F I N A L   R E P O R T

FLORIDA CENTRAL ATLANTIC COAST RECONNAISSANCE OFFSHORE SAND SEARCH (ROSS)

Prepared for
Florida Department of Environmental Protection
Bureau of Beaches and Coastal Systems
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Figure 6-1. Flow diagram showing systematic approaches to offshore sand searches, based on major steps that incorporate a range of subset activities that are restrained by local circumstances.

Appendices

Appendix A Online Query Builder Users Manual

Appendix B Interactive Mapping Users Manual

In January of 2001 The Florida Department of Environmental Protection (FDEP) Office of Beaches and Coastal Systems (OBCS) contracted with URS Corporation to develop a database that can be addressed, searched and manipulated through an online query builder as well as ArcIMS Geographic Information System (GIS) routines that provide access over the Internet (Web) for compiling and disseminating available coastal and nearshore data. The project was titled the "Reconnaissance Level Regional Sand Search for the Florida Panhandle" or SandPan for short.

The project involved gathering together into one central enterprise database the relevant data from historical, present and future studies conducted in the Panhandle region of the Florida Gulf Coast. Granulametric, geophysical, and spatial data were included, as well as an annotated bibliography of all references related to nearshore and coastal processes which are instrumental in locating and characterizing sand sources for use in the overall context of the Florida coastal management plan. This data is instrumental in minimizing the cost of initial data searches needed for each nourishment project undertaken by FDEP contractors.

In February of 2003, the OBCS, at that time renamed the Bureau of Beaches and Wetland Resources (BBWR), again contracted with URS to continue development of the database and online components of the Sandpan database project with Florida's southwest Gulf Coast as the project area. One benefit of this new project was the teaming of URS with Coastal Planning and Engineering (CPE) of Boca Raton, Florida. With this addition of a more project-focused coastal engineering firm, the Sandpan reconnaissance framework could be more focused at the individual beach nourishment project level. With the union of these two fundamental ways of searching and viewing the available data, it was determined by BBWR that Sandpan needed to be expanded to include the new classes of data that can be of value in engineering beach nourishment operations. This new database and associated Web site is called the "Reconnaissance Offshore Sand Search" or ROSS (Figure 1-1).

With the completion of the Southwest Gulf Coast Sand Search, the newly named Bureau of Beaches and Coastal Systems (BBCS) approved the continuation of the ROSS project to encompass the entire Florida Atlantic coast. The work was organized and authorized into a series of "Phases". There are four Phases that correspond to the three regional sand search areas for the Atlantic Coast and an east coast field study plan. Phase I is the southeast and includes Dade, Broward and Palm Beach Counties, Phase II is the central region made up of Martin, St. Lucie, Indian River and Brevard counties, Phase III is the northeast region which includes Volusia, Flagler, St. Johns, Duval and Nassau counties and Phase IV is the field work portion of the contract. The regional sand searches were set up on an overlapping time schedule, with the field work to be run concurrently. The overall work for each sand search Phase was designed along the same parameters to produce similar outcomes. This report represents the second of a three report series for the Florida Atlantic Coast.

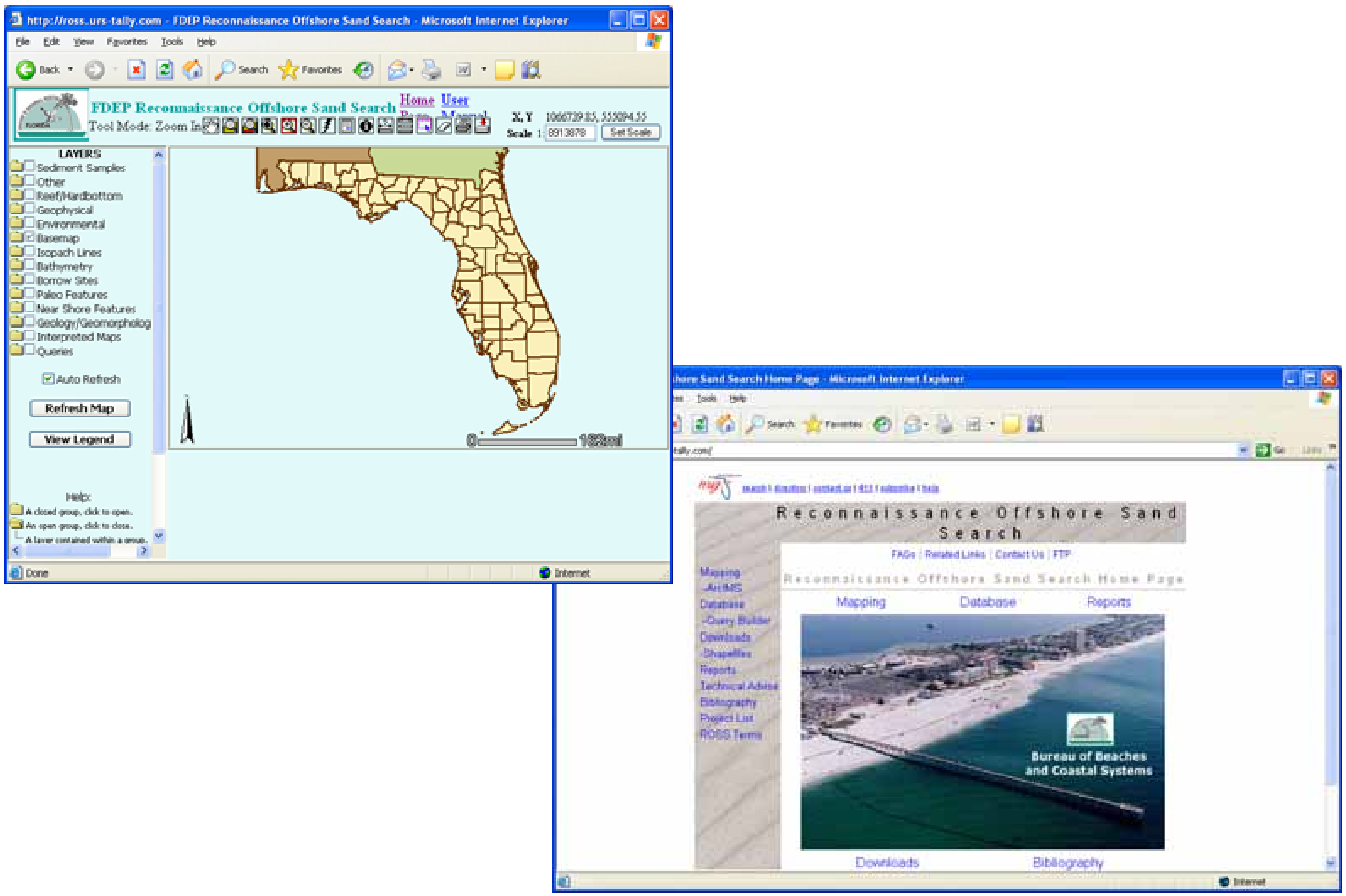


Figure 1-1. The Reconnaissance Offshore Regional Sand Search (ROSS) Home Page and the ROSS Internet Map Service (IMS) Page.

2.1 LEGACY DATA: THE SEARCH PROCESS

Using the same approach that was used during the original Sandpan and subsequent Southwest Florida Gulf Coast projects, URS and CPE conducted an exhaustive literature search for relevant applicable data. This included all previous reports, core logs, sediment sampling data, isopach maps and other geotechnical, geophysical, bathymetric or sedimentological data available that specifically identifies or studies the distribution of offshore sand resources of the Florida Southeast Atlantic coast. This information was obtained from the BBCS, the Florida Geological Survey, the University of Florida, the University of South Florida, the Florida State University, the U.S. Army Corp of Engineers (USACE), the U.S. Geological Survey (USGS), the Minerals Management Service (MMS), and previous studies conducted by various consultants contracting with the BBCS.

Additionally, the Florida Atlantic Coast Sand Search has presented opportunities that were not available in the Panhandle and Southwest Gulf Coast sand searches. The most important aspect is the effort that individual counties have extended with their own beach management programs. This has led to the development of expertise among these entities that has been used as an aid in determining the types and amounts of data in the region and as a contribution to the development of the sand resource and geological conceptual model.

As of this report date, eighteen datasets have been added to ROSS for the Central Phase II region. This brings the number of datasets to 144. These include theses, dissertations, Government reports and Consultant reports. A total of 1,735 samples, 169 cores, 36 jet probes and approximately 1,787 miles of geophysical data have been added during this phase of the project. This has increased the database to approximately 12,000 sand samples, 4,100 cores, 220 jet probes and over 7,500 miles of geophysical data in the form of sub-bottom profile images.

2.2 DATA SELECTION PROCESS FOR ROSS

With the need to focus on data which enhances the database without diminishing storage capacity, and therefore slowing down the search and retrieval process, URS and CPE developed a Data Acquisition and Entry Plan. This plan was used as the framework for deciding which data will be incorporated into ROSS and which data will be archived outside of the database for the Southeast project. An example of this selection process could include data from a previous study of a borrow site. If a series of cores were taken from a site that was subsequently developed, storing all the sample data from these cores may be unnecessary. Taking a representative sample of the cores which adequately describes the area would be appropriate. Storing only this data would save space, as well as limit the return hits from the database, consequently speeding up the query process. The original individual records will be kept in an electronic archive, but they will not be in the database or on the associated ftp site.

2.3 THE DATABASE

2.3.1 Data Types

Two basic types of data are stored in the database. The first is tabular data used to store information about sediment properties. The original Sandpan database schema consisted of thirteen data tables that include three associated look-up tables. These tables contained data related to the sediment sample itself. Included were fields for sediment grain size, texture, mineralogy, both Munsell and descriptive color, organic content, shell content, heavy mineral content, collection method, location information, core layer information, the analytical methods used in analysis, and both Wentworth and USC classification schemes. Project information like project name, managing agency, contact names, project date, driller and collection methods are also included. Several other geologic parameters like sphericity, angularity, and gradation have also been recorded.

The new ROSS database schema is an expansion of the Sandpan schema and currently includes thirty-three relational data tables. The database has been expanded and enhanced to allow for more comprehensive search and comparison functions than previously available. Several new tables were added so that searches could be structured that would return data on descriptive properties of sediment layers found within cores. Included are tables which store layer structure, lithology, and textural qualifiers. The capabilities for using descriptive information about sediment and sediment layer properties have been enhanced by adopting the U.S. Army Corps of Engineers standard core description procedures for characterizing sediments and core layers.

With the addition of the more project-focused analysis that includes storing data on core layers, the expanded database now contains these column headings:

AGENCY_ID
AGENCY_NAME
ANALYTICAL_METHOD_ID
ANALYTICAL_METHOD_NAME
ANALYTICAL_METHOD_DESCRIPTION
ANGULARITY_ID
ANGULARITY
PK_BIBSUMMARY
AUTHOR
AUTHOR_LAST_NAME
AUTHOR_INITIALS
TITLE
KEYWORDS
PAPER_YEAR
ABSTRACT
PUBLISHER
CALCULATION_METHOD_ID
CALCULATION_METHOD_NAME
CALCULATION_METHOD_DESCRIPTION
COLLECTION_METHOD_ID
COLLECTION_METHOD
COLLECTION_METHOD_DESCRIPTION
COLOR_DESCRIPTOR_ID
COLOR_TONE_ID
COLOR_TONE
COLOR_ID
COLOR
CONTACT_ID
CONTACT_NAME
CONTACT_PHONE
CORE_LAYER_QUALIFIER_ID
CL_CORE_LAYER_ID
STX_SOIL_TEXTURE_ID
SD_SOIL_DESCRIPTOR_ID
ST_SOIL_TYPE_ID
L_LITHOLOGY_ID
S_SORTING_ID
QUALIFIER
CORE_LAYER_ID
CORE_CORE_ID
LS_LAYER_STRUCTURE_ID
USCS_USCS_CLASSIFICATION_ID
CMTX_COLOR_MATRIX_ID
BOTTOM_OF_LAYER_INTERVAL
TOP_OF_LAYER_INTERVAL
MUNSELL_HUE_WET

COLOR_DESCRIPTOR
COLOR_MATRIX_ID
CT_COLOR_TONE_ID
CD_DESCRIPTOR_ID
COL_COLOR_ID
COLOR_TONE_ID
CM_COLLECTION_METHOD_ID
PRJ_PROJECT_ID
DRL_DRILLER_ID
COLLECTION_DATE
CORE_TOP_ELEVATION
CORE_LENGTH
CORE_DIAMETER
X_COORD
Y_COORD
STATE_X
STATE_Y
STATE_ZONE
LONGITUDE
LATITUDE
LORAN_X
LORAN_Y
PENETRATION_DEPTH
RECOVERED_LENGTH
DIRECTION
OVERBURDEN
DEPTH_RX
GROUNDWATER_ELEVATION
PERCENT_RECOVERED
CORE_IDENTIFIER
DRILLER_ID
DRILLER_NAME
DRILL_TYPE
AGN_AGENCY_ID
GUEST_NAME
PK_GUESTBOOK
GUEST_ORG
GUEST_EMAIL
GUEST_DATE_VISIT
MUNSELL_VALUE_WET
MUNSELL_CHROMA_WET
CORE_LAYER_COMMENTS
CORE_LAYER_IDENTIFIER
CORE_ID
LAYER_STRUCTURE
LAYER_STRUCTURE
LITHOLOGY
HUE
VALUE
CHROMA
CMTX_COLOR_MATRIX_ID
PROJECT_ID
AGN_AGENCY_ID_POSSESSING
AGN_AGENCY_ID_MANAGING
CON_CONTACT_ID
PROJECT_NAME
PROJECT_DATE
PROJECT_LOCATION
HORIZONTAL_COORDINATE_SYSTEM
HORIZONTAL_DATUM
VERTICAL_DATUM
PROJECTION
SAMPLE_ID
PRJ_PROJECT_ID
LAB_LAB_ID
AM_ANALYTICAL_METHOD
SLU_SPHERICITY_ID
ALU_ANGULARITY_ID
CM_COLLECTION_METHOD_ID
USCS_USCS_CLASSIFICATION_ID
CMTX_COLOR_MATRIX_ID
MUNSELL_HUE_DRY
MUNSELL_VALUE_DRY
MUNSELL_CHROMA_DRY
MUNSELL_HUE_WET
MUNSELL_VALUE_WET
MUNSELL_HUE_WASHED
MUNSELL_VALUE_WASHED

GUEST_COMMENT
GUEST_EMAIL_UPDATE
LAB_ID
LAB_NAME
LAB_ADDRESS
LAYER_STRUCTURE_ID
SAMPLE_DATE
SAMPLE_COMMENTS
ANALYSIS_DATE
LAB_REMARKS
X_COORD
Y_COORD
STATE_X
STATE_Y
STATE_ZONE
LORAN_X
LORAN_Y
LONGITUDE
LATITUDE
RANGE_MONUMENT
RM_TRANSECT_LOCATION
TOP_OF_SAMPLE_INTERVAL
BOTTOM_OF_SAMPLE_INTERVAL
GRAB_ELEVATION
MEAN
MEDIAN
STD
SKEWNESS
KURTOSIS
MEAN_ORIGINAL
MEDIAN_ORIGINAL
STD_ORIGINAL
SKEWNESS_ORIGINAL
KURTOSIS_ORIGINAL
CALC_CALC_METHOD_ID_MEAN
CALC_CALC_METHOD_ID_MEDIAN
CALC_CALC_METHOD_ID_STD
CALC_CALC_METHOD_ID_SKEW
CALC_CALC_METHOD_ID_KURT
MUNSELL_CHROMA_WASHED
MUNSELL_HUE_UNKNOWN
MUNSELL_VALUE_UNKNOWN
MUNSELL_CHROMA_UNKNOWN
SAMPLE_IDENTIFIER
CARBONATE_DISSOLVED
HEAVY_MINERALS_DISSOLVED
ORGANICS_REMOVED
SHELL_FRAGMENTS_REMOVED
PHI
USCS_COBBLE
USCS_COARSE_GRAVEL
USCS_FINE_GRAVEL
USCS_COARSE_SAND
USCS_MEDIUM_SAND
USCS_FINE_SAND
USCS_SILT
USCS_CLAY
WW_BOULDER
WW_COBBLE
WW_GRAVEL
WW_PEBBLE
WW_VERY_COARSE_SAND
WW_COARSE_SAND
WW_MEDIUM_SAND
WW_FINE_SAND
WW_VERY_FINE_SAND
WW_SILT
WW_CLAY
WW_COLLOID
SAMP_SAMPLE_ID
CL_CORELAYER_ID
VIRTUAL_SAMPLE
PK_SITEINFO
SITE_QUESTION
SITE_INFO
USERMAN
USERMAN_LOCATION
COLUMN_NAME

PCT_FINES
PCT_PAN_FRACTION
PCT_CARBONATE
PCT_SHELL_FRAGMENTS
PCT_HEAVY_MINERALS
PCT_ORGANICS
SAMPLE_DATA_YN
CORE_DATA_YN
DISPLAY_GROUP
SOIL_DESCRIPTOR_ID
SOIL_DESCRIPTOR
SOIL_TEXTURE_ID
OIL_TEXTURE
SOIL_TYPE_ID
ALIAS
DESCRIPTION
DISPLAY_ORDER
DISPLAY_YN
PHI_RANGE
SOIL_TYPE
SORTING_ID
SORTING
STANDARD_DEVIATION
SPHERICITY_ID
SPHERICITY
USCS_CLASSIFICATION_ID
CLASSIFICATION_NAME
CLASSIFICATION_DESCRIPTION

The second type of data stored in the database is spatial data. Spatial features along with their accompanying attributes reside in the ORACLE relational database as Spatial Database Engine (SDE) layers. These spatial features are stored much like any other data types, as a string of characters or as a number. This enables the end user to optimize the abilities of this corporate database management system to manipulate large datasets and relate them to a geographic location on the earth.

Important issues that users need to understand are the restrictions and caveats involved with any of the data sets. To accomplish this goal, metadata (or data about the data) have been created for each data set and each spatial layer. These metadata conform to the Federal Geographic Data Committee (FGDC) requirements. The FGDC coordinates the development of the National Spatial Data Infrastructure (NSDI). The NSDI encompasses policies, standards, and procedures for organizations to cooperatively produce and share geographic data. The 17 federal agencies that make up the FGDC are developing the NSDI in cooperation with organizations from state, local and tribal governments, the academic community, and the private sector. For more information, see www.fgdc.gov.

2.3.2 Accessing the Database

Access to the ORACLE database is possible using one of three methods. The most direct is to click on the Query Builder link found on the ROSS homepage (Figure 2-1). This link will take you directly to the online Enhanced Query Builder page (Figure 2-2).

The Enhanced Query Builder is a custom-built application that allows the user to create Structured Query Language (SQL) statements. These SQL statements access real-time data from the ORACLE relational database. Unique WHERE clause statements may be constructed by the user that are added to an SQL statement one criteria at a time. These SQL statements are what tell the computer to retrieve all the data for which the set of conditions are true. These statements may be set to return data from all of the thirty-three tables residing in the ROSS database. Once the query is executed, the data matching the search criteria are returned on the Sand Sample Query Results page.

At the bottom of the Sand Sample Query Results page there are three other options provided to the user. These are accessed by clicking on one of the three buttons found at the bottom of this page. These will enable the user to either “Download Data”, in a Tab delimited format, “Go Back” to the Enhanced Query Builder to perform another query, or spatially “View in ArcIMS” the data that was returned by the query. A detailed Users Guide for the Enhanced Query Builder can be found in Appendix A.

The second way to access the ROSS database is through the online Internet Map Service (IMS) which is accessible through the ROSS homepage ArcIMS link. The IMS site was initially developed using the ESRI “out of the box” ArcIMS software. Appendix B contains the user’s guide for the ROSS Interactive Mapping site.

Figure 2-3 is a screen capture of the on-line mapping page within the ROSS Web site. On the left side of the image are folders, which contain the many different “layers” with which the user may interact. These layers are the spatial representations of the tabular data residing in the Oracle database. Most of these layers have been created especially for this project, with data generated by this project. However, some of these layers, including the Artificial Reefs, Sea Grass Beds, and others, were downloaded from other sites and incorporated in the ROSS on-line mapping. This illustrates the versatility of on-line mapping. Designers can combine data and information accessed over the Internet with local data for display, query, and analysis. For instance, environmental issues in potential renourishment areas are a concern. As an on-line search of state government spatial data repositories was conducted, many shapefiles dealing with environmental issues were found at the Florida Geographic Data Library (FGDL). These shapefiles were subsequently downloaded from the FGDL site, re-projected and added to the ROSS site.

The third way to access data residing in the ROSS database is to download the data directly to the users’ own workstation. By using the Downloads link on the ROSS homepage the user is taken to a location where all the data residing in the database is available for quick and easy download (Figure 2-4).

This data is stored as SDE layers in both spatial and tabular format. Spatial data is in shapefile format, therefore allowing the user to add these to their own Geographic Information System (GIS), combining them with other shapefiles that the user may have developed or received from other sources. Shapefiles contain data from a relational database management system (RDBMS). The RDBMS may be pulled out of the shapefile as a stand-alone portable format to be used with the ArcView software on a local machine. Downloading the tabular data is accomplished through the Enhanced Query Builder. This data may be downloaded in a tab-delimited format compatible with several analytical and graphing software packages. The user may download all or part of the data.

By design, the ROSS site currently does not include tools used for composite statistical analysis, as the Bureau of Beaches and Coastal Systems (BBCS) does not desire to constrain the design professional to any particular suite of analytical products. The intent of this project web site is to allow the user to view the data spatially over the Web, to be able to query the data on several different levels and to download this data to their own workstation for advanced analysis.

2.4 DATA ENTRY

To accommodate the various entities that will supply data for inclusion into the ROSS database, two separate data entry tools will be made available. The first is a purpose-built Microsoft Access front end and the second is the commercially available software gINT.

The Microsoft Access front end is a customized data entry form that makes use of a user-friendly graphical user interface or GUI. From the main page of the front end the user will be able to access the appropriate page for data input (Figure 2-5).

A PROJECT INFORMATION page includes places to enter pertinent information on the project (Figure 2-6). This includes Project name, location, managing agency, and contacts.

Project level parameters are also defined. These parameters are entered in fields that define the projection information and horizontal and vertical datums. There is a Grade Scale field that allows the user to select which of three grain-size recording measures were used: phi, millimeter, or sieve size. For example, by choosing phi, as shown in Figure 2-6, the user then checks the appropriate boxes for the phi values used. This information will later determine, in the "Add a Sample" page data entry form, which fields will be available for data entry. This acts as a quality control feature to help eliminate incorrect data entries.

Once Project Information is recorded, the user may proceed to enter data. If cores were collected for the project, the user needs to click on the CORES button on the main page of the front end, pulling up the Core Entry page. Here, data relative to the collection location, elevation, penetration, recovery and other detailed information of the core is entered (Figure 2-7).

After data from the core is entered, information on the actual core layers may be added. This is a new feature of the *enhanced* ROSS database. In the old Sandpan design, only the core location information was stored. With the ROSS design the user may add data describing the core layers themselves. Click on the Add Layer Information For This Core button and the Core Layer Information page appears (Figure 2-8). On this page a user will be able to enter layer structure, composition, texture, lithology and sediment type. There is also a comments field for use in adding any other information the user finds pertinent.

The next step in entering data is to input individual sample information. This data entry tool recognizes two Sample types, Samples from a Core and Grab Samples. To enter information about a Core Sample, click the Add Sample To This Core button on the Core Entry form. To enter information about Grab Samples, click the Grab Samples button on the Main Page. The Sample Entry Page or Sample Information Interface (Figure 2-9) is used for adding data related to the individual sample. Included are fields for all data columns residing in the database relating to sediment samples. On the bottom portion of the page is a series of boxes representing phi sizes used in the sieving analysis. Some of these boxes are open and some are shaded.

The open boxes with values beside them are the same phi sizes set as the phi sizes on the Project Information page. When the user originally set up the project and chose the phi sizes, these were then transferred to this page, therefore only allowing data to be input into the correct fields. This eliminates the likelihood of the user placing data values in the wrong category.

The second data entry tool has been chosen because of its multi-faceted abilities. This is the commercially available gINT software. The data output formats for core logs and various other engineering and geological tools from the gINT software have been adopted by the Jacksonville

District Army Corps of Engineers (USACE). The developers of gINT have taken the database table structure created for the ROSS database and incorporated it into commercially available software for contractors. Contractors will then be able to input data into this structure and deliver it to BBCS for almost seamless entry into the ROSS database.

2.5 OTHER FEATURES AND TOOLS

2.5.1 The Annotated Bibliography

Another feature of the ROSS Web site is the searchable Annotated Bibliography (Figure 2-10). There are currently over 900 references in the database covering topics on sediments found on the continental shelf, sedimentary processes, sea level curves and fluctuations, and the resulting changes in the shoreline over the last 12,000 years.

A large portion of these references are theses, dissertations and reports not readily accessible. The Annotated Bibliography page is designed to allow the user to search by the Author's last name, title of the paper or key word(s). There may also be an accompanying summary or abstract of the paper provided, copyrights permitting.

2.5.2 Web Site (ross.urs-tally.com)

The ROSS Web site is the means to an end. By navigating through the Web site, all the ROSS data, on-line interactive mapping, query builders to access the database, data downloads, reports, shapefiles and the annotated bibliography are available at the touch of a button. There is a New Users page with frequently asked questions that may help in understanding the functions of this Web site. New questions and answers will be posted as they are received and answered.

The ROSS database and Internet Map Service were created to provide access to both spatial and tabular data for a wide variety of online users. This site will enable BBCS staff, coastal engineers, the academic community and the general public to view and download all relevant data from historical, current and future studies conducted around the state of Florida.

The ROSS Web site was designed with three intentions. The first is to allow users to view data spatially over the web and be able to download this data in both tabular and shapefile format to a personal workstation for advanced analysis. The second is to give the coastal engineering community the ability to cut the cost of an initial design and permitting phase of a beach nourishment project. By compiling all the available data together in one easy-to-use location, more detailed evaluations of sand deposits needed for these projects may be conducted. Finally, the database has located and digitally-preserved a large portion of data that once resided in perishable formats.

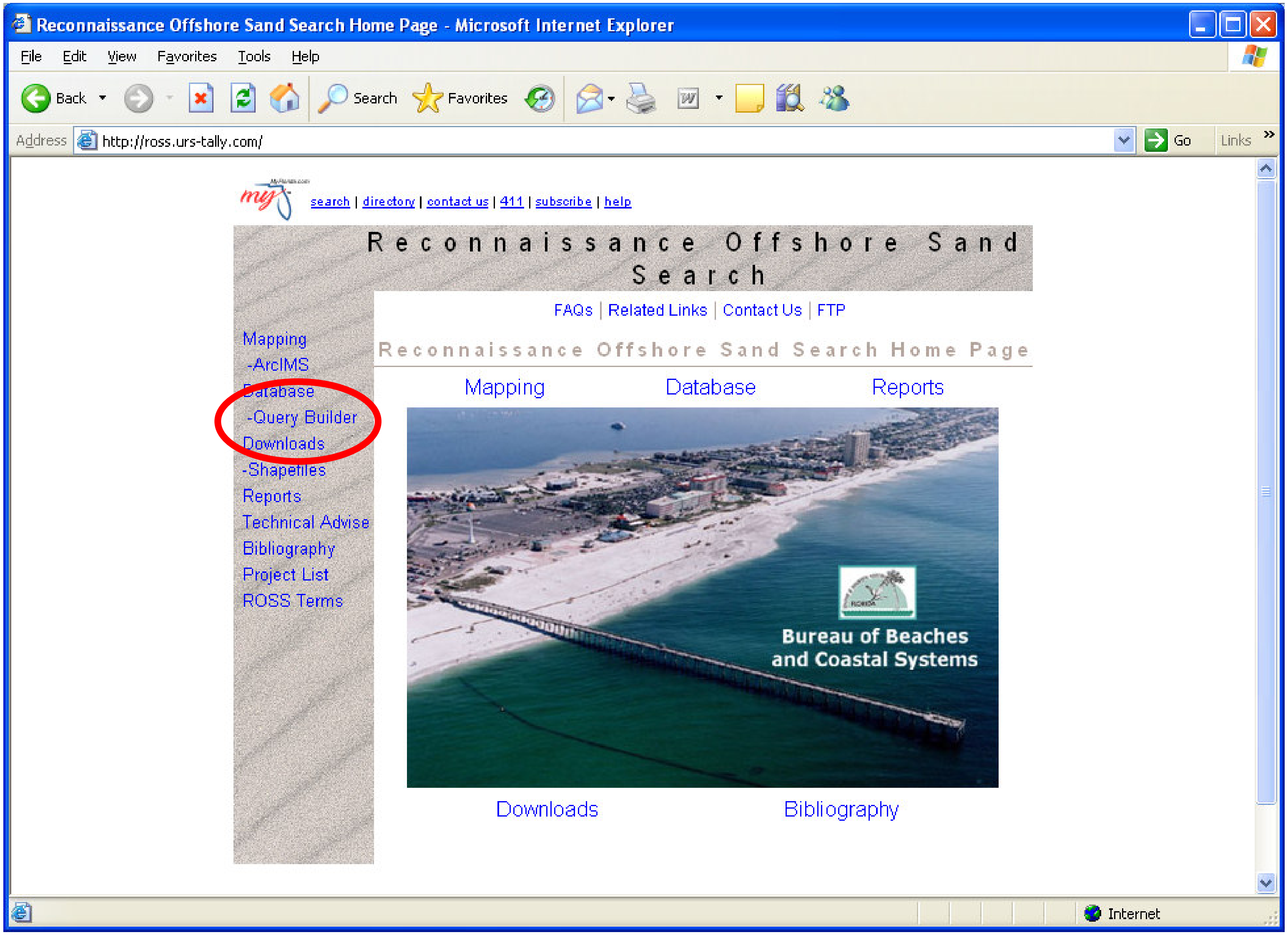


Figure 2-1. The ROSS home page showing the Query Builder link.

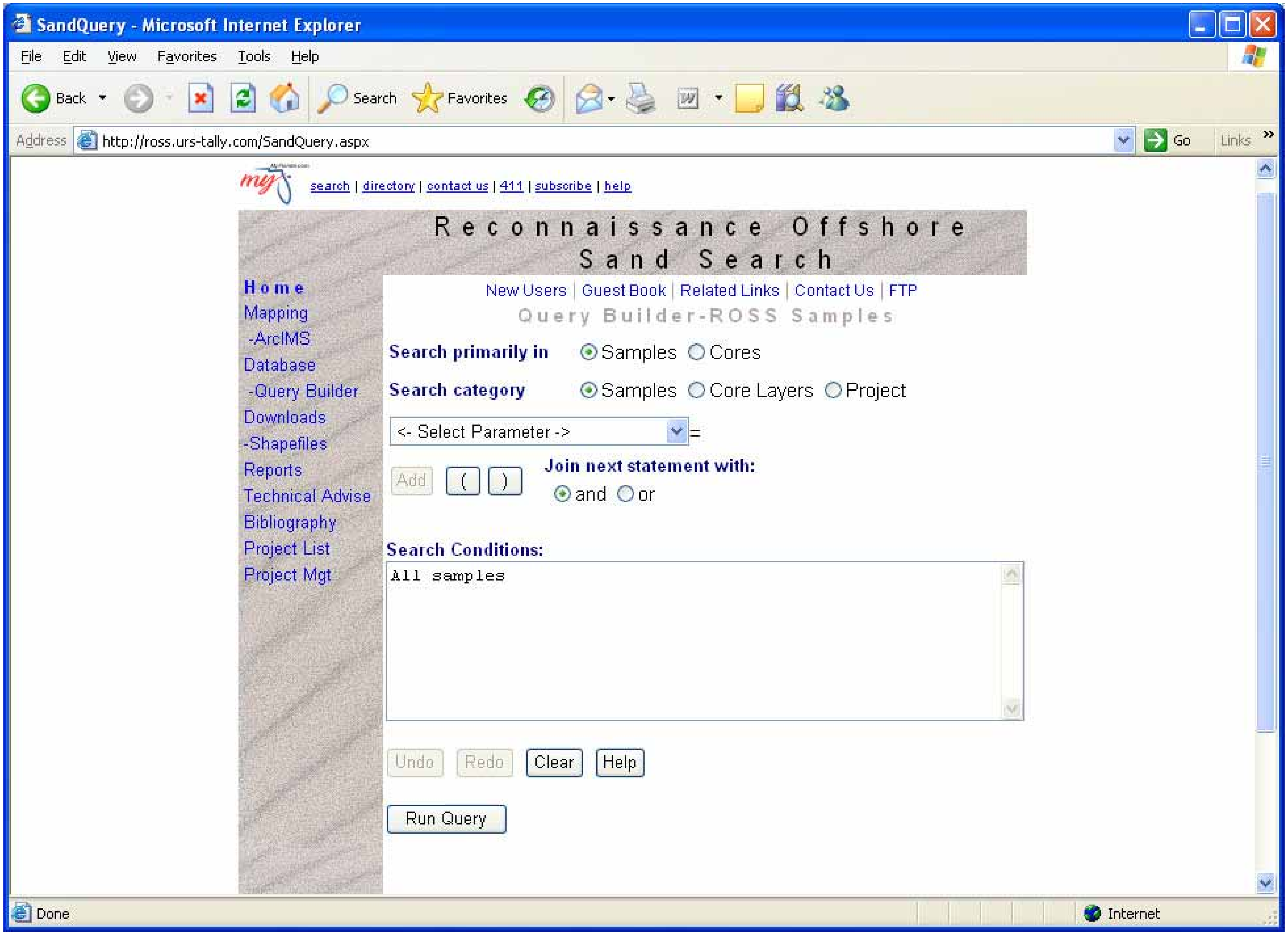


Figure 2-2. The Enhanced Query Builder page.

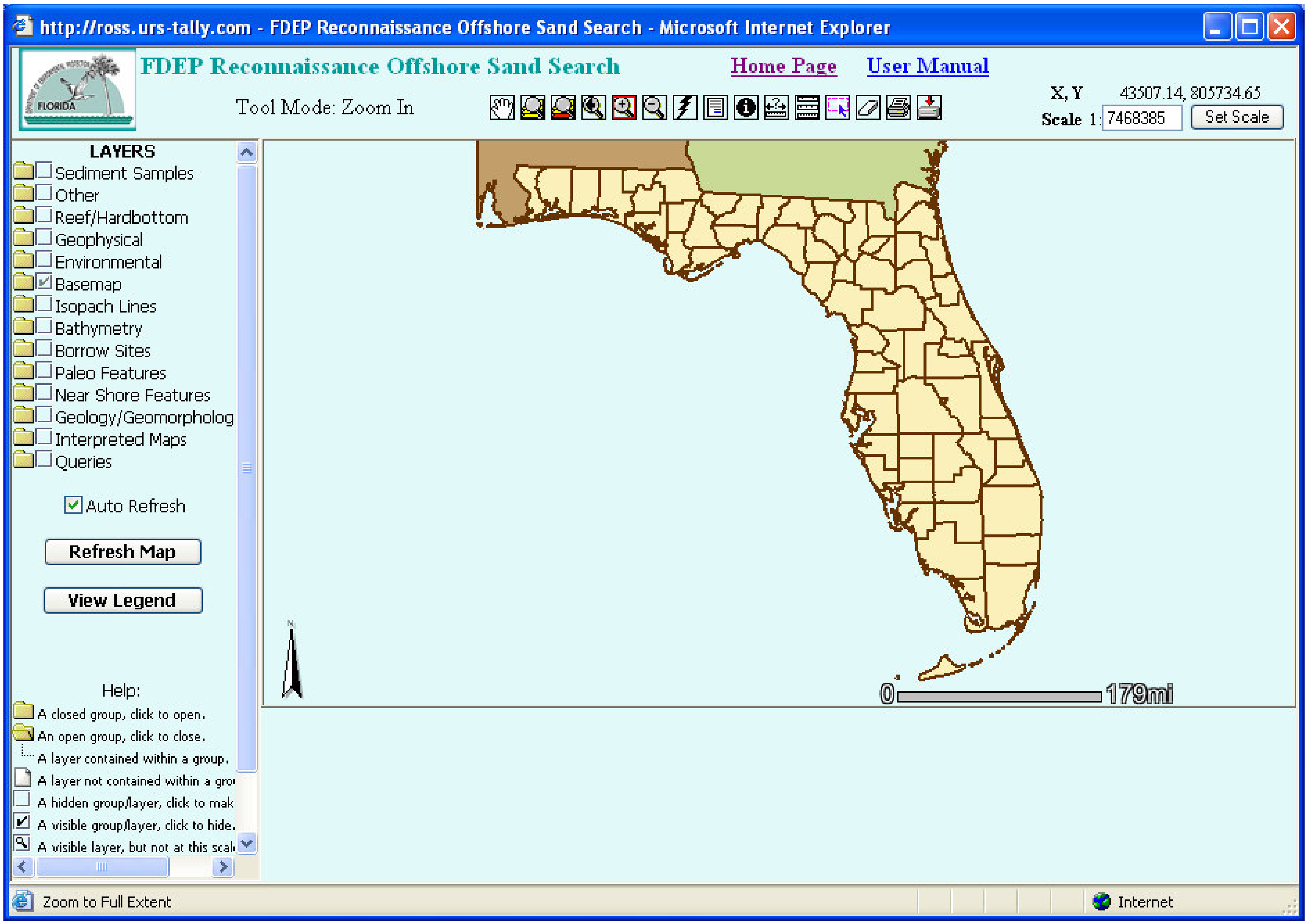


Figure 2-3. The ROSS on-line mapping page.

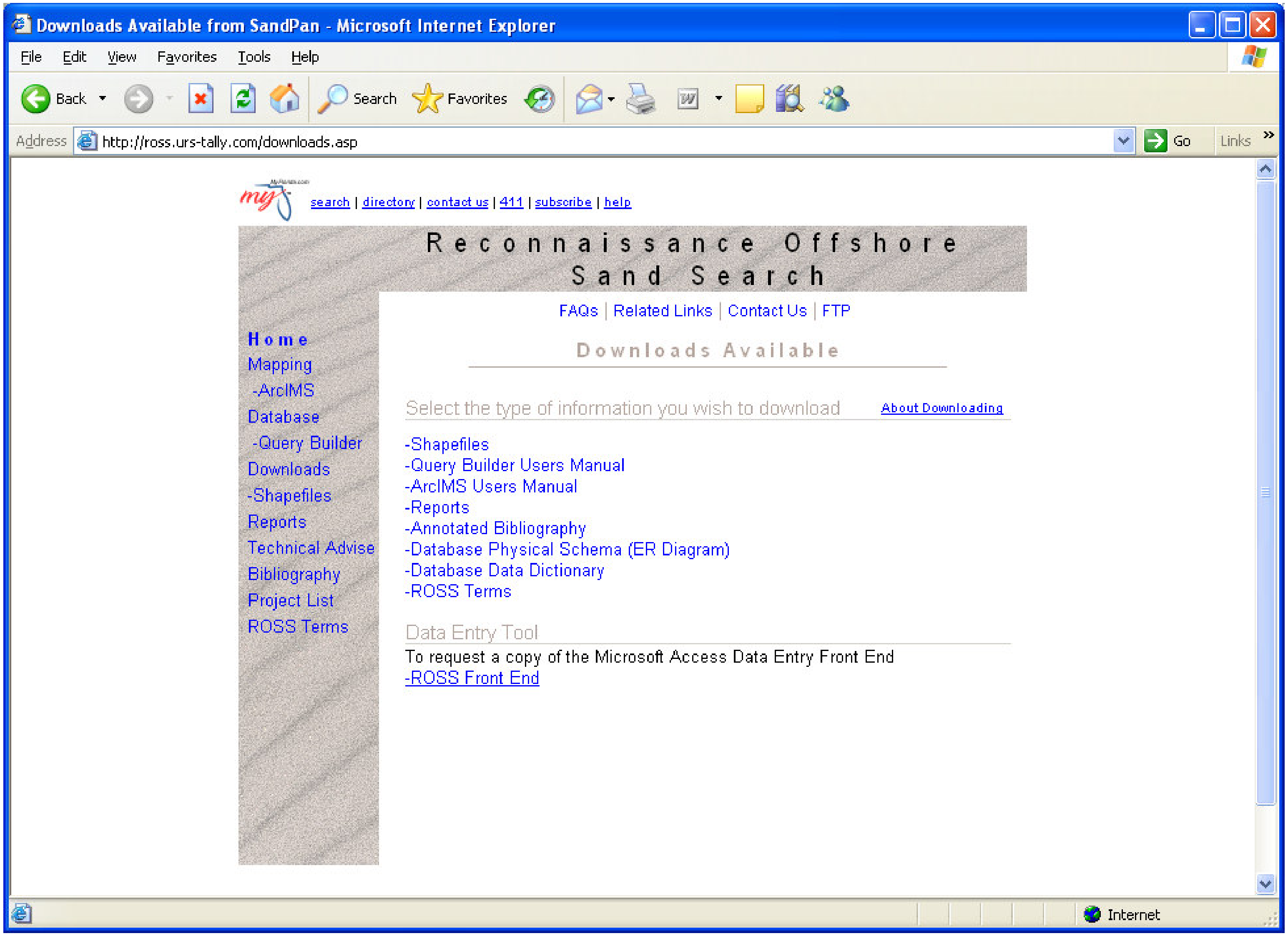


Figure 2-4. The ROSS Downloads page.

Figure 2-5. The ROSS Front End main page.

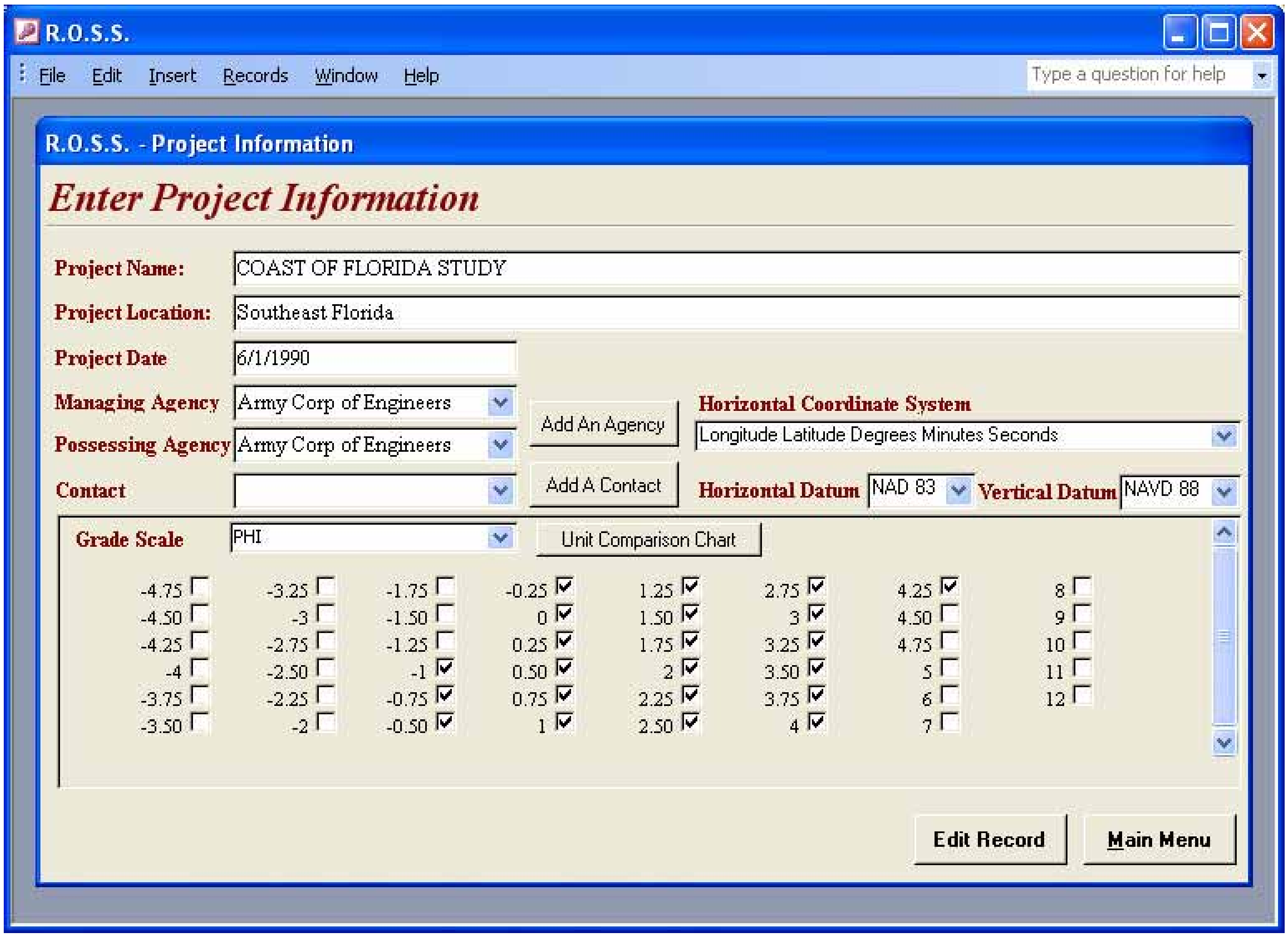


Figure 2-6. The ROSS Front End Project Information page.

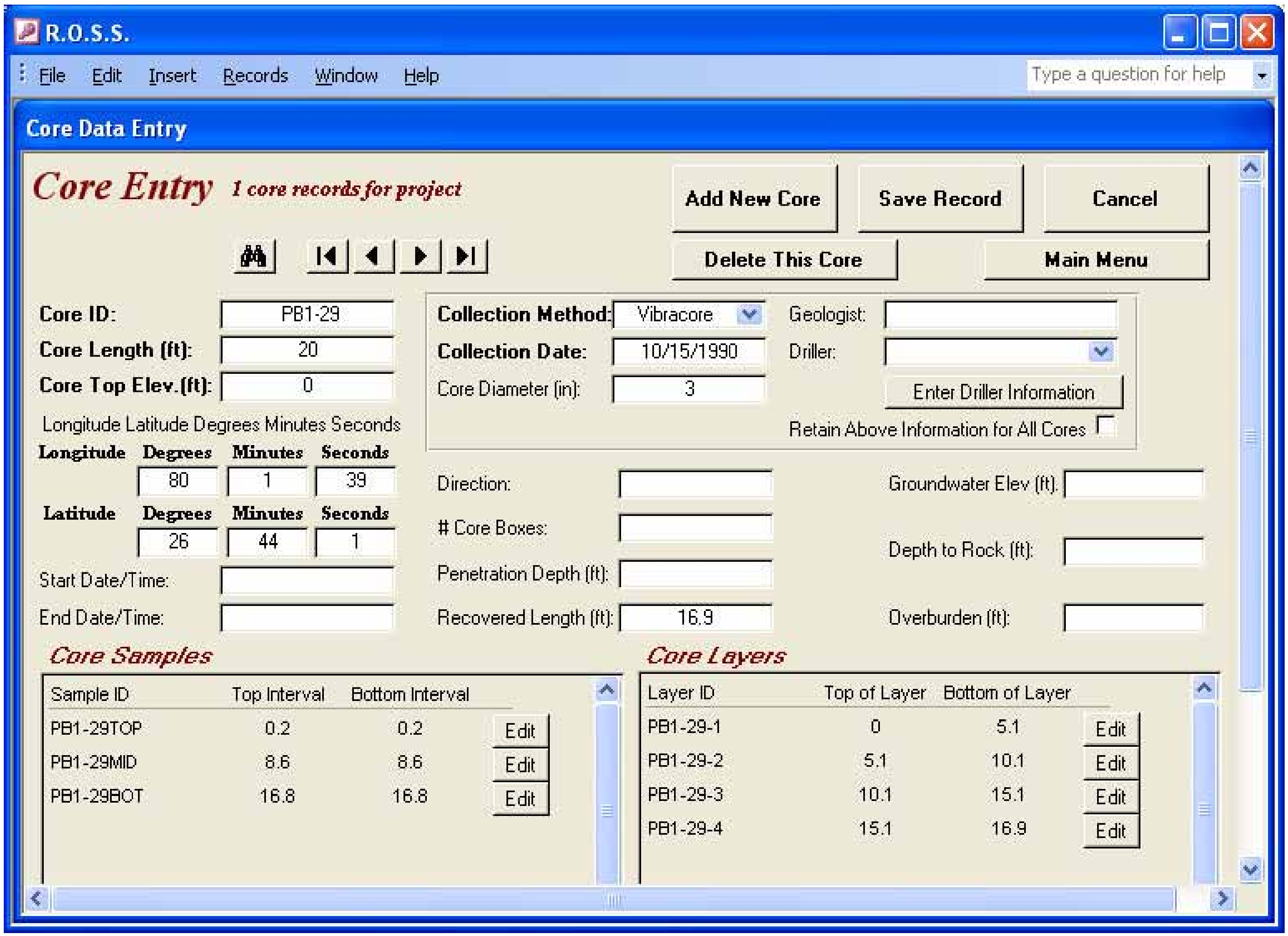


Figure 2-7. The ROSS core entry interface.

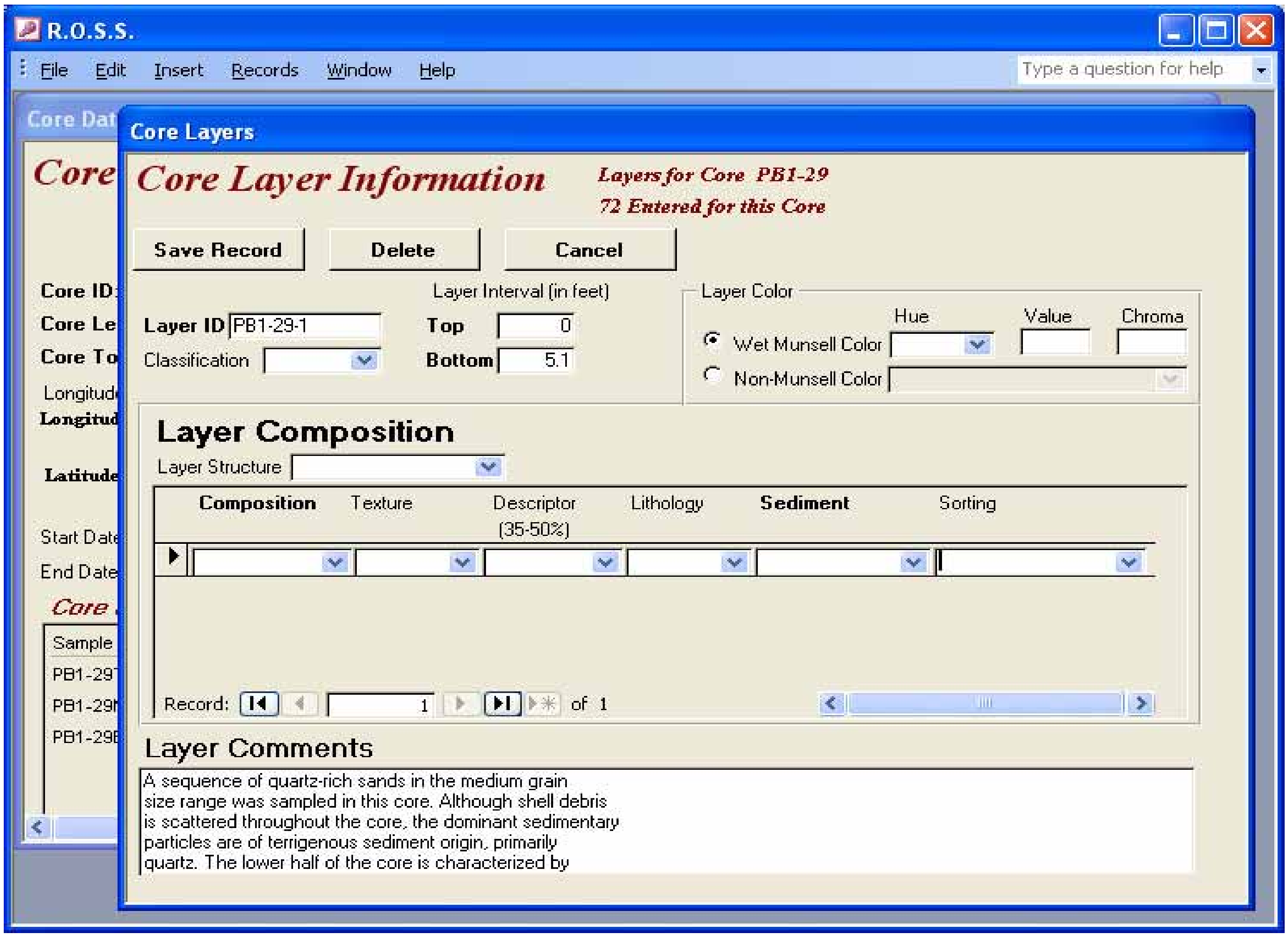


Figure 2-8. The ROSS core layer information interface.

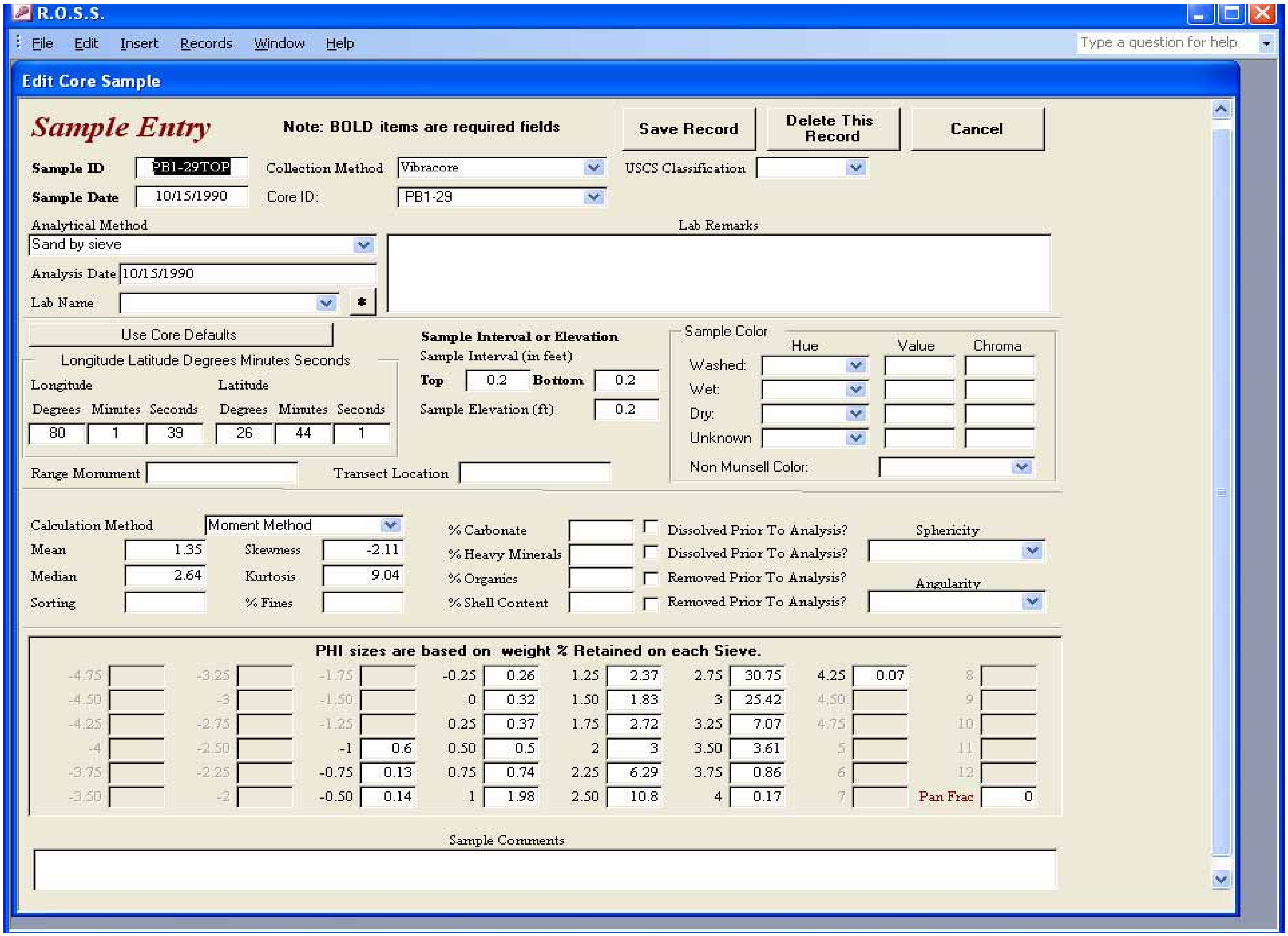


Figure 2-9. The ROSS sample information interface.

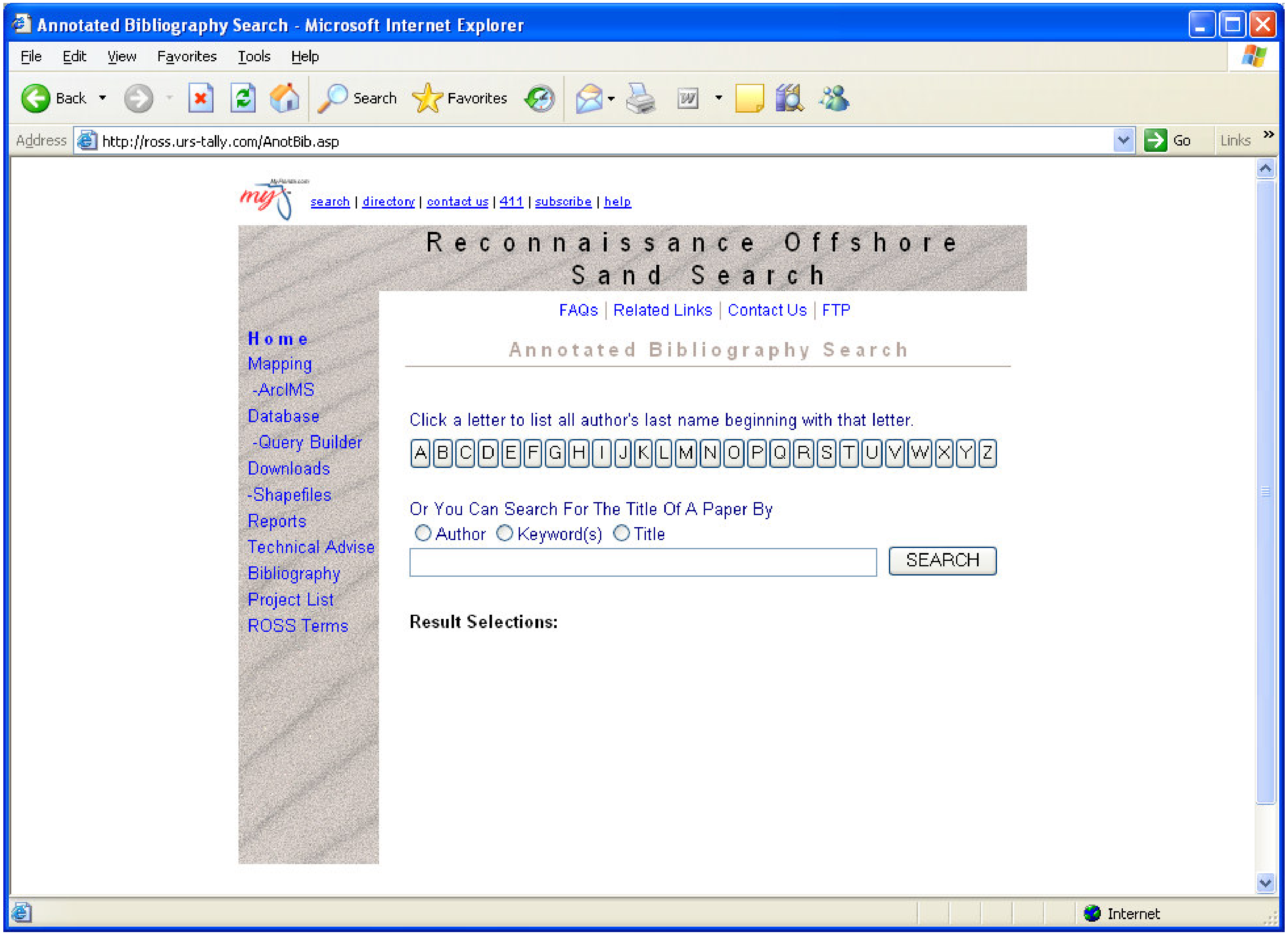


Figure 2-10. The Annotated Bibliography page.

3.1 PURPOSE, GOAL AND PROJECT DESIGN

The overall purpose of this reconnaissance-level project is to determine the sand resource potential on the continental shelf along the central Florida Atlantic coast. Results of the project will be incorporated into the ROSS (Reconnaissance Offshore Sand Search) database for the State of Florida, Bureau of Beaches and Coastal Systems (BBCS). Critical to this assessment of sand resource potential is the determination of areas related to prior investigations, areas actually exploited for sand as evidenced by borrow pits, areas that were investigated but not exploited, and areas that have not been investigated. In this way, a comprehensive overview of the status of sand resource investigations can be compiled and studied as guidance for future work. Development of a coastal geological framework or conceptual geologic model is part of the scope of work because it facilitates comprehension of sediment distribution patterns, provides background for better understanding the types of sedimentary bodies that occur in the study area, and indicates geological and geomorphologic constraints on the evolution and maintenance of sedimentary basins on the shelf.

Key to this study was the availability of NOAA bathymetric data offshore Brevard, Indian River, St. Lucie, and Martin counties. Although limited by quality of the data, the NOAA bathymetry provided a convenient base for mapping seafloor topography, determining geomorphologic units, and establishing a submarine land topology that could be related to morphosedimentary bodies (Figure 3-1). Analyses of sandy seafloor areas could thus be conducted in a GIS environment, based on iterative queries to ascertain specific types of sedimentary bodies by area. By assuming arbitrary depths of one and two meters, it was possible to estimate potential sediment volumes by mapping unit and area within each county. Results of the study were to indicate potential sand resources by type of deposit and location on the continental shelf.

3.2 INTRODUCTION

The most prominent geological and geomorphologic features along the central east coast of Florida include the cuspate foreland of Cape Canaveral and associated offshore shoals. Cape Canaveral is a strip of land in Brevard County, Florida, near the center of the Florida Atlantic coast at 28°33′21″N, 80°36′17″W. It is part of a region known as the Space Coast, and is the site of the Kennedy Space Center, and the Cape Canaveral Air Force Station. The name "Canaveral" *(Cañaveral* in Spanish) was given to the area by Spanish explorers, and it literally means "canebrake". It can be interpreted as "Cape of Canes". Seaward extensions of the 'Cape of Canes' are marked by extensive offshore shoals and ridge fields. These large sedimentary features are propagated downdrift by longshore and littoral drift sequences that are distally manifested in Indian River, St. Lucie, and Martin counties as ridge fields, sand flats, and shoreface attached sand sheets.

Because of the prominent topographic nature of the Cape, one of the largest cuspate forelands in the world, it drew the attention of early explorers and scientists. Some of these early studies are mentioned here as background to development of the geological model that is relevant to offshore sand searches. More recent sediment resource studies have been conducted by the Florida Geological Survey (*e.g*. Freedenberg *et al*., 1995, 2000; Hoenstine *et al*., 2002) for the Minerals Management Service (areas seaward of the state-federal boundary at the three mile limit) and as part of sand search investigations for beach nourishment projects in state waters

(Finkl *et al*., 2006a). Initial comments here feature establishment of the offshore study area on the continental shelf and its general features as appreciated in historical and modern studies, especially as they are related to sedimentary bodies and the recognition of discrete segments of seafloor comprised by groups of similar features.

3.2.1 Study Area and Coastal Geological Framework

The study area along the central east coast of Florida occurs in the Atlantic and Gulf Coast Physiographic Province (Walker and Coleman, 1987). Terrestrial and estuarine systems are comprised by barrier island (beach-dune) systems and the Indian River Lagoon, including the Mosquito Lagoon sub-basin. Environmental deterioration of beaches and dunes, due to coastal erosion, is the impetus for offshore sand searches to provide beach-quality sediments for restoration. The offshore portion of the study area lies on the continental shelf physiographic units: shoreface, inner shelf plain, outer shelf, and Florida-Hatteras Slope (Figure 3-2). Both areas are briefly described as they relate to background, coastal erosion, and offshore sand resources.

The barrier island complex, including the Mosquito Lagoon sub-basin, has taken an estimated 240,000 years to form and is the result of multiple rises and falls in sea level (Brooks, 1972; Fernald and Patton, 1984). More specifically, the central east coast of Florida is formed mainly by eroded relict dune lines (Rink and Forrest, 2005) and broad marine terraces, as well as the present barrier islands and lagoon system. Terraces were formed during high stillstands, which allowed erosion by waves and currents to form flat plains that emerged as flatlands when the sea level subsided (Brooks, 1972, 1982; Mehta and Brooks, 1973; Glatzel, 1986).

The lowest terrace in the Mosquito Lagoon watershed is called the Silver Bluff Terrace. As sea level receded, dune ridges, including the Atlantic Coastal Ridge, formed on this terrace (Schnable and Goodell, 1968). The Mosquito Lagoon drainage basin is bordered by the Atlantic Coastal Ridge on the west and the Atlantic Beach Ridge (Barrier Islands) on the east. Mosquito Lagoon was created by a small number of physiographic features.

A predominant physiographic land feature of the barrier island system in this area is Cape Canaveral. Cape Canaveral is a cuspate foreland (Stauble, 1988), similar to Cape Hatteras (North Carolina) where a sandy cape developed by the meeting of offshore currents. The Mosquito Lagoon barrier islands were created, in part, by this cuspate foreland. Additionally, to the north, the flood-tidal delta of the migrating (until stabilized) Ponce de Leon Inlet and a now-closed second inlet that was located near Bethune Beach influenced the physiography of Mosquito Lagoon (Stauble, 1988). Unlike many barrier islands, the barrier islands associated with Mosquito Lagoon have only a single dune ridge averaging 3.6 m in height (Woodward-Clyde, 1994). For the vast majority of its length, the dune is stable, backed by a dense growth of saw palmetto (*Serenoa repens*) and several other species of hardy shrubs and grasses.

Some areas along the barrier island of Mosquito Lagoon are very narrow, which makes them susceptible to over-wash and likely spots for inlet formation. In the fall of 1999, small, temporary inlets were formed from overwash at several spots along the barrier island during hurricanes Dennis, Floyd, Harvey, and Irene. These overwashes may become larger and more frequent if hurricane intensity and frequency increase. Also, if global warming continues as predicted, sea-level rise will exacerbate these impacts.

The seaward side of the study area is comprised by a portion of the Atlantic continental shelf. The Atlantic margin continental shelf varies considerably in width, gradient, and morphologic complexity over the 1864.11 mi it extends along the east coast of the United States. Almost all of it is covered by a surficial sand sheet, often with some gravel (Hollister, 1985). South of the former glaciated area, the shelf is characterized by fields of relatively well-oriented, linear, northeast-trending shoals (Duane *et al*., 1972). These shoals form a small angle with the coast (usually less than 35°), display complex bathymetry, have up to 32.81 ft m of local relief, and have side slopes of a few degrees. As well-organized morphologic features, they extend from water depths of only a few meters out to depths of about 197 ft. Even though they show large variation in size, complexity, and distribution along the eastern seaboard, they nevertheless can be grouped into arcuate (inlet and cape-associated) and linear shapes (Duane *et al*., 1972).

The shoals, composed of Holocene sands, rarely attain thicknesses greater than 32.81 ft and generally rest on horizontal strata of marsh, lagoon, and estuarine deposits. Radiocarbon dating of the underlying material indicates that the shoals are younger than the last transgression and are therefore less than 11,000 years old (Walker and Coleman, 1987). The shoal sands, which bear evidence of recent modification by current and wave activity, are generally well-sorted, medium-grained sands that are similar in lithology to present shoreline beaches. Although there are numerous theories concerning their origin, it is generally accepted that they were formed by nearshore processes. Shoals that are now isolated on the shelf are judged to have been formerly shoreface-connected and subsequently detached during the coastal retreat that accompanied the last rise in sea level.

Carbonate sediments occur on most modern continental shelves (Ginsburg and James, 1974). Because the various skeletal and nonskeletal grains are not moved far from their environments of formation, their distribution is a reliable tool on continental shelves for interpreting the history of Holocene deposition. Holocene shelf carbonates, summarized by Ginsburg and James (1974), are grouped into two intergrading categories: open shelves (*e.g.* eastern Gulf of Mexico) and rimmed shelves (*e.g*. south Florida). Rimmed shelves are those in which a continuous or semi continuous rim or barrier lagoon on the shelf margin restricts circulation and wave action on the adjacent shelf lagoon. The rim along the southeast Florida coast is a barrier reef, which terminates just south of the Martin County – Palm Beach County line.

The thin accumulation of surface sediments on open shelves is largely relict and formed in shallow water earlier in the Holocene. The deposits of rimmed shelves, especially the shallower ones, are often thick, young (<6000 years old), and continuous, with contemporary deposits. Sand and granular-sized grains are the most frequent and widespread form of carbonate on modern shelves. Coral algal reefs and algal hardgrounds are characteristic of shelf margins in tropical seas. Lime muds and mixtures of lime mud and sands are limited to lagoons rimmed by shelf-margin barriers.

Surface sediments of the western North Atlantic shelf are relict and were deposited in shallow water earlier in the Holocene, as described by Emery (1968), Emery and Uchupi (1972), and Milliman *et al*. (1972). From Cape Hatteras south to Miami the percentage of carbonate increases progressively. Milliman *et al*. (1972) mapped nine assemblages of carbonate sand grains on the southern shelf. North of Jacksonville, molluscan debris predominates over the interior shelf with zones of ooid-peloid and coralline algae near the margin. From Jacksonville to Miami, where the percentage of carbonate is higher, ooid-peloid sands are more extensive, barnacle fragments are a significant component, and the molluscan sand zone is narrower. The age of the ooid sand near the shelf margin off Florida ranges from 9000 to 14,000 years BP (Macintyre and Milliman, 1970).

From Cape Hatteras to Cape Kennedy, the ridges of the shelf margin are interpreted as erosional remnants of Pleistocene limestone, capped by shallow-water calcarenite and coralline algal limestone. Milliman *et al*. (1972) radiocarbon dated two samples of the algal limestone at about 12,000 and 27,000 years BP. From Cape Kennedy to Palm Beach the ridges are relict dunes or beach ridges capped with prolific growth of living branched corals (*Oculina* sp.)(Macintyre and Milliman, 1970). From Palm Beach to Miami the single ridge is an 'inactive' reef of hermatypic corals, octocorals, and sponges, with a narrow halo of carbonate sand rich in fragments of algae (Ginsburg and James, 1974).

3.2.2 Geological Development of the South-Central Atlantic Coast of Florida

The northern boundary of the basement structure supporting the Florida Platform was a linear structural basin located between the Peninsular Arch and the Paleozoic (4500 to 544 Ma) rocks of the southeastern United States. This structural zone originally was related to a suture zone and accreted continental terrain associated with the final closing of the Iapetus Ocean (proto-Atlantic Ocean). During the Jurassic Period when seafloor rifting and continental drift separated the Americas from Africa, the initial carbonate stratigraphic sequences onlapped from the south onto the Peninsular Arch basement rocks. As the Peninsular Arch became covered with shallow water carbonates during the Early Cretaceous (146 to 65 Ma) (due to subsidence and sea-level rise) to form the Suwannee Saddle and the seaway that flooded it (variously called the Suwannee Strait, Channel or Seaway; the Gulf Trough; or the Georgia Channel System) (Hine, 1997), this basin and seaway were paramount in maintaining the carbonate sediment producing environment to the south.

There are two fundamentally different views concerning the topographic complexity of the early basement structure underlying the Florida-Bahamas region. In one view, Mullins and Lynts (1977) postulated that the Bahamas Bank formed during the Jurassic on top of rift-generated horst-and-graben topography (the so-called "graben hypothesis"). During long-term subsidence associated with the regional passive margin setting, carbonate derived sedimentation on the megabank kept pace, forming thick (up to 8.7 mi) shallow-water limestones. Sheridan *et al*. (1988) and Leg 101 Scientific Party (1988) postulates a great, contiguous carbonate megabank, extending from the West Florida Escarpment (in the Gulf of Mexico) to the Blake-Bahamas Escarpment (western Blake-Bahama Basin), had formed by the Late Jurassic on a basement terrain not segmented into large horsts and grabens (the so-called "megabank hypothesis"). Whether horst-and-graben or megabank, karst developed in Paleocene, Eocene, and Oligocene limestones to produce subsurface and exposed sinkholes and local stratigraphic deformation in the form of folds and sags (Meisburger and Duane, 1971; Popenoe *et al*., 1984). These folds have about 80 m of subsurface relief. Karstification (dissolution) proceeded during the late Oligocene (38 to 24 Ma) to early Miocene (24 to 5 Ma) low stands of sea level. These structures probably control modern coastal morphology and shelf topography from Cape Canaveral to the St. Lucie River estuary.

3.2.3 Features of the Continental Shelf

The study area occurs on the southern extension of the major physiographic unit identified by Uchupi (1968) as the East Coast Shelf. The Florida Hatteras Slope occurs seaward. The East Coast shelf is a gently seaward-sloping submarine plain bordering the Atlantic coast from near Cape Cod to the Florida Keys. The south-central Florida Atlantic shelf area is part of the southeastern shelf. Following Price's (1954) geomorphologic terminology, Meisburger and Duane (1971) subdivide the Florida shelf into three main units: shoreface (low water line to about -39.37 ft), inner shelf plain (-39.37 to -75.46 ft MLW), and outer shelf that is transitional from the 'flat' inner shelf to the top of the Florida-Hatteras Slope lying at -78.74 to -229.67 ft LMW (Low Mean Water). The slope break generally falls between the -65.62 and -78.74 ft depth contour. These units are shown in Figure 3-2.

Sub bottom features of the inner shelf were interpreted from zigzag reconnaissance seismic surveys (Meisburger and Duane, 1971). The shallowest reflector, light gray or white calcarenite or sediment containing calcarenite fragments, lies just below the shelf surface and outcrops at -59.06 to -68.9 ft MLW. The calcarenite layer dips seaward at about 1 on 1300 slope and is parallel to the general dip of the surface of the inner-shelf zone.

Shoreface Zone

The shoreface zone between North Palm Beach and Cape Canaveral is a relatively narrow terrace-like feature that extends from mean low water to depths of -29.53 to -39.37 ft. This 2,952.8 to 459.32 ft wide zone dips seaward on a slope of 1 on 80. Shoals that occur in the segment between Hobe Sound and Vero Beach often extend into the shoreface (Figure 3-2). Coquina outcrops alongshore and on the inner shelf suggests that the shoreface may be partly composed of consolidated or semi-consolidated coquina rock of the Anastasia Formation. There is often 4.92 to 9.84 ft of sediment over the coquina rock in the shoreface zone (Meisburger and Duane, 1971).

Inner Shelf Plain

According to Meisburger and Duane (1971), the inner shelf plain (Figure 3-2) is characterized by an extremely gentle seaward slope, narrow depth range (between -39.37 to -75.46 ft), and its general alignment is parallel to the shoreline. Morphologically, the inner-shelf plain consists of a series of platforms or step-like flats (areas of reduced gradient), gentle slopes leading from one level to the next, and shoals. The features are bathymetrically subdued, not topographically prominent. Shoal ridges and hills are most extensively developed south of Sebastian Inlet. These shoals are linear and most are aligned in a northeasterly direction. In profile, inner-shelf shoals show a smooth regular surface with both symmetrical and asymmetrical cross-sectional forms. Where asymmetrical, the steeper flanks face east or southeast (seaward). Analyses of seismic reflection profiles indicate that the shoals are superposed on the surface of the flat.

Outer-Shelf Zone

This is dominantly a zone (Figure 3-2) of discontinuous broken topography of generally low relief (9.84 to 22.97 ft). The seafloor is characterized by rocky or coral reef patches, ridges, ledges, cliffs, and depressions. Linear trends of ridges or abruptly steepening slopes are typical of this zone. Although these features are discontinuous and highly irregular, some ridges are fairly persistent at water depths of 68.9 to 88.58 ft MLW.

3.2.4 Prior Differentiation of Seafloor Morphologic Types

The study area contains what Shepard (1968) refers to as a cuspate foreland coast, a type of Secondary Coast in his classification system. Cuspate forelands are a special type of barrier that has a point projecting toward the open sea, as he describes for Cape Kennedy.

Many continental shelves display a distinctive surface topography that is commonly described as ‘ridge and swale’ topography (Palmer and Wilson, 1978), as occurs offshore from the coasts of Delaware, Maryland, and Virginia. These shelf areas are characterized by elongate ridges of unconsolidated sands tens of kilometers long and a few kilometers wide. Their presence in parallel sets has generally been attributed to both submergence of barrier islands (static, relict features preserved on the shelf surface) and to dynamic constructional processes generating ridges that are built and maintained by present shelf currents (dynamic features formed by the present hydraulic regimes associated with storms). On the inner continental shelf, these sand ridges connect with the shoreface, or they may occur as isolated bathymetric highs. In water depths less than 65.62 ft, waves and inner shelf currents are believed to modify these shoals (Duane *et al*., 1972).

Linear sand bodies characterize the continental shelf in the study area. These features are generically referred to as sand ridges and are grouped for purposes of reference into distinct ridge fields, areas containing morphologically similar groups of sand ridges. Off (1976) refers to linear sand bodies caused by tidal currents as ‘tidal current ridges’ (a rhythmic series of ridges oriented parallel with a tidal current) and ‘sand waves’ (oriented perpendicular to the tidal current direction). Recognition of linear sand bodies goes back to Playfair (1802) who described the morphological evolution of sand banks in the North Sea as resulting from tides and currents. Similar features are described for the Bahama Bank by Agassiz (1894), Newell and Rigby (1957), Illing (1954), and Purdy (1961). Tidal current ridges develop where there is a source of sediment and a tidal current strong enough to move that sediment. Most oceanographic charts use the terms ‘sand bank,’ ‘bank,’ or ‘shoal’ indiscriminately as depth indicators. The Coast and Geodetic Survey uses the non-genetic terms ‘sand ridges’ or ‘finger shoals’ (Off, 1976).

The origin of the term ‘sand wave’ goes back to fluvial geomorphology when Hinder (1882) described these waves in the Mississippi River. Sand waves in tidal currents was reported, for example, along the coast of England (Cornish, 1901a,b), Taiwan (Boggs, 1974), Long Island Sound (Bokuniewicz, Gordon and Kastens, 1977; Fenster *et al*., 1990), North Sea (Caston and Stride, 1973), northern Bering Sea (Field et al., 1981), Irish Sea (Harvey, 1966), and Chesapeake Bay (Ludwick, 1972). Sand waves have additionally been considered in terms of genesis morphology, including internal structure, for example, historically by Van Veen (1935) and more recently by Allen (1980).

Houbolt (1976) describes groups of sand ridges in the North Sea between England, Belgium, and The Netherlands, an area referred to as the Well Bank. In this area of strong tidal currents, the ridges seem to be moving slowly northeastwards. During marine transgressions that are not accompanied by strong tidal currents, only thin veneers of sand are formed. Transport during such a transgression is mainly by wave action, which is always directed toward the shore. As a result, sand made available by marine erosion during the transgression is transported towards the shore, where it is deposited on coastal barriers and in tidal channels. Occurrence of sand ridges has been described for numerous types of situations, for example, in theory and practice by Pilkey et al. (1969); Swift et al (1972, 1978, 1984); Stahl, Koczan and Swift (1974); Swift and Field (1981); Belderson (1986); McBride and Moslow (1991); Parker, Lanfredi and Swift (1982); Snedden *et al*. (1994); Snedden and Dalrymple (1999).

Terms like sand sheets (*e.g*. Knebel, 1981; Fenster, 2005), shoals (*e.g*. Field and Duane, 1974; Penland *et al*., 1989), and banks (*e.g*. Stride *et al*., 1982; Dyer and Huntley, 1999; McBride, 2005; McBride e*t al*., 1999) are also used to describe characteristic sedimentary features on the seafloor. Often these terminologies overlap and features merge with one another or are palimpsest (overlapping) with bars occurring on sand sheets and ridges on shoals and banks.

In the case of the post-glacial transgression, much of the sand made available by marine erosion was not transported towards the shore but was preserved at sea in the southern bight of the North Sea (Houbolt, 1976). Houbolt (1976) uses the term 'ridge' for an elongated rise of the seafloor, either straight or curved, at least 16.40 ft high, which stretches parallel to the direction of the tidal currents. Synonyms for "ridge" are knoll, bank, and rug. Sand ridges are thus distinct from mega-ripples, which are usually smaller and oriented perpendicular to the tidal current. Synonyms for "sand ridges" are sand wave, underwater dune, and large sand ripple.

3.3 METHODOLOGY

The basic methodology of this reconnaissance assessment of offshore sand resources on the continental shelf off the central east coast of Florida involved acquisition and manipulation of digital bathymetric data from NOAA (NOAA-GEODAS bathymetry), graphic display of the reformatted data points, and interpretation of the resulting spatial distribution patterns of bathymetric highs and lows in terms of seafloor physiographic units. Bathymetric patterns were interpreted as morphosedimentary bodies in terms of sand flats, ridge fields, transverse bar systems, and shoals. About nineteen mapping units were derived from the bathymetric data, not including ebb-tidal delta complexes at major inlets (not mapped because they were too small to show at the mapping scale).

Historical (published and unpublished) data was perused to gather background information about the area and to assess sand resource potentials. Some historical data was general in scope while other data was point specific. Geotechnical (grab samples and vibracores) and geophysical data (seismic reflection profile surveys) were, for example, assessed from a variety of sources including the Florida Geological Survey, Minerals Management Service, and data from Coastal Planning & Engineering for the St. Lucie offshore sand search. By combining seafloor mapping units, geotechnical, and geophysical data, it was possible to estimate sediment volumes by geomorphologic mapping unit. The latter procedure was accomplished in a GIS platform where various criteria could be queried. Each methodology is briefly described as follows.

3.3.1 Bathymetric Data Reformatting

The conceptual geological model is based on interpretation of reformatted NOAA bathymetry that was specifically collated for this project into a coherent mapping unit plus reference to the more detailed St. Lucie sand search. Due to differences in scale and resolution of the original NOAA data, reliability of bathymetric units varies from sheet to sheet. The conceptual geological model is incomplete in the sense that large areas of seafloor bathymetry (approximately 184,068 ha, 36% of the study area) is not amenable to interpretation of landform types. Nevertheless, most of the study area contained usable bathymetric plots that could be interpreted. Those units make up the conceptual model for application in offshore sand searches. Procedures, operations, and results are described for development of sand search protocols in the Central Atlantic Coast Sand Search Model (CACSSM), as formulated here.

Bathymetric data (NOS Hydrographic Survey Data) were obtained from the NOAA Geophysical Data Center (NGDC at www.ngdc.noaa.gov). The hydrographic data consists of historic survey information from the 1930's to present. Spacing of data grid cells varied on average from about 328.08 ft to more than 1,968.50 ft, providing a wide range of spatial resolutions. Bathymetric grids were created using Surfer® to interpolate the data to equally spaced intervals so that resulting spatial distribution patterns would better resemble recognizable topography. Because grid cell spacing varied according to original data resolution in each bathymetric survey area, the shelf was divided into sheets with the same grid spacing. Grid spacing intervals, based on Customary units, are listed by ascending order of survey sheets as follows: Reformatted NOAA Sheet 1, 250 ft (76 m) grid spacing; Reformatted NOAA Sheet 2, 250 ft (76 m) grid spacing; Reformatted NOAA Sheet 3, 1000 ft (304 m) grid spacing; Reformatted NOAA Sheet 4, 1000 ft (76 m) grid spacing; Reformatted NOAA Sheets 5a and 5b, 1000 ft (76 m) grid spacing; and Reformatted NOAA Sheet 6, - 500 ft (152 m) grid spacing.

The reformatted NOAA bathymetric data comprises millions of points in a bathymetric database for a coastal study segment that spans 126 mi alongshore and up to 26.7 mi offshore to cover nearly 1962 mi^2 of seabed. When this reconnaissance coverage is printed at a nominal map scale where 1 cm = 1.86 mi (RF of about 1:40,000), it provides convenient handling capabilities in one map sheet. A single map sheet is useful because spatial patterns become recognizable for the first time viz. extent and continuity of sediment ridges, sand flats, shoals, nearshore bars, *etc*. On these color-ramped bathymetric charts where there is rapid change in depth, as along flanks of ridges, well-defined dark shadows emphasize closely spaced isobaths. Shaded relief bathymetric maps with about a tenfold exaggeration of vertical scale produce discrete sounding patterns that can be interpreted in terms of topographic units. The reformatted NOAA reconnaissance bathymetric datasets provide fair discrimination of geomorphologic units and this cognitive recognition of various large-scale geomorphologic units leads to the development of a seafloor typology. Validation of typologies is achieved by sea-truthing, supported by geophysical and geotechnical surveys.

Bathymetric survey areas with 1000-ft grids (Reformatted NOAA Sheets 3, 4, and 5a,b) had the poorest bathymetric coverage in the NGDC database. The original survey points spaced from 1000 to 2000 ft apart provided low resolution of bottom features compared to more detailed surveys. Because much of the seafloor in these areas was not easily interpreted due to low resolution of the data, parts of these mapping sheets were simply designated as 'Undifferentiated Seafloor.' That is, apart from strongly differentiated large-scale bathymetric features, the data did not permit reliable interpretation of seafloor features. Included in these low-resolution datasets were digital processing artifacts of the re-gridding process that tended to obscure smaller-scale low-relief features. More detailed interpretation of seabed features in these low-resolution mapping areas will require additional bathymetric surveys. The basic methodology for these low-resolution areas was thus to avoid interpretation of subtle relief features because they may be artifacts in the data.

The basic mapping procedure was to group similar, spatially-related seafloor features into discrete mapping units. Recognition of seafloor features from the color-ramped bathymetry depends on the experience and knowledge of the interpreter. The product is the result of interpretation and deductive reasoning. The essential points of the mapping procedures are described, for example, by Benedet *et al*. (2004); Finkl and Warner (2004); Finkl (2005); Finkl, Benedet and Andrews (2005); and Finkl *et al*. (2007). The present work is an extension of the geological model for the continental shelf off the southern Atlantic coast of Florida, as prepared for the ROSS database project (Finkl, Andrews and Benedet, 2007).

3.3.2 Historical Data Analysis Offshore St. Lucie County

General background information relating to the occurrence of sand resources on the inner continental shelf off of St. Lucie County, Florida, is presented here because it provides a window into the types of seafloor conditions that occur throughout the general study area. This vignette briefly introduces some basic understanding of shelf evolution and geodynamics, which will be used to further develop the conceptual geological model for offshore sand searches along the central east coast of Florida.

