Offshore Sand Search Guidelines

September 21, 2010

Bureau of Beaches and Coastal Systems
Florida Department of Environmental Protection

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I. PROGRAM AUTHORIZATION AND BACKGROUND

1. Authorization

As stipulated in Chapter 161, Florida Statutes, the Legislature recognizes that beach erosion is a statewide problem, and that a state-initiated program (with funding support) is the most efficient means to properly manage Florida beaches. The Legislature has authorized the Florida Department of Environmental Protection (Department) to take necessary steps to implement a beach management and shore protection program. The Department has implemented this program using a number of ecosystem management tools, including: (1) funding assistance, (2) strategic planning, (3) environmental data acquisition and analysis, (4) project management, (5) regulatory oversight and (6) development of innovative technologies. Key among those factors which must be considered for any viable restoration or nourishment project is proper identification of a suitable source of beach-compatible sand.

For this document, the Department's Bureau of Beaches and Coastal Systems (Bureau) has combined two ecosystem management tools (environmental data acquisition/analysis and regulatory oversight) into one initiative - the Offshore Sand Search Guidelines project.

2. Background

From the 1960s through the mid-1980s, the search for potential borrow areas focused on Florida's coastal and nearshore waters. At that time, locating beach compatible sand did not routinely make use of a sophisticated sand search plan or extensive laboratory investigation. Tidal inlet shoals (ebb, flood) or nearshore sands were frequently targeted (i.e., Jupiter Island, 1973-1983; Ft. Pierce, 1983) as reliable sources of suitable sand. These borrow areas were generally close to the proposed project area and required a minimal economic investment.

Coastal and nearshore sand deposits were initially identified on the basis of their distinct geomorphology and/or local relief. These deposits accumulated from the diversion of littoral drift and therefore their "suitability" as beach fill was rarely in doubt. The process of estimating sediment quality and quantity were facilitated by shallow water and mild conditions of wave climate. Design considerations were minimal (i.e., median grain-size, percent fines) and generally limited to the performance of the proposed beach fill as a "soft solution" to shore protection. Environmental regulation was also minimal.

By the mid-1980s, the search for potential borrow areas began to move offshore. Several factors were responsible for this change, including the depletion of coastal and nearshore sand reserves and increased demand created by the urbanization of Florida's coastline and implementation of the Beach Management Act of 1986. Most of the coastal and nearshore sand deposits that had not yet been utilized were no longer considered as potential borrow areas because they generally lacked sufficient volume or could not be dredged under the increasing environmental constraints of habitat (i.e., seagrass, nearshore hardbottom) and water quality protection.

The search for offshore sand was initially a relatively simple task. Shoreface-connected and isolated shoals (e.g., Cape Canaveral Shoals, Brevard County; Capron Shoal, Ft. Pierce) were identified on the basis of their distinct geomorphology in water depths generally less than 30 feet. However, confirmation of suitability for beach placement now requires a more in-depth field and laboratory investigation, as these sand deposits are relict features that formed several thousand years ago and can be as much as 20 miles from the project area (e.g., Brevard County's South Reach Shore Protection Project). Initial volume estimates were also subject to revision after the details of sedimentology and stratigraphy were determined.

The search for offshore borrow areas has continued to move further offshore and field investigations now routinely include a survey of surface and sub-surface features. A successful offshore sand search is now commonly facilitated by the participation of a multidisciplinary team capable of designing an investigation that will detect sand resources that do not necessarily display a distinct geomorphology or must be identified using sub-bottom seismic surveys. Multidisciplinary teams may include a professional geologist, professional engineer, professional surveyor, and a marine archeologist with experience in the coastal systems of Florida.

Determination of compatibility includes consideration of sediment grain size, sediment composition and color. These additional compatibility constraints reflect the fact that beach nourishment projects are no longer designed solely for shore protection. Parameters related to environmental function, recreational use, and aesthetics are now routinely evaluated.

Today, offshore sand searches extend to distances in excess of six miles offshore and are conducted in water depths approaching 100 feet. Potential borrow areas may not be present as distinct bathymetric features, but instead as subtle sub-bottom features identifiable only on the basis of geophysics and the presence of distinct internal sedimentary structures. Investigations may require the use of vibracores, bathymetric, seismic, magnetometer, and sidescan surveys. To ensure compatibility with the project beach and a sufficient volume of recoverable material, a much denser data set must be acquired from both the potential borrow area and the project beach.

3. Goals and Guideline Objectives

The Department's principle objective is to establish technical recommendations of content, format, and quality of geologic information while providing maximum flexibility to modify an investigation as warranted by project-specific conditions. Once the Department adopts the offshore sand search guidelines document, it can be used for guidance to develop a standard Scope of Work for use by local project sponsors. Not all projects will be required to include each task that is referenced in the guidelines. Tasks may be omitted from a project's Scope of Work as long as each omission is justified by an explanation of site-specific conditions or project-specific design parameters. Conversely, additional tasks may be warranted in an investigation when accompanied by an explanation of their necessity.

When the guidelines document is used appropriately, professional engineers/ professional geologists will be able to draft a Scope of Work, conduct an offshore investigation, and deliver a report knowing *a priori* that each element meets the expectations of State and local project sponsors. Thus, the need for additional iterations requiring more resource expenditure and time will be minimized. This document does not constitute specific requirements of sand search investigations, but it documents the overall process that provides the Department with reasonable assurance of the quality of the data received and standardizes the formats for deliverables for the Reconnaissance Offshore Sand Search/ Offshore Sand Source Inventory, Scope of Work deliverables, and Joint Coastal Permit application submittals.

An additional goal of these guidelines is to formalize the content and format of geotechnical data submitted to the Department for review. These guidelines detail the content and format of the deliverables to ensure that deliverables/submittals contain the correct information, and to allow for a more streamlined review by Bureau staff. The sand search report should be submitted in paper copy and include detailed maps of the study area/ borrow area, including locations of seismic lines, bathymetric contours, and vibracores.

The Department encourages coordination with Bureau staff at each step of the sand search investigation. Coordination often begins with the submittal of a Scope of Work for review. The Department also encourages the local sponsor to submit sand search scopes of work for review even if it is only a courtesy review and State cost-sharing funds are not being requested. Scope of Work review furthers one of the goals of this guideline by allowing for review of the plan of investigation to ensure that the data collected (and ultimately submitted) for review are adequate for the permitting process.

4. ROSS / OSSI

The Reconnaissance Offshore Sand Search/ Offshore Sand Source Inventory (ROSS/OSSI) is a statewide program to identify strategic offshore sand resources for the planning and construction of beach nourishment projects by the Department and local government sponsors. The ROSS/OSSI system provides a comprehensive tool that allows the identification and assessment of potential offshore sand resources that are suitable for beach nourishment projects. The 2007 Legislature amended Chapter 161.144, F. S., to require the Department to develop and maintain an inventory of identified offshore sand sources that provides information on location and classification of sand sources as potential, proposed or permitted borrow areas. The Department is developing a comprehensive web-based Offshore Sand Source Inventory (OSSI) with additional information on sand volume and quality as a tool for strategic planning of sand resources.

At the end of each phase of the investigation, ROSS/OSSI data should be submitted and/or updated. This includes more than simply shapefiles of the borrow area and vibracore/seismic line locations. Updated information for inclusion in OSSI should be submitted at each stage of the sand search and design as the borrow area evolves from potential to proposed to permitted. This includes an update of the available/used volume of beach compatible sand and sediment composite data to characterize the material remaining in the borrow area.

