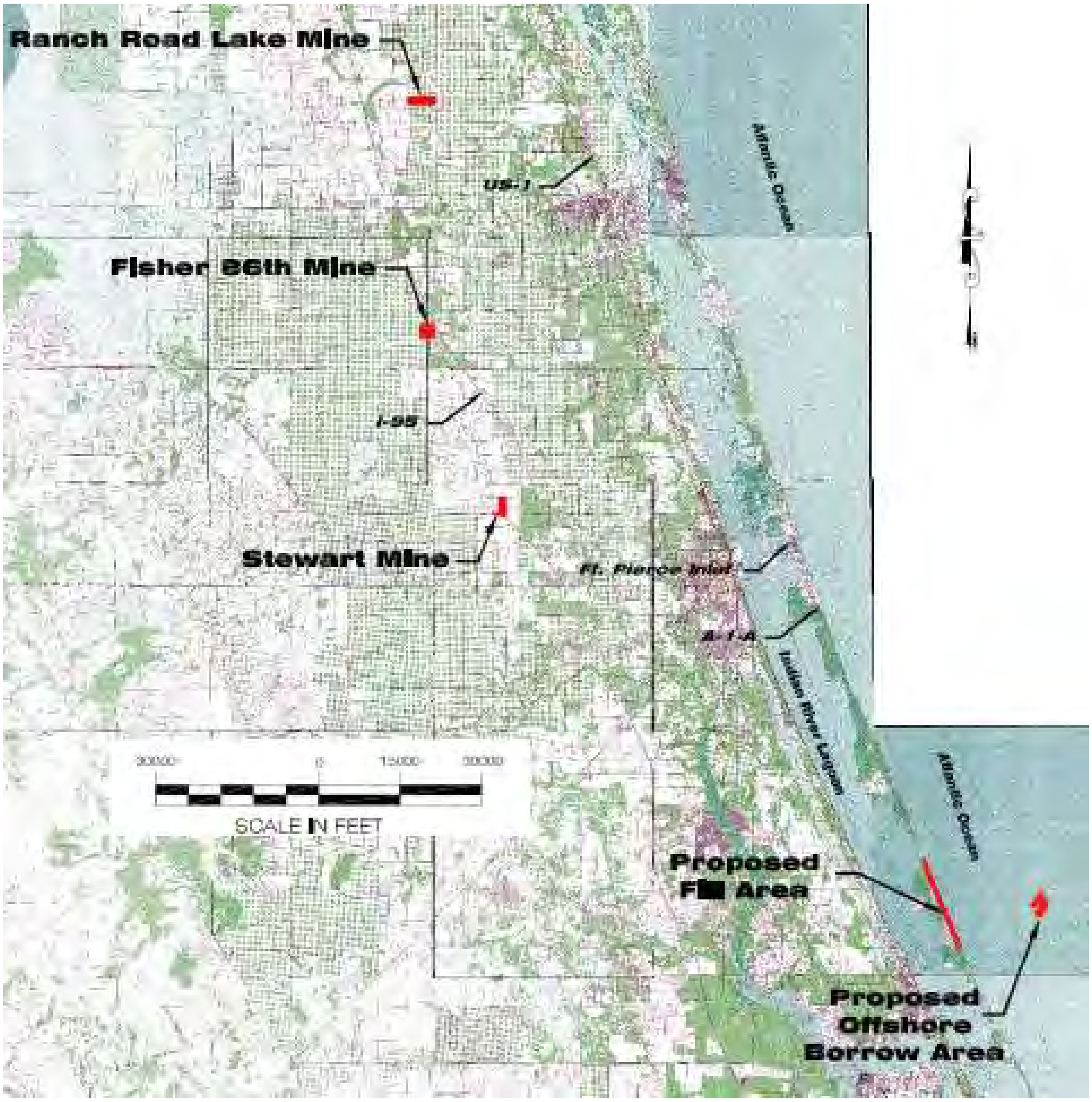


Figure 3: South County Beach Project - Initial Construction Alternative Borrow Areas

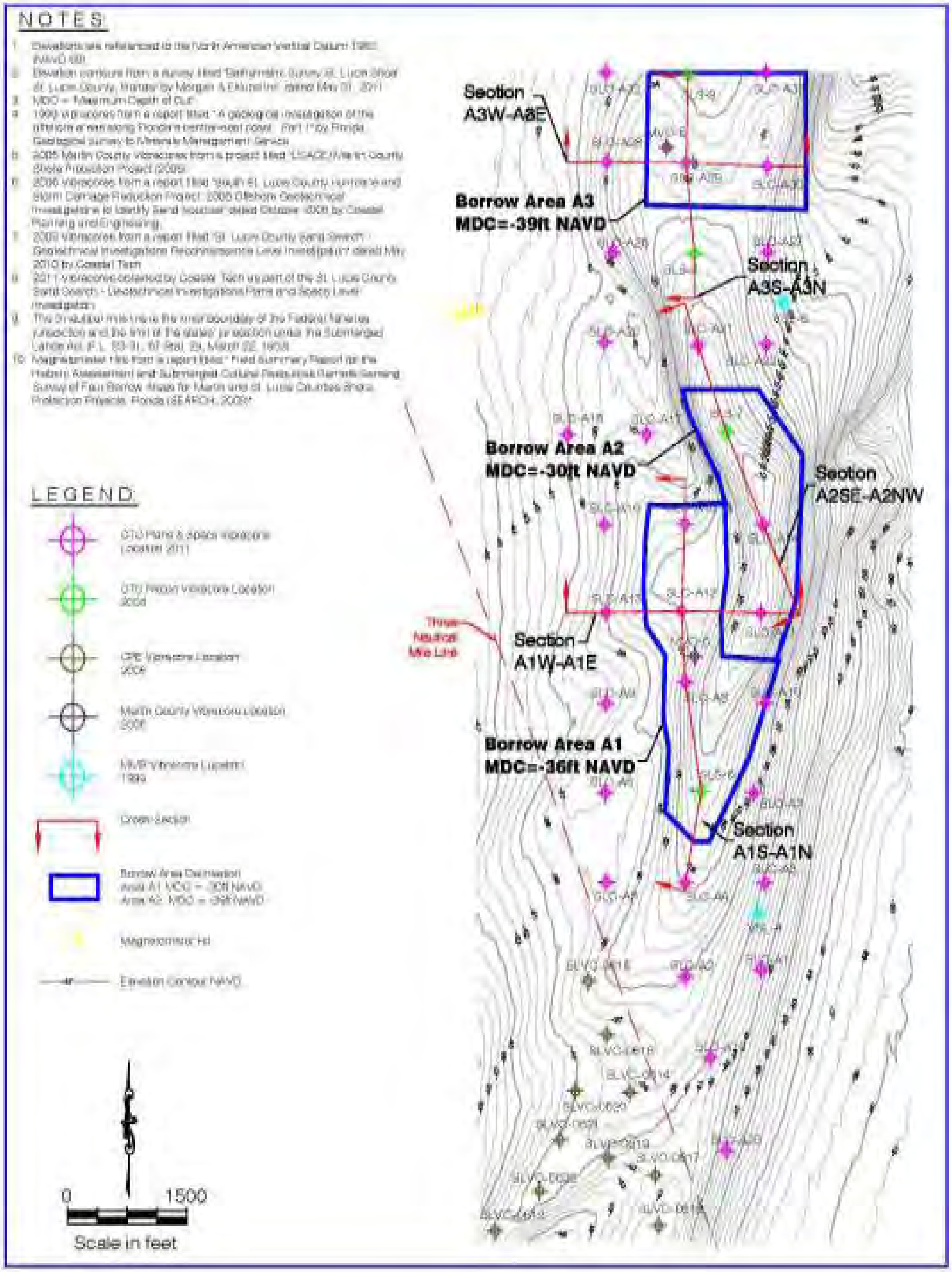


Figure 4a: South County Beach Project – Potential "50-year" Borrow Area

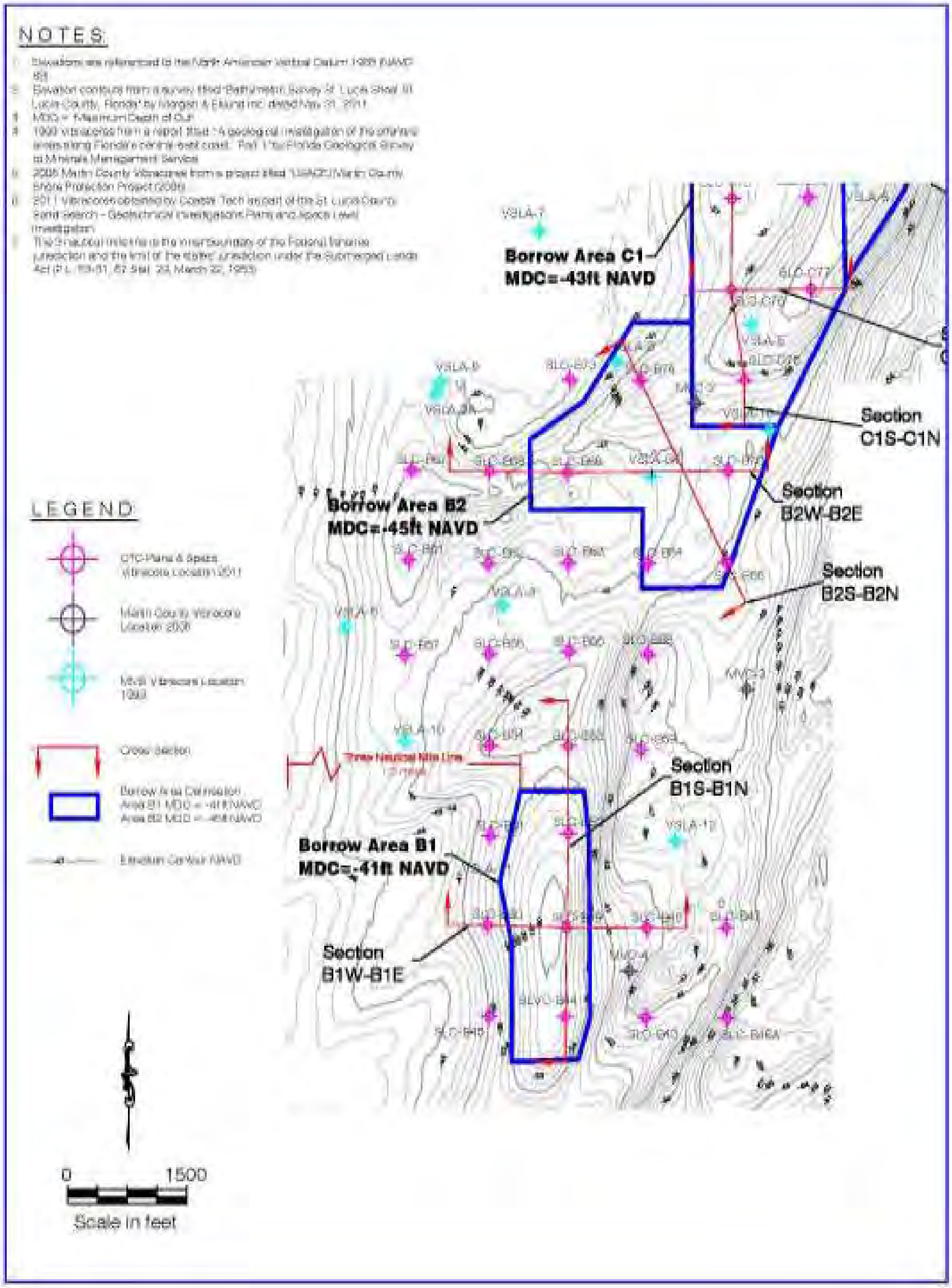


Figure 4b: South County Beach Project – Potential "50-year" Borrow Area

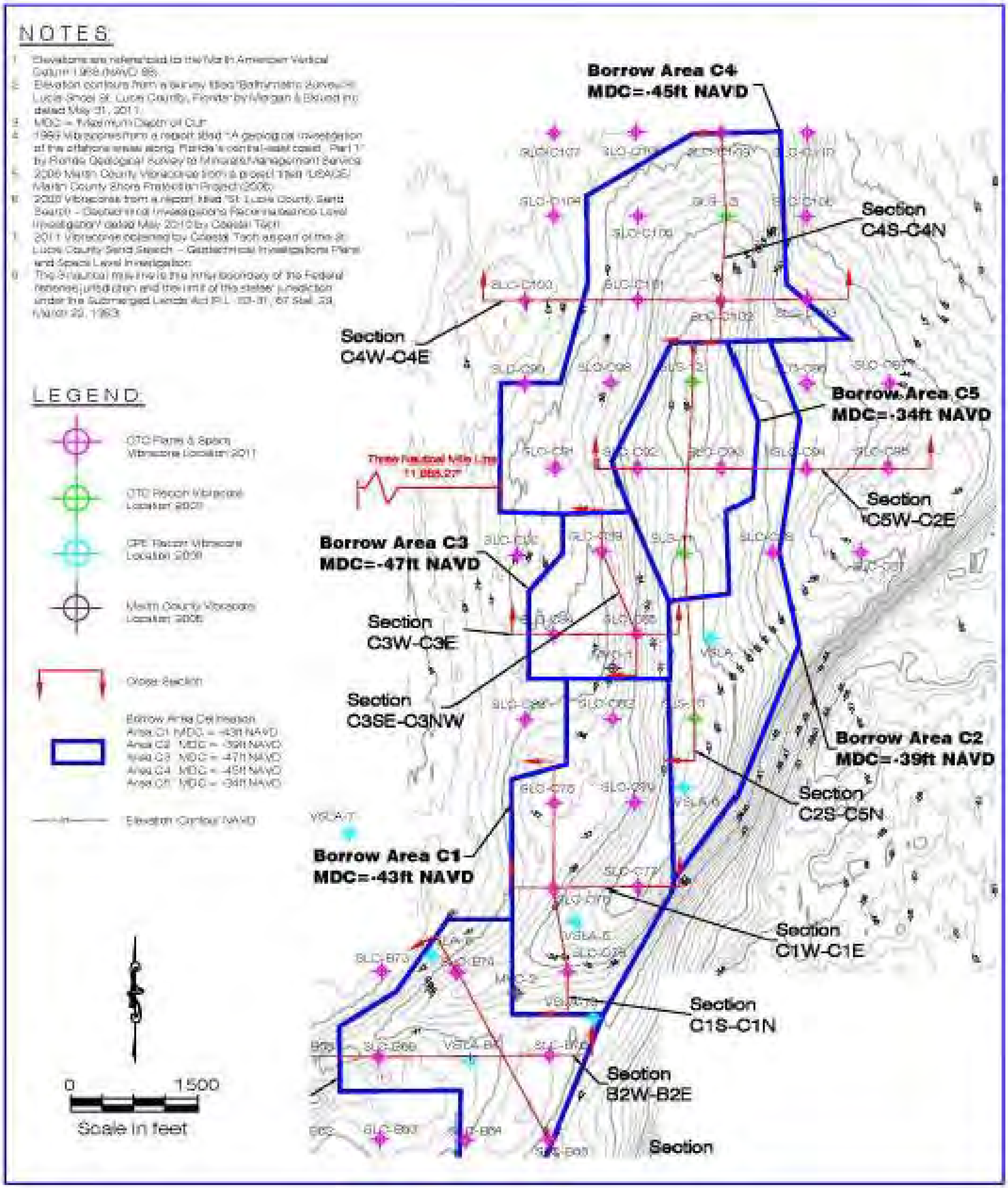


Figure 4c: South County Beach Project – Potential "50-year" Borrow Area

Data, Methodology, and Period of Analysis

Ft. Pierce Shore Protection Project: The predicted needs are based upon an annual average of the total volume of sand (3,359,400 cy) placed over the period from March 1999 to May 2012, which (a) best reflects the sand volume needed to regularly maintain the project and (b) corresponds to an annual rate of 254,923 cy/yr – rounded to 260,000cy/yr. Although a groin field is under consideration, the groin field is not expected to reduce the future sand needs, but is expected to increase the renourishment frequency.

South County Beach Project: The predicted needs are based upon the predicted volumes needed to maintain the project over a 50 year life.

Assumptions

Ft. Pierce Shore Protection Project: N/A

South County Beach Project: For design, future losses and renourishment requirements were estimated based upon background rates and beach-fill-modeling. However, actual future losses might be more reliably estimated based upon performance of the adjacent "Martin County Hurricane and Storm Damage Reduction Project". As identified for the Martin County project (Taylor Engineering Inc, May 2012):

- The "USACE's 1993 General Design Memorandum projected a loss rate of 53,600 cy/year."
- "Given the 14 year time frame between the initial construction and most recent survey, the projected annual requirement is 105,360 cy/year or nearly twice the rate projected by the USACE"; this is equivalent to 4.87 cy/ft/yr for the 21,630 feet of the Martin County project.

For the proposed South County Beach Project, it is herein comparably assumed that future sand loss from the South County Beach Project area will occur at a rate of up to 4.87 cy/ft/yr. Over the Project fill area (17,439 feet), this corresponds to a future need of 84,928 cy/yr – rounded to 90,000 cy/yr.

Environmental Considerations Impacting Estimates

Ft. Pierce Shore Protection Project: N/A

South County Beach Project: A "refuge patch" has been designated along the crest of the St, Lucie Shoal to preserve the recognized pelagic fisheries spawning along this shoal.

References

Taylor Engineering, Inc, “Ft. Pierce Shore Protection Project - 2011 Two-Year Post-Construction Monitoring Report”, August 2011

Taylor Engineering Inc, “Martin County, FL - Sand Needs Evaluation for Beach Nourishment”, May 2012

Coastal Tech, “St. Lucie County - South County - Beach & Dune Restoration Project - Design Document”, September 15, 2009 (revised July 6, 2010)

Coastal Tech, “St. Lucie County Sand Search - Plans & Specs – Level Investigation - Geotechnical Report”, February 29, 2012

9.2 Needs Determination: Martin County, FL

Martin County, FL

Sand Needs Evaluation for Beach Nourishment

A component of the:

Southeast Florida Sediment Assessment and Needs Determination (SAND) Report

Submitted to:
Florida Department of Environmental Protection
Bureau of Beaches & Coastal Systems
Tallahassee, FL

Prepared by:
Taylor Engineering, Inc. on behalf of Martin County and
Applied Technology & Management on behalf of Jupiter Island and Martin County

Date
May 2012

Executive Summary

The purpose of this report is to estimate the current and future demand for sand for beach nourishment in Martin County. The Florida Department of Environmental Protection and the U.S. Army Corps of Engineers will use this estimate with similar estimates of the sand needs of the remaining southeast Florida counties to determine a range of the amount of sand needed over the next 50 years to sustain southeast Florida's federal and non-federal beach nourishment projects. Ultimately, they will compare the estimated needs of this region to the availability of sand for beach nourishment purposes. This comparison will occur through the Southeast Florida Sediment Assessment and Needs Determination (SAND) Report, a joint effort led by the Florida Department of Environmental Protection and supported by the southeast Florida counties and the U.S. Army Corps of Engineers.

The table below summarizes the considered beach nourishment projects and projected 50-year renourishment requirements for Martin County. The table briefly describes the fundamental assumptions applied to derive the required sand volumes. The following pages provide additional detail.

Table E.1 Estimate of Martin County's 50-Year Sand Needs

MARTIN COUNTY, FLORIDA											
Projected Sand Requirement over next 50 years (Current and Future)											
						Estimated Future Annual Sand Demand *not including current requirement					
Name	**Sponsor/Agency**	**Initial Construction Date**	**Monument Range**	**Length of Nourishment (ft)**	**"C" Estimated Current Requirement (cy)**	**"R" Estimated Rate (cy/yr)**	**"F"= R x 50 Estimated Future Demand Over 50 Years (cy)**	**"C + F" Estimated 50-yr Requirement (cy)**	**"(C + F)/50/ft" Estimated Requirement per Year per Linear Foot (cy/yr/ft)**	**Basis of Estimate**	**Comments**
Martin County Hurricane and Storm Damage Reduction Project	Martin County/ USACE	1996	R1 to R25	21,630	286,000	158,000	7,900,000	8,186,000	8	Placement history Historic erosion rates 2010 survey results	Assumes volumentric requirements at historic rates. "R" includes 50% contingency to account for uncertainty in future projections.
Bathtub Beach/ Sailfish Point	Martin County	2010	R34.2 to R40.5	5,600	175,000	25,000	1,250,000	1,425,000	5	Historic erosion rates	Assumes combined Martin County/ Sailfish Point project
Town of Jupiter Island	Town of Jupiter Island	1973	R76A to R84 R88 to R112	28,000	0	250,000	12,500,000	12,500,000	9	Historic erosion rates	Nourishment completed in 4/2012. Assumes volumetric requirements at historic rates. More effective utilization/ bypassing at St. Lucie Inlet could reduce this value.
Total					461,000	433,000	21,650,000	22,111,000			

Main Report

Introduction and Project Status

The county divides the management of its beaches into three distinct areas: 1) the federal Martin County Hurricane and Storm Damage Reduction Project comprising the northern four miles of county shoreline on Hutchinson Island, 2) Bathtub Beach/Sailfish Point, and 3) the beaches south of St. Lucie inlet that include Jupiter Island, Hobe Sound National Wildlife Refuge and St. Lucie Inlet State Park.

Martin County Hurricane and Storm Damage Reduction Project

The hurricane and storm damage reduction project, described in the Martin County, Florida, Shore Protection Project General Design Memorandum (USACE, 1993), provides for 1) a protective beach berm and storm dune along four miles of Hutchinson Island (from FDEP reference monument R-1 to R-25); 2) periodic nourishment of the restored beach and such adjacent shoreline as needed and justified for the life of the project (note: federal participation expires in 2045); and 3) extensive multiyear beach performance monitoring. The project design includes a landward dune 20 ft wide at an elevation of 12.5 ft mean sea level. The dune slopes down to a beach (berm) 35 ft wide at an elevation of 8 ft mean sea level. The beach berm then slopes down into the ocean at its intersection with the existing bottom. An additional volume of sand placed seaward of this design berm acts as a sacrificial feature that can erode but does not adversely affect the design storm protection benefit of the beach project. The sacrificial volume, known as advance nourishment, should last for approximately 11 years according to the USACE (1993).

Initial construction of the project began December 13, 1995, ended April 10, 1996, and placed approximately 1.34 million cubic yards (mcy) of beach quality sand. The project, including beach and dune restoration, extended about four miles beginning at the Martin/St. Lucie County line. In addition to the federally authorized project length, the project was extended an additional 2,000 feet at state and local expense. During initial construction, a severe northeaster affected the project area from March 11 – 13, 1996. The project had progressed about two-thirds through construction before the storm hit the area. After the storm, the contractor completed the project and replaced some of the lost sand at the south end of the project area. This storm, a series of hurricanes in 1999 (Dennis, Floyd, and Irene), and normal beach fill dispersion caused the project area to lose about 75% of the beach fill placed during initial construction. This severe erosion prompted the first renourishment in 2001, five years before the expected 11-year renourishment interval. Completed in the spring of 2001 and 2002, the first renourishment project placed 304,000 cubic yards (cy) of sand over only about one half of the project area because of federal funding and marine turtle construction window constraints.

In September 2004, Hurricanes Frances and Jeanne made landfall within the federal project area. In response, the 2005 renourishment project placed approximately 885,000 cy and included a 600-foot dune nourishment.

Figure 1 presents an overview of the project and borrow areas.

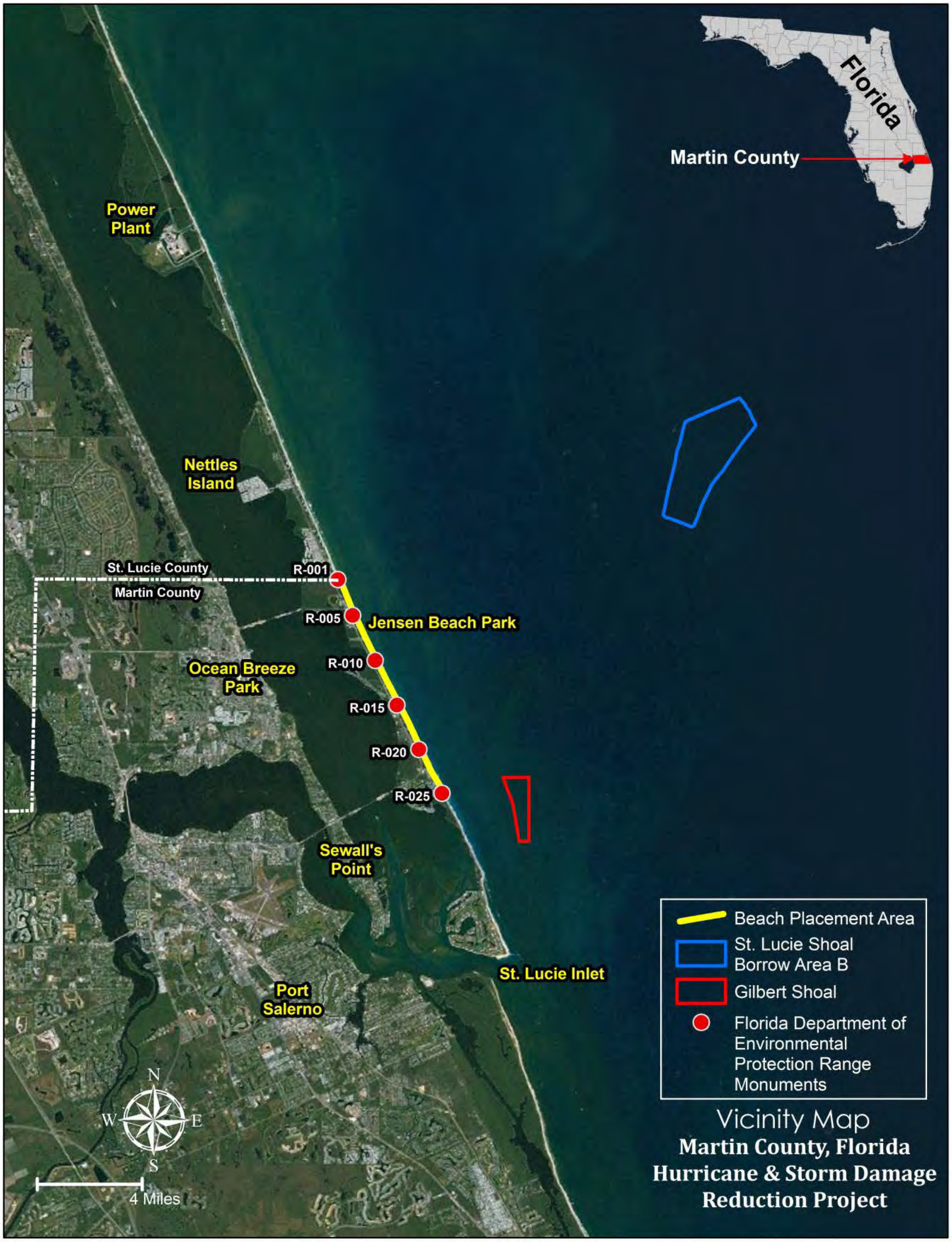


Figure 1 Location Map Showing Martin County Hurricane and Storm Damage Reduction Project

Gilbert Shoal served as the borrow area for each nourishment. Recent borrow area survey data indicate insufficient volumes of beach quality material dispersed over large areas of Gilbert Shoal for future renourishments. The USACE initiated sand source investigations in 2006 and 2007 to identify sufficient material for the next renourishment and the remaining 33 years of authorized project life. Those investigations concentrated on three potential areas located between three and six miles offshore of northern Martin and southern St. Lucie counties. The investigation identified “Area B” in 60-foot water depths near southern St. Lucie County as the recommended borrow area because it lies close to shore and contains a large amount of quality sand (currently estimated by USACE at 12 mcy). Mining the shoal required Martin County obtain a lease from the U.S. Minerals Management Service and sign a Memorandum of Agreement with the USACE. The USACE estimates Area B should contain enough material for the remaining project life.

Table 1 Available Volume Permitted Construction Template to Aug 2010 Survey

Mon.	Distance	Fill Volume	
		cy/ft	cy
R-1	441.7	0.0	0
R-2	884.9	21.9	19,409
R-3	903.3	20.5	18,476
R-4	872.7	25.8	22,489
R-5	803.3	31.5	25,290
R-6	933.8	20.8	19,449
R-7	992.9	23.2	23,017
R-8	899.9	19.9	17,925
R-9	899.4	11.6	10,405
R-10	899.9	14.7	13,253
R-11	901.4	2.5	2,278
R-12	895.4	8.6	7,667
R-13	893.2	8.7	7,765
R-14	904.8	21.7	19,639
R-15	873.4	19.5	16,996
R-16	892.8	7.1	6,364
R-17	933.1	13.0	12,107
R-18	905.3	16.5	14,930
R-19	921.3	12.7	11,720
R-20	923.5	6.8	6,292
R-21	899.9	0.0	0
R-22	895.5	0.0	0
R-23	900.0	0.0	17
R-24	904.5	11.8	10,713
R-25	450.1	0.0	0
Total	**21,626**	**-**	**286,201**

Based on an August 2010 beach profile survey, the permitted construction template can hold about 286,000 cy. Given roughly two years have passed since this survey, one may safely assume the template will hold more material.

Bathtub Beach County Park

The dynamic nature of Bathtub Beach results in extreme changes in beach width over short periods. Recent storms have eroded the beach into Bathtub Beach County Park, causing its closure annually since 2007 along with loss of structures. Additional erosion could lead to complete loss of the park and ultimately, MacArthur Boulevard, a hurricane evacuation route. To date the County has reacted to each erosion emergency independently. In 2009, the county secured a permit to provide as-needed protection of infrastructure after erosion events. This approach provides those concerned with Bathtub Beach and Bathtub Beach Reef a minimal, and to date, unsatisfactory long-term solution to these recurring problems. The project includes dredging approximately 25,000 cy of the St. Lucie Inlet flood shoal and placing that material on the beach. Consistent with the state-adopted (1995) St. Lucie Inlet Management Plan, dredging the flood shoal reintroduces lost material into the littoral system. Although not directly placed on downdrift beaches as per the plan, littoral transport will move the material into the inlet's impoundment basin which will subsequently be dredged, placing the material on the downdrift beaches.

A more efficient and stable solution for Bathtub Beach is to address those erosion issues in concert with the beaches immediately to the South in the private community of Sailfish Point. These beaches compromise a reach that is bounded by a rocky headland to the north and a St. Lucie Inlet north jetty to the south. Initial construction of the joint Bathtub Beach/Sailfish Point project by Martin County and the Sailfish Point POA is currently scheduled for December 2013 .

Figure 2 presents an overview of the project and borrow areas.

Figure 2 Location Map Showing Bathtub Beach County Park Project

Jupiter Island Beach Restoration Project

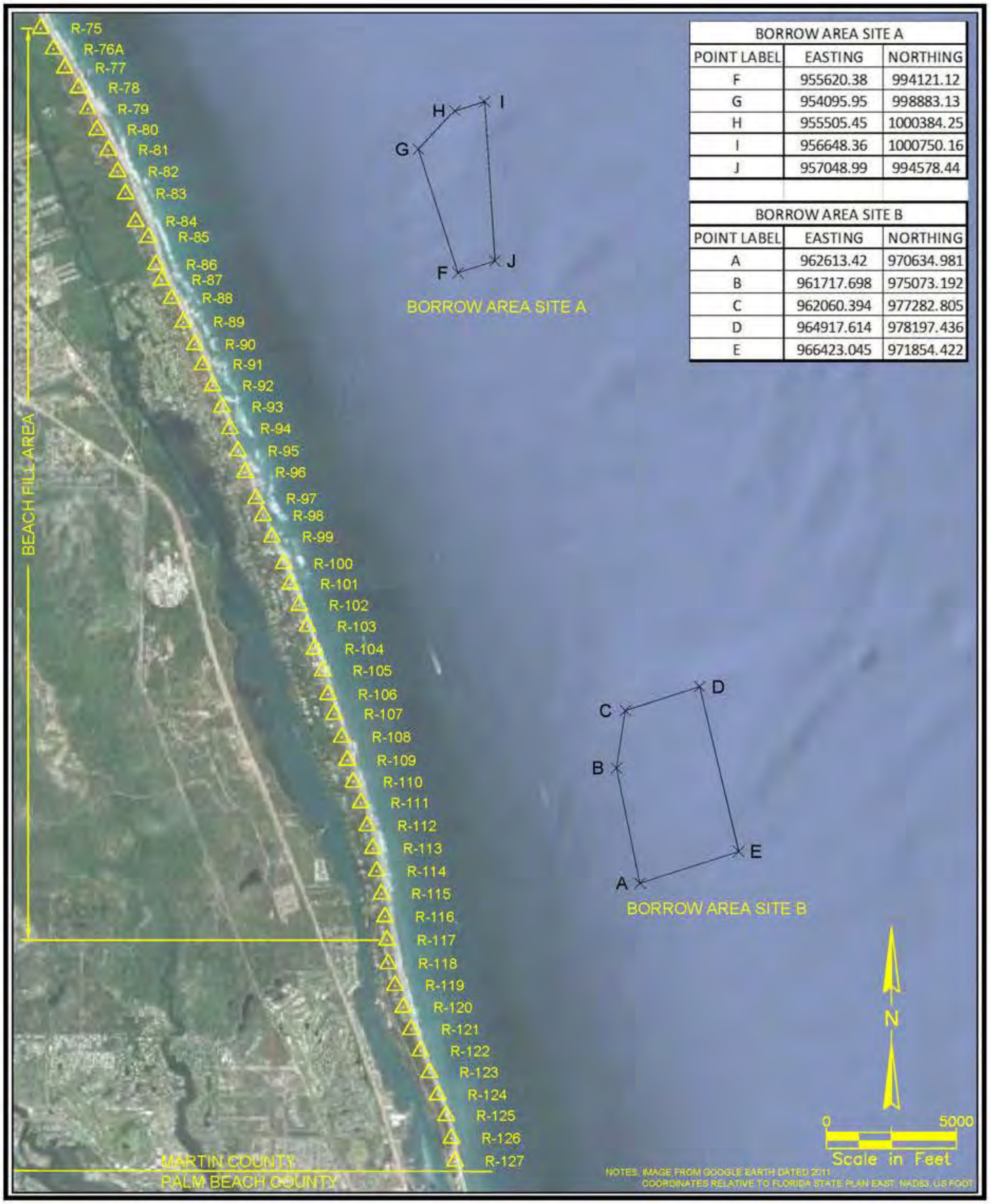
The Town of Jupiter Island has been conducting regular nourishment within the Town boundaries for several decades. Town-wide nourishment utilizing an offshore source was formalized with a major placement in 1973, and periodic nourishment of this project has occurred since project initiation. Placement has been historically conducted within the Town boundaries (between R-75 and R-117), though placement densities have varied based on the volume required within the established project template. Two borrow areas have been established, permitted and utilized for this project. These borrow areas are located approximately two miles offshore of the Town (Borrow sites A and B). Project renourishment was completed in April 2012 with the placement of approximately 1,150,000 cubic yards from Borrow Site B utilizing a hopper dredge.

Data, Methodology, and Period of Analysis

Martin County Hurricane and Storm Damage Reduction Project
To develop the 50-year sand needs for this project, the present study applied measured beach volume changes from November 1995 to July 2008 and the project's beach fill placement history.

Notably, the USACE's 1993 General Design Memorandum projected a loss rate of 53,600 cy/year. Applying this loss rate to the USACE's projected 11-year nourishment interval produced an anticipated renourishment volume of 589,600 cy/event. However, as shown below, actual project performance has not met these projected values.

Since initial construction in 1995, various projects have placed 1,189,000 cy (178,000 cy in 2001; 126,000 cy in 2002; and 885,000 cy in 2005) along the project area. As illustrated above in Table 1, the calculated existing deficit based on a 2010 survey is 286,000 cy. Given the 14 year time frame between the initial construction and most recent survey, the projected annual requirement is 105,360 cy/year or nearly twice the rate projected by the USACE. Applying a 50% contingency for uncertainty associated with future projections, the assumed annual need is **158,000 cy/year**. Over the 50-year life of the project, the contingency provides an additional 2.65 Mcy to the project. For comparison purposes, the 2005 project placed 885,000 cy to repair damage caused by the severe 2004 hurricane season. The 2.65 Mcy provides sufficient material to address three similar storm repair projects over the 50-year project life.



BORROW AREA SITE A		
POINT LABEL	EASTING	NORTHING
F	955620.38	994121.12
G	954095.95	998883.13
H	955505.45	1000384.25
I	956648.36	1000750.16
J	957048.99	994578.44

BORROW AREA SITE B		
POINT LABEL	EASTING	NORTHING
A	962613.42	970634.981
B	961717.698	975073.192
C	962060.394	977282.805
D	964917.614	978197.436
E	966423.045	971854.422

Figure 3 Town of Jupiter Island Nourishment Project Location Map

Bathtub Beach County Park

To develop the 50 year sand needs for this project, the present study utilized a numerical model which relied on annual physical monitoring surveys of the area. Results indicate that project limits for nourishment would run from R-35 south to R-40. This initial fill requires placement of approximately 200,000 cy, with annual needs of 25,000 cy/year. Sand sources may include inlet flood shoals and/or an as yet undetermined offshore source. Notably, the 25,000 cy/year need represents the net need assuming continued placement of approximately 20,000 to 25,000 cy/year of sand from periodic maintenance dredging of the Sailfish Point navigation channel and marina basin.

Jupiter Island Beach Restoration Project

Erosion rates for the Jupiter Island Restoration Project are based on the measured project volumetric erosion rate as determined through beach profile surveys. The reported rate is based on measured erosions of the project between the 2007 and 2012 nourishment events, though this rate is consistent with measured rates which have occurred since project inception. Long-term erosion rates (since 1973) for the project area have ranged from approximately 200,000 cubic yards per year to 250,000 cubic yards per year. For this study a rate of 250,000 cubic yards per year was utilized consistent with recent project area behavior.

Assumptions

The calculation of total project volume requirement carries several assumptions. (1) The renourishment needs for all projects will continue until the end of 2062 and that the joint Bathtub Beach/Sailfish Point project will be initiated in 2013. This assumption further implies that all projects will continue to receive federal and state permits for nourishment activities and that the federal project will extend its federal authorization beyond 2045, the current expiration date. (2) All projects, including Bathtub Beach/Sailfish Point, will continue to receive full funding at least until the end of 2062. (3) The size of all projects will remain constant for the next 50 years. (4) No additional projects will begin in the county before the end of 2062. (5) Local rates of erosion will not change significantly in the next 50 years. Insufficient data regarding future erosion rates caused by sea level rise and other factors dictate this study apply constant erosion rates.

Environmental Considerations Impacting Estimates

All projects must consider effects of beach fill migration on nearshore hardbottom resources. The original 1996 construction of the federal beach project authorized coverage of a maximum of 1.32 acres. The county constructed an artificial reef to mitigate for this coverage in September 2000. Subsequent nourishment projects have constructed a similar construction template to the 1996 project to avoid additional hardbottom impacts.

Bathtub Beach, a shallow beach area protected from wave energy by nearshore and offshore reefs, provides excellent bathing, swimming, snorkeling and diving. Wormrock reef exposed at low tide creates a protected tidal pool providing close-up views of marine life. Beach nourishment templates have attempted to provide a buffer between the toe of fill and the reef.

The Jupiter Island project template has been designed to avoid direct and secondary impacts to adjacent nearshore hardbottom resources. In addition a minimum 1,000 foot buffer has been established between the project borrow areas and adjacent offshore hardbottom resources.

Analysis

Table 2 summarizes results of the sand needs assessment. Overall, the projected volume required to nourish Martin County beaches is 22,111,000 cy over the next 50 years.

Table 2 Summary of Martin County's Future Sand Needs

Martin County								
Projected Sand Requirement over next 50 years (Current and Future)								
Name	**Project Type**	**Year Started**	**Monument Range**	**Sand Need (cy/yr)**	**Year of Last Nourishment**	**Year of Next Nourishment**	**50-Year Volume Requirement**	**Historic Sand Source**
Martin County Hurricane and Storm Damage Reduction Project	Federal	1996	R1 to R25	158,000	2005	2012	8,186,000	Gilbert Shoal (1996 - 2005); St. Lucie Shoal (2012 -)
Bathtub Beach/ Sailfish Point	non-Federal	2010	R34.2 to R40.5	25,000	2009	2013	1,425,000	St. Lucie Inlet Flood Shoal TBD Offshore Source
Town of Jupiter Island	non-Federal	1973	R76A to R84 R88 to R112	250,000	2012	2018	12,500,000	Offshore

References

U.S. Army Corps of Engineers (USACE). 1993. Martin County, Florida, Shore Protection Project, General Design Memorandum with Environmental Assessment. Jacksonville District.

9.3 Needs Determination: Palm Beach County, FL

Palm Beach County, Florida

Sand Needs Evaluation for Beach Nourishment

A component of the:

Southeast Florida Sediment Assessment and Needs Determination (SAND) Report

Submitted to:
Florida Department of Environmental Protection
Bureau of Beaches & Coastal Systems
Tallahassee, FL

Prepared by:
Palm Beach County Environmental Resources Management

Date
April 26, 2012
Revised May 7, 2012
Revised June 8, 2012

Executive Summary

The purpose of this report is to estimate the current and future demands for offshore sand resources for beach nourishment in Palm Beach County over the next 50 years. This estimate will be used in conjunction with similar estimates of the remaining Southeast Florida counties compared to the availability of local sand resources. This comparison will be accomplished through the Southeast Florida Sediment Assessment and Needs Determination (SAND) Report, a joint effort led by the Florida Department of Environmental Protection and supported by the Southeast Florida counties and the U.S. Army Corps of Engineers.

The considered beach nourishment projects and projected 50-year renourishment requirements for Palm Beach County are summarized Table 1. The table briefly describes the fundamental assumptions upon which the required sand volumes are based. Additional detail is provided in the following pages.

TABLE 1. PALM BEACH COUNTY, FL											
Projected Sand Requirement over next 50 years (Current and Future)											
						Estimated Future Annual Sand Demand *not including current requirement					
Name	**Sponsor/Agency**	**Initial Construction Date**	**Monument Range**	**Length of Nourishment (ft)**	**"C" Estimated Current Requirement (cy)**	**"R" Estimated Rate (cy/yr)**	**"F"= R x 50 Estimated Future Demand Over 50 Years (cy)**	**"C + F" Estimated 50-yr Requirement (cy)**	**"(C + F)/50/ft" Estimated Requirement per Year per Linear Foot (cy/yr/ft)**	**Basis of Estimate**	**Comments**
Jupiter/Carlin	PB County/USACE	1995	R13.5-R19	5,544	1,167,000	86,000	4,300,000	5,467,000	20	Surveyed Beach Change (2008-2012)	Estimated current requirement assumed a 2012 renourishment. Project delayed till at least 2014. Estimated annual sand demand calculated from 2008-2012 surveys.
Juno Beach	PBCounty/FDEP	2001	R26-R38	12,800	950,000	107,000	5,350,000	6,300,000	10	Surveyed Beach Change (2001-2009)	
Mid-Town	Town of PB/PB County/FDEP	1995	R90-R101	13,500	1,000,000	125,000	6,250,000	7,250,000	11	Consultant design, engineering, and monitoring reports	
Phipps Ocean Park	Town of PB/PB County/FDEP	2006	R119-R126	11,340	1,000,000	125,000	6,250,000	7,250,000	13	Consultant design, engineering, and monitoring reports	
Ocean Ridge	PB Co./FDEP/USACE	1998	R153-R159	5,702	585,000	56,500	2,825,000	3,410,000	12	Surveyed Beach Change (2006-2012)	Sand bypass at South Lake Worth Inlet is included in the estimated annual demand. Current requirement assumes a 2013 project.
Delray Beach	City Of Delray Beach/PB County /USACE	1973	R180-R188.5	14,200	1,200,000	120,000	6,000,000	7,200,000	10	Surveyed Beach Change (2002-2011)	50 year projection is based on 2002 - 2011 surveys.
North Boca Raton	City of Boca Raton/PB County/USACE	1988	R205-R212	8,300	800,000	75,000	3,750,000	4,550,000	11	Project performance to date	Does not include future storm recovery projects.
Central Boca Raton	City of Boca Raton/PB County/USACE	2004	R216-H222	7,600	500,000	73,000	3,650,000	4,150,000	11	Project performance to date	Does not include future storm recovery projects.
Total					7,202,000	767,500	38,375,000	45,577,000			

[1] Sources of estimates: Jupiter/Carlin (2010 JCP Application,Attachment B, p. 5, Taylor Engineering), Juno Beach (1-Year Post-Construction Monitoring Report by Applied Technology & Management, 2011, p. 12), Palm Beach Mid-Town and Phipps Ocean Park (Rob Weber, Town of Palm Beach; Mid-Town and Phipps 3 yr Monitoring Reports, Applied Technology & Management), Ocean Ridge (Olsen Associates, 2012 JCP Application, p. 7), Delray Beach (Paul Dorling, City of Delray Beach), North and Central Boca Raton (Applied Technology & Management) .

Introduction and Project Status

Palm Beach County contains four Federal and five non-Federal active shore protection projects along its 45 miles of coastline. The projects detailed in this report are shown in Figure 1. This report does not include various repetitive activities such as inlet sand bypassing and dune restoration projects (e.g., Lantana and Singer Island); nor does it include the South End Palm Beach Restoration Project at Reach 8 (currently in permitting). Upland sand mines are the expected sources for those projects.

Jupiter/Carlin. The General Design Memorandum (GDM) for the Jupiter/Carlin segment of the Palm Beach County Shore Protection Project (SPP) was approved in 1994. The project begins just south of Jupiter Inlet at R13.5 and continues south 1.05 miles to R19. The initial nourishment was completed in 1995 and included removal of three derelict concrete pile and wood panel groins and placement of approximately 603,800 cy of sand from the ebb tidal shoal at Jupiter Inlet.

The first renourishment was completed in March 2002 with the addition of approximately 625,000 cy of sand dredged from an offshore borrow area two miles northeast of the fill area.

Planning and design of the proposed second renourishment began in early 2008 and is ongoing. The current status of the project beach is critically eroded. The 2012 renourishment quantity of 995,600 cy was estimated for the joint coastal permit application to FDEP submitted in 2010 by Taylor Engineering, Inc. That volume was based on existing conditions and anticipated background erosion. Assuming an erosion rate of 86,000 cy/yr, the renourishment volume for 2014 will be 1,167,600 cy.

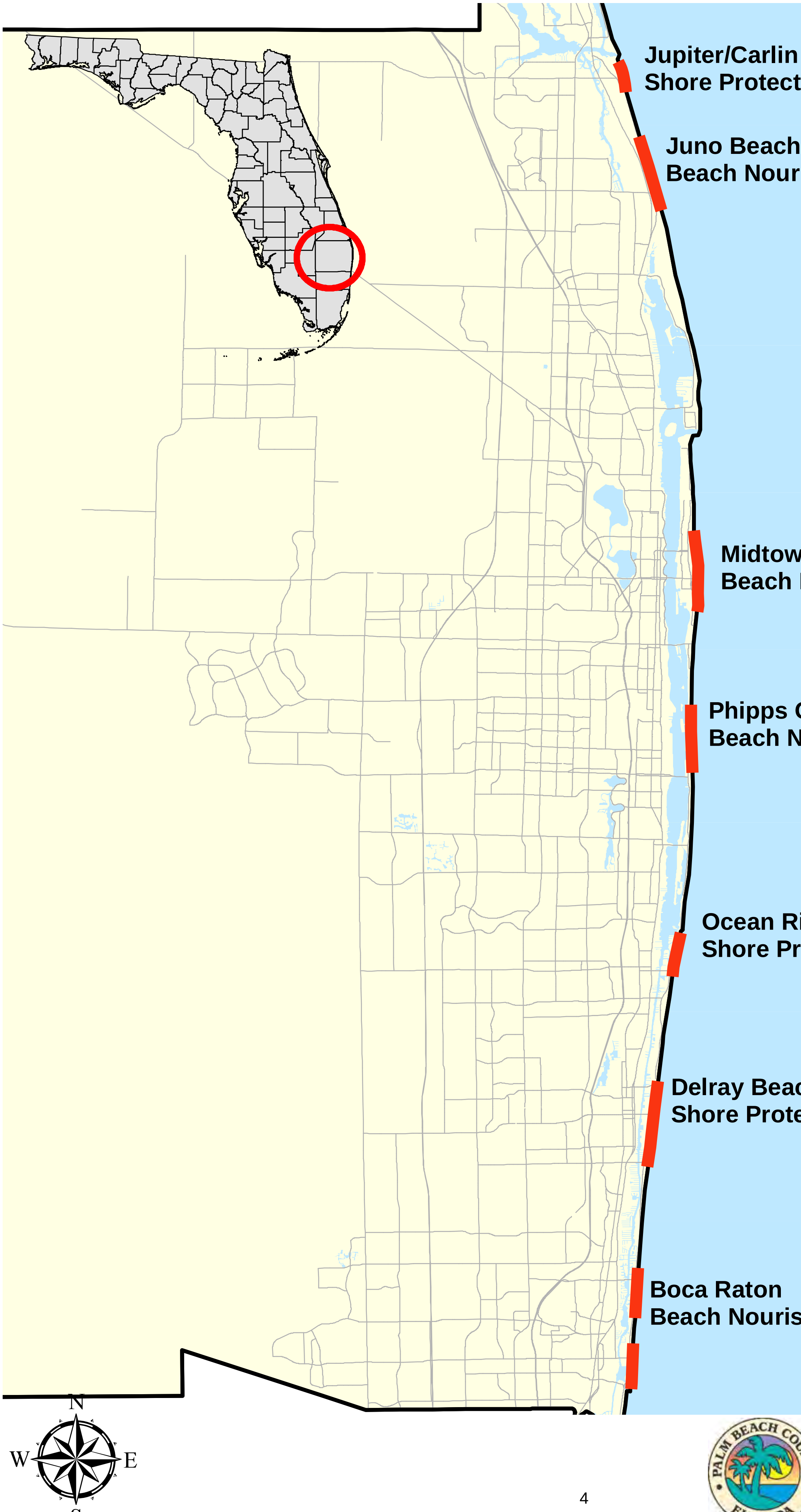
Figure 2 shows the project fill limits and the borrow areas for the 1995 and 2002 nourishment events.

Juno Beach. The Juno Beach SPP is not a federally authorized project. The project receives equal funding from State and local cost-sharing. Project limits extend from R26 to R38. The initial nourishment of the 2.4 mile beach was conducted in 2001, using a hopper dredge to excavate and transport 1,000,000 cy of sand from an offshore borrow area five miles north of the fill area.

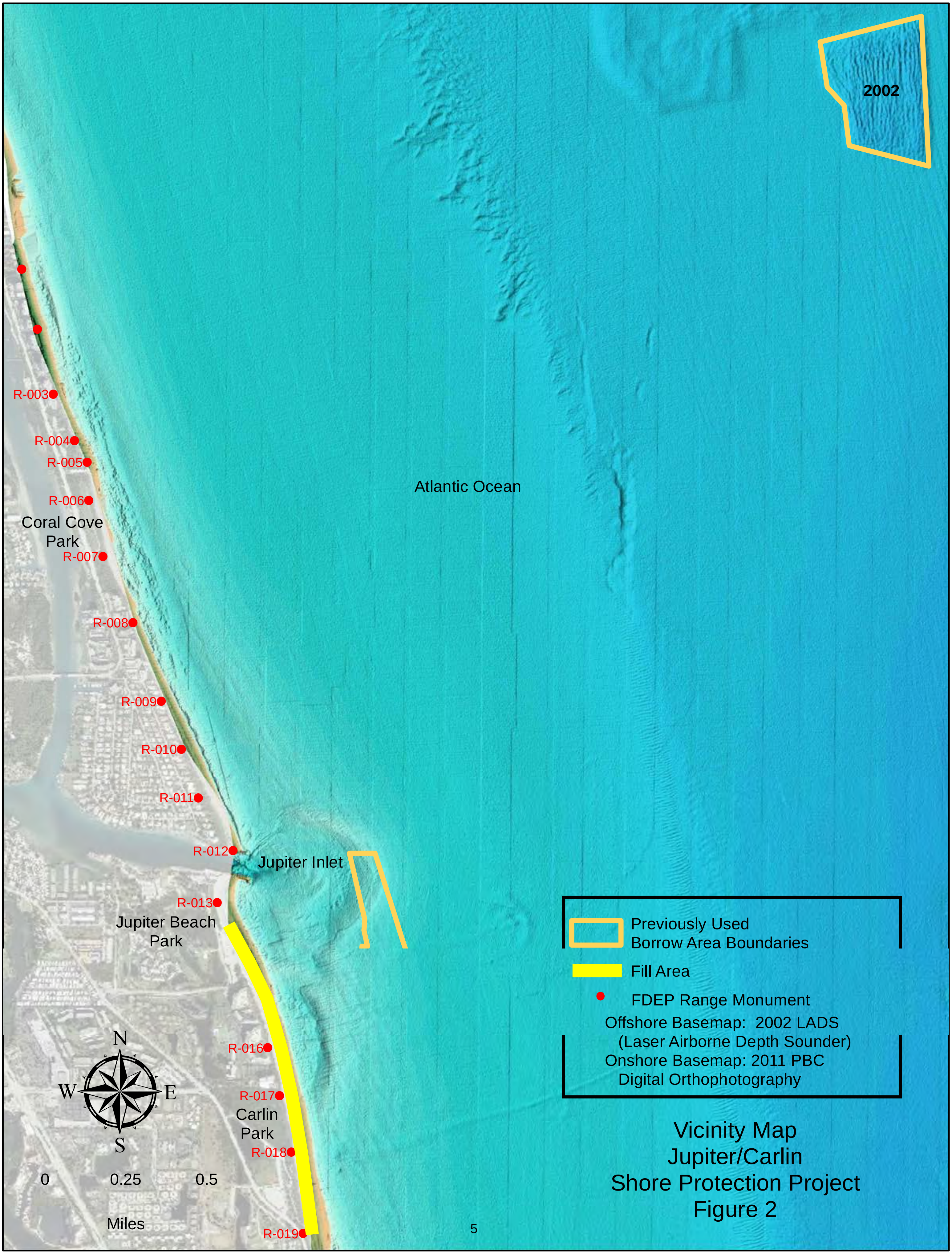
The first renourishment of the Juno Beach SPP was completed in April 2010 using 916,000 cy of sand from a borrow area offshore of Singer Island, 4 miles south of the south limit of the fill area.

Figure 3 shows the project fill limits and the borrow areas from the 2001 and 2009 nourishment events.

Town of Palm Beach. Two non-Federal beach nourishment projects are located within the Town of Palm Beach: Midtown and Phipps Ocean Park/Reach 7. Cost-sharing for both projects is divided between the State, County, and Town governments.



Location Map
Palm Beach County
Shore Protection Projects
Figure 1


2002
Atlantic Ocean
R-003
R-004
R-005
R-006
Coral Cove Park
R-007
R-008
R-009
R-010
R-011
R-012
Jupiter Inlet
R-013
Jupiter Beach Park
R-016
R-017
Carlin Park
R-018
R-019
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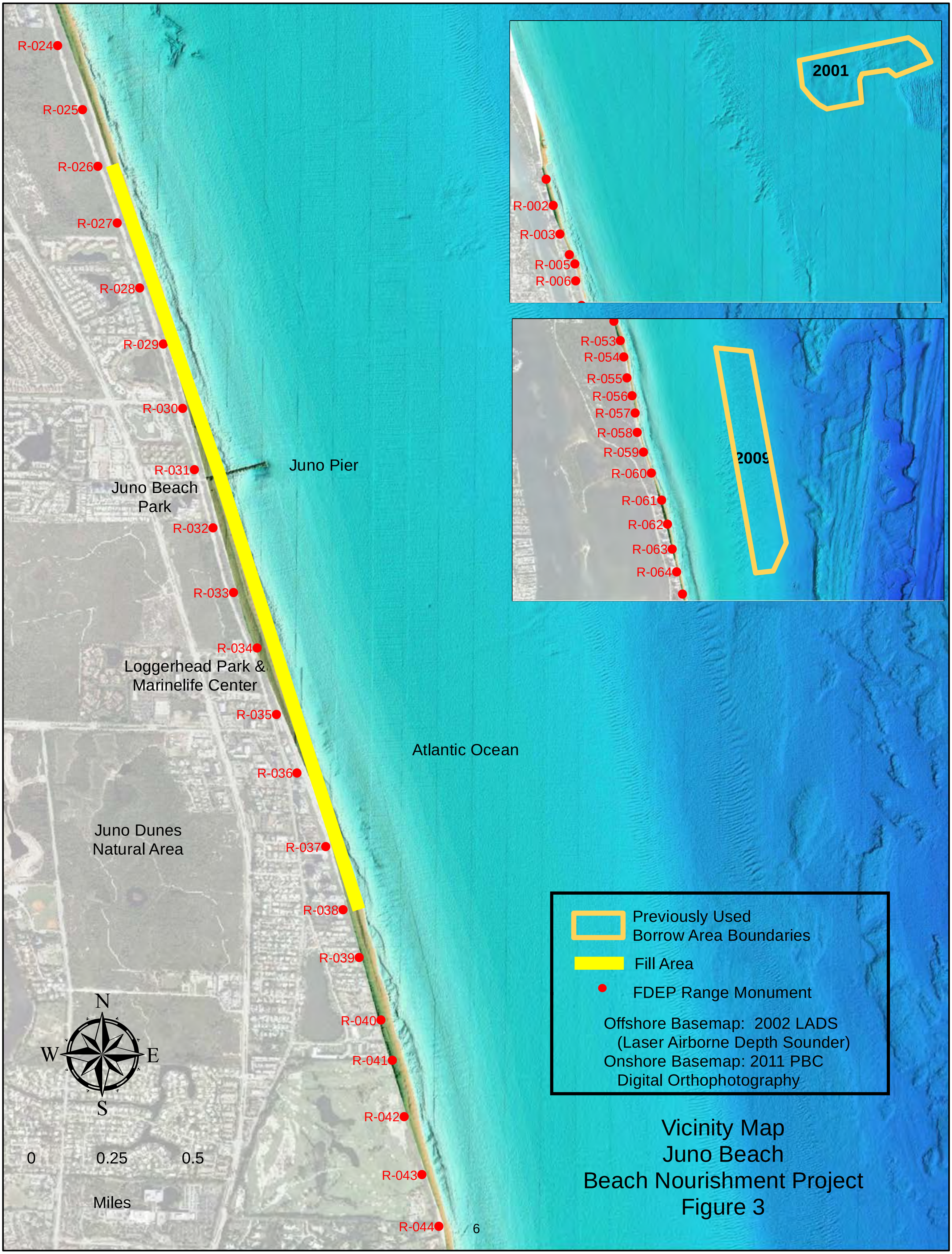
Miles
Previously Used Borrow Area Boundaries
Fill Area
FDEP Range Monument
Offshore Basemap: 2002 LADS (Laser Airborne Depth Sounder)
Onshore Basemap: 2011 PBC Digital Orthophotography
Vicinity Map
Jupiter/Carlin
Shore Protection Project
Figure 2



R-024
R-025
R-026
R-027
R-028
R-029
R-030
R-031
Juno Pier
Juno Beach
Park
R-032
R-033
R-034
Loggerhead Park &
Marinelife Center
R-035
Atlantic Ocean
R-036
Juno Dunes
Natural Area
R-037
R-038
R-039
R-040
R-041
R-042
R-043
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R-003
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R-006
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R-055
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R-057
R-058
R-059
R-060
R-061
R-062
R-063
R-064
2009
Previously Used
Borrow Area Boundaries
Fill Area
FDEP Range Monument
Offshore Basemap: 2002 LADS
(Laser Airborne Depth Sounder)
Onshore Basemap: 2011 PBC
Digital Orthophotography
Vicinity Map
Juno Beach
Beach Nourishment Project
Figure 3

The Mid-Town Beach Nourishment Project was initially constructed in 1995 as an emergency project using 880,000 cy of sand from an offshore borrow area located three miles north-northeast of the fill area. Project limits extended from R95 to R100. The project beach was renourished in 2003 with 1.3 million cy of sand from the same borrow area used in 1995. In response to the impacts of hurricanes Frances, Jeanne, and Wilma, an emergency project was constructed in 2006 using the 1995 borrow area Fill limits for the 2003 and 2006 events were R90-R94.2 and R94.5-R101. A smaller scale interim project using an upland source is planned for Mid-Town in 2014, followed by a major renourishment in 2017.

The 1.4 mile Phipps Ocean Park/Reach 7 project (R119-R126) was initially nourished in 2006 with 1,228,00 cy of sand from two offshore sand sources located approximately 1.5 and 2.6 miles from the south end of the project area, respectively. The first renourishment of this project is scheduled for 2013, and the fill limits will likely be expanded to R119-R127. Three offshore borrow areas are proposed for the 2013 project.

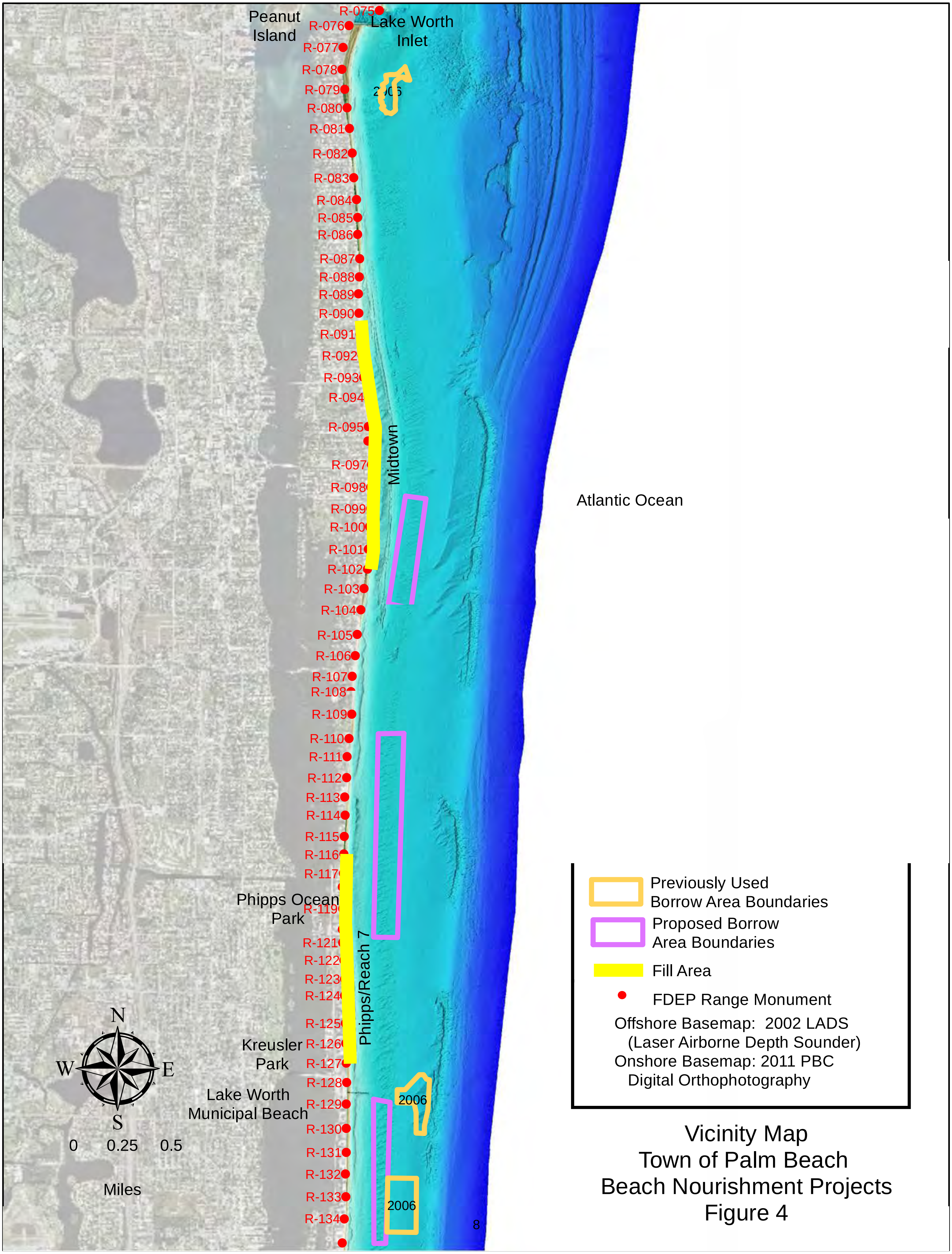
Figure 4 shows the fill limits and the borrow areas for the Mid-Town and Phipps Ocean Park beach nourishment projects.

<u>Ocean Ridge.</u> The Federal GDM for the Ocean Ridge segment of the Palm Beach County SPP was approved in 1996. The project included partial or complete removal of 11 derelict groins and construction of eight rock groins in 1997 and placement of about 900,000 cy of sand from a borrow area 1700 ft offshore of the fill area in 1998. The initial project limits were between T152 and R159. This 1.42 mile project included filling of the groin field.

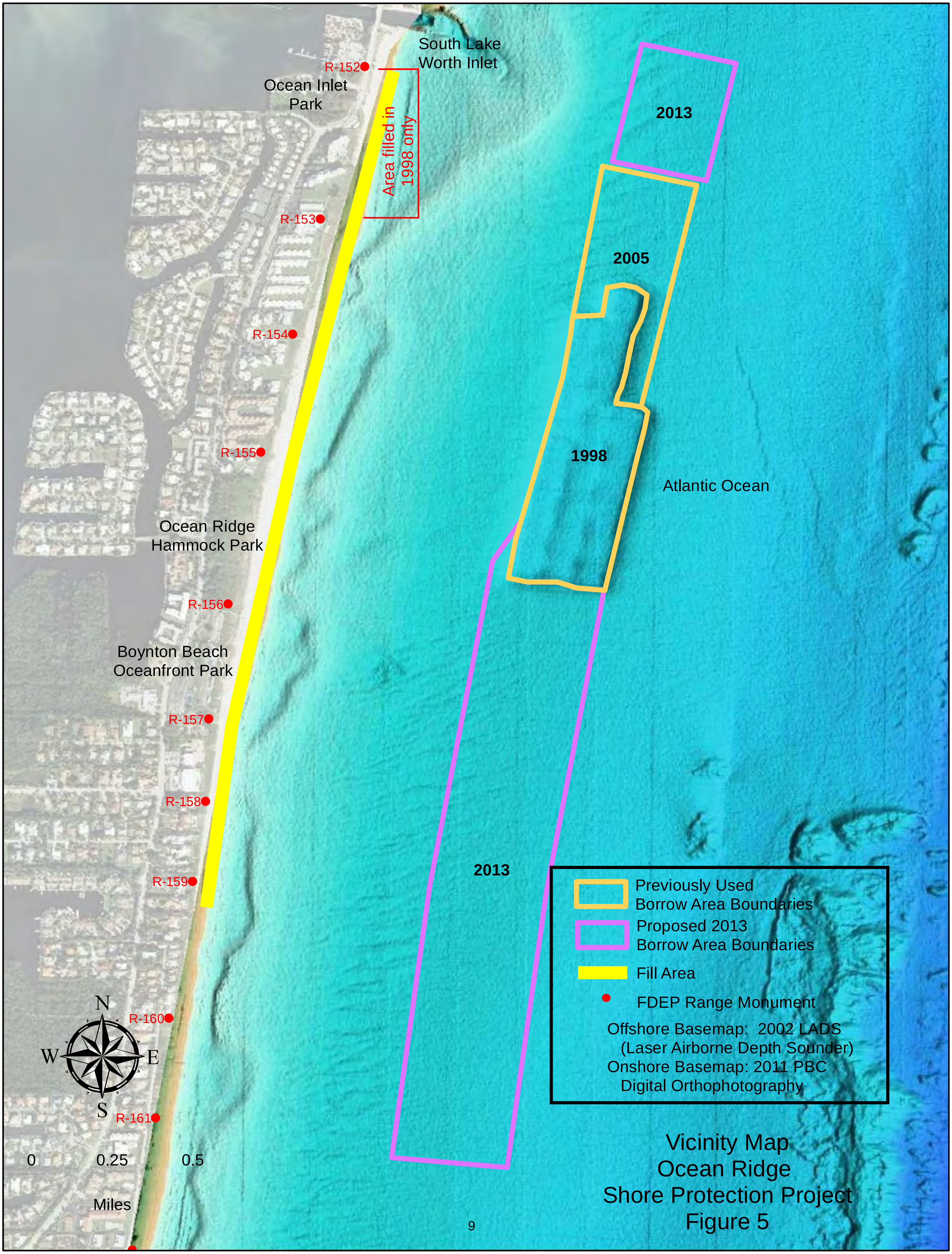
The first renourishment was completed in December 2005 and did not include placement of sand in the groin field. Approximately 585,000 cy of sand was transported to the beach between R153 and R159 via pipeline from a borrow area adjacent to the 1998 borrow area. Addition of fill in the groin field is not proposed for future projects, as the structures, combined with inlet bypassing of the sand transfer plant at South Lake Worth Inlet (originally constructed in 1937), have been maintaining the beach width since the construction of the groin field.

Figure 5 shows the project fill limits and the borrow areas for the 1998, 2005, and proposed 2013 nourishment events.

<u>Delray Beach.</u> The 1973 Delray Beach SPP was the first large scale beach restoration in South Florida. The initial nourishment was completed in 1973 with 1.635 million cy of sand placed between R176 and R188.5 (2.7 miles). The first renourishment was completed in 1978 with the placement of 700,000 cy of sand. Subsequent projects



Vicinity Map
Town of Palm Beach
Beach Nourishment Projects
Figure 4



Vicinity Map
Ocean Ridge
Shore Protection Project
Figure 5

were conducted in 1984, 1992 (1.23 million cy), 2002 (1.23 million cy), and 2005 (hurricane repair). The next project scheduled for Fall 2012. Cost-sharing for the project is divided between the Federal, State, County, and City governments.

Figure 6 shows the fill limits and the nearby offshore borrow areas for the past and proposed nourishment events at Delray Beach.

Boca Raton. Two project areas within the Boca Raton city limits utilize offshore borrow areas: the North (R205-R212) and Central (R216-H222) Boca Raton Beach Renourishment projects. A third project south of Boca Raton Inlet (R223-R227) utilizes sand from the inlet's ebb shoal and is not included in this report.

The federally funded North Boca Raton Project was initially nourished in 1988 with 1,102,000 cy of sand. The 1.45 mile project was renourished in 1998 (680,000 cy) and 2010 (782,200 cy). The next renourishment is scheduled for 2020.

The Central Boca Raton Project was initially nourished in 2004 with 480,000 cy of sand. At the same time, a groin 170 in length was constructed 1,600 feet north of the Boca Raton Inlet, and the weir in the inlet's north jetty was shifted 50 feet seaward. In 2006, 363,000 cy of sand from the inlet ebb shoal was placed within the 1.5 mile project limits as hurricane damage repair.

The map in Figure 7 shows the North and Central Boca Raton Beach Nourishment projects and corresponding borrow areas.

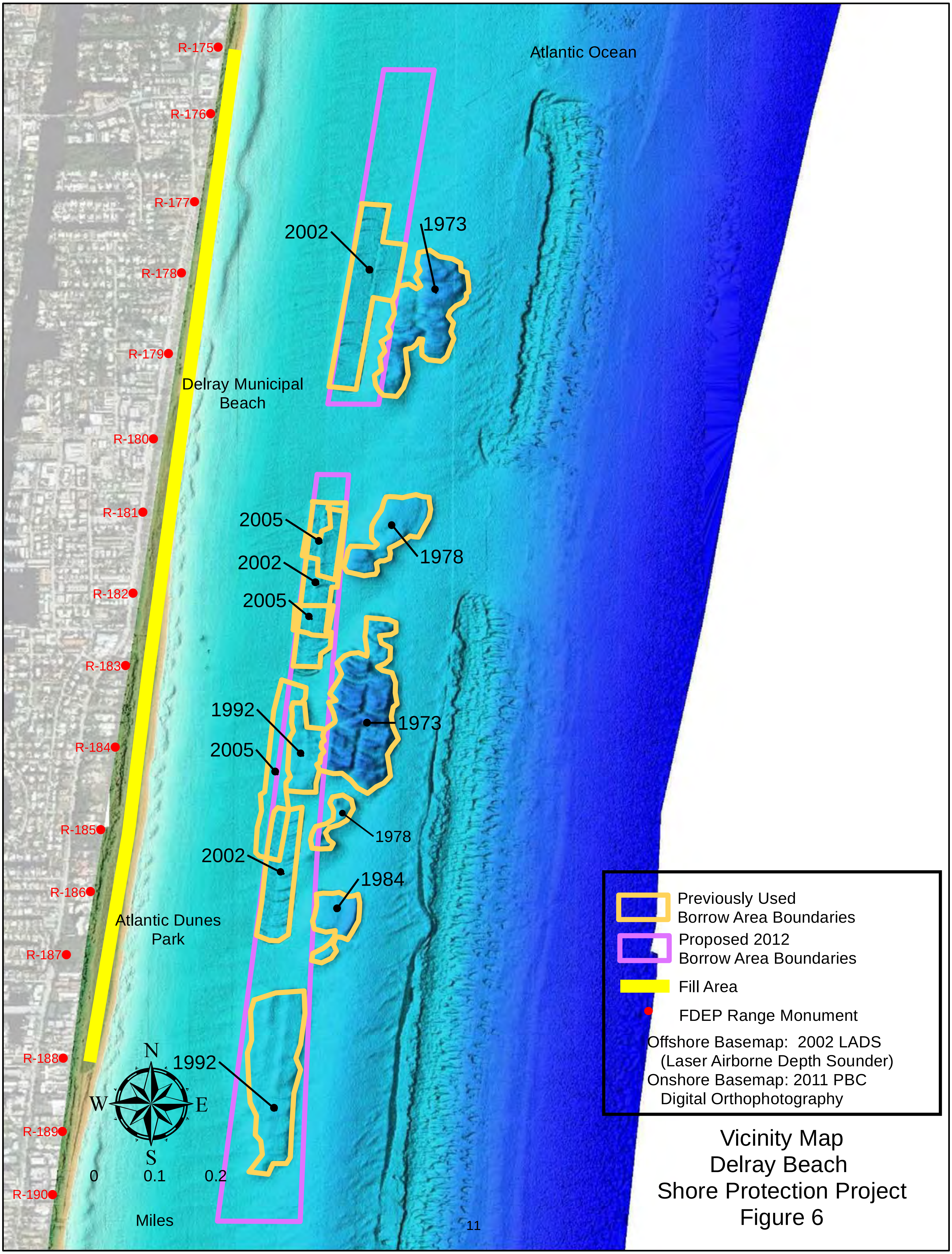
Data, Methodology, and Period of Analysis

Current and 50-year sand requirements:
Estimated annual sand demand was calculated from comparisons of County-wide beach and nearshore profiles surveyed annually. Traditional beach and hydrographical survey methods were used to collect profile data at FDEP reference monuments along set azimuths.

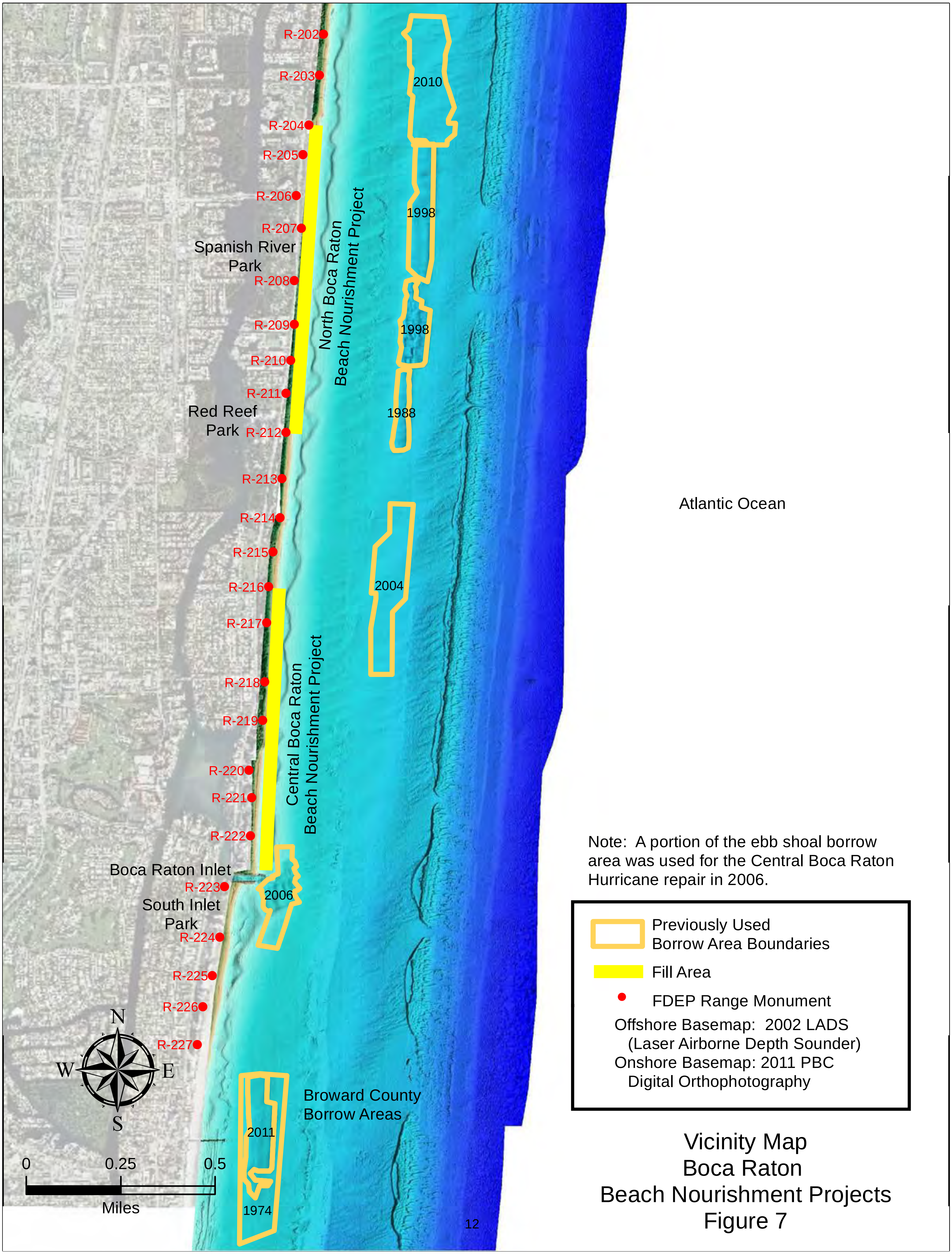
Renourishment intervals and overfill ratios were taken from GDMs (for Federal projects) and post-construction monitoring reports (for Federal and non-Federal projects). The period of analysis for each project is dependent upon the nourishment history of the project. Where the dates are known, the years over which the survey data was evaluated are listed in Table 1 under the column heading "Basis of Estimate".