The continental shelf off the east coast of Florida is a drowned (flooded) coastal plain that was exposed subaerially and submerged in many eustatic cycles of sea-level change. The shelf thus shares terrestrial and marine sediments in thick sedimentary sequences that date back to the initiation of continental drift when North and South America rifted away from Africa in the Jurassic Period (206 to 144 Ma, mega annum or million years). The present configuration, morphology, and surficial sedimentary cover of the inner shelf thus results from a long, complicated history that is briefly summarized here as background.

Reconnaissance study of sediments associated with seafloor mapping units off St. Lucie County provide insight into the geological complexity of sediment distribution patterns, range of geomorphic features, and usefulness of prior survey data in reconnaissance-scale assessment of sand resource potential on the continental shelf along the central east coast of Florida. In the example of the St. Lucie data, several conclusions emerge from the merger of historical data with contemporary survey techniques. Review of historical geotechnical data facilitated the creation of a geo-referenced 3D image of the seabed using NOAA-GEODAS Hydrographic data (Figure 3-3) to select target areas for the offshore surveys. Based on the analysis of historical data and experience from past projects near St. Lucie County, it was concluded that nearshore sand ridges had the most potential for storing beach-quality sand.

Study of a color-ramped bathymetric model (see Figures 3-3 and 3-4) showed the presence of prominent shallow-water and deepwater sand ridges. The shallow-water ridges occurred shoreward of the 3-mile limit that separates state from federal waters. This legacy data was used to select target locations for reconnaissance surveys, indicated by the red rectangles in Figure 3-4.

3.3.3 Reconnaissance Bathymetry and Surface Samples

Subsequent reconnaissance investigations followed a sand search protocol outlined by Finkl, Khalil and Andrews (1997), Finkl, Benedet and Andrews (2003), Benedet *et al*. (2004) and Finkl and Khalil (2005). The protocol suggests that, in areas where bathymetrically positive features (sand ridges) occur, reconnaissance investigations should concentrate on obtained recent bathymetry data and reconnaissance sand samples (Phase I), followed by jet probes (Phase II) and finally seismic and vibracores (Phase III).

Because the NOAA bathymetric data used in the historical data analysis is at least a decade old, it is necessary to obtain current bathymetry data to accurately map the sand ridge boundaries and relief. To supplement the bathymetric survey, reconnaissance samples were obtained using surface ponar grabs. These samples are an inexpensive method to confirm historical data in surficial layers before further investigations are conducted. Results from this reconnaissance bathymetry and sand sampling survey were analyzed to provide further up-to-date information regarding sand ridge geomorphology and quality of surface sands within the target sand ridges.

The bathymetric data obtained by CPE (November 2005) was gridded at high resolution and proved essential in providing better definition of the sand ridges previously identified based on scattered historical data. The new bathymetric data showed prominent ridges in both study areas and emphasized well-defined series of shore-oblique ridges mapped in the nearshore survey area (Figure 3-5). Substantial sand ridges are also located in the survey area located further offshore. The location and shape of the ridges in the updated bathymetry differed slightly from that identified from interpretation of the NOAA-NOS data. The surface sediment samples confirmed that these ridges contained beach quality sand in surface layers and that future survey efforts are warranted in these areas.

3.3.4 Example of Seafloor Sediments Offshore St. Lucie County

Surface sediments in the Ft. Pierce area (Figures 3-3, 3-4 and 3-5), based on color and gross composition, group into five main types: (A) clean, poorly sorted, brown shelly sand; (B) gray, fairly well sorted, calcareous sand; (C) silty gray sand and shelly gravel; (D) clean, light gray, fine to medium-grained, well-sorted calcareous sand; and (E) white to light gray, generally poorly sorted, calcareous mud, sand, or gravel that is often lithified (Meisburger and Duane, 1971). Interpretations of sediment distribution patterns are based on common factors creating similarities in sediment type viz. (1) deposit age, (2) provenance (sediment source area), (3) environment and circumstances of deposition, and (4) post-depositional history. Additionally, quartzose fine sands and silty cohesive very fine sands are widely distributed throughout the shoreface zone.

All sediments in the Ft. Pierce shelf area that have a brown coloration and which are devoid of silt or clay are classified as Type A. The group is variable but in most places is medium to very coarse, poorly sorted calcareous sand. Quartz is variably present, ranging from a few percent to over 40 percent. Type A sediment usually overlies Types B and C, but it also occurs in direct contact with Types D and E.

Type A Sediments

This group of sediments generally does not occur on the outer shelf area. Over the inner shelf flats, Type A sediments occur as a relatively thin blanket deposit less than 5 ft thick. Over shoals, Type A sediments thicken appreciably (to 30 ft or more) and seismic data indicates that some smaller shoals are entirely composed of this material. Thickness of Type A sediments is related to shelf topography, being thick under shoals and thin in the flats and swales.

Type B Sediments

According to Meisburger and Duane (1971), these sediments are probably a facies of the Type A group, the main difference being the color of Type B constituent particles that range from white through gray to black (in contrast to the brownish and reddish colors of Type A). Type B sediment is gray-colored calcareous sand that is usually fairly well sorted, but may be poorly sorted in some places.

Type C Sediments

This sediment group is normally gray, silty, very coarse skeletal sand to sandy shell gravel. It tends to be slightly cohesive when wet but dries to friable lumps of silt, sand, and shells. Quartz particles, present in small quantity, range from silt-size to very coarse, irregular, but well-rounded grains. Type C sediment is probably nearly continuous throughout the inner shelf area. Surface exposures of Type C sediment are uncommon, the layer being overlain by Types A and B.

Type D Sediments

These sediments are light gray or pale brownish gray, fine-to-medium, well sorted calcareous sand, probably of organic origin. Locally, Type D sediments contain shells and shell fragments in sufficient quantity to constitute a second size mode but most often the sediment has few inclusions of other materials. Constituent particles are generally rounded and sometimes polished. The ‘salt and pepper’ aspect of this sediment is due to contrasting light and dark colors.

Type E Sediments

This material on the inner shelf is quite variable, occurring as indurated (hardened) rocks and calcareous clays to coarse sands. Re-deposition of calcium carbonate in grain interstices appears to have accounted for greater density although grain size and sorting may be equally important (Meisburger and Duane, 1971).

3.3.5 Detailed Geotechnical and Geophysical Investigations

Geophysical surveys were conducted in April 2006 and consisted of seismic, sidescan and magnetometer investigations (see Figure 3-6 for geophysical tracklines). Vibracores were obtained in June 2006 after processing and analysis of seismic data. Vibracores followed the preliminary analysis of seismic results because the interpretation of seismic records allowed for optimized selection of vibracore locations. After the vibracores were selected and analyzed, the seismic records were re-interpreted and the different seismic reflectors were correlated with vibracore layer boundaries. High-resolution seismic data, calibrated to vibracores, was then used to interpolate sediment thickness between wider spaced cores. Locations of the seismic cross-sections shown are indicated in Figure 3-6. Examples of seismic cross-sections for one selected location in the nearshore and offshore areas are shown in Figure 3-7.

In the example of a sand ridge shown in Figure 3-7, analysis of vibracores confirms the presence of good quality sand. Thickness of the fine quartz sands making up the ridge was about 19.69 ft with small lenses of finer or coarser grained materials. Shell hash was commonly present in the upper parts of the vibracores (for example, Lines 059 and 256). The sands tend to be grayish in color and contain traces of silt throughout.

Forty vibracores were obtained from the two study areas, 24 in the nearshore area and 16 in the offshore location (Figure 3-6). In the nearshore area, the vibracores indicate that the upper 6 to 12 ft of the sand ridge thickest segments contain clean (moderately to moderately well sorted) fine to medium sand generally ranging from 0.3 mm to 0.6 mm (most commonly occurring grain size classes) with low silt percentage (less than 5%) and shell content ranging from 1% to 5%. Bottom sediment layers become gradually poorly to very poorly sorted and contain mixtures of sandy-silty-clayey sediments with high shell content (shell hash, shell fragment, whole shells and some rock fragments). The location of the vibracores in the nearshore area is shown in Figure 3-8. A cross-section of the thickest sand ridge (second one from north to south) showing vertical sequencing of sediment layers is shown in Figure 3-9.

All sixteen (16) vibracores in the offshore study area penetrated at least 15 ft into the seabed. The offshore cores generally exhibit a fining downward (coarsening upward) sequence. Clean (moderately to moderately well sorted) sands occur in the upper 9.84 to 13.78 ft of the cores. Textural characteristics for most of the samples obtained within the clean sand layer include a mean grain size generally ranging from 0.3 mm to 0.7 mm (most commonly occurring grain size classes), low silt content (less than 5%) and low shell content. Similar to the nearshore area, bottom sediment layers (mostly between 14.76 to 19.69 ft deep into the vibracores) become gradually poorly to very poorly sorted and contain mixtures of sandy-silty-clayey sediments with shell fragments/shell hash and scattered rock fragments. The location of the vibracores on the offshore area is shown in Figure 3-10. A cross-section of the northern ridge in this study area (drawn in a NE-SW orientation), shows the vertical sequence of sediment layers (Figure 3-11).

3.3.6 Sediment Thickness and Volumes

Sediment volumes and textural properties (composites) were calculated for each of the sand ridges investigated. An isopach map that shows sediment thickness in each ridge was created by calculating the difference between seabed elevations (bathymetry) and the base of the clean sand layer. The clean sand layer was defined as the upper sediment layer of the sand ridges that contained moderately to moderately well-sorted quartz sand with grain sizes generally ranging from 0.3 mm to 0.7 mm and less than 5% silt. Elevations of the base of the clean sand layer were obtained from interpretation of the high-resolution seismic records calibrated to the vibracore data. Isopach maps of the nearshore and offshore study areas are shown in Figures 3-12, 3-13, 3-14.

Thickness of the clean sand layer ranges from 3.94 to 15.75 ft in the nearshore sand ridges (Figures 3-12 and 3-13). Nearshore sand sources 1 and 3 contain the thickest clean sand layers with the ridge crest 8 to 16 feet thick and side slopes about 4 to 6 feet thick. Nearshore sand sources 2 and 4 contain ridge crests 4 to 8 feet thick and side slopes about 4 feet thick (Figures 3-12 and 3-13). As expected, sand thickness decreases toward the side slopes and at the ridge base.

Orientation of the thicker sediment packages ranges from shore parallel (southern ridges) to shore-oblique (northern ridges). Four sand sources were defined in the nearshore study area (Figures 3-12 and 3-13). Sand volumes were computed based on sediment thicknesses shown in the isopachous maps, minus a 1 foot safety buffer between the clean sand layer and underlying poor sand layers (sand, silt, clay, shell and rock fragments). These nearshore sand sources combined contain an estimated 4.2 x 10^6 cy of clean sandy sediments.

Thicker clean sand layers occur in the offshore study area (sand source 5) in relation to the nearshore area. In the offshore study area, clean sand thickness ranges from 4 to 20 feet; thicknesses generally increase to the E-NE and reach a maximum near state-federal water boundaries (Figure 3-14). Sediment thickness increases seaward (to the east) because large high-relief ridges are located further offshore (seaward of the state-federal boundary) and the seaward edge of the study area includes the tip of these large offshore ridge systems (see Figures 3-3 and 3-4 for a sub regional view of the bathymetry). Thicker sands in offshore study areas occur in two segments, one shore-parallel zone near the state-federal water boundary with clean sand thickness ranging from 16 to 20 feet and a shore-oblique ridge on the southern segment of the study area containing clean sands (6 to 16 feet thick.

One large sand source that combines these two segments was defined in the offshore study area (Figure 3-14). Sand volumes were computed using the sediment thickness shown in the isopach (Figure 3-14). Sand source 5 contains about 4.9 x 10^6 cy of clean sandy sediments.

Sub-samples obtained from the 40 vibracores available for five sand sources were used to calculate sand source composite characteristics. Composite mean grain size, percent silt, and sorting were computed for each vibracore by calculating the weighted average (average of each sample weighted by the length of core represented). The composite mean grain size, percent silt and sorting for the entire sand source were computed by averaging the weighted results for all cores within the limits of the sand source. Sand source composite grain size ranged from 0.39 mm to 0.47 mm (nearshore sand sources) and 0.44 mm for the offshore sand source. Silt percentage was less than 3.5% in all sand sources.

3.3.7 Provenance

The source of most sediment particles on the inner shelf off of Ft. Pierce is the benthic biota (Meisburger and Duane, 1971). Organisms contributing to the material are indigenous. Quartz, the only non-carbonate element present in significant quantity, must have been derived from the Piedmont Province because no quartz-bearing rocks outcrop on the Florida Peninsula (*e.g*. Puri, *et al*, 1959; Pilkey *et al*., 1969). The dominant carbonate suite may have been created in recent times by organisms inhabiting the area of accumulation or may have originated outside of the area and subsequently entered as detrital sediments. It is also possible that the skeletal fragments were reworked from older underlying formations. All three processes probably played a part in sedimentation of the inner shelf area off of Ft. Pierce. It is also likely that through time, the dominant depositional processes may have differed for different sediment types.

3.3.8 St. Lucie Sand Resource Vignette

The example of the detailed sand resource investigation on the inner shelf plain off the Ft. Pierce area in St. Lucie County shows the types of morphosedimentary conditions that can be anticipated elsewhere in the study area. This detailed survey demonstrates that beach-quality sediments are associated with sediment ridges, even when they occur outside of large ridge fields on the inner shelf plain. This detailed information was also used to develop the conceptual geological model, at least that portion that describes nearshore morphosedimentary conditions.

3.4 CHARACTERIZATION OF SEAFLOOR MAPPING UNITS

Morphological units comprised of combinations of depth, shape, and arrangement of soundings, and shadow patterns were drawn freehand in the paper chart at a scale of 1:4,000 and then digitized on screen. This dual procedure was followed because it is easier to identify and follow patterns on a large chart than by scrolling multiple computer screens. Screen resolution was better than print resolution and patterns marked on the reformatted NOAA bathymetric charts could be modified on screen during digitizing phases in ArcView (ArcGIS). The final digital product is thus compiled in a spatial context that facilitates analysis and computation of selected parameters such as areas for sand flats, ridge fields, and shoals (Figures 3-15A and 3-15B).

Prior to embarking on the actual mapping process based on image interpretation, the color-ramped chart (3D model of the seafloor topography) was visually inspected and partially mapped in an effort to ascertain the range of features that could be identified in the study area, as described by Finkl, Benedet and Andrews (2004, 2005a,b). A list of topographic features that occurred on the chart was compiled to a master list to make a comprehensive legend. Nineteen major landform features (Table 3-1) were found to occur in the survey area. These features are organized in terms of a geomorphologic classification scheme. There are many possibilities for interpretation of features and the orientation depends on the purpose, which in this case was production of a geomorphologic map. The classification scheme is summarized in Table 3-1, where mapping units are organized by their primary mode of occurrence as sand flats, ridge fields, shoals, or nearshore bars.

Because the development of a morphological classification scheme can be an endless task, it is necessary to focus on the purpose of the survey and to rationalize procedures for consistently recognizing features that are identifiable at specific scales of observation. The nominal scale of observation for the central Atlantic coast of Florida was determined for ease of handling of paper copy (at a scale of 1:40,000).

For large-scale mapping purposes, the printed map sheet provided sufficient detail for recognition of major features but still showed general spatial trends. It was thus possible to identify a range of features while not becoming bogged down by too much detail, as might occur on sand flats where there are numerous diabathic channels.

The other point to consider is the balance between what can be seen, what can be mapped, and what is useful or practical to delineate at a reconnaissance scale. The natural spatial heterogeneity of morphological units on the seafloor determines to a large extent what should be mapped. In a sense, then, most natural units are predetermined and they reflect the units that have been mapped and described by other researchers working elsewhere.

The main morphological features occurring in the study area are summarized in Table 3-1 in terms of sandy bottom types with/without diabathic channels, sedimentary deposits arranged on the seafloor as long ridges, shoals, and related features. Mapping unit morphometrics, summarized in Table 3-1 and shown in Figures 3-15A and 3-15B, are used to calculate sediment volumes for the various sedimentary features. Sand flats are the most areally extensive features mapped in the study area: Farmton Sand Flat (34,961 ha), Cocoa Sand Flat (52,472 ha), St. Lucie Sand Flat (61,010 ha). These features are followed by ridge fields: Kennedy Ridge Field (20,537 ha), Merritt Ridge Field (14,109 ha), Mims Ridge Field (12,121 ha), Malabar (63,941 ha), Indian River Ridge Field (33,620 ha), Martin Ridge Field (11,114 ha), and the Dickinson Ridge Field (1,192 ha). Shoals account for the following smaller areas: Patrick Shoal (1,365 ha), Melbourne

Shoal (2089), Capron Shoal (3,916 ha), Ankona Shoal (1,883), Gilbert Shoal (2,872 ha), Roseland Shoal (1,426 ha), Gifford Shoal (1,443 ha), and Salerno Shoal (842 ha). Areas for these morphological features are important because they are used in calculations of potential sand volumes.

Hectares for seafloor mapping units become truncated when considered by county, as shown in Figures 3-16A and 3-16B where volumes are shown graphically by cubic meters per mapping unit. Morphometrics are also provided in the following discussion by county in Table 3-2 (Brevard County), Table 3-3 (Indian River County), Table 3-4 (St. Lucie County), and Table 3-5 (Martin County). In Brevard County, the continental shelf area takes up 207,007 ha and mapped sedimentary features account for about 67% of the shelf area. In Indian River County, about 41% of the continental shelf study area contained mapped sedimentary features covering about 84,965 ha. About 71% of the St. Lucie shelf area is occupied by sedimentary features that comprise about 50,874 ha. For the Martin County sector of the overall study area, 31,518 ha were mapped with sand flats, ridge fields, and shoals collectively making up 79% of the total area. Diabathic channel fields were present throughout most of the sand flat mapping area of the survey.

This classification of seafloor morphological types is open-ended and can be amended as required. These units, which are keyed to the reformatted NOAA color-ramped maps, represent an initial attempt to characterize the nature of the inner continental shelf along the central Atlantic coast of Florida. Seafloor mapping units are described by county, from north to south.

The study area shows a diverse range of morphological features extensive unconsolidated sedimentary deposits such as tidal sand flats and sand ridges (referred to as linear shoals by Duane *et al*., 1972). About twenty distinct types of submarine geomorphologic units were identified and mapped. Each county is thus generally characterized by its distinct submarine physiographic units, which are sedimentary bodies that can support exploitation of sand resources for beach nourishment.

Salient morphometric properties of seafloor topographic units are described by county from north to south, starting with Brevard County and ending with Martin County. Parts of the offshore continental shelf in all counties are designated as 'Undifferentiated Seafloor' due to low-resolution bathymetric data. The mapping units described by county in the following discussion are shown in Figures 3-15A and 3-15B.

3.5 PREVIOUS BEACH NOURISHMENTS

Numerous beach nourishments have taken place along the central Florida coast. These projects are brief summaries of files obtained from the Bureau of Beaches and Coastal Processes (Tallahassee, Florida). Additional information can be obtained from the Beach Erosion Control Project Monitoring Database Information System (http://beach15.beaches.fsu.edu/).

Brevard County

In the **North Reach Beach Fill** project, about 3,204,900 yds^3 of fill were placed in 2001 between R3 to R54.5 (15,128 m shoreline length) along a coastal segment where the alongshore transport rate is estimated to be on the order of 50,000 to 100,000 cy per year to the south. The constructed berm width was 118 ft. The volume density was approximately 64 cy/ft in about 11% of the county beachfront (Table 3-6). The **Patrick AFB Beach Fill** project included about 598,250 yds^3

of fill that was placed in 2001 between R53 and R70 (16,368 ft shoreline length), giving a volume density of about 40 cy/ft along nearly 4% of the county beachfront (Table 3-6). The constructed berm width was 75 ft. The **South Reach Beach Fill, Segment I**, project placed about 1,182,900 cy of fill between R122 and R139 with an average volume density of about 74 cy/ft along 3.5% of county beachfront. The **South Reach Beach Fill, Segment II**, placed about 230,900 cy between R118.3 and R123.5 with an average fill density of about 110 cy/ft along 1% of county beachfront (Table 3-6).

Indian River County

Beach Restoration Sectors 1 & 2, between R4 and T17 (12,670.60 ft shoreline length), placed about 589,350 cy with a volume density of about 46.5 cy/ft over 2.4 miles in 2003 along about 10.26% of county beachfront (Table 3-6).

St. Lucie County

The **Second Ft. Pierce Beach Renourishment** included about 830,000 cy that was placed between R34 and T41 (6,863.5 ft shoreline length) in 1999 (Table 3-6). The volume density was estimated to be about 121 cy/ft along about 4.76% of county beachfront. The **Third Ft. Pierce Beach Nourishment – Phase I** (2003), located between R34 and R36 (2,112.86 ft shoreline length) (Table 3-6), placed about 336,000 cy along 0.4 miles with an average volume density of about 125 cy/ft along about 1.47% of county beachfront (Table 3-6).

Martin County

The **Martin County 4-Mile Beach Restoration** project (1995-1996) was located between R1 and R25 (6,598 m shoreline length). About 1,340,000 cy of fill were placed with an average volume density of about 62 cy/ft along 16.43 of county beachfront (Table 3-6). The **Jupiter Island Beach Restoration** project (1995-1996), located between R77 and R106 (26,929.26 ft shoreline length), placed about 1,740,000 cy with an average volume density of about 64 cy/ft along 20.44% of county beachfront.

3.6 AREAS NOT TESTED ENOUGH TO DETERMINE SAND RESOURCE POTENTIAL

Large areas of the continental shelf were covered by low-resolution NOAA bathymetry that could not be reformatted to finer grid spacing. As a result, large tracts had to be mapped as undifferentiated seafloor in both state and federal waters. The unit accounts for about 21,000 ha landward of the 3-mile limit and about 162,000 ha seaward of the state-federal boundary (Table 3-7). The problem is worse in deeper water where 88% of the Undifferentiated Seafloor mapping unit falls under federal jurisdiction. The problem is less severe in shallow water landward of the 3-mile limit where 12% of the Undifferentiated Seafloor mapping unit falls under state jurisdiction. Looking at the problem from a different perspective, of the total federal shelf area mapped, about 42% is comprised by the Undifferentiated Seafloor mapping unit. Of the total shelf area under state jurisdiction, about 17% is comprised of the Undifferentiated Seafloor mapping unit (Table 3-7).

For state waters, the problem of poor quality bathymetric data is most prevalent in southern Brevard County and along all of Indian River County (Figures 3-15A and 3-16A). New, more detailed bathymetric surveys are required in these areas to estimate sand resource potentials. Perusal of Figures 3-15A-B and 3-16A-B indicates that there is no reason to suspect that the seafloor mapped as 'undifferentiated' is any different than adjacent areas. The fact that large-scale shoals and ridge fields could be interpreted from the poor-quality bathymetric data in 'undifferentiated' areas indicates that similar features, in addition to sand flats, are likely to occur in these areas and that they will be identified in new bathymetry. With the present bathymetric data, it is not possible to produce reliable interpretations of seafloor morphologies in areas now designated as 'undifferentiated.'

All of the reformatted NOAA data, Sheets 1 through 7 (Figures 3-15A-B and 3-16A-B), contain acquisition bathymetric data points that are too widely spaced for meaningful interpretation of seafloor morphology. Except for shelf areas of southern Brevard County and most of Indian River County, as already described, most of the Undifferentiated Seafloor mapping unit occurs seaward of the 3-mile limit and extends to the seaward mapping boundary at 147.64 ft. New estimates of potential sand resources on the continental shelf along the central Florida Atlantic coast will undoubtedly increase if new bathymetric data is obtained.

For the remaining areas of seafloor that have been interpreted in terms of morphosedimentary units (*i.e*. transverse bars, ridge fields, sand flats, and shoals), it is emphasized that the interpretations are based on reconnaissance NOAA bathymetry that was reformatted to closer grid spacing where possible. Assumptions were made as to thickness of sedimentary bodies, based on local relief as measured from the bathymetry. These assumptions, summarized in Table 3-8, provided a means for measure for this reconnaissance survey but require refinement for more detailed investigations.

3.7 PROMISING AREAS NOT PREVIOUSLY INVESTIGATED

In the example of the St. Lucie detailed survey, sediment ridges on the inner shelf plain in state waters were found to contain up to 4,708,600 cy of beach-compatible sands. As interpreted in this reconnaissance report, those sand ridges occur as higher elevations in the St. Lucie Sand Flat mapping unit. More detailed study of morphosedimentary features within the 3-mile limit, as per the example of the St. Lucie sand search study, would increase understanding of sand resource potential. Clearly, the preferred approach would be to conduct more detailed bathymetric surveys (compared to existing NOAA bathymetric data) in state waters over the length of the study area. The purpose of acquiring up-to-date bathymetric coverage would be to provide a reliable basis for interpreting seafloor morphosedimentary features in the form of maps of the inner continental shelf. Once spatial distribution patterns of morphosedimentary features have been ascertained, sand resource potentials can be estimated in a countywide inventory, as demonstrated here on a reconnaissance basis for a larger region (Martin County through Brevard County). If countywide inventories of sand resource potentials on the continental shelf are not desired, then smaller piecemeal sand searches could be conducted. Based on interpretation of the existing re-formatted NOAA bathymetric data, obvious sand targets would include ridge fields and shoals in state waters as shown in Figures 3-15A and B.

The most promising areas in Martin County thus include the Dickinson Ridge Field (offshore R112 to R122), Salerno Shoal (offshore R84 to R93), Martin Ridge Field (offshore R56 to R73), and the Gilbert Shoal (offshore R2 to R33) (Figure 3-17A). In St. Lucie County, the most promising targets would be Capron Shoal (offshore R45 to R57 and offshore R76 to R102) and the Indian River Ridge Field (offshore R6 to R46). In Indian River County, the most promising sand target would be the Indian River Ridge Field (offshore R75 to R119). Much of the shelf area here is mapped as undifferentiated seafloor and more detailed bathymetric survey is required for recommendations that are more specific. Brevard County has a plethora of potential sand sources that include Roseland Shoal (offshore Indian River County R2 to R4), the Malabar Ridge Field (offshore R101 to R114; R119 to R133; and R143 to R174), Melbourne Shoal (offshore R61T to R86), Patrick Shoal (offshore R32 to R37), South and North Kennedy Ridge Fields (see Figure 3-17A), and the Canaveral Transverse Bar system (Figure 3-17A).

Sand flats occur in state waters on the central Florida Atlantic coast. At the present scale of mapping and grid spacing of bathymetric data, it is not possible to reliably break down the sand flat units into smaller morphosedimentary units. More detailed bathymetry of shelf area under state jurisdiction will permit interpretation of seafloor features that will contain the same kinds of morphosedimentary bodies already identified in adjacent areas where bathymetric control is sufficient for feature recognition. At this juncture, it is not possible to single out potential sand targets on sand flats that would have priority over more obvious sand resources as occur in ridges and shoals. Nevertheless, sand flats contain enormous sediment volumes and they should not be neglected as potential sand resources, especially when they occur close to shore. The example of the St. Lucie sand search illustrated the importance of detailed survey in a sand flat area where small ridges can provide significant volumes of usable sand.

Perusal of Figure 3-17B shows MMS seismic survey lines superimposed over seafloor mapping units, morphosedimentary features plus undifferentiated seafloor. Extension of selected MMS seismic track lines from federal waters into state waters, involving about 68.3-line mi from nearshore to the 3-mile limit, would increase regional knowledge of potential sand resources in state waters. The existing seismic reflection profiles provide sub-bottom information seaward of the 3-mile limit. If some of these track lines were extended into state waters, continuity of mapped morphosedimentary features could be achieved to advantage. It is thus recommended that five MMS seismic track lines per county be extended shoreward of the 3-mile limit. Extensions are suggested on the basis that they would cross mapped morphosedimentary features and extend knowledge of regional stratigraphy, indicate lateral continuity of seismostratigraphic layers, provide layer depth information, and provide a basis for potential sand volume estimates because there would be good depth control. The suggested new seismic track lines are summarized in Table 3-9. Briefly, the following extensions are suggested by county: Brevard (B26, B38, B49, B66, and B76), Indian River (IR9, IR15, IR25, and IR32), St. Lucie County (IR41, IR47, SL7, SL6A, and SL23), and Martin County (SL29, SL35, M6, M14, and M19).

Some new seismic lines are suggested to cross undifferentiated seafloor in Brevard and Indian River counties. The justification for these extensions is that potentially usable morphosedimentary features are likely to occur in state waters even though they were not mapped in this survey due to poor quality bathymetric data. Two additional seismic track lines are also suggested for Brevard County, one shore-normal section from R40 to the 3-mile limit and one just north of the entrance to Port Canaveral (see Figure 3-17B, Table 3-9). These additional seismic cross-sections would provide stratigraphic information to the apex of the cuspate foreland.

As part of Phase IV portion of this project, multiple geophysical tracklines in the form of sub-bottom profiles were run along the east coast of Florida, from the Martin/Palm Beach county lines northward to the FL/GA border at the St. Mary's river. These lines and associated images are discussed in detail in Section 4 as they relate to identified potential sand source areas.

An important consideration in the appraisal of areas not previously investigated is recognition of mapping unit homogeneity. The map showing seafloor physiographic units (Figure 3-2) and the subdivision of these units by characteristics of their sedimentary covers in the form of morphosedimentary units (Figure 3-15A-B and 3-16A-B) contains broad-scale reconnaissance mapping units. These mapping units are mostly made up of complex sedimentary bodies that have more than one morphological expression. That is, swales or intervening lower-elevation areas must exist in order for a unit to have positive topographic expression. Mapping units for ridge field thus comprise ridge and swale topography and may include wider lower-lying areas between sand ridges. Spacing of NOAA bathymetric grids determines what can be extracted from the bathymetric data giving limits to levels of interpretation.

Because most areas not previously investigated have no detailed bathymetric surveys, this study had to rely on broadly spaced bathymetric data points. Quality of the mapping units would be increased by re-survey of the continental shelf area. Reformatting of the NOAA bathymetric data was a stopgap effort to extract as much information from the digital files as possible. Digital geospatial information in the form of bathymetric data point to a large extent determined the scale of observation and level of classification of seafloor features.

The precision of any prediction (*e.g*. targets for future sand searches) using the classification presented in this study is dependent on the homogeneity of the mapping unit and on the spatial variability within mapping units. The spatial variability is typically not ascertained, and without a measure of the spatial variability within each mapping unit, little is known regarding the reliability of the modal morphosedimentary unit. Continuous classification is possible by using different types of geostatistical tools, which are capable of accounting for the continuous nature of sedimentary cover and allows an individual morphosedimentary unit to be assigned totally, partially or not at all to a particular class. For the purposes of this study, the typology that resulted from visual inspection of bathymetric patterns was considered adequate for reconnaissance work.

Extension of MMS seismic track lines is thus seen as an essential part of efforts to better comprehend the occurrence of morphosedimentary features in state waters. This new information will help extend knowledge for features on the outer shelf plain to the inner shelf plain. Suggested extensions of seismic track lines in federal waters to state waters are given in Table 3-9, as suggested previously but with the added caveat of transfer of knowledge combined with acquisition of new information.

3.8 LIMITATIONS OF SAND RESOURCE POTENTIALS

Sand resource potentials are limited by the quality of the bathymetric data that was used to interpret seafloor features. Because the grid spacing of data points varied with the bathymetric survey, seafloor topography was not mapped uniformly over the study area. Large areas of continental shelf contained poor quality (widely spaced data points) bathymetric data and it was not possible to reliably interpret seafloor features. These areas were mapped as undifferentiated seafloor, that is, they were not interpreted. This means that about 22,000 ha of seafloor landward of the 3-mile limit was uninterpretable and left unmapped (Table 3-7). From the 3-mile limit to the 147.64 ft isobath, about 163,000 ha were not mapped due to poor bathymetric data.

Of the morphosedimentary features that were mapped (for areas see Table 3-7), several assumptions were made regarding unit thickness. Local relief, determined from the digital bathymetric maps in a GIS platform, was acquired for each type of morphological feature and noted as a minimum, maximum, and average. This information, summarized in Table 3-7, was presented by morphosedimentary feature by county in a series of tables viz. Brevard County (Table 3-2), Indian River County (Table 3-3), St. Lucie County (Table 3-4), and Martin County (Table 3-5). In addition to local relief, another variable was the estimated mean areal coverage of sediment ridges *per se* in the ridge field mapping unit. Actual ridges might cover only 30% of the ridge field mapping unit, for example, and so it was important to disclose the estimate of areal coverage. Error in the estimation of percent coverage would affect volume calculations.

Sand resource potentials also depend on interpretation of seafloor topography in terms of morphosedimentary units such as sand ridges, shoals, sand flats, transverse bars, *etc*. The morphological interpretation is based on experience and requires familiarity with marine geomorphology and topographic expression as depicted in bathymetric data. Whether a particular unit is interpreted as a shoal or ridge field may not be as crucial as recognition of a positive relief feature and its spatial relationships with surrounding relief forms. Such may be the case, for example, with previously named bathymetric features such as the Capron Shoal and Gilbert Shoal, which probably would have been interpreted as ridge fields in the present reconnaissance survey. Nevertheless, the salient point here is recognition of morphosedimentary features and determination of their morphometric properties, which are in turn used to calculate sediment volumes.

There are thus several caveats related to interpretation of bathymetric features and calculation of potential sediment volumes. In a general reconnaissance survey such as this, recognition of primary features is a first cut in the bathymetric data in hand. More detailed work will improve spatial delineation and volume calculations.

3.9 DISCUSSION

Application of reformatted NOAA bathymetry to the continental shelf off the central Florida Atlantic coast in the form of digital color-ramped imagery (3D model of seafloor topography) permits interpretation of bathymetry as sequences of landforms. The resulting interpretive maps that depict sedimentary seafloor features (morphosedimentary bodies) present a rational basis for delineating bottom types, particularly sediment ridges, shoals, transverse bar systems, and sand flats. Reformatted NOAA bathymetry provides useful imagery for interpretive purposes and the results can be dramatic and useful, but caveats are associated with training and experience of the interpreter. This reconnaissance survey of sand resources required comprehensive mapping of identifiable sedimentary seafloor features in order to evaluate modes of occurrence for various types of sedimentary bodies. The present reconnaissance mapping scale (1:2000 operation scale for hard copy maps) precludes detailed investigation of many types of features but has the advantage of providing an overview of general relationships between mapping units.

These geospatial relationships combined with collateral data (*e.g*. vibracore logs, seismic reflection profiles in the example of the St. Lucie sand search) were used to build a model of the coastal surficial geological framework. The geological model is essentially comprised of two overarching types of continental shelf units, one dominated by the Canaveral cuspate foreland and the other by a narrowing shelf with elongated sediment ridges and shoals. Perusal of the interpreted NOAA bathymetric units in a GIS platform showed that areal distributions of sedimentary bodies are strongly influenced by abundant sediment supply around the Canaveral cuspate foreland and accumulation of sediments in positive topographic relief features such as ridges and shoals. Without interpretation of the reformatted NOAA bathymetry, these relationships could not be established on a regional basis. Prior work by Meisburger and Duane (1971) and Duane *et al*. (1972), for example, identified general bottom types in reconnaissance study, but there was no integrated interpretation of trends or geospatial variation within and between the counties along the southeast coast. The gradation of bottom types from northern Brevard County to the general latitude of R140 (Melbourne Beach) reflects directional accumulation of sediments as influenced by the bedrock high upon which the cuspate foreland developed. There is a buildup of sediments on the updrift (northern) flank of the cuspate foreland with clear offshore bypassing around the apex in the form of well-developed transverse bar systems and ridges. Seafloor units on the downdrift (south) side of the cuspate foreland are characterized by large sand sheets (Cocoa Sand Flat), ridge fields (Malabar Ridge Field), and shoals. These morphosedimentary features become more constrained southward from Indian River County as the continental shelf narrows and the features themselves become more shore parallel in alignment. The comprehensive geological model developed in this study incorporates intra-county variation in seafloor geomorphologic units as well as gradation in distal northern and southern parts of the study area to different geomorphologic regimes.

Potential sand volumes were estimated by interpreting reformatted NOAA bathymetry to produce a reconnaissance classification of bottom types in terms of morphosedimentary units. Morphometric properties of the various units were then determined in an effort to quantify volume estimates on a sound basis, even though the effort was conducted on large-scale features. Total sediment volumes thus determined indicated the presence of massive sand resources on the continental shelf. Summarized by county, total potential sand resources are: Brevard County (4,309,110,300 cy), Indian River County (8,771,124,108 cy), St. Lucie County (1,343,448,400 cy), and Martin County (745,731,200 cy). Although extensive sand resources occur in sand flats, the most easily extractable deposits are most likely associated with shoals, bars, and ridges. Suggested sand targets worthy of more detailed investigation, as summarized in this report, are indicated as a first cut in regional assessments. Detailed studies in the form of strategic sand searches, as described by Finkl, Khalil and Andrews (1997) and Finkl and Khalil (2005), are required for more accurate determination of sand reserves. These volumes, determined from reconnaissance survey, indicate the presence of significant offshore sand resources along the central Atlantic coast of Florida. These deductions are confirmed by Hoenstine *et al*. (2002) who studied positive relief features (*e.g*. ridges and shoals) using 23ft long vibracores off St. Lucie County and found at least 26,159,000 cy of restoration-quality sand. They indicate that further studies will only increase this volume estimate where the ridges contained 23 ft. of good quality sand.

Evolution of inner shelf sediments, including morphosedimentary bodies that make up shoals and ridges, have been discussed by Duane *et al*. (1972) and Field (1974). Of particular note are strandlines that Field (1974) documented by the presence of an intertidal clam, *Donax variabilis*. Shoreface-connected and isolated linear shoals (sand ridges) associated with the Cape are reported to have formed by coastal-retreat processes (e.g. Duane et al. (1972).

Sand-rich areas, as reported by Nocita *et al*. (1990) correspond to what they termed ‘shoal areas’ but in this survey this bathymetric designation is translated into morphosedimentary units that include transverse bars, shoals, sand ridges, and parts of sand flats. In the region studied by Nocita *et al*. (1990) offshore Cape Canaveral, more than 70% of the sample area contained sand. Shoals, transverse bars, and sand ridges contained more than 90% sand. Some areas of shell-gravel-rich surficial sediment occurred nearshore and offshore, but these areas were of minor areal extent. The south flank of the Cape (southern margin of the South Kennedy Ridge Field) contained more than 5% mud in water depths ranging from 13.12 to 32.8 ft. According to Nocita *et al*. (1990), large sand bodies making up shoals (and what are referred to as ridge fields in this study) offshore Cape Canaveral appear to be possible relict features containing Pleistocene stratigraphic sections. Buried fluvial channels were also noted to occur in the area, as observed in seismic profiles.

3.10 CONCLUSION

By reformatting reconnaissance NOAA bathymetric data, it was possible to map large areas of seafloor along the central Florida Atlantic coast. Of the total survey area (508,237 ha), about 184,000 ha (about 35% of the study area) were designated as 'Undifferentiated Seafloor' due to poor quality bathymetric data. The remaining area (324,133 ha) contained bathymetric grid spacing of sufficient density to identify large-scale seafloor features. These features were classified and mapped to produce a seafloor topology that would provide a basis for estimating sand resources. The unifying mapping principle was based on the shape, form, and spatial distribution patterns of morphologically similar features that could be grouped together in relatively homogeneous patterns. These morphosedimentary features, which were described in terms of bars, ridge fields, sand flats, and shoals, accounted for about 4.3 billion cubic meters of sediment that have potential as sand resources. Although sand flats are areally extensive and contain large sediment volumes, shoals and ridge fields are obvious targets for further study. It is recommended that geophysical surveys in federal waters be extended shoreward into state waters to better understand the nature and distribution of morphosedimentary features that make up sand resource potential on the continental shelf. Additionally, more detailed bathymetric surveys in state and federal waters are required to better estimate spatial distribution patterns of sedimentary bodies that have potential as sand resources for beach nourishment.

Table 3-1. Submarine physiographic units on the inner central Florida Shelf along the Florida Atlantic coast.

Physiographic Provinces	Morphometry[1]	Description	Comments/Source
Bars			
Canaveral Transverse Bars	Bars 186 to 310.7 mi wide, up to 1.24 mi long, 75° to 90° azimuth (3,218 ha).	Bar field 11.2 mi long by 1.86 mi wide, 5 to 39.4 ft water depth.	Defined in this work. Occurs on the shoreface updrift from Cape Canaveral.
Ridge Fields			
Dickinson Ridge Field	Ridges 492 to 1,640 ft wide, 0.932 to 1.55 mi long, maximum relief of 29.5ft. 23-79 ft water depth (1,200 ha)	Small ridge field located 2.8 to 3.7 mi offhsore, surrounded by sand flats.	Defined in this work. Extends from inner shlef to Florida-Hatteras Slope.
Kennedy - North	Ridges 2,460 to 2,953 ft wide, 1.24- 6.2 mi long, 100° azimuth, 0.312 to 3.7 mi offshore, 19.7 to 39.4 ft local relief (12,062 ha).	Well-developed shallow water ridges in 16.4 to 65.6 ft water depth, transverse to the shore but shoreface connected inshore.	Defined in this work. Occurs on the shoreface offshore the apex of the Cape. Part referred to as 'Chester Shoal' (Nocita *et al* ., 1990).
Kennedy - South	Ridges 984 to 1,969 ft wide, 2.5 to 3.7 mi long (ave 1.9 to 2.8 mi long), 40° – 60° azimuth, 0.31 to 9.3 mi offshore, 16.4 to 32.8 ft local relief (8,475 ha).	Pronounced, narrow, shallow-water ridges in 9.8 to 65.6 ft water depth, transverse to the shore or bathymetric platform.	Defined in this work. Occurs on the shoreface offshore the apex of the Cape, extending into the inner shelf. Part referred to as 'Southeast Shoal' (Nocita *et al* ., 1990).
Merritt	Ridges 2,297 ft to 0.62 mi wide, 3.7 - 6.2mi long, 50° to 60° azimuth, 1.2 mi wavelength, 6.2 to 18.7 mi offshore, 6.6 to 13.2 ft local relief (14,109 ha).	Distinct, large, deepwater ridges in 65.6 to 98.40 ft water depth, separated by swales 3,9370 ft wide.	Defined in this work. Extends from the inner shelf plain across the outer shelf onto the Florida-Hatteras Slope
Mims	Ridges 1,640 ft to 1.2 mi wide, shore ridges 0.93 to 1.9 mi long, long ridges 6.8 to 9.3 mi long, 1,476 to 1,968 ft wavelength, 45° - 75° azimuth, 2.8 to 11.2mi offshore, 19.7 to 39.4 ft local relief (12,121 ha).	Distinct, shallow-water ridges in 26.3 to 82 ft water depth and sediment plateaus (up to 3.73 mi wide), leading to divergent complex patterns southward and shoreward.	Defined in this work. Occurs on the inner shelf plain on the northeast flank of Cape Canaveral. Part referred to as 'Ohio-Hetzel Shoal' (Nocita et al, 1990).

Table 3-1. Submarine physiographic units on the inner central Florida Shelf along the Florida Atlantic coast.

Malabar	Ridges 0.62-1.9 mi wide, 3.12-18.6 mi long, 30° - 50° azimuth, 0.19 to 12.4 mi offshore, 13.12 to 23 ft local relief (63,941 ha).	Singular large ridges in 49.2 to 82 ft water depth that merge into sediment platforms (up to 2.8 mi wide), shoreward portions deflected shoreward with 85° azimuth in water depths of 32.8-49 ft.	Defined in this work. Extends from seaward portion of inner shelf plain across the outer shelf onto the Florida-Hatteras Slope.
Indian River	Ridges 0.62-1.2 mi wide, 2.8 to 3.7 mi long, 45° to 55° azimuth, 3.7 to 15.5 mi offshore, 1,476 to 1,969 ft wavelength, 13.12 to 26.25 ft local relief (33,620 ha).	Moderately well developed ridges merging to interior sediment platforms, central ridge crest azimuth 50° to 85° azimuth, up to 9.9 mi long, 13.12 to 65.6 ft water depth.	Defined in this work. From seaward margin of shoreface across inner shelf plain to Florida-Hatteras Slope, offshore central Indian River County. Part of shoreward extension referred to as 'Indian River Shoal' and part of seaward portion referred to as 'Bethel Shoal' (Meisburger and Dune, 1971)
Martin	Ridges 1,312 ft wide, shorter ridges average 1.9 mi in length, longer ridge average 6.2 mi in length, 50° to 65° azimuth, 3.73 to 10.6 mi offshore, 0.62 to 1.9 mi wavelength, 9.84 to 19.69 ft local relief (11,114 ha).	Subdued shallow- to deepwater ridges (26.25 to 82 ft) that merge with surrounding sand flats, southern-most extension of the primary ridge is shoreface attached.	Defined in this work. Most extensive offshore southern St. Lucie County and northern Martin County on inner shelf plain and outer shelf onto the Florida-Hatteras Slope
Sand Flats			
Farmton	Sand flat main trunk about 6.2 wide by 12.4 mi long in average water depth of 52.5 ft, some minor ridges 3,937 ft long on 55° azimuth (34,961 ha).	Equant shaped sandy bottom with some small sand ridges near margin of sand flat, bisected by the Kennedy Ridge Field.	Defined in this work. Characteristic of inner shelf plain on northeast flank of Cape Canaveral.
Cocoa	Sand flat average width about 7.45 mi, 31.07 mi long to inverted southern apex, in 39.4 ft water depth,4.9 ft local relief (52,472 ha).	Inverted triangle shape with apex pointing southwards, bisected by Patrick and Melbourne shoals, with deep incursions by Malabar Ridge Field.	Defined in this work. Characterizes the inner shelf plain off the southern flank of Cape Canaveral. Part referred to as Southeast Shoal (Nocita *et al*., 1990).

Table 3-1. Submarine physiographic units on the inner central Florida Shelf along the Florida Atlantic coast.

St. Lucie	Sand flat 3.73 to 9.3 mi wide by 47.2 mi long, average water depth of 55.8 ft, local relief 4.92 ft (61,010 ha).	Trapezoidal-shaped with narrow south end, diabathic channels (15-20° azimuth) present throughout but better developed and most extensive offshore southern Martin County and all of St. Lucie County.	Defined in this work. Characterizes much of the inner shelf plain St. Lucie County.
Shoals			
Patrick	Shoal 4.35 mi long by 1.56 mi wide, 20-25° azimuth, about 1.9 mi offshore in 39.37 ft water depth (1,365 ha).	Offshore shallow area offshore Brevard County, within Cocoa Sand flat, pronounced sand ridges not evident.	Defined in this work. Occurs on the inner shelf plain offshore R20 in Brevard County.
Melbourne	Shoal 5.6mi long by 1.9 mi wide, 55-70° azimuth, 0.19 to 2.49 mi offshore in 49.21ft water depth (2,089 ha).	Offshore shallow area offshore Brevard County, within Cocoa Sand flat, some pronounced sand ridges trending NE-SW (~40° azimuth).	Defined in this work. Occurs on the inner shelf plain off R90 in Brevard County.
Roseland	Shoal 3.73mi long by 4.16 mi wide, 90° azimuth, 2.8 mi offshore in 39.37 ft to 49.21ft water depth (1,426 ha).	Offshore shallow area offshore Brevard County, within undifferentiated seafloor, pronounced sand ridges not evident.	Defined in this work. Occurs on the inner shelf plain off R10 in Indian River County.
Gifford	Shoal 3.73 mi long by 1.9 mi wide, 90-110° azimuth, 6.84 mi offshore in 32.81 to 39.37 ft water depth (836 ha).	Offshore shallow area offshore Brevard and Indian River counties, within undifferentiated seafloor, pronounced sand ridges not evident.	Defined in this work. Occurs on the inner shelf plain off R10 in Indian River County.
Ankona	Shoal 5.6 mi long by 1.9 mi wide, 135° azimuth, 2.8 to 5.6 mi offshore in 39.37 ft water depth (1,883 ha).	Shallow area offshore St. Lucie County, linking the Capron Shoal with the Gilbert Shoal within the St. Lucie Sand flat.	Defined in this work. Occurs on the inner shelf plain off central St. Lucie County.

Table 3-1. Submarine physiographic units on the inner central Florida Shelf along the Florida Atlantic coast.

Capron	Shoal 22.37 mi long by 0.93 mi wide, 85-90° azimuth, northern segment about 5.6 mi offshore, southern segment is shoreface attached, in 32.8 ft water depth (3,916 ha).	Long, narrow shoal offshore St. Lucie County, trending transverse to the shore, within St. Lucie Sand flat mapping unit.	NOAA, Coast & Geodetic Survey. Occurs on the inner shelf plain off central St. Lucie County. Part of southern extension referred to as 'Pierce Shoal' (Meisburger and Duane, 1971).
Gilbert	Shoal 15 mi long by 0.932mi wide, 90-100° azimuth, northern segment about 7.5mi offshore, southern segment shoreface attached, in 19.7 to 39.37 ft water depth (2,872 ha).	Long, narrow shoal offshore St. Lucie and Martin counties, trending transverse to the shore, within St. Lucie Sand flat mapping unit.	NOAA, Coast & Geodetic Survey. Occurs on the inner shelf plain off southern St. Lucie County and northern Martin County. Part refereed to as 'St. Lucie Shoal' (Meisburger and Duane, 1971).
Salerno	Shoal 3.42 mi long by 1.9 mi wide, 90° azimuth, about 1.9mi offshore in 32.81 to 55.8 ft water depth (842 ha).	Small equant-shaped shallow area offshore Martin County.	Defined in this work. Occurs on the inner shelf plain off Martin County.
Undifferentiated Seafloor	Spacing of bathymetric grid point too coarse to permit reliable interpretation of morphology (184,068 ha).		Not mapped
[1] Based on measurements from Figures 1b and 14a and 14b.			

Table 3-2.
Sand resource potential in Brevard County by morphosedimentary units where volume calculations are based on percent areal coverage in the mapping unit, which is less than unity for bars and ridge fields.

Morphosedimentary Features	**Shelf Area (ha)[1]**	**% of County Continental Shelf Area[2]**	**% Area Used in Volume Calculations[3]**	**Max 9.0 (ft)[4]**	**Average Sediment Thickness (ft)[5]**	**Sediment Volume (yd^3)**
Canaveral Transverse Bar	3,218	1	0.35	15.1	5.9	26,942,914
Cocoa Sand Flat	52,472	17	1	6.6	6.6	1,359,658,338
Farmton Sand Flat	34,961	11	1	6.6	6.6	905,920,299
Gifford Shoal	836	<1	1	4.9	2.6	8,336,433
Malabar Ridge Field	63,941	21	0.5	24.9	5.9	764,700,023
Melbourne Shoal	2,089	1	1	4.9	2.6	20,818,144
Merritt Ridge Field	14,109	5	0.7	24.9	7.9	314,977,669
Mims Ridge Field	12,121	4	0.35	24.9	9.8	169,120,918
North Kennedy Ridge Field	12,062	4	0.65	20.0	12.1	375,063,886
Patrick Shoal	1,365	<1	1	9.8	3.0	16,328,806
Roseland Shoal	1,426	<1	1	9.8	3.9	22,745,307
South Kennedy Ridge Field	8,475	3	0.8	20.0	12.1	324,330,824
Total	**207,075**	**67**				**4,308,943,559**

[1] For conversion of hectares (ha) to square kilometers (100 ha = 1 km^2) move decimal point two digits to the left.

[2] Refers to continental shelf area offshore from county lines for ease of reference. State waters lie shoreward of the 3-mile and federal waters are seaward.

[3] Some mapping units embrace larger areas than sand ridges *per se* , for example, to simplify mapping. Areas thus designated as ridge fields contains sand ridges plus intervening swales and sand plain units.

[4] Based on measurement of local relief from the reformatted NOAA bathymetry. These measurements are limited by the grid scale of the NOAA bathymetric data.

[5] Based on estimates of variation in local relief within a GIS polygon.

Table 3-3.
Sand resource potential in Indian River County by morphosedimentary units where volume calculations are based on percent areal coverage in the mapping unit, which is less than unity for ridge fields.

Morphosedimentary Feature	**Shelf Area (ha)**	**% of County Continental Shelf Area**	**% Shelf Area Used in Volume Calculations**	**Max Sediment Thickness (ft)**	**Average Sediment Thickness (ft)**	**Sediment Volume (yds^3)**
Gifford Shoal		1	1	15.1	7.5	18,133,733
Indian River Ridge Field	31,390	37	0.65	20.0	9.8	813,425,148
St. Lucie Sand Flat	2,540	3	1	6.6	6.6	65,816,403
Total	**33,930**	**41**				**897,375,284**

Table 3-4.
Sand resource potential in St. Lucie County by morphosedimentary units where volume calculations are based on percent areal coverage in the mapping unit, which is less than unity for ridge fields.

Morphosedimentary Feature	**Shelf Area (ha)**	**% of County Continental Shelf Area**	**% Area Used in Volume Calculations**	**Max Sediment Thickness (ft)**	**Average Sediment Thickness (ft)**	**Sediment Volume (yds^3)**
Ankona Shoal	1,883	3	1	4.9	2.0	15,011,707
Capron Shoal	3,916	5	1	9.8	4.9	78,060,900
Gilbert Shoal	1,727	2	1	20.0	12.1	82,643,079
Indian River Ridge Field A	184	0.3	0.9	15.1	5.9	3,964,817
Indian River Ridge Field B	2,046	3	0.8	15.1	7.9	52,195,053
	7,224	10	0.45	35.1	18.0	233,277,201
St. Lucie Sand Flat	33,895	47	1	6.6	6.6	878,346,386
Total	**50,875**	**71**				**1,343,499,144**

Table 3-5.
Sand resource potential in Martin County by morphosedimentary units where volume calculations are based on percent areal coverage in the mapping unit, which is less than unity for ridge fields and Gilbert Shoal.

Morphosedimentary Feature	**Shelf Area (ha)**	**% of County Continental Shelf Area**	**% Area Used in Volume Calculations**	**Max Sediment Thickness (ft)**	**Average Sediment Thickness (ft)**	**Sediment Volume (yds^3)**
Dickinson Ridge Field	1,192	3	0.6	29.8	7.5	21,386,063
Gilbert Shoal	1,145	3	0.45	15.1	7.9	16,431,397
Martin Ridge Field A	461	1	0.3	4.9	2.6	1,378,822
Martin Ridge Field B	3,429	9	0.45	9.8	7.5	46,144,321
Salerno Shoal	842	2	1	20.0	7.9	26,860,965
St Lucie Sand Flat	24,449	61	1	6.6	6.6	633,557,743
Total	**31,518**	**79**				**745,759,310**

Table 3-6.
Summary data for beach restoration projects along the central Florida Atlantic coast based on length of renourished beach, percent of county ocean beachfront, and percent of the study area.

County	Beach Restoration Project[1]	Project Length (ft)	% County Beach- Front	% Study Area
Brevard	Brevard County, South Reach Beach Fill, Segment 1	15,941	3.5	1.87
Brevard	Brevard County, South Reach Beach Fill, Segment 2	4,963	1.09	0.58
Brevard	Brevard County, North Reach Beach Fill	49,620	10.9	5.81
Brevard	Brevard County, Patrick AFB Beach Fill	16,364	3.6	1.92
Indian River	Indian River County Beach Restoration Sectors 1 & 2	12,667	10.26	1.48
St. Lucie	Third Ft. Pierce Beach Restoration-Phase 1	2112.32	1.47	0.25
St. Lucie	Second Ft. Pierce Beach Restoration	6,862	4.76	0.8
Martin	Martin 4-Mile Beach Restoration	21,641	16.43	2.53
Martin	Jupiter Island Beach Restoration	26,922	20.44	3.15
Total		**157,092**		**18.39**

[1] Based on Beach Erosion Control Project Monitoring Database Information System.

Table 3-7. Explanation of mapping units occurring in state and federal waters, based on the 3-mile limit and showing the breakdown of hectares and percentages zone of occurrence and by unit.

Morphosedimentary Feature	**State Shelf Area (ha)[1]**	**Federal Shelf Area (ha)[2]**	**Total Shelf Area (ha)**	**State Area (%)[3]**	**Federal Area (%)[4]**	**State % by Unit[5]**	**Federal % by Unit[6]**
Ankona Shoal	117	1,766	1,883	0.1	0.46	6.21	93.79
Canaveral Transverse Bar	3,218	0	3,218	2.63	0	100	0
Capron Shoal	2,964	952	3,916	2.42	0.25	75.69	24.31
Cocoa Sand Flat	26,558	25,914	52,472	21.67	6.72	50.61	49.39
Dickinson Ridge Field	528	664	1,192	0.43	0.17	44.3	55.7
Farmton Sand Flat	5,860	29,101	34,961	4.78	7.55	16.76	83.24
Gifford Shoal	0	1,443	1,443	0	0.37	0	100
Gilbert Shoal	1,572	1,300	2,872	1.28	0.34	54.74	45.26
Indian River Ridge Field	7,896	25,724	33,620	6.44	6.67	23.49	76.51
Kennedy Ridge Field	13,861	6,676	20,537	11.31	1.73	67.49	32.51
Malabar Ridge Field	2,689	61,252	63,941	2.19	15.88	4.21	95.79
Martin Ridge Field	1,125	9,970	11,095	0.92	2.59	10.14	89.86
Melbourne Shoal	1,659	430	2,089	1.35	0.11	79.41	20.59
Merritt Ridge Field	0	14,109	14,109	0	3.66	0	100
Mims Ridge Field	67	12,054	12,121	0.05	3.13	0.55	99.45
Patrick Shoal	429	937	1,366	0.35	0.24	31.41	68.59
Roseland Shoal	497	930	1,427	0.41	0.24	34.83	65.17
Salerno Shoal	842	0	842	0.69	0	100	0
St Lucie Sand Flat	31,387	29,623	61,010	25.61	7.68	51.45	48.55
Undifferentiated Seafloor	21,289	162,779	184,068	17.37	42.21	11.57	88.43
TOTAL	**122,559**	**385,624**	**508,183**	**100**	**100**	**24.12**	**75.88**

[1] Percentage of total study area under State of Florida jurisdiction, *i.e*. landward of 3-mile limit.

[2] Percentage of total study area under federal jurisdiction, *i.e*. seaward of 3-mile limit.

[3] Percentage of state-controlled continental shelf area comprised by mapping unit, *i.e.* landward of 3-mile limit.

[4] Percentage of federally-controlled continental shelf area comprised by mapping unit, *i.e*. seaward of 3-mile limit.

[5] Percentage of mapping unit under state jurisdiction, *i.e.* landward of 3-mile limit.

[6] Percentage of mapping unit under federal jurisdiction, *i.e*. seaward of 3-mile limit.

Table 3-8.
Explanation of method used to calculate total volumes by sedimentary feature where bars and ridge fields occupied less than the total unit area mapped

Morphosedimentary Feature	**Area (ha)**	**% Total Study Area**	**% Area Used in Calculations**	**Average Thickness (ft)**	**Max Thickness (ft)**	**Volume (yds^3)**
Ankona Shoal	1,883	0.37	1	3.28	6.56	15,011,707
Canaveral Transverse Bar	3,218	0.63	0.35	6.56	16.4	26,944,974
Capron Shoal	3,916	0.77	1	6.56	9.84	78,060,900
Cocoa Sand Flat	52,472	10.32	1	6.56	0	1,255,165,195
Dickinson Ridge Field	1,192	0.23	0.6	6.56	29.52	21,386,063
Farmton Sand Flat	34,961	6.88	1	6.56	0	836,298,059
Gifford Shoal	1,443	0.28	1	3.28	9.84	17,258,252
Gilbert Shoal	2,872	0.57	1	6.56	19.68	91,609,601
Indian River Ridge Field	33,620	6.62	0.5	6.56	19.68	469,128,659
Malabar Ridge Field	63,941	12.58	0.5	6.56	26.24	764,758,490
Martin Ridge Field	11,114	2.19	0.35	6.56	19.68	108,560,662
Melbourne Shoal	2,089	0.41	1	3.28	6.56	33,311,576
Merritt Ridge Field	14,109	2.78	0.7	6.56	26.24	315,001,751
Mims Ridge Field	12,121	2.38	0.35	9.84	26.24	169,133,849
North Kennedy Ridge Field	12,062	2.37	0.65	13.12	19.68	375,092,562
Patrick Shoal	1,365	0.27	1	3.28	9.84	16,330,054
Roseland Shoal	1,426	0.28	1	3.28	9.84	22,747,046
Salerno Shoal	842	0.17	1	6.56	19.68	26,860,965
South Kennedy Ridge Field	8,475	1.67	0.8	13.12	19.68	324,355,622
St. Lucie Sand Flat	61,010	12	1	6.56	0	642,431,412
Undifferentiated Seafloor	184,104	36.22		0	0	0
Total	**508,235**	**100**				**5,609,447,399**

Table 3-9.
Suggested shoreward extensions of MMS seismic track lines from federal waters into state waters for the purpose of acquiring information related to sand resource potential landward of the 3-mile limit.

County/ Shore Location	Extension of MMS Seismic Track Line	Comments, Justification for Landward Extension of MMS Seismic Track Line into State Waters
BREVARD COUNTY		
R-3	B5	Downcoast margin of cuspate foreland, covers Cocoa Sand Flat
R33	B13	Offshore from R33, covers landward margin of Patrick Shoal
R-72-T	B26	Cuts across Melbourne Shoal and transects Cocoa Sand Flat
R-109-T	B38	Cuts across sand ridges associated with a shore-transverse arm of the Malabar Ridge Field and the Cocoa Sand Flat
R-141	B49	Cuts across sand ridges associated with a shore-transverse arm of the Malabar Ridge Field and the Cocoa Sand Flat
R-190	B66	Provides stratigraphic information for unmapped seafloor features as it crosses the 'Undifferentiated Seafloor' mapping unit
R-218OS	B76	Crosses the southwestern part of the Roseland Shoal and undifferentiated seafloor
INDIAN RIVER COUNTY		
T-31	IR9	Crosses undifferentiated seafloor providing new information on potential sand resources occurring in yet undetected morphosedimentary features
R-50	IR15	Crosses undifferentiated seafloor providing new information on potential sand resources occurring in yet undetected morphosedimentary features
R-80	IR25	Crosses shoreward part of the Indian River Ridge Field and the northern extension of the St. Lucie Sand Flat
R-104	IR32	Crosses shoreward part of the Indian River Ridge Field and the northern extension of the St. Lucie Sand Flat
ST. LUCIE COUNTY		
R-14	IR41	Crosses prominent ridges associated with the Indian River Ridge Field and St. Lucie Sand Flat
R-34	IR47	Crosses shoreward segment of Capron Shoal, St. Lucie Sand Flat, and southern part of a prominent ridge associated with the Indian River Ridge Field
R-56	SL7	Crosses western margin of Ankona Shoal, central segment of Capron Shoal, and St. Lucie Sand Flat
R-88	SL6A	Crosses St. Lucie Sand Flat and Capron Shoal
R-112	SL23	Crosses central segment of the Gilbert Shoal and St. Lucie Sand Flat
MARTIN COUNTY		
R-20	SL29	Crosses shoreward arm of Martin Ridge Field, southern part of Gilbert Shoal, St. Lucie Sand Flat
R-41	SL35	Crosses St. Lucie Sand Flat and southern extension of Gilbert Shoal
R-64	M6	Crosses southern extension of the Martin Ridge Field and St. Lucie Sand Flat
R-95	M14	Crosses Salerno Shoal and St. Lucie Sand Flat
R-112	M19	Crosses Dickinson Ridge Field and St. Lucie Sand Flat

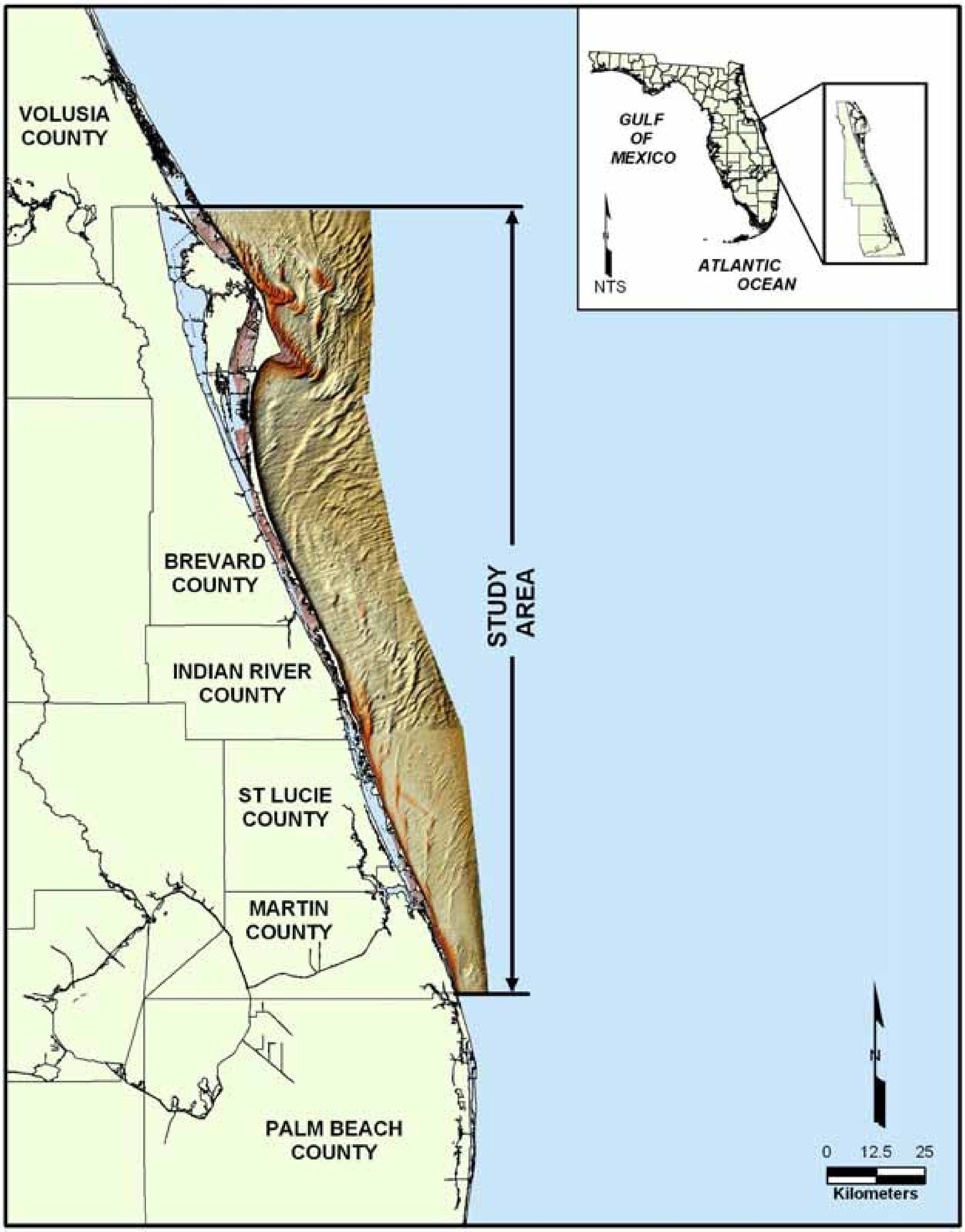
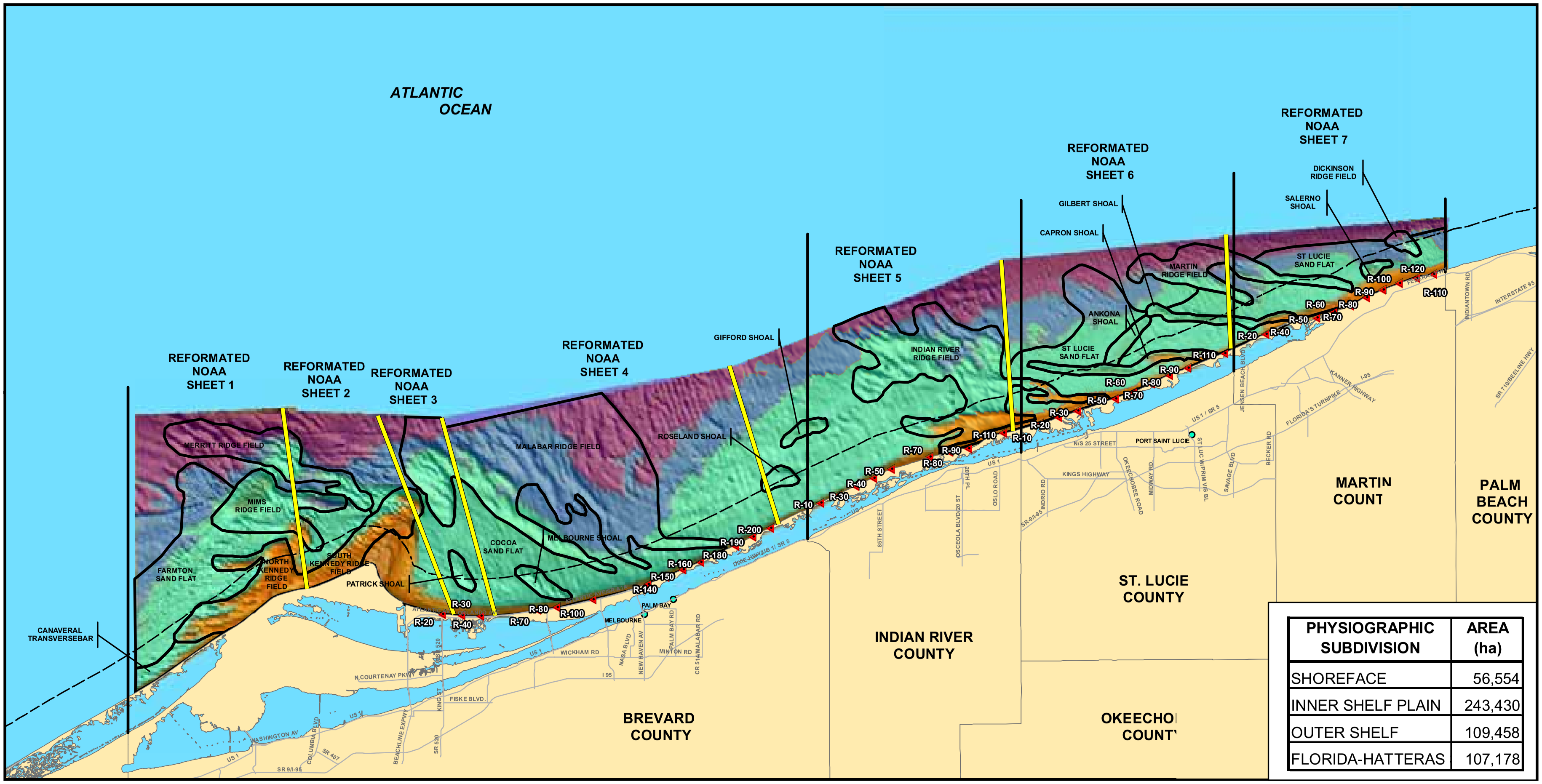


Figure 3-1. Location of the study area along the central Florida Atlantic continental shelf, covering about 720 km2. The study area is defined by re-formatted NOAA bathymetry in state and federal waters along Brevard, Indian River, St. Lucie, and Martin counties.



PHYSIOGRAPHIC SUBDIVISION	AREA (ha)
SHOREFACE	56,554
INNER SHELF PLAIN	243,430
OUTER SHELF	109,458
FLORIDA-HATTERAS	107,178

LEGEND

- CITIES
- FDEP MONUMENTS
- COUNTY LINES
- REFORMATED NOAA SHEETS
- FEDERAL STATE BOUNDARY
- ROADS
- OFFSHORE MORPHOLOGY

PHYSIOGRAPHIC SUBDIVISION

- SHOREFACE
- INNER SHELF PLAIN
- OUTER SHELF
- FLORIDA-HATTERAS SLOPE

0 8 16 Kilometers

N

TITLE:

PHYSIOGRAPHIC SUBDIVISION OF THE CENTRAL FLORIDA ATLANTIC CONTINENTAL SHELF

COASTAL PLANNING & ENGINEERING, INC
2481 NW BOCA RATON BLVD.
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX.(561) 391-9116

DATE: 05/07/07	BY: HMV	COMM NO: 7849.27	FIGURE 3-2

G:\DEP-URS\Centraleast_Florida_MXD\Central_ROSS_CONTOURS.mxd

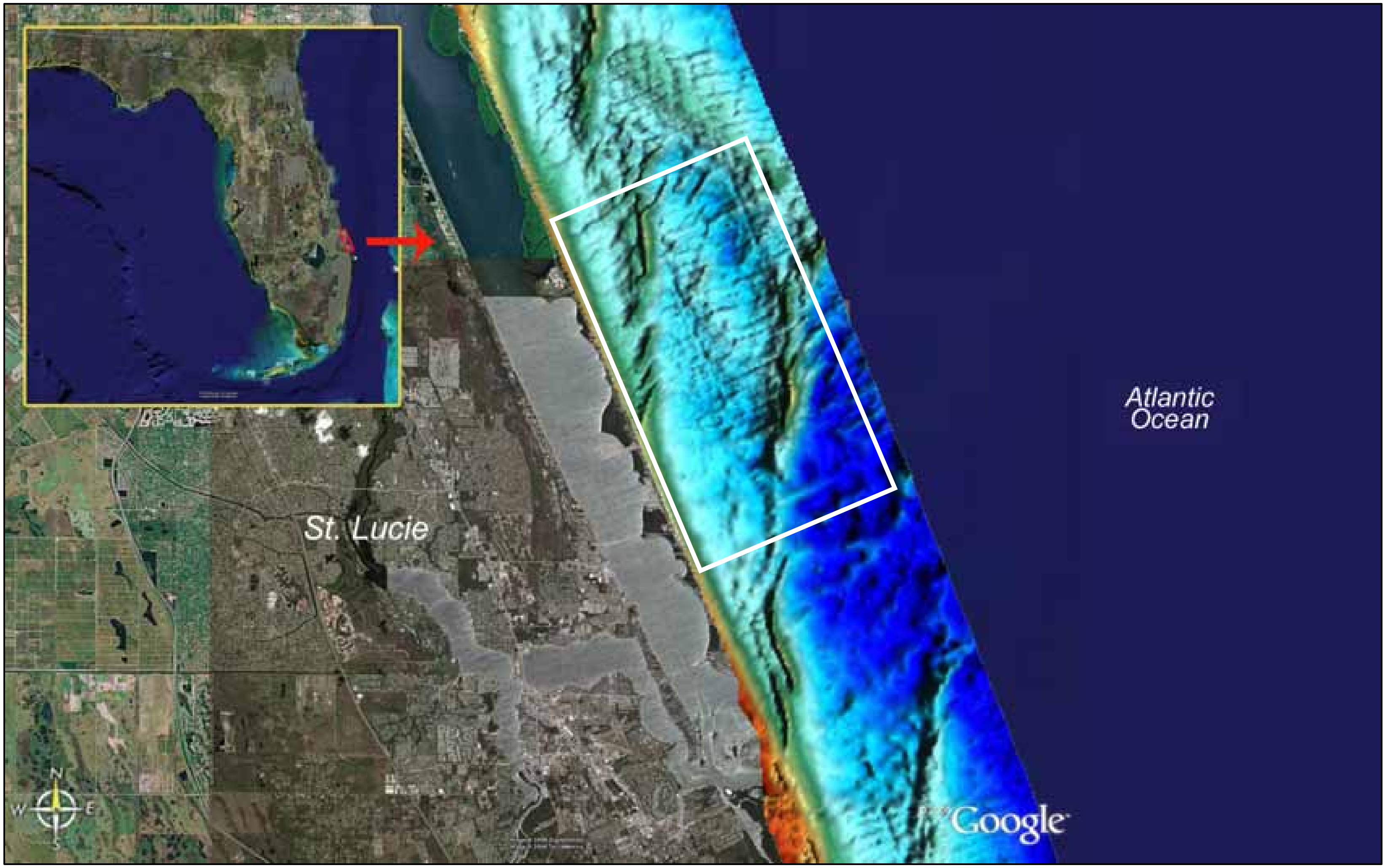


Figure 3-3. Location diagram of the St. Lucie project area (white-lined box). The composite image combines a 3D bathymetric model (created from reformatted historical NOAA-GEODAS bathymetric data) and aerial photography obtained from Google Earth Pro®. (From Finkl *et al.*, 2006).

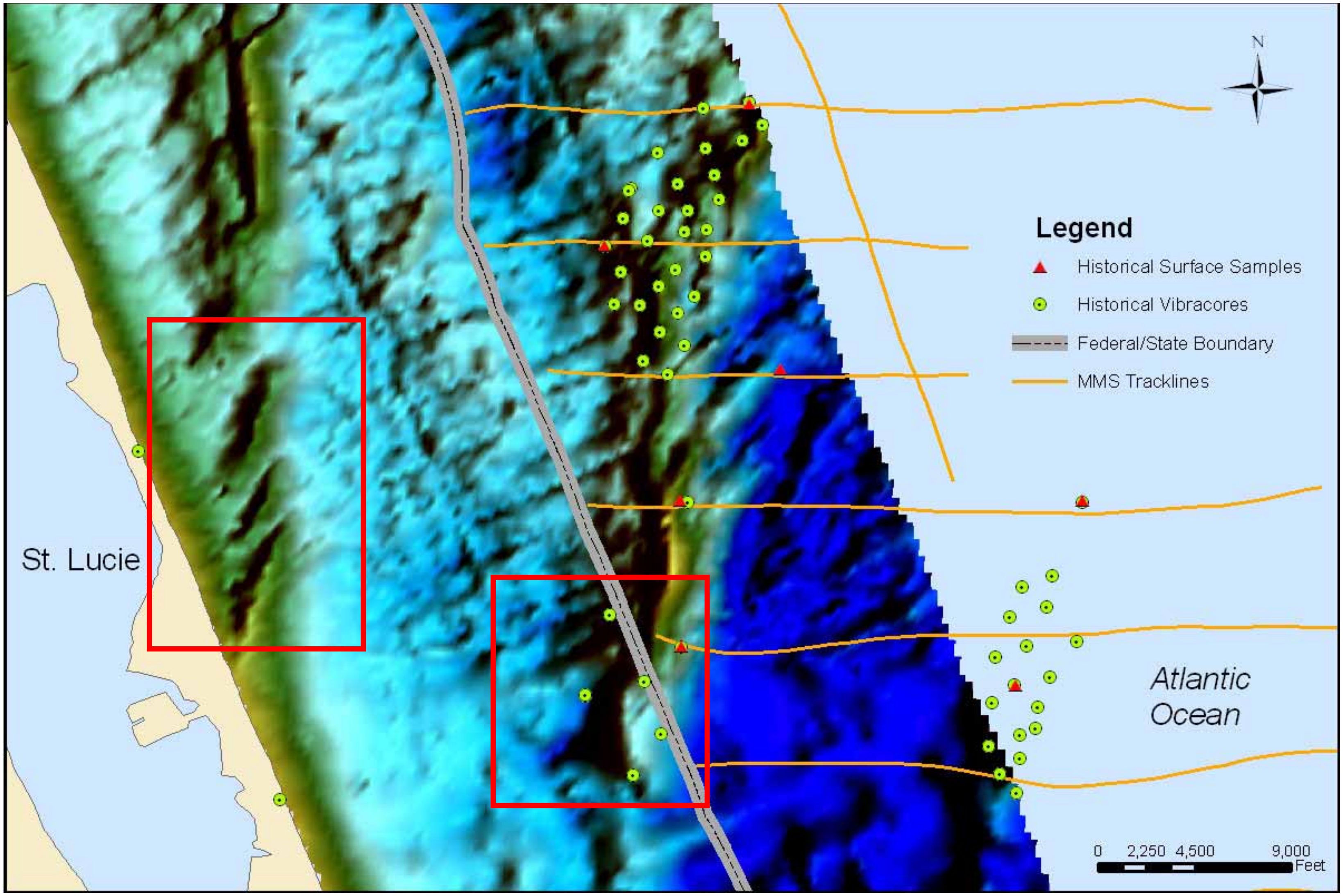


Figure 3-4. Location of historic geotechnical and geophysical data overlaid on top of a 3D bathymetric model created using reformatted NOAA-GEODAS bathymetry data. Sand ridges identified offshore of the project area (see red rectangles) were selected for reconnaissance investigations. (From Finkl *et al*., 2006).

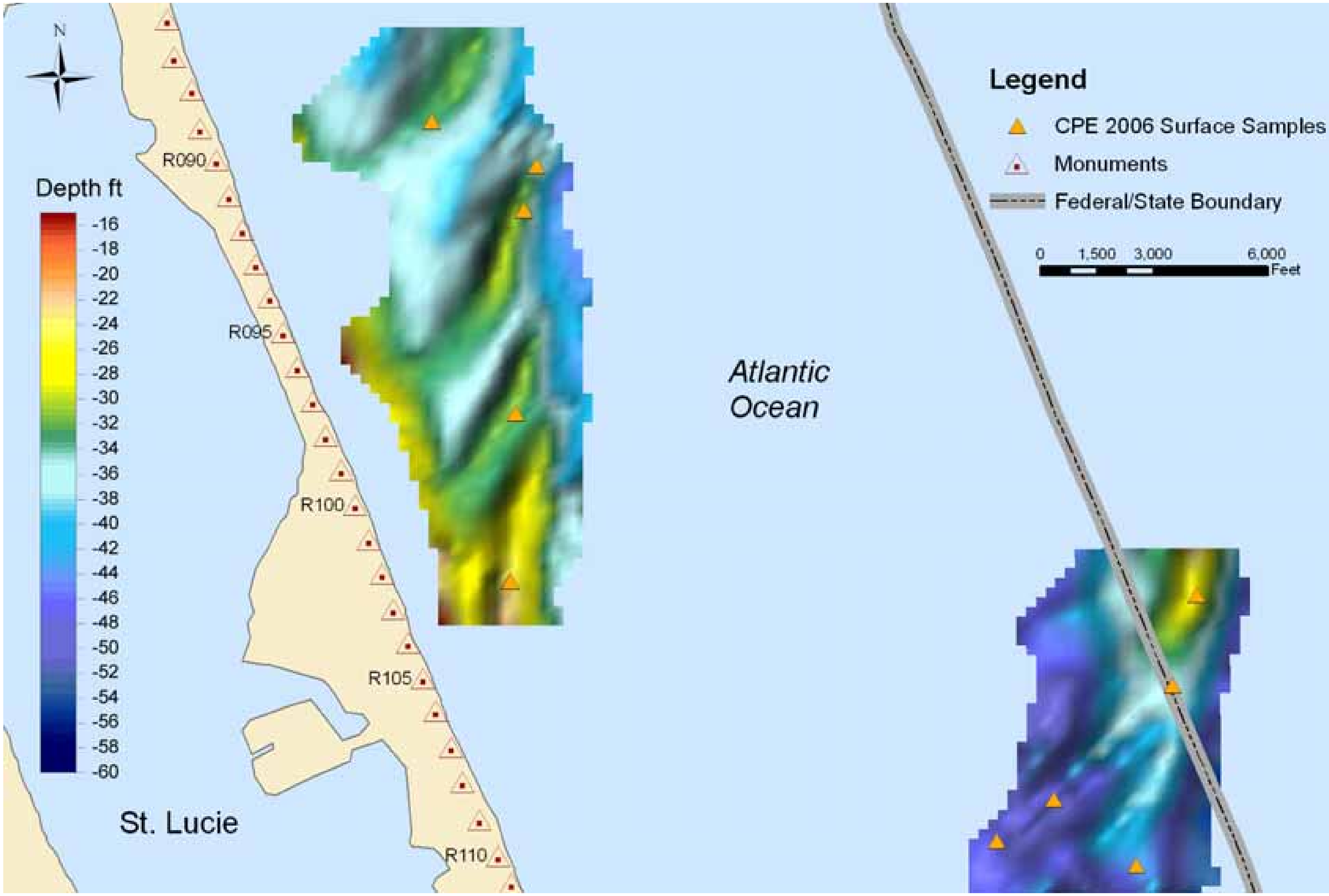


Figure 3-5. Three-dimensional bathymetric model created from updated bathymetry obtained by CPE and location of surface sand samples. (From Finkl *et al*., 2006).

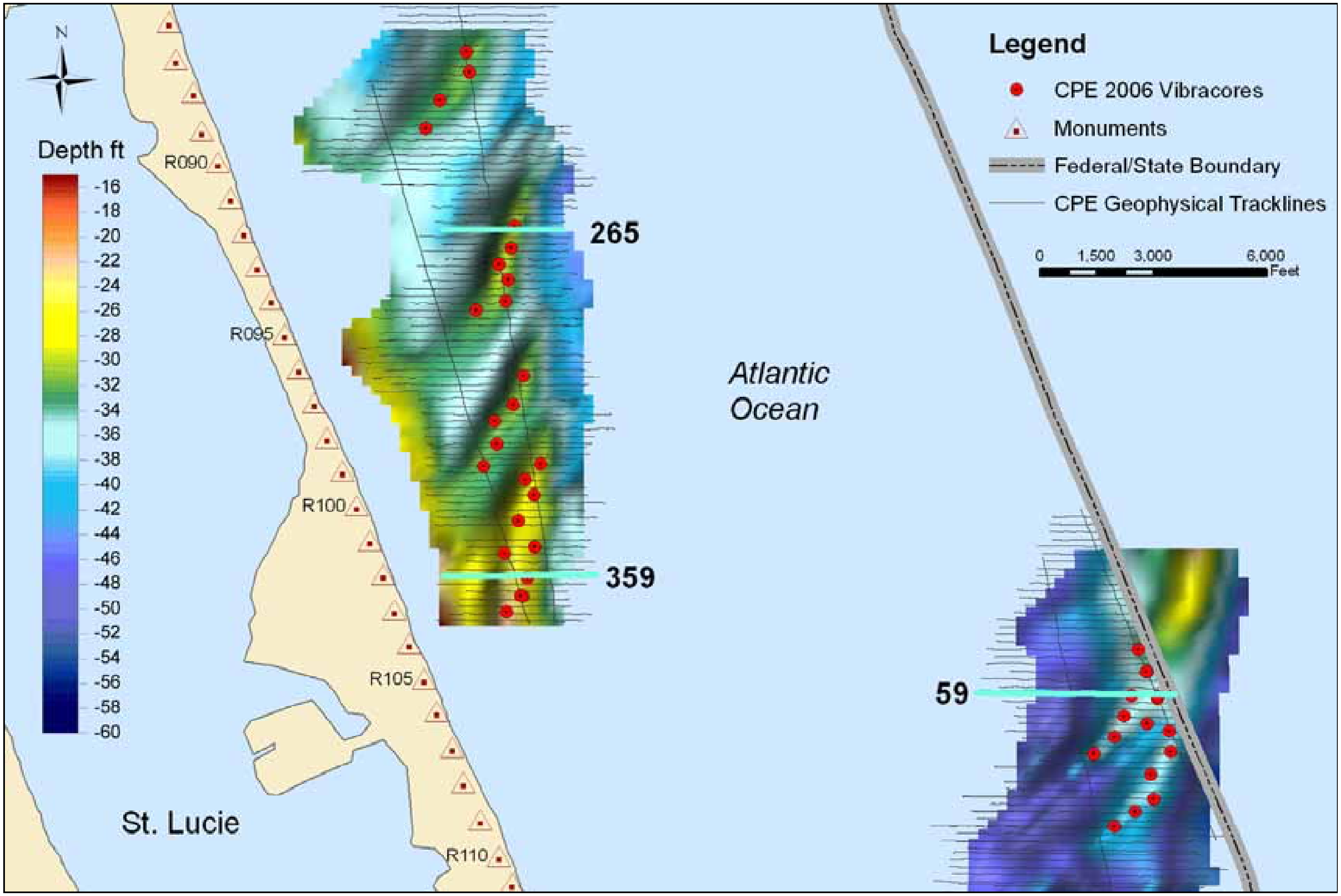


Figure 3-6. Location of seismic tracklines, vibracores and selected seismic cross-sections. Cross-sectional seismic profiles for the highlighted blue tracklines are shown in Figure 3-7. (From Finkl *et al*., 2006).