5. Other Agency Requirements

This document is meant to serve as a guideline for investigating a potential sand source such that the information collected and submitted meets the permitting requirements for the

Bureau. Current guidance from the State Historic Preservation Office (SHPO) and the Bureau of Ocean Energy Management, Regulation, and Enforcement (BOEMRE) (formerly the Minerals Management Service) suggests that the remote sensing surveys should utilize modern remote sensing technology and include the collection of magnetometer, bathymetric, sidescan sonar and sub-bottom seismic profiling data. These data must be collected in real-time, correlated with either a Real Time Kinematic Global Positioning System (RTK GPS) or a Differential Global Positioning System (DGPS). The surveys must be directed by a professional surveyor and mapper and coordinated with a qualified marine archaeologist. The marine archaeologist should have experience in the operation of remote sensing instrumentation and specific knowledge of Florida's maritime history. Magnetic anomalies that indicate a potentially significant cultural resource are identified for avoidance by the marine archaeologist. The marine archaeologist will typically provide recommendations for horizontal and/or vertical offset buffers. SHPO requires that vibracores collected subsequent to the remote sensing survey be collected within 50 feet of the as-run remote sensing survey lines and must avoid any cultural resources identified as potentially significant by the marine archaeologist, using buffers accepted by SHPO.

This document does not detail all requirements of other State and Federal agencies, including BOEMRE or SHPO, for investigating and permitting borrow sources and their recipient beach placement sites. Communication and coordination on the part of the local sponsor and the professional engineer/ professional geologist is still necessary to ensure other agency requirements are met, especially as requirements of State and Federal agencies are subject to change.

II. PRINCIPAL STAGES OF AN OFFSHORE SAND SEARCH

Most large engineering or scientific investigations proceed in a series of stages. To a first approximation, all offshore sand search investigations follow the same generalized procedures. Sand search investigations differ in the size of the area they cover. To be technically effective while remaining cost efficient, sand search investigation programs should involve the following principle tasks:

1. Office study and planning

The office study stage of a sand search involves the establishment of volumetric objectives and criteria for the sediment characteristics deemed to be compatible with the recipient beach, a review of existing information, the development of a survey design and sampling plan of the reconnaissance level field investigation, and the development of a budget and timeline. At the conclusion of the office study, offshore areas that have the potential to meet the sediment compatibility criteria are designated for reconnaissance level investigation and permits for field investigations are obtained from the appropriate agencies. The application of experience and professional judgment by a coastal geologist is critical in planning a successful offshore sand search.

2. Reconnaissance level investigation of potential borrow areas

Using the information collected during the office study, a reconnaissance level investigation shall be developed. During the reconnaissance level investigation, data are collected throughout a large area or at a number of discreet sedimentary features to obtain a limited amount of information on potential borrow sources. This stage typically involves the collection of a comprehensive set of bathymetric records, sub-bottom seismic surveys, sidescan sonar surveys, magnetometer surveys, vibracores, and samples of native/existing beach sediments (if not previously collected). Based on the results of the reconnaissance investigations, the sand search area or targeted sedimentary features can be further refined to the most promising sand deposits, and a more detailed design level field investigation can be planned.

3. Design level investigation of potential borrow areas

Based on the analysis of the data from the reconnaissance level investigation, the collection of additional data is typically required during this stage to fully examine the proposed borrow areas and comply with regulatory requirements. Additional vibracores and sub-bottom seismic data may be collected at this stage to fill in data gaps and create data coverage adequate for design and permitting of the proposed borrow area. These additional data may also include a more detailed sidescan sonar survey to detect obstructions, hard-bottom or other environmental resources and a magnetometer survey to detect cultural resources of historical significance and obstructions to dredging. These cultural and environmental resource surveys should be performed on a closer line spacing to fill in data gaps and provide adequate data coverage to delineate any resources in the area. Continuing coordination and communication with the resource agencies on the part of the local sponsor and their coastal geologist is necessary to ensure all agency requirements are met.

4. Detailed characterization of specific borrow sites and designation as potential, proposed, or unsuitable for future use

After the reconnaissance and design level investigations are completed, data will exist in a quantity and quality sufficient to designate a borrow area as potential, proposed, or unsuitable for future use. Potential borrow areas may have been identified in the office study or reconnaissance level investigation as potential, but not further investigated for use in the current study or in enough detail to designate it as proposed. Proposed borrow areas contain enough data in a sufficient quantity and quality to move to permitting.

During an investigation, borrow areas may be designated as a potential sand source, but may not be investigated further. While the targeted sedimentary feature may be beach compatible, its use may not be necessary to meet the volumetric need for the current project. It may not be further investigated or developed because a closer or more compatible source is available. A feature may be designated as unsuitable for future use for a given project or abandoned entirely due to poor sediment quality. When data are updated for the ROSS/OSSI database at each stage of an investigation, the borrow area designations should be reevaluated and appropriately changed. The geotechnical data will be included in ROSS/OSSI regardless of sediment quality so that future researchers can evaluate all of the available data and determine sediment compatibility for future projects.

5. Compatibility analysis and final design of the specific borrow area

The compatibility analysis will include the identification of suitable and unsuitable sediment horizons based on the sediment criteria established for the project and considerations of potential borrow area material performance after project construction. The final borrow area design and the borrow area plans and specifications are prepared when all the concerns regarding the sediment quality within the borrow area, the cultural resource impact potential, the environmental consideration, and the physical considerations have been addressed. The results of the previous tasks will be used to define the geometry (i.e., lateral boundaries and excavation depths) of the borrow area(s).

Each of these investigation stages may include similar operational elements. Each stage of investigation may involve planning, field sampling, laboratory testing, data analysis and reporting. Professional judgment of a coastal geologist is necessary when interpreting the data collected and planning each step of the investigation and final design of the borrow area. The scope or level of effort in each stage depends on the types of borrow sources being investigated, the design parameters of the proposed fill area, the amount of available information and the relative degree of 'success' in each antecedent stage of the sand search. The following sections describe the objectives and tasks that should provide adequate coastal data for beach management planning and permitting.

III. PRIMARY TASKS OF AN OFFSHORE SAND SEARCH

Task 1- Office Study and Planning

a) Preliminary Planning

This stage involves an office study of maps, charts, the ROSS/OSSI database, and literature sources concerning the targeted general investigation area. These materials provide information on the regional geomorphology and geology, help to identify features that may contain potential fill material, and suggest a logical sequence and boundaries for the study.

At the beginning of a sand search, specifications are established as the minimum criteria for beach-compatible sediment suitable for the proposed project area. The specifications are based on the native/existing beach sediment characteristics at the proposed project area, which may require additional sediment sampling and analysis at the project beach during this stage of the investigation. The specifications include silt content, visual shell content, carbonate content, gravel content, moist Munsell color, sorting, and grain size distribution.

Offshore sites are chosen as preliminary targets based on any information that leads the investigator to a source of potentially beach compatible sand. Areas of silty, clayey, or rocky material are omitted from the investigation. This may come at the beginning of the investigation with knowledge of the geology and paleogeography of the area, past vibracore and seismic investigations, or initial reconnaissance field information collected in the area. At the conclusion of the preliminary planning phase, offshore sites are identified for reconnaissance level investigation.

b) Survey Design and Sampling Plan

The office study involves planning the reconnaissance level field investigation. The planning includes the specification of field data to be collected and the equipment needed to execute the data collection. Surface grab samples, vibracore samples, sub-bottom seismic and sidescan sonar records from previous investigations may be reviewed and incorporated as a means of providing preliminary information on the targeted offshore site(s). Historic data may be incorporated into the final borrow area design if the quality of the data meets current guidelines and is adequate to illustrate the composite character of the material. The Department should be consulted regarding the suitability of historic data for use in the final design during investigation planning. A borrow area shall not be designed solely on historic data.

Another important task is laying out the preliminary survey or trackline plots to be followed by the survey vessel while collecting bathymetric and seismic reflection data during the reconnaissance level field investigation. The coverage and spacing of the reconnaissance level surveys and vibracores should be sufficient to determine if the site contains potentially beach compatible sediment. The design level field investigation will include more closely spaced vibracores and perhaps additional sub-bottom seismic surveys within the potential borrow area.