Assumptions

All active projects in the County will receive complete renourishments throughout the next 50 years and will continue to receive full funding at least until the end of 2062.



Vicinity Map
Delray Beach
Shore Protection Project
Figure 6



Vicinity Map
Boca Raton
Beach Nourishment Projects
Figure 7

The size of all active projects will remain constant for the next 50 years. No additional projects will begin in the County before the end of 2062. Local rates of erosion will not change significantly in the next 50 years. Borrow area boundaries will maintain adequate buffer distances from reefs.

Environmental Considerations Impacting Estimates

The distance of the borrow area from reefs (see Assumptions) and cable corridors has a potentially significant impact when analyzing resources and calculating the amount of useable sand.

Analysis

Table 2 summarizes the results of the county-wide sand needs assessment. The estimated 50-year sand volume required for beach nourishment in Palm Beach County is 45,577,000 cubic yards.

Table 2. Palm Beach County summary of project information.

Project	Project Type (Federal/non-Federal)	Initial Construction	Monument Range	Renourishment Volume (cy/yr)	Renour. Interval (yr)	Year of Last Renour.	Year of Next Renour	No. of Events Before End of 2062	50-yr Volume Required (cy)	Historic Sand Source
Jupiter/Carlin	Federal	1995	R13-19	86,000	7	2002	2014	7	5,467,000	offshore
Juno Beach	non-Federal	2001	R26-38	107,000	7	2010	2016	7	6,300,000	offshore
Mid-Town	non-Federal	1995	R90-R101[1]	125,000	8	2006[3]	2017[4]	6	7,250,000	offshore
Phipps	non-Federal	2006	R119-R126[2]	125,000	8	2006	2013	7	7,250,000	offshore
Ocean Ridge	Federal	1998	R153-159	56,500	6	2005	2013	9	3,410,000	offshore
Delray Beach	Federal	1973	R180-188.5	120,000	10	2005[3]	2012	6	7,200,000	offshore
N. Boca Raton	Federal	1988	R205-R212	80,000	10	2010	2020	6	4,550,000	offshore
C. Boca Raton	non-Federal	2004	R216-H222	75,000	8	2006[3]	2014	7	4,150,000	offshore
Total				774,500					45,577,000	

[1]1995 fill limits were R95-R100; 2003 and 2006 fill limits were R90-R94.2 and R94.5-R101.

[2]2013 project south fill limit likely to extend to R127

[3]Hurricane damage repair.

[4]Interim project using upland source planned for 2014.

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9.4 Needs Determination: Broward County, FL

Broward County, FL

Sand Needs Evaluation for Beach Nourishment

A component of the:

Southeast Florida Sediment Assessment and Needs Determination (SAND) Report

Submitted to:
Florida Department of Environmental Protection
Bureau of Beaches & Coastal Systems
Tallahassee, FL

Prepared by:
Christopher G. Creed, P.E.
Olsen Associates, Inc.
Jacksonville, FL

Date
April 19, 2012
August 17, 2012 (revised)

Executive Summary

The purpose of this report is to estimate the current and future demand for sand for beach nourishment in Broward County. This estimate will be used in conjunction with similar estimates of the sand needs of the remaining southeast Florida counties to determine a range of the amount of sand needed over the next 50 years to sustain southeast Florida's Federal and non-federal beach nourishment projects. Ultimately, the estimated needs of this region will be compared to the availability of sand for beach nourishment purposes. This comparison will be accomplished through the Southeast Florida Sediment Assessment and Needs Determination (SAND) Report, a joint effort led by the Florida Department of Environmental Protection and supported by the southeast Florida counties and the U.S. Army Corps of Engineers.

The considered beach nourishment projects and projected 50-year renourishment requirements for Broward County are summarized in the table below. The table briefly describes the fundamental assumptions upon which the required sand volumes are based. Additional detail is provided in the following pages.

Based upon the information and analyses summarized therein the future annual sand demand for the Broward County shoreline (Segments I, II, and III) is expected to be 210,000 cy/yr. Over a 50-yr period, the total estimated demand would be 11,650,000 cy, including 1,150,000 cy required to address current needs. In the event sand bypassing is implemented at Port Everglades Inlet, the 50-yr sand requirement for Broward County would be reduced to 8,650,000 cy.

Summary of estimated current and expected future sand nourishment needs for the Broward County, Florida Atlantic Ocean shoreline.

Broward County, Florida											**4/19/2012 (Revised 8/16/2012)**
Projected Sand Requirement over next 50 years (Current and Future)											
Name	**Sponsor/ Agency**	**Initial Construction Date**	**Monument Range**	**"L" Length of Nourishment (ft)**	**"CR" Estimated Current Requirement (cy)**	**"AD" Estimated Annual Sand Demand (cy/yr)**	**"FD" = AD x 50 Estimated Future Demand Over 50 Years (cy)**	**"CR + FD" Estimated 50-yr Requirement (cy)**	**"FD/50/L" Estimated Requirement Per Year Per Linear Foot (cy/yr/ft)**	**Basis of Estimate**	**Comments**
Segment I	Towns of Deerfield and Hillsboro Beach	1970	R6 to R14	6,000	0	40,000	2,000,000	2,000,000	6.7	Surveyed Beach Change (1993-2009) *(Reliable period prior to 2011 nourishment project. Effects of 1998 nourishment eliminated from estimate.)*	Future sand placement is expected to occur mostly only along Hillsboro Beach between R6 and R14
Segment II	Broward County/USACE	1970	R25 to R72	46,200	750,000	40,000	2,000,000	2,750,000	0.9	Surveyed Beach Change (1983-2011) *(Post-1982 dredge improvements for Hillsboro Inlet sand bypass)*	Estimated annual sand demand is inclusive of localized gross losses and not net beach volume change. Future sand demand is expected to be stable or reduced due to benefits from sand bypassing at Hillsboro Inlet
Segment III (John U. Lloyd)	Broward County/ USACE/FDEP	1979	R85.7 to R93	7,300	260,000	53,000	2,650,000	2,910,000	7.3	Surveyed Beach Change (1989-2011)	It is expected that sand bypassing at Port Everglades could reduce the annual sand demand to 13,000 cy or less
Segment III (Hollywood/ Hallandale/ Dania)	Broward County/USACE/ Cities of Hollywood/ Hallandale Beach	1971	R99 to R128	30,300	140,000	77,000	3,850,000	3,990,000	2.5	Surveyed Beach Change (1993-2011)	
Total					1,150,000	210,000	10,500,000	11,650,000			Could be reduced to 8,650,000 if sand bypassing at Port Everglades is implemented.

Notes:
1) It is assumed that future nourishment activities in Broward County will be limited by the presence and required protection of nearshore hardbottom resources.
Accordingly, future sand requirements will be specfied to mostly maintain established conditions and not result in significant widening of beach conditions beyond historical extents.

MAIN REPORT

INTRODUCTION AND PROJECT STATUS

Comprehensive beach nourishment began as a means of restoring and maintaining the Broward County beaches in 1970. Since then, both Federal and non-Federal projects have been completed. Presently, over 16 miles of Broward County's 24 miles of beaches have been restored and are maintained either through the Broward County beach management program or through projects sponsored by local municipalities. To-date, more than eleven million cubic yards of sand have been added to the Broward County beaches through nourishment. A brief history of the beach nourishment projects is outlined below. The locations of the projects are shown in **Figure 1**.

With the exception of relatively small projects that have used upland sand sources, the beaches of Broward County have been restored and maintained with sand derived from borrow areas located offshore of the county coastline in addition to sand bypassed at Boca Raton and Hillsboro Inlets. The observed beach change conditions used to establish the expected future demand in this report implicitly include the historical and existing contributions of sand bypassing to the Broward County beach system. As such, it is assumed that sand bypassing will continue at typical historical rates and is not be considered a source of material to meet the future demand which the exception of sand bypass at Port Everglades if and when it becomes available in the future.

Segment I - (North County Line (R-1) to Hillsboro Inlet (R-24). Although part of the authorized Broward County Federal project, Segment I stabilization and restoration efforts to-date have been sponsored and funded by the local communities of Deerfield Beach and Hillsboro Beach.

Three large-scale nourishment projects have been completed in Segment I. The first was constructed in 1972 along 5,000 ft of Hillsboro Beach. The sand was placed between monuments R-7 to R-12. The placed volume is reported to be about 500,000 cy (Olsen Associates, Inc./CPE, 1998). The second project was complete in 1998. That project included the placement of about 555,000 cy of sand between R-6 and R-12 (Olsen Associates, Inc., 2010b). The third and most recent nourishment along the Segment I shoreline included the placement of about 355,000 cy of sand between R-6 and R-12 (CSI, 2011).

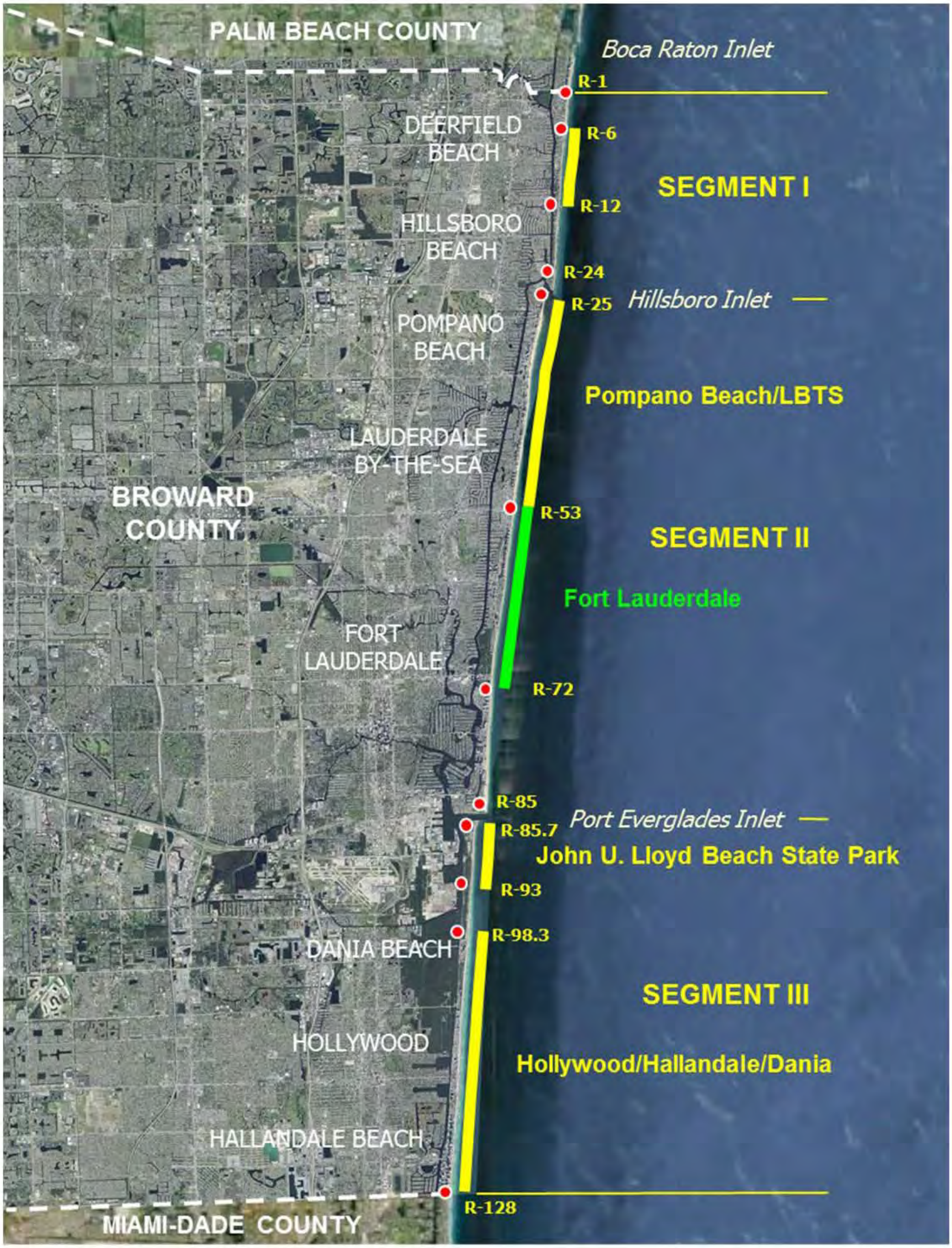

Figure 1: Location of Broward County shoreline reaches and past (yellow) and expected future areas (green) where beach nourishment occurs.

In sum, approximately 1,410,000 cy of sand was placed along the Segment I shoreline between 1972 and 2011. The sand for these three projects was dredged from borrow areas immediately offshore of the Segment I shoreline.

Boca Raton Sand Bypassing. The Segment I shoreline also receives sand indirectly from sand bypassing activities at Boca Raton Inlet in Palm Beach County. Sand bypassing at that inlet includes almost continuous dredging of the inlet channel and periodic dredging of the inlet ebb shoal. On average, the continuous sand bypass activity transfers about 56,000 cy/yr (1979 to 2011 record) from the inlet channel to the immediate downdrift shoreline. Sand entrained by the inlet is also transferred to the downdrift shoreline through periodic dredging of a portion of the inlet ebb shoal. Between 1979 and 2011, there were four ebb shoal dredging events. In sum, almost 970,000 cy of sand were bypassed across the inlet during these events. On average, about 240,000 cy is bypassed across this inlet in this manner every eight to ten years. Sand from these periodic projects is placed along the 4,000 feet of shoreline immediately downdrift of the inlet (Olsen Associates, Inc., 2011).

Regardless of past sand placement and bypassing efforts, portions of the Segment I shoreline have not been continually maintained to acceptable conditions. This suggests that past sand placement and bypassing efforts have not been sufficient to meet demand.

Segment II - (Hillsboro Inlet (R-25) to Port Everglades (R-85)). The beach restoration and renourishment efforts to-date along the Broward County Segment II shoreline have been completed through the Broward County Federal Shore Protection Project authorization.

The initial restoration of the Segment II shoreline occurred along a portion of Pompano Beach (R-31 to R-49) in 1970. Approximately 1,100,000 cy of sand were placed during that project.

The first and only renourishment to-date of the Segment II shoreline project was constructed in 1983. That work replenished the previous (1970) project areas and extended the project northward to Hillsboro Inlet (R-25) and southward to Lauderdale-By-The-Sea (R-53). The fill volume placed during 1983 project is reported to be approximately 1,909,000 cy (Olsen Associates, Inc./CPE, 1998).

Since 1970, approximately 3,009,000 cy of sand have been placed along the Segment II shoreline (R-25 to R-53) from offshore borrow areas.

Hillsboro Inlet Sand Bypassing. Of Broward County's two modern ocean inlets, regular sand bypassing occurs only at Hillsboro Inlet. Sand bypassing at this inlet provides significant benefits to the Segment II beach system. A program for periodic bypassing at Hillsboro Inlet has been in place since 1959. Originally, sand was bypassed with an eight-inch dredge. This dredge was replaced by a fourteen-inch dredge in 1982 which significantly increased the sand bypassing capacity for the inlet. Since the 1982 dredge improvements, sand bypassing records from the inlet suggest that the annual sand bypass rate averages about 107,000 cy/yr. Assuming this rate has been generally consistent since 1983 -- and records suggest it has been -- it is estimated that since 1983, the Hillsboro Inlet sand bypass project has added an additional 3,000,000 cy of sand to the Segment II shoreline.

Between 1983 and 2011, more than 6,000,000 cy of sand were added to the Segment II shoreline through sand nourishment and bypassing at Hillsboro Inlet. This addition of sand resulted in overall net accretion along most of the Segment II shoreline. However, there are areas where some persistent narrow beach conditions and erosion occur even with this input of sand to the Segment II shoreline. As such, some future nourishment along areas of the Segment II shoreline is expected to be required.

Current renourishment needs along the Segment II shoreline include about 200,000 cy between R-25 and R-53 (previously constructed areas) and 550,000 cy between R-53 and R-72 (planned extension of the Federal project). An LRR and JCP Application are currently under preparation and coordination for this work. Sand placement for this project is planned to begin in 2013-14 using upland sources.

Segment III - (Port Everglades (R-85.7) to South County Line (R-128)). Like Segment II, the beach restoration and maintenance efforts along the Segment III shoreline have been conducted through the Federal Shore Protection Project. There are two areas along the Segment III shoreline where the project has been constructed and maintained. These include the northern portion of the John U. Lloyd Beach State Park (JUL) shoreline (R85.7/Port Everglades south jetty to R-93) and the Dania Beach/Hollywood/Hallandale Beach shoreline (R-98.3 to R-128).

The northern shoreline along JUL, located immediately south of Port Everglades, was initially nourished as part of the Federal Shore Protection Project in 1977. During that project approximately 1,090,000 cy of sand were placed between monuments R-86 and R-93. This project reach was renourished in 1989 and again in 2005/06 with the placement of approximately 603,000 cy and 570,000 cy of sand, respectively, within the historical project limits.

The southernmost portion of the county (R-124 to R-128, Hallandale Beach), was initially nourished in 1971. The placed fill volume is believed to have been approximately 360,000 cy.

In 1979 a major project renourished the Hallandale area and extended the project limits northward along Hollywood. This project placed 1,980,000 cy of sand between monuments R-101 and R-128. In 1991, this same project area was renourished with another 1,110,000 cy of beach fill.

In 2005/06, the previously constructed areas of Hollywood and Hallandale were renourished. In addition, to improve project performance, a taper was added to the northern end of the project into Dania Beach (R-98.3). This project included the placement of 1,415,000 cy (pay and non-pay) of sand between R-98.3 and R-128. Of this, 188,000 cy were paid for by the USACE as part of the PL84-99 post-storm restoration authorization.

In addition to these Federal actions, several smaller sand nourishment projects have been completed by the local communities. In 2001, the Diplomat Hotel placed approximately 75,000 cy of sand between R-121 and R-124. In 2011, the City of Hollywood placed an additional 60,000 cy of sand between R-120 and R-124 in southern Hollywood. These smaller projects have used upland mines as the source for sand fill.

In sum, approximately 7,263,000 cy of sand has been placed along the Segment III shoreline between 1970 and 2011 -- 2,263,000 cy in JUL and 5,000,000 cy in Dania Beach/Hollywood/Hallandale Beach. With the exception of the small upland projects and about 50,000 cy of sand from a Port Everglades channel maintenance event in 2005/06, all of the material placed along the Segment III shoreline has been derived from borrow areas offshore of Broward County.

Presently, sand input to the Segment III shoreline is from sand nourishment. The Segment does not benefit from regular sand bypassing at Port Everglades inlet.

Port Everglades Entrance Sand Bypassing. A program for reliable periodic sand bypassing at Port Everglades does not yet exist; however, Broward County is presently pursing the implementation of a sand bypass project at this inlet. It is anticipated that a sand bypass project could provide the equivalent of between 40,000 and 60,000 cy/yr to the Segment III beaches (Olsen Associates, Inc., 2007).

Total Sand Nourishment (1970-2011). Since comprehensive sand nourishment efforts (Federal and non-Federal) began in Broward County in about 1970, there has been more than 11.7 million cubic yards of sand placed along portions of the three shoreline Segments. More than 98 percent of this sand nourishment was dredged from borrow areas offshore of the Broward County shoreline. An additional 3.0 million cubic yards sand has been bypassed across Hillsboro Inlet that has benefitted navigation interests at that location and the Segment II beaches. There have also been several smaller truck haul projects in Segment I and II that have been implemented to address highly localized erosion problems. Records suggest that the total volume for these smaller projects combined is less than 25,000 cy.

DATA, METHODOLOGY, AND PERIOD OF ANALYSIS

Data. Data used for the evaluation of future sand needs in Broward County include the following…

- Available beach profile data from the Broward County and FDEP database for the 140 primary and intermediate monitoring stations in Broward County. Comprehensive project and/or county-wide beach survey data are available the dates 1979, 1983, 1989, 1993, 1998, 1999, 2001, 2005, 2006, 2007, 2008, 2009 and 2011.

- Published beach change rates from evaluation of the available beach profile data noted above. This information is principally available in published engineering and physical monitoring reports.

- Published sand bypass rates at Boca Raton and Hillsboro Inlets. This information is available from the City of Boca Raton and the Hillsboro Inlet District. The latest comprehensive compilation of available data was prepared by Olsen Associates, Inc. (2011).

- Expected sand bypass rates at Port Everglades Inlet (Olsen Associates, Inc., 2007).

Methodology. Anticipated future sand needs were evaluated for each Broward County shoreline Segment, Segment I, II, and III. Sand needs are determined strictly from the perspective of historical beach volume changes including the performance of prior constructed projects. Shoreline changes and desired minimum positions were not considered.

Typical sand loss rates, evaluated from the longest reliable record of changes that are expected to be representative of future conditions are used as the basis for determining future sand requirements. An assessment of the current needs for each reach is also made. This considers documented sand losses since the last renourishment event along each Segment and/or required volume of the planned Segment II project.

Period of Analysis. The period of analysis varied for each Segment. Selection of each respective period was based upon the following…

- the date of past sand placement events,

- the availability and reliability of beach profile data that is reflective of beach conditions that are expected to exist in the future, and

- the date of the most recent inlet improvements that are expected to influence future shoreline conditions

The general evaluation period each Segment is as follows…

- Segment I – 1993 to 2009 (16 years)
- Segment II – 1983 to 2011 (28 years)
- Segment III – 1989 to 2011 (22 years)

In some instances, there may be gaps which each period when beach change information is not available or is affected by sand placement or other events that would adversely affect the assessment of an expected typical long term trend of future sand needs.

ASSUMPTIONS

To develop anticipated future sand needs for Broward County, the following general assumptions were implemented.

- Following completion of the planned Segment II nourishment, there will be no future efforts to widen the Broward County shoreline beyond historical conditions.

- Given that a significant amount of the sand volume placed in the past was required to initially re-establish large areas of the highly eroded beach system, past sand placement volumes cannot be annualized to represent expected future sand needs.

- The amount of future regularly scheduled sand placement -- beyond that accomplished through routine inlet sand bypassing -- will be equivalent to documented average annual sand loss rates for the restored and maintained beach system. These long-term rates are assumed to include the effects of commonly occurring storms and sea-level rise, both of which occurred during the period of analysis.

- Beach volume changes are estimated by computing the unit volume change at each FDEP monument and applying the average end area method using the direct distance between adjacent monuments. The unit volume change is computed by estimating beach change between subsequent measured conditions from the back beach -- where the berm intersects the existing upland contour or the seaward edge of vegetation -- to the beach toe/nearshore hardbottom interface.

- Sand bypassing at Hillsboro Inlet will be maintained at or above the 107,000 cy/yr that was typical between 1983 and 2011.

- If and when sand bypassing at Port Everglades is implemented, it will supply between 40,000 and 60,000 cy/yr to the Segment III shoreline. This will result in an equivalent reduction in the amount of sand required from other sources to maintain the Segment III beaches in the future.

- The need estimates do not include potential requirements for extraordinary post-storm restoration, textural differences between native beach and source sediments, and losses commonly encountered in the excavation, transport and handling of fill material.

ENVIRONMENTAL CONSIDERATIONS AND IMPACT ESTIMATES

The principal environmental constraint for sand placement along the Broward County shoreline is the nearshore hardbottom that lie along the seaward extent of most of the beaches along the Broward County Atlantic Ocean coastline. Increases in beach width can contribute to temporary and permanent coverage of these hardbottom resources. Following completion of the planned Segment II project future sand placement efforts, which is expected to include some limited net beach widening and un avoidable impacts to nearshore hardbottom, it is assumed that all future beach nourishment efforts will only include sand placement within the historical seaward extent of the Broward County beach system. This would be expected to avoid future project related impacts to hardbottom resources that have not been impacted and mitigated for, as required, in the past.

ANALYSIS

Values and ranges of expected future sand required in Broward County were derived principally from existing analyses and reports. Other than some basic reorganizing of available volume change information, no additional volume change computations from the beach profile database were performed.

The primary sources for information are existing engineering and physical monitoring reports. The reports used most include…

- Olsen Associates, Inc./CPE (1998) – engineering report
- Olsen Associates, Inc. (2010a) – engineering report
- Olsen Associates, Inc. (2010b) – physical monitoring report
- Olsen Associates, Inc. (2011) – physical monitoring report
- USACE (2003) – engineering report

In addition to specific analyses of county-wide beach changes, the engineering reports Olsen Associates, Inc./CPE (1998) and USACE (2003) include a compilation and synopsis of information and results from numerous past reports by others. Olsen Associates, Inc. (2010a) also includes an evaluation of the long-term county-wide beach change conditions updated with an extensive database compiled between 1998 and 2009. The analyses in this report specifically addresses beach volume change with and without the influence of past beach nourishment efforts. The physical monitoring reports Olsen Associates, Inc. (2010b and 2011), update representative beach and sand bypass rates through 2011. Assessment of these prior reports and analyses suggests the following requirements for future demand for beach sand renourishment in Broward County, as summarized in **Table 1**.

Segment I

Existing Requirement. Given that a comprehensive nourishment project was completed along this Segment I shoreline in 2011, it is assumed that the Segment I shoreline does not have an existing immediate requirement for sand.

Annual and Future Requirement. Two approaches are applied to estimate the long-term sand demand for the Segment I shoreline. The influence and volumetric benefits of sand transport from the north, including sand bypassing at Boca Raton Inlet, are implicitly included in the estimates.

The first approach considers the long-term sand losses for the period from 1993 to 2009 (Olsen Associates, Inc., 2010a). Eliminating the influence of beach fill construction on beach change data, this approach suggests an annual sand land loss rate along the entire Segment I shoreline of about 40,000 cy/yr.

The second approach is based upon a direct comparison of beach change conditions that occurred between 2001 and 2009, after the 1998 beach fill project and before the 2011 project (Olsen Associates, Inc., 2010b). It is assumed that data collected during this period and the resultant beach volume changes are not significantly affected by temporary effects of the 1998 beach fill equilibration or the highly eroded conditions that existed immediately prior to the 2011 beach nourishment project. That is, it is assumed that a sufficient volume sand was in the Segment I system during this period such that the full sand loss potential from the beach is captured by survey. From this approach, it is estimated that the average annual sand loss rate for the entire Segment I shoreline is about 25,000 cy/yr.

Accordingly, it is assumed that the annual sand demand for the Segment I shoreline may range from 25,000 to 40,000 cy/yr. Over a 50-yr period, the expect sand demand for the Segment I shoreline would be up to 2,000,000 cy. It anticipated that most of this will be required between R-6 and R-12.

Segment II

Existing Requirement. The existing requirement for the Segment II shoreline is based upon the scope of the planned Segment II restoration and renourishment project. Based upon 2011 beach conditions and the project scope described in USACE (2003), it is anticipated that the project will include the placement of up to 750,000 cy[1] of sand.

Annual and Future Requirement. USACE (2003) summarizes a detailed assessment of beach changes along the Segment II shoreline for the period from 1983 to 1998 and 1993 to 1998. The 1983 survey, although a reliable survey,

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1 This volume has been adjusted from the required volume of 930,000 cy reported by USACE (2003) to construct the described Segment II project. Between 2001 (the date of the survey used to specific Segment II fill volume requirements) and 2011, the Segment II shoreline, along the planned sand placement areas, gained about 180,000 cy of sand. To prevent encroachment of the Segment II beach beyond that described in USACE (2003), the total required fill volume was revised to reflect the volume change that occurred between 2001 and 2011 and the 2011 beach conditions.

included only that reach of shoreline where the 1983 beach nourishment project was constructed (R-25 to R-53). The 1993 and 1998 surveys included the entire Segment II shoreline. Comparison of these surveys suggest that Segment II as a whole was net accretional. However, there are areas of the Segment II shoreline, specifically R-36 to R-43 and R-51 to R-72, that were persistently erosional. To estimate the amount of sand that may be required in the future to maintain the Segment II beaches, the gross loss of sand from areas that are persistently erosional is used. Using the 1983/1998 (R-25 to R-53) and 1993/1998 (R-53 to R-85) surveys it is estimated that the Segment II shoreline requires about 27,000 cy/yr to maintain beach conditions at desired levels. This may be a conservative prediction because a more recent study of the Segment II shoreline (C. Creed, personal communication, 2012) suggests that the sand loss rate from 2001-2011 has been significantly lower than the historical rates described in USACE (2003). Nonetheless, for determining expected future need for this reach and assigning a range of possible future values, the value reported by USACE (2003) is multiplied by a factor of 1.5 to establish an upper estimate. This reason for this is simply to be conservative with the estimate of future need.

For the purpose of estimating future needs for the Segment II shoreline, it is assumed that the annual demand may vary from between 27,000 and 40,000 cy/yr. Over a 50-yr period, the expect sand demand for the Segment I shoreline would be up to 2,000,000 cy. It is expected that most of the future sand requirements along the Segment II shoreline will be located between R-36 and R-43 (Pompano Beach) and R-53 and R-72 in Fort Lauderdale.

Segment III

Existing Requirement. For this estimate, it is assumed that the completed 2005/06 nourishment project along the Segment III shoreline represents the baseline condition along the Segment III shoreline. An estimate for the amount of sand that may be presently required to bring the Segment III beaches back to the baseline condition was developed by an assessment of the amount of sand that has been lost from the Segment III shoreline since completion of the 2005/06 project – six years ago.

As of April 2011 (5.2 years following project completion and the time of the most recent Segment III monitoring survey), the Segment III project areas had lost 329,700 cy (217,300 cy in JUL and 112,400 cy in Dania Beach/ Hollywood/Hallandale Beach). This is equivalent to about 63,400 cy/yr (41,800 cy/yr in JUL and 21,600 cy/yr in Dania Beach/ Hollywood/Hallandale Beach). Extrapolating to six years post-project, the existing deficit along the Segment III shoreline is estimated to be about 400,000 cy (260,000 cy in JUL and 140,000 cy in

Dania Beach/ Hollywood/Hallandale Beach). Consideration is not given to the 60,000 cy (more or less) of sand placed in southern Hollywood by truck haul from an upland source in early 2012.

<u>Annual and Future Requirement.</u> USACE (2003) summaries a detail assessment of beach changes along the Segment III shoreline. The analysis address changes along the John U. Lloyd Beach State Park (JUL) (R-85.7 to R-93) and Dania Beach/Hollywood/Hallandale (R-98.3 and R-128). These are the only two reaches of shoreline in Segment III where sand has been placed in the past and is expected to be placed in the future. Data between 1989 and 1998 are used to evaluate expected average annual sand loss rates in JUL. This represents a significant post-1989 project period where there is sufficient sand in the beach system such that actual sand loss potential can be evaluated. For the Dania Beach/ Hollywood/ Hallandale Beach reach, the assessment period was 1991 to 1998. Between 1998 and 2005 (pre-2005/06 project construction) it is expected that documented sand loss rates may have been lower than potential rates because of the significant sediment deficit that existed along portions of the Segment III shoreline during that during.

USACE (2003) reports the average annual sand loss rate in JUL to be 53,000 cy/yr. The same for the Dania Beach/Hollywood/Hallandale Beach project reach was estimated to be 77,000 cy/yr.

Since completion of the 2005/06 project (2006-2011), the sand loss rate along the JUL and Dania Beach/Hollywood/Hallandale Beach shoreline has been 42,000 cy/yr and 22,000 cy/yr, respectively (Olsen Associates, Inc., 2011). The observed changes in Dania Beach/Hollywood/Hallandale Beach since 2006 are significantly lower than historical levels (by over 70%) and so that 22,000 cy/yr value may be imprudently low for future planning purposes. Thus, for this assessment, this rate is doubled for the purposes of estimating minimum future need.

Accordingly, it is assumed that the annual sand demand for the JUL reach of the Segment III shoreline may range from 42,000 to 53,000 cy/yr. Over a 50-yr period, the expected sand demand for the Segment III shoreline would be up to 2,650,000 cy. It anticipated that most of this will be required between R-85.7 and R-93.

For the Dania Beach/Hollywood/Hallandale Beach shoreline, it is assumed that the annual sand demand may range from 44,000 to 77,000 cy/yr. Over a 50-yr period, the expect sand demand for the Segment III shoreline would be up to 3,850,000 cy. It anticipated that most of this will be required between R-98.3 and R-128.

SUMMARY

The future annual sand demand for the entire Broward County shoreline (Segments I, II, and III) is expected to be 210,000 cy/yr. Over a 50-yr period, the total estimated demand would be 11,650,000 cy, including 1,150,000 cy required to address current needs. In the event sand bypassing is implemented at Port Everglades Inlet, the 50-yr sand requirement for Broward County would be reduced to 8,650,000 cy.

Table 1: Summary of estimated current and expected future sand nourishment needs for the Broward County, Florida Atlantic Ocean shoreline.

Broward County, Florida — **4/19/2012 (Revised 8/16/2012)**

Projected Sand Requirement over next 50 years (Current and Future)

Name	Sponsor/ Agency	Initial Construction Date	Monument Range	"L" Length of Nourishment (ft)	"CR" Estimated Current Requirement (cy)	"AD" Estimated Annual Sand Demand (cy/yr)	"FD" = AD x 50 Estimated Future Demand Over 50 Years (cy)	"CR + FD" Estimated 50-yr Requirement (cy)	"FD/50/L" Estimated Requirement Per Year Per Linear Foot (cy/yr/ft)	Basis of Estimate	Comments
Segment I	Towns of Deerfield and Hillsboro Beach	1970	R6 to R14	6,000	0	40,000	2,000,000	2,000,000	6.7	Surveyed Beach Change (1993-2009) *(Reliable period prior to 2011 nourishment project. Effects of 1998 nourishment eliminated from estimate.)*	Future sand placement is expected to occur mostly only along Hillsboro Beach between R6 and R14
Segment II	Broward County/USACE	1970	R25 to R72	46,200	750,000	40,000	2,000,000	2,750,000	0.9	Surveyed Beach Change (1983-2011) *(Post-1982 dredge improvements for Hillsboro Inlet sand bypass)*	Estimated annual sand demand is inclusive of localized gross losses and not net beach volume change. Future sand demand is expected to be stable or reduced due to benefits from sand bypassing at Hillsboro Inlet
Segment III (John U. Lloyd)	Broward County/ USACE/FDEP	1979	R85.7 to R93	7,300	260,000	53,000	2,650,000	2,910,000	7.3	Surveyed Beach Change (1989-2011)	It is expected that sand bypassing at Port Everglades could reduce the annual sand demand to 13,000 cy or less
Segment III (Hollywood/ Hallandale/ Dania)	Broward County/USACE/ Cities of Hollywood/ Hallandale Beach	1971	R99 to R128	30,300	140,000	77,000	3,850,000	3,990,000	2.5	Surveyed Beach Change (1993-2011)	
Total					1,150,000	210,000	10,500,000	11,650,000			Could be reduced to 8,650,000 if sand bypassing at Port Everglades is implemented.

Notes:
1) It is assumed that future nourishment activities in Broward County will be limited by the presence and required protection of nearshore hardbottom resources.
Accordingly, future sand requirements will be specfied to mostly maintain established conditions and not result in significant widening of beach conditions beyond historical extents.

REFERENCES

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9.5 Needs Determination: Miami-Dade County, FL

Dade County, FL

Sand Needs Evaluation for Beach Nourishment

A component of the:

Southeast Florida Sediment Assessment and Needs Determination (SAND) Report

Submitted to:
Florida Department of Environmental Protection
Bureau of Beaches & Coastal Systems
Tallahassee, FL

Prepared by:
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Date
1 June 2012

Executive Summary

The purpose of this report is estimate the volume of sand required to maintain Miami-Dade County's beach renourishment projects over the next 50 years. The present and future needs of all of Miami-Dade County's projects will be included in this estimate, including the two segments of the Dade County Beach Erosion Control and Hurricane Protection (BEC & HP) Project, and projects along the barrier islands of Fisher Island, Virginia Key, and Key Biscayne. This estimate will be used in conjunction with similar estimates of the sand needs of Martin, St. Lucie, Palm Beach, and Broward counties to determine the volume of sand needed over the next 50 years to sustain all of southeast Florida's Federal and non-federal beach nourishment projects. Ultimately, the estimated renourishment needs of this region will be compared to the total volume of sand available from borrow sources. This comparison will be accomplished through the Southeast Florida Sediment Assessment and Needs Determination (SAND) Report, a joint effort led by the Florida Department of Environmental Protection and supported by the southeast Florida counties and the U.S. Army Corps of Engineers.

The projected 50-year renourishment requirements for all of Miami-Dade County's beach nourishment projects are summarized in the table below. The table briefly describes the fundamental assumptions associated with each estimate. Additional detail on the study methodology is provided in the following pages and in the documents referenced at the end of this discussion. The table below includes both the current sediment need (such as a pending construction project, or initial project nourishment requirement) and the estimated future renourishment volume required over the next 50 years.

MIAMI-DADE COUNTY, FL											
Projected Sand Requirement over next 50 years (Current and Future)											
						Estimated Future Annual Sand Demand *not including current requirement					
Name	Sponsor/Agency	Initial Construction Date	Monument Range	Length of Nourishment (ft)	"C" Estimated Current Requirement (cy)	"R" Estimated Rate (cy/yr)	"F"= R x 50 Estimated Future Demand Over 50 Years (cy)	"C + F" Estimated 50-yr Requirement (cy)	"(C + F)/50/ft" Estimated Requirement per Year per Linear Foot (cy/yr/ft)	Basis of Estimate	Comments
Sunny Isles	Miami-Dade County	1988	R7 - R19.3	12,300	465,500	50,000	2,500,000	2,965,500	4.8	Surveyed Beach Change (2005-2011)	Analysis limited to post-breakwater (2002) period only.
"Main Segment" : Gov Cut thru Haulover Park	Miami-Dade County	1975	R19.3 - R74	54,700	1,301,800	205,000	10,250,000	11,551,800	4.2	Surveyed Beach Change (2005-2011)	Assumes Contracts "E" and "G" partially fulfill Current Requirement
Fisher Island	Private	1991	R75 - R78	3,000	0	520	26,000	26,000	0.2	AE Consultant	Any future renourishments are assumed to be of aragonite.
Virginia Key	Miami-Dade County (de-authorized Federal Project)	1969	R79 - R88	11,000	0	0	0	0	0.0	Miami-Dade County	Extensive nearshore seagrass limits any future construction. Minimal erosion; few upland structures to protect.
Key Biscayne	Miami-Dade County	1969	R89 - R110	21,000	25,000	8,000	400,000	425,000	0	Miami-Dade County	Extensive nearshore seagrass limits any future construction. Erosion rates have historically been low on Virginia Key.
Total					1,792,300	263,520	13,176,000	14,968,300			

Main Report

Introduction and Project Status

Sand borrow areas offshore of Miami-Dade County are nearly depleted, and a search is currently underway to find acceptable alternative borrow sources to sustain the Miami-Dade County shore protection program into the future. In support of this effort, an analysis was conducted to determine the erosion rates that are currently affecting the various project segments. These rates were then projected forward in time to estimate the total future sediment requirements of the projects over the next 50 years, using 2012 as the baseline year. The full length of the Miami-Dade County Atlantic shoreline is shown in figure 1 below, including the limits of the Federal Beach Erosion Control & Hurricane Protection (BEC & HP) project and the barrier islands of Fisher Island, Virginia Key, and Key Biscayne. The boundary of all previously-used offshore borrow sources is also shown.

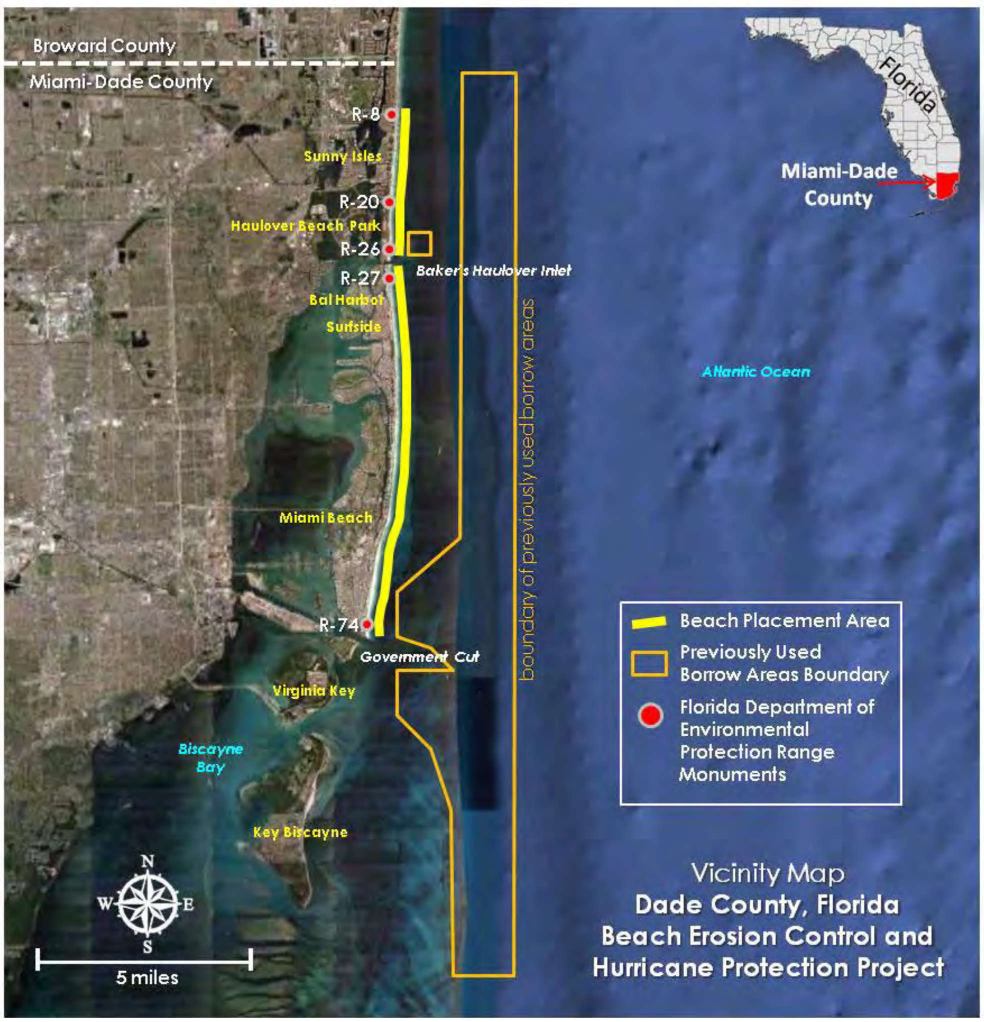


Figure 1: Miami-Dade County shoreline, project areas, and boundary of previously used offshore borrow areas.

The Federally-authorized Dade County BEC & HP project is by far the largest beach renourishment project in Dade County. This project was constructed in two main segments, described as follows :

- The first ("main") segment extends from Government Cut northward through Haulover Beach Park, covering a distance of 10.7 miles. Construction of this segment began in 1975.
- The second segment spans the 2.4-mile length of Sunny Isles, beginning immediately north of the "main" segment. Construction of this segment began in 1988.

The beach renourishment projects on Fisher Island, Virginia Key, and Key Biscayne are much smaller in scope, and are renourished very infrequently, or not at all.

Data, Methodology, and Period of Analysis

Historical volumetric change rates of the beaches have been developed from periodic monitoring surveys of the beach. These historical erosion rates are then used to predict future erosion rates along the length of Miami-Dade County. Periodic monitoring surveys (of varying scopes) have been performed since well before construction of the Federal BEC & HP project. However, not all of these surveys are still applicable to present-day conditions along the project, for a variety of reasons.

Construction of the Federal project beginning in 1975 changed the littoral environment to such a large degree that surveys taken prior to 1975 will be excluded from this analysis. Stabilizing structures have been added in some areas over the years, further changing the patterns of sediment movement within the project. The most recent structures were added from 1999 - 2002, and have altered sediment flow within the Federal project to the point that surveys taken prior to 2002 no longer accurately represent present-day conditions, at least in the vicinity of the structures. The severe storms of 2004-05 resulted in the movement of large volumes of material over a short time period, and may represent the upper boundary of sediment movement along the Miami-Dade County coastline. These values were, however, included in this analysis in order to capture the effects of low-frequency events, and to be consistent with the methodologies used for determining the future sediment needs of the other southeast Florida counties.

In general, three different approaches will be taken in an effort to evaluate all relevant data towards the goal of establishing projected future erosion/renourishment rates. The first two methods do not fully account for the effects of the 2004-05 storms; the third method does include these storm effects. The first method excludes the period prior to 2002 from this analysis because of the significant structural modifications to the project as summarized above, and the survey interval 2005–2011 remains as the primary dataset. Although relatively short, this dataset best represents the project in its current condition for the reasons discussed above, although it includes some rebounding effects from the 2004-05 storms. The survey profiles used in this analysis extend seaward for a distance of about 3,000 feet from each DNR survey monument along the Miami-Dade County shoreline, but volume computations are limited to landward of the depth of closure, which is typically in the 15-20 foot depth range. A second method will be to selectively examine older datasets. In several areas of the project the structural additions that alter 'historic' littoral processes are some distance away and should have minimal effect. The examination of older survey databases can, in these cases, provide additional data to support a particular choice of erosion rate. Finally, the volume required to reconstruct select project segments can be calculated to establish a third erosion rate. This method examines the erosion of each project segment since its last renourishment. The volume eroded from the construction template is determined by comparison of that construction template with the most recent (2011) survey, then divided by the number of years since the renourishment. The erosion of a particular project segment since the previous renourishment can be assumed to be a repeatable process, and the measured loss of material from the segment can be used to establish a projected future erosion rate. In many ways this provides the best long-term measure of erosion rates along each project segment due to the long timeframe involved, since the most recent renourishment for the purposes of this analysis was in 2003 (2012 renourishment events are excluded). Since this method spans the period of structural alteration of the project (1999-2002) in some areas, the resulting values must be weighted accordingly. Note that this analysis will include all effects from the 2004-05 storms for each project segment.

Assumptions

It is assumed that the measured shoreline changes over the period from 2005-2011 best represent the performance of the Miami-Dade County shoreline in its present configuration. No additional erosion control structures were added during this period, and minimal beach renourishments were placed.

Analysis

Calculation of Annual Sand Demand. A detailed analysis of each segment of the Dade County BEC & HP project was conducted in a recent investigation conducted by the Jacksonville District, Corps of Engineers (reference 1). The methodology used in reference 1 is briefly described in the previous sections of this discussion. In this analysis, survey data from each individual segment of the project was examined, and an average annual erosion rate was established for each of the following sections of the Dade County BEC & HP project, proceeding from north to south : Sunny Isles, Haulover Park, Bal Harbour, Surfside, and Miami Beach. The project was broken up into these segments to better capture the localized differences in performance that exist along these areas.

A summary of the resulting projected future annual erosion rates from reference 1 are provided in the following table, and a brief explanation of the data and methodology used to derive each of these values is provided in the following narrative. The full analysis used to establish these erosion rates is too lengthy to be included in its entirety in this report, and can be reviewed in reference 1.

Projected Future Erosion Rates*	
Segment of Shoreline	Projected Future Erosion Rate (cy/yr)
Sunny Isles	50000
Haulover Park	30000
Bal Harbour	30000 **
Surfside	45000
Miami Beach	100000
TOTAL :	255000

* within limits of Federal project, from ref. 1

** excludes material from Haulover ebb shoal

This table summarizes the projected annual volume of material required for placement north of Government Cut. Note that the northernmost community in Miami-Dade County, Golden Beach, is excluded from this analysis. Golden Beach is not part of the Federal project, and no non-Federal beach renourishments are conducted along this segment of shoreline. But because Golden Beach is located adjacent to two large-scale Federal beach erosion control projects (Broward County BEC to the north and Dade County BEC to the south) material infills naturally to this region, and this community has never required any fill placement to maintain a stable beach. This situation is expected to continue for the next 50 years, and no fill placements are projected for Golden Beach during that time. The derivation of the rates for each of the remaining communities along the Miami-Dade County BEC & HP project are briefly described :

Sunny Isles : The Sunny Isles segment of the Dade County BEC & HP project was initially constructed in 1988, and limited portions of Sunny Isles have been renourished in 1990, 1994, 1997, 1998, and 1999. Most of these maintenance events have been concentrated near the north end of the project because of rapid erosion due to end losses. In order to reduce these losses a breakwater was constructed along northern Sunny Isles in 2002 and the full length of Sunny Isles was renourished at that time. This solution proved highly effective and no additional fill placement has been required since construction of the breakwater and beach fill in 2002. The most recent monitoring surveys (taken in April 2011) show that the Sunny Isles segment is eroding at a much slower rate than in the pre-breakwater era, and that renourishment of this segment will very likely not be required for several more years.

An analysis of monitoring survey data for Sunny Isles was conducted in order to calculate past erosion rates, which may be applicable to projecting future project needs. The selected datasets represent project performance in the post-breakwater era only, since construction of this structure completely altered historic erosion rates and sedimentation patterns along much of the Sunny Isles shoreline. These “post-breakwater” surveys were taken in 2005, 2007, 2009, and 2011.

The measured volumetric change rates along Sunny Isles are highly variable. Annual change rates vary from a low of -105,656 cy/yr (from 2005-2007) to a high of +238,034 cy/yr (from 2007-2009). The overall longterm erosion rate along the 2.5-mile length of Sunny Isles as measured between 2005-2011 is -9,881 cy/yr. This rate appears unreasonably low to use as a basis of future volumetric projections. The calculated 2005-2011 rate includes only a part of the erosional effects of the unusually severe hurricane seasons of 2004-05, but it includes all of the period of post-storm recovery, and may therefore underestimate the 'true' ongoing erosion rate.

As an alternative analysis, losses from the 2001 beach fill were calculated based on the April 2011 beach profile survey. From this survey, losses from the 2001 construction template equaled -415,490 cy along the full length of Sunny Isles. Based on the 9.5-year interval between construction and survey, the calculated average annual change rate is -43,736 cy/yr. This value is higher than the long-term rate calculated above (2005-2011) in part because it fully includes the effects of the 2004-05 storms.

To briefly summarize, volumetric change rates along Sunny Isles have proven to be extremely variable, ranging from highly erosive to highly accretionary, depending on the time interval examined. For the most part, erosion rates tend to be low (less than -10,000 cy/yr) along Sunny Isles, but are occasionally much greater (more than -100,000 cy/yr). A weighted average will be assumed in order to approximate the most realistic value possible, and in an attempt to smooth out the extreme fluctuations observed in some of the monitoring data, while remaining (reasonably) conservative in estimating future beach fill needs. A value of -50,000 cy/yr is selected based on the data presented above. This value best approximates the amount of actual erosion measured along the limits of the most recent (2001) beach fill, over a relatively long (9.5 year) period. Since the effects of the storms of 2004-05 are included in the calculation of this value, -50,000 cy/yr should present a fairly conservative estimate of future erosion rates along Sunny Isles through the remaining years of the project life.

Haulover Park : Haulover Park has historically been one of the least-erosive areas of the Dade County BEC & HP project. This segment was initially constructed in 1978, and even during initial construction the volume of fill placed was only 300,000 cy along the 1.1-mile length of this segment. Two small-scale renourishments (less than 50,000 cy each) were performed in 1980 and 1984 using material dredged from the adjacent Federal navigation channel at Bakers Haulover Inlet. One relatively large-scale renourishment (235,000 cy) was performed in 1987 and this segment of the project has not required renourishment since.

Volumetric changes were calculated along Haulover Park based on the 2005, 2007, 2009, and 2011 surveys. The annualized volumetric changes for the three corresponding survey intervals were -65,488 cy/yr, +65,165 cy/yr, and +28,770 cy/yr, respectively. The average annual volumetric change between 2005 and 2011 was a net accretion of +11,838 cy/yr. Except for the 2005-2007 interval, all survey intervals show accretion along this reach. The 2005-2007 interval was likely influenced by the hurricanes of 2005; this erosion rate is not indicative of the long-term performance of this project segment and should not be weighted heavily in establishing longterm future volumetric projections. Neither should the accretionary values during the other time periods be used, other than to provide a verification that the erosion along Haulover Park tends to be low, relative to the other parts of the Project.

As an alternative analysis, an examination of older survey data from the 2001 Evaluation Report was conducted for comparison purposes. Based on survey data from 1990-2000, a measured erosion rate of -5,436 cy/yr is calculated along Haulover Park. As with the more recent survey analysis presented above, there is a great deal of variation in erosion rates within this 10-year period, depending on the survey interval selected.

Finally, another point of view was gained from an examination of the current condition of the project (April 2011 survey) versus the construction template, which shows that little or no fill is required to reconstruct the construction template along this reach at this time. This construction template was last filled in 1987 with the placement of 235,000 cy. If it is assumed that this segment erodes in the next few years to the point where renourishment was required, an erosion rate could be established based on the volume required to rebuild the same template, and the time interval between renourishments. Based on the present state of the project this scenario appears unlikely, so this analysis would present a "worst-case" scenario for this segment of the project. Assuming a renourishment project in 2015, a time interval of 28 years would exist between subsequent renourishments. Further assuming the renourishment values would be about the same as in the 1987 project, 235,000 cy would be replaced. The resulting erosion rate is therefore calculated to be -8,400 cy/yr. Note that under this assumed scenario this value, although quite low, still includes the effects of the 2004-05 storms.

In order to remain conservative, the volumes developed in this section are averaged between the 'low' values in the -10,000 cy/yr range and the one 'high' value from the 2005-07 interval (-65,488 cy/yr). The resulting rounded average will be around 30,000 cy/yr. Again, there is no historical evidence to support such a high value as a long-term erosion rate, but in the interests of providing a conservative estimate of future sediment needs this value is adopted for Haulover Park because it has been shown to be within the range of possible erosion values.

Bal Harbour : Bal Harbour was the first segment of the Dade County BEC & HP project to be constructed. Initial construction was completed in 1975, and this segment has remained one of the most rapidly-eroding segments of the project to date. This is primarily due to its location on the south side of Bakers Haulover Inlet. The inlet interrupts the predominantly southward flow of sediment, creating a sediment deficit along the Bal Harbour shoreline.

As with the analyses of other segments along the Federal project, volumetric changes were measured along Bal Harbour based on the 2005, 2007, 2009, and 2011 surveys. The annualized volumetric changes for the three corresponding survey intervals were -48,426 cy/yr, -12,188 cy/yr, and -28,426 cy/yr, respectively. The average annual volumetric change between 2005 and 2011 was a net erosion of -32,310 cy/yr. These volumetric changes fall within a much more narrow range than the rates from the previously analyzed project segments. Rates tend to average to the -30,000 cy/yr range, with the highest value (-48,426 cy/yr) measured between 2005-2007.

A check of older erosion rates from the 2001 Evaluation Report was conducted for comparison purposes. Based on survey data from 1990-2000, a 10-year average erosion rate of -54,602 cy/yr was measured. More variation between the individual survey intervals was noted with this older database than with the newer (2005-2011) database.

As a final check the volume that would be required to reconstruct the 2003 construction template along Bal Harbour was calculated. A total of 332,513 cy would be required, based on analysis of the April 2011 survey. Adding in the 33,000 cy placed in 2010 and averaging this volume over the 8-year period that it took to erode, an annual erosion rate of -45,689 cy/yr is calculated. Since the baseline year for computation of this erosion rate is 2003, this value includes the effects of the 2004-05 storms.

The three rates calculated from three different databases/methodologies are more internally consistent than the rates observed north of Bakers Haulover Inlet. In general, approximate rates of 30,000, 45,000 and 55,000 are calculated. In order to be conservative for future renourishment needs the ‘high’ rate is rounded upwards and an annual erosion value of -60,000 cy/yr is selected for Bal Harbour. This conservative estimate is adopted for this segment because Bal Harbour has historically been, and continues to be, one of the most highly-erosive regions of the project.

Unlike other regions of the project, Bal Harbour is periodically renourished using a local, naturally-replenishing borrow area. The ebb shoal at Bakers Haulover Inlet intercepts a large portion of the southbound littoral sediment that bypasses around Bakers Haulover Inlet. This large shoal is periodically dredged and material placed along the downdrift shoreline at Bal Harbour. Long-term monitoring surveys have shown that this shoal consistently accretes at an average rate of 30,000 cy/yr. It has been estimated that this shoal could be used once every 10 years to supply 300,000 cy of material to the Bal Harbour shoreline. This was in fact accomplished in the 2003 Bal Harbour renourishment, and is proposed again for the 2012 “Contract G” renourishment of Bal Harbour. The periodic use of the Bakers Haulover Inlet ebb shoal effectively reduces the sediment requirement of Bal Harbour from outside sources, from 60,000 cy/yr to 30,000 cy/yr.

Surfside : Surfside is located between two of the most highly-erosive areas of the Dade County project : Bal Harbour and northern Miami Beach. In spite of this location Surfside has historically performed very well, in part because it receives substantial nourishment from the predominantly southward transport of sediment from Bal Harbour to the north. The Surfside segment of the Project was initially constructed in 1978, and has only been renourished once, in 1999.

Volumetric changes were measured along Surfside based on the 2005, 2007, 2009, and 2011 surveys. The annualized volumetric changes for the three corresponding survey intervals were -34,774 cy/yr, +5,323 cy/yr, and -27,326 cy/yr, respectively. The average annual volumetric change between 2005 and 2011 was a net erosion of -22,105 cy/yr. As with the other project segments, the 2005-07 interval represents the highest erosion rates measured during this period of analysis. These erosion rates show more variability than those observed at Bal Harbour, with some accretion observed in the 2007-2009 interval.

The older erosion rates from the 2001 Evaluation Report were examined for comparison. Surfside is located approximately midway between the structures added in 2001 and 2002. This represents a minimum distance of several miles, and littoral processes in the area should be largely unaffected by those structures. Based on survey data from 1990-2000, an erosion rate of -43,228 cy/yr was measured along the length of Surfside. Less variability in volumetric change values occurred across the 1990-2000 time interval than across the 2005-2011 interval.

The project was renourished to its full construction template during the only renourishment of this area, which was performed in 1999. As a final check, the volume that would be required to reconstruct the 1999 construction template along Surfside was calculated. A total of 414,051 cy would be required, based on the April 2011 survey. Averaging this volume over the 12-year period that it took to erode, an erosion rate of -34,504 cy/yr is calculated. Note that this value includes the storm years of 2004-05.

Based on the foregoing discussion an erosion rate of -45,000 cy/yr is selected for future volumetric projections along Surfside. This rate represents only a slight rounding-up of the measured erosion rate from the 1990-2000 survey analysis, and is justified because the Surfside shoreline has proven to be relatively stable over time. This segment of the Project remains in relatively good condition today, even though it was last renourished 12 years ago.

Miami Beach : Miami Beach is the longest segment of the project, at a length of about 7.5 miles. This is also the most complex region, because of the variety of the coastal environment (and the littoral characteristics) along its length. Much of the region is moderately erosional, some areas are relatively stable, other areas are very highly erosional, and still other areas are consistently accretional.

The entire southern reach of the project is consistently accretional and can be completely excluded from any consideration of ever requiring any future beach renourishments. Sediment is transported predominantly from north to south along the Dade County shoreline, and the southern reach of the project forms a large embayment that tends to function as an impoundment basin. Southbound sediment is transported into this area and is blocked from further southward transport by the north jetty at Government Cut (Miami Harbor entrance). These jetties also block wave energy from the south, preventing the northward transport of material out of the area.

The breakpoint between the erosive area and the accretional area is located near survey monument DNR-65. This monument is located about 2 miles north of the southern end of the project. Therefore, of the 7.5-mile length of the Miami Beach segment, the southern 2 miles are consistently accretional and the northern 5.5 miles are consistently erosional. Since the accretional southern reach will not contribute to the future sediment requirements of the Dade County BEC & HP project, it will be eliminated from the remainder of this analysis. It is acknowledged that this southern sub-reach has in the past been used as a source of borrow material in backpassing operations, and may occasionally be used as a limited borrow source in the future. At the present time it appears that due to a variety of political and environmental reasons, its future use is uncertain and it will not be included in this analysis as a sediment source.

The 5.5-mile reach of Miami Beach north of DNR-65 is erosional to varying degrees, and constitutes the region of interest in calculating future sediment needs along the Miami Beach segment of the Dade County BEC & HP project. Several erosional hotspot areas have been known to exist along this reach, including the 63rd and 32nd St regions. The areas between hotspots are generally stable to moderately erosional. In order to calculate future sediment needs, volumetric changes over the 2005-2011 period were calculated as in the preceding analyses.

Erosion rates during this period were highly variable, both spatially and temporally. The longterm volumetric change rate, averaged over all time periods over the full length of the northern reach of Miami Beach, is only -520 cy/yr. However, this negligible rate can be misleading : areas of high erosion are balanced by areas of low erosion or accretion. In practice, material tends to be transported out of the hotspot areas (due to wave energy focusing and other factors discussed in the 2001 *Evaluation Report*) and deposited in the regions between the hotspots. These “between-hotspot” areas tend to erode slowly or not at all.

There is reason to assume that this situation will change in the near future however. Construction of the Section 227 Reefball breakwater at 63rd St (R-46) in 2013 will reduce erosional losses along the northernmost of the Miami Beach hotspot areas. And according to survey data and field observations by the local sponsor, the erosional region south of the 32nd St breakwaters may finally be beginning to stabilize as natural bypassing of the structure has finally begun. Within the hotspot areas, the annual erosion rates amount to a total of -28,300 cy/yr during the 2005-2011 survey interval. This value will be rounded upward to 30,000 cy/yr, and applies to the hotspot areas only.

The areas between the hotspots are much more stable, primarily because material eroded from the hotspots constantly renourishes these areas. Selectively choosing only erosive values and omitting accretionary values from the survey database yields an annual erosion rate of -5,400 cy/yr. It is suspected that this value may be unreasonably low, based on historic knowledge of the project’s performance.

An examination of the older databases show that erosion rates from the 1997 CSI sediment budget provide an annual erosion rate of -33,000 cy/yr, and this value includes ‘hotspot’ erosion as well as the regions adjacent to the hotspots. This CSI dataset is based on survey data from 1980-1996, a period of time prior to construction of the 32nd Street breakwaters. The values presented in this study would tend to corroborate the low erosion values observed along the areas between hotspots in the 2005-2011 database. An update to this CSI analysis was performed in the 2001 Evaluation Report. Based on surveys taken between 1990 and 2000, an annual erosion rate of -203,100 cy/yr was measured along the northern reach of Miami Beach. This higher value does include the effects of Hurricane Andrew and does include the erosional hotspots, but the large difference between these datasets is still difficult to reconcile. The most prudent option may be to perform a weighted average of these values, which yields an annual erosion rate of – 98,400 cy/yr. This value will be rounded up to -100,000 cy/yr for the purposes of future volumetric projections. These rates were calculated along the entire northern sub-reach of Miami Beach, and include the “hotspot” areas, which were calculated separately in the discussion above. The annual erosion rate of the “hotspot” areas (-30,000 cy/yr) must be removed, resulting in a net annual future projected erosion rate of (100,000 – 30,000) = 70,000 cy/yr along the segments of northern Miami Beach between the hotspot areas. The “hotspot” and “non-hotspot” areas are treated separately in this analysis mainly because of the different frequencies of renourishment required for each region.

The third methodology was applied to the Miami Beach segment of the project as follows : The volumes required to re-construct the construction template were calculated at each DNR monument, relative to the 2011 survey. The number of years that have elapsed since the last construction was determined, at each DNR monument. This segment of the project was constructed in five separate contracts and portions of this segment were renourished by the Corps of Engineers at four different times, so the resulting time intervals since the last renourishment were highly variable along the Miami Beach segment of the project. The first construction event occurred in 1978 and the most recent renourishment event occurred in 2001, so in every case the storms of 2004-05 are included in this period of analysis. By dividing the volume required to reconstruct the design template by the number of years that have elapsed since the template was last constructed at each DNR monument, annual erosion rates were calculated as -42,480 cy/yr along the “hotspot” areas, and -26,450 cy/yr along the “non-hotspot” areas. The total volume of material required annually according to this analysis is therefore 68,930 cy/yr. The bottom-line value of 100,000 cy/yr as determined in the analysis in the preceding paragraph is far more conservative, and is adopted for use along the Miami Beach segment of the project.

Calculation of Present Sand Need. Once the annual projected future erosion rates were calculated for each reach of shoreline, the volumes of sand currently required to renourish each corresponding reach of the project were added, to determine the total sand requirement for each segment of the shoreline. Based on the most recent county-wide monitoring survey (April 2011), the volumes currently required to renourish heavily eroded sections of the Dade County BEC project were calculated. These values were then adjusted to the assumed baseline year of 2012 and are summarized in table 1, under the column titled “Estimated Current Requirement”. For example, analysis of the 2011 survey showed that 415,500 cy was required for renourishment of the Sunny Isles segment of the BEC project. Accounting for continued erosion from the 2011 survey to the baseline year of 2012, the adjusted renourishment volume is calculated as 415,500 cy + (50,000 cy/yr x 1 year) = 465,500 cy.

Similarly, for the “Main Segment” of the project a volume of 1,647,800 cy was calculated based on the 2011 survey. Adjusting this value for erosion between 2011 and 2012 yields a value of 1,647,800 cy + 205,000 cy/yr = 1,852,800 cy. Of this volume, a total of 281,000 cy was placed along Miami Beach during the construction of “Contract E” in 2012, and 270,000 cy is planned to be placed along Bal Harbour during the construction of “Contract G” in late 2012. This reduces the volume of sediment currently required for maintenance to the ”Main Segment” of the project to 1,301,800 cy.

The volume of material required to maintain the Dade County BEC & HP project represents the greatest sediment requirement along the County’s shoreline. However, in an effort to provide a comprehensive estimate of future sediment needs in Miami-Dade County, the shorelines along the three barrier islands south of Government Cut will be included in this analysis as well. Fisher Island, Virginia Key, and Key Biscayne have all received beach fill placements in the past. None of these areas are currently active Federal projects, but may require some degree of periodic renourishment in the future. Future beach fill needs in these areas will be based on past performance, similar to the methodology used to estimate future needs for the Dade County BEC & HP project.

Fisher Island is a private community located immediately south of Government Cut. A privately-funded beach fill was constructed along its eastern shoreline in 1991, using approximately 26,000 cy of aragonite from a Bahamian source as the fill material. A small second beach was constructed immediately to the south using an additional 2,000 cy +/- of Bahamian aragonite. The project has eroded very little since construction, and the engineering consultant for this project estimates that the annual erosion rate is about 5,200 cy every 10 years, or 26,000 cy over the 50-year period of analysis (reference 2).

Virginia Key is located immediately south of Fisher Island. The eastern shoreline of Virginia Key is the site of a now-deauthorized Federal beach erosion control project. This shoreline is heavily armored with groins and as a result erosion rates are very low. Miami-Dade County advises that no fill placements have been made since deauthorization, and no future placements are planned or needed at this time. In addition, any potential fill placement would be minimal due to extensive seagrass growth in the nearshore zone along Virginia Key. Miami-Dade County has estimated that the future sediment need along Virginia Key over the next 50 years is zero. The volume of placement projected in the Southeast Atlantic Regional Sediment Management Plan (reference 3) is in agreement that no sediment will be placed along Virginia Key in the next 50 years.

Key Biscayne is located south of Virginia Key, and is the most southerly barrier island along Miami-Dade County. As with Virginia Key, any fill placements along Key Biscayne are minimal due to extensive seagrass growth in the nearshore zone. Miami-Dade County advises that in 2012 a locally-funded renourishment project will place 25,000 cy of fill from an upland sand mine along portions of the Key Biscayne shoreline, the first such renourishment since 2003. The volume of future placement projected in the Southeast Atlantic Regional Sediment Management Plan (reference 3) is 121,000 cy every 15 years, equating to an average erosion rate of about 8,000 cy/yr.

Summary

In the preceding analysis average annual erosion rates were established for each project segment along the Miami-Dade County shoreline. These erosion rates were used as a basis to determine future renourishment needs for the next 50 years along each segment of the Miami-Dade County shoreline. The result of this analysis is the summary table at the beginning of this document, which provides the volumes required for placement along each segment of the Miami-Dade County shoreline over the next 50 years.

The values in this summary table represent the volumes required <u>*as measured on the beach*</u>. The corresponding volumes <u>*required at the borrow area*</u> will typically be about 30 percent greater. Based on this conservative loss rate between borrow area and fill area the total volume of borrow material required <u>*at the borrow source*</u> to maintain the Miami-Dade County shoreline over the next 50 years is 14,968,300 cy x 1.3 = 19,458,800 cy.

References

1) 2012 Fact Sheet : “Volume Projections through End of Project Life, Dade County BEC & HP Project”, March 2012.

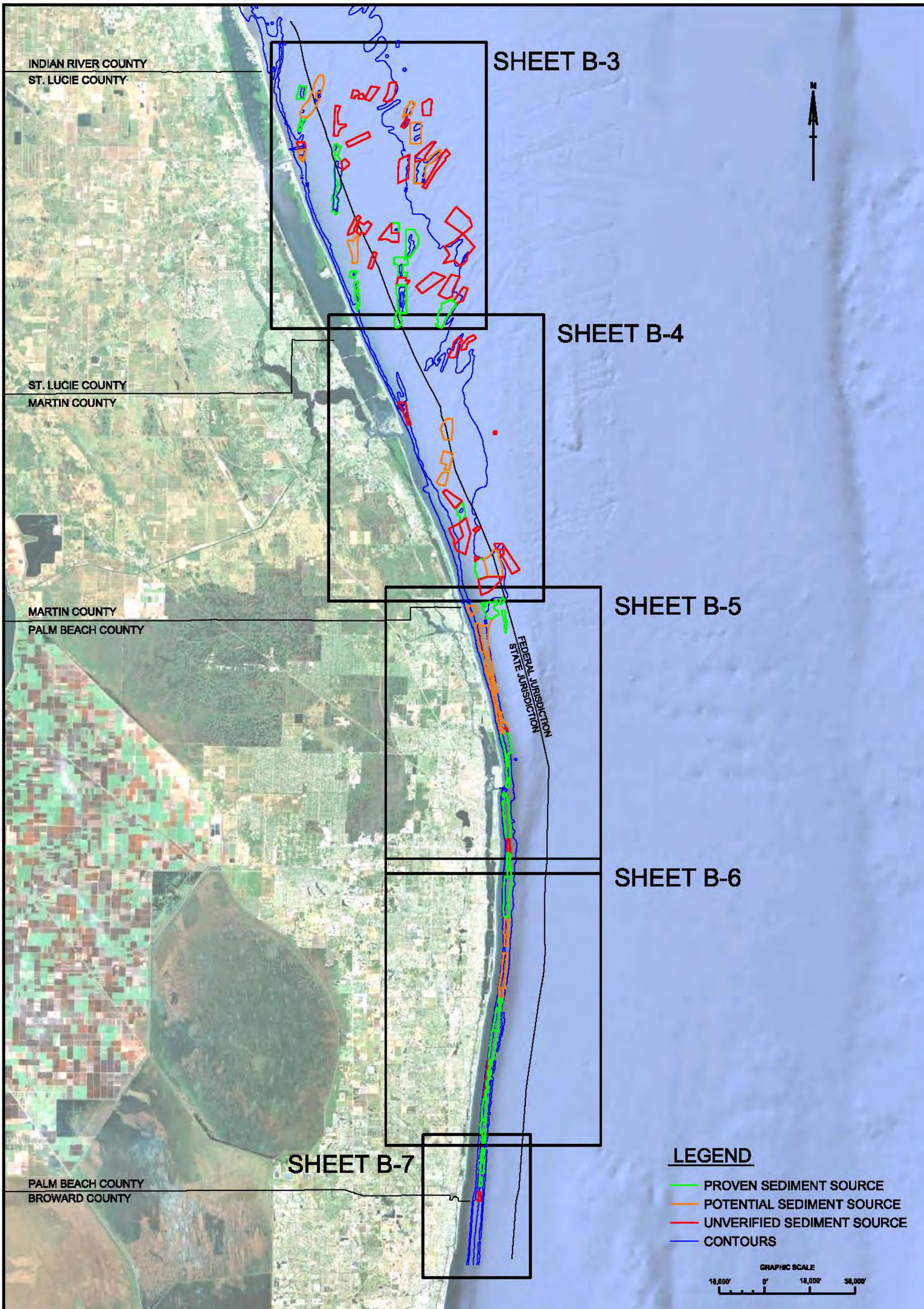
2) Dr. Kevin Bodge, Olsen Associates Inc, personal communication, March 2012.

3) Southeast Atlantic Regional Sediment Management Plan for Florida, Final Report, Jacksonville District, U.S. Army Corps of Engineers, July 2009.

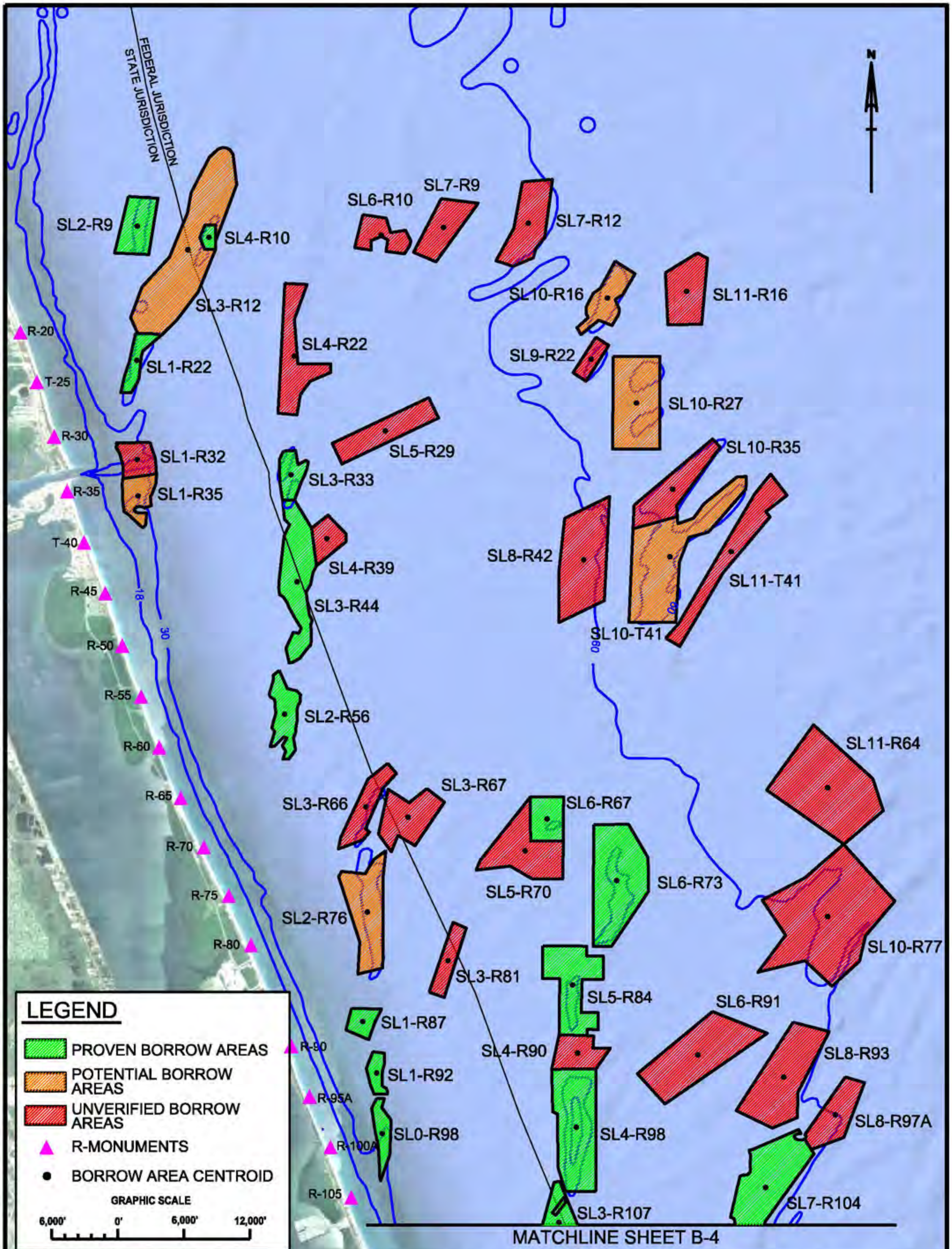
4) Dade County, Florida, Beach Erosion Control & Hurricane Protection Project, Evaluation Report, Jacksonville District, Corps of Engineers, October 2001.

5) Dade County Regional Sediment Budget, Coastal Systems International, Inc, Coral Gables, Florida, January 1997.