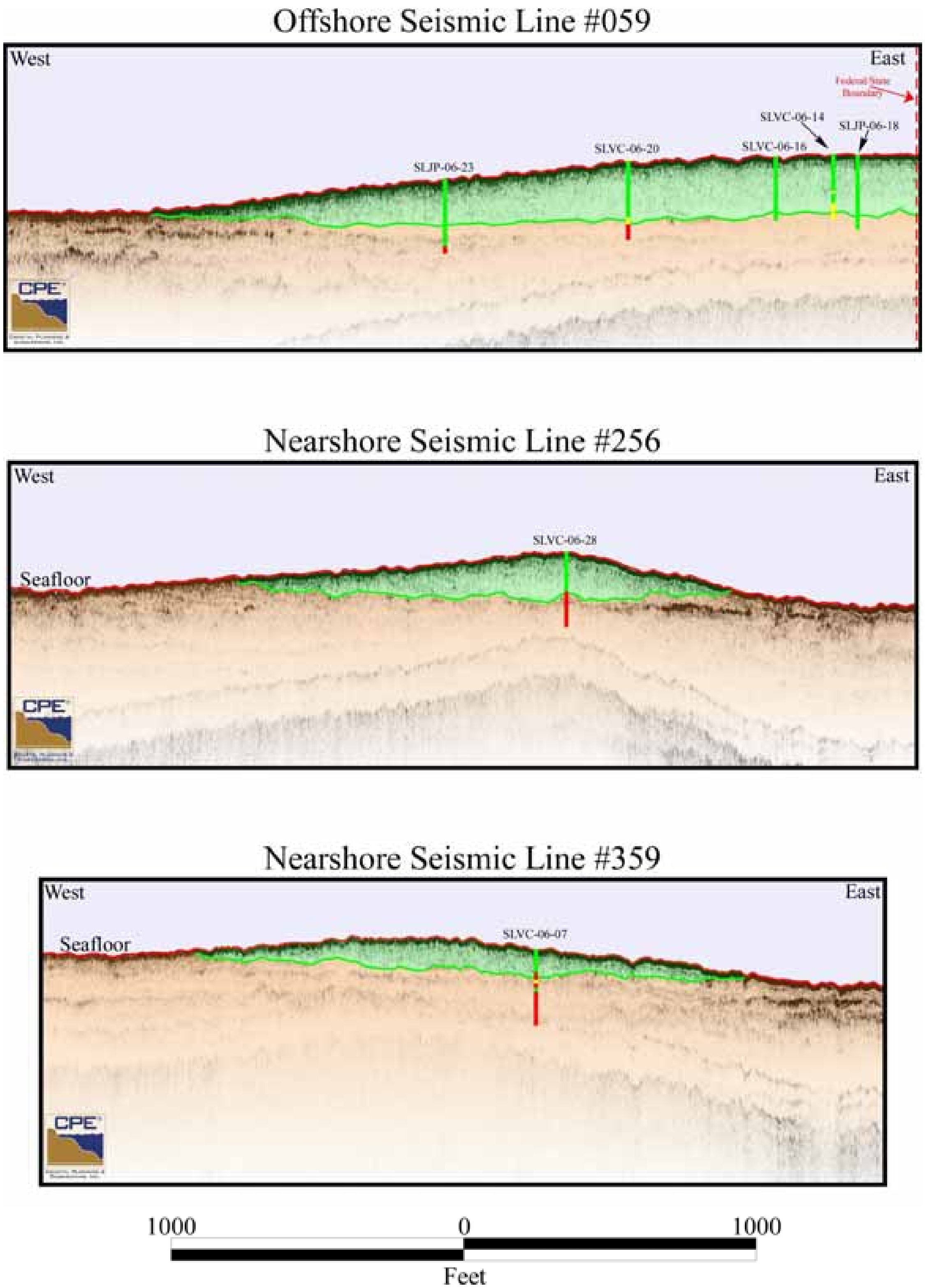


Figure 3-7. Seismic images showing correlation between seismic reflectors and vibracores layers. The thickness of the clean sand deposits correlate with sand ridge relief, but deposit thickness decreases away from ridge crests. The location of the seismic lines in plan view is shown in Figure 3-6. (From Finkl *et al*., 2006).

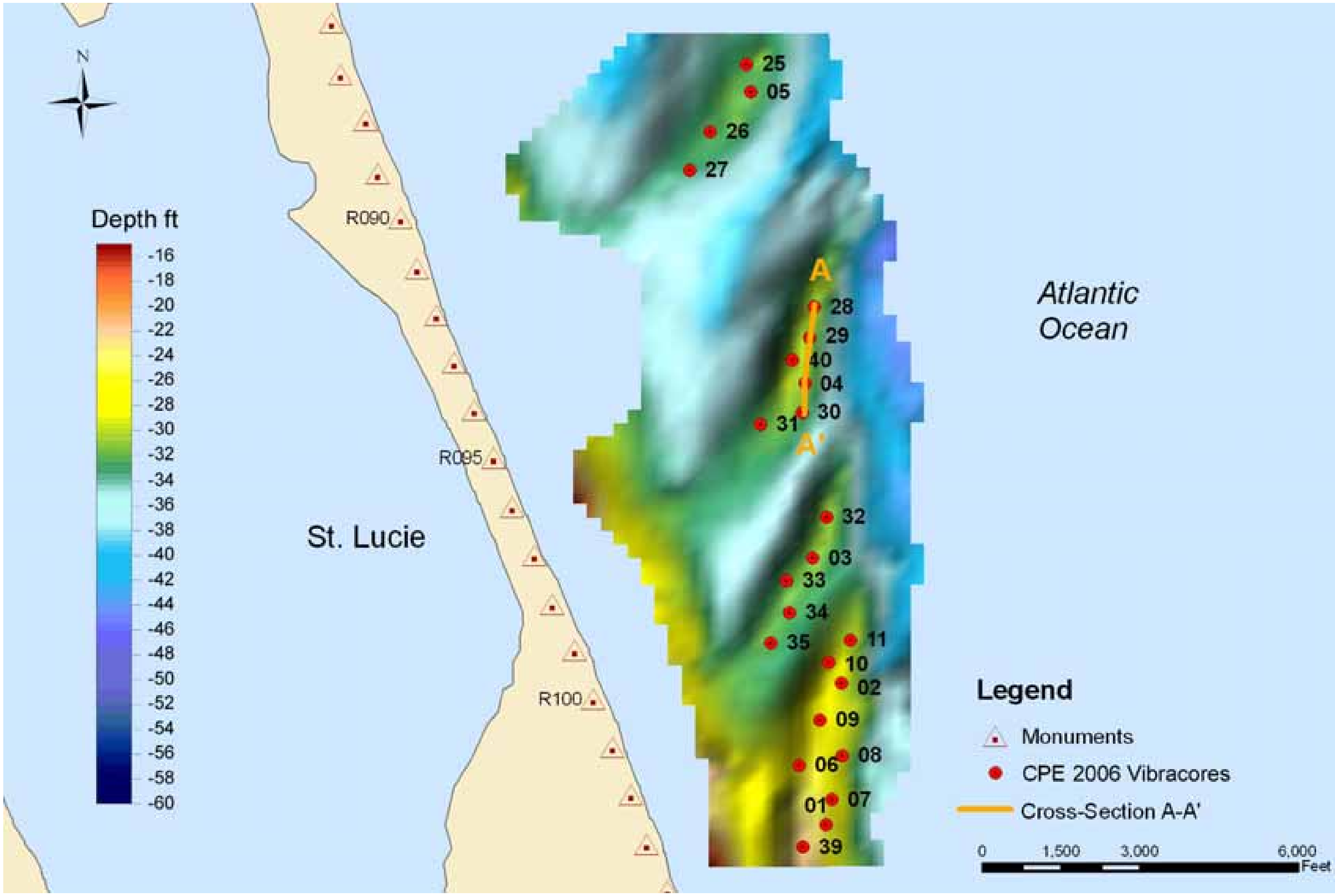


Figure 3-8. Zoom view of the nearshore study area showing vibracores and location of vibracore cross-section A-A' (Figure 3-9). (From Finkl *et al.*, 2006).

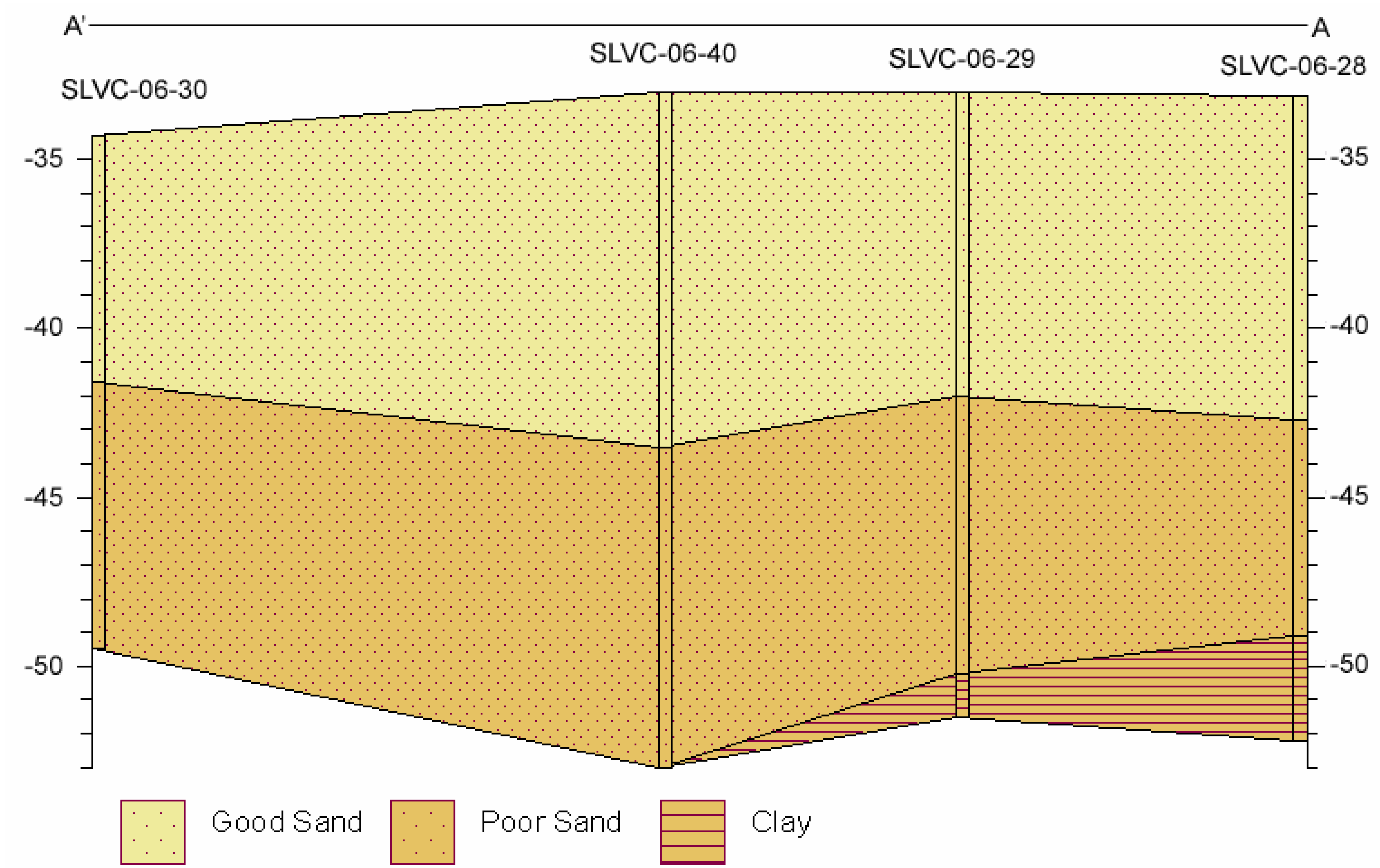


Figure 3-9. Schematic cross section based on interpretation of vibracore data (see Figure 3-8 for cross-section location). Sediments in the vibracores were divided into three main categories: (1) good sand, (2) poor sand and (3) clay. The “good sand” layer contains clean sandy sediments (fine to medium sand less than 5% silt, generally less than 5% shell, moderately to moderately well sorted). “Poor sands” are those sandy layers mixed with more than 5% fines (silt or clay) and shell/rock fragments. The clay contains clay-sized particles. (From Finkl *et al*., 2006).

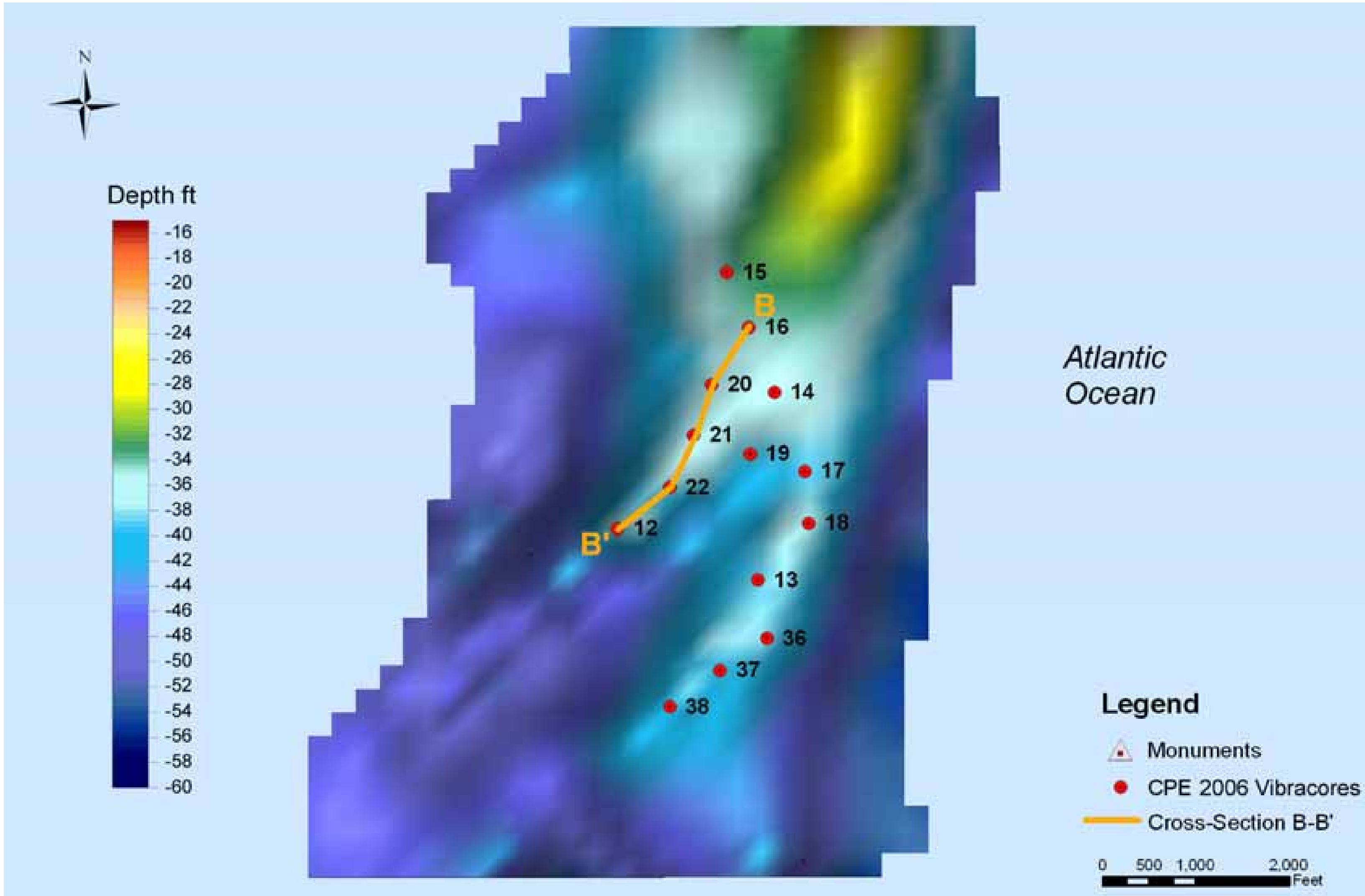


Figure 3-10. Zoom view of the offshore study area showing vibracores and location of vibracore cross-section B-B' (Figure 3-11). (From Finkl *et al*., 2006).

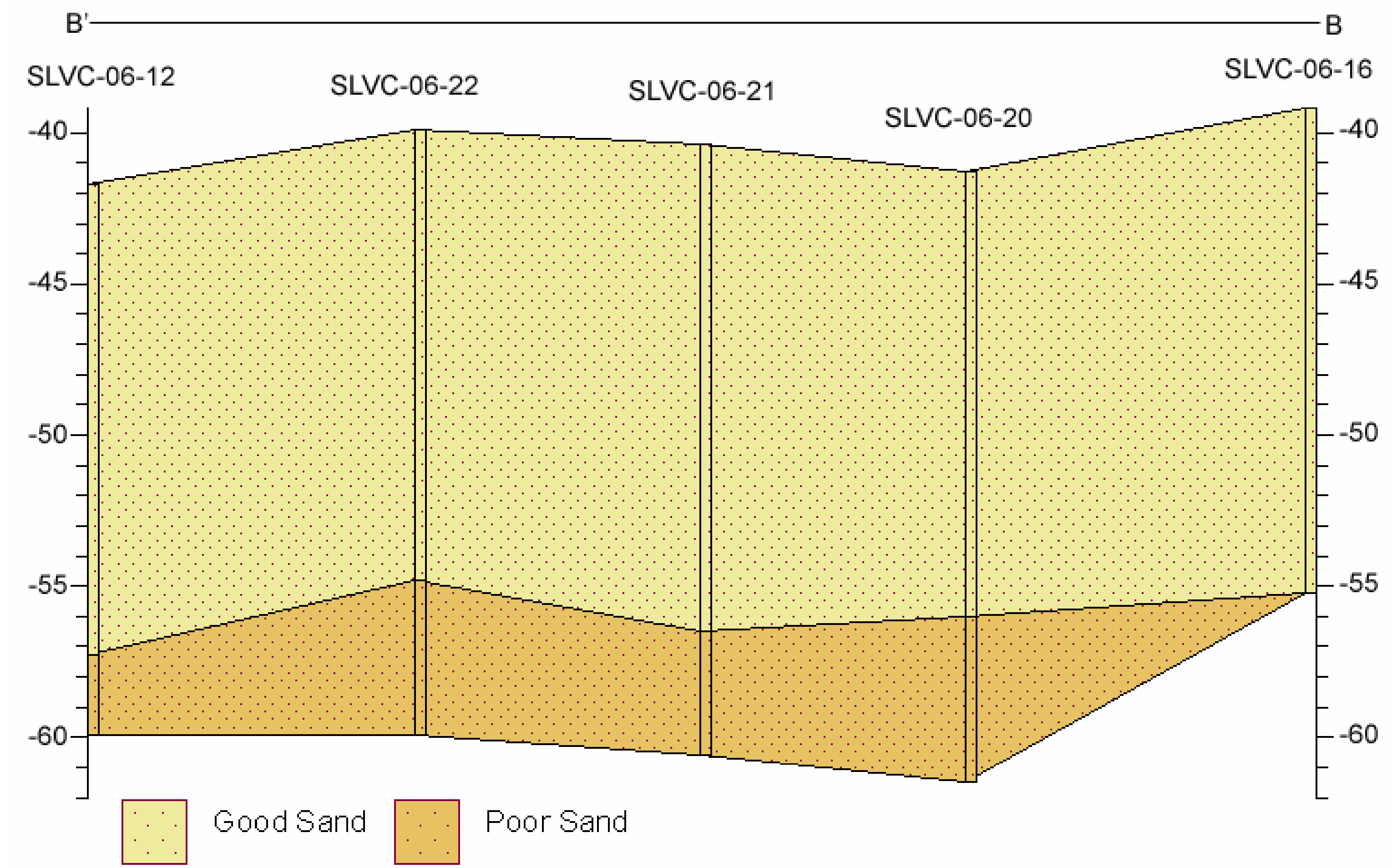


Figure 3-11. Schematic cross section based on interpretation of vibracore data (see Figure 3-10 for location). Sediments in the vibracores were divided into two main categories: (1) good sand, (2) poor sand, and (3) clay. The "good sand" layer contains clean sandy sediments (fine to medium sand less than 5% silt, generally less than 5% shell, moderately to moderately well sorted). "Poor sands" contain sandy layers mixed with more than 5% fines (silt or clay) and shell/rock fragments. (From Finkl *et al*., 2006).

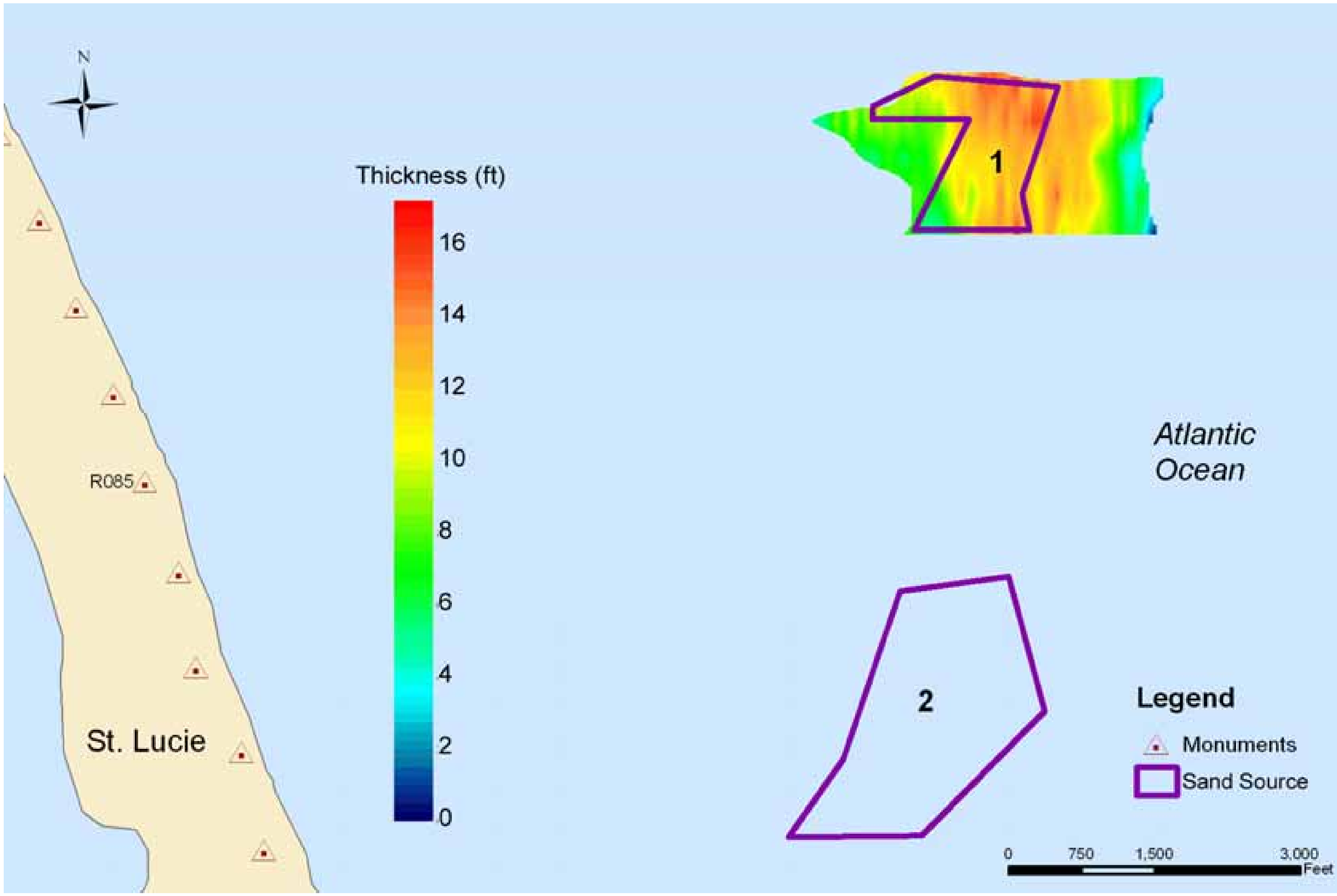


Figure 3-12. Isopach of nearshore Sand source 1 and sand source layout. Sediment thickness is greater at the ridge crest and diminishes with distance from the crest (to the east and west). (From Finkl *et al*., 2006).

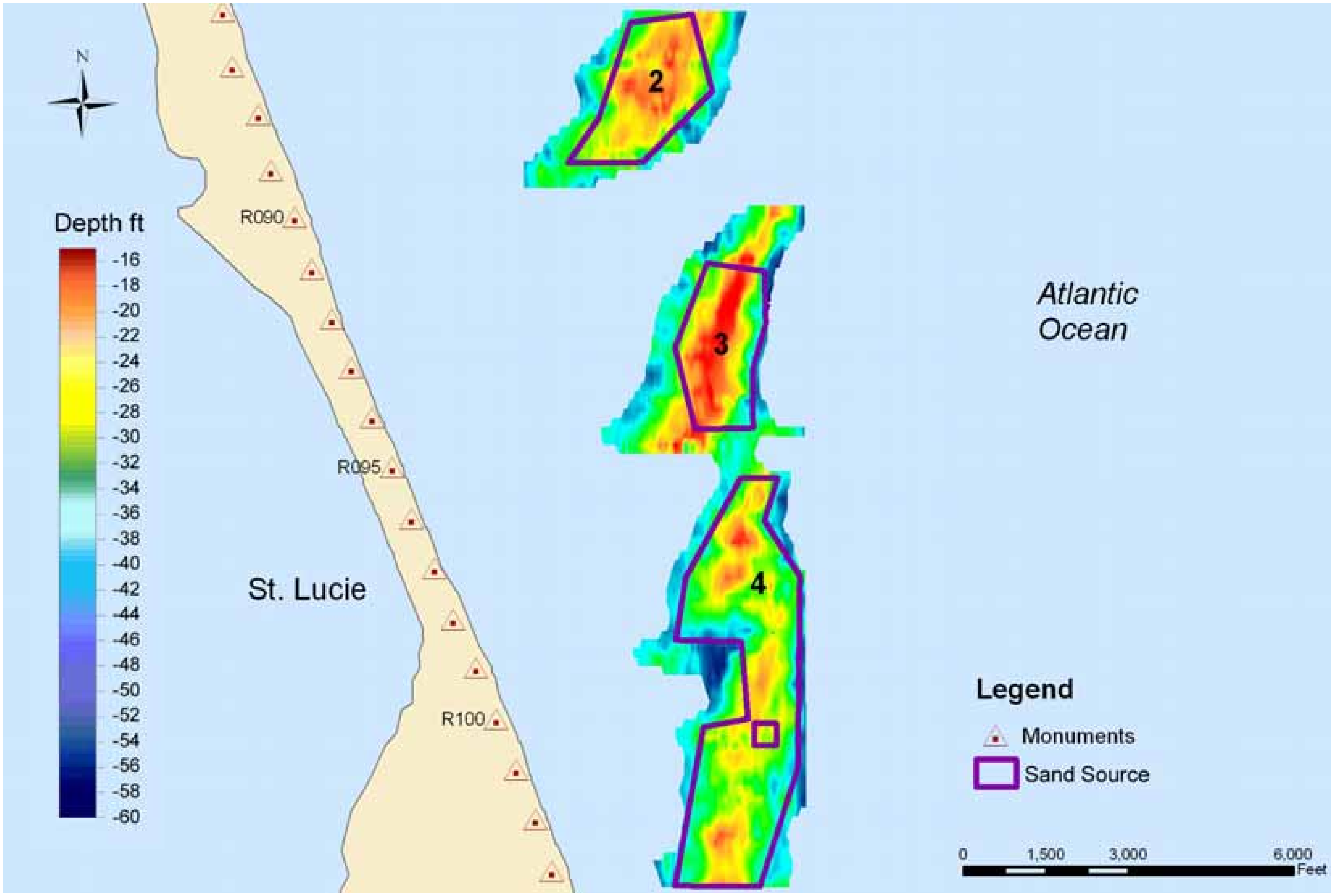


Figure 3-13. Sediment thickness (isopach map) for Sand sources 2, 3 and 4. (From Finkl *et al*., 2006).

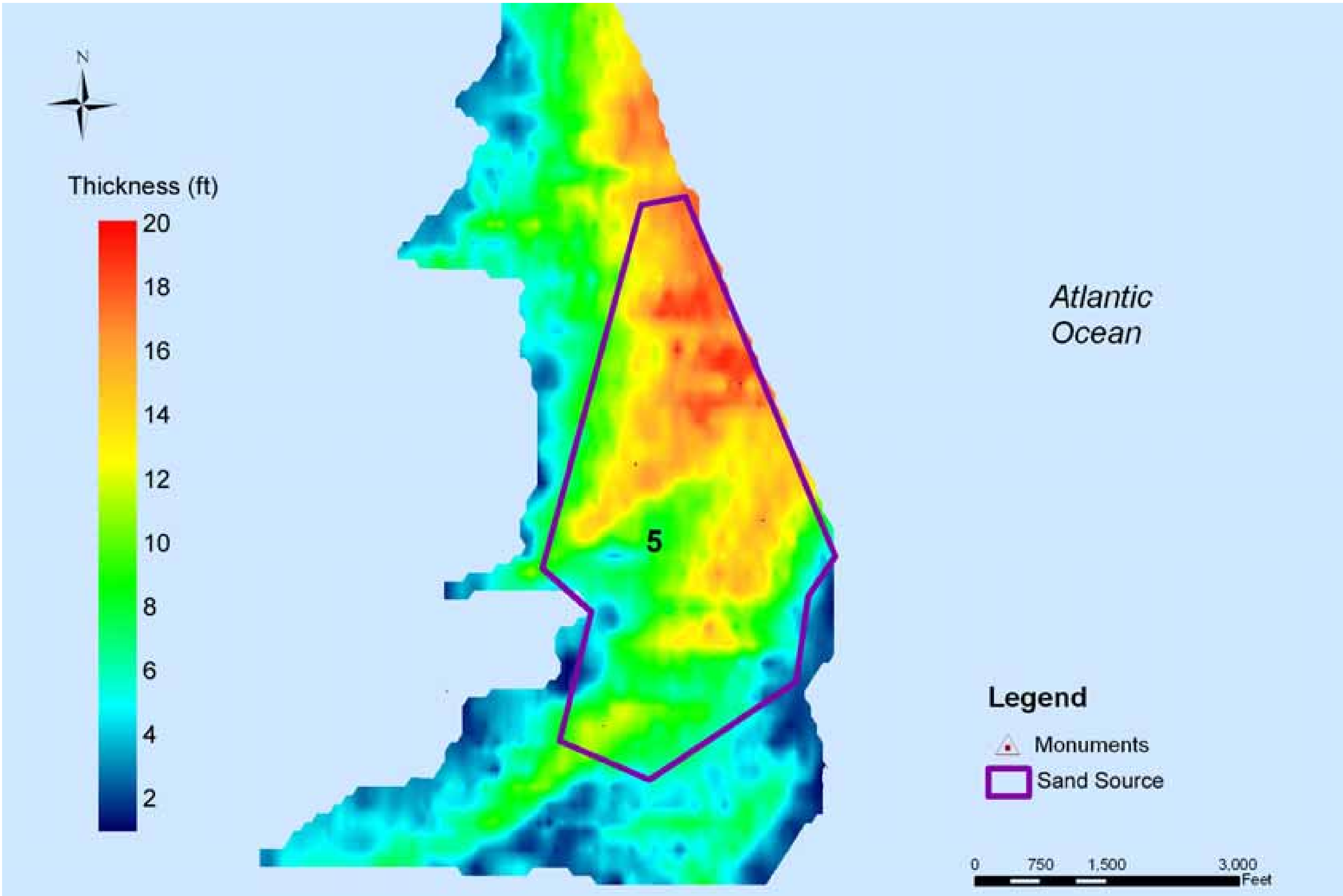
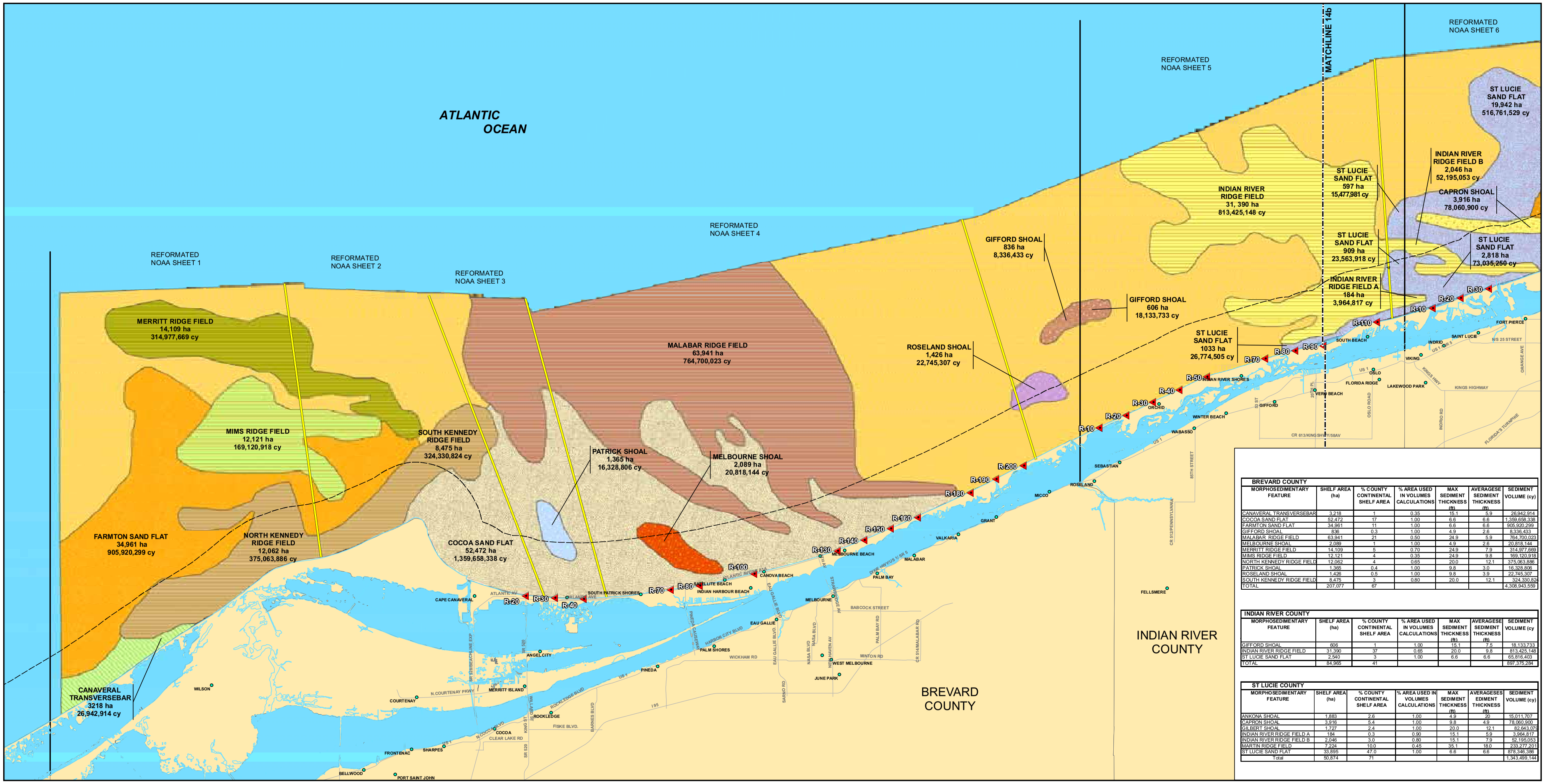


Figure 3-14. Sediment isopachs for the offshore sand source. Sediment thickness increases to the NE, towards the main ridge crest. This study area is the terminus (W-SW corner) (between Range monuments 103 and 111) of a very large sediment ridge that lies seaward of the study area (to the E-NE) (see Figure 3-4). Only the corner of the ridge was surveyed because the seaward section lies in Federal waters under MMS jurisdiction. It is anticipated, however, that the seaward continuation of this sand body represents a significant sand reserve for future renourishments in St. Lucie County. (From Finkl *et al.*, 2006).



BREVARD COUNTY						
MORPHOSEDIMENTARY FEATURE	SHELF AREA (ha)	% COUNTY CONTINENTAL SHELF AREA	% AREA USED IN VOLUMES CALCULATIONS	MAX SEDIMENT THICKNESS (ft)	AVERAGESE SEDIMENT THICKNESS (ft)	SEDIMENT VOLUME (cy)
CANAVERAL TRANSVERSEBAR	3,218	1	0.35	15.1	5.9	26,942,914
COCOA SAND FLAT	52,472	17	1.00	6.6	6.6	1,359,658,338
FARMTON SAND FLAT	34,961	11	1.00	6.6	6.6	905,920,299
GIFFORD SHOAL	836	0.3	1.00	4.9	2.6	8,336,433
MALABAR RIDGE FIELD	63,941	21	0.50	24.9	5.9	764,700,023
MELBOURNE SHOAL	2,089	1	1.00	4.9	2.6	20,818,144
MERRITT RIDGE FIELD	14,109	5	0.70	24.9	7.9	314,977,669
MIMS RIDGE FIELD	12,121	4	0.35	24.9	9.8	169,120,918
NORTH KENNEDY RIDGE FIELD	12,062	4	0.65	20.0	12.1	375,063,886
PATRICK SHOAL	1,365	0.4	1.00	9.8	3.0	16,328,806
ROSELAND SHOAL	1,426	0.5	1.00	9.8	3.9	22,745,307
SOUTH KENNEDY RIDGE FIELD	8,475	3	0.80	20.0	12.1	324,330,824
TOTAL	207,077	67				4,308,943,559

INDIAN RIVER COUNTY						
MORPHOSEDIMENTARY FEATURE	SHELF AREA (ha)	% COUNTY CONTINENTAL SHELF AREA	% AREA USED IN VOLUMES CALCULATIONS	MAX SEDIMENT THICKNESS (ft)	AVERAGESE SEDIMENT THICKNESS (ft)	SEDIMENT VOLUME (cy
GIFFORD SHOAL	606	1	1.00	15.1	7.5	18,133,733
INDIAN RIVER RIDGE FIELD	31,390	37	0.65	20.0	9.8	813,425,148
ST LUCIE SAND FLAT	2,540	3	1.00	6.6	6.6	65,816,403
TOTAL	84,965	41				897,375,284

ST LUCIE COUNTY						
MORPHOSEDIMENTARY FEATURE	SHELF AREA (ha)	% COUNTY CONTINENTAL SHELF AREA	% AREA USED IN VOLUMES CALCULATIONS	MAX SEDIMENT THICKNESS (ft)	AVERAGESES EDIMENT THICKNESS (ft)	SEDIMENT VOLUME (cy)
ANKONA SHOAL	1,883	2.6	1.00	4.9	20	15,011,707
CAPRON SHOAL	3,916	5.4	1.00	9.8	4.9	78,060,900
GILBERT SHOAL	1,727	2.4	1.00	20.0	12.1	82,643,079
INDIAN RIVER RIDGE FIELD A	184	0.3	0.90	15.1	5.9	3,964,817
INDIAN RIVER RIDGE FIELD B	2,046	3.0	0.80	15.1	7.9	52,195,053
MARTIN RIDGE FIELD	7,224	10.0	0.45	35.1	18.0	233,277,201
ST LUCIE SAND FLAT	33,895	47.0	1.00	6.6	6.6	878,346,386
Total	50,874	71				1,343,499,144

LEGEND:

- CITIES
- FDEP MONUMENTS
- MATCHLINE
- COUNTY LINES
- ROADS
- REFORMATED NOAA SHEETS
- FEDERAL STATE BOUNDARY

OFFSHORE MORPHOLOGY:

BARS
- CANAVERAL TRANSVERSE BAR

SAND FLATS
- COCOA SAND FLAT
- FARMTON SAND FLAT
- ST LUCIE SAND FLAT

RIDGE FIELDS
- INDIAN RIVER RIDGE FIELD
- MALABAR RIDGE FIELD
- MARTIN RIDGE FIELD
- MERRITT RIDGE FIELD
- MIMS RIDGE FIELD
- NORTH KENNEDY RIDGE FIELD
- SOUTH KENNEDY RIDGE FIELD

SHOALS
- CAPRON SHOAL
- GIFFORD SHOAL
- MELBOURNE SHOAL
- PATRICK SHOAL
- ROSELAND SHOAL
- UNDIFFERENTIATED SEAFLOOR
- UNDIFFERENTIATED SEAFLOOR

N

0 5 10 Kilometers

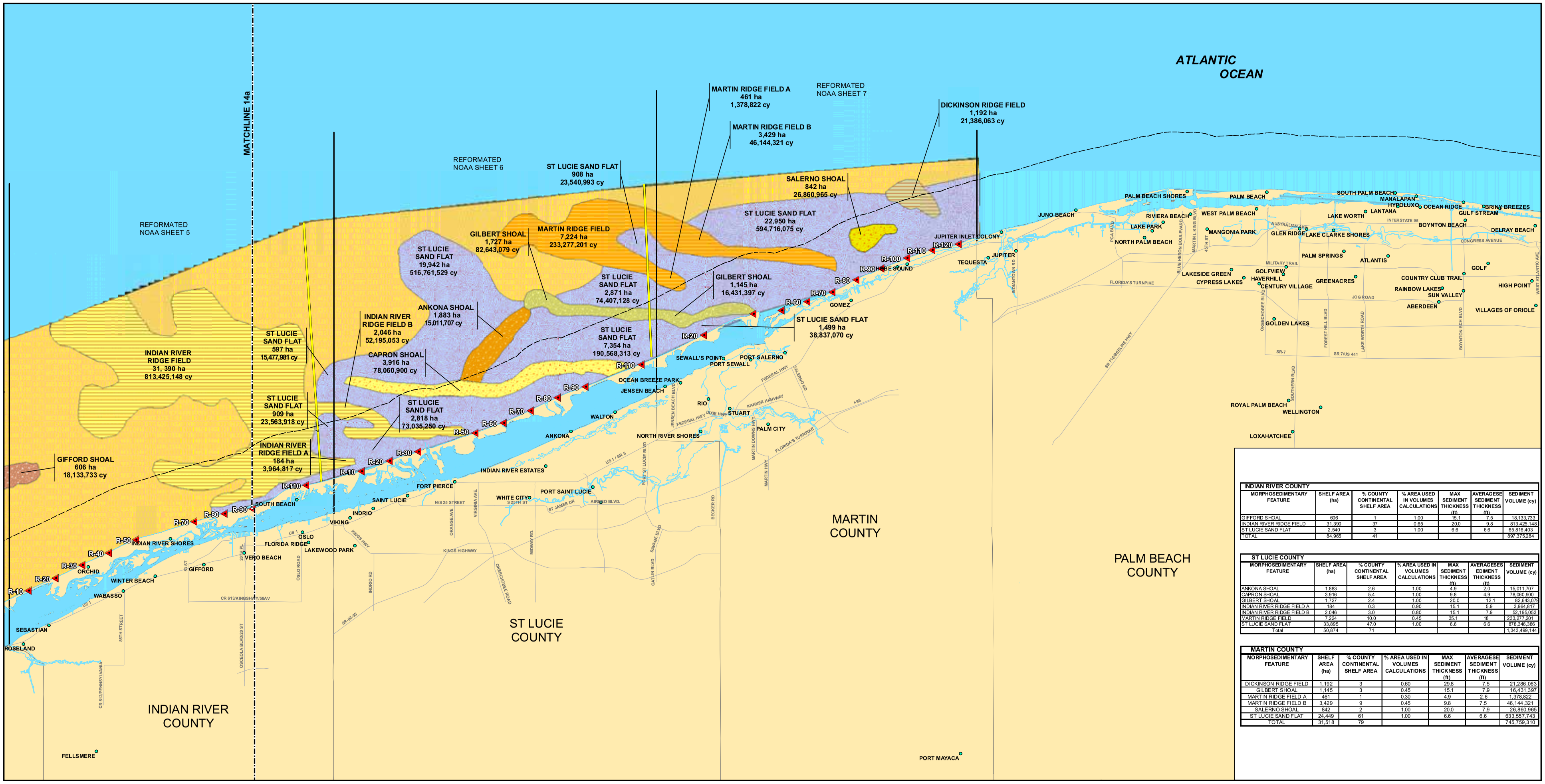
TITLE:

POTENTIAL SAND RESOURCES ALONG THE CENTRAL FLORIDA ATLANTIC COAST

CPE
COASTAL PLANNING & ENGINEERING, INC
2481 NW BOCA RATON BLVD.
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX.(561) 391-9116

DATE: 05/04/07	BY: HMV	COMM NO: 7849.27	FIGURE 3-15A

G:\DEP-URS\Centraleast_Florida_MXD\Central_ROSS_Morphology_SHEET_1.mxd



INDIAN RIVER COUNTY						
MORPHOSEDIMENTARY FEATURE	SHELF AREA (ha)	% COUNTY CONTINENTAL SHELF AREA	% AREA USED IN VOLUMES CALCULATIONS	MAX SEDIMENT THICKNESS (ft)	AVERAGESE SEDIMENT THICKNESS (ft)	SEDIMENT VOLUME (cy)
GIFFORD SHOAL	606	1	1.00	15.1	7.5	18,133,733
INDIAN RIVER RIDGE FIELD	31,390	37	0.65	20.0	9.8	813,425,148
ST LUCIE SAND FLAT	2,540	3	1.00	6.6	6.6	65,816,403
TOTAL	84,965	41				897,375,284

ST LUCIE COUNTY						
MORPHOSEDIMENTARY FEATURE	SHELF AREA (ha)	% COUNTY CONTINENTAL SHELF AREA	% AREA USED IN VOLUMES CALCULATIONS	MAX SEDIMENT THICKNESS (ft)	AVERAGESES EDIMENT THICKNESS (ft)	SEDIMENT VOLUME (cy)
ANKONA SHOAL	1,883	2.6	1.00	4.9	2.0	15,011,707
CAPRON SHOAL	3,916	5.4	1.00	9.8	4.9	78,060,900
GILBERT SHOAL	1,727	2.4	1.00	20.0	12.1	82,643,079
INDIAN RIVER RIDGE FIELD A	184	0.3	0.90	15.1	5.9	3,964,817
INDIAN RIVER RIDGE FIELD B	2,046	3.0	0.80	15.1	7.9	52,195,053
MARTIN RIDGE FIELD	7,224	10.0	0.45	35.1	18	233,277,201
ST LUCIE SAND FLAT	33,895	47.0	1.00	6.6	6.6	878,346,386
Total	50,874	71				1,343,499,144

MARTIN COUNTY						
MORPHOSEDIMENTARY FEATURE	SHELF AREA (ha)	% COUNTY CONTINENTAL SHELF AREA	% AREA USED IN VOLUMES CALCULATIONS	MAX SEDIMENT THICKNESS (ft)	AVERAGESE SEDIMENT THICKNESS (ft)	SEDIMENT VOLUME (cy)
DICKINSON RIDGE FIELD	1,192	3	0.60	29.8	7.5	21,286,063
GILBERT SHOAL	1,145	3	0.45	15.1	7.9	16,431,397
MARTIN RIDGE FIELD A	461	1	0.30	4.9	2.6	1,378,822
MARTIN RIDGE FIELD B	3,429	9	0.45	9.8	7.5	46,144,321
SALERNO SHOAL	842	2	1.00	20.0	7.9	26,860,965
ST LUCIE SAND FLAT	24,449	61	1.00	6.6	6.6	633,557,743
TOTAL	31,518	79				745,759,310

LEGEND:

- CITIES
- FDEP MONUMENTS
- MATCHLINE
- COUNTY LINES
- ROADS
- REFORMATED NOAA SHEETS
- FEDERAL STATE BOUNDARY

OFFSHORE MORPHOLOGY:

SAND FLATS
- ST LUCIE SAND FLAT

RIDGE FIELDS
- DICKINSON RIDGE FIELD
- INDIAN RIVER RIDGE FIELD
- MARTIN RIDGE FIELD

SHOALS
- ANKONA SHOAL
- CAPRON SHOAL
- GIFFORD SHOAL
- GILBERT SHOAL
- SALERNO SHOAL

UNDIFFERENTIATED SEAFLOOR
- UNDIFFERENTIATED SEAFLOOR

N

0 5 10 Kilometers

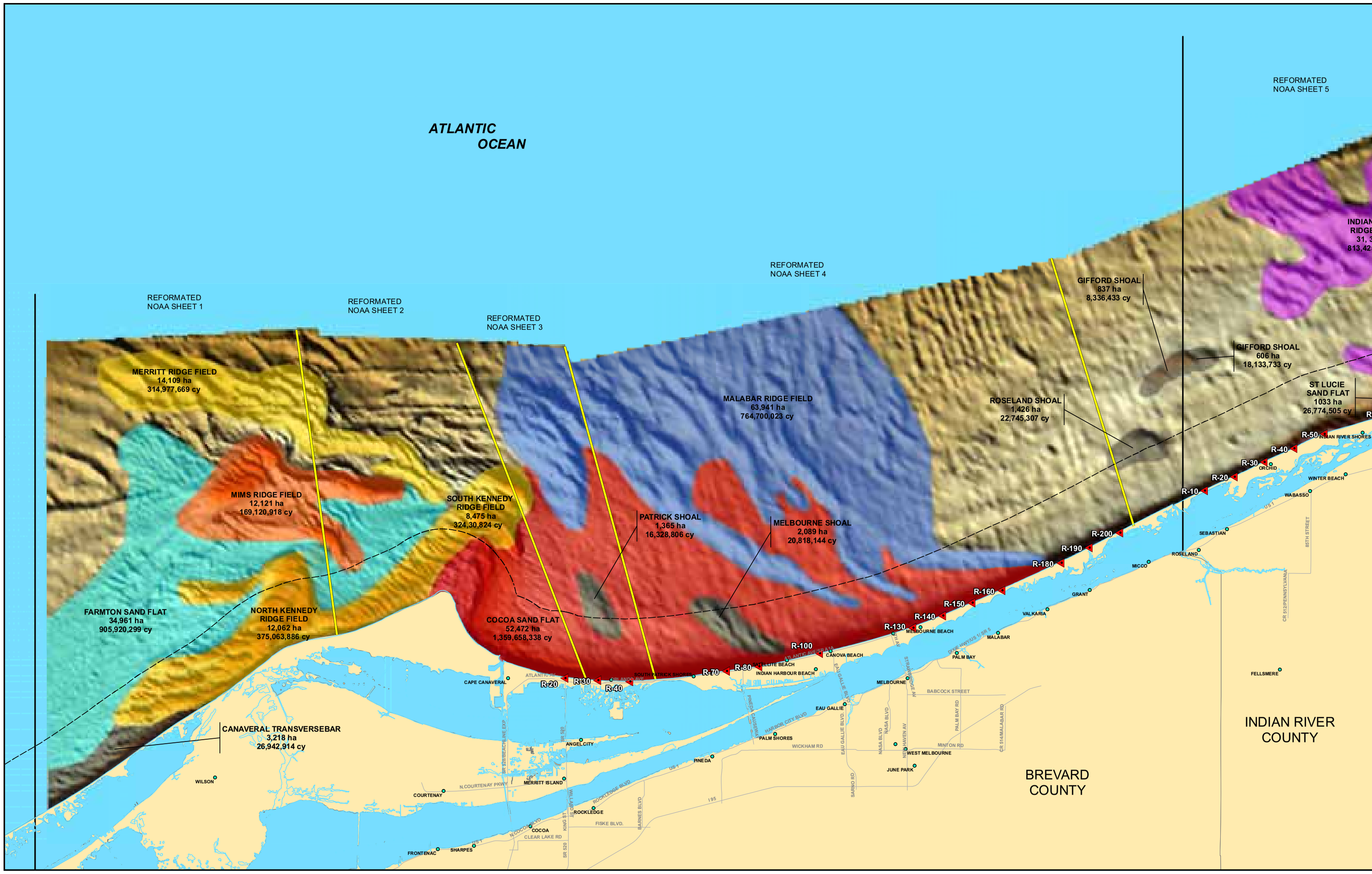
TITLE:

POTENTIAL SAND RESOURCES ALONG THE CENTRAL FLORIDA ATLANTIC COAST

COASTAL PLANNING & ENGINEERING, INC
2481 NW BOCA RATON BLVD.
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX.(561) 391-9116

DATE: 05/04/07	BY: HMV	COMM NO: 7849.2	FIGURE 3-15B

G:\DEP-URS\Centraleast_Florida_MXD\Central_ROSS_Morphology_SHEET_2.mxd



BREVARD COUNTY						
MORPHOSEDIMENTARY FEATURE	SHELF AREA (ha)	% COUNTY CONTINENTAL SHELF AREA	% AREA USED IN VOLUMES CALCULATIONS	MAX SEDIMENT THICKNESS (ft)	AVERAGESE SEDIMENT THICKNESS (ft)	SEDIMENT VOLUME (cy)
CANAVERAL TRANSVERSEBAR	3,218	1	0.35	15.1	5.9	26,842,914
COCOA SAND FLAT	52,472	17	1.00	6.6	6.6	1,359,658,338
FARMTON SAND FLAT	34,961	11	1.00	6.6	6.6	905,920,299
GIFFORD SHOAL	836	0.3	1.00	4.9	2.6	8,336,433
MALABAR RIDGE FIELD	63,941	21	0.50	24.9	5.9	764,700,023
MELBOURNE SHOAL	2,089	1	1.00	4.9	2.6	20,818,144
MERRITT RIDGE FIELD	14,109	5	0.70	24.9	7.9	314,977,669
MIMS RIDGE FIELD	12,121	4	0.35	24.9	9.8	169,120,918
NORTH KENNEDY RIDGE FIELD	12,062	4	0.65	20.0	12.1	375,063,886
PATRICK SHOAL	1,365	0.4	1.00	9.8	3.0	16,328,806
ROSELAND SHOAL	1,426	0.5	1.00	9.8	3.9	22,745,307
SOUTH KENNEDY RIDGE FIELD	8,475	3	0.80	20.0	12.1	324,330,824
TOTAL	207,077	67				4,308,943,559

INDIAN RIVER COUNTY						
MORPHOSEDIMENTARY FEATURE	SHELF AREA (ha)	% COUNTY CONTINENTAL SHELF AREA	% AREA USED IN VOLUMES CALCULATIONS	MAX SEDIMENT THICKNESS (ft)	AVERAGESE SEDIMENT THICKNESS (ft)	SEDIMENT VOLUME (cy)
GIFFORD SHOAL	606	1	1.00	15.1	7.5	18,133,733
INDIAN RIVER RIDGE FIELD	31,390	37	0.65	20.0	9.8	813,425,148
ST LUCIE SAND FLAT	2,540	3	1.00	6.6	6.6	65,816,403
TOTAL	84,965	41				897,375,284

ST LUCIE COUNTY						
MORPHOSEDIMENTARY FEATURE	SHELF AREA (ha)	% COUNTY CONTINENTAL SHELF AREA	% AREA USED IN VOLUMES CALCULATIONS	MAX SEDIMENT THICKNESS (ft)	AVERAGESES EDIMENT THICKNESS (ft)	SEDIMENT VOLUME (cy)
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MARTIN RIDGE FIELD	7,224	10.0	0.45	35.1	18.0	233,277,201
ST LUCIE SAND FLAT	33,895	47.0	1.00	6.6	6.6	878,346,386
Total	50,874	71				1,343,499,144

LEGEND:

- CITIES
- FDEP MONUMENTS
- MATCHLINE
- FEDERAL STATE BOUNDARY
- COUNTY LINES
- ROADS
- REFORMATED NOAA SHEETS

OFFSHORE MORPHOLOGY VOLUME IN CUBIC YARDS:

- 1,378,000 - 130,000,000
- 130,000,001 - 260,000,000
- 260,000,001 - 390,000,000
- 390,000,001 - 520,000,000
- 520,000,001 - 650,000,000
- 650,000,001 - 780,000,000
- 780,000,001 - 900,000,000
- 900,000,001 - 1,000,000,000

N

0 5 10 Kilometers

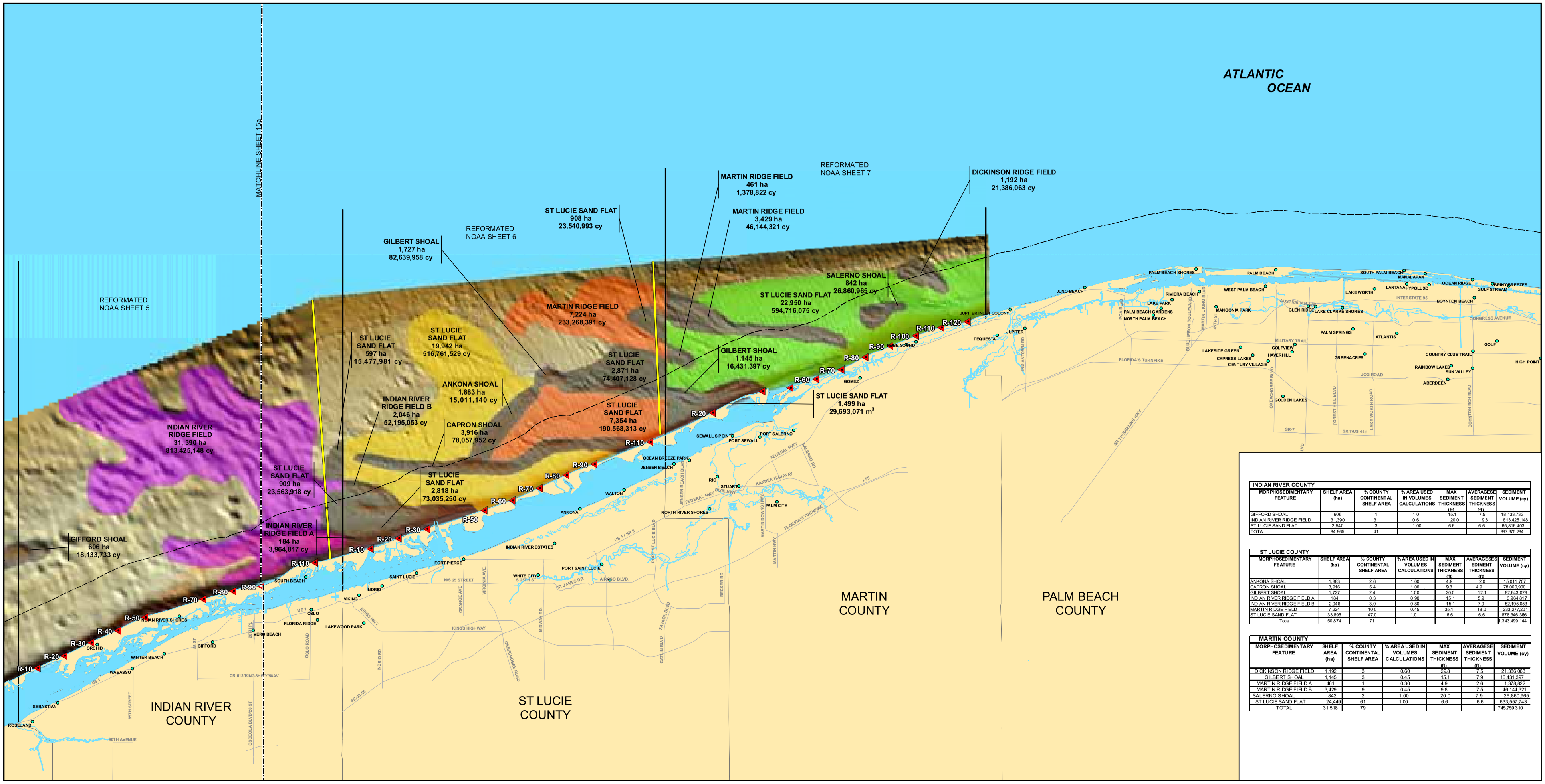
TITLE:

SEAFLOOR MAPPING UNITS ALONG THE CENTRAL FLORIDA ATLANTIC COAST

COASTAL PLANNING & ENGINEERING, INC
2481 NW BOCA RATON BLVD.
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX.(561) 391-9116

DATE: 05/04/07 | BY: HMV | COMM NO: 7849.27 | **FIGURE 3-16A**

G:\DEP-URS\Centraleast_Florida_MXD\CENTRAL_TRI_COUNTY_VOLUME_AREA_ESTIMATIONS_SHEET_1.mxd



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ST LUCIE COUNTY						
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MARTIN RIDGE FIELD	7,224	10.0	0.45	35.1	18.0	233,277,201
ST LUCIE SAND FLAT	33,895	47.0	1.0	6.6	6.6	878,346,386
Total	50,874	71				1,343,499,144

MARTIN COUNTY						
MORPHOSEDIMENTARY FEATURE	SHELF AREA (ha)	% COUNTY CONTINENTAL SHELF AREA	% AREA USED IN VOLUMES CALCULATIONS	MAX SEDIMENT THICKNESS (ft)	AVERAGESE SEDIMENT THICKNESS (ft)	SEDIMENT VOLUME (cy)
DICKINSON RIDGE FIELD	1,192	3	0.60	29.8	7.5	21,386,063
GILBERT SHOAL	1,145	3	0.45	15.1	7.9	16,431,397
MARTIN RIDGE FIELD A	461	1	0.30	4.9	2.6	1,378,822
MARTIN RIDGE FIELD B	3,429	9	0.45	9.8	7.5	46,144,321
SALERNO SHOAL	842	2	1.00	20.0	7.9	26,860,965
ST LUCIE SAND FLAT	24,449	61	1.00	6.6	6.6	633,557,743
TOTAL	31,518	79				745,759,310

LEGEND:

- CITIES
- FDEP MONUMENTS
- MATCHLINE
- FEDERAL STATE BOUNDARY
- COUNTY LINES
- ROADS
- REFORMATED NOAA SHEETS

OFFSHORE MORPHOLOGY VOLUME IN CUBIC YARDS:

- 1,378,000 - 130,000,000
- 130,000,001 - 260,000,000
- 260,000,001 - 390,000,000
- 390,000,001 - 520,000,000
- 520,000,001 - 650,000,000
- 650,000,001 - 780,000,000
- 780,000,001 - 900,000,000
- 900,000,001 - 1,000,000,000

N

0 5 10 Kilometers

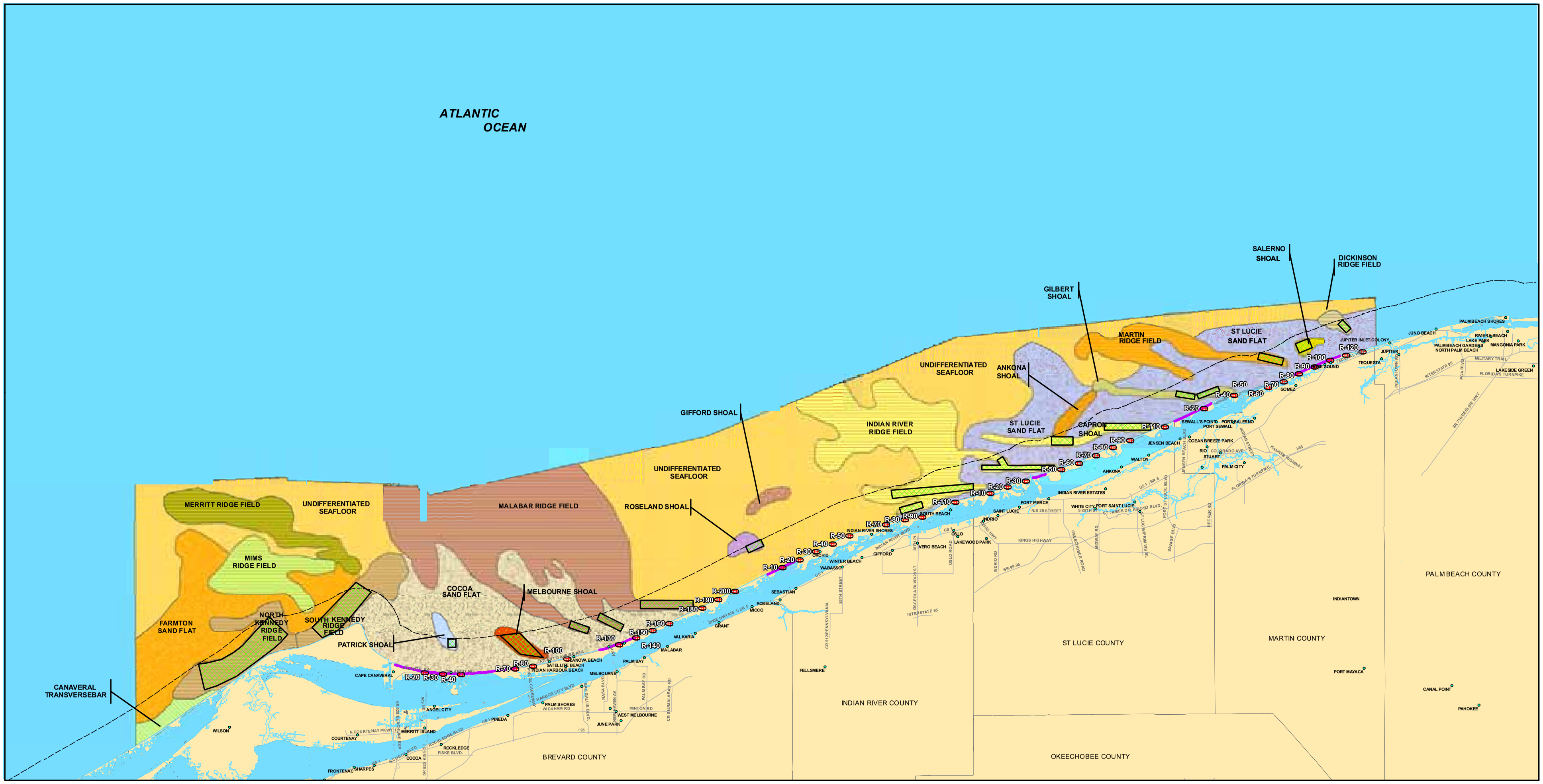
TITLE:

SEAFLOOR MAPPING UNITS ALONG THE CENTRAL FLORIDA ATLANTIC COAST

COASTAL PLANNING & ENGINEERING, INC
2481 NW BOCA RATON BLVD.
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX.(561) 391-9116

DATE: 05/04/07 | BY: HMV | COMM NO: 78 | **FIGURE 3-16B**

G:\DEP-URS\Centraleast_Florida_MXD\CENTRAL_TRI_COUNTY_VOLUME_AREA_ESTIMATIONS_SHEET_2.mxd



LEGEND:

- BEACH RENOURISHMENT PROJECTS
- FEDERAL STATE BOUNDARY
- REFORMATED NOAA SHEETS
- ROADS
- PROPOSED SAND TARGET AREAS

OFFSHORE MORPHOLOGY:

- ANKONA SHOAL
- CANAVERAL TRANSVERSE BAR
- CAPRON SHOAL
- COCOA SAND FLAT
- DICKINSON RIDGE FIELD
- FARMTON SAND FLAT
- GIFFORD SHOAL
- GILBERT SHOAL
- INDIAN RIVER RIDGE FIELD
- KENNEDY RIDGE FIELD
- MALABAR RIDGE FIELD
- MARTIN RIDGE FIELD
- MELBOURNE SHOAL
- MERRITT RIDGE FIELD
- MIMS RIDGE FIELD
- PATRICK SHOAL
- ROSELAND SHOAL
- SALERNO SHOAL
- ST LUCIE SAND FLAT
- UNDIFFERENTIATED SEAFLOOR

N

0 8 16 Km

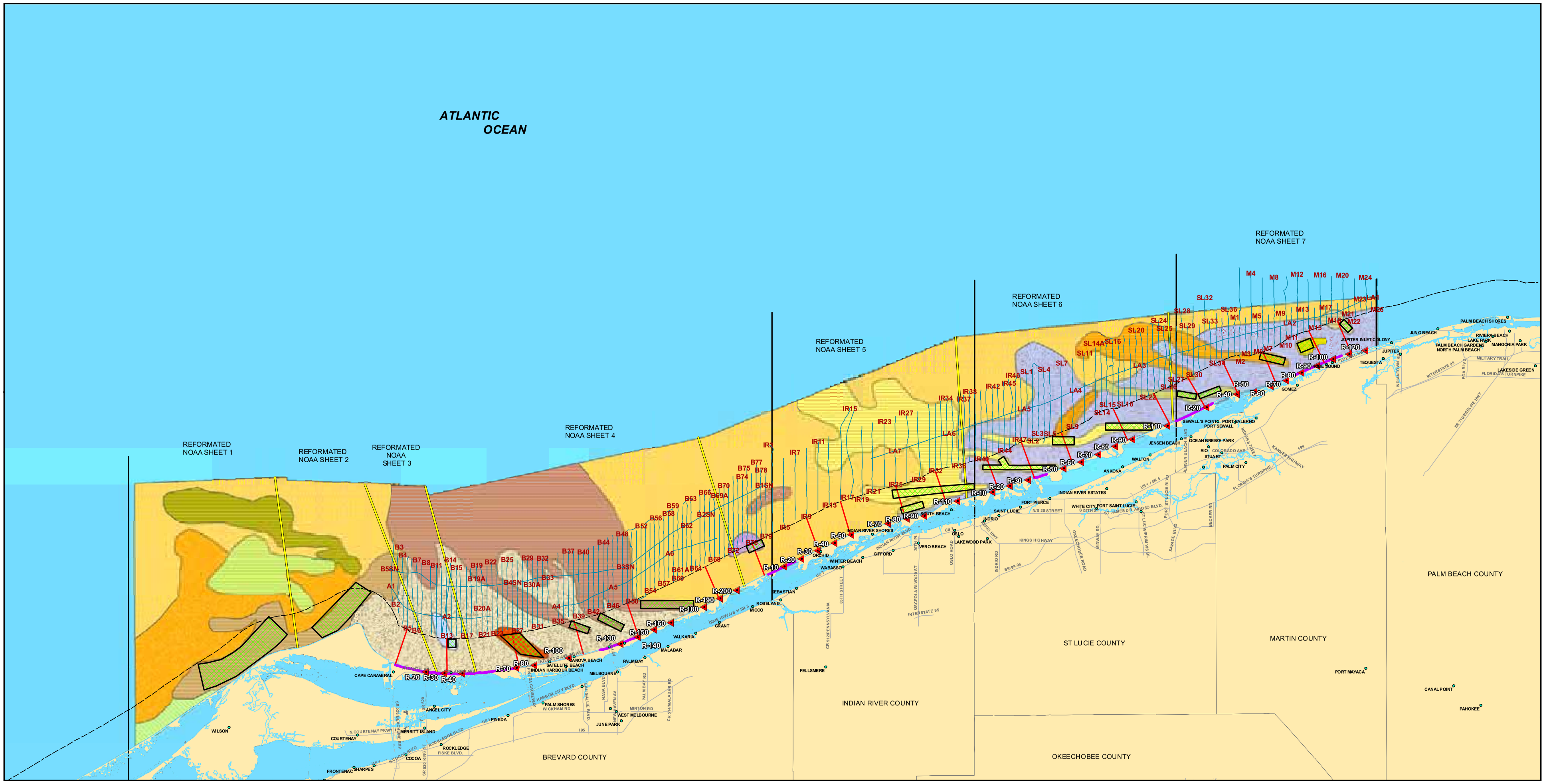
TITLE:

EXTENSION OF SEISMIC-REFLECTION PROFILE SURVEY LINES IN SOUTHERN BREVARD, INDIAN RIVER, ST. LUCIE, AND MARTIN COUNTIES, CENTRAL FLORIDA ATLANTIC COAST

CPE
COASTAL PLANNING & ENGINEERING, INC
2481 NW BOCA RATON BLVD.
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX.(561) 391-9116

DATE: 05/04/07	BY: HMV	COMM NO: 7849.27	FIGURE 3-17A

G:\DEP-URS\Centraleast Florida\ MXD\Central ROSS Morphology SHEET 1.mxd



LEGEND:

- SURVEY TRACKLINES
- BEACH RENOURISHMENT PROJECTS
- PROPOSED SEISMIC PROFILE LINES
- FEDERAL STATE BOUNDARY
- REFORMATED NOAA SHEETS
- ROADS
- COUNTY LINES
- FDEP MONUMENTS
- PROPOSED SAND TARGET AREAS

OFFSHORE MORPHOLOGY:

- ANKONA SHOAL
- CANAVERAL TRANSVERSE BAR
- CAPRON SHOAL
- COCOA SAND FLAT
- DICKINSON RIDGE FIELD
- FARMTON SAND FLAT
- GIFFORD SHOAL
- GILBERT SHOAL
- INDIAN RIVER RIDGE FIELD
- KENNEDY RIDGE FIELD
- MALABAR RIDGE FIELD
- MARTIN RIDGE FIELD
- MELBOURNE SHOAL
- MERRITT RIDGE FIELD
- MIMS RIDGE FIELD
- PATRICK SHOAL
- ROSELAND SHOAL
- SALERNO SHOAL
- ST LUCIE SAND FLAT
- UNDIFFERENTIATED SEAFLOOR

N

0 8 16 Kilometers

TITLE:

EXTENSION OF SEISMIC-REFLECTION PROFILE SURVEY LINES IN SOUTHERN BREVARD, INDIAN RIVER, ST. LUCIE, AND MARTIN COUNTIES, CENTRAL FLORIDA ATLANTIC COAST

CPE
COASTAL PLANNING & ENGINEERING, INC
2481 NW BOCA RATON BLVD.
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX.(561) 391-9116

DATE: 05/04/07	BY: HMV	COMM NO: 7849.27	FIGURE 3-17B

G:\DEP-URS\Centraleast_Florida_MXD\Central_ROSS_Morphology_SHEET_1.mxd

4.1 INTRODUCTION

A total of eighteen potential sand source areas have been identified in the Phase II central region. Eight are located in the nearshore waters off Brevard County, two off Indian River County, three off St. Lucie County and five off Martin County (Figure 4-1). Several of these areas were selected for further investigation using the data and information found in the ROSS database, i.e., the available geophysical data as well as the available vibracore, jet probe and grab sample information.

The process of analysis was the same for each of the areas selected. This included using the data and information residing in the ROSS database, by turning on the different Layers on the ArcIMS site, utilizing the images on the associated ftp site and accessing the data in the Oracle database through the Enhanced Query Builder (EQB). The analysis followed five steps by showing: 1) the location of the potential sand source areas, 2) the location of the geophysical tracklines, 3) the geophysical images (from the ftp site), 4) the vibracore and/or jet probe and grab sample locations and 5) the data pertaining to each core layer or sand sample from the Oracle database

As part of the Phase IV Fieldwork portion of the overall Florida Atlantic Coast Sand Search project, approximately 650 line miles of geophysical data was collected in the form of sub-bottom profiles. This data was collected within the 3 mile state waters limit and has resulted in a reconnaissance level dataset that extends from the Martin – Palm Beach county line, north to the Florida – Georgia border at the St. Mary's River. Along most of this coast, this is the only available geophysical data. The naming convention for these lines is as follows: the first annotation refers the county code and line number; the second annotation is the direction the line was run and the third annotation is the line segment. For example, with reference to line number IR08_E_000: IR08 is Indian River county, line 8; E refers to the direction of the line and; 000 is the line segment. Each line was divided into segments due to file size and to increase ease of viewing and downloading from the ROSS ftp site. Figures are organized to show the areas from north to south. Each of these lines has been post-processed so that their orientation is from west on the left to east on the right. As of this date, no additional processing or interpretation has been undertaken on these images. Further interpretation of these figures is scheduled for a future task..

4.2 BREVARD COUNTY

The survey area in Brevard County occupies approximately 311,046 ha and extends from the Volusia County line to the Indian River County line, a distance of approximately 64.6 mi. Extending 16.7 to 24.8 mi offshore, the shelf area is quite diverse, comprising nearshore bar fields, sand flats, ridge fields, and shoals.

The largest single area in the study area (311,046 ha, 54% of the total area), Brevard County seafloor features are related to development of the large cuspate foreland referred to as Cape Canaveral. The Cape, plus its lagoonal, beachridge, and dune systems, dominates terrestrial and submarine landscapes, including the continental shelf area where the cape rests on a pre-existing topographic high. The main morphological features on the continental shelf include: the Canaveral Transverse Bar Field (Reformatted NOAA Sheet 1), Kennedy Ridge Field (Reformatted NOAA Sheets 1 and 2), Malabar Ridge Field (Reformatted NOAA Sheets 3 and 4), Merritt Ridge Field (Reformatted NOAA Sheets 1 and 2), Mims Ridge Field (Reformatted

NOAA Sheets 1 and 2), Farmton Sand flat (Reformatted NOAA Sheets 1 and 2), Cocoa Sand flat (Reformatted NOAA Sheets 2, 3, and 4), Patrick Shoal (Reformatted NOAA Sheet 3), and Melbourne Shoal (Sheet 4). Sheet numbers for reformatted NOAA bathymetry are noted for informational purposes and because resolution (grid size) affects interpretation of seafloor features.

Potential sand resources in the mapped area of the continental shelf in Brevard County (approximately 207,000 ha) amount to something on the order of 4.3x 10^9 yds ^{3} (4309,110,261 yds^3) of sediment. This sediment volume estimate is based on assumptions for average thickness of morphosedimentary units such as bars, ridge fields, and sand flats. Parameters used in calculations of volume estimates are summarized in Table 4-1. The Cocoa Sand Flat has the largest sediment volume, but the Malabar Ridge Field may offer greater ease of dredging access as the deposits are heaped into ridges. The sand resource potential of each mapping unit is discussed in relation to geographic occurrence, spatial distribution patterns, and morphosedimentary properties, as summarized in Figures 3-15A and 3-16A and Table 4-1.

Eight potential sand source areas have been identified offshore of Brevard County (Figure 4-2).

4.2.1 BE-1 and BE-2 and the Kennedy Ridge Field

The Kennedy Ridge Field, as defined here, is bordered on its seaward margin by the Farmton Sand Flat mapping unit and on the south by the Cocoa Sand flat (Figure 3-15A). Most of the unit (20,537 ha, 7% of mapped shelf area off Brevard County) resides in state waters. Because ridges have different orientations, the ridge field is conveniently divided into two parts, north (12,062 ha) and south (8,475 ha) separated at approximately the boundary of reformatted NOAA Sheets 1 and 2 (Figure 3-15A).

BE-1

The northern portion of the Kennedy Ridge Field, occupying 4% of the county shelf area, is characterized by shoreface ridges that range from 2,460.6 to 2,952.8 ft in width and extending from 2 to 6.21 mi in length. The ridges, which have an azimuth of about 100°, extend up to3.7 mi offshore with a maximum local relief of about 19.69 to 39.37 ft (Table 3-1). They occur in water depths ranging from 16.40 to 65.62 ft. Ridge crests are shown in Figure 3-15A. Potential sand resources in the northern segment of the Kennedy Ridge Field (Figure 3-15A) are estimated to range on the order of 375.1 x 10^6 yds^3 (375,078,395.97 yds^3) (Figure 3-16A, Table 4-1). Calculations were based on estimated ridge coverage of 65% of the mapping unit where ridges averaged about 12.14 ft in thickness. Some isolated examples of local relief reach approximately 20.01 ft.

Area BE-1 lies just offshore of the Kennedy Space Center between Florida Range Monuments V049 and V0101 (Figure 4-3). Data residing in ROSS shows one vibracore and 15 grab samples have been collected in this area (Figure 4-4), The vibracore and 14 of these samples are from the Florida Geological Survey (FGS) Sand, Gravel and Heavy Mineral Resources Potential of Surficial Sediments Offshore of Cape Canaveral, Florida Phase II and Final Report (Nocita *et al*, 1989). The remaining grab sample is from the United States Geological Survey East Coast Database (USGS, 2005). The data from the vibracore does not contain descriptive information but does include mean grain size values from two samples taken from this core. These means are 0.4 and 0.56 phi (Table 4-3). The grab samples collected during the FGS study list mean grain size values ranging between -0.06 to 2.84 phi (Table 4-4). The grab sample from the East Coast database only shows a description of the sample as "medium fine quartz sand with some shell". The values of the samples place them in the medium to fine sand category using the United Soils Classification (USC) system, which corresponds to the description from the USGS sample.

Currently, the only geophysical data in ROSS for this area was collected as part of the Phase IV Task of this project. Five tracklines, BE05_NW, BE06_E, BE07_NW, BE08_E and BE09_NW were run across this feature targeting the areas of prominent relief. These features along with the locations of the tracklines are shown in Figure 4-5. Selected portions of these lines are presented as Figures 4-6A through 4-6E. In each of these figures, the sand ridges are clearly visible as positive relief features. Potential sand sources occur as deposits on the top of these ridges. Volume calculations for this based on 3, 6 and 9 feet cuts are 69,300,583, 138,601,166 and 207,901,750 yds^3 respectively (Table 4-2).

BE-2

The southern segment of the ridge field, residing predominantly in state waters and occupying 3% of the county shelf area, features sand ridges that range from 984.25 to 1,968.5 ft in width and about 1.86 to 2.8 mi in length. These ridges, occurring near the apex of the cuspate foreland, range in azimuth from 40° to 60° and extend up to 9.3 mi offshore onto the inner shelf with maximum local relief of about 16.40 to 3.28 ft (Table 3-1). They occur in water depths ranging from 9.84 to 393.27 ft.

Potential sand resources in the southern segment of the Kennedy Ridge Field (Figure 3-15A) are estimated to range on the order of 324.3×10^6 yds^3 (324,343,371.50 yds^3) (Figure 3-16A, Table 4-1). Calculations were based on an estimated 80% ridge coverage in the mapping unit where ridges averaged approximately 12.14 ft in thickness, with isolated examples of local relief reaching up to 20.01 ft.

Area BE-2 is located between FDEP Range Monuments V115 and V155 (Figure 4-7). As part of the 1989 FGS study "Sand, Gravel and Heavy Mineral Resources Potential of Surficial Sediments Offshore of Cape Canaveral, Florida Phase II and Final Report (Nocita *et al*, 1989), four vibracores and six grab samples were collected in this area (Figure 4-8). Five sediment samples were extracted from the vibracores from between the 0 and 1 foot core depth (Table 4-5). Their mean grain-size values range between 1.15 to 3.19 phi. The data from the grab samples are shown in Table 4-6. The mean grain-size values of these samples range from 0.8 to 3.46 phi, placing these samples in the fine to medium USC classification. There is no descriptive information for these samples.

Geophysical data for this area is from the Phase IV Task of this study. Five transects were run to get a reconnaissance level picture of this potential sand source. These are lines BE10_NE, BE11_ W, BE12 _NE, BE13_W and BE14_ S (Figure 4-9). Selected sections of these lines are presented as Figures 4-10A through 4-10E.

An examination of these lines shows the subsurface stratigraphic layers dip seaward. Vertical relief on these features is not as much as on the ridges in Area BE-1. The volumes associated with 3, 6, and 9 feet cuts are 38,859,759, 77,719,518 and 116,679,277 yds3 respectively (Table 4-2).

4.2.2 BE-3 and the Patrick Shoal

This shoal area, defined here offshore Brevard County (Figure 3-15A, Reformatted NOAA Sheet 3), occurs on the inner shelf plain in state and federal waters as an enclave within the Cocoa Sand Flat. The shoal, which occupies about 1365 ha, lies about 2.49 mi offshore monuments R27 to R39 and is about 1.55 mi wide by 4.35 mi long with an average 20-25° azimuth (Table 3-1).

Potential sand resources in the Patrick Shoal are estimated to be on the order of 16.3 x 10^6 yds^3 (16,329,437.56 yds^3) (Figure 3-16A, Table 4-1). This volume calculation is based on 100% of the mapping unit being comprised by a shoal that averages at least 2.95 ft in thickness, although local relief ranges up to 9.84 ft suggesting that the volume estimates could be doubled.

BE-3

Located off Cocoa Beach between range monuments R032 and R037(Figure 4-11), this area sits on the southwestern edge of Patrick Shoal. Currently, there is no vibracore or grab sample data (Figure 4-12) associated with this area in ROSS. However, as part of the Phase IV portion of this project, 1 geophysical trackline, BE20_N_000 (Figure 4-13), was run in a south to north transect across the shoal at the extreme eastern edge along the 3 mile state boundary limit. This line, shown in Figure 4-14, shows there is a layer of potentially usable sand that is approximately 40 feet in thickness. The volumes of potential sand calculated for 3 ft. cut is, 2,124,376 yds^3, for a 6 ft. cut is 4,248,752 yds^3 and for a 9 ft. cut is 6,373,127 yds^3. These values are presented in Table 4-2.

4.2.3 BE-4 and Melbourne Shoal

The Melbourne Shoal (2089 ha) lies on the inner shelf plain mostly in state waters about 5 mi south of Patrick Shoal, as an enclave within the Cocoa Sand Flat mapping unit (Figure 3-15A, Reformatted NOAA Sheet 4). This shoal, lying downdrift from the apex of the Canaveral cuspate foreland, is about 1.86 mi wide and 5.59 mi long. It extends along a 55° to 70° azimuth from 0.19 to 2.49 mi offshore. (Table 3-1). Within the shoal itself, there are some small sand ridges that trend along a 40° azimuth.

Potential sand resources in the Melbourne Shoal (Figure 3-15A) are estimated to be on the order of 20.8 x 10^6 yds^3 (20,818,949.22 yds^3) (Figure 3-16A, Table 4-1). This volume calculation is based on 100% of the mapping unit being comprised by a shoal that averages at least 2.62 ft in thickness. Local relief ranges up to 4.92 ft, however, suggesting that the volume estimates could be somewhat larger.