Locations of the vibracores selected during the office study should be based on analysis of the seismic reflection records and the configuration of the sedimentary feature. Vibracore locations should be located on or within 50 feet of a seismic track line and avoid potential cultural and environmental resources. A dynamic vibracoring plan is often used to allow the geologist to pursue the most compatible material while in the field. Both primary and secondary locations for vibracores can be identified in the survey design and sampling plan. Secondary locations can be vibracored based upon field-logging of the primary vibracores while on the ship used to conduct the vibracoring.

c) Permitting for Field Investigations

Currently, the Department requires that investigators obtain a de minimus permit exemption for geotechnical investigations such as vibracoring. The submittal of a shapefile of the investigation area is required in the permit application. This shapefile aids the Department in tracking and reporting the investigations occurring throughout the State as required by Chapter 161.144, F.S.

Depending on the timing of the investigations, a de minimus permit exemption request may be required at both the reconnaissance and design levels. If the sand search is occurring in Federal waters, a geotechnical and/or geophysical investigation permit may be required from the BOEMRE. The application for and receipt of these exemptions/permits should be included in the Scope of Work, schedule, and budget for the sand search. The requirements for these permits affect the sequence and specifications of the field investigations.

Task 2- Reconnaissance Field Investigations

The collection of geophysical data should be conducted under the responsible charge of a professional geologist registered in the State of Florida. All navigation and survey control for seismic, sidescan, magnetometer, bathymetry, and positioning for vibracores/ surface samples should be certified by a professional surveyor registered in the State of Florida. The geophysical instrumentation for remote sensing surveys must represent state-of-the-art technology and must be deployed in a manner that limits interference among the instrumentation systems. Data recorders should be interfaced with the navigation system (i.e., via Hypack Max® or similar software) to ensure proper integration of information. All instrumentation must be adequately tuned and all recorded data must be readable, accurate, and properly annotated. Poor quality data resulting from inadequate acquisition or processing techniques is not acceptable and may result in the need to repeat the survey.

Vertical and horizontal data will be collected and presented in feet referenced to the North American Vertical Datum of 1988 (NAVD 88) and North American Datum of 1983/1990 (HARN NAD 83/90), respectively. Map products intended for permit and proprietary purposes should reference horizontal coordinates in the Florida State Plane Coordinate System.

a) Bathymetric Survey

The reconnaissance level field investigation includes a bathymetric survey, which is conducted to map seafloor topography and identify the most prominent bathymetric highs within the boundaries of the potential borrow area(s). Prior to the start of the survey, an offshore tide gauge is set in the vicinity of the project area to record water levels during the survey for data post-processing. The fathometer is calibrated and interfaced with a DGPS. Alternatively, a RTK-GPS may be used for more accurate positioning, which may require the establishment of an elevated base station for surveys that are several miles offshore.

At each stage of the investigation, efforts will be made to reduce the vertical inaccuracies during surveys and other data collection processes, such as recording the top of hole elevations for the vibracores. Vertical inaccuracies are cumulative through the process of identifying, designing, and dredging a borrow area beginning with the survey methods used during the reconnaissance level investigation through the vertical location control of the dredge head. To ensure survey control and accuracy standards are consistent with Department specifications, the professional surveyor will submit a certification that the hydrographic survey meets BBCS Technical Standards established in Part II.A of the *BBCS Monitoring Standards for Beach Erosion Control Projects* and minimum technical standards of Chapter 61G17-6, F.A.C., which references the requirements set forth in the United States Army Corps of Engineers manual EM 1110-2-1003.

b) Sub-bottom (seismic) Profile Survey

A sub-bottom profile should be conducted simultaneously with the bathymetric survey to interpret subsurface sediment distribution and define the thickness of the sand deposit within the targeted sedimentary feature(s). During the reconnaissance level investigations, seismic lines should be spaced such that the general geomorphology and character of the area being investigated can be determined.

Seismic reflection profile surveys must be performed using a high-frequency “chirp” sub-bottom acoustic profiler operating a linear frequency sweep over full spectrum frequency range within the 0.5- to 16-kHz bandwidth to provide continuous and very high resolution information on near-surface geologic features. Systems that are frequency modulated and full-wave rectified are preferred. The sub-bottom profiler system should be run to provide penetration that exceeds the anticipated depth of disturbance below the design dredge depth during dredging operations. The data collected must be recorded digitally to allow signal processing to improve data quality further and allow export to a workstation for integrated interpretation and mapping of the data.

Any sub-bottom profiler system with a chirp full spectrum sub-bottom towfish is recommended for subsurface remote sensing surveys. The equipment should transmit an FM pulse that is linearly swept over a full spectrum frequency range (also called a “chirp pulse”). A versatile wideband FM sub-bottom profiler that collects digital normal incidence reflection data over many frequency ranges is recommended. This instrumentation should be able to generate cross-sectional images of the seabed (to a depth of up to 50 ft). The tapered waveform spectrum results in images that have virtually constant resolution with depth.

Throughout an offshore seismic reflection survey, selection of the chirp pulse and acquisition gain settings should be modified in real time to obtain the best possible resolution of subsurface features and the sequence stratigraphy (i.e., vertical sequence and lateral distribution of sediment bodies comprised by different grain sizes and sediment composition). This in turn will optimize data quality and enhance subsequent interpretation. The towfish should be towed at an optimum depth and location that maximizes the acoustic reflection of the outgoing seismic pulse while reducing towfish motion and noise associated with the vessel movement and sea surface conditions. Horizontal positioning of the towfish should be obtained to achieve the required survey accuracies by utilizing automated hydrographic positioning systems that correct for the layback position of the towfish.

c) Sidescan sonar survey

A sidescan sonar survey should be conducted to identify environmental resources (such as hardbottom areas and sea grass beds), items of historical significance and/or navigation hazards/debris. The coverage and spacing of the survey lines should include the geologic feature and adjacent areas that could potentially be affected by the dredging activity. Spacing should also take into account the requirements of other agencies.

A towed, dual-channel, dual-frequency, sidescan sonar system operating between 300- and 1000-kHz to provide a continuous planimetric image of the seafloor is preferred for remote sensing surveys. The sidescan sonar sensor should be towed above the seafloor at a distance that is 10 to 20 percent of the range of the instrument. The equipment should use full-spectrum chirp technology to deliver wide-band, high-energy pulses coupled with high resolution and superb signal to noise ratio echo data. The sidescan should be interfaced to the GPS system along with positioning data from the onboard navigational system to ensure proper positioning of the survey. Horizontal positioning of the towfish should be obtained to achieve the required survey accuracies by utilizing automated hydrographic positioning systems that correct for the layback position of the towfish.

If the historic data collected during the office study, such as cultural or environmental resource investigations/mapping, clearly indicates the absence of natural and cultural resources in the investigation area, this survey may not be necessary for the targeted sedimentary feature. However, other agencies, such as BOEMRE or SHPO, may require sidescan surveys on a specific spacing as verification of the absence of resources. The requirements of other agencies should be considered when planning this portion of the investigation.

d) Magnetometer survey

A magnetometer survey should be conducted to identify buried objects of ferrous (iron) composition. This is required for offshore dredging projects that have the potential to impact features of historical significance (cultural resources) such as shipwreck debris. The magnetometer survey is also important to identify the location of buried objects such as cables, pipeline debris and other manmade items that may interfere with dredging operations.

The purpose of the magnetometer survey is to establish the presence of, and subsequent exclusion zones around, any potential underwater wrecks, submerged hazards, or any other features that would affect borrow area delineation and dredging activities. The magnetometer sensor must be towed as near as possible to the seafloor and in a manner that limits interference from the vessel hull and the other survey instruments. The magnetometer should have a sensitivity of less than one gamma (γ) or one nanoTesla (nT), and the data sampling interval should not exceed one second. The background noise level should not exceed a total of 3 γ peak to peak. The navigation program should be interfaced with the magnetometer in order to collect positioning data digitally in real-time.

