APPENDIX B SEDIMENT ANALYSIS

APPENDIX B

SEDIMENT ANALYSIS REPORT

Carteret County, North Carolina Sand Search Investigation

DRAFT Final Geotechnical Report

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Moffatt & Nichol, Inc.

Submitted by:

Coastal Tech
Melbourne, FL

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COASTAL TECH
COASTAL TECHNOLOGY CORPORATION

Executive Summary

This document presents the results of an advanced "*Plans & Specs*" level geotechnical investigation to identify the stratigraphy of potential borrow areas with beach-compatible sand to provide for future nourishment of Atlantic Ocean beaches in Carteret County, North Carolina. As part of the Moffatt & Nichol, Inc. (M&N) team, Coastal Tech herein presents the results of these investigations based upon offshore vibracores to delineate potential borrow areas with enough beach compatible sand to fulfill the long-term (up to 50 years) needs of Carteret County. M&N estimates this need at 15.7 to 26.9 million cubic yards (Mcy) over 30 years or 26 to 44.8 Mcy over 50 years.

Five main potential borrow areas were investigated – including (1) the main ebb channel of Bogue Inlet – a renewable source associated with maintenance of the inlet channel, (2) the Morehead City Outer Harbor – a renewable source associated with maintenance of the inlet channel, (3) the Current Ocean Dredge Material Disposal Site (ODMDS) in Federal waters offshore of Beaufort Inlet, (4) the Old ODMDS located directly north of the Current ODMDS across the Federal jurisdictional border in State waters, (5) Area Y, and (6) Area Z directly offshore of Emerald Isle in State waters. This investigation included the extraction of 164 twenty-foot vibracores in the Current and Old ODMDS, Areas Y and Z, and 5 ten-foot vibracores in Bogue Inlet by Alpine Ocean Seismic Survey, as well as bathymetric, seismic and backscatter surveys performed by Geodynamics offshore of Bogue Banks. Data from the Morehead City Outer Harbor were referenced from prior studies and reports by the USACE.

Based on analyses of these potential borrow areas, a total of approximately ~ 20 Mcy of sand from non-renewable offshore borrow areas is recommended for use as a sand source for nourishment of Carteret County beaches. These potential borrow areas are ranked "A", where sufficient data is available to define the stratigraphy, and the data show that the borrow area material is consistent with the applicable State Rules and solidly compatible with the native beach. Approximately 1.4 Mcy of material was identified in what is ranked as "B" potential borrow areas due to lack of data or lower compatibility of the sediment. Finally about 2.2 Mcy of material is located in borrow areas ranked as "C" due to insufficient data or poor compatibility of material.

In addition to the non-renewable offshore borrow areas, several renewable borrow areas offer significant additional volumes of beach quality material. These include a possible ~15.3 Mcy over 30 years or about 25.5 Mcy over 50 years coming from maintenance of Bogue and Beaufort Inlets.

The total estimated volume available from the non-renewable and renewable borrow areas totals about 35 Mcy available over 30 years, or 45 Mcy over 50 years. These volumes meet the estimated long-term needs of the County.

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1.0 Offshore Borrow Area Investigation

1.1 Scope of Investigation

Coastal Tech was contracted by Moffat & Nichol, Inc. (M&N) to assimilate and review geotechnical investigation results associated with the Bogue Banks Master Beach Nourishment Plan and to identify beach-compatible sand resources for the long term beach-nourishment needs of Carteret County (County). M&N estimates the volume of sediment required to meet the 50-year needs of the County is between 26.0 and 44.8 million cubic yards (Mcy), while the required volume to meet the 30-year needs of the County is estimated to be between 15.7 and 26.9 Mcy. Coastal Tech herein examines the sand resources offshore of Carteret County located within the current and former Ocean Dredge Material Disposal Site (ODMDS), Bogue Inlet channel, the Morehead City Harbor outer channel, and Areas Y and Z, which are directly offshore of Emerald Isle in State waters. Figure 1.1 illustrates the location of these potential borrow areas and the general domain of this investigation. This document presents and summarizes results of the geotechnical investigation and delineates potential borrow areas for future nourishment of Carteret County beaches.

1.2 Geologic Setting

Bogue Banks is a southward facing barrier island located adjacent to Cape Lookout on a lower energy east-west trending shoreline in Onslow Bay. At 25.4 miles long, the island is the longest and widest in southeastern North Carolina (Cleary and Pilkey, 1996). Beaufort Inlet, which has a Federally maintained navigation channel, borders the island on the east, while the shallow draft Bogue Inlet borders the island on the west. The backbarrier of Bogue Banks features Bogue Sound, which is an open water lagoon with considerably less marsh vegetation than the backbarriers to the south (Cleary and Pilkey, 1996). Influx into Bogue Sound includes sources such as the White Oak River on the west and the Newport River on the east. The island is characterized by mature dunes with foredune elevations up to 33 feet NAVD88 (Kana et al., 2002). These higher oceanfront elevations impede washovers that would typically provide sedimentation to the backbarrier on which vegetation would take hold. Bogue Banks was at one time a regressive barrier from approximately 3000 years-before-present (ybp) to 1100 ybp, after which time the absence of overwash material to the backbarrier led to backbarrier erosion and island narrowing with periodic breaching along the central portion of the island (Elliot, 2010). Initiation of overwash is the precursor to an island becoming transgressive (Cleary and Pilkey, 1996; Elliot, 2010).

The shoreface of Onslow Bay seaward of Bogue Banks is characterized by the outcropping of middle Tertiary sediments where barrier island transgression and sea-level rise has resulted in the removal of the majority of the more modern sediments (Hine and Snyder, 1984). Relic channels of Pleistocene and Holocene age incise the upper shoreface, but terminate where the edge of the modern sediments meets these exposed Tertiary sediments in the nearshore (Hine and Snyder, 1984).

Bogue Inlet, which separates Bogue Banks from Bear Island, occupies one of these historic channels incised by the White Oak River during lower sea level (Hine and Snyder, 1984). Bogue

Inlet is periodically dredged with a sidecast dredge by the US Army Corps of Engineers to maintain safe navigation. The inlet channel generally migrates eastward with associated spit growth on the updrift side. In 2005, the inlet channel was realigned to a more shore normal direction in an effort to provide the most beneficial orientation for the adjacent shorelines and alleviate erosion on the Emerald Isle shoulder (CPE, 2004).

Beaufort Inlet hosts the Morehead City Harbor and is Federally maintained as a deep draft port. The outer harbor is dredged to a depth of –47 feet NAVD88 with more shallow draft portions in the inner harbor. Sedimentation into the Morehead City Inner Harbor is from numerous sources, including the Newport River and the North River (USACE, 2001). Many references suggest that Beaufort Inlet has been recognized on maps since the 1600's (for example, Fisher, 1962; Wells and McNinch, 2001). The inlet has been dredged for navigation purposes since 1911 (Olsen, 2006) and is stabilized by a terminal groin at Ft. Macon.

The beaches of Bogue Banks are subject to the erosive forces of tropical systems or hurricanes, the effects of the adjacent inlets, and to a lesser extent due to their south-facing orientation, winter frontal storms or "nor'easters".

1.3 Previous Investigations

There have been many prior investigations of potential sand resources both offshore of Carteret County and within the adjacent inlets. The different segments of Morehead City Harbor were examined within Beaufort Inlet to determine whether the dredged material would be suitable for beach placement (USACE, 2001; USACE, 2009; USACE, 2010; Olsen, 2006). It was determined that material within the Inner Harbor was likely to contain silt in excess of 10% by weight, and thus be non-compatible with the native beach, while the Outer Harbor and main inlet channel produced beach quality material (USACE, 2010).

Coastal Science and Engineering (CSE) investigated the Current Ocean Dredged Material Disposal Site (Current ODMDS) in association with emergency fill projects for Emerald Isle, Indian Beach, and Pine Knoll Shores following Hurricanes Isabel and Ophelia. CSE developed a borrow area in the northern portion of the Current ODMDS with 14 vibracores in 2006 (CSE, 2007). Olsen and Associates also completed a desk-top estimation of the volume of beach quality material that may be available in the Current and Old ODMDS (Olsen, 2006).

Prior to the channel realignment in Bogue Inlet in 2005, Coastal Planning and Engineering (CPE) took jet probes and vibracores within the proposed channel template, which demonstrated that the material was suitable for beach placement (CPE, 2004). Additionally, in 2008 the USACE took vibracores within the inlet backbarrier in the Atlantic Intracoastal Waterway channel; the results of which indicate that this material is suitable for beach placement when dredging is required (Ben Lackey, personal communication).

CSE performed a multi-phase offshore sand search in association with the Bogue Banks Beach Nourishment Project where CSE attempted to find beach quality material in close proximity to the project areas. CSE extracted and analyzed vibracores from borrow areas offshore of central Emerald Isle to Pine Knoll Shores, including areas it identified as borrow areas A and B (CSE, 2001). In 2002, offshore of Bogue Banks, an extensive grid of vibracores was taken by the USACE. These core logs and sediment analysis results were obtained by the M&N Team for the purpose of planning this Plans & Specs level field investigation.

1.4 Bathymetric Survey

Data from two separate bathymetric surveys were utilized throughout this report to calculate the total estimated volume of sediment within a proposed borrow area above the designated cut elevation. These multibeam bathymetric surveys were performed by Geodynamics in 2009 and 2011. The 2009 data set covers the Old Ocean Dredge Material Disposal Site and Bogue Inlet, while the 2011 survey covers the currently active Ocean Dredge Material Disposal Site and Area Y. The two data sets were successfully merged by Geodynamics and the data set that was utilized for each volume calculation is referenced throughout this report for clarity. The location and elevation of all data were collected and reported using the North Carolina State Plane (NAD83), U.S. Survey Feet horizontal datum and NAVD88 vertical datum. Survey lines through each potential borrow area were spaced at 200-foot intervals and soundings were collected continuously with a maximum point spacing of 10-foot along the profile line (Geodynamics, 2011).

1.5 Seismic and Backscatter Surveys

A seismic survey was conducted by Geodynamics, under contract with M&N, in July 2011 for the purpose of establishing the extent of the upper layer of sand throughout the Current ODMDS and Area Y. This survey was performed simultaneously with the multibeam backscatter and bathymetry surveys. Data from 2009 Geodynamics surveys were used for the Old ODMDS, Area Z and Bogue Inlet. Sub-bottom profile data were collected and analyzed for acoustic reflectors and anomalies that can indicate the presence and quantities of beach re-nourishment resources. Multibeam backscatter surveys were conducted to identify surficial anomalies as well as the presence of hardbottom. All surveys were conducted in accordance with State and Federal regulations (Geodynamics, 2011).

1.6 Geotechnical Investigation

In December 2012, a total of 164 20-foot vibracores were extracted by Alpine within the potential offshore borrow areas including the Old ODMDS, the Current ODMDS, Area Y, and Area Z. In April 2012, five 10-foot vibracores were taken in Bogue Inlet channel. The locations of these vibracores are shown in Figure 1.1. Vibracore locations were designed to define the stratigraphy of the potential borrow areas including the horizontal and vertical extent of the upper layer of sand in each area, and to meet current and future state rules for sediment investigations. Historical data were reviewed from a series of existing vibracores from across the nearshore of Onslow Bay previously obtained in association a USACE study performed in 2002. These data included general vibracore logs, as well as granularmetric data from representative sediment samples.

Representative samples from the 2012 vibracores were analyzed in Coastal Tech's *Coastal Geology and Sediments Lab* to characterize texture and composition. Potential borrow area boundaries were refined from that previously outlined in prior studies, using the bathymetric, seismic survey data, vibracore logs and sedimentologic sample data.

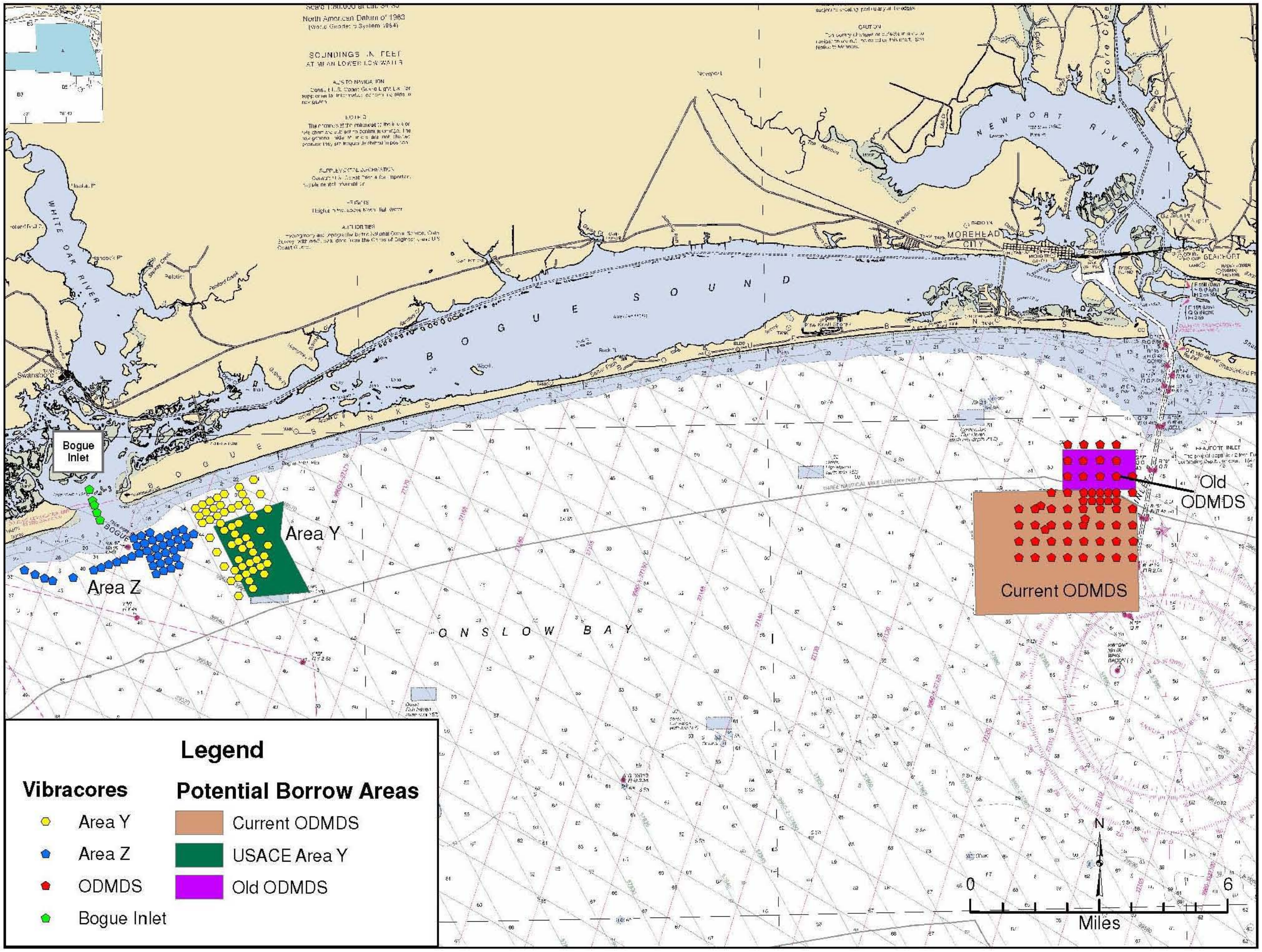

Figure 1.1 – Location of Potential Borrow Areas & 2012 Vibracores

boundaries were refined from that previously outlined in prior studies, using the bathymetric, seismic survey data, vibracore logs and sedimentologic sample data.

2.0 Laboratory Analyses

A total of 599 representative sediment samples were obtained by Alpine from the 2012 vibracores and transferred to Coastal Tech's *Coastal Geology and Sediments Lab* in Melbourne, Florida. These samples were analyzed using standard laboratory methods to characterize texture and composition. Sediment texture was quantified using nested sieves consistent with USACE procedures, and described in accordance with the Unified Soils Classification (USC) System. These methods are consistent with State Rules, including Rule 15A NCAC 07H.0312 Technical Standards for Beach fill Projects.

Gradation analysis was performed using 20 sieves ranging from -4.25 φ to +4 φ at ½φ intervals, including the -2.25 φ and +3.75 φ sieves. Samples that appeared to contain flocculated fines were wet sieved prior to dry sieving. This entailed obtaining a dry sample weight, soaking the sample in a 5% $(NaPO_3)_6$ solution overnight, washing the sample over a #230 sieve, and obtaining a new dry weight to accurately quantify the amount of fines in the sample. The samples that contained fines in excess of 5% or more by weight passing through the #200 sieve were assigned a Unified Soils Classification Code on the basis of visual examination by a registered professional geologist.

Composition was determined through Loss on Ignition. This process entails burning a ~20g sample in a crucible at 550^{o}C for two hours to burn off the organic material, and again at 1000^{o}C for three hours to burn off the calcium carbonate material. The weight percent lost after the 550^{o}C burn corresponds to the weight percent organic material in the sample. The weight percent lost after the 1000^{o}C burn corresponds to the amount of CO_2 burned off of the $CaCO_3$ molecules in the sample. The molecular weight of the CO_2 molecule is 44% of the molecular weight of the $CaCO_3$ molecule, so the weight loss is then multiplied by 2.27 to ascertain the percent $CaCO_3$ that was in the sample.

Laboratory results of the sediment sample analyses conducted by Coastal Tech are summarized throughout the report and provided in digital format (see enclosed discs) within this report as follows:

- Appendix 1 – CD-ROM containing 2012 Alpine Ocean Seismic Survey report with Coastal Tech sediment results
- Appendix 2 – CD-ROM Containing gINT and Other Digital Files

3.0 Native Beach

Previous sampling and analysis of native beach sediments was utilized to determine compatibility of the potential borrow areas with Carteret County beaches. In 2001, CSE obtained 64 samples from the dune, berm beachface, and low tide terrace at 16 evenly spaced transects between stations 48 and 78. Four of these dune samples were excluded from this analysis because the samples were obtained from dunes that were formed with sand excavated from the lower beach, and do not reflect sand naturally occurring in the dune. The 28 samples from adjacent transects were physically combined and analyzed together to define the composite characteristics of the native beach. These data represent the beach characteristics prior to the Bogue Banks Beach Restoration projects in 2002 (Phase I) and 2003 (Phase II). The resulting native beach composite is fine grained, moderately well sorted quartz sand with less than 1% fines and less than 2% gravel. The CSE report indicates that the material had an average of 15-20% shell content. The composite has a mean grain size of 0.30 mm (CSE, 2001).

The proposed borrow area material must meet the characteristics prescribed by North Carolina Administrative Code "Technical Standards for Beach Fill Projects" (15A NCAC 07H .0312) herein referred to as the "Rule". The Rule requires that the weight percent fines, gravel and granular size material not exceed the native beach weight percent by more than 5%. However, if the material is dredged from a federally maintained navigation channel the Rule only stipulates that it must contain less than 10% fines by weight. In addition, the weight percent calcium carbonate may not exceed the native by more than 15%. The native beach characteristics and the resulting parameters required of the borrow material are shown in Table 3.1.