BE-4

This area is located offshore of Patrick Air Force Base between Florida Range Monuments R062 and R086 (Figure 4-15). Three vibracores were taken within this area as part of the Olsen Associates “Sand Source Analysis for Beach Restoration, Brevard County, Florida” (1989) study Figure 4-16). These cores have written geologic descriptions but no granulametric data associated with them (Table 4-7). The information supplied in this table indicates that most of the cores were collected in sandy-clayey sediments. One important item to note for this area is that these cores were not located on the sand ridge features targeted by the geophysical data collection effort of Phase IV (Figure 4-17).

Geophysical data for this area was collected as part of Phase IV of this project. A total of five tracklines intersected the three main positive relief features. These are lines BE24_NW, BE25_E, BE26a_NW, BE26_E and BE27_NW (Figures 4-18A through 4-18D).. The volumes associated with the sources are shown in Table 4-2.

4.2.4 BE-7 and the Malabar Ridge Field

The Malabar Ridge Field mapping unit, as defined here, occurs predominantly in federal waters (on the outer shelf and Florida-Hatteras Slope), except for three large, discrete ridges (85° azimuth) that extend into shallower waters (3.28 ft to 49.21 ft) offshore from monuments R97 to R175 (Reformatted NOAA Sheets 3 and 4, Figure 3-15A). The mapping unit occupies about 63,941 ha (about 21% of the mapped shelf area) and is bounded shoreward by the Cocoa Sand Flat mapping unit and by undifferentiated seafloor to the north and south. Large individual ridges tend to range from 0.621 to 1.86 mi in width and up to 18.64 mi in length along 30° to 50° azimuths in 49.21 to 82 ft. water depth (Table 3-1). The sand ridges extend up to 12.43 mi offshore and display approximately 13.12 to 23 ft. of local relief.

Potential sand resources in the Malabar Ridge Field (Figure 3-15A), which occupies about 63,941 ha), are estimated to be on the order of 764.7 x 10^6 yds^3 (764,729,607.38 yds^3) (Figure 3-16A, Table 4-1). This volume calculation is based on an estimated 50% coverage (31,971 ha) of the mapping unit by ridges that averaged about 5.91ft in thickness with maximum local relief of about 24.93 ft. The remaining parts of the mapping unit are comprised of swales and low-angle slopes of the ridges.

BE-7

Three potential sand source areas, BE-5, BE-6 and BE-7 have been identified within the Malabar Ridge Field. Each of these is located on an extension of this field from Federal waters into State waters. BE-7, delineated in Figure 4-19, is the largest of these three and the only one to have vibracores or grab samples analyzed within its border (Figure 4-20). There are two vibracores in Area BE-7. One comes from the Olsen Associates “Sand Source Analysis for Beach Restoration, Brevard County, Fl 1989” study and the other is from the “Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida” study (Meisburger & Duane, 1971). Information from both vibracores shows that sediments are comprised of mostly fine to medium quartz sand (Table 4-8).

The grab sample information is from the USGS East Coast Database (USGS, 2005). Two samples were taken and the information contained in ROSS shows the sediment to be medium to coarse sand with a mean grain size of 0.53 phi (Table 4-9).

Geophysical data for BE-7 is from the Phase IV Task of this project. Lines BE34_E, BE35_NW, BE36_E, BE37_NW and BE38_E (Figure 4-21) were run the cross this portion of the Malabar Ridge Field. Looking at the seismic images, the northern portion of this Area B-7 shows what appears to be silty overburden on top of several feet of potentially usable sand deposits (up to 25 feet in thickness). Moving southward in this area, the silty overburden appears to get progressively thinner toward the south border of Area BE-7 (Figures 4-22A through 4-22C).

4.2.5 BE-8 and the Roseland Shoal

The Roseland Shoal (1426 ha), lies along the southernmost offshore border of Brevard County on the inner shelf plain in state and federal waters (Figure 3-15A, Reformatted NOAA Sheets 4 and 5). The unit was mapped as an enclave within undifferentiated seafloor because of its very distinct morphology. The shoal is about 3.73 mi long by nearly 4.16 mi wide. Lying about 2.8 mi offshore from monuments R198 to R2180S, the shoal generally trends along a 90° azimuth.

Potential sand resources in the Roseland Shoal (Figure 3-15A) are estimated to be on the order of 22.7 x 10^6 yds^3 (22,746,186.96 yds^3) (Figure 3-16A, Table 4-1). This volume calculation is based on 100% of the mapping unit being comprised by shoal that averages at least 3.94 ft in thickness, although local relief ranges up to 3 m suggesting that the volume estimates could be larger.

BE-8

BE-8 is located on the southern most portion of Roseland Shoal. This area lies in the nearshore waters off Sebastian Inlet between range monuments R207 and R219 (Figure 4-23). This area is situated on the portion of the shoal which resides in state waters. Volumes calculated for this area are 3,789,427 yds^3 for a 3 ft. cut, 7,578,854 yds^3 for a 6 ft. cut and 11,368,281 yds^3 for a 9 ft. cut (Table 4-2).

One grab sample, S2B1GS12 (Figure 4-24), was collected within Area BE-8 during the FGS study "An Environmental Assessment of the Offshore Area Along East-Central Florida". The data in ROSS lists the mean grainsize as 1.48 phi corresponding to fine sand using the USC.

Only 1 geophysical image is located in Area BE-8. Figure 4-25 shows line BE_41_W_000 taken as part of the Phase IV portion of this project. The potentially usable sand is seen as the lighter band below the sea bottom reflector. This image (Figure 4-26) shows there is approximately 50 ft. thickness of potentially usable sand in this area of the shoal.

4.2.6 Additional Offshore Sand Sources in Brevard County Area

Several additional areas represent locations that offer potential for sand sources. These areas are found mostly in Federal waters and therefore are not included as potential sand sources for this study. Brief descriptions of these areas are included below to help further the understanding of occurrences of sand in this region.

Canaveral Transverse Bars

This nearshore bar field, as defined here, occurs on the northern part of Reformatted NOAA Sheet 1 (Figure 3-15A) in state waters. The shoreface bar field is bordered on its seaward margin by the Farmton Sand Flat and on its southern margin by the Kennedy Ridge Field. The unit, comprised by numerous bars and troughs, extends about 11.18 mi alongshore and about1.86 mi offshore, covering an area of about 3218 ha (about 1% of the county offshore mapped area) in water that ranges in depth from 4.92 ft. to 39.37 ft. The Canaveral Transverse Bars mapping unit groups distinctive nearshore bar systems that range from 984.25ft. to 1,640.42 ft. in width and extends about 1.24 mi in length (Table 3-1). These prominent features trend 75° to 90° azimuth (the angle the topographic trend makes with 0°).

Potential sand resources are estimated to be on the order of 26.9 x 10^6 yds^3 (26,943,956.32 yds^3) based on an average thickness of 5.91 ft and an estimated 35% coverage of the mapping unit by bars that have a local relief of 4.92ft. to 15.09 ft. (Figure 3-16A, Table 4-1).

Mims Ridge Field

The Mims Ridge Field, as defined here, occurs mostly on the inner shelf in federal waters and occupies about 12,121 ha (4% of the shelf area) and is surrounded on its shoreward side by the Farmton Sand Flat mapping unit, occurs about 3.106 to 11.18 mi offshore in federal waters (Figure 3-15A, Reformatted NOAA Sheets 1 and 2). Individual ridges trend 45° to 75° azimuth, are 0.31 mi to 1.24 mi wide by up to 9.32 mi long and display wavelengths of about 1,476.38ft to 1,969 ft (Table 3-1). Local relief ranges from 19.69 ft to 39.37 ft in water depths ranging from 26.25 ft to 82.02 ft.

Potential sand resources in the Mims Ridge Field (Figure 3-15A) are estimated to range on the order of 169.1 x 10^6 yds^3 (169,127,461.22 yds^3) (Figure 3-16A, Table 4-1). Calculations were based on an estimated 35% ridge coverage (4,242 ha) in the mapping unit where ridges averaged about 9.84 ft in thickness but with isolated examples of local relief reaching about 24.93 ft.

Merritt Ridge Field

The Merritt Ridge Field, as defined here and occurring seaward of the Mims Ridge Field in federal waters (extends across the inner and outer shelves onto the Florida-Hatteras Slope), occupies about 14,000 ha (about 5% of the mapped shelf area) and lies about 6.21 to18.64 mi offshore in water depths ranging from 65.62 ft to 98.43 ft (Figure 3-15A, Reformatted NOAA Sheets 1 and 2). Bearing 50° to 60°, individual sand ridges are 2.296 ft. to 0.621 mi wide by 3.73 mi. to 6.21 mi in length. (Table 3-1). These sand ridges have a local relief of about 7.87 to 24.93 ft. and are mostly surrounded by undifferentiated seafloor.

Sand resource potential in the Merritt Ridge Field (Figure 3-15A) is estimated to be on the order of 315 x 10^6 yds^3 (314,989,854.46 yds^3) (Figure 3-16A, Table 4-1). This volume calculation is based on an estimated 70% coverage of the mapping unit by ridges per se that averaged about 7.87 ft in thickness with maximum local relief amounting to about 24.93 ft. The remaining parts of the mapping unit are comprised by swales and low-angle slopes of the ridges.

Farmton Sand Flat

The Farmton Sand Flat mapping unit (Figure 3-15A), as defined here, occurs mostly on the inner shelf plain in federal waters off the northeast coast of the Canaveral cuspate foreland, as shown on reformatted NOAA Sheets 1 and 2. The sand flat, occupying about 34,961 ha (11% of the mapped shelf area) is bounded shoreward by the Canaveral Transverse Bars and Kennedy Ridge Field while seaward margins merge with the Mims and Merritt ridge fields and undifferentiated seafloor. Occupying an area of about 34,961 ha, the mapping unit is about 6.21mi. wide by about 22.37 mi long in water depths ranging from 36.09 ft. to 68.90 ft. (Table 3-1). Some minor ridges with a 55° azimuth and extending 6.562 ft. in length occur on the sand flat. These low ridges have a local relief of about 4.92 ft.

Potential sand resources in the Farmton Sand Flat (Figure 3-15A) are estimated to be on the order of 906 x 10^6 yds^3 (905,955,347.14 yds^3) (Figure 3-16A, Table 4-1). This volume calculation is based on 100% of the mapping unit being comprised by sand flat that averages at least 6.56 ft in thickness.

Cocoa Sand Flat

The Cocoa Sand Flat, as defined in this study, extends along the inner shelf plain on the southeast coast of the Canaveral cuspate foreland and is terminated northwards by the Kennedy Ridge Field mapping unit and seaward by the Malabar Ridge Field mapping unit (Figure 3-15A; Reformatted NOAA Sheets 2, 3 and 4). This sand flat occurs alongshore on the inner shelf in state waters but extends offshore into federal waters. This extensive sand flat, occupying 52,472 ha (17% of the mapped shelf area) and extending up to13.67 mi offshore, has an average width of about 7.46 mi and extends about31.07 mi along the coast in state and federal waters. The sand flat has a local relief of about 4.92 ft to 6.56 ft in water depths averaging 39.37 ft (Table 3-1).

Potential sand resources in the Cocoa Sand Flat (Figure 3-15A), which occupies about 52,472 ha, are estimated to be on the order of 1.4 x 10^9 yds^3 (1,359,710,940.02 yds^3) (Figure 3-16A, Table 4-1). This volume calculation is based on 100% of the mapping unit being comprised by sand flat that averages at least 6.56 ft in thickness.

Gifford Shoal

As defined here, Gifford Shoal (836 ha) (Figure 3-15A) lies on the inner shelf plain in federal waters offshore the towns of Micco and Roseland and occupies an area of about 836 ha in Brevard County and is mapped as an enclave within undifferentiated seafloor. The overall shoal dimensions (Brevard County and Indian River County) are about 3.73 mi long by 1.86 mi wide along a 90° to 110° azimuth about 6.84 mi offshore. With a local relief of about 9.84 ft, pronounced sand ridges are not evident in the low-resolution NOAA bathymetry. The shoal lies in about 29.53 to 45.93 ft water depth.

Potential sand resources in the northern segment of the shoal in Brevard County (Figure 3-15A) are estimated to be about 8.3 x 10^6 yds^3 (8,336,755.48 yds^3), based on an estimated 100% of the mapping unit where the sediment thickness averages at least 0.8 m (Figure 3-16A, Table 4-1).

4.3 INDIAN RIVER COUNTY

The survey area in Indian River County occupies approximately 84,965 ha and extends from the Brevard County line to the St. Lucie County line, for a distance of approximately 20.50 mi. Extending 16.16 mi offshore, the shelf area may be quite diverse, as occurs to the north in Brevard County, but the low-resolution NOAA bathymetry mostly precludes interpretation of seafloor features. Major features that could be differentiated from the poor quality bottom topography include ridge fields, sand flats, and shoals.

Potential sand resources in the mapped area of the continental shelf in Indian River County (about 85,000 ha) amount to something on the order of 8.77 x 10^6 yds^3 (877,124,083.50 yds^3) of sediment. This sediment volume estimate is based on assumptions for average thickness of morphosedimentary units such as ridge fields, sand flats, and shoals. Parameters used in calculations of volume estimates are summarized in Table 4-10. The Indian River Ridge Field has the largest sediment volume (813.4 x 10^6 yds^3, 813,425,148.40 yds^3), but the Gifford Shoal may offer an advantage by its proximity to the shoreline. The sand resource potential of each mapping unit is discussed in relation to geographic occurrence, spatial distribution patterns, and morphosedimentary properties, as summarized in Figures 3-15A and 3-16A and Table 4-10.

Two potential sand source areas have been identified offshore of Indian River County (Figure 4-27).

4.3.1 IR-1, IR-2 and the Indian River Ridge Field

As defined here, the Indian River Ridge Field (Figure 3-15A, Reformatted NOAA Sheet 5) is a large mapping unit (31,390 ha, 37% of county shelf area) in state and federal waters that contains moderately well-developed ridges that merge to interior sediment platforms. The ridge field extends from the seaward margin of the shoreface across the inner shelf plain to the Florida-Hatteras Slope. The prominent central ridge crest has an azimuth of 50° to 85° (Table 3-1). The main ridge crest ranges up to 9.942 mi in length in water depths of 13.12 to 65.62 ft. Local relief is about 16.4 ft. Most of the other ridge sets making up the mapping unit are 0.621 to1.243 mi wide by 2.8 to 3.73 mi long with a 45° to 55° azimuth. Ridge wavelengths are on the order of 1,476.4 to 1,968.5 ft for ridges with local relief of about 13.12 to 26.25 ft.

Potential sand resources in the Indian River Ridge Field (Figure 3-15A), which occupies about 31,390 ha), are estimated to be on the order of 813.4 x 10^6 yds^3 (813,425,148.40 yds^3) (Figure 3-16A, Table 3). This volume calculation is based on an estimated 65% coverage (20,404 ha) of the mapping unit by ridges that averaged about 9.84 ft in thickness with maximum local relief ranging up to about 19.69 ft. The remaining parts of the mapping unit are comprised of swales and low-angle slopes of the ridges. Two potential sand source areas IR-1 and IR-2 have been selected within this larger physiographic region. Both are located off Vero Beach. (Figure 4-19)

IR-1

In Indian River County, IR-1 is the closest potential borrow area to shore. It is situated between the St Lucie Sand Flat and the Undifferentiated Seafloor physiographic regions (Figure 4-28). A review of the ROSS database reveals that 1 vibracore is found in this area (Figure 4-29). This core is from the “Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida” study (Meisburger & Duane, 1971). Descriptive information for the core layers shows the sediments are made up mostly of silty sand, which becomes coarser at depth (Table 4-11). Associated granulametric information from a sample analyzed from an upper section of this core shows a mean grain size of 1.57 phi, placing this in the fine sand category using the USC.

Geophysical data for Area IR-1 was collected during the Phase IV Task of this project. Two tracklines cross this area and these are seen in Figure 4-30. Each of these lines shows there is a large quantity of sand that has the potential for being beach fill material. Further exploration in this location is needed to prove out these deposits. (Figures 4-31).

IR-2

Area IR-2 is located just seaward of Area IR-1 (Figure 4-32). As with IR-1, it is situated in the Indian River Ridge Field and is seen as a valuable potential sand resource. The ROSS database contains five vibracore records from within this area (Figure 4-33). These are from the “Indian River County 1999 Pre-Engineering Design Project Geotechnical Investigation Core Borings IR-

South Cores 1-26" (Applied Technology and Management, 1999) and the "Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida" study (Meisburger & Duane, 1971). The data associated with these cores shows most of the core layers are made up of fine to medium sand with thin lenses of silt and silty sand. The mean grain sizes for samples taken from within the cores have a range in size of 0.15 to 1.64 phi. This places these samples in the fine to medium sand size using the USC (Table 4-12).

As part of the Phase IV task of this project, 6 geophysical tracklines were run in a zig-zag pattern across this area (Figure 4-34). These are IR07_NW, IR08_E, IR09_NW, IR10_E, IR-11_NW and IR12_E. The images associated with these tracklines are presented in Figures 4-35A through 4-35C. Each of these images shows that there is a large potential for sand reserves to be found off Indian River County.

4.3.2 Additional Offshore Sand Resources in Nearshore Indian River County Area

There are three other areas that are potential sand sources off Indian River County. These are the Gifford Shoal, St. Lucie Sand Flat and Undifferentiated Seafloor. The Gifford Shoal lies in Federal waters and is, therefore, not under consideration for this report. The Indian River County portion of the St Lucie Sand Flat is a small extension of the larger sand flat region found off St Lucie County. It will be discussed in further detail in the following St Lucie County section of this report.

Most of the continental shelf in state and federal waters off Indian River County is mapped as undifferentiated seafloor (50,428 ha, 60% of study area in Indian River County). Due to the poor quality of NOAA bathymetry on Figure 3-15A and 3-15B (Reformatted NOAA Sheets 5 and 6), it is not possible to accurately identify seafloor features except for prominent sand ridges and shoals.

Gifford Shoal

The southern portion of Gifford Shoal (Figure 3-15A, Reformatted NOAA Sheet 5) lies in federal waters offshore monuments R1 to R16 in Indian River County and occupies an area of about 600 ha (about 1% of the mapped shelf area) and is mapped as an enclave within undifferentiated seafloor. The southern portion of the shoal is about 1.86 mi long by 1.24 mi wide along a 90° to 110° azimuth about 6.84 mi offshore. Although there is local relief of about 15.09 ft, sequences of sand ridges are not evident in the low-resolution NOAA bathymetry. The shoal lies in about 36.09 to 45.93 ft. water depth.

Potential sand resources in the southern segment of the Gifford Shoal in Indian River County (Figure 3-15A) are estimated to be about 18.1 x 10^6 yds^3 (18,133,733.18 yds^3) (Figure 3-16A, Table 4-10), based on an estimated 100% of the mapping unit where the sediment thickness averages at least 7.55 ft. Local relief ranges up to 15.09 ft.

St. Lucie Sand Flat

Part of the St. Lucie Sand Flat (Figure 3-15A, Reformatted NOAA Sheet 5), characterizing much of the inner shelf plain, occurs in federal and state waters offshore Indian River County. This small northern segment of the sand flat occupies an area of about 2540 ha (about 3% of the county shelf area) and lies in water depths ranging from 6 to 17 m. This shoreface-attached sand sheet is similar to major occurrences offshore St. Lucie County to the south. For a complete description of the St. Lucie Sand Flat mapping unit, refer to (Table 3-1) and discussion of mapping units in St. Lucie County.

Potential sand resources in northern extensions of the St. Lucie Sand Flat into Indian River County (Figure 3-15A) are estimated to be on the order of 65.8 x 10^6 yds^3 (65,816,403.80 yds^3) over a combined area of about 2540 ha (Figure 3-16A, Table 4-10). These small extensions of the sand flat from St. Lucie County into Indian River County account for only 3% of the total shelf area in the county but provide significant potential sand resources close to shore.

4.4 ST. LUCIE COUNTY

The survey area in St. Lucie County occupies approximately 50,874 ha and extends from the Indian River County line to the Martin County line, an along-coast distance of about 20.51 mi. Extending 11.18 to 16.16 mi offshore, the shelf area is quite diverse being comprised by sand flats, ridge fields, and shoals. The most extensive seafloor-mapping unit is the St. Lucie Sand Flat, followed by undifferentiated seafloor farther offshore.

Potential sand resources in the mapped area of the continental shelf offshore St. Lucie County (about 51,000 ha) amount to something on the order of 1.3 x 10^9 yds^3 (1,343,448,402.83 yds^3) of sediment. This sediment volume estimate is based on assumptions for average thickness of morphosedimentary units, such as ridge fields, sand flats, and shoals. Parameters used in calculations of volume estimates are summarized in Table 4-13. The St. Lucie Sand Flat has the largest sediment volume (about 878.3 x 10^6 yds^3, 878,313,213.33 yds^3), followed by the Martin Ridge Field (about 233.3 x 10^8 yds^3, 233,268,390.76 yds^3). Shoals also contain significant sediment volumes in this area. The sand resource potential of each mapping unit is discussed in relation to geographic occurrence, spatial distribution patterns, and morphosedimentary properties, as summarized in Figures 3-15B and 3-16B and Table 4-13.

Three potential sand source areas have been identified offshore of St. Lucie County (Figure 4-36). These will be discussed below.

4.4.1 SL-1 and the Indian River Ridge Field

Two small segments of the Indian River Ridge Field extend southward from Indian River County into state and federal waters off St. Lucie County (Figure 3-15B, Reformatted NOAA Sheet 6). This extension occupies about 2,230 ha (about 3% of the county offshore shelf area) and is surrounded by the St. Lucie Sand Flat. As mapped here, the unit has about 4.6 m of local relief and occurs in water depths ranging from 19.69 to 45.93 ft. For a full description of the unit, refer to the definition and discussion in Indian River County.

Potential sand resources in the Indian River Ridge Field A (Figure 3-16B), which occupies about 184 ha) in St. Lucie County, are estimated to be on the order of 4.0 x 10^6 yds^3 (3,964,667.71 yds^3) (Table 4-13). This volume calculation is based on an estimated 90% coverage (166 ha) of the mapping unit by ridges per se that averaged about 5.91 ft in thickness with maximum local relief amounting to about 15.09 ft. The remaining parts of the mapping unit are comprised by swales and low-angle slopes of the ridges.

Potential sand resources in the Indian River Ridge Field B (Figure 3-15B), which occupies about 2046 ha) in St. Lucie County, are estimated to be on the order of 52.2 x 10^6 yds^3 (52,193,082.02

yds^3) (Figure 3-16B, Table 4-13). This volume calculation is based on an estimated 85% coverage (1637 ha) of the mapping unit by ridges per se that averaged about 7.87 ft in thickness with maximum local relief amounting to about 15.09 ft. The remaining parts of the mapping unit are comprised by swales and low-angle slopes of the ridges.

SL-1

Area SL-1 is located offshore in the vicinity of the towns of St Lucie and Ft Pierce between range monuments R005 and R046 (Figure 4-37). The ROSS database lists vibracores from 4 studies undertaken in this area but no grab samples or jet probes (Figure 4-38). Three cores are from the “Geotechnical and Borrow Area Investigation, Phase I-Reconnaissance Level (1994) (Coastal Technology Corp., 1995), two are from the “Ft. Pierce Inlet Sand Bypassing Feasibility Study, St. Lucie County 2004” (Taylor Engineering Inc., 2004), eight are from the “Fort Pierce, Florida Shore Protection Project Reevaluation Report Section 934 Study with Environmental Assessment” (USACE, 1995) and three are from the “Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida” study(Meisburger and Duane, 1971). Data associated with these cores is presented in Table 4-14. The majority of this data shows that the sediments from these cores are comprised of mostly fine to medium sand with isolated occurrences of shells and shell hash. In two cores, from the Ft. Pierce Inlet Sand Bypassing Feasibility Study, St. Lucie County 2004 study (Taylor Engineering, Inc., 2004), seven samples were collected and analyzed. The data shows that the mean grain size for these samples ranged from 0.65 to 1.92 phi, placing this sediment in the medium to fine sand category using the USC.

A total of seven geophysical tracklines from the Phase IV task of this project were taken in Area SL-1 (Figure 4-39). Selected portions of these lines are shown in Figures 4-40A through 4-40D. These images show that this part of the coast is very similar to that found offshore Indian River County. There is ample evidence that extensive sand deposits exist in these areas.

4.4.2 SL-2 and the Capron Shoal

The Capron Shoal (Figure 3-15B, Reformatted NOAA Sheet 6) extends most of the length of St. Lucie County, mostly in state waters on the inner shelf plain offshore from monuments R5 to R107 from, a distance of about 18.641 mi transverse to the shore. The shoal, which averages about 0.932 mi in width and has a general azimuth of about 85° to 90°, extends from about 5.59 mi offshore in the north in 52.49 ft water depth and terminates in the nearshore zone in the south. Local relief ranges from 4.92 to 9.84 ft. The shoal, covering about 5% of the shelf area, is surrounded by the St. Lucie Sand Flat mapping unit.

The sand resource potential of Capron Shoal (Figure 3-15B) is estimated to be on the order of 78.1 x 10^6 yds^3 (78,057,951.62 yds^3) (Figure 3-16B, Table 4-13). Although local relief ranged up to 3 m on the shoal, a conservative 1.5 m average thickness was assumed for the volume calculation. It is likely that the shoal contains a greater sand volume than estimated here.

Two potential sand source areas SL-2 and SL-3 been selected on Capron Shoal. SL-2 is located approximately in the middle of this feature and SL-3 is located towards the southern end. Both of these areas have been extensively cored as part of past projects, but it is believed there are still usable quantities of recoverable sand for future nourishment projects. Only SL-2 will be discussed here.

SL-2

Located offshore between Range Monuments R044 and R057 (Figure 4-41), data in this Area has been collected for 3 different projects. A review shows that thirty-one vibracores are listed for the “Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report” (Coastal Technology Corp., 1994), twenty-four vibracores are from the “Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation” (Coastal Technology Corp., 1996), and two vibracores from the “Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida: study (Meisburger & Duane, 1971)(Figure 4-42, Table 4-15).

These cores were all taken on top of a large shore parallel ridge that is the major feature within this area. The descriptive information in this data indicates that the majority of these cores contain mostly medium to fine sand, with a few cores showing traces of shell. Sediment samples taken from some of the cores show a mean grain size range from -0.36 to 2.13 phi placing these samples in the medium to fine category based on the USC.

The geophysical data for this area was collected as part of Phase IV of this project. Two lines, SL07_NW and SL08_E cross over the main positive relief feature in SL-2 (Figure 4-43). Even though this feature has had numerous vibracores taken on it (see above paragraph, the geophysical data clearly shows the sand ridge is still intact. Another consideration for area SL-2 is the sand on each side of this feature. Each of the geophysical images show there is a potential for good quality sand on the flanks of this feature (Figure 4-44).

Five other areas that are potential sand sources off St Lucie County are discussed below. These are the Martin Ridge Field, Gilbert Shoal, Ankona Shoal, St. Lucie Sand Flat and Undifferentiated Seafloor. Of these, the Martin Ridge Field, Ankona Shoal and undifferentiated Seafloor lie in Federal waters and are not included as analyzed potential sand sources for this study. Gilbert Shoal and St Lucie Sand Flat are discussed here as secondary potential areas.

4.4.3 Additional Offshore Sand Resources in Nearshore St. Lucie County Area

Martin Ridge Field

The Martin Ridge Field, defined here, occupies about 7224 ha (10% of the county offshore shelf area) and resides about 4.97 to 11.18 mi offshore in federal waters from monument R58 to the Martin County line (Figure 3-15B, Reformatted NOAA Sheet 6). The mapping unit extends across the inner shelf plain to the Florida-Hatteras Slope. The subdued shallow to deepwater ridges occur in water depths ranging from 55.77 to 114.8 ft. The ridge field merges with sand flats shoreward and with undifferentiated seafloor seaward. Local relief ranges to 35.10 ft. Shoreward extensions of the ridge field are shoreface attached.

Potential sand resources in the northern segment of the Martin Ridge Field in St. Lucie County (Figure 3-15B) are estimated to be on the order of 233.3 x 10^6 yds^3 (233,268,390.76 yds^3) (Figure 3-16B, Table 4-13). This volume calculation was based on 45% coverage of the mapping unit (about 3,251 ha) by ridges with a maximum local relief of 35.10 ft but assuming an average thickness of 18.04 ft (Table 4-13).

Gilbert Shoal

The Gilbert Shoal (Figure 3-15B, Reformatted NOAA Sheet 6) lies more or less parallel to the Capron Shoal on the inner shelf plain in state and federal waters, but stepped southeastwards from monuments R69 to R115 in water depths ranging from 29.53 to 49.21 ft. The total length of this transverse shoal is about 14.91 mi, but about 8.7 mi lie in St. Lucie County. The shoal averages about 0.932 mi in width and lies along a 90° to 100° azimuth. The northern part of the shoal lies about 6.21 mi offshore whereas the southern segment is about 2.49 mi offshore. Local relief ranges up to 19.7 ft. The shoal, occupying about 2% of the shelf area, is surrounded by the St. Lucie Sand Flat mapping unit, except on its northeast apex where it is bounded by undifferentiated seafloor in deeper water.

Potential sand resources in the Gilbert Shoal (Figure 3-15B), which occupies about 1,727 ha in St. Lucie County, are estimated to be on the order of 82.6 x 10^6 yds^3 (82,639,957.63 yds^3) (Figure 3-16B, Table 4-13). Although local relief was about 19.69 ft., an average thickness of 12.14 ft. was used for calculation of volume.

Ankona Shoal

The Ankona Shoal (Figure 3-15B, Reformatted NOAA Sheet 6), defined here, lies on the inner shelf plain almost wholly in federal waters along a 135° azimuth to connect the midsection of the Capron Shoal with the northern head of the Gilbert Shoal. The Ankona Shoal, about 5.59 mi long by 1.86 mi wide, lies 2.8 to 5.6 mi offshore in water depths ranging from 36.09 to 39.37 ft. Local relief averages 4.92 ft. The shoal makes up about 3% of the offshore mapping area in the county.

Potential sand resources in the Ankona Shoal (Figure 3-15B), which occupies about 1,883 ha, are estimated to be on the order of 15.0 x 10^6 yds^3 (15,011,139.76 yds^3) (Figure 3-16B, Table 4-13). Although local relief was about 4.92 ft, a conservative average thickness of 1.97 ft was used for calculation of volume.

St. Lucie Sand Flat

The St. Lucie Sand Flat (Figure 3-15B, Reformatted NOAA Sheet 6), defined here, is the most extensive mapping unit in state and federal waters on the continental shelf off St. Lucie County occupying about 47% (33,895 ha) of the mapped shelf area. The unit extends the entire length of the county offshore for a total distance of about 13.67 mi and averages about 4.35 mi wide. This sand flat occurs alongshore to seaward water depths of about 85.30 ft, presenting a rectangular shape except for the seaward extending arm offshore from monuments R26 to R59. Diabathic channels (Finkl, Andrews and Benedet, 2006a), aligned along azimuths ranging from 15° to 20°, are characteristic features of these sand flats. The diabathic channels have a local relief of about 4.92 ft, giving total local relief in the mapping unit of about 14.76 ft (relief on the sand flats including channel depth). This extensive planar seafloor is broken by sand ridge fields (Indian River Ridge Field in the northwest and Martin Ridge Field in the southeast). Shoals (Capron, Gilbert, and Ankona) also interrupt the expanse of the sand flat. This sand sheet is shoreface attached and extends seaward to undifferentiated seafloor, which may contain sand flat units.

Potential sand resources in the St. Lucie Sand Flat (Figure 3-15B) are estimated to be on the order of 878.3 x 10^6 yds^3 (878,313,213.33 yds^3) (Figure 3-16B, Table 4-13). This volume calculation is based on 100% of the mapping unit being comprised by sand flat that conservatively averages at least 6.56 ft in thickness.

Undifferentiated Seafloor

Approximately 21,200 ha of shelf study area off St. Lucie County is occupied by undifferentiated seafloor (29% of the mapping area in the county) (Figure 3-15B, Reformatted NOAA Sheet 6) in federal waters. The area may be comprised by sand flats with some sand ridges, but it was difficult to interpret the color-ramped NOAA bathymetry at the acquisition scale. Diabathic channels were used to infer the presence of sand flats closer to shore, based on experience in Palm Beach County as described by Finkl, Benedet and Andrews (2006a) where diabathic channels were diagnostic of sand flat units.

4.5 MARTIN COUNTY

The survey area in Martin County occupies approximately 40,013 ha and extends from the St. Lucie County line to the Palm Beach County line, an along-coast distance of about 19.9 mi. Extending 5.6 to 10.56 ft offshore, the shelf area is the narrowest segment in the study area. It is comprised of sand flats, ridge fields, and shoals. The most extensive seafloor-mapping unit is the St. Lucie Sand flat, followed by undifferentiated seafloor sediments located farther offshore. Morphosedimentary units identified here are extensions of those mapped in northern Palm Beach County (Finkl, Andrews and Benedet, 2007). The seafloor off the northern portion of Palm Beach County contains extensive sand flats that are characterized by diabathic channels that extend up to several kilometers offshore from the shoreface onto the inner shelf plain. Diabathic channels on the shoreface and inner shelf plain are known as good sand sources in Palm Beach County (Finkl, Andrews and Benedet, 2006b) and their extension into Martin County suggests the presence of similar potential sand resources. Sand ridge fields also extend from northern Palm Beach County into Martin County seafloor areas.

Potential sand resources in the mapped area of the continental shelf offshore Martin County (about 31,000 ha) amount to something on the order of 745.7 x 10^6 yds^3 (745,731,144.90 yds^3) of sediment. This sediment volume estimate is based on assumptions for average thickness of morphosedimentary units, such as ridge fields, sand flats, and shoals. Parameters used in calculations of volume estimates are summarized in Table 4-16. The St. Lucie Sand Flat has the largest sediment volume (about 633.5 x 10^6 yds^3, 633,533,814.86 yds^3) followed by the Martin Ridge Field (about 47.1 x 10^6 yds^3, A: 1,378,769.59 yds^3 and B: 46,142,578.40 yds^3), but shoals also contain significant sediment volumes. The sand resource potential of each mapping unit is discussed in relation to geographic occurrence, spatial distribution patterns, and morphosedimentary properties, as summarized in Figures 3-15A and 3-16A and Table 4-16.

Three potential sand source areas have been identified offshore of Martin County (Figure 4-45). These will be discussed below.

4.5.1 MI-1, MI-2 and the Gilbert Shoal

The southern extension of the Gilbert Shoal lies wholly within state waters offshore Martin County (Figure 3-15B, Reformatted NOAA Sheet 7) from monument R1 to R42. Here, the 1145-ha shoal lies about 2.49 mi offshore in about 45.9 ft water depth on the St. Lucie County –

Martin County line but terminates to the south in the nearshore. The total length of this transverse shoal is about14.91 mi, but about 6.21 mi in Martin County, taking up about 3% of the mapped shelf area. The shoal, which averages about 0.93 mi in width and lies along a 90° to 100° azimuth, has a maximum local relief of about 15.09 ft.

Potential sand resources in the Gilbert Shoal (Figure 3-15B) are estimated to be on the order of 16.4 x 10^6 yds^3 (16,430,776.27 yds^3) (Figure 3-16B, Table 4-16). This volume calculation is based on 100% of the mapping unit being comprised by sand flat that conservatively averages at least 7.87 ft in thickness.

Two areas MI-1 and MI-2 have been identified within this physiographic region. These areas are situated on the southern arm of the Gilbert Shoal. MI-1 lies between Range Monuments R02 and R015 and MI-2 lies between R016 and R031. Of these two, MI-2 is the only one with any vibracore data associated with it; therefore, this one will be discussed further (Figure 4-46).

MI-2

Twenty vibracores are listed in the ROSS database as part of the "Final Report (Vol. I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida" project (Applied Technology and Management, 1994), twenty-three vibracores for Martin County Beach Erosion Control (1978) (Taylor Engineering, 1978) and three vibracores from the "Feasibility Report with Environmental Impact Statement Beach Erosion Control Study Martin County Florida" (USACE, 1986) (Figure 4-47). Data from these cores shows the majority of the sediments are made up of mostly fine to medium sand with varying amounts of shell and or shell hash (Table 4-17). All of the cores listed for the Final Report (Vol. I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida" project (Applied Technology and Management, 1994) show that sediment samples were extracted from the cores however, the data associated with these samples is not in the database. This is most likely a result of this being a study for which only paper records were available and therefore some data was not forthcoming.

Geophysical data residing in ROSS was taken for the Phase IV portion of this project. Two lines, MI03_E and MI04_NW cross Area MI-2 (Figure 4-48). Much like the rest of this area of the coast, there appears to be the potential for large quantities of sand in and around the targeted potential sand source areas (Figure 4-49).

4.5.2 MI-3 and the Martin Ridge Field

The Martin Ridge Field (Figure 3-15B, Reformatted NOAA Sheet 7), occupies about 3,890 ha in Martin County, and lies in state and federal waters about 1.24 to 8.7 mi offshore from monuments R1 to R80. The subdued shallow to deepwater ridges occur in water depths ranging from 29.53 to 88.58 ft. The ridge field is mostly surrounded by the St. Lucie Sand Flat mapping unit, except on its northeastern margin with it merges with undifferentiated seafloor seaward. Shoreward extension of the ridge field is shoreface attached in about 29.53 ft water depth off monument R72.

Potential sand resources in the Martin County segment of the Martin Ridge Field A (Figure 3-15B) are estimated to be on the order of 1.4 x 10^6 yds^3 (1,378,769.59 yds^3) (Figure 3-16B, Table 4-16). This volume calculation was based on 30% coverage of the mapping unit (about 138 ha) by ridges with a maximum local relief of 4.92 ft but assuming an average thickness of 2.62 ft (Table 4-16).

Potential sand resources in the Martin County segment of the Martin Ridge Field B (Figure 3-15B) are estimated to be on the order of 46.1 x 10^6 yds^3 (46,142,578.40 yds^3) (Figure 3-16B, Table 4-16). This volume calculation was based on 45% coverage of the mapping unit (about 1,543 ha) by ridges with a maximum local relief of 9.84 ft but assuming an average thickness of 7.55 ft (Table 4-16).

A potential sand source area has been identified within the Martin Ridge Field. This is designated as Area MI-3. At this time there is no vibracore, jet probe or grab sample data associated with this area, therefore, this area will not be discussed further.

4.5.3 MI-4 and the Salerno Shoal

Lying 1.86 mi offshore on the inner shelf plain in state waters, the Salerno Shoal is about 3.11 mi long by 1.86 mi wide. The small shoal has a general azimuth of about 90° and occupies about 842 ha, about 2% of the mapped shelf area. Local relief ranges up to 20.01 ft but averages about 7.87 ft.

Potential sand resources in the Salerno Shoal (Figure 3-15B) are estimated to be about 26.9 x 10^6 yds^3 (26,859,950.57 yds^3) (Figure 3-16B, Table 4-16). This volume calculation is based on 100% of the mapping unit being comprised by sand flat that conservatively averages at least 7.87 ft in thickness.

MI-4

Borrow area MI-4 is located within the Salerno Shoal. This area is offshore Hobe Sound and lies between Range Monuments R077 and R090 (Figure 4-50). Vibracore data in ROSS shows that six vibracores are listed from the "Sand Search 1989 Jupiter Island Beach Renourishment Program" project (Figure 4-51). Core layer descriptive information shows the sediments are mostly fine to medium sand with a few showing trace silt (Table 4-18). No jet probes or grab samples are currently in the database for this area.

Three geophysical tracklines cross MI-4. These are MI09_E, MI10_NW and MI11_E (Figure 4-52). Line MI09 E is the northernmost of these three. In this image the beginnings of the shoal feature can be seen as the area above the uppermost red horizontal index line. Moving south through the next two lines (Figure 4-53A through 4-53B) the shoal becomes more visible with the vertical relief reaching 10-15 feet.

4.5.4 Additional Offshore Sand Resources in Nearshore Martin County Area

Dickinson Ridge Field

The Dickson Ridge Field lies off the southeast coast of Martin county, offshore from Jupiter Island (Figure 3-16B, Reformatted NOAA Sheet 7). This small ridge field, which lies in state and federal waters and occupies about 1,200 ha (about 3% of the mapped shelf area) (Table 4-16), lies about 2.8 to 3.73 mi offshore. Sand ridges comprising the unit extend from the inner shelf plain across the outer shelf onto the Florida-Hatteras Slope. It is surrounded by sand flats and lies in 22.97 to78.74 ft water depth. The ridge field contains sand ridges that are about 492.13 to 1,640.2 ft wide by 0.932 to 1.55 mi long with wavelengths of about 1,968.50 ft. Maximum local relief on the ridge field is about 29.53 ft.

Potential sand resources of the Dickinson Ridge Field (Figure 3-15B) are estimated to be on the order of 21.4 x 10^6 yds^3 (21,385,255.21 yds^3) (Figure 3-16B, Table 4-16). This volume calculation was based on 60% coverage of the mapping unit (about 715 ha) by ridges with a maximum local relief of 29.86 ft but assuming an average thickness of 7.55 ft (Table 4-16).

Another area for consideration is the St Lucie Sand Flat. This is an expansive physiographic region extending from St Lucie County in the north, southward to the south boundary of our study area. This region has been discussed in greater detail above in the St Lucie county portion of this section.

St. Lucie Sand Flat

Occupying 24,449 ha (61% of mapped shelf area) in state and federal waters, the St. Lucie Sand Flat (Figure 3-16B, Reformatted NOAA Sheet 7) is the most extensive mapping unit on the continental shelf off Martin County. The unit extends the entire length of the county offshore for a total distance of about 19.9 mi and averages about 4.35 mi wide. This sand flat occurs alongshore to seaward water depths of about 68.9 ft, presenting a more or less rectangular shape. Diabathic channels (Finkl, Andrews and Benedet, 2006a), aligned along azimuths ranging from 15° to 20°, are characteristic features of these sand flats. The diabathic channels have a local relief of about 4.92 ft, giving total local relief in the mapping unit of about 11.48 ft (relief on the sand flats including channel depth). This extensive planar seafloor is broken by the sand ridges (Martin Ridge Field and Mims Ridge Field) and shoals (Gilbert and Salerno). This sand sheet is shoreface attached and extends seaward to undifferentiated seafloor, which may contain sand flat units.

Potential sand resources in the St. Lucie Sand Flat (Figure 3-15B) are estimated to be on the order of 633.5 x 10^6 yds^3 (633,533,814.86 yds^3) (Figure 3-16B, Table 4-16). This volume calculation is based on 100% of the mapping unit being comprised by sand flat that conservatively averages at least 6.56 ft in thickness.

4.6 SUMMARY OF POTENTIAL SAND RESOURCES ALONG THE CENTRAL FLORIDA ATLANTIC COAST

The preceding analysis reported on the kind and sequence of seabed topography in relation to sedimentary bodies. This information was communicated by county, but this summary reports total occurrence of morphosedimentary features for the whole study area on the continental shelf off the central Florida Atlantic coast (Table 3-6). Based on this reconnaissance survey, the total estimated volume of potential sand resources on the continental shelf amounts to something on the order of 5.6 x 10^9 yds^3 (5.6 billion cubic yards). This estimate is based on conservative deposit thicknesses that were derived from local relief on ridges and shoals and to a certain extent on the sand flats where diabathic channels gave an indication of surficial relief.

Although large sediment volumes are associated with sand flats (697.1 x 10^6 yds^3), large volumes are also associated with ridge fields that are more easily dredged. Sediment volumes for ridge fields are calculated for the total area and not by individual ridges, which would be supported by survey that is more detailed. Based on estimates of total sediment volume in ridge fields, the Malabar Ridge Field (763.8x 10^6 yds^3) contains the largest volume followed by the Kennedy Ridge Field (697.1 x 10^6 yds^3), Indian River Ridge Field (468.2 x 10^6 yds^3), Merritt Ridge Field (313.9 x 10^6 yds^3), and the Martin Ridge Field (107.3 x 10^6 yds^3). The Canaveral Transverse Bar system contains about 26.2 x 10^6 yds^3 with the added advantage of lying close to shore. Shoal areas likewise contain significant sediment volumes: Gilbert Shoal (91.6 x 10^6 yds^3), Capron Shoal (78.5 x 10^6 yds^3), Melbourne Shoal (32.7 x 10^6 yds^3), Salerno Shoal (26.2 x 10^6 yds^3), Roseland Shoal (22.2 x 10^6 yds^3), Gifford Shoal (17 x 10^6 yds^3), Patrick Shoal (15.7 x 10^6 yds^3), and the Ankona Shoal (14.4 x 10^6 yds^3).

Undifferentiated seafloor accounted for about 184,000 ha (Table 3-8), constituting the most areally significant mapping unit. However, potential sand resources could not be estimated due to poor quality (low-resolution) bathymetric data. Sand flats occupied the largest area of morphosedimentary features followed by ridge fields. The percentage area used in calculations of potential sand resources as well as average deposits thickness and maximum thickness are summarized in Table 3-8.

Although some ridge fields extend farther offshore on the Florida-Hatteras Slope, they mostly occur on the inner shelf plain and outer shelf. Segments of some ridge fields extend shoreward onto the shoreface, for example the northern extension of the Kennedy Ridge Field, southeastern extension of the Malabar Ridge Field, and shoreward extension of the Indian River Ridge Field (Figure 3-17). Because these parts of ridges fields lie close to shore, they are obvious targets for more detailed sand searches. Shoreward segments of the Capron and Gilbert shoals are also shoreface attached and their nearness to the shore and possible beach renourishment areas makes them potential targets for closer investigation of sand resource potential.

The sedimentary wedge piled along the updrift (northern) margin of Cape Canaveral and series of ridges offshore the cape's apex (South Kennedy Ridge Field) in state waters provides a large sand source that lies close to shore. Because these ridges present an obvious strategic sand reserve, they should be investigated in detail to ascertain sand quality.

Sediment volumes for potential sand resources are indicated in Table 3-7 by areas under state and federal jurisdiction. These considerations become important for beach restoration projects due to different restrictions of use under state and federal codifications, thus requiring indication of the 3-mile limit. As far as potential sand resources are concerned, sand flats occupy large areas but are surpassed by the Kennedy Ridge Fields (20,537 ha) that takes up 67.49% of the state shelf area (landward of the 3-mile limit). In the present survey, federal area amounts to about 386,000 ha (88% of total area) whereas the state area comes to about 123,000 ha (12% of total area) out of a total survey area of about 508,000 ha (1961 mi^2). The occurrence of mapping units within state and federal jurisdiction is summarized in Table 3-7.

One hundred percent of the Canaveral Transverse Bar system and Salerno Shoal occur within the 3-mile limit. All other mapping units occur partially under federal jurisdiction, except for the Gifford Shoal and Merritt Ridge Field which occur wholly in federal waters. The Farmton Sand Flat, Malabar Ridge Field, and Mims Ridge Field occur mostly in federal waters (Table 3-7). Of the morphosedimentary bodies with sand resource potential, the Cocoa Sand Flat takes up about 22% of state waters followed by the Kennedy Ridge Field (about 11%). Undifferentiated seafloor takes up about 17% and 42% of state and federal shelf area, respectively.

Table 4-1.Sand resource potential in Brevard County by morphosedimentary units where volume calculations are based on percent aerial coverage in the mapping unit, which is less than unity for bars and ridge fields.

Morphosedimentary Features	Shelf Area (ha)[1]	% of County Continental Shelf Area[2]	% Area Used in Volume Calculations[3]	Max Sediment Thickness (ft)[4]	Average Sediment Thickness (ft)[5]	Sediment Volume (yds^3)
Canaveral Transverse Bar	3,218	1	0.35	15.088	5.904	26,944,974
Cocoa Sand Flat	52,472	17	1	6.56	6.56	1,359,762,295
Farmton Sand Flat	34,961	11	1	6.56	6.56	905,989,564
Gifford Shoal	836	<1	1	4.92	2.624	8,337,070
Malabar Ridge Field	63,941	21	0.5	24.928	5.904	764,758,490
Melbourne Shoal	2,089	1	1	4.92	2.624	20,819,736
Merritt Ridge Field	14,109	5	0.7	24.928	7.872	315,001,751
Mims Ridge Field	12,121	4	0.35	24.928	9.84	169,133,849
North Kennedy Ridge Field	12,062	4	0.65	20.008	12.136	375,092,562
Patrick Shoal	1,365	<1	1	9.84	2.952	16,330,054
Roseland Shoal	1,426	<1	1	9.84	3.936	22,747,046
South Kennedy Ridge Field	8,475	3	0.8	20.008	12.136	324,355,622
Total	**207,077**	**67**				**4,309,273,014**

[1] For conversion of hectares (ha) to square kilometers (100 ha = 1 km^2) move decimal point two digits to the left.

[2] Refers to continental shelf area offshore from county lines for ease of reference. State waters lie shoreward of the 3-mile and federal waters are seaward.

[3] Some mapping units embrace larger areas than sand ridges *per se* , for example, to simplify mapping. Areas thus designated as ridge fields contain sand ridges plus intervening swales and sand plain units.

[4] Based on measurement of local relief from the reformatted NOAA bathymetry. These measurements are limited by the grid scale of the NOAA bathymetric data.

[5] Based on estimates of variation in local relief within a GIS polygon.

Table 4-2. Florida Central Atlantic Nearshore Potential Borrow Areas.

Area ID	Areal Extent (sq.ft)	Areal Extent (acres)	Total Volume (3 ft cut) Yds^3	Total Volume (6 ft cut) Yds^3	Total Volume (9 ft cut) Yds^3
BE-1	623,705,249	14,318	69,300,583	138,601,166	207,901,750
BE-2	349,737,830	8,029	38,859,759	77,719,518	116,579,277
BE-3	19,119,382	439	2,124,376	4,248,752	6,373,127
BE-4	127,254,038	2,921	14,139,338	28,278,675	42,418,013
BE-5	37,518,048	861	4,168,672	8,337,344	12,506,016
BE-6	53,849,753	1,236	5,983,306	11,966,612	17,949,918
BE-7	121,257,134	2,784	13,473,015	26,946,030	40,419,045
BE-8	34,104,844	783	3,789,427	7,578,854	11,368,281
IR-1	41,524,955	953	4,613,884	9,227,768	13,841,652
IR-2	164,333,538	3,773	18,259,282	36,518,564	54,777,846
MI-1	29,406,130	675	3,267,348	6,534,696	9,802,043
MI-2	32,584,206	748	3,620,467	7,240,935	10,861,402
MI-3	51,634,807	1,185	5,737,201	11,474,402	17,211,602
MI-4	39,952,105	917	4,439,123	8,878,245	13,317,368
MI-5	21,746,610	499	2,416,290	4,832,580	7,248,870
SL-1	106,659,959	2,449	11,851,107	23,702,213	35,553,320
SL-2	49,754,148	1,142	5,528,239	11,056,477	16,584,716
SL-3	88,968,272	2,042	9,885,364	19,770,727	29,656,091

Table 4-3. BE-1 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Bottom of Layer Interval	Top of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Sand, Gravel and Heavy Mineral Resources Potential of Surficial Sediments Offshore of Cape Canaveral, Florida Phase II and Final Report	78	0						78-1	1	1	0.4
Sand, Gravel and Heavy Mineral Resources Potential of Surficial Sediments Offshore of Cape Canaveral, Florida Phase II and Final Report	78	0						78-2	2	2	0.56

Table 4-4. BE-1 results from ROSS grab sample query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
East-coast database							MEDIUM FINE SHELL,QUARTZ	L028			
Sand, Gravel and Heavy Mineral Resources Potential of Surficial Sediments Offshore of Cape Canaveral, Florida Phase II and Final Report								S-55	0	0	1.1
Sand, Gravel and Heavy Mineral Resources Potential of Surficial Sediments Offshore of Cape Canaveral, Florida Phase II and Final Report								S-58	0	0	0.61
Sand, Gravel and Heavy Mineral Resources Potential of Surficial Sediments Offshore of Cape Canaveral, Florida Phase II and Final Report								S-60	0	0	-0.09
Sand, Gravel and Heavy Mineral Resources Potential of Surficial Sediments Offshore of Cape Canaveral, Florida Phase II and Final Report								S-61	0	0	-0.06
Sand, Gravel and Heavy Mineral Resources Potential of Surficial Sediments Offshore of Cape Canaveral, Florida Phase II and Final Report								S-62	0	0	0.37
Sand, Gravel and Heavy Mineral Resources Potential of Surficial Sediments Offshore of Cape Canaveral, Florida Phase II and Final Report								S-63	0	0	0.37
Sand, Gravel and Heavy Mineral Resources Potential of Surficial Sediments Offshore of Cape Canaveral, Florida Phase II and Final Report								S-64	0	0	2.84

Table 4-4. BE-1 results from ROSS grab sample query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Sand, Gravel and Heavy Mineral Resources Potential of Surficial Sediments Offshore of Cape Canaveral, Florida Phase II and Final Report								S-65	0	0	0.59
Sand, Gravel and Heavy Mineral Resources Potential of Surficial Sediments Offshore of Cape Canaveral, Florida Phase II and Final Report								S-67	0	0	0.96
Sand, Gravel and Heavy Mineral Resources Potential of Surficial Sediments Offshore of Cape Canaveral, Florida Phase II and Final Report								S-81	0	0	0.21
Sand, Gravel and Heavy Mineral Resources Potential of Surficial Sediments Offshore of Cape Canaveral, Florida Phase II and Final Report								S-82	0	0	1.51
Sand, Gravel and Heavy Mineral Resources Potential of Surficial Sediments Offshore of Cape Canaveral, Florida Phase II and Final Report								S-87	0	0	0.63
Sand, Gravel and Heavy Mineral Resources Potential of Surficial Sediments Offshore of Cape Canaveral, Florida Phase II and Final Report								S-90	0	0	1.25
Sand, Gravel and Heavy Mineral Resources Potential of Surficial Sediments Offshore of Cape Canaveral, Florida Phase II and Final Report								S-69	0	0	2.02

Table 4-5. BE-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Length	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Sand, Gravel and Heavy Mineral Resources Potential of Surficial Sediments Offshore of Cape Canaveral, Florida Phase II and Final Report	20	0							20-1	1	1	1.43
Sand, Gravel and Heavy Mineral Resources Potential of Surficial Sediments Offshore of Cape Canaveral, Florida Phase II and Final Report	20	0							20-2	2	2	1.15
Sand, Gravel and Heavy Mineral Resources Potential of Surficial Sediments Offshore of Cape Canaveral, Florida Phase II and Final Report	40	0							40	0	0	3.09
Sand, Gravel and Heavy Mineral Resources Potential of Surficial Sediments Offshore of Cape Canaveral, Florida Phase II and Final Report	42	0							42-1	1	1	3.19
Sand, Gravel and Heavy Mineral Resources Potential of Surficial Sediments Offshore of Cape Canaveral, Florida Phase II and Final Report	42	0							42-2	2	2	
Sand, Gravel and Heavy Mineral Resources Potential of Surficial Sediments Offshore of Cape Canaveral, Florida Phase II and Final Report	43	0							43	0	0	2.66

Table 4-6. BE-2 results from ROSS grab sample query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Bottom of Layer Interval	Top of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Of Sample Interval	Mean
Sand, Gravel and Heavy Mineral Resources Potential of Surficial Sediments Offshore of Cape Canaveral, Florida Phase II and Final Report								S-45	0	0	1.24
Sand, Gravel and Heavy Mineral Resources Potential of Surficial Sediments Offshore of Cape Canaveral, Florida Phase II and Final Report								S-47	0	0	3.46
Sand, Gravel and Heavy Mineral Resources Potential of Surficial Sediments Offshore of Cape Canaveral, Florida Phase II and Final Report								S-48	0	0	0.89
Sand, Gravel and Heavy Mineral Resources Potential of Surficial Sediments Offshore of Cape Canaveral, Florida Phase II and Final Report								S-49	0	0	0.8
Sand, Gravel and Heavy Mineral Resources Potential of Surficial Sediments Offshore of Cape Canaveral, Florida Phase II and Final Report								S-93	0	0	1.45
Sand, Gravel and Heavy Mineral Resources Potential of Surficial Sediments Offshore of Cape Canaveral, Florida Phase II and Final Report								S-94	0	0	1.58

Table 4-7. BE-4 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Sand Source Analysis for Beach Restoration, Brevard County, Fl 1989	29	-37.9	29-1	0	10.3	LIGHT GRAY	mostly Sand				
Sand Source Analysis for Beach Restoration, Brevard County, Fl 1989	29	-37.9	29-2	10.3	11.2	GRAY	mostly Shelly Sand				
Sand Source Analysis for Beach Restoration, Brevard County, Fl 1989	29	-37.9	29-3	11.2	20	GRAY	mostly Clay; trace Shell Fragments; trace Whole Shell				
Sand Source Analysis for Beach Restoration, Brevard County, Fl 1989	31	-42.2	31-1	0	2.3	DARK GRAY	mostly Shelly Clay				
Sand Source Analysis for Beach Restoration, Brevard County, Fl 1989	31	-42.2	31-2	2.3	3.2	GRAY	mostly Clay				
Sand Source Analysis for Beach Restoration, Brevard County, Fl 1989	31	-42.2	31-3	3.2	4	GRAY	mostly Clayey Sand				
Sand Source Analysis for Beach Restoration, Brevard County, Fl 1989	31	-42.2	31-4	4	5.8	GRAY	mostly Clay				
Sand Source Analysis for Beach Restoration, Brevard County, Fl 1989	31	-42.2	31-5	5.8	13.2	GRAY	mostly Sandy Clay				
Sand Source Analysis for Beach Restoration, Brevard County, Fl 1989	31	-42.2	31-6	13.2	14.3		mostly Organic Clay; trace Sand				
Sand Source Analysis for Beach Restoration, Brevard County, Fl 1989	31	-42.2	31-7	14.3	16.6	GREENISH GRAY	mostly Clay; trace Quartz Sand				
Sand Source Analysis for Beach Restoration, Brevard County, Fl 1989	32	-42.2	32-1	0	1.7	GRAY	mostly Medium Quartz Sand; trace Clay				
Sand Source Analysis for Beach Restoration, Brevard County, Fl 1989	32	-42.2	32-2	1.7	4.2	GRAY	mostly Shelly Sand; trace Clay				
Sand Source Analysis for Beach Restoration, Brevard County, Fl 1989	32	-42.2	32-3	4.2	4.8	GRAY	mostly Shelly Clay				

Table 4-7. BE-4 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Sand Source Analysis for Beach Restoration, Brevard County, Fl 1989	32	-42.2	32-4	4.8	11.8	GRAY	mostly Sand; trace Clay; trace Shell Fragments				
Sand Source Analysis for Beach Restoration, Brevard County, Fl 1989	32	-42.2	32-5	11.8	12.3	DARK GRAY	mostly Organic Clay				
Sand Source Analysis for Beach Restoration, Brevard County, Fl 1989	32	-42.2	32-6	12.3	13.2	GREENISH TAN	mostly Shelly Clay; trace Fine Quartz Sand				

Table 4-8. BE-7 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Sand Source Analysis for Beach Restoration, Brevard County, Fl 1989	56	-41.5	56-1	0	1.5	DARK GRAY	mostly Clay; trace Quartz Sand				
Sand Source Analysis for Beach Restoration, Brevard County, Fl 1989	56	-41.5	56-2	1.5	3.2	LIGHT GRAY	mostly Medium Quartz Sand				
Sand Source Analysis for Beach Restoration, Brevard County, Fl 1989	56	-41.5	56-3	3.2	6.2	GREENISH GRAY	mostly Medium Shelly Quartz Sand				
Sand Source Analysis for Beach Restoration, Brevard County, Fl 1989	56	-41.5	56-4	6.2	9.4	GRAY	mostly Fine To Medium Quartz Sand				
Sand Source Analysis for Beach Restoration, Brevard County, Fl 1989	56	-41.5	56-5	9.4	18.1	LIGHT GRAY	mostly Medium To Coarse Quartz Sand; trace Shell Fragments				
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	184	0	184-1	0	2	5YR 5/2	mostly Well Sorted Fine Quartz Sand				
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	184	0	184-2	2	3	5YR 4/1	mostly Poorly Sorted Silty Quartz Sand				
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	184	0	184-3	3	6	5YR 7/2					

Table 4-9. BE-7 results from ROSS grab sample query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
East-coast database							MED-CRS VERY CLEAN QUARTZ SAND WITH BROKEN FRAGMENTS OF PELECYPODS.	1538 A			0.53
East-coast database							GREY-BLACK, SULFIDE IMPREGNATED,TOP OF SAMPLE.	1538 B			

Table 4-10.
Sand resource potential in Indian River County by morphosedimentary units where volume calculations are based on percent areal coverage in the mapping unit, which is less than unity for ridge fields

Morphosedimentary Feature	Shelf Area (ha)	% of County Continental Shelf Area	% Shelf Area Used in Volume Calculations	Max Sediment Thickness (ft)	Average Sediment Thickness (ft)	Sediment Volume (yds^3)
Gifford Shoal	606	1	1	15.088	7.544	18,134,418
Indian River Ridge Field	31,390	37	0.65	20.008	9.84	813,455,871
St. Lucie Sand Flat	2,540	3	1	6.56	6.56	65,818,890
Total	**34,536**	**41**				**897,409,178**

[1] For conversion of hectares (ha) to square kilometers (100 ha = 1 km^2) move decimal point two digits to the left.

[2] Refers to continental shelf area offshore from county lines for ease of reference. State waters lie shoreward of the 3-mile and federal waters are seaward.

[3] Some mapping units embrace larger areas than sand ridges *per se* , for example, to simplify mapping. Areas thus designated as ridge fields contain sand ridges plus intervening swales and sand plain units.

[4] Based on measurement of local relief from the reformatted NOAA bathymetry. These measurements are limited by the grid scale of the NOAA bathymetric data.

[5] Based on estimates of variation in local relief within a GIS polygon.

Table 4-11. IR-1 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	78	0	78-1	0	1	10YR 7/2	mostly Silty Quartz Sand	78-1	1	1	1.57
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	78	0	78-2	1	6	10YR 6/1	mostly Silty Sand	78-1	1	1	1.57
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	78	0	78-3	6	9		mostly Coarse Quartz Sand				
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	78	0	78-4	9	9.7		mostly Medium Sand				

Table 4-12. IR-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Indian River County 1999 Pre-Engineering Design Project Geotechnical Investigation Core Borings IR-South Cores 1-26	IR-S-25	-17.3	IR-S-25a	0	10.4	TAN	mostly Medium To Fine Sand	S-25-1	0	1	0.3
Indian River County 1999 Pre-Engineering Design Project Geotechnical Investigation Core Borings IR-South Cores 1-26	IR-S-25	-17.3	IR-S-25a	0	10.4	TAN	mostly Medium To Fine Sand	S-25-3	7.5	8.5	0.46
Indian River County 1999 Pre-Engineering Design Project Geotechnical Investigation Core Borings IR-South Cores 1-26	IR-S-25	-17.3	IR-S-25a	0	10.4	TAN	mostly Medium To Fine Sand	S-25-2	3.5	4.5	0.58
Indian River County 1999 Pre-Engineering Design Project Geotechnical Investigation Core Borings IR-South Cores 1-26	IR-S-25	-17.3	IR-S-25b	10.4	12.1	LIGHT BROWNISH GRAY	mostly Fine Sand	S-25-4	10.5	11.5	0.26
Indian River County 1999 Pre-Engineering Design Project Geotechnical Investigation Core Borings IR-South Cores 1-26	IR-S-25	-17.3	IR-S-25c	12.1	15.7	BROWN	mostly Silty Sand				
Indian River County 1999 Pre-Engineering Design Project Geotechnical Investigation Core Borings IR-South Cores 1-26	IR-S-25	-17.3	IR-S-25d	15.7	17.5	BROWN	mostly Silty Sand; trace Shell				
Indian River County 1999 Pre-Engineering Design Project Geotechnical Investigation Core Borings IR-South Cores 1-26	IR-S-25	-17.3	IR-S-25e	17.5	18.9	LIGHT BROWNISH GRAY	mostly Coarse Sand				

Table 4-12. IR-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	42	0	42-1	0	2	10YR 6/2	mostly Very Coarse Quartz Sand				
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	42	0	42-2	2	4	10YR 7/1	mostly Well Sorted Medium Quartz Sand	42-1	4	4	1.43
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	42	0	42-3	4	8	10YR 7/2	mostly Very Coarse Quartz Sand; trace Shell	42-1	4	4	1.43
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	42	0	42-3	4	8	10YR 7/2	mostly Very Coarse Quartz Sand; trace Shell	42-2	8	8	1.64
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	42	0	42-4	8	10.4	10YR 8/2	mostly Coarse Gravely Quartz Sand	42-2	8	8	1.64
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	76	0	76-1	0	2	10YR 7/3	mostly Very Coarse Quartz Sand	76-1	0	0	0.15
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	76	0	76-2	2	3	10YR 7/2	mostly Silty Sand				

Table 4-12. IR-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	76	0	76-3	3	5	10YR 8/3	mostly Medium Quartz Sand				
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	76	0	76-4	5	10.3	10YR 8/3	mostly Fine Quartz Sand				
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	77	0	77-1	0	1	10YR 7/3	mostly Gravely Shell				
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	77	0	77-2	1	10	10YR 7/3	mostly Medium Quartz Sand	77-1	5	5	1.61
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	77	0	77-3	10	10.3	10YR 7/2	mostly Very Coarse Silty Quartz Sand				
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	89	0	89-1	0	1	10YR 6/1	mostly Very Coarse Shelly Quartz Sand				
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	89	0	89-2	1	5	10YR 6/1	mostly Fine To Coarse Shelly Quartz Sand				

Table 4-12. IR-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	89	0	89-3	5	8.3	10YR 7/1	mostly Fine To Very Fine Quartz Sand; trace Shell				

Table 4-13.
Sand resource potential in St. Lucie County by morphosedimentary units where volume calculations are based on percent areal coverage in the mapping unit, which is less than unity for ridge fields.

Morphosedimentary Feature	**Shelf Area (ha)**	**% of County Continental Shelf Area**	**% Area Used in Volume Calculations**	**Max Sediment Thickness (ft)**	**Average Sediment Thickness (ft)**	**Sediment Volume (yds^3)**
Ankona Shoal	1,883	3	1	4.92	1.968	15,011,707
Capron Shoal	3,916	5	1	9.84	4.92	78,060,900
Gilbert Shoal	1,727	2	1	20.008	12.136	82,643,079
Indian River Ridge Field A	184	0.3	0.9	15.088	5.904	3,964,817
Indian River Ridge Field B	2,046	3	0.8	15.088	7.872	52,195,053
Martin Ridge Field	7,224	10	0.45	35.096	18.04	233,277,201
St. Lucie Sand Flat	33,895	47	1	6.56	6.56	878,346,386
Total	**50,875**	**71**				**1,343,499,144**

[1] For conversion of hectares (ha) to square kilometers (100 ha = 1 km^2) move decimal point two digits to the left.

[2] Refers to continental shelf area offshore from county lines for ease of reference. State waters lie shoreward of the 3-mile and federal waters are seaward.

[3] Some mapping units embrace larger areas than sand ridges *per se* , for example, to simplify mapping. Areas thus designated as ridge fields contain sand ridges plus intervening swales and sand plain units.

[4] Based on measurement of local relief from the reformatted NOAA bathymetry. These measurements are limited by the grid scale of the NOAA bathymetric data.

[5] Based on estimates of variation in local relief within a GIS polygon.

Table 4-14. SL-1 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Geotechnical and Borrow Area Investigation, Phase I-Reconnaissance Level (1994)	CB-STL-D1	-28	D1a	0	4.5	BROWN	mostly Medium Quartz Sand				
Geotechnical and Borrow Area Investigation, Phase I-Reconnaissance Level (1994)	CB-STL-D1	-28	D1b	4.5	6.6	GRAY	mostly Fine Quartz Sand				
Geotechnical and Borrow Area Investigation, Phase I-Reconnaissance Level (1994)	CB-STL-D1	-28	D1c	6.6	9	GRAY	mostly Medium To Fine Quartz Sand; trace Shell Hash				
Geotechnical and Borrow Area Investigation, Phase I-Reconnaissance Level (1994)	CB-STL-D1	-28	D1d	9	10		mostly Medium To Fine Silty Quartz Sand; trace Shell Hash				
Geotechnical and Borrow Area Investigation, Phase I-Reconnaissance Level (1994)	CB-STL-D2	-30	D2a	0	3.6	BROWN	mostly Medium Quartz Sand; trace Whole Shell				
Geotechnical and Borrow Area Investigation, Phase I-Reconnaissance Level (1994)	CB-STL-D2	-30	D2b	3.6	5.1	GRAYISH BROWN	mostly Fine Quartz Sand				
Geotechnical and Borrow Area Investigation, Phase I-Reconnaissance Level (1994)	CB-STL-D2	-30	D2c	5.1	6.9	GRAYISH BROWN	mostly Fine Quartz Sand; trace Whole Shell				
Geotechnical and Borrow Area Investigation, Phase I-Reconnaissance Level (1994)	CB-STL-D2	-30	D2d	6.9	9.6	GRAYISH BROWN	mostly Fine Quartz Sand				
Geotechnical and Borrow Area Investigation, Phase I-Reconnaissance Level (1994)	CB-STL-D2	-30	D2e	9.6	10	GRAY	mostly Silty Quartz Sand; trace Coarse Shell				
Geotechnical and Borrow Area Investigation, Phase I-Reconnaissance Level (1994)	CB-STL-F3	-28	F3a	0	3	BROWN	mostly Medium To Fine Quartz Sand				
Geotechnical and Borrow Area Investigation, Phase I-Reconnaissance Level (1994)	CB-STL-F3	-28	F3b	3	7.2	BROWN	mostly Medium To Fine Quartz Sand				
Geotechnical and Borrow Area Investigation, Phase I-Reconnaissance Level (1994)	CB-STL-F3	-28	F3c	7.2	9.2	GRAY	mostly Medium To Fine Quartz Sand; trace Silt				
Geotechnical and Borrow Area Investigation, Phase I-Reconnaissance Level (1994)	CB-STL-F3	-28	F3d	9.2	10	GRAY	mostly Silty Quartz Sand; trace Clay				

Table 4-14. SL-1 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Ft. Pierce Inlet Sand Bypassing Feasibility Study, St. Lucie County 2004	FP-02-1	-26.5	FP-02-1-1	0	1.8		mostly Fine To Medium Sand	FP-02-1-1	0	0	0.66
Ft. Pierce Inlet Sand Bypassing Feasibility Study, St. Lucie County 2004	FP-02-1	-26.5	FP-02-1-1	0	1.8		mostly Fine To Medium Sand	FP-02-1-2	1	1	0.99
Ft. Pierce Inlet Sand Bypassing Feasibility Study, St. Lucie County 2004	FP-02-1	-26.5	FP-02-1-2	1.8	7.8		mostly Very Fine To Very Coarse Sand	FP-02-1-3	4	4	1.82
Ft. Pierce Inlet Sand Bypassing Feasibility Study, St. Lucie County 2004	FP-02-1	-26.5	FP-02-1-3	7.8	9.8		mostly Very Fine Silty Sand	FP-02-1-4	9	9	1.92
Ft. Pierce Inlet Sand Bypassing Feasibility Study, St. Lucie County 2004	FP-02-2	-22.9	FP-02-2-1	0	2.6		mostly Medium Sand	FP-02-2-1	0	0	0.82
Ft. Pierce Inlet Sand Bypassing Feasibility Study, St. Lucie County 2004	FP-02-2	-22.9	FP-02-2-1	0	2.6		mostly Medium Sand	FP-02-2-2	1	1	0.95
Ft. Pierce Inlet Sand Bypassing Feasibility Study, St. Lucie County 2004	FP-02-2	-22.9	FP-02-2-2	2.6	8.8		mostly Fine To Medium Sand	FP-02-2-3	4	4	1.51
Fort Pierce, Florida Shore Protection Project Reevaluation Report Section 934 Study with Environmental Assessment	CB-1	-16	CB-1-1	0	10	LIGHT GRAYISH	mostly Medium Sand				
Fort Pierce, Florida Shore Protection Project Reevaluation Report Section 934 Study with Environmental Assessment	CB-1	-16	CB-1-2	10	20	LIGHT GRAYISH WHITE	mostly Fine To Very Fine Quartz Sand				
Fort Pierce, Florida Shore Protection Project Reevaluation Report Section 934 Study with Environmental Assessment	CB-2	-20	CB-2-1	0	10	GRAY	mostly Medium Sand				
Fort Pierce, Florida Shore Protection Project Reevaluation Report Section 934 Study with Environmental Assessment	CB-2	-20	CB-2-2	10	20	LIGHT GRAYISH WHITE	mostly Very Fine To Fine Quartz Sand; trace Pebbly Rock				

Table 4-14. SL-1 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Fort Pierce, Florida Shore Protection Project Reevaluation Report Section 934 Study with Environmental Assessment	CB-5	-21.8	CB-5-1	0	5	GRAY	mostly Fine To Medium Quartz Sand				
Fort Pierce, Florida Shore Protection Project Reevaluation Report Section 934 Study with Environmental Assessment	CB-5	-21.8	CB-5-2	5	7	GRAY	mostly Shelly Sand				
Fort Pierce, Florida Shore Protection Project Reevaluation Report Section 934 Study with Environmental Assessment	CB-5	-21.8	CB-5-3	7	20	LIGHT GRAYISH	mostly Fine Silty Quartz Sand; isolated Limestone				
Fort Pierce, Florida Shore Protection Project Reevaluation Report Section 934 Study with Environmental Assessment	CB-7	-19.5	CB-7-1	0	8	GRAY	mostly Very Fine To Coarse Shelly Quartz Sand				
Fort Pierce, Florida Shore Protection Project Reevaluation Report Section 934 Study with Environmental Assessment	CB-7	-19.5	CB-7-2	8	20	LIGHT GRAYISH	mostly Fine To Medium Shelly Quartz Sand				
Fort Pierce, Florida Shore Protection Project Reevaluation Report Section 934 Study with Environmental Assessment	CB-8	-21.5	CB-8-2	3.5	20	GRAY	mostly Fine To Medium Quartz Sand				
Fort Pierce, Florida Shore Protection Project Reevaluation Report Section 934 Study with Environmental Assessment	CB-9	-18.2	CB-9-1	0	12	TAN	mostly Shelly Sand				
Fort Pierce, Florida Shore Protection Project Reevaluation Report Section 934 Study with Environmental Assessment	CB-9	-18.2	CB-9-2	12	20	LIGHT GRAYISH	mostly Fine Silty Quartz Sand; isolated Limestone				

Table 4-14. SL-1 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Fort Pierce, Florida Shore Protection Project Reevaluation Report Section 934 Study with Environmental Assessment	CB-10	-18.2	CB-10-1	0	5	TAN	mostly Shelly Sand				
Fort Pierce, Florida Shore Protection Project Reevaluation Report Section 934 Study with Environmental Assessment	CB-10	-18.2	CB-10-2	5	15.5	GRAY	mostly Fine To Medium Shelly Quartz Sand				
Fort Pierce, Florida Shore Protection Project Reevaluation Report Section 934 Study with Environmental Assessment	CB-10	-18.2	CB-10-3	15.5	18	LIGHT GRAYISH	mostly Shelly Quartz Sand				
Fort Pierce, Florida Shore Protection Project Reevaluation Report Section 934 Study with Environmental Assessment	CB-11	-18.5	CB-11-1	0	12	TAN	mostly Fine To Medium Quartz Sand				
Fort Pierce, Florida Shore Protection Project Reevaluation Report Section 934 Study with Environmental Assessment	CB-11	-18.5	CB-11-2	12	20	LIGHT GRAYISH	mostly Fine Silty Quartz Sand; isolated Limestone				
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	51	0	51-1	0	5	10YR 7/2	mostly Well Sorted Medium Sand				
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	51	0	51-2	5	8	10YR 7/1	mostly Coarse Quartz Sand				
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	51	0	51-3	8	10.6	10YR 6/2	mostly Medium To Coarse Quartz Sand				
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	86	0	86-1	0	1	10YR 7/3	mostly Medium Quartz Sand				

Table 4-14. SL-1 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	86	0	86-2	1	4	10YR 6/2	mostly Coarse Quartz Sand				
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	86	0	86-3	4	6	10YR 5/1	mostly Medium Quartz Sand				
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	86	0	86-4	6	8	10YR 7/1	mostly Very Fine Quartz Sand; trace Shell				
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	87	0	87-1	0	6	10YR 6/2	mostly Very Coarse Shelly Quartz Sand	87-1	0	0	0.65
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	87	0	87-2	6	9.3	10YR 6/1	mostly Medium To Coarse Quartz Sand				

Table 4-15. SL-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C3	-21.3	C3a	0	4.8	GRAYISH BROWN	mostly Medium To Fine Quartz Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C3	-21.3	C3b	4.8	9.5	GRAYISH BROWN	mostly Medium Quartz Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C4	-23.6	C4a	0	5	BROWN	mostly Medium Quartz Sand; trace Shell Hash; trace Whole Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C4	-23.6	C4b	5	9.6	BROWN	mostly Medium Quartz Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C4	-23.6	C4c	9.6	12	BROWN	mostly Medium To Fine Quartz Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C4	-23.6	C4d	12	16.3	BROWN	mostly Medium To Fine Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C4	-23.6	C4e	16.3	16.6	GRAY	mostly Clayey Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C5	-24.4	C5a	0	5.5	BROWN	mostly Medium Quartz Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C5	-24.4	C5b	5.5	7	GRAYISH BROWN	mostly Medium Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C5	-24.4	C5c	7	13.8	GRAYISH BROWN	mostly Medium To Fine Quartz Sand; trace Fine Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C5	-24.4	C5d	13.8	15	GRAYISH BROWN	mostly Fine Quartz Sand; trace Silt				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C6	-33	C6a	0	3	BROWN	mostly Medium To Fine Quartz Sand; trace Coarse Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C6	-33	C6b	3	5		mostly Fine Quartz Sand				

Table 4-15. SL-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C6	-33	C6c	5	7	GRAY	mostly Medium To Fine Quartz Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C6	-33	C6d	7	14	GRAY	mostly Fine Quartz Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C6	-33	C6e	14	17	GRAY	mostly Clay				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C7	-28.6	C7a	0	5.5	GRAYISH BROWN	mostly Medium To Fine Quartz Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C7	-28.6	C7b	5.5	6.5	BROWN	mostly Medium To Fine Quartz Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C7	-28.6	C7c	6.5	8	GRAY	mostly Medium To Fine Quartz Sand; trace Silt				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C7	-28.6	C7d	8	9	GRAY	mostly Fine Silty Quartz Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C8	-25.4	C8a	0	4	BROWN	mostly Medium To Fine Quartz Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C8	-25.4	C8b	4	9	GRAYISH BROWN	mostly Medium To Fine Quartz Sand; trace Shell Fragments				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C9R2	-30.2	C9R2a	0	5.4	TAN	mostly Medium To Fine Quartz Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C9R2	-30.2	C9R2b	5.4	7.4	GRAY	mostly Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C9R2	-30.2	C9R2c	7.4	9	GRAY	mostly Medium Quartz Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C9R2	-30.2	C9R2d	9	10	GRAY	mostly Sand; trace Carbonate Clay; trace Shell				

Table 4-15. SL-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C17	-28.3	C17a	0	0.7	BROWN	mostly Medium To Fine Quartz Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C17	-28.3	C17b	0.7	5	GRAYISH BROWN	mostly Medium To Fine Quartz Sand; trace Whole Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C17	-28.3	C17c	5	6.4	GRAY	mostly Gravely Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C17	-28.3	C17d	6.4	8.2	GRAY	mostly Silty Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-18	-19.5	C18a	0	12	BROWN	mostly Medium To Fine Quartz Sand; trace Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-18	-19.5	C18b	12	18.4	BROWNISH GRAY	mostly Medium To Fine Quartz Sand; trace Coarse Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C19	-31.5	C19a	0	1.2	BROWN	mostly Medium To Fine Quartz Sand; trace Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C19	-31.5	C19b	1.2	2.4	GRAY	mostly Gravely Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C19	-31.5	C19c	2.4	6.5	GRAYISH BROWN	mostly Medium To Fine Sand; trace Whole Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C20	-27.2	C20a	0	8.3	BROWN	mostly Medium To Fine Quartz Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C20	-27.2	C20b	8.3	11	BROWN	mostly Fine Quartz Sand; trace Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C20	-27.2	C20c	11	11.6		mostly Gravely Sand; trace Large Whole Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C21R2	-29.1	C21R2a	0	1.4	BROWN	mostly Medium To Fine Quartz Sand				

Table 4-15. SL-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C21R2	-29.1	C21R2b	1.4	2.7	BROWN	mostly Medium To Fine Quartz Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C21R2	-29.1	C21R2c	2.7	10.5	BROWN	mostly Medium To Fine Quartz Sand; trace Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C22	-30.2	C22a	0	3.6	BROWN	mostly Medium To Fine Quartz Sand; trace Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C22	-30.2	C22b	3.6	6.5	GRAY	mostly Medium To Fine Quartz Sand; trace Whole Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C22	-30.2	C22c	6.5	8.6	GRAY	mostly Medium Silty Quartz Sand; trace Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C22	-30.2	C22d	8.6	8.8	GRAY	mostly Clayey Rock; trace Shell; trace Whole Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C22	-30.2	C22e	8.8	9.4	GRAY	mostly Silty Rock; trace Whole Shell; trace Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C23	-23.6	C23a	0	5	BROWN	mostly Medium To Fine Quartz Sand; trace Whole Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C23	-23.6	C23b	5	6.7	BROWN	mostly Medium To Fine Quartz Sand; trace Fine Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C23	-23.6	C23c	6.7	9.6	BROWN	mostly Medium To Fine Quartz Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C23	-23.6	C23d	9.6	16	BROWN	mostly Medium To Fine Quartz Sand; trace Fine Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C23	-23.6	C23e	16	20	BROWN	mostly Medium To Fine Sand; trace Shell; trace Whole Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C24	-23.6	C24a	0	3	BROWN	mostly Medium To Fine Quartz Sand; trace Shell				

Table 4-15. SL-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C24	-23.6	C24b	3	11	BROWN	mostly Medium To Fine Quartz Sand; trace Shell; trace Small Whole Shell; trace Silt				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C24	-23.6	C24c	11	11.5	GRAY	mostly Rock; trace Shell Fragments; trace Large Whole Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C25	-31.2	C25a	0	3	GRAYISH BROWN	mostly Medium To Fine Quartz Sand; trace Fine Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C25	-31.2	C25b	3	10	GRAYISH BROWN	mostly Medium To Fine Quartz Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C25	-31.2	C25c	10	11.3	GRAY	mostly Rock				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C26	-27.4	C26a	0	5.4	GRAYISH BROWN	mostly Medium To Fine Quartz Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C26	-27.4	C26b	5.4	7	BROWN	mostly Medium To Fine Quartz Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C26	-27.4	C26c	7	8.7	GRAY	mostly Rock; trace Silt				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C27	-29.5	C27a	0	1.2	BROWN	mostly Fine Quartz Sand; trace Whole Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C27	-29.5	C27b	1.2	4.2	BROWN	mostly Medium To Fine Quartz Sand; trace Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C27	-29.5	C27c	4.2	7.8	BROWN	mostly Fine Quartz Sand; trace Whole Shell; trace Shell Fragments; trace Shell Hash				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C28	-23.6	C28a	0	3.4	BROWN	mostly Medium To Fine Quartz Sand				

Table 4-15. SL-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C28	-23.6	C28b	3.4	9	BROWN	mostly Medium To Fine Quartz Sand; trace Shell Fragments; trace Coarse Sand; trace Shell; trace Whole Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C28	-23.6	C28c	9	15	BROWN	mostly Medium To Fine Quartz Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C28	-23.6	C28d	15	19.2	GRAYISH BROWN	mostly Medium To Fine Quartz Sand; trace Fine Shell; trace Shell Fragments				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C29	-28.4	C29a	0	6	BROWN	mostly Medium To Fine Quartz Sand; trace Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C29	-28.4	C29b	6	7.4	GRAYISH BROWN	mostly Medium To Fine Quartz Sand; trace Coarse Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C29	-28.4	C29c	7.4	8.8	GRAY	mostly Silty Rock; trace Large Shell; trace Shell Fragments				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C30	-30.4	C30a	0	1.3	BROWN	mostly Medium Quartz Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C30	-30.4	C30b	1.3	5.3	BROWN	mostly Medium To Fine Quartz Sand; trace Whole Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C30	-30.4	C30c	5.3	9.3	BROWN	mostly Fine Quartz Sand; trace Whole Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C30	-30.4	C30d	9.3	10.2		mostly Shelly Rock				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C31	-30.5	C31a	0	2.7		mostly Fine Quartz Sand; trace Fine Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C31	-30.5	C31b	2.7	9.1		mostly Fine Quartz Sand; trace Shell Fragments; trace Small Whole Shell				

Table 4-15. SL-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C32	-27.8	C32a	0	4.5	BROWN	mostly Medium To Fine Quartz Sand; trace Fine Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C32	-27.8	C32b	4.5	9.2	BROWN	mostly Medium To Fine Quartz Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C33	-28.7	C33a	0	8	BROWN	mostly Medium To Fine Quartz Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C34	-29.9	C34a	0	2.6	BROWN	mostly Medium To Fine Quartz Sand; trace Whole Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C34	-29.9	C34b	2.6	6	GRAYISH BROWN	mostly Medium To Fine Quartz Sand; trace Silt; trace Fine Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C35	-32.2	C35a	0	5.5	BROWN	mostly Medium To Fine Quartz Sand; trace Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C35	-32.2	C35b	5.5	6.6	GRAY	mostly Medium To Fine Quartz Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C35	-32.2	C35c	6.6	8.3	GRAY	mostly Medium To Fine Silty Quartz Sand; trace Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C35	-32.2	C35d	8.3	8.6	GREENISH GRAY	mostly Clay				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C35	-32.2	C35e	8.6	9.5	GRAY	mostly Silty Rock				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C35	-32.2	C35f	9.5	10	GREENISH GRAY	mostly Clay				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C35	-32.2	C35g	10	10.9	GRAY	mostly Silty Rock				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C36	-27.5	C36a	0	0.9	BROWN	mostly Medium To Fine Quartz Sand; trace Fine Shell				

Table 4-15. SL-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C36	-27.5	C36b	0.9	4.3	BROWN	mostly Medium To Fine Quartz Sand; trace Shell Fragments; trace Whole Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C36	-27.5	C36c	4.3	9.7	GRAYISH BROWN	mostly Medium To Fine Quartz Sand; trace Fine Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C38	-30.6	C38a	0	2.4	GRAYISH BROWN	mostly Medium To Very Fine Quartz Sand; trace Coarse Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C38	-30.6	C38b	2.4	9.6		mostly Medium To Fine Quartz Sand; trace Whole Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C38	-30.6	C38c	9.6	10.2		mostly Silty Sand; trace Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-39	-29	C39a	0	2	GRAYISH BROWN	mostly Medium Quartz Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-39	-29	C39b	2	5.5	GRAYISH BROWN	mostly Medium To Fine Quartz Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-39	-29	C39c	5.5	9	GRAYISH BROWN	mostly Fine Quartz Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-39	-29	C39d	9	10	GRAY	mostly Fine Quartz Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C40	-29.6	C40a	0	4.2	GRAYISH BROWN	mostly Medium To Fine Quartz Sand; trace Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C40	-29.6	C40b	4.2	5.3	GRAYISH BROWN	mostly Medium To Fine Quartz Sand; trace Fine Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C40	-29.6	C40c	5.3	9.8	GRAYISH BROWN	mostly Medium To Fine Quartz Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C41	-28.1	C41a	0	0.7	BROWN	mostly Medium To Fine Quartz Sand				