The coverage and spacing of the survey lines should include the geologic feature and adjacent area that could potentially be affected by the dredging activity. Spacing should also take into account the requirement guidelines of other agencies. If the office study clearly indicates the absence of resources in the investigation area, this survey may not be necessary for the targeted sedimentary feature. However, other agencies, such as BOEMRE or SHPO, may require magnetometer surveys on a specific spacing as verification of the absence of resources. The requirements of other agencies should be considered when planning this portion of the investigation. Horizontal positioning of the towfish should be obtained to achieve the required survey accuracies by utilizing automated hydrographic positioning systems that correct for the layback position of the towfish.

e) Vibracore Collection

The direct sampling of sub-bottom materials is essential for borrow source identification and evaluation. This is usually accomplished by means of a continuous coring apparatus that can obtain 20-foot cores of unconsolidated sediments. In the types of sediments usually encountered in borrow site exploration, gravity corers are not suitable for obtaining cores of the requisite length; some type of power corer must be used, usually vibrator driven coring devices. In the reconnaissance level field exploration, vibracore locations are chosen to better understand the geology of the feature by correlation with the seismic data and to verify the presence of beach-compatible sediment. The vibracores should be sited on, or within 50 feet of, the seismic lines collected in order to validate the interpretation of both the vibracores and the seismic data.

Often, a dynamic vibracoring plan is used to allow the geologist to delineate the most compatible material, rather than being held to a rigid plan set forth in the survey design and sampling plan. A dynamic vibracoring plan is often used to allow the geologist to pursue the most compatible material. Both primary and secondary locations for vibracores can be identified in the survey design and sampling plan. Secondary locations can be vibracored based upon field-logging of the primary vibracores while on the ship used to conduct the vibracoring. Each core is split longitudinally, visually analyzed and logged "on the fly" during field operations to optimize field operations by modifying secondary vibracore locations as needed. Collected vibracores are then sectioned and shipped to the geotechnical laboratory for processing and analysis. Sampling and analysis of the vibracores follows the protocol as outlined in Section IV below.

Core penetration depth and rate will be monitored and recorded (penetrometer records). A minimum recovery of 80 percent of the sediment penetrated at each core location is necessary to provide the geologist and the Department with reasonable assurance that the stratigraphy and material being sampled is accurately represented in the vibracores. In the event that refusal is encountered prior to achieving the desired depth and/or recovery, an additional vibracore shall be taken and/or a hydraulic jetting technique will be used to facilitate a second attempt and to optimize the probability of achieving core penetration to the desired depth. It should be anticipated during this task that all vibracores used in the design of the borrow area must extend a minimum of two feet below the final maximum dredge depth. Vibracore penetration and recovery objectives must be achieved as these are a limiting factor in determining the maximum dredge depth.

Task 3- Design level Field Investigations

a) Sub-bottom seismic survey

If widely-spaced seismic survey lines were collected during the reconnaissance level investigation, then additional seismic survey lines should be collected during the design level investigation. The denser line spacing of a design level survey will provide a more detailed understanding of the extent of stratigraphic layer(s) within the potential borrow area. This information will assist in defining the area of influence of each vibracore in design of the final borrow area. Additional seismic data may also aid in cultural/environmental resource identification. The professional judgment of an experienced coastal geologist is necessary in planning the location and spacing of these survey lines to best map the stratigraphy of the potential borrow area.

b) Sidescan sonar survey

A design level sidescan sonar survey may be necessary to further identify environmental resources (such as hardbottom areas and sea grass beds), items of historical significance and/or navigation hazards/debris identified during the reconnaissance level investigation. The coverage and spacing of the survey lines should include the potential borrow area and adjacent area that may be effected by the dredging activity. Spacing should also take into account the requirement guidelines of other agencies necessary for the final design of the proposed borrow area. The coverage of the survey should include the geologic feature and adjacent areas that may be affected by the dredging activity, but the line spacing should be denser in order to fully define the resources.

If the office study and reconnaissance level investigation clearly indicate the absence of natural and cultural resources in the investigation area, a survey during the design level field investigation may not be necessary. However, other agencies, such as BOEMRE and SHPO, may require sidescan surveys on a specific spacing as verification of the absence of resources. The extent of the survey and line spacing should follow the guidelines of these other agencies.

c) Magnetometer survey

A design level magnetometer survey may be necessary to further identify buried objects within the proposed borrow area that may or may not have been identified during the reconnaissance level investigation. The coverage and spacing of the survey lines should include the potential borrow area and adjacent area that could potentially be effected by the dredging activity. Spacing should also take into account the requirement guidelines of other agencies necessary for the final design of the proposed borrow area.

If the office study and reconnaissance level investigation clearly indicate the absence of cultural or historic resources in the investigation area, a survey during the design level field investigation may not be necessary. However, other agencies, such as BOEMRE and SHPO, may require magnetometer surveys on a specific spacing as verification of the absence of resources. The guidelines of other agencies should be considered when planning this portion of the investigation.

d) Cultural Resources Investigation

Once the limits of the borrow area are defined, detailed geophysical investigations with a close line spacing should be used to investigate the presence of cultural resources within the proposed borrow limits. This task is conducted to refine the limits of the potential borrow area(s) identified in the preliminary tasks. A detailed cultural resource investigation is required to fulfill permit requirements for the potential borrow area(s). The cultural resource surveys generally consist of magnetometer, sidescan and seismic surveys and may be conducted in conjunction with the survey tasks described above. A marine archaeologist's report may be necessary at various stages of the investigation to satisfy BOEMRE or SHPO requirements and obtain subsequent investigation permits.

It is recommended that selected magnetic anomalies within the potential borrow area(s) be field verified through diver verification if they significantly impact the borrow area. Diver verification can allow for the maximization of use and increased dredging efficiency of the borrow area by eliminating magnetic anomalies as resources and/or reducing buffers. All work must be performed with the expressed permission and in accordance with the survey requirements of the SHPO. A report must be submitted to SHPO (and BOEMRE if necessary) for review. The proposed borrow area(s) will be modified, as required by SHPO, to avoid areas of potential historical cultural resources.

If any significant cultural resources (i.e., shipwrecks, large cultural artifacts, etc.) are mapped within the limits of the proposed borrow area or adjacent area potentially affected by the dredging activity, the borrow area design must be modified to avoid disturbing these resources. This is usually accomplished by adding no-dredge buffers around the cultural resource feature(s) or by modifying margins of the borrow area (when the cultural resource features occur near the borrow area boundaries).

e) Vibracore Collection

Additional vibracores should be collected to adequately characterize the sediment for final design of the borrow area. Vibracores should be spaced no more than 1,000-feet apart. Vibracores should be of a sufficient length such that they extend at least two feet below the maximum dredge depth. It should be noted that vibracore length and recovery (minimum of 80%) could be a limiting factor in the borrow area design and should be considered when determining the vibracore lengths during all phases of vibracoring. Vibracores should be sited such that the seismic lines can be used to correlate the area between vibracores for a better understanding of the relationship between compatible and non-compatible sediment layers. Additional discussion regarding siting and core recovery are provided in Task 2 above. Sampling and analysis of the vibracores follows the protocol as outlined in Section IV below.

Task 4- Compatibility Analysis and Borrow Area Design

A compatibility analysis is used to ensure the borrow area material is similar to the recipient beach sediments and will maintain the environmental functions and character of the beach. The sediment identified in the cores should be compared to native and/or existing (if no native data exists) beach samples with respect to textural and compositional parameters, as previously described, and color similarity. The compatibility assessment will include the identification of unsuitable sediment horizons and considerations of potential borrow area material performance after project construction.

The following is a qualitative description of the review of quantitative data that the Department uses to determine compatibility. There is no quantitative protocol for determining similarity because the data and science does not exist for a quantitative determination of similarity needed to maintain the general character and environmental function of the material occurring on the beach and in the adjacent dune and coastal system. Therefore, in the absence of additional scientific research, this will remain a qualitative process of reviewing quantitative data.