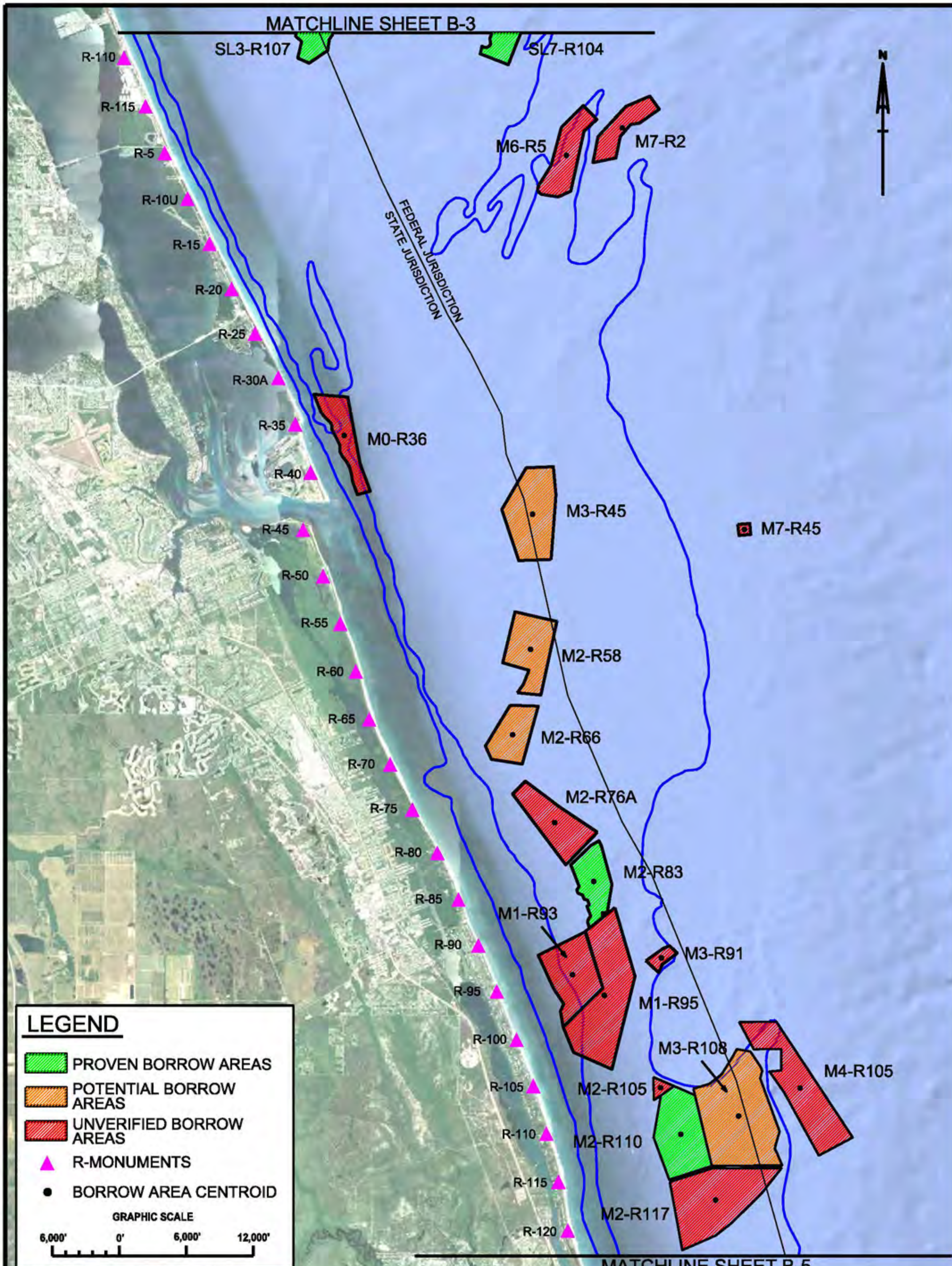
10.0 SEDIMENT SOURCE CALCULATION SHEETS



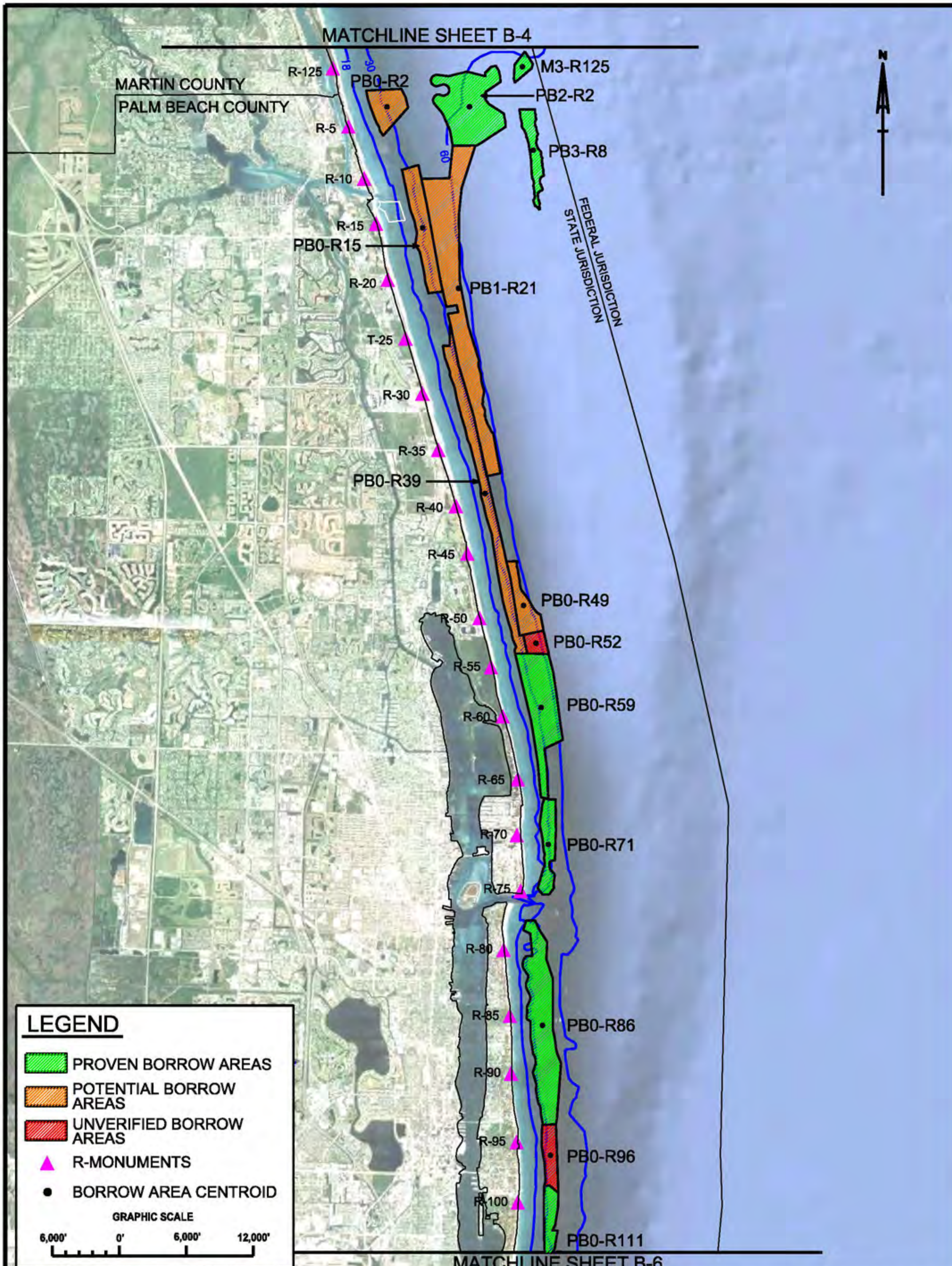
US Army Corps of Engineers Jacksonville District	GEOTECHNICAL DRAWINGS	Dsn by: JDO Dwn by: CJB	MARTIN, ST. LUCIE AND PALM BEACH COUNTY, FLORIDA SOUTHEAST FLORIDA SEDIMENT ASSESSMENT AND NEEDS DETERMINATION BORROW AREA OVERVIEW MAP	PLATE **B-2**
	DEPARTMENT OF THE ARMY JACKSONVILLE DISTRICT, CORPS OF ENGINEERS JACKSONVILLE, FLORIDA	Ckd by: JDO Dated: MAY 2013		



US Army Corps of Engineers Jacksonville District	GEOTECHNICAL DRAWINGS	Dsn by: JDO	ST. LUCIE, MARTIN AND PALM BEACH COUNTY, FLORIDA	PLATE
		Dwn by: CJB	SOUTHEAST FLORIDA SEDIMENT ASSESSMENT AND NEEDS DETERMINATION	
	DEPARTMENT OF THE ARMY JACKSONVILLE DISTRICT, CORPS OF ENGINEERS JACKSONVILLE, FLORIDA	Ckd by: JDO		**B-3**
		Dated: MAY 2013	BORROW AREA LOCATION MAP	



US Army Corps of Engineers Jacksonville District	GEOTECHNICAL DRAWINGS	Dsn by: JDO Dwn by: CJB	ST. LUCIE, MARTIN AND PALM BEACH COUNTY, FLORIDA SOUTHEAST FLORIDA SEDIMENT ASSESSMENT AND NEEDS DETERMINATION BORROW AREA LOCATION MAP	PLATE B-4
	DEPARTMENT OF THE ARMY JACKSONVILLE DISTRICT, CORPS OF ENGINEERS JACKSONVILLE, FLORIDA	Ckd by: JDO Dated: MAY 2013		



US Army Corps of Engineers
Jacksonville District

GEOTECHNICAL DRAWINGS

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

Dsn by: JDO
Dwn by: CJB
Ckd by: JDO
Dated: MAY 2013

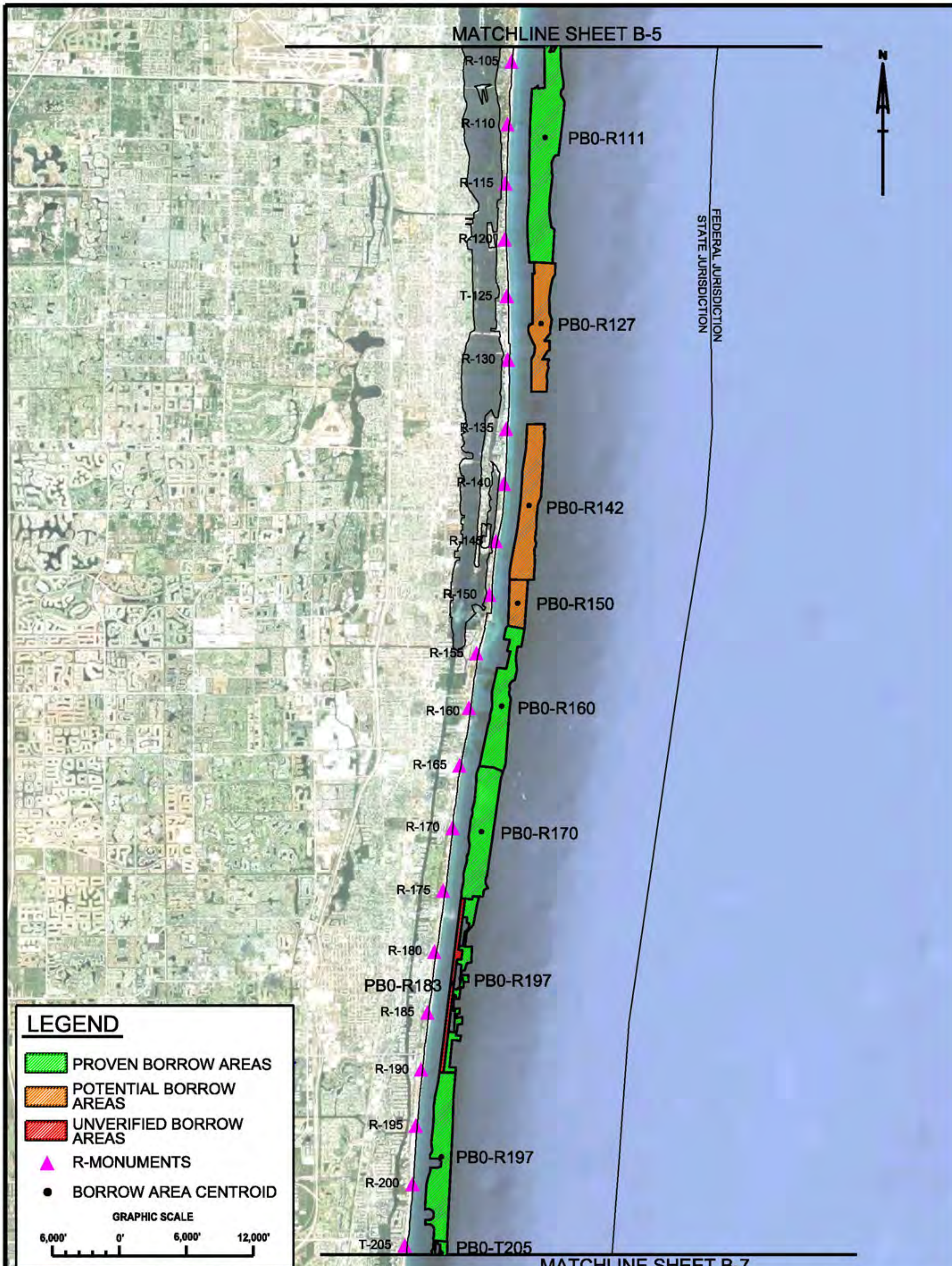
ST. LUCIE, MARTIN AND PALM BEACH COUNTY, FLORIDA

SOUTHEAST FLORIDA SEDIMENT ASSESSMENT AND NEEDS DETERMINATION

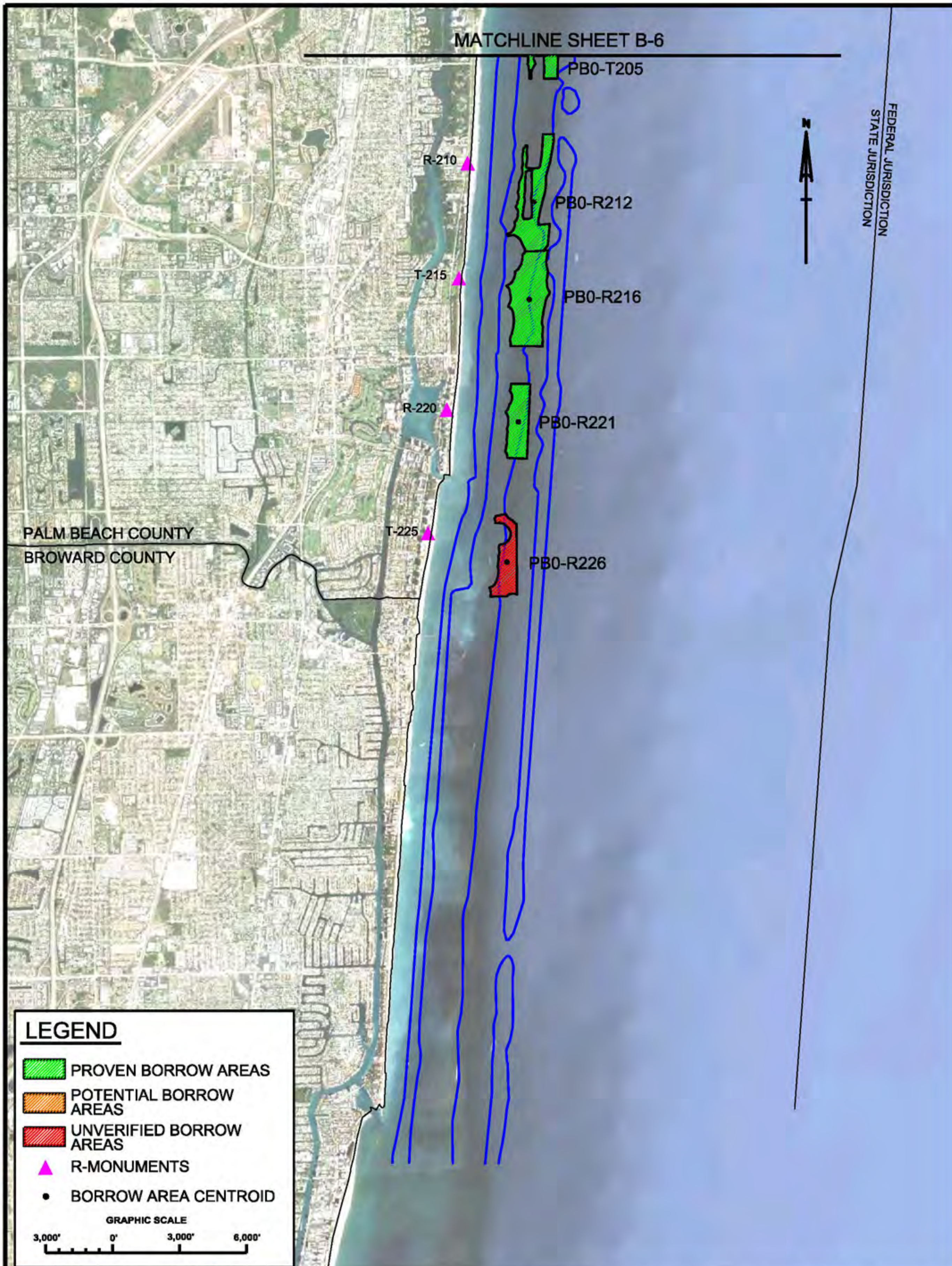
BORROW AREA LOCATION MAP

PLATE

B-5



US Army Corps of Engineers Jacksonville District	GEOTECHNICAL DRAWINGS	Dsn by: JDO	ST. LUCIE, MARTIN AND PALM BEACH COUNTY, FLORIDA	PLATE
		Dwn by: CJB	SOUTHEAST FLORIDA SEDIMENT ASSESSMENT AND NEEDS DETERMINATION	
	DEPARTMENT OF THE ARMY JACKSONVILLE DISTRICT, CORPS OF ENGINEERS JACKSONVILLE, FLORIDA	Ckd by: JDO		**B-6**
		Dated: MAY 2013	BORROW AREA LOCATION MAP	



US Army Corps of Engineers Jacksonville District	GEOTECHNICAL DRAWINGS	Dsn by: JDO Dwn by: CJB	ST. LUCIE, MARTIN AND PALM BEACH COUNTY, FLORIDA SOUTHEAST FLORIDA SEDIMENT ASSESSMENT AND NEEDS DETERMINATION	PLATE
	DEPARTMENT OF THE ARMY JACKSONVILLE DISTRICT, CORPS OF ENGINEERS JACKSONVILLE, FLORIDA	Ckd by: JDO Dated: MAY 2013	BORROW AREA LOCATION MAP	**B-7**

10.1 St. Lucie County, FL: PROVEN

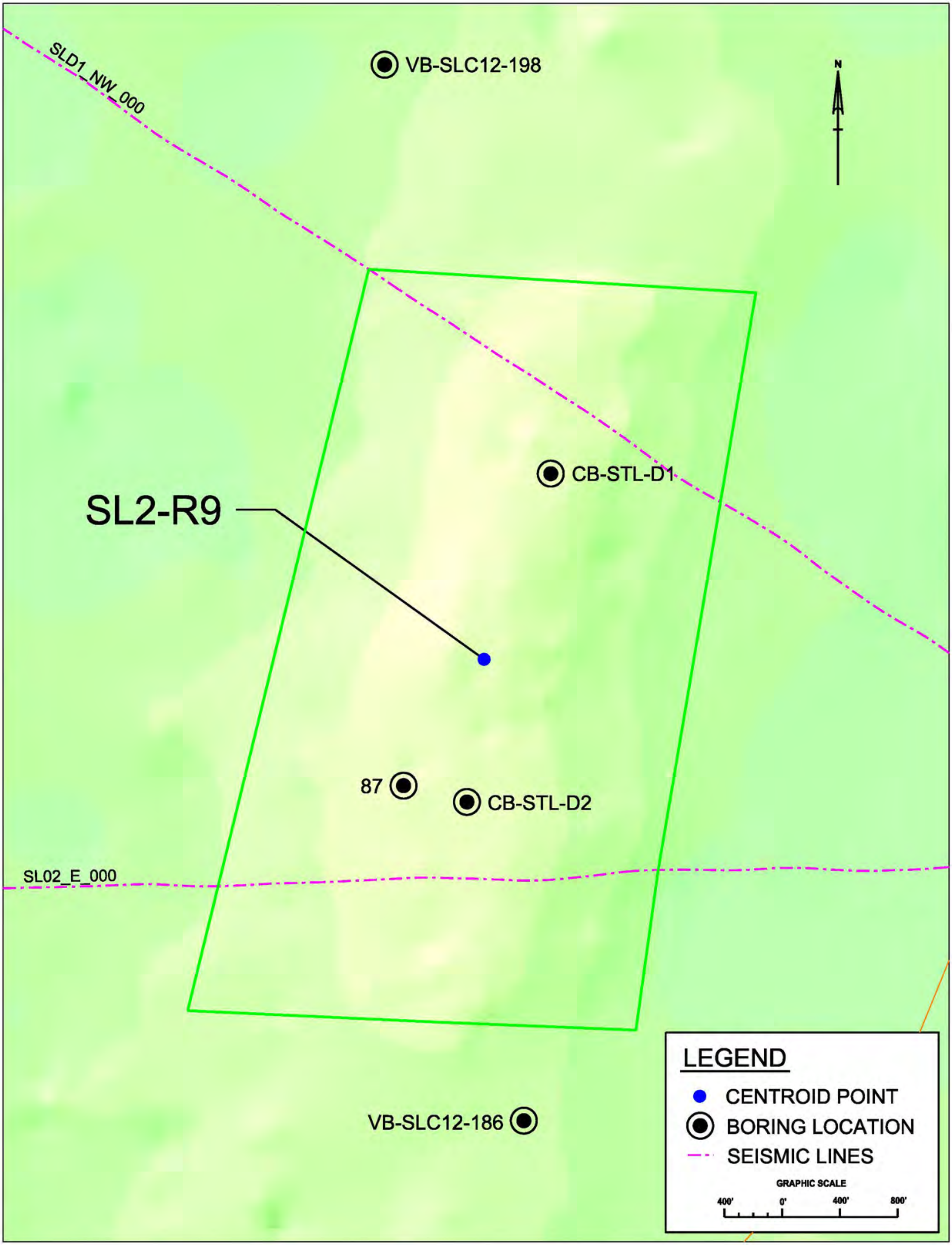
Sediment Source ID: SL2-R9 Category: Proven

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	118,922,944	89,099,008
Volume (cy)	4,404,553	3,299,963
Area (ft^2)	14,911,968	14,911,968
Average Thickness (ft)	8.0	6.0

Narrative: The area was delineated by COE, Ft. Pierce SPP GRR, revised March 2008 and modified in the 2009 RSM. The lateral east-west boundaries were adjusted based on cores, geomorphology, and seismic data. The sediment thickness can be seen on the seismic imaging. The boundary was adjusted to minimum four (4) ft thickness at the edges.

Material Description	
Mean mm:	0.65
Munsel value range:	6 (wet)
Color:	brown
Physical description:	fine to medium grained sand-sized quartz and coarse-grained sand-sized shell

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
CB-STL-D1	892267	1162964	-28	9
CB-STL-D2	892847	1165238	-30	9.6
87	891828	1163077	unknown	9.3
Sediment Source Edge				4
			Average	8.0


VB-SLC12-198
SLD1_NW_000
N
SL2-R9
CB-STL-D1
87
CB-STL-D2
SL02_E_000
VB-SLC12-186
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
GRAPHIC SCALE
400'
0'
400'
800'

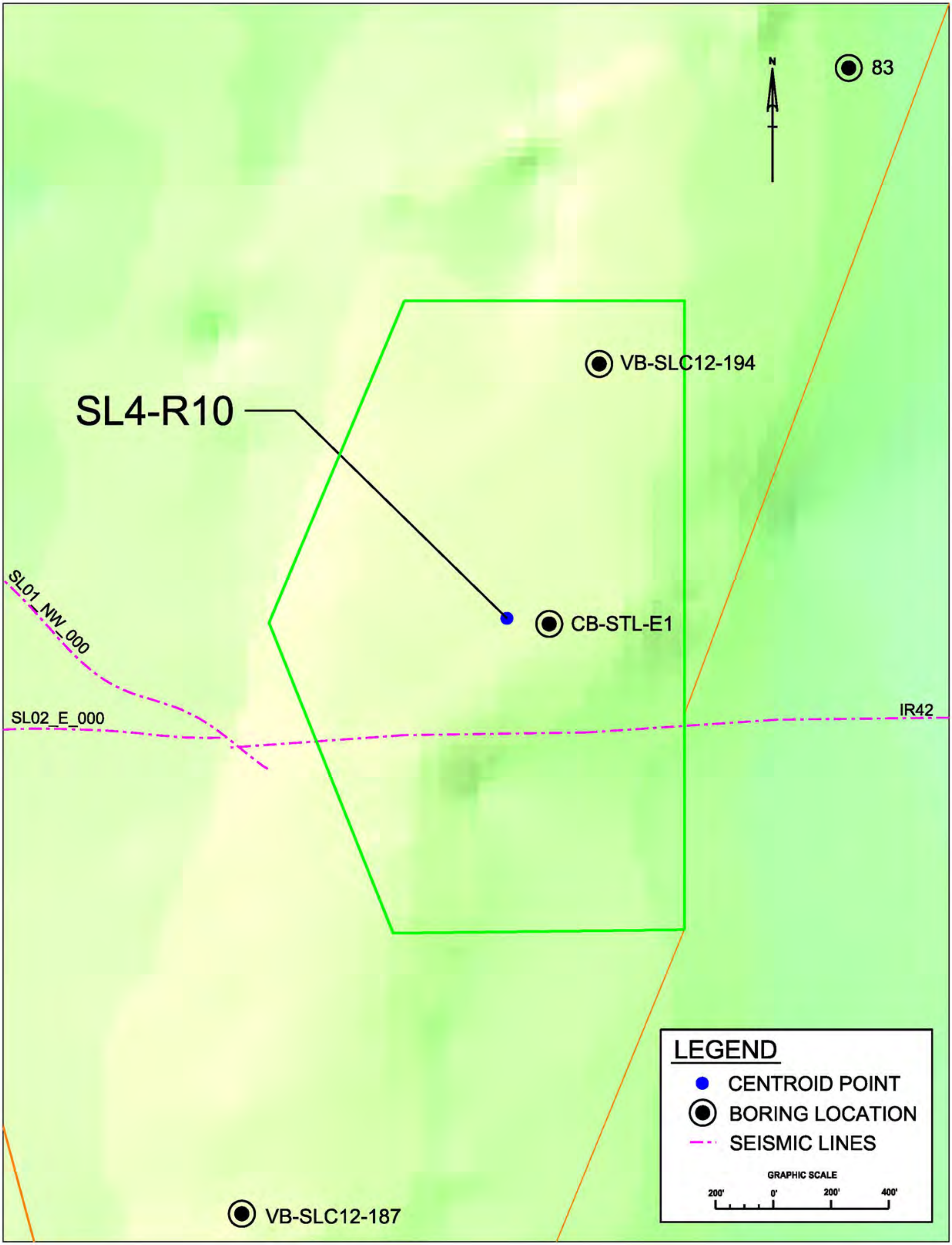
Sediment Source ID: SL4-R10 Category: Proven

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	21,298,251	15,995,782
Volume (cy)	788,824	592,436
Area (ft^2)	2,651,235	2,651,235
Average Thickness (ft)	8.0	6.0

Narrative: Area delineated by COE Ft. Pierce SPP, revised March 2008. Source boundary was un-changed for the SAND Study.

Material Description	
Mean mm:	0.35 - 0.4
Munsell value range:	5 (moist)
Color:	gray/gray-brown
Physical description:	coarse grained shelly sand

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
VB-SLC12-194	899217	1163829	-34.7	10.1
VB-STL-E1	898817	1162385	-27	10
Sediment Source Edge				4
			Average	8.0


N
83
VB-SLC12-194
SL4-R10
CB-STL-E1
SL01_NW_000
SL02_E_000
IR42
VB-SLC12-187
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
GRAPHIC SCALE
200'
0'
200'
400'

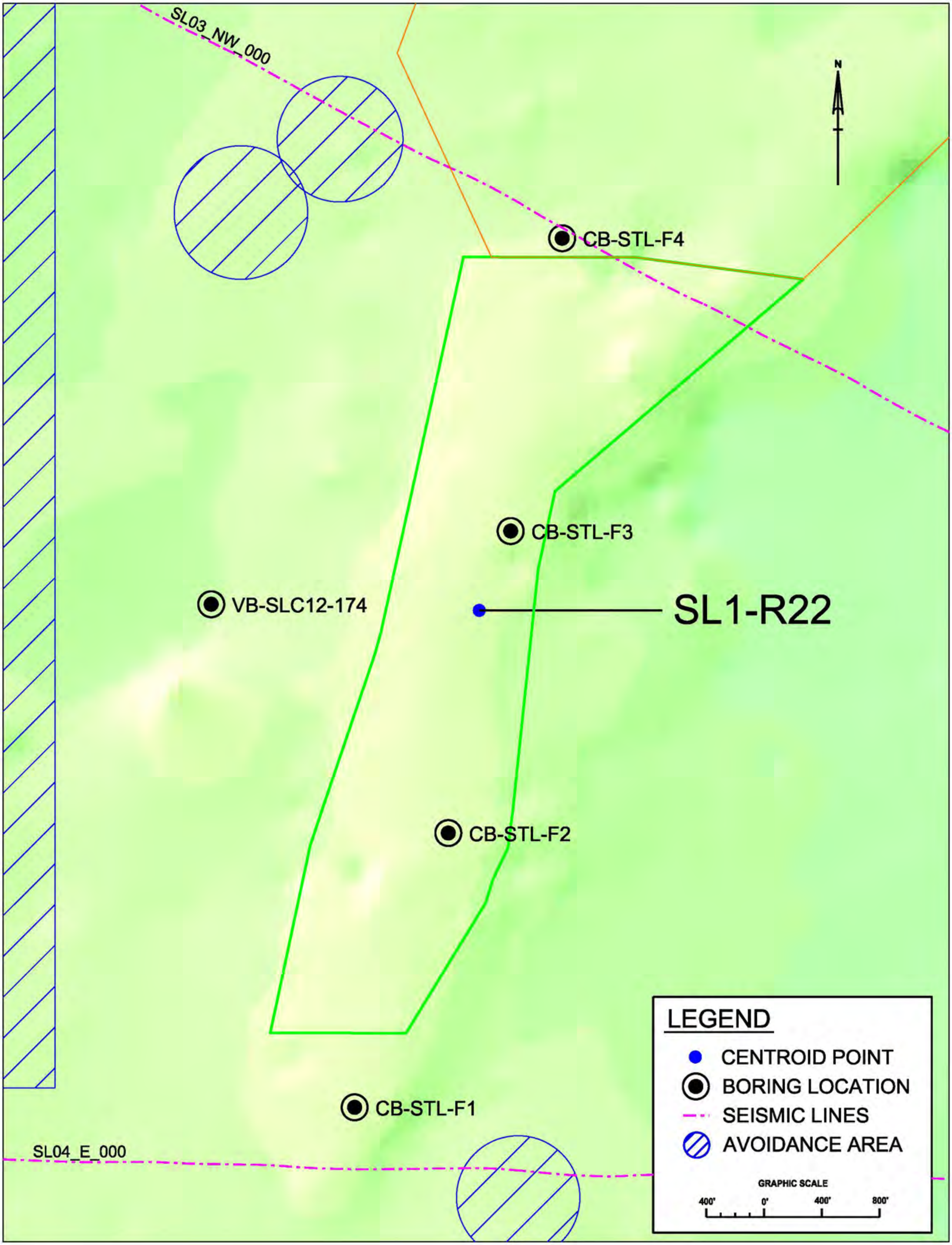
Sediment Source ID: SL1-R22 Category: Proven

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	46,215,319	32,103,771
Volume (cy)	1,711,678	1,189,029
Area (ft^2)	7,055,774	7,055,774
Average Thickness (ft)	6.6	4.6

Narrative: The area was delineated by COE, Ft. Pierce SPP GRR, revised March 2008 and modified in the 2009 RSM. For the SAND study the southern portion of the polygon was removed because boring CB-STL-F1 did not meet the study criteria.

Material Description	
Mean mm:	Not Available
Munsell value range:	Not Available
Color:	brown, gray brown
Physical description:	medium to fine grained quartz and shell

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
CB-STL-F2	892137.8	1150243	-30	8.9
CB-STL-F3	892569.8	1152334	-28	9
CB-STL-F4	892926.8	1154361	-28	4.3
Sediment Source Edge				4
			Average	6.6


SL03_NW_000
CB-STL-F4
CB-STL-F3
VB-SLC12-174
SL1-R22
CB-STL-F2
CB-STL-F1
SL04_E_000
N
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
AVOIDANCE AREA
GRAPHIC SCALE
400'
0'
400'
800'

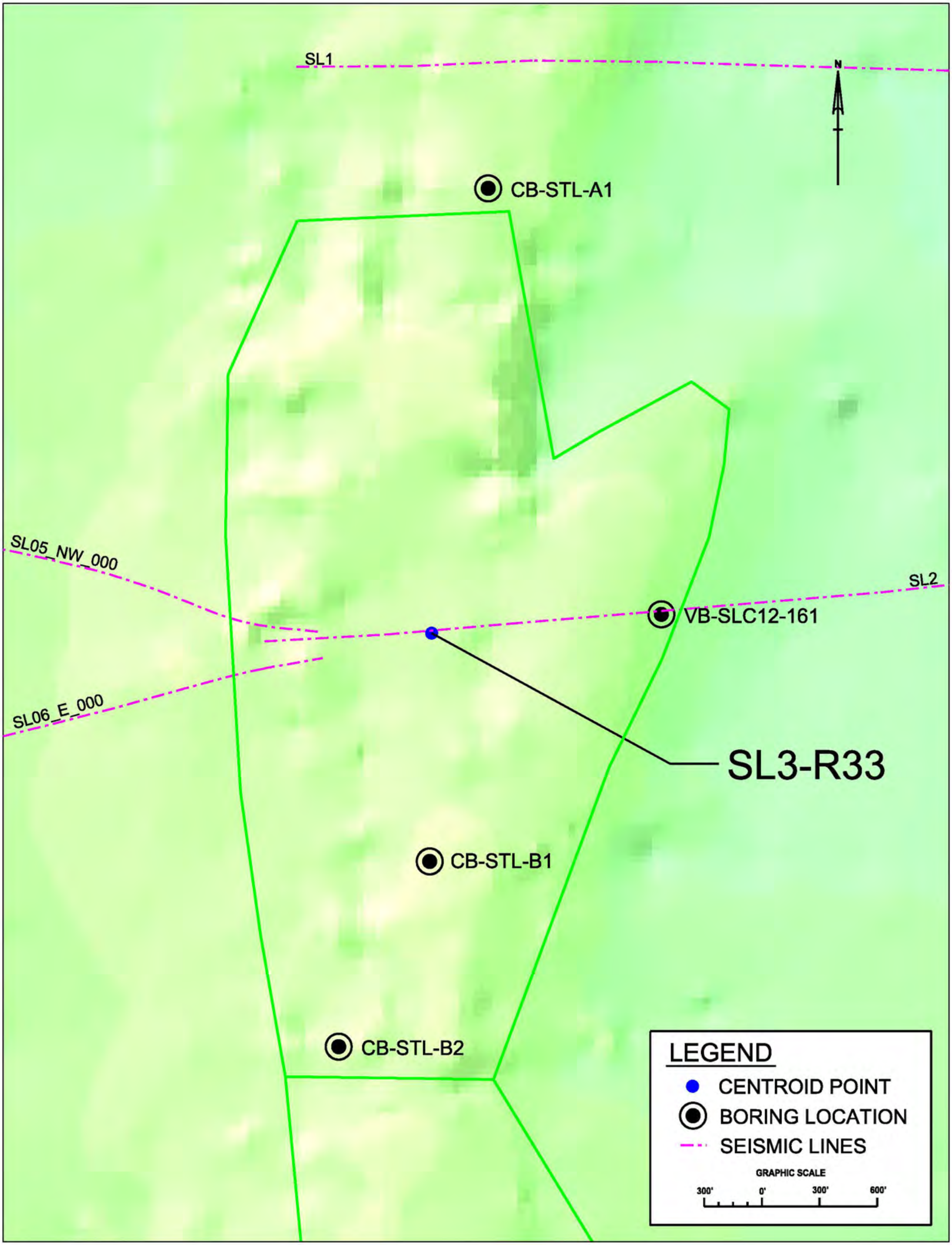
Sediment Source ID: SL3-R33 Category: Proven

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	51,442,264	35,046,323
Volume (cy)	1,905,269	1,298,012
Area (ft^2)	8,197,970	8,197,970
Average Thickness (ft)	6.3	4.3

Narrative: This area was originally delineated for the Ft. Pierce SPP GRR, revised March 2008 using the Recon level borings. The area was expanded using seismic and bathymetric data.

Material Description	
Mean mm:	0.31
Munsell value range:	4 (wet) 5 (dry)
Color:	brown
Physical description:	poorly graded fine to medium grained quartz sand with shell

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
CB-STL-B1	906344	1140217	-31	10
CB-STL-B2	905871	1139255	-32	5
VB-SLC12-161	907548	1141500	-40.8	6.1
Sediment Source Edge				4
			Average	6.3



SL1
N
CB-STL-A1
SL05_NW_000
SL2
VB-SLC12-161
SL06_E_000
SL3-R33
CB-STL-B1
CB-STL-B2
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
GRAPHIC SCALE
300'
0'
300'
600'

Sediment Source ID: SL3-R44 Category: Proven

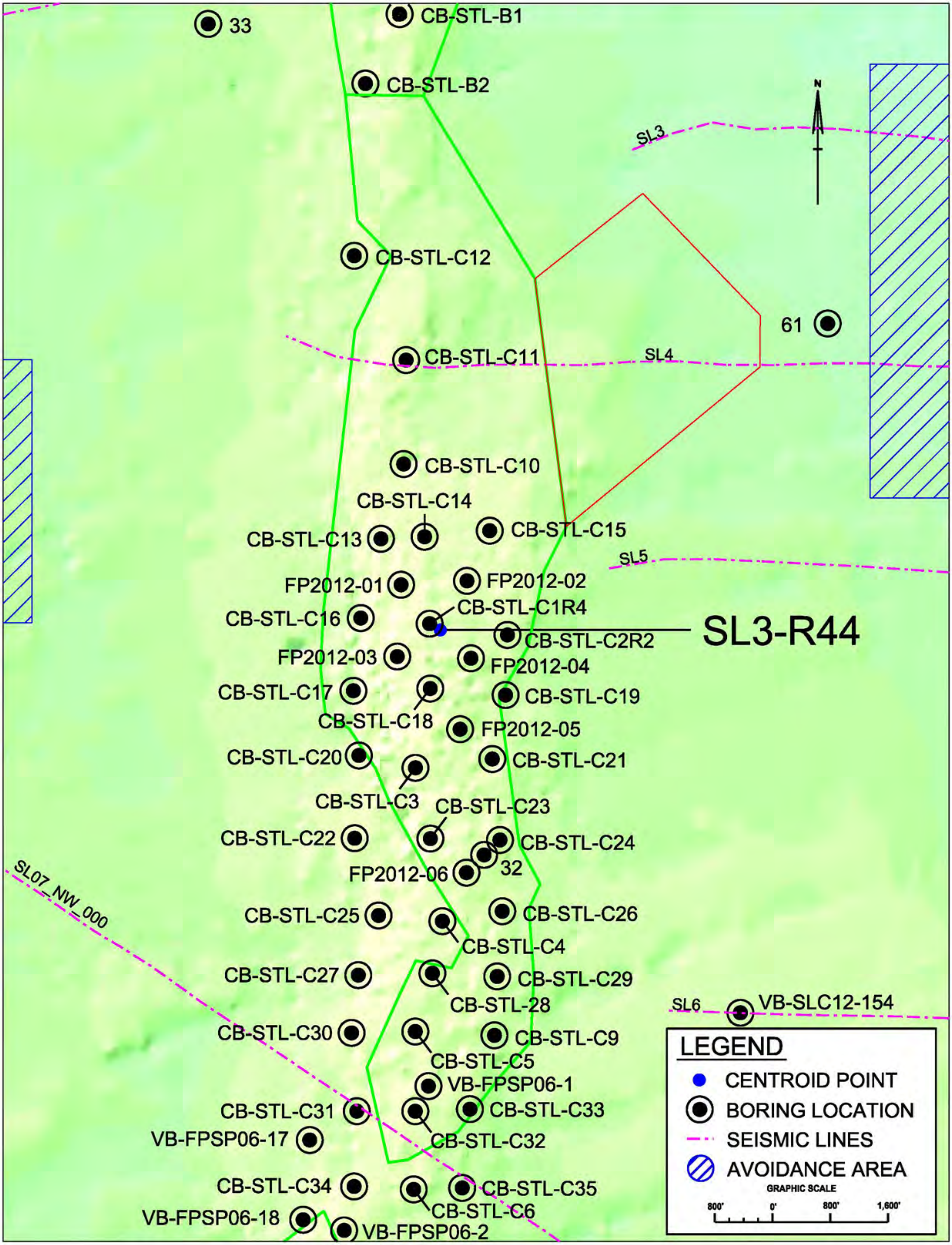
	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	313,629,492	251,850,866
Volume (cy)	11,615,907	9,327,810
Area (ft^2)	30,889,313	30,889,313
Average Thickness (ft)	10.2	8.2

Narrative: Horizontal datum shift has been applied to CB-STL- borings. A vertical datum shift has been applied to CB-STL- borings of -3.2'. This area is the Capron Shoal. It has been used many time as part of the St. Lucie County Shore Protection Project. In the 2009 RSM is was reported to be depleted. However, further examination shows otherwise. Additional borings are needed to find the full depth of the deposit.

Material Description	
Mean mm:	0.23 to 0.94
Munsell value range:	4 (wet) to 5 (wet)
Color:	gray brown
Physical description:	Sand, poorly to well graded, fine sand sized quartz and fine to coarse sand sized shell hash

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
FP2012-01	906365	1132313	-32.1	12.4
FP2012-02	907278	1132367	-27.4	12.6
FP2012-03	906312	1131319	-31.7	10
FP2012-04	907333	1131295	-22.9	14
FP2012-05	907183	1130313	-24	11.9
FP2012-06	907271	1128326	-29.6	10.5
VB-FPSP06-01	906744	1125370	24.3	9.7
CB-STL-C1R4	906760	1131772	-25.5	10
CB-STL-C2R2	907839	1131617	-34.7	6.5
CB-STL-C3	906564	1129777	-24.5	9.5
CB-STL-C5	906562	1126124	-27.6	15
CB-STL-C9	907659	1126071	-33.5	7.4
CB-STL-C10	906400	1133983	-32.2	10
CB-STL-C11	906435	1135423	-31.7	6.6
CB-STL-C12	903692	1140081	-35.6	10
CB-STL-C13	906086	1132948	-30.2	5.6

CB-STL-C14	906691	1132976	-28.1	15
CB-STL-C15	907593	1133060	-29.8	7.9
CB-STL-C16	905806	1131850	-31.6	6.8
CB-STL-C17	905704	1130843	-31.5	5
CB-STL-C18	906769	1130874	-22.7	18.4
CB-STL-C21	907629	1129898	-32.3	10.5
CB-STL-C23	906771	1128796	-30.4	20
CB-STL-C24	907735	1128777	-26.8	4.5
CB-STL-C26	907767	1127790	-30.6	7
CB-STL-C28	906799	1126930	-26.8	19.2
CB-STL-C29	907697	1126887	-31.6	7.4
CB-STL-C32	906562	1125050	-31	9.2
CB-STL-C33	907319	1125049	-31.9	8
Sediment Source Edge				4
			Average	10.2


33
CB-STL-B1
CB-STL-B2
N
SL3
CB-STL-C12
61
CB-STL-C11
SL4
CB-STL-C10
CB-STL-C14
CB-STL-C13
CB-STL-C15
SL5
FP2012-01
FP2012-02
CB-STL-C1R4
CB-STL-C16
SL3-R44
CB-STL-C2R2
FP2012-03
FP2012-04
CB-STL-C17
CB-STL-C19
CB-STL-C18
FP2012-05
CB-STL-C20
CB-STL-C21
CB-STL-C3
CB-STL-C23
CB-STL-C22
CB-STL-C24
SL07_NW_000
32
FP2012-06
CB-STL-C25
CB-STL-C26
CB-STL-C4
CB-STL-C27
CB-STL-C29
CB-STL-28
SL6
VB-SLC12-154
CB-STL-C30
CB-STL-C9
CB-STL-C5
VB-FPSP06-1
CB-STL-C31
CB-STL-C33
VB-FPSP06-17
CB-STL-C32
CB-STL-C34
CB-STL-C35
CB-STL-C6
VB-FPSP06-18
VB-FPSP06-2
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
AVOIDANCE AREA
GRAPHIC SCALE
800'
0'
800'
1,600'

Sediment Source ID: SL2-R56 Category: Proven

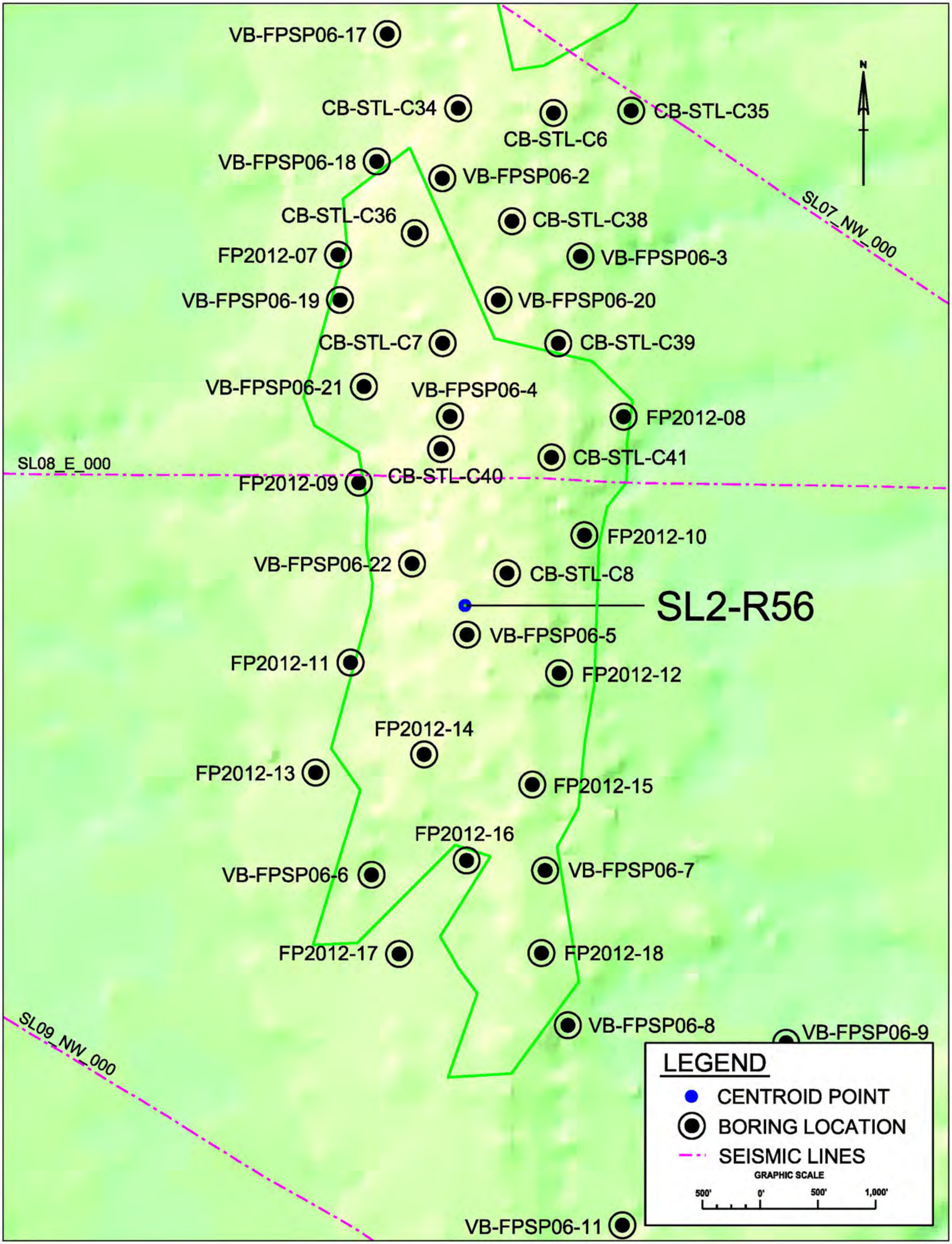
	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	99,705,895	73,308,305
Volume (cy)	3,692,811	2,715,122
Area (ft^2)	13,198,795	13,198,795
Average Thickness (ft)	7.6	5.6

Narrative: Horizontal datum shift has been applied to CB-STL- borings. A vertical datum shift has been applied to CB-STL- borings of -3.2'. This area is the Capron Shoal. It has been used many time as part of the St. Lucie County Shore Protection Project. In the 2009 RSM is was reported to be depleted. However, further examination shows the deposit may contain more material. Additional borings are needed to find the full depth of the deposit.

Material Description	
Mean mm:	0.23 to 0.94
Munsell value range:	4 (wet) to 5 (wet)
Color:	gray brown
Physical description:	sand, poorly to well graded, fine sand sized quartz and fine to coarse sand sized shell hash

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
FP2012-08	907147	1121308	-37.6	5.5
FP2012-09	904852	1120737	-35.6	6.9
FP2012-10	906807	1120282	-37.1	5.8
FP2012-12	906587	1119087	-34	7.8
FP2012-14	905418	1118383	-32.9	6
FP2012-15	906355	1118122	-33.4	8
FP2012-16	905786	1117464	-36.9	5.5
FP2012-18	906435	1116662	-35.1	6
VB-FPSP06-02	905576	1123373	-29	7.7
VB-FPSP06-04	905643	1121310	-29.3	9.8
VB-FPSP06-05	905790	1119420	-26.6	10
VB-FPSP06-06	904963	1117340	-31.4	7.7
VB-FPSP06-08	906664	1116037	-32.6	4.5
VB-FPSP06-18	905008	1123519	-31.1	8.7
VB-FPSP06-19	904690	1122319	-30.4	5
VB-FPSP06-21	904897	1121569	-30.5	6.7

VB-FPSP06-22	905314	1120036	-30.4	7.9
CB-STL-C7	905579	1121945	-31.8	8
CB-STL-C8	906137	1119953	-28.6	9
CB-STL-C36	905337	1122899	-30.7	9.7
CB-STL-C39	906581	1121944	-32	11
CB-STL-C40	905565	1121029	-32.8	9.8
CB-STL-C41	906522	1120956	-31.3	10.3
Sediment Source Edge				4
			Average	7.6



VB-FPSP06-17
CB-STL-C34
CB-STL-C6
CB-STL-C35
VB-FPSP06-18
VB-FPSP06-2
SL07_NW_000
CB-STL-C36
CB-STL-C38
FP2012-07
VB-FPSP06-3
VB-FPSP06-19
VB-FPSP06-20
CB-STL-C7
CB-STL-C39
VB-FPSP06-21
VB-FPSP06-4
FP2012-08
SL08_E_000
CB-STL-C41
FP2012-09
CB-STL-C40
FP2012-10
VB-FPSP06-22
CB-STL-C8
SL2-R56
VB-FPSP06-5
FP2012-11
FP2012-12
FP2012-14
FP2012-13
FP2012-15
FP2012-16
VB-FPSP06-6
VB-FPSP06-7
FP2012-17
FP2012-18
SL09_NW_000
VB-FPSP06-8
VB-FPSP06-9
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
GRAPHIC SCALE
500'
0'
500'
1,000'
VB-FPSP06-11
N

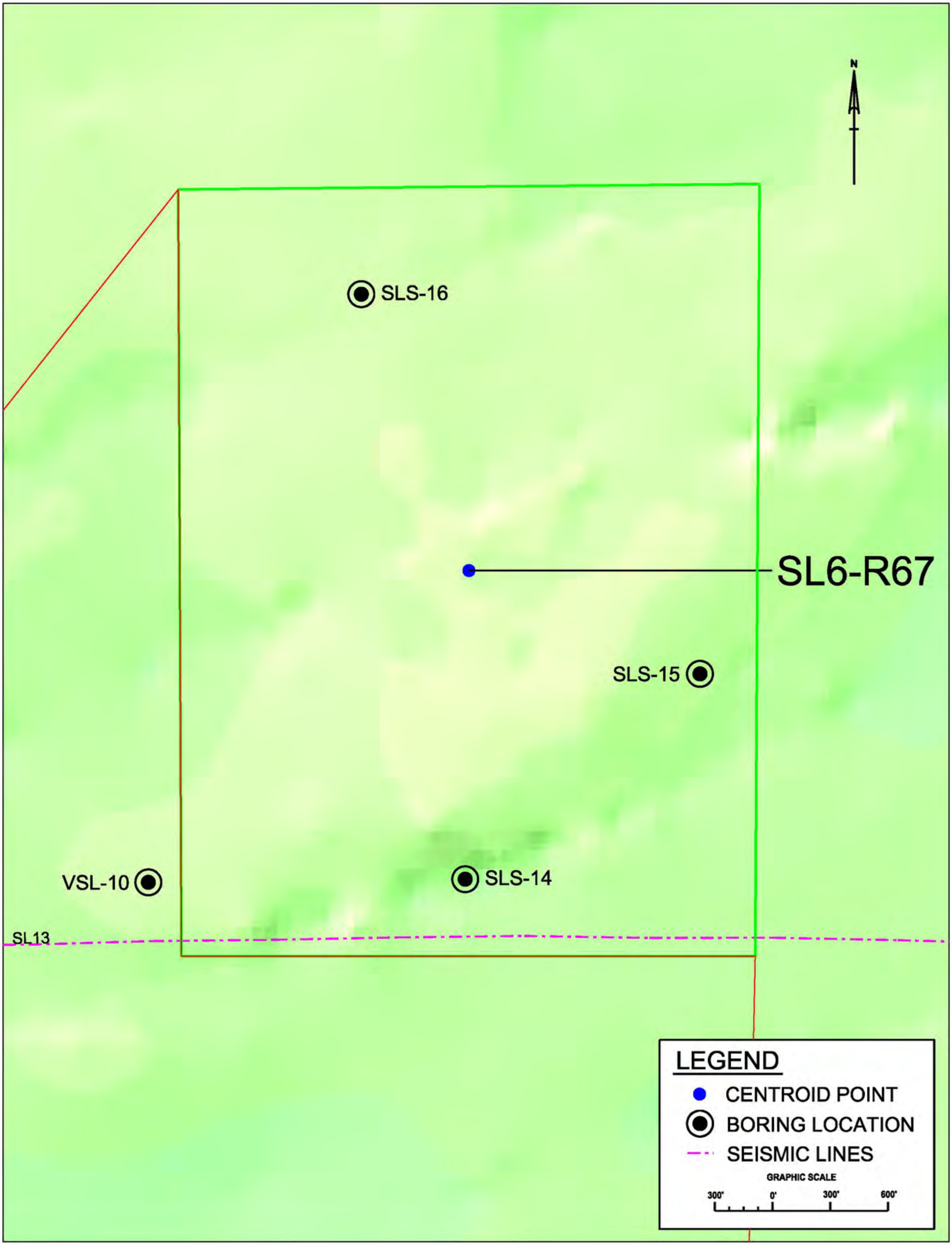
Sediment Source ID: SL6-R67 Category: Proven

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)		
Volume* (cy)		464,400*
Area (ft^2)	11,989,648	11,989,648
Average Thickness (ft)	0.0	-2.0
* Volume determined from Coastal Tech 2011 report		

Narrative: Area was originally delineated by USACE. A design level investigation by Coastal Tech was done in 2011. Volumes presented for the Sediment Source are taken directly from the volume estimates from the Coastal Tech Report.

Material Description	
Mean mm:	0.39 to 0.43
Munsell value range:	4 (wet) to 6 (wet)
Color:	light olive brown, grayish brown, yellowish gray
Physical description:	fine to medium sand-sized skeletal carbonate with fine sand-sized quartz

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
SLS-14	929577	1108559	-34.6	
SLS-15	929981	1109568	-36.3	
SLS-16	929037	1111598	-35.3	
VSL-10	927927	1108544	-40	
			Average	


N
SLS-16
SL6-R67
SLS-15
VSL-10
SLS-14
SL13
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
GRAPHIC SCALE
300'
0'
300'
600'

Sediment Source ID: SL6-R73 Category: Proven

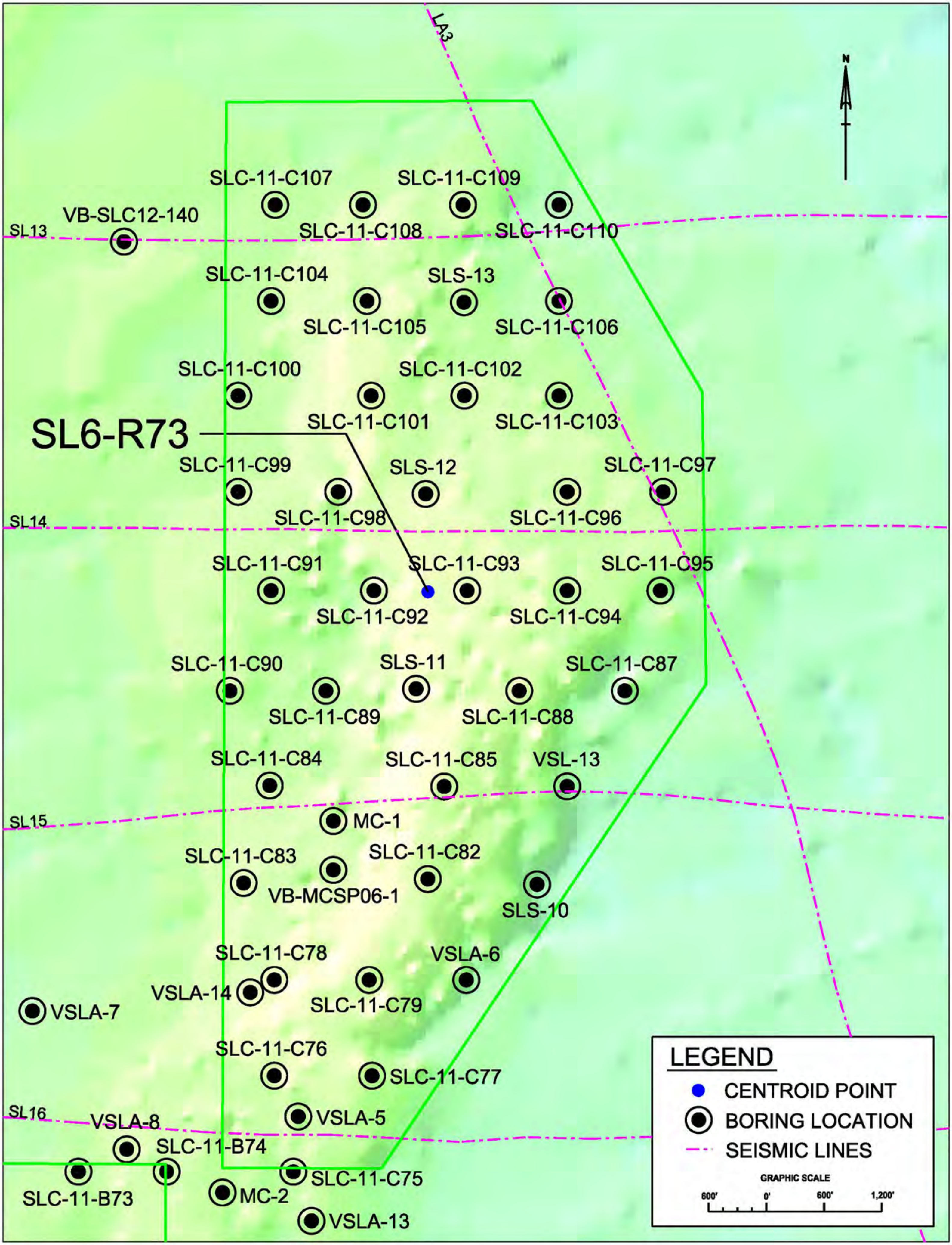
	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)		
Volume (cy)		6,726,000*
Area (ft^2)	44,150,086	44,150,086
Average Thickness (ft)	0.0	-2.0
* Volume determined from Coastal Tech 2011 report		

Narrative: Area was originally delineated by USACE. A design level investigation by Coastal Tech was done in 2011. Volumes presented for the Sediment Source are taken directly from the volume estimates from the Coastal Tech Report.

Material Description	
Mean mm:	0.24 to 0.77
Munsell value range:	4 (wet) to 6 (wet)
Color:	light grayish brown to grayish brown
Physical description:	fine to medium sand-sized skeletal sand with fine sand-sized quartz

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
SLC-11-C75	934400	1098576	-35.6	
SLC-11-C76	934231	109956	-36.4	
SLC-11-C77	935237	1099576	-29.2	
SLC-11-C78	934240	1100569	-36.4	
SLC-11-C79	935203	1100581	-34.1	
SLC-11-C82	934937	1101579	-36.7	
SLC-11-C83	933896	1101566	-39.8	
SLC-11-C84	934237	1102586	-39.9	
SLC-11-C85	935227	1102593	-35.1	
SLC-11-C87	937887	1103569	-40.3	
SLC-11-C88	936833	1103568	-36.4	
SLC-11-C89	934809	1103584	-39.3	
SLC-11-C90	933803	1103535	-39.9	
SLC-11-C91	934256	1104574	-39.1	
SLC-11-C92	935230	1104569	-32.3	

SLC-11-C93	936241	1104569	-32.1	
SLC-11-C94	937231	1104564	-36.8	
SLC-11-C95	938216	1104571	-43.5	
SLC-11-C96	937235	1105564	-37.6	
SLC-11-C97	938231	1105565	-42.2	
SLC-11-C98	934914	1105572	-37.1	
SLC-11-C99	933887	1105559	-41.8	
SLC-11-C100	933892	1106561	-44.1	
SLC-11-C101	935243	1106568	-36.9	
SLC-11-C102	936233	1105667	-31.5	
SLC-11-C103	937239	1106576	-41.1	
SLC-11-C104	934235	1107567	-41.9	
SLC-11-C105	935241	1107568	-37.8	
SLC-11-C106	937232	1107564	-45.4	
SLC-11-C107	934239	1108561	-41.7	
SLC-11-C108	935218	1108574	-42.1	
SLC-11-C109	936241	1108563	-40.7	
SLC-11-C110	937241	1108564	-44.6	
SLS-10	937056	1101523	-27.2	
SLS-11	935799	1103553	-29	
SLS-12	935899	1105578	-28	
SLS-13	936296	1107568	-35.2	
VB-MCSP06-1	934939	1101673	-37.3	
VSLA-5	934575	1099112	unknown	
VSLA-6	936321	1100531	unknown	
VSLA-13	937370	1102540	unknown	
VSLA-14	934076	1100401	unknown	
MC-1	934939	1102181	unknown	
			Average	



LA3
SLC-11-C107
SLC-11-C109
VB-SLC12-140
SL13
SLC-11-C108
SLC-11-C110
SLC-11-C104
SLS-13
SLC-11-C105
SLC-11-C106
SLC-11-C100
SLC-11-C102
SL6-R73
SLC-11-C101
SLC-11-C103
SLC-11-C99
SLS-12
SLC-11-C97
SLC-11-C98
SLC-11-C96
SL14
SLC-11-C91
SLC-11-C93
SLC-11-C95
SLC-11-C92
SLC-11-C94
SLC-11-C90
SLS-11
SLC-11-C87
SLC-11-C89
SLC-11-C88
SLC-11-C84
SLC-11-C85
VSL-13
SL15
MC-1
SLC-11-C83
SLC-11-C82
VB-MCSP06-1
SLS-10
SLC-11-C78
VSLA-6
VSLA-14
SLC-11-C79
VSLA-7
SLC-11-C76
SLC-11-C77
SL16
VSLA-8
VSLA-5
SLC-11-B74
SLC-11-C75
SLC-11-B73
MC-2
VSLA-13
N
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
GRAPHIC SCALE
600'
0'
600'
1,200'

Sediment Source ID: SL5-R84 Category: Proven

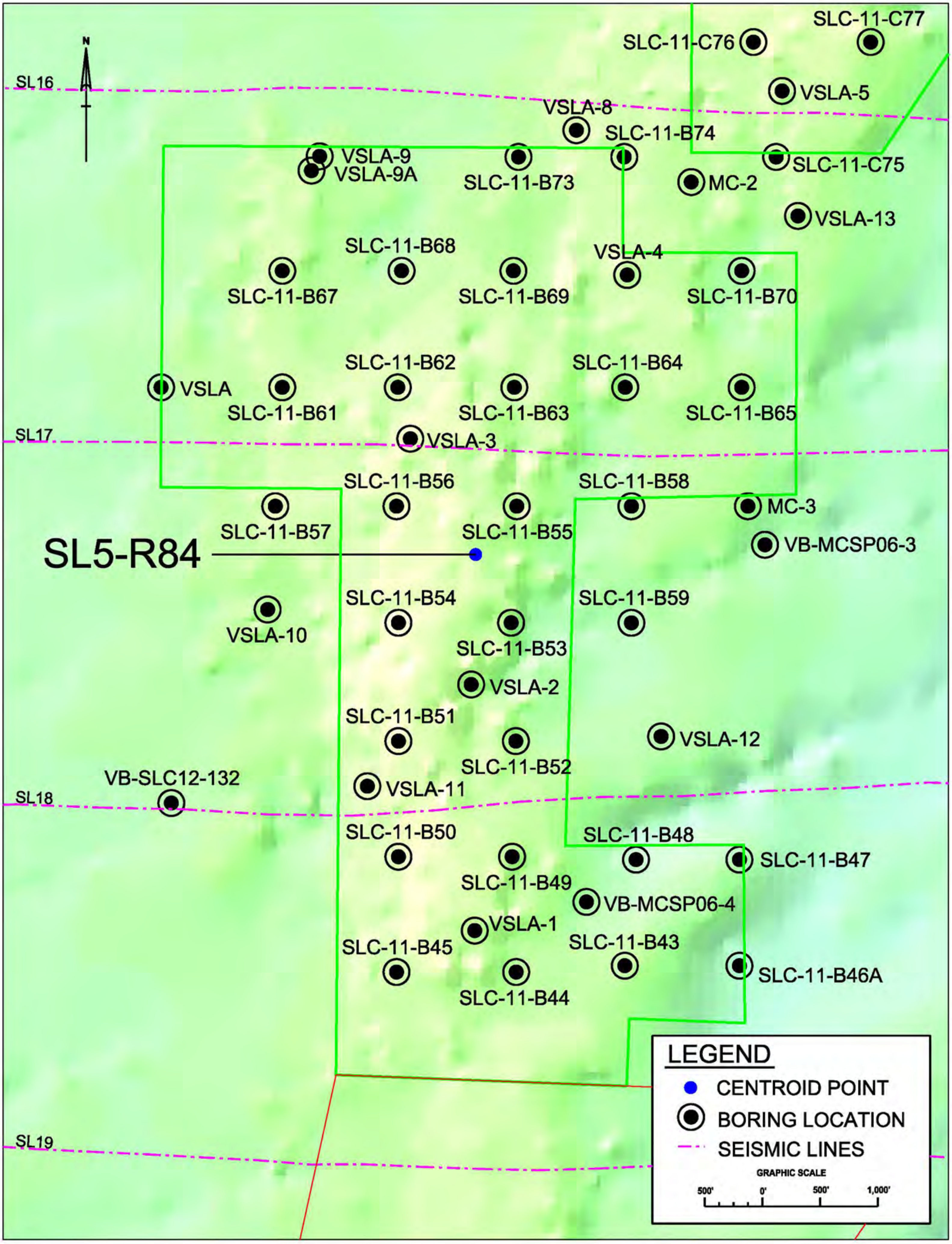
	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)		
Volume (cy)		1,912,000*
Area (ft^2)	27,900,357	27,900,357
Average Thickness (ft)	0.0	-2.0
* Volume determined from Coastal Tech 2011 report		

Narrative: Area delineated by COE Ft. Pierce SPP GRR, revised March 2008. A design level investigation by Coastal Tech was done in 2011. Volumes presented for the Sediment Source are taken directly from the volume estimates from the Coastal Tech Report.

Material Description	
Mean mm:	0.24 to 0.95
Munsell value range:	4-5 (wet) to 5-7 (dry)
Color:	light olive brown to grayish brown
Physical description:	medium grained sand sized skeletal sand and quartz

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
SLC-11-B43	933155	1091575	-44.1	
SLC-11-B44	932143	1091586	-31.3	
SLC-11-B45	931179	1091592	-39.6	
SLC-11-B46A	934178	1091570	-53.4	
SLC-11-B47	934165	1092564	-45.1	
SLC-11-B48	933170	1092557	-44.2	
SLC-11-B49	932158	1092562	-30.6	
SLC-11-B50	931156	1092591	-36.8	
SLC-11-B51	931193	1093573	-37.9	
SLC-11-B52	932178	1093598	-32.1	
SLC-11-B53	932177	1094556	-35.4	
SLC-11-B54	931181	1094561	-34.1	
SLC-11-B55	932186	1095592	-36.2	
SLC-11-B56	931179	1095567	-39.1	
SLC-11-B57	930114	1095553	-41.5	

SLC-11-B58	933187	1095562	-46.6	
SLC-11-B59	933097	1094513	-46.3	
SLC-11-B61	930166	1096602	-38.7	
SLC-11-B62	931167	1096560	-42.1	
SLC-11-B63	932179	1096573	-41.3	
SLC-11-B64	933180	1096562	-39.9	
SLC-11-B65	934176	1096569	-40.5	
SLC-11-B67	930203	1097584	-39.9	
SLC-11-B68	931182	1097572	-41.1	
SLC-11-B69	932161	1097561	-41.2	
SLC-11-B70	934190	1097581	-38.9	
SLC-11-B73	932198	1098585	-45.2	
VSLA-1	931911	1091832	unknown	
VSLA-2	931880	1093966	unknown	
VSLA-3	931352	1096097	unknown	
VSLA-4	933232	1097516	unknown	
VSLA-9	930566	1098545	unknown	
VSLA-11	930980	1093084	unknown	
VB-MCSP06-4	934879	1092080	-40.5	
			Average	


N
SL16
SL17
SL18
SL19
SL5-R84
SLC-11-C76
SLC-11-C77
VSLA-5
VSLA-8
SLC-11-B74
SLC-11-C75
VSLA-9
VSLA-9A
SLC-11-B73
MC-2
VSLA-13
SLC-11-B68
VSLA-4
SLC-11-B67
SLC-11-B69
SLC-11-B70
SLC-11-B62
SLC-11-B64
VSLA
SLC-11-B61
SLC-11-B63
SLC-11-B65
VSLA-3
SLC-11-B56
SLC-11-B58
MC-3
SLC-11-B57
SLC-11-B55
VB-MCSP06-3
SLC-11-B54
SLC-11-B59
VSLA-10
SLC-11-B53
VSLA-2
SLC-11-B51
VSLA-12
SLC-11-B52
VB-SLC12-132
VSLA-11
SLC-11-B50
SLC-11-B48
SLC-11-B47
SLC-11-B49
VB-MCSP06-4
VSLA-1
SLC-11-B43
SLC-11-B45
SLC-11-B46A
SLC-11-B44
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
GRAPHIC SCALE
500'
0'
500'
1,000'

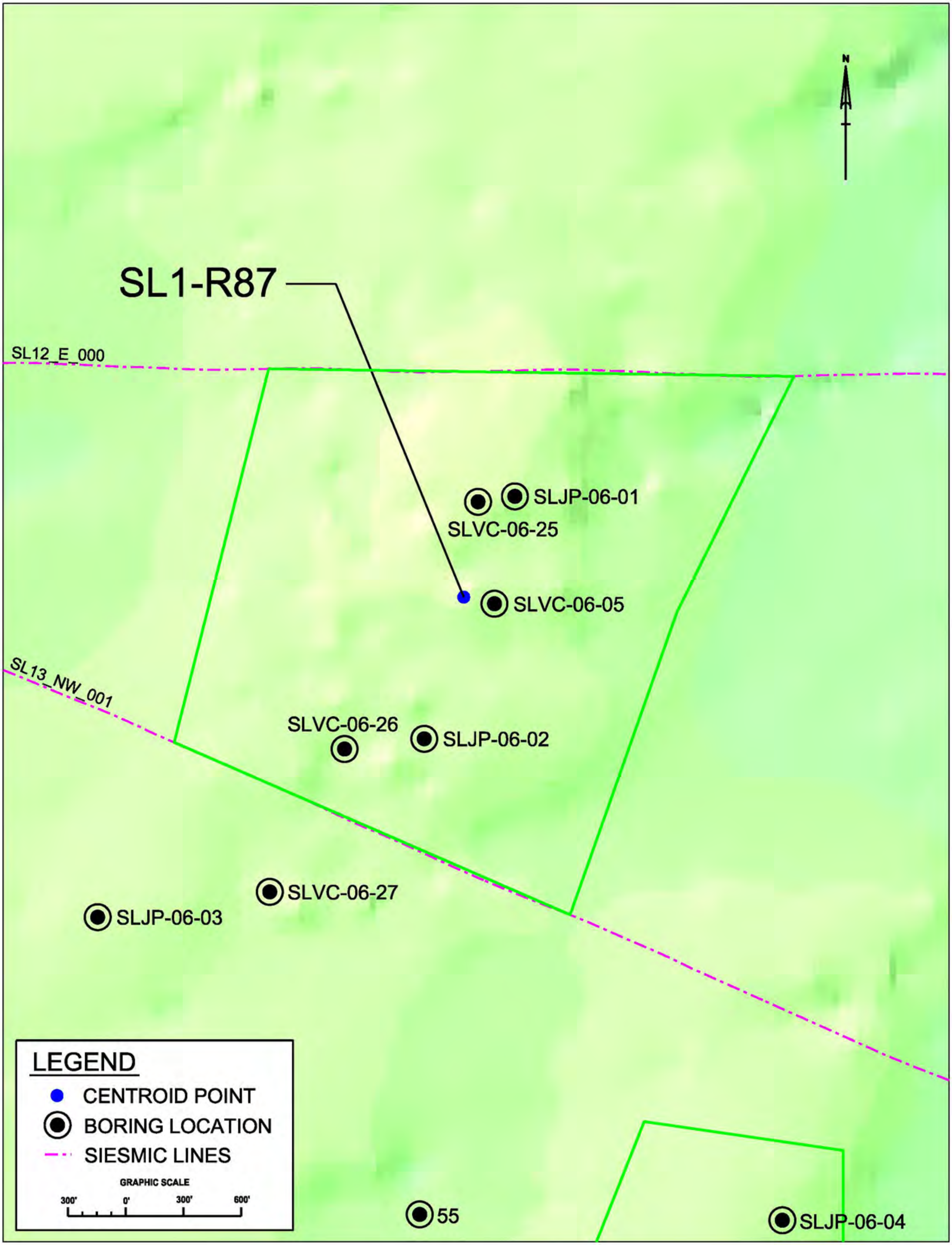
Sediment Source ID: SL1-R87 Category: Proven

	No Verticalt Buffer	2ft Vertical Buffer
Volume (cf)	43,625,203	31,794,640
Volume (cy)	1,615,748	1,177,579
Area (ft^2)	5,915,282	5,915,282
Average Thickness (ft)	7.4	5.4

Narrative: The area was delineated by CPE. Jacksonville COE questioned the volume of beach quality material. Seismic and bathymetric data was used to expand the deposit.

Material Description	
Mean mm:	0.21 - 0.44
Munsell value range:	4 (wet) 5 (dry)
Color:	grayish brown
Physical description:	fine-to-medium grained quartz sand with trace shell and trace silt

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
SLVC-06-05	913014	1091733	-35	9.9
SLVC-06-25	912929	1092262	-35.7	8.5
SLVC-06-26	912235	1090978	-35.8	7.1
*SLJP-06-01	913120	1092290	unknown	15
*SLJP-06-02	912649	1091031	unknown	14
Sediment Source Edge				4
* Jet probe data not included in volume calculations.			Average	7.4



N
SL1-R87
SL12_E_000
SLJP-06-01
SLVC-06-25
SLVC-06-05
SL13_NW_001
SLVC-06-26
SLJP-06-02
SLVC-06-27
SLJP-06-03
LEGEND
CENTROID POINT
BORING LOCATION
SIESMIC LINES
GRAPHIC SCALE
300'
0'
300'
600'
55
SLJP-06-04

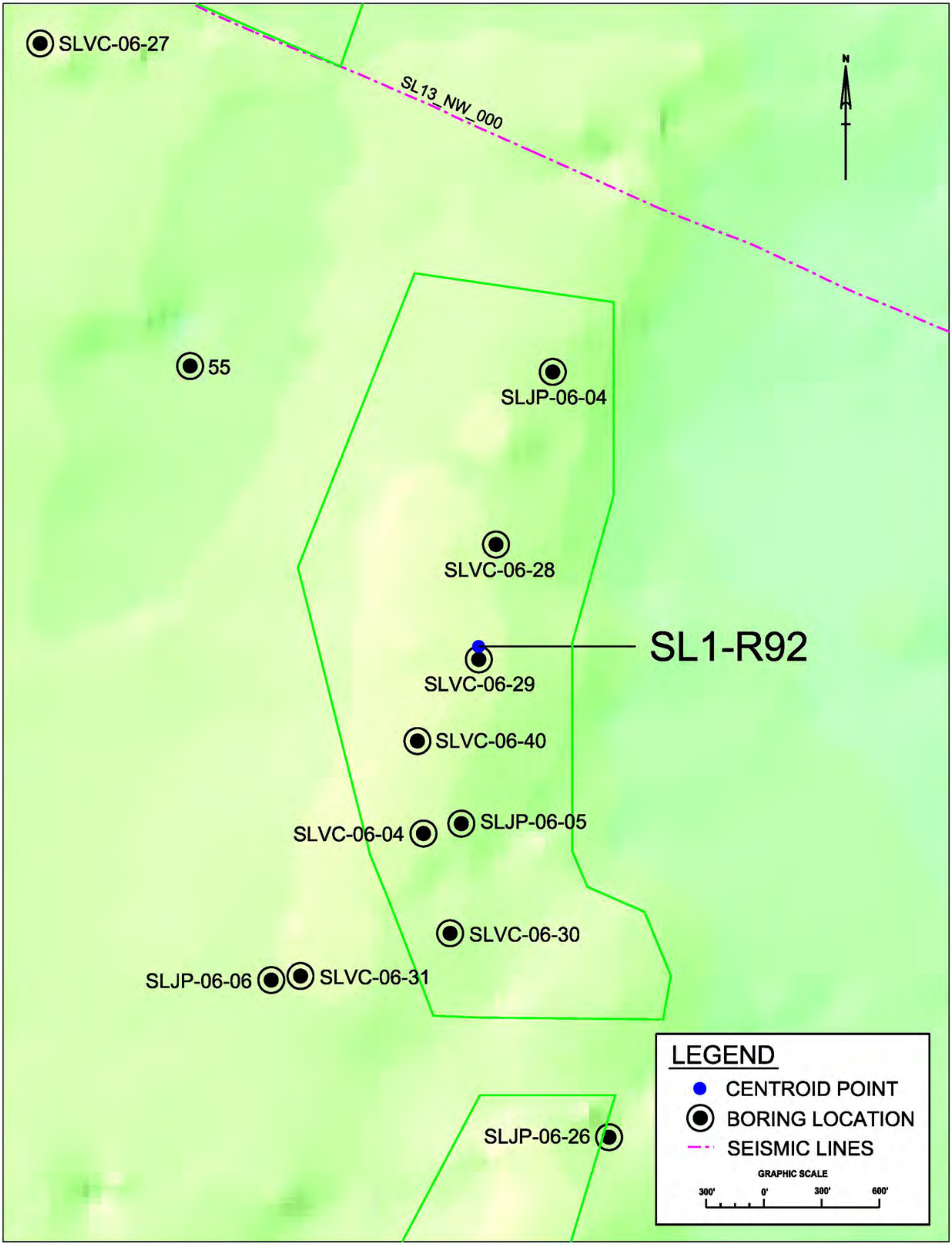
Sediment Source ID: SL1-R92 Category: Proven

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	37,693,178	27,986,780
Volume (cy)	1,396,044	1,036,547
Area (ft^2)	4,853,199	4,853,199
Average Thickness (ft)	7.8	5.8

Narrative: The area was delineated by CPE. Jacksonville COE questioned the volume of beach quality material. The south/southeast boundary was extended based on cores and geomorphology, increasing the volume in the deposit.