Characteristic	2001 Native	Rule Requirements	Required Borrow Site Parameters
Fines <#230	Reported: 0%, Assumed: <1%	<1% + 5%	≤ 6%
Sand (> #230 & <#10)	Reported at 98.68%	-	-
Granular (>#10 & < #4)	Reported combined at 1.32%, Assumed 0.7% each	0.7% + 5%	≤ 6%
Gravel (>#4)		0.7% + 5%	≤ 6%
Calcium Carbonate	Reported at 15-20%	20% + 15%	≤ 35%

Table 3.1 – Native Beach Characteristics and Rule Parameters

4.0 Borrow Area Delineation and Compatibility Analysis

Potential borrow areas were delineated, and compatibility for use as beach fill was assessed based upon the following:

(1) vibracore sedimentology (i.e., texture and composition), and stratigraphy,
(2) volume weighted composite vibracore and borrow area granularmetrics and organic / carbonate contents – from 2012 vibracores,
(3) the composite native beach granularmetrics,
(4) the Rule parameters (Table 3.1), and
(5) the Overfill Factor (R_a) per the *Coastal Engineering Manual* (USACE, 2002).

Note that borrow area composites were formulated using only data from vibracores obtained by Alpine under contract with M&N in 2012. Data from vibracores obtained by USACE in 2002 and others were consulted for general consistency and compatibility, but were not included in the calculation of composites presented herein because these potential borrow areas were adequately covered with modern cores.

Surficial sediments within potential borrow areas are assessed based on overall sediment quality. Sediment in the upper layer of each vibracore is characterized as either:

- Good - if the samples in this layer have low fines and gravel size content (<3%), appear to be light in color per the core photographs, and the layer thickness would be worth dredging (>3 feet);
- Poor - if the samples in the upper layer contain appreciable fines or gravel (>5%), were very dark in color in the core photographs, or if the upper layer was very thin (<2 feet);
- Moderate: if any of the sample characteristics were between "Good" and "Poor".

Color-coding (Good = green; Poor = red; Moderate = orange) these vibracore characterizations in the plan-view maps assisted in visually determining where there were clusters of "Good" material from which borrow areas could be delineated after further study of the full granularmetrics. These color codes are shown in some of the plan-view figures in this report.

The potential borrow areas are delineated around clusters of "Good" vibracores, where a proposed cut-depth was identified at 2 feet above the underlying non-compatible material. Composite characteristics were then calculated for each area and compatibility with the native beach was assessed. Each sample was weighted within the vibracore to develop vibracore composite characteristics, and each vibracore composite was weighted within the potential borrow area to develop potential borrow area composite characteristics. Textural compatibility was assessed by comparison of composite sample mean grain sizes, grain size distribution, and sorting coefficients for the native beach and each potential borrow area.

Potential borrow areas are ranked based on (a) confidence in the stratigraphy per the available vibracore data, and (b) the quality and compatibility of the potential borrow area material with the native beach sediments and the Rule - per the following:

- A - If the stratigraphy of a potential borrow area is well defined, and the material is highly compatible with the native beach and the Rule, it is ranked as an "A" level borrow area.
- B - If a potential borrow area needs some more vibracores to confidently define the stratigraphy, has a moderately high overfill factor, and/or may have a characteristic that is slightly out of compliance with the Rule, it is given a "B" ranking.
- C - Finally, if a potential borrow area has insufficient data to define the stratigraphy, has a high overfill factor, and/or poor or questionable compatibility of material with the native beach, it is given a "C" ranking.

A preliminary maximum cut elevation was selected for each vibracore where the sample analyses indicated sediment consistent with the Rule. This cut elevation was established to be two feet above the boundary with non-compatible material. This two foot buffer is often used in practice to provide for a margin of error in dredging, recognize uncertainties in extrapolation of conditions from core to core, and ultimately to avoid dredging of non-compatible material. Once all maximum cut elevations were delineated for each vibracore, the investigation areas were divided into separate potential borrow areas where the vibracores point to a similar cut elevation. A final cut elevation was selected for each potential borrow area based on the lowest common cut elevation that still allowed for a two foot buffer above non-compliant material.

The Overfill Factors shown in Appendix 4 and summarized in this report were calculated for reference, but the compliance of material with the Rule is the basis used herein for delineation or exclusion of potential borrow areas. The Overfill Factor is a common design element in coastal engineering practice used for simple comparison of potential borrow source material to native beach material. The Overfill Factor seeks to estimate, based on grain-size distributions, what volume of borrow source fill is necessary to functionally replace a "unit" of native beach sand. The Overfill Factor was estimated via methods prescribed by the USACE *Coastal Engineering Manual* and was calculated for each potential borrow area.

Conceptual geologic cross sections were drawn for the Ocean Dredge Material Disposal Site as determined through examination of the vibracore sediment samples and interpolation of likely stratigraphy between the cores. The stratigraphy within the Ocean Dredge Material Disposal Site is not naturally occurring, and is meant only to show the extent of the surficial (uppermost) layer of sediment. In these cross-sections the vibracore is presented with the actual Unified Soil Classification (USC) code represented in the stratigraphy within the core, while the stratigraphy between the cores is presented as a USC code that generalizes the nature of the adjacent strata for ease of interpretation. For example, adjacent samples may differ in USC code based on a slight percentage difference in fines or gravel, so the most common USC code (from all the surrounding cores) is chosen to represent the stratigraphy between cores.

Potential borrow area composite and compatibility data calculated by Coastal Tech are provided within this report as follows:

- Appendix 3 – Potential Borrow Area Composite Curves
- Appendix 4 – Potential Borrow Area Overfill Factor Calculations

4.1 The Old ODMDS

The previously utilized dredge disposal area referred to herein as the Old ODMDS is located directly north of the currently utilized disposal area. The two are separated by the approximate State/Federal water jurisdictional boundary located three miles offshore. The largest mound of disposal material straddles the boundary between the Old ODMDS in State waters and the currently active ODMDS in Federal waters (Figure 4.1). The majority of this mound is located within the boundaries of the Old ODMDS. This mound was separated into two potential borrow areas, designated Old ODMDS 1 and Old ODMDS 2 (Figure 4.2), with cut depths that differ by one foot; this separation maximizes the potential borrow area volume, while still maintaining a two foot buffer above non-compatible material.

4.1.1 Old ODMDS 1

The largest portion of the mound was designated Old ODMDS 1 (Figure 4.2). The majority of disposal material appears to be clean sand, while the material below roughly -54 feet NAVD88 contains >6% silt, which is not compliant with the Rule parameters and therefore not compatible with the native beach. Figure 4.3 exhibits the conceptual stratigraphy of the main ODMDS mound based on the vibracores extracted. Using a maximum cut to elevation -52 feet NAVD88,

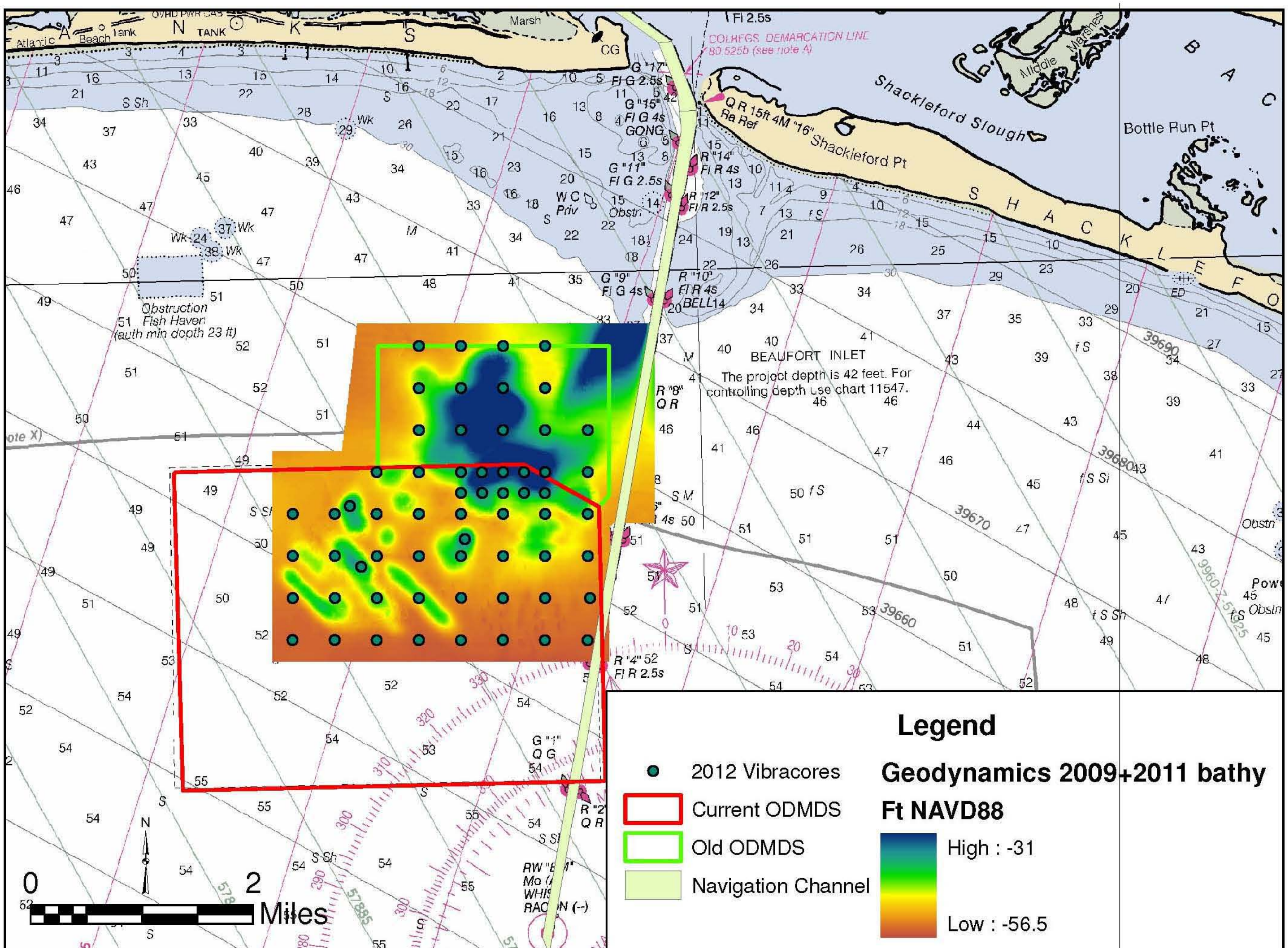

Figure 4.1 – Old and Current Ocean Dredge Material Disposal Sites

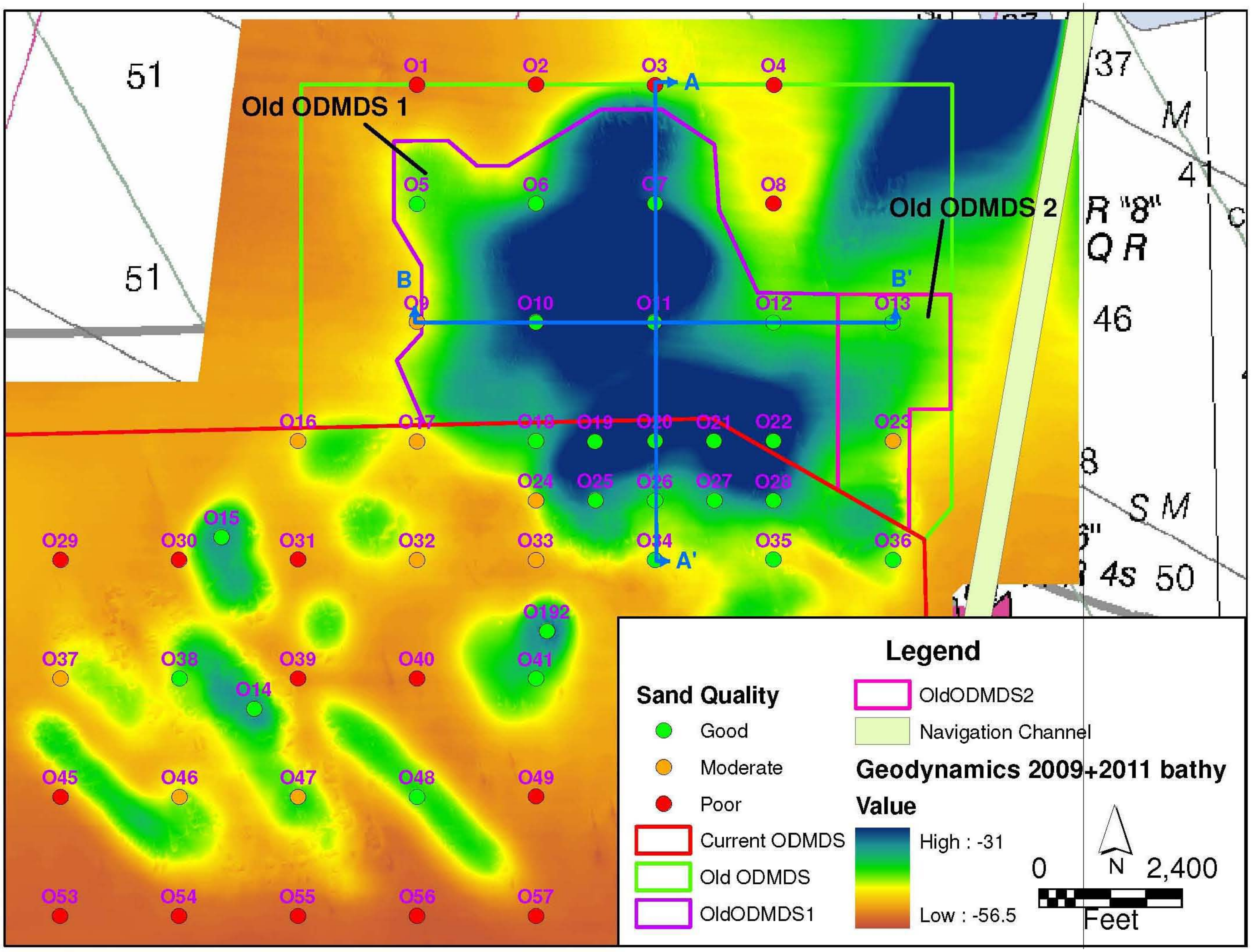

Figure 4.2 – Old ODMDS Potential Borrow Areas

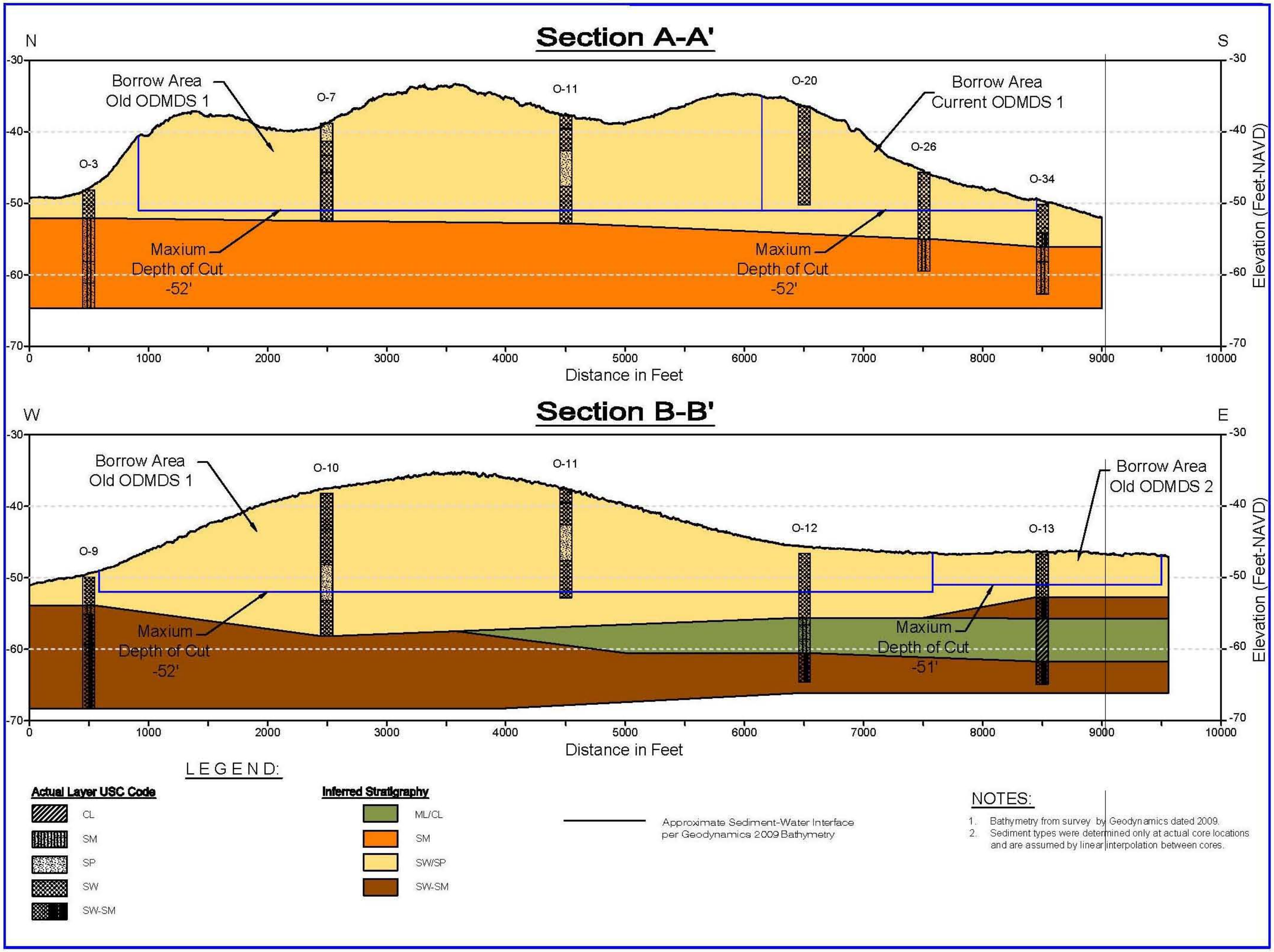

Figure 4.3 – Primary ODMDS Mound Cross-Section

and the 2009 bathymetry provided by Geodynamics, this area is estimated to contain about 13.14 Mcy of beach compatible material, as defined by twenty vibracores.

Fine grained (0.30 mm), poorly sorted quartz sand comprises the Old ODMDS 1 borrow area. This is the same mean grain size as the native beach composite, although the native beach material is better sorted (with a sorting coefficient of 0.61 for the native and 1.11 for the borrow area). The composition includes 13.6% carbonate material in the form of shell hash, which is similar to the reported native carbonate content of 15-20%. The characteristics of this material are compliant with the parameters set forth by the Rule shown in the center column of Table 4.1. A comparison of the grain size distribution curves of the Old ODMDS 1 borrow area and the 2001 native beach composite curve shows that the distributions are quite similar (see Figure A3.1 in Appendix 3). The overfill factor for the Old ODMDS 1 borrow area is calculated to be 1.30.

Characteristic	Required Borrow Site Parameters	Old ODMDS 1
Fines <#230	≤ 6%	**0.53%**
Sand (> #230 & <#10)	-	**96.00%**
Granular (>#10 & < #4)	≤ 6%	**2.14%**
Gravel (>#4)	≤ 6%	**1.33%**
Calcium Carbonate	≤ 35%	**13.55%**

Table 4.1 – Old ODMDS 1 Composite Characteristics and Rule Parameters

4.1.2 Old ODMDS 2

Adjacent to the Old ODMDS 1 potential borrow area is the Old ODMDS 2 potential borrow area, where the cut elevation is raised one foot to maintain the two foot buffer above non-compatible material. This borrow area is on the northeast flank of the large mound in the Old ODMDS (Figures 4.2 and 4.3) and is defined by two vibracores. Based on the bathymetric survey performed by Geodynamics in 2009 and using a maximum cut to elevation -51 feet NAVD88, this area is estimated to contain about 1.1 Mcy of beach compatible material. This potential borrow area has a composite mean grain size of 0.32 mm, which is only slightly coarser than the native beach sand. It contains less than 1% gravel and fines, and 13.6% calcium carbonate. This composite is quite similar to the Old ODMDS 1 composite, as well as the native beach, as reflected in the grain size distribution curve shown in Figure A3.2 in Appendix 3. The material has an estimated Overfill Factor of 1.25, meets the parameters set forth by the Rule (see Table 4.2), and is thus deemed compatible with the native beach.