In addition, the Department has not made similarity determinations a quantitative process because of the variability of sediments found on the beaches of Florida. If enumerated parameters were set for determining similarity, the acceptable ranges in parameters would have to take into account the values found throughout the State. However, the upper (or lower) end of the range may not maintain general character and functionality on all beaches. For example, a range of acceptable mean grain sizes for the entire State will include mean grain sizes that would be much too coarse for beaches in the Panhandle. As another example, the color of the beaches throughout the State is rather variable. Material acceptable for placement on one east coast beach, such as Indian River and Martin County beaches, may not be acceptable for placement on a different east coast beach, such as St. Johns County, much less a beach in Escambia County. For shellier beaches, the acceptable range of mean grain size and sorting may be wider compared to projects where finer quartz sediments with little to no carbonate/ shell content is acceptable. For these reasons, the Department has not set enumerated parameters for ranges used to determine similarity.

At each step, the sediment characteristics are compared to the native/existing beach sediments for the project and compatibility determined. The Department begins its review with an examination of the sediment characteristics of the individual samples of the borrow area, reviews the extent of layering in the borrow area and the sediment characteristics for each layer, and then looks at the individual vibracores and their area of influence. The Department recognizes that discreet layers of non-compatible material may exist within the borrow area that do not adversely impact the overall sediment quality of the borrow area. Minor layers of non-compatible material may be included in the borrow area design as long as the Department has reasonable assurance that the minor layers will not change the composite character of the material and that the non-compatible will not be concentrated on the beach during placement. Finally, each subarea of the borrow area (if applicable) is examined, followed by the borrow area as a whole. Therefore, determinations of compatibility are not based simply on the overall characteristics of the borrow area.

Determinations of compatibility should take into account the environmental functions of the native material within the berm/dry beach. Therefore, the compatibility analysis should compare the borrow area composite statistics to the overall beach sediment characteristics and also to the berm/dry beach composite statistics. This is important to ensure that the material placed on the beach is compatible for turtle nesting.

In addition to the composite grain size statistics for the borrow area and beach sediments described above, frequency curves (histograms) and cumulative frequency curves of the composites should be created for visual comparison of the grain size distribution of the borrow area and beach sediments. The curves should be plotted such that they overlie each other for easier comparison. Composite statistics should also be created for each vibracore and its area of influence. For projects that include multiple borrow areas, composites should be created for each borrow area.

Composite grain size parameters of the borrow area material created for the compatibility analysis are used in the engineering and structural design of the beach fill. A compatibility analysis should be performed using several standard industry procedures, such as overfill ratio methods and equilibrium profile methods for grain size and qualitative comparisons of additional parameters. These methods include Dean (Dean, R.G. 1974. "Compatibility of Borrow Material for Beach Fill." *Proceedings, 14th International Conference on Coastal Engineering.* ASCE, 1319-1333.), Krumbein and James (Krumbein, W.C., and James, W.R. 1965. "Spatial and Temporal Variations in Geometric and Material Properties of a Natural Beach," Technical Report No. 44, Coastal Engineering Research Center, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.), and the USACE method (U.S. Army Corps of Engineers. 2003. Coastal Engineering Manual (EM 1110-2-110): Part V, p. v-4-25.).

The first step in reviewing the material in a borrow area is to determine whether the enumerated parameters in Chapter 62B-41.007(2)(j)1-5, F.A.C. are exceeded. If they are, that parameter for the beach is examined to determine if the beach exceeds the parameters, which would provide justification for accepting the exceedance in the borrow area material. If the borrow area material exceeds the enumerated parameters and the beach does not, the Department suggests that that the borrow area be redesigned to avoid the material containing excess silt, gravel or rock.

In order to maintain the general character of the beach, the composition of the borrow area material and the native/ existing material is compared. If a beach is predominantly quartz, the borrow area material should be predominantly quartz. Similarly, if the beach has a high shell content, the borrow area material should maintain that general character by containing comparable amounts of shell material.

Reviewing the curves for individual samples and various composites can reveal the presence of coarser and finer portions of the sediment distribution of the borrow area material as compared to the beach. One factor that is being considered closely is the relative portion of fine sand. Higher fine sand content in the fill material compared to the native/ existing material on the beach may lead to chronic turbidity. Therefore, fine sand content and not simply silt content is examined when determining the potential for turbidity and compatibility.

The next step in the compatibility review is to determine the similarity in the mean grain size, sorting, and distribution of the sediments (unimodal or bimodal). Similarity in mean grain size is often determined based on tenths of a millimeter, but can be determined to hundredths of a millimeter depending on the sediment type. It is generally accepted that material with a higher shell content will often have a higher mean grain size. A higher shell content will also often lead to a higher sorting value. It is also recognized that a borrow area may contain layers of shellier material and sandier material. Therefore, for beaches with a higher shell content, the acceptable range of mean grain size and sorting may be wider compared to beaches with finer quartz sediments with little to no carbonate/ shell content. Similarity of sediments with high shell content is often determined to tenths of a millimeter. Similarity of sediments with a low shell content is often determined to hundredths of a millimeter when possible.

In addition, sorting values should be similar such that beaches with higher sorting values are restored/ nourished with material with a higher sorting value when possible. The main purpose in examining the sorting and distribution of the sediments is to ensure that material with a bimodal distribution is not placed on a beach with a unimodal distribution. This is to reduce the potential impact to turtle nesting ability. For this reason, the shapes of the cumulative frequency curves and the frequency curves (histograms) are reviewed for similarity.

After the mean grain size and sorting parameters are examined, the visual shell content and carbonate content are examined. In general, the visual shell content and the carbonate content are related. When one value is higher, the other will be as well. When the carbonate content is high, but the visual shell content is low, the reviewer is alerted to the potential for fine-grained carbonate. Fine-grained carbonate may be associated with turbidity and cementation/crusting of sediments, and accordingly should be identified as a risk and avoided where possible. Where visual shell and carbonate content in a borrow area are higher, a larger range in allowable mean grain size is often determined compatible to account for the fluctuations in shell content through a borrow area.

The final step in determining compatibility is color. The only mention of color in Rule is the statement in Chapter 62B-41.007(2)(j), F.A.C., that beach compatible fill shall be similar in color. The Rule speaks to maintaining environmental function and character. It does not speak to maintaining aesthetic qualities of the beach. While the Department recognizes the desire of local communities to maintain a given color, the Department cannot use this as the sole basis to review sediment for compatibility and exclude a sand source from use.

The main focus of maintaining similarity in color is for sea turtles. While there has been no scientific correlation drawn between sediment color and temperature and sex ratios of turtles, it is generally accepted that these factors are related. Therefore, the color of the borrow area material should be similar. It is generally accepted that moist sediment is slightly darker (one Munsell value) than dry sediment and that fill material will lighten one Munsell value once placed on the beach and allowed to dry in the sun.

When reviewing sand sources for color compatibility, a range if hues may be sought for similarity, but the most important sediment color criterion is the value. The “value” component of the Munsell notation is an indication of lightness. The “chroma” notation is indicative of the strength, or saturation, of a color, or its departure from a neutral of the same value. When searching for sand, Chroma should be specified as a 1 for the fill material unless the native or existing material has a higher chroma value.

The source of the color of the material should be taken into account when determining similarity of color. For example, iron staining of material (often seen in the Panhandle of Florida) will not bleach and is not removed by abrasion during the dredging process. Iron staining is a natural process, often has a distinct color, and can be seen when the material is visually examined. The color of the shell content often drives the overall color of the fill material. Even though the quartz grains may be the same color, the color of shell may vary. Depending on the shell material, the color will likely lighten one value once exposed to the sun and allowed to dry after placement. In some cases, the interstitial or pore water contained in a borrow area is the cause for material to appear darker than is the actual sediments. Color determinations made by inspecting the vibracores are often darker than the resulting dredged and placed sand, as the dredging process washes the sediment and removes the dark interstitial fluid. For this reason, it is often useful to make multiple color determinations if it is suspected that the material appears darker due to dark interstitial or pore water. Washing a few samples to mimic the dredging process is often helpful to determine if this is the case.