Material Description	
Mean mm:	0.26 - 0.45
Munsell value range:	4 (wet) 5 (dry)
Color:	dark gray
Physical description:	shell hash with fine-grained quartz sand

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
SLVP-06-04	914035	1086185	-34	8.9
SLVP-06-28	914215	1087635	-33.1	9.6
SLVP-06-29	914126	1087038	-33	9
SLVP-06-40	913807	1086614	-33	7.8
*SLJP-06-04	914510	1088531	unknown	19
*SLJP-06-05	913838	1086134	unknown	18
SLVC-06-30	913977	1085616	-34.3	7.3
Sediment Source Edge				4
* Jet probe data not included in volume calculations.			Average	7.8


SLVC-06-27
SL13_NW_000
55
SLJP-06-04
SLVC-06-28
SL1-R92
SLVC-06-29
SLVC-06-40
SLJP-06-05
SLVC-06-04
SLVC-06-30
SLJP-06-06
SLVC-06-31
SLJP-06-26
N
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
GRAPHIC SCALE
300'
0'
300'
600'

Sediment Source ID: SL0-98 Category: Proven

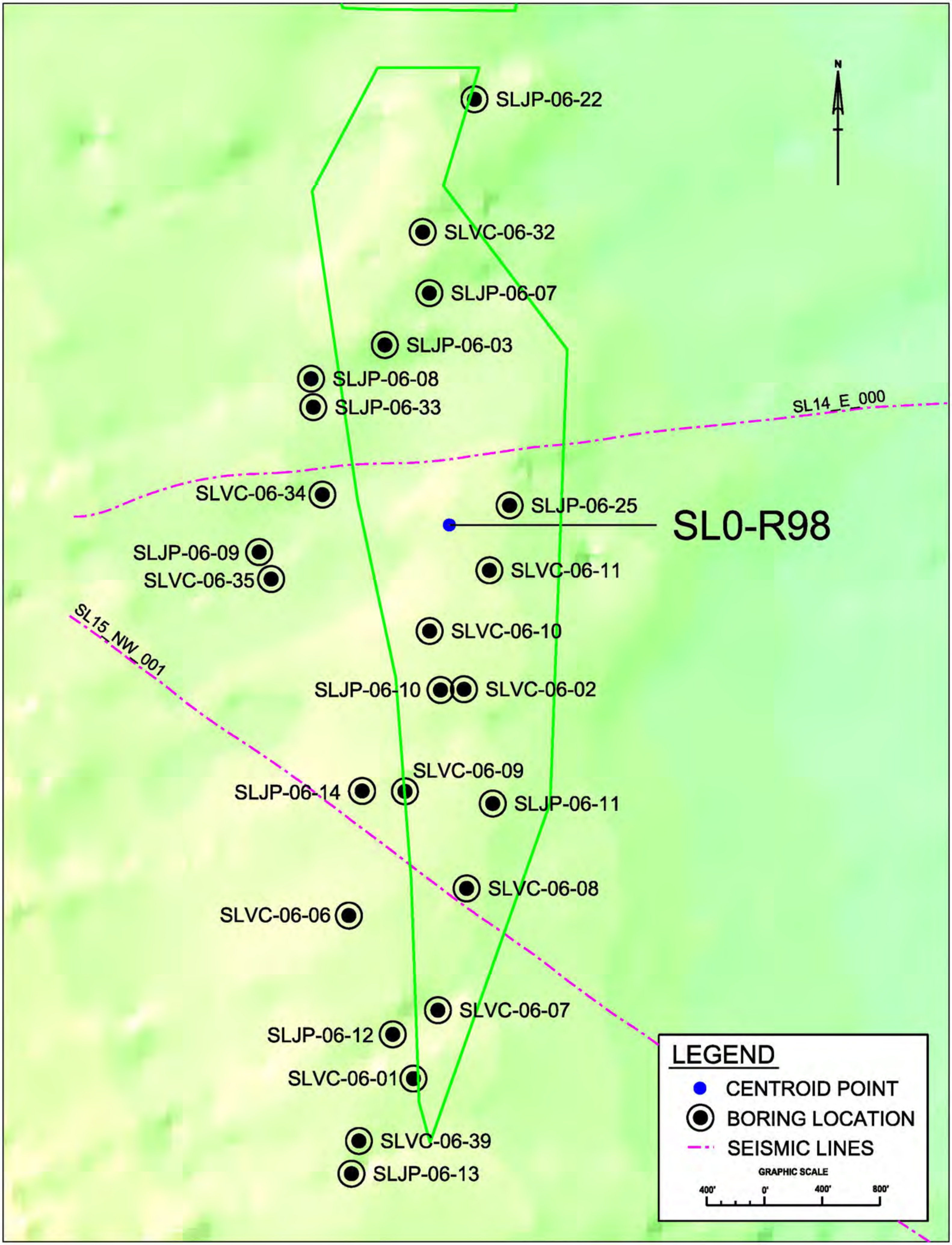
	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	51,328,472	36,642,214
Volume (cy)	1,901,055	1,357,119
Area (ft^2)	7,343,129	7,343,129
Average Thickness (ft)	7.0	5.0

Narrative: Area delineated by CPE. Jacksonville COE questioned volume of beach quality material, but the area has since been expanded in size based on seismic data. A depth of closure of -28 feet was applied to the shoreward edge of this area.

Material Description	
Mean mm:	0.25 - 0.52
Munsell value range:	4 (wet) to 5 (dry)
Color:	brown gray
Physical description:	fine grained quartz, interbedded with shell hash

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
*SLJP-06-07	914490	1083215	unknown	16
*SLJP-06-10	914567	1080467	unknown	10
*SLJP-06-11	914929	1079681	unknown	15
*SLJP-06-12	914236	1078083	unknown	12
*SLJP-06-13	913950	1077118	unknown	14
*SLJP-06-25	915045.7	1081745	unknown	17
*SLJP-06-26	914802.5	1084557	unknown	18
SLVC-06-01	914379.4	1077777	-27.7	8
SLVC-06-02	914729.8	1080472	-31.1	8
SLVC-06-03	914181.6	1082856	-33.9	5
SLVC-06-07	914549.1	1078250	-30.4	7.5
SLVC-06-08	914748	1079093	-31.5	7.8
SLVC-06-10	914491.6	1080875	-32.4	6.9
SLVC-06-11	914905.8	1081296	-32.7	7.9
SLVC-06-32	914443.6	1083638	-33.8	8.1
SLVC-06-39	914001.8	1077345	-25	6.7

Sediment Source Edge		4
*jet probes not considered in volume calculation	Average	7.0



N
SLJP-06-22
SLVC-06-32
SLJP-06-07
SLJP-06-03
SLJP-06-08
SLJP-06-33
SL14_E_000
SLVC-06-34
SLJP-06-25
SL0-R98
SLJP-06-09
SLVC-06-35
SLVC-06-11
SL15_NW_001
SLVC-06-10
SLJP-06-10
SLVC-06-02
SLVC-06-09
SLJP-06-14
SLJP-06-11
SLVC-06-08
SLVC-06-06
SLVC-06-07
SLJP-06-12
SLVC-06-01
SLVC-06-39
SLJP-06-13
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
GRAPHIC SCALE
400'
0'
400'
800'

Sediment Source ID: SL4-R98 Category: Proven

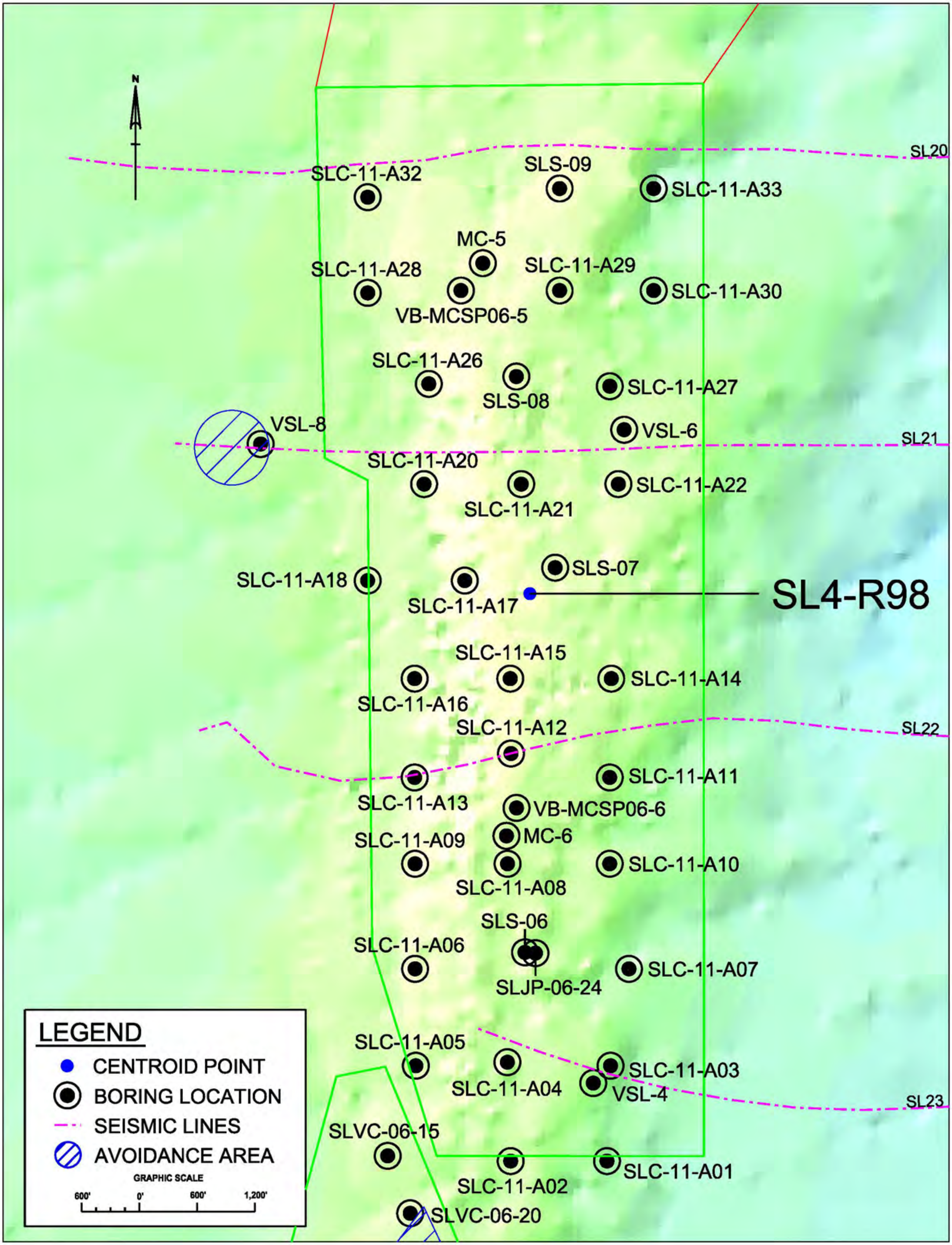
	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)		
Volume (cy)		2,344,000*
Area (ft^2)	39,838,625	39,838,625
Average Thickness (ft)	0.0	-2.0
* Volume determined from Coastal Tech 2011 report		

Narrative: Area was originally delineated by USACE. A design level investigation by Coastal Tech was done in 2011. Volumes presented for the Sediment Source are taken directly from the volume estimates from the Coastal Tech Report.

Material Description	
Mean mm:	0.46 to 0.56
Munsell value range:	5 (wet) to 6 (dry)
Color:	light olive brown to light brownish gray
Physical description:	medium grained sand sized shell with little fine grain quartz

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
SLC-11-A01	932943	1076473	-44.1	
SLC-11-A02	931991	1076400	-34.7	
SLC-11-A03	932966	1077443	-40.2	
SLC-11-A04	931989	1077442	-29.8	
SLC-11-A05	930994	1077448	-37.5	
SLC-11-A06	930982	1078442	-36.6	
SLC-11-A07	932855	1078442	-32.9	
SLC-11-A08	931991	1079672	-29.0	
SLC-11-A09	930991	1079435	-37.9	
SLC-11-A10	932999	1079443	-31.6	
SLC-11-A11	932944	1080442	-20.0	
SLC-11-A12	931942	1080466	-29.5	
SLC-11-A13	930990	1080447	-35.1	
SLC-11-A14	932975	1081424	-19.6	
SLC-11-A15	931985	1081430	-31.7	

SLC-11-A16	930972	1081423	-36.8	
SLC-11-A17	931501	1082432	-37.1	
SLC-11-A18	930505	1082425	-39.8	
SLC-11-A19	932306	1075494	-40.2	
SLC-11-A20	930969	1083453	-38.1	
SLC-11-A21	932151	1083418	-23.1	
SLC-11-A22	933010	1083430	-31.9	
SLC-11-A23	932503	1074465	-46.8	
SLC-11-A26	931076	1084447	-36.5	
SLC-11-A27	933030	1084454	-35.1	
SLC-11-A28	930999	1085458	-34.9	
SLC-11-A29	932000	1085453	-32.4	
SLC-11-A30	933024	1085412	-31.7	
SLC-11-A32	930992	1086452	-38.3	
SLC-11-A33	933006	1086454	-33.6	
VSL-4	932904	1077105	-37.1	
VSL-6	933225	1083890	-36	
SLS-06	932106	1079962	-25.8	
SLS-07	932508	1082457	-20	
SLS-08	932105	1084442	-27.6	
SLS-09	932026	1086423	-35.4	
VB-MCSP06-5	931756	1085619	-29.5	
VB-MCSP06-6	932106	1079962	-26.5	
			Average	



N
SL20
SL21
SL22
SL23
SLC-11-A32
SLS-09
SLC-11-A33
MC-5
SLC-11-A28
SLC-11-A29
SLC-11-A30
VB-MCSP06-5
SLC-11-A26
SLS-08
SLC-11-A27
VSL-8
VSL-6
SLC-11-A20
SLC-11-A21
SLC-11-A22
SLS-07
SLC-11-A18
SLC-11-A17
SL4-R98
SLC-11-A15
SLC-11-A14
SLC-11-A16
SLC-11-A12
SLC-11-A11
SLC-11-A13
VB-MCSP06-6
MC-6
SLC-11-A09
SLC-11-A10
SLC-11-A08
SLS-06
SLC-11-A06
SLC-11-A07
SLJP-06-24
SLC-11-A05
SLC-11-A03
SLC-11-A04
VSL-4
SLVC-06-15
SLC-11-A02
SLC-11-A01
SLVC-06-20
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
AVOIDANCE AREA
GRAPHIC SCALE
600'
0'
600'
1,200'

Sediment Source ID: SL7-104 Category: Proven

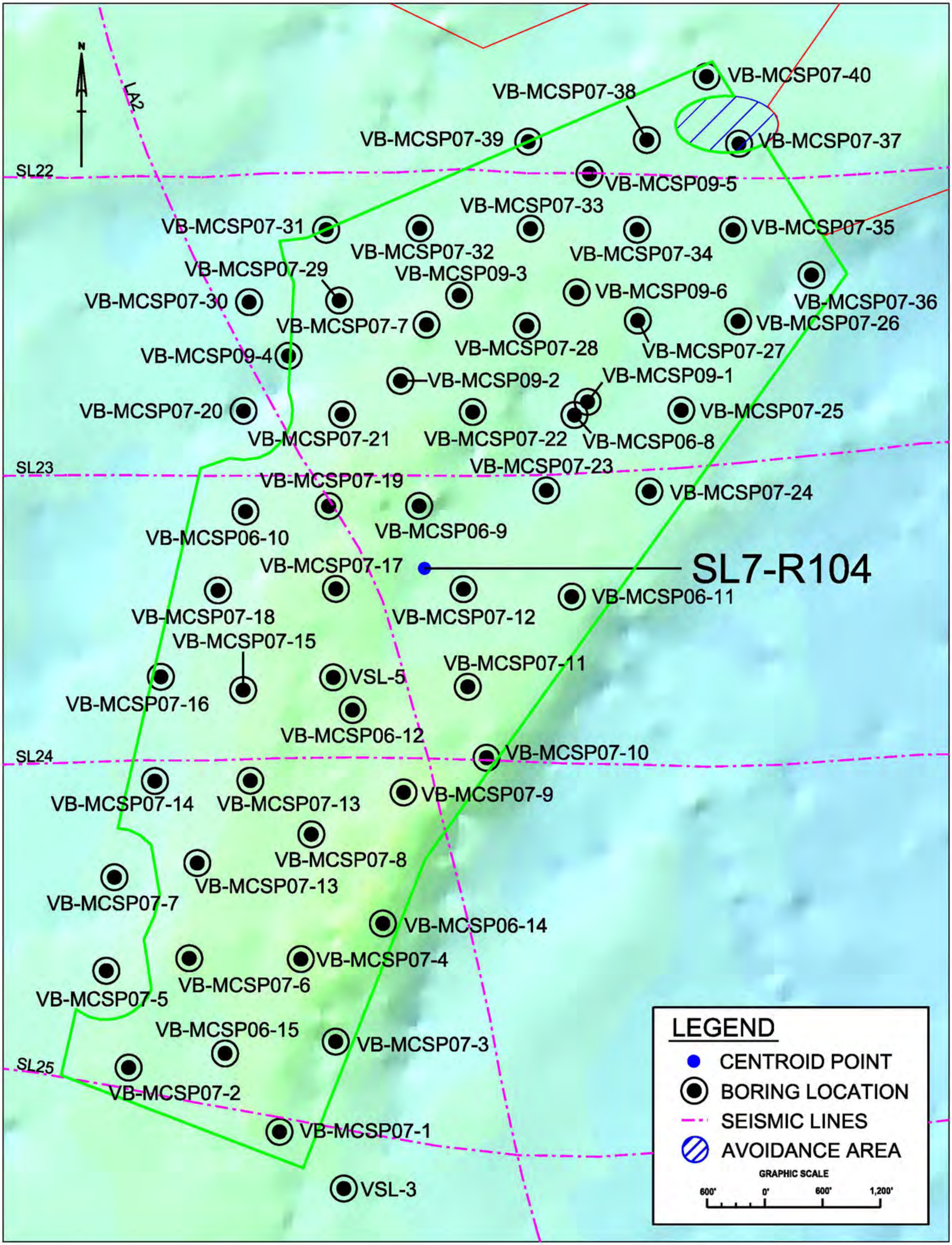
	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	425,761,138	342,695,217
Volume (cy)	15,768,931	12,692,415
Area (ft^2)	41,532,960	41,532,960
Average Thickness (ft)	10.3	8.3

Narrative: Originally delineated by USACE Martin County BEC Sand Search Investigation. The area was revised to exclude a cultural resource buffer and the influence of vibracore that do not meet the sediment criteria of the sand study.

Material Description	
Mean mm:	0.39
Munsell value range:	4 (wet) to 7 (wet)
Color:	light gray to brownish
Physical description:	fine to medium sand sized quartz, some fine to medium sand sized carbonate, little to some coarse sand sized shell, gets finer and darker with depth

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
VB-MCSP07-1	947939	1070851	-47	11
VB-MCSP07-2	946371	1071518	-49.9	10
VB-MCSP07-3	948523	1071788	-46.5	12.9
VB-MCSP07-4	948161	1072645	-43.7	12.9
VB-MCSP07-6	947003	1072653	-47.7	11.8
VB-MCSP07-8	948270	1073941	-44.9	17.8
VB-MCSP07-9	949229	1074376	-45.3	16.6
VB-MCSP07-10	950091	1074736	-46.9	15.3
VB-MCSP07-11	949896	1075473	-48	13.5
VB-MCSP07-12	949851	1076487	-52.3	8.9
VB-MCSP07-13	947636	1074498	-48.8	12.5
VB-MCSP07-14	946644	1074494	-56.4	5
VB-MCSP07-15	947561	1045439	-49.7	10.7
VB-MCSP07-16	946706	1075577	-55.6	4
VB-MCSP07-17	948525	1076490	-46.4	12.9
VB-MCSP07-18	947300	1076474	-53.5	6

VB-MCSP07-19	948450	1077350	-49.4	9
VB-MCSP07-21	948590	1078302	-52.5	10.5
VB-MCSP07-22	949947	1078327	-49.1	16.5
VB-MCSP07-23	950713	1077512	-54.8	8
VB-MCSP07-24	951783	1077502	-53	17.1
VB-MCSP07-25	952115	1078345	-54.2	16.6
VB-MCSP07-26	952706	1079268	-55.5	10
VB-MCSP07-27	951663	1079276	-52.5	10.3
VB-MCSP07-28	950510	1079220	-52.5	8.2
VB-MCSP07-29	948559	1079484	-55.5	6.1
VB-MCSP07-31	948424	1080220	-56.4	5
VB-MCSP07-32	949396	1080234	-55.8	7.7
VB-MCSP07-33	950547	1080231	-52.9	19.3
VB-MCSP07-34	951656	1080220	-54.3	4.3
VB-MCSP07-35	952653	1080217	-54.5	8
VB-MCSP07-36	953468	1079749	-56.1	8.3
VB-MCSP07-37	952715	1081113	-55.9	10
VB-MCSP07-38	951757	1081152	-53.3	11
VB-MCSP07-39	950525	1081135	-56.2	8
VB-MCSP07-40	952378	1081811	-54.8	13
VB-MCSP09-1	951141	1078432	-57.3	8
VB-MCSP09-2	949196	1078650	-54.6	11
VB-MCSP09-3	949806	1079537	-56.2	7
VB-MCSP09-4	948033	1078910	-59.7	6.7
VB-MCSP09-5	951161	1080800	-57.5	7.5
VB-MCSP09-6	951028	1079569	-57.5	7.9
Sediment Source Edge				4
			Average	10.3


N
LA2
SL22
SL23
SL24
SL25
VB-MCSP07-40
VB-MCSP07-38
VB-MCSP07-39
VB-MCSP07-37
VB-MCSP09-5
VB-MCSP07-33
VB-MCSP07-31
VB-MCSP07-35
VB-MCSP07-32
VB-MCSP07-34
VB-MCSP07-29
VB-MCSP09-3
VB-MCSP07-30
VB-MCSP09-6
VB-MCSP07-36
VB-MCSP07-7
VB-MCSP07-26
VB-MCSP07-28
VB-MCSP07-27
VB-MCSP09-4
VB-MCSP09-2
VB-MCSP09-1
VB-MCSP07-20
VB-MCSP07-25
VB-MCSP07-21
VB-MCSP07-22
VB-MCSP06-8
VB-MCSP07-23
VB-MCSP07-19
VB-MCSP07-24
VB-MCSP06-10
VB-MCSP06-9
VB-MCSP07-17
SL7-R104
VB-MCSP06-11
VB-MCSP07-18
VB-MCSP07-12
VB-MCSP07-15
VB-MCSP07-11
VSL-5
VB-MCSP07-16
VB-MCSP06-12
VB-MCSP07-10
VB-MCSP07-9
VB-MCSP07-14
VB-MCSP07-13
VB-MCSP07-8
VB-MCSP07-13
VB-MCSP07-7
VB-MCSP06-14
VB-MCSP07-4
VB-MCSP07-6
VB-MCSP07-5
VB-MCSP06-15
VB-MCSP07-3
VB-MCSP07-2
VB-MCSP07-1
VSL-3
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
AVOIDANCE AREA
GRAPHIC SCALE
600'
0'
600'
1,200'

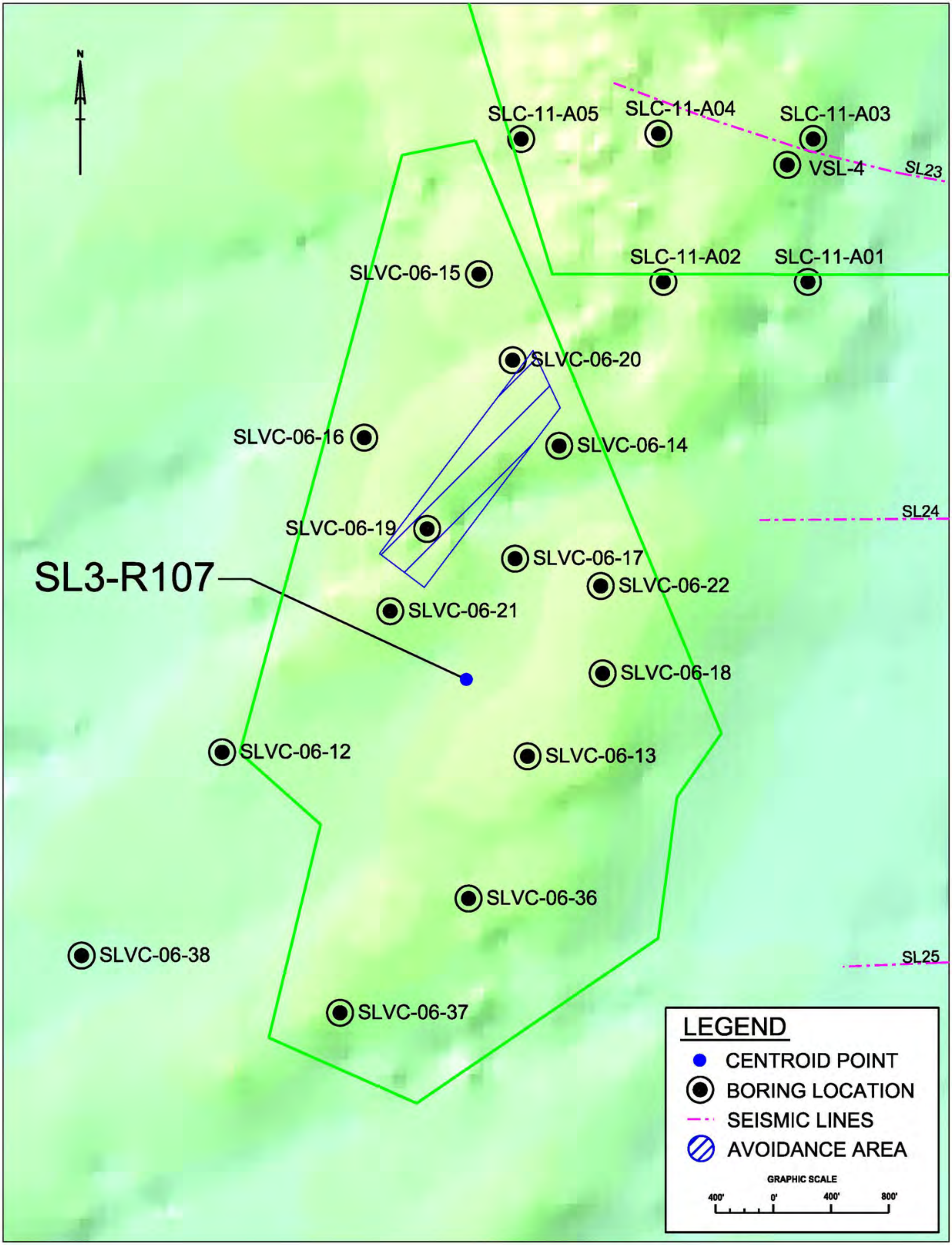
Sediment Source ID: SL3-R107 Category: Proven

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	165,940,769	140,502,736
Volume (cy)	6,145,954	5,203,805
Area (ft^2)	12,719,017	12,719,017
Average Thickness (ft)	13.0	11.0

Narrative: Delineated in CPE, 2006, South St. Lucie County HSDR Project. Avoidance area is not included in the volume calculation.

Material Description	
Mean mm:	0.26 to 0.94
Munsell value range:	4 (wet) to 6 (wet)
Color:	gray to grayish brown
Physical description:	fine sand-sized quartz, fine to coarse sand-sized shell

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
SLVC-06-12	929594	1073568	-41.7	15.6
SLVC-06-13	931104	1073010	-41.5	15.2
SLVC-06-14	931293	1075107	-39.3	12.5
SLVC-06-15	930767	1076349	-36.8	15.8
SLVC-06-16	931001	1075752	-39.2	16
SLVC-06-17	931611	1074189	-41.9	14.2
SLVC-06-18	931652	1073625	-41	12.1
SLVC-06-19	931018	1074378	-42	14.6
SLVC-06-20	930603	1075127	-41.3	11.9
SLVC-06-21	930408	1074584	-40.4	15
SLVC-06-22	930153	1074015	-39.9	14.9
SLVC-06-36	931196	1072374	-42.3	13.7
SLVC-06-37	930695	1072025	-42	11.2
SLVC-06-38	930152	1071631	-42.9	9
Sediment Source Edge				4
			Average	13.0


N
SLC-11-A05
SLC-11-A04
SLC-11-A03
VSL-4
SL23
SLC-11-A02
SLC-11-A01
SLVC-06-15
SLVC-06-20
SLVC-06-16
SLVC-06-14
SL24
SLVC-06-19
SLVC-06-17
SL3-R107
SLVC-06-22
SLVC-06-21
SLVC-06-18
SLVC-06-12
SLVC-06-13
SLVC-06-36
SLVC-06-38
SL25
SLVC-06-37
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
AVOIDANCE AREA
GRAPHIC SCALE
400'
0'
400'
800'

10.2 St. Lucie County, FL: POTENTIAL

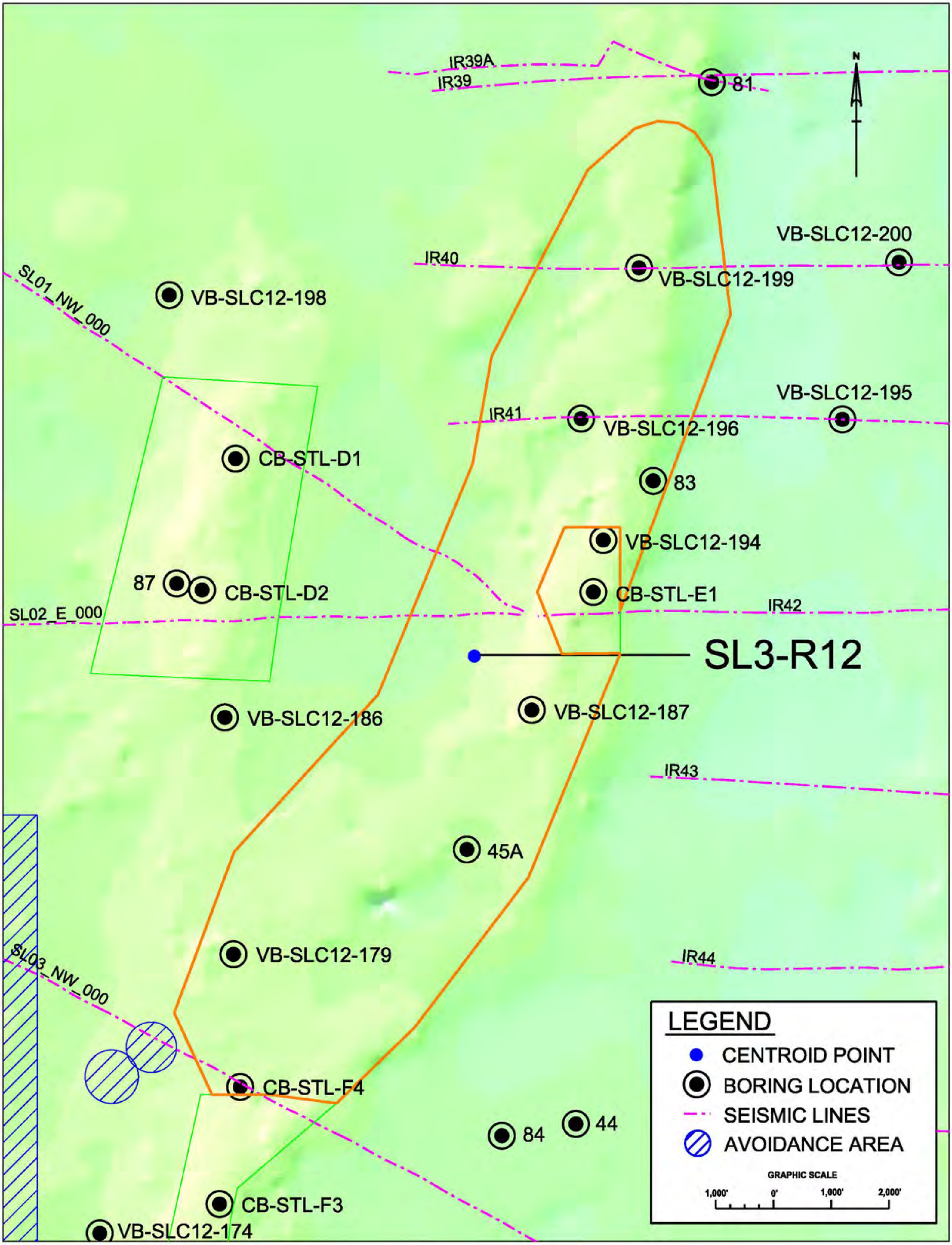
Sediment Source ID: SL3-R12 Category: Potential

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	524,635,895	402,220,853
Volume (cy)	19,430,959	14,897,069
Area (ft^2)	61,207,521	61,207,521
Average Thickness (ft)	8.6	6.6

Narrative: The area was delineated by COE. The data was obtained from the Ft. Pierce SPP GRR, revised March 2008. The area was expanded as a result of the 2012 SAND Study. Coquina and clay encountered at terminal depth of cores.

Material Description	
Mean mm:	0.34 to 0.5
Munsell value range:	4 (wet) 6 (dry)
Color:	gray
Physical description:	poorly-sorted coarse shelly sand

Boring Dsignation	Easting	Northing	Elevation (ft)	Thickness (ft)
VB-SLC12-179	892810	1156658	-36.4	7.9
VB-SLC12-187	897979	1160887	-36.8	8.4
VB-SLC12-196	898832	1165931	-36.6	11.4
VB-SLC12-199	899836	1168542	-36.8	14.3
83	900082	1164854	unknown	8
45A	896853	1154872	unknown	6
Sediment Source Edge				4
			Average	8.6


IR39A
IR39
81
N
VB-SLC12-200
IR40
VB-SLC12-199
SL01_NW_000
VB-SLC12-198
VB-SLC12-195
IR41
VB-SLC12-196
CB-STL-D1
83
VB-SLC12-194
87
CB-STL-D2
CB-STL-E1
IR42
SL02_E_000
SL3-R12
VB-SLC12-186
VB-SLC12-187
IR43
45A
VB-SLC12-179
IR44
SL03_NW_000
CB-STL-F4
84
44
CB-STL-F3
VB-SLC12-174
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
AVOIDANCE AREA
GRAPHIC SCALE
1,000'
0'
1,000'
2,000'

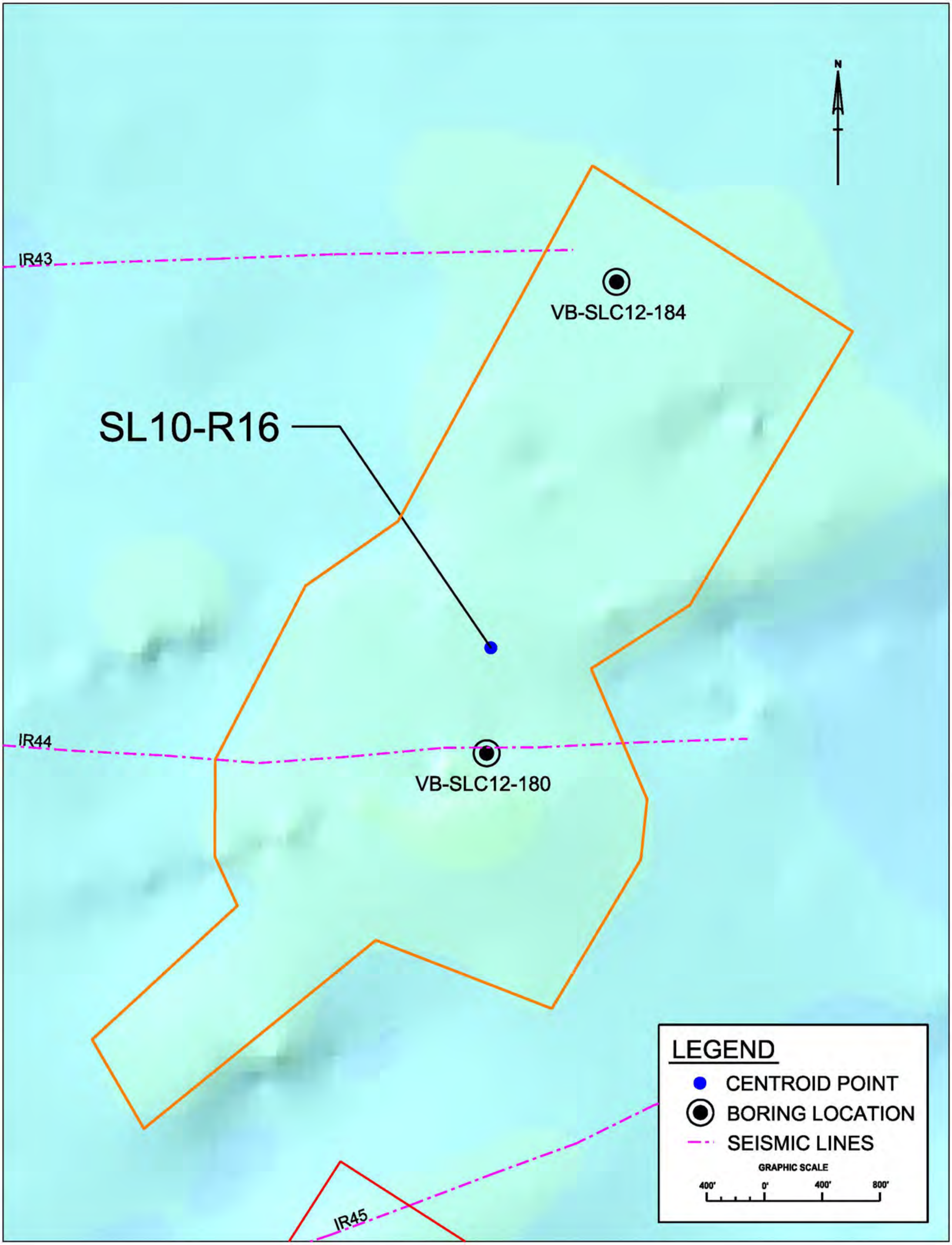
Sediment Source ID: SL10-R16 Category: Potential

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	106,244,758	78,528,734
Volume (cy)	3,934,991	2,908,472
Area (ft^2)	13,858,012	13,858,012
Average Thickness (ft)	7.7	5.7

Narrative: The area was delineated in the SAND Study using bathymetric and seismic evidence and two vibracore.

Material Description	
Mean mm:	0.25 - 0.43
Munsell value range:	4 (wet) 5 (dry)
Color:	olive gray to dark gray
Physical description:	fine sand-sized quartz and fine to coarse sand-sized shell

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
VB-SLC12-180	935055	1156712	-59.8	9.8
VB-SLC12-184	935955	1159976	-61.9	9.2
Sediment Source Edge				4
			Average	7.7



N
IR43
VB-SLC12-184
SL10-R16
IR44
VB-SLC12-180
IR45
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
GRAPHIC SCALE
400'
0'
400'
800'

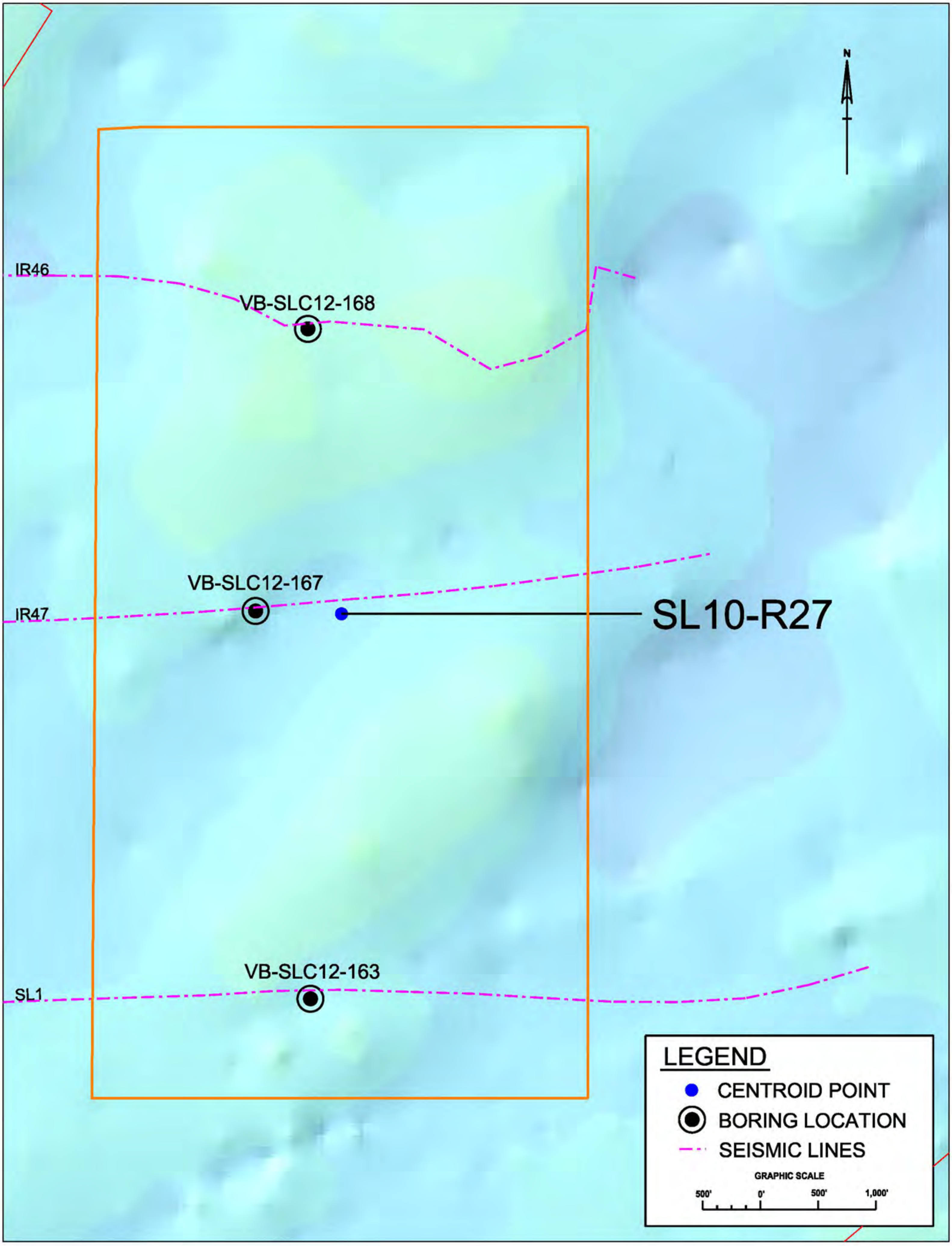
Sediment Source ID: SL10-R27 Category: Potential

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	381,027,278	309,304,496
Volume (cy)	14,112,121	11,455,722
Area (ft^2)	35,861,391	35,861,391
Average Thickness (ft)	10.6	8.6

Narrative: The area was delineated in the SAND Study using bathymetric and seismic evidence along with three vibracore.

Material Description	
Mean mm:	0.39 - 0.71
Munsell value range:	4 (wet) 5 (dry)
Color:	dark gray
Physical description:	fine-grained quartz sand, fine-to-coarse sand sized shelll

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
VB-SLC12-163	937448	1144586	-62.8	11
VB-SLC12-167	936973	1147943	-60.8	12.5
VB-SLC12-168	937426	1150385	-59.3	15
Sediment Source Edge				4
			Average	10.6


N
IR46
VB-SLC12-168
VB-SLC12-167
IR47
SL10-R27
VB-SLC12-163
SL1
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
GRAPHIC SCALE
500'
0'
500'
1,000'

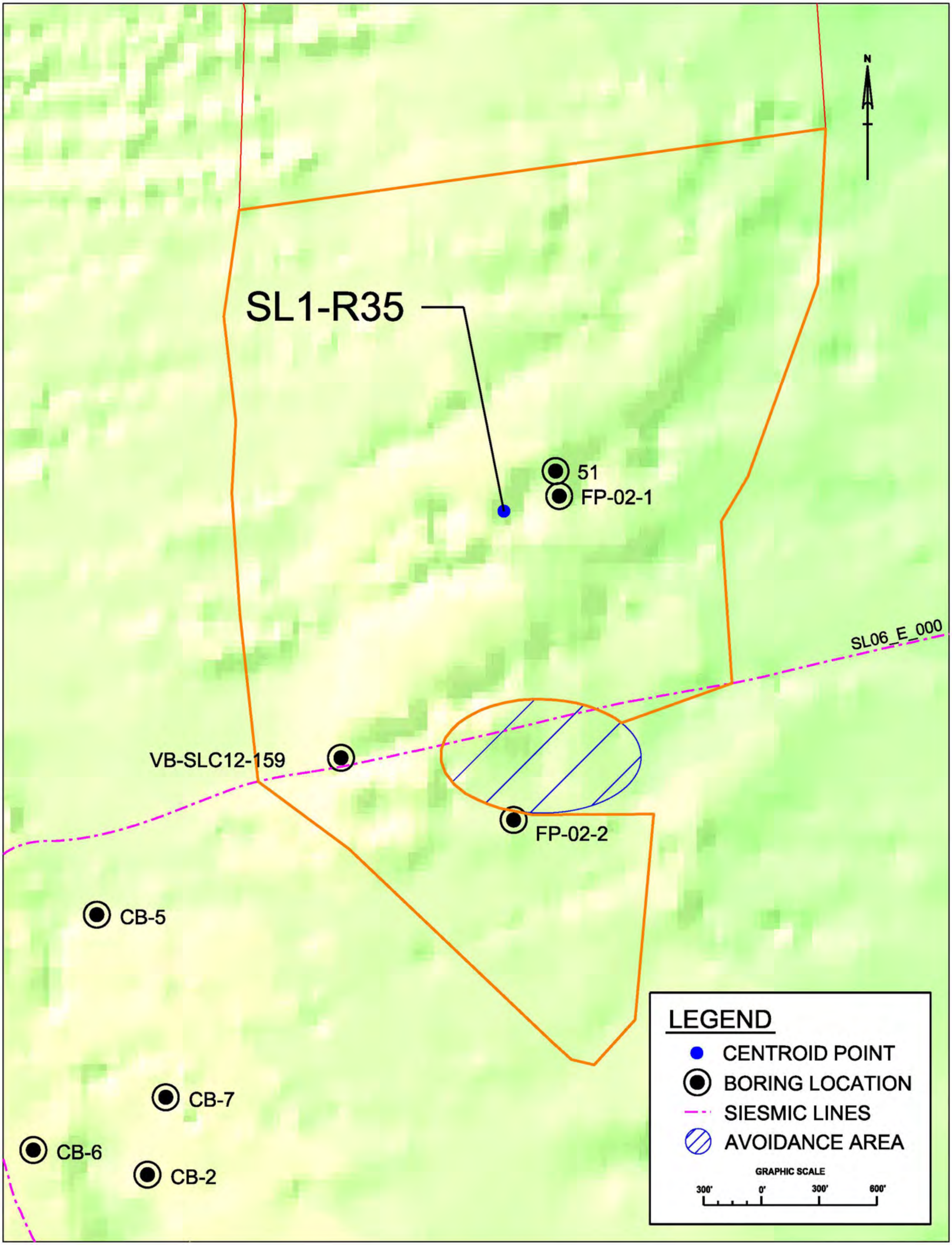
Sediment Source ID: SL1-R35 Category: Potential

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	68,627,965	49,458,143
Volume (cy)	2,541,776	1,831,783
Area (ft^2)	9,584,911	9,584,911
Average Thickness (ft)	7.2	5.2

Narrative: Avoidance area located in the center of the deposit has been excluded from the deposit boundary. This is the southern part of the Ft. Pierce Inlet ebb shoal.

Material Description	
Mean mm:	0.26 to 0.52
Munsell value range:	4 (wet) to 6 (wet)
Color:	gray
Physical description:	fine to medium grained sand and shell fragments

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
VB-SLC12-159	891618	1138202	-26.9	4.6
FP-02-1	892752	1139561	-26.5	7.8
FP-02-2	892515	1137879	-22.9	8.8
51	892733	1139691	unknown	10.6
Sediment Source Edge				4
			Average	7.2


SL1-R35
51
FP-02-1
SL06_E_000
VB-SLC12-159
FP-02-2
CB-5
CB-7
CB-6
CB-2
N
LEGEND
CENTROID POINT
BORING LOCATION
SIESMIC LINES
AVOIDANCE AREA
GRAPHIC SCALE
300'
0'
300'
600'

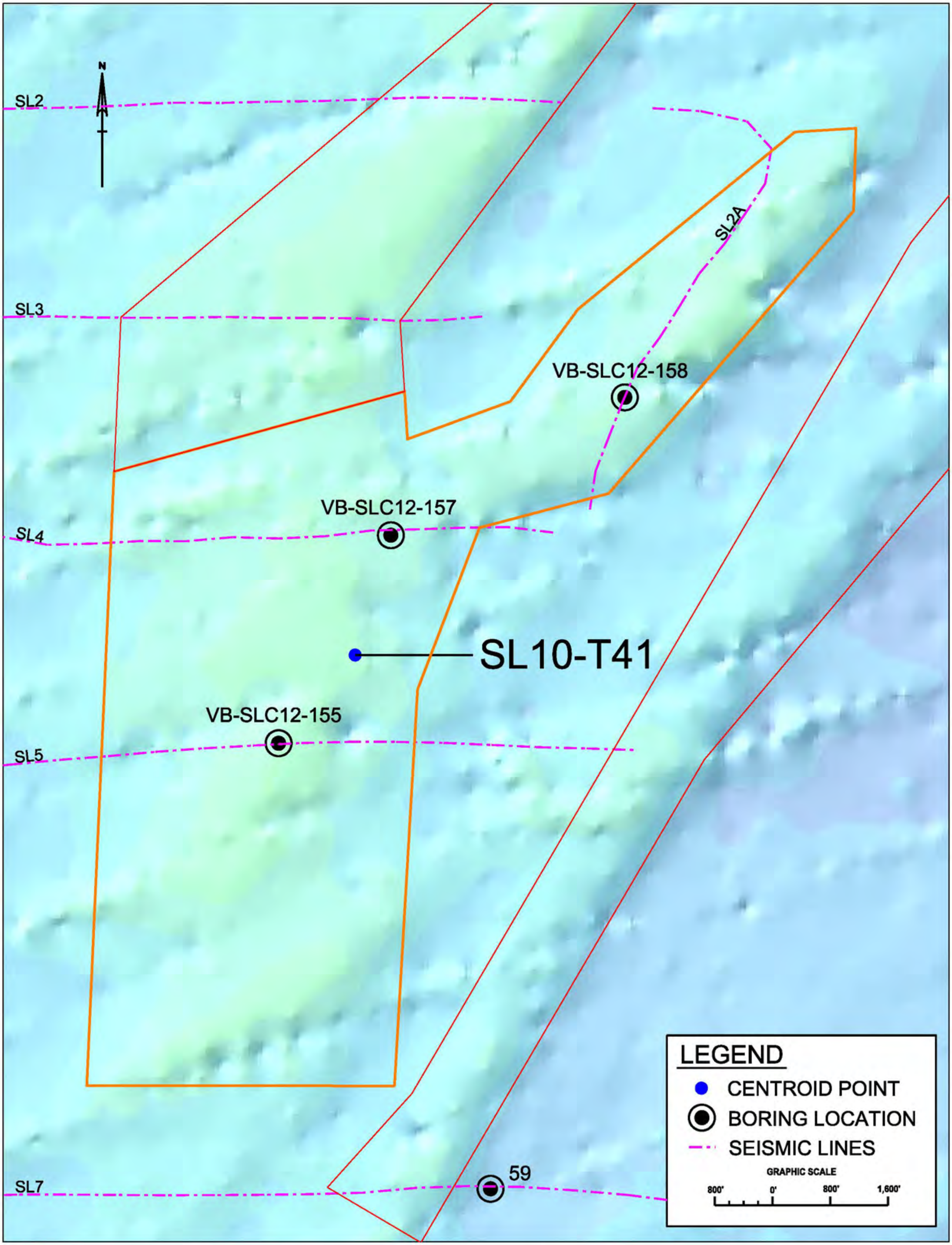
Sediment Source ID: SL10-T41 Category: Potential

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	584,958,090	479,797,085
Volume (cy)	21,665,114	17,770,262
Area (ft^2)	52,580,502	52,580,502
Average Thickness (ft)	11.1	9.1

Narrative: This area was delineated in the SAND Study using bathymetric and seismic evidence with three vibracore.

Material Description	
Mean mm:	0.24 - 0.52
Munsell value range:	4 (wet) 5 (dry)
Color:	light greenish gray to dark gray
Physical description:	fine to medium sand-sized quartz with fine to coarse sand-sized carbonate

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
VB-SLC12-155	939689	1132732	-59.9	13.6
VB-SLC12-157	941245	1135611	-64	9.3
VB-SLC12-158	944487	1137520	-61.5	17.6
Sediment Source Edge				4
			Average	11.1



N
SL2
SL2A
SL3
VB-SLC12-158
VB-SLC12-157
SL4
SL10-T41
VB-SLC12-155
SL5
SL7
59
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
GRAPHIC SCALE
800'
0'
800'
1,600'

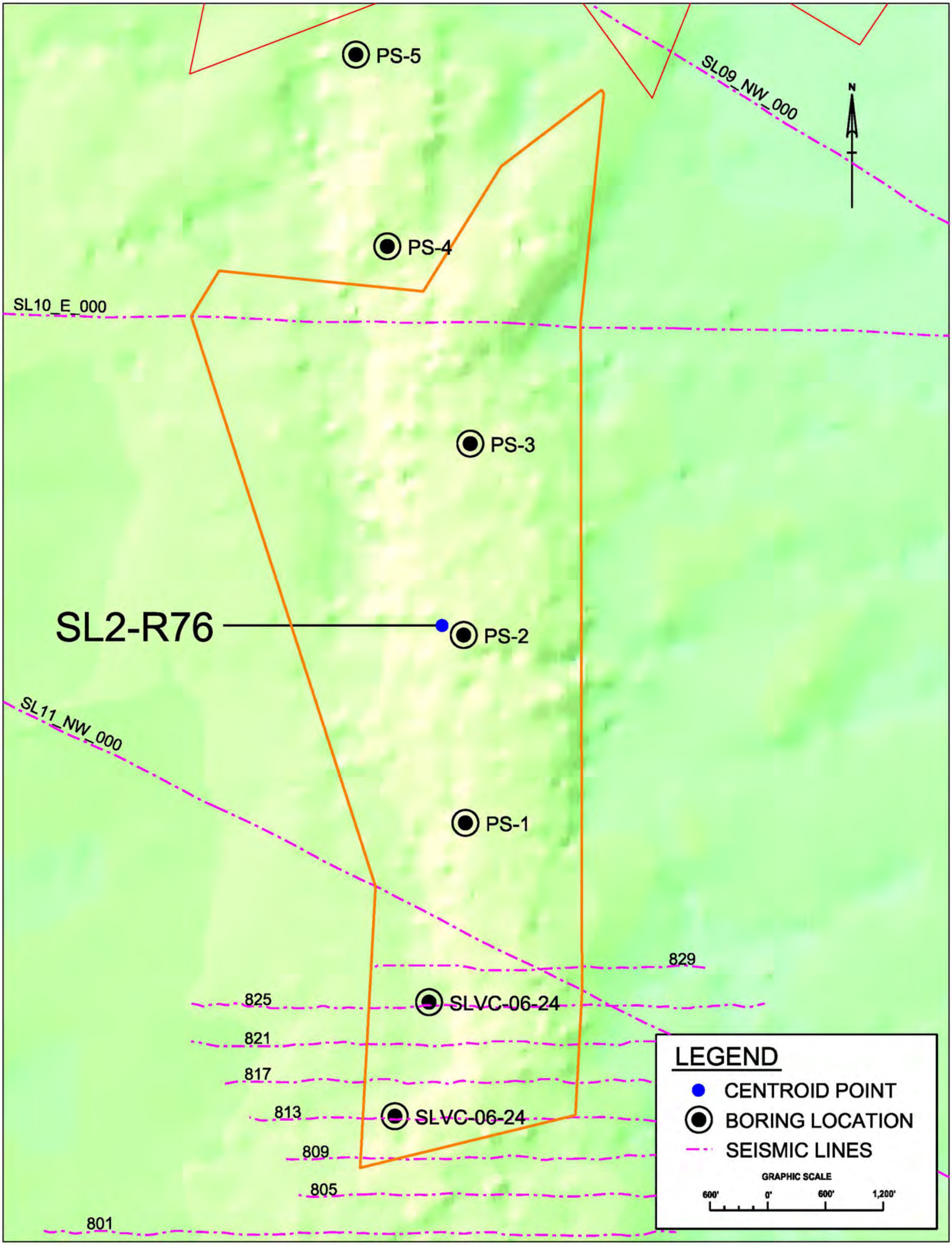
Sediment Source ID: SL2-R76 Category: Potential

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	254,314,222	199,228,109
Volume (cy)	9,419,045	7,378,819
Area (ft^2)	27,543,057	27,543,057
Average Thickness (ft)	9.2	7.2

Narrative: The area was originally identified in the Ft. Pierce GRR Recon level study in 2008. The deposit boundaries were extended based upon seismic imaging and vibracore data. Coquina and clay were encountered at terminal depth of vibracores.

Material Description	
Mean mm:	0.23 to 0.65
Munsell value range:	4-5 (wet) 6 (dry)
Color:	gray to grayish brown
Physical description:	fine grained quartz sand with fine to coarse sand-sized carbonate

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
PS-1	913519	1099656	-25.9	10.5
PS-2	913502	1101607	-23.1	8.8
PS-3	913570	1103595	-26.6	17
SLVC06-23	913141	1097794	-35.1	10
SLVC06-24	912786	1096609	-38.1	5.1
Sediment Source Edge				4
			Average	9.2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SL09_NW_000
N
PS-4
SL10_E_000
PS-3
SL2-R76
PS-2
SL11_NW_000
PS-1
829
825
SLVC-06-24
821
817
813
SLVC-06-24
809
805
801
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
GRAPHIC SCALE
600'
0'
600'
1,200'

10.3 St. Lucie County, FL: UNVERIFIED

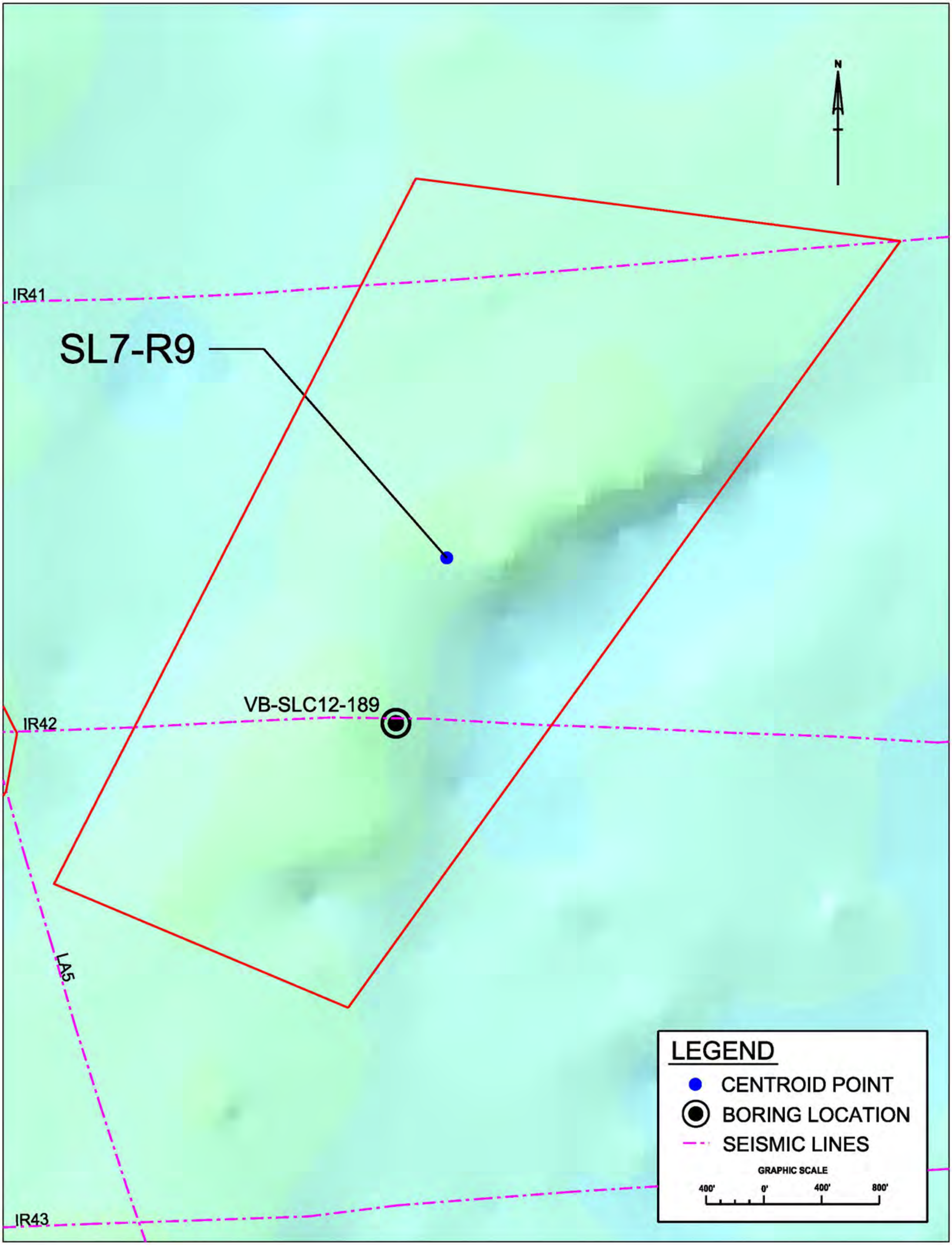
Sediment Source ID: SL7-R9 Category: Unverified

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	54,192,113	33,742,259
Volume (cy)	2,007,115	1,249,713
Area (ft^2)	10,224,927	10,224,927
Average Thickness (ft)	5.3	3.3

Narrative: Area delineated in SAND Study using bathymetric and seismic evidence and two vibracore.

Material Description	
Mean mm:	0.32 to 0.57
Munsell value range:	4 (wet) to 5 (dry)
Color:	greenish grey to dark grey
Physical description:	fine sand-sized quartz and fine to coarse sand-sized shell

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
VB-SLC12-189	916193	1162622	-55.7	5.4
VB-SLC12-191	913633	1162644	-54.7	6.5
Sediment Source Edge				4
			Average	5.3


N
IR41
SL7-R9
VB-SLC12-189
IR42
LA5
IR43
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
GRAPHIC SCALE
400'
0'
400'
800'

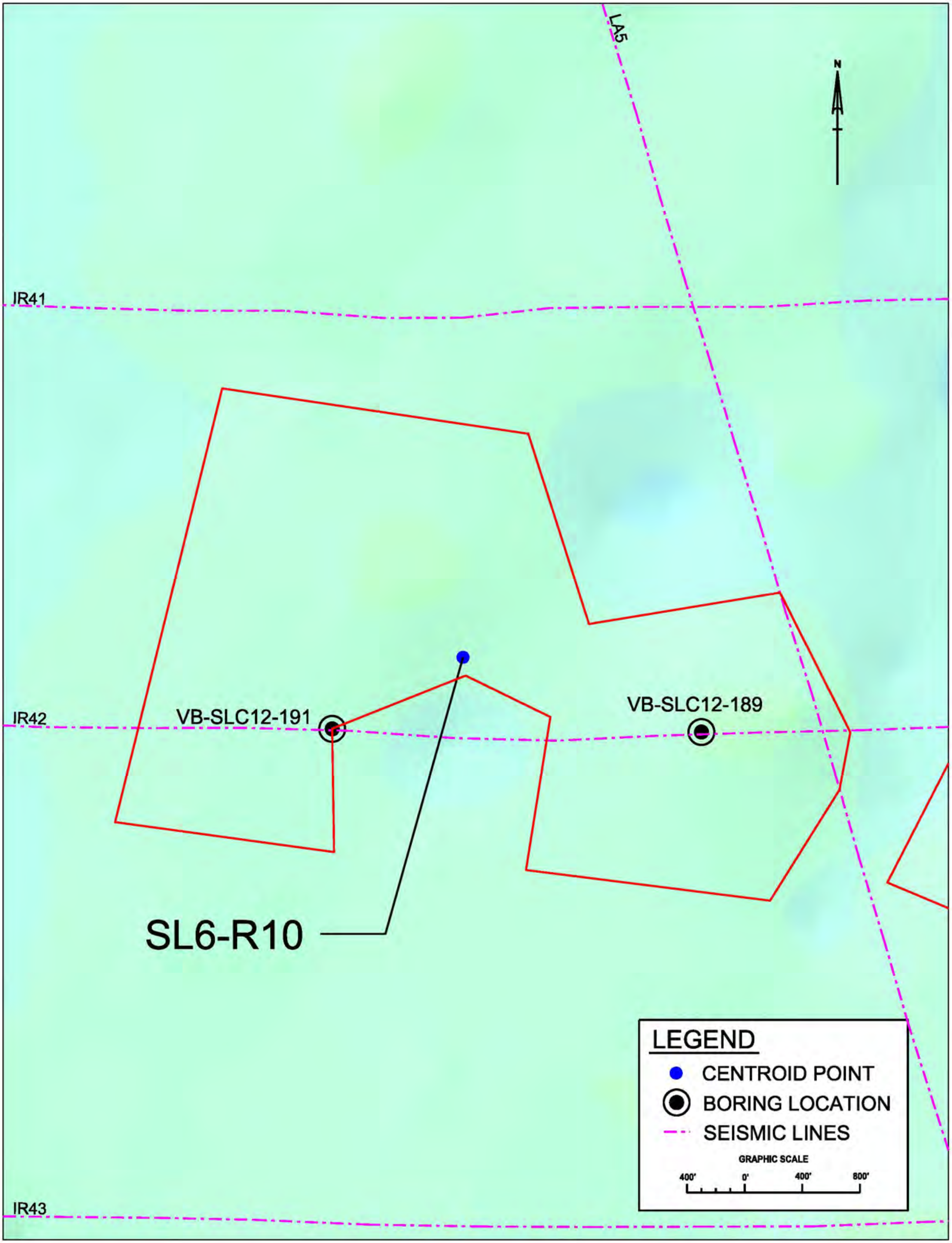
Sediment Source ID: SL6-R10 Category: Unverified

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	158,686,884	127,107,405
Volume (cy)	5,877,292	4,707,682
Area (ft^2)	15,789,740	15,789,740
Average Thickness (ft)	10.1	8.1

Narrative: Area delineated in SAND Study using bathymetric and seismic evidence and one vibracore.

Material Description	
Mean mm:	0.44 to 0.47
Munsell value range:	4 (wet) to 5(dry)
Color:	gray, greenish gray to dark gray
Physical description:	fine grained sand-sized quartz and fine to coarse sand sized shell

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
VB-SLC12-192	919851	1162690	-51.4	16.1
Sediment Source Edge				4
			Average	10.1



LA5
N
IR41
IR42
IR43
VB-SLC12-191
VB-SLC12-189
SL6-R10
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
GRAPHIC SCALE
400'
0'
400'
800'

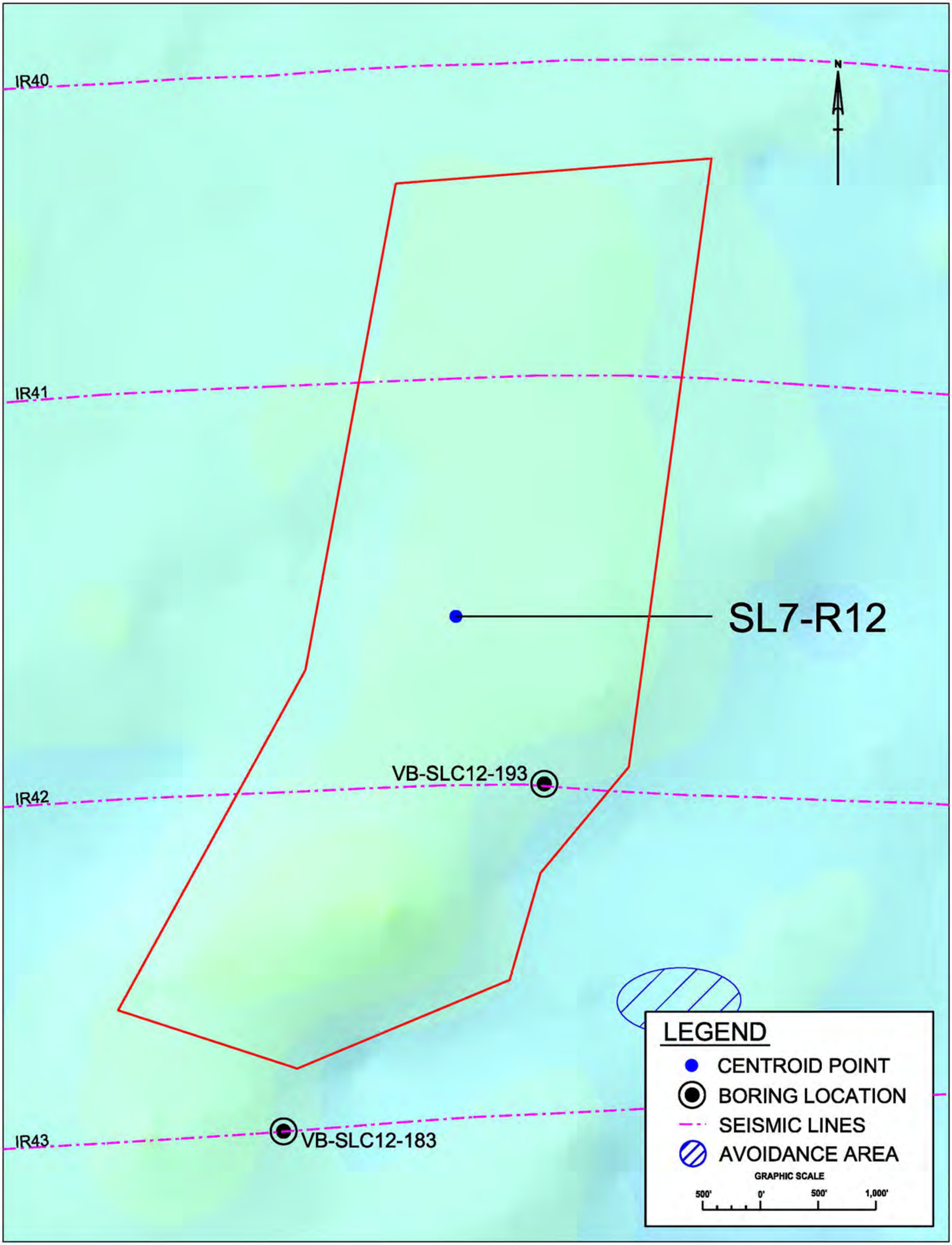
Sediment Source ID: SL7-R12 Category: Unverified

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	164,769,508	120,830,972
Volume (cy)	6,102,574	4,475,221
Area (ft^2)	21,969,268	21,969,268
Average Thickness (ft)	7.5	5.5

Narrative: Area delineated in SAND Study using bathymetric and seismic evidence and one vibracore.

Material Description	
Mean mm:	0.35 - 0.51
Munsell value range:	4 (wet) 5 (dry)
Color:	gray, greenish gray, dark gray
Physical description:	fine quartz sand and fine-to-coarse sand-sized shell

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
VB-SLC12-193	928657	1162784	-55.4	11
Sediment Source Edge				4
			Average	7.5



IR40
IR41
IR42
IR43
N
SL7-R12
VB-SLC12-193
VB-SLC12-183
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
AVOIDANCE AREA
GRAPHIC SCALE
500'
0'
500'
1,000'

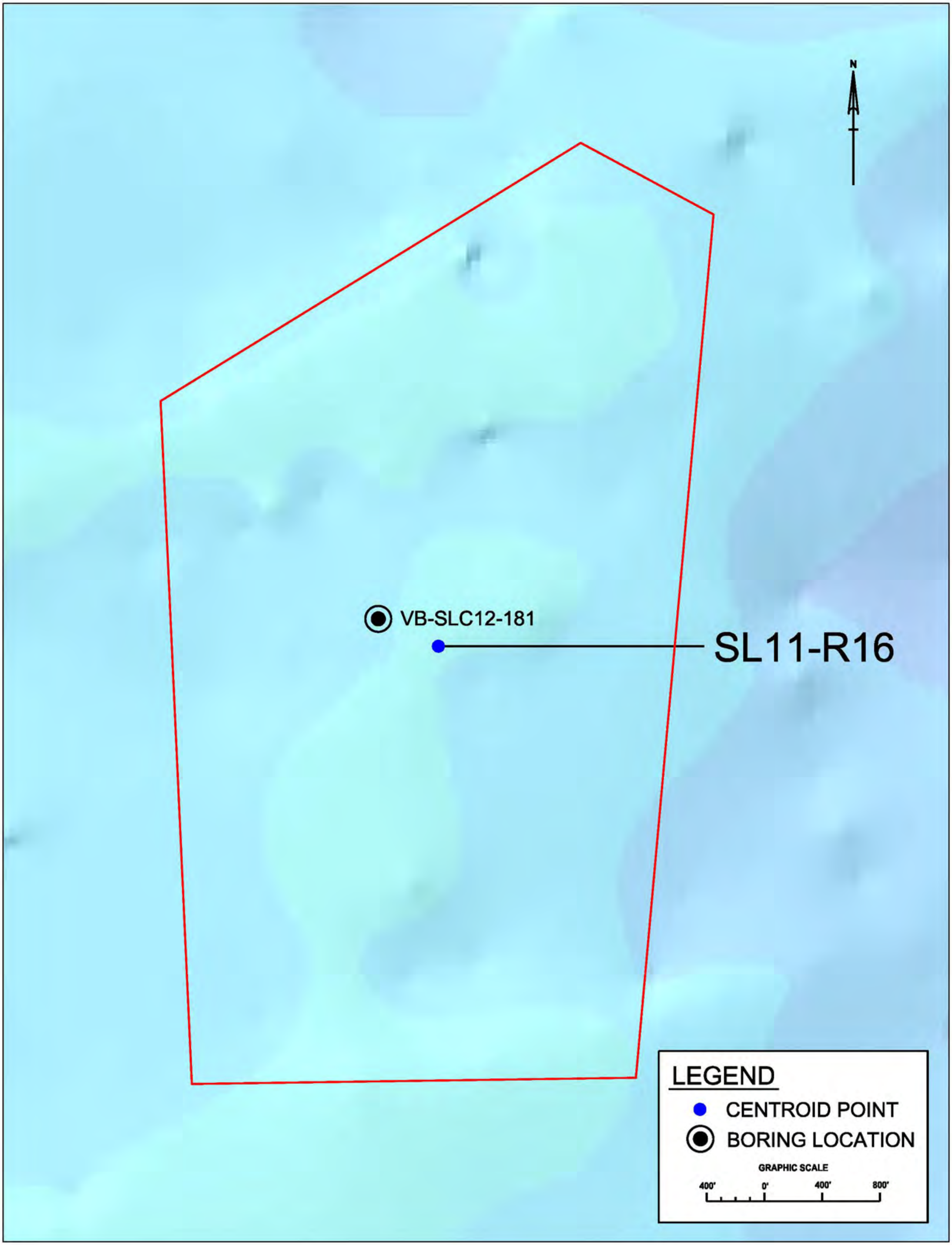
Sediment Source ID: SL11-R16 Category: Unverified

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	114,569,863	74,719,476
Volume (cy)	4,243,328	2,767,388
Area (ft^2)	19,925,194	19,925,194
Average Thickness (ft)	5.8	3.8

Narrative: The area delineated as part of 2012 SAND Study using one vibracore. The boundaries were adjusted correspond with the bathymetry.