Characteristic	Required Borrow Site Parameters	Old ODMDS 2
Fines <#230	≤ 6%	**0.20%**
Sand (> #230 & <#10)	-	**96.30%**
Granular (>#10 & < #4)	≤ 6%	**2.49%**
Gravel (>#4)	≤ 6%	**1.01%**
Calcium Carbonate	≤ 35%	**13.57%**

Table 4.2 – Old ODMDS2 Composite Characteristics and Rule Parameters

4.2 The Current ODMDS

The currently active ODMDS is located across the 3-mile jurisdictional line that separates State and Federally regulated waters (Figure 4.1). The Morehead City ODMDS was established by the EPA in 1972 by Section 102(c) of the Marine Protection, Research, and Sanctuaries Act of 1972, and the Final Rule (Vol. 52 No. 157) effective in 1987 per the Morehead City Ocean Dredged Material Disposal Site: Site Management and Monitoring Plan (USACE, 2009). The USACE Ocean Disposal Database lists disposal amounts for the current ODMDS beginning in 1989. Placement of material in the current ODMDS has declined since 1995 with the advent of use of the Nearshore disposal area, which (a) is located on the seaward flank of the Beaufort Inlet ebb tidal delta and (b) was established in an effort to dispose of beach quality material in a zone that would keep it within the littoral system. However, material is still disposed of in the ODMDS when (a) the wave climate does not allow dredges to approach the relatively shallow Nearshore area, which is estimated to be at -26 feet to -40 feet (datum unknown) (Olsen, 2006) or (b) when the disposal material contains fines in excess of 10% by weight.

The Current ODMDS was divided into several potential borrow areas. The large mound that includes Old ODMDS 1 and 2 also extends across the federal water boundary into the Current ODMDS, where it comprises the potential borrow area deemed Current ODMDS 1, as shown in Figure 4.4. Current ODMDS 1, is discussed below followed by the smaller disposal mounds present in the Current ODMDS. These smaller mounds have varying degrees of certainty with respect to their granularmetric characteristics based on the number of vibracores that penetrate the thickest portion of the mounds. These mounds will be presented based on the degree of confidence that the data provide in the granularmetrics.

4.2.1 Current ODMDS 1

Current ODMDS 1 is the Federal water extension of the large mound that also includes Old ODMDS 1 and 2 (Figure 4.2 and 4.4). Based on the bathymetric survey performed by Geodynamics in 2011 and a maximum cut to elevation -52 feet NAVD88, this area may contain about 4.23 Mcy of beach compatible material. This portion of the large mound is defined by fourteen (14) vibracores. The sediment composite for this borrow area reflects poorly sorted fine grained quartz sand with a mean grain size of 0.30mm, which is the same as the native beach composite. This material has less than 1% fines and less than 2% gravel, with approximately 13.3% carbonate material in the form of shell hash. The grain size distribution curve is quite similar to the native beach, with slightly more of the coarsest material present in the borrow area (Figure A3.3 in Appendix 3).

Based on the Rule parameters, this material is compatible with the native beach (Table 4.3). Volume-weighted average composite mean grain size and sorting coefficients for Current ODMDS 1 and the Carteret County native beach composite calculated from the CSE 2001 data were compared to calculate the Overfill Factor of 1.25. This is quite similar to the other portions of this large mound and it is illustrative to see the comparison of the three granularmetric

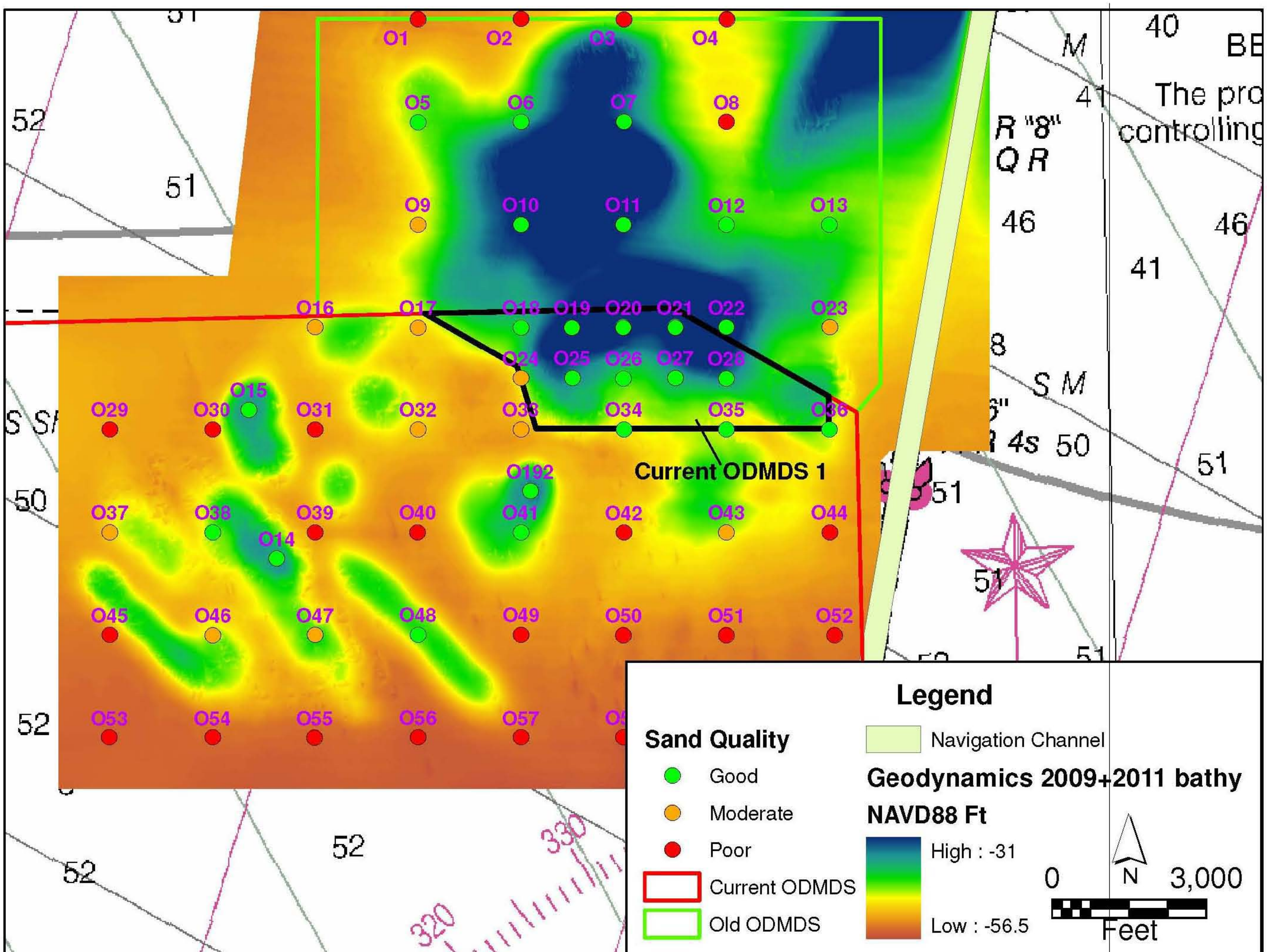

Figure 4.4 – Current ODMDS 1 Potential Borrow Area

frequency distribution curves together on one plot to see the similarity of the curves, and thus the consistency of the material throughout this large disposal mound as shown in Figure A3.4 in Appendix 3.

Characteristic	Required Borrow Site Parameters	Current ODMDS 1
Fines <#230	< 6%	**0.52%**
Sand (> #230 & <#10)	-	**96.06%**
Granular (>#10 & < #4)	< 6%	**2.06%**
Gravel (>#4)	< 6%	**1.36%**
Calcium Carbonate	< 35%	**13.29%**

Table 4.3 – Current ODMDS 1 Composite Characteristics and Rule Parameters

4.2.2 Higher Confidence Mounds

The higher confidence mounds include those that have at least one vibracore that penetrates the thickest part of the mound within a potential borrow area, allowing the stratigraphy to be better defined. These mounds were named for the defining core(s) out of simplicity. These mounds include Mounds O-15, O-192, O-48 and the adjoining Mound O-14/O-47 (Figure 4.5). If multiple vibracore composites were used in preparing the composite for the mound, they were weighted equally within the borrow area. The sedimentology, volumes, and compatibility of these mounds are discussed below.

4.2.2.1 Mound O-15

Mound O-15 is located west of the main ODMDS mound and is penetrated only by Core O-15, so this vibracore composite was used to define the mound sedimentology (Figure 4.5). Using the bathymetric survey performed by Geodynamics in 2011 and a maximum cut to elevation -50 feet NAVD88, this mound may contain approximately 356,000 cubic yards (cy) of beach quality material. Fine grained, moderately sorted quartz sand comprises this mound; the composite of Core O-15 has a mean grain size of 0.24 mm, which is finer than the native beach composite (0.30mm). This finer mean grain size may be because Mound O-15 contains a slightly lower carbonate shell content of 10%.

A comparison of the Mound O-15 composite grain size distribution curve and that of the native composite reveals the generally finer nature of the mound composite (Figure A3.5 in Appendix 3). For example, when comparing only the percent finer than the 2φ sieve, the curve shows that 65% of the Mound material is finer than the 2φ sieve, while only 42% of the native composite is finer than the same sieve. As a result of this finer mean grain size, the Mound O-15 Overfill Factor is 1.60, which is higher than the previously discussed borrow areas. However, the material still falls within the parameters set forth by the Rule as shown in Table 4.4, and is thus still compatible with the native beach, although it is not expected to perform quite as well as the previously discussed borrow sites. Due to the higher overfill factor, Mound O-15 was assigned a "B" ranking.

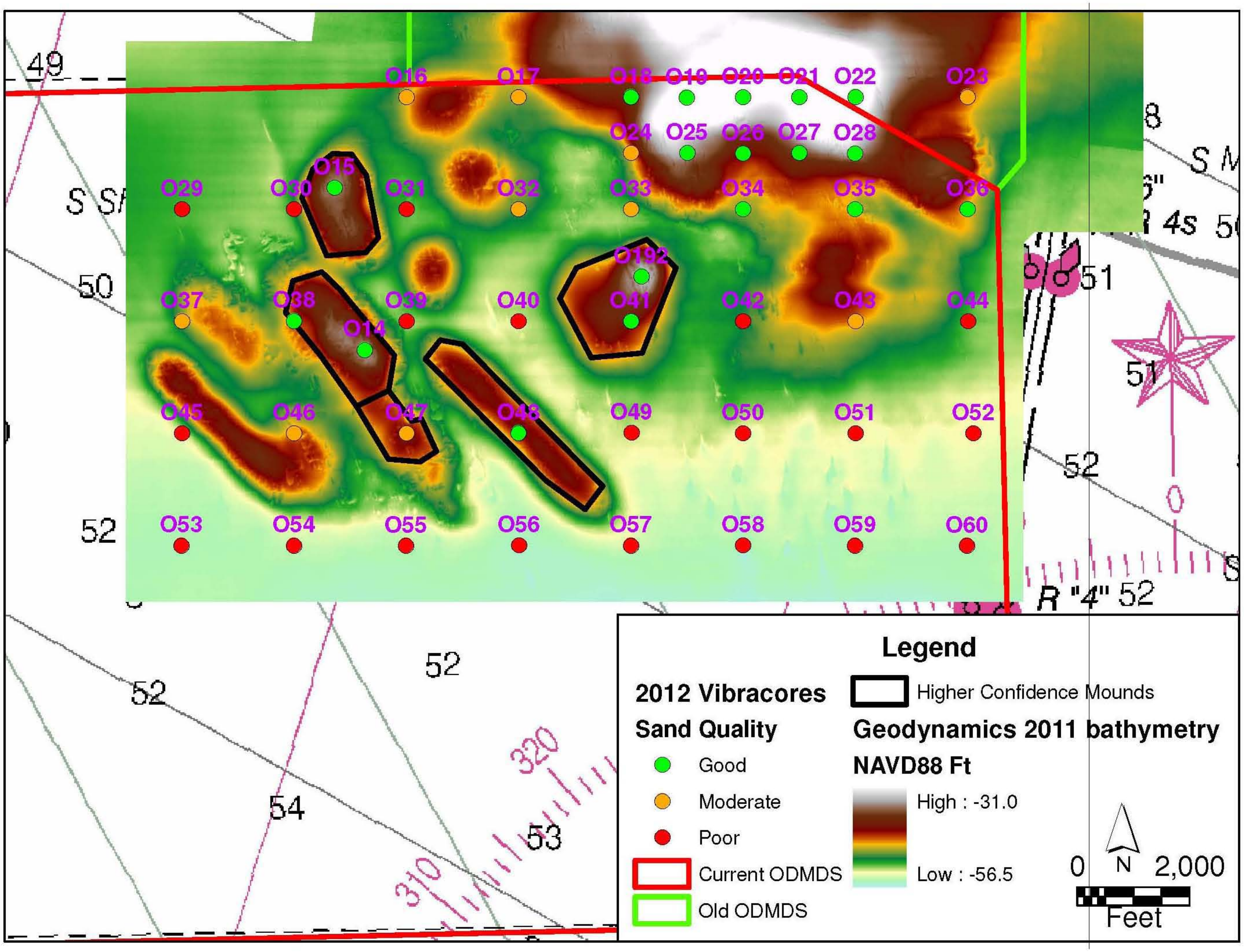

Figure 4.5 – Current ODMDS Higher Confidence Mounds

Characteristic	Required Borrow Site Parameters	Mound O-15
Fines <#230	≤ 6%	**0.07%**
Sand (> #230 & <#10)	-	**99.23%**
Granular (>#10 & < #4)	≤ 6%	**0.54%**
Gravel (>#4)	≤ 6%	**0.16%**
Calcium Carbonate	≤ 35%	**10.10%**

Table 4.4 – Mound O-15 Composite Characteristics and Rule Parameters

4.2.2.2 Mound O-192

Mound O-192 is southwest of Current ODMDS 1 (Figure 4.5). Vibracores O-192 and O-41 penetrated this mound and these vibracore composites were given equal weight in preparing the mound composite. Using the bathymetric survey performed by Geodynamics in 2011 and a maximum cut to elevation -53 feet NAVD88, this mound may contain approximately 785,270 cy of beach quality material. Mound O-192 is characterized by fine grained, poorly sorted quartz sand with about 20% carbonate content in the form of shell hash. Generally the material shows a trend of fine gray sand interbedded with coarser tan shell hash.

The mean grain size is 0.36mm, which is coarser than the other borrow areas previously presented, as well as the native beach (0.30mm). This may be due to the higher shell content relative to the other borrow areas. A comparison of the grain size distribution curve for Mound O-192 and the native beach curve illustrates the divergence of the curves in the larger grain sizes where Mound O-192 has a higher percentage of coarser material, as well as the otherwise similar nature of the curve in the finer grain sizes (Figure A3.6 in Appendix 3). The O-192 mound material falls within the parameters set forth in the Rule as shown in Table 4.5, and is thus considered compatible with the native beach. The Overfill factor was calculated to be 1.25. This mound is given an "A" ranking.

Characteristic	Required Borrow Site Parameters	Mound O-192
Fines <#230	≤ 6%	**0.13%**
Sand (> #230 & <#10)	-	**93.07%**
Granular (>#10 & < #4)	≤ 6%	**3.43%**
Gravel (>#4)	≤ 6%	**3.37%**
Calcium Carbonate	≤ 35%	**19.59%**

Table 4.5 – Mound O-192 Composite Characteristics and Rule Parameters

4.2.2.3 Mound O-48

Mound O-48 is a northwest/southeast trending mound located in the center part of the Current ODMDS and is penetrated only by Core O-48, so this vibracore composite was used to define the mound sedimentology (Figure 4.5). Using the bathymetric survey performed by Geodynamics in 2011 and a maximum cut to elevation -52 feet NAVD88, this mound may contain approximately 468,740 cy of beach quality material. Fine grained, moderately sorted quartz sand comprises this mound. Mound O-48 has a mean grain size of 0.20 mm which is significantly finer than the native beach composite (0.30mm). This finer mean grain size may be due to the slightly lower carbonate shell content of less than 8% that this mound contains.

A comparison of the Mound O-48 composite grain size distribution curve and that of the native composite illustrates the finer nature of the mound composite (Figure A3.7 in Appendix 3). For example, when comparing only the percent finer than the 2φ sieve, the curve shows that 82% of the Mound material is finer than the 2φ sieve, while only 42% of the native composite is finer than the same sieve. The finer nature of the Mound O-48 material results in a high Overfill Factor of 2.25. This mound composite also approaches the compatibility threshold with respect to fines content as the mound contains 5.91% fines, nearing the 6% threshold (Table 4.6). As a result of the high Overfill Factor, relatively higher fines content, and lack of additional vibracores, Mound O-48 should be a low priority sand source with a "C" ranking.

Characteristic	Required Borrow Site Parameters	Mound O-48
Fines <#230	≤ 6%	**5.91%**
Sand (> #230 & <#10)	-	**92.83%**
Granular (>#10 & < #4)	≤ 6%	**1.11%**
Gravel (>#4)	≤ 6%	**0.15%**
Calcium Carbonate	≤ 35%	**7.76%**

Table 4.6 – Mound O-48 Composite Characteristics and Rule Parameters

4.2.2.4 Mound O-14/O-47

The mound that is penetrated by vibracores O-14, O-47, and O-38 is located directly west of Mound O-48 (Figure 4.5). This mound was assigned two different cut depths to maximize the volume of beach quality material that may be excavated from it. However, one composite was developed from the two areas because it is assumed the mound might be excavated as one borrow site. Using the 2011 Geodynamics bathymetry and the a maximum cut to elevation -49 feet NAVD88 for the portion of the mound including vibracores O-14 and O-38, and a maximum cut to elevation -53 feet NAVD88 for the area including vibracore O-47, this mound may contain approximately 566,028 cy of beach quality material. These vibracores show the same fine gray sand inter-bedded with coarser tan shell hash that is typical of this disposal area.

This mound is characterized by fine grained, poorly sorted quartz sand with less than 1% fines, less than 2% gravel and about 20% carbonate content in the form of shell hash. The mean grain size of 0.38 mm is coarser than the native (0.30mm) and may be attributable to the relatively higher carbonate content of this mound compared to some of the other potential borrow areas. A comparison of the grain size distribution curve with that of the native beach composite shows that the curves diverge in the coarser grain sizes where the mound material contains more of the coarse material (Figure A3.8 in Appendix 3). The granularmetric characteristics of this mound fall within the parameters set forth by the Rule, indicating that this material is compatible with the native beach (Table 4.7). The Overfill Factor was calculated to be 1.20. This mound is assigned an "A" ranking.

Characteristic	**Required Borrow Site Parameters**	**Mound O-14 / O-47**
Fines <#230	≤ 6%	**0.23%**
Sand (> #230 & <#10)	-	**93.43%**
Granular (>#10 & < #4)	≤ 6%	**4.71%**
Gravel (>#4)	≤ 6%	**1.63%**
Calcium Carbonate	≤ 35%	**19.80%**

Table 4.7 – O-14 / O-47 Mound Composite Characteristics and Rule Parameters

4.2.3 Lower Confidence Mounds

The lower confidence mounds (ranked as "B" or "C") include those that only have vibracores on the flanks, and none that penetrate the thickest portion of the mounds, such that the stratigraphy of the mound has not be adequately defined (Figure 4.6). As a result, the characteristics of the mound material can only be inferred from the adjacent vibracores. It is recommended that these mounds be sampled with additional vibracores in the thickest portion of the mounds to confirm the sediment characteristics inferred from the existing cores. There are two mounds that fall into this category of Lower Confidence Mounds; discussed below.