The final borrow area design and the borrow area plans and specifications are prepared when all the concerns regarding the sediment quality within the borrow area, the cultural resource impact potential, the environmental consideration and the physical considerations have been addressed. The final borrow area design shape and cut depths may differ significantly from the design prepared at the end of the survey plan and initial borrow area design due to the implementation of no-dredge buffers that reduce negative impacts from dredging. In addition, a minimum two-foot buffer above non-compatible material should exist below the maximum dredge depth. If a reduced buffer (less than two feet) is proposed, more stringent dredging control and accuracy requirements shall be necessary. A buffer less than two feet will only be considered if the offshore sand search investigation provides adequate survey accuracy during the collection of the geotechnical and geophysical data. Consideration will also be given to the environmental resources in both the borrow area and the placement area, the type of dredge to be used, and the nature of the non-compatible material beyond the buffer that may be encountered during dredging. Potential impact to adjacent environmental resources (such as hardbottom and seagrass) should dredging occur below the buffer into non-compatible material could preclude use of a reduced buffer. A pipeline cutter head dredge typically disturbs material below the maximum dredge depth compared to a hopper dredge. As such, the buffer above non-compatible material may be greater than two feet depending upon the depth to which the material below the excavation device will be disturbed.

The results of the previous tasks will be used to define the geometry (i.e., lateral boundaries and excavation depths) of the borrow sites. Based on the results of the previous tasks, the vertical and horizontal limits of the final borrow area(s) will be identified and mapped. The borrow area limits should be referenced to State Plane Coordinates.

The final design of a borrow area should be one that is economically feasible to dredge and considers conservation of sand resources. The design should allow all the available beach compatible sediment in the borrow area to be dredged in such a manner that no significant quantity of beach compatible material remains where it is not technically or economically feasible to dredge in a subsequent event. Considerations should also be made for the feasibility of dredging a borrow area that contains a number of subareas with variable dredge depths.

After a borrow area has been delineated, plan view maps and cross-sections of the area should be prepared. These maps must include the location of each vibracore, seismic survey lines, bathymetry, the proposed horizontal boundaries of each borrow area, and the maximum dredge depth.

Task 5- ROSS/OSSI Data

At the end of each phase of the investigation, ROSS/OSSI data shall be submitted and/or updated. This includes more than simply shapefiles of the borrow area and vibracore/seismic line locations. Updated information for inclusion in OSSI should be submitted to the Department at this stage of the sand search for both the proposed borrow area (borrow area designed in Task 4 above) and for the remaining potential areas identified and investigated during the sand search.

The updated ROSS/OSSI data should include the available volume of beach compatible sand and composites of the geotechnical information included in OSSI to reflect the change in material remaining in the borrow area(s). New/updated shapefiles will reflect the change in the aerial extent of each designation of borrow areas based on the sand search investigation. Targeted sedimentary features will change designation through sand search investigations as the quantity and quality of the data collected changes. These designation changes may occur as a portion of the borrow area is excluded from further investigation at the time, excluded as unsuitable for future use, or further investigated to become potential, proposed, or permitted.

A brief definition of the borrow area designations is included below. More information can be found in OSSI documents.

Potential borrow areas are those areas that have some level of data within them beyond just empirical data. This data should include a minimum of 2-5 vibracores at no greater than 5,000-foot spacing and sited on sub-bottom seismic lines, and one or more sub-bottom seismic lines over the area. The spacing of vibracores can be increased using additional seismic data depending on the homogeneity of the sedimentary feature. The level of data should show that there is potential for useable sand, suggesting further data collection is necessary.

Proposed borrow areas require a higher quantity and quality of data than potential borrow areas. The data for proposed borrow areas should include a minimum of magnetometer, sub-bottom seismic, and sidescan sonar data collected on 90 to 300 meters spacing through the target feature. The data should also include vibracores sited on the sub-bottom seismic lines and collected at a maximum spacing of 1,000 to 3,000 feet.

Permitted borrow areas (those borrow areas being submitted for JCP permitting) should include the highest level of data coverage. This coverage includes magnetometer, sub-bottom seismic, and sidescan sonar at line spacing suitable for cultural and environmental resource determinations. In addition, vibracores shall be spaced at no greater than 1,000 feet.

Professional judgment of the coastal geologist/engineer should be used when determining the designation of the borrow areas, the available quantity of beach compatible sediment within each borrow area, and calculating the composites of the geotechnical data within each designation.

Task 6- Generation of a final report

The final report should include the following in paper copy:

- Description of the work performed.
- Description of the geology/ geomorphology of the study area.
- Bathymetric maps.
- Isopach maps of sediment thickness, and/or the elevation of the bottom of beach compatible material.
- Plan view map of vibracore locations and survey tracklines depicting both the investigation as a whole (all vibracore and seismic survey tracklines) and each targeted sedimentary feature/ borrow area.
- Cross-sections of the borrow area(s).
- Vibracore logs.
- Tabular summary of gradation analyses for the beach and borrow area sediments including mean (phi), mean (mm), median (mm), standard deviation/sorting (phi), visual shell content, carbonate percentage, silt percentage (material passing the #230

sieve), fine gravel content (percent retained on the #4 sieve but passing the 3.4" sieve), coarse gravel content (percent retained on ¾-inch sieve) (if necessary for the project), and moist Munsell color.

- Tabular summary of composite statistics.
- Sediment compatibility analysis, including the sediment criteria set for the project.
- A description of the methodology used to calculate the composite values and formulas to illustrate the calculations.
- Recommendations and conclusions for future work and/or use of borrow areas identified.
- Discussion of borrow area design with respect to dredging efficiency and conservation of sand resources.
- Preliminary design drawings of the final borrow area(s) (if design level report).

The final report should include at minimum the following in electronic copy on an attached CD/DVD:

- Electronic (pdf) copy of the portion of the report submitted on paper.
- Sub-bottom (seismic) survey profiles.
- Frequency (histogram) and cumulative frequency curves, sieve data sheets, color determinations, and carbonate analyses for the beach and borrow area sediments.
- Vibracore penetrometer records.
- Active, unlocked spreadsheets used to calculate composite sediment data. A description of the methodology used to calculate the composite values within the spreadsheet and formulas to illustrate the calculations should be included in the deliverable, especially if only inactive spreadsheets are provided.
- OSSI/Updated OSSI data for the entire study area.
- The document, especially the sediment data attached electronically, should be tabbed in the pdf document to allow for easy navigation through the document.

The final borrow area design and geotechnical report should be submitted to the project sponsor and the Department as a Scope of Work deliverable for review and comment to ensure that the data collected is adequate and acceptable for permitting.

Task 7- Deliverables

At a minimum, the consultant should provide the following work products:

- The geotechnical report outlined in Task 6.
- All geotechnical data for the potential borrow area, including but not limited to core logs, grain size data sheets, (cumulative) frequency curves, % carbonate, % shell, moist Munsell color, and core photographs in electronic formats suitable for inclusion in the ROSS database.
- All geotechnical data for the native/existing beach (including but not limited to grain size data sheets, (cumulative) frequency curves, % carbonate, % shell, moist Munsell color).
- An active spreadsheet of any composites created, along with the (cumulative) frequency curves and summary statistics of the composites for both the proposed

borrow area and the native/existing beach. A description of the methodology used to calculate the composite values within the spreadsheet and formulas to illustrate the calculations should be included in the deliverable, especially if only inactive spreadsheets are provided.