Table 4-15. SL-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C41	-28.1	C41b	0.7	4.6	GRAYISH BROWN	mostly Fine Quartz Sand; trace Fine Shell				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C41	-28.1	C41c	4.6	7.5	GRAY	mostly Fine Quartz Sand				
Geotechnical and Borrow Area Investigation, Phase II-Plans and Specifications Level Report (1994)	CB-STL-C41	-28.1	C41d	7	10.3	GRAY	mostly Medium To Fine Quartz Sand				
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C17	-28.3	CB-STL-C17-1	0	0.7		SAND, poorly graded, medium to fine grained quartz and shell hash, little coarse shell gravel, brown. 90% shell.	CB-STL-C17-1	0.4	0.4	0.4
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C17	-28.3	CB-STL-C17-2	0.7	5		SAND, poorly graded, medium to fine grained quartz and shell hash, gray-brown. 65% shell. Occaisonal whole shells.	CB-STL-C17-2	2.8	2.8	1.23
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C17	-28.3	CB-STL-C17-3	5	6.4		Gravelly SAND, poorly graded, gray. 95% shell.				
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C17	-28.3	CB-STL-C17-4	6.4	8.2		Silty SAND, gay. 65% shell.				
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C18	-19.5	CB-STL-C18-1	0	12		SAND, poorly graded, medium to fine grained quartz and shell hash, trace of shell gravel, lenses of fine shell gravel, brown. 90% shell. Lens of coarse chell gravel at -22.9 ft to -23.5 ft. Lens of coarse shell gravel at -24.7 ft to -25.2 ft.	CB-STL-C18-1	2.9	2.9	0.59

Table 4-15. SL-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C18	-19.5	CB-STL-C18-1	0	12		SAND, poorly graded, medium to fine grained quartz and shell hash, trace of shell gravel, lenses of fine shell gravel, brown. 90% shell. Lens of coarse chell gravel at -22.9 ft to -23.5 ft. Lens of coarse shell gravel at -24.7 ft to -25.2 ft.	CB-STL-C18-2	8.7	8.7	0.53
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C18	-19.5	CB-STL-C18-2	12	18.4		SAND, poorly graded, medium to fine grained quartz and shell hash, trace of coarse shell gravel, brown to gray. 50% shell.	CB-STL-C18-3	15	15	0.64
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C19	-31.5	CB-STL-C19-1	0	1.2		SAND, poorly graded, medium to fine grained quartz and shell hash, trace of fine shell gravel, brown. 90% shell.	CB-STL-C19-1	0.6	0.6	0.72
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C19	-31.5	CB-STL-C19-2	1.2	2.4		Gravelly SAND, poorly graded, coarse shell gravel, rigid clay, gray. 90% shell.				
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C19	-31.5	CB-STL-C19-3	2.4	6.5		SAND, poorly graded, medium to fine grained, gray-brown. 65% shell. Occaisonal whole shells decreasing down core.	CB-STL-C19-2	4.5	4.5	1.77
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C20	-27.2	CB-STL-C20-1	0	8.3		SAND, poorly graded, medium to fine grained quartz and shell hash, brown. 85% shell. Brown grades to gray at-33.7 ft.	CB-STL-C20-1	4.1	4.1	1.17

Table 4-15. SL-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C20	-27.2	CB-STL-C20-2	8.3	11		SAND, poorly graded, fine grained quartz and shell hash, brown. 65% shell. Occaisonal small lenses of fine shell gravel increasing in size down core.	CB-STL-C20-2	9.1	9.1	2.13
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C20	-27.2	CB-STL-C20-3	11	11.6		Gravelly SAND, large whole shells, gray. 95% shell.				
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C21R2	-29.1	CB-STL-C21R2-1	0	1.4		SAND, poorly graded, medium to fine grained quartz and shell hash, little coarse shell gravel, brown. 70% shell.				
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C21R2	-29.1	CB-STL-C21R2-2	1.4	2.7		SAND, poorly graded, medium to fine grained quartz and shell hash, brown. 70% shell.	CB-STL-C21R2-1	2	2	1.64
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C21R2	-29.1	CB-STL-C21R2-3	2.7	10.5		SAND, poorly graded, medium to fine grained quartz and shell hash, trace of shell gravel, brown. 80% shell.	CB-STL-C21R2-2	6	6	0.66
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C22	-30.2	CB-STL-C22-1	0	3.6		SAND, poorly graded, medium to fine grained quartz and shell hash, trace of shell gravel, brown. 90% shell. Fine shell gravel and lenses of coarse (whole) shell gravel.	CB-STL-C22-1	1.8	1.8	0.36
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C22	-30.2	CB-STL-C22-2	3.6	6.5		SAND, poorly graded, medium to fine grained quartz and shell hash, gray. 65% shell. Occaisonal small whole shells, lens of coarse shell gravel at -35.7 ft.	CB-STL-C22-2	5	5	0.36

Table 4-15. SL-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C22	-30.2	CB-STL-C22-3	6.5	8.6		Silty SAND, medium grained quartz and shell hash, gray. 50% shell. Lenses of shell gravel between -37.0 ft and -37.2 ft., and -38.1 ft and -39.8 ft.				
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C22	-30.2	CB-STL-C22-4	8.6	8.8		Clayey GRAVEL, medium grained sand, whole shells, gray. 75% shell.				
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C22	-30.2	CB-STL-C22-5	8.8	9.4		Silty GRAVEL, medium grained sand, whole shells, gray. 75% shell.				
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C23	-23.6	CB-STL-C23-1	0	5		SAND, poorly graded, medium to fine grained quartz and shell hash, brown. 90% shell. Occasional whole shellls.	CB-STL-C23-1	2.5	2.5	0.84
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C23	-23.6	CB-STL-C23-2	5	6.7		SAND, poorly graded, medium to fine grained quartz and shell hash, trace of fine shell gravel, brown. 90% shell. Large shells at -29.6 ft.	CB-STL-C23-2	5.8	5.8	0.5
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C23	-23.6	CB-STL-C23-3	6.7	9.6		SAND, poorly graded, medium to fine grained quartz and shell hash, brown. 90% shell.	CB-STL-C23-3	8.2	8.2	1.23
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C23	-23.6	CB-STL-C23-4	9.6	16		SAND, poorly graded, medium to fine grained quartz and shell hash, finer than above, brown. 75% shell. Thin lenses of fine shell gravel.	CB-STL-C23-4	12.8	12.8	1.11

Table 4-15. SL-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C23	-23.6	CB-STL-C23-5	16	20		SAND, poorly graded, medium to fine grained, trace of fine shell gravel, generally coarser than above (-33.2 ft to -39.6 ft.), brown grades to gray at core bottom. 60% shell. Occaisonal whole shells.	CB-STL-C23-5	18	18	0.58
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C24	-23.6	CB-STL-C24-1	0	3		SAND, poorly graded, medium to fine grained quartz and shell hash, brown. 65% shell. Lens of shell gravel between -31.9 ft and -32.6 ft.	CB-STL-C24-1	1.5	1.5	0.75
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C24	-23.6	CB-STL-C24-2	3	11		SAND, poorly graded, medim to fine grained quartz and shell hash, trace of silt, generally finer grained than -26.7 ft to -29.7 ft., brown. Occasional small whole shells. 65% shell.	CB-STL-C24-2	4.5	4.5	-0.36
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C24	-23.6	CB-STL-C24-2	3	11		SAND, poorly graded, medim to fine grained quartz and shell hash, trace of silt, generally finer grained than -26.7 ft to -29.7 ft., brown. Occasional small whole shells. 65% shell.	CB-STL-C24-3	8.5	8.5	0.96
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C24	-23.6	CB-STL-C24-3	11	11.5		GRAVEL, poorly graded, large whole and shell fragments, fine grained matrix, gray. 70% shell.				
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C25	-31.2	CB-STL-C25-1	0	3		SAND, poorly graded, medium to fine grained quartz and shell hash, trace of fine shell gravel, gray-brown. 70% shell. Lens of fine shell gravel.	CB-STL-C25-1	1.5	1.5	0.81

Table 4-15. SL-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C25	-31.2	CB-STL-C25-2	3	10		SAND, poorly graded, medium to fine grained quartz and shell hash, gray-brown. 70% shell.	CB-STL-C25-2	6.5	6.5	1.49
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C25	-31.2	CB-STL-C25-3	10	11.3		GRAVEL, poorly graded, shell hash, fine grained matrix, gray. 80% shell.				
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C26	-27.4	CB-STL-C26-1	0	5.4		SAND, poorly graded, medium to fine grained quartz and shell hash, gray-brown. 65% shell.	CB-STL-C26-1	2.7	2.7	1.08
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C26	-27.4	CB-STL-C26-2	5.4	7		SAND, poorly graded, medium to fine grained quartz and shell hash, finer grained thatn -27.4 ft. to -32.8 ft., brown. 70% shell.	CB-STL-C26-2	6.2	6.2	1.46
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C26	-27.4	CB-STL-C26-3	7	8.7		GRAVEL, poorly graded, coarse to medium sand, silt, gray. 80% shell.				
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C27	-29.5	CB-STL-C27-1	0	1.2		SAND, poorly graded, fine quartz and shell hash, little fine shell gravel, brown. 90% shell. Occaisional small whole shells.	CB-STL-C27-1	0.6	0.6	0.1
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C27	-29.5	CB-STL-C27-2	1.2	4.2		SAND, poorly graded, medium to fine grained quartz and shell hash, trace of shell gravel, brown. 65% shell.	CB-STL-C27-2	2.7	2.7	0.34
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C27	-29.5	CB-STL-C27-3	4.2	7.8		SAND, poorly graded, fine grained quartz and shell hash, brown. 65% shell. Occasional gravel sized whole shells and shell fragments. Lens of coarse shell gravel at -36.5 ft to -37.0 ft.	CB-STL-C27-3	6	6	1.71

Table 4-15. SL-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C28	-23.6	CB-STL-C28-1	0	3.4		SAND, poorly graded, medium to fine grained quartz and shell hash, brown. 65% shell.	CB-STL-C28-1	1.7	1.7	1.17
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C28	-23.6	CB-STL-C28-2	3.4	9		SAND, poorly graded, medium to fine grained quartz and shell hash, trace of fine shell gravel and coarse sand, brown. 65% shell. Lens of fine gravel sized shell fragments at -27.5 ft to -28.2 ft. Occasional small whole shells at -30.6 ft. to -32.2 ft.	CB-STL-C28-2	6.2	6.2	1.23
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C28	-23.6	CB-STL-C28-3	9	15		SAND, poorly graded, medium to fine grained quartz and shell hash, brown. 65% shell. Gravel sized shell content decreasing down core to -38.6 ft.	CB-STL-C28-3	12	12	1.36
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C28	-23.6	CB-STL-C28-4	15	19.2		SAND, poorly graded, medium to fine grained quartz and shell hash, trace of fine shell gravel, gray-brown. 65% shell. Generally coarser than -32.6 ft to -38.6 ft. Occasional coarse gravel-sized shell fragments.	CB-STL-C28-4	16.5	16.5	0.65
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C29	-28.4	CB-STL-C29-1	0	6		SAND, poorly graded, medium to fine grained quartz and shell hash, brown. 90% shell. Occasional gravel sized shells at -31.2 ft to -32.2 ft and at -33.9 ft to -34.4 ft.	CB-STL-C29-1	3	3	1.19

Table 4-15. SL-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C29	-28.4	CB-STL-C29-2	6	7.4		SAND, poorly graded, medium to fine grained quartz and shell hash, trace of coarse sand, gray-brown. 65% shell.	CB-STL-C29-2	6.7	6.7	1.39
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C29	-28.4	CB-STL-C29-3	7.4	8.8		Silty GRAVEL, large shells and shell fragments, rigid sand matrix, gray. 65% shell.				
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C30	-30.4	CB-STL-C30-1	0	1.3		SAND, poorly graded, medium grained quartz and shell hash, little coarse grained sand and fine shell gravel, brown. 90% shell.	CB-STL-C30-1	0.6	0.6	0.35
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C30	-30.4	CB-STL-C30-2	1.3	5.3		SAND, poorly graded, medium to fine grained quartz and shell hash, brown. 65% shell. Occaisonal gravel-sized whole shells.	CB-STL-C30-2	3.3	3.3	1.19
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C30	-30.4	CB-STL-C30-3	5.3	9.3		SAND, poorly graded, fine grained quartz and shell hash, brown. 65% shell. Occasional pockets of fine gravel-sized whole shells.	CB-STL-C30-3	7.3	7.3	1.62
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C30	-30.4	CB-STL-C30-4	9.3	10.2		Lenses of shell gravel with sand and silt at -39.7 ft to -40.7 ft				
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C31	-30.5	CB-STL-C31-1	0	2.7		SAND, poorly graded, medium to fine grained quartz and shell hash, trace of fine shell gravel, gray-brown. 95% shell.	CB-STL-C31-1	1.3	1.3	0.6

Table 4-15. SL-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C31	-30.5	CB-STL-C31-2	2.7	9.1		SAND, poorly graded, fine grained quartz and shell hash, some medium grained sand and shell fragments, gray-brown. 75% shell. Occasional small whole shells.	CB-STL-C31-2	5.9	5.9	1.68
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C32	-27.8	CB-STL-C32-1	0	4.5		SAND, poorly graded, medium to fine grained quartz and shell hash, trace of fine shell gravel, brown. 65% shell.	CB-STL-C32-1	3	3	0.99
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C32	-27.8	CB-STL-C32-2	4.5	9.2		SAND, poorly graded, medium to fine grained quartz and shell hash, brown. 65% shell	CB-STL-C32-2	6	6	1.03
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C33	-28.7	CB-STL-C33-1	0	8		SAND, poorly graded, medium to fine grained quartz and shell hash, brown. 65% shell.	CB-STL-C33-1	2.7	2.7	1.34
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C33	-28.7	CB-STL-C33-1	0	8		SAND, poorly graded, medium to fine grained quartz and shell hash, brown. 65% shell.	CB-STL-C33-2	5.4	5.4	1.23
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C34	-29.9	C34-1	0	2.6		SAND, poorly graded, medium to fien grained quartz and shell hash, brown. 90% shell. Pockets of gravel-sized whole shells.	C34-1	1.3	1.3	0.94
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C34	-29.9	C34-2	2.6	6		SAND, poorly graded, medium to fine grained quartz and shel hash, gray-brown. 75% shell.	C34-2	4.9	4.9	1.45
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C34	-29.9	C34-3	6	9.4		SAND, poorly graded, medium to fine grained quartz and shell hash, trace of fine shell gravel, trace of silt, gray-brown.	C34-3	7.2	7.2	0.58

Table 4-15. SL-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C35	-32.2	C35-1	0	5.5		SAND, poorly graded, medium to fine grained quartz and shell hash, brown. 80% shell. Occasional pockets of shell gravel.	C35-1	2.7	2.7	1.23
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C35	-32.2	C35-2	5.5	6.6		SAND, poorly graded, medium to fine grained quartz and shell hash, gray. 80% shell.	C35-2	6	6	1.41
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C35	-32.2	C35-3	6.6	8.3		Silty SAND, poorly graded, medium to fine grained quartz and shell hash, trace of fine shell gravel, gray. 60% shell.	C35-3	7.4	7.4	1.25
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C35	-32.2	C35-4	8.3	8.6		CLAY, high plasticity, green-gray.				
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C35	-32.2	C35-5	8.6	9.5		Silty GRAVEL, gray. 90% shell.				
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C35	-32.2	C35-6	9.5	10		CLAY, green-gray.				
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C35	-32.2	C35-7	10	10.9		Silty GRAVEL, gray. 90% shell.				
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C36	-27.5	C36-1	0	0.9		SAND, poorly graded, medium to fine grained quartz and shell hash, trace of fine shell gravel, brown. 90% shell.	C36-1	0.5	0.5	0.65
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C36	-27.5	C36-2	0.9	4.3		SAND, poorly graded, medium to fine grained quartz and shell hash, brown. 60% shell. Occasional pockets and lenses of gravel-sized whole shells and shell fragments.	C36-2	2.6	2.6	0.94

Table 4-15. SL-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C36	-27.5	C36-3	4.3	9.7		SAND, poorly graded, medium to fine grained quartz and shell hash, gray-brown. 60% shell. Occasional lenses of fine shell gravel.	C36-3	7	7	1.2
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C38	-30.6	C38-1	0	2.4		SAND, poorly graded, medium grained quartz and shell hash, some fine grained quartz and shell hash, some fine grained sand, little fine shell gravel, trace of coarse grained sand, gray-brown. 90% shell. Pockets of coarse shell gravel in sand matrix at-3	C38-1	1.2	1.2	-0.28
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C38	-30.6	C38-2	2.4	9.6		SAND, poorly graded, medium to fine grained quartz and shell hash. 60% shell fragments. Lens of coarse shell hash at -36.6 ft to -37.0 ft. Occasional small whole shell at -36.6 ft to -40.2 ft.	C38-2	4.8	4.8	1.45
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C38	-30.6	C38-2	2.4	9.6		SAND, poorly graded, medium to fine grained quartz and shell hash. 60% shell fragments. Lens of coarse shell hash at -36.6 ft to -37.0 ft. Occasional small whole shell at -36.6 ft to -40.2 ft.	C38-3	7.2	7.2	1.41
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C38	-30.6	C38-3	9.6	10.2		Silty SAND, whole gravel-sized shells. 75% shell.				
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C39	-29	C39-1	0	2		SAND, poorly graded, medium grained quartz and shell hash, gray-brown. 80% shell.	C39-1	1	1	0.78

Table 4-15. SL-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C39	-29	C39-2	2	5.5		SAND, poorly graded, medium to fine grained quartz and shell hash, gray-brown. 70% shell.	C39-2	4.3	4.3	1.28
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C39	-29	C39-3	5.5	9		SAND, poorly graded, fine grained quartz and shell hash, little medium grained sand, gray-brown. 70% shell.	C39-3	6.6	6.6	1.34
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C39	-29	C39-4	9	11		SAND, poorly graded, fine grained quartz and shell hash, little medium grained sand, gray. 705 shell.	C39-4	10	10	2.06
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C40	-29.6	C40-1	0	4.2		SAND, poorly graded, medium to fine grained quartz and shell hash, trace of fine shell gravel, gray-brown. 80% shell. Occasional pockets of whole shell with shell hash matrix.	C40-1	2.1	2.1	0.66
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C40	-29.6	C40-2	4.2	5.3		SAND, poorly graded, medium to fine grained quartz and shell hash, trace of fine shell gravel, gray-brown. 80% shell.	C40-2	4.7	4.7	0.91
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C40	-29.6	C40-3	5.3	9.8		SAND, poorly graded, medium to fine grained quartz and shell hash, increased fraction of fine grained sand, gray-brown. 70% shell.	C40-3	7.5	7.5	1.35
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C41	-28.1	C41-1	0	0.7		SAND, poorly graded, medium to fine grained quartz and shell hash, brown. 80% shell.				

Table 4-15. SL-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C41	-28.1	C41-2	0.7	4.6		SAND, poorly graded, fine grained quartz and shell hash, little medium grained, trace of fine shell gravel, gray-brown. 60% shell.	C41-1	2.6	2.6	1.58
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C41	-28.1	C41-3	4.6	7.5		SAND, poorly graded, medium to fine grained quartz and shell hash, gray. 65% shell.	C41-2	6.1	6.1	1.71
Ft. Pierce, FL, Shore Protection Project Phase II - Geotechnical and Borrow Area Investigation	CB-STL-C41	-28.1	C41-4	7.5	10.3		SAND, poorly graded, medium to fine grained quartz and shell hash, gray. 65% shell.	C41-3	8.9	8.9	1.58
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	32	0	32-1	0	4	LIGHT BROWNISH GRAY	mostly Coarse Sand	32-1	1	1	0.79
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	32	0	32-2	4	7	GRAY	mostly Coarse Sand; trace Clay	32-2	5	5	1.18
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	32	0	32-3	7	10	GRAY	mostly Silty Sand; trace Fine Quartz Sand				
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	53	0	53-1	0	8	10YR 7/3	mostly Coarse Quartz Sand	53-1	1	1	0.99
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	53	0	53-1	0	8	10YR 7/3	mostly Coarse Quartz Sand	53-2	6	6	1.06
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	53	0	53-2	8	9	10YR 7/1	mostly Very Coarse Quartz Sand				
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	53	0	53-3	9	10	10YR 6/1	mostly Coarse Quartz Sand				
Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida	53	0	53-4	10	10.4	10YR 6/11	mostly Coarse Sandy Sand				

Table 4-16.
Sand resource potential in Martin County by morphosedimentary units
where volume calculations are based on percent areal coverage
in the mapping unit, which is less than unity for ridge fields and Gilbert Shoal.

Morphosedimentary Feature	**Shelf Area (ha)**	**% of County Continental Shelf Area**	**% Area Used in Volume Calculations**	**Max Sediment Thickness (ft)**	**Average Sediment Thickness (ft)**	**Sediment Volume (yds^3)**
Dickinson Ridge Field	1,192	3	0.6	29.848	7.544	21,386,063
Gilbert Shoal	1,145	3	0.45	15.088	7.872	16,431,397
Martin Ridge Field A	461	1	0.3	4.92	2.624	1,378,822
Martin Ridge Field B	3,429	9	0.45	9.84	7.544	46,144,321
Salerno Shoal	842	2	1	20.008	7.872	26,860,965
St Lucie Sand Flat	24,449	61	1	6.56	6.56	633,557,743
Total	**31,518**	**79**				**745,759,310**

[1] For conversion of hectares (ha) to square kilometers (100 ha = 1 km^2) move decimal point two digits to the left.

[2] Refers to continental shelf area offshore from county lines for ease of reference. State waters lie shoreward of the 3-mile and federal waters are seaward.

[3] Some mapping units embrace larger areas than sand ridges *per se* , for example, to simplify mapping. Areas thus designated as ridge fields contain sand ridges plus intervening swales and sand plain units.

[4] Based on measurement of local relief from the reformatted NOAA bathymetry. These measurements are limited by the grid scale of the NOAA bathymetric data.

[5] Based on estimates of variation in local relief within a GIS polygon.

Table 4-17. MI-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Feasibility Report with Environmental Impact Statement Beach Erosion Control Study Martin County Florida	CB-M-17	-28	CB-M-17-1	0	14.1						
Feasibility Report with Environmental Impact Statement Beach Erosion Control Study Martin County Florida	CB-M-17	-28	CB-M-17-2	14.1	14.8	GRAY	mostly Medium To Coarse Shelly Sand				
Feasibility Report with Environmental Impact Statement Beach Erosion Control Study Martin County Florida	CB-M-17	-28	CB-M-17-3	14.8	16.3	TAN	mostly Fine To Medium Sand				
Feasibility Report with Environmental Impact Statement Beach Erosion Control Study Martin County Florida	CB-M-7	-23	CB-M-7-1	0	9.6		mostly Medium To Coarse Sand				
Feasibility Report with Environmental Impact Statement Beach Erosion Control Study Martin County Florida	CB-M-7	-23	CB-M-7-2	9.6	14.5		mostly Very Fine To Medium Sand				
Feasibility Report with Environmental Impact Statement Beach Erosion Control Study Martin County Florida	CB-M-7	-23	CB-M-7-3	14.5	19.9		mostly Medium To Coarse Sand				
Feasibility Report with Environmental Impact Statement Beach Erosion Control Study Martin County Florida	CB-M-8	-36	CB-M-8-1	0	9.6		mostly Fine To Medium Sand				
Feasibility Report with Environmental Impact Statement Beach Erosion Control Study Martin County Florida	CB-M-8	-36	CB-M-8-2	9.6	9.8		mostly Medium Sandy Limestone				
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-10 R1	-21.15	ATM-10 R1-1	0	4.6	BLACKISH BROWN	mostly Medium To Coarse Shelly Sand	ATM-10 R1-1	1	1	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-10 R1	-21.15	ATM-10 R1-1	0	4.6	BLACKISH BROWN	mostly Medium To Coarse Shelly Sand	ATM-10 R1-2	2.7	2.7	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-10 R1	-21.15	ATM-10 R1-1	0	4.6	BLACKISH BROWN	mostly Medium To Coarse Shelly Sand	ATM-10 R1-3	4	4	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-10 R1	-21.15	ATM-10 R1-2	4.6	6.9	GRAY	mostly Medium Shelly Sand	ATM-10 R1-4	6	6	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-10 R1	-21.15	ATM-10 R1-3	6.9	8.5	GRAY	mostly Fine To Medium Shelly Sand	ATM-10 R1-5	7	7	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-10 R1	-21.15	ATM-10 R1-3	6.9	8.5	GRAY	mostly Fine To Medium Shelly Sand	ATM-10 R1-6	8	8	

Table 4-17. MI-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-10 R1	-21.15	ATM-10 R1-4	8.5	12	BROWN	mostly Medium To Coarse Shelly Sand	ATM-10 R1-7	12	12	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-10 R1	-21.15	ATM-10 R1-4	8.5	12	BROWN	mostly Medium To Coarse Shelly Sand	ATM-10 R1-8	12	12	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-10 R1	-21.15	ATM-10 R1-5	12	12.7	GRAY	mostly Fine Sand	ATM-10 R1-7	12	12	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-10 R1	-21.15	ATM-10 R1-5	12	12.7	GRAY	mostly Fine Sand	ATM-10 R1-8	12	12	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-10 R2	-21.05	ATM-10 R2-6	11	13.3	GRAY	mostly Medium To Coarse Shelly Sand	ATM-10 R2-9	11	11	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-10 R2	-21.05	ATM-10 R2-7	13.3	18.4	GRAY	mostly Fine Sand; trace Silt; trace Shell Fragments	ATM-10 R2-12	16	16	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-10 R2	-21.05	ATM-10 R2-7	13.3	18.4	GRAY	mostly Fine Sand; trace Silt; trace Shell Fragments	ATM-10 R2-13	18	18	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-10 R2	-21.05	ATM-10 R2-7	13.3	18.4	GRAY	mostly Fine Sand; trace Silt; trace Shell Fragments	ATM-10 R2-11	14	14	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-10 R2	-21.05	ATM-10 R2-7	13.3	18.4	GRAY	mostly Fine Sand; trace Silt; trace Shell Fragments	ATM-10 R2-10	13.4	13.4	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-2 R1	-30.45	ATM-2 R1-1	0	9.6	BROWN	mostly Medium To Coarse Shelly Sand; trace Large Shell Hash	ATM-2 R1-1	0	0	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-2 R1	-30.45	ATM-2 R1-1	0	9.6	BROWN	mostly Medium To Coarse Shelly Sand; trace Large Shell Hash	ATM-2 R1-2	1.2	1.2	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-2 R1	-30.45	ATM-2 R1-1	0	9.6	BROWN	mostly Medium To Coarse Shelly Sand; trace Large Shell Hash	ATM-2 R1-5	6	6	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-2 R1	-30.45	ATM-2 R1-1	0	9.6	BROWN	mostly Medium To Coarse Shelly Sand; trace Large Shell Hash	ATM-2 R1-6	8	8	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-2 R1	-30.45	ATM-2 R1-1	0	9.6	BROWN	mostly Medium To Coarse Shelly Sand; trace Large Shell Hash	ATM-2 R1-4	4	4	

Table 4-17. MI-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-2 R1	-30.45	ATM-2 R1-1	0	9.6	BROWN	mostly Medium To Coarse Shelly Sand; trace Large Shell Hash	ATM-2 R1-3	2	2	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-2 R1	-30.45	ATM-2 R1-2	9.6	11.3	GRAY	mostly Fine Sand	ATM-2 R1-7	10	10	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-2 R2	-31.35	ATM-2 R2-3	11	14.3	BROWN	mostly Medium To Coarse Shelly Sand	ATM-2 R2-8	11	11	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-2 R2	-31.35	ATM-2 R2-3	11	14.3	BROWN	mostly Medium To Coarse Shelly Sand	ATM-2 R2-9	13	13	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-2 R2	-31.35	ATM-2 R2-4	14.3	15.7	GRAY	mostly Fine Shelly Sand	ATM-2 R2-10	15	15	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-2 R2	-31.35	ATM-2 R2-5	15.7	16		mostly Fine To Coarse Shelly Sand				
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-4 R1	-36.85	ATM-4 R1-1	0	4.5	DARK GRAY	mostly Medium To Coarse Shelly Sand	ATM-4 R1-1	0	0	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-4 R1	-36.85	ATM-4 R1-1	0	4.5	DARK GRAY	mostly Medium To Coarse Shelly Sand	ATM-4 R1-2	2	2	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-4 R1	-36.85	ATM-4 R1-1	0	4.5	DARK GRAY	mostly Medium To Coarse Shelly Sand	ATM-4 R1-3	4	4	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-4 R1	-36.85	ATM-4 R1-2	4.5	4.9		mostly Fine Sand				
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-4 R1	-36.85	ATM-4 R1-3	5.4	5.7		mostly Sandy Shell Hash				
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-4 R1	-36.85	ATM-4 R1-4	5.7	8.6	GRAY	mostly Coarse Shell; trace Whole Shell	ATM-4 R1-5	8	8	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-4 R1	-36.85	ATM-4 R1-4	5.7	8.6	GRAY	mostly Coarse Shell; trace Whole Shell	ATM-4 R1-4	6	6	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-4 R1	-36.85	ATM-4 R1-5	8.6	9.1	GRAYISH OLIVE	mostly Shell Hash				

Table 4-17. MI-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-4 R1	-36.85	ATM-4 R1-6	9.1	14.7	GRAY	mostly Medium To Fine Shelly Sand				
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-4 R2	-36.55	ATM-4 R2-7	13.2	14.9	WHITE	mostly Shell Hash				
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-4 R2	-36.55	ATM-4 R2-8	14.9	16.9	WHITEISH TAN	mostly Shell				
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-4 R2	-36.55	ATM-4 R2-9	16.9	17.2	WHITE	mostly Fine Silty Sand; trace Shell				
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-4 R2	-36.55	ATM-4 R2-10	17.2	18.3	WHITE	mostly Fine Silty Sand				
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-6 R1	-29.75	ATM-6 R1-1	0	3.8	BROWN	mostly Medium To Coarse Shelly Sand	ATM-6 R1-1	0	0	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-6 R1	-29.75	ATM-6 R1-1	0	3.8	BROWN	mostly Medium To Coarse Shelly Sand	ATM-6 R1-2	2	2	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-6 R1	-29.75	ATM-6 R1-2	3.8	4.1	OLIVEISH GRAY	mostly Fine Sand; trace Carbonate Shell	ATM-6 R1-3	4	4	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-6 R1	-29.75	ATM-6 R1-3	4.1	5	DARK OLIVEISH GRAY	mostly Fine To Coarse Sand; trace Silt; trace Carbonate Shell				
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-6 R1	-29.75	ATM-6 R1-4	5	5.6	DARK GRAYISH	mostly Carbonate Shell				
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-6 R1	-29.75	ATM-6 R1-5	5.6	6	OLIVEISH GRAY	mostly Carbonate Shell Hash	ATM-6 R1-4	6	6	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-6 R1	-29.75	ATM-6 R1-6	6	7.2	DARK BROWNISH GRAY	mostly Medium To Coarse Shelly Sand; trace Whole Shell	ATM-6 R1-4	6	6	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-6 R1	-29.75	ATM-6 R1-7	7.2	13	BROWN	mostly Medium To Coarse Shelly Sand	ATM-6 R1-8	10	10	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-6 R1	-29.75	ATM-6 R1-7	7.2	13	BROWN	mostly Medium To Coarse Shelly Sand	ATM-6 R1-7	12	12	

Table 4-17. MI-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-6 R1	-29.75	ATM-6 R1-7	7.2	13	BROWN	mostly Medium To Coarse Shelly Sand	ATM-6 R1-6	10	10	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-6 R1	-29.75	ATM-6 R1-7	7.2	13	BROWN	mostly Medium To Coarse Shelly Sand	ATM-6 R1-5	8	8	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-6 R2	-30	ATM-6 R2-8	13	14.2	OLIVEISH GRAY	mostly Fine Sand; trace Shell Fragments	ATM-6 R2-9	13	13	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-6 R2	-30	ATM-6 R2-9	14.2	16		mostly Fine Shelly Sand	ATM-6 R2-10	15	15	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-7	-24.1	ATM-7-1	0	8.6	GRAY	mostly Medium To Coarse Shelly Sand	ATM-7-1	0	0	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-7	-24.1	ATM-7-1	0	8.6	GRAY	mostly Medium To Coarse Shelly Sand	ATM-7-6	8	8	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-7	-24.1	ATM-7-1	0	8.6	GRAY	mostly Medium To Coarse Shelly Sand	ATM-7-5	6	6	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-7	-24.1	ATM-7-1	0	8.6	GRAY	mostly Medium To Coarse Shelly Sand	ATM-7-4	4	4	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-7	-24.1	ATM-7-1	0	8.6	GRAY	mostly Medium To Coarse Shelly Sand	ATM-7-3	2	2	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-7	-24.1	ATM-7-1	0	8.6	GRAY	mostly Medium To Coarse Shelly Sand	ATM-7-2	1	1	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-7	-24.1	ATM-7-2	8.6	8.9	LIGHT GRAY	mostly Fine Sand				
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-7	-24.1	ATM-7-3	8.9	10	BROWN	mostly Gravely Shell Hash; trace Whole Shell; trace Shell Fragments	ATM-7-7	10	10	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-7	-24.1	ATM 7-4	10	13	DARK GRAY	mostly Medium To Coarse Shelly Sand	ATM-7-8	12	12	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-7	-24.1	ATM 7-4	10	13	DARK GRAY	mostly Medium To Coarse Shelly Sand	ATM-7-7	10	10	

Table 4-17. MI-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-7	-24.1	ATM-7-5	13	13.7		mostly Shell Hash				
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-7	-24.1	ATM-7-6	13.7	16	GRAY	mostly Very Fine Sand; trace Shell Fragments	ATM-7-10	16	16	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-7	-24.1	ATM-7-6	13.7	16	GRAY	mostly Very Fine Sand; trace Shell Fragments	ATM-7-9	14	14	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-8	-22.55	ATM-8 R1-1	0	11	BLACKISH BROWN	mostly Medium To Coarse Shelly Sand; trace Shell	ATM-8 R1-2	1	1	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-8	-22.55	ATM-8 R1-1	0	11	BLACKISH BROWN	mostly Medium To Coarse Shelly Sand; trace Shell	ATM-8 R1-3	4	4	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-8	-22.55	ATM-8 R1-1	0	11	BLACKISH BROWN	mostly Medium To Coarse Shelly Sand; trace Shell	ATM-8 R1-1	0	0	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-8	-22.55	ATM-8 R1-1	0	11	BLACKISH BROWN	mostly Medium To Coarse Shelly Sand; trace Shell	ATM-8 R1-5	8	8	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-8	-22.55	ATM-8 R1-1	0	11	BLACKISH BROWN	mostly Medium To Coarse Shelly Sand; trace Shell	ATM-8 R1-6	10	10	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-8	-22.55	ATM-8 R1-1	0	11	BLACKISH BROWN	mostly Medium To Coarse Shelly Sand; trace Shell	ATM-8 R1-4	6	6	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-8	-22.55	ATM-8 R1-2	11	12	GRAY	mostly Fine To Medium Sand; trace Whole Shell	ATM-8 R1-7	12	12	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-8 R2	-22.25	ATM-8 R2-3	11	12		mostly Medium To Coarse Shelly Sand	ATM-8 R2-8	11	11	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-8 R2	-22.25	ATM-8 R2-3	11	12		mostly Medium To Coarse Shelly Sand	ATM-8 R2-9	12	12	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-8 R2	-22.25	ATM-8 R2-4	12	13.2	GRAY	mostly Fine Sand; trace Whole Shell	ATM-8 R2-9	12	12	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-8 R2	-22.25	ATM-8 R2-5	13.2	13.7		mostly Medium To Coarse Shelly Sand				

Table 4-17. MI-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-8 R2	-22.25	ATM-8 R2-6	13.7	15.7	GRAY	mostly Fine Sand; trace Shell	ATM-8 R2-10	14	14	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-8 R2	-22.25	ATM-8 R2-7	15.7	16		mostly Shell Hash	ATM-8 R2-11	16	16	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-8 R2	-22.25	ATM-8 R2-8	16	16.9	DARK GRAYISH BLACK	mostly Medium To Coarse Shelly Sand	ATM-8 R2-11	16	16	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-8 R2	-22.25	ATM-8 R2-9	16.9	17.2	GRAY	mostly Fine Sand; trace Silt; trace Shell; isolated Whole Shell				
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-9	-36.75	ATM-9-1	0	4.9	BROWNISH GRAY	mostly Fine To Coarse Shelly Sand; trace Shell	ATM-9-1	0	0	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-9	-36.75	ATM-9-1	0	4.9	BROWNISH GRAY	mostly Fine To Coarse Shelly Sand; trace Shell	ATM-9-2	2	2	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-9	-36.75	ATM-9-1	0	4.9	BROWNISH GRAY	mostly Fine To Coarse Shelly Sand; trace Shell	ATM-9-3	4	4	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-9	-36.75	ATM-9-2	4.9	5.1	OLIVEISH GRAY	mostly Inorganic Clay				
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-9	-36.75	ATM-9-3	5.1	7	OLIVEISH GRAY	mostly Medium To Coarse Shelly Sand	ATM-9-4	6	6	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-9	-36.75	ATM-9-4	7	7.3	OLIVEISH GRAY	mostly Shell Hash				
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-9	-36.75	ATM-9-5	7.3	7.5	DARK GRAY	mostly Medium To Coarse Shelly Sand				
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-9	-36.75	ATM-9-6	7.5	8.3	WHITE	mostly Very Fine Sand	ATM-9-5	8	8	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-9	-36.75	ATM-9-7	8.3	8.9	OLIVEISH GRAY	mostly Shell				
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-9	-36.75	ATM-9-8	8.9	9.3		mostly Fine Shelly Sand				

Table 4-17. MI-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-9	-36.75	ATM-9-9	10.5	12.9	WHITE	mostly Coarse Shell Hash	ATM-9-7	12	12	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-9	-36.75	ATM-9-10	12.9	14.2	WHITE	mostly Fine Sand				
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-9	-36.75	ATM-9-11	14.6	15.7		mostly Shell Hash				
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-9	-36.75	ATM-9-12	15.7	16.3	OLIVEISH GRAY	mostly Fine Shelly Sand	ATM-9-6	16	16	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-9	-36.75	ATM-9-12	15.7	16.3	OLIVEISH GRAY	mostly Fine Shelly Sand	ATM-9-9	16	16	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-9	-36.75	ATM-9-13	16.3	19.2	WHITE	mostly Shell				
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-A	-34.55	ATM-A-1	0	2.7	BROWN	mostly Medium To Coarse Shelly Sand	ATM-A-1	0	0	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-A	-34.55	ATM-A-1	0	2.7	BROWN	mostly Medium To Coarse Shelly Sand	ATM-A-2	1.3	1.3	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-A	-34.55	ATM-A-1	0	2.7	BROWN	mostly Medium To Coarse Shelly Sand	ATM-A-3	2	2	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-A	-34.55	ATM-A-2	2.7	3		mostly Shell Hash				
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-A	-34.55	ATM-A-3	3	6.5	GRAY	mostly Medium To Fine Sand	ATM-A-4	4	4	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-A	-34.55	ATM-A-3	3	6.5	GRAY	mostly Medium To Fine Sand	ATM-A-5	6	6	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-A	-34.55	ATM-A-4	6.5	7.5	DARK GRAYISH	mostly Carbonate Shell Hash	ATM-A-6	7	7	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-A	-34.55	ATM-A-5	7.5	9.1	GRAY	mostly Fine Sand	ATM-A-7	8	8	

Table 4-17. MI-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-A	-34.55	ATM-A-6	9.1	11.9	DARK GRAYISH	mostly Coarse Shelly Sand	ATM-A-8	10	10	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-A	-34.55	ATM-A-7	11.9	13.2	DARK GRAYISH	mostly Shell	ATM-A-9	12	12	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-A	-34.55	ATM-A-8	13.7	16.3	WHITE	mostly Fine Shelly Sand				
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-B	-35.1	ATM-B-1	0	4.5	BROWN	mostly Medium To Coarse Shelly Sand	ATM-B-1	0	0	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-B	-35.1	ATM-B-1	0	4.5	BROWN	mostly Medium To Coarse Shelly Sand	ATM-B-3	4	4	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-B	-35.1	ATM-B-1	0	4.5	BROWN	mostly Medium To Coarse Shelly Sand	ATM-B-2	2.3	2.3	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-B	-35.1	ATM-B-2	4.5	6.2	DARK GRAYISH	mostly Medium To Coarse Sand	ATM-B-4	6	6	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-B	-35.1	ATM-B-3	6.2	6.9	GRAY	mostly Fine To Medium Sand				
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-B	-35.1	ATM-B-4	6.9	8.1	DARK GRAYISH	mostly Coarse Shelly Carbonate Sand	ATM-B-5	8	8	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-B	-35.1	ATM-B-5	8.1	10	GRAY	mostly Fine To Medium Sand	ATM-B-6	10	10	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-B	-35.1	ATM-B-6	10	12.7	GRAY	mostly Fine Sand; trace Shell	ATM-B-7	12	12	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-B	-35.1	ATM-B-6	10	12.7	GRAY	mostly Fine Sand; trace Shell	ATM-B-6	10	10	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-B	-35.1	ATM-B-7	12.7	14.3		mostly Fine Muddy Sand	ATM-B-8	14	14	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-B	-35.1	ATM-B-8	14.3	14.8	DARK BROWNISH	mostly Clay				

Table 4-17. MI-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-B	-35.1	ATM-B-9	14.8	15.8		mostly Carbonate Shell				
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-B	-35.1	ATM-B-10	15.8	16.3	GRAY	mostly Fine Sand	ATM-B-9	16	16	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-B	-35.1	ATM-B-11	16.3	17.3		mostly Fine Shelly Sand				
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-C	-33.3	ATM-C-1	0.3	3.2	BROWN	mostly Medium To Coarse Shelly Sand	ATM-C-2	2	2	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-C	-33.3	ATM-C-2	3.2	6.4	GRAY	mostly Fine Sand; trace Carbonate Shell	ATM-C-3	4	4	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-C	-33.3	ATM-C-2	3.2	6.4	GRAY	mostly Fine Sand; trace Carbonate Shell	ATM-C-4	6	6	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-C	-33.3	ATM-C-3	6.4	7.1	DARK GRAYISH	mostly Medium To Coarse Shelly Sand				
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-C	-33.3	ATM-C-4	7.1	8.5		mostly Fine Sand; trace Shell	ATM-C-5	8	8	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-C	-33.3	ATM-C-5	8.5	10.2	GRAY	mostly Fine To Coarse Sand	ATM-C-6	10	10	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-C	-33.3	ATM-C-6	10.2	10.7	GRAY	mostly Fine Sand; trace Carbonate Shell				
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-C	-33.3	ATM-C-7	10.7	11.3	GRAY	mostly Coarse Shelly Sand				
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-C	-33.3	ATM-C-8	11.3	12.1	GRAY	mostly Fine Sand	ATM-C-7	12	12	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-C	-33.3	ATM-C-9	12.1	14	GRAY	mostly Fine Silty Sand	ATM-C-8	14	14	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-C	-33.3	ATM-C-10	14	15	BROWN	mostly Shell Hash	ATM-C-8	14	14	

Table 4-17. MI-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-D R1	-23.1	ATM-D R1-1	0	10.3	BROWNISH GRAY	mostly Fine To Very Coarse Shelly Sand	ATM-D R1-1	0	0	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-D R1	-23.1	ATM-D R1-1	0	10.3	BROWNISH GRAY	mostly Fine To Very Coarse Shelly Sand	ATM-D R1-2	2	2	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-D R1	-23.1	ATM-D R1-1	0	10.3	BROWNISH GRAY	mostly Fine To Very Coarse Shelly Sand	ATM-D R1-3	4	4	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-D R1	-23.1	ATM-D R1-1	0	10.3	BROWNISH GRAY	mostly Fine To Very Coarse Shelly Sand	ATM-D R1-4	6	6	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-D R1	-23.1	ATM-D R1-1	0	10.3	BROWNISH GRAY	mostly Fine To Very Coarse Shelly Sand	ATM-D R1-6	10	10	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-D R1	-23.1	ATM-D R1-1	0	10.3	BROWNISH GRAY	mostly Fine To Very Coarse Shelly Sand	ATM-D R1-5	8	8	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-D R1	-23.1	ATM-D R1-2	10.2	12.3	GRAYISH BROWN	mostly Fine To Coarse Shelly Carbonate Sand	ATM-D R1-7	12	12	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-D R1	-23.1	ATM-D R1-3	12.3	12.8	DARK GRAYISH	mostly Medium To Coarse Shelly Sand; trace Shell Hash				
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-D R1	-23.1	ATM-D R1-4	12.8	14	GRAY	mostly Fine Sand; trace Shell	ATM-D R1-8	14	14	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-D R2	-22.9	ATM-D R2-5	12.2	14		mostly Fine To Medium Shelly Sand	ATM-D R2-10	14	14	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-D R2	-22.9	ATM-D R2-6	14	15.8	GRAY	mostly Fine To Medium Sand	ATM-D R2-10	14	14	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-D R2	-22.9	ATM-D R2-7	15.8	16.9		mostly Fine To Medium Sand	ATM-D R2-11	16	16	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-D R2	-22.9	ATM-D R2-8	16.9	17.4		mostly Fine To Medium Shelly Sand				
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-E	-31.5	ATM-E-1	0	4.9	BROWN	mostly Medium To Coarse Shelly Carbonate Sand	ATM-E-1	0	0	

Table 4-17. MI-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-E	-31.5	ATM-E-1	0	4.9	BROWN	mostly Medium To Coarse Shelly Carbonate Sand	ATM-E-2	2	2	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-E	-31.5	ATM-E-1	0	4.9	BROWN	mostly Medium To Coarse Shelly Carbonate Sand	ATM-E-3	4	4	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-E	-31.5	ATM-E-2	4.9	6.8	GRAY	mostly Fine Sand; trace Silt; trace Shell	ATM-E-4	6	6	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-E	-31.5	ATM-E-3	6.8	7.8	DARK GRAYISH	mostly Fine To Coarse Sand				
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-E	-31.5	ATM-E-4	7.8	13.8	OLIVEISH GRAY	mostly Fine Sand; trace Shell Fragments	ATM-E-5	8	8	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-E	-31.5	ATM-E-4	7.8	13.8	OLIVEISH GRAY	mostly Fine Sand; trace Shell Fragments	ATM-E-6	10	10	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-E	-31.5	ATM-E-4	7.8	13.8	OLIVEISH GRAY	mostly Fine Sand; trace Shell Fragments	ATM-E-7	12	12	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-E	-31.5	ATM-E-5	13.8	14.3		mostly Carbonate Shell	ATM-E8	14	14	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-E	-31.5	ATM-E-6	14.3	15.5	OLIVEISH GRAY	mostly Fine Sand				
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-E	-31.5	ATM-E-7	15.5	16		mostly Coarse Shell	ATM-E-9	16	16	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-G R1	-24.45	ATM-G R1-1	0	6.9	BROWN	mostly Medium To Coarse Shelly Sand	ATM-G R1-1	0	0	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-G R1	-24.45	ATM-G R1-1	0	6.9	BROWN	mostly Medium To Coarse Shelly Sand	ATM-G R1-2	2	2	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-G R1	-24.45	ATM-G R1-1	0	6.9	BROWN	mostly Medium To Coarse Shelly Sand	ATM-G R1-3	4	4	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-G R1	-24.45	ATM-G R1-1	0	6.9	BROWN	mostly Medium To Coarse Shelly Sand	ATM-G R1-4	0	0	

Table 4-17. MI-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-G R1	-24.45	ATM-G R1-1	0	6.9	BROWN	mostly Medium To Coarse Shelly Sand	ATM-G R1-5	0	0	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-G R1	-24.45	ATM-G R1-2	6.9	8.2	DARK GRAYISH	mostly Fine To Coarse Shelly Sand				
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-G R1	-24.45	ATM-G R1-3	8.2	9	DARK BROWNISH GRAY	mostly Fine To Coarse Shelly Carbonate Sand				
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-G R1	-24.45	ATM-G R1-4	9	9.3	GRAY	mostly Fine Sand; trace Carbonate Shell				
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-G R2	-24.65	ATM-G R2-5	9	10	BROWN	mostly Medium To Coarse Shelly Sand	ATM-G R2-6	9.3	9.3	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-G R2	-24.65	ATM-G R2-5	9	10	BROWN	mostly Medium To Coarse Shelly Sand	ATM-G R2-7	9	9	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-G R2	-24.65	ATM-G R2-6	10	11.3	LIGHT TANISH GRAY	mostly Fine Sand; trace Shell	ATM-G R2-8	11	11	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-G R2	-24.65	ATM-G R2-7	11.3	11.7	DARK GRAYISH	mostly Coarse Shelly Sand				
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-G R2	-24.65	ATM-G R2-8	11.7	13.1	OLIVEISH GRAY	mostly Fine Sand; trace Shell	ATM-G R2-9	13	13	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-G R2	-24.65	ATM-G R2-9	13.1	13.3	DARK GRAYISH	mostly Coarse Shelly Sand				
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-G R2	-24.65	ATM-G R2-10	13.3	15.1	OLIVEISH GRAY	mostly Fine Sand; trace Carbonate Shell	ATM-G R2-10	15	15	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-G R2	-24.65	ATM-G R2-11	15.1	19.3	BROWNISH GRAY	mostly Medium To Coarse Shelly Sand; trace Shell Fragments; trace Whole Shell	ATM-G R2-11	16	16	
Final Report (Vol I&II) Vibracore Sampling Collection and Geotechnical Testing in the Atlantic Ocean off the Coast of South Florida	ATM-G R2	-24.65	ATM-G R2-11	15.1	19.3	BROWNISH GRAY	mostly Medium To Coarse Shelly Sand; trace Shell Fragments; trace Whole Shell	ATM-G R2-12	19	19	
Martin County Beach Erosion Control (1978)	CB-M-11	-31.5	CB-M-11a	0	9.5	GRAY	mostly Fine To Medium Shelly Sand				

Table 4-17. MI-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Martin County Beach Erosion Control (1978)	CB-M-11	-31.5	CB-M-11b	9.5	11	GRAY	mostly Fine Quartz Sand; trace Silt				
Martin County Beach Erosion Control (1978)	CB-M-12	-28	CB-M-12a	0	6.2	GRAY	mostly Medium To Coarse Shelly Sand				
Martin County Beach Erosion Control (1978)	CB-M-12	-28	CB-M-12b	6.2	9.9	LIGHT GRAYISH	mostly Very Fine To Medium Sand; trace Shell				
Martin County Beach Erosion Control (1978)	CB-M-12	-28	CB-M-12c	9.9	16.4	GRAY	mostly Shell Fragments; trace Silt; trace Sand				
Martin County Beach Erosion Control (1978)	CB-M-12	-28	CB-M-12d	16.4	17	GRAY	mostly Medium To Coarse Shelly Sand				
Martin County Beach Erosion Control (1978)	CB-M-12	-28	CB-M-12e	17	20		mostly Sandy Silt; trace Inorganics; isolated Shell				
Martin County Beach Erosion Control (1978)	CB-M-13	-36	CB-M-13a	0	10.2		mostly Very Fine To Coarse Shelly Sand; trace Silt				
Martin County Beach Erosion Control (1978)	CB-M-13	-36	CB-M-13b	10.2	11.5		mostly Limestone; trace Shell; trace Silt; trace Sand				
Martin County Beach Erosion Control (1978)	CB-M-17	-28	CB-M-17a	0	14.1		mostly Fine To Medium Sand				
Martin County Beach Erosion Control (1978)	CB-M-17	-28	CB-M-17b	14.1	14.8	GRAY	mostly Medium To Coarse Shelly Sand				
Martin County Beach Erosion Control (1978)	CB-M-17	-28	CB-M-17c	14.8	16.3	TAN	mostly Fine To Medium Sand; trace Shell				
Martin County Beach Erosion Control (1978)	CB-M-18	-30	CB-M-18	0	11	GRAY	mostly Fine To Medium Shelly Quartz Sand; trace Silt				
Martin County Beach Erosion Control (1978)	CB-M-21	-36.5	CB-M-21a	0	4.7	GRAY	mostly Medium To Coarse Shelly Sand				
Martin County Beach Erosion Control (1978)	CB-M-21	-36.5	CB-M-21b	4.7	6.6		mostly Fine To Medium Shelly Quartz Sand; trace Silt				
Martin County Beach Erosion Control (1978)	CB-M-21	-36.5	CB-M-21c	6.6	7.3		mostly Shelly Limestone				
Martin County Beach Erosion Control (1978)	CB-M-3	-25	CB-M-3a	0	17.3	GRAY	mostly Medium To Coarse Sand				
Martin County Beach Erosion Control (1978)	CB-M-3	-25	CB-M-3b	17.3	20.2	LIGHT GRAYISH	mostly Very Fine To Medium Sand; trace Shell				

Table 4-17. MI-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Martin County Beach Erosion Control (1978)	CB-M-8	-36	CB-M-8a	0	9.6		mostly Fine To Medium Shelly Sand; trace Silt				
Martin County Beach Erosion Control (1978)	CB-M-8	-36	CB-M-8b	9.6	9.8		mostly Medium Sandy Limestone				
Martin County Beach Erosion Control (1978)	CM-B-7	-23	CB-M-7a	0	9.6		mostly Medium To Coarse Sand				
Martin County Beach Erosion Control (1978)	CM-B-7	-23	CM-B-7b	9.6	14.5		mostly Very Fine To Medium Sand; trace Shell; trace Silt				
Martin County Beach Erosion Control (1978)	CM-B-7	-23	CM-B-7c	14.5	19.9		mostly Medium To Coarse Sand				
Martin County Beach Erosion Control (1999)	CB-MC99-1	-25.6	CB-MC99-1a	0	6.5	GRAY	mostly Fine To Medium Sand				
Martin County Beach Erosion Control (1999)	CB-MC99-2	-25	CB-MC99-2a	0	5.9	GRAY	mostly Fine To Medium Silty Sand				
Martin County Beach Erosion Control (1999)	CB-MC99-3	-24.4	CB-MC99-3a	0	6	GRAY	mostly Fine To Medium Silty Sand				
Martin County Beach Erosion Control (1999)	CB-MC99-4	-23.5	CB-MC99-4a	0	5.8	GRAY	mostly Fine To Medium Silty Sand				
Martin County Beach Erosion Control (1999)	CB-MC99-5	-27	CB-MC99-5a	0	6.3	GRAY	mostly Fine To Medium Silty Sand				
Martin County Beach Erosion Control (1999)	CB-MC99-6	-28.2	CB-MC99-6a	0	6.4	GRAY	mostly Fine To Medium Silty Sand				
Martin County Beach Erosion Control (1999)	CB-MC99-7	-28.1	CB-MC99-7a	0	5.8	GRAY	mostly Fine To Medium Silty Sand				
Martin County Beach Erosion Control (1999)	CB-MC99-8	-31.4	CB-MC99-8a	0	5.9	GRAY	mostly Fine To Medium Silty Sand				
Martin County Beach Erosion Control (1999)	CB-MC99-9	-33.3	CB-MC99-9a	0	5.7	GRAY	mostly Fine To Medium Silty Sand				
Martin County Beach Erosion Control (1999)	CB-MC99-10	-31.2	CB-MC99-10a	0	9.2	GRAY	mostly Fine To Medium Silty Sand				
Martin County Beach Erosion Control (1999)	CB-MC99-11	-32	CB-MC99-11a	0	6.7	GRAY	mostly Fine To Medium Silty Sand				
Martin County Beach Erosion Control (1999)	MC-3	-24.7	MC-3a	0	6.8	TAN	mostly Medium To Fine Sand; trace Whole Shell				
Martin County Beach Erosion Control (1999)	MC-3	-24.7	MC-3b	6.8	11.9	LIGHT GRAYISH	mostly Fine Sand				
Martin County Beach Erosion Control (1999)	MC-3	-24.7	MC-3c	11.9	15.1	TAN	mostly Medium To Fine Sand; trace Shell				
Martin County Beach Erosion Control (1999)	MC-3	-24.7	MC-3d	15.1	17.1	TAN	mostly Coarse Shell				
Martin County Beach Erosion Control (1999)	MC-3	-24.7	MC-3e	17.1	19.5	GRAY	mostly Coarse Shell				

Table 4-17. MI-2 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Martin County Beach Erosion Control (1999)	MC-3	-24.7	MC-3f	19.5	20.3	LIGHT GRAYISH	mostly Fine Sand				
Martin County Beach Erosion Control (1999)	MC-5	-29.2	MC-5a	0	1.6	TAN	mostly Medium Sand				
Martin County Beach Erosion Control (1999)	MC-5	-29.2	MC-5b	1.6	9.3	TAN	mostly Medium Sand; trace Whole Shell				
Martin County Beach Erosion Control (1999)	MC-5	-29.2	MC-5c	9.3	11.5	GRAY	mostly Fine Sand				
Martin County Beach Erosion Control (1999)	MC-5	-29.2	MC-5d	11.5	12.4	GRAY	mostly Very Fine Sand				
Martin County Beach Erosion Control (1999)	MC-5	-29.2	MC-5e	12.4	19.6	LIGHT GRAYISH	mostly Fine Sand; trace Whole Shell				
Martin County Beach Erosion Control (1999)	MC-5	-29.2	MC-5f	19.6	20	GRAY	mostly Mud				
Martin County Beach Erosion Control (1999)	MC-5	-29.2	MC-5g	20	20.3	GRAY	mostly Medium Sand				
Martin County Beach Erosion Control (1999)	MC-6	-26.4	MC-6a	0	9.2	TAN	mostly Medium Sand; trace Whole Shell				
Martin County Beach Erosion Control (1999)	MC-6	-26.4	MC-6b	9.2	12	GRAYISH BEIGE	mostly Medium Sand				
Martin County Beach Erosion Control (1999)	MC-6	-26.4	MC-6c	12	18.5	LIGHT GRAYISH	mostly Fine Sand				
Martin County Beach Erosion Control (1999)	MC-6	-26.4	MC-6d	18.5	19	GRAY	mostly Fine Sand				

Table 4-18. MI-4 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Sand Search 1989 Jupiter Island Beach Renourishment Program	7	-39.2	7a	0	1.5	GRAY	mostly Coarse Sand	1-Jul	0	1.5	
Sand Search 1989 Jupiter Island Beach Renourishment Program	7	-39.2	7a	0	1.5	GRAY	mostly Coarse Sand	2-Jul	1.5	4.5	
Sand Search 1989 Jupiter Island Beach Renourishment Program	7	-39.2	7b	1.5	4.5	LIGHT GRAYISH	mostly Very Fine To Medium Sand; trace Silt	1-Jul	0	1.5	
Sand Search 1989 Jupiter Island Beach Renourishment Program	7	-39.2	7b	1.5	4.5	LIGHT GRAYISH	mostly Very Fine To Medium Sand; trace Silt	2-Jul	1.5	4.5	
Sand Search 1989 Jupiter Island Beach Renourishment Program	7	-39.2	7b	1.5	4.5	LIGHT GRAYISH	mostly Very Fine To Medium Sand; trace Silt	3-Jul	4.5	5.6	
Sand Search 1989 Jupiter Island Beach Renourishment Program	7	-39.2	7c	4.5	5.6	GRAY	mostly Sand	2-Jul	1.5	4.5	
Sand Search 1989 Jupiter Island Beach Renourishment Program	7	-39.2	7c	4.5	5.6	GRAY	mostly Sand	3-Jul	4.5	5.6	
Sand Search 1989 Jupiter Island Beach Renourishment Program	7	-39.2	7c	4.5	5.6	GRAY	mostly Sand	4-Jul	5.6	18.8	
Sand Search 1989 Jupiter Island Beach Renourishment Program	7	-39.2	7d	5.6	18.8	LIGHT GRAYISH	mostly Very Fine To Medium Sand; trace Silt	3-Jul	4.5	5.6	
Sand Search 1989 Jupiter Island Beach Renourishment Program	7	-39.2	7d	5.6	18.8	LIGHT GRAYISH	mostly Very Fine To Medium Sand; trace Silt	4-Jul	5.6	18.8	
Sand Search 1989 Jupiter Island Beach Renourishment Program	10	-32.8	10a	0	6.9	TANISH GRAY	mostly Medium To Coarse Quartz Sand	1-Oct	0	6.9	
Sand Search 1989 Jupiter Island Beach Renourishment Program	10	-32.8	10a	0	6.9	TANISH GRAY	mostly Medium To Coarse Quartz Sand	2-Oct	6.9	14.5	

Table 4-18. MI-4 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Sand Search 1989 Jupiter Island Beach Renourishment Program	10	-32.8	10b	6.9	14.5	LIGHT GRAYISH	mostly Very Fine To Medium Sand; trace Silt	1-Oct	0	6.9	
Sand Search 1989 Jupiter Island Beach Renourishment Program	10	-32.8	10b	6.9	14.5	LIGHT GRAYISH	mostly Very Fine To Medium Sand; trace Silt	2-Oct	6.9	14.5	
Sand Search 1989 Jupiter Island Beach Renourishment Program	11	-32.2	11a	0	8.8	TANISH GRAY	mostly Medium To Coarse Quartz Sand	1-Nov	0	8.8	
Sand Search 1989 Jupiter Island Beach Renourishment Program	11	-32.2	11a	0	8.8	TANISH GRAY	mostly Medium To Coarse Quartz Sand	2-Nov	8.8	15.7	
Sand Search 1989 Jupiter Island Beach Renourishment Program	11	-32.2	11b	8.8	15.7	LIGHT GRAYISH	mostly Very Fine To Medium Sand; trace Silt	1-Nov	0	8.8	
Sand Search 1989 Jupiter Island Beach Renourishment Program	11	-32.2	11b	8.8	15.7	LIGHT GRAYISH	mostly Very Fine To Medium Sand; trace Silt	2-Nov	8.8	15.7	
Sand Search 1989 Jupiter Island Beach Renourishment Program	12	-45	12a	0	2.7	TANISH GRAY	mostly Medium To Coarse Sand	1-Dec	0	2.7	
Sand Search 1989 Jupiter Island Beach Renourishment Program	12	-45	12a	0	2.7	TANISH GRAY	mostly Medium To Coarse Sand	2-Dec	2.7	13	
Sand Search 1989 Jupiter Island Beach Renourishment Program	12	-45	12b	2.7	13	LIGHT GRAYISH	mostly Very Fine To Medium Sand; trace Silt	1-Dec	0	2.7	
Sand Search 1989 Jupiter Island Beach Renourishment Program	12	-45	12b	2.7	13	LIGHT GRAYISH	mostly Very Fine To Medium Sand; trace Silt	2-Dec	2.7	13	
Sand Search 1989 Jupiter Island Beach Renourishment Program	13	-44.6	13a	0	1.8	GRAY	mostly Sand; trace Silt	13-1	0	1.8	
Sand Search 1989 Jupiter Island Beach Renourishment Program	13	-44.6	13a	0	1.8	GRAY	mostly Sand; trace Silt	13-2	1.8	2.8	

Table 4-18. MI-4 results from ROSS vibracore query.

Sand Query ResultsProject Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Sand Search 1989 Jupiter Island Beach Renourishment Program	13	-44.6	13b	1.8	2.8	LIGHT GRAYISH	mostly Very Fine To Medium Sand; trace Silt	13-1	0	1.8	
Sand Search 1989 Jupiter Island Beach Renourishment Program	13	-44.6	13b	1.8	2.8	LIGHT GRAYISH	mostly Very Fine To Medium Sand; trace Silt	13-2	1.8	2.8	
Sand Search 1989 Jupiter Island Beach Renourishment Program	13	-44.6	13b	1.8	2.8	LIGHT GRAYISH	mostly Very Fine To Medium Sand; trace Silt	13-3	2.8	4.1	
Sand Search 1989 Jupiter Island Beach Renourishment Program	13	-44.6	13c	2.8	4.1	GRAY	mostly Very Fine To Coarse Sand	13-2	1.8	2.8	
Sand Search 1989 Jupiter Island Beach Renourishment Program	13	-44.6	13c	2.8	4.1	GRAY	mostly Very Fine To Coarse Sand	13-3	2.8	4.1	
Sand Search 1989 Jupiter Island Beach Renourishment Program	13	-44.6	13c	2.8	4.1	GRAY	mostly Very Fine To Coarse Sand	13-4	4.1	9.2	
Sand Search 1989 Jupiter Island Beach Renourishment Program	13	-44.6	13d	4.1	9.2	LIGHT GRAYISH	mostly Very Fine To Fine Sand; trace Silt	13-3	2.8	4.1	
Sand Search 1989 Jupiter Island Beach Renourishment Program	13	-44.6	13d	4.1	9.2	LIGHT GRAYISH	mostly Very Fine To Fine Sand; trace Silt	13-4	4.1	9.2	
Sand Search 1989 Jupiter Island Beach Renourishment Program	23	-40.1	23a	0	11.9	LIGHT GRAYISH	mostly Very Fine To Fine Sand; trace Silt; trace Shell	23-1	0	11.9	

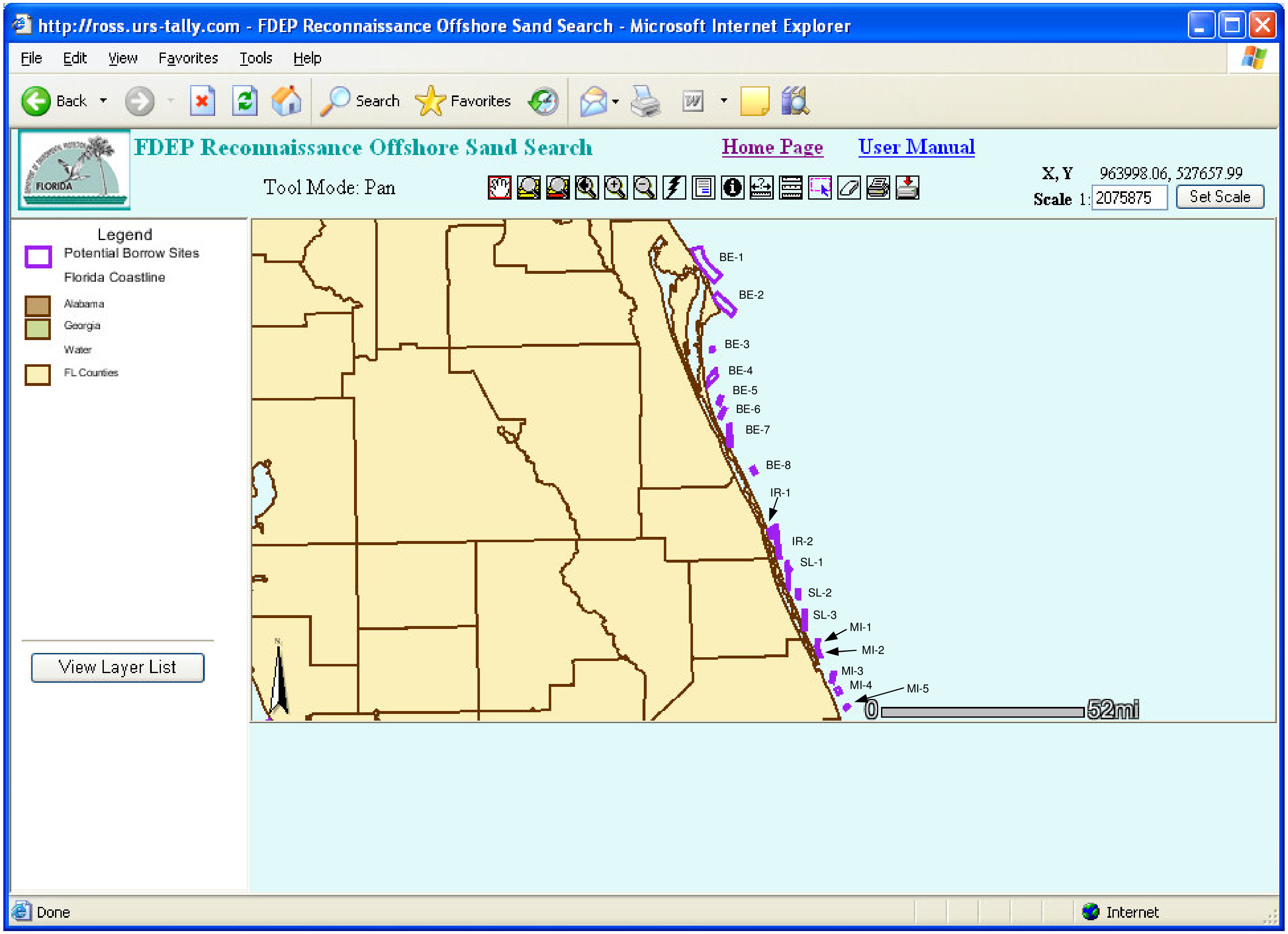


Figure 4-1. Potential Sand Source Areas for the Central Atlantic Phase II Region.

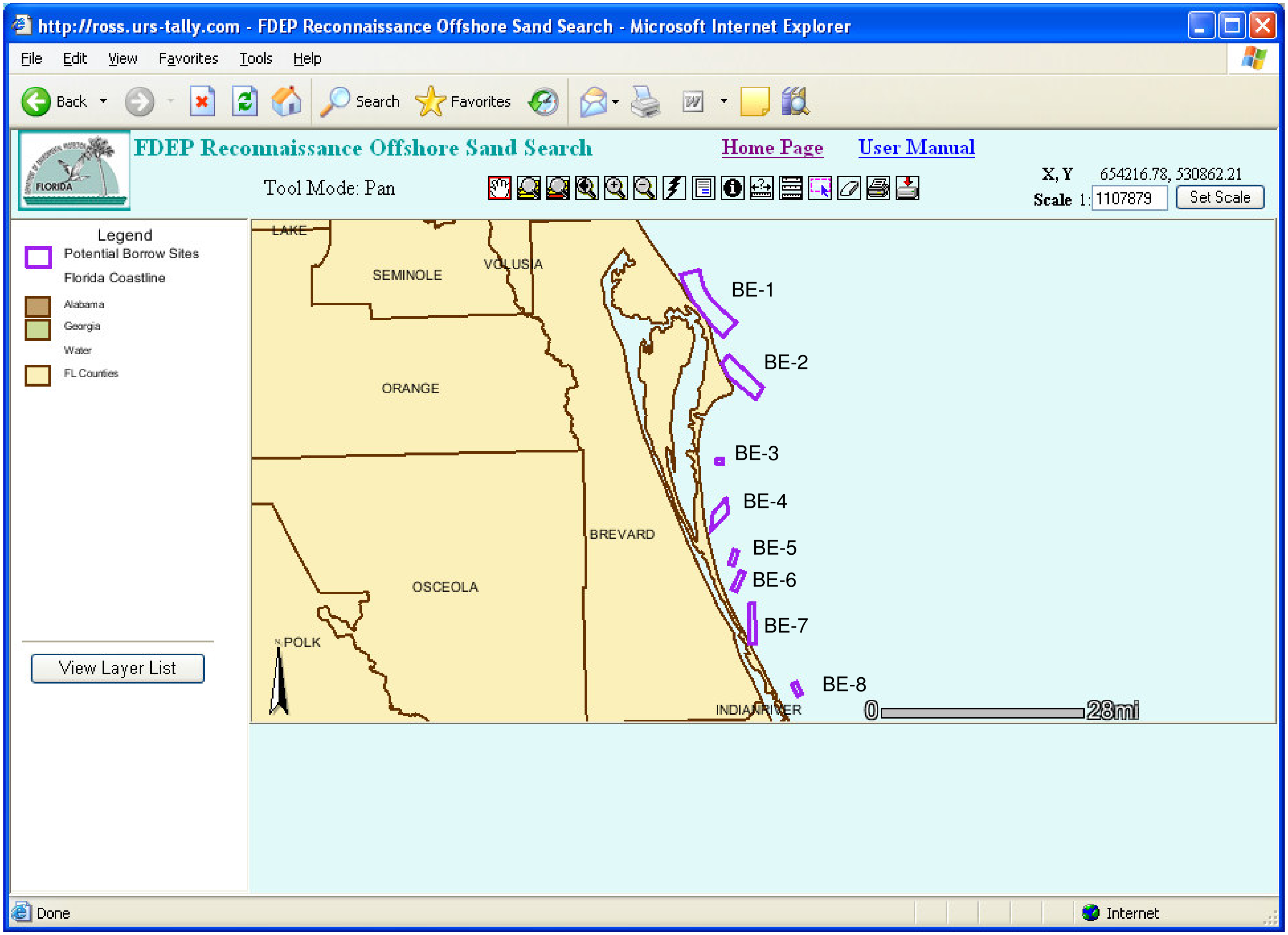


Figure 4-2. Brevard County Nearshore Potential Borrow Areas.

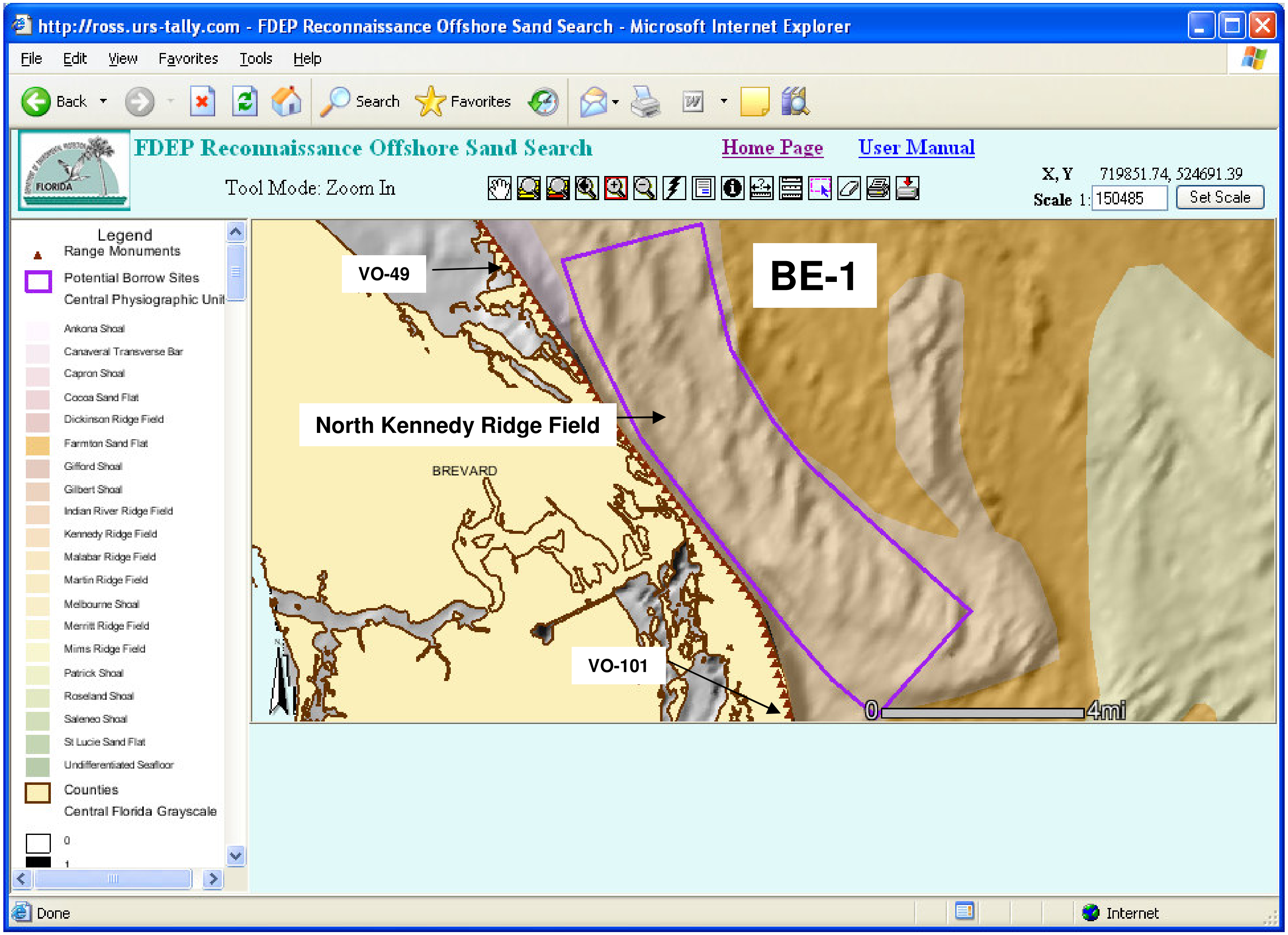


Figure 4-3. Brevard County Area BE-1 showing physiographic zones overlaying the gray scale image.

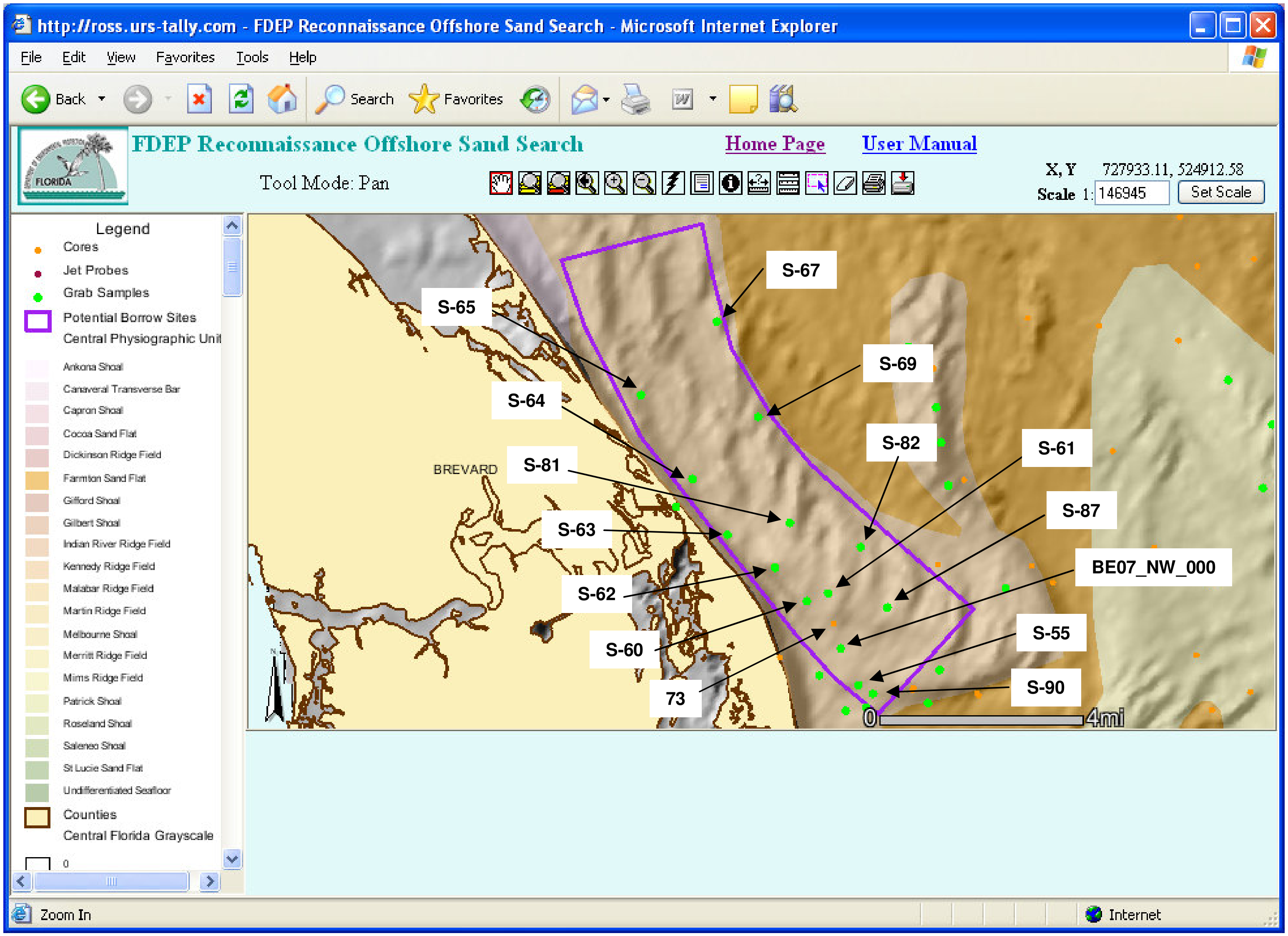


Figure 4-4. Brevard County Area BE-1 showing Vibracore and Grab Sample locations.

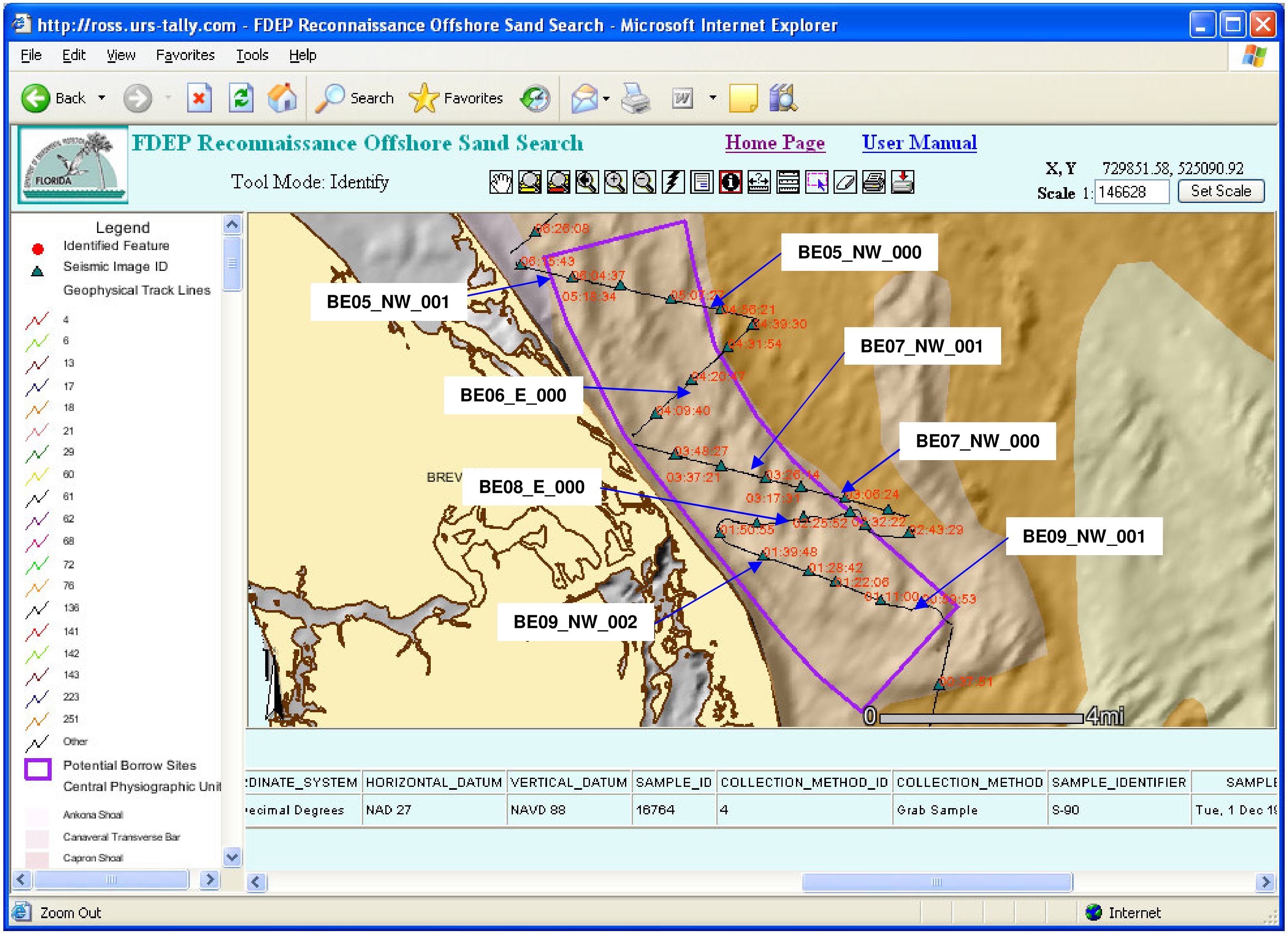


Figure 4-5. Brevard County Area BE-1 showing geophysical trackline locations and timestamps.

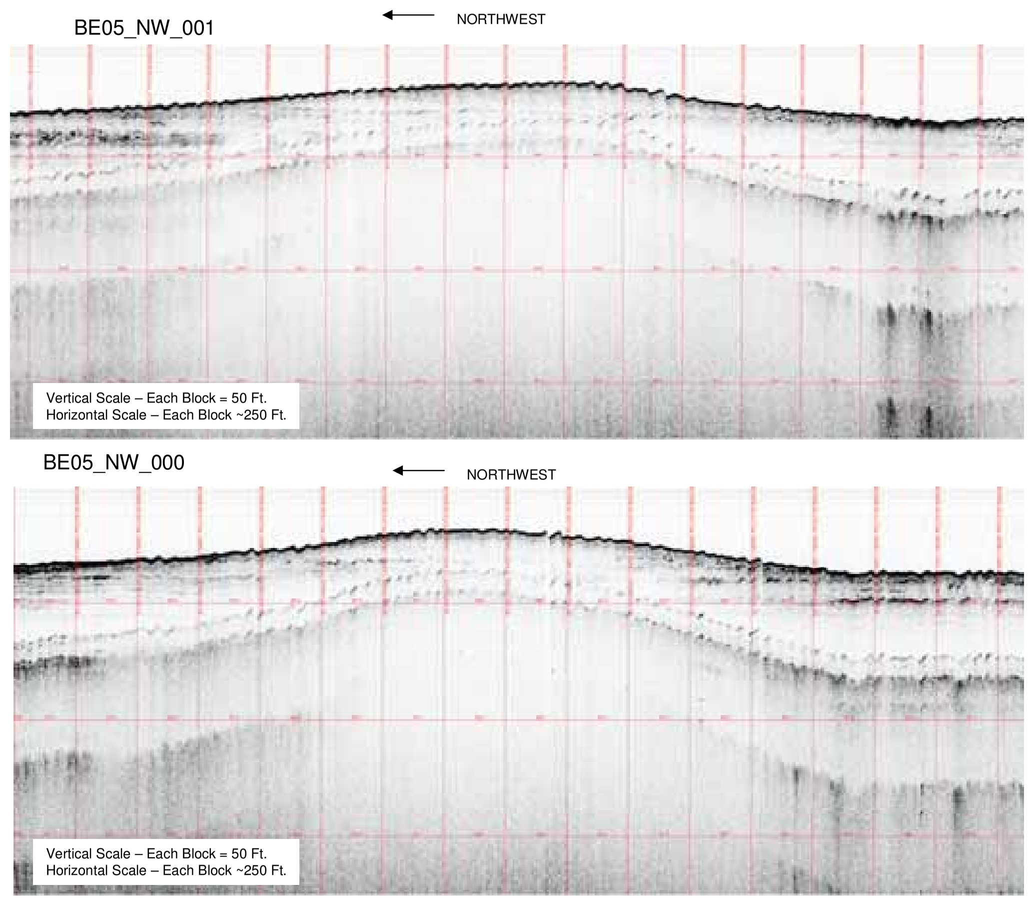


Figure 4-6A. Brevard County Area BE-1. Portions of lines BE05_NW_001 (above) and BE05_NW_000 (below) showing two prominent sand ridges within the North Kennedy Ridge Field.