Material Description	
Mean mm:	0.4 - 0.63
Munsell value range:	3 (wet) 5 (dry)
Color:	gray
Physical description:	fine-grained quartz sand, fine-to-coarse sand size shell

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
VB-SLC12-181	941857	1158231	-68.3	7.5
Sediment Source Edge				4
			Average	5.8


N
VB-SLC12-181
SL11-R16
LEGEND
CENTROID POINT
BORING LOCATION
GRAPHIC SCALE
400'
0'
400'
800'

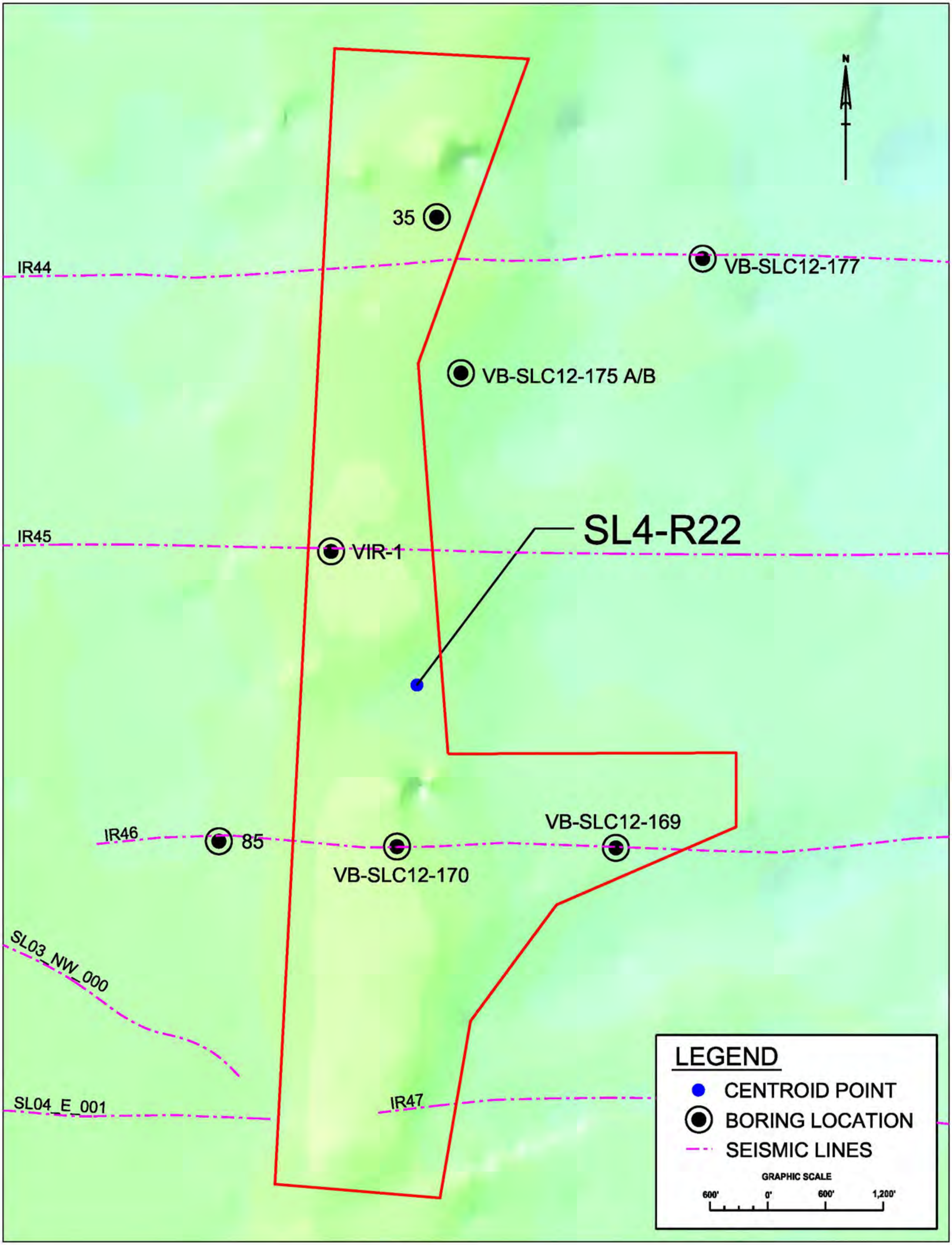
Sediment Source ID: SL4-R22 Category: Unverified

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	164,528,294	118,952,589
Volume (cy)	6,093,641	4,405,651
Area (ft^2)	22,787,852	22,787,852
Average Thickness (ft)	7.2	5.2

Narrative: Deposit was delineated using bathymetry, seismic and vibracores with laboratory data. It is in the northern part of the Capron Shoal.

Material Description	
Mean mm:	0.28 to 0.48
Munsell value range:	4 (wet) to 7 (dry)
Color:	gray, yellow to olive gray
Physical description:	fine sand sized quartz , fine to coarse grained sand-sized shell

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
VB-SLC12-169	908717	1150473	-48.4	5
VB-SLC12-170	906442	1150486	-38.9	11.1
VIR-1	905757	1153552	unknown	8
35	906855	1157024	unknown	8
Sediment Source Edge				4
			Average	7.2


N
35
IR44
VB-SLC12-177
VB-SLC12-175 A/B
SL4-R22
IR45
VIR-1
VB-SLC12-169
IR46
85
VB-SLC12-170
SL03_NW_000
SL04_E_001
IR47
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
GRAPHIC SCALE
600'
0'
600'
1,200'

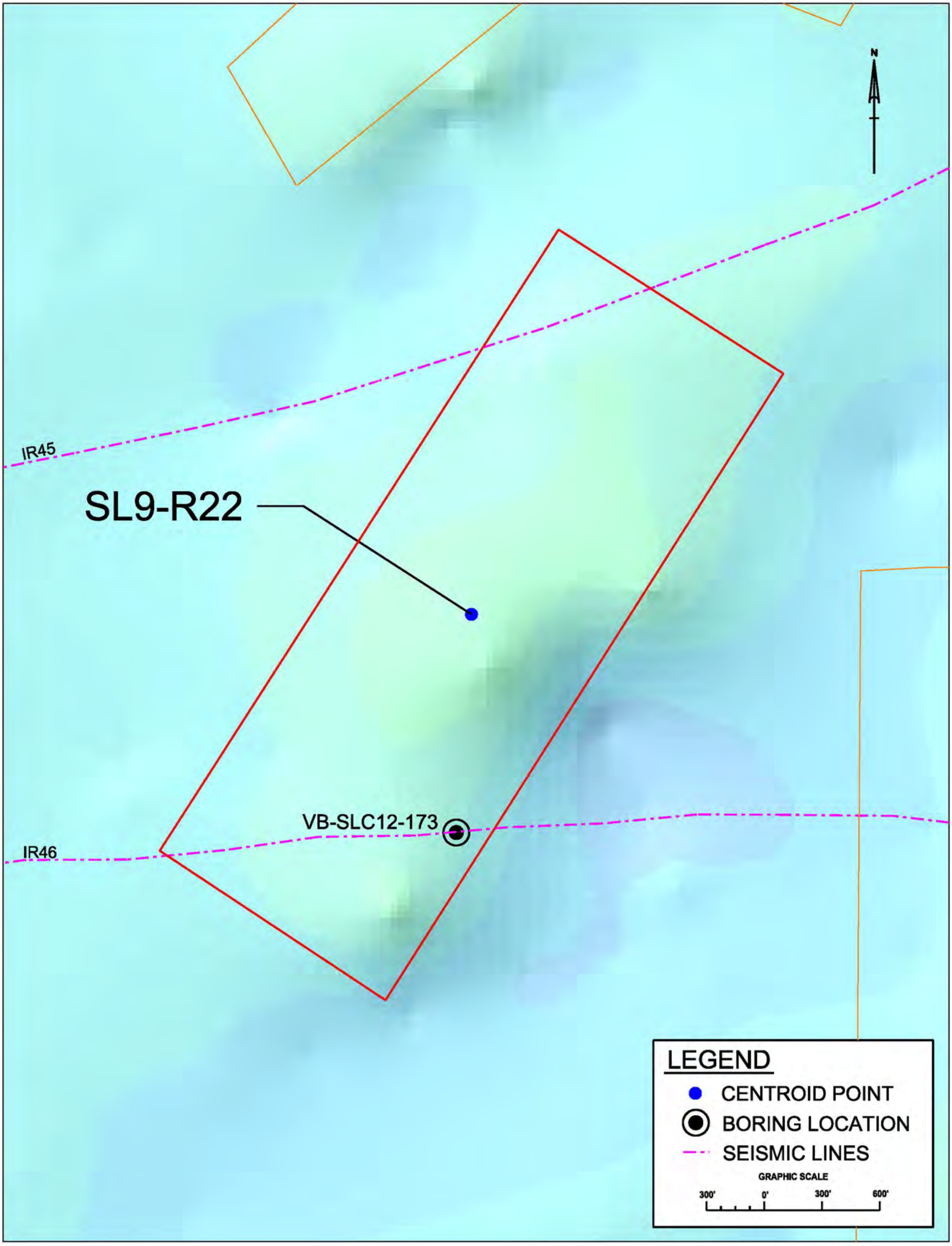
Sediment Source ID: SL9-R22 Category: Unverified

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	26,312,529	15,572,721
Volume (cy)	974,538	576,767
Area (ft^2)	5,369,904	5,369,904
Average Thickness (ft)	4.9	2.9

Narrative: The area was delineated in the SAND study using bathymetric and seismic evidence and one vibracore

Material Description	
Mean mm:	0.33 to 0.49
Munsell value range:	4 (wet to 5 (wet)
Color:	dark greenish gray to dark gray
Physical description:	fine sand-sized quartz with fine to coarse sand-sized shell

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
VB-SLC12-173	933510	1150753	-56.1	5.8
Sediment Source Edge				4
			Average	4.9



N
IR45
SL9-R22
VB-SLC12-173
IR46
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
GRAPHIC SCALE
300'
0'
300'
600'

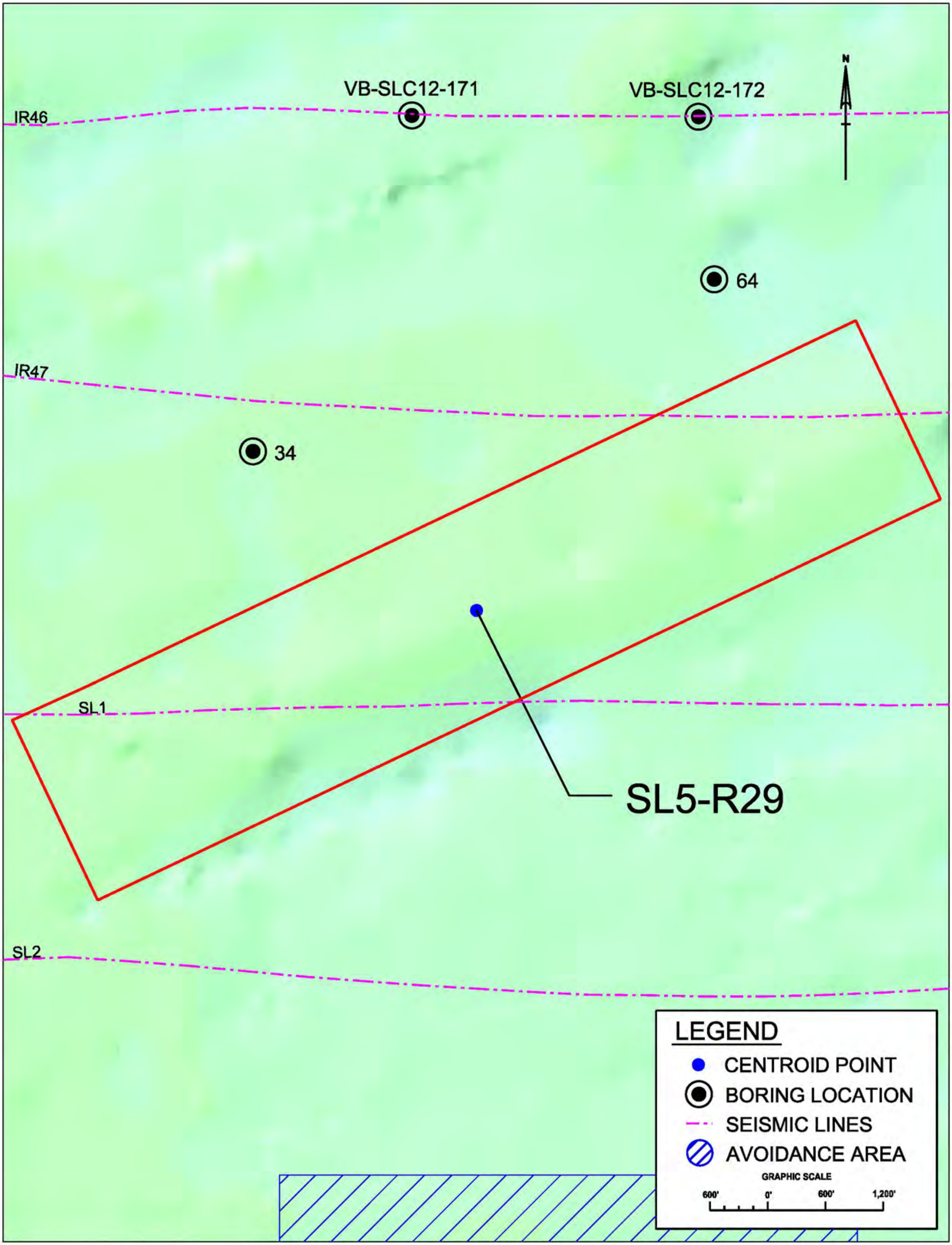
Sediment Source ID: SL5-R29 Category: Unverified

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)		
Volume (cy)		
Area (ft^2)	19,931,691	19,931,691
Average Thickness (ft)	0.0	-2.0

Narrative: This area has no vibracores within the boundaries. It was delineated in the SAND study based on bathymetric and seismic evidence. It contributes no volume to the SAND Study.

Material Description	
Mean mm:	
Munsell value range:	
Color:	
Physical description:	

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
			Average	



VB-SLC12-171
VB-SLC12-172
N
IR46
64
IR47
34
SL1
SL5-R29
SL2
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
AVOIDANCE AREA
GRAPHIC SCALE
600'
0'
600'
1,200'

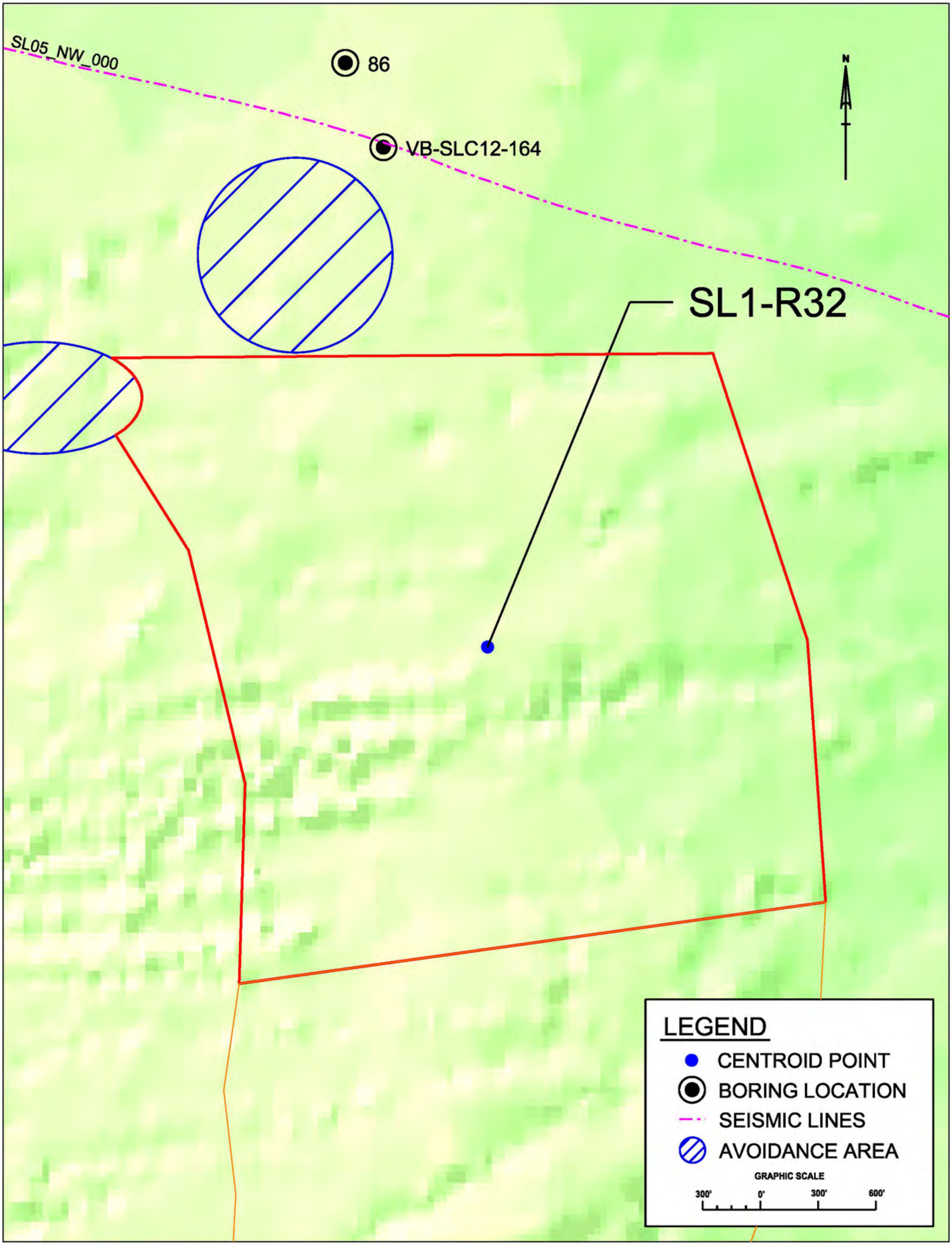
Sediment Source ID: SL1-R32 Category: Unverified

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)		
Volume (cy)		
Area (ft^2)	9,364,325	9,364,325
Average Thickness (ft)	0.0	-2.0

Narrative: Avoidance areas to the north have been removed from the deposit boundary. This area is part of the Ft. Pierce inlet ebb shoal, has no borings located within the deposit boundary, and contributes no volume to the SAND Study.

Material Description	
Mean mm:	
Munsell value range:	
Color:	
Physical description:	

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
			Average	



SL05_NW_000
86
VB-SLC12-164
N
SL1-R32
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
AVOIDANCE AREA
GRAPHIC SCALE
300'
0'
300'
600'

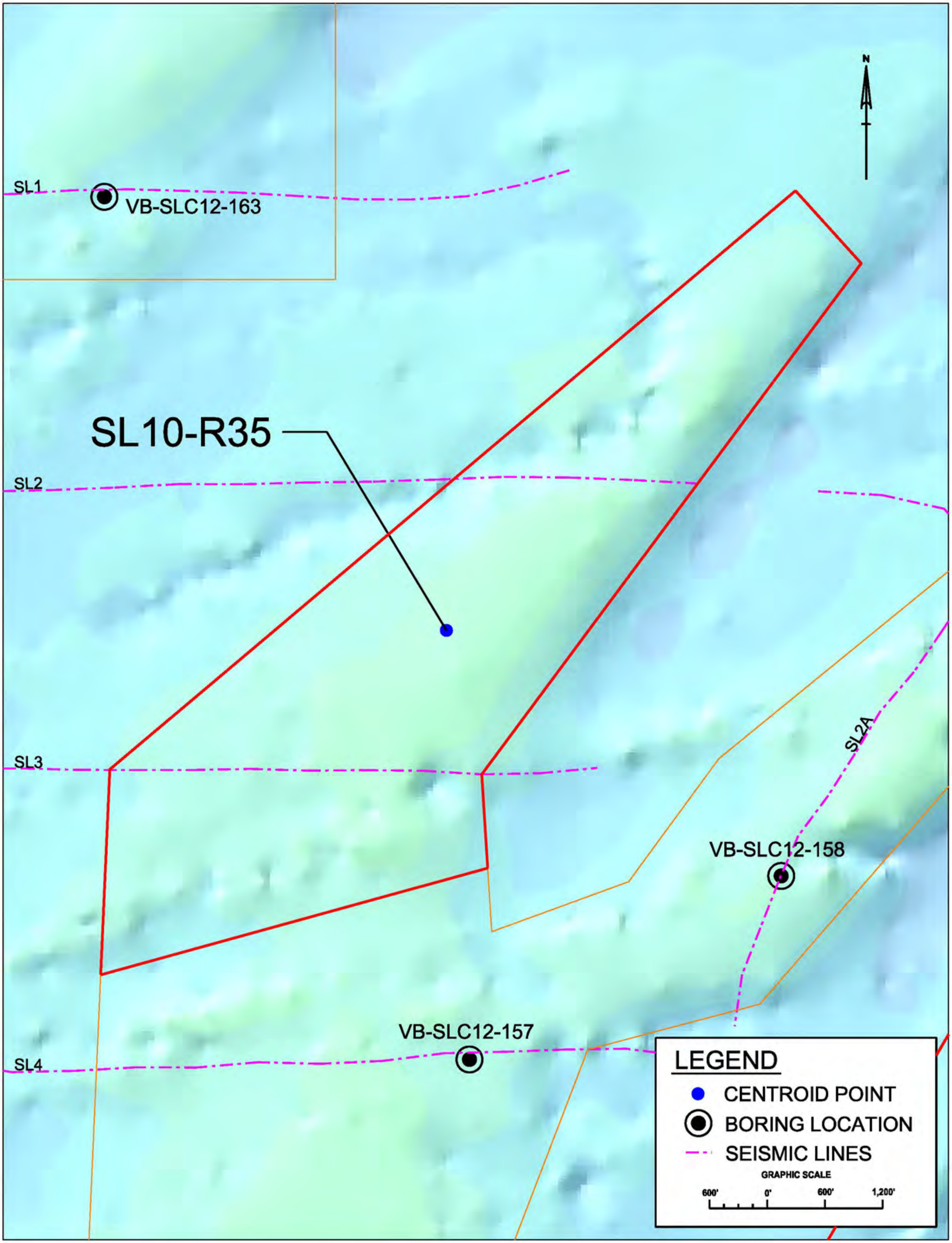
Sediment Source ID: SL10-R35 Category: Unverified

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)		
Volume (cy)		
Area (ft^2)	21,265,557	21,265,557
Average Thickness (ft)	0.0	-2.0

Narrative: This area has no vibracores within the boundaries. It was delineated in the SAND study based on bathymetric and seismic evidence. It contributes no volume to the SAND Study.

Material Description	
Mean mm:	
Munsell value range:	
Color:	
Physical description:	

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
			Average	


N
SL1
VB-SLC12-163
SL10-R35
SL2
SL3
SL2A
VB-SLC12-158
VB-SLC12-157
SL4
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
GRAPHIC SCALE
600'
0'
600'
1,200'

Sediment Source ID: SL4-R39 Category: Unverified

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)		
Volume (cy)		
Area (ft^2)	8,425,153	8,425,153
Average Thickness (ft)	0.0	-2.0

Narrative: This area has no vibracores within the boundaries. It was delineated in the SAND study based on bathymetric and seismic evidence. It contributes no volume to the SAND Study.

Material Description

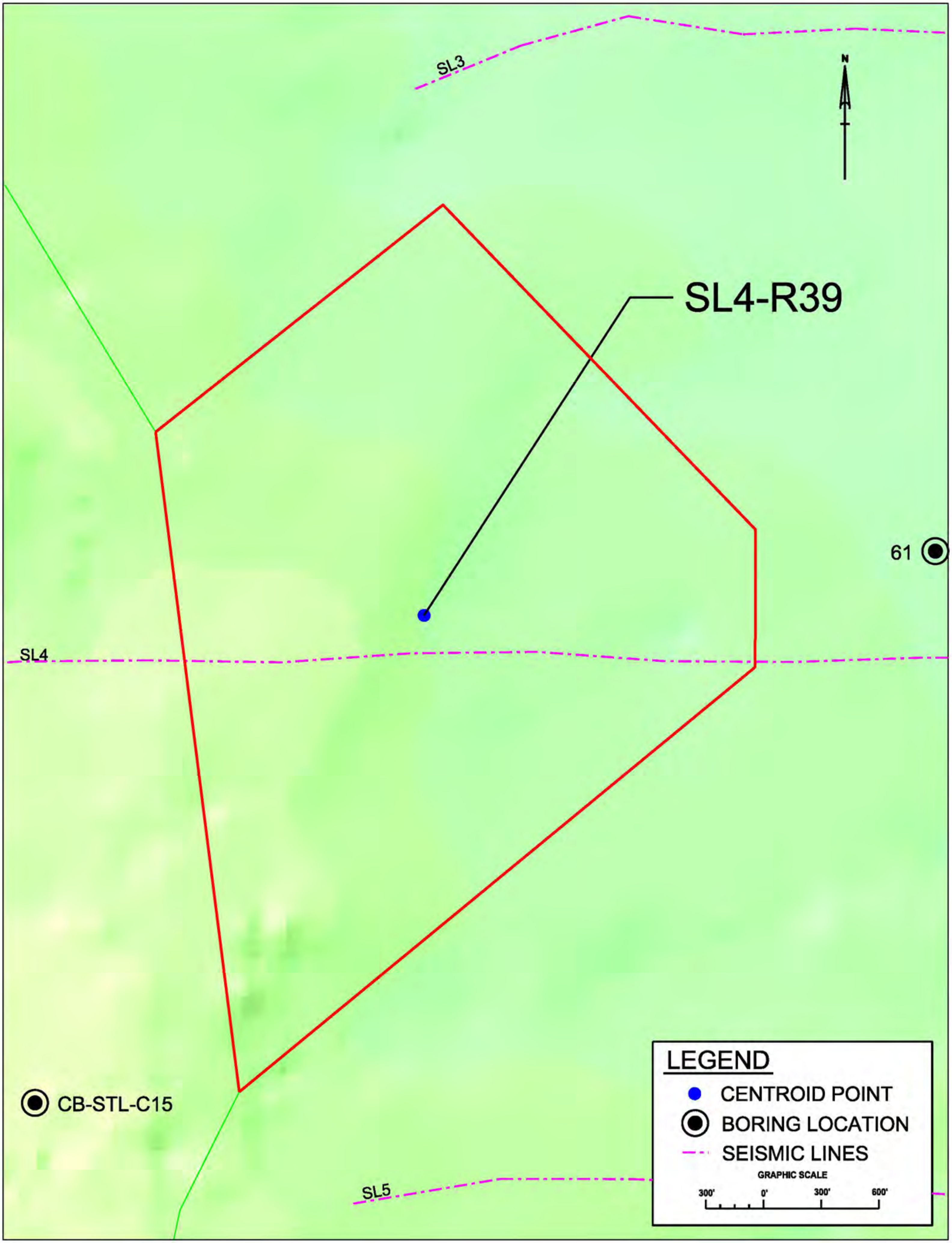
Mean mm:

Munsell value range:

Color:

Physical description:

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
			Average	


SL3
SL4-R39
61
SL4
CB-STL-C15
SL5
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
GRAPHIC SCALE
300'
0'
300'
600'
N

Sediment Source ID: SL11-T41 Category: Unverified

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)		
Volume (cy)		
Area (ft^2)	26,620,044	26,620,044
Average Thickness (ft)	0.0	-2.0

Narrative: This area has no vibracores within the boundaries. It was delineated in the SAND study based on bathymetric and seismic evidence. It contributes no volume to the SAND Study.

Material Description

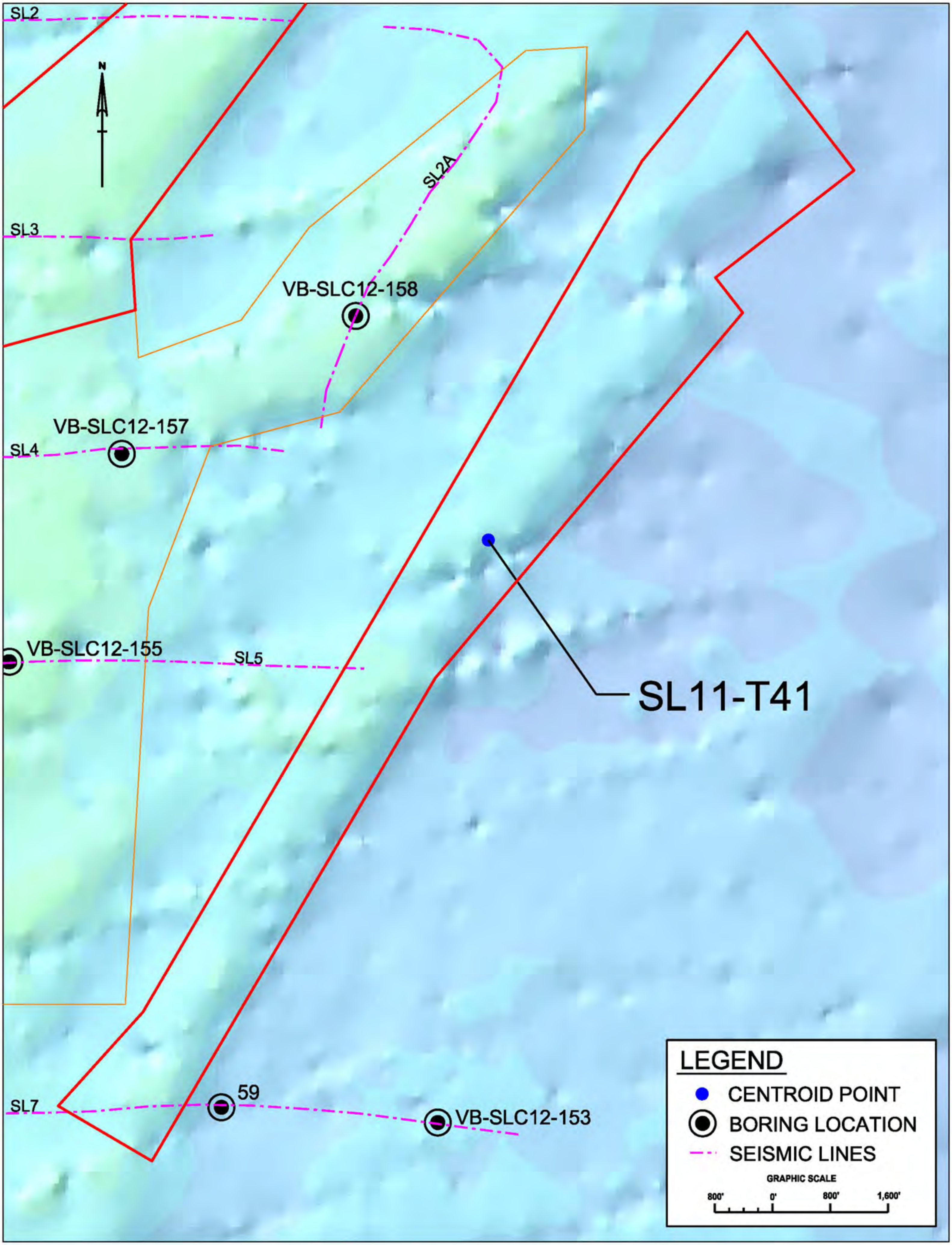
Mean mm:

Munsell value range:

Color:

Physical description:

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
			Average	



N
SL2
SL2A
SL3
VB-SLC12-158
VB-SLC12-157
SL4
VB-SLC12-155
SL5
SL11-T41
SL7
59
VB-SLC12-153
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
GRAPHIC SCALE
800'
0'
800'
1,600'

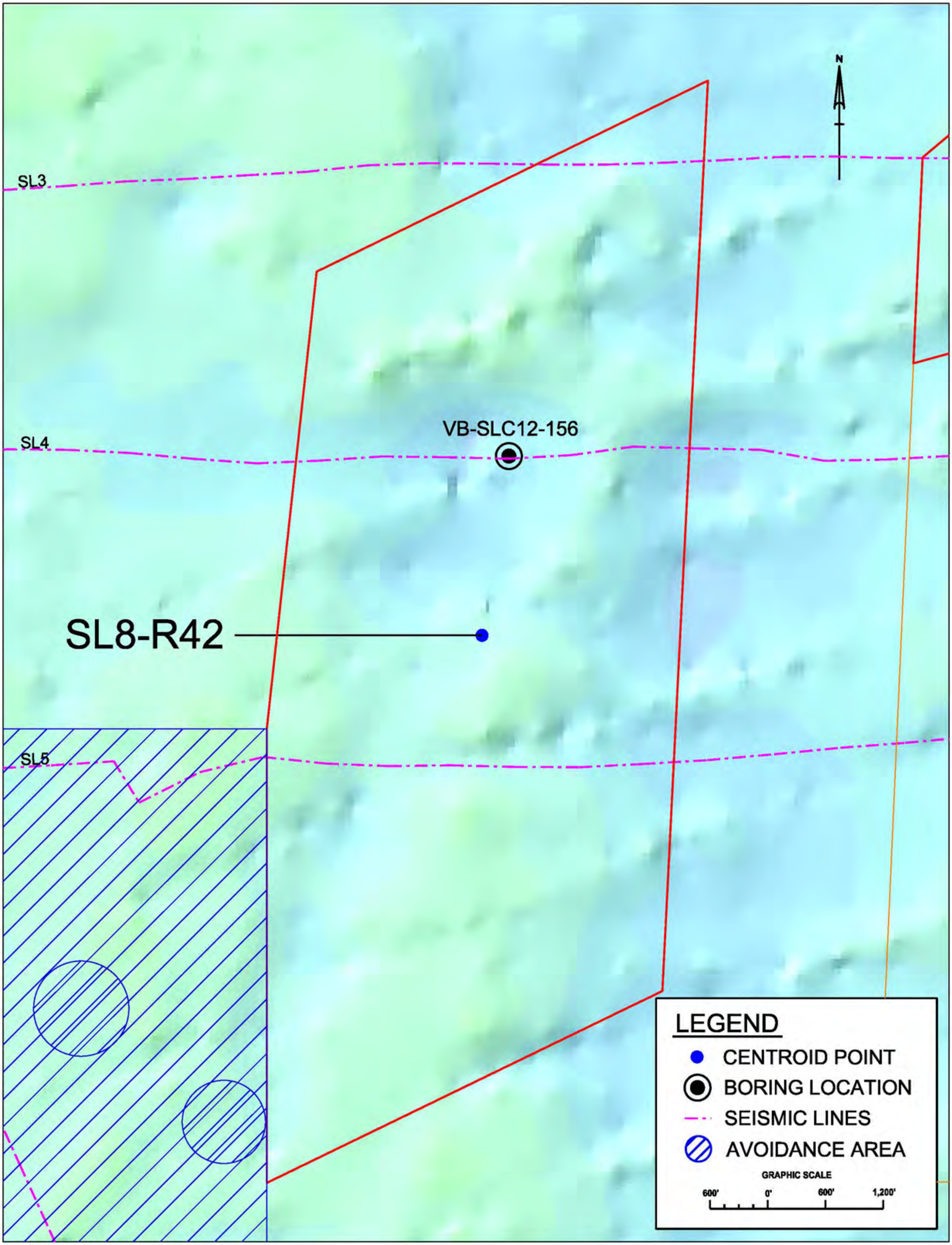
Sediment Source ID: SL8-R42 Category: Unverified

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	175,180,529	97,322,516
Volume (cy)	6,488,168	3,604,538
Area (ft^2)	38,929,006	38,929,006
Average Thickness (ft)	4.5	2.5

Narrative: The area was delineated using bathymetric and seismic evidence combined with one vibracore.

Material Description	
Mean mm:	0.35 to 0.56
Munsell value range:	4-5 (wet) to 5-6 (dry)
Color:	gray
Physical description:	fine to medium sand-sized quartz with fine to coarse sand sized shell

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
VB-SLC12-156	933206	1135528	-70.1	5
Sediment Source Edge				4
			Average	4.5



SL3
SL4
SL5
VB-SLC12-156
SL8-R42
N
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
AVOIDANCE AREA
GRAPHIC SCALE
600'
0'
600'
1,200'

Sediment Source ID: SL11-R64 Category: Unverified

	No Vertical Buffer	With 2ft Vertical Buffer
Volume (cf)		
Volume (cy)		
Area (ft^2)	60,229,531	60,229,531
Average Thickness (ft)	0.0	-2.0

Narrative: This area has no vibracores within the boundaries. It was delineated in the SAND study based on bathymetric evidence. It contributes no volume to the SAND Study.

Material Description

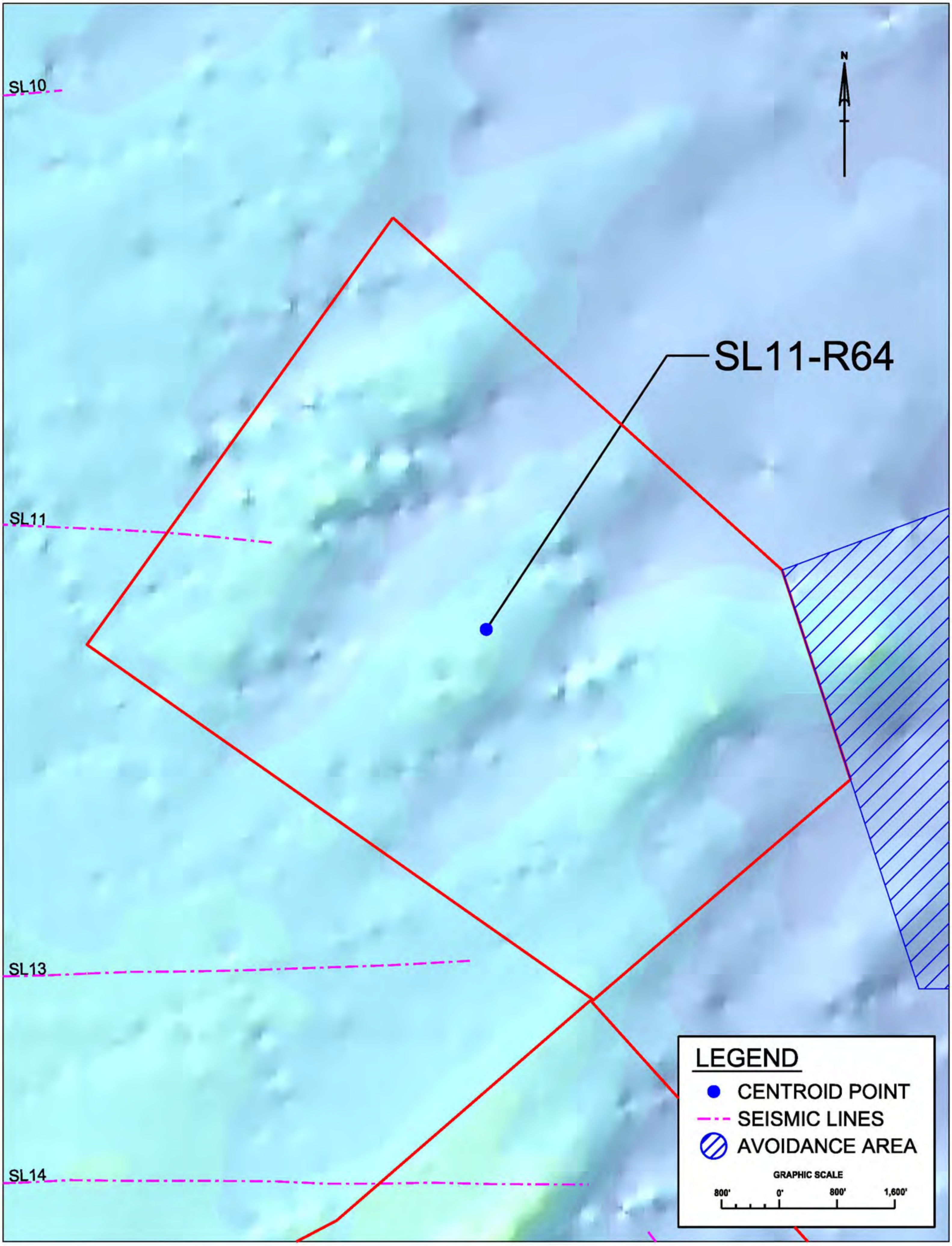
Mean mm:

Munsell value range:

Color:

Physical description:

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
			Average	0.0



SL10
SL11
SL13
SL14
SL11-R64
N
LEGEND
CENTROID POINT
SEISMIC LINES
AVOIDANCE AREA
GRAPHIC SCALE
800'
0'
800'
1,600'

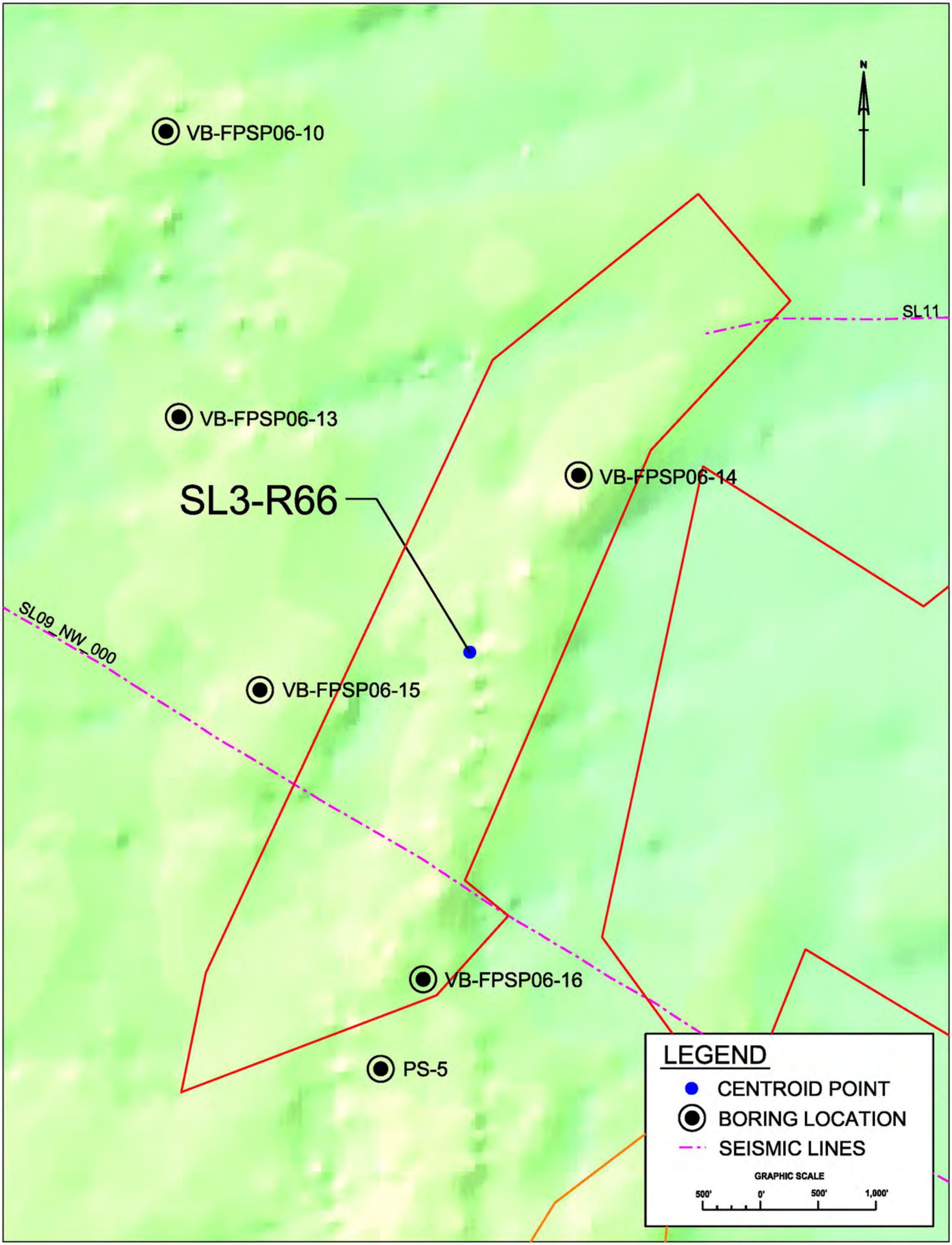
Sediment Source ID: SL3-R66 Category: Unverified

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	61,975,268	35,602,814
Volume (cy)	2,295,380	1,318,623
Area (ft^2)	13,186,227	13,186,227
Average Thickness (ft)	4.7	2.7

Narrative: The area was delineated by 2012 SAND Study using existing cores, seismicity and bathymetry.

Material Description	
Mean mm:	Not Available
Munsell value range:	4 - 6 (wet) 5 - 6 (dry)
Color:	olive to dark gray
Physical description:	coarse-grained shelly sand

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
VB-FPSP16-14	9145095	1112772	-38.4	5.8
VB-FPSP16-16	912749	1108410	-31.9	4.3
Sediment Source Edge				4
			Average	4.7


N
VB-FPSP06-10
SL11
VB-FPSP06-13
VB-FPSP06-14
SL3-R66
SL09_NW_000
VB-FPSP06-15
VB-FPSP06-16
PS-5
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
GRAPHIC SCALE
500'
0'
500'
1,000'

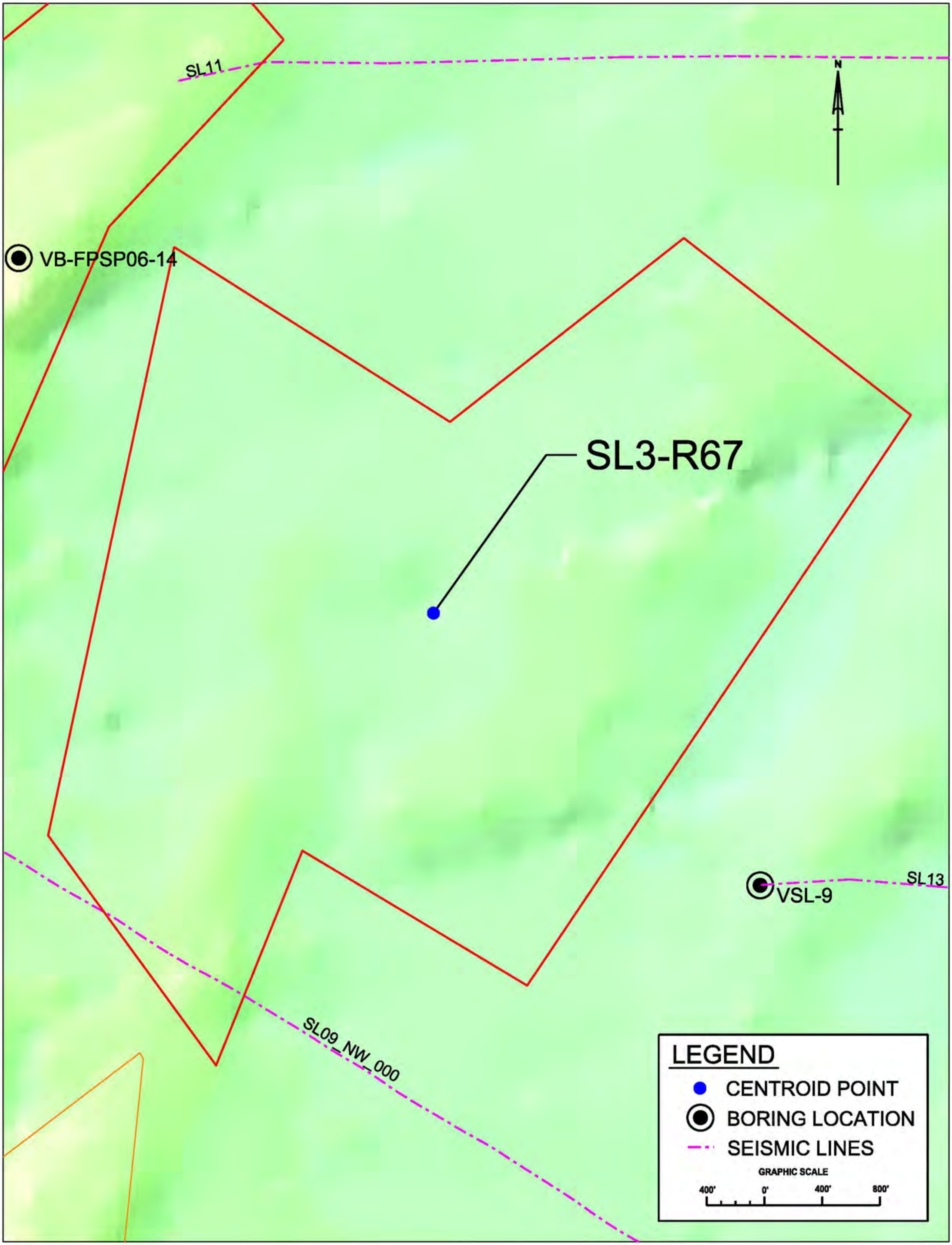
Sediment Source ID: SL3-R67 Category: Unverified

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)		
Volume (cy)		
Area (ft^2)	19,457,231	19,457,231
Average Thickness (ft)	0.0	-2.0

Narrative: This area has no vibracores within the boundaries. It was delineated in the SAND study based on bathymetric evidence. It contributes no volume to the SAND Study.

Material Description	
Mean mm:	
Munsell value range:	
Color:	
Physical description:	

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
			Average	



SL11
VB-FPSP06-14
SL3-R67
VSL-9
SL13
SL09_NW_000
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
GRAPHIC SCALE
400'
0'
400'
800'

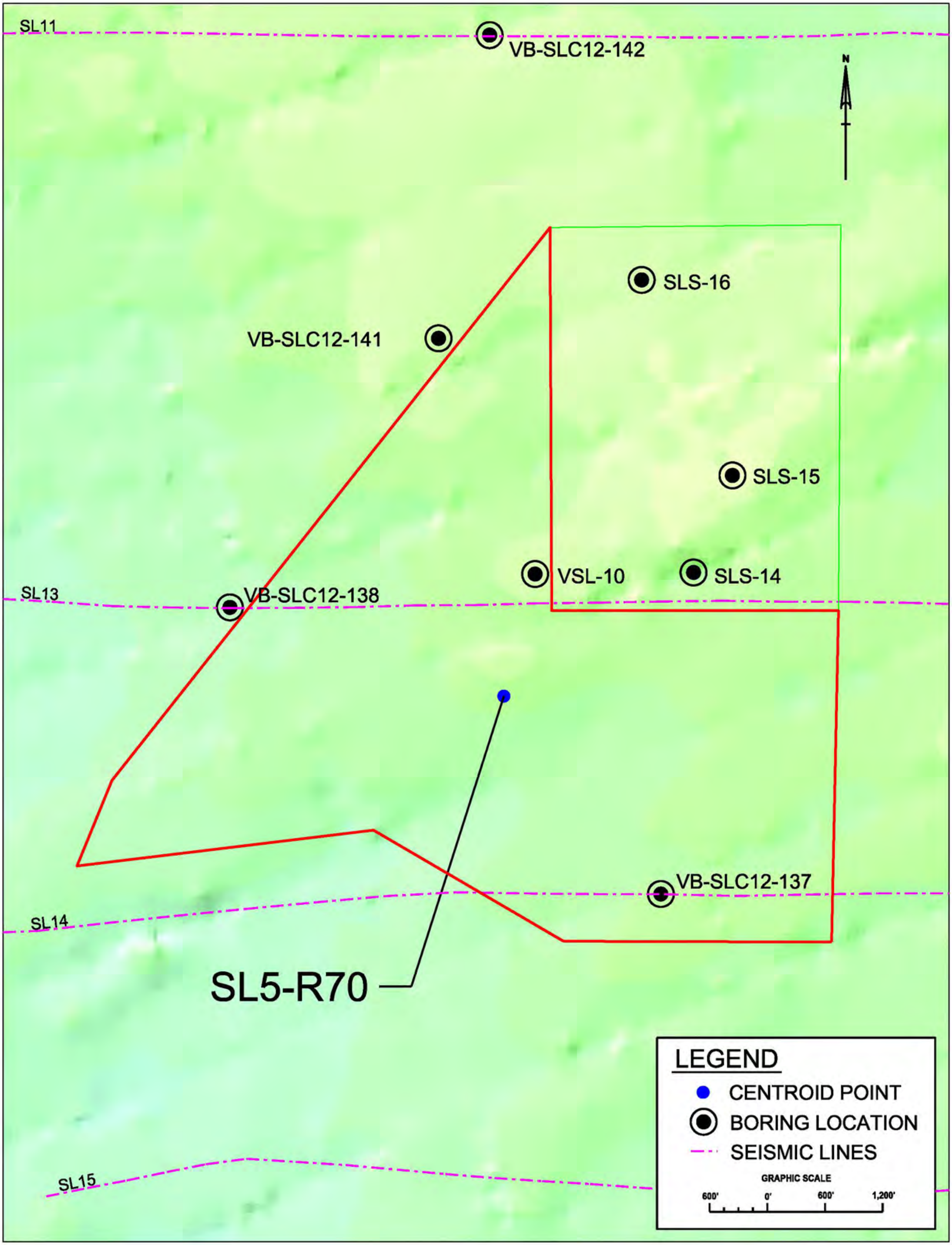
Sediment Source ID: SL5-R70 Category: Unverified

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	226,774,837	172,348,876
Volume (cy)	8,399,068	6,383,292
Area (ft^2)	27,212,980	27,212,980
Average Thickness (ft)	8.3	6.3

Narrative: Area delineated in A Geological Investigation Along Florida's Central-East Coast of Sand Resources in the Offshore Area, Florida Geological Society, 1997. Area was refined using bathymetry and seismic data.

Material Description	
Mean mm:	0.16 to 0.49
Munsell value range:	4 (wet) to 5 (dry)
Color:	gray to dark gray
Physical description:	fine sand-sized quartz with fine to coarse sand-sized shell, grain size gets finer with depth

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
VSL-10	927926.8	1108544	-40	12
VB-SLC12-137	929237	1105220	-44.7	9
Sediment Source Edge				4
			Average	8.3


SL11
VB-SLC12-142
N
SLS-16
VB-SLC12-141
SLS-15
VSL-10
SLS-14
SL13
VB-SLC12-138
VB-SLC12-137
SL14
SL5-R70
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
GRAPHIC SCALE
600'
0'
600'
1,200'
SL15

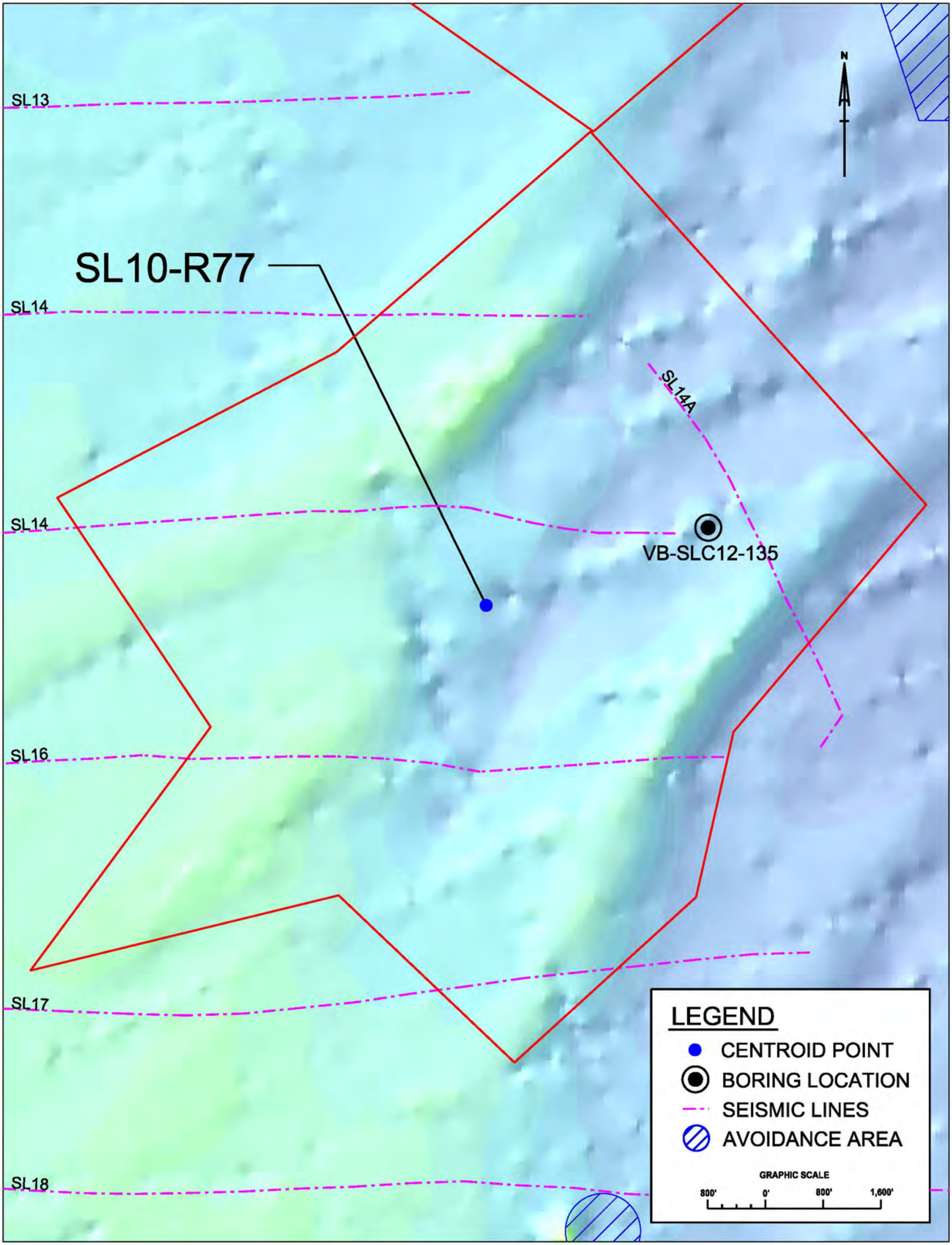
Sediment Source ID: SL10-R77 Category: Unverified

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	711,262,479	541,914,270
Volume (cy)	26,343,055	20,070,899
Area (ft^2)	84,674,105	84,674,105
Average Thickness (ft)	8.4	6.4

Narrative: The area delineated as part of 2012 SAND Study using bathymetric and seismic evidence and two vibracore.

Material Description	
Mean mm:	0.14 to 0.95
Munsell value range:	4 (wet) to 5-7 (dry)
Color:	gray, greenish gray to dark gray
Physical description:	fine sand-sized quartz and fine to coarse sand sized shell

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
VB-SLC12-135	958155	1102377	-81.2	5.8
VB-SLC12-136	952703	1102606	-57.4	15.4
Sediment Source Edge				4
			Average	8.4


N
SL10-R77
SL13
SL14
SL14
SL14A
VB-SLC12-135
SL16
SL17
SL18
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
AVOIDANCE AREA
GRAPHIC SCALE
800'
0'
800'
1,600'

Sediment Source ID: SL3-R81 Category: Unverified

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)		
Volume (cy)		
Area (ft^2)	9,128,251	9,128,251
Average Thickness (ft)	0.0	-2.0

Narrative: This area has no vibracores within the boundaries. It was delineated in the SAND study based on bathymetric and seismic evidence. It contributes no volume to the SAND Study.

Material Description

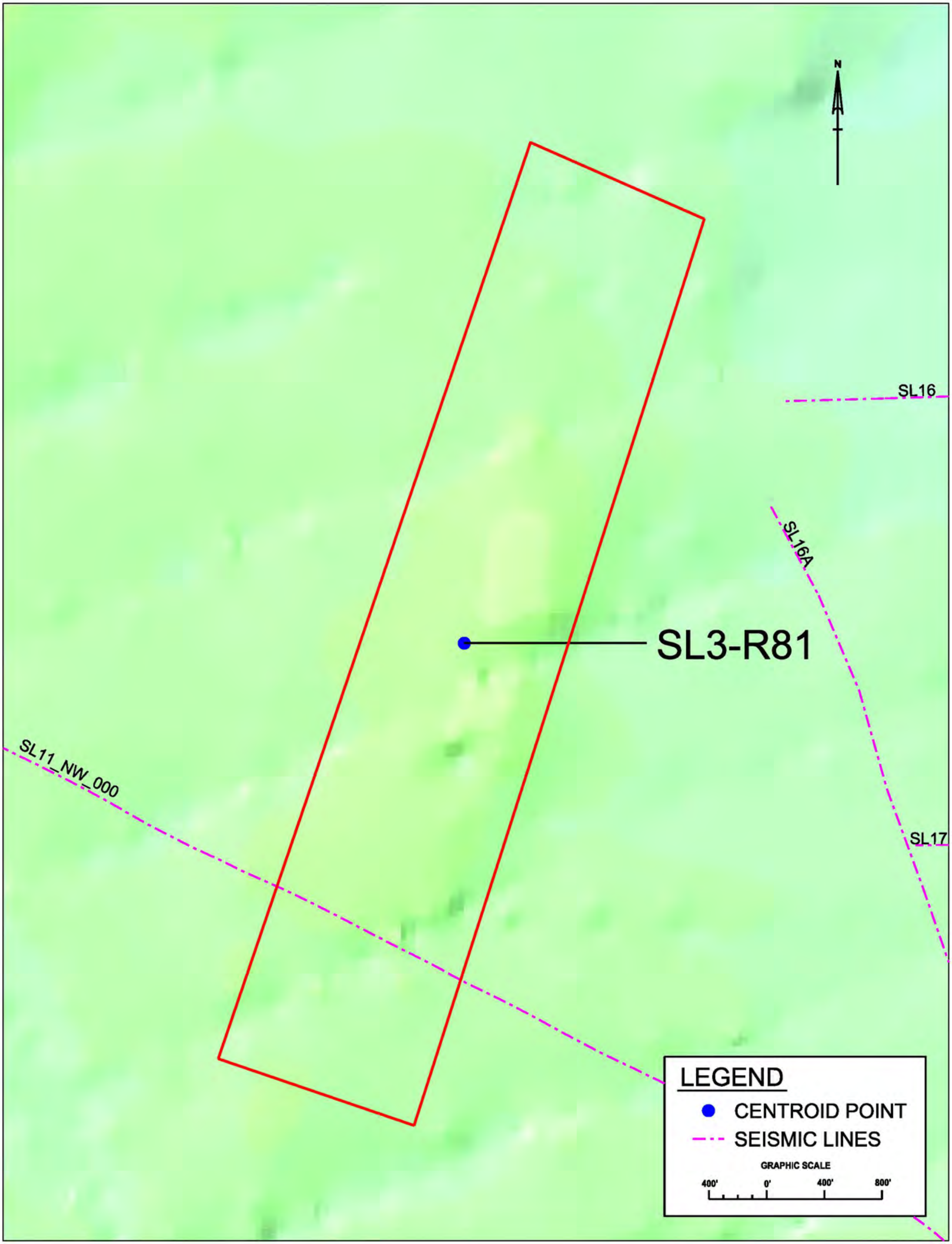
Mean mm:

Munsell value range:

Color:

Physical description:

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
			Average	


N
SL16
SL16A
SL3-R81
SL11_NW_000
SL17
LEGEND
CENTROID POINT
SEISMIC LINES
GRAPHIC SCALE
400'
0'
400'
800'

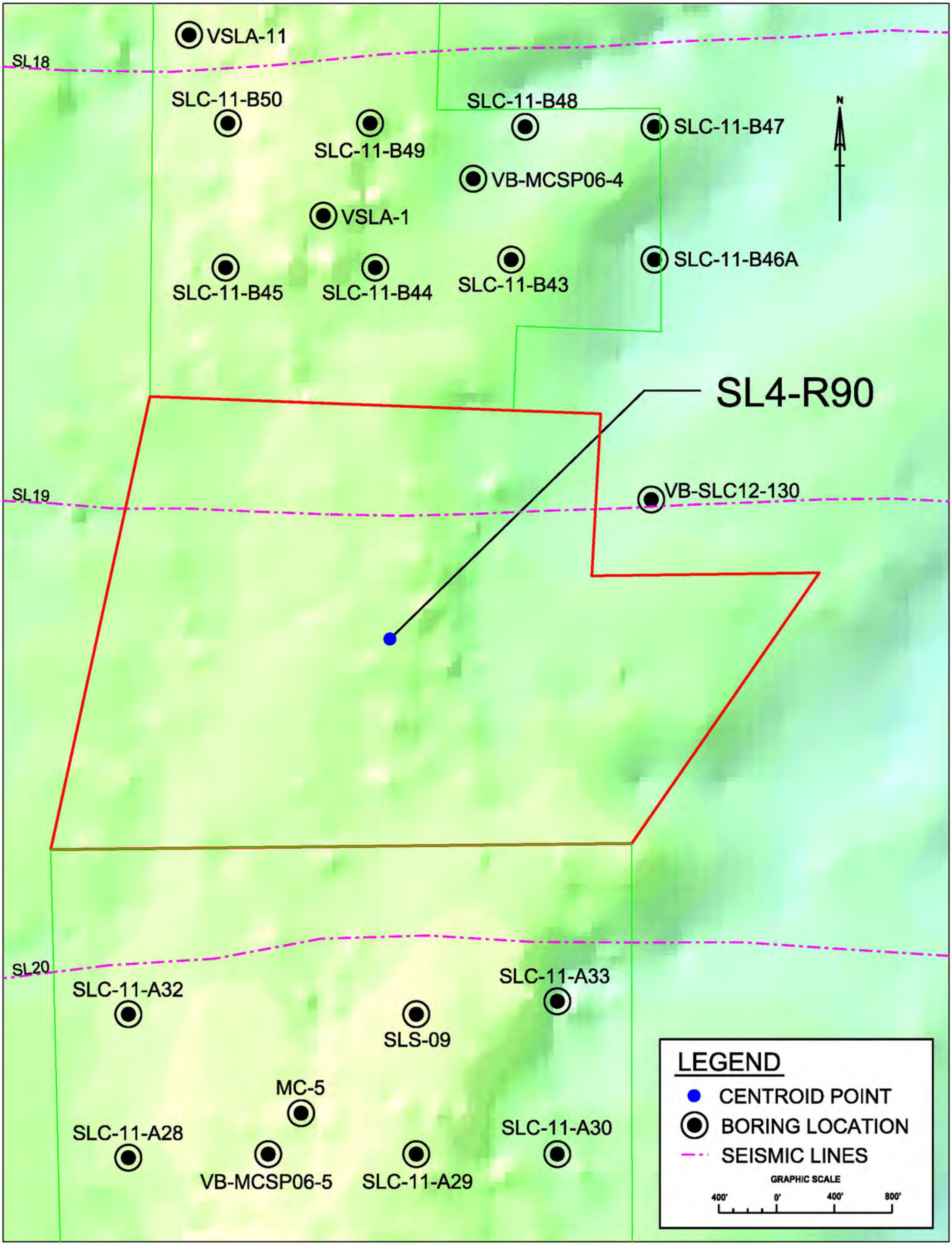
Sediment Source ID: SL4-R90 Category: Unverified

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)		
Volume (cy)		
Area (ft^2)	12,184,033	12,184,033
Average Thickness (ft)	0.0	-2.0

Narrative: This area has no vibracores within the boundaries. It was delineated in the SAND study based on bathymetric and seismic evidence. It is in a linear shoal between two proven sediment sources. This sediment source contributes no volume to the SAND Study.

Material Description	
Mean mm:	
Munsell value range:	
Color:	
Physical description:	

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
			Average	


VSLA-11
SL18
SLC-11-B50
SLC-11-B48
SLC-11-B47
SLC-11-B49
VB-MCSP06-4
VSLA-1
SLC-11-B46A
SLC-11-B45
SLC-11-B44
SLC-11-B43
SL4-R90
SL19
VB-SLC12-130
SL20
SLC-11-A32
SLC-11-A33
SLS-09
MC-5
SLC-11-A28
SLC-11-A30
VB-MCSP06-5
SLC-11-A29
N
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
GRAPHIC SCALE
400'
0'
400'
800'

Sediment Source ID: SL6-R91 Category: Unverified

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	228,056,690	145,126,984
Volume (cy)	8,446,544	5,375,073
Area (ft^2)	41,464,853	41,464,853
Average Thickness (ft)	5.5	3.5

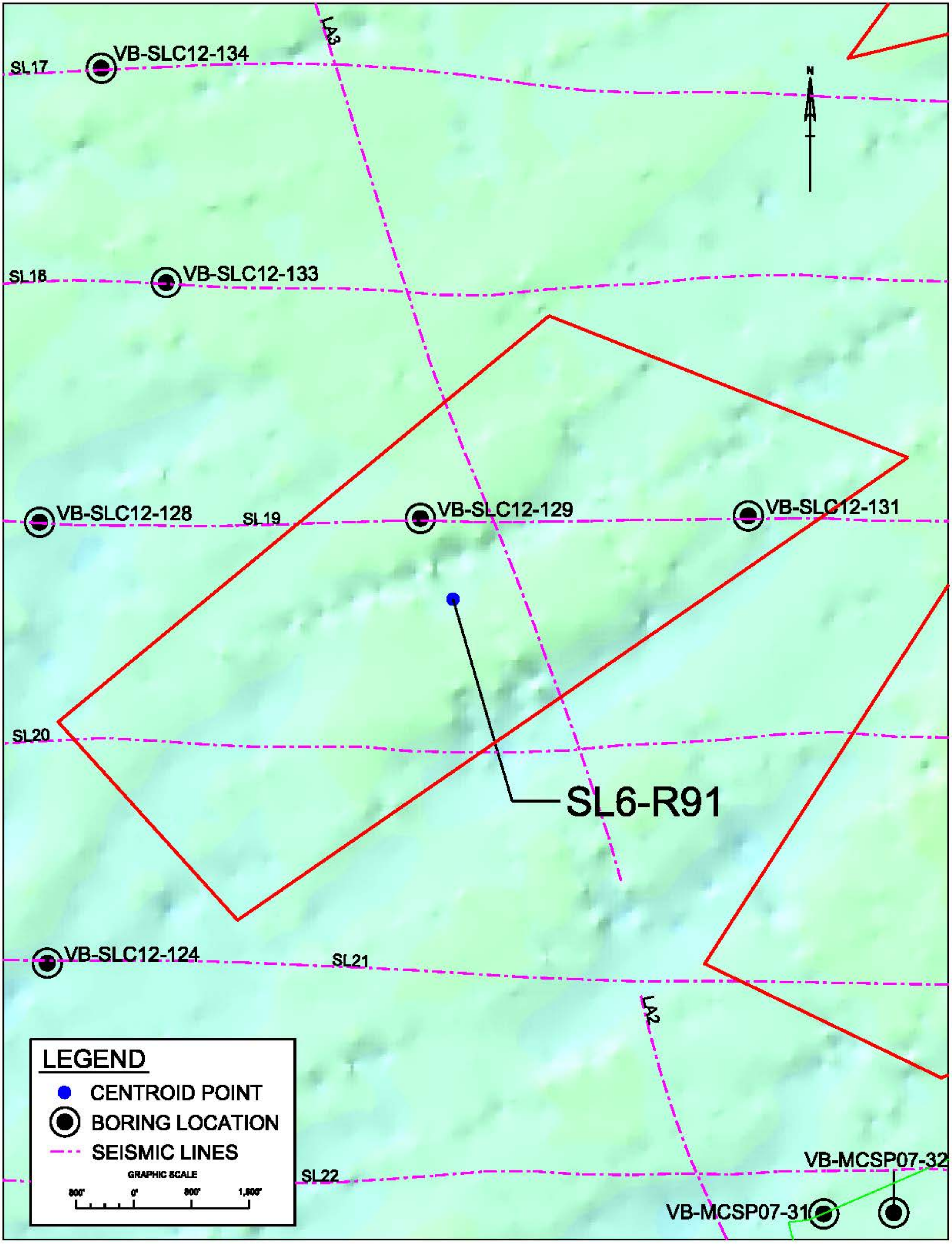
Narrative: The area was delineated by SAND Study using seismic and bathymetric evidence and vibracores.

Material Description	
Mean mm:	0.15 to 0.68
Munsell value range:	4 - 6 (wet) 5 - 6 (dry)
Color:	gray to dark gray
Physical description:	fine to coarse sand-sized shell and fine sand-sized quartz

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
VB-SLC12-129*	942832	1089866	-55.6	4.9
VB-SLC12-131**	947379	1089901	-59.6	7.6
Sediment Source Edge				4
			Average	5.5

* Sediments encountered were predominately shell rather than quartz sand.

** Sediments encountered were poorly sorted fine-to-medium quartz sand and medium-to-coarse sand-sized shell.



LA3
VB-SLC12-134
SL17
N
SL18
VB-SLC12-133
VB-SLC12-128
SL19
VB-SLC12-129
VB-SLC12-131
SL20
SL6-R91
VB-SLC12-124
SL21
LA2
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
GRAPHIC SCALE
800'
0'
800'
1,600'
SL22
VB-MCSP07-32
VB-MCSP07-31

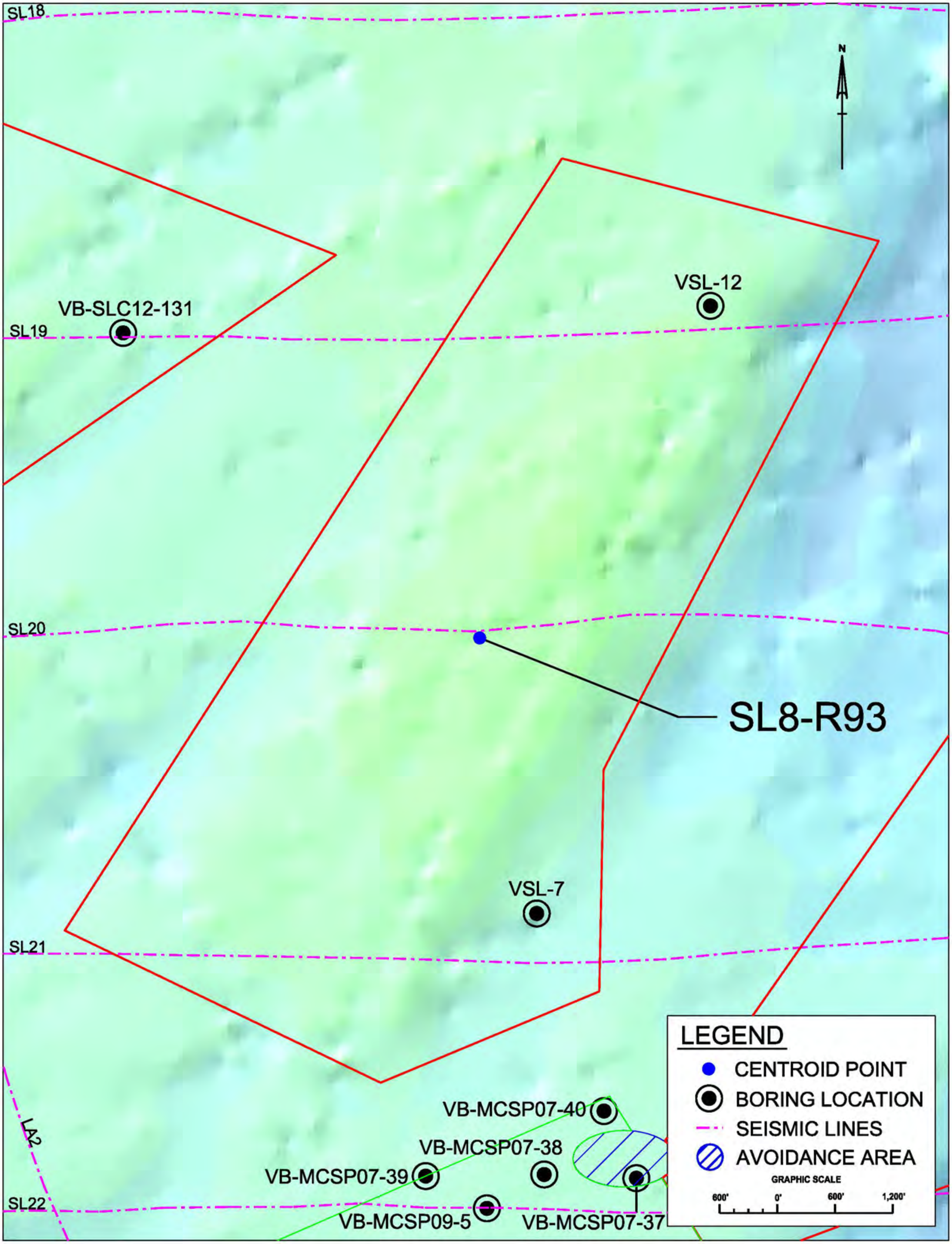
Sediment Source ID: SL8-R93 Category: Unverified

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	433,154,519	356,715,487
Volume (cy)	16,042,760	13,211,685
Area (ft^2)	38,219,516	38,219,516
Average Thickness (ft)	11.3	9.3

Narrative: The area was delineated using bathymetric and seismic evidence combined with two vibracore.

Material Description	
Mean mm:	Not Available
Munsell value range:	Not Available
Color:	very light orange, light olive brown to grayish brown
Physical description:	fine to coarse sand-sized shell bed with fine quartz sand

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
VSL-7	951679	1083865	-58.6	10
VSL-12	953485	1090182	unknown	20
Sediment Source Edge				4
			Average	11.3



SL18
N
VSL-12
VB-SLC12-131
SL19
SL20
SL8-R93
VSL-7
SL21
LA2
VB-MCSP07-40
VB-MCSP07-38
VB-MCSP07-39
SL22
VB-MCSP09-5
VB-MCSP07-37
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
AVOIDANCE AREA
GRAPHIC SCALE
600'
0'
600'
1,200'

Sediment Source ID: SL8-R97A Category: Unverified

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)		
Volume (cy)		
Area (ft^2)	16,897,827	16,897,827
Average Thickness (ft)	0.0	-2.0

Narrative: This area has no vibracores within the boundaries. It is a seaward extension of a shoal that is a proven sediment source. It was delineated in the SAND study based on bathymetric and seismic evidence. This sediment source contributes no volume to the SAND Study.