4.2.3.1 Mound O-35

Mound O-35 is located directly south of Current ODMDS 1, and in fact shares the composite data from core O-35 with Current ODMDS 1 (Figure 4.6). The other vibracore used in the composite of Mound O-35 was vibracore O-43 on the southern end of the mound. These core composites were weighted equally in the mound composite. Using the 2011 Geodynamics bathymetric data and a maximum cut to elevation -52 feet NAVD88, this mound may contain approximately 499,500 cy of beach quality material. Vibracore O-43 shows the same fine gray sand inter-bedded with coarser tan shell hash seen in previous mounds in the ODMDS.

Fine grained, poorly sorted quartz sand comprises Mound O-35. The cores suggest this mound may contain less than 1% fines or gravel and 15% carbonate in the form of shell hash. These characteristics are quite similar to the native beach, and all required parameters fall within the requirements set forth by the Rule (Table 4.8). The grain size distribution curve is similar to the native beach (Figure A3.9 in Appendix 3). Using these data the Overfill Factor was calculated to be 1.30. This mound is assigned a "B" ranking because it only has two vibracores on opposite flanks, with no sampling of the main part of the mound.

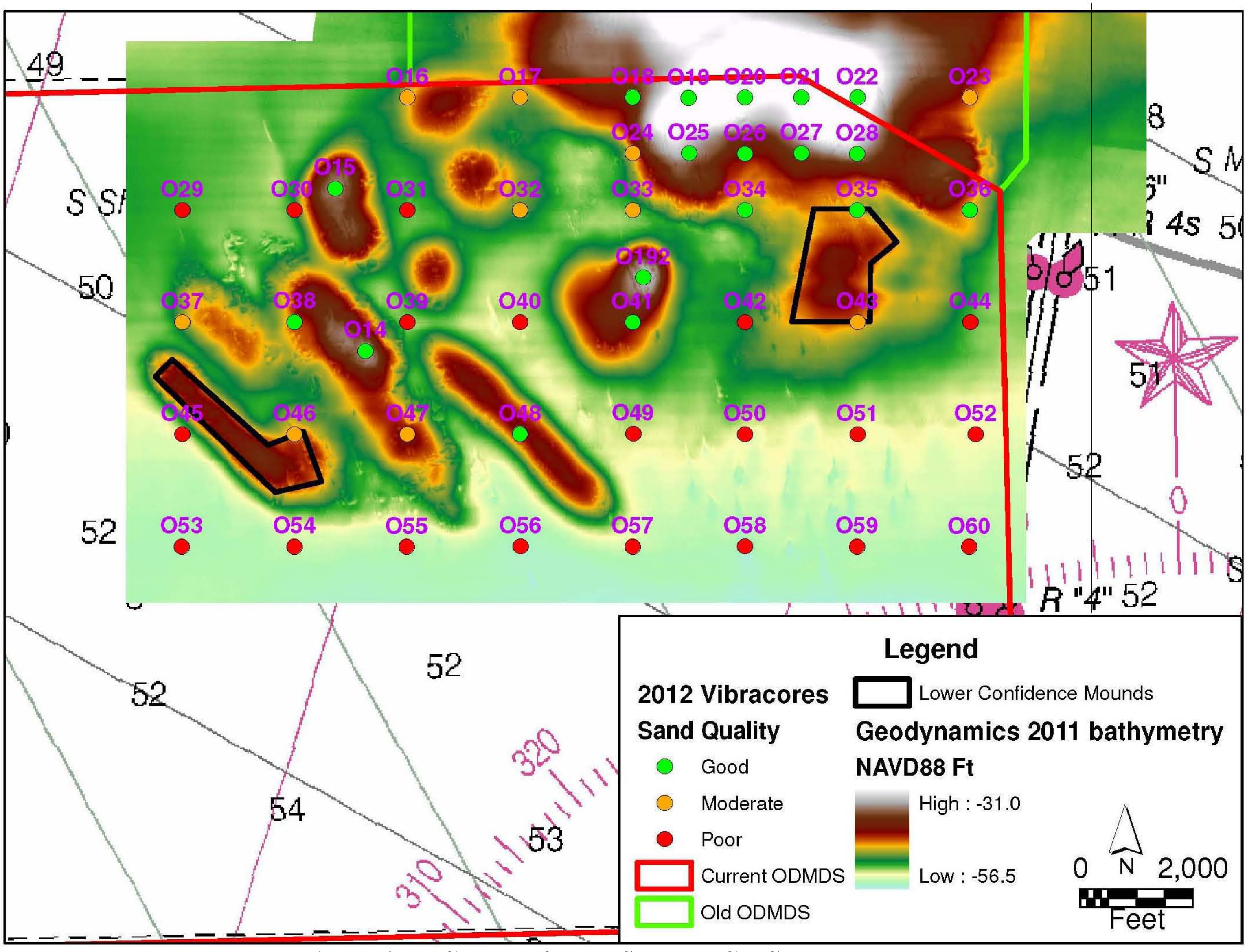

Figure 4.6 – Current ODMDS Lower Confidence Mounds

Characteristic	Required Borrow Site Parameters	Mound O-35
Fines <#230	≤ 6%	**0.31%**
Sand (> #230 & <#10)	-	**96.08%**
Granular (>#10 & < #4)	≤ 6%	**2.65%**
Gravel (>#4)	≤ 6%	**0.96%**
Calcium Carbonate	≤ 35%	**15.20%**

Table 4.8 –Mound O-35 Composite Characteristics and Rule Parameters

4.2.3.2 Mound O-46

Mound O-46 is the southwestern-most mound in the Current ODMDS (Figure 4.6). Vibracore O-46 was the only core used in the composite calculation. Using the Geodynamics 2011 bathymetric data and a maximum cut to elevation -53 feet NAVD88, this mound may contain 493,564 cy of beach quality material. This vibracore shows the similar fine gray sand inter-bedded with coarser tan shell hash that is typical of the ODMDS. This material overlays dark gray silty material.

Vibracore O-46 indicates that this mound may contain fine grained, poorly sorted quartz sand with less than 1% fines and less than 3% gravel. The O-46 vibracore composite had about 18% carbonate. The composite has a mean grain size of 0.40 mm, which is coarser than the other mound composites. The slightly higher carbonate content may be partially responsible for the higher mean grain size. This composite does just slightly exceed the Rule requirement for granular size material (Table 4.9), however, the composite meets the other Rule provisions. It is likely that with additional sampling of this mound, the composite weight percent granular may fall within compliance. The higher mean grain size results in a low Overfill Factor of 1.25. The Overfill Factor is likely still above 1 due to the high sorting coefficient of 1.5. The comparison of the grain size distribution curves illustrates the divergence in the higher grain size levels where the mound contains more of the coarse material (Figure A3.10 in Appendix 3). This mound is given a “B” ranking because it is only penetrated on the flank by one vibracore, and ideally further coring would be performed to delineate the horizontal and vertical extents of the beach quality material within the mound.

Characteristic	Required Borrow Site Parameters	Mound O-46
Fines <#230	≤ 6%	**0.37%**
Sand (> #230 & <#10)	-	**90.60%**
Granular (>#10 & < #4)	≤ 6%	**6.27%**
Gravel (>#4)	≤ 6%	**2.76%**
Calcium Carbonate	≤ 35%	**18.17%**

Table 4.9 –Mound O-46 Composite Characteristics and Rule Parameters

4.2.4 Contingency Mounds

The Contingency Mounds are the remaining mounds in the Current ODMDS that do not have any vibracores in them, and do not have cores that penetrate enough of the flanks to speculate as to the granularmetrics of the mounds. Conceptual cut depths were inferred from surrounding vibracores for the purpose of calculating potential volumes. These mounds include those shown in Figure 4.7. The total volume of material above the proposed cut depths shown in Table 4.10 is about 320,000 cy.

Mound	Cut Elevation NAVD88	Volume (cy)
O-16	-50ft	95,326
O-39	-52ft	94,352
O-37/O-38	-51ft	71,233
O-32	-50ft	58,543
	Total	**319,454**

Table 4.10 – Potential Volumes in Current ODMDS Contingency Mounds

4.4 Area Y

Area Y is located offshore of Emerald Isle in State waters (Figure 4.8). The material in Area Y is spatially highly variable, but the upper layers mostly consist of material that contains fines far in excess of those permitted by the Rule. Originally, vibracores were to be collected on a 1000 foot by 1000 foot grid, but initial vibracores showed poor material, so a wider spacing of 2000 feet by 2000 feet was used with additional vibracores being collected where better material was encountered. There were two areas where the material does not contain excessive fines, as defined by two adjacent vibracores, and preliminary estimates are made about volumes and sediment characteristics. However, in both cases the cores surrounding the two shore-perpendicular cores do not contain comparable clean sand, so it is impossible to reliably define the spatial extent of the resource.

4.4.1 Vibracores Y-80 / Y-75

Vibracores Y-80 and Y-75 are about 2000 feet apart (Figure 4.8). No vibracores were taken to the east or south of these vibracores due to hardbottom buffer requirements. The vibracores taken to the west of these are also 2000 feet away, and have one to two feet of dark gravel (non-compliant with the Rule) overlying the sand. Therefore, the upper layer of sediment in these adjacent cores is not beach-compatible. Although the characteristics of the upper layer in cores Y-80/Y-75 are defined herein, this area should be considered a low priority borrow area with a "C" ranking because there are insufficient vibracores to designate a reliable borrow area and most of the material appears to be of relatively poor quality.

Drawing a rectangle around the ocean bottom represented by the two cores, and using the Geodynamics 2011 bathymetry and a maximum cut to elevation -56 feet NAVD88, a potential volume of 1.08 Mcy is estimated. However, the rectangle is conceptual as the extent of the sand layer is not defined by the cores. The composite of the samples within this rectangle shows that the material is fine grained (0.23 mm), moderately well sorted sand with less than 3% fines and no gravel material. This material is dark in color and contains almost no shell. These

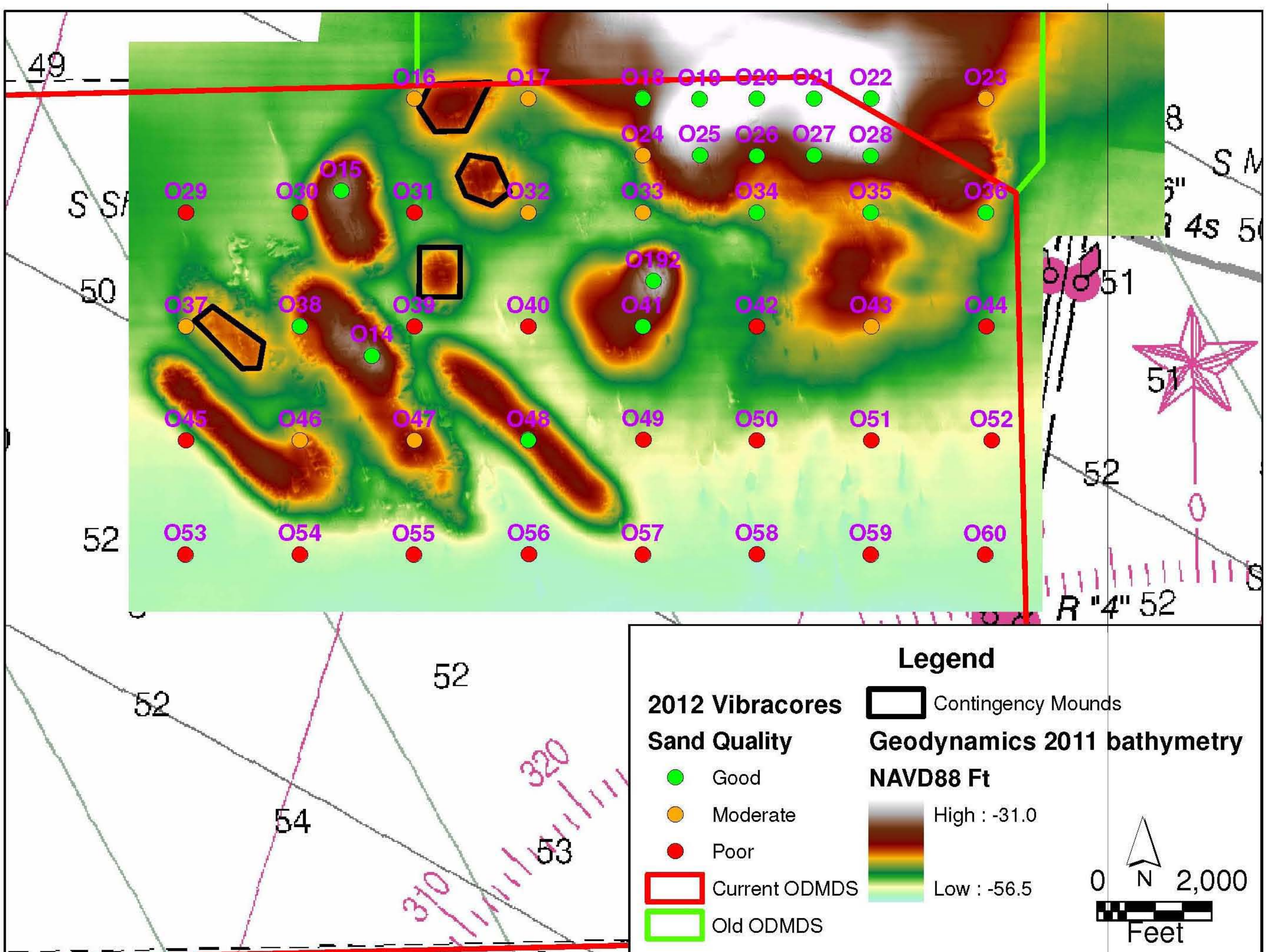

Figure 4.7 – Current ODMDS Contingency Mounds

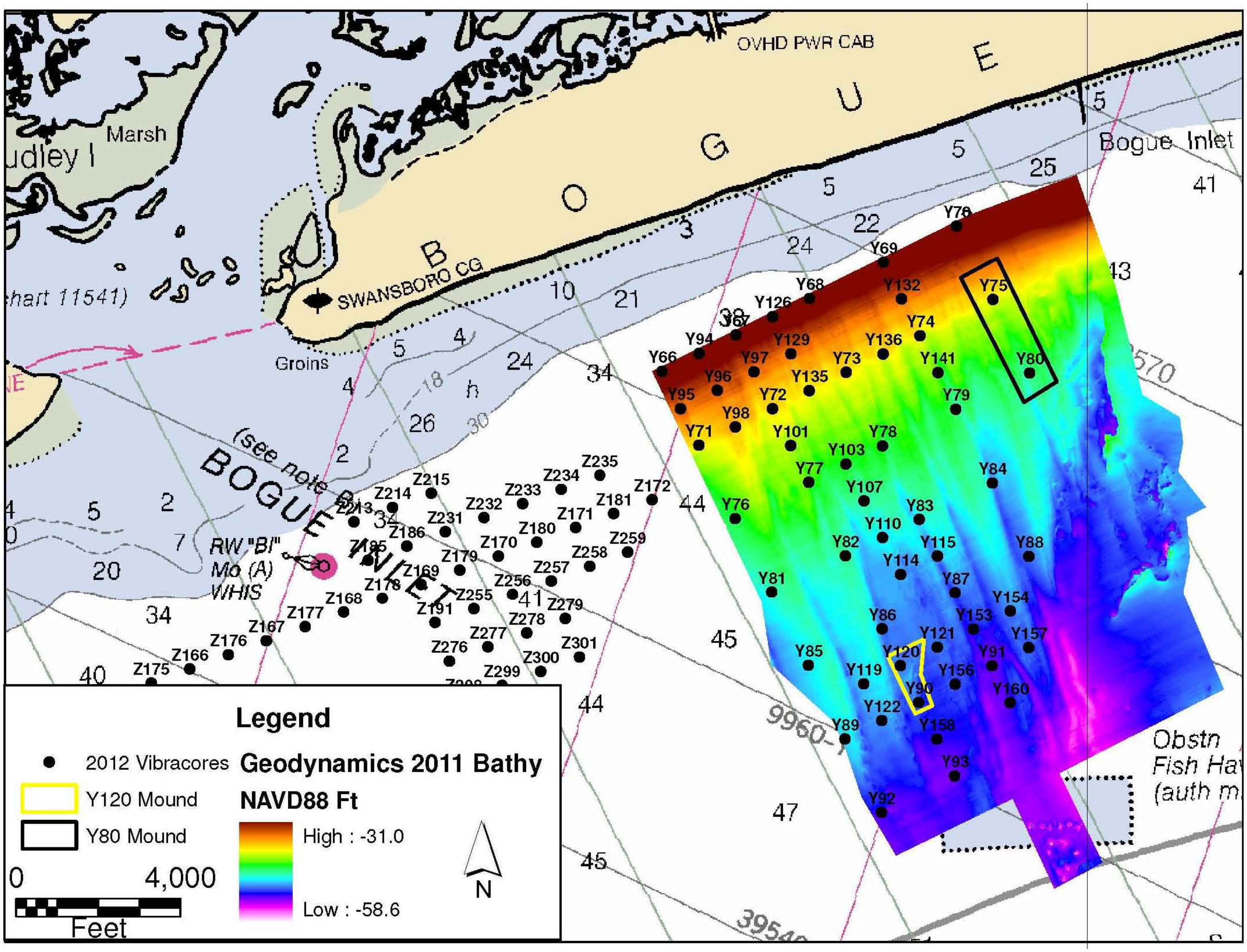

Figure 4.8 – Area Y Vibracores and Potential Borrow Areas

characteristics fall within the parameters set forth by the Rule, although it is significantly finer grained than the native composite (Table 4.11). The resulting Overfill Factor is 2.5 This indicates that this material would perform poorly as compared to native beach sand. The grain size distribution curve illustrates the finer nature of the borrow material throughout the grain sizes (Figure A3.11 in Appendix 3).

Characteristic	Required Borrow Site Parameters	Mound Y-80 / Y-75
Fines <#230	≤ 6%	**2.37%**
Sand (> #230 & <#10)	-	**97.55%**
Granular (>#10 & < #4)	≤ 6%	**0.08%**
Gravel (>#4)	≤ 6%	**0.00%**
Calcium Carbonate	≤ 35%	**1.85%**

Table 4.11 – Mound Y-80 / Y-75 Composite Characteristics and Rule Parameters

4.4.2 Vibracores Y-120 / Y-90

The other potential borrow area in Area Y surrounds vibracores Y-120 and Y-90 (Figure 4.8). Core Y-90 penetrates a small ridge and Y-120 is just adjacent to the ridge. Using an assumed area of influence that incorporates this ridge to a cut elevation of -62 feet NAVD88, based on the Geodynamics 2011 survey data, a volume of 379,675 cy is calculated. As with the previous potential borrow area delineated in Area Y, the area of influence for this potential borrow area is uncertain because adjacent vibracores do not contain this upper layer of sand.

The material in this mound has a mean grain size of 0.40 mm with about 2% fines; the material is significantly coarser than the native beach. The composite exceeds the gravel parameter set forth by the Rule with nearly 8% gravel by weight (Table 4.12). However, the material contains only trace calcium carbonate, and an inspection of the samples shows that the gravel-sized material is smooth river rock, rather than shell, which is not desirable in placement on the beach. The grain size distribution curve differs from the native in both the coarse and fine ends of the curve, where the Y-120/Y-90 material contains significantly more coarse material and some more fine material (Figure A3.12 in Appendix 3). The sediment is also dark in color. The Overfill Factor was calculated to be 1.30. However, this area should be considered a low priority borrow area that would need to be further defined if it is ever proposed for use, which is not recommended as the material is not compatible with the native beach.