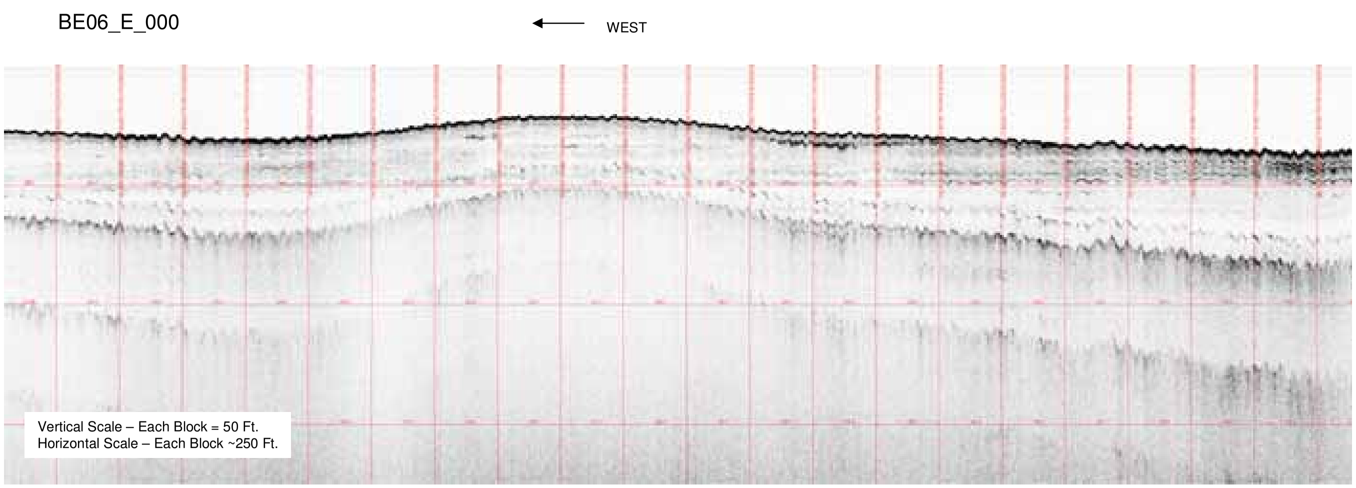
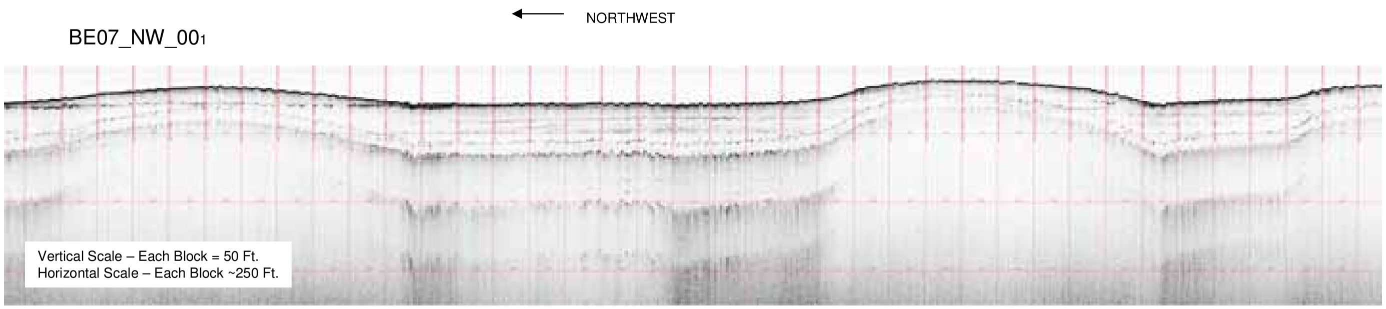


Figure 4-6B. Brevard County Area BE-1. Line BE06_E_000 showing the location of a sand ridge.



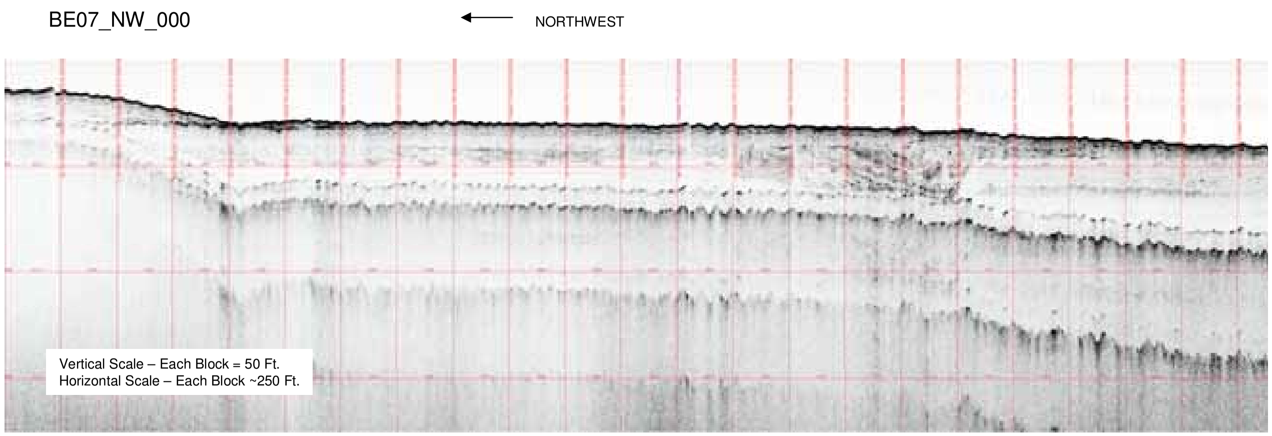


Figure 4-6C. Brevard County Area BE-1. Line BE07_NW_001 (above) and Line BE07_NW_000 (below). Showing the location of three prominent sand ridges.

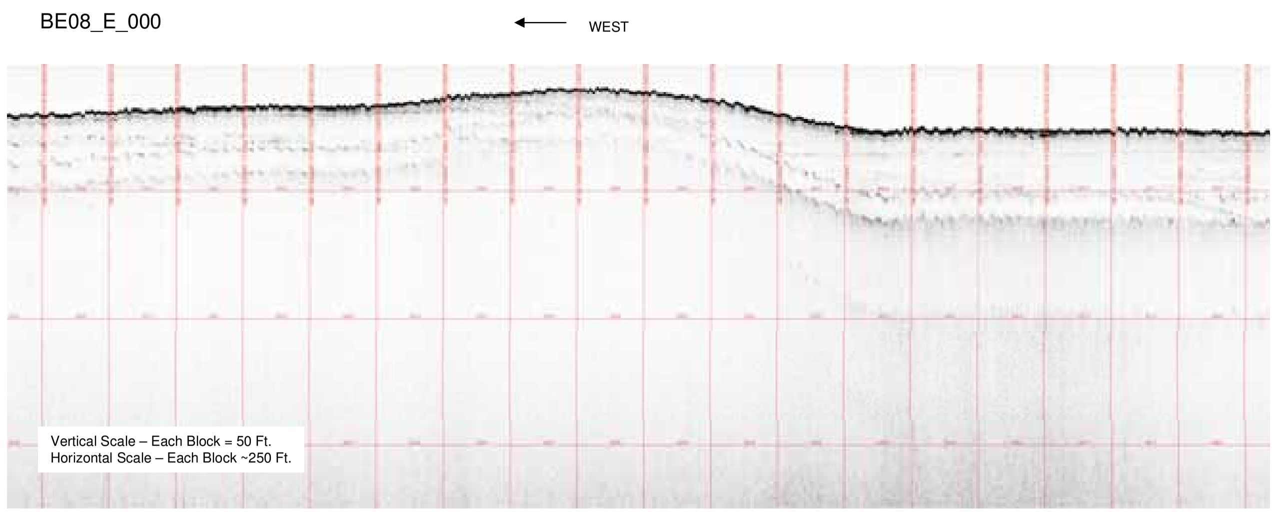


Figure 4-6D. Brevard County Area BE-1. Line BE08_E_000 showing the location of a sand ridge.

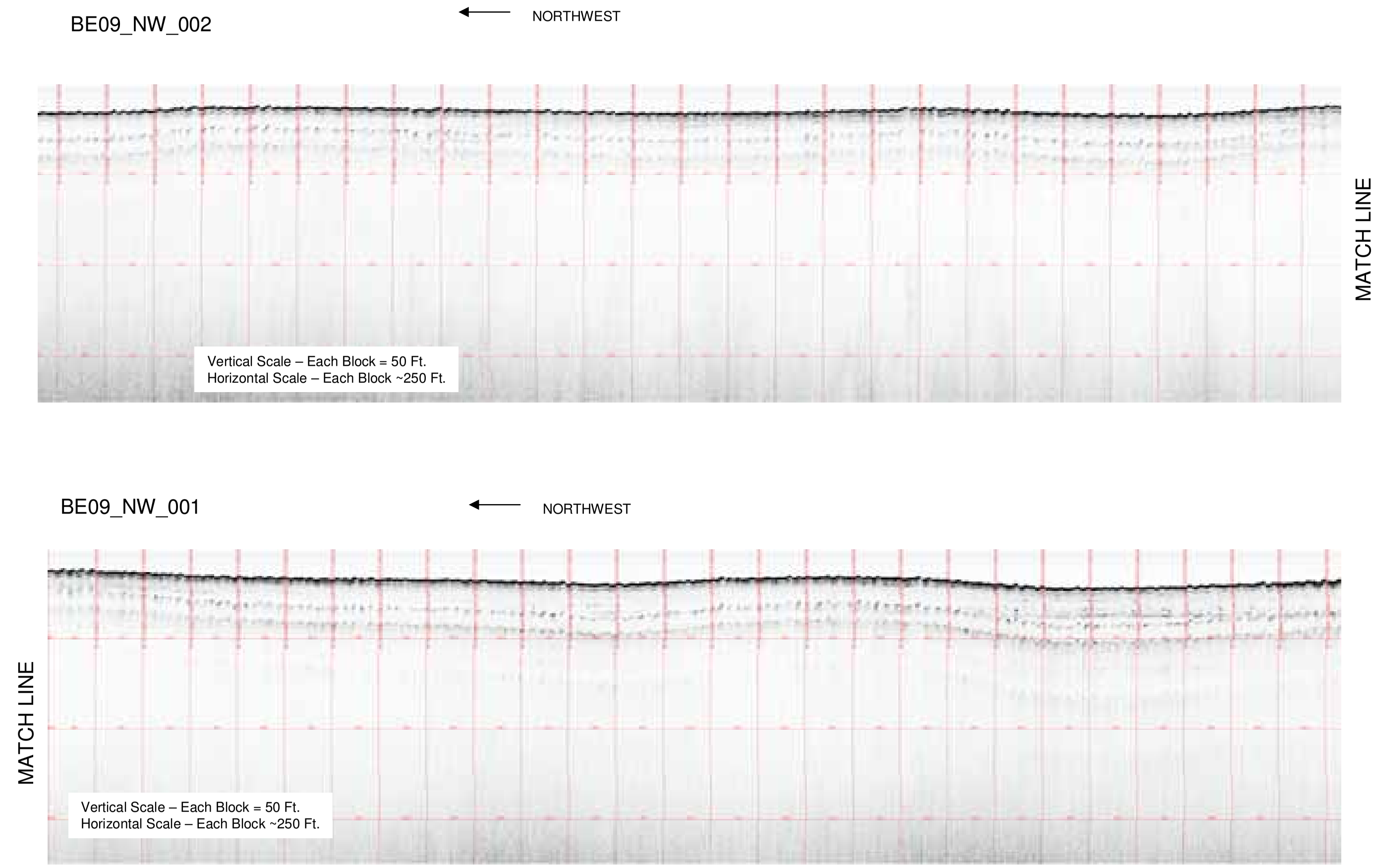


Figure 4-6E. Brevard County Area BE-1 Lines BE09_NW_002 and BE09_NW_001. Because this transect extends down the long axis of the feature the sand ridges are not as apparent.

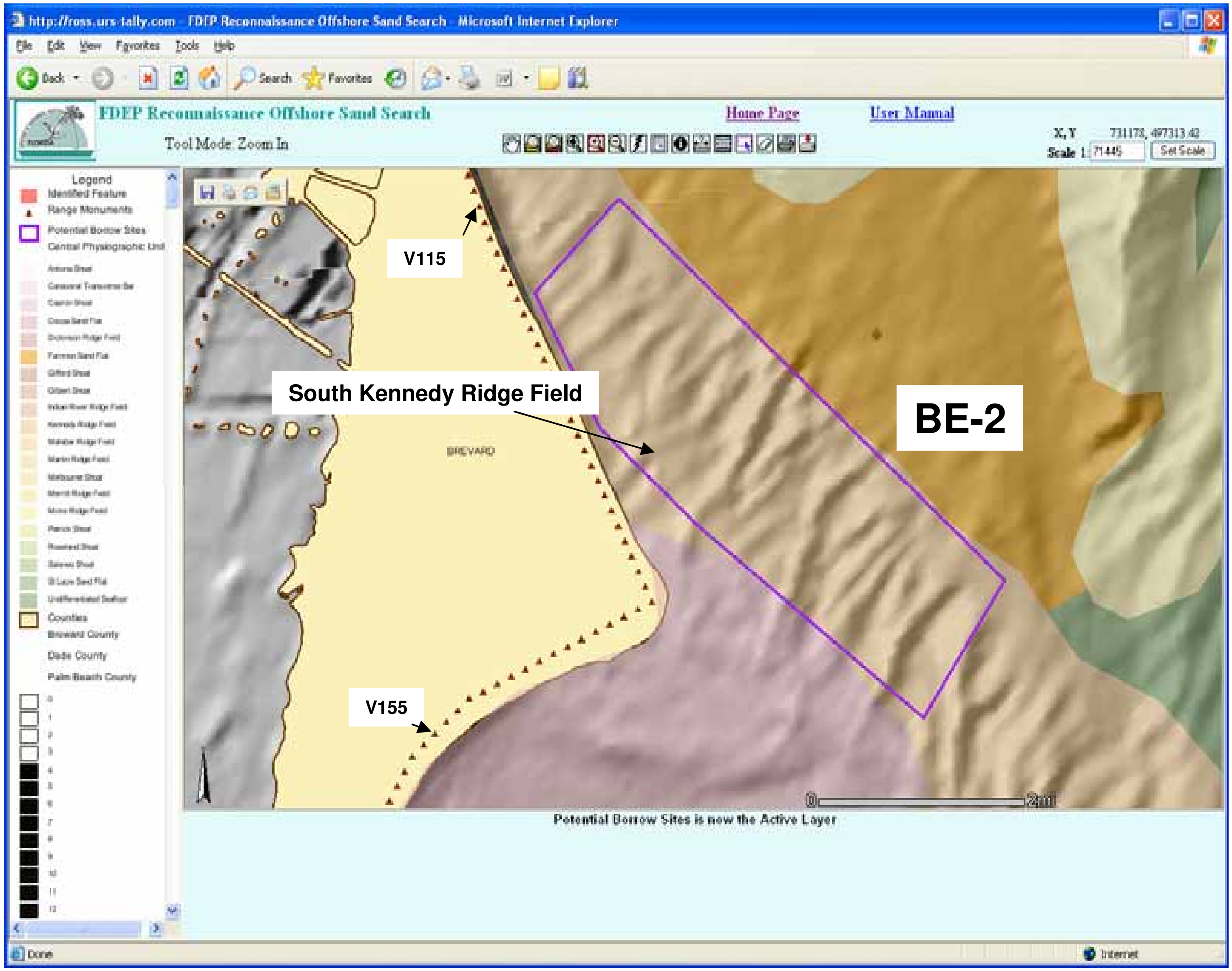


Figure 4-7. Brevard County Area BE-2 showing physiographic zones overlaying the gray scale image.

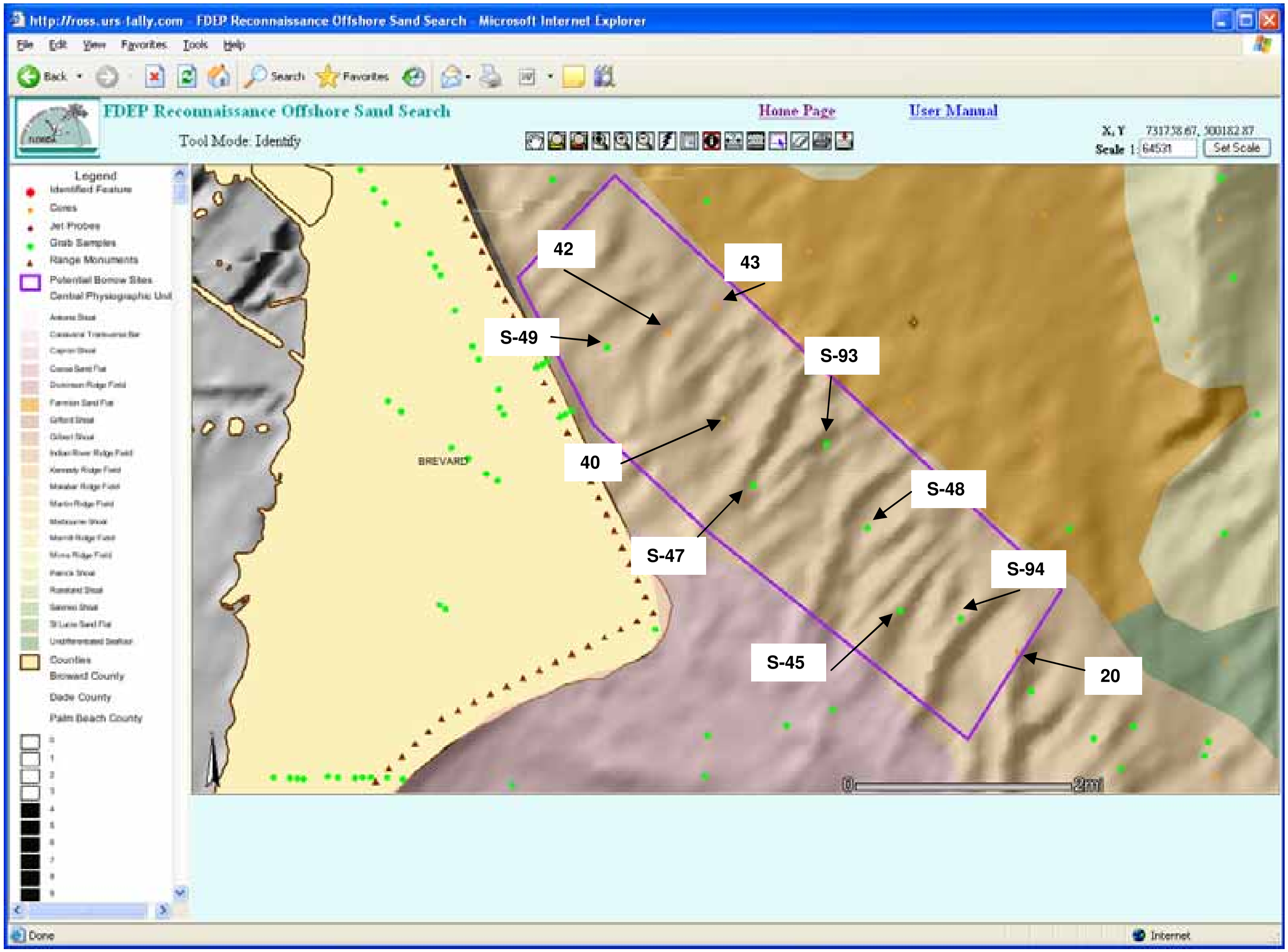


Figure 4-8. Brevard County Area BE-2 showing Vibracore and Grab Sample locations.

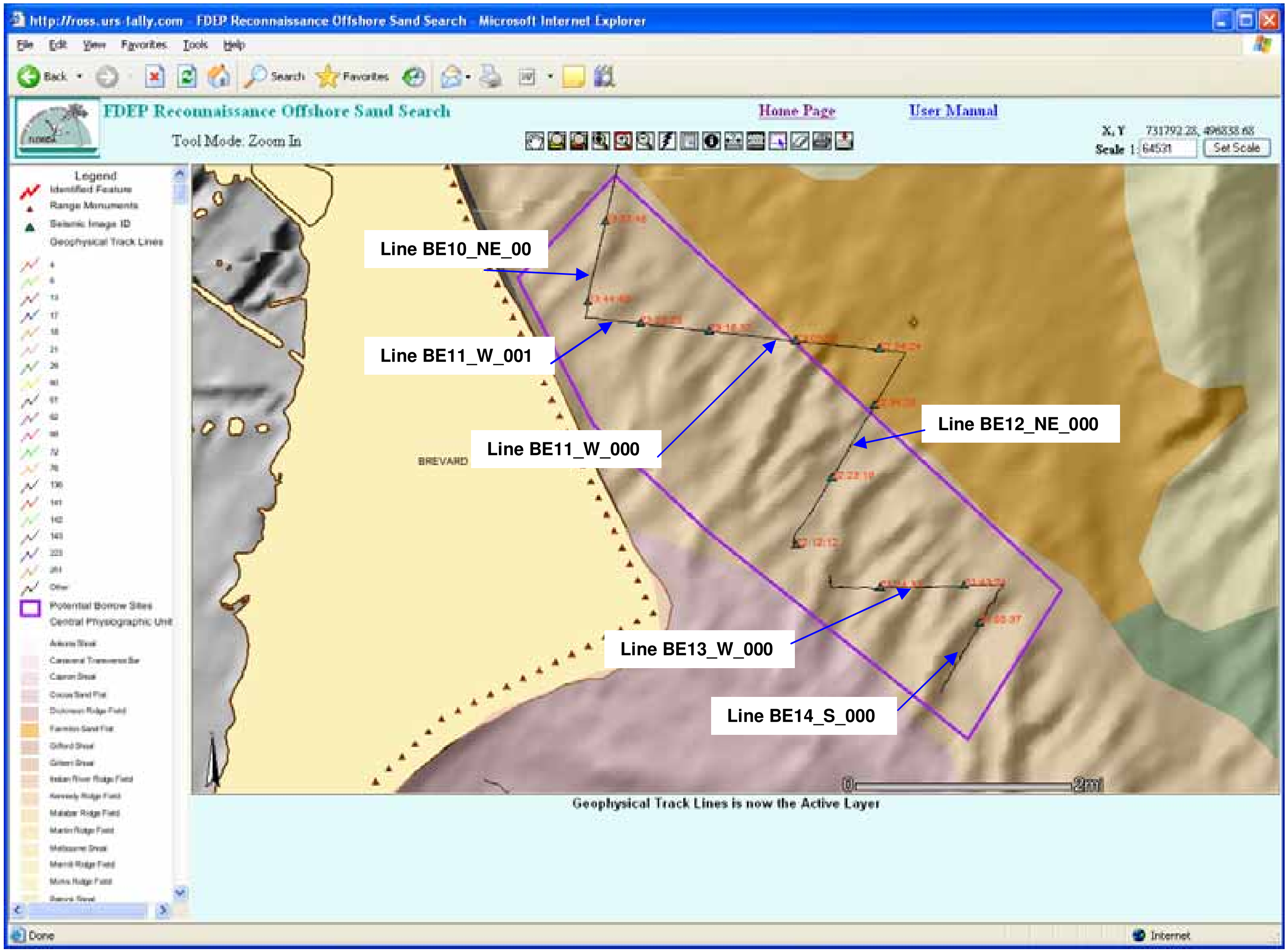
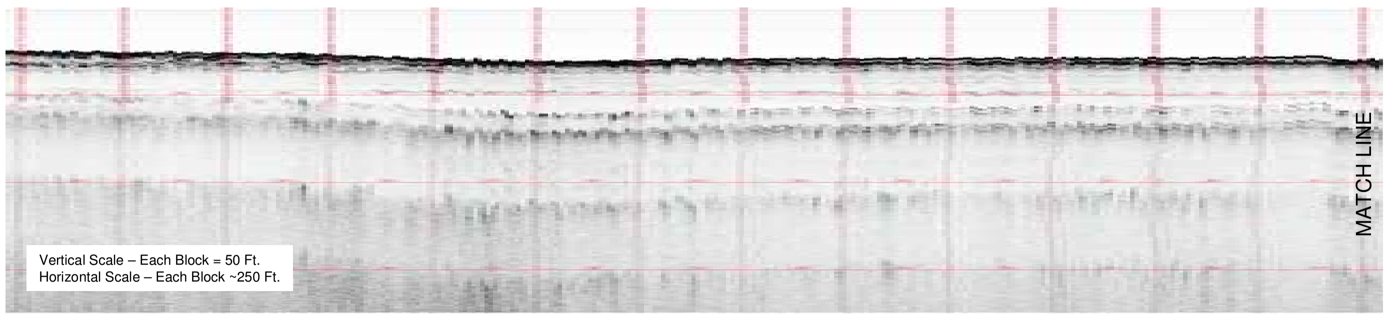


Figure 4-9. Brevard County Area BE-2 showing geophysical trackline locations and timestamps.



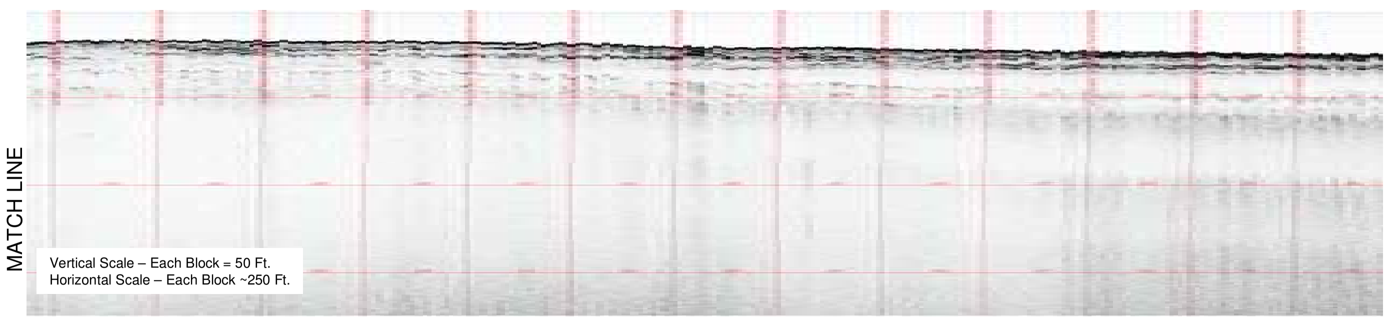


Figure 4-10A. Brevard County Area BE-2 Line BE10_NE_000. Even though the vertical relief is only a few feet, the potential for good quality sand below the surface makes this area a candidate for future study.

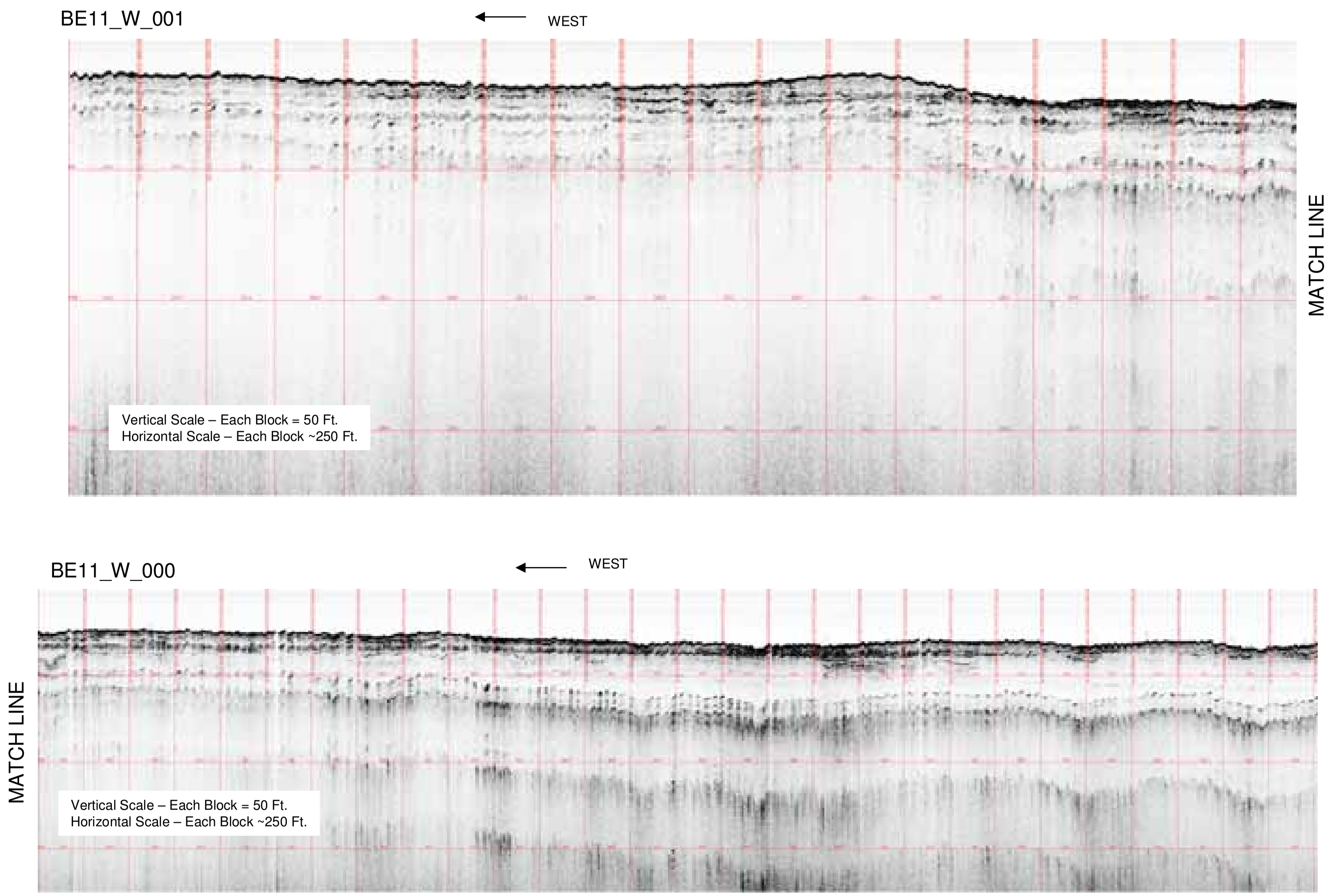


Figure 4-10B. Brevard County Area BE-2 Line BE11_W_000. Two sand ridges are seen in this image.

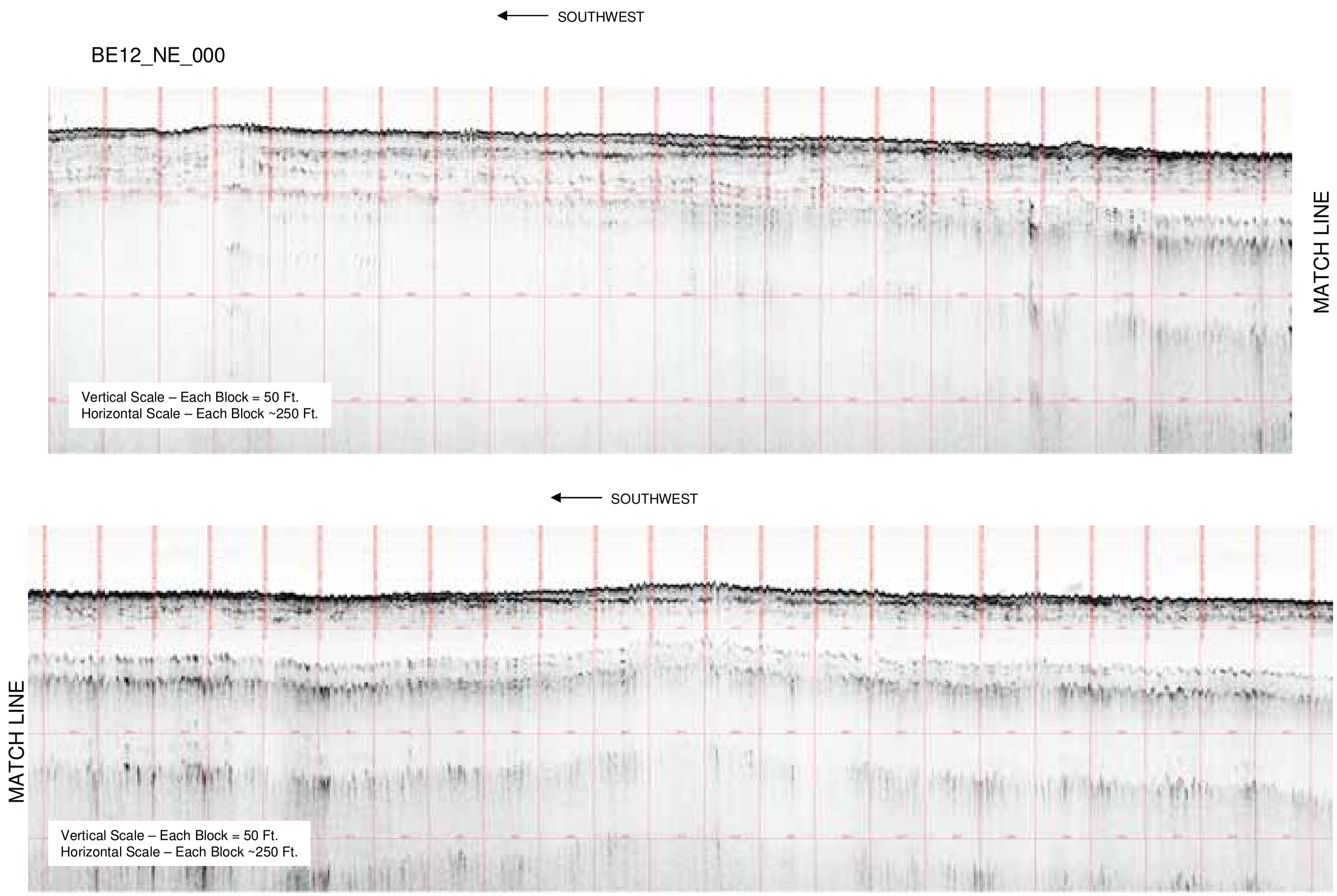


Figure 4-10C. Brevard County Area BE-2 Line BE12_NE_000 showing the existence of several potential sand deposits.

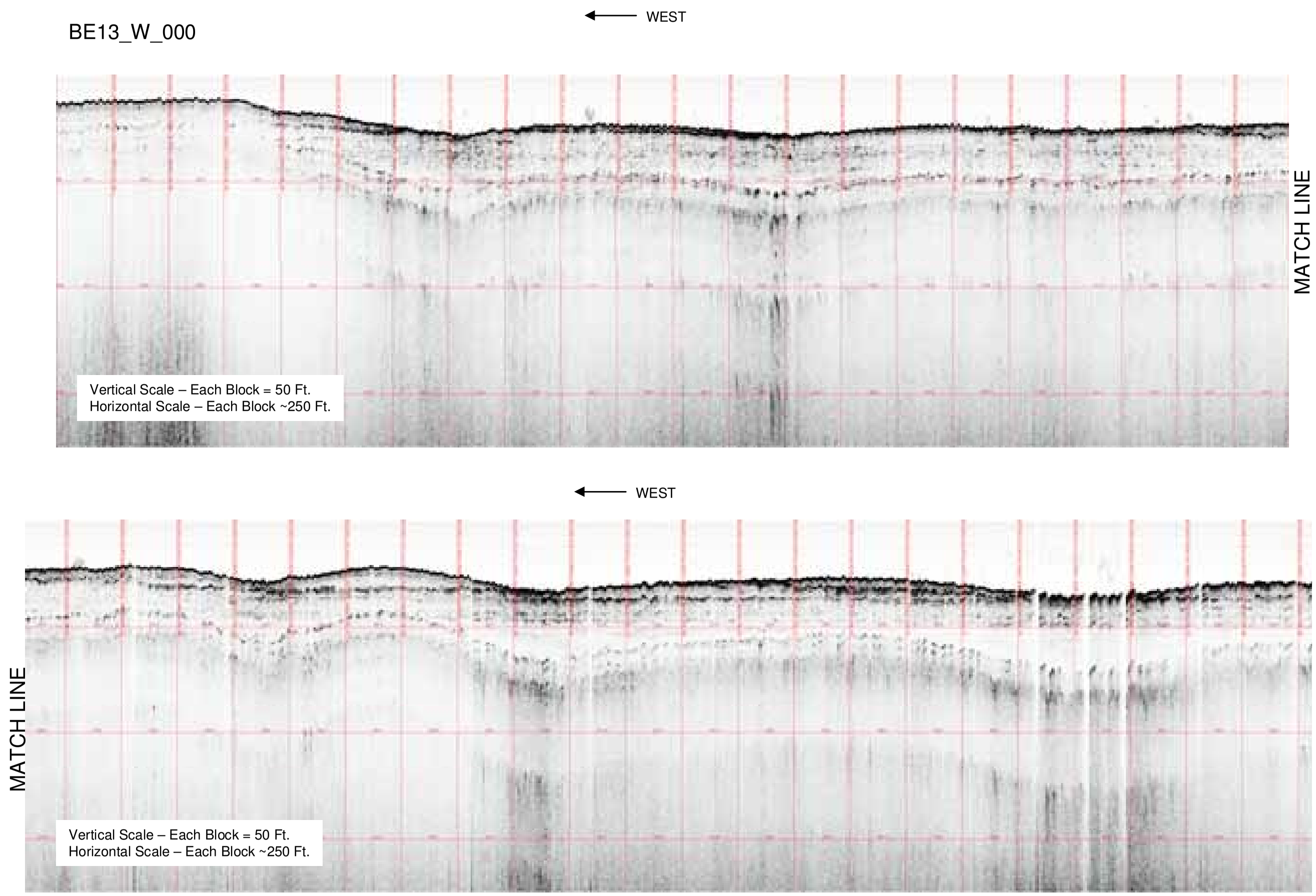


Figure 4-10D. Brevard County Area BE-2 Line BE13_W_000. Five highly potential sand sources are found on this line.

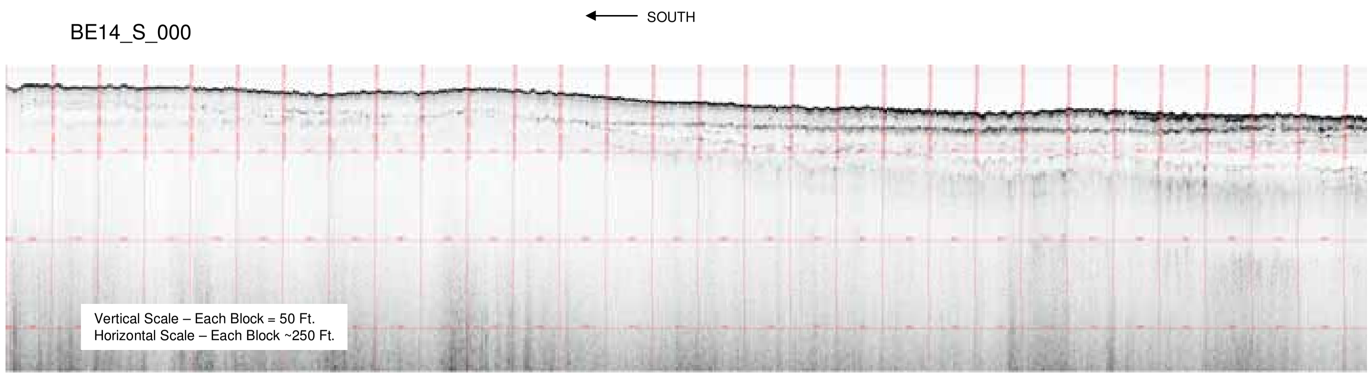


Figure 4-10E. Brevard County Area BE-2 Line BE14_S_000 . Potential sand sources are seen as the upper most layer on this image. This layer is approximately 10 to 12 feet in thickness.

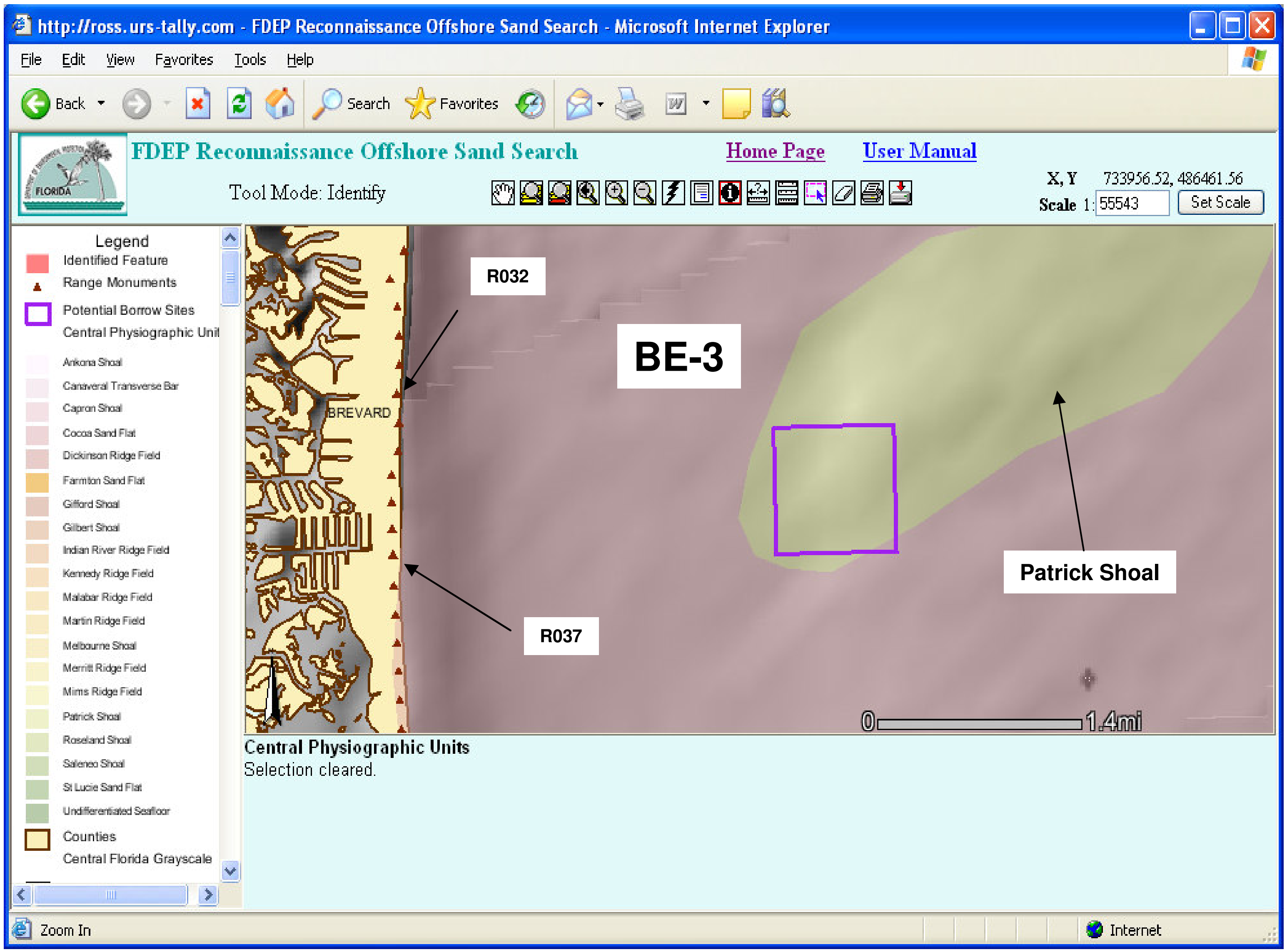


Figure 4-11. Brevard County Area BE-3 showing physiographic zones overlaying the gray scale image.

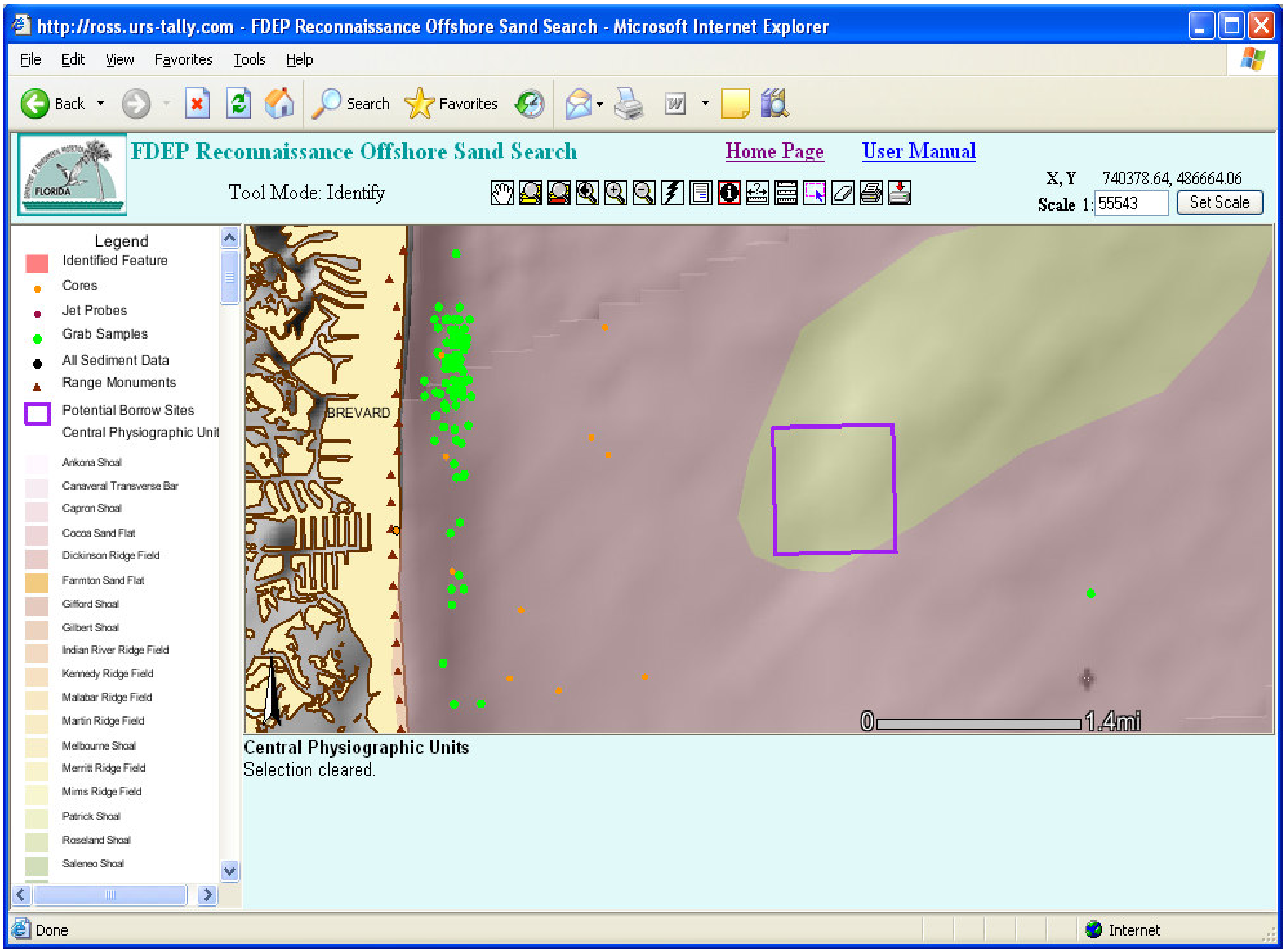


Figure 4-12. Brevard County Area BE-3 showing locations of vibracores and grab samples.

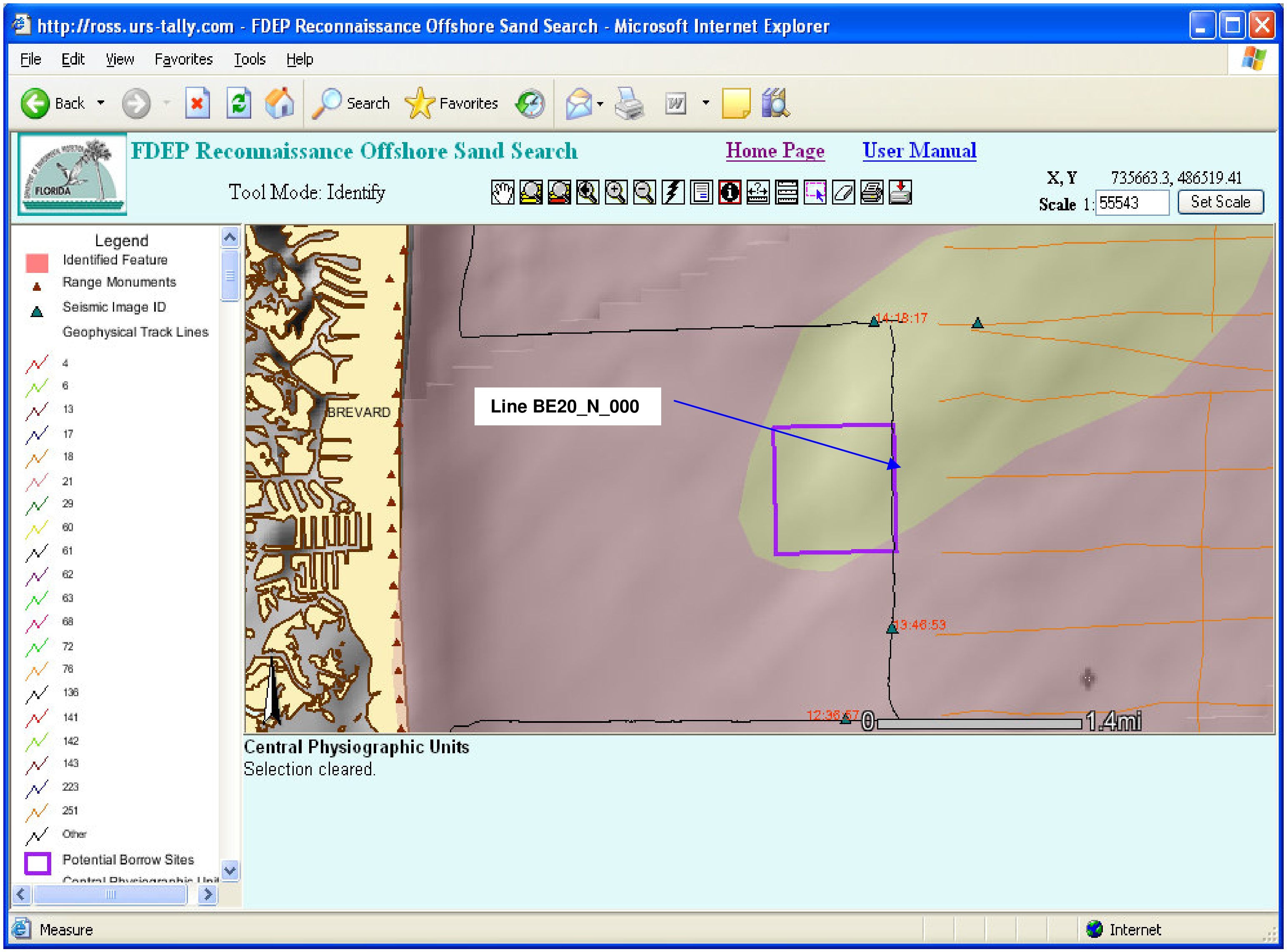


Figure 4-13. Brevard County Area BE-3 showing geophysical trackline locations and timestamps.

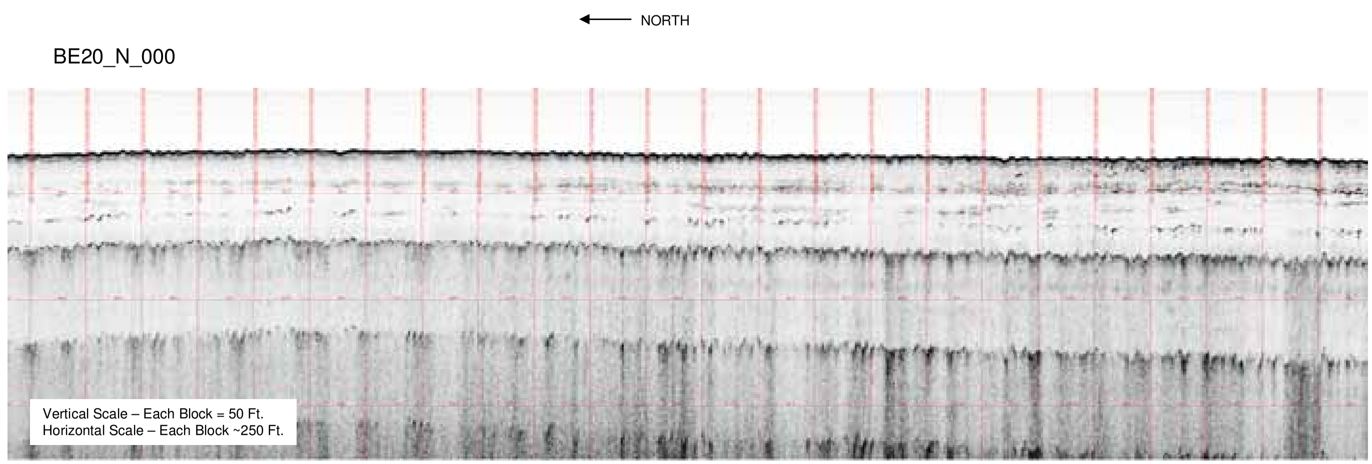


Figure 4-14. Brevard County Area BE-3 Line BE20_N_000. This line transects the shoal from south to north. The potential usable sand in this area is approximately 40 to 50 feet in thickness

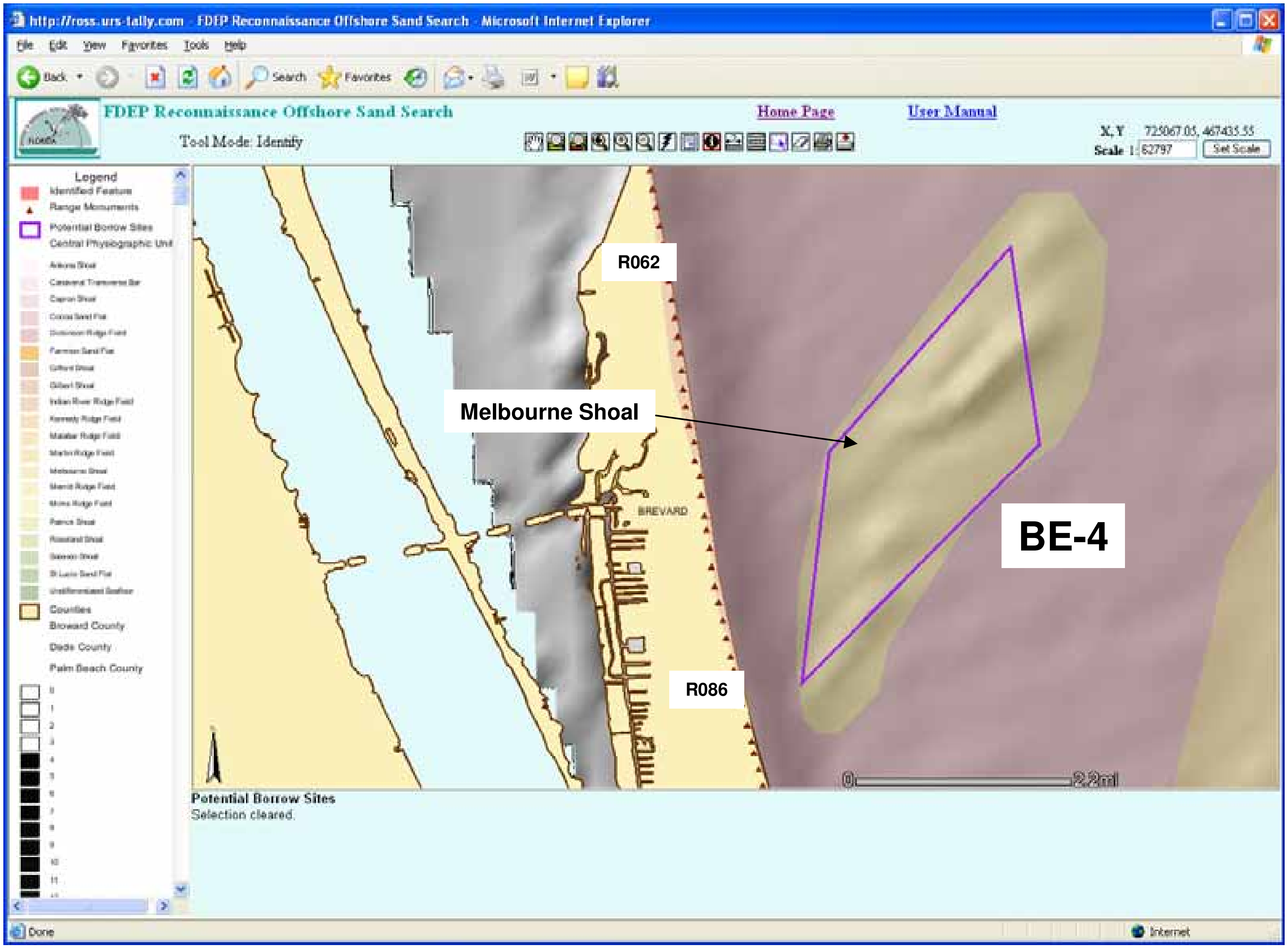


Figure 4-15. Brevard County Area BE-4 showing physiographic zones overlaying the gray scale image.

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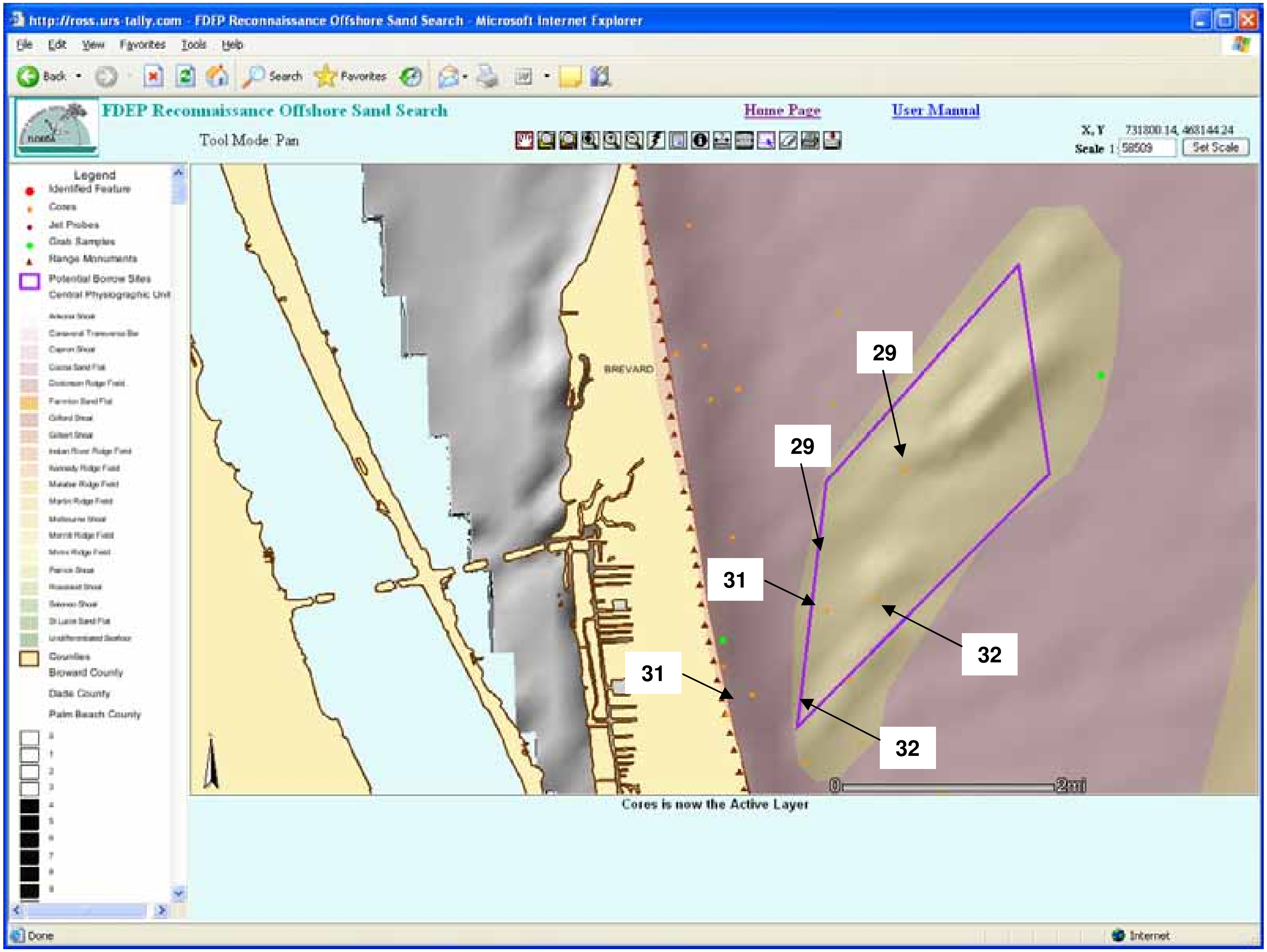


Figure 4-16. Brevard County Area BE-4 showing Vibracore and Grab Sample locations.

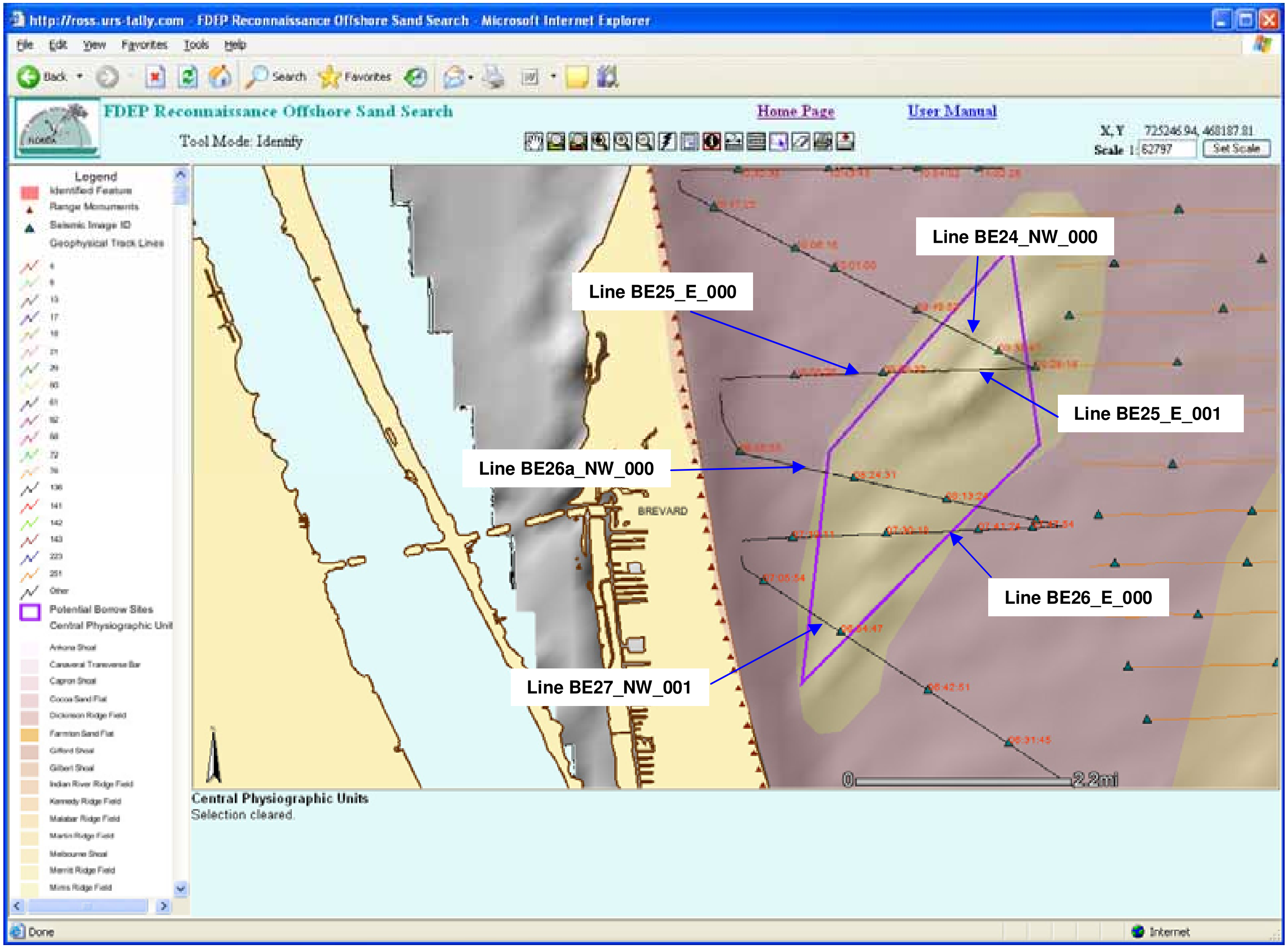


Figure 4-17. Brevard County Area BE-4 showing geophysical trackline locations and timestamps.

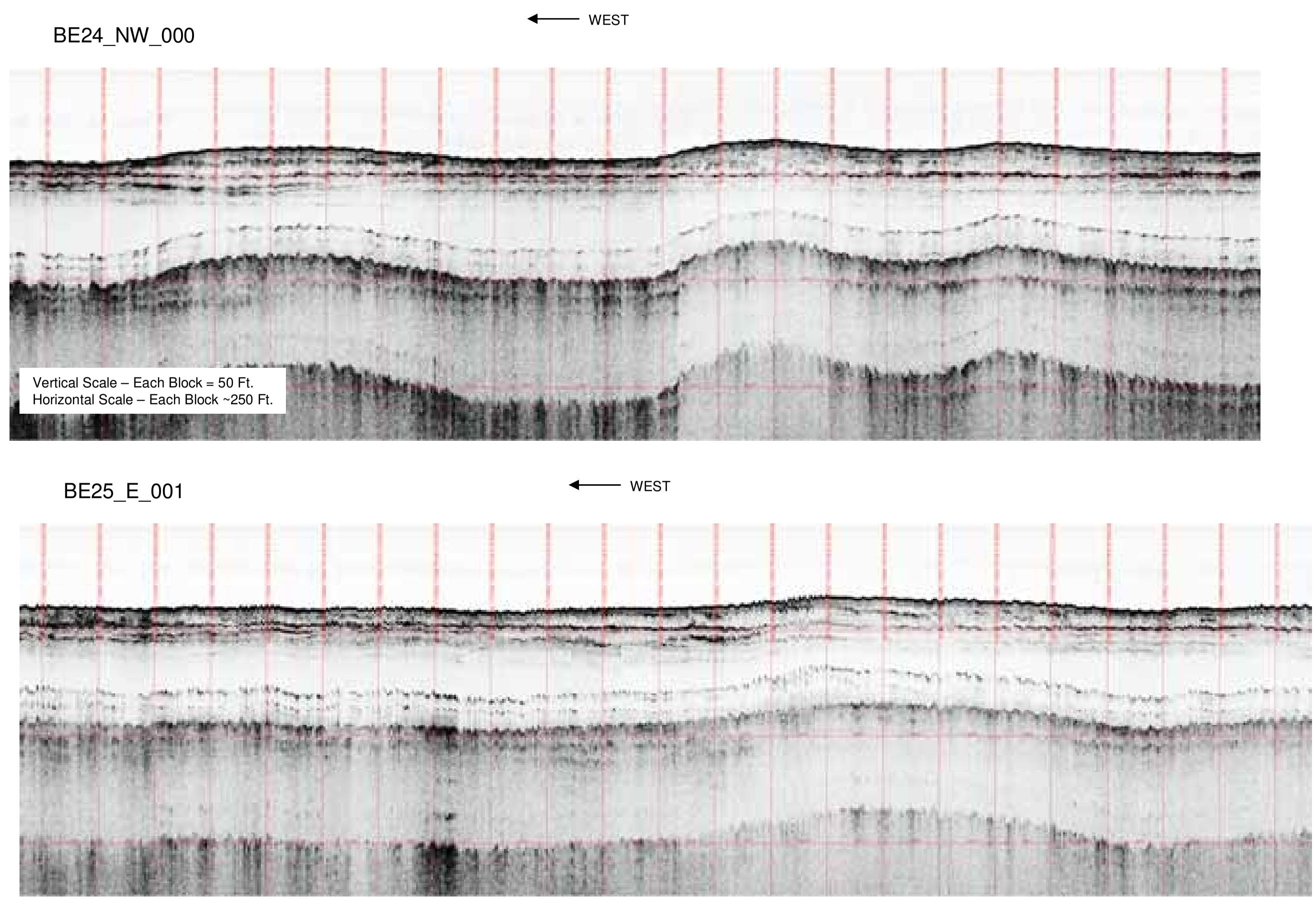
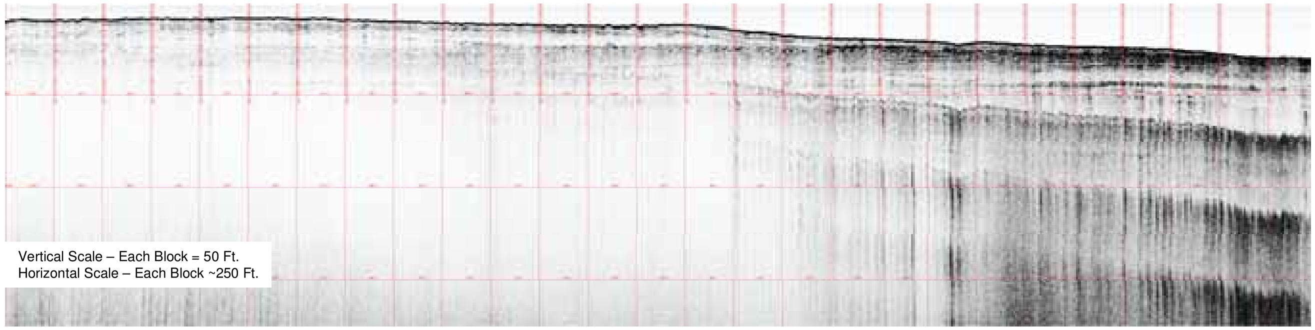


Figure 4-18A. Brevard County Area BE-4 Lines BE24_NW_000 and BE25_E_001.
These images show the largest positive relief features in Area BE-4.

BE26a_NW_000

← WEST



BE26_E_000

← WEST

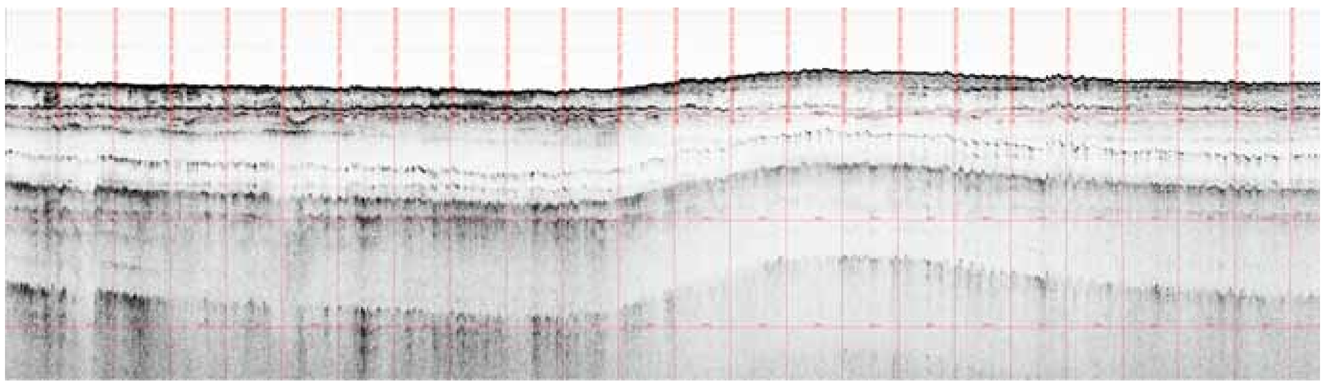


Figure 4-18B. Brevard County Area BE-4 Lines BE26a_NW _000 and BE26_E_000. These images are of the feature located in the middle of Area BE-4. Line BE26a crosses just the northern tip of this ridge.

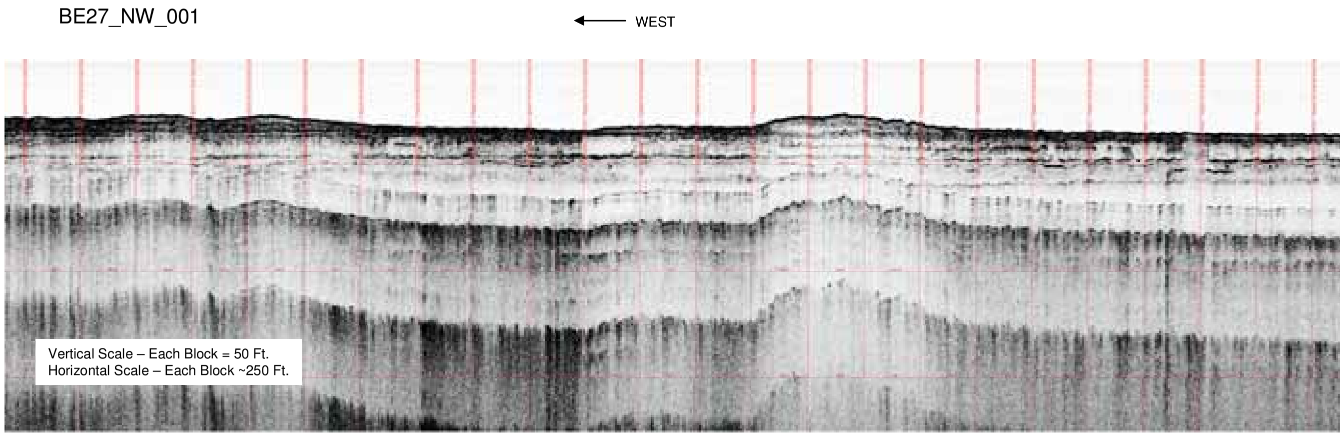


Figure 4-18C. Brevard County Area BE-4 Line 27_NW_001. This line crosses the third most southern feature in Area BE-4. The ridge is circled (in red) on the image.

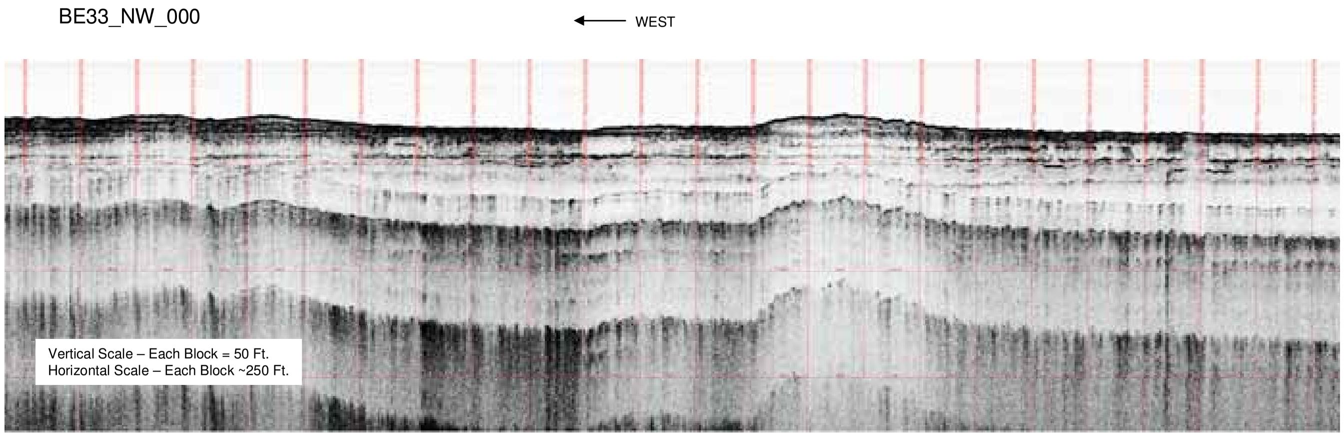


Figure 4-18D. Brevard County Area BE-4 Line 27_NW_001. This line crosses the third most southern feature in Area BE-4. The ridge is circled (in red) on the image.

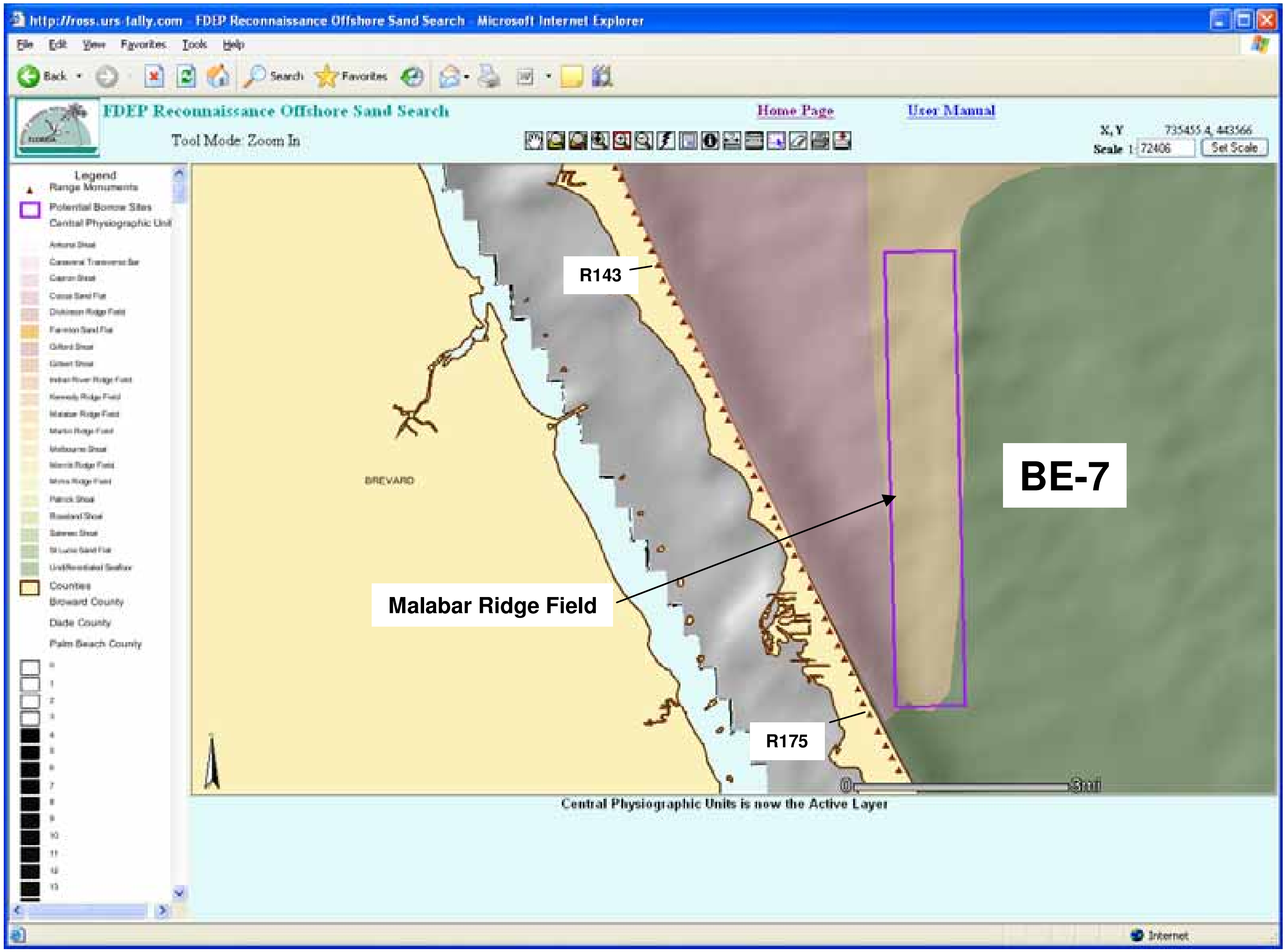


Figure 4-19. Brevard County Area BE-7 showing physiographic zones overlaying the gray scale image.

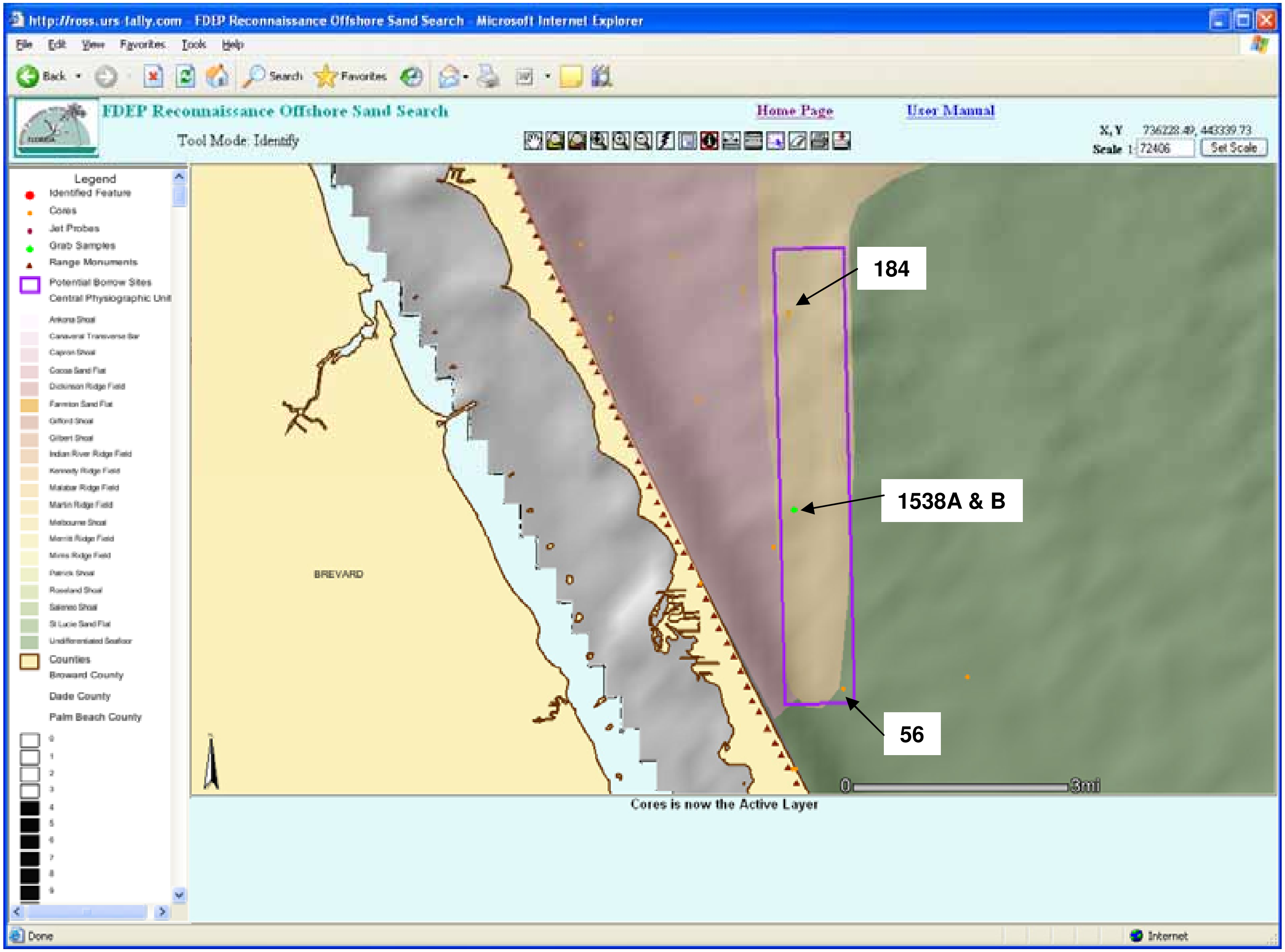


Figure 4-20. Brevard County Area BE-7 showing Vibracore and Grab Sample locations.