Material Description

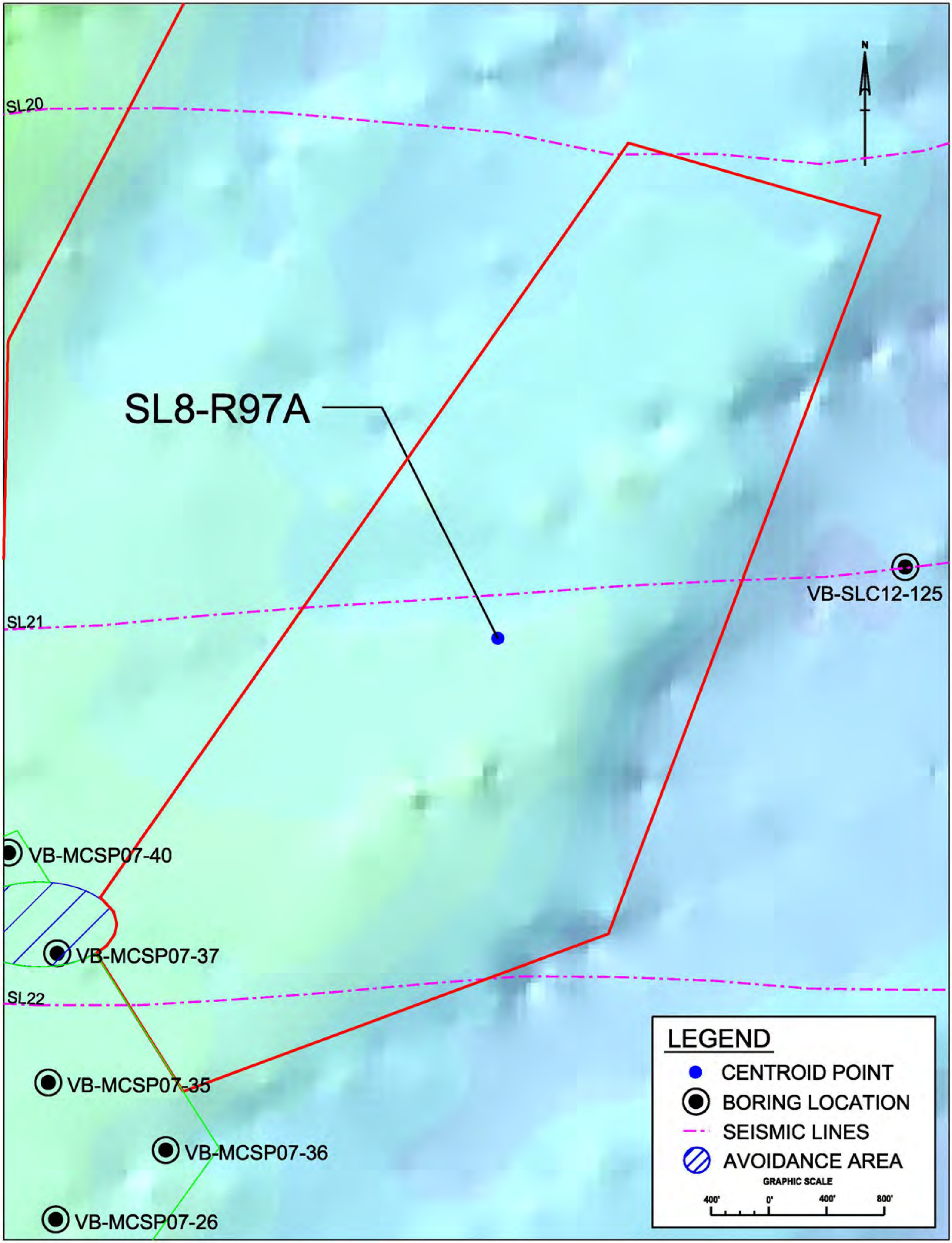
Mean mm:

Munsell value range:

Color:

Physical description:

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
			Average	


N
SL20
SL8-R97A
VB-SLC12-125
SL21
VB-MCSP07-40
VB-MCSP07-37
SL22
VB-MCSP07-35
VB-MCSP07-36
VB-MCSP07-26
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
AVOIDANCE AREA
GRAPHIC SCALE
400'
0'
400'
800'

10.4 Martin County, FL: PROVEN

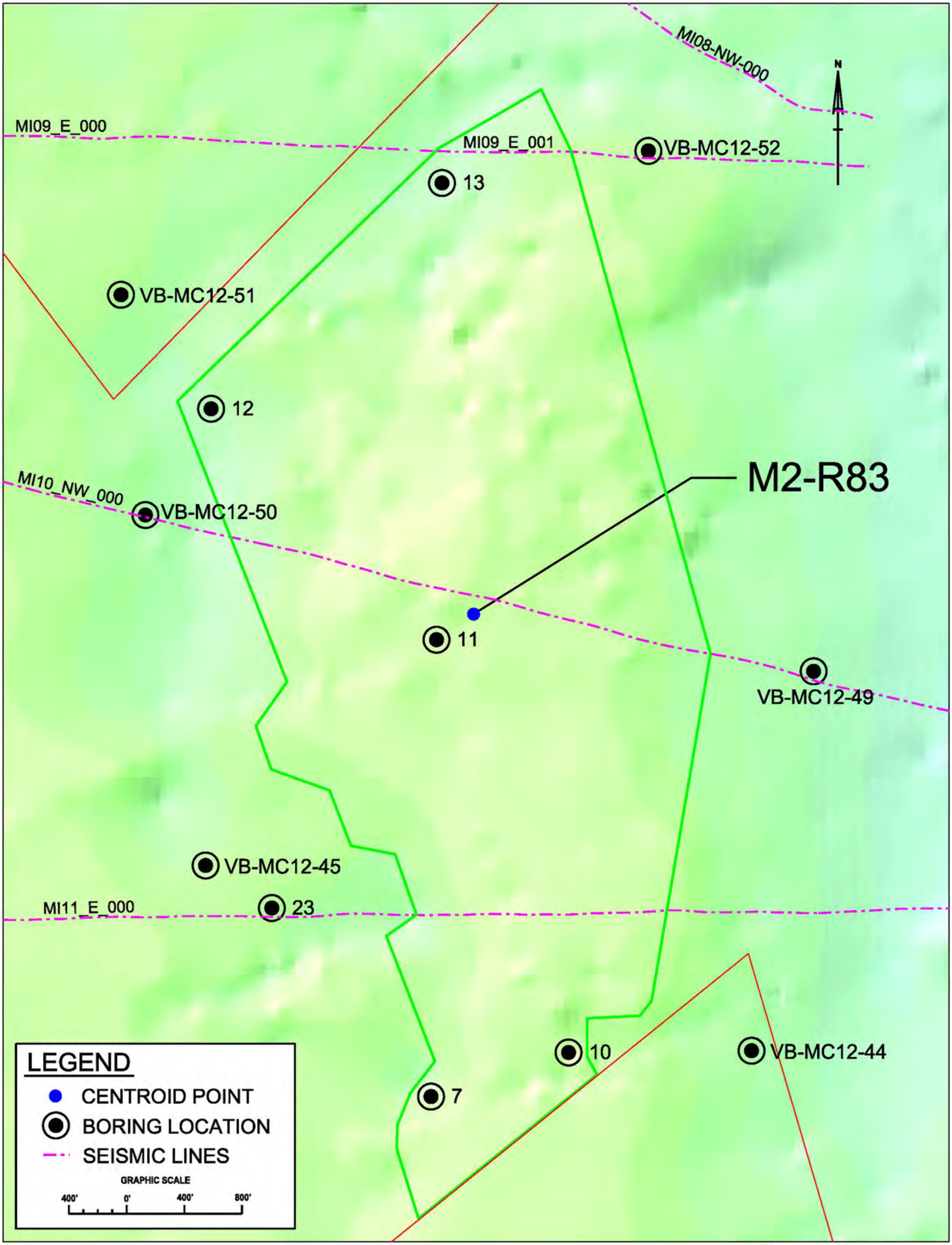
Sediment Source ID: M2-R83 Category: Proven

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	203,185,067	170,761,918
Volume (cy)	7,525,373	6,324,515
Area (ft^2)	16,211,574	16,211,574
Average Thickness (ft)	12.5	10.5

Narrative: The deposit was originally delineated for the ROSS Sand Search 1989 Jupiter Island Beach Renourishment Program. The vibracore data were obtained from G and B Sand Search 1989 Jupiter Island Beach Renourishment Program and 2012 SAND Study. The original deposit delineation was altered, based upon the vibracore and seismic data, to meet the requirements of the SAND Study criteria.

Material Description	
Mean mm:	0.13 - 0.78
Munsell value range:	4-5 (wet) 5-6 (dry)
Color:	gray to light gray
Physical description:	shelly sand overlying a fine-grained quartz sand

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
Jupiter Island, 1989, #7	955544	994000	-39.2	18.8
Jupiter Island, 1989, #10	956497	994305	-32.8	14.5
Jupiter Island, 1989, #11	955582	997162	-32.2	15.7
Jupiter Island, 1989, #12	954020	998762	-45	13
Jupiter Island, 1989, #13	955620	1000324	-44.6	9.2
Sediment Source Edge				4
			Average	12.5


MI08-NW-000
N
MI09_E_000
MI09_E_001
VB-MC12-52
13
VB-MC12-51
12
M2-R83
MI10_NW_000
VB-MC12-50
11
VB-MC12-49
VB-MC12-45
MI11_E_000
23
10
VB-MC12-44
7
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
GRAPHIC SCALE
400'
0'
400'
800'

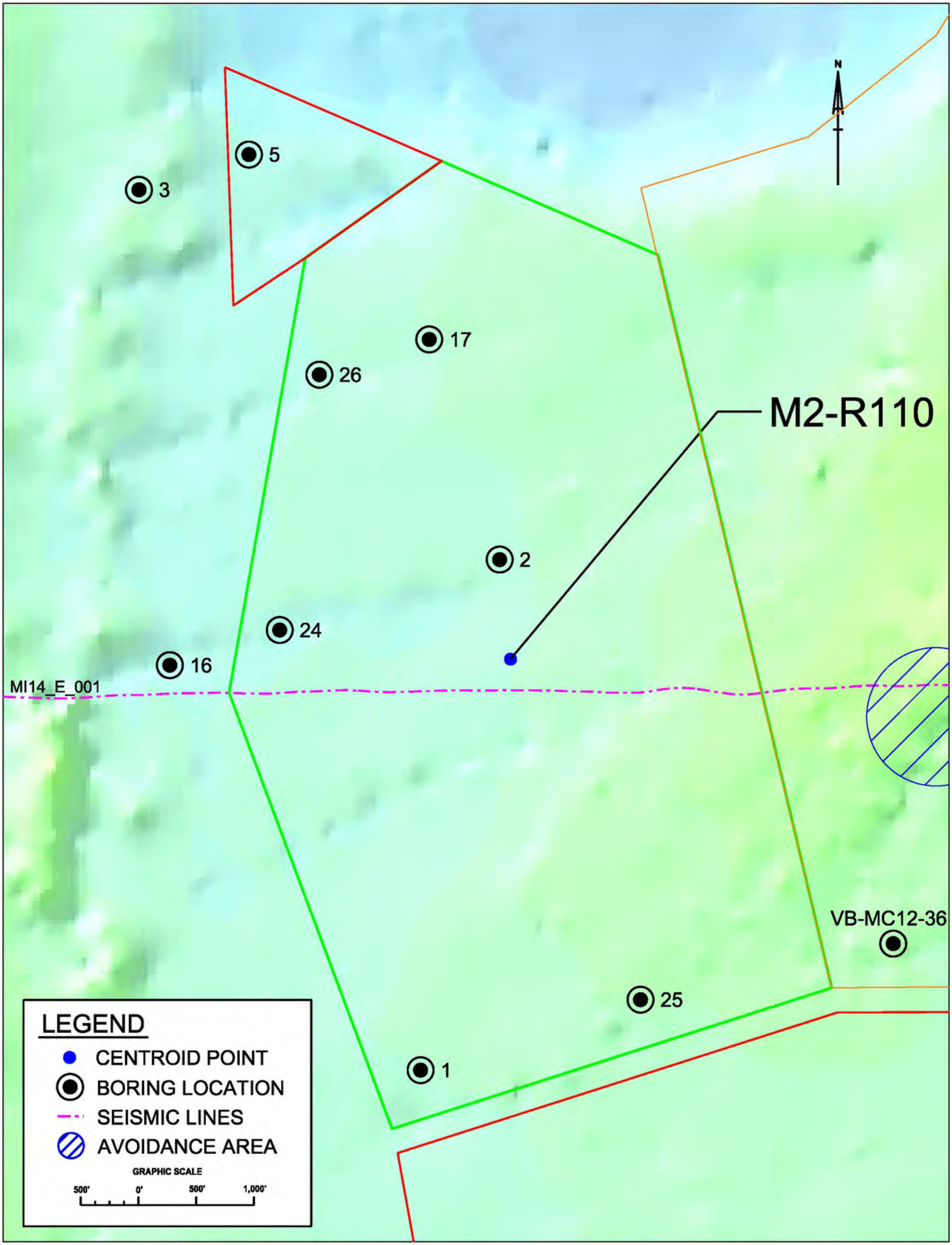
Sediment Source ID: M2-R110 Category: Proven

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	329,979,725	270,600,340
Volume (cy)	12,221,471	10,022,235
Area (ft^2)	29,689,693	29,689,693
Average Thickness (ft)	11.1	9.1

Narrative: The vibracore data were obtained from G and B Sand Search 1989 Jupiter Island Beach Renourishment Program. Data were also pulled from the FDEP ROSS Phase II Central Sand Search. The deposit area was expanded based upon vibracore, bathymetric and seismic evidence.

Material Description	
Mean mm:	0.42 - 0.66
Munsell value range:	4-5 (wet) 5-6 (dry)
Color:	light gray to gray
Physical description:	Very fine to coarse sand-sized quartz with coarse sand-sized shell

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
Jupiter Island, 1989, #1	962861	971141.6	-53.2	12.4
Jupiter Island, 1989, #2	963546	975560.8	-53.9	16.1
Jupiter Island, 1989, #17	962936	977465.9	-53.2	13.2
Jupiter Island, 1989, #24	961641	974950.8	-58.2	8.6
Jupiter Island, 1989, #25	964765.9	971751.7	-47.7	12.5
Jupiter Island, 1989, #26	961984	977160.9	-56.5	11
Sediment Source Edge				4
			Average	11.1



M2-R110
5
3
17
26
2
24
16
MI14_E_001
VB-MC12-36
25
1
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
AVOIDANCE AREA
GRAPHIC SCALE
500'
0'
500'
1,000'
N

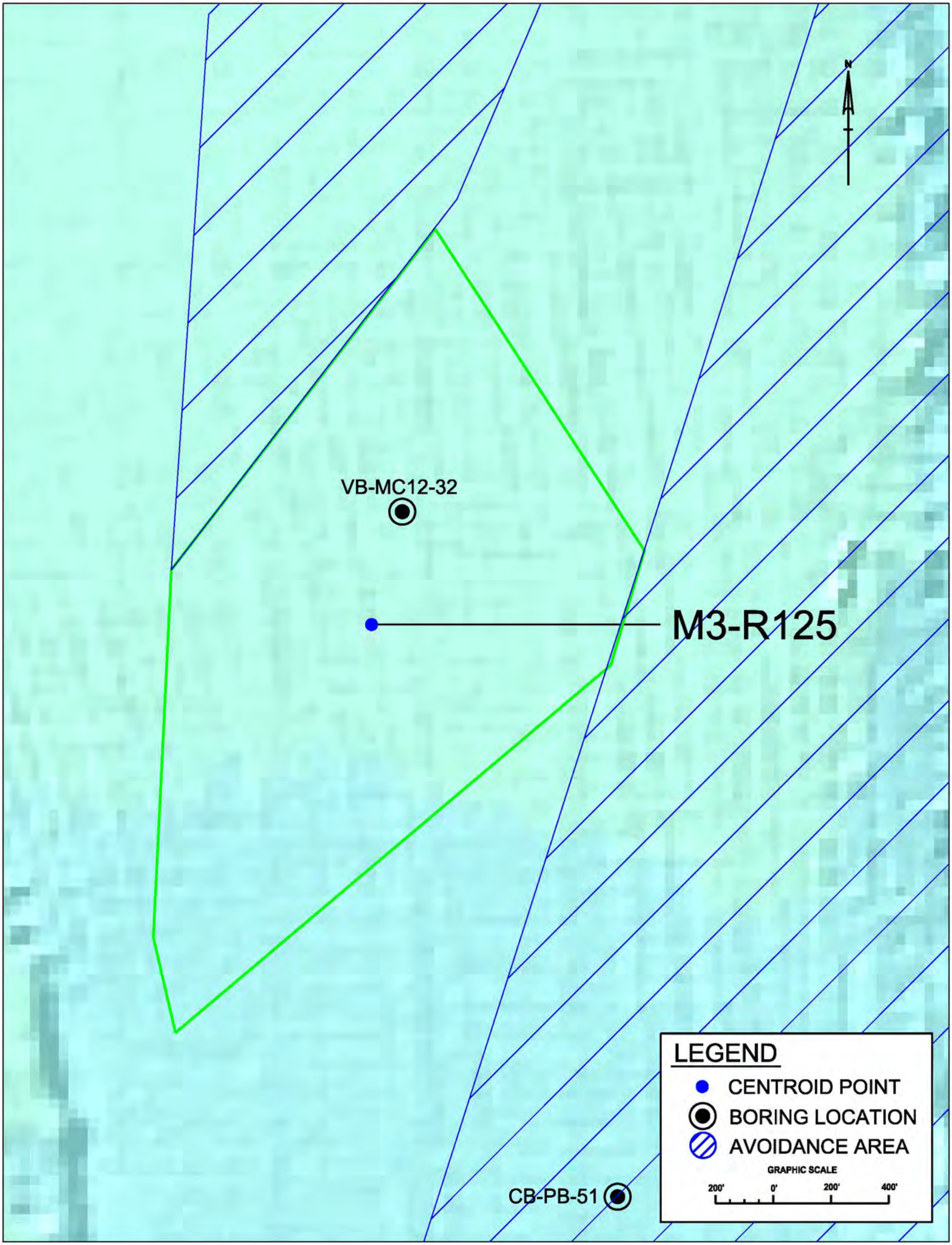
Sediment Source ID: M3-R125 Category: Proven

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	22,047,127	16,978,822
Volume (cy)	816,560	628,845
Area (ft^2)	2,534,153	2,534,153
Average Thickness (ft)	8.7	6.7

Narrative: The deposit was originally delineated in 1999 as noted in the Palm Beach County Environmental Resources Management (PBC ERM) Department GIS. Two cores could not be located. The original area was reduced due to a cable easement that crosses to the north.

Material Description	
Mean mm:	0.28 - 0.37
Munsell value range:	4 (wet) 5 (dry)
Color:	pale olive to dark gray
Physical description:	fine-to-coarse carbonate sand with few fine quartz sand

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
VB-MC12-32	972257	962445	-63.7	13.4
Sediment Source Edge				4
			Average	8.7


N
VB-MC12-32
M3-R125
CB-PB-51
LEGEND
CENTROID POINT
BORING LOCATION
AVOIDANCE AREA
GRAPHIC SCALE
200'
0'
200'
400'

10.5 Martin County, FL: POTENTIAL

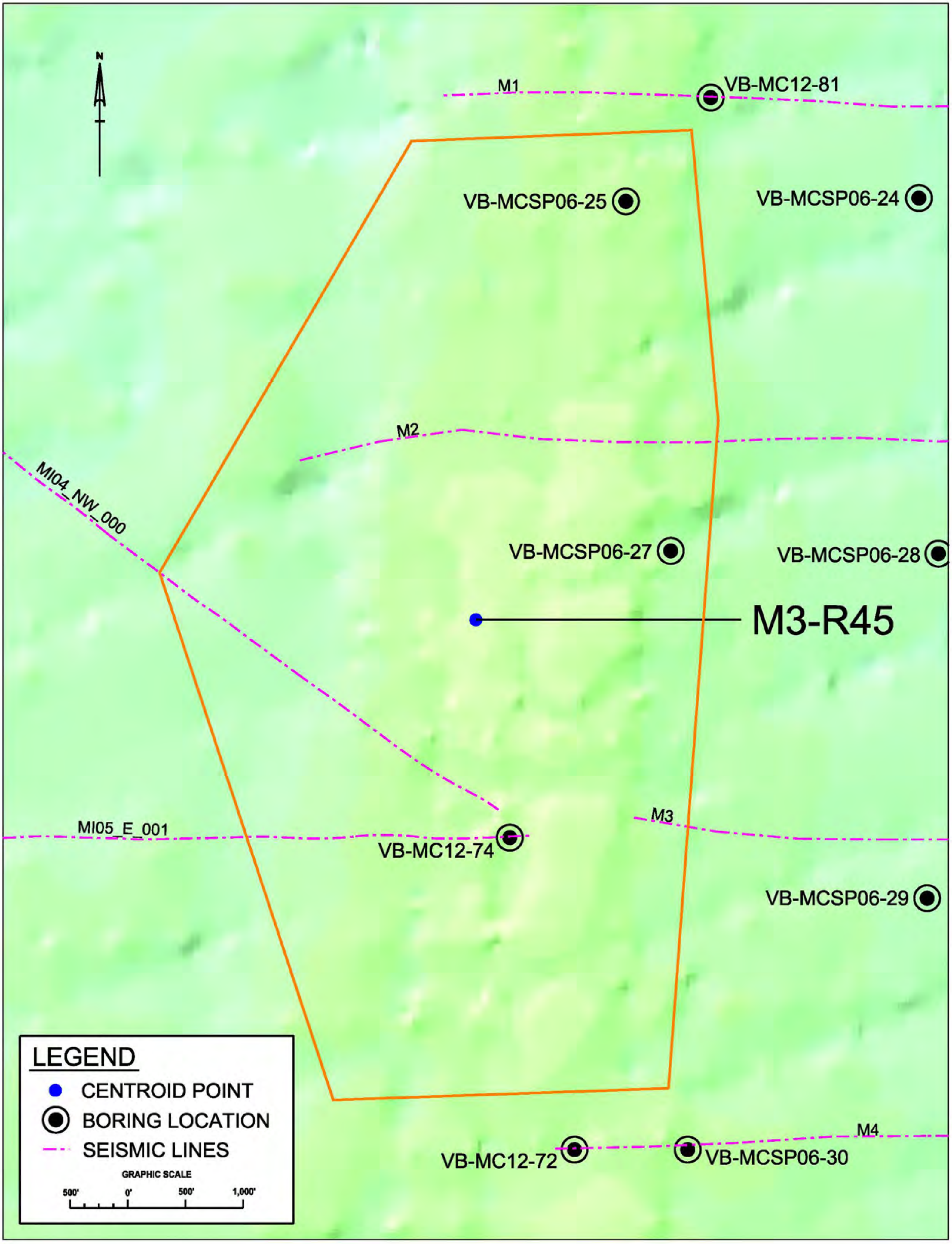
Sediment Source ID: M3-R45 Category: Potential

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	261,076,055	198,791,509
Volume (cy)	9,669,484	7,362,648
Area (ft^2)	31,142,273	31,142,273
Average Thickness (ft)	8.4	6.4

Narrative: Narrative: The sediment source was originally delineated in the FDEP ROSS Phase II Central Sand Search. Vibracore data were obtained from G and B Sand Search 1989 Jupiter Island Beach Renourishment Program. The deposit was refined using bathymetric and seismic evidence with 2012 SAND Study borings.

Material Description	
Mean mm:	0.35 - 0.58
Munsell value range:	4 (wet) 5 (dry)
Color:	tan
Physical description:	medium to coarse shell sand with quartz sand

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
VB-MCSP06-25	951651	1033854	-40.6	5.5
VB-MCSP06-27	952040	1030823	-40.8	6
VB-MC12-74	950645	1028337	-36.7	13.3
Jupiter Island 1989. #18	795500	1024500	-35.2	12.4
Jupiter Island 1989. #20	795500	1032500	-38.3	9.1
Sediment Source Edge				4
			Average	8.4


N
M1
VB-MC12-81
VB-MCSP06-25
VB-MCSP06-24
M2
MI04_NW_000
VB-MCSP06-27
VB-MCSP06-28
M3-R45
M3
MI05_E_001
VB-MC12-74
VB-MCSP06-29
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
GRAPHIC SCALE
500'
0'
500'
1,000'
M4
VB-MC12-72
VB-MCSP06-30

Sediment Source ID: M2-R58 Category: Potential

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	173,712,244	129,265,615
Volume (cy)	6,433,787	4,787,615
Area (ft^2)	22,223,315	22,223,315
Average Thickness (ft)	7.8	5.8

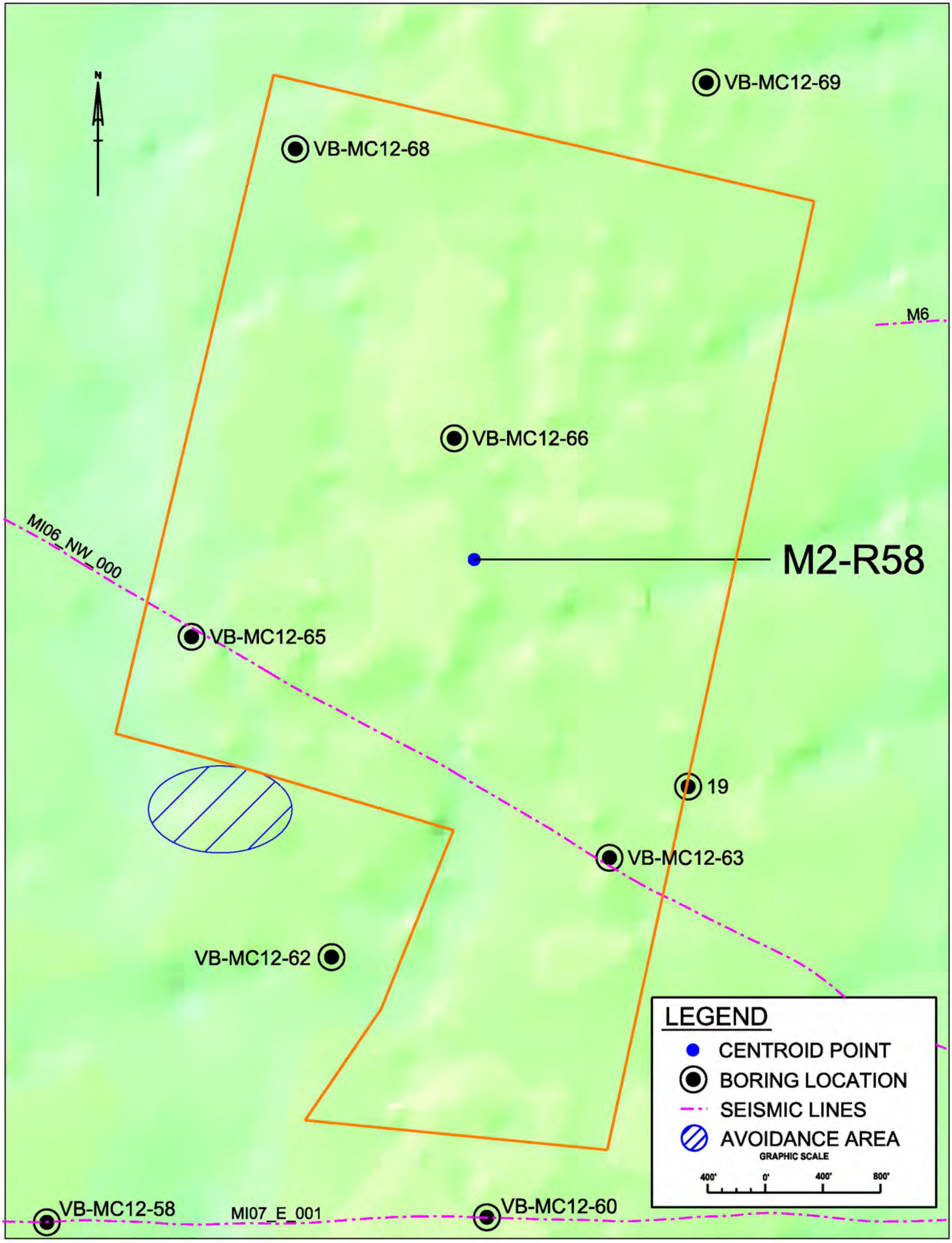
Narrative: The sediment source was originally delineated in the FDEP ROSS Phase II Central Sand Search. Vibracore data were obtained from G and B Sand Search 1989 Jupiter Island Beach Renourishment Program. The deposit was refined using bathymetric and seismic evidence with 2012 SAND Study borings.

Material Description	
Mean mm:	0.15 - 0.59
Munsell value range:	4-5 (wet) 5-6 (dry)
Color:	Gray
Physical description:	medium to coarse sand-sized shell, very fine to medium sand-sized quartz

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
19	951661	1016543	-47	10.5
VB-MC12-63	951115	1016049	-42.8	8
VB-MC12-65*	948213	1017583	-43.7	4.5
VB-MC12-66	950037	1018961	-40.5	9.7
VB-MC12-68**	948934	1020970	-42.3	10.2
Sediment Source Edge				4
			Average	7.8

* Silt content is less than 4.5%, however shell content is high.

** Included based upon light color seen in photos, laboratory classified color as Munsell value 3


N
VB-MC12-69
VB-MC12-68
M6
VB-MC12-66
MI06_NW_000
M2-R58
VB-MC12-65
19
VB-MC12-63
VB-MC12-62
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
AVOIDANCE AREA
GRAPHIC SCALE
400'
0'
400'
800'
VB-MC12-58
MI07_E_001
VB-MC12-60

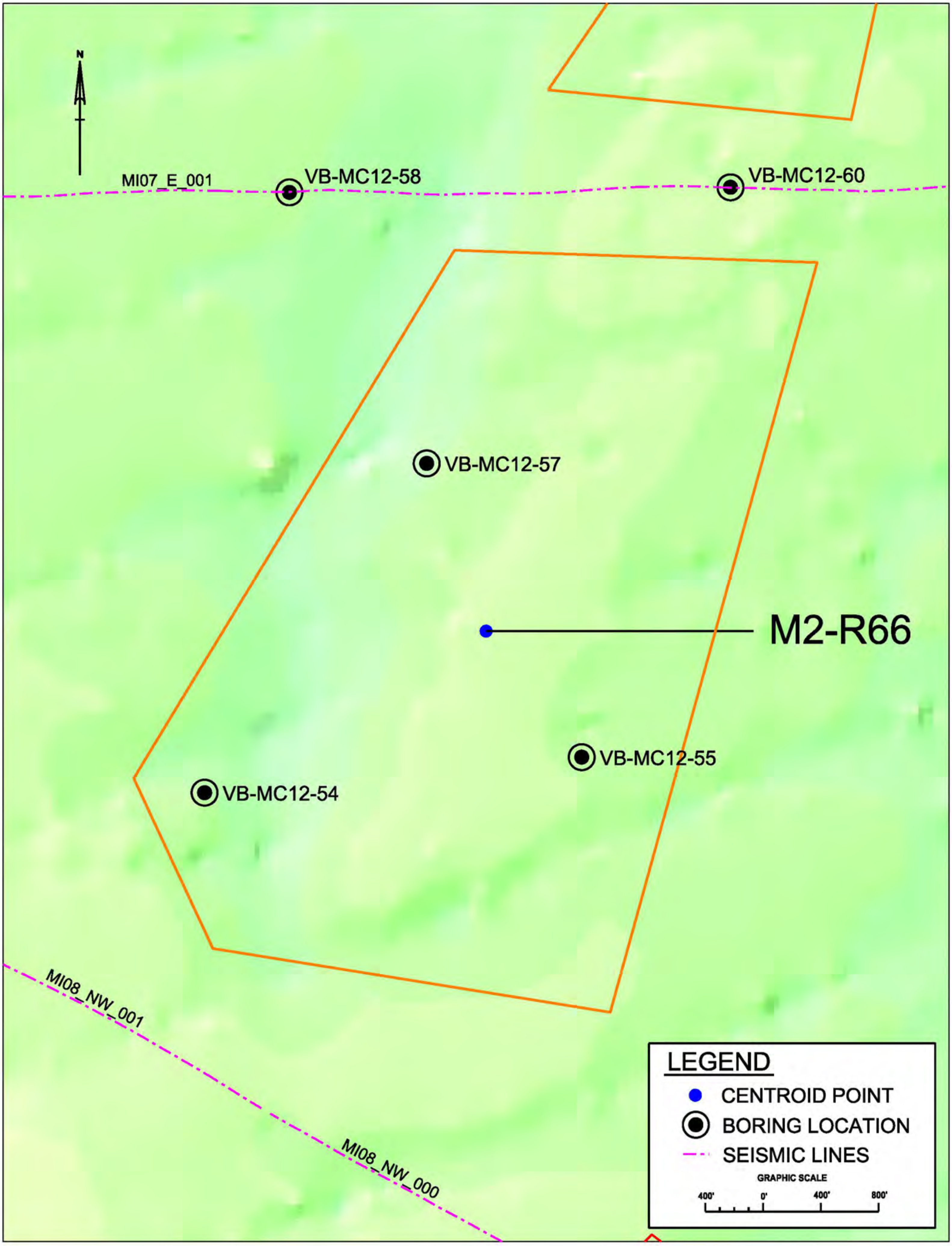
Sediment Source ID: M2-R66 Category: Potential

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	118,211,594	86,370,088
Volume (cy)	4,378,207	3,198,892
Area (ft^2)	15,920,753	15,920,753
Average Thickness (ft)	7.4	5.4

Narrative: The sediment source was originally delineated in the FDEP ROSS Phase II Central Sand Search. Vibracore data were obtained from G and B Sand Search 1989 Jupiter Island Beach Renourishment Program. The deposit was refined using bathymetric evidence and 2012 SAND Study borings.

Material Description	
Mean mm:	0.15 to 0.59
Munsell value range:	4-5 (wet) to 5-6 (dry)
Color:	light gray to gray
Physical description:	medium to coarse sand-sized shell, very fine to medium sand-sized quartz

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
VB-MC12-54	946620	1009362	-44.7	5.1
VB-MC12-55	949233	1009608	-41	13.2
VB-MC12-57	948159	1011642	-43.2	7.4
Sediment Source Edge				4
			Average	7.4



N
MI07_E_001
VB-MC12-58
VB-MC12-60
VB-MC12-57
M2-R66
VB-MC12-55
VB-MC12-54
MI08_NW_001
MI08_NW_000
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
GRAPHIC SCALE
400'
0'
400'
800'

Sediment Source ID: M3-R108 Category: Potential

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	610,515,503	501,250,983
Volume (cy)	22,611,685	18,564,851
Area (ft^2)	54,632,260	54,632,260
Average Thickness (ft)	11.2	9.2

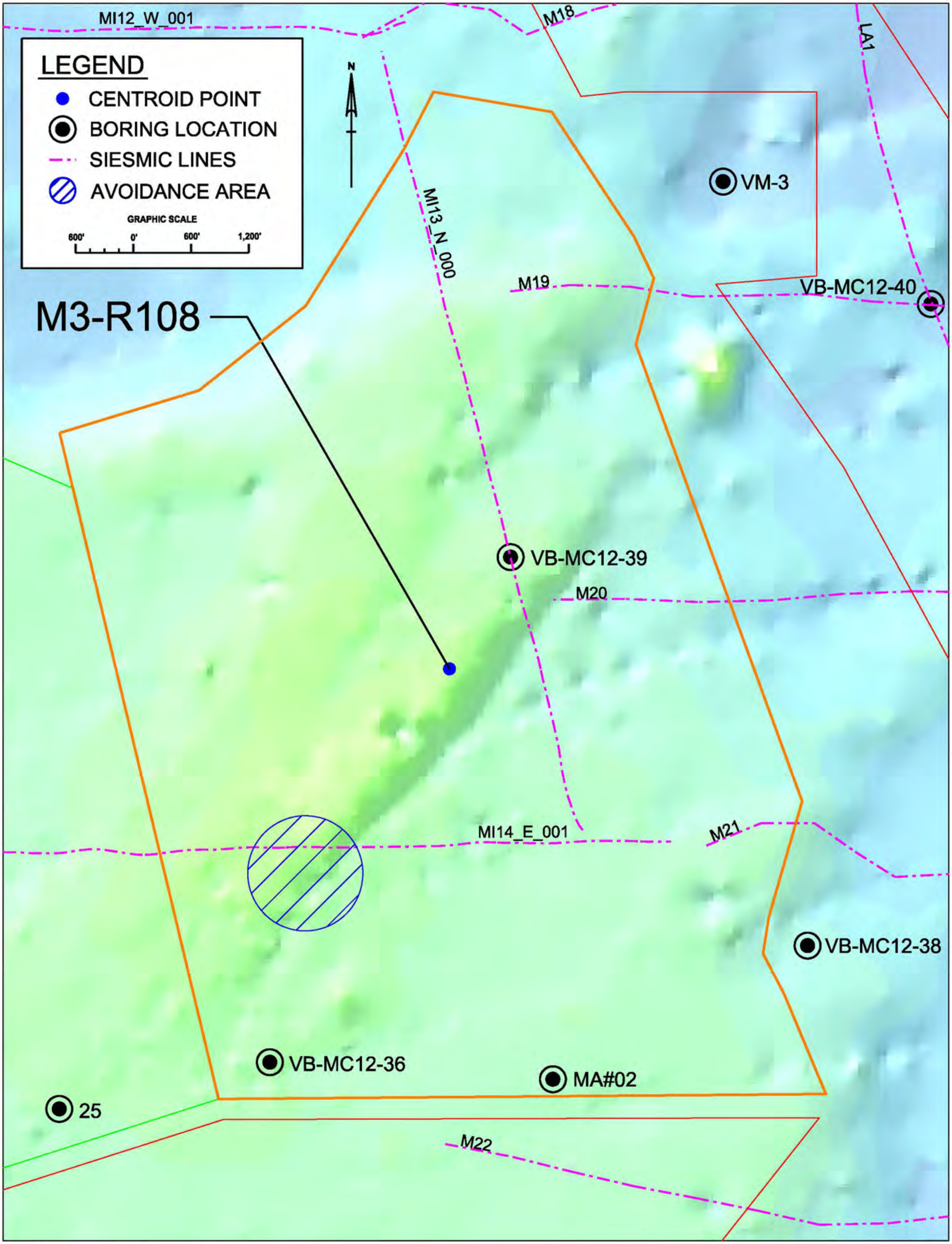
Narrative: The area delineated as part of 2012 SAND Study. The square footage for the avoidance area in the polygon was removed. The deposit was delineated using bathymetric and seismic evidence and vibracores.

Material Description	
Mean mm:	0.21 - 0.48
Munsell value range:	3 - 4 (wet) 5 (dry)
Color:	gray, dark gray to greenish gray
Physical description:	fine-to-medium quartz sand with fine-to-coarse sand-sized shell fragments

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
VB-MC12-36*	966955	972237	-50.7	10.9
VB-MC12-39	969458	977487	-49.5	17.3
MA #02**	969897.8	972059.7	unknown	12.5
Sediment Source Edge				4
			Average	11.2

*The thickness was changed to 10.9 feet due to a color change, below Munsell value is 3.

**Massive, coarse shell and quartz sand bed with the shell content increasing with depth. No sieve analysis was performed on the core sediments.


LEGEND
CENTROID POINT
BORING LOCATION
SIESMIC LINES
AVOIDANCE AREA
GRAPHIC SCALE
600'
0'
600'
1,200'
N
M3-R108
MI12_W_001
M18
LA1
MI13_N_000
VM-3
M19
VB-MC12-40
VB-MC12-39
M20
MI14_E_001
M21
VB-MC12-38
VB-MC12-36
MA#02
25
M22

10.6 Martin County, FL: UNVERIFIED

Sediment Source ID: M7-R2 Category: Unverified

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)		
Volume (cy)		
Area (ft^2)	12,275,880	12,275,880
Average Thickness (ft)	0.0	-2.0

Narrative: This area has no vibracores within the boundaries. It was delineated in the SAND study based on bathymetric and seismic evidence. It contributes no volume to the SAND Study.

Material Description

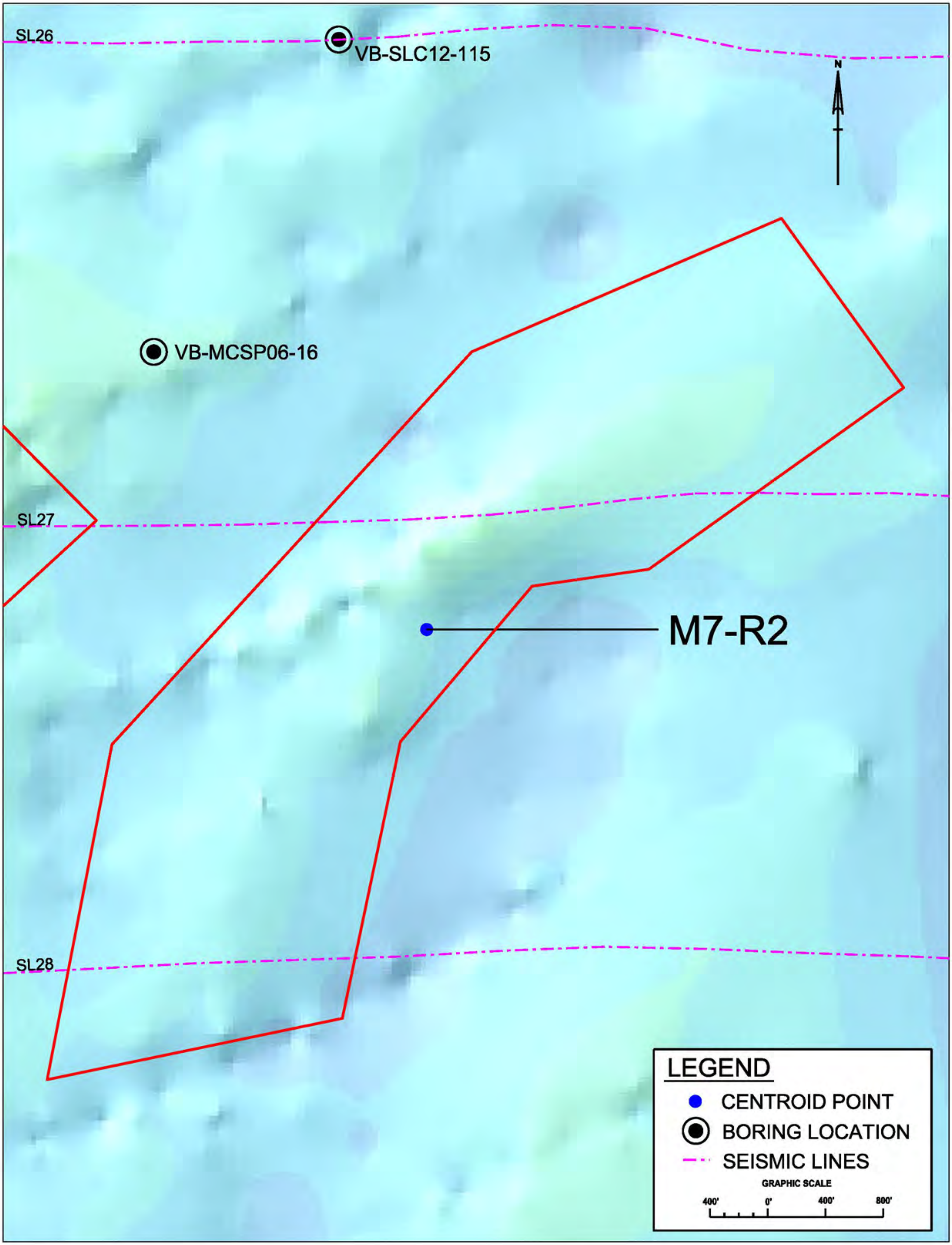
Mean mm:

Munsell value range:

Color:

Physical description:

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
			Average	


SL26
VB-SLC12-115
N
VB-MCSP06-16
SL27
M7-R2
SL28
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
GRAPHIC SCALE
400'
0'
400'
800'

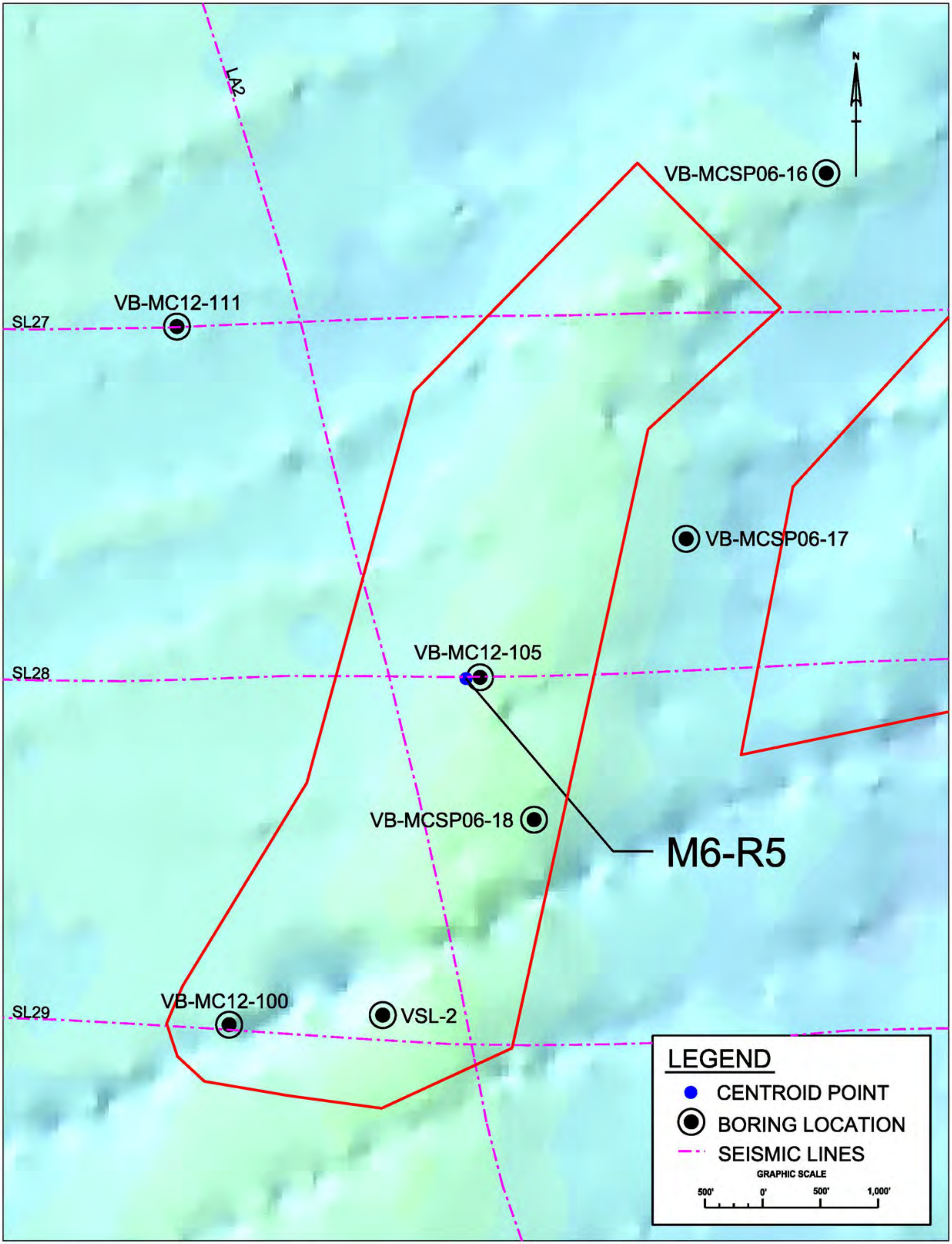
Sediment Source ID: M6-R5 Category: Unverified

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	93,181,491	57,204,082
Volume (cy)	3,451,166	2,118,670
Area (ft^2)	17,988,705	17,988,705
Average Thickness (ft)	5.2	3.2

Narrative: The area delineated as part of 2012 SAND Study using vibracores, bathymetric and seismic evidence.

Material Description	
Mean mm:	0.41 - 0.61
Munsell value range:	3 (wet) 5 (dry)
Color:	gray to very dark gray
Physical description:	fine-grained quartz sand with some fine to coarse grained sand-sized shell and trace fine grained gravel-size shell.

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
VB-MCSP06-18	953986	1061133	-52.7	4.4
VSL-2	952674.8	1059440	-53.3	6
VB-MC12-100	951344	1059357	-61.6	4.9
VB-MC12-105	953518	1062366	-57.4	6.6
Sediment Source Edge				4
			Average	5.2



LA2
VB-MCSP06-16
VB-MC12-111
SL27
VB-MCSP06-17
VB-MC12-105
SL28
VB-MCSP06-18
M6-R5
VB-MC12-100
SL29
VSL-2
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
GRAPHIC SCALE
500'
0'
500'
1,000'
N

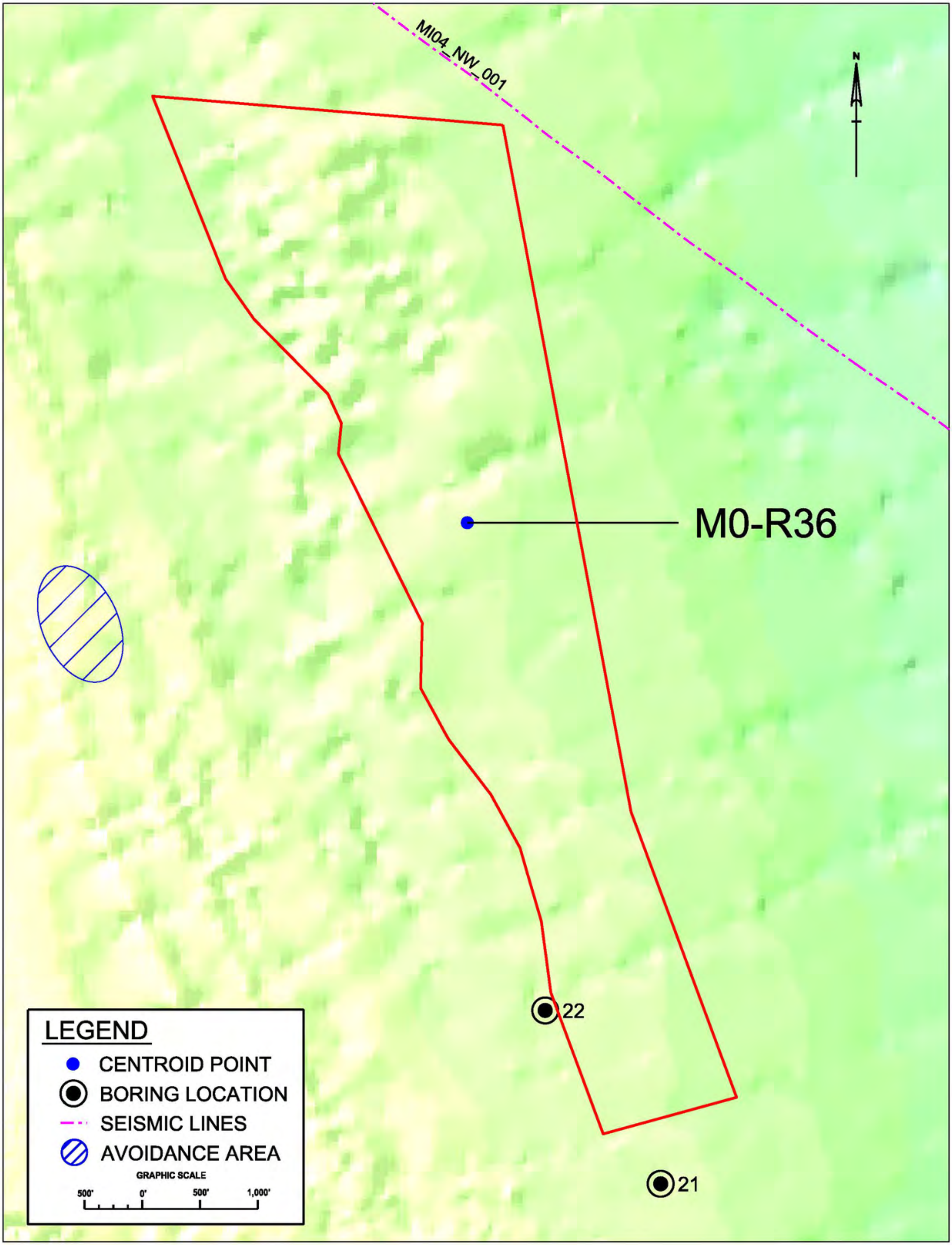
Sediment Source ID: M0-R36 Category: Unverified

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	101,185,984	70,289,500
Volume (cy)	3,747,629	2,603,315
Area (ft^2)	15,448,242	15,448,242
Average Thickness (ft)	6.6	4.6

Narrative: The area delineated as part of 2012 SAND Study. The deposit connects the southern extension of Gilbert shoal and outer ebb shoal of St. Lucie Inlet.

Material Description	
Mean mm:	0.22 to 0.38
Munsell value range:	N/6
Color:	gray
Physical description:	medium grained sand sized quartz, gray and white calcareous fragments

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
22	934161.5	1033044	-24.3	9.1
Sediment Source Edge				4
			Average	6.6



MI04_NW_001
N
M0-R36
22
21
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
AVOIDANCE AREA
GRAPHIC SCALE
500'
0'
500'
1,000'

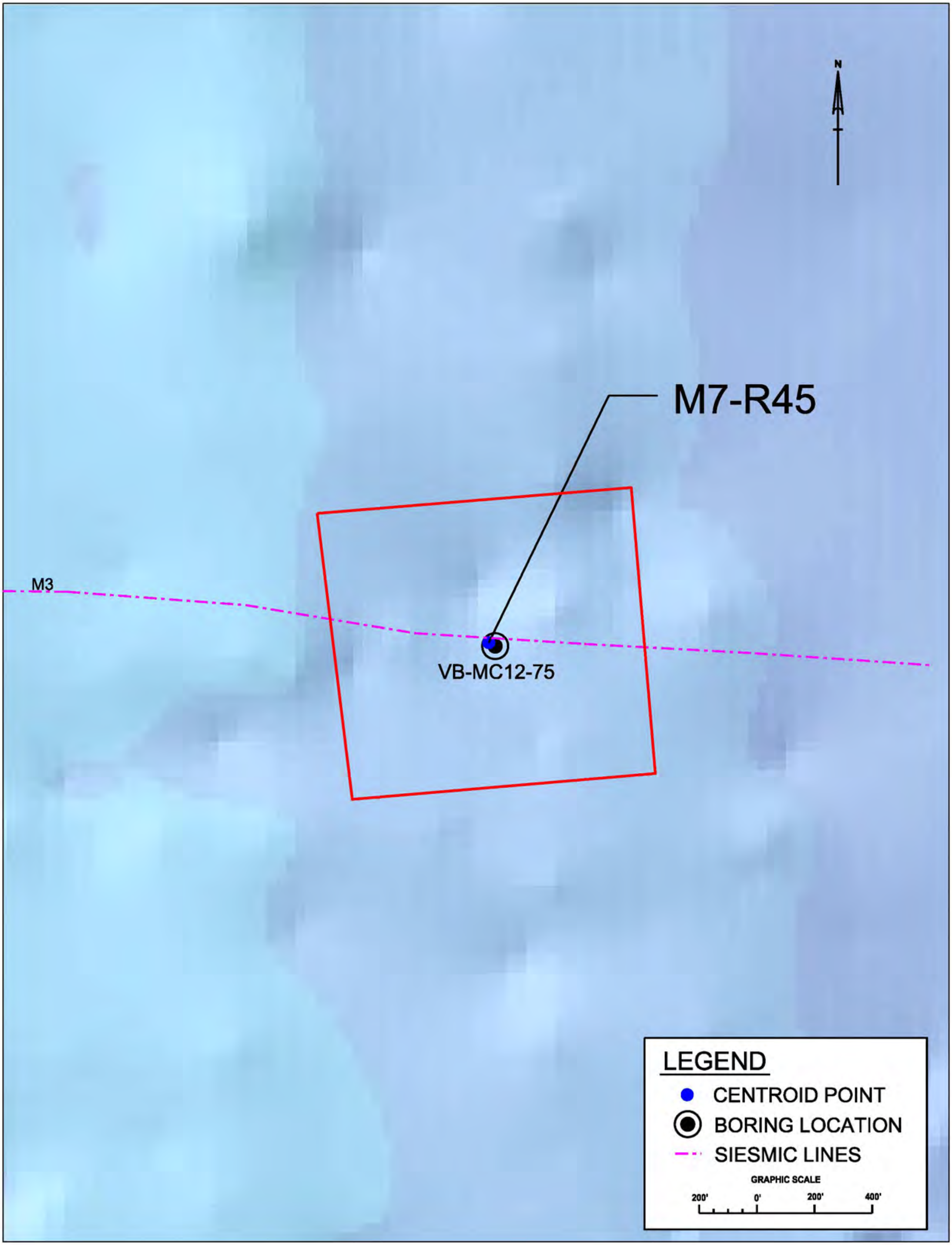
Sediment Source ID: M7-R45 Category: Unverified

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	5,336,323	3,201,794
Volume (cy)	197,642	118,585
Area (ft^2)	1,067,265	1,067,265
Average Thickness (ft)	5.0	3.0

Narrative: The area delineated as part of 2012 SAND Study. This deposit was delineated using seismic, but is constrained to the foot print of a single vibracore. The seismic lines show that this is a large unconsolidated shelf slope deposit. More data is required to fully delineate the deposit.

Material Description	
Mean mm:	0.19
Munsell value range:	4 (wet) 6 (dry)
Color:	light gray
Physical description:	fine grained quartz sand with little coarse-to-medium grained carbonate sand

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
VB-MC12-75	969359	1028844	-84.7	6
Sediment Source Edge				4
			Average	5.0


N
M7-R45
M3
VB-MC12-75
LEGEND
CENTROID POINT
BORING LOCATION
SIESMIC LINES
GRAPHIC SCALE
200'
0'
200'
400'

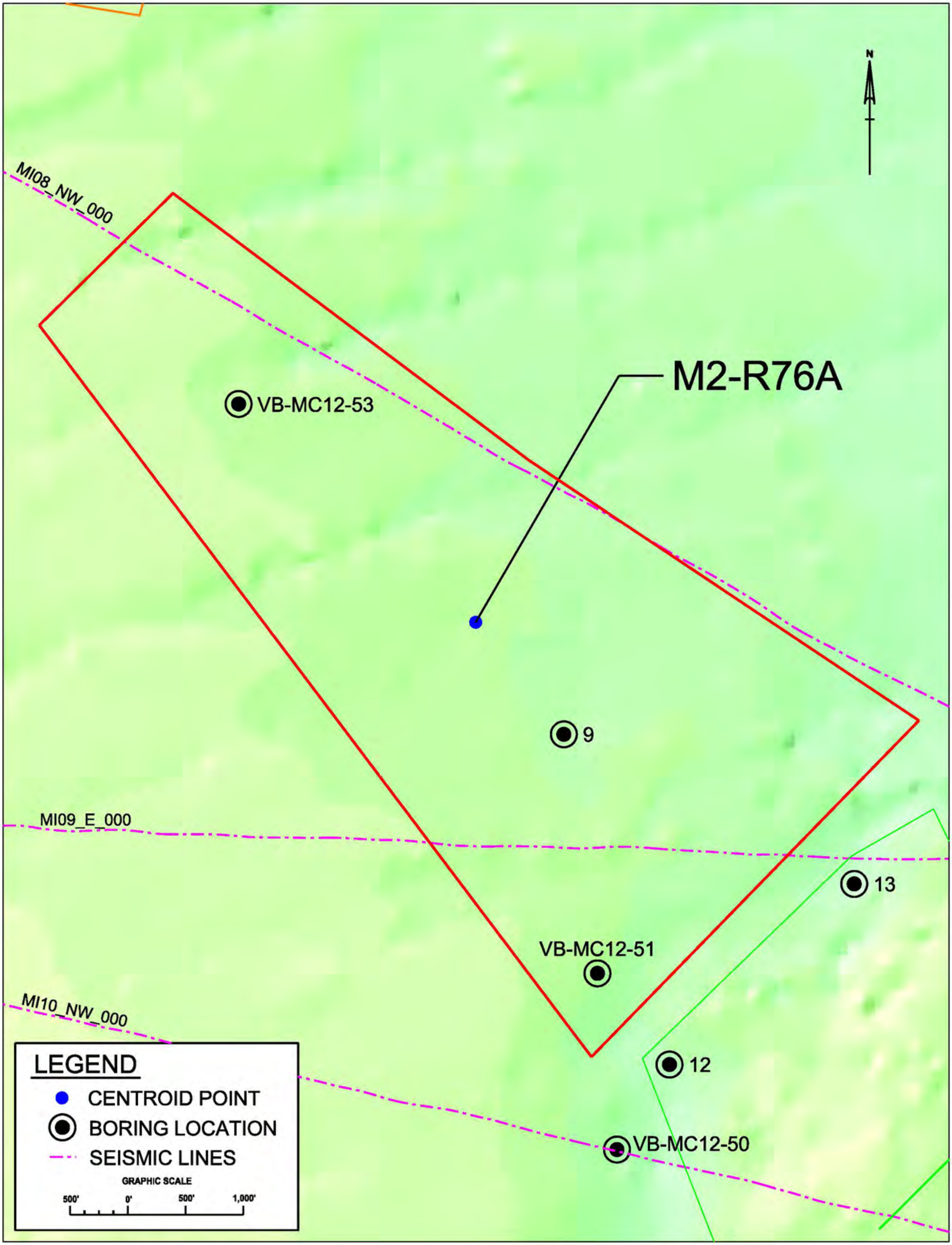
Sediment Source ID: M2-R76A Category: Unverified

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	240,216,917	196,541,118
Volume (cy)	8,896,923	7,279,301
Area (ft^2)	21,837,902	21,837,902
Average Thickness (ft)	11.0	9.0

Narrative: This area was delineated during the SAND study using seismic evidence and vibracore data.

Material Description	
Mean mm:	0.13 - 0.21
Munsell value range:	4 (wet) 6 (dry)
Color:	gray
Physical description:	fine grained quartz sand with little shell

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
VB-MC12-53	953396	999551	-40.3	9
VB-MC12-51	950288	1004479	-40.8	17.4
9	953105	1001620	-40.9	13.6
Sediment Source Edge				4
			Average	11.0



N
MI08_NW_000
M2-R76A
VB-MC12-53
9
MI09_E_000
13
VB-MC12-51
MI10_NW_000
12
VB-MC12-50
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
GRAPHIC SCALE
500'
0'
500'
1,000'

Sediment Source ID: M3-R91 Category: Unverified

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)		
Volume (cy)		
Area (ft^2)	2,826,924	2,826,924
Average Thickness (ft)	0.0	-2.0

Narrative: This area has no vibracores within the boundaries. It was delineated in the SAND study based on bathymetric and geomorphic evidence. It contributes no volume to the SAND Study.

Material Description

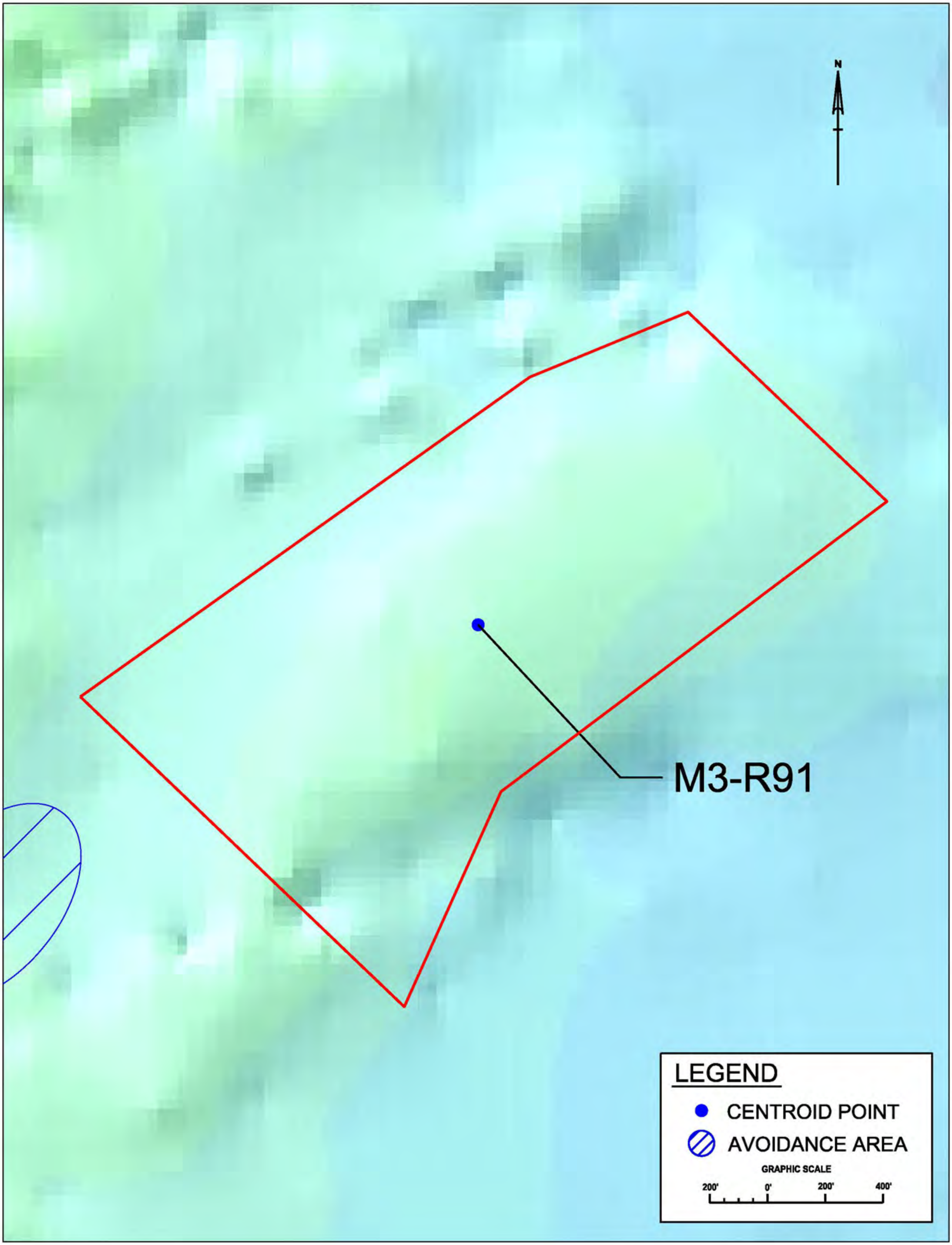
Mean mm:

Munsell value range:

Color:

Physical description:

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
			Average	


N
M3-R91
LEGEND
CENTROID POINT
AVOIDANCE AREA
GRAPHIC SCALE
200'
0'
200'
400'

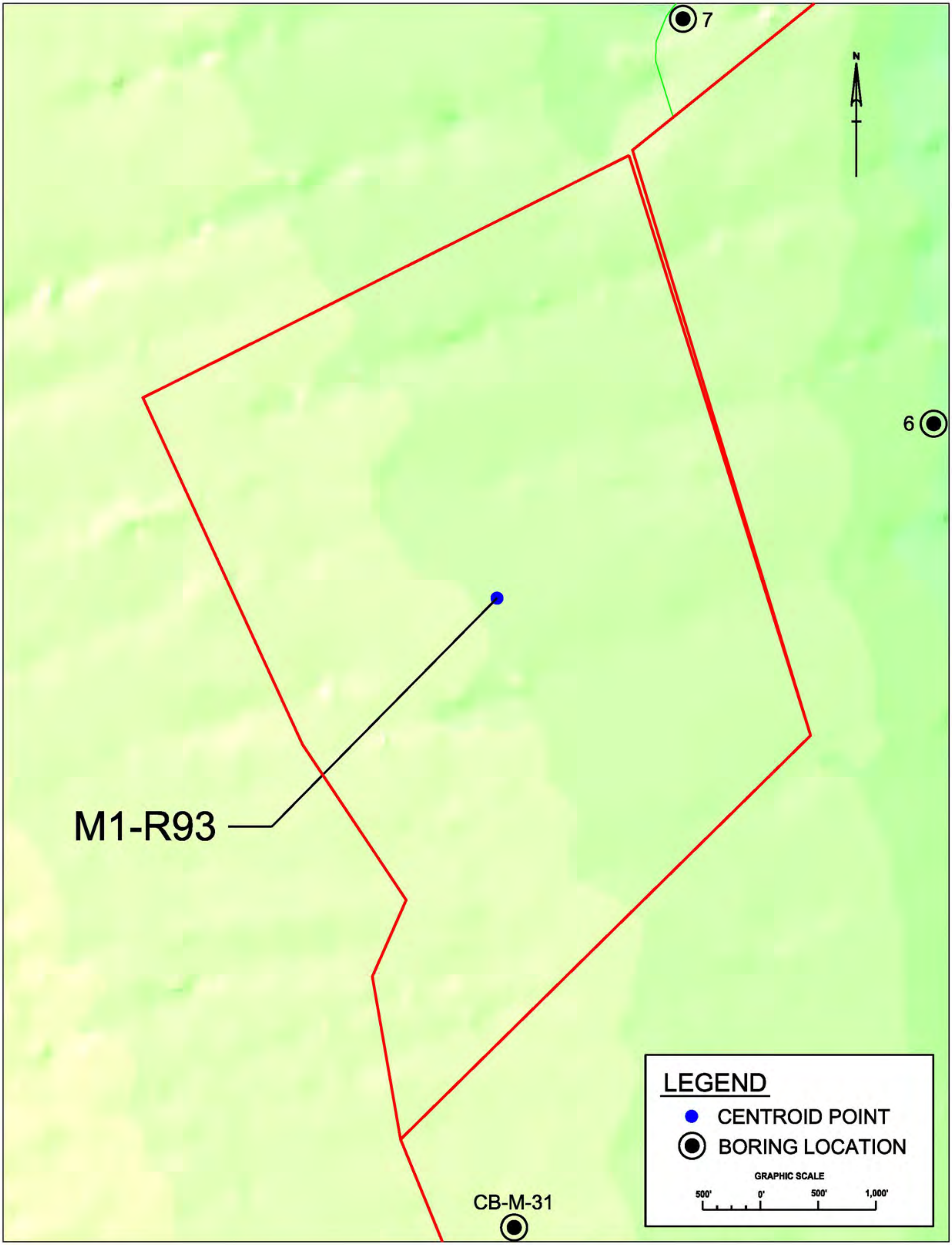
Sediment Source ID: M1-R93 Category: Unverified

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)		
Volume (cy)		
Area (ft^2)	25,749,733	25,749,733
Average Thickness (ft)	0.0	-2.0

Narrative: This area has no vibracores within the boundaries. It was delineated in the SAND study based on bathymetric and geomorphic evidence. It contributes no volume to the SAND Study.

Material Description	
Mean mm:	
Munsell value range:	
Color:	
Physical description:	

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
			Average	


7
N
6
M1-R93
CB-M-31
LEGEND
CENTROID POINT
BORING LOCATION
GRAPHIC SCALE
500'
0'
500'
1,000'

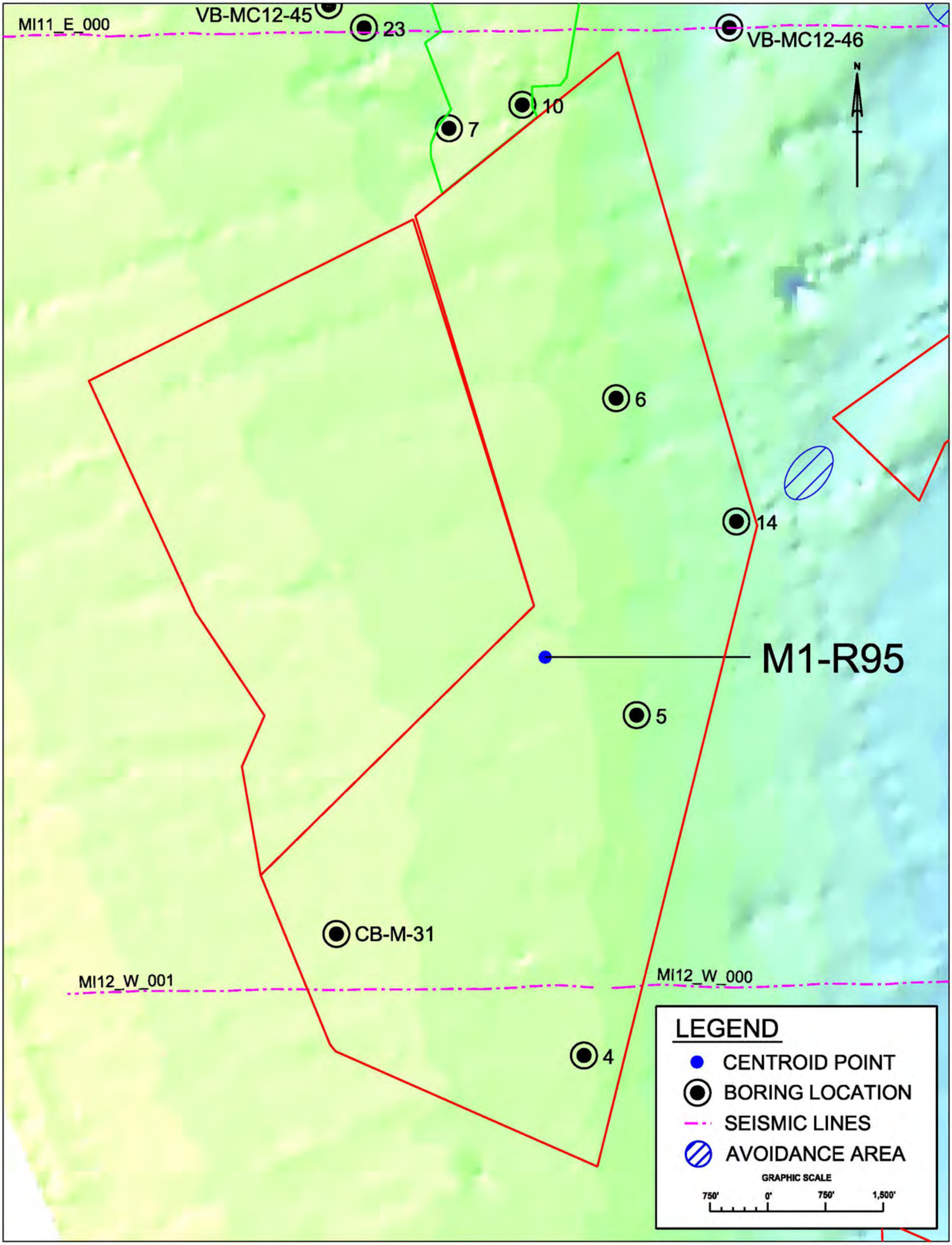
Sediment Source ID: M1-R95 Category: Unverified

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	637,117,845	543,718,370
Volume (cy)	23,596,957	20,137,717
Area (ft^2)	46,699,737	46,699,737
Average Thickness (ft)	13.6	11.6

Narrative: The area delineated as part of 2012 SAND Study. It was delineated based on vibracores, bathymetric and seismic evidence.

Material Description	
Mean mm:	0.14 - 0.19
Munsell value range:	4 (wet) to 6 (dry)
Color:	light gray
Physical description:	very fine-to-medium quartz sand

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
VB-MC12-44	957765	994317	-47.6	15.5
4	957298	981961	-36.8	15.9
5	957983	986380	-41.2	15.8
6	957716	990495	-42.4	15.5
14	959278	988895	-52.2	19
CB-M-31	954082	983539	unknown	9.8
Sediment Source Edge				4
			Average	13.6



MI11_E_000
VB-MC12-45
23
VB-MC12-46
10
7
6
14
M1-R95
5
CB-M-31
MI12_W_001
MI12_W_000
4
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
AVOIDANCE AREA
GRAPHIC SCALE
750'
0'
750'
1,500'

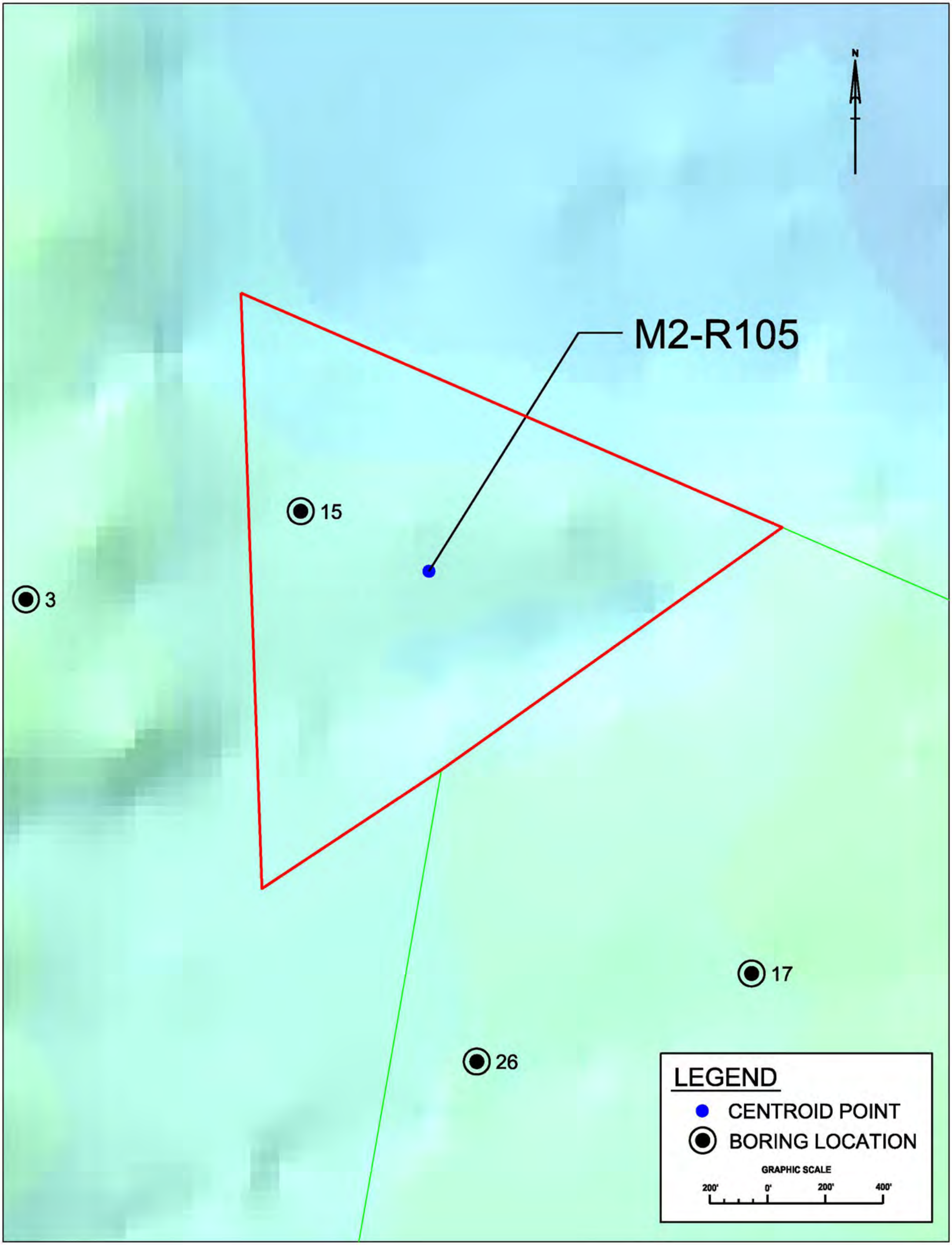
Sediment Source ID: M2-R105 Category: Unverified

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	9,419,131	5,574,588
Volume (cy)	348,857	206,466
Area (ft^2)	1,922,272	1,922,272
Average Thickness (ft)	4.9	2.9

Narrative: The area delineated as part of 2012 SAND Study using a single vibracore from the ICONS Study.