Characteristic	Required Borrow Site Parameters	Mound Y-120 / Y-90
Fines <#230	≤ 6%	**2.04%**
Sand (> #230 & <#10)	-	**86.60%**
Granular (>#10 & < #4)	≤ 6%	**3.43%**
Gravel (>#4)	≤ 6%	**7.93%**
Calcium Carbonate	≤ 35%	**1.50%**

Table 4.12 – Mound Y-120 / Y-90 Composite Characteristics and Rule Parameters

4.5 Area Z

Forty-three vibracores were taken within Area Z, directly southeast of Bogue Inlet in an attempt to locate the relict White Oak River channel (Figure 4.9). The only sand that appeared to be beach quality in this area was underneath several feet of fine grained material with between 10-80% silt. The exception is vibracore Z-174, which contains about seven feet of clean light gray sand below 0.4 feet of silty sand. However, the two USACE vibracores from 2002 that were taken adjacent to this core showed poor material in the upper layer. As a result, the spatial extent of this resource is not defined and additional sampling in this area would be required if this resource is to be developed. The one composite sample from this upper layer is very poorly sorted and has a mean grain size of 0.35 mm, which is coarser than the native, likely due to the relatively high gravel content. This sample contains gravel-sized shell in excess of the 6% threshold (Table 4.13).

Characteristic	Required Borrow Site Parameters	Core Z - 174
Fines <#230	$\leq$ 6%	**1.34%**
Sand (> #230 & <#10)	-	**84.57%**
Granular (>#10 & < #4)	$\leq$ 6%	**2.28%**
Gravel (>#4)	$\leq$ 6%	**11.81%**
Calcium Carbonate	$\leq$ 35%	**11.10%**

Table 4.13 – Core Z-174 Composite Characteristics and Rule Parameters

4.6 Renewable Potential Borrow Areas

Renewable potential borrow areas are regularly dredged, naturally replenish, and offer repeated use as a sand source for beach nourishment. These areas have been previously identified and evaluated for compatibility with the native beach. These areas are described below.

4.6.1 Bogue Inlet Channel

Five vibracores were taken within the previously authorized channel relocation template from the 2005 Bogue Inlet relocation project (Figure 4.10). Based upon the vibracores and 2009 Geodynamics bathymetry, the previously excavated channel has infilled with fine grained, poorly sorted quartz sand with less than 1% fines or gravel and about 15% calcium carbonate in the form of shell hash. The samples taken from these cores have a composite mean grain size of 0.33 mm, which is slightly coarser than the native beach (0.30mm), indicating that the channel has in-filled with beach-compatible sand, which likely came from the surrounding beaches. This is supported by the low Overfill Factor of 1.15. This material falls within the parameters set forth by the Rule (Table 4.14) and has a similar grain size distribution to the native beach (Figure A3.13 in Appendix 3).

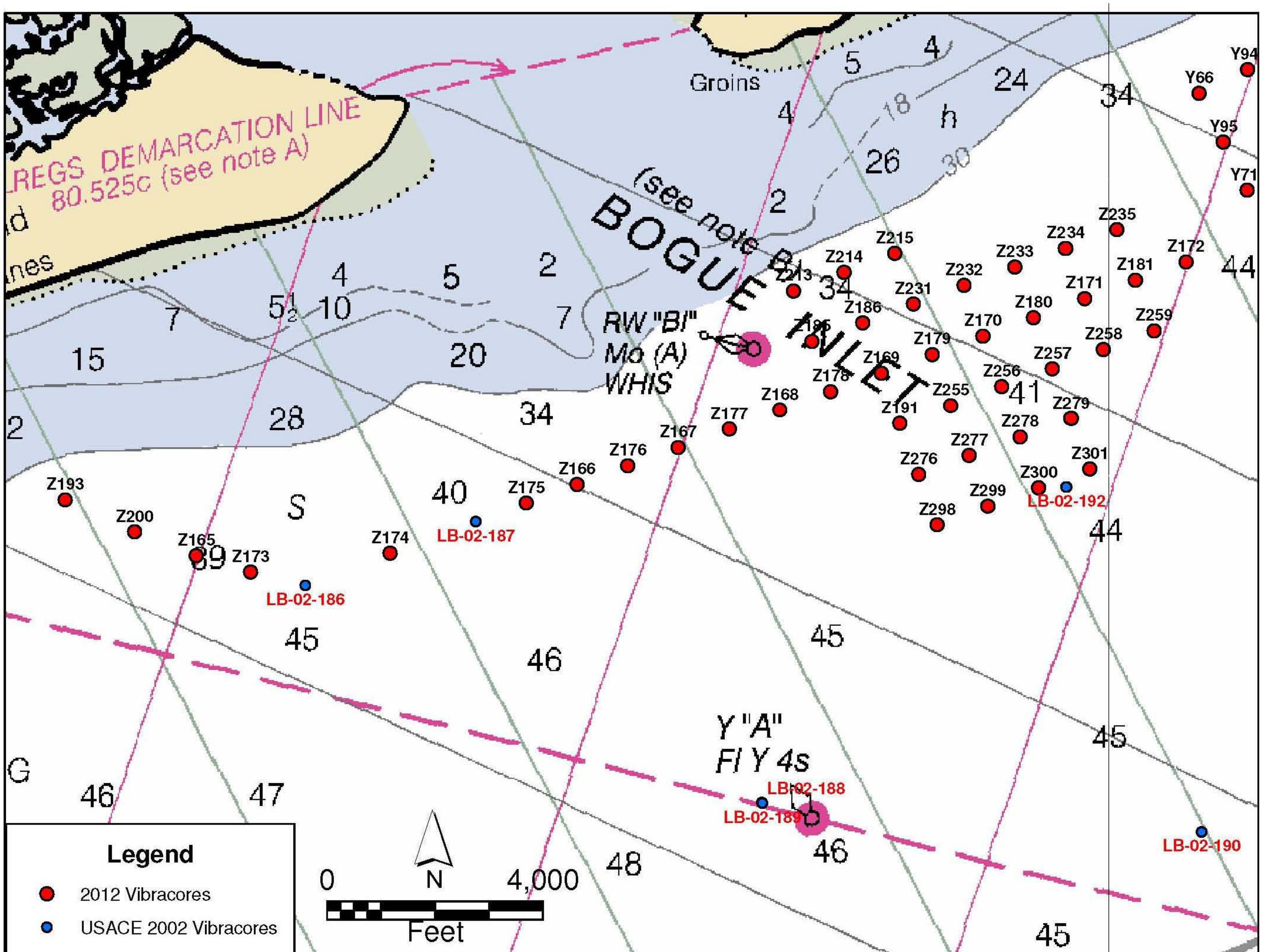

Figure 4.9 – Area Z Vibracores

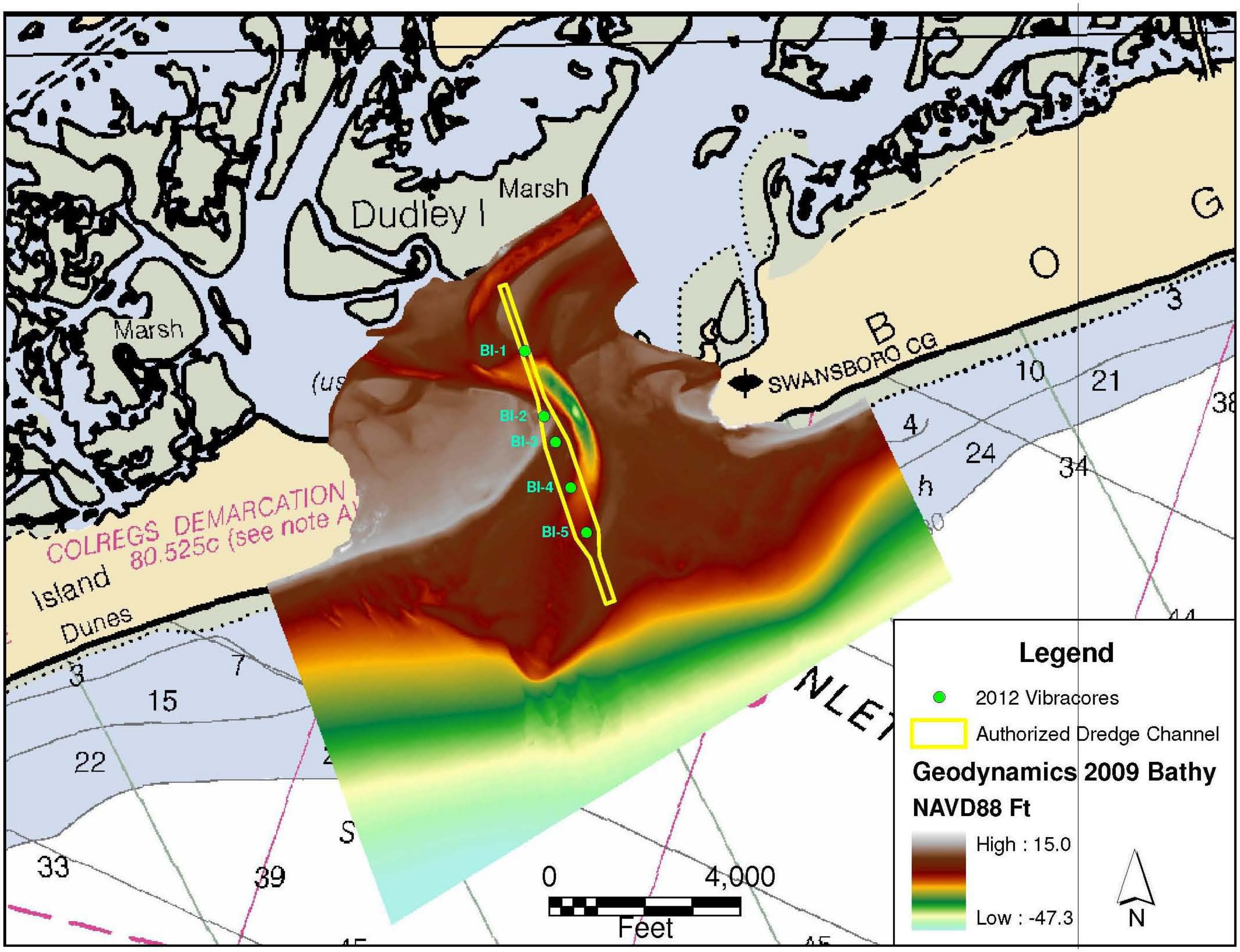

Figure 4.10 – Bogue Inlet Vibracores and Authorized Channel Location

Characteristic	Required Borrow Site Parameters	Bogue Inlet Channel
Fines <#230	$\leq$ 6%	**0.15%**
Sand (> #230 & <#10)	-	**96.61%**
Granular (>#10 & < #4)	$\leq$ 6%	**2.40%**
Gravel (>#4)	$\leq$ 6%	**0.84%**
Calcium Carbonate	$\leq$ 35%	**14.96%**

Table 4.14 – Bogue Inlet Channel Composite Characteristics and Rule Parameters

If the channel is dredged to the template associated with the previously authorized dredge depth of -18 feet NAVD88, it may produce between 850,000 cy to 1 Mcy of beach quality material as it did in 2005. This indicates that the channel may shoal up to about 100,000 cy per year. The 2012 vibracores only extended to a maximum of about 6 feet below the channel bottom or to around -12 feet NAVD88. However, it may be assumed that the previously excavated channel in-filled with only modern beach-compatible sand as the spit on the Bear Island shoulder migrates eastward into the inlet channel. The vibracores previously obtained within the inlet channel prior to the 2005 channel relocation also did not penetrate the full proposed dredge depth, while the excavated material proved to be beach-compatible sand.

4.6.2 Morehead City Outer Harbor

Outer portions of the Morehead City Harbor that are dredged regularly have proven to provide beach quality sand, while the inner portions of the Harbor generally produce sand with higher silt contents (USACE, 2009). The Outer Harbor consists of the Cutoff and Range A out to Station 110+00 (Figure 4.11). The Rule states that material dredged in association with a federal navigation project need only contain less than 10% silt in order to be deemed compatible with the native beach. The USACE tested 23 post-placement samples following the 2004 nourishment, which used this material, and found that it contained <1% fines, 6.4% gravel and 15.7% carbonate material (Olsen, 2006; USACE, 2010) (Table 4.15). Olsen and Associates estimated that the maintenance dredging of this portion of the channel will produce about 950,000 cy of sand per event (2006). The USACE Morehead City Harbor draft Dredged Material Management Plan (DMMP) estimates that the Outer Harbor is shoaling at a rate of 1.2 Mcy per year (2012). Depending on the final DMMP, there may be between 228,000-635,000 cy of sand available for beach placement annually. For the purposes of calculating available quantities of beach quality sand, a mid-range amount of 400,000 cy/yr is assumed to be available from this source.

Characteristic	Required Borrow Site Parameters	Morehead City Outer Harbor
Fines <#230	$\leq$ 6%	**<1%**
Sand (> #230 & <#10)	-	**Not Reported**
Granular (>#10 & < #4)	$\leq$ 6%	**Not Reported**
Gravel (>#4)	$\leq$ 6%	**6.40%**
Calcium Carbonate	$\leq$ 35%	**15.70%**

Table 4.15 – Morehead City Outer Harbor Composite Characteristics and Rule Parameters

4.6.3 Bogue Inlet – Atlantic Intracoastal Waterway Crossing

In addition to the sediment available from relocation of the main Bogue Inlet channel discussed in section 4.6.1 above, there is additional periodic dredging in the Atlantic Intracoastal Waterway (AIWW) Crossing (Figure 4.12). This channel is dredged every two to three years via pipeline dredge. Each dredging event can produce about 65,000 cy of sand that has traditionally been placed on "The Point" on western Emerald Isle (www.protectthebeach.com). These channel sediments were sampled by the USACE in 2002; results revealed that the sediment generally contained less than 2% fines or gravel, which is compatible with the Rule stipulation that material from a federally maintained navigation channel contain less than 10% fines by weight to be considered compatible with the native beach. A review of the sediment data from the analyses performed by Caitlin for the USACE shows the general character of the sediment that shoals in the AIWW Crossing, given in Table 4.16, below.

Characteristic	**Required Borrow Site Parameters**	**Bogue Inlet AIWW Crossing**
Fines <#230	≤ 6%	**<2%**
Sand (> #230 & <#10)	-	**>94%**
Granular (>#10 & < #4)	≤ 6%	**<2%**
Gravel (>#4)	≤ 6%	**<2%**
Calcium Carbonate	≤ 35%	**<15%**

Table 4.16 – Bogue Inlet AIWW Crossing Composite Characteristics and Rule Parameters

5.0 Conclusion

In summary, the potential borrow areas examined in this investigation were ranked based on the amount of data available and the compatibility of the material with the native beach composite as outlined by the Rule, as well as the Overfill Factor (Table 5.1). Potential borrow areas are given an A, B or C designation to reflect their desirability and reliability as a borrow area. Potential borrow areas designated by "A" are recommended for use as a sand source for nourishment of Carteret County beaches. Potential Borrow areas designated by "B" require additional vibracores to reliably define the stratigraphy or demonstrate compatibility of the sediment with the native beach consistent with the Rule. Potential Borrow areas designated by "C" are not recommended for use as a sand source for nourishment of Carteret County beaches due to insufficient data or poor compatibility of the sediment.

An estimated 19,821,325 cy of beach compatible material is given an "A" ranking because there is a significant amount of data available to define the stratigraphy, and the data show that the borrow area material is consistent with the Rule and solidly compatible with the native beach. About 1,348,975 cy of material was given the "B" ranking based on a lack of data and/or a higher Overfill Factor. If additional sampling verifies that the thickest portion of the mound is consistent with the sediment on the flanks, much of this volume can be moved into the "A" ranking. Finally, approximately 2,248,000 cy of material was given a "C" ranking because of a lack of data on these mounds, or because of poor compatibility; this material is not recommended for use as a sand source for beach nourishment.