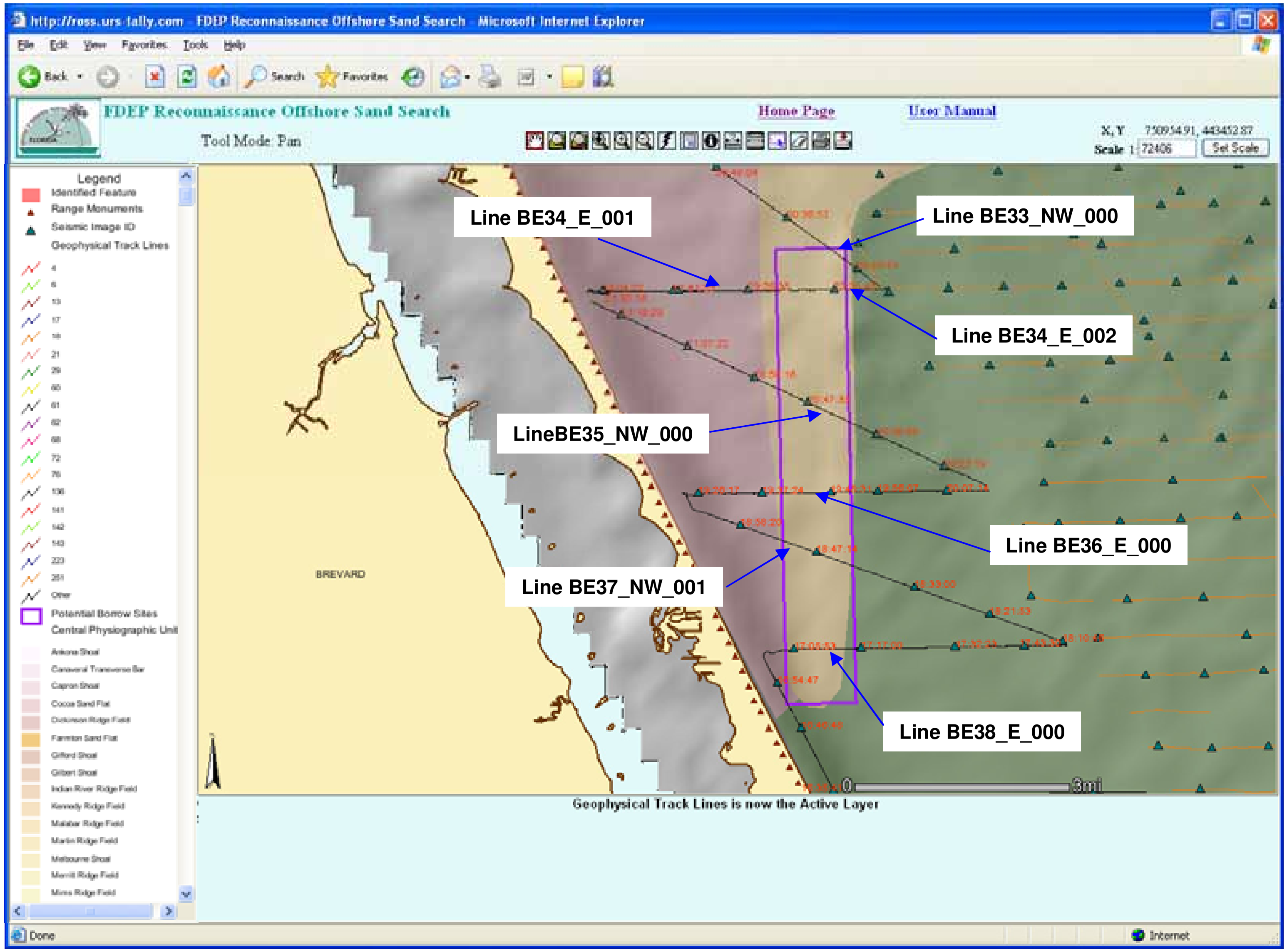
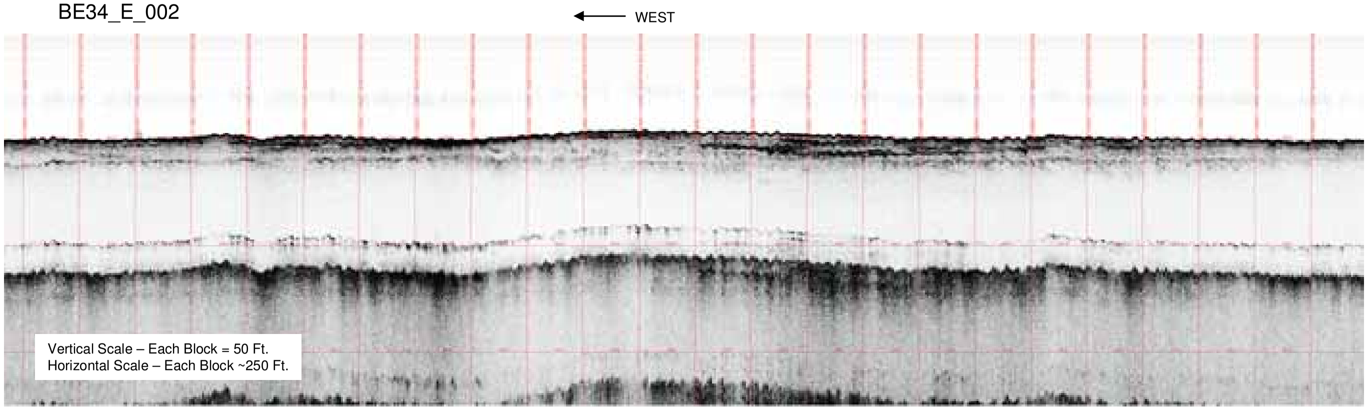


Figure 4-21. Brevard County Area BE-7 showing geophysical trackline locations and timestamps.

BE34_E_002



BE35_NW_000

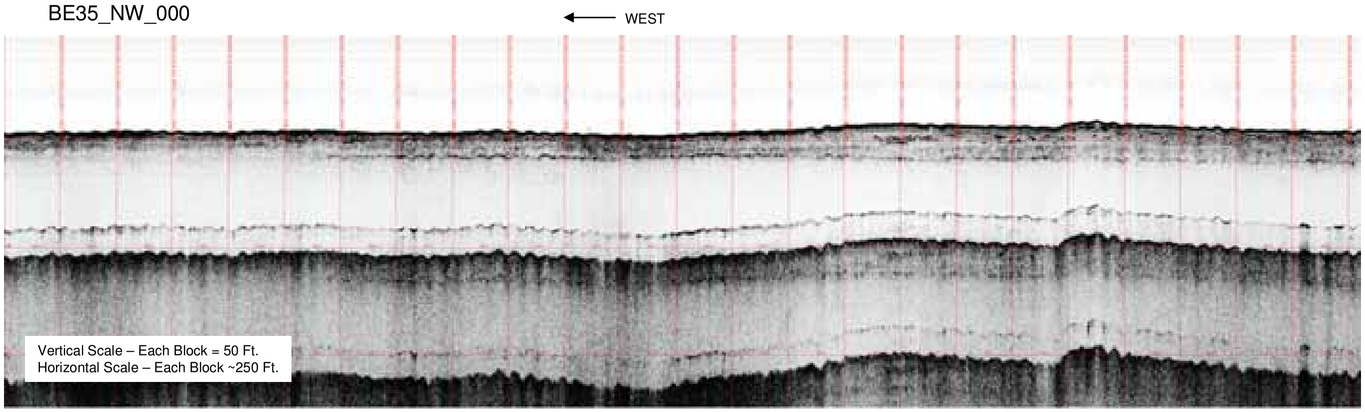
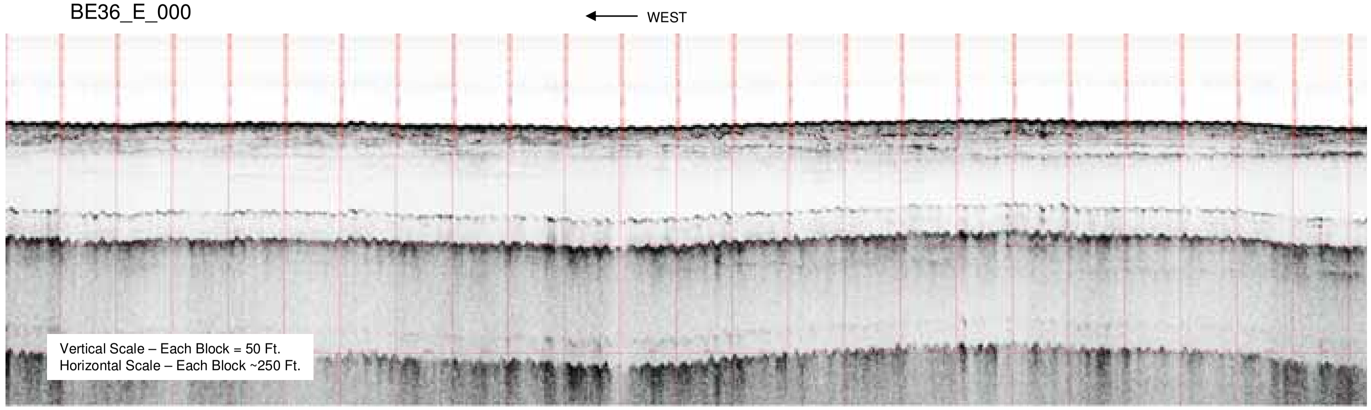


Figure 4-22A. Brevard County Area BE-7 Line BE34_E_002 and BE35_NW_000.

BE36_E_000



BE37_NW_001

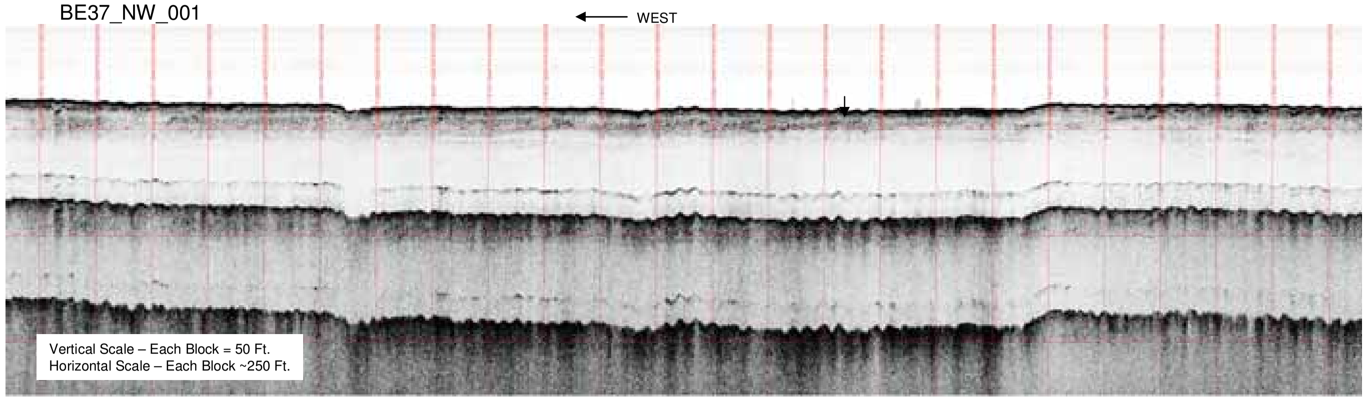


Figure 4-22B. Brevard County Area BE-7 Line BE36_E_000 and BE37_NW_001..

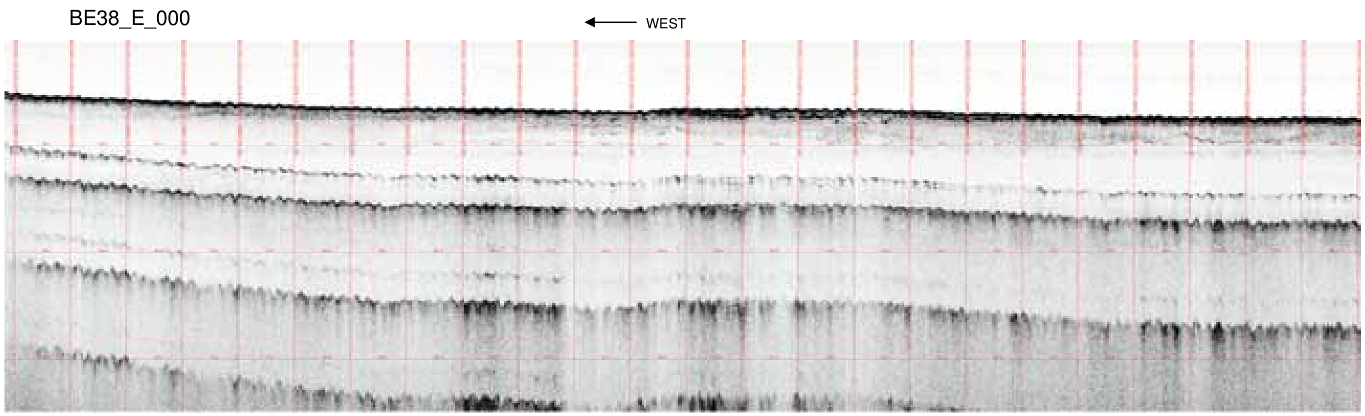


Figure 4-22C. Brevard County Area BE-7 Line BE38_E_000.

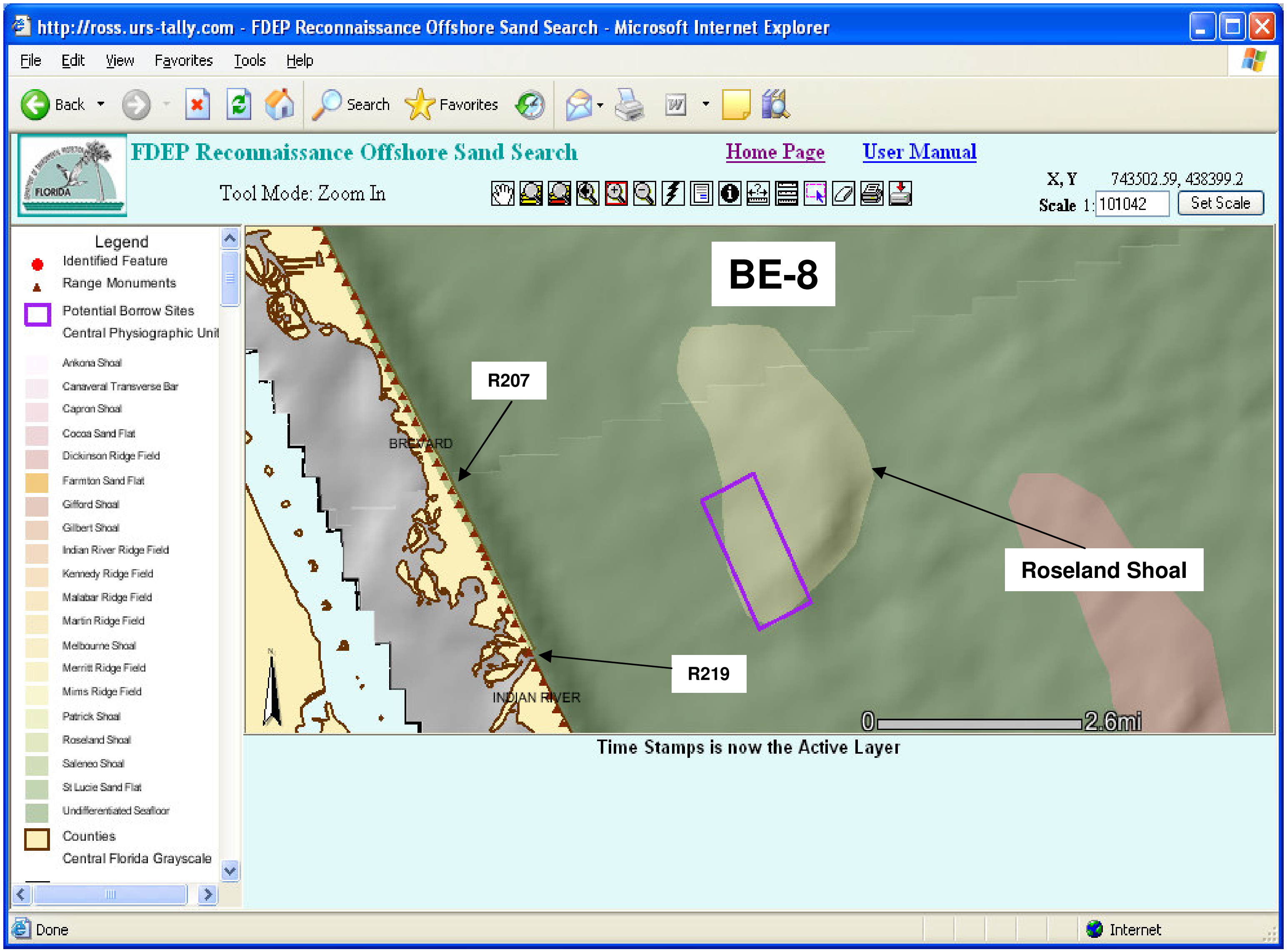


Figure 4-23. Brevard County Area BE-8 showing physiographic zones overlaying the gray scale image.

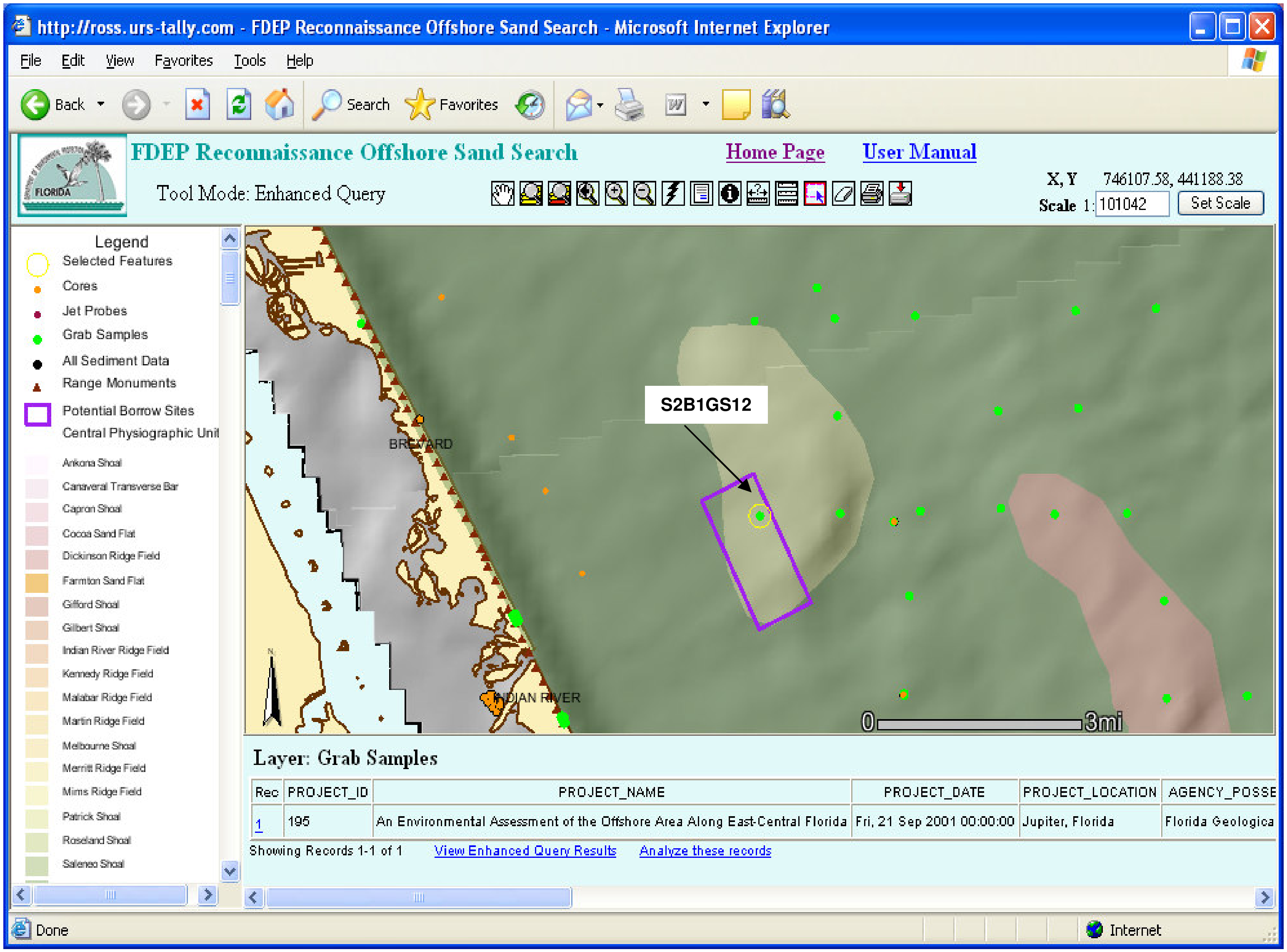


Figure 4-24. Brevard County Area BE-8 showing locations of vibracores and grab samples.

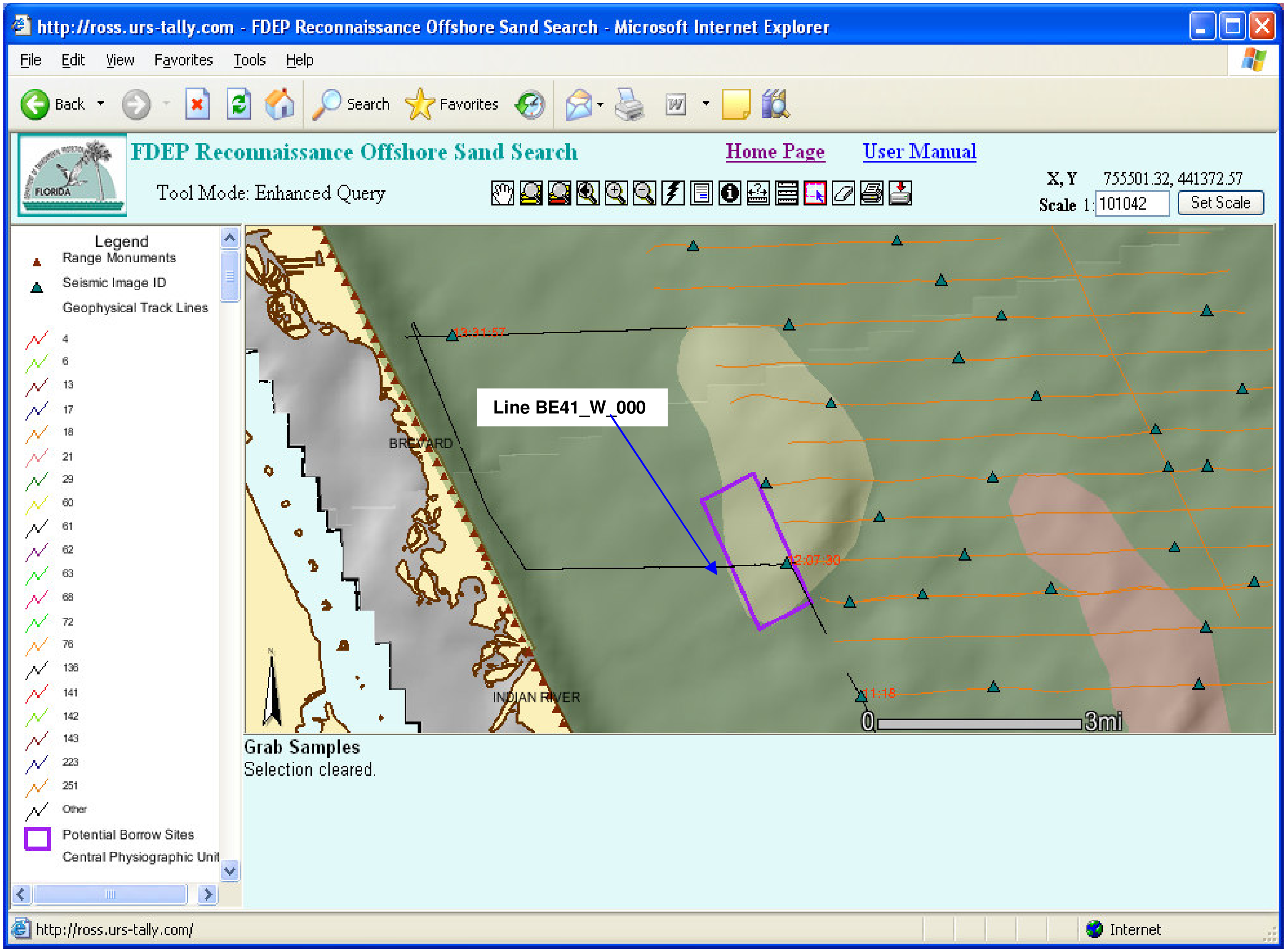


Figure 4-25. Brevard County Area BE-8 showing geophysical trackline locations and timestamps.

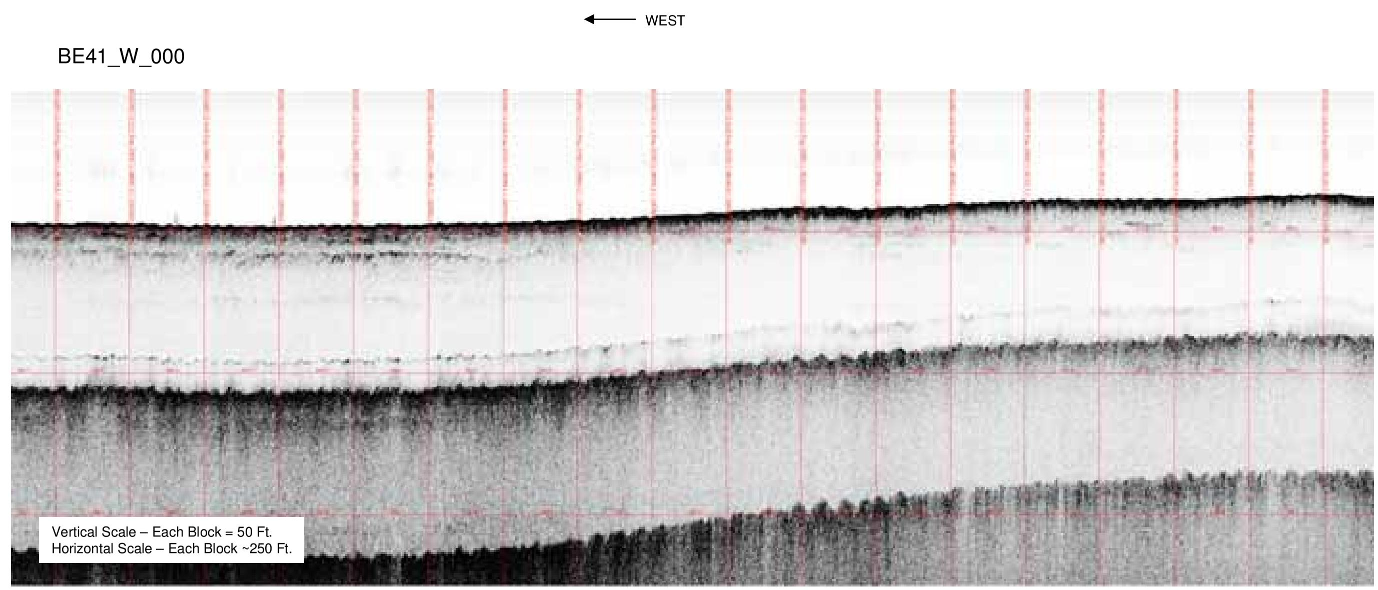


Figure 4-26. Brevard County Area BE-8 Line BE41_W_000.This image shows a large layer of potentially usable sand on this shoal. The thickness of this layer approaches 50 feet.

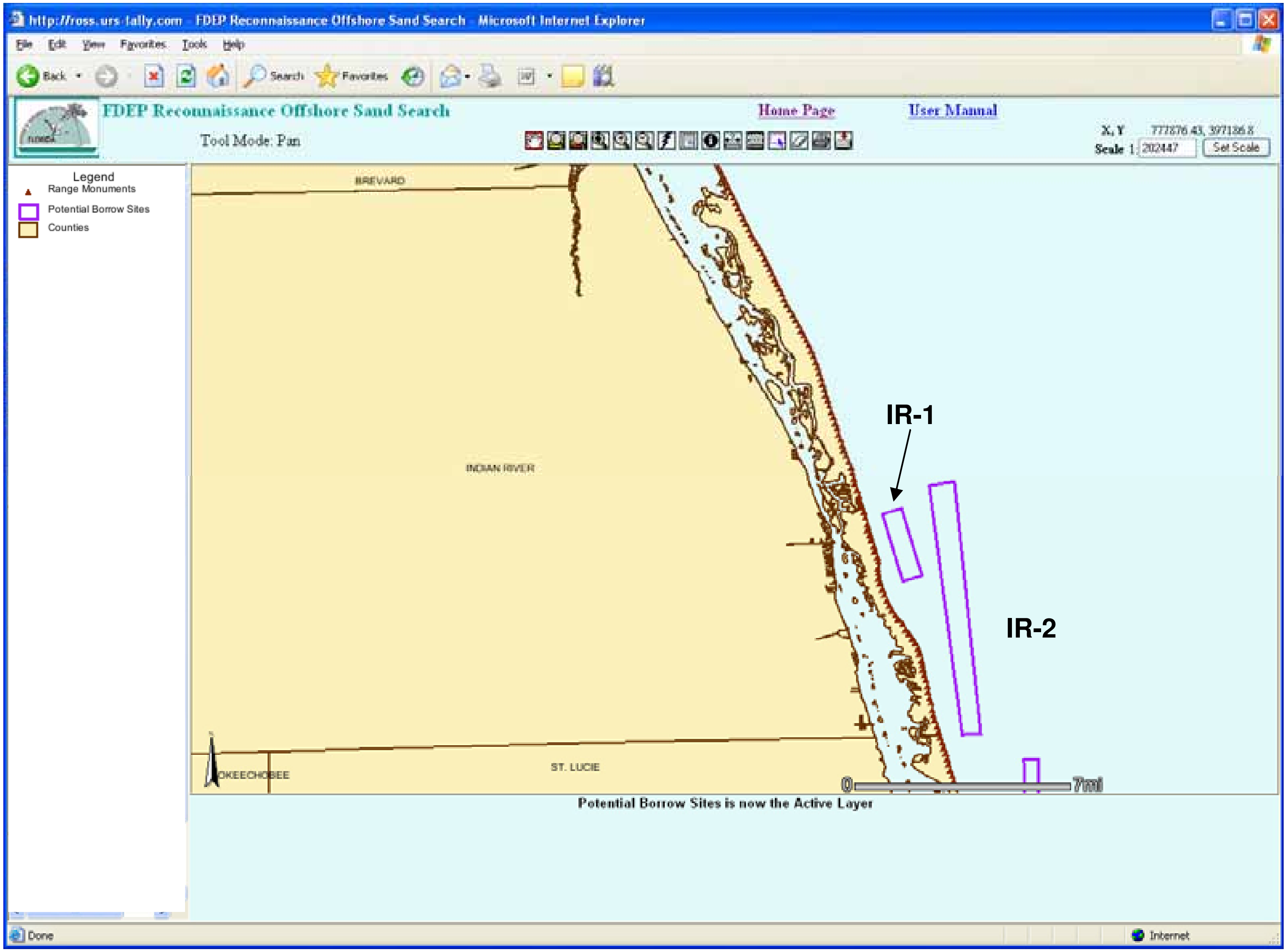


Figure 4-27. Indian River County Nearshore Potential Borrow Areas.

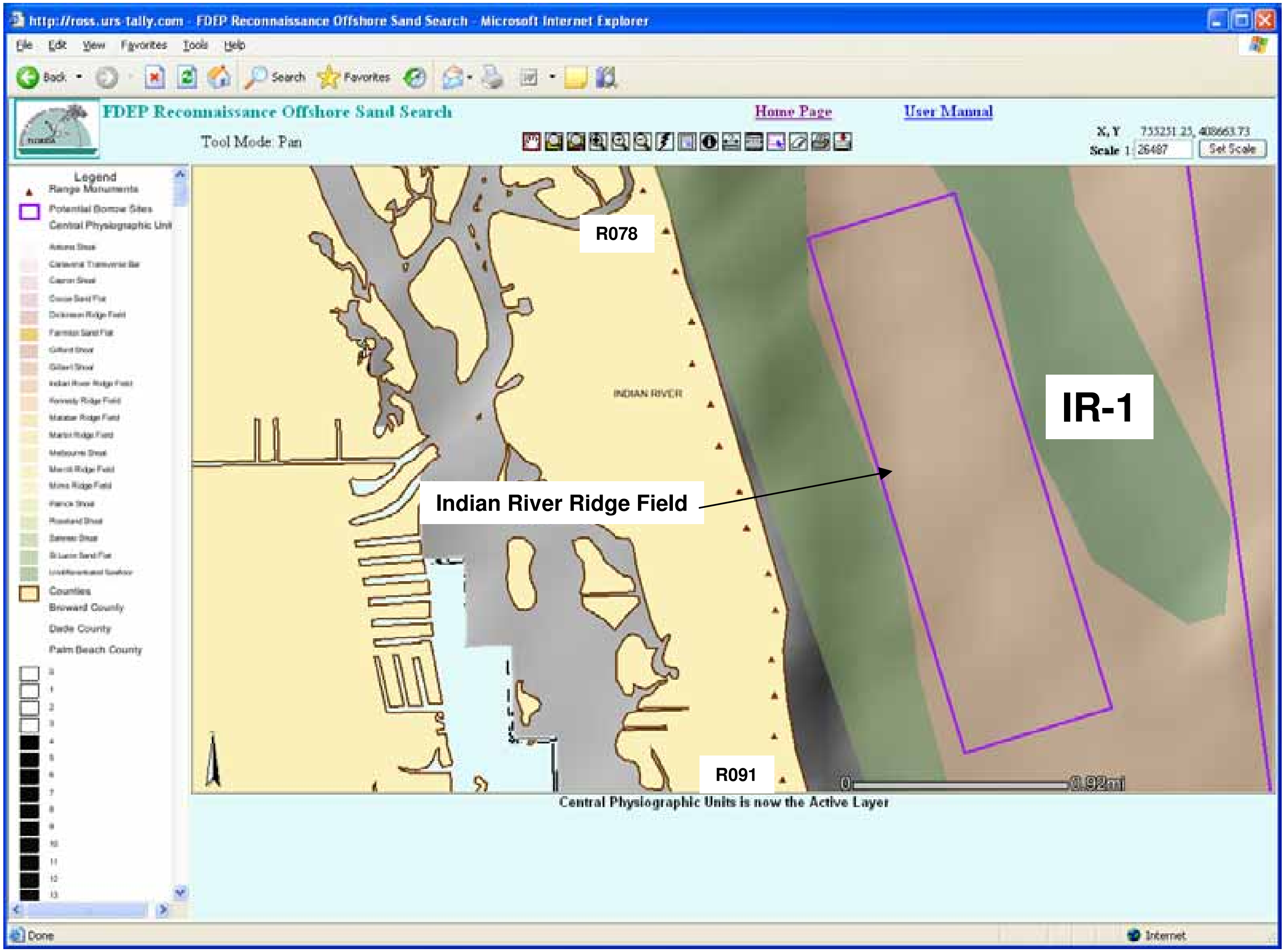


Figure 4-28. Indian River County Area IR-1 showing physiographic zones overlaying the gray scale image.

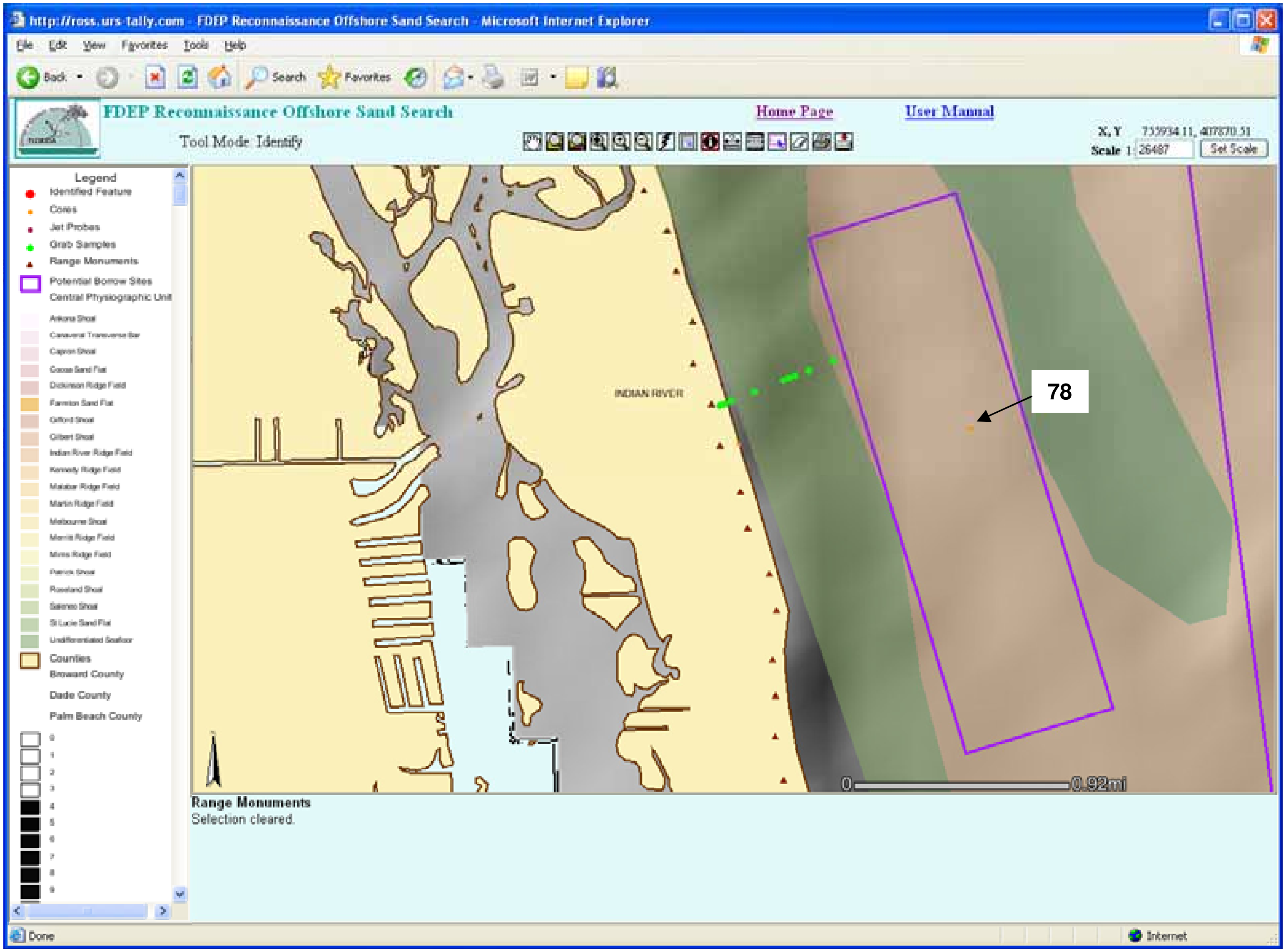


Figure 4-29. Indian River County Area IR-1 showing Vibracore and Grab Sample locations.

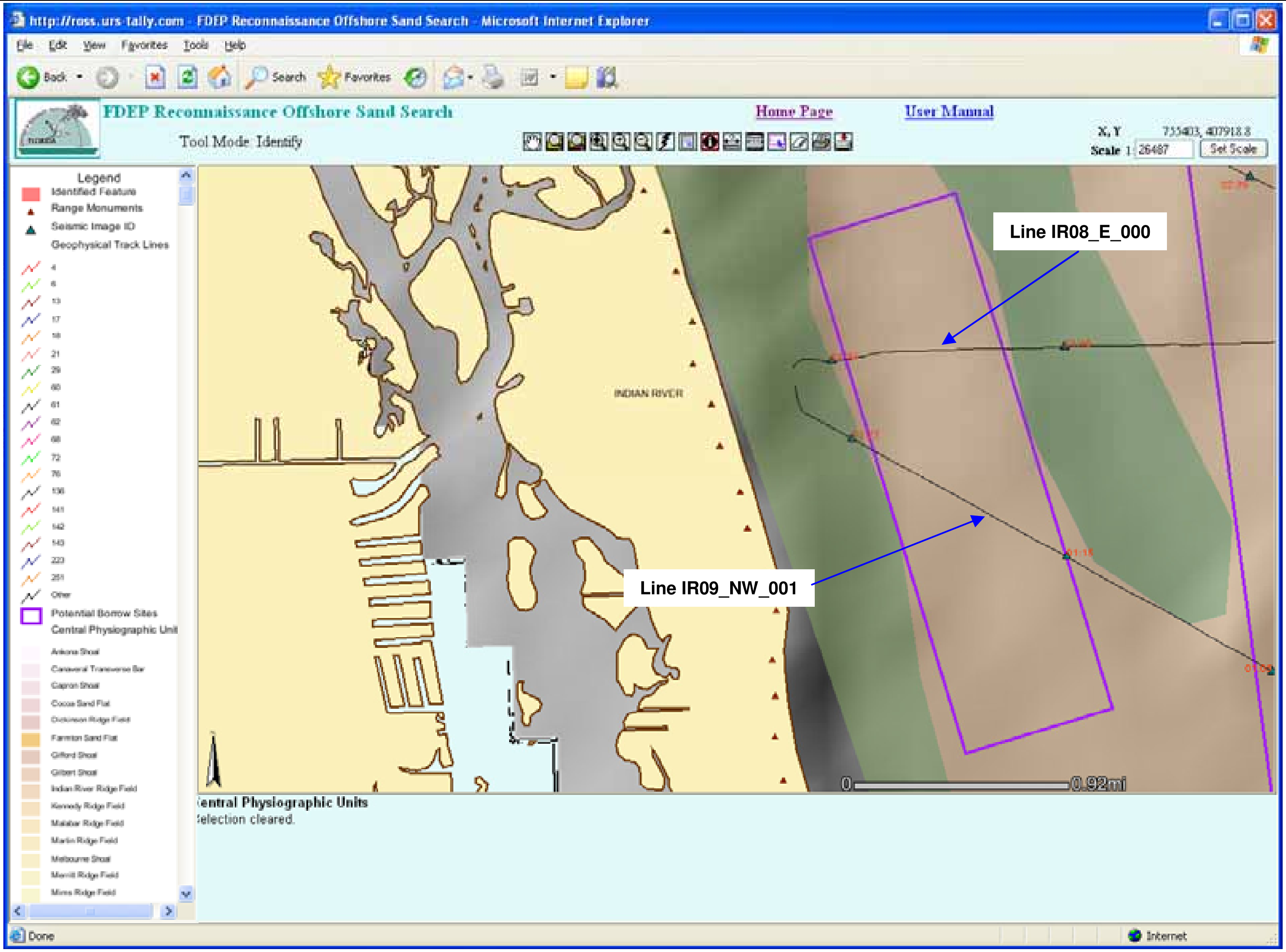
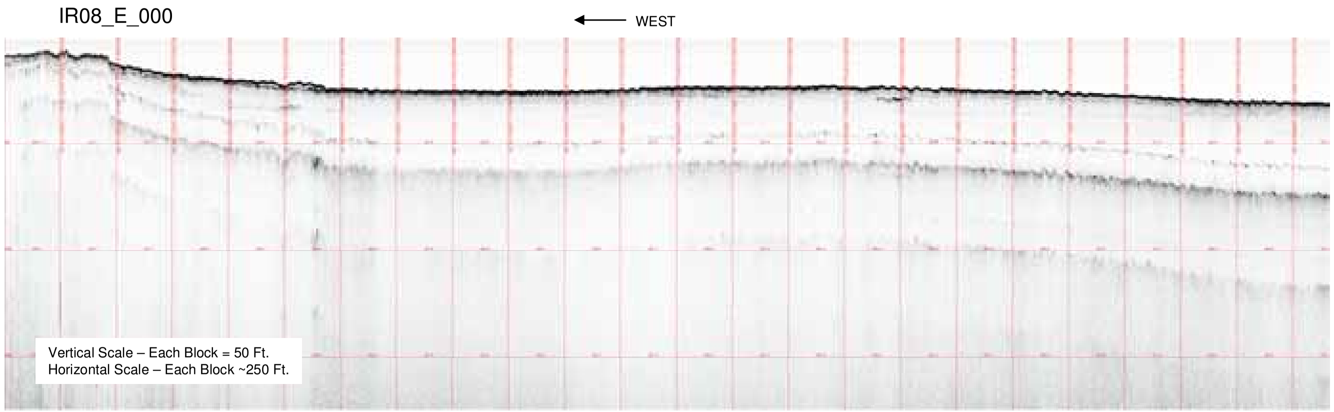


Figure 4-30. Indian River County Area IR-1 showing geophysical trackline locations and timestamps.



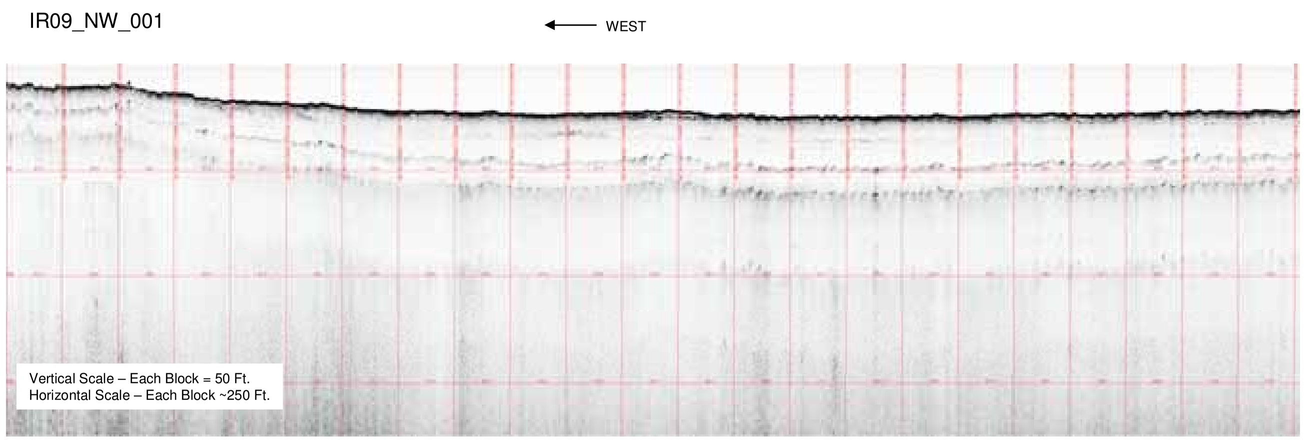
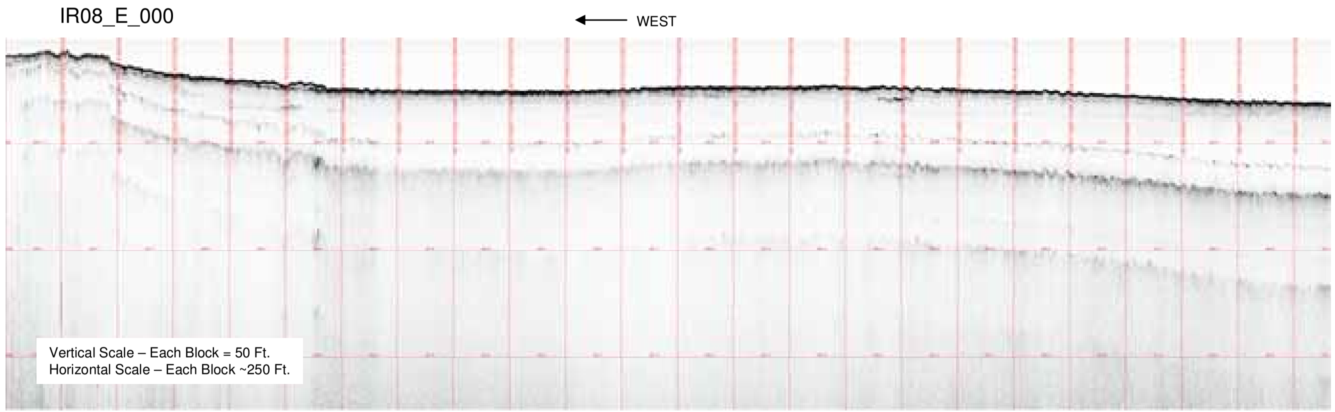


Figure 4-31A. Indian River County Area IR-1. Lines IR08_E_000 (above) and IR09_NW_001 (below) shows there is the potential for useable sand in this area.



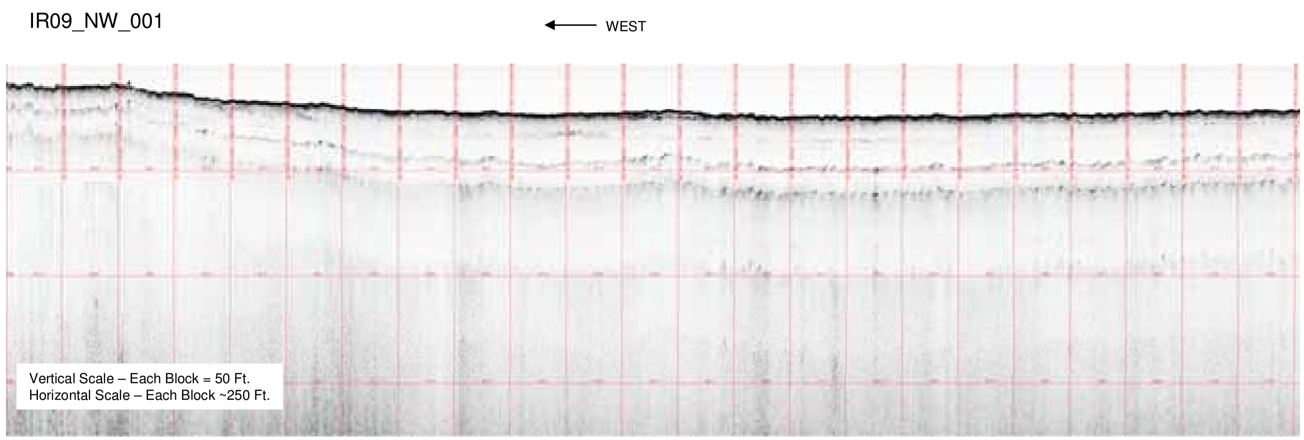


Figure 4-31B. Indian River County Area IR-1. Lines IR08_E_000 (above) and IR09_NW_001 (below) shows there is the potential for useable sand in this area.

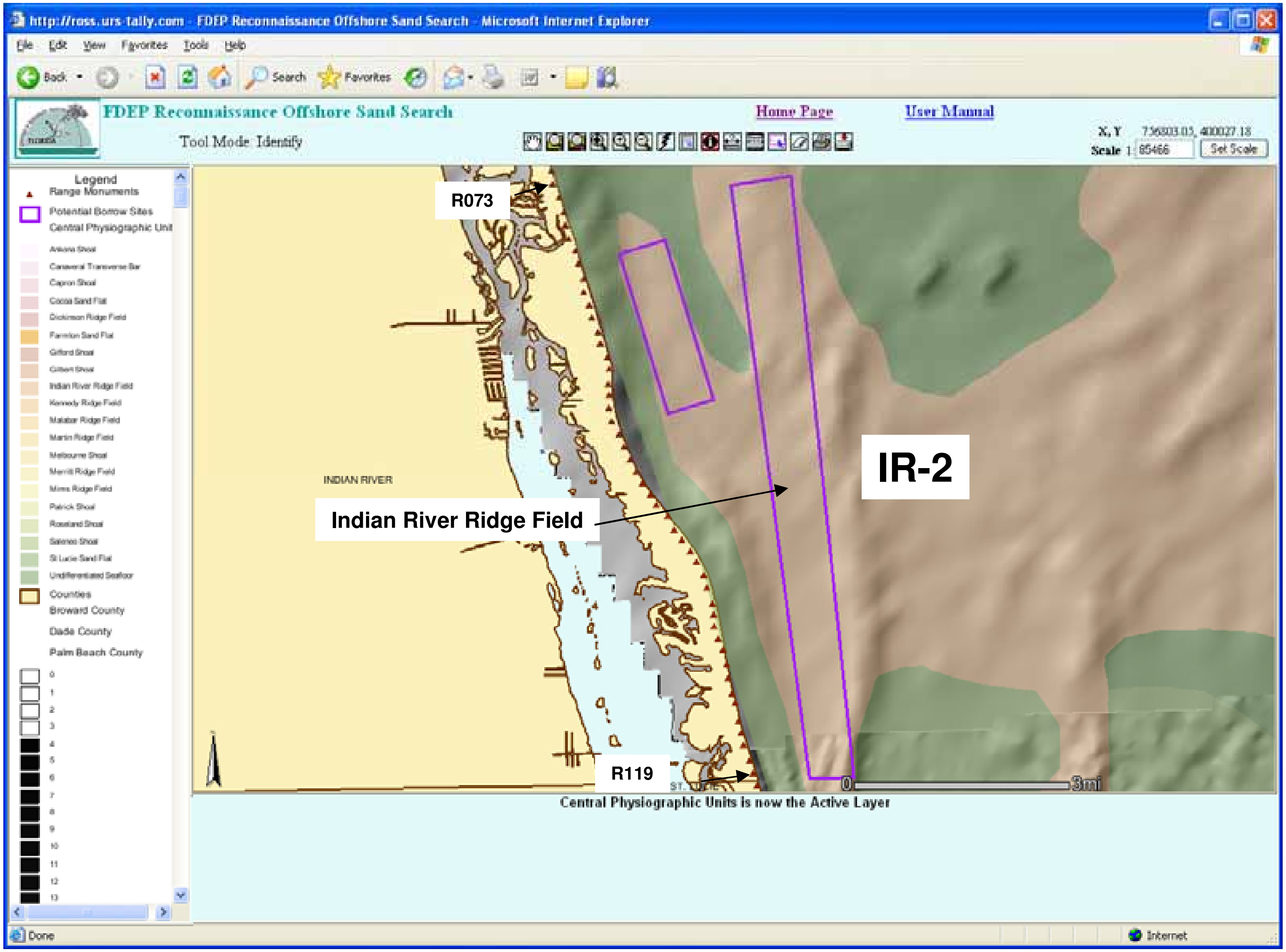


Figure 4-32. Indian River County Area IR-2 showing physiographic zones overlaying the gray scale image.

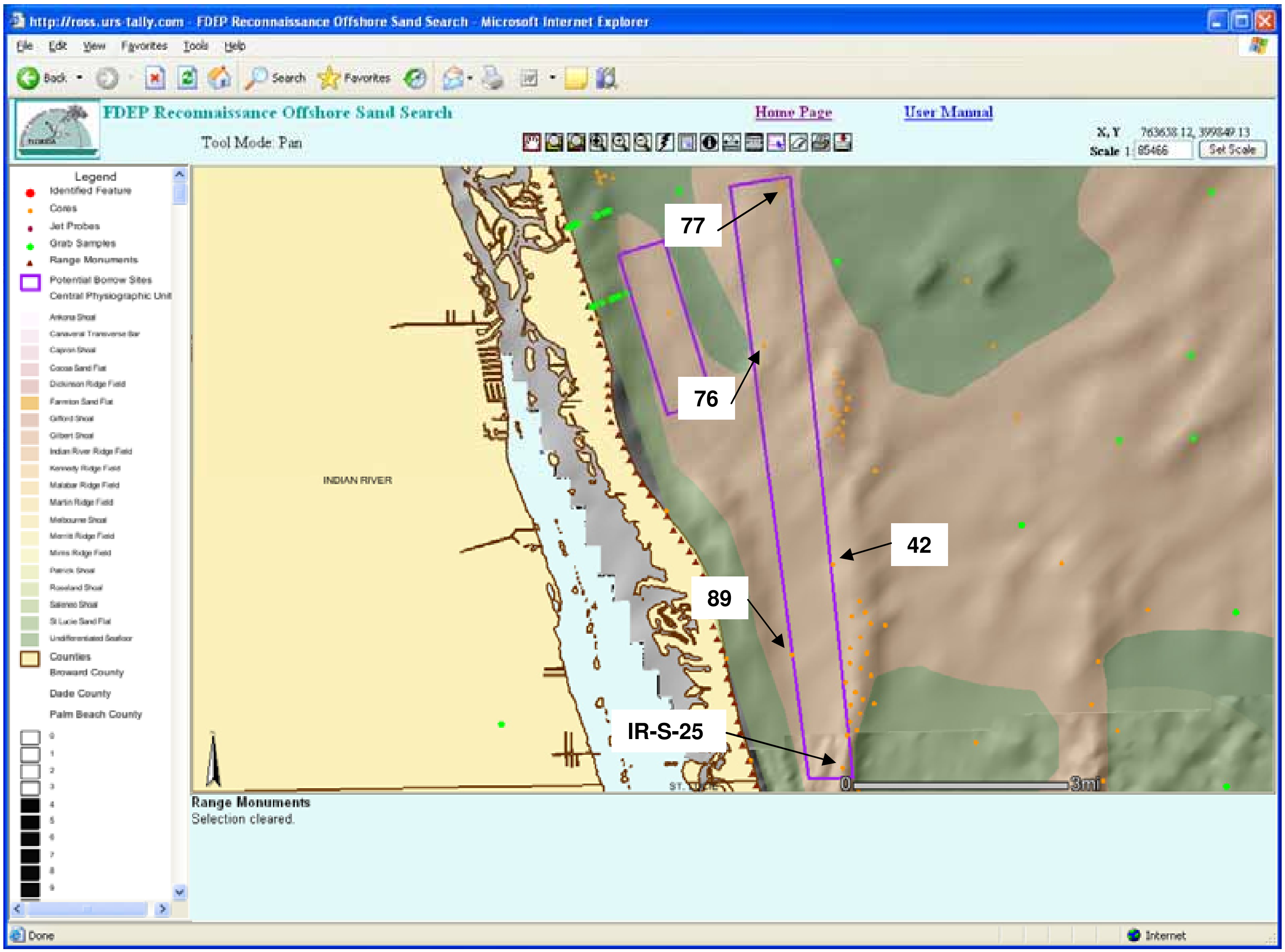


Figure 4-33. Indian River County Area IR-2 showing Vibracore and Grab Sample locations.

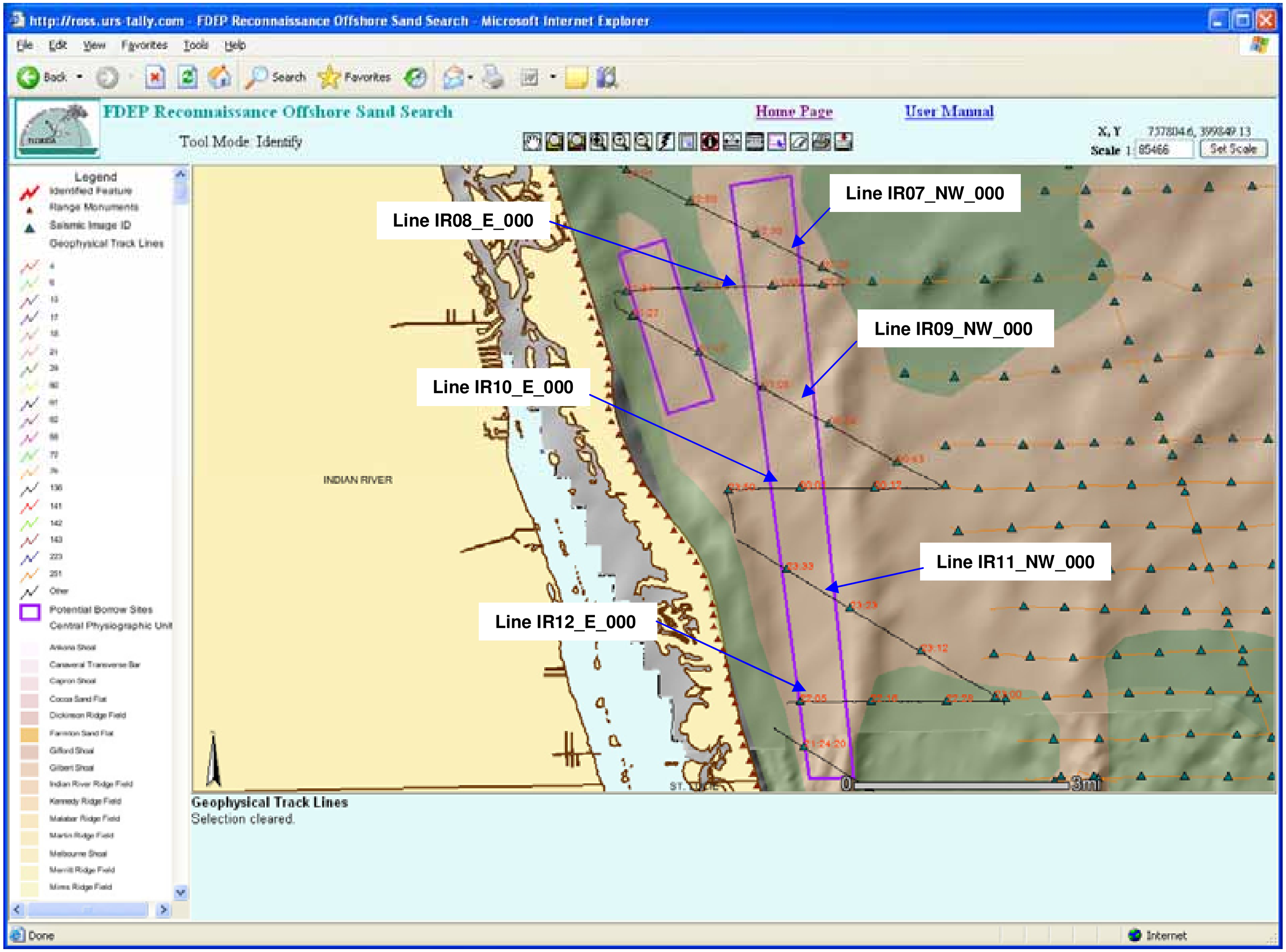
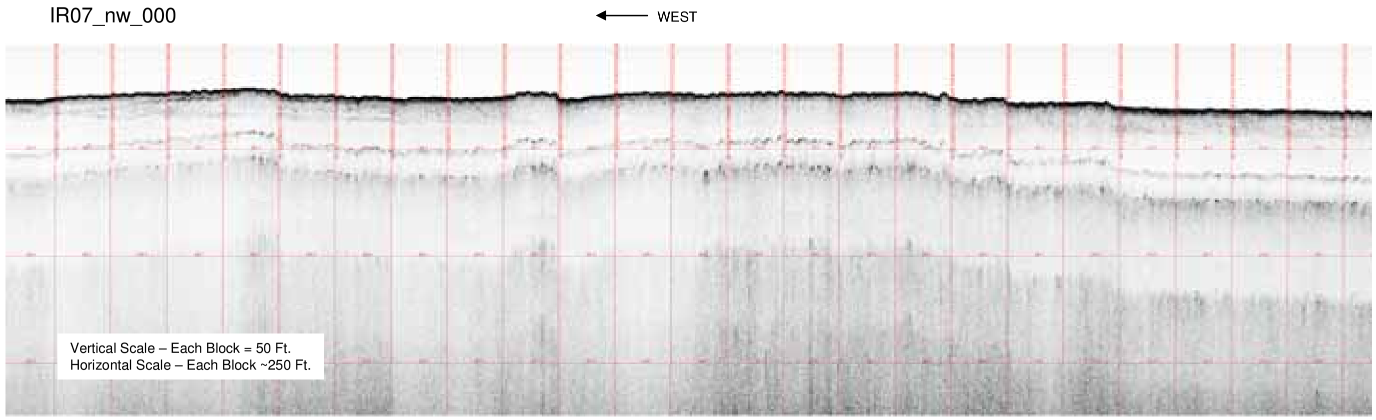


Figure 4-34. Indian River County Area IR-2 showing geophysical trackline locations and timestamps.



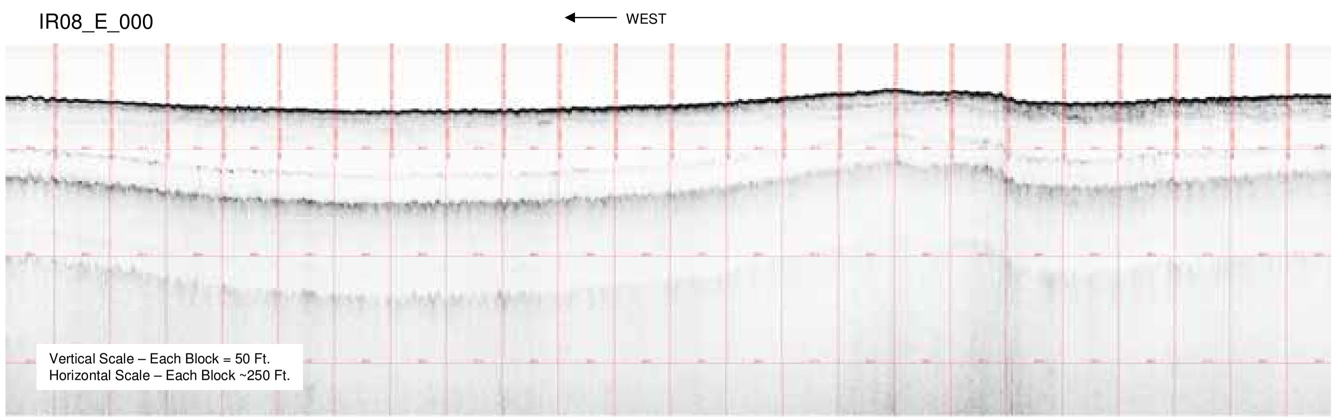


Figure 4-35A. Indian River County Area IR-2. Lines IR07_nw_000 (above) and IR08_E_000 (below) showing the potential for several feet of usable sand sources.

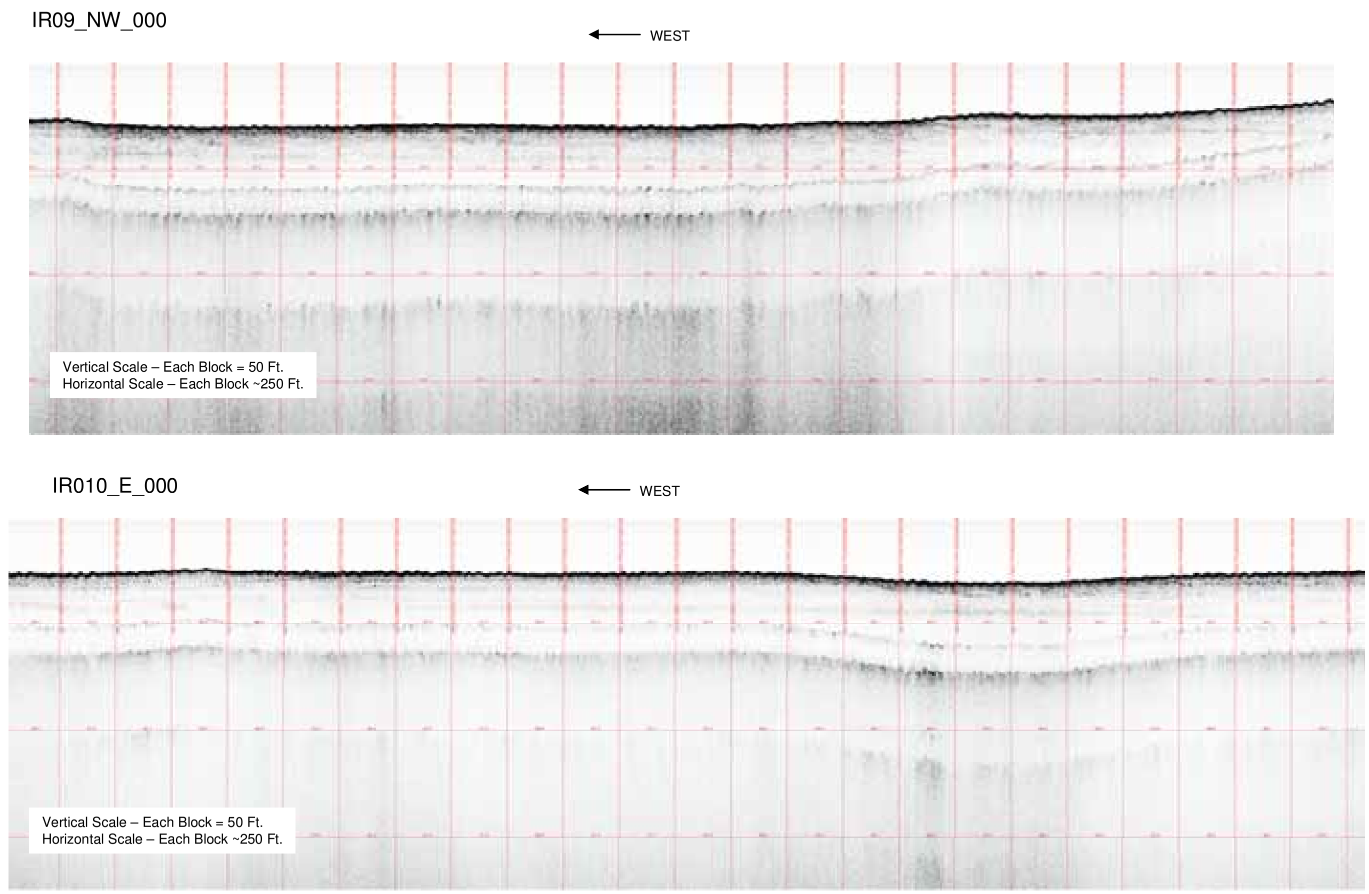
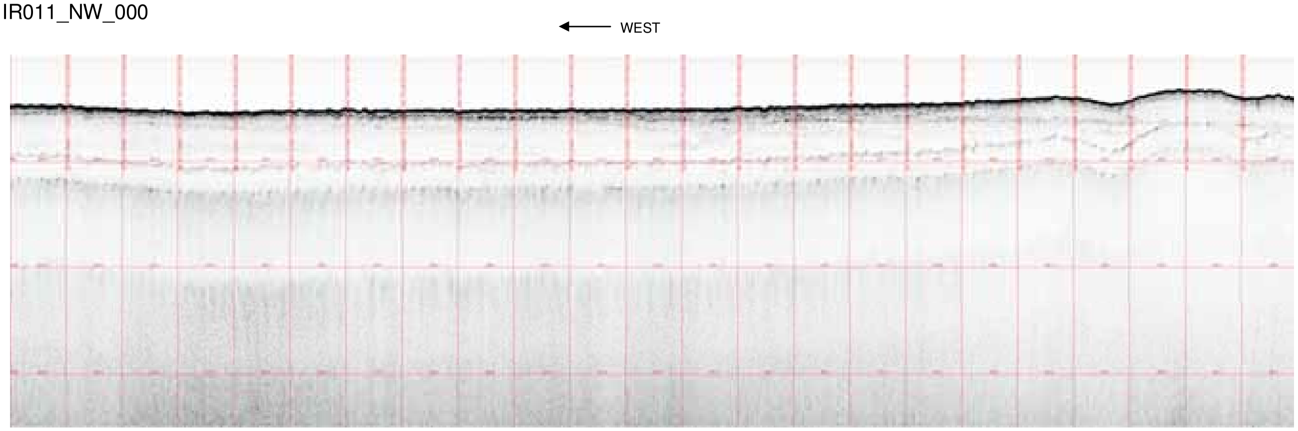


Figure 4-35B. Indian River County Area IR-2. Lines IR09_NW_000 (above) and IR10_E_000 (below). As with the other images for this region the sand potential is apparent.

IR011_NW_000



IR12_E_000

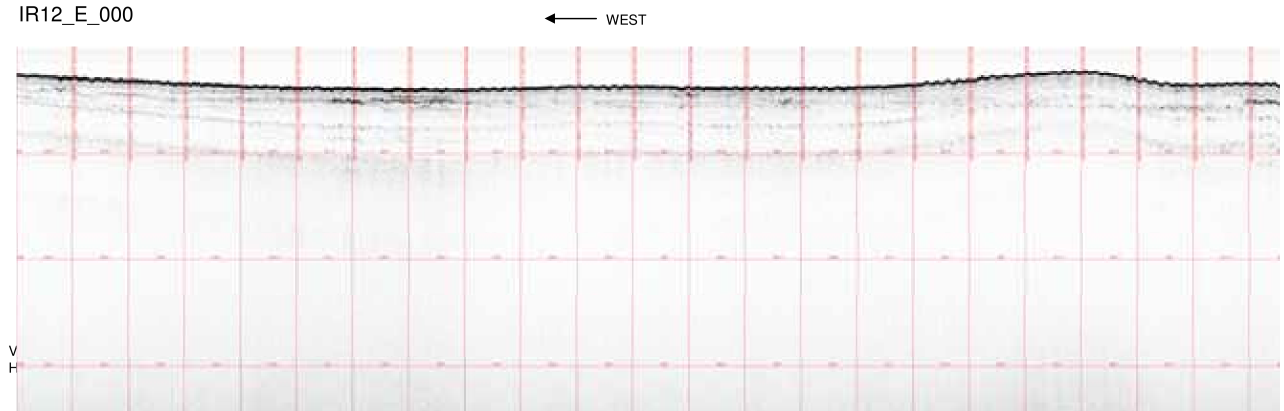


Figure 4-35C. Indian River County Area IR-2. Lines IR11_NW_000 (above) and IR12_E_000 (below). These images show the potential sand deposits extend to the south end of Indian River county.

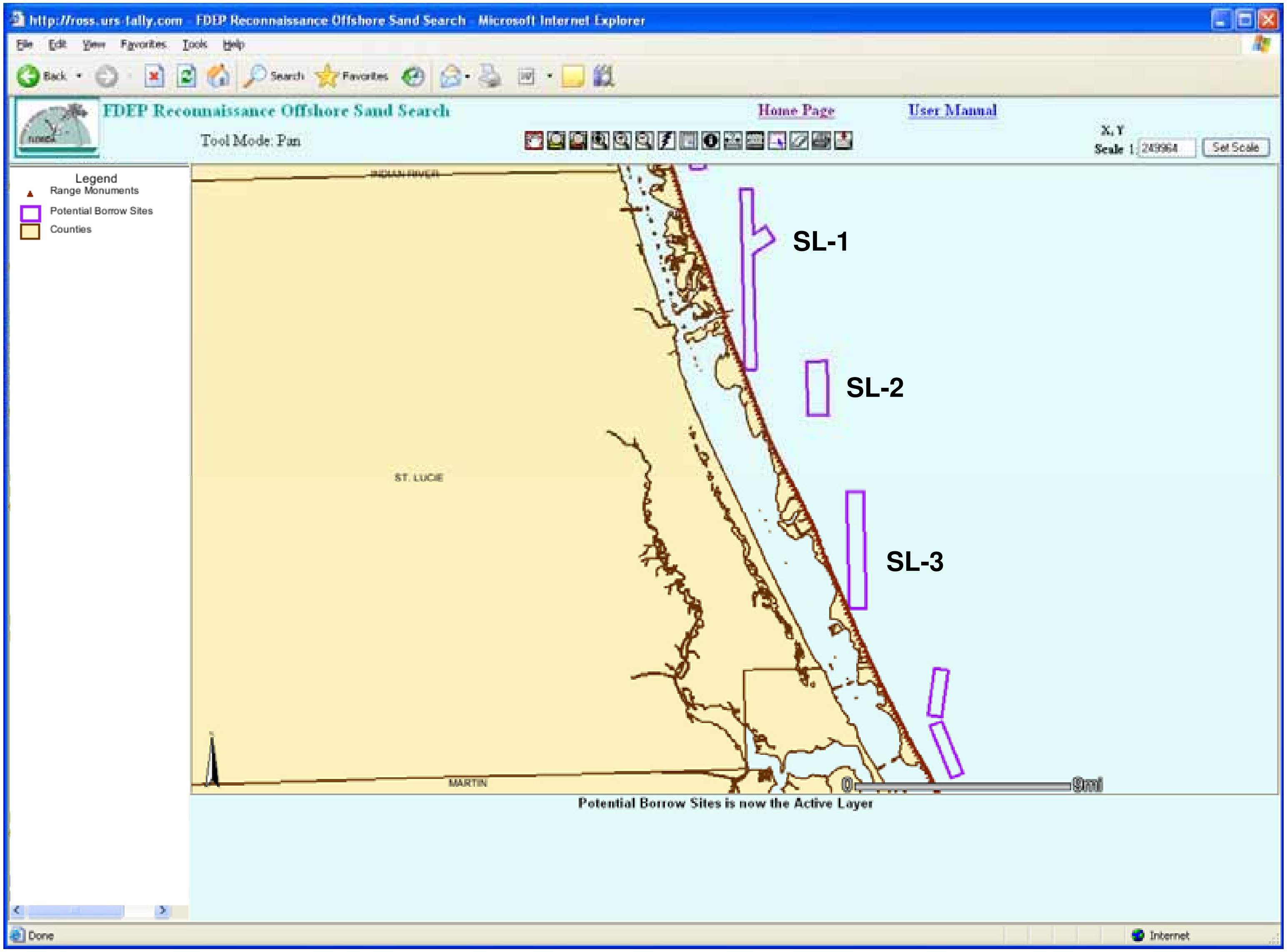


Figure 4-36. St. Lucie County Nearshore Potential Borrow Areas.

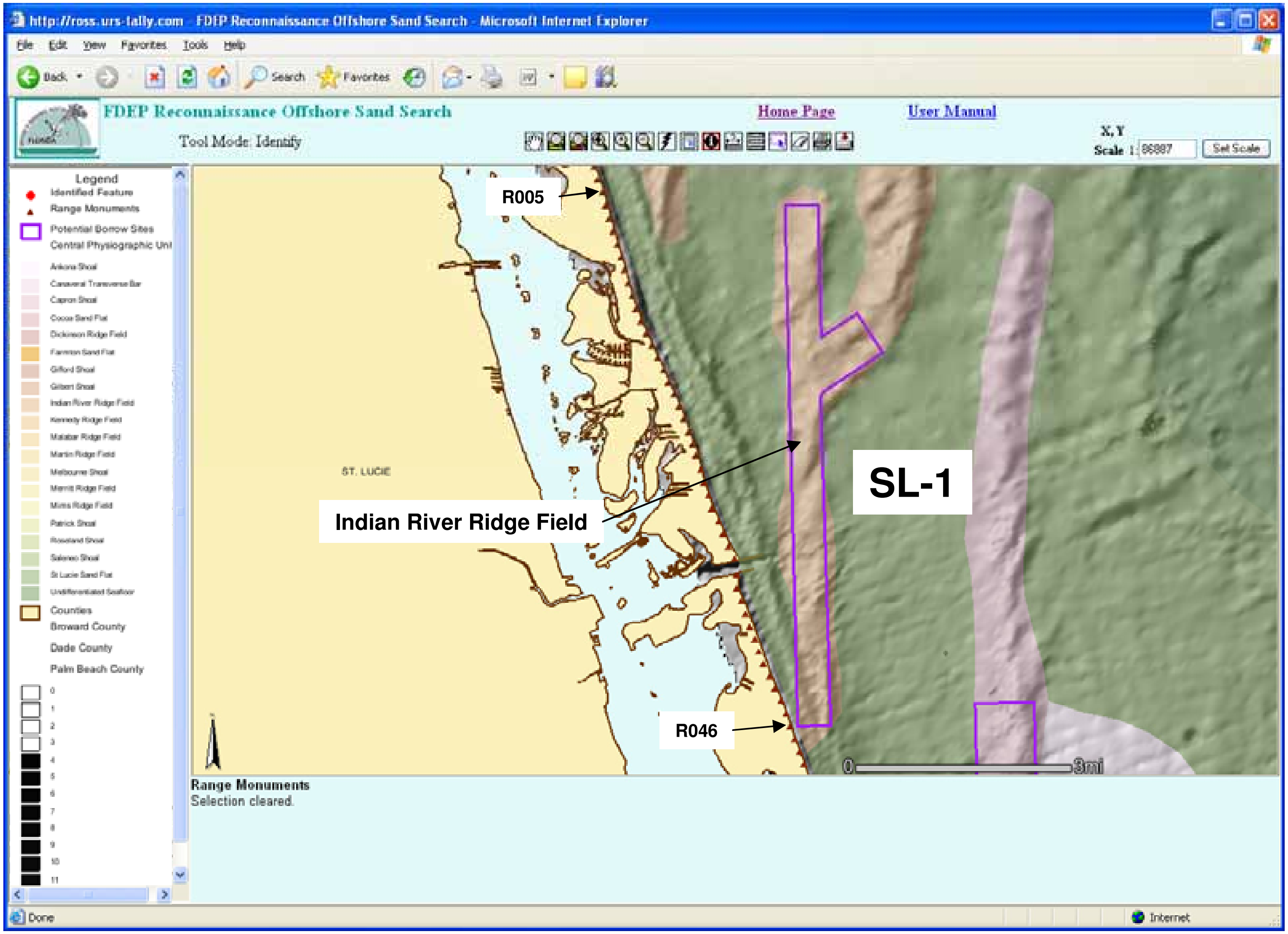


Figure 4-37. St. Lucie County Area SL-1 showing physiographic zones overlaying the gray scale image.

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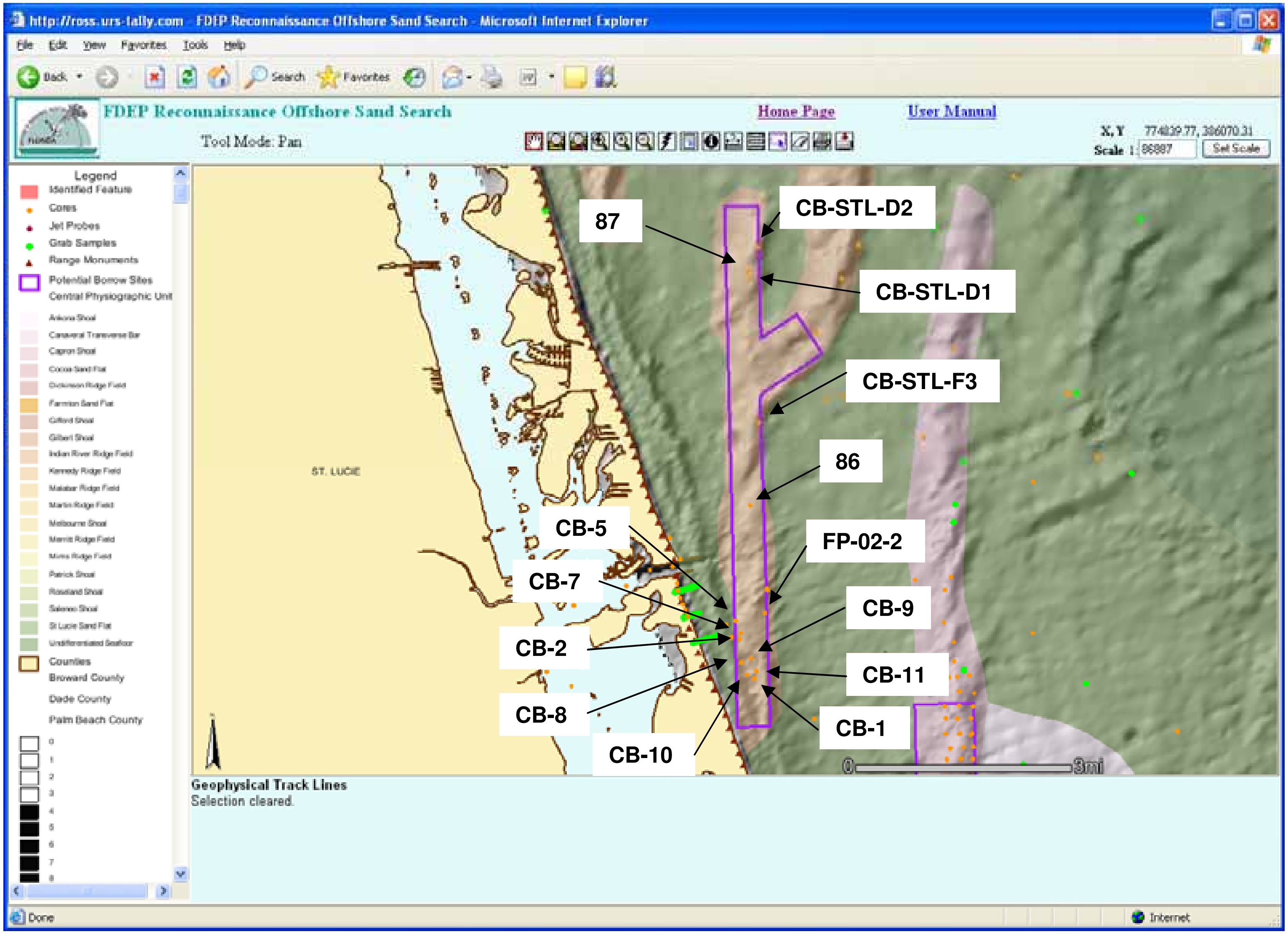


Figure 4-38. St. Lucie County Area SL-1 showing Vibracore and Grab Sample locations.

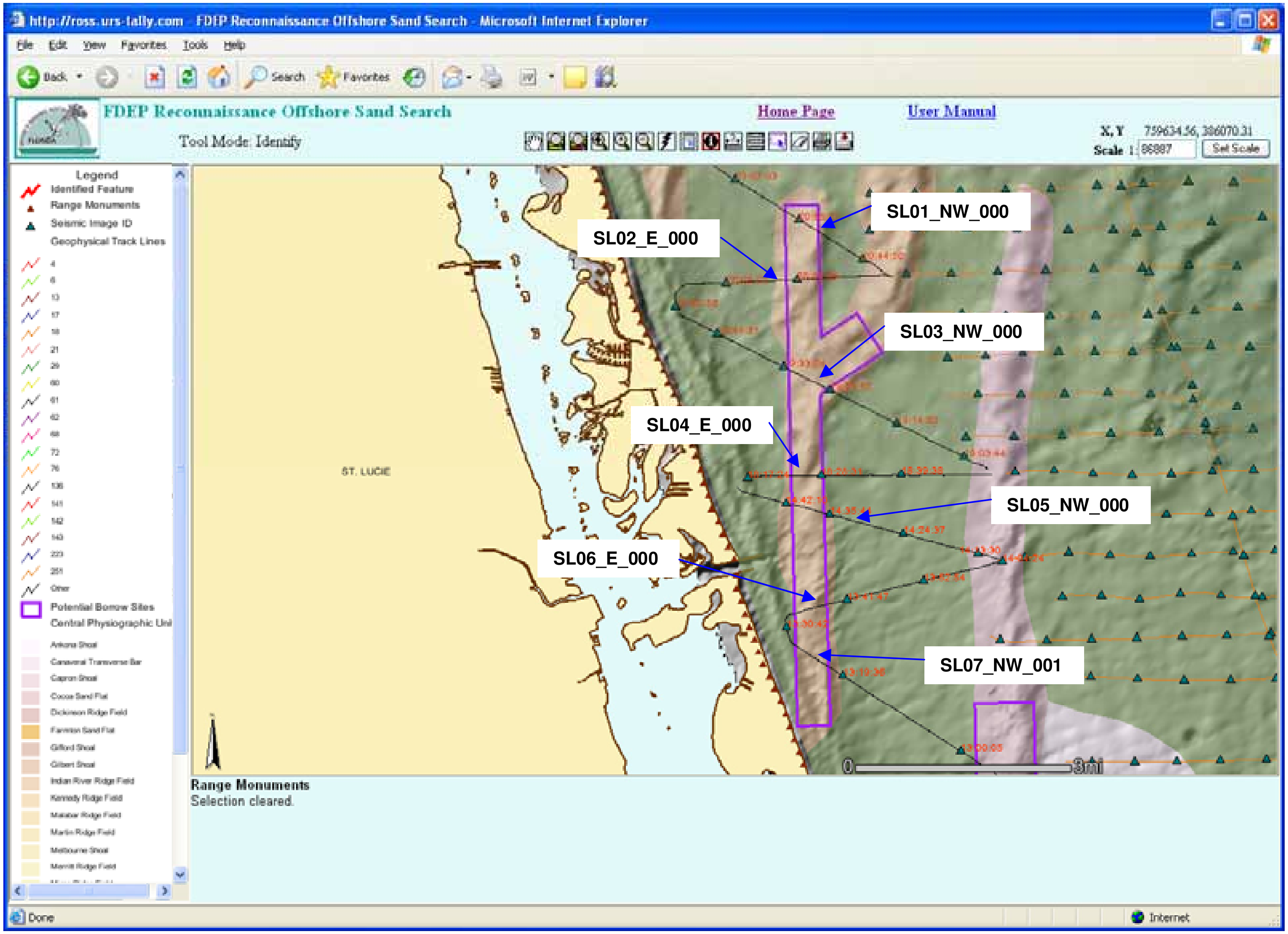


Figure 4-39. St. Lucie County Area SL-1 showing geophysical trackline locations and timestamps.