Material Description	
Mean mm:	0.36
Munsell value range:	unknown
Color:	gray
Physical description:	medium to coarse sand-sized shell with quartz

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
15	961374	979066	-59.3	5.8
Sediment Source Edge				4
			Average	4.9



N
M2-R105
15
3
17
26
LEGEND
CENTROID POINT
BORING LOCATION
GRAPHIC SCALE
200'
0'
200'
400'

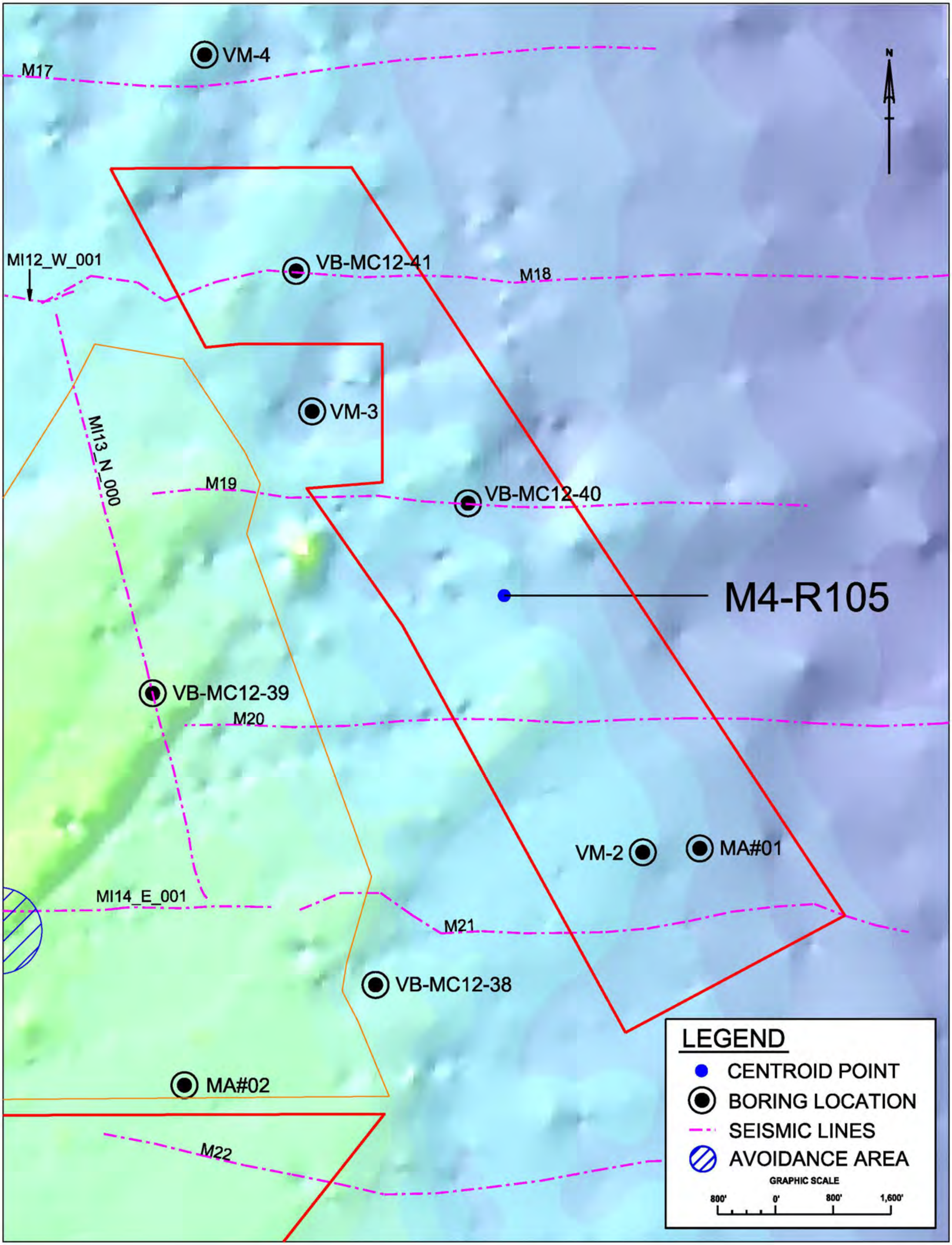
Sediment Source ID: M4-R105 Category: Unverified

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	416,387,708	342,297,369
Volume (cy)	15,421,767	12,677,680
Area (ft^2)	37,045,170	37,045,170
Average Thickness (ft)	11.2	9.2

Narrative: The area delineated as part of 2012 SAND Study. The boundary adjustments made based on seismic data which showed outcrop of rock/hard bottom on the seaward side. The southern boundary was also adjusted upward because sediment in vibracores were too dark (Munsell value of 3).

Material Description	
Mean mm:	0.26 - 0.64
Munsell value range:	3 (wet) 5 (dry)
Color:	dark gray
Physical description:	medium to coarse quartz sand with little shell.

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
VB-MC12-40	973827	980118	-73	10.2
VB-MC12-41	971446	983335	-68.4	14.1
MA#01	977038.7	975338.8	unknown	14.1
VM-2	976248.9	975284.6	-65.8	13.8
Sediment Source Edge				4
			Average	11.2


VM-4
M17
N
MI12_W_001
VB-MC12-41
M18
VM-3
MI13_N_000
M19
VB-MC12-40
M4-R105
VB-MC12-39
M20
VM-2
MA#01
MI14_E_001
M21
VB-MC12-38
MA#02
M22
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
AVOIDANCE AREA
GRAPHIC SCALE
800'
0'
800'
1,600'

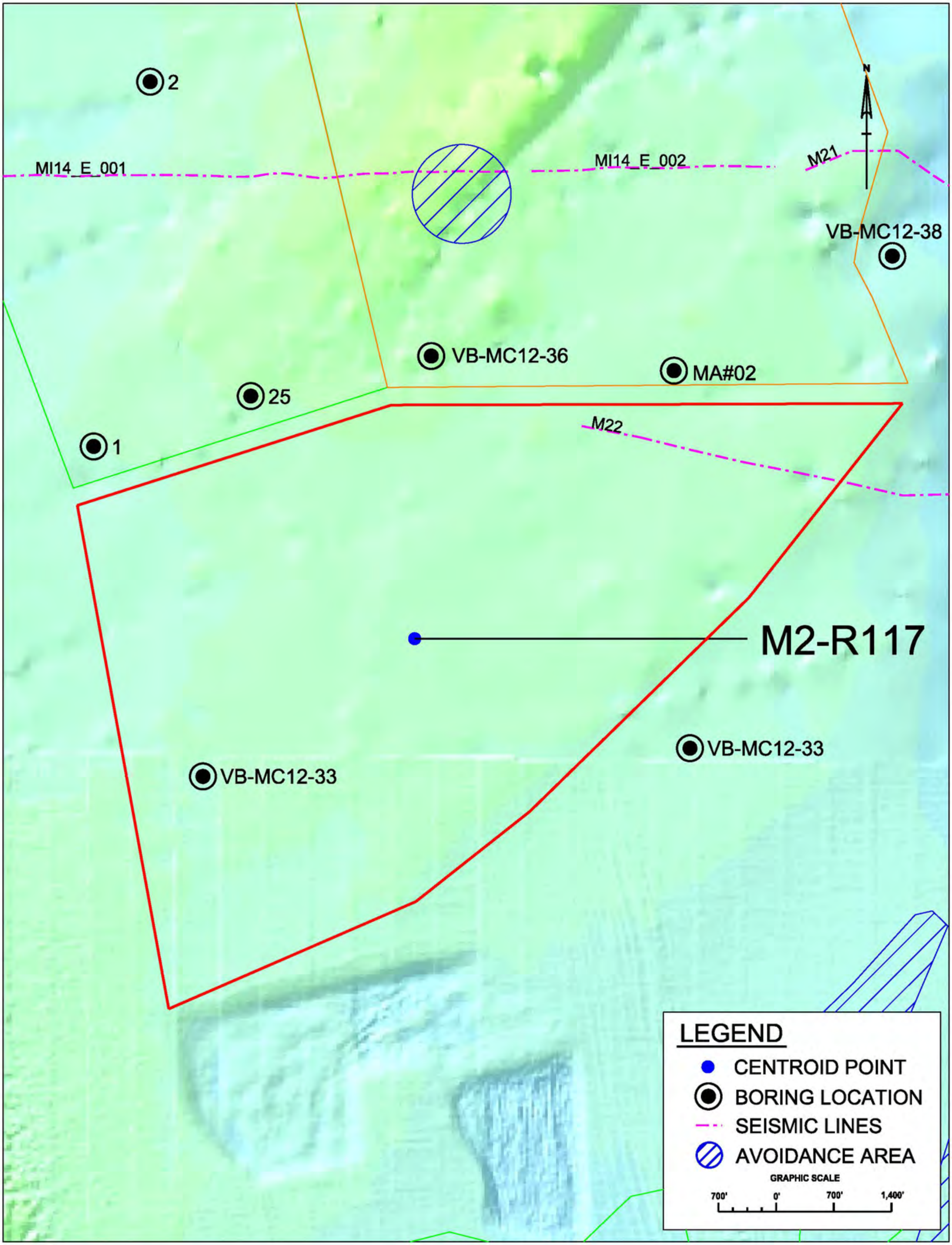
Sediment Source ID: M2-R117 Category: Unverified

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	388,778,432	305,170,167
Volume (cy)	14,399,201	11,302,599
Area (ft^2)	41,804,132	41,804,132
Average Thickness (ft)	9.3	7.3

Narrative: The area delineated in 2012 SAND Study and falls between several proven and depleted sand sources. The area was adjusted based on bathymetric evidence.

Material Description	
Mean mm:	0.38 - 0.5
Munsell value range:	4 (wet) 4 (dry)
Color:	dark gray
Physical description:	poorly-sorted, mostly fine-to-coarse grained sand-sized carbonate with little fine grained gravel-sized shell

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
VB-MC12-33	964186	967143	-56.2	14.6
Sediment Source Edge				4
			Average	9.3


2
MI14_E_001
MI14_E_002
M21
VB-MC12-38
VB-MC12-36
MA#02
25
1
M22
M2-R117
VB-MC12-33
VB-MC12-33
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
AVOIDANCE AREA
GRAPHIC SCALE
700'
0'
700'
1,400'

10.7 Palm Beach County, FL: PROVEN

Sediment Source ID: PB2-R2 Category: Proven

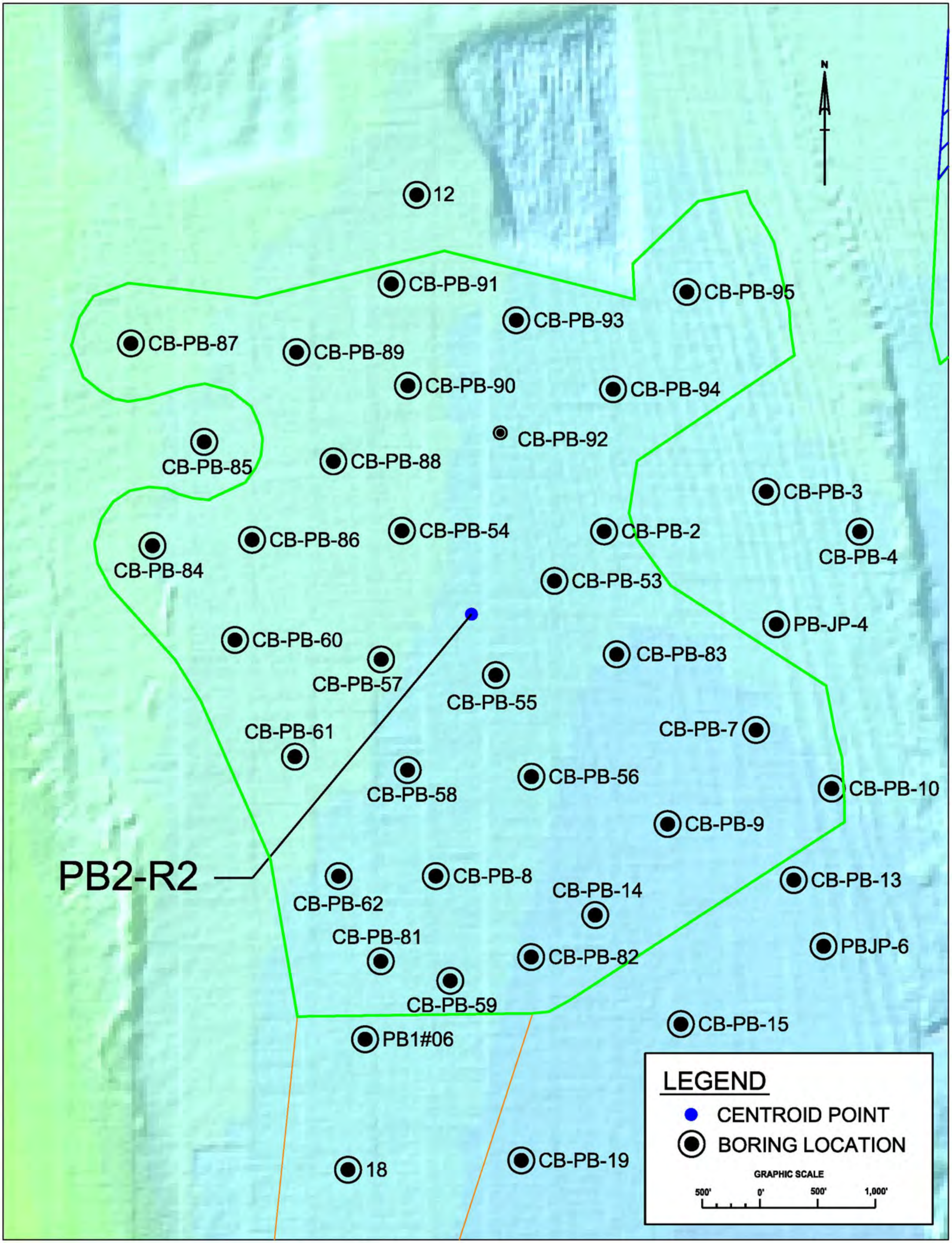
	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	311,451,256	250,804,341
Volume (cy)	11,535,232	9,289,050
Area (ft^2)	30,323,458	30,323,458
Average Thickness (ft)	10.3	8.3

Narrative: Originally delineated by PBC ERM Dept. Part of the original area has been used as a borrow source. The area has been revised to exclude previously dredged areas for the SAND Study.

Material Description	
Mean mm:	0.23 - 0.58
Munsell value range:	not available
Color:	gray to dark gray
Physical description:	fine to medium grained sand and shell with rock fragments

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
CB-PB-2	968560	959190	-65.9	12.9
CB-PB-7	969877	957469	-57.8	8.5
CB-PB-8	967101	956202	-65.1	8.5
CB-PB-9	969110	956653	-68.2	9.4
CB-PB-10	970532	956961	-67.4	20.3
CB-PB-14	968483	955864	-66.6	5.9
CB-PB-53	968129	958761	-66	5.1
CB-PB-54	966807	959196	-63.1	6.2
CB-PB-55	967621	957944	-65.9	19.1
CB-PB-56	967930	957064	-67.2	14
CB-PB-57	966627	958081	-63.4	10.1
CB-PB-58	966857	957121	-65.4	11.4
CB-PB-59	967226	955294	-66.5	7.9
CB-PB-60	965360	958248	-61.5	6.6
CB-PB-61	965880	957237	-63	4.4
CB-PB-62	966259	956202	-65.3	11.1

CB-PB-81	966624	955464	-65.7	11.1
CB-PB-82	967928	955501	-68.2	8.4
CB-PB-83	968669	958124	-67.5	15.1
CB-PB-84	964645	959066	-59.3	5.5
CB-PB-86	965508	959118	-61.1	9.1
CB-PB-87	964459	960820	-58.2	9.4
CB-PB-88	966213	959797	-61.9	11.5
CB-PB-89	965894	960743	-61	11.6
CB-PB-90	966860	960453	-63.4	11.1
CB-PB-91	966717	961335	-62.2	10.7
CB-PB-92	967660	960045	-64.5	12
CB-PB-93	967798	961021	-64.3	11.7
CB-PB-94	968638	960422	-65.4	9
CB-PB-95	969278	961266	-65	16.8
Sediment Source Edge				4
			Average	10.3


N
12
CB-PB-91
CB-PB-95
CB-PB-93
CB-PB-87
CB-PB-89
CB-PB-90
CB-PB-94
CB-PB-92
CB-PB-85
CB-PB-88
CB-PB-3
CB-PB-54
CB-PB-2
CB-PB-4
CB-PB-86
CB-PB-84
CB-PB-53
PB-JP-4
CB-PB-60
CB-PB-83
CB-PB-57
CB-PB-55
CB-PB-61
CB-PB-7
CB-PB-58
CB-PB-56
CB-PB-10
CB-PB-9
PB2-R2
CB-PB-62
CB-PB-8
CB-PB-14
CB-PB-13
CB-PB-81
CB-PB-82
PBJP-6
CB-PB-59
CB-PB-15
PB1#06
18
CB-PB-19
LEGEND
CENTROID POINT
BORING LOCATION
GRAPHIC SCALE
500'
0'
500'
1,000'

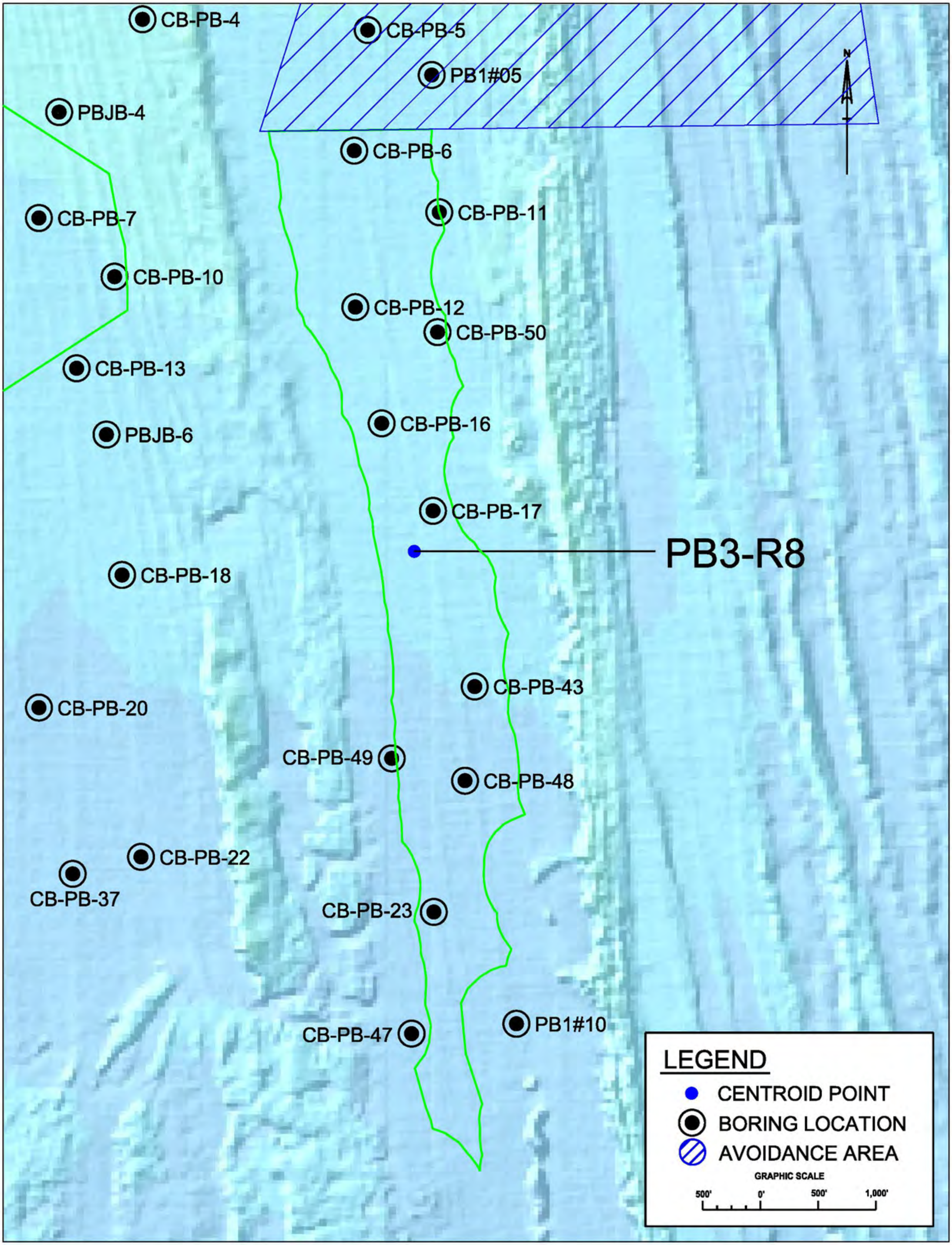
Sediment Source ID: PB3-R8 Category: Proven

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	82,829,389	67,298,878
Volume (cy)	3,067,755	2,492,551
Area (ft^2)	7,765,255	7,765,255
Average Thickness (ft)	10.7	8.7

Narrative: Originally delineated by PBC ERM Dept. Part of the original area has been used as a borrow source. The area has been revised to exclude previously dredged areas for the SAND Study.

Material Description	
Mean mm:	0.23 - 0.58
Munsell value range:	not available
Color:	gray to dark gray
Physical description:	fine to medium grained sand and shell with rock fragments

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
PB95-C6	972608	958052	-69.8	18.2
PB95-C11	973344	9575719	-68.2	10.3
PB95-C12	972617	956698	-70.5	7
PB95-C16	972845	955692	-59.6	11.8
PB95-C17	973290	954935	-67.5	10
PB95-C23	973297	951464	-69.5	10.7
PB95-C43	973651	953415	-69.4	12.4
PB96-C50	973329	956482	-69.5	11.6
Sediment Source Edge				4
			Average	10.7


CB-PB-4
CB-PB-5
PB1#05
N
PBJB-4
CB-PB-6
CB-PB-7
CB-PB-11
CB-PB-10
CB-PB-12
CB-PB-50
CB-PB-13
CB-PB-16
PBJB-6
CB-PB-17
PB3-R8
CB-PB-18
CB-PB-43
CB-PB-20
CB-PB-49
CB-PB-48
CB-PB-22
CB-PB-37
CB-PB-23
PB1#10
CB-PB-47
LEGEND
CENTROID POINT
BORING LOCATION
AVOIDANCE AREA
GRAPHIC SCALE
500'
0'
500'
1,000'

Sediment Source ID: PB0-R59 Category: Proven

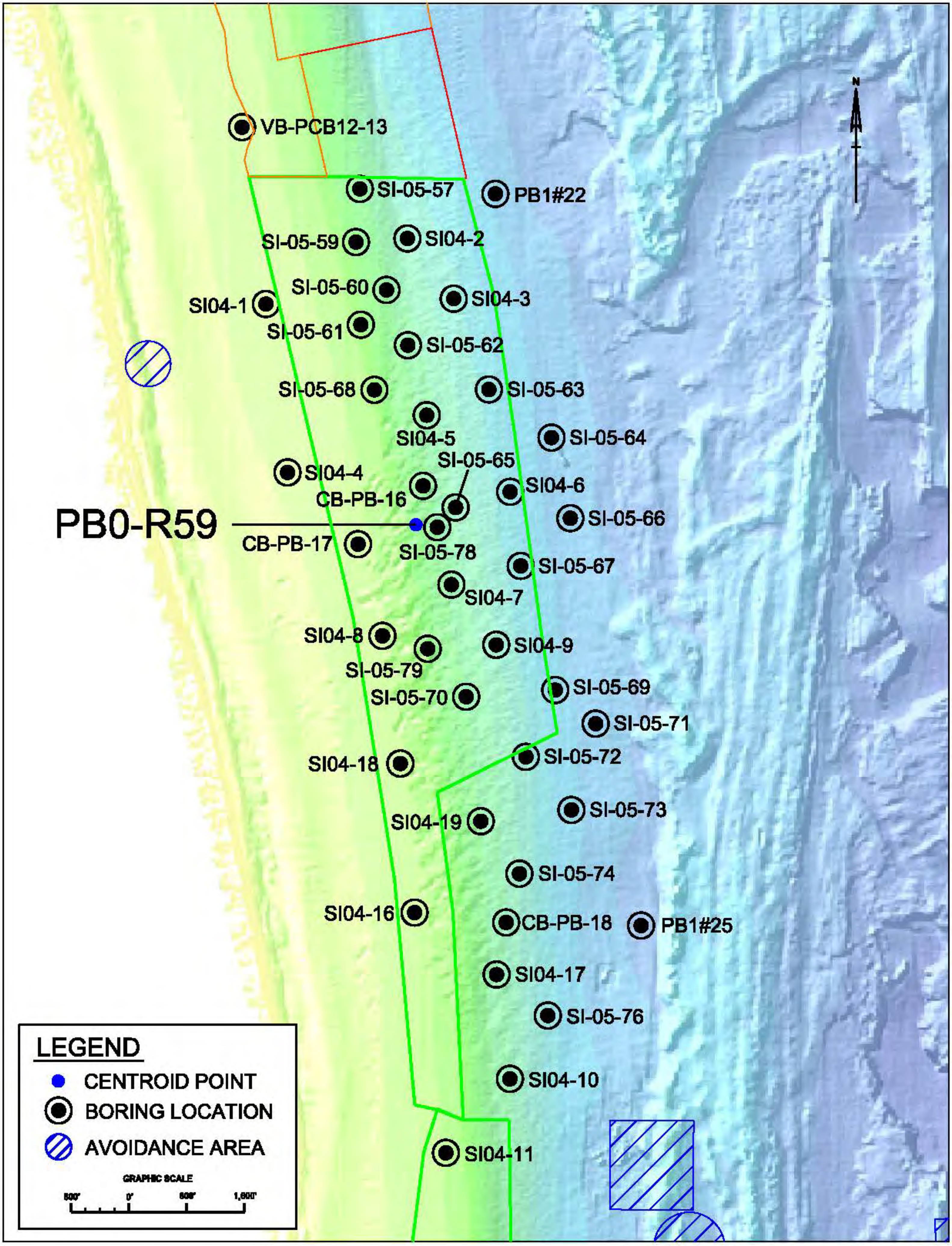
	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	414,220,752	361,998,078
Volume (cy)	15,341,509	13,407,336
Area (ft^2)	26,111,337	26,111,337
Average Thickness (ft)	15.9	13.9

Narrative: This sediment source was originally delineated by the Palm Beach County ERM Department. It was modified in the SAND Study to exclude areas that have already been dredged and to remove the influence of borings that do not meet the criteria of the SAND study. The western edge of the sediment source boundary was set at the depth of closure, -25 ft.

Material Description	
Mean mm:	0.13 - 0.59
Munsell value range:	5 - 7 (wet)
Color:	gray
Physical description:	fine to medium grained quartz sand, varying amounts of coarse grained sand size to fine grained gravel sized shell and coral fragments

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
CB-PB-16	973925	905233	-43.2	10.5
SI04-2	973708	908659	-58.5	16.7
SI04-3	974350	907826	-62.1	18.2
SI04-5	973977	906211	-53	20.1
SI04-6	975132	905151	-66.1	20.2
SI04-7	974318	903865	-51	19.1
SI04-8	973363	903156	-31.6	16.8
SI04-9	974940	903032	-58.6	14.6
SI04-18	973611	901388	-30.9	17.9
SI-05-57	973049	909346	-49.9	18.3
SI-05-58	947424	909266	-68.5	10.8
SI-05-59	972996	908609	-45	20.2
SI-05-60	973418	907947	-50.8	15.9
SI-05-61	973063	907465	-41.3	20.3
SI-05-62	973715	907180	-53.9	20.2
SI-05-63	974838	906568	-66.3	12

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
SI-05-65	974377	904934	-57.5	20.3
SI-05-67	975278	904125	-67.9	11.6
SI-05-68	973252	906563	-40.8	20.2
SI-05-70	974523	902313	-52.3	14.7
SI-05-72	975350	901481	-64	17.8
SI-05-77	973688	905367	-45.3	11.1
SI-05-78	974123	904661	-51.4	17.5
SI-05-79	973990	902977	-44.3	17.6
SIVC-12-1	973717	909394	-63.7	13.3
SIVC-12-2	974457	908606	-66.6	8.2
SIVC-12-3	974463	907109	-69.3	18.6
SIVC-12-4	974664	905754	-69.4	7.2
SIVC-12-5	975585	903313	-71.7	9.6
SIVC-12-6	975169	902298	-67.7	20
SIVC-12-7	974599	901463	-49.1	20
SIVC-12-8	975360	900706	-63.4	20
Sediment Source Edge				4
			Average	15.9


VB-PCB12-13
SI-05-57
PB1#22
SI-05-59
SI04-2
SI-05-60
SI04-3
SI04-1
SI-05-61
SI-05-62
SI-05-68
SI-05-63
SI04-5
SI-05-64
SI-05-65
SI04-4
SI04-6
CB-PB-16
PB0-R59
SI-05-66
CB-PB-17
SI-05-78
SI-05-67
SI04-7
SI04-8
SI04-9
SI-05-79
SI-05-69
SI-05-70
SI-05-71
SI-05-72
SI04-18
SI-05-73
SI04-19
SI-05-74
SI04-16
CB-PB-18
PB1#25
SI04-17
SI-05-76
SI04-10
SI04-11
LEGEND
CENTROID POINT
BORING LOCATION
AVOIDANCE AREA
GRAPHIC SCALE
N

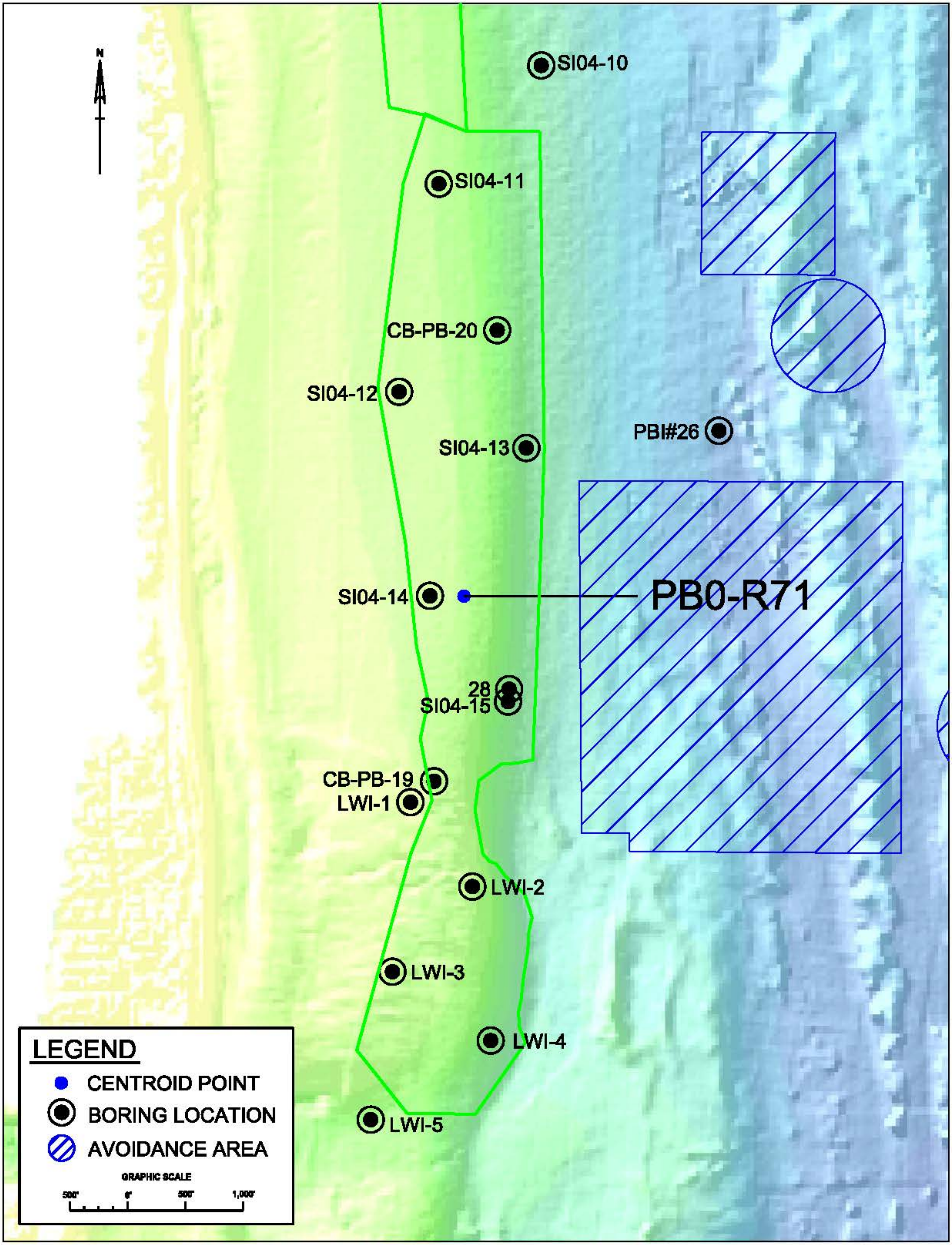
Sediment Source ID: PB0-R71 Category: Proven

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	113,445,801	94,367,828
Volume (cy)	4,201,696	3,495,105
Area (ft^2)	9,538,986	9,538,986
Average Thickness (ft)	11.9	9.9

Narrative: This area is a combination of two previously defined areas from the Palm Beach County ERM Department and includes a portion of the Lake Worth Inlet ebb shoal. The area has been adjusted to account for the depth of closure and hardbottom in the vicinity.

Material Description	
Mean mm:	0.18 - 0.33
Munsell value range:	5 - 7 (wet)
Color:	gray to light brown
Physical description:	fine to medium grained quartz sand with sand sized shell fragments

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
CB-PB-19	974201	890823	-39	18
CB-PB-20	974748	894729	-45	8
28	974851	891621	-48	8
SI04-11	974242	895996	-34	12
SI04-12	973898	894195	-27	16
SI04-13	975000	893709	-51	9
SI04-14	974165	892429	-28	18
SI04-15	974842	891514	-46	11
LWI-1	973996	890642	-29	17
LWI-2	974532	889912	-49	8
LWI-3	973840	889175	-22	18
LWI-4	974691	888578	-49	4
LWI-5	973652	887894	-35	15
Sediment Source Edge				4
			Average	11.9



N
SI04-10
SI04-11
CB-PB-20
SI04-12
SI04-13
PBI#26
SI04-14
PB0-R71
28
SI04-15
CB-PB-19
LWI-1
LWI-2
LWI-3
LWI-4
LWI-5
LEGEND
CENTROID POINT
BORING LOCATION
AVOIDANCE AREA
GRAPHIC SCALE
500'
0'
500'
1,000'

Sediment Source ID: PB0-R86 Category: Proven

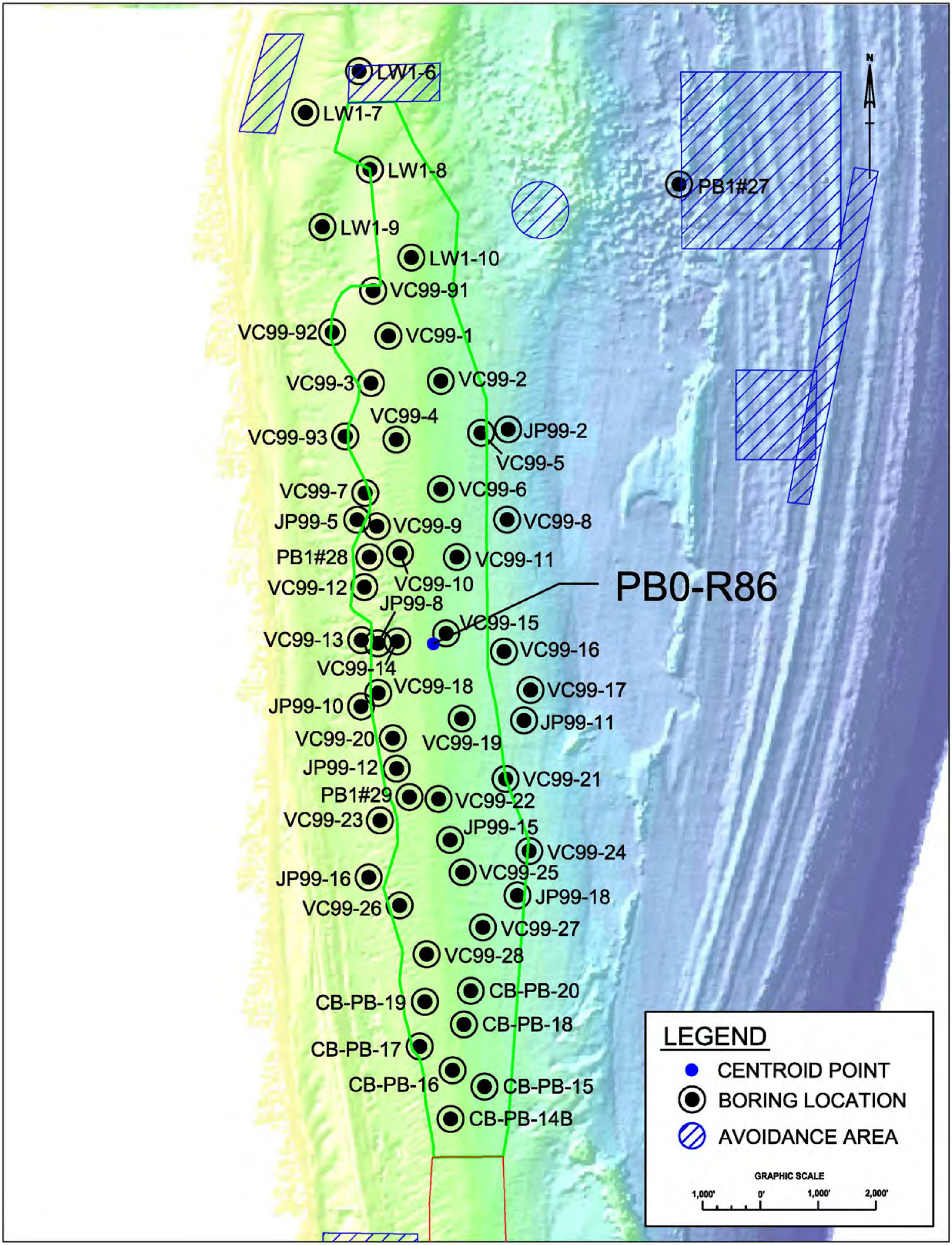
	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	526,252,784	455,614,827
Volume (cy)	19,490,844	16,874,623
Area (ft^2)	35,318,979	35,318,979
Average Thickness (ft)	14.9	12.9

Narrative: This area is a combination of two previously defined areas from the Palm Beach County ERM Department and includes a portion of the Lake Worth Inlet ebb shoal. The area has been adjusted to account for the depth of closure and hardbottom in the vicinity.

Material Description	
Mean mm:	0.13 - 0.53
Munsell value range:	6 (wet) to 7 (wet) based on logs
Color:	tan, gray to light gray
Physical description:	fine grained quartz sand with few rock and coral fragments

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
LWI-8	972854	884446	-30	16.5
LWI-10	973572	882921	-37	20
JP99-2	975248	879946	-61.5	17
JP99-5	972631	878381	-28.3	6.5
JP99-8	972992	876243	-33	20
JP99-10	972701	875150	-30.9	20
JP99-11	975523	874909	-59.2	20
JP99-12	973317	874074	-34.8	4
JP99-15	974242	872839	-46.2	19
JP99-16	972832	872192	-28.8	7
JP99-18	975410	871879	-58.7	6
VC99-1	973176	881562	-33.8	14.5
VC99-2	974082	880785	-44	18.4
VC99-3	972872	880747	-32.9	11.4
VC99-4	973312	879770	-36.4	14.7
VC99-5	974779	879886	-56.6	15.3
VC99-6	974082	878913	-46	19.6
VC99-7	972773	878846	-29.6	10.2
VC99-8	975230	878384	-60	20

VC99-9	972974	878268	-32.1	15.9
VC99-10	973374	877802	-37.1	16.9
VC99-11	974361	877736	-50.7	12.2
VC99-12	972758	877217	-30.4	19.3
VC99-13	972704	876298	-31	17.8
VC99-14	973329	876277	-36.7	12
VC99-15	974174	876415	-46.9	4.5
VC99-18	972997	875383	-33.3	17
VC99-19	974444	874939	-49.7	10
VC99-20	973250	874601	-34.6	19.4
VC99-21	975205	873896	-55.4	19.5
VC99-22	974044	873549	-42.7	17.3
VC99-23	973027	873177	-31.8	15.5
VC99-24	975613	872648	-58	16.3
VC99-25	974461	872279	-49.3	15.8
VC99-26	973368	871707	-35.4	16.1
VC99-27	974810	871327	-52	19
VC99-28	973836	870861	-38.9	17.6
VC99-91	972911	882346	-31	15.6
VC99-92	972199	881628	-25.5	4.4
VC99-93	972428	879825	-27.5	6.6
PB1#28	972844	877734	unknown	14.2
PB1#29	973539	873584	unknown	16.9
PB-14B	974252	868008	-35	13.8
PB-15	974840	868568	-44	14
PB-16	974285	868850	-38	18.1
PB-17	973718	869263	-34	18
PB-18	974482	869644	-44	19
PB-19	973807	870037	-44	19.6
PB-20	974600	870226	-34	18.6
Sediment Source Edge				4
			Average	14.9



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CB-PB-15
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N
LEGEND
CENTROID POINT
BORING LOCATION
AVOIDANCE AREA
GRAPHIC SCALE
1,000'
0'
1,000'
2,000'

Sediment Source ID: PB0-R111 Category: Proven

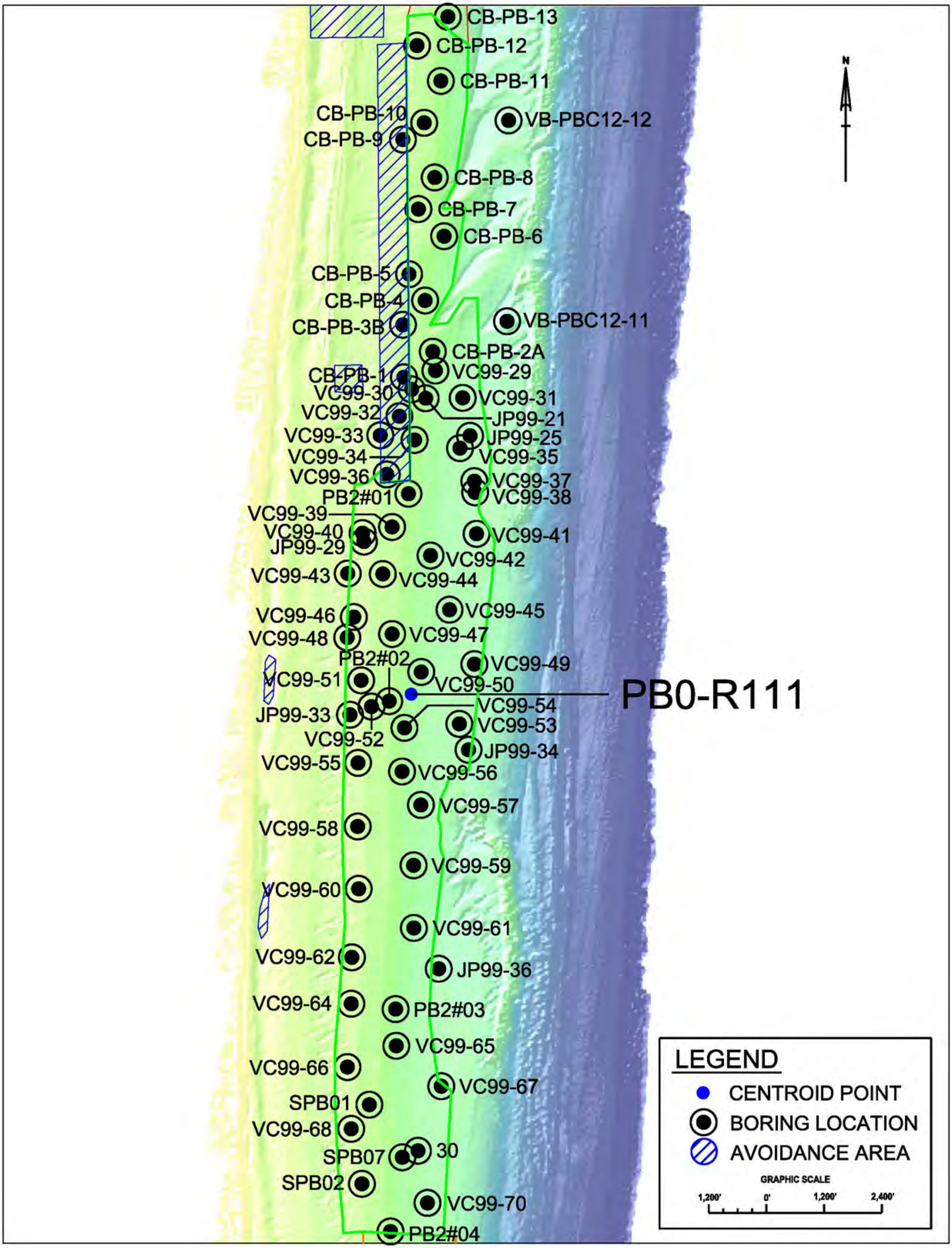
	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	877,579,908	780,034,289
Volume (cy)	32,502,960	28,890,159
Area (ft^2)	48,772,810	48,772,810
Average Thickness (ft)	18.0	16.0

Narrative: This sediment source is a cobination of several areas that were originally delineated by the Palm Beach County ERM Department.

Material Description	
Mean mm:	0.15 - 0.57
Munsell value range:	6 - 7 (wet)
Color:	gray
Physical description:	fine to coarse grained quartz sand with shell fragments and coral fragments

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
30	974326	838273	unknown	9
PB2#01	974128	851922	unknown	10.6
PB2#02	973728	847613	unknown	13.8
PB2#03	973862	841215	unknown	17
PB2#04	973756	836595	unknown	17.9
PB-2	974618	854887	-42	18.7
PB-2A	974618	854887	-42	15
PB-4	974475	855937	unknown	19.8
PB-5	974141	856484	-32	19.5
PB-6	974870	857273	-42	19.9
PB-7	974335	857836	-35	14
PB-8	974676	858493	-38	19.6
PB-10	974456	859628	-36	17
PB-11	974801	860499	-42	19.3
PB-12	974307	861233	-33	14
JP99-21	974486	853906	-42	20
JP99-25	975409	853126	-48.8	12
JP99-29	973203	850928	-30.8	20

JP99-33	972913	847330	-29.4	20
JP99-34	975377	846602	-53.8	19
JP99-36	974758	842053	-54.5	20
VC99-29	974689	854481	-43.2	9.5
VC99-30	974195	854091	-38.2	17.9
VC99-31	975256	853914	-48.6	16.4
VC99-34	974256	853040	-40.6	19.8
VC99-35	975200	852870	-48.6	19.2
VC99-37	975498	852184	-49.5	18.4
VC99-38	975514	851951	-43.3	16.7
VC99-39	973788	851232	-36.2	20.2
VC99-40	973175	851104	-30.3	16.1
VC99-41	975544	851089	-48.6	20
VC99-42	974588	850639	-44.6	19.5
VC99-43R2	972860	850247	-28.8	22.5
VC99-44	973595	850255	-35	19.5
VC99-45	974982	849513	-46.8	20.2
VC99-46	972994	849360	-29.6	19.7
VC99-47	973789	849008	-37.2	19.9
VC99-48	972857	848935	-28.7	16.4
VC99-49	975499	848382	-50.1	19.8
VC99-50	974394	848219	-44.2	19.5
VC99-51	973145	848045	-31.8	18.4
VC99-52	973360	847500	-33.6	20
VC99-53	975186	847140	-49.9	17.6
VC99-54	974046	847058	-44.5	19.8
VC99-55	973080	846330	-32.5	19.1
VC99-56	973995	846151	-43.6	19.8
VC99-57	974387	845456	-48.8	19.8
VC99-58	973073	845009	-33.3	18.9
VC99-59	974236	844202	-47.1	20.1
VC99-60	973094	843714	-32.9	18.5
VC99-61	974241	842901	-49.3	18.5
VC99-62	972953	842290	-32.3	20.1
VC99-64	972940	841327	-32.2	20.2
VC99-65	973876	840452	-46.1	20.2
VC99-66	972860	840011	-32.5	19.6
VC99-67	974811	839612	-52.6	20
VC99-68	972938	838727	-33	19.9
VC99-70	974524	837188	-49.9	19.8
Sediment Source Edge				4
			Average	18.0



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VC99-67
SPB01
VC99-68
SPB07
30
SPB02
VC99-70
PB2#04
N
LEGEND
CENTROID POINT
BORING LOCATION
AVOIDANCE AREA
GRAPHIC SCALE
1,200'
0'
1,200'
2,400'

Sediment Source ID: PB0-R160 Category: Proven

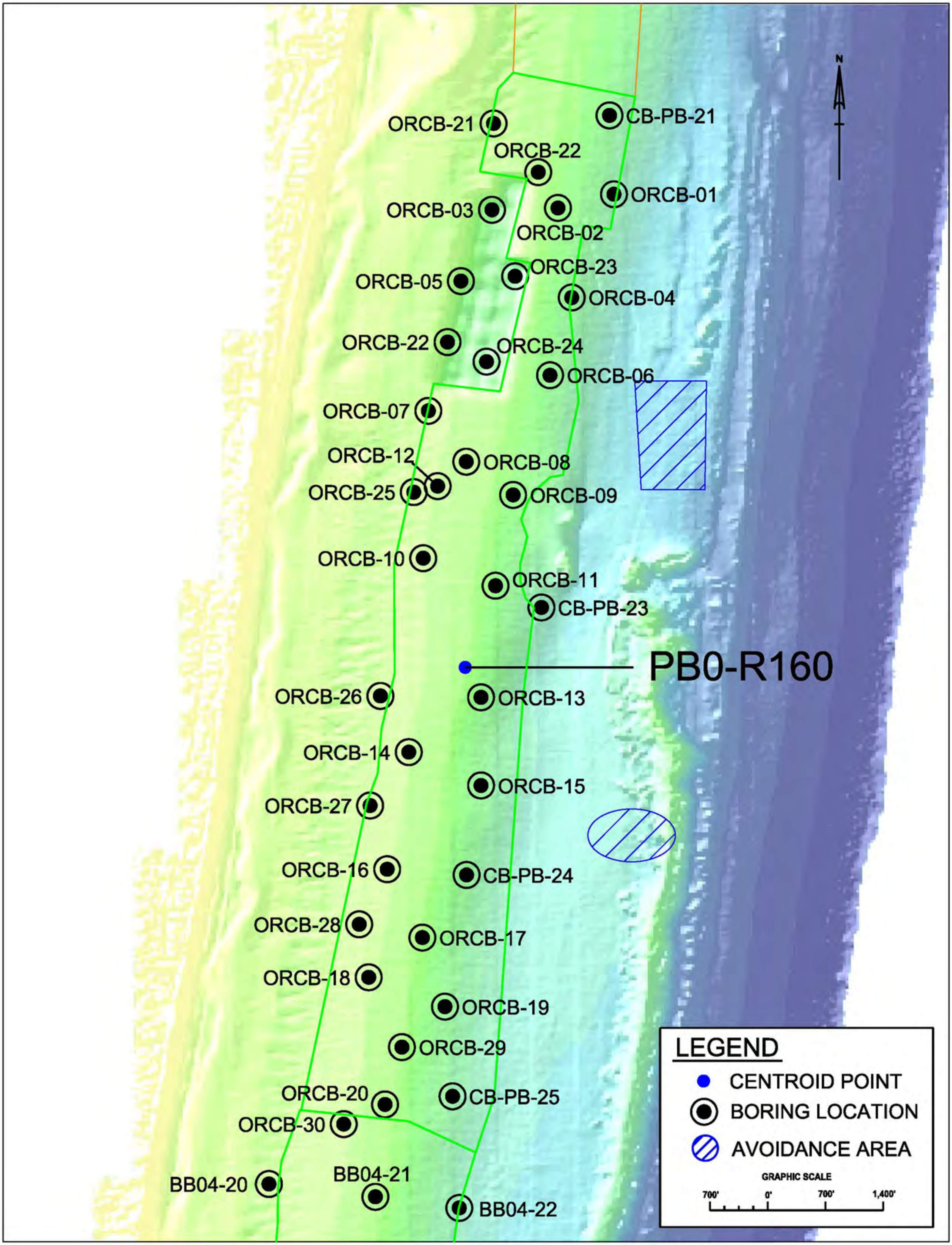
	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	286,458,702	245,656,038
Volume (cy)	10,609,582	9,098,372
Area (ft^2)	20,401,332	20,401,332
Average Thickness (ft)	14.0	12.0

Narrative: Originally delineated by PBC ERM Dept. The original area has been modified to remove previously dredged areas, hardbottom and the depth of closure.

Material Description	
Mean mm:	0.19 to 0.42
Munsell value range:	6 (wet)
Color:	gray, tan to brown
Physical description:	fine to medium sand-sized quartz, medium sand to fine gravel-sized shell fragments, scattered coral and rock fragments.

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
ORCB-01	972093	802569	-55	14
ORCB-02	971414	802403	-43.3	17.1
ORCB-03	970614	802381	-31.3	16.9
ORCB-04	971581	801318	-50	16.5
ORCB-06	971318	800376	-47	17.2
ORCB-07	969842	799945	-49	15.3
ORCB-08	970302	799329	-35	17.6
ORCB-09	970870	798926	-43	16.4
ORCB-10	969780	798160	-33	14.6
ORCB-11	970657	797825	-44.3	13.3
ORCB-12	969955	799033	-35	18.7
ORCB-13	970481	796473	-45	13.5
ORCB-14	969605	795809	-33.9	16.5
ORCB-15	970481	795405	-50	17.8
ORCB-16	969343	794390	-36	17.2
ORCB-17	969770	793562	-40	6.9
ORCB-18	969119	793081	-33	12
ORCB-19	970044	792725	-50	12.7

ORCB-20	969317	791540	-38	14.8
ORCB-21	970633	803427	-29	14.1
ORCB-22	971175	802837	-35	15.4
ORCB-23	970894	801575	-36	4.3
ORCB-25	969665	798960	-33	15.5
ORCB-26	969261	796490	-33	15.5
ORCB-27	969136	795162	-34	15.4
ORCB-28	969004	793723	-32	15.7
ORCB-29	969522	792235	-27	14.6
ORCB-30	968816	791302	-33	13.4
CB-PB-21	972039	803524	-45.6	16
CB-PB-23	971214	797562	-37.2	14
CB-PB-24	970306	794321	-19.3	9
CB-PB-25	970136	791639	26.9	16
20	unknown	unknown	-41	5.5
Sediment Source Edge				4
			Average	14.0



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ORCB-21
CB-PB-21
ORCB-22
ORCB-01
ORCB-03
ORCB-02
ORCB-05
ORCB-23
ORCB-04
ORCB-22
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ORCB-29
ORCB-20
CB-PB-25
ORCB-30
BB04-20
BB04-21
BB04-22
LEGEND
CENTROID POINT
BORING LOCATION
AVOIDANCE AREA
GRAPHIC SCALE
700'
0'
700'
1,400'

Sediment Source ID: PB0-R170 Category: Proven

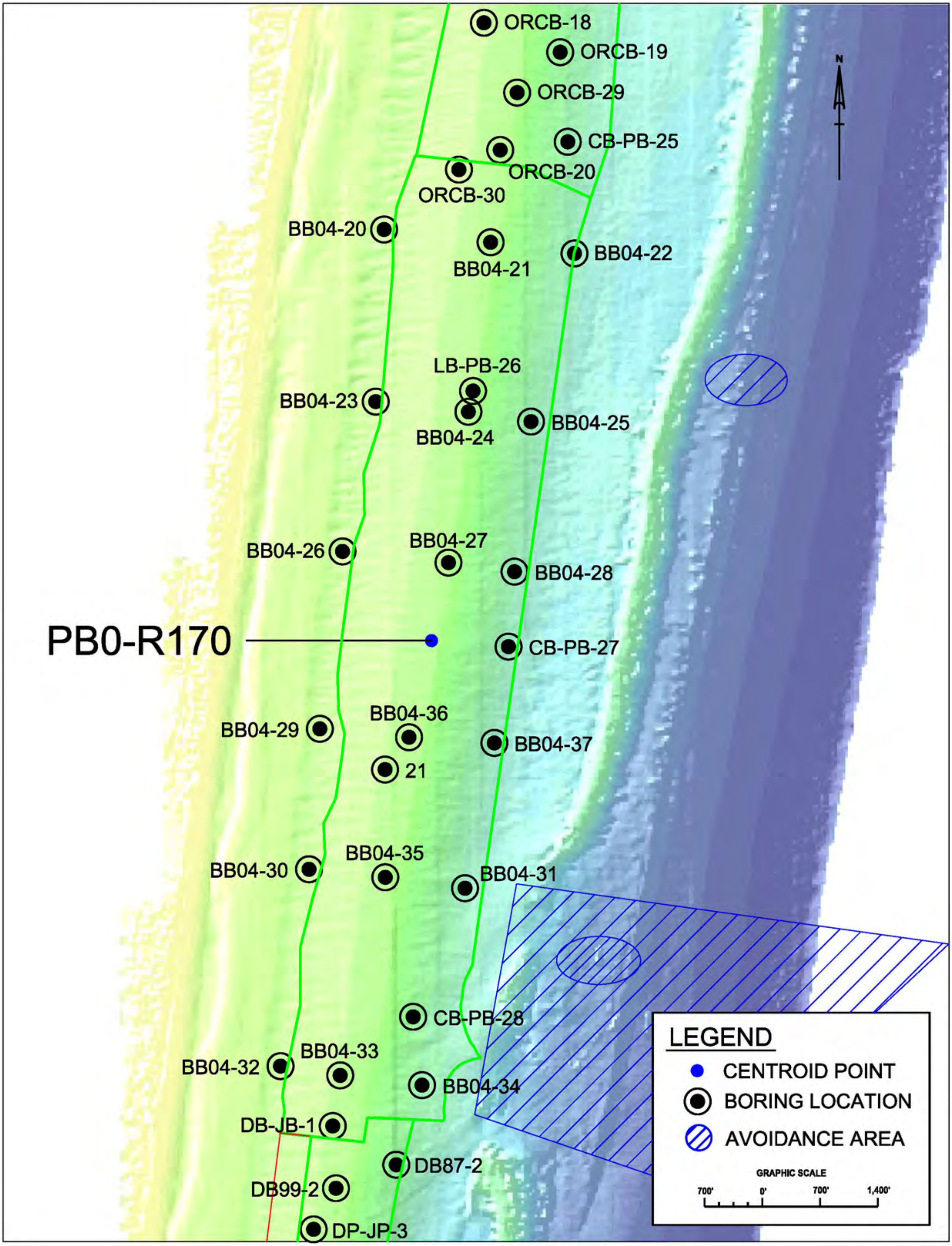
	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	377,079,342	328,450,088
Volume (cy)	13,965,902	12,164,818
Area (ft^2)	24,314,627	24,314,627
Average Thickness (ft)	15.5	13.5

Narrative: Originally delineated by the PBC ERM Dept. The area was adjusted to account for hardbottom and the depth of closure.

Material Description	
Mean mm:	0.16 - 0.54
Munsell value range:	5 - 7 (wet)
Color:	gray to tan
Physical description:	fine to medium grained quartz sand, little coarse sand-sized shell,

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
ORCB-30	968816	791302	-33	13.4
CB-PB-26	968987	788619	-20.6	19
CB-PB-27	969417	785522	-28.5	7.3
CB-PB-28	968261	781036	-20.6	18
DB-JP-1	967920	784032	-36	20
21	967286	779712	-44	6.5
BB04-20	967909	790576	-24.7	18.1
BB04-21	969200	790421	-36.4	19.1
BB04-23	967807	788491	-27	19
BB04-24	968931	788367	-37	19
BB04-25	969690	788249	-52	11
BB04-26	967404	786675	-24.8	17.1
BB04-27	968689	786540	-37.1	18.9
BB04-28	969490	786430	-54.8	9.2
BB04-29	967130	784526	-24.1	19.3
BB04-30	966999	782823	-25.4	19
BB04-31	968890	782594	-53.5	17.5
BB04-32	966653	780438	-24.6	19.1

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
BB04-33 R1R2	967376	780326	-33.7	21
BB04-34	968369	780207	-51.4	18.1
BB04-35	967923	782726	-34.9	15.4
BB04-36	968211	784423	-35.1	15.9
BB04-37	969246	784355	-57.9	7.7
Sediment Source Edge				4
			Average	15.5



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ORCB-19
ORCB-29
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ORCB-30
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BB04-27
BB04-28
PB0-R170
CB-PB-27
BB04-29
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21
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BB04-31
CB-PB-28
BB04-32
BB04-33
BB04-34
DB-JB-1
DB87-2
DB99-2
DP-JP-3
N
LEGEND
CENTROID POINT
BORING LOCATION
AVOIDANCE AREA
GRAPHIC SCALE
700'
0'
700'
1,400'

Sediment Source ID: PB0-R182 Category: Proven

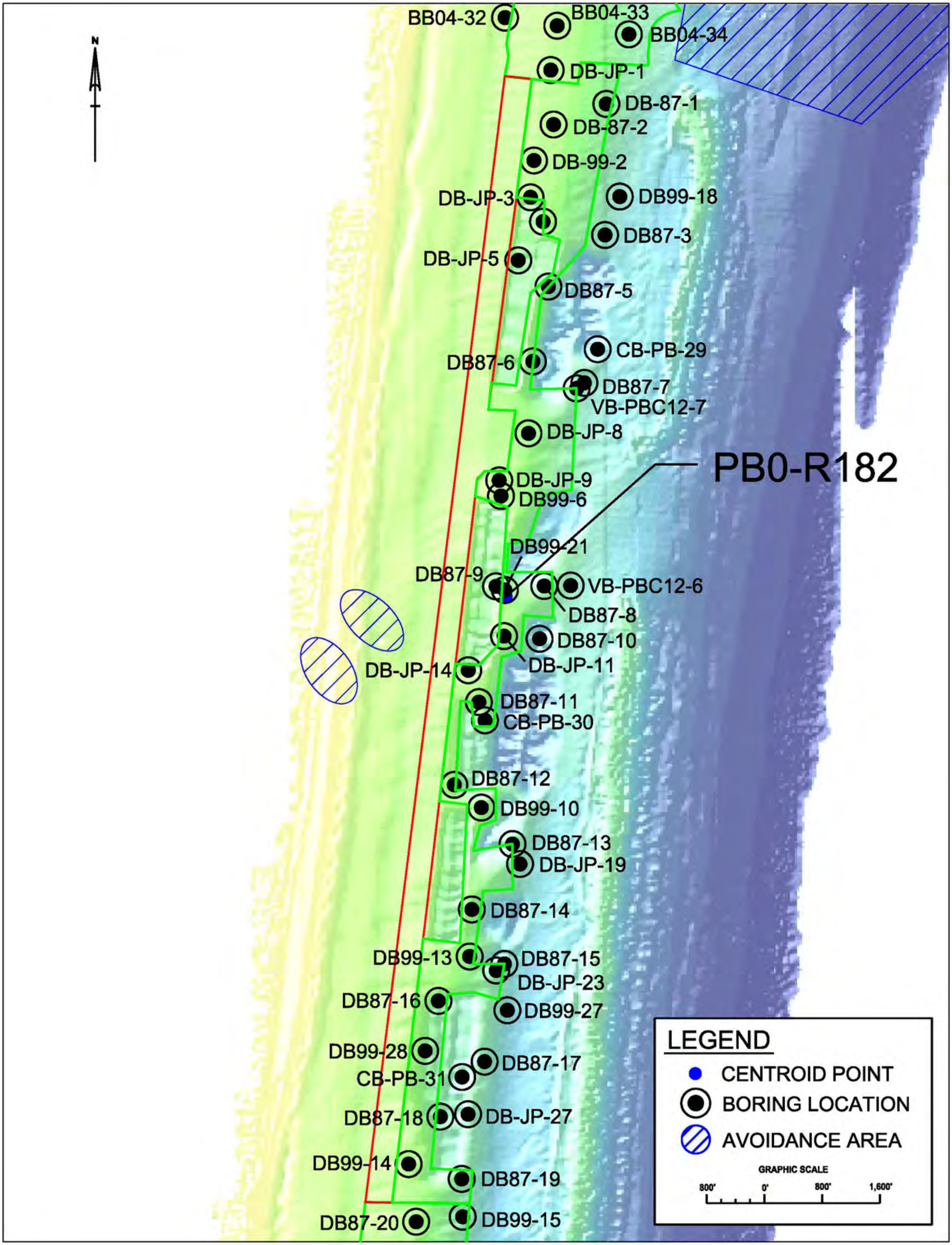
	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	161,024,487	142,928,943
Volume (cy)	5,963,870	5,293,665
Area (ft^2)	9,047,772	9,047,772
Average Thickness (ft)	17.8	15.8

Narrative: Originally delineated by the PBC ERM Dept. The original area has been used multiple times as a borrow area. Previously dredged areas have been removed from the sediment source boundary for the SAND study. Many borings terminated in good material; future investigations may show more material exists in previously dredged areas.

Material Description	
Mean mm:	0.19 to 0.32
Munsell value range:	5 (wet) to 7 (wet)
Color:	gray
Physical description:	fine grained quartz sand with few shell fragments

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
CB-PB-30	966375	770708	-18	12
VB-PBC12-6	966640	771874	-42.9	19
VB-PBC12-7	966978	774682	-43.9	18.4
DB-87-2	967325	778958	-36	18
DB-87-4	967180	777612	-35	18.8
DB-87-5	967254	776714	-60	20
DB-87-6	967039	775678	-65	18.9
DB-87-9	966529	772564	-36	18.7
DB-87-11	966291	770960	-36	14
DB-87-12	965951	769815	-34	19.7
DB-87-13	966756	768995	-57	17.8
DB-87-14	966193	768090	-48	18
DB-87-15	966644	767336	-60	14.3
DB-87-16	965730	766823	-35	16
DB-87-17	966370	765982	-56	13.6
DB-87-18	965757	765220	-43	16.8
DB-87-19	966053	764358	-57	15.5
DB-99-2	967054	778460	-33.5	18.4
DB-99-6	966597	773815	-36.5	18.2

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
DB-99-10	966325	769500	-41	19
DB-99-13	966163	767438	-46	19.6
DB-99-14	965317	764564	-34.1	18.9
DB-99-15	966066	763834	-55	18.3
DB-99-27	966685	766693	-62.2	18.2
DB-99-28	965546	766131	-47.3	18.8
DB-JP-3	967006	777950	-34	20
DB-JP-5	966836	777077	-32	20
DB-JP-8	967645	775304	-58	20
DB-JP-9	966572	774030	-35	20
DB-JP-11	966651	772513	-37	20
DB-JP-14	966144	771401	-32	20
DB-JP-19	966861	768719	-61	20
DB-JP-23	966531	767244	-58	20
DB-JP-27	966141	765254	-58	20
Sediment Source Edge				4
			Average	17.8



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CB-PB-31
DB87-18
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DB99-14
DB87-19
DB87-20
DB99-15
LEGEND
CENTROID POINT
BORING LOCATION
AVOIDANCE AREA
GRAPHIC SCALE
800'
0'
800'
1,600'

Sediment Source ID: PB0-R197 Category: Proven

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	380,932,562	330,132,870
Volume (cy)	14,108,613	12,227,143
Area (ft^2)	25,399,846	25,399,846
Average Thickness (ft)	15.0	13.0

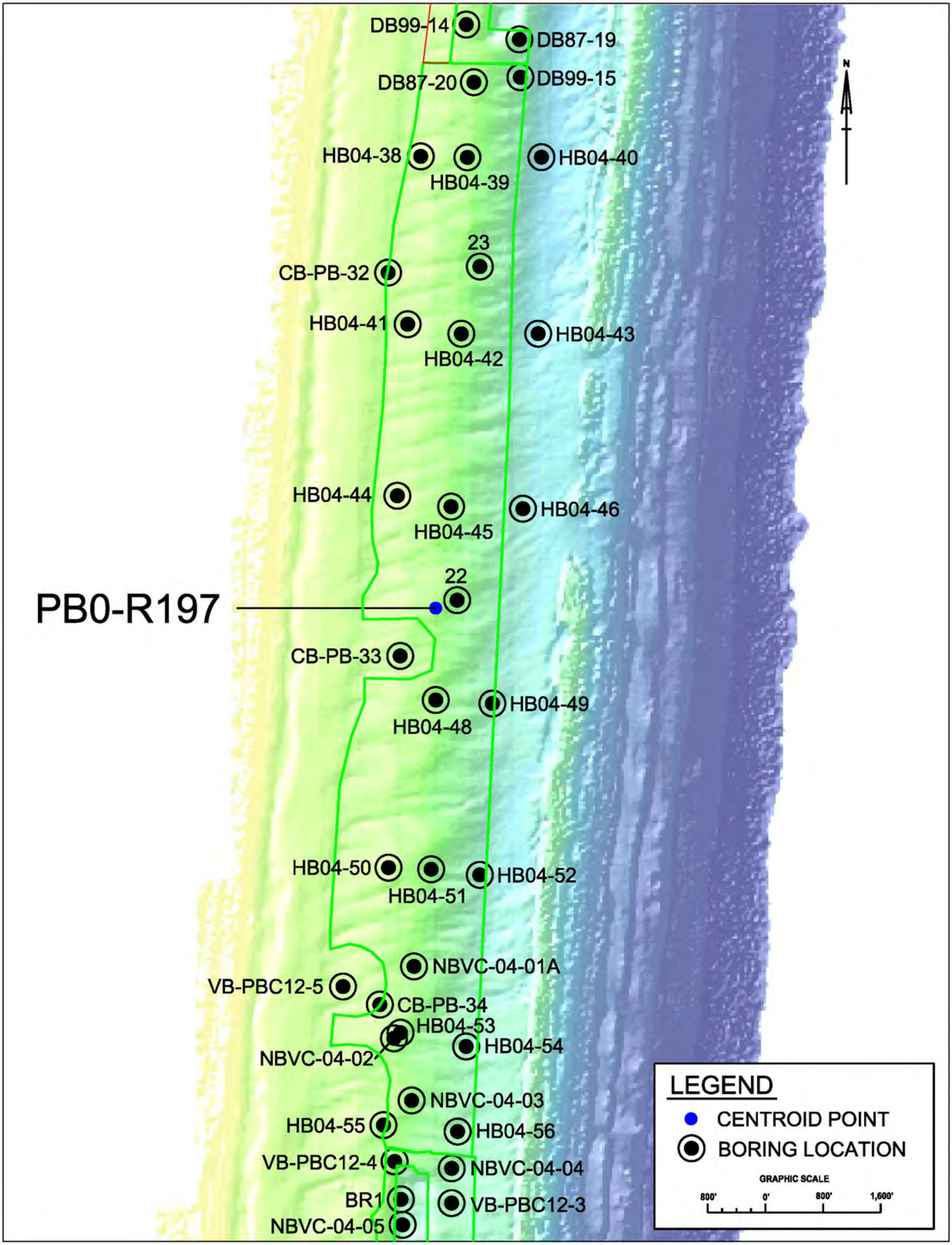
Narrative: Originally delineated by PBC ERM Dept. Area revised to remove hardbottom and for depth of closure consideration.

Material Description	
Mean mm:	0.18 - 0.39
Munsell value range:	6 (wet) to 7.5 (wet)
Color:	gray
Physical description:	fine to medium grained quartz and with trace to little shell hash

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
DB87-20	965422	763765	-43	15.7
CB-PB-32	964233	761128	-32	14
CB-PB-33	964401	755819	-38.8	5.5
DB99-15	966066	763834	-55	18.3
22	965190	756591	-40	10.2
23	965505	761212	-42	10
HB04-38	964685	762738	-28.1	17.9
HB04-39	965332	762724	-38.8	18.7
HB04-41	964504	760413	-29.7	15.2
HB04-42	965248	760281	-40.9	15.1
HB04-44	964362	758037	-29.3	18
HB04-45	965106	757887	-40.8	17.9
HB04-46	966102	757858	-61.3	4.4
HB04-48	964894	755208	-41.3	16.8
HB04-49	965679	755161	-55.9	19.3

HB04-50 R2	964239	752887	-32.2	18
HB04-51	964830	752864	-42.4	17
HB04-52	965504	752787	-58.3	17.6
HB04-53	964314	750523	-36.5	18.5
HB04-54	965315	750410	-53.3	20.2
HB04-55	964169	749321	-35.8	17
HB04-56	965197	749232	-51.2	17.9
VB-PBC12-4*	965115	748722	-55.8	18.4
Sediment Source Edge				4
			Average	15.0

*Boring data also used to define Sediment Source PB0-T205.



DB99-14
DB87-19
DB87-20
DB99-15
N
HB04-38
HB04-39
HB04-40
23
CB-PB-32
HB04-41
HB04-42
HB04-43
HB04-44
HB04-45
HB04-46
22
PB0-R197
CB-PB-33
HB04-48
HB04-49
HB04-50
HB04-51
HB04-52
NBVC-04-01A
VB-PBC12-5
CB-PB-34
HB04-53
NBVC-04-02
HB04-54
NBVC-04-03
HB04-55
HB04-56
VB-PBC12-4
NBVC-04-04
BR1
VB-PBC12-3
NBVC-04-05
LEGEND
CENTROID POINT
BORING LOCATION
GRAPHIC SCALE
800'
0'
800'
1,600'

Sediment Source ID: PB0-T205 Category: Proven

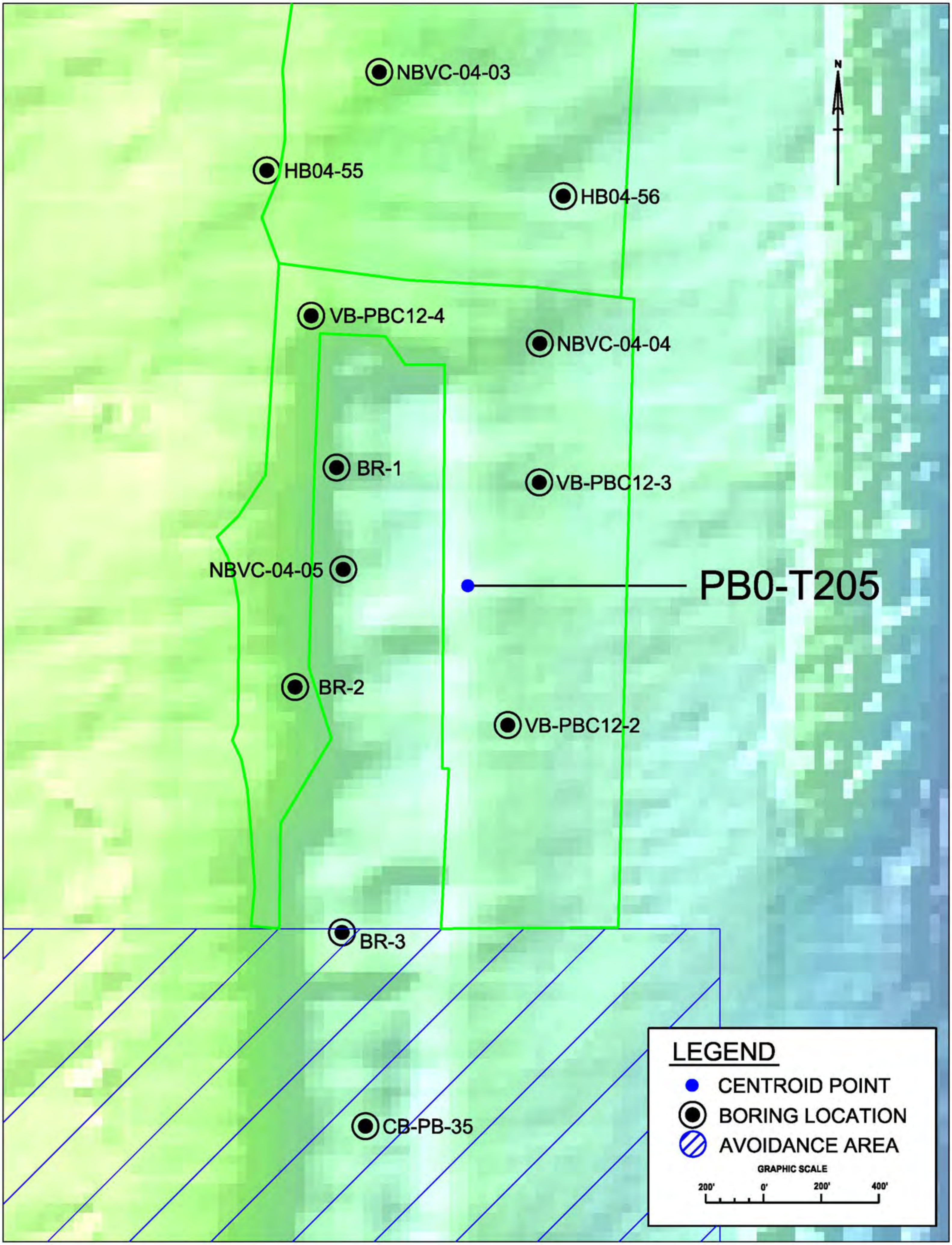
	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	24,456,142	20,543,159
Volume (cy)	905,783	760,858
Area (ft^2)	1,956,491	1,956,491
Average Thickness (ft)	12.5	10.5

Narrative: Originally delineated in ROSS database. Part of the original area has been used as a borrow source. The area has been revised to exclude hardbottom and previously dredged areas for the SAND Study.