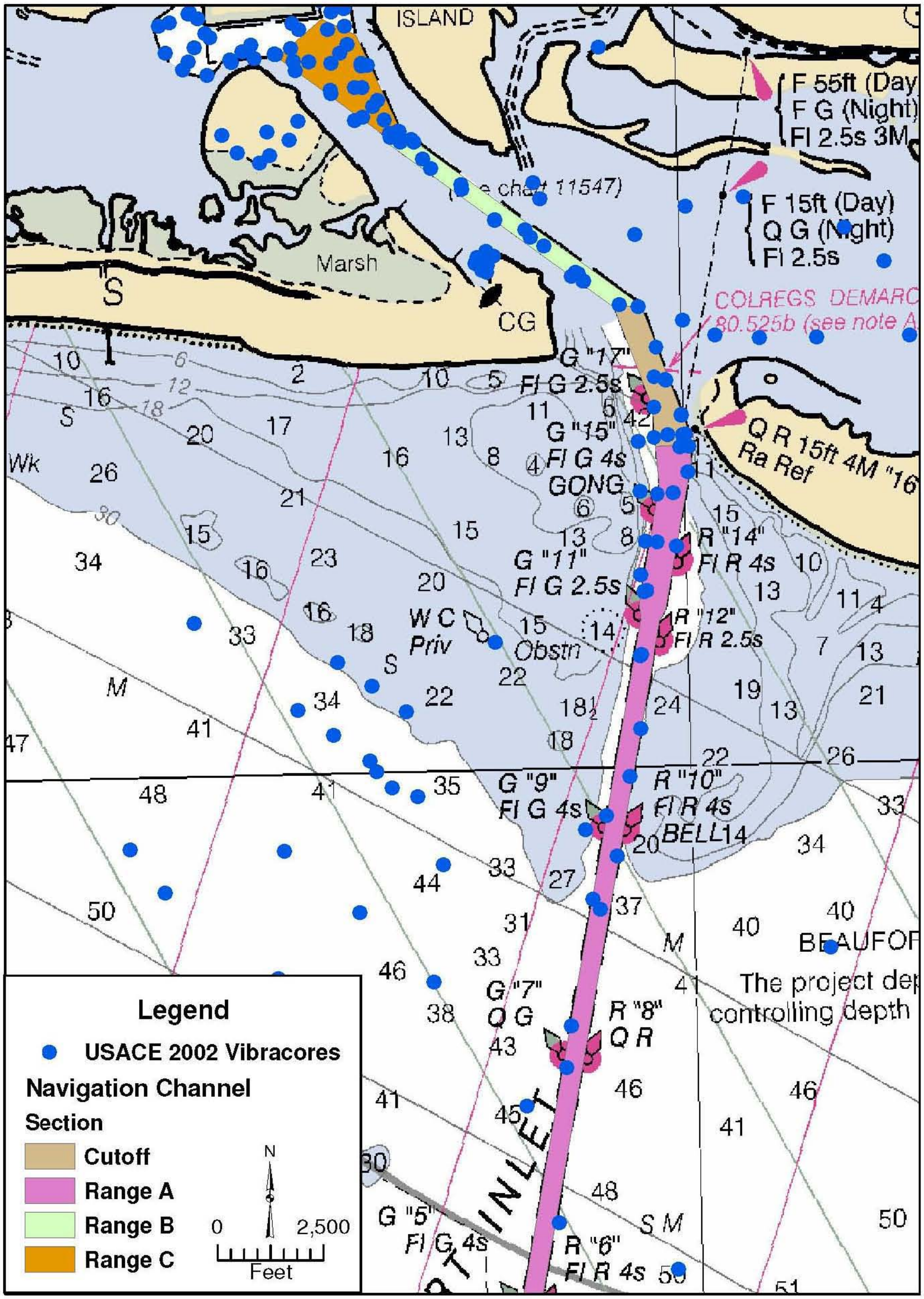

Figure 4.11 – Morehead City Channel Vibracore and Section Locations

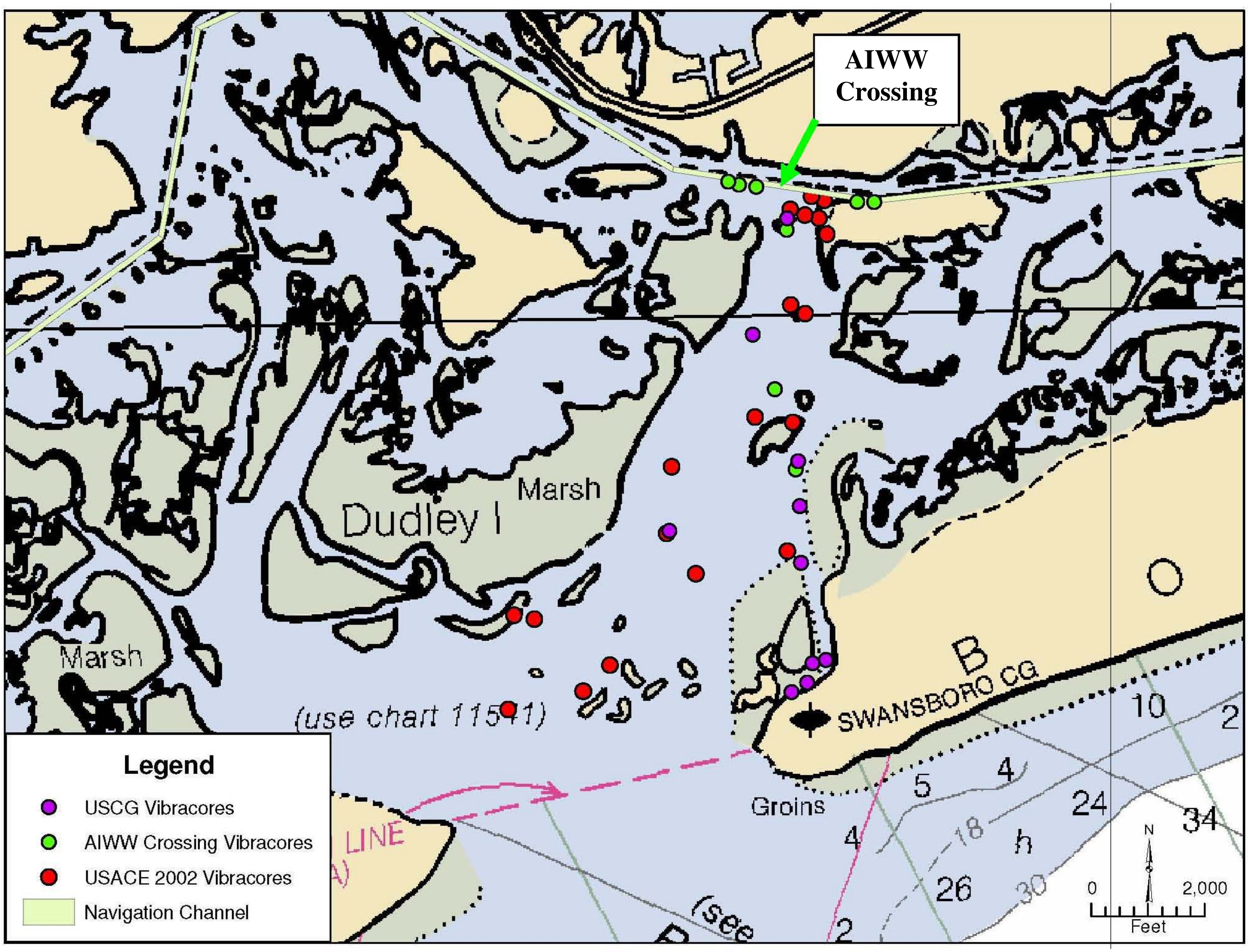

Figure 4.12 – Bogue Inlet AIWW Crossing

Area	Section	Navigation	Volume	Mean Grain Size (mm)	Fines (%)	CaCO3 (%)	Overfill Factor	Rank
Native Beach	CSE 2001 Composite	-	-	0.3	<1%	≤20%	-	-
Old ODMDS	Old ODMDS 1	no	13,138,307	0.3	0.53	13.6	1.25	A
	Old ODMDS 2	no	1,098,108	0.32	0.2	13.6%	1.25	A
Current ODMDS	Current ODMDS 1	no	4,233,612	0.3	0.52	13.3%	1.25	A
	O-192 Mound	no	785,270	0.36	0.13	19.6%	1.25	A
	O-14/O-47 Mound	no	566,028	0.38	0.23	19.8%	1.2	A
	O-15 Mound	no	355,920	0.24	0.07	10.1%	1.6	B
	O-35 Mound	no	499,491	0.3	0.31	15.2%	1.3	B
	O-46 Mound	no	493,564	0.4	0.37	18.2%	1.25	B
	O-48 Mound	no	468,740	0.2	5.91	7.8%	2.25	C
	Remaining Mounds	no	~320,000	-	-	-	-	C
Area Y	Y-80 Mound	no	1,079,853	0.23	2.37	1.5%	2.50	C
	Y-120 Mound	no	379,675	0.4	2.04	1.5%	1.30	C

Table 5.1 – Characteristics, Ranking and Volume of Non-Renewable Potential Borrow Areas

In addition to the non-renewable borrow areas ranked above, renewable borrow areas may provide approximately 15,322,992 cy over 30 years or 25,538,320 over 50 years (see Table 5.2). When added to the "A" ranked non-renewable material outlined above, there may be a total of 35,144,317 cy available over 30 years, which meets the 30 year estimated need of 15.7-26.9 Mcy. The combined non-renewable and renewable borrow areas may provide 45,359,645 cy available over 50 years, which meets the estimated 50 year need of 26-44.8 Mcy.

Area	Section	Volume	Dredging Frequency	30 yr Total volume	50 yr Total volume
MHC Outer Harbor	Cutoff+Range A to STA 110	400,000 cy (assumed)	1 years	12,000,000	20,000,000
Bogue Inlet	Inlet Relocation	847,664 cy	10 years	2,542,992	4,238,320
	AIWW Crossing	65,000 cy	2.5 years	780,000	1,300,000
			Totals:	**15,322,992**	**25,538,320**