- Complete citations for reports of geotechnical data cited in the planning stage that contain data that will be used to characterize the beach and/or borrow area sediment. (The actual reports cited should be available upon request.)
- All of the above data should also be provided in the form of a summary table including the mean, median (d50), standard deviation (sorting), moist Munsell color, silt percent, fine gravel content, visual shell content and carbonate content.
- Shapefiles of the borrow area for inclusion in the ROSS database.
- At the end of each phase of the investigation, updated shapefiles and composite geotechnical/engineering data will be submitted to the Department for inclusion in the ROSS/OSSI database.
- Updated information for inclusion in OSSI as the borrow area evolves from potential to proposed to permitted. This includes an update of the composites of the geotechnical information included in OSSI and an estimated volume of potentially beach compatible sediment.
- All geotechnical, geophysical, and remote sensing information in electronic files suitable for input to the Department's Reconnaissance Offshore Sand Search (ROSS) database. The data can be submitted in the form of Access or gINT files. Include any shapefiles or PDF files including but not limited to seismic images with time stamp annotations, seismic tracklines, seismic shotpoints, core locations and borrow area outlines. If html files are provided of the seismic data, a shapefile of the tracklines should still be included.
- Preliminary design plan drawings of the selected alternative design.
- Certification statement of bathymetric survey results for vertical accuracy purposes.
- Borrow area remote sensing survey data and maps created from the data, including bathymetric, seismic, sidescan and magnetometer data as appropriate for the project.
- Borrow site wave effects analysis report, if applicable.
- Certification by a Professional Geologist registered in the State of Florida for the geotechnical data submitted.
- Cultural resources investigation report.
- Progress reports submitted to the Department throughout the investigation.
- An executive summary in the final report documenting the process, results and recommendations for additional work.

It should be noted that data requirements and formats may change with advances in technology with respect to the equipment used to collect, process, analyze, and store data. They may also change with time as new pieces of information are determined by the Department to be necessary to the review of borrow areas and determinations of compatibility.

IV. DATA ANALYSIS AND REPORTING

1. Analysis of Bathymetric Data

The purpose of the bathymetric data analysis is to determine the bathymetry of the study area for use later in the process (such as determining volumes and cross-checking elevations collected during the vibracore and seismic data collection), to verify the top of hole elevation for the vibracores (which also serves as a cross-check for the elevation taken at the time of vibracore collection), and to note any areas that may have a bathymetric expression indicative of a possible sand source.

2. Vibracore Sedimentological Analysis

The vibracore analysis includes logging, sampling and photographing the vibracores obtained from the study area. The purpose of this is to adequately describe the material collected in the vibracores, and therefore, the target sedimentary feature. Once the vibracores have been analyzed, they should be correlated to the processed, interpreted seismic data.

a) Preparation and photography

Color photographs of the split cores, including an 18% gray card for comparison and control, are taken. The photographs should be labeled with the project name, core name, and core section. The photographs should include a legible scale along the length of the vibracore section such that the specific depth of a layer/feature can be identified and compared to the vibracores log. There should also be a notation of the direction of the top of the core section, either by using an arrow or direct notation of depth within the vibracore. The photographs should be free of shadows with a consistent light source that mimics noon-day sun. The photographs should be taken from above the core rather than from one end/side looking across the vibracore to avoid distortion.

b) Logging

The vibracores are transferred to a geotechnical laboratory where they are described by a qualified geologist based on visual observation utilizing the ROSS-compatible version of ENG Form 1836 in accordance with Unified Soil Classification System (USCS) terminology and United State Army Corps of Engineers (USACE) format – including lithologic descriptions and mineralogic details. On each vibracore log, preferably in the remarks column, the sample depth within the vibracore, silt content, mean grain size (mm), carbonate percentage (if determined), visual shell estimate, USCS classification, and moist Munsell color should be noted for each sample analyzed from that vibracore.

Vibracore logs should not be decompacted to account for compaction or loss during vibracoring. Decompaction is the process by which some investigators will describe the recovered portion of the vibracore as if it spanned the entire penetrated length of the vibracore. In some cases, individual layers are expanded based on the sediment character and professional judgment of the geologist/engineer logging the vibracore, or the professional geologist certifying the geotechnical data, to make it appear that 100% of the penetrated length was recovered. In other cases, a mathematical approach is taken whereby additional length/thickness is added to each layer in a core assuming the compaction of sediments during vibracoring was uniform to make the recovery appear to be 100% of the penetrated length. Neither method above should be employed. The core should be described based on the actual length recovered.

The location of voids and areas of no recovery should be noted on the vibracore logs. Reasons for lack of recovery should be noted on the vibracore log and in the geotechnical report as necessary. Reasons may include loss during vibracore retrieval from bottom of core tube or staking/plugging the core tube with clay, hard-packed sands, or rock.

c) Sub-sample selection

Sediment samples are collected from major sediment horizons to capture the changes in sediment character within each core for gradation and composition analysis. Samples should be collected from the entire length of the core such that the sampling characterizes not only the beach compatible sediment, but also the non-compatible material lying below the potential design depth of the borrow area. This provides reasonable assurance that the material below the dredge depth is known to the Department and any risks associated with that material, such as increased silt content, are identified and characterized. A virtual sample is a sample collected and analyzed from a layer within a vibracore which is then used to represent another layer within the same or neighboring vibracores. Virtual samples may be used once a clear pattern of recurring layers within or between vibracores is identified. Based upon the judgment of a professional geologist, the character of the sediment within the layers represented by the virtual samples is determined to be nearly identical. Virtual samples may be used to represent both compatible and non-compatible layers. Virtual samples may not be used to represent more than 25% of the vibracore samples. The Department may require that additional samples be collected and analyzed to validate the use of virtual samples.

3. Laboratory Testing

Once the vibracores have been photographed and sampled, the samples are analyzed for color, visual shell content, grain size distribution, and a subset of samples for carbonate content.

a) Color

By convention, the color of sediment collected in conjunction with an offshore sand search is quantified following the methods defined in the Munsell Soil Book of Colors. This method was initially developed as an offshoot of soil science. Munsell color notations have three components: hue, value and chroma. The “hue” component indicates the color of the sample in relation to red, yellow, green, blue and purple. For coastal sediments from many areas of Florida, the hue of the sample is often denoted relative to red and yellow. However, sediments from some coastal areas are frequently white, tan, or very light gray. Munsell has prepared a supplemental set of nearly white hues, wherein choices between white and light gray have been expanded to more than 20 options of white hues.

Munsell color classification of the samples should be conducted on moist samples prior to drying to obtain the in-situ color of the sediments. Directions for the use of the charts are provided with each handbook.

Sample color determinations should be performed on a moist sample, under non-polarized light conditions that mimic noon-day sun, and preferably by the same technician for the entire project (because human color perception is somewhat variable between observers). If multiple technicians are working on the same project, they should meet to examine the color of various strata encountered during the logging process. If an inconsistency exists in the color determinations, a consensus will be reached as to the appropriate Munsell designation for these layers. The majority of the beach sediments in Florida do not neatly match a given Munsell color. The sediment can fall between colors, but whole numbers for value should be chosen rather than approximating between two values with a decimal fraction. In addition, the presence of shell and heavy minerals can influence the color of the sample. While the color of the quartz component of the sediment may not vary very much, the mottling caused by varying percentages of shell and heavy minerals can greatly affect the overall color of a sample.

b) Grain size and texture

Sieve analyses of vibracore samples should be performed in accordance with the American Society for Testing and Materials (ASTM) Standard Methods Designation D 421-85 and D 422-63 for particle size analysis of soils. These methods cover the quantitative determination of the distribution of sand particles. For sediment finer than the No. 230 sieve (4.0 phi) the ASTM Standard Test Method, Designation D 1140-54 should be used. Following the sieve analysis, the samples should be classified using the USCS according to ASTM D 2487 and D 2488.

The following U.S. Standard sieves should be used: 3/4", 5/8", 3.5, 4, 5, 7, 10, 14, 18, 25, 35, 45, 60, 80, 120, 170, and 230. The ¾", the #4, and the #230 are currently required by Rule 62B-41.007(2)(j), F.A.C. All sediment statistics should be computed using the moment method. Results should be presented in gradation analysis tables and plotted in cumulative grains size distribution curves, and frequency distribution curve (histograms). Statistical parameters should include mean and median grain size (in phi and mm), sorting coefficient (phi), silt content (% passing the #230 sieve), fine gravel content (cumulative % material retained on #4 sieve), percent shell (visual estimate), percent carbonates by weight (laboratory tests) and moist Munsell color.

c) Carbonate and Visual Shell Analysis

Sediment composition is determined for 25-33% of the core samples using the loss on ignition (LOI) or acid digestion method to quantify the sample weight percent organic matter and carbonate content. If acid digestion is being used, the Department recommends using the basic methodology described in Twenhofel, W.H. and Tyler, S.A., 1941, Methods of Study of Sediments. New York: McGraw-Hill, 183 p. The ASTM standard for carbonate testing (D 4373-02) should *not* be followed, as it requires the pulverizing and splitting of samples to obtain a one-gram sample. Pulverizing and splitting of beach sands introduces unnecessary error into the testing. The samples selected for carbonate analysis should be those within the cores likely to be included in the borrow area.