Material Description	
Mean mm:	0.21 - 0.27
Munsell value range:	3-4 (wet) 5-6 (dry)
Color:	gray
Physical description:	fine to medium grained quartz sand with some fine to coarse grained carbonate sand and fine to medium grained sand-sized shell

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
BR-1*	964177	743995	-41	8
BR-3*	964169	743996	-41	6
VB-PBC12-2	965004	747401	-53.2	20
VB-PBC12-3	965113	748241	-55.2	18.6
VB-PBC12-4	965115	748722	-55.8	18.4
Sediment Source Edge				4
			Average	12.5

*top of boring dredged in 1988.


NBVC-04-03
HB04-55
HB04-56
VB-PBC12-4
NBVC-04-04
BR-1
VB-PBC12-3
NBVC-04-05
PB0-T205
BR-2
VB-PBC12-2
BR-3
CB-PB-35
LEGEND
CENTROID POINT
BORING LOCATION
AVOIDANCE AREA
GRAPHIC SCALE
200'
0'
200'
400'
N

Sediment Source ID: PB0-R212 Category: Proven

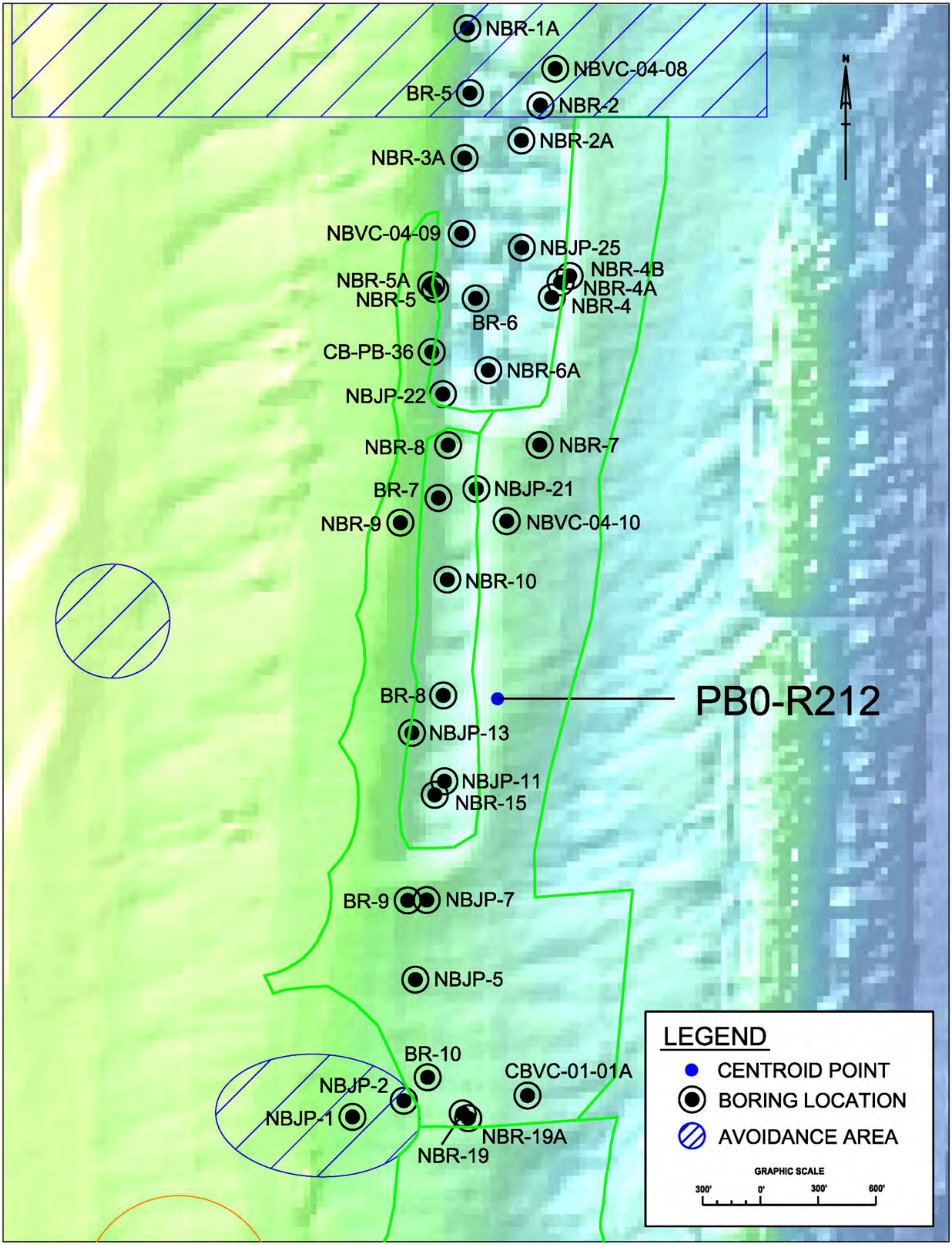
	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	74,813,175	65,686,688
Volume (cy)	2,770,858	2,432,840
Area (ft^2)	4,563,243	4,563,243
Average Thickness (ft)	16.4	14.4

Narrative: Originally delineated in ROSS database. Part of the original area has been used as a borrow source. The area has been revised to exclude hardbottom and previously dredged areas for the SAND Study.

Material Description	
Mean mm:	0.21 - 0.30
Munsell value range:	5 (wet) to 6 (wet)
Color:	gray
Physical description:	medium grained quartz sand with shell

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
NBR-2	964563	744270	-53.7	ref NBR-2A
NBR-2A	964196	744334	-52.8	20
NBJP-25	964715	743384	-50.5	20
CB-PB-36	964559	742506	-33.3	9.5
NBR-6	964566	742515	-48	ref NBR-6A
NBR-6A	964033	742231	-47.2	20
NBJP-22	964388	742111	-44	20
NBJP-21	964079	741807	-51	16
NBR-10	964014	740689	-56.6	19
NBJP-13	963873	740141	-56	15
NBJP-11	963913	739730	-56.5	13
NBR-15	964496	739128	-57	16
NBJP-7	964188	739010	-50	20
BR-9	964159	739035	-47	16
NBJP-5	963853	739101	-50	21
CBVC-01-01A	964430	746683	-57.2	17

NBJP-2	964267	747533	-48	19
NBR-19	964434	747940	-53.3	ref NBJP-19A
NBJP-1	964411	748292	-43	18
NBR-19A	964323	748818	-53.8	20
Sediment Source Edge				4
			Average	16.4


NBR-1A
NBVC-04-08
BR-5
NBR-2
NBR-2A
NBR-3A
NBVC-04-09
NBJP-25
NBR-5A
NBR-5
NBR-4B
NBR-4A
NBR-4
BR-6
CB-PB-36
NBR-6A
NBJP-22
NBR-8
NBR-7
BR-7
NBJP-21
NBR-9
NBVC-04-10
NBR-10
BR-8
PB0-R212
NBJP-13
NBJP-11
NBR-15
BR-9
NBJP-7
NBJP-5
BR-10
CBVC-01-01A
NBJP-2
NBJP-1
NBR-19A
NBR-19
LEGEND
CENTROID POINT
BORING LOCATION
AVOIDANCE AREA
GRAPHIC SCALE
300'
0'
300'
600'
N

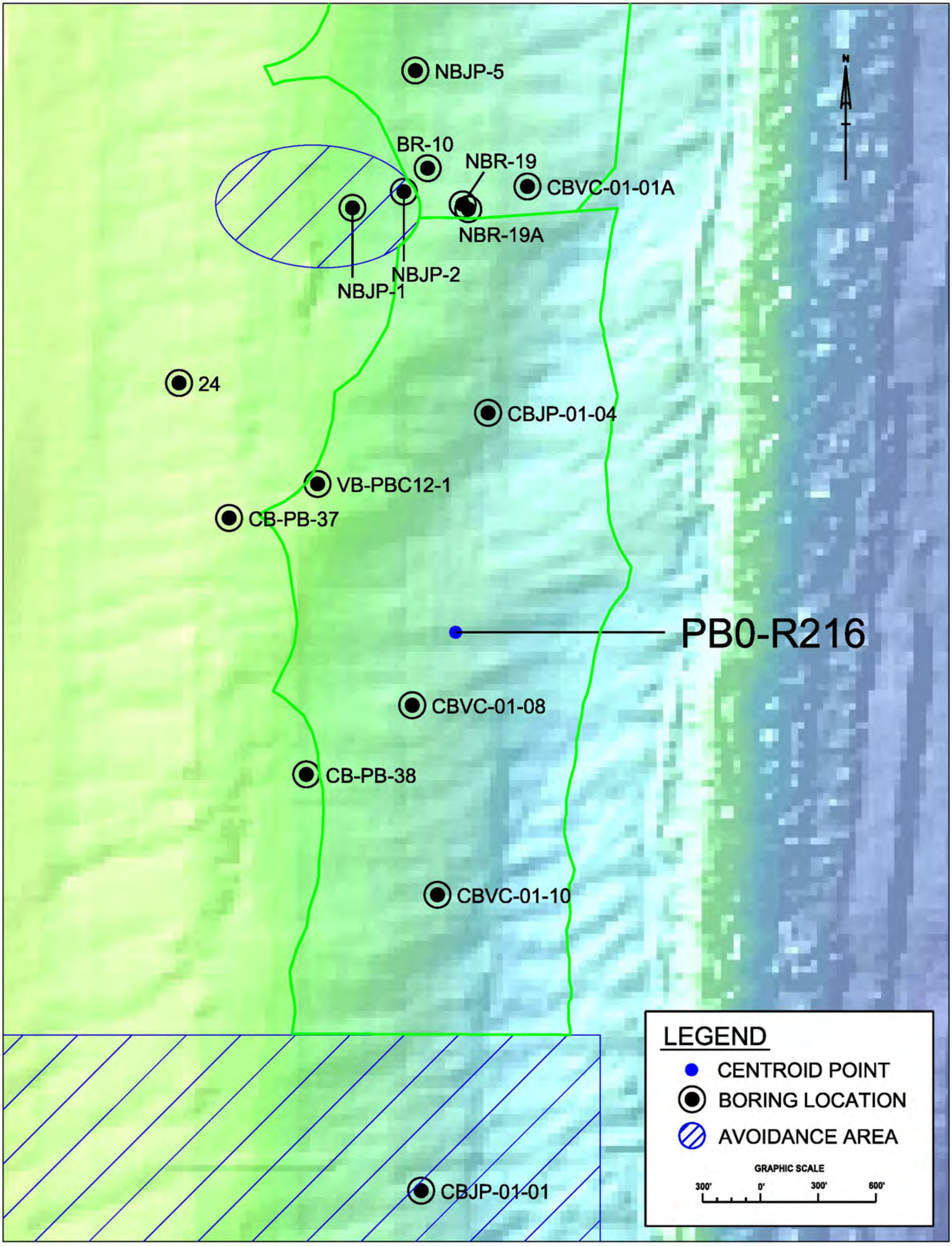
Sediment Source ID: PB0-R216 Category: Proven

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	59,088,737	47,082,318
Volume (cy)	2,188,472	1,743,790
Area (ft^2)	6,003,210	6,003,210
Average Thickness (ft)	9.8	7.8

Narrative: Originally delineated in ROSS database. Area revised to exclude hardbottom areas with buffers for the SAND Study.

Material Description	
Mean mm:	0.20 - 0.48
Munsell value range:	5 (wet) 6 (dry)
Color:	gray
Physical description:	fine-to-medium grained sand with trace shell and shell hash

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
CB-PB-37	962945	737407	-55.1	10
CB-PB-38	963346	736075	-33.8	4.5
CBVC-01-04	964291	737953	-57.6	9.1
CBVC-01-08	963897	736434	-53.8	17.3
CBVC-01-10	964028	735450	-58.8	19
VB-PBC12-1	962685	738108	-29.9	5
Sediment Source Edge				4
			Average	9.8


NBJP-5
BR-10
NBR-19
CBVC-01-01A
NBR-19A
NBJP-2
NBJP-1
24
CBJP-01-04
VB-PBC12-1
CB-PB-37
PB0-R216
CBVC-01-08
CB-PB-38
CBVC-01-10
CBJP-01-01
N
LEGEND
CENTROID POINT
BORING LOCATION
AVOIDANCE AREA
GRAPHIC SCALE
300'
0'
300'
600'

Sediment Source ID: PB0-R221 Category: Proven

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	37,101,508	31,047,648
Volume (cy)	1,374,130	1,149,913
Area (ft^2)	3,026,930	3,026,930
Average Thickness (ft)	12.3	10.3

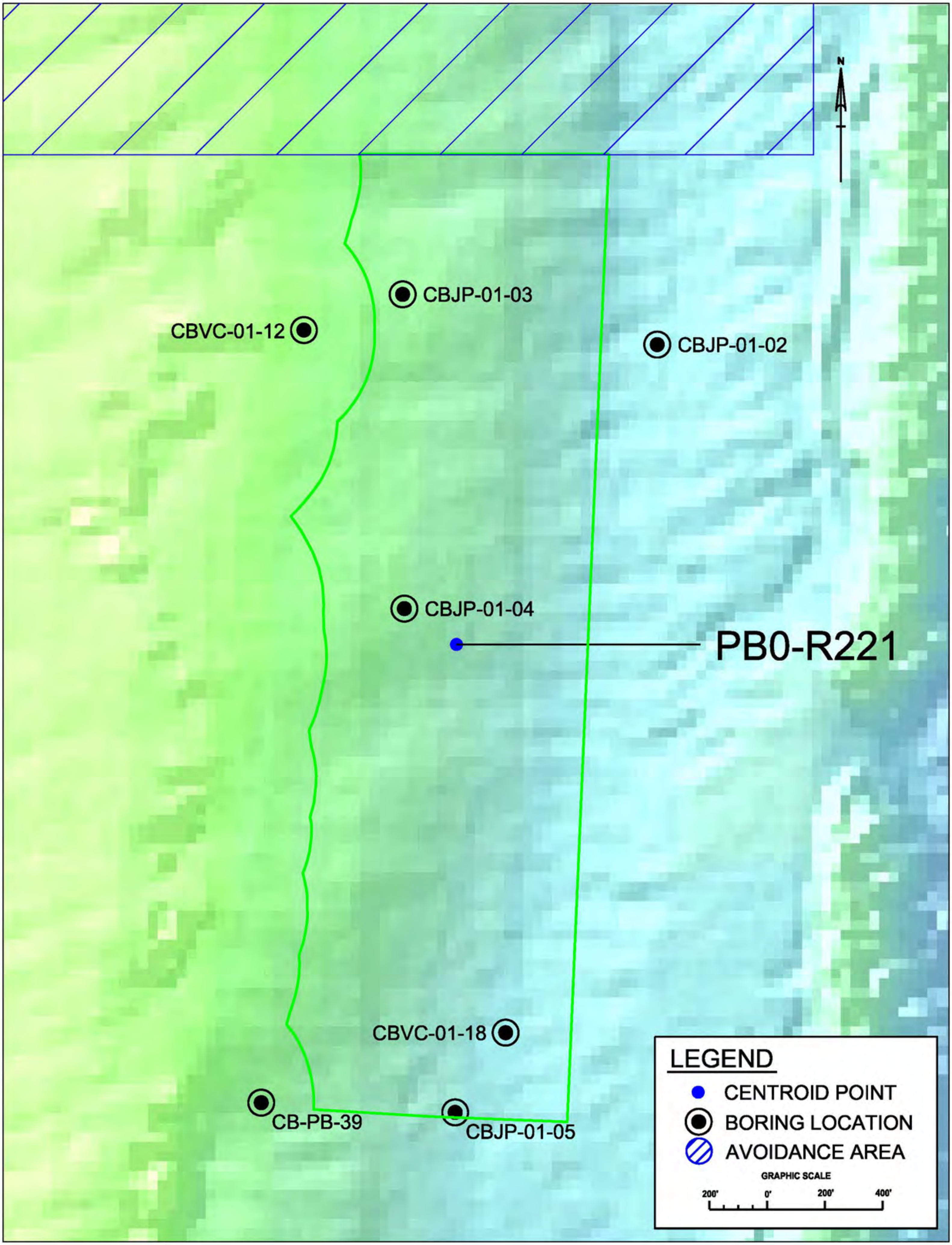
Narrative: Originally delineated in ROSS database. The area has been revised to exclude hardbottom with buffers for the SAND Study.

Material Description	
Mean mm:	0.13 - 0.19
Munsell value range:	4-5 (wet) 7 (dry)
Color:	gray
Physical description:	fine-to-medium quartz sand with some sand sized shell fragments

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
CBJP-01-03	963449	732547	-48	20
CBVC-01-12	963107	732423	-41.5	14.7
CBJP-01-04	963455	731459	-50.9	20
CBJP-01-05*	963631	729715	-62.7	10
CBVC-01-18**	963806	729991	-64.1	5.1
CB-PB-39	962959	729749	-43.2	12
Sediment Source Edge				4
			Average	12.3

*Boring encountered coral fragments below ten (10) ft. Material would likely require screening.

**Boring defines the eastern edge based upon a five (5) ft thickness of acceptable material.



N
CBJP-01-03
CBVC-01-12
CBJP-01-02
CBJP-01-04
PB0-R221
CBVC-01-18
CB-PB-39
CBJP-01-05
LEGEND
CENTROID POINT
BORING LOCATION
AVOIDANCE AREA
GRAPHIC SCALE
200'
0'
200'
400'

10.8 Palm Beach County, FL: POTENTIAL

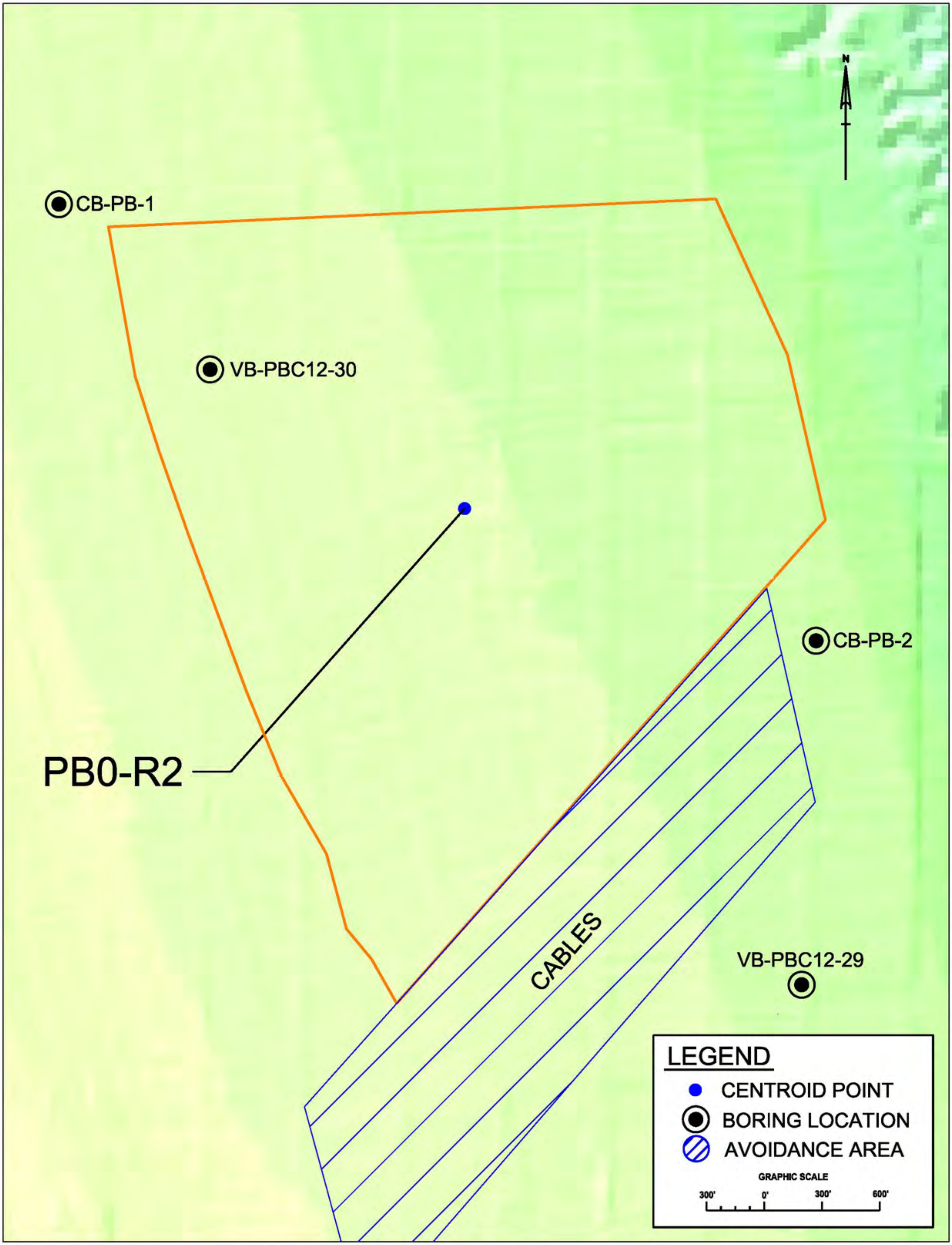
Sediment Source ID: PB0-R2 Category: Potential

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	121,500,809	102,214,966
Volume (cy)	4,500,030	3,785,739
Area (ft^2)	9,642,921	9,642,921
Average Thickness (ft)	12.6	10.6

Narrative: The area was delineated in ROSS database. Cable located along south border. The western edge of the sediment source boundary was set at the depth of closure, -25 ft. The northeastern boundary was adjusted based on seismic and bathymetric evidence.

Material Description	
Mean mm:	0.13 to 0.17
Munsell value range:	4-5 (wet) to 6-7 (dry)
Color:	gray
Physical description:	fine sand-sized quartz, trace med to coarse sand-sized shell

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
CB-PB-1	957913.07	960050.19	-22.8	16
VB-PBC12-30	958699	959192	-29.3	17.8
Sediment Source Edge				4
			Average	12.6


N
CB-PB-1
VB-PBC12-30
CB-PB-2
PB0-R2
CABLES
VB-PBC12-29
LEGEND
CENTROID POINT
BORING LOCATION
AVOIDANCE AREA
GRAPHIC SCALE
300'
0'
300'
600'

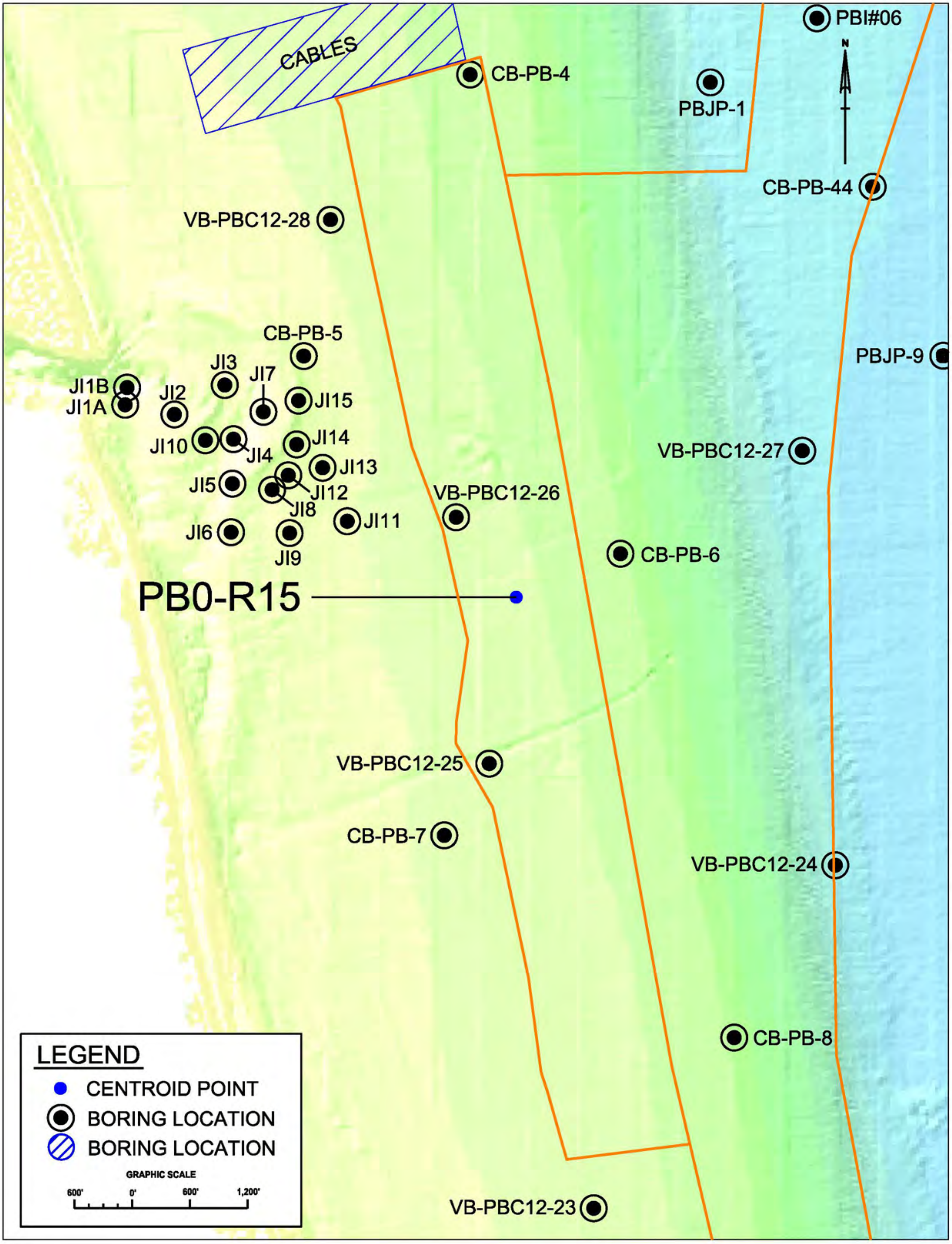
Sediment Source ID: PB0-R15 Category: Potential

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	225,708,030	193,114,812
Volume (cy)	8,359,557	7,152,400
Area (ft^2)	16,296,609	16,296,609
Average Thickness (ft)	13.9	11.9

Narrative: The area was delineated in ROSS database. Cable located along north border. The western edge of the sediment source boundary was set at the depth of closure, -25 ft. The additional area adjustments are based on the SAND Study vibracore.

Material Description	
Mean mm:	0.13 - 0.19
Munsell value range:	4-5 (wet) 7 (dry)
Color:	gray
Physical description:	fine-to-medium quartz sand with some shell

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
CB-PB-4	962734	953072	-33.6	17
VB-PBC12-25	962932	945903	-26	16.9
VB-PBC12-26	962588	948466	-30.8	17.5
Sediment Source Edge				4
			Average	13.9


CABLES
CB-PB-4
PBI#06
PBJP-1
N
CB-PB-44
VB-PBC12-28
CB-PB-5
PBJP-9
JI3
JI7
JI1B
JI1A
JI2
JI15
JI10
JI4
JI14
JI13
JI5
JI12
JI8
JI11
JI6
JI9
VB-PBC12-26
VB-PBC12-27
CB-PB-6
PB0-R15
VB-PBC12-25
CB-PB-7
VB-PBC12-24
CB-PB-8
VB-PBC12-23
LEGEND
CENTROID POINT
BORING LOCATION
BORING LOCATION
GRAPHIC SCALE
600'
0'
600'
1,200'

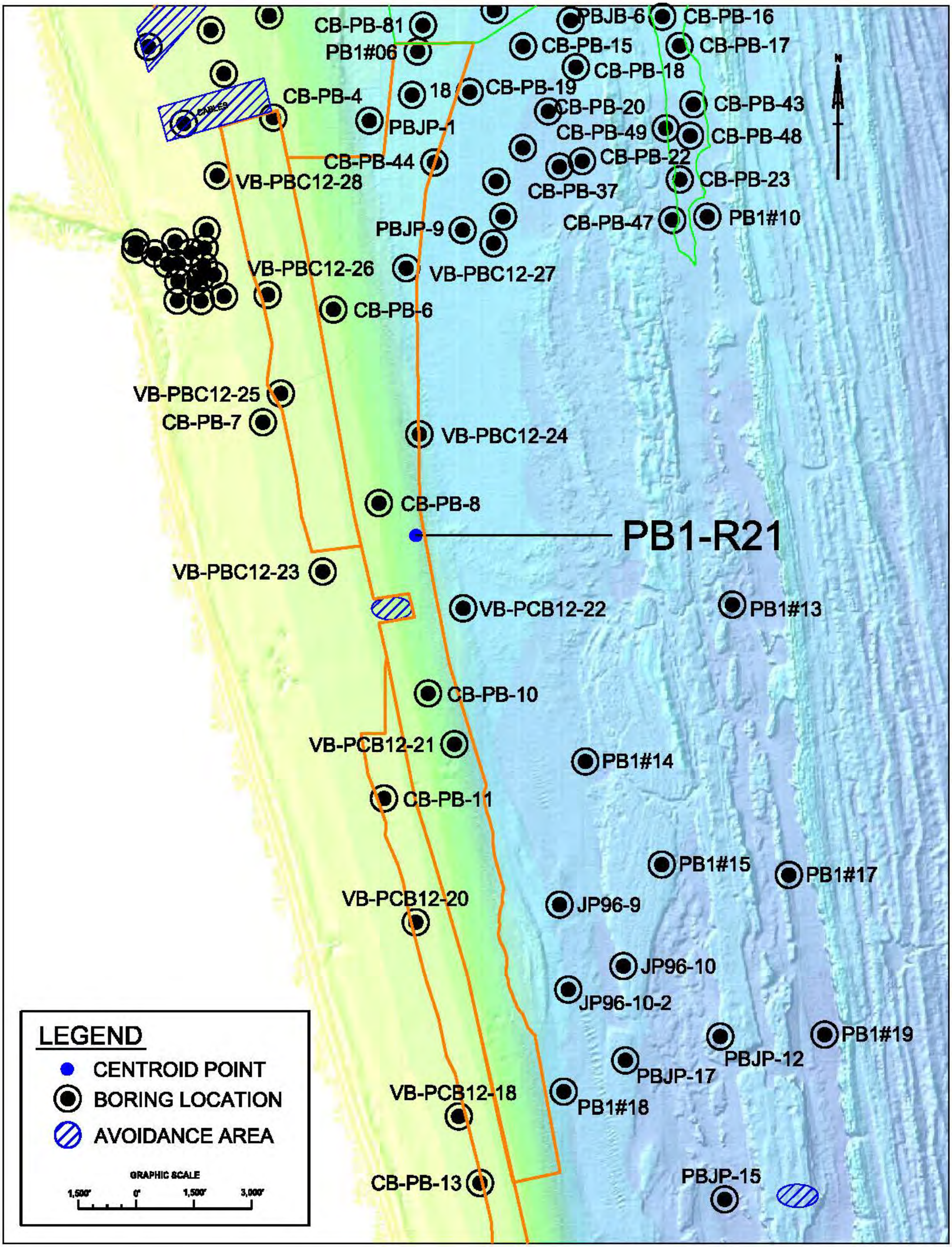
Sediment Source ID: PB1-R21 Category: Potential

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	608,799,885	500,085,620
Volume (cy)	22,548,144	18,521,690
Area (ft^2)	54,357,133	54,357,133
Average Thickness (ft)	11.2	9.2

Narrative: The area was delineated in the ROSS database. The area was expanded in the SAND study using seismic evidence and new vibracore. Hardbottom areas with buffers have been excluded.

Material Description	
Mean mm:	0.14 - 0.24
Munsell value range:	4 (wet) 5 - 6 (dry)
Color:	gray
Physical description:	fine to medium grained quartz sand with shell

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
CB-PB-4	962734	953072	-33.6	17
CB-PB-6	964297	948087	-37.6	14
CB-PB-8	965480	943052	-32.6	17
CB-PB-10	966757	938111	-27	17
CB-PB-12	967994	930155	-31.7	17
PB1#06	966340	953658	unknown	7.3
PB1#18	970281	927767	unknown	4.5
VB-PBC12-21	967441	936793	-53.1	12
VB-PBC12-24	966531	944846	-61.8	7.9
VB-PBC12-27	966188	949158	-68	5.5
source area edge				4
			Average	11.2


CB-PB-81
PB1#06
PBJB-6
CB-PB-16
CB-PB-15
CB-PB-17
CB-PB-18
CB-PB-4
18
CB-PB-19
CB-PB-20
CB-PB-43
PBJP-1
CB-PB-49
CB-PB-48
CB-PB-44
CB-PB-22
VB-PBC12-28
CB-PB-37
CB-PB-23
PBJP-9
CB-PB-47
PB1#10
VB-PBC12-26
VB-PBC12-27
CB-PB-6
VB-PBC12-25
CB-PB-7
VB-PBC12-24
CB-PB-8
PB1-R21
VB-PBC12-23
VB-PCB12-22
PB1#13
CB-PB-10
VB-PCB12-21
PB1#14
CB-PB-11
PB1#15
PB1#17
VB-PCB12-20
JP96-9
JP96-10
JP96-10-2
PB1#19
PBJP-12
PBJP-17
VB-PCB12-18
PB1#18
CB-PB-13
PBJP-15
LEGEND
CENTROID POINT
BORING LOCATION
AVOIDANCE AREA
GRAPHIC SCALE
1,500'
0'
1,500'
3,000'
N

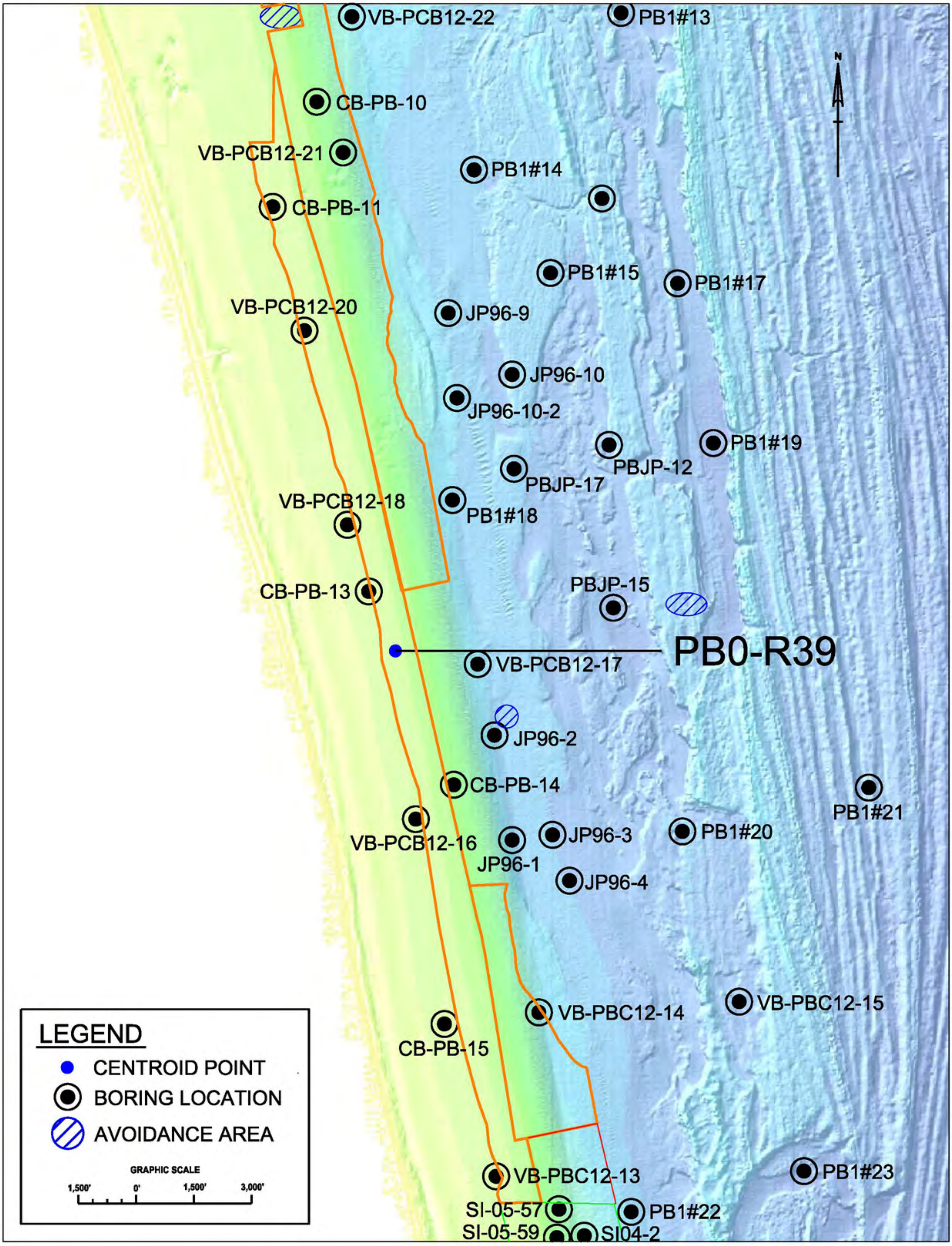
Sediment Source ID: PB0-R39 Category: Potential

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	410,510,064	357,541,023
Volume (cy)	15,204,076	13,242,260
Area (ft^2)	26,484,520	26,484,520
Average Thickness (ft)	15.5	13.5

Narrative: The area was delineated in the ROSS database. The western edge of the sediment source boundary was set at the depth of closur of -25 ft.

Material Description	
Mean mm:	0.13 - 0.19
Munsell value range:	4-5 (wet) 7 (dry)
Color:	gray
Physical description:	fine-to-medium quartz sand with some sand sized shell fragments

Boring Designations	Easting	Northing	Elevation (ft)	Thickness (ft)
CB-PB-11	965612	935383	-20.2	17
CB-PB-12	967994	930155	-31.7	17
CB-PB-13	968107	925393	20.9	17
CB-PB-14	970318	920372	-37.1	18
CB-PB-15	970074	914157	-25.9	12.4
VB-PBC12-13	971417	910201	-32.2	13.7
VB-PBC12-16	969332	919478	-28.5	18.9
VB-PBC12-18	967554	927123	-29.3	20
VB-PBC12-20	966436	932167	-31.3	17
Sediment Source Edge				4
			Average	15.5



VB-PCB12-22
PB1#13
CB-PB-10
VB-PCB12-21
PB1#14
CB-PB-11
PB1#15
PB1#17
VB-PCB12-20
JP96-9
JP96-10
JP96-10-2
PB1#19
PBJP-12
PBJP-17
VB-PCB12-18
PB1#18
CB-PB-13
PBJP-15
PB0-R39
VB-PCB12-17
JP96-2
CB-PB-14
PB1#21
VB-PCB12-16
JP96-3
PB1#20
JP96-1
JP96-4
VB-PBC12-14
VB-PBC12-15
CB-PB-15
LEGEND
CENTROID POINT
BORING LOCATION
AVOIDANCE AREA
GRAPHIC SCALE
1,500'
0'
1,500'
3,000'
VB-PBC12-13
PB1#23
SI-05-57
PB1#22
SI-05-59
SI04-2
N

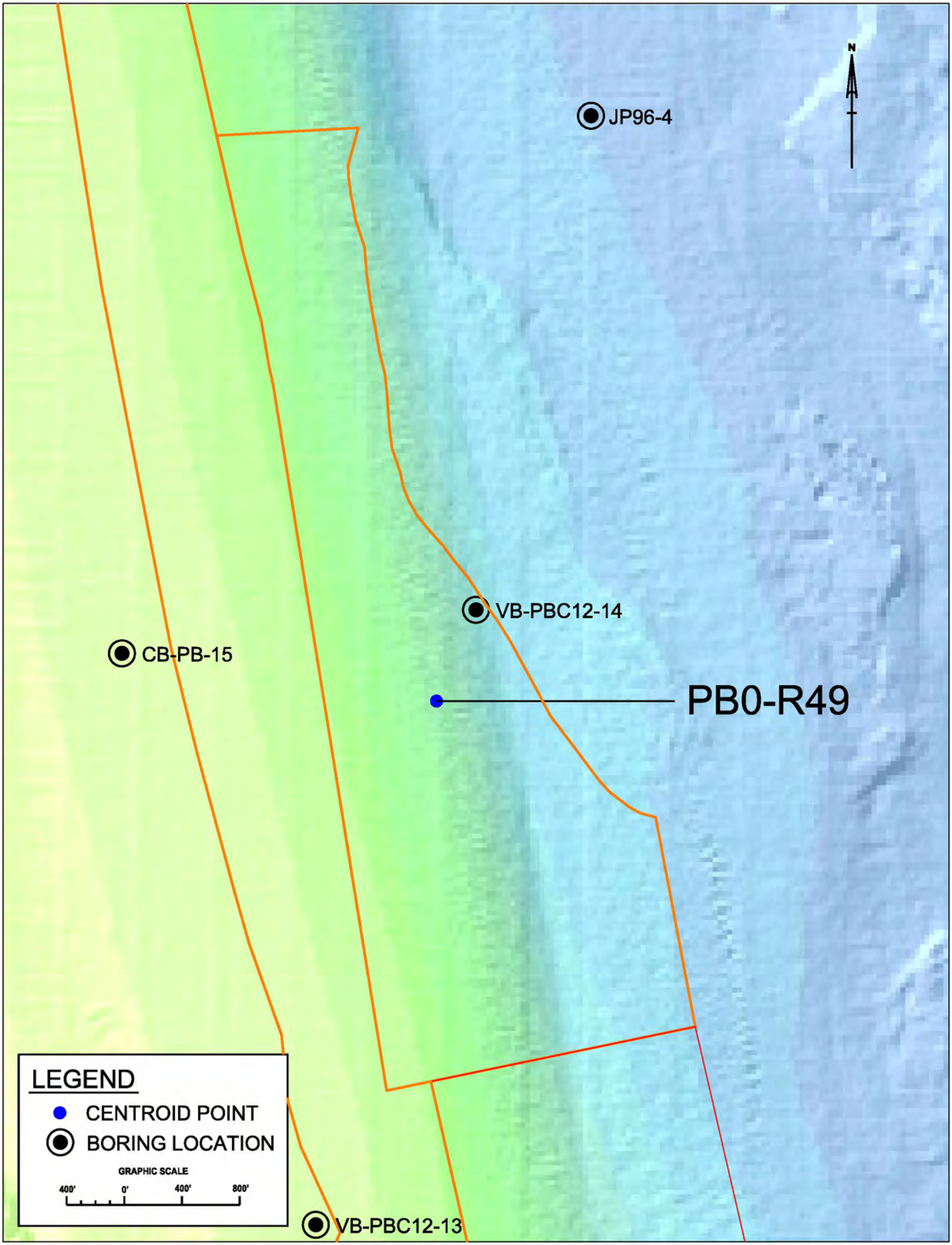
Sediment Source ID: PB0-R49 Category: Potential

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	84,489,165	66,887,255
Volume (cy)	3,129,228	2,477,306
Area (ft^2)	8,800,955	8,800,955
Average Thickness (ft)	9.6	7.6

Narrative: This area was delineated in the ROSS database. Sand study boring data and seismic evidence were used to refine the sediment source boundaries.

Material Description	
Mean mm:	0.13 - 0.47
Munsell value range:	4-5 (wet) to 5-6 (dry)
Color:	gray
Physical description:	fine grained sand-sized quartz

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
VB-PBC12-24	972527	914459	-63.2	15.2
Sediment Source Edge				4
			Average	9.6


N
JP96-4
VB-PBC12-14
CB-PB-15
PB0-R49
LEGEND
CENTROID POINT
BORING LOCATION
GRAPHIC SCALE
400'
0'
400'
800'
VB-PBC12-13

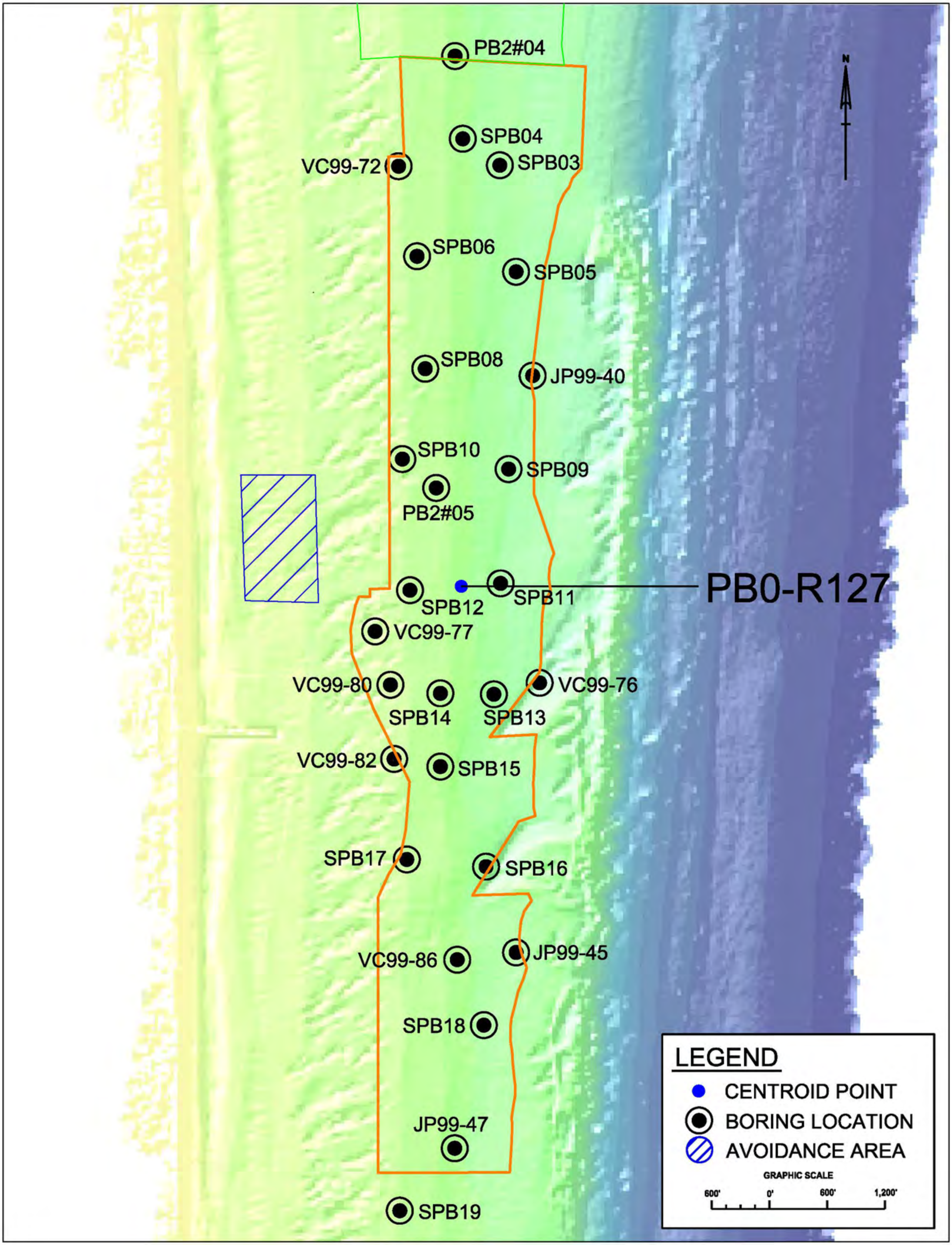
Sediment Source ID: PB0-R127 Category: Potential

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	298,296,102	262,421,646
Volume (cy)	11,048,004	9,719,320
Area (ft^2)	17,937,228	17,937,228
Average Thickness (ft)	16.6	14.6

Narrative: The area was delineated in ROSS database. The area was revised taking in to account hardbottom, depth of closure and cores with respect to the SAND Study criteria.

Material Description	
Mean mm:	0.14 - 0.26 0.46mm in single layer of VC99-72
Munsell value range:	6 - 7 (wet)
Color:	tan and gray
Physical description:	fine to medium grained quartz sand and coarse grained sand-sized shell

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
PB2#05	973560	832110	unknown	18.5
JP99-45	974390	827286	-45.9	11
JP99-47	973752	825252	-43.2	20
VC99-72	973169	835451	-34.3	20.1
VC99-77	972925	830620	-31.3	19.5
VC99-76	974634	830086	-30.3	16.8
VC99-80	973084	830065	-32.1	19.8
VC99-82	973122	829295	-33	18.7
VC99-86	973778	827210	-42.7	17.9
source area edge				4
			Average	16.6



PB2#04
SPB04
VC99-72
SPB03
SPB06
SPB05
SPB08
JP99-40
SPB10
SPB09
PB2#05
SPB12
SPB11
PB0-R127
VC99-77
VC99-80
VC99-76
SPB14
SPB13
VC99-82
SPB15
SPB17
SPB16
VC99-86
JP99-45
SPB18
JP99-47
SPB19
N
LEGEND
CENTROID POINT
BORING LOCATION
AVOIDANCE AREA
GRAPHIC SCALE
600'
0'
600'
1,200'

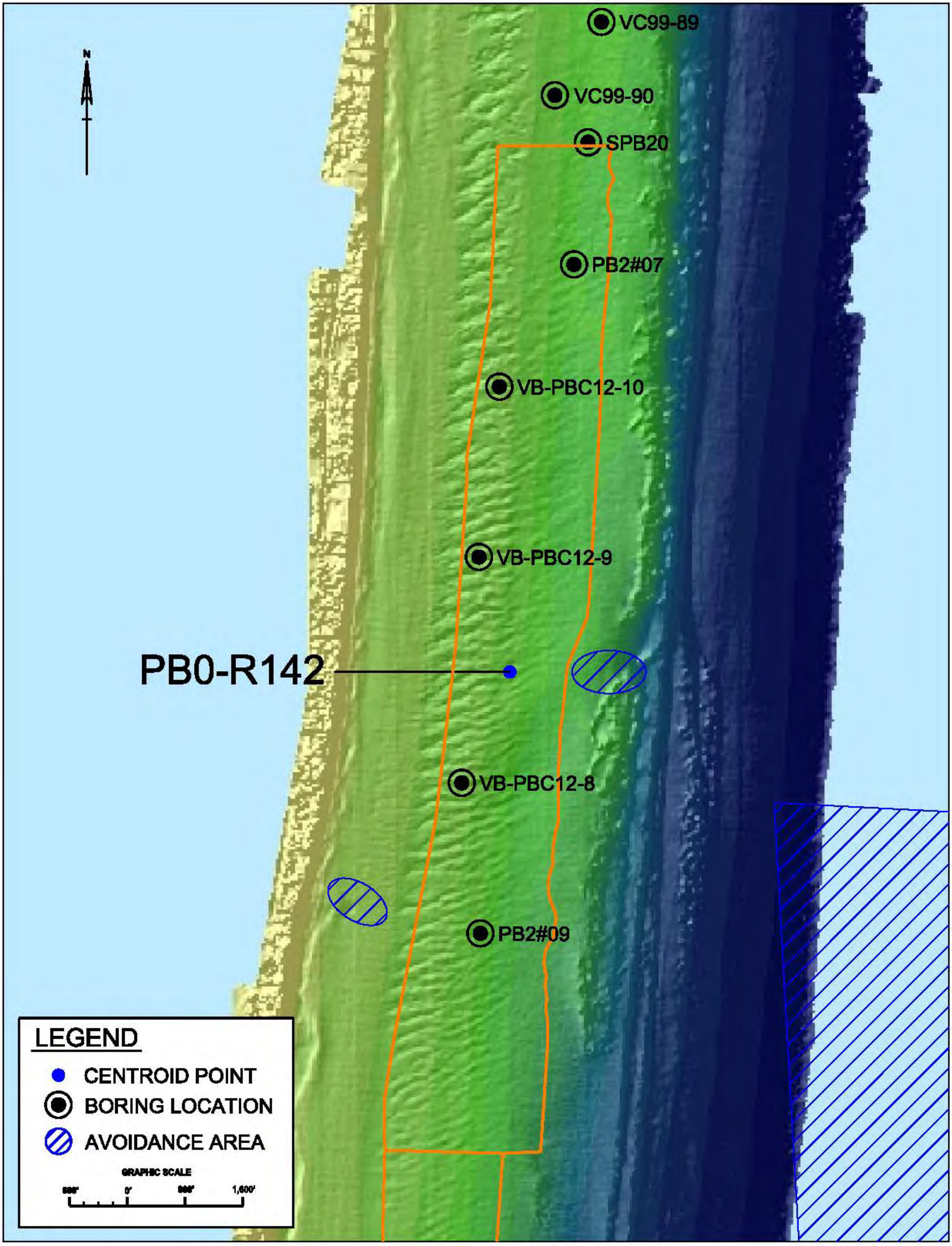
Sediment Source ID: PB0-R142 Category: Potential

	No Vertical Buffer	2ftVertical Buffer
Volume (cf)	366,417,288	316,901,439
Volume (cy)	13,571,011	11,737,090
Area (ft^2)	24,757,925	24,757,925
Average Thickness (ft)	14.8	12.8

Narrative: The area was delineated by ROSS database. 2012 SAND Study added borings and expanded the area with consideration for hardbottom and depth of closure.

Material Description	
Mean mm:	0.18 - 0.45
Munsell value range:	4 - 5 (wet) 5 - 6 (dry)
Color:	gray
Physical description:	fine to medium grained quartz sand with trace to little shell

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
PB2 #7	973630	820443	unknown	15.3
PB2 #9	972333	811181	unknown	17.5
VB-PBC12-8	972075	813265	-33	18.6
VB-PBC12-9	972313	816392	-29.9	16.3
VB-PBC12-10	972596	818750	-31.8	17.1
source area edge				4
			Average	14.8


N
VC99-89
VC99-90
SPB20
PB2#07
VB-PBC12-10
VB-PBC12-9
PB0-R142
VB-PBC12-8
PB2#09
LEGEND
CENTROID POINT
BORING LOCATION
AVOIDANCE AREA
GRAPHIC SCALE
0'
1,600'

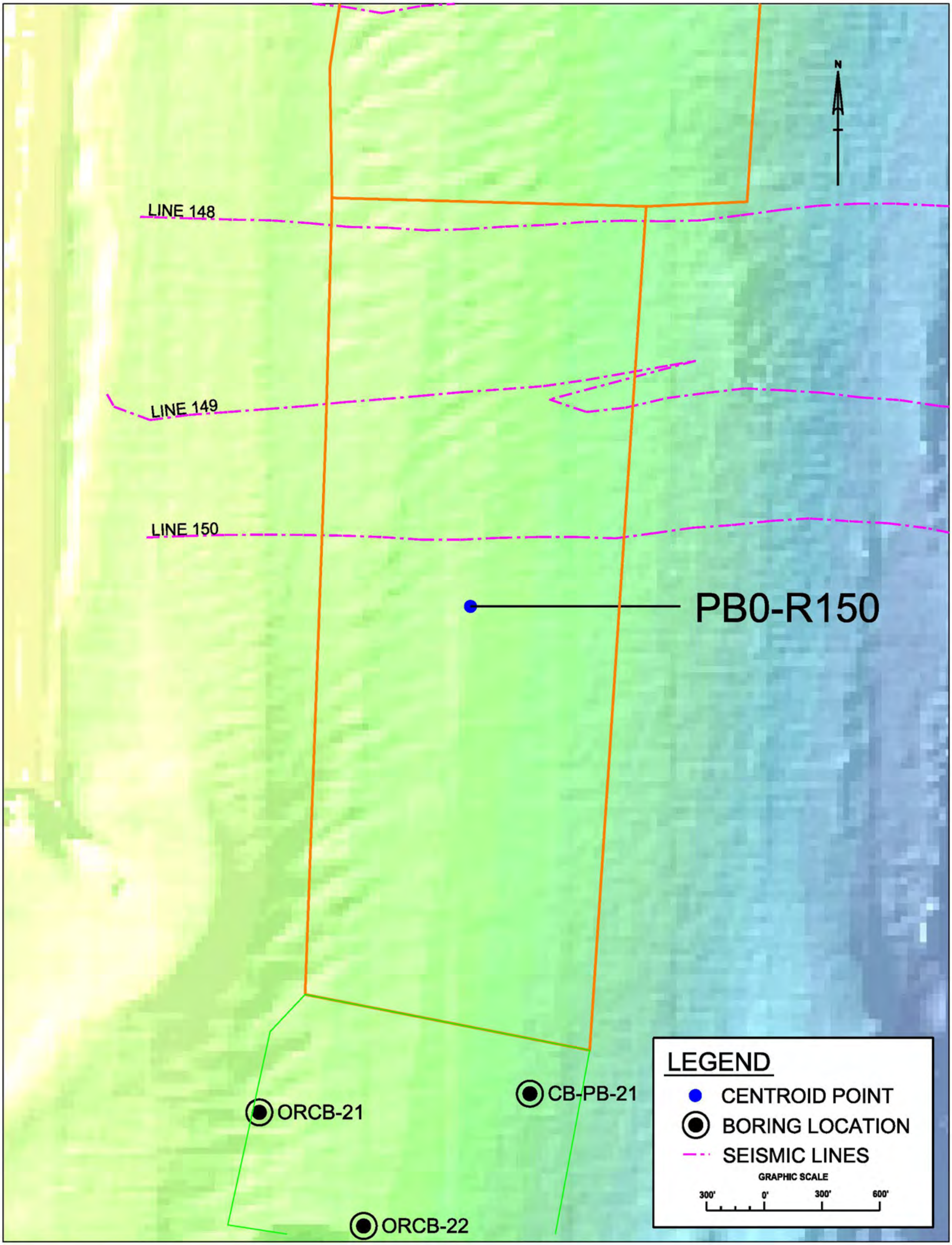
Sediment Source ID: PB0-R150 Category: Potential

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	87,395,264	74,103,208
Volume (cy)	3,236,862	2,744,563
Area (ft^2)	6,646,028	6,646,028
Average Thickness (ft)	13.2	11.2

Narrative: This area was delineated using historical borings in the southern portion of the deposit and seismic evidence in the northern portion of the deposit.

Material Description	
Mean mm:	not available
Munsell value range:	6 (wet)
Color:	gray to brownish gray
Physical description:	fine to medium sand-sized quartz, medium sand-sized to fine gravel sized shell fragments.

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
OR11-1A	971650	804708	-39.3	14.1
OR11-2	971178	804468	-35.4	20
OR11-3	971492	804022	-38.4	14.5
source area edge				4
			Average	13.2


N
LINE 148
LINE 149
LINE 150
PB0-R150
CB-PB-21
ORCB-21
ORCB-22
LEGEND
CENTROID POINT
BORING LOCATION
SEISMIC LINES
GRAPHIC SCALE
300'
0'
300'
600'

10.9 Palm Beach County, FL: UNVERIFIED

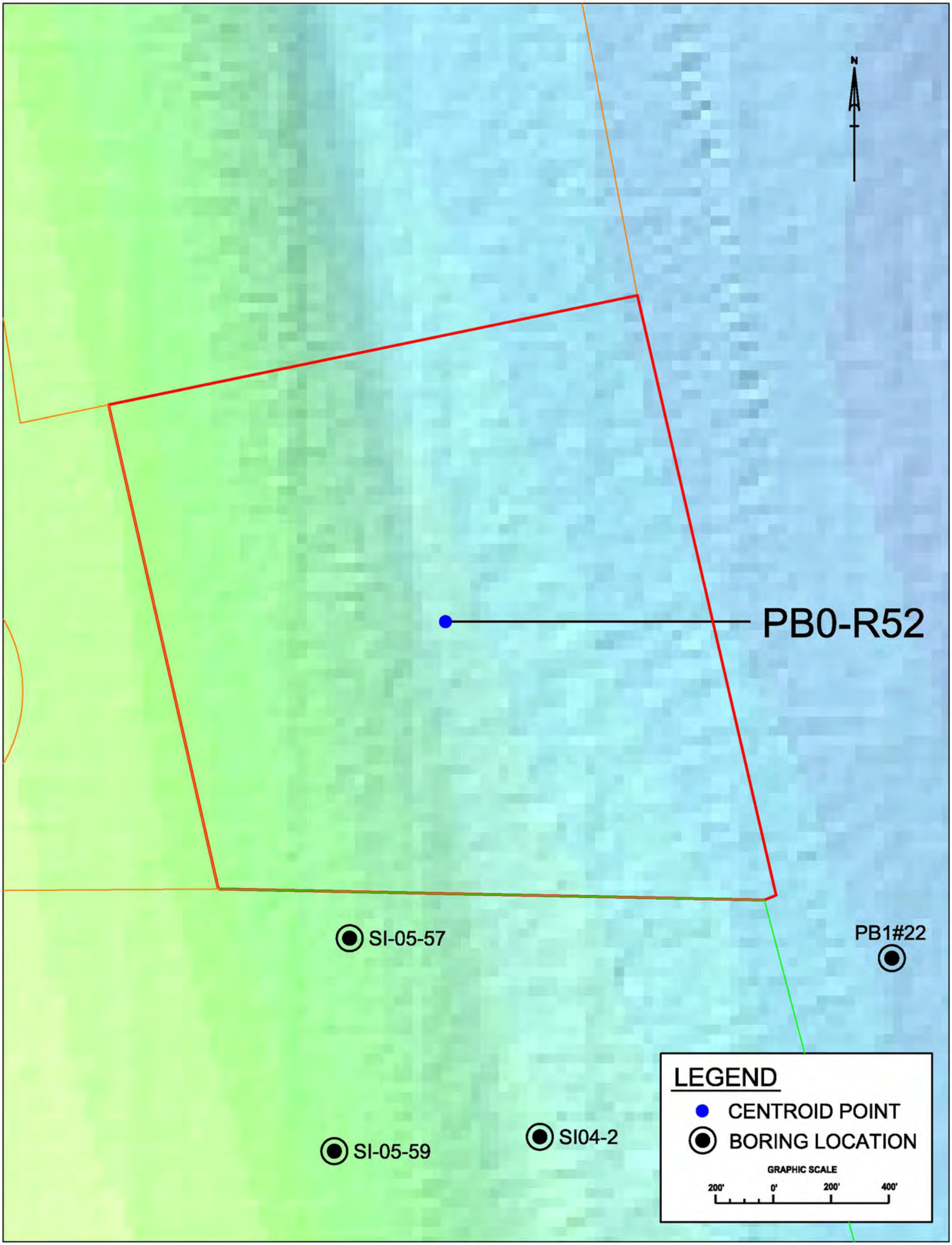
Sediment Source ID: PB0-R52 Category: Unverified

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)		
Volume (cy)		
Area (ft^2)	3,624,771	3,624,771
Average Thickness (ft)	0.0	-2.0

Narrative: This area has no vibracores within the boundaries. It was delineated in the SAND study based on geomorphic evidence and alignment with other sediment source delineations. This area does not contribute volume to the SAND Study.

Material Description	
Mean mm:	
Munsell value range:	
Color:	
Physical description:	

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
			Average	



N
PB0-R52
SI-05-57
PB1#22
SI-05-59
SI04-2
LEGEND
CENTROID POINT
BORING LOCATION
GRAPHIC SCALE
200'
0'
200'
400'

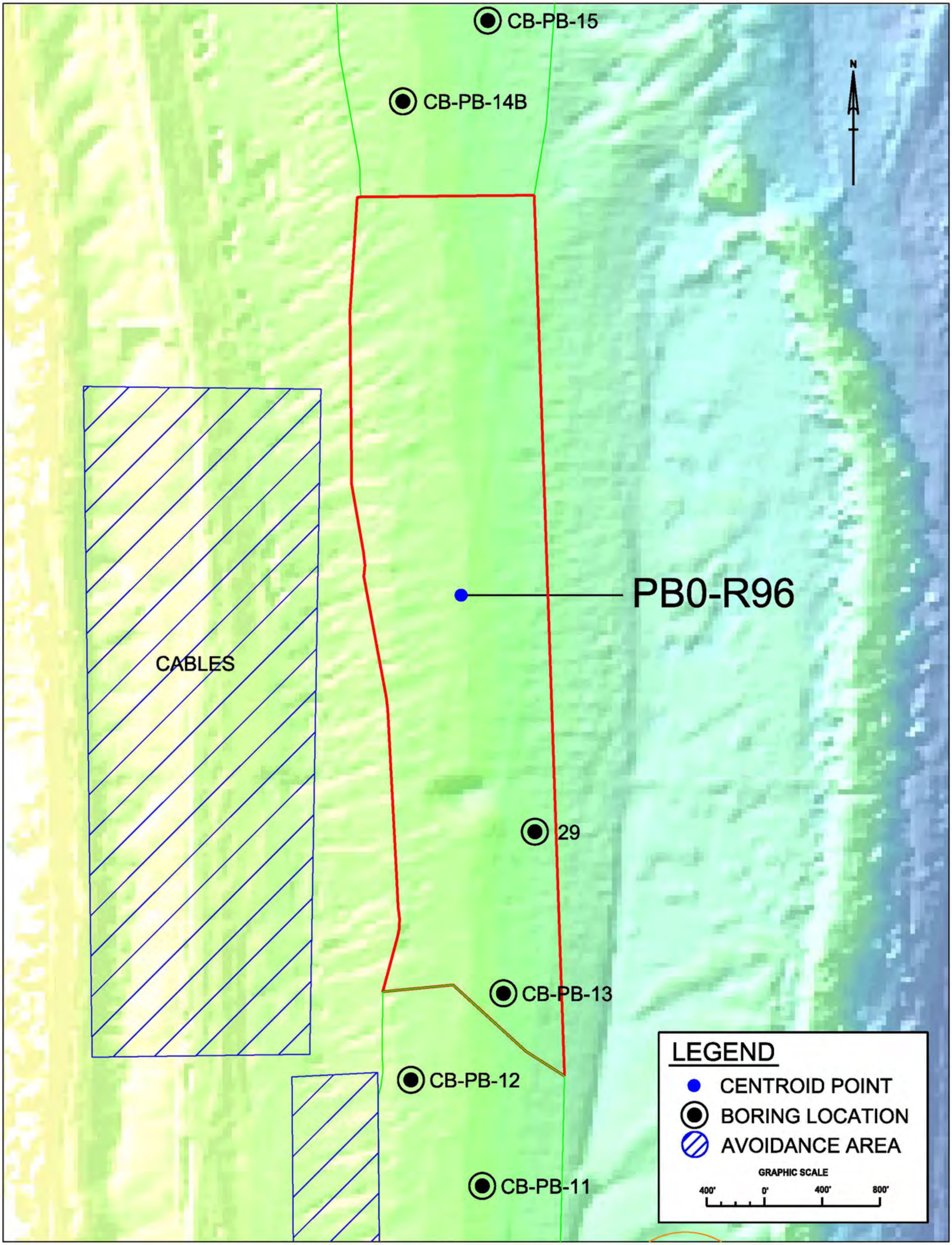
Sediment Source ID: PB0-R96 Category: Unverified

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	90,243,228	76,359,654
Volume (cy)	3,342,342	2,828,135
Area (ft^2)	6,941,787	6,941,787
Average Thickness (ft)	13.0	11.0

Narrative: This area is the combination of several smaller unverified areas that were delineated in the ROSS database. The western edge of the sediment source boundary was set at the depth of closure of -25 ft.

Material Description	
Mean mm:	0.19 to 0.23
Munsell value range:	7 (wet)
Color:	light gray
Physical description:	fine to medium grained sand-sized quartz, brown calcareous fragments

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
29	975166	862951	unknown	9
CB-PB-13	974948	861832	-20.9	17
Sediment Source Edge				4
			Average	13.0


CB-PB-15
CB-PB-14B
N
PB0-R96
CABLES
29
CB-PB-13
CB-PB-12
CB-PB-11
LEGEND
CENTROID POINT
BORING LOCATION
AVOIDANCE AREA
GRAPHIC SCALE
400'
0'
400'
800'

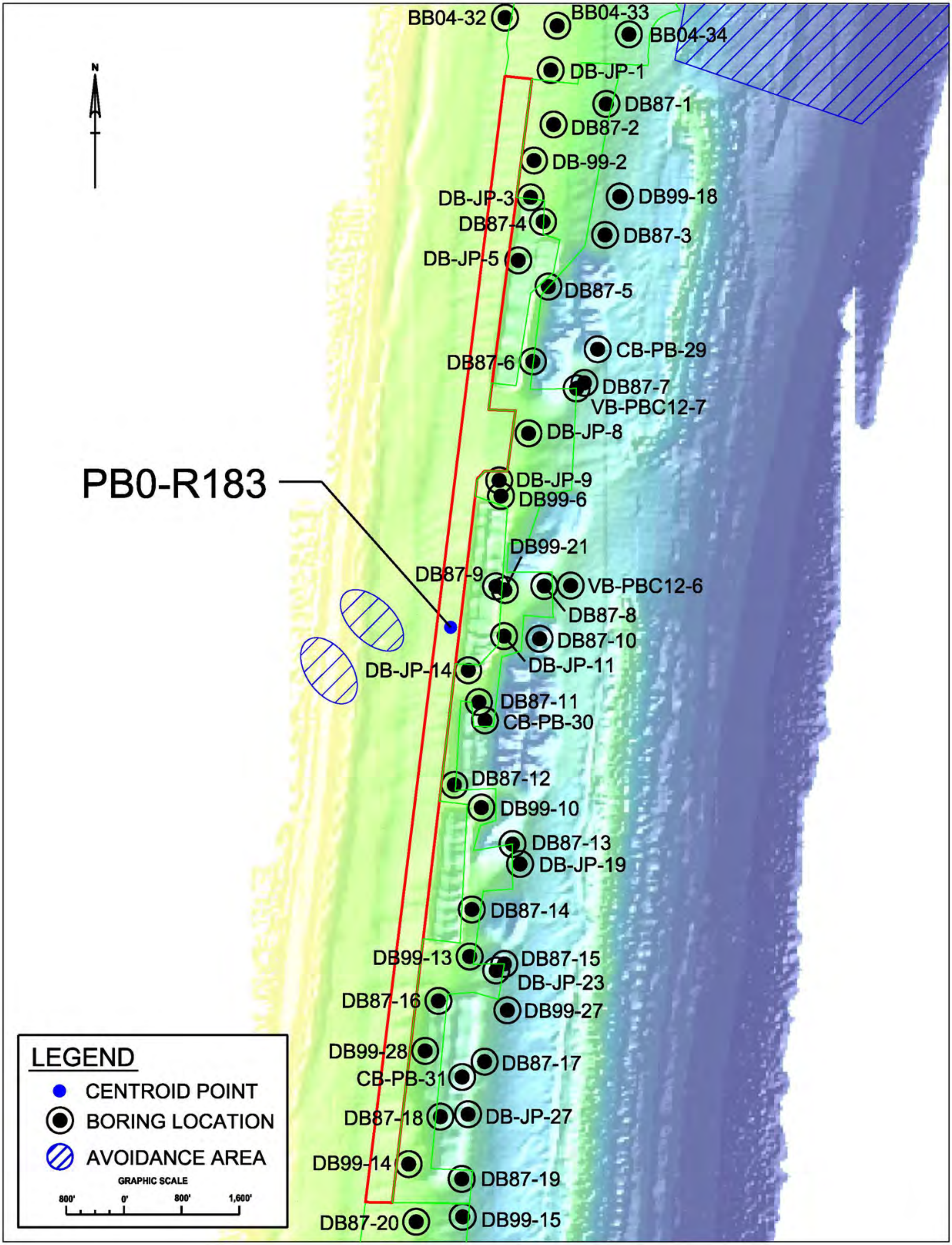
Sediment Source ID: PB0-R183 Category: Unverified

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)		
Volume (cy)		
Area (ft^2)	5,720,284	5,720,284
Average Thickness (ft)	0.0	-2.0

Narrative: This area was previously un-delineated. There are borings that influence the area from Proven area PB0-182, but there are no borings in this sediment source. This area contributes no volume to the SAND Study.

Material Description	
Mean mm:	
Munsell value range:	
Color:	
Physical description:	

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
			Average	


N
BB04-32
BB04-33
BB04-34
DB-JP-1
DB87-1
DB87-2
DB-99-2
DB-JP-3
DB99-18
DB87-4
DB87-3
DB-JP-5
DB87-5
CB-PB-29
DB87-6
DB87-7
VB-PBC12-7
DB-JP-8
PB0-R183
DB-JP-9
DB99-6
DB99-21
DB87-9
VB-PBC12-6
DB87-8
DB87-10
DB-JP-11
DB-JP-14
DB87-11
CB-PB-30
DB87-12
DB99-10
DB87-13
DB-JP-19
DB87-14
DB99-13
DB87-15
DB-JP-23
DB87-16
DB99-27
DB99-28
DB87-17
CB-PB-31
DB87-18
DB-JP-27
DB99-14
DB87-19
DB87-20
DB99-15
LEGEND
CENTROID POINT
BORING LOCATION
AVOIDANCE AREA
GRAPHIC SCALE
800'
0'
800'
1,600'

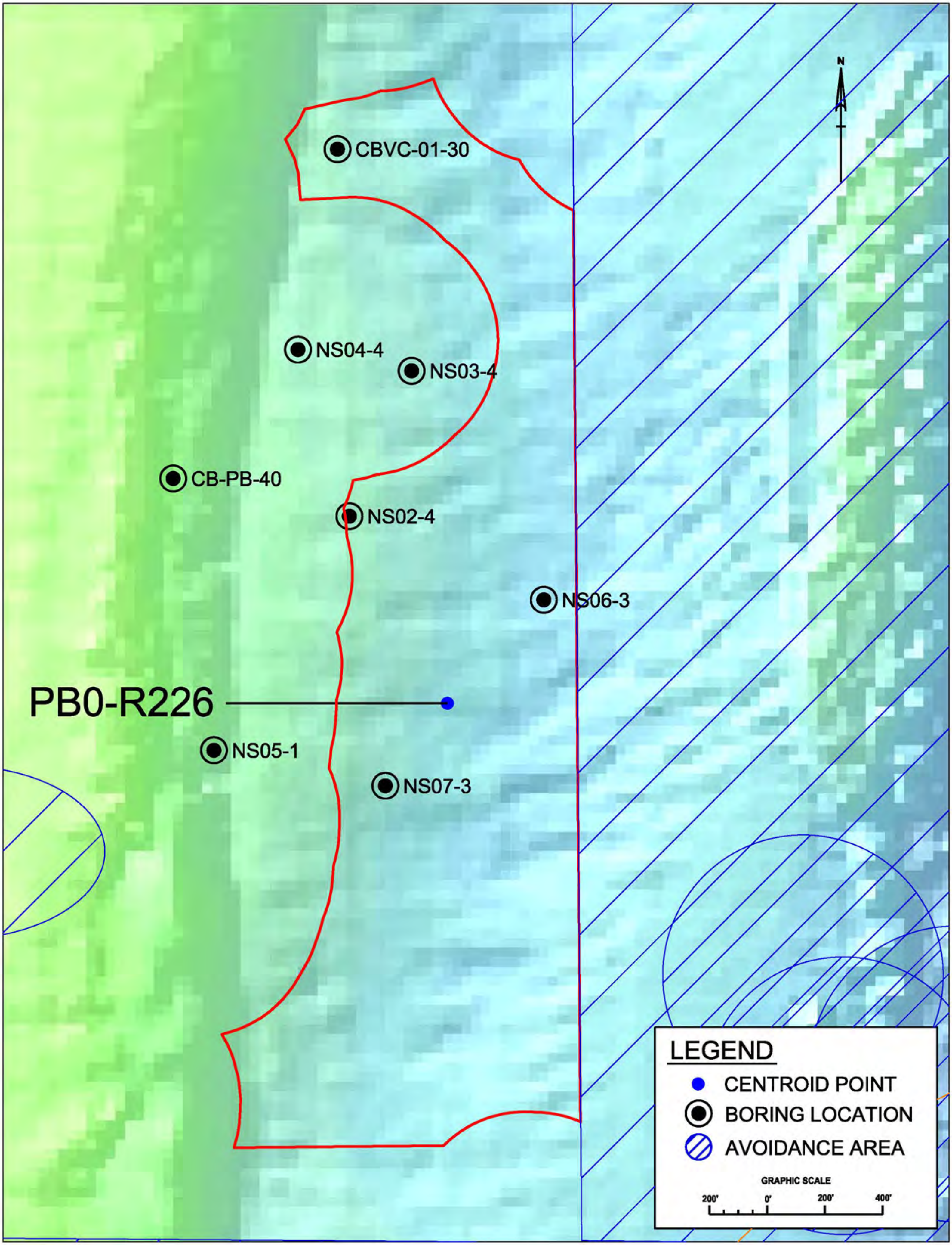
Sediment Source ID: PB0-R226 Category: Unverified

	No Vertical Buffer	2ft Vertical Buffer
Volume (cf)	14,609,221	9,248,039
Volume (cy)	541,082	342,520
Area (ft^2)	2,680,591	2,680,591
Average Thickness (ft)	5.5	3.5

Narrative: This area was delineated in the ROSS database. The area was revised to remove hardbottom with buffers for the SAND Study. Several borings are located in the deposit; but the boring logs were unable to be located. If these borings are located and the material is suitable, the area will meet the criteria for a Proven sediment source.

Material Description	
Mean mm:	0.28 to 0.32
Munsell value range:	5 (wet) to 5 (dry)
Color:	gray
Physical description:	fine to medium sand-sized quartz, trace shell hash

Boring Designation	Easting	Northing	Elevation (ft)	Thickness (ft)
CBVC-01-30	962736	726975	-59.5	6.9
Sediment Source Edge				4
			Average	5.5


N
CBVC-01-30
NS04-4
NS03-4
CB-PB-40
NS02-4
NS06-3
PB0-R226
NS05-1
NS07-3
LEGEND
CENTROID POINT
BORING LOCATION
AVOIDANCE AREA
GRAPHIC SCALE
200'
0'
200'
400'