Table 5.2 – Volume of Renewable Potential Borrow Areas

6.0 References

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Appendix 1

CD-ROM Containing
Alpine Ocean Seismic Survey, Inc.
Geotechnical Report

Appendix 2

CD-ROM Containing gINT
And Other Digital Files

Appendix 3

Potential Borrow Area
Composite Curves

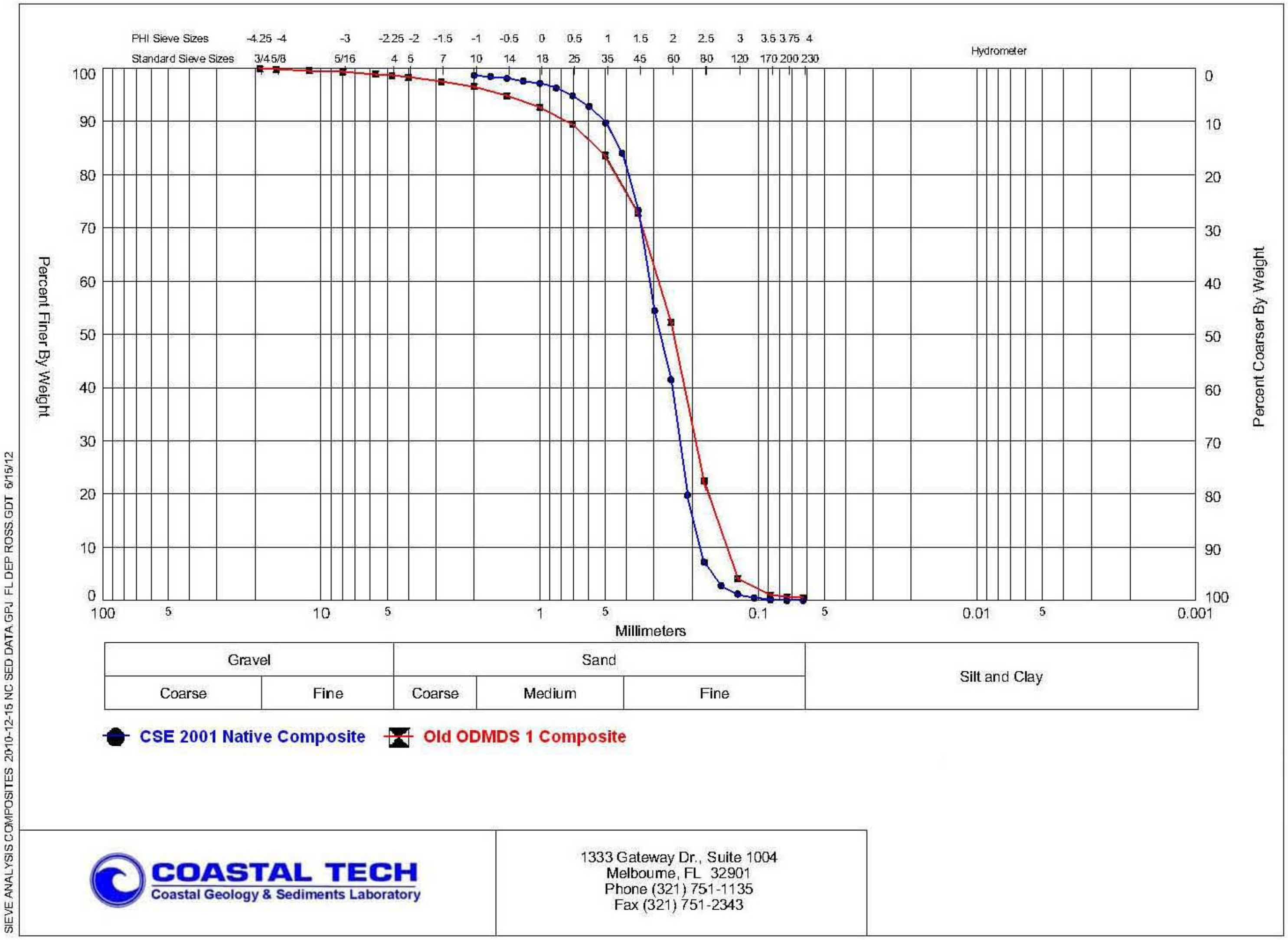

Figure A3.1 – Composite Curves of Old ODMDS 1 and CSE 2001 Native Beach

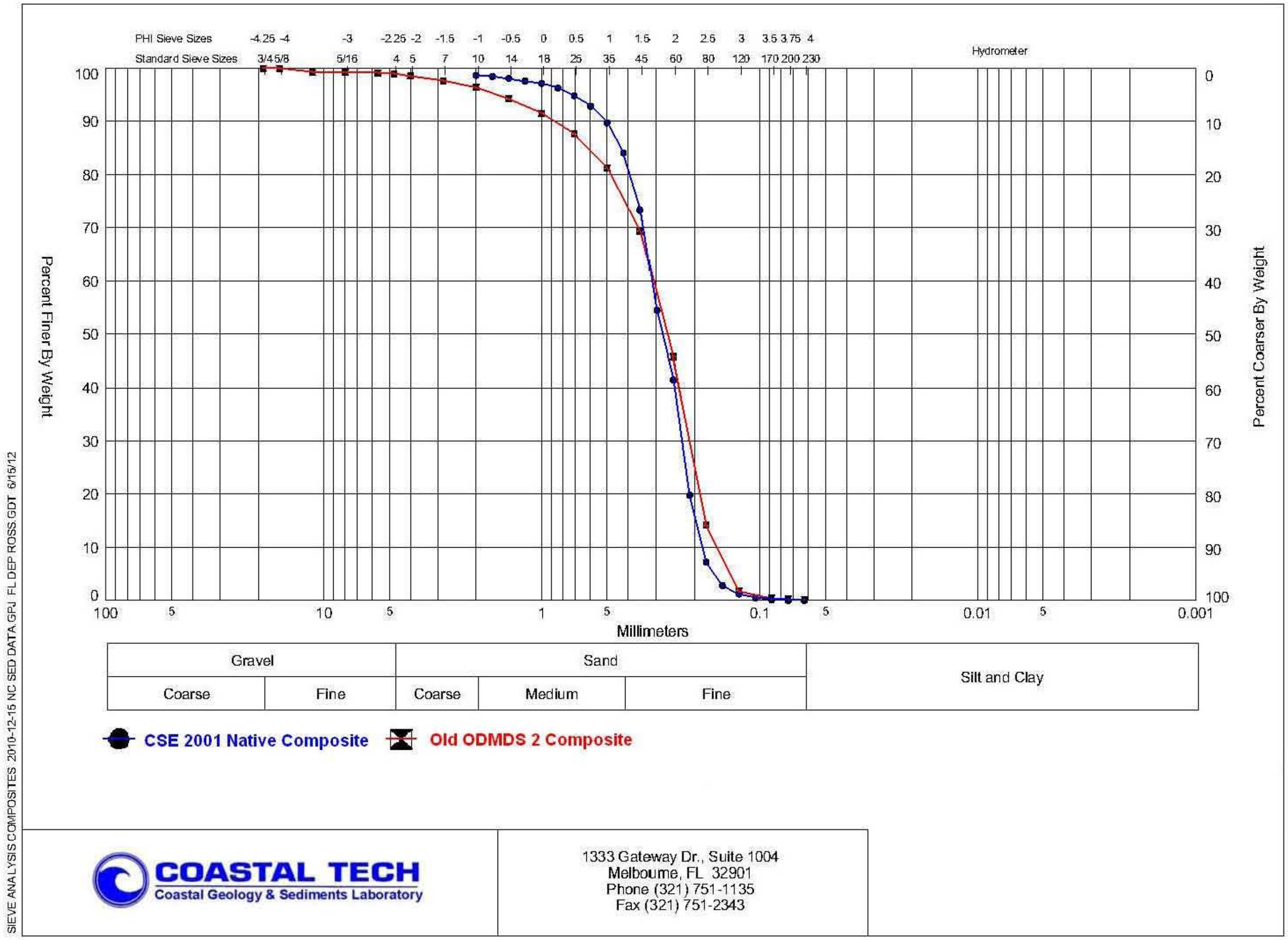

Figure A3.2 – Composite Curves of Old ODMDS 2 and CSE 2001 Native Beach

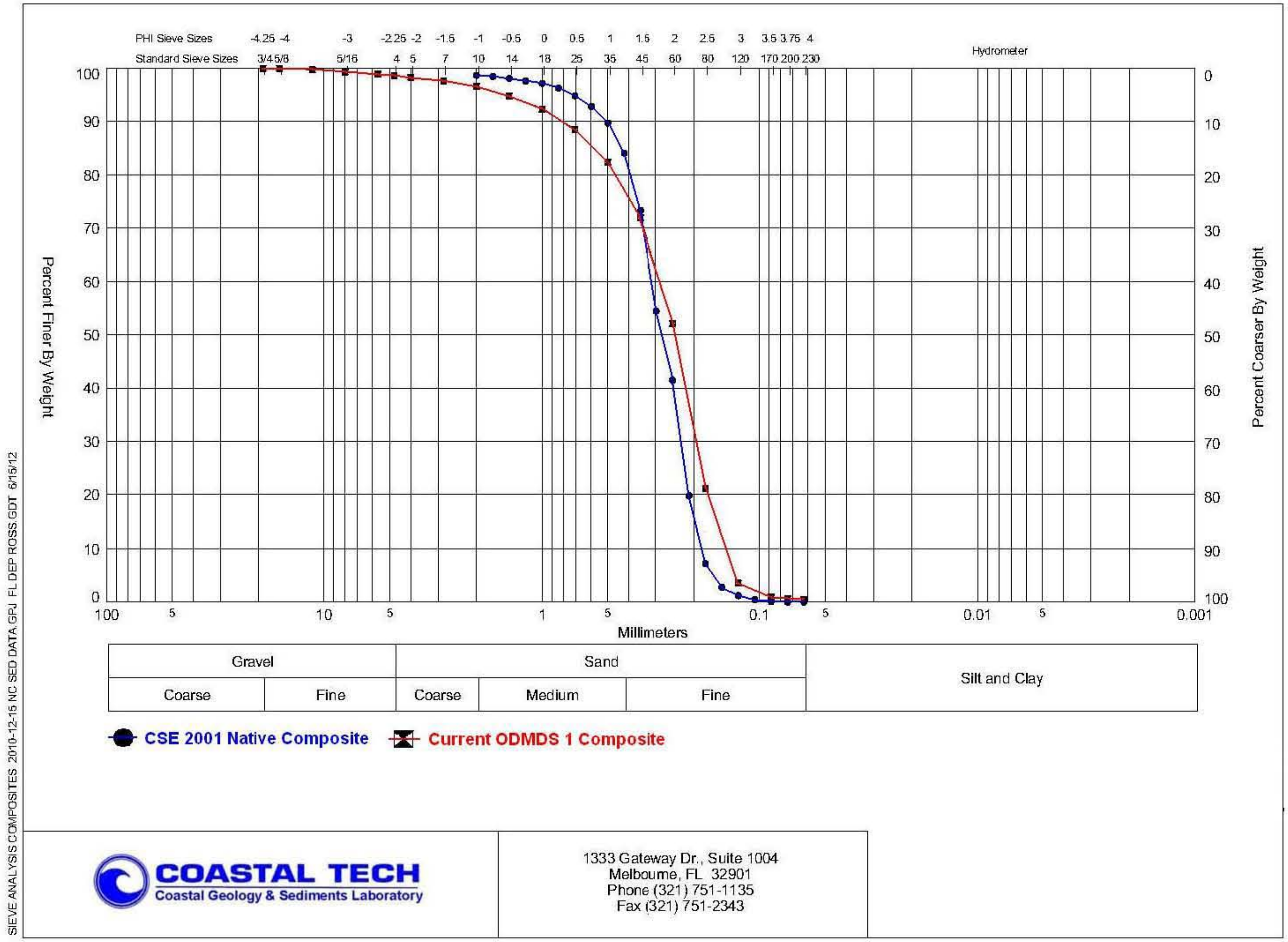

Figure A3.3 – Composite Curves of Current ODMDS 1 and CSE 2001 Native Beach

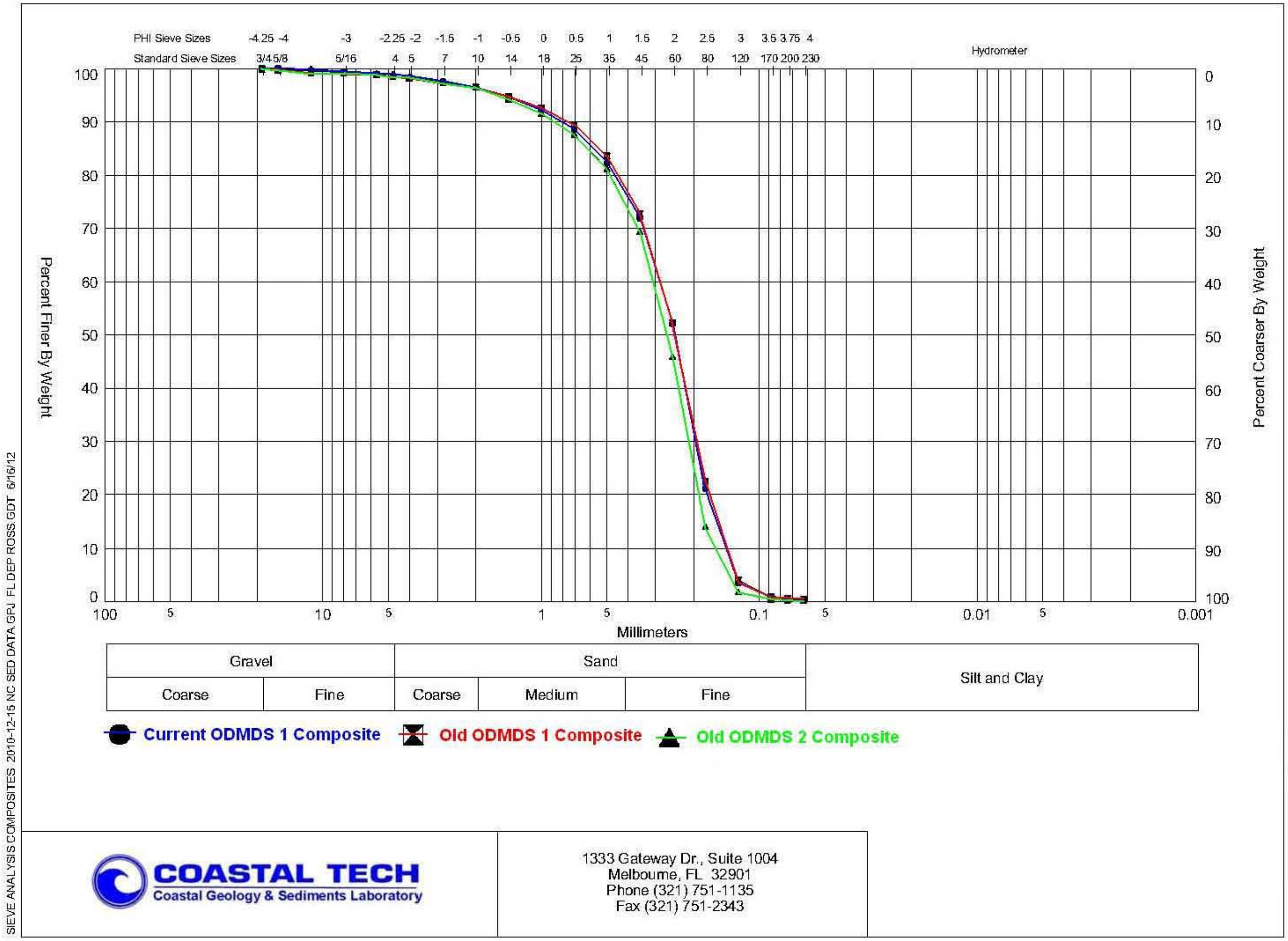

Figure A3.4 – Composite Curves of Old ODMDS 1, Old ODMDS 2, and Current ODMDS 1

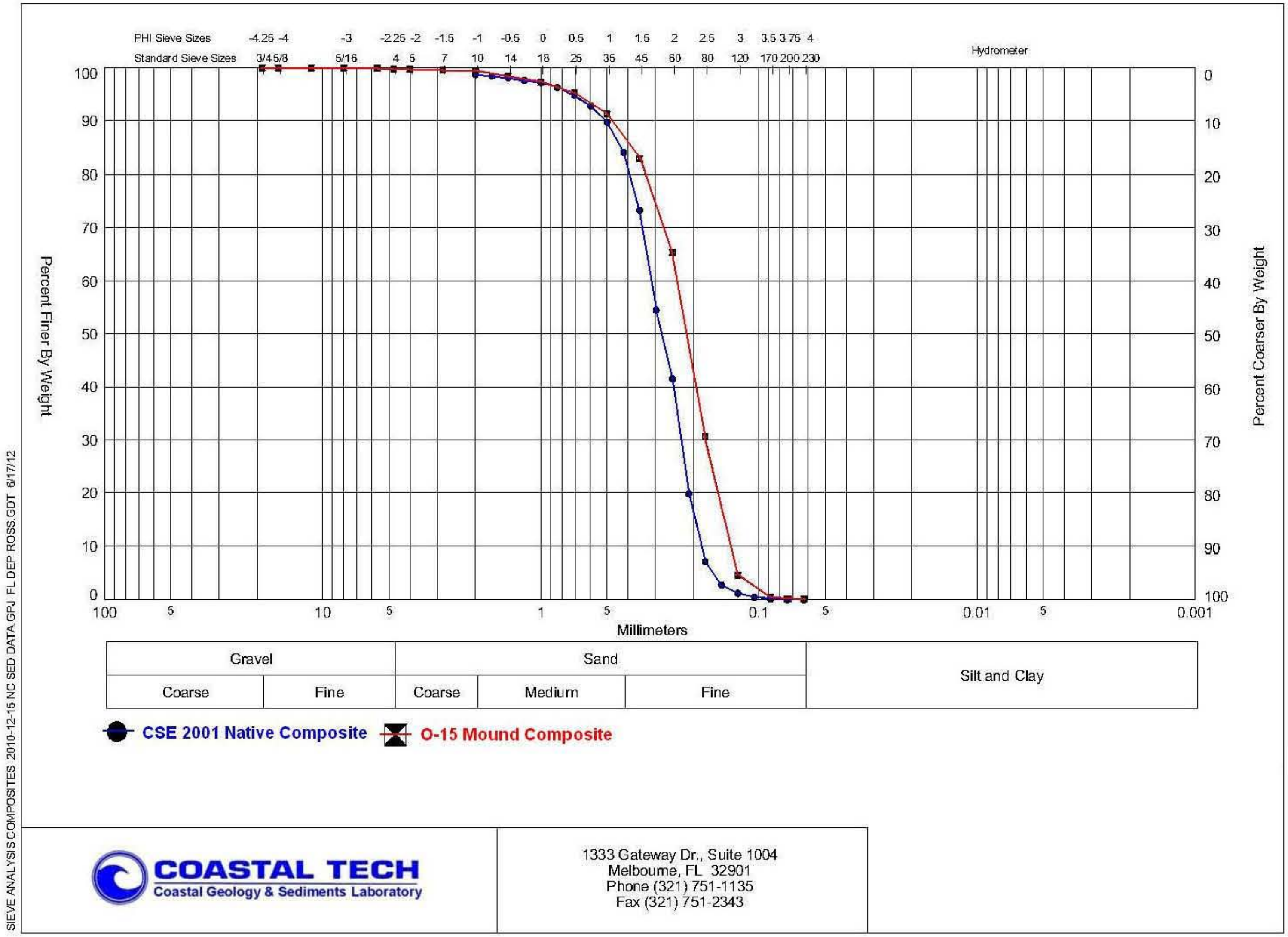

Figure A3.5 – Composite Curves of Mound O-15 and CSE 2001 Native Beach

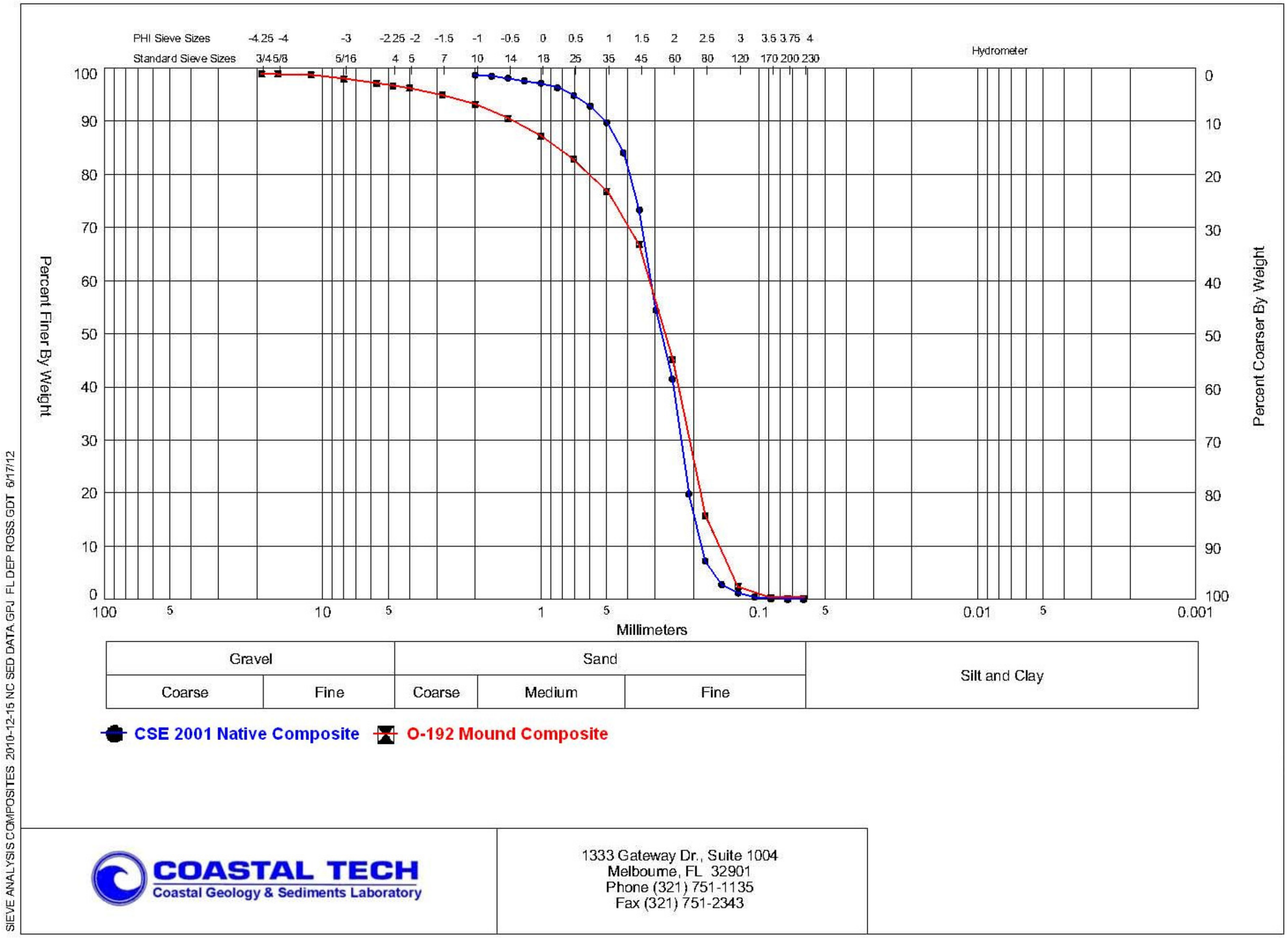

Figure A3.6 – Composite Curves of Mound O-192 and CSE 2001 Native Beach

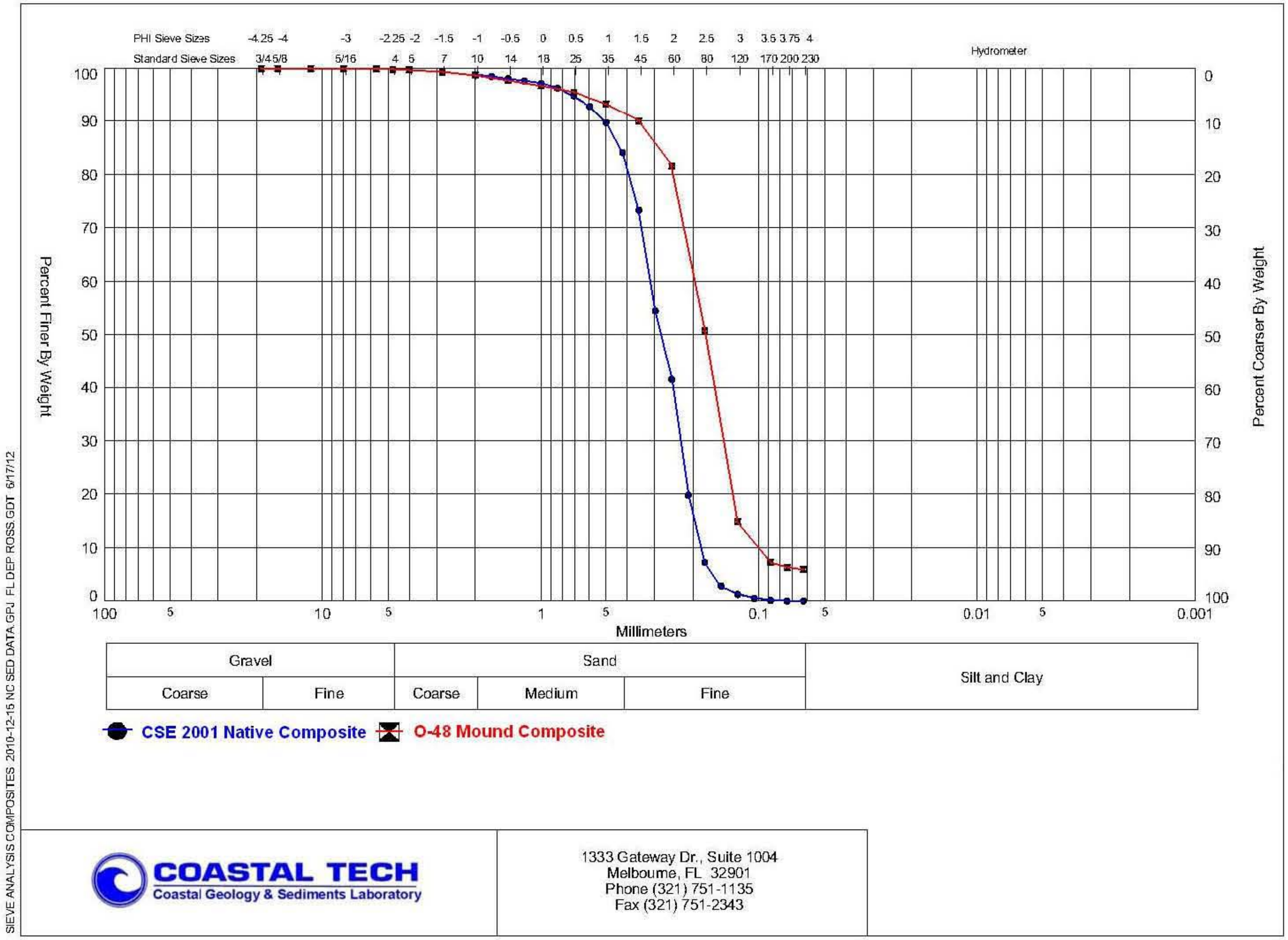

Figure A3.7 – Composite Curves of Mound O-48 and CSE 2001 Native Beach

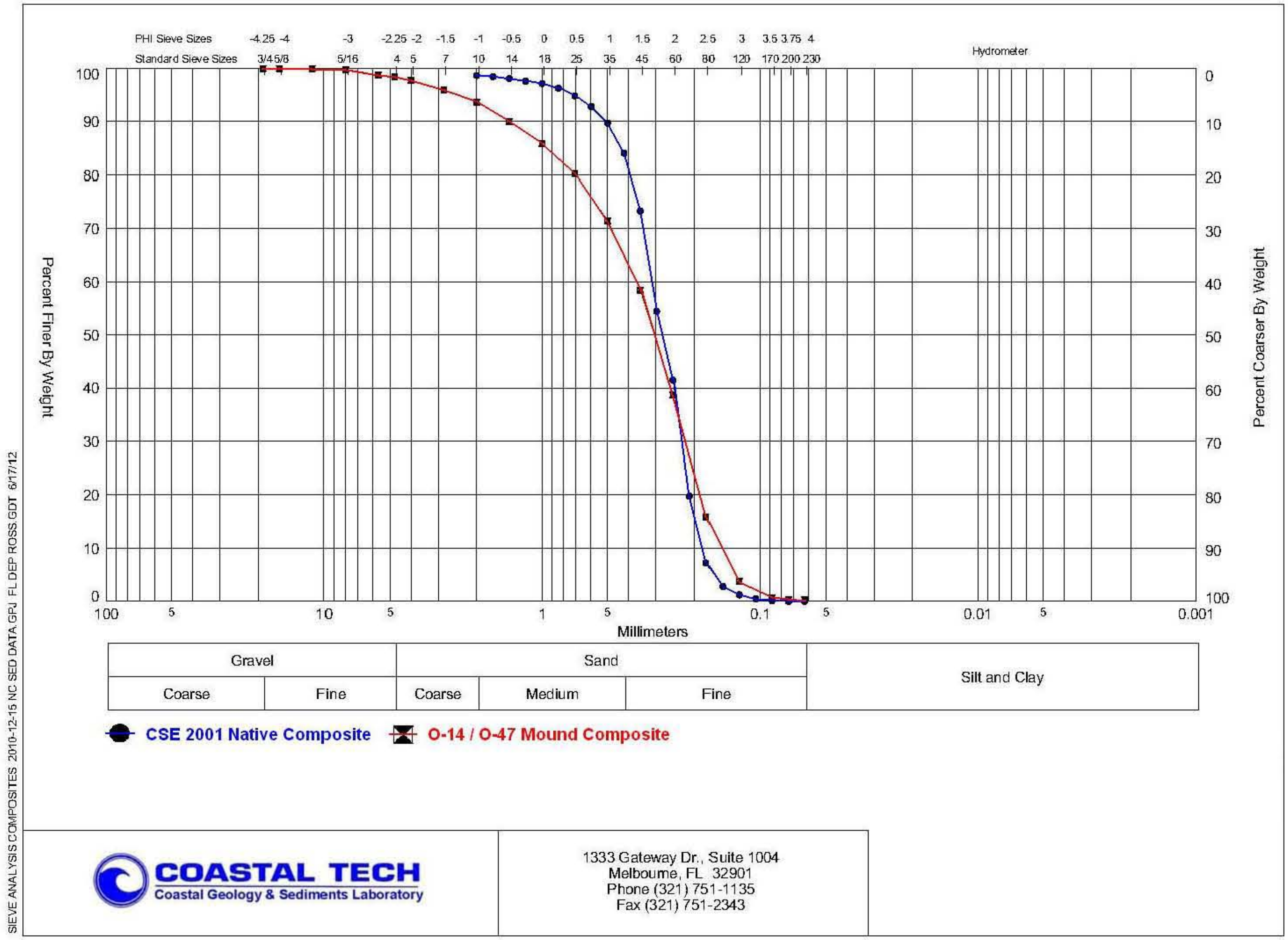

Figure A3.8 – Composite Curves of Mound O-14/O-47 and CSE 2001 Native Beach

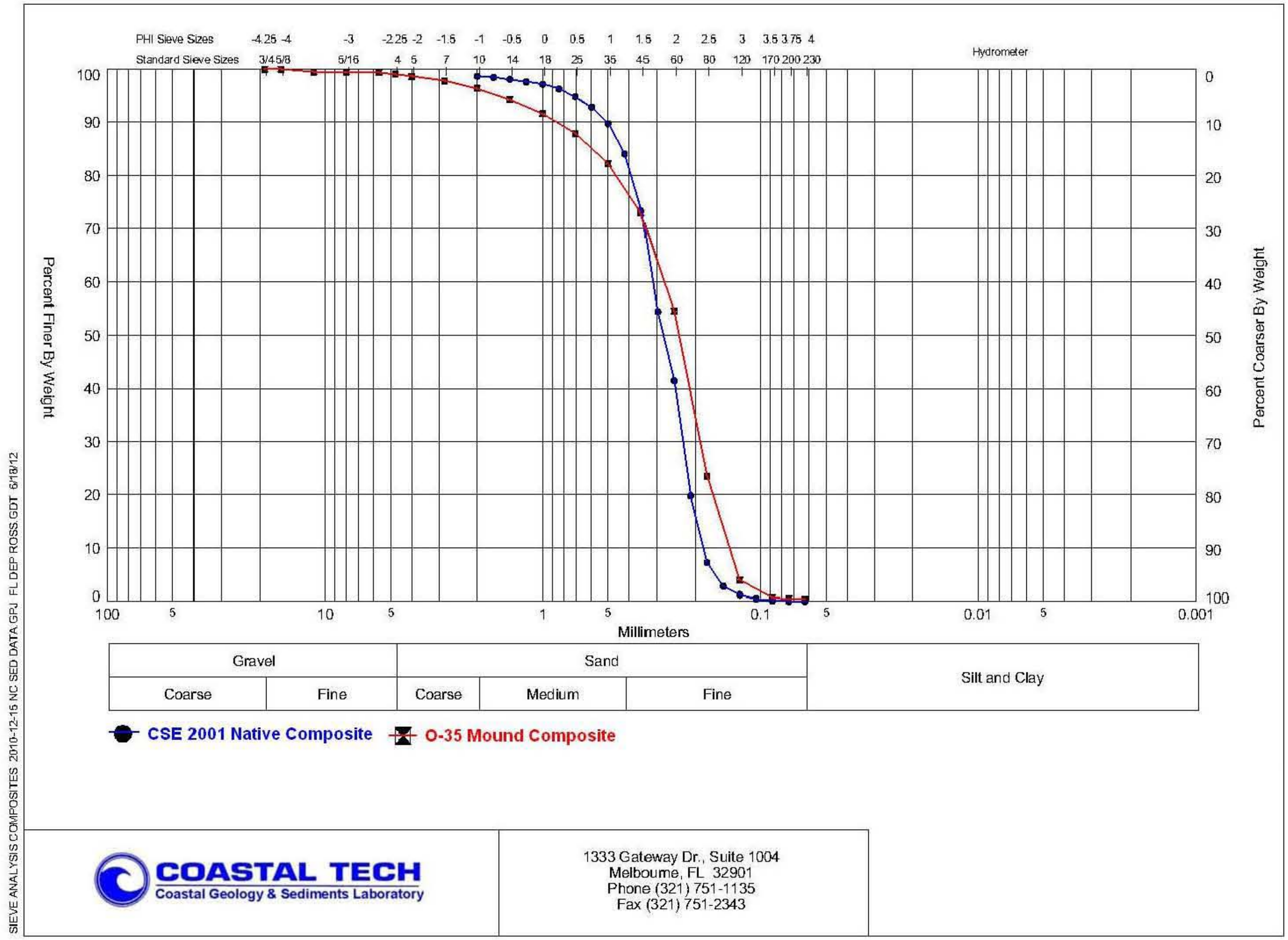

Figure A3.9 – Composite Curves of Mound O-35 and CSE 2001 Native Beach