Dependent upon the location of the borrow area, a subset of the samples (roughly half) that undergo carbonate testing should be re-sieved in order to identify the distribution of the carbonate material. This re-sieving is to be performed on the same samples that underwent carbonate testing and follow the same protocol outlined herein for sieve analysis.

Samples from borrow areas along the southwest, southeast, and central east coasts shall undergo a post-carbonate testing sieve analysis. Roughly half of the samples that are tested for carbonate should undergo post-carbonate sieving. Therefore, the size of the sample carbonate tested should be large enough that an adequate sample size remains for sieving. Since the use of LOI does not allow for a large enough sample to sieve after carbonate testing, acid digestion should be used.

While carbonate testing is still required, samples from borrow areas along the Panhandle and northeast coasts do not need to undergo post-carbonate testing sieve analyses. The expectation is that carbonate from the Panhandle and northeast coasts will not be fine sand- or silt-sized.

A visual estimate of the relative abundance of shell material in each of the samples selected for carbonate analysis should also be provided. Relative abundance of shell material should be determined by visual estimate of sample sieve splits using a binocular scope (if necessary) and reported as a volume percent of the total sample.

4. Seismic Data Processing

The first data processing step is to calculate the approximate depth of the reflector below the sound source by converting the two-way travel time (the time in milliseconds that it takes for the "chirp pulse" to leave the source, hit the reflector and return to the source) to feet by utilizing an approximate value for the speed of sound through both the water and underlying geology. This estimate of the composite sound velocity is based on several assumptions including the speed of sound through water (which is typically 1.5 m/ms) as well as on the speed of sound through the sediment (which can vary from 1.6 m/ms for unconsolidated sediment to >1.7 m/ms for limestone).

The imagery should then be processed to reduce noise effects (commonly due to the vessel, sea state, or other natural and anthropogenic phenomenon) and enhance stratigraphy. This can be done using the processing features available in SonarWiz.MAP +SBP®; AGC, swell filter, and a user-defined gain control (UGC). The SonarWiz.MAP +SBP® AGC is similar to the Discover-SB® AGC feature, where the data are normalized in order to remove the extreme high and low returns, while enhancing the contrast of the middle returns. In order to appropriately apply the swell filter and UGC functions, the sub-bottom data should be bottom-tracked to produce an accurate baseline representation of the seafloor. Once this is done through a process of automatic bottom tracking (based on the high-amplitude signal associated with the seafloor) and manual digitization, the swell filter and UGC should be applied to the data. The swell filter is based on a ping averaging function that removes vertical changes in the data due to towfish movement caused by the sea state. The swell filter should be increased or decreased depending on the period and frequency of the sea surface wave conditions. Special care should be taken to not remove, or smooth over, geologic features that are masked by the sea state noise. The final

step is to apply the UGC. The SonarWiz.MAP +SBP® UGC feature allows the user to define amplitude gains based on either the depth below the source, or the depth below the seafloor.
This processing allows for the removal of the noise within the water column, increase the contrast within the stratigraphy, and increase the amplitude of the stratigraphy with depth.

After data processing, sub-surface data interpretation should be performed. This can be done using SonarWiz.MAP +SBP® software or similar post-processing methods. Using the SonarWiz.MAP +SBP® platform, processed seismic profile lines can be opened to digitally display the recorded sub-surface stratigraphy. Using the software's Sonar File Manager, color coded vibracore descriptions can be added directly to the seismic profiles. Using the vibracore descriptions as a guide, the seismic stratigraphy can be interpreted and the depth of the base of the good quality material (top of marginal to poor quality material) determined. The stratigraphic reflector that best correlates with this layer can then be digitized. Not all of the seismic lines can be annotated in this way. If a core was not collected near a particular seismic line, then it cannot be annotated because there is no control for digitization.

Using the seafloor and the reflector representing non beach-compatible material, the thickness of the sediment wedge can be calculated and exported in order to develop an isopach (sediment thickness) map of each feature. The maps that are created should be verified by importing and gridding the thickness data in a software package (such as Golden Software, Inc's Surfer 8®, or AutoCAD Civil 3D). After gridding the data, contour maps showing sediment thickness can be produced. The contour maps can then be checked for discrepancies in the data and adjustments made. Once the data is verified, final thicknesses can be exported to be used in the borrow area design process.

Upon the completion of interpretation and digitization, all of the seismic data should then be exported as a "Web" based project of HTML/JPEG files viewable in any standard web browser software package. Shapefiles of the seismic tracklines should also be provided in the deliverable for inclusion in ROSS/OSSI.

If the seismic data cannot be presented in HTML/JPEG files viewable with a web browser, jpeg images of the lines should be provided for all of the raw images and the subset of those that are annotated. In addition, all of the trackline shapefiles, time stamp annotations, and seismic shotpoints should be produced and included in the deliverable for inclusion in ROSS/OSSI.

V. PERMIT APPLICATION REQUIREMENTS

After the sand search investigation and borrow area design is complete, the work will support a JCP application submitted to the Department. Although the consultant may have previously submitted the deliverables as specified in Task 7 above, the JCP application must include a sub-set of project-specific information for examination by other resource agencies and the general public reviewing the application. The permit application must include all relevant project details including geotechnical and environmental information.

The minimum geotechnical information required in a JCP application includes:

- Core borings and sediment grain size analyses from representative points throughout the area to be excavated. Core spacing should be no more than 1,000 feet on center. Core logs should extend at least 2 feet below the proposed bottom elevation. The depth of each visible horizon in the log should be reported relative to NAVD and the material in each stratum classified according to USCS or Wentworth classification.
- Particle size analyses of the sediment and measures of the percentage of organics by dry weight. Gradation curves should be produced from sieve analyses of each stratum in the core. Grain size must be determined down to the standard unit 230 sieve size.
- A table with the following column headers: 1) sieve number, 2) diameter in mm, 3) diameter in phi units, 4) weight retained on sieve, 5) weight percent retained on sieve, 6) cumulative weight retained on sieve, 7) cumulative weight percent retained on sieve. All weights and percentages should be recorded to the nearest 0.01 gm.
- A table with columns for mean, median (d50), standard deviation (sorting), moist Munsell color, silt percent, fine gravel content, and carbonate content of each sample. A table with the same columns must be included for any composites created, such as individual vibracores, borrow areas, and the native/existing beach.
- Frequency and cumulative frequency plots of each sample.
- The active spreadsheet used to calculate composite statistics, as well as a cumulative frequency curve of the composite(s). This should include a description of the methodology used to calculate the composite values within the spreadsheet and formulas to illustrate the calculations.
- Chemical analyses of the sediment will be required if there is reason to believe that sediment is contaminated. (This is not included in the deliverable outlined in Task 7.)
- An analysis of the compatibility of the fill material with respect to the native sediment at the disposal site. This should include all relevant computations, the overfill ratios and the composite graphs of the grain size distribution of the fill material and the native sediment at the disposal site.
- Dredge plan to ensure that the final borrow area design is economically feasible to dredge and achieves the objective of conservation of sand resources.
- A sediment QA/QC plan that will ensure that the sediment to be used for beach restoration or nourishment will meet the standard in paragraph Chapter 62B-41.007(2)(j), F.A.C. (This is not included in the deliverable outlined in Task 7.)
- All geotechnical information in electronic files suitable for input to the ROSS database. The data can be submitted in the form of Access or gINT files. Include any shapefiles or PDF files including but not limited to seismic images with time stamp annotations, seismic tracklines, seismic shotpoints, core locations and borrow area outlines.