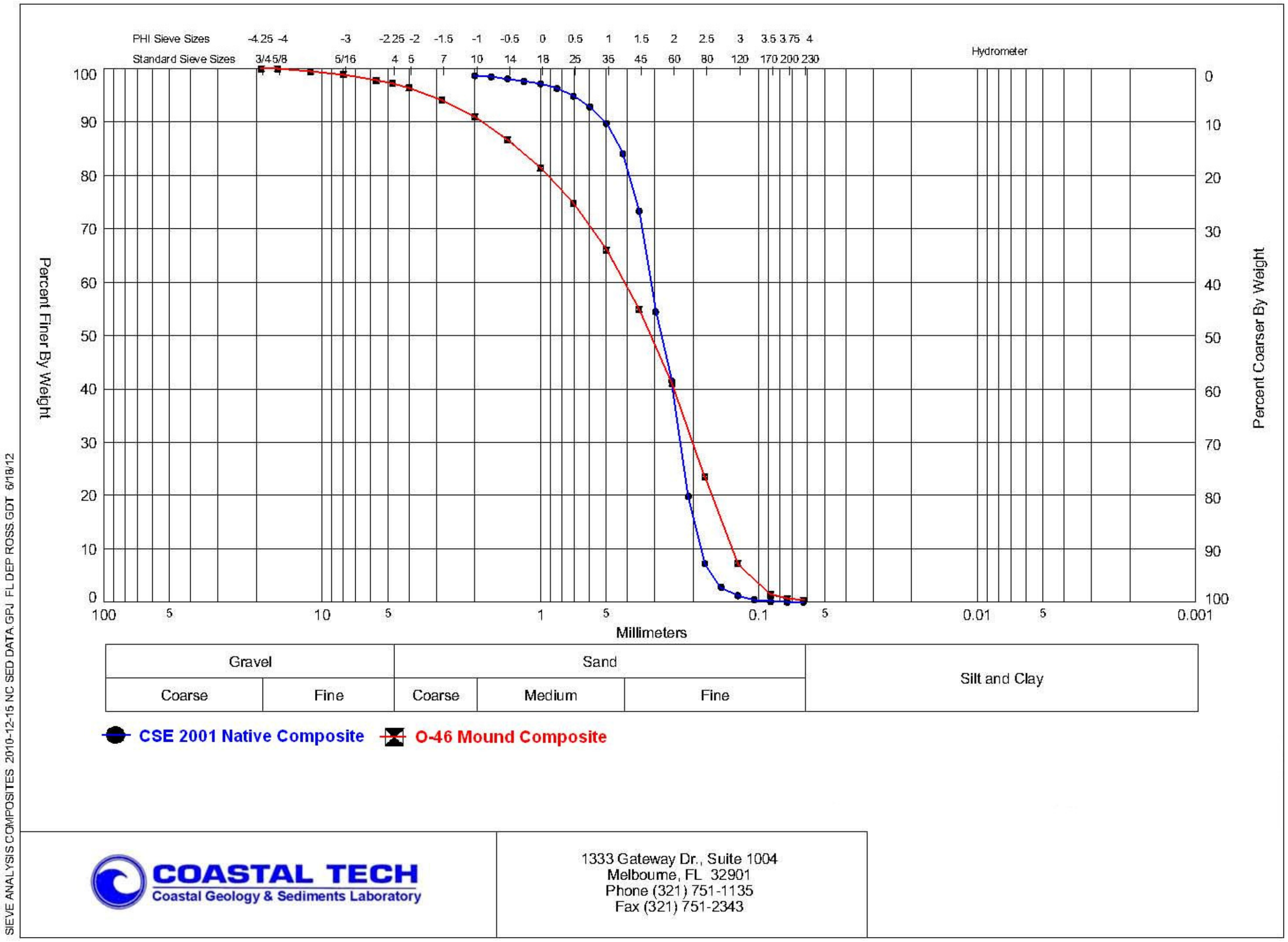

Figure A3.10 – Composite Curves of Mound O-46 and CSE 2001 Native Beach

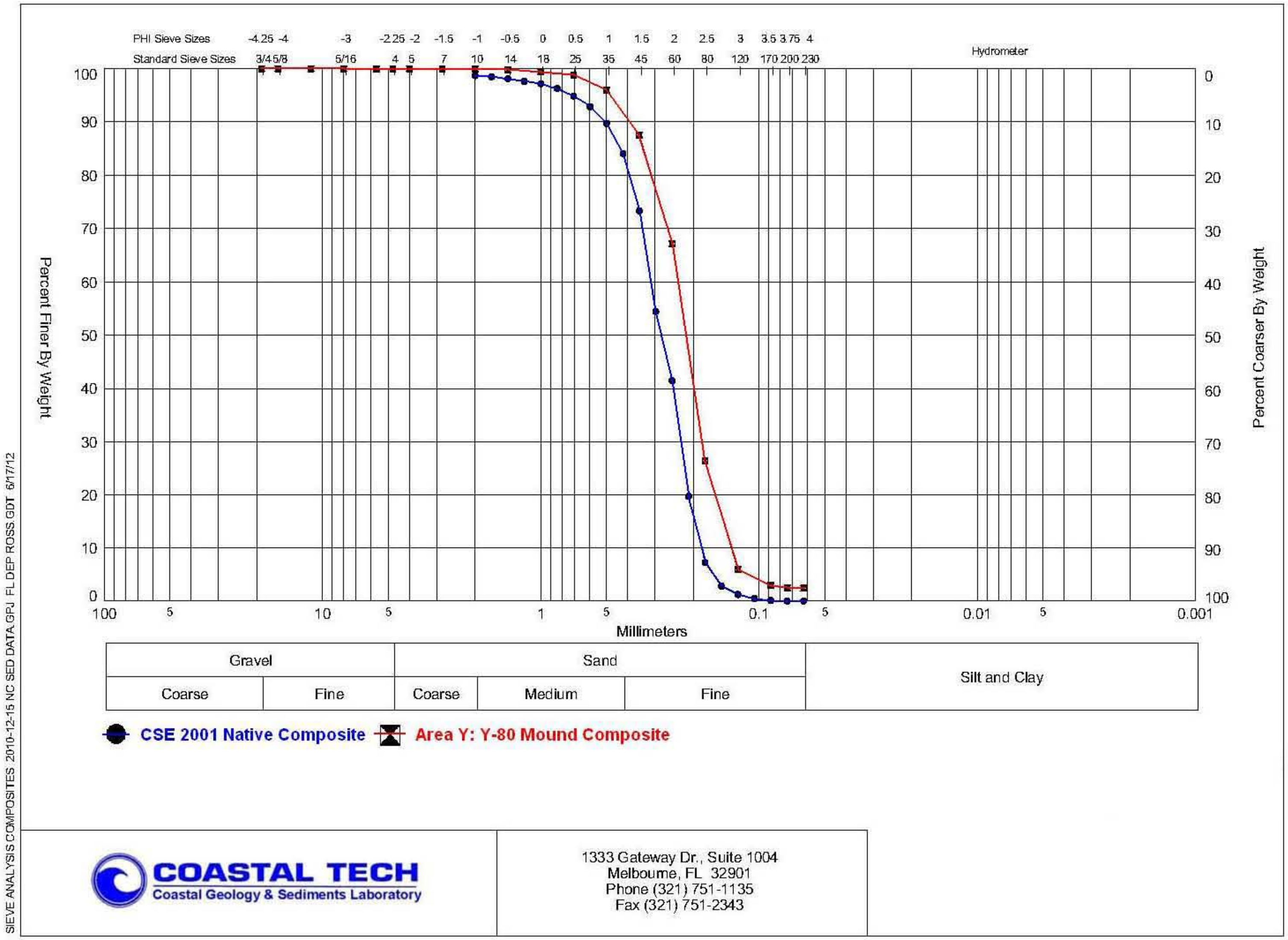

Figure A3.11 – Composite Curves of Area Y: Y-80 Mound and CSE 2001 Native Beach

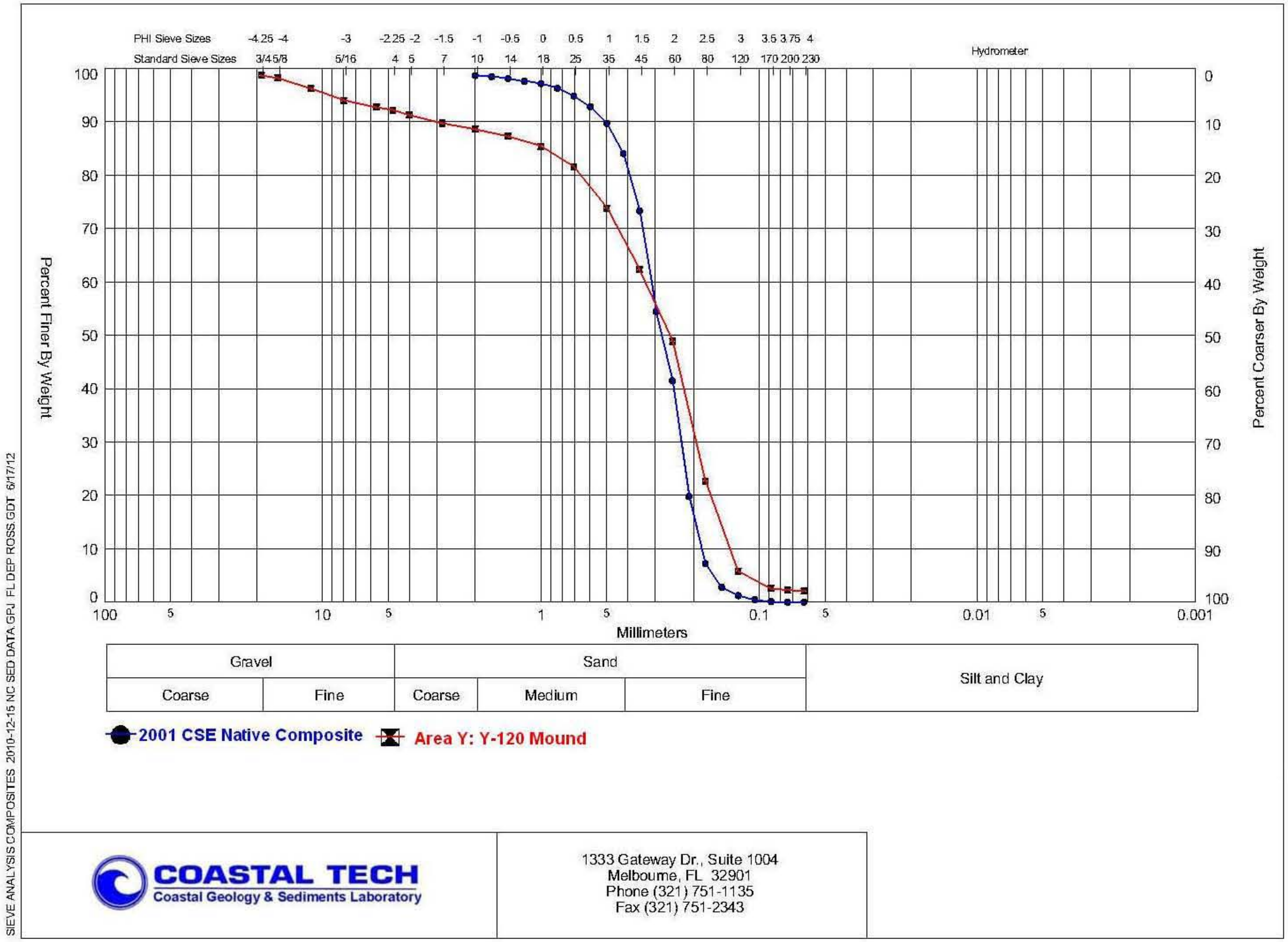

Figure A3.12 – Composite Curves of Area Y: Y-120 Mound and CSE 2001 Native Beach

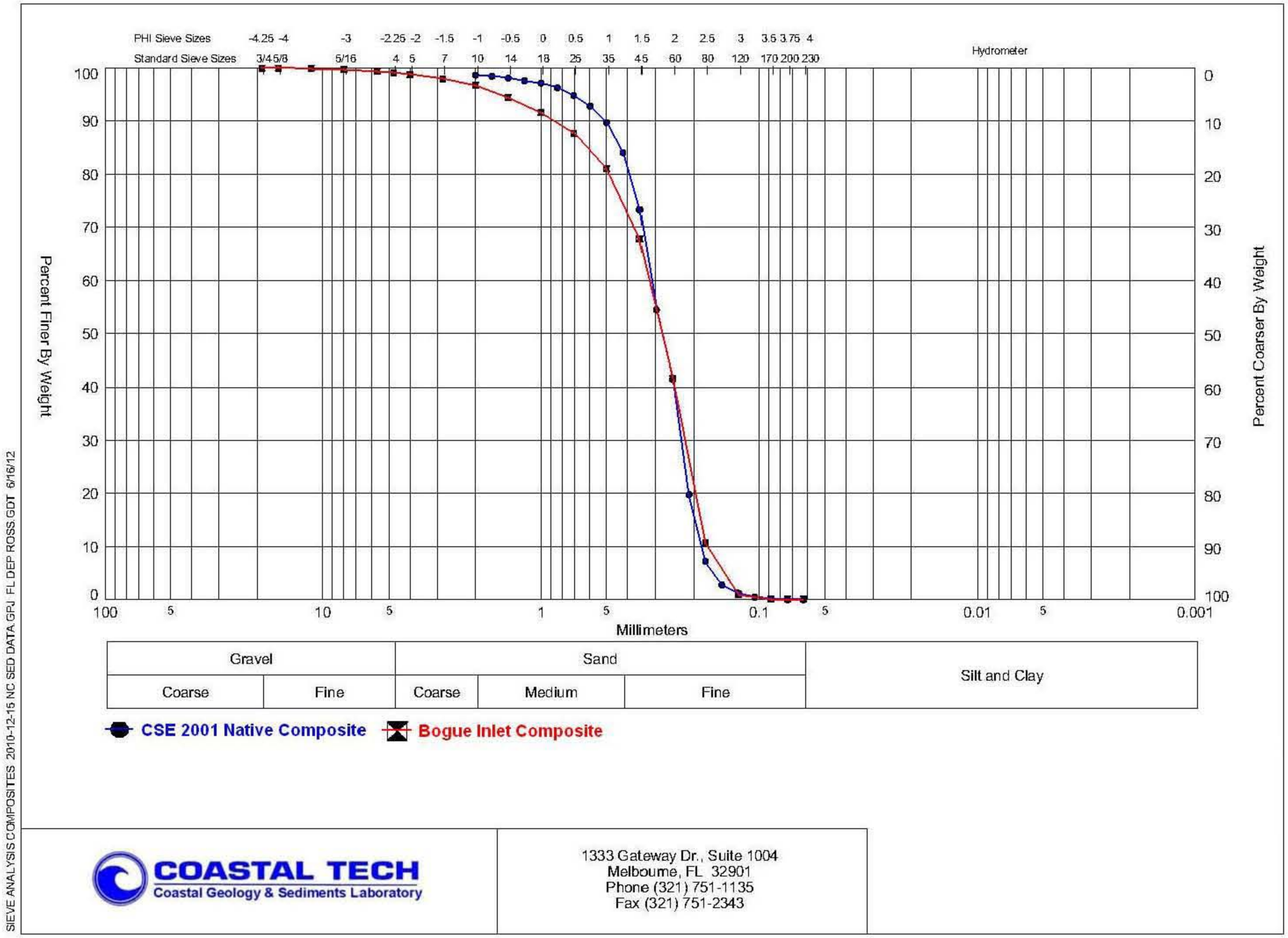

Figure A3.13 – Composite Curves of Bogue Inlet Channel and CSE 2001 Native Beach

Appendix 4

Potential Borrow Area
Overfill Factor Calculations

Bogue Banks

Sand Sample	Descriptive Statistics			James Method (1975)		
	Mean (mm)	*Mean (phi)*	*Std. Dev. (phi)*	$(M_b-M_n)/s_n$	s_b/s_n	**Overfill Factor**
2001 Native Composite	0.30	1.75	0.61	--	--	**--**
Old ODMDS1 Composite	0.30	1.76	1.11	0.02	1.82	1.30
Old ODMDS2 Composite	0.32	1.63	1.1	-0.20	1.80	1.25
Current ODMDS1 Composite	0.30	1.73	1.12	-0.03	1.84	1.25
Bogue Inlet Composite	0.33	1.59	1.03	-0.26	1.69	1.15
Y80 Composite	0.23	2.13	0.60	0.62	0.98	2.50
Y120 Composite	0.40	1.31	1.64	-0.72	2.69	1.30
Mound 15 Composite	0.24	2.07	0.80	0.52	1.31	1.60
Mound 192 Composite	0.36	1.47	1.26	-0.46	2.07	1.25
Mound O-14 Composite	0.38	1.40	1.28	-0.57	2.10	1.20
Mound O-35 Composite	0.30	1.76	1.14	0.02	1.87	1.30
Mound O-46 Composite	0.40	1.31	1.50	-0.72	2.46	1.25
Mound O-48 Composite	0.20	2.29	0.86	0.89	1.41	2.25