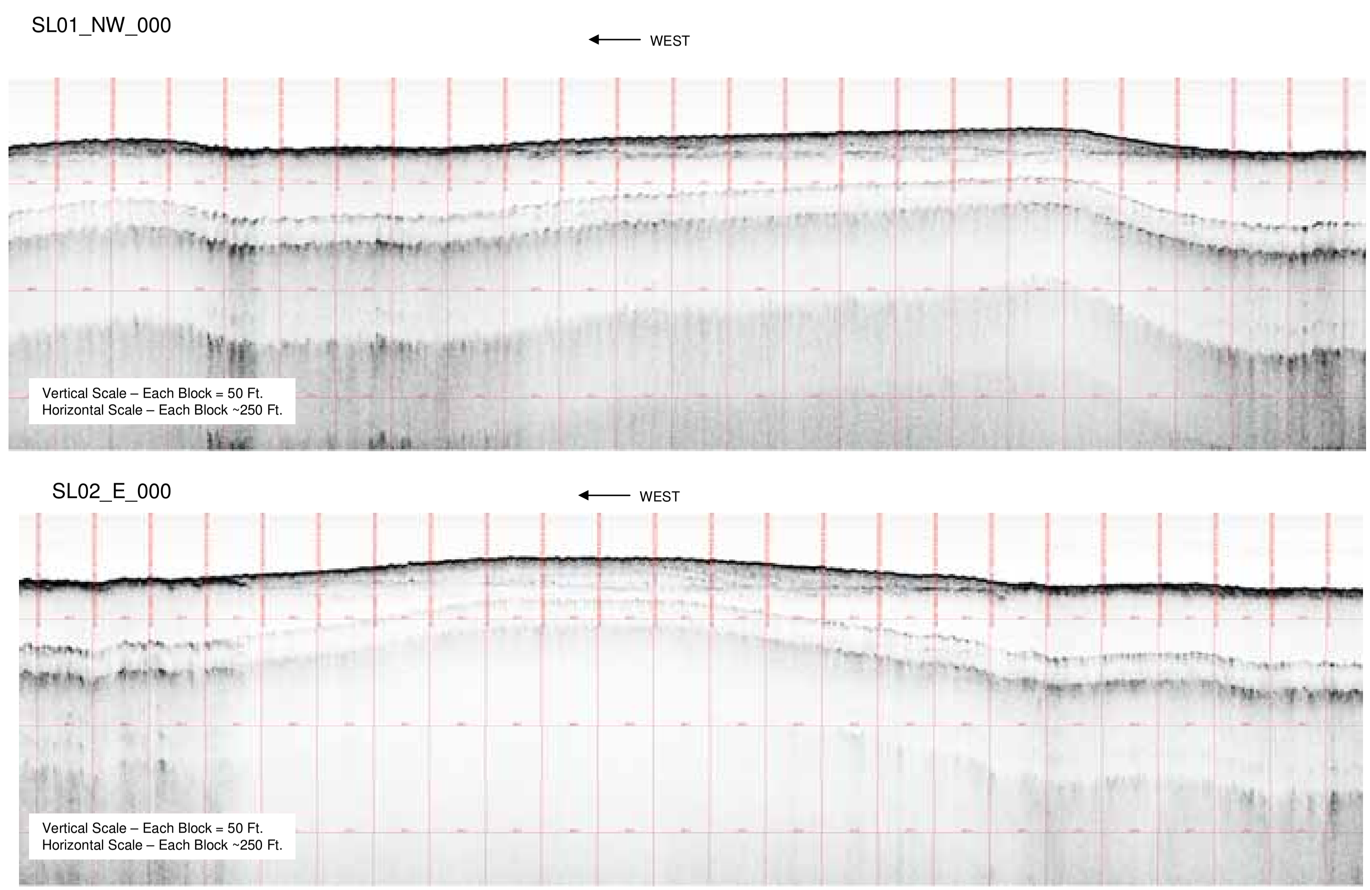


Figure 4-40A. St Lucie County Lines Area SL1. SL01_NW_000 and SL02_E_000.

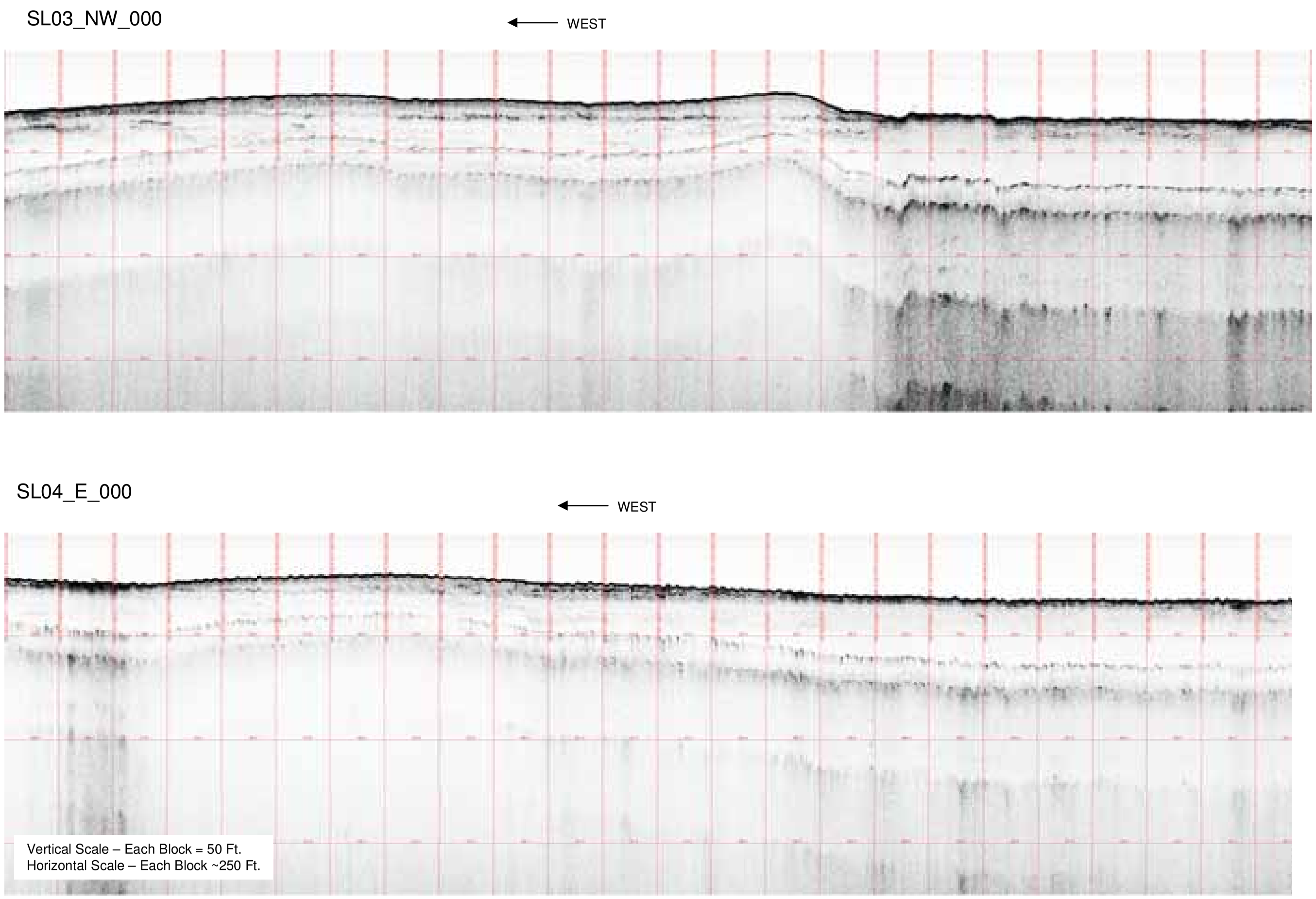
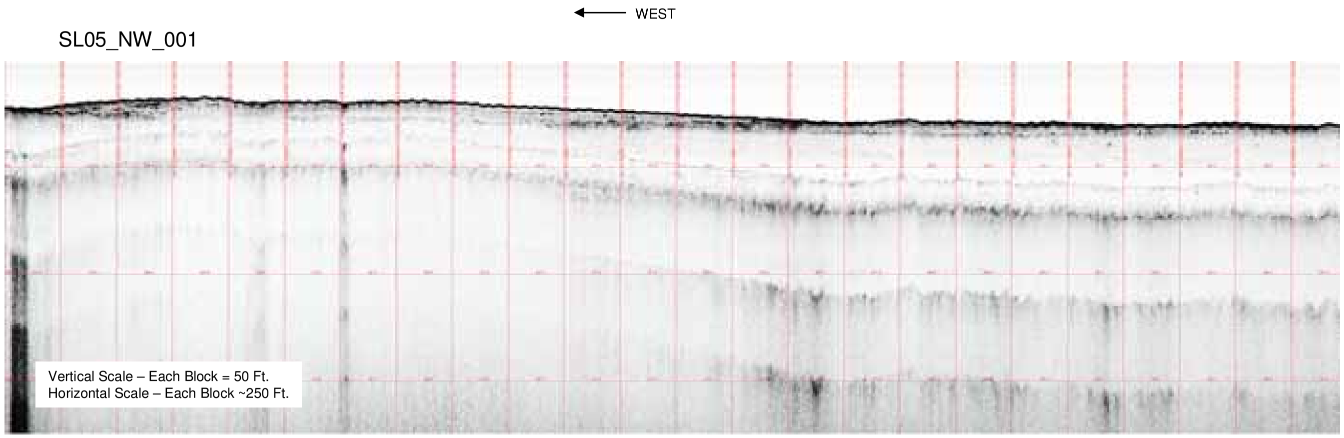


Figure 4-40B. St Lucie County Lines Area SL1. SL03_NW_000 and SL04_E_000.



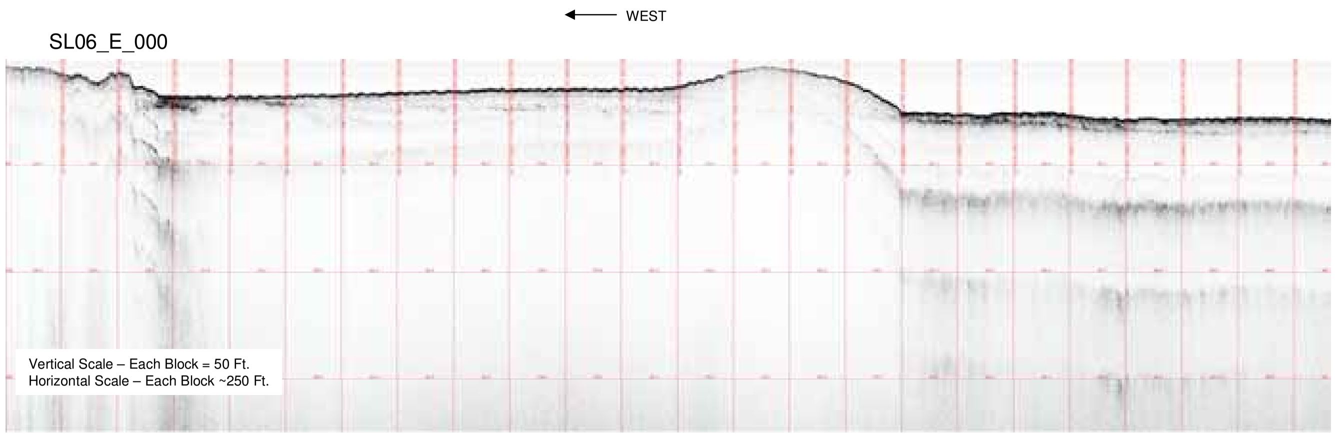


Figure 4-40C. St Lucie County Lines Area SL1. SL05_NW_001 and SL06_E_000.

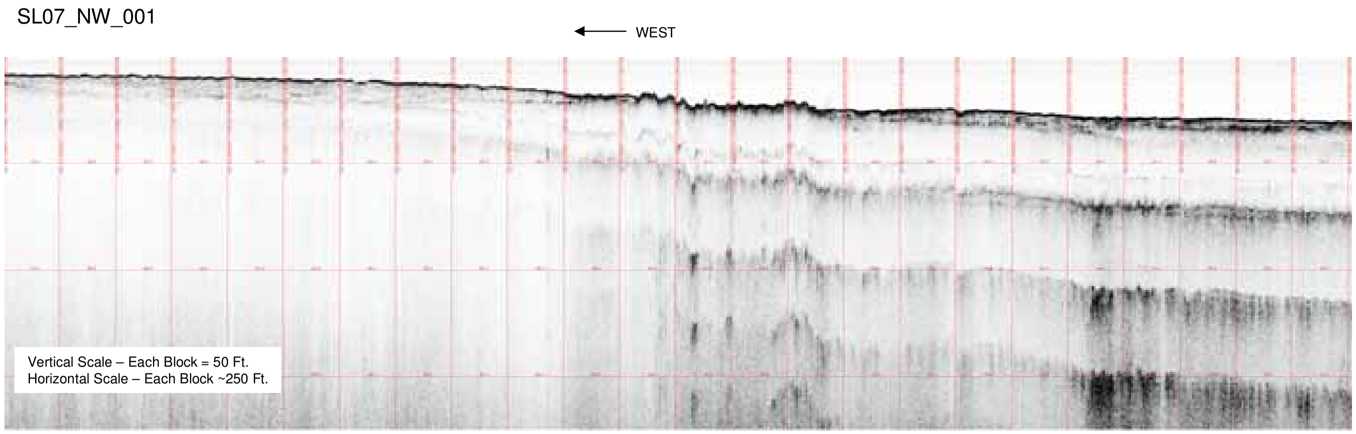


Figure 4-40D. St Lucie County Area SL-1 Line SL07_NW_001.

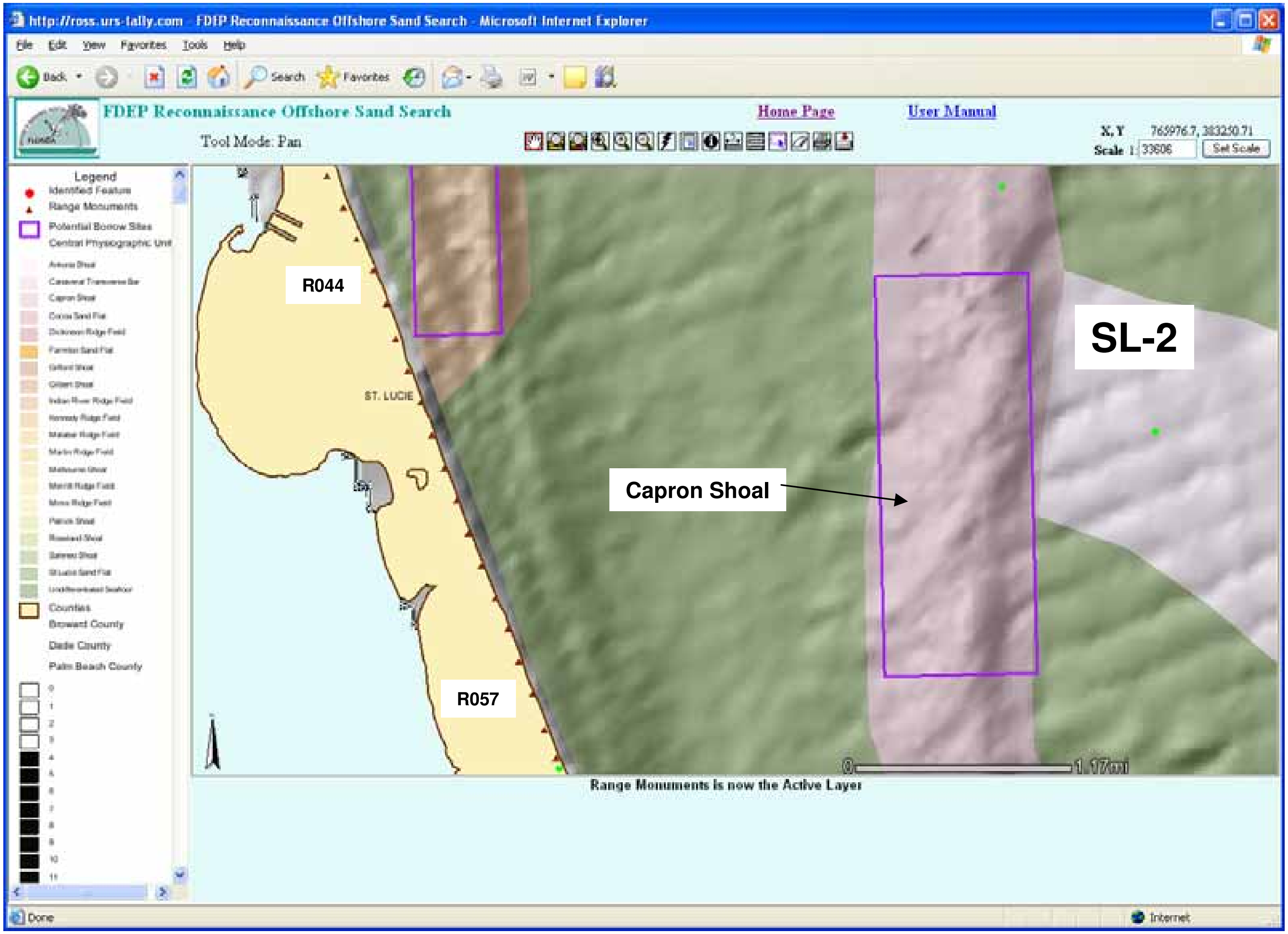


Figure 4-41. St. Lucie County Area SL-2 showing physiographic zones overlaying the gray scale image.

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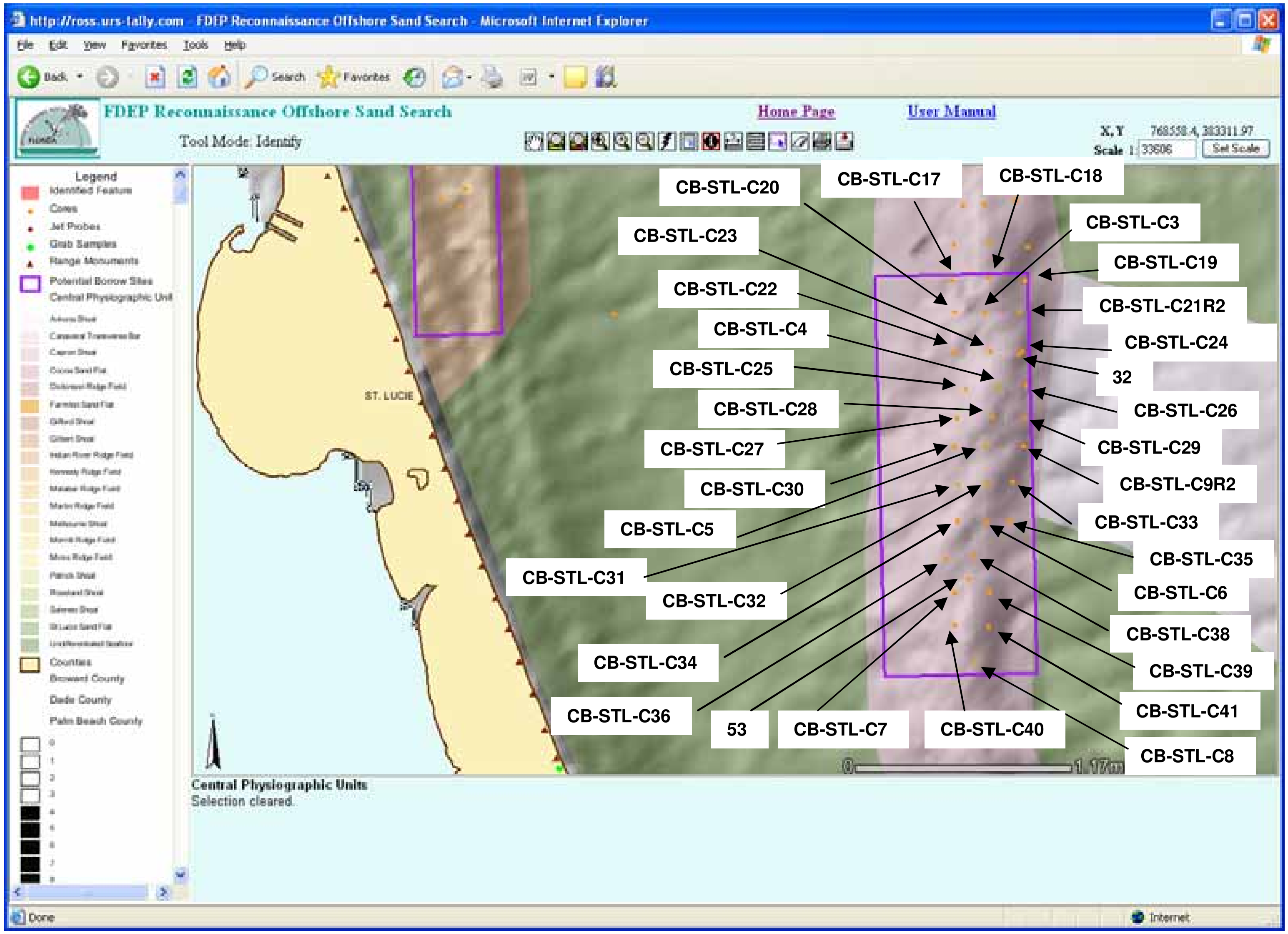

Figure 4-42. St. Lucie County Area SL-2 showing Vibracore and Grab Sample locations.

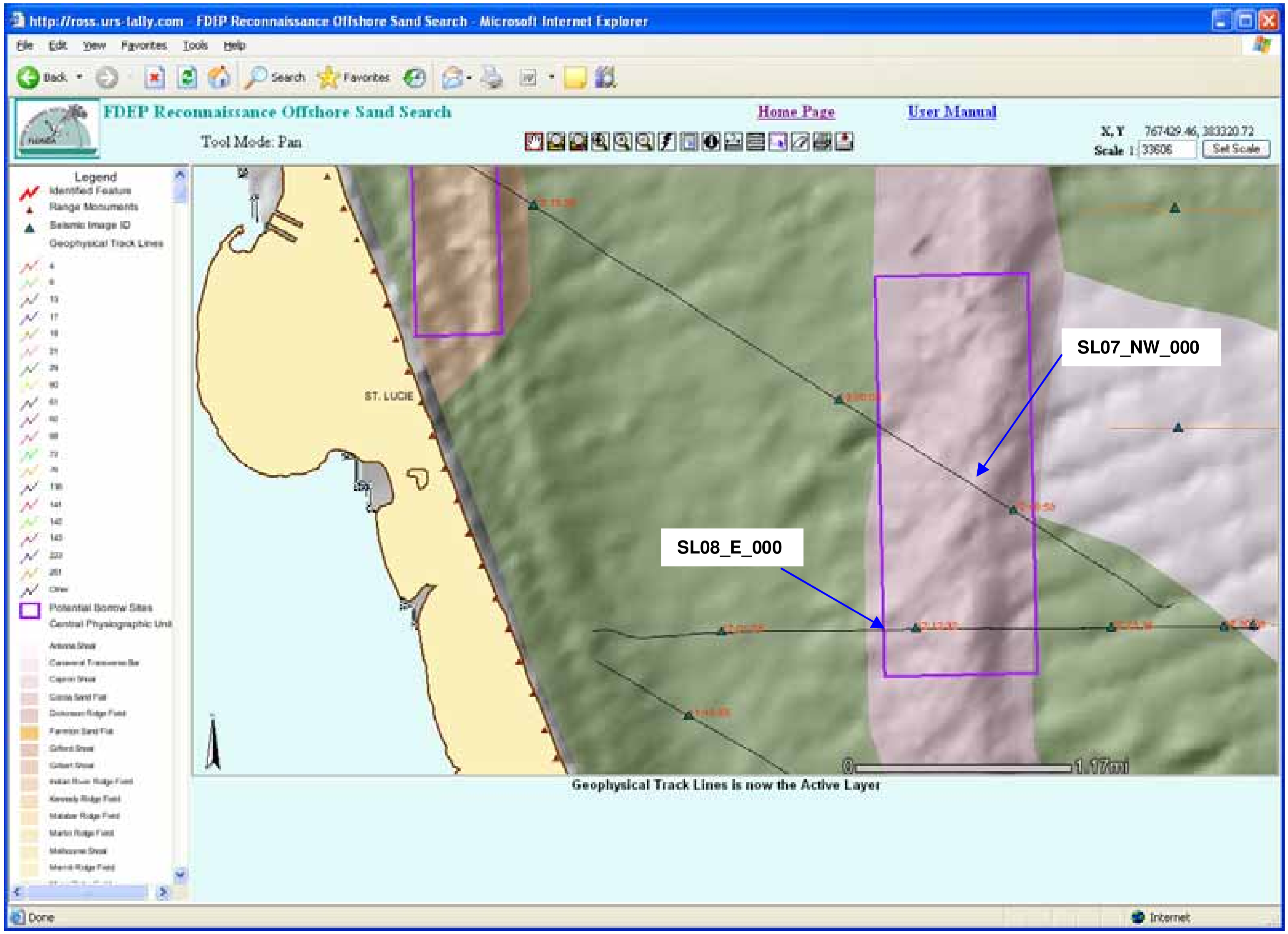

Figure 4-43. St. Lucie County Area SL-2 showing geophysical trackline locations and timestamps.

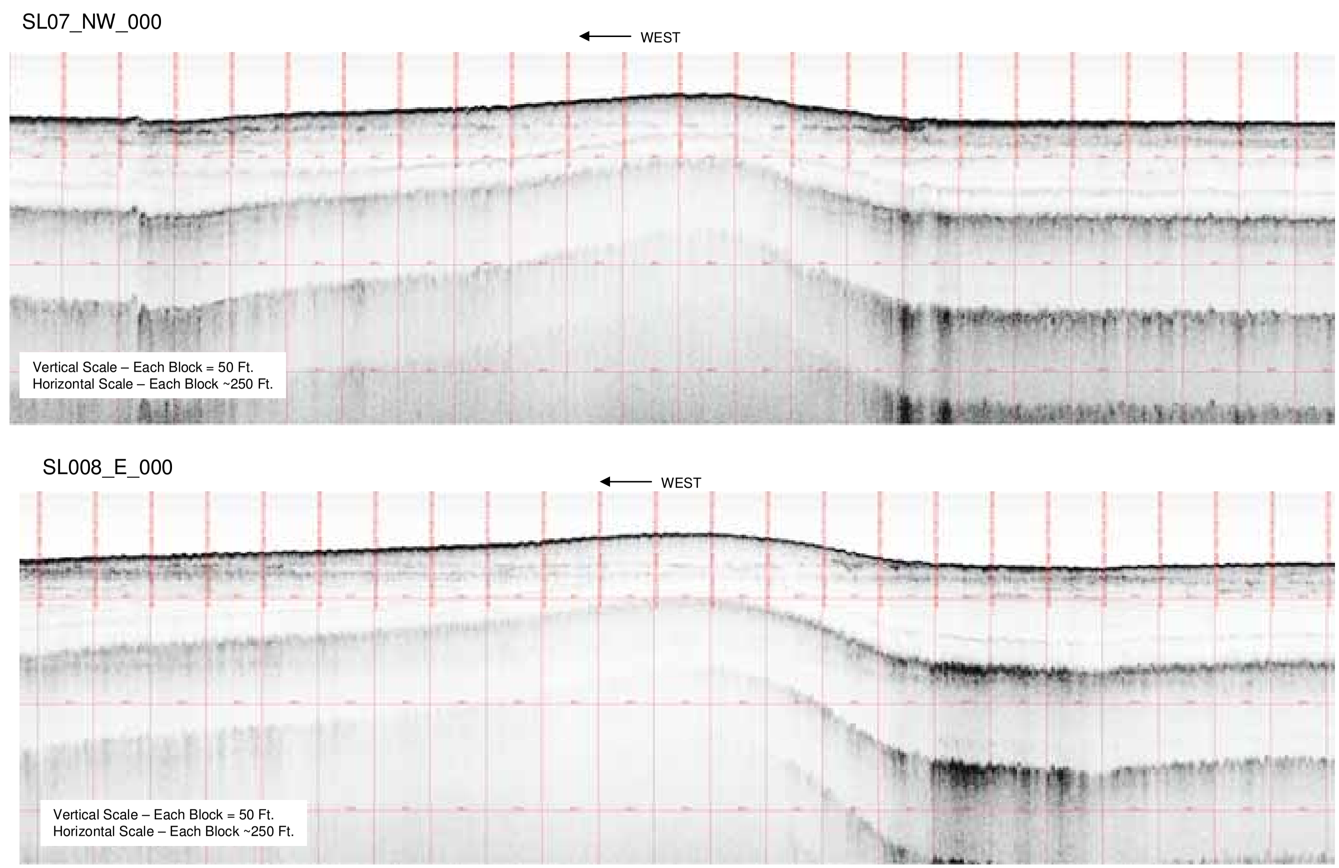

Figure 4-44. St Lucie County Area SL-2 Line SL07_NW_000 and SL08_E_000.

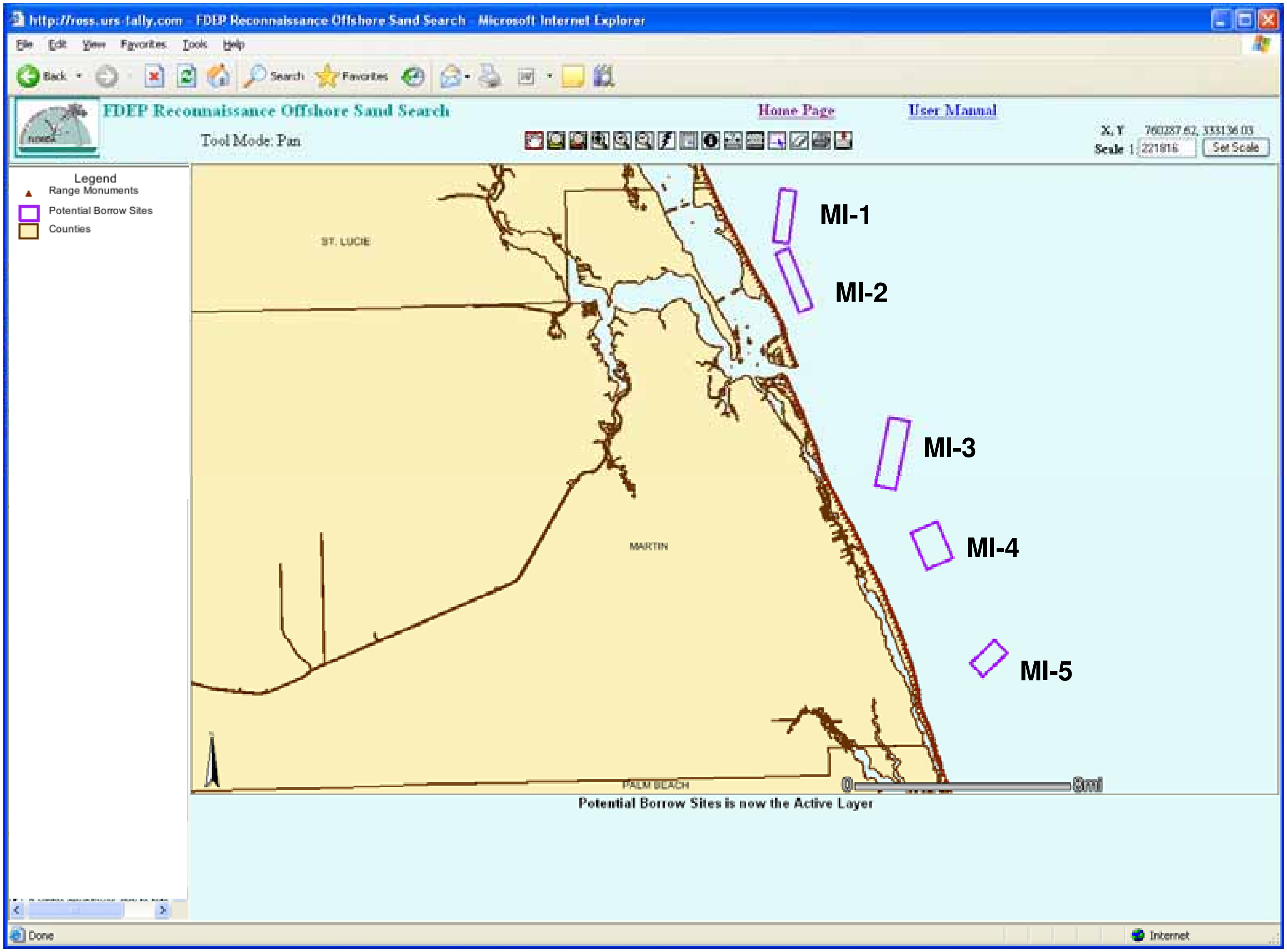

Figure 4-45. Martin County Nearshore Potential Borrow Areas.

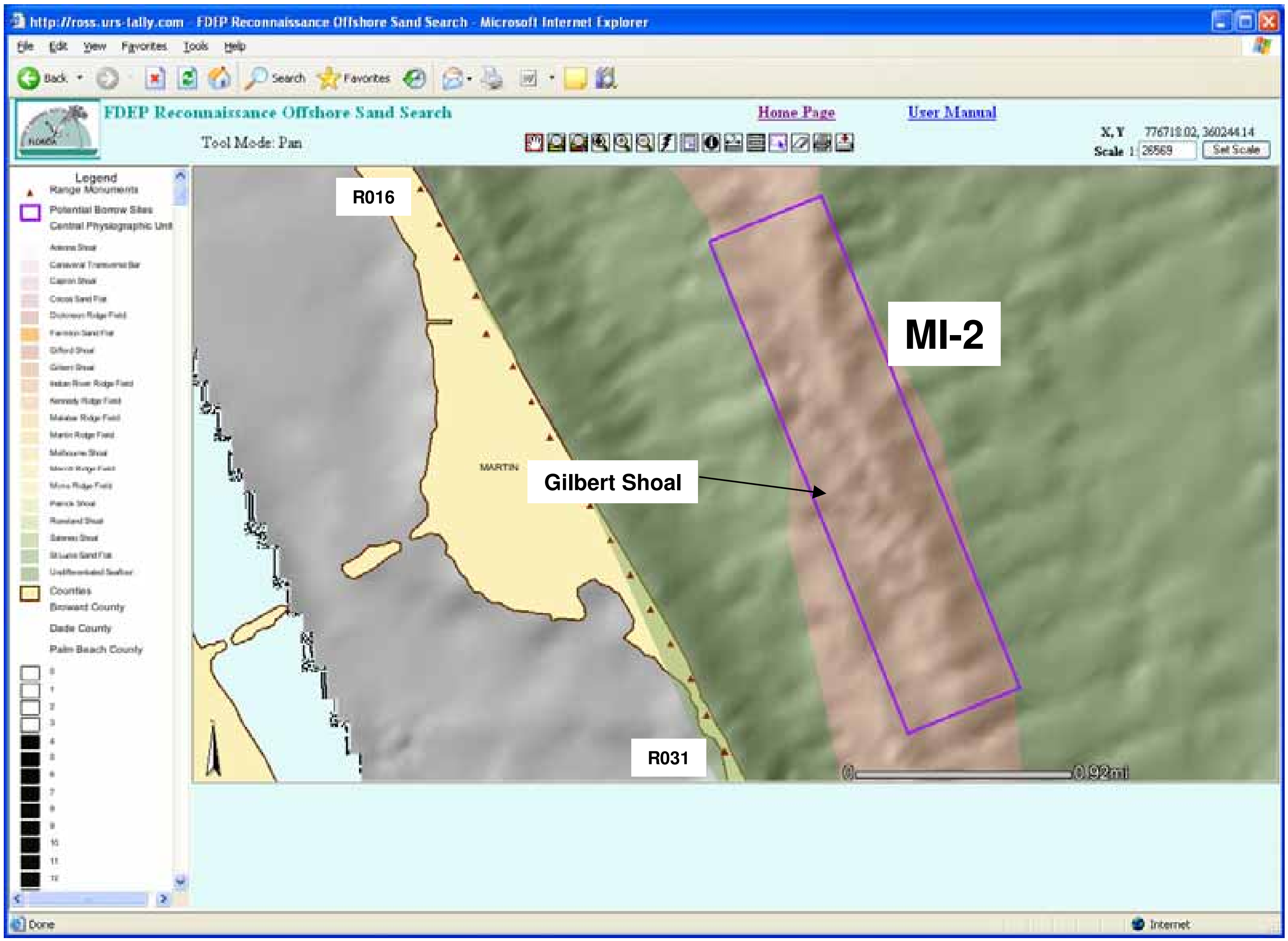

Figure 4-46. Martin County Area MI-2 showing physiographic zones overlaying the gray scale image.

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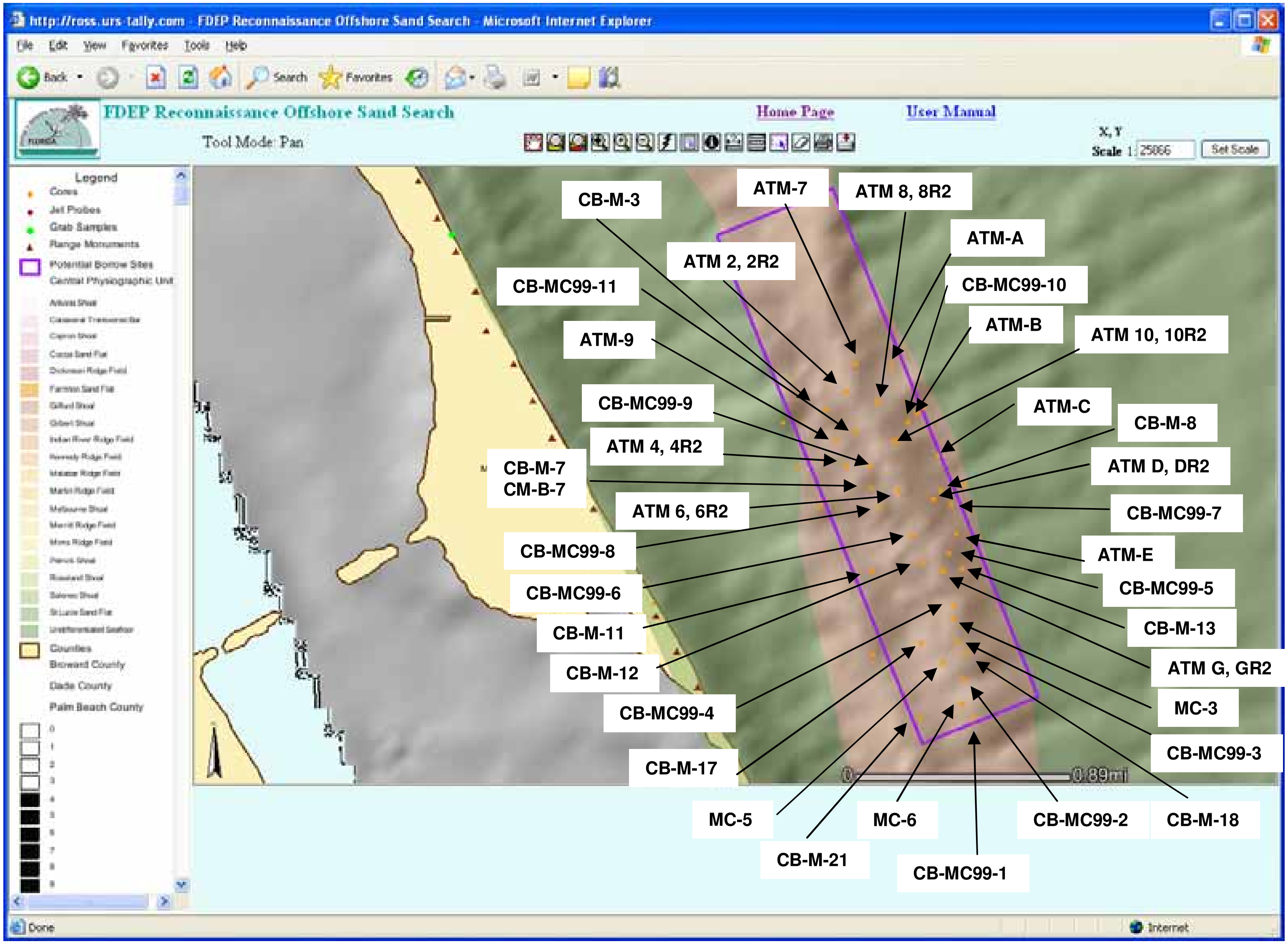

Figure 4-47. Martin County Area MI-2 showing Vibracore and Grab Sample locations.

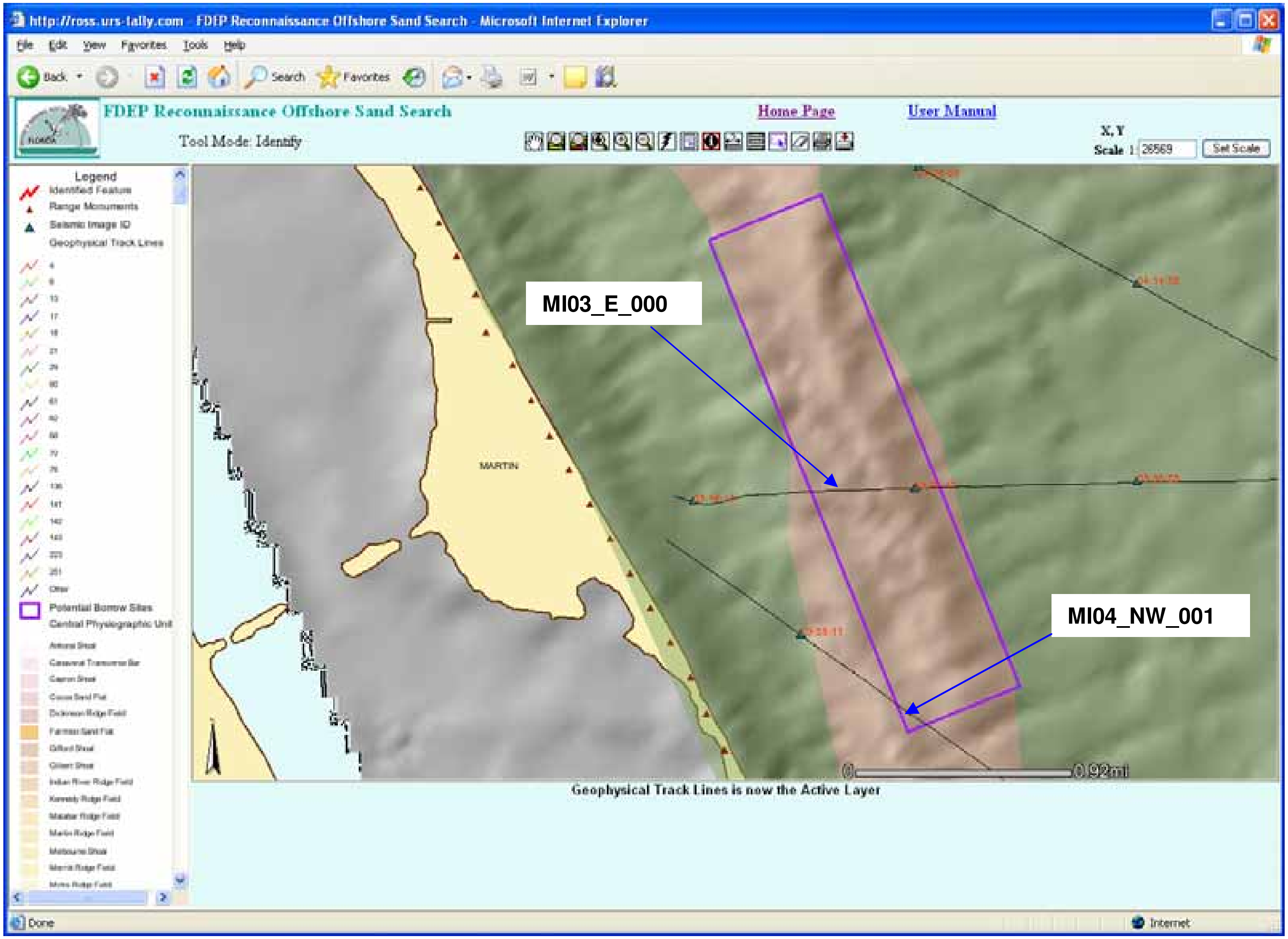

Figure 4-48. Martin County Area MI-2 showing geophysical trackline locations and timestamps.

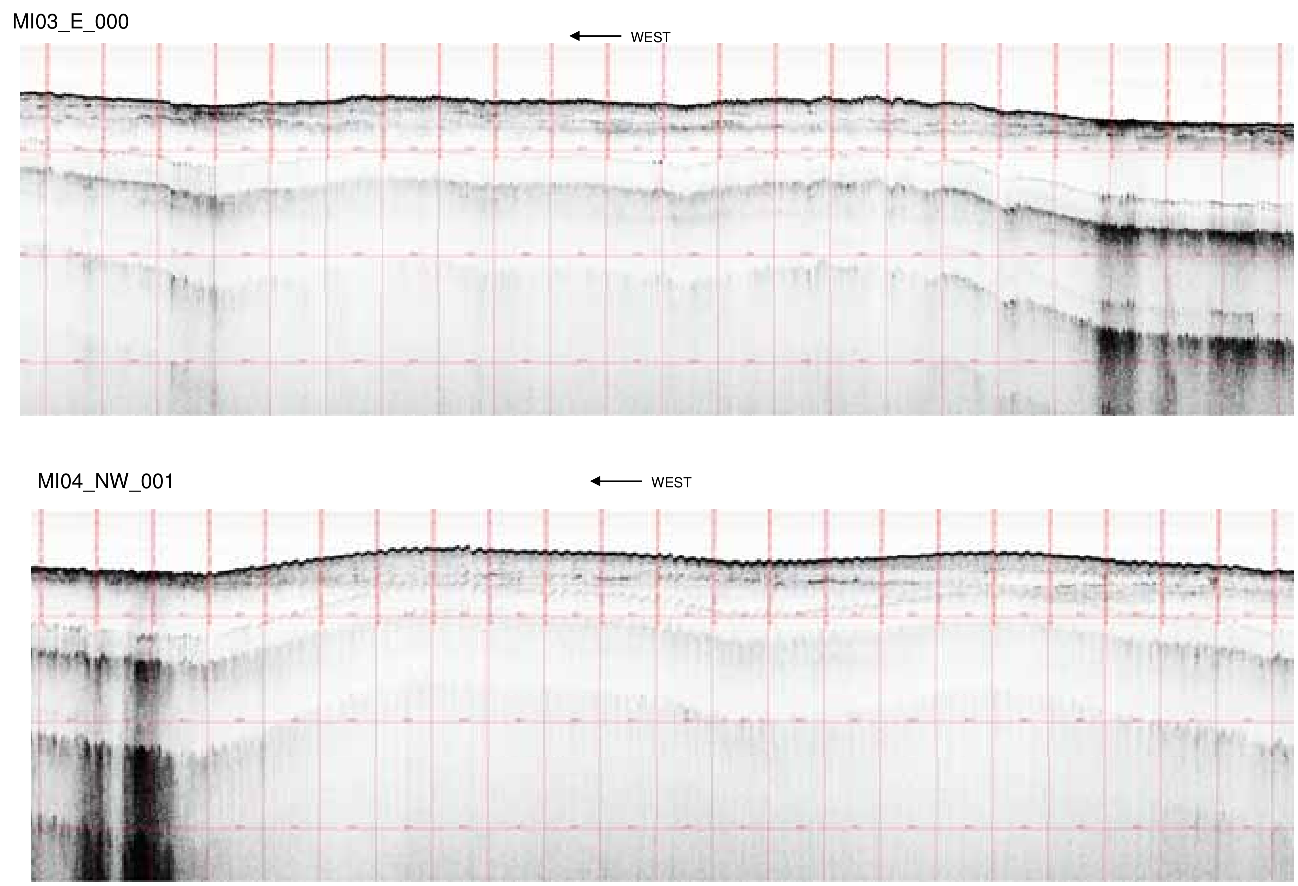

Figure 4-49. Martin County Area MI-2 Lines MI03_E_000 and MI04_NW_001.

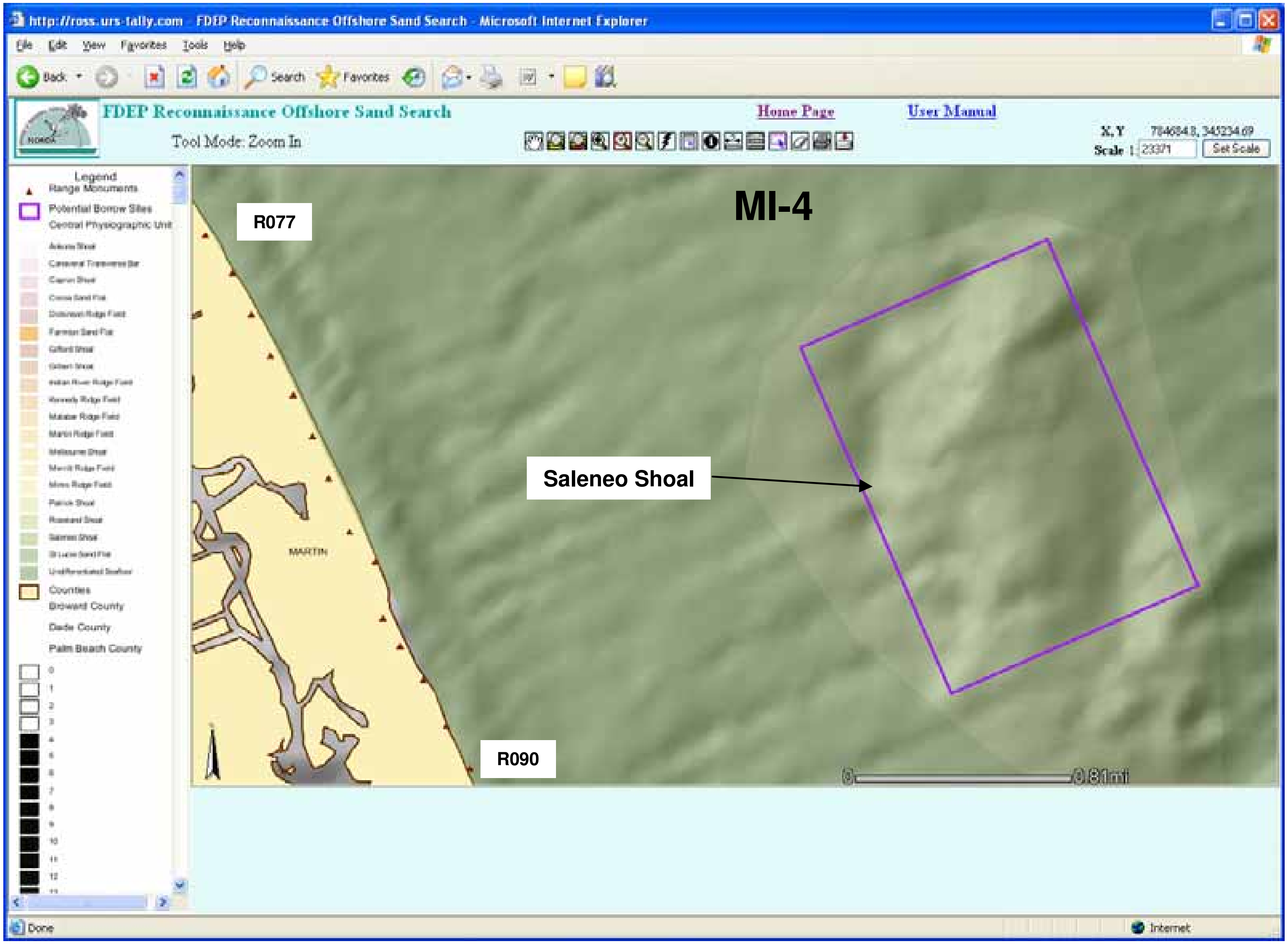

Figure 4-50. Martin County Area MI-4 showing physiographic zones overlaying the gray scale image.

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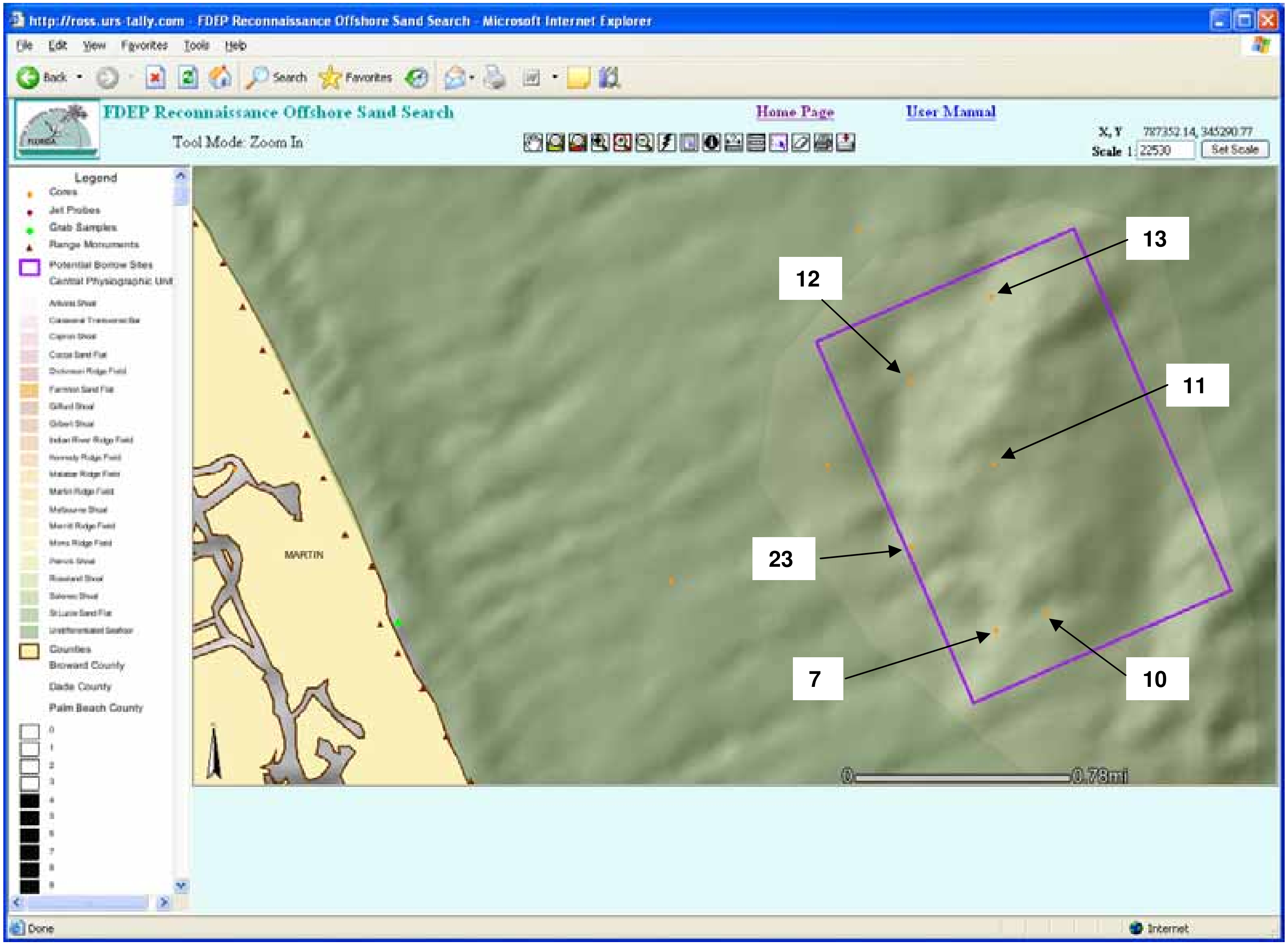


Figure 4-51. Martin County Area MI-4 showing Vibracore and Grab Sample locations.

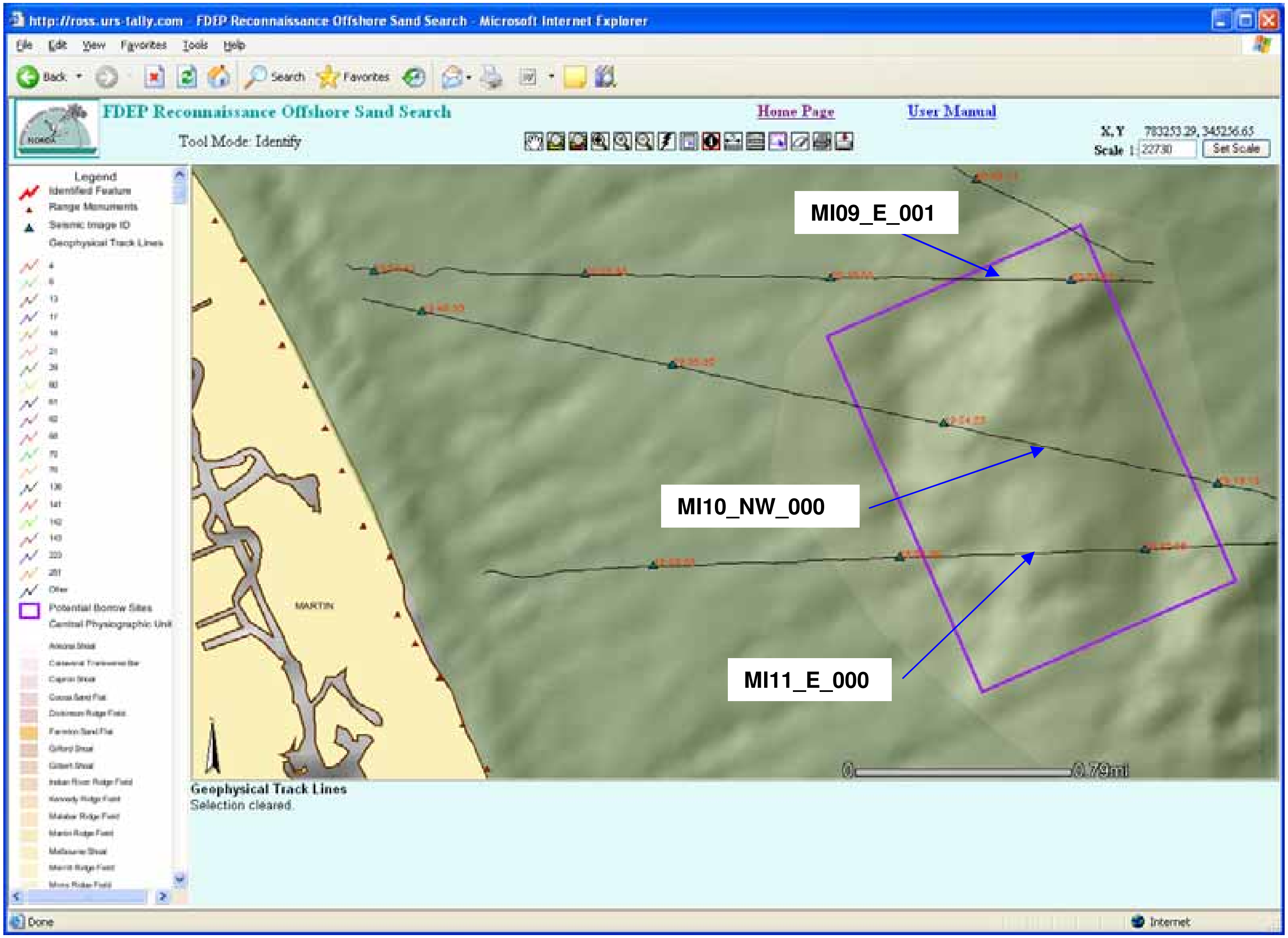


Figure 4-52. Martin County Area MI-4 showing geophysical trackline locations and timestamps.

MI09_E_001

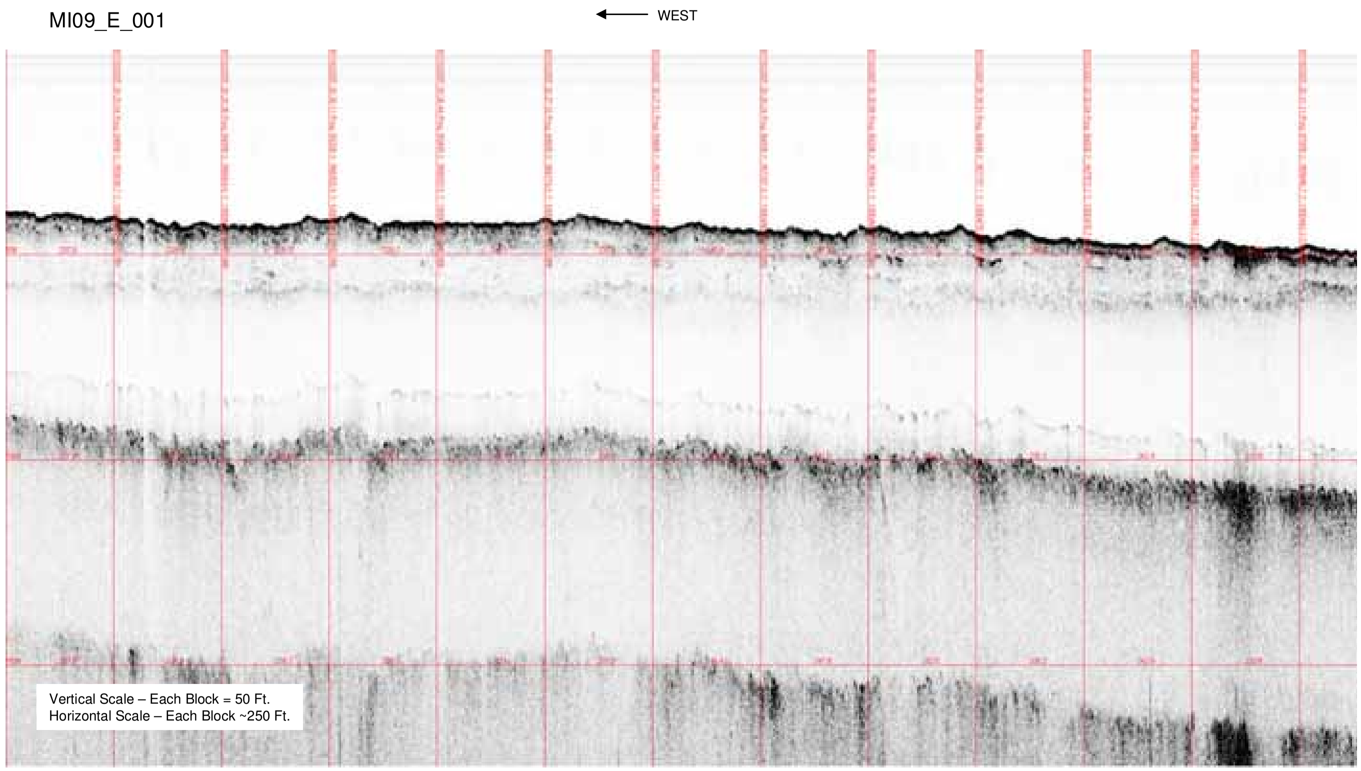


Figure 4-53A. Martin County Area MI-4 Line MI09_E_001

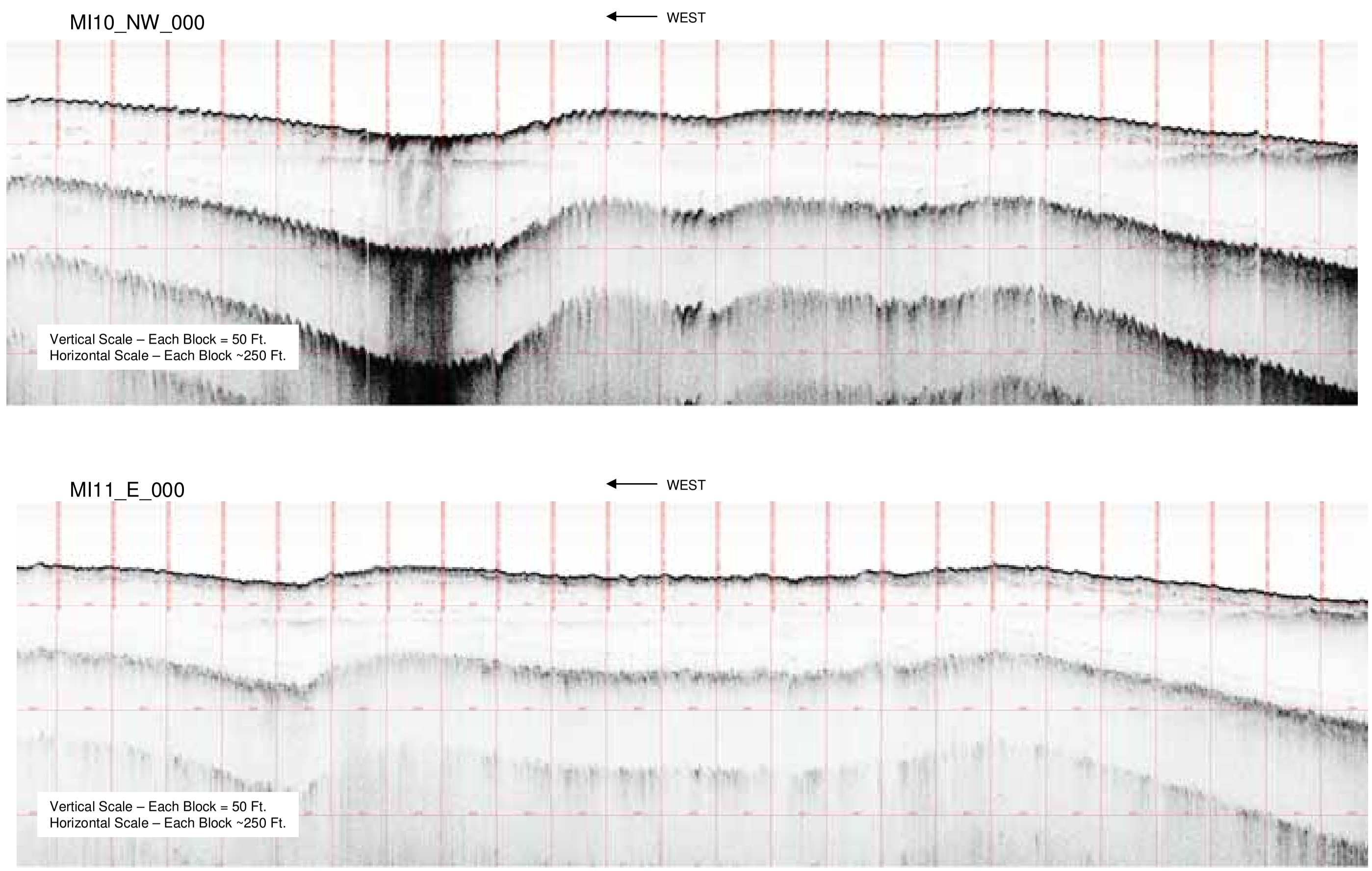


Figure 4-53B. Martin County Area MI-4 Line MI10_NW_000 and MI11_E_000.

Environmentally sensitive areas, shown in Figures 5-1 and 5-2, include seagrass beds, salt marsh, mangroves, rare and imperiled waters, right whale critical habitat, piping plover critical habitat, manatee critical habitat, aquatic preserves, national estuary program sites, dredged disposal sites, artificial reefs, and turtle nesting sites. They are shown in relation to the offshore morphology for ease of reference. Most of the environmentally sensitive areas do not occur offshore, but are restricted to estuarine waters that lie landward of barrier islands and Canaveral cuspate foreland.

Sensitive offshore environments are associated with the critical habitat of the Northern Right Whale (*Eubalaena glacialis*), (R170 northwards in Brevard County). The critical habitat in the study area between 30’15”N and 28’00”N Latitude extends from the coast to 5 nautical miles (5.96 mi) offshore (Figure 5-1). Manatee critical habitat occurs offshore from R100 northwards in Brevard County. Artificial reefs occur offshore all counties in the study area. Two dredge disposal sites occur in the study area, one offshore R40 to R60 in Brevard County and the other offshore R50 in St. Lucie County (Figure 5-1 and 5-2). Artificial reefs occurring seaward of the mapped seafloor morphology are not shown, although they are included in electronic databases.

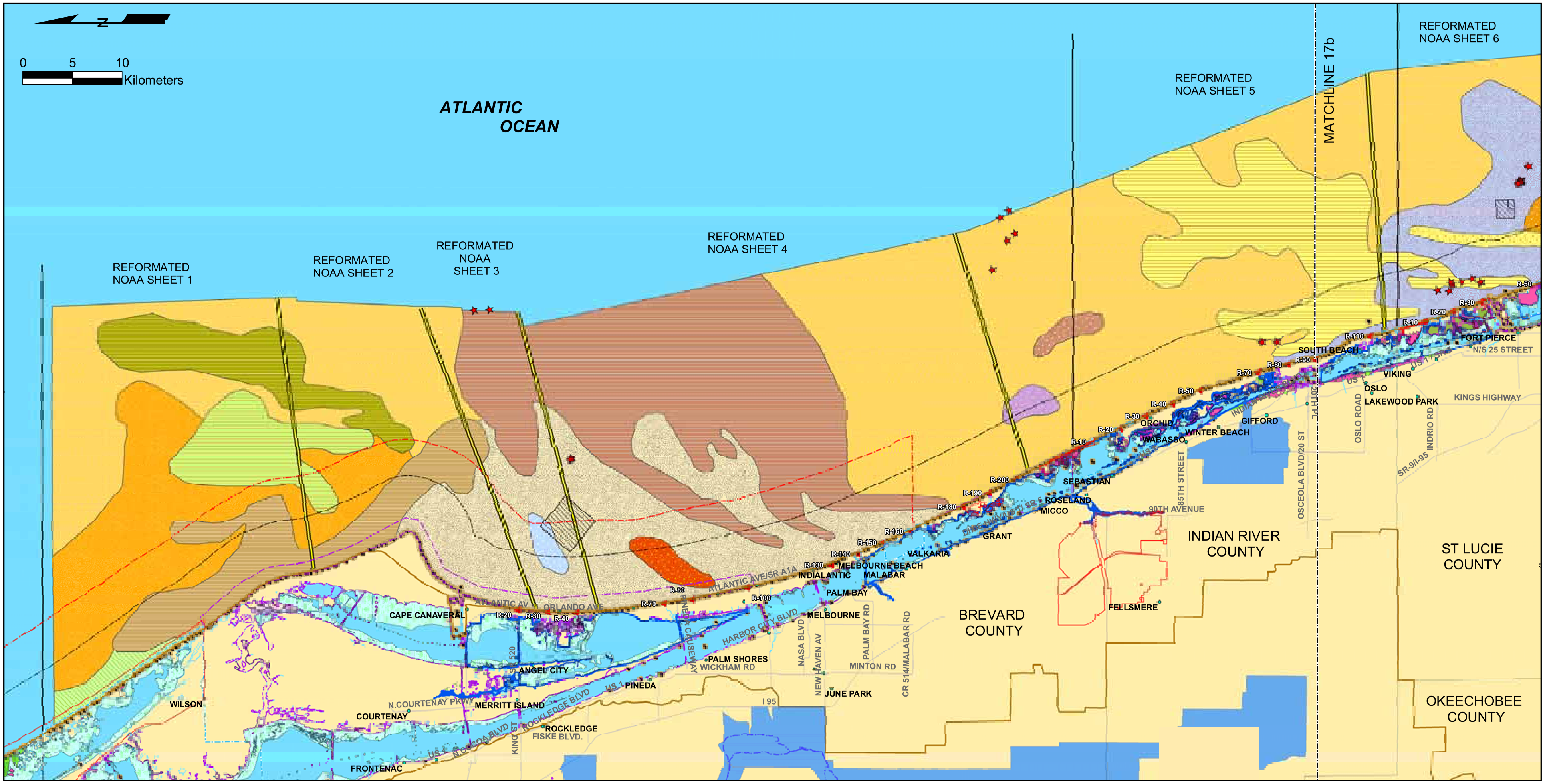
The open ocean beach-dune system is more complicated than offshore environmentally sensitive areas. Here, sea turtle nesting sites are generally pervasive through the study area. Piping plover critical habitat occurs near R50 to R60 in Martin County, east of Port Salerno and north of Gomez (Figure 5-2). Parts of some parks, the Coastal Barrier Resource System, boundaries of the National Estuary Program occur along the shore.

Information related to environmentally sensitive areas may be found by visiting websites of the organizations listed in Table 5-1. More detailed information regarding environmentally sensitive areas should be obtained from the appropriate agency.

Table 5-1.
Sources of data for environmentally sensitive areas along the central Florida Atlantic coast, based on acquisition from primary government agencies as available on the web or other sources of public information.

Data	Source
Aquatic Preserves	Florida Department of Environmental Protection
Artificial Reefs (Deployment Events)	Florida Fish and Wildlife Conservation Commission, Division of Marine Fisheries Management
Beach Renourishment Projects	Beach Erosion Control Project Monitoring Database, Florida State University
Coastal Barrier Resource System	National Oceanic Atmospheric Administration, Coastal Service Center
Johnson's Seagrass Critical Habitat	National Coastal Data Development Center
Manatee Critical Habitat	United States Fish And Wildlife Service
Mangroves	Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute
National Estuary Program Areas	National Oceanic Atmospheric Administration, Coastal Service Center
Nature Conservancy Priority Ecological Resource Areas	Florida Natural Areas Inventory
Piping Plover Critical Habitat	United States Fish and Wildlife Service
Right Whale Critical Habitat	Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute
Saltmarsh Locations	Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute
Seagrass	Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute
Sea Turtle Nesting Sites	Florida Fish and Wildlife Conservation Commission
State Parks	Florida Department of Environmental Protection
Watershed Locations of Rare and Imperiled Fish	Florida Fish and Wildlife Conservation Commission

Note: This information is displayed in graphic form in Figures 5-1A and 5-2.



LEGEND:

- ARTIFICIAL REEFS
- SEA TURTLE NESTING
- RIGHT WHALE CRITICAL HABITAT
- JOHNSONS SEAGRASS CRITICAL HABITAT
- MANATEE CRITICAL HABITAT
- PIPING PLOVER CRITICAL HABITAT
- 1999 SEAGRASS
- SALTMARSH
- RARE & IMPERILED WATERS
- MANGROVES
- PARKS
- NATIONAL ESTUARY PROGRAM
- COASTAL BARRIER RESOURCE SYSTEM
- AQUATIC PRESERVES
- DREDGE MATERIALS DISPOSAL SITES
- CITIES
- FDEP MONUMENTS
- MATCHLINE
- FEDERAL STATE BOUNDARY
- COUNTY LINES
- ROADS
- REFORMATED NOAA SHEETS

OFFSHORE MORPHOLOGY:

- ANKONA SHOAL
- CANAVERAL TRANSVERSE BAR
- CAPRON SHOAL
- COCOA SAND FLAT
- FARMTON SAND FLAT
- GIFFORD SHOAL
- INDIAN RIVER RIDGE FIELD
- KENNEDY RIDGE FIELD
- MALABAR RIDGE FIELD
- MARTIN RIDGE FIELD
- MELBOURNE SHOAL
- MERRITT RIDGE FIELD
- MIMS RIDGE FIELD
- PATRICK SHOAL
- ROSELAND SHOAL
- ST LUCIE SAND FLAT
- UNDIFFERENTIATED SEAFLOOR

TITLE:

ENVIRONMENTALLY SENSITIVE AREAS IN SOUTHERN BREVARD, INDIAN RIVER, ST. LUCIE, AND MARTIN COUNTIES, CENTRAL FLORIDA ATLANTIC COAST

COASTAL PLANNING & ENGINEERING, INC
2481 NW BOCA RATON BLVD.
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX.(561) 391-9116

DATE: 05/04/07	BY: HMV	COMM NO: 7849.27	FIGURE 5-1

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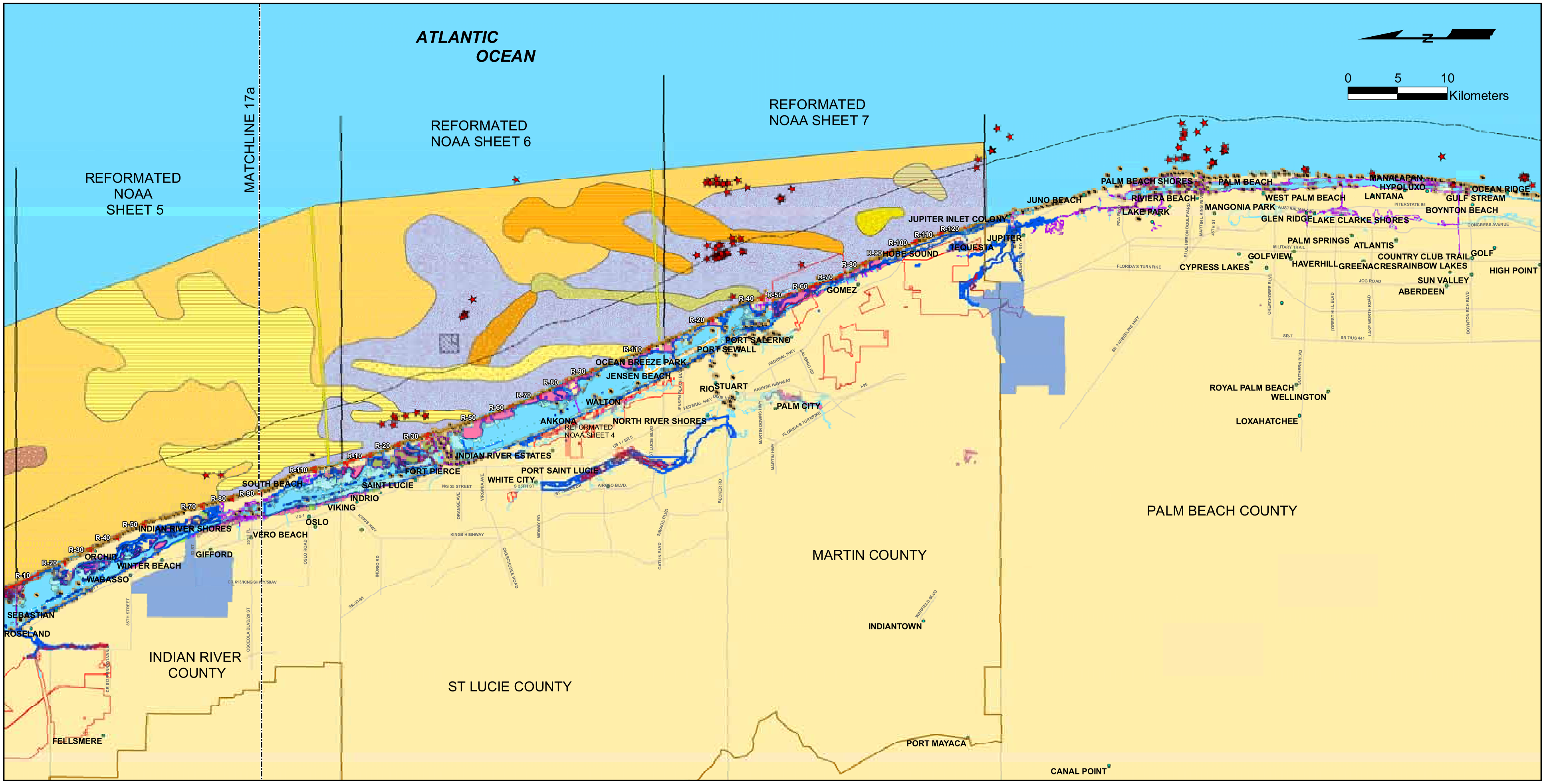

LEGEND:

- ARTIFICIAL REEFS
- SEA TURTLE NESTING
- RIGHT WHALE CRITICAL HABITAT
- JOHNSONS SEAGRASS CRITICAL HABITAT
- MANATEE CRITICAL HABITAT
- PIPING PLOVER CRITICAL HABITAT
- 1999 SEAGRASS
- SALTMARSH
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- MANGROVES
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- AQUATIC PRESERVES
- DREDGE MATERIALS DISPOSAL SITES
- CITIES
- FDEP MONUMENTS
- MATCHLINE
- FEDERAL STATE BOUNDARY
- COUNTY LINES
- ROADS
- REFORMATED NOAA SHEETS

OFFSHORE MORPHOLOGY:

- ANKONA SHOAL
- CAPRON SHOAL
- DICKINSON RIDGE FIELD
- GIFFORD SHOAL
- GILBERT SHOAL
- INDIAN RIVER RIDGE FIELD
- MARTIN RIDGE FIELD
- SALERNO SHOAL
- ST LUCIE SAND FLAT
- UNDIFFERENTIATED SEAFLOOR

TITLE:

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PH. (561) 391-8102
FAX.(561) 391-9116

DATE: 05/04/07	BY: HMV	COMM NO: 7849.27	FIGURE 5-2

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6.1 METHODOLOGICAL APPROACH FOR SAND SEARCHES ON THE CENTRAL FLORIDA ATLANTIC COAST

Offshore sand resources along the central Florida Atlantic coast occur in four main depositional settings: (1) offshore sand ridges on the inner shelf plain, outer shelf and shoreward portion of the Florida-Hatteras Slope, (2) transverse bars on the shoreface (3) shoals on the inner shelf plain, and (4) sand flats on the inner shelf plain (Finkl and Andrews, 2007). Bathymetrically positive features known as sand ridges that have been used in many nourishment projects along this coast and are the most prominent offshore sand deposit. These deposits are offshore "mounds of sand" anchored in hardbottom that are generally composed of admixed silicates (quartz) and carbonates (shell fragments, shell hash). Generally, silt content increases with depth and rock fragments are encountered in the boundary between the ridge's sandy sediments and the underlying hardbottom. However, sediment thickness and specific composition varies between ridges within the same field and between ridges located in different geographic locations along the coast. Transverse bars occur on the northeast flank of Cape Canaveral providing a sand resource close to shore. Shoals occurring on the inner shelf plain are often shoreface-attached, providing a sand resource that is close to shore. Sand flats contain large volumes of sandy sediments that may have resource potential. Positive relief features should probably receive priority of investigation because they offer greatest ease of exploitation.

Searches for beach quality sand on sand ridges, in transverse bar systems, or in shoals should be based on investigations that feature a logical sequence of steps (Figure 6-1). Sand search procedures developed, for example, by Finkl, Khalil and Andrews (1997), Benedet *et al*. (2004), Finkl and Khalil (2005), and Finkl *et al*. (2006) follow strategic sand search protocols that are widely accepted in the industry. The three-phased protocol suggests that, in areas where bathymetrically positive features (*e.g.* sand ridges, bars, shoals) occur, reconnaissance investigations should concentrate on bathymetric data (preferably recently obtained) and reconnaissance sand samples (Phase I), followed by jet probes (Phase II), and finally seismic reflection (sub-bottom) profiles and vibracores (Phase III).

A logical sequence of offshore sand searches targeting sand resources along the central Florida Atlantic coast should approximate the following steps. These suggested procedures can be adapted to individual survey requirements, but they nevertheless provide a basic framework for sequencing steps in a logical cost-effective progression.

6.1.1 Review of Historical Data

Using the ROSS database, the investigator should download historical datasets containing seabed relief information and descriptions of geotechnical data (vibracore logs, jet probe logs, and grain size data) and geophysical data (sidescan sonar and seismic reflection profiles) to identify initial target areas for more detailed investigation. The gray scale shaded relief image available from ROSS should be used to identify offshore morphosedimentary features (sand ridges, bars, shoals, sand flats) occurring near a project area. The geotechnical and geophysical layers should then be turned on to see if available sediment data overlie morphosedimentary features of interest. These data may provide initial information regarding deposit thickness and sediment textural properties. After target ridges are identified and data availability checked, the investigator can design a reconnaissance survey plan.

6.2 RECONNAISSANCE SURVEY PLAN

The reconnaissance survey plan should focus on obtaining better definition of seafloor geomorphology and morphosedimentary properties. Commonly, a few (more than five) offshore morphosedimentary features are selected on the basis of the Phase 1 analyses. These potential sand targets typically are narrowed down to one or two features for more detailed field investigations that may define final borrow areas.

The bathymetric data that is used to define the morphosedimentary features of interest in Phase 1 most likely will consist of historical NOAA-NOS data that may be several decades old. Because morphosedimentary features tend to be modified by tidal currents and wave action, an updated bathymetric survey is required to determine whether seafloor features changed shape or migrated over time. A reconnaissance seismic reflection profile survey can be conducted simultaneously with the bathymetric survey to determine sediment thickness. Bathymetric data and seismic records (obtained from chirp systems such as the Edgetech 512i) can be used to determine sediment thickness and presentation of results in an isopachous map. Undesirable materials such as rubble layers or presence of fine-grained sediments can normally be identified in seismic records if calibration data (*i.e.* historical vibracores) are available. Line spacing in reconnaissance surveys depends on the survey area, but generally ranges from 1000 to 2000 ft.

Traditionally, sand quality and thickness are investigated during preliminary sampling surveys using surface grab samples and jet probes. Because vibracores are more expensive and time-consuming, they are reserved for detailed phases of offshore investigation when the search area has been narrowed down to target areas using other methods.

Sand quality and thickness may be investigated during preliminary sampling surveys using surface samples, jet probes or widely spaced vibracores. Surface grab samples can be deceiving because they only sample the upper few inches of seafloor sediments (generally sediment transported by modern processes) and do not show the characteristics of deeper lying sediments. Jet probes are a cost-effective method to estimate sediment thickness and broadly indicate sediment quality in deeper layers. Because sediment samples extracted from jet probes are disturbed by the water jet, silt content may be underestimated.

One important consideration of sediment variability is that sand quality on the surface, as indicated by surface samples and widely spaced jet probes, may not always be the most effective procedure to select morphosedimentary features for further investigation during reconnaissance efforts. It may be found, for example, that relict sediments underlying the feature surface contain cleaner sandy sediments (*e.g.* fewer shell and rubble fragments) than the surface sediments. This occurs because modern sedimentation processes that are linked to the upper layers of sedimentation on a sand ridge, for example, may be significantly different from relict sedimentation processes that formed the ridge. Evidence of relict processes is normally found in deeper subsurface layers that have been unaffected by subsequent events. Thus, it is suggested that during reconnaissance investigations of offshore morphosedimentary features on the central Florida Atlantic coast, at least one undisturbed sample (vibracore) be acquired on each sedimentary feature that is under investigation to supplement jet probe and surface sample data. The purpose of this suggestion is to provide better insight into the nature of sediment comprising the core of the feature under study.

Reconnaissance sampling plans should be designed to target the crests or divides of the main morphosedimentary features. Spacing between samples will thus span a range depending on the size of the area under investigation, the total volume targeted, and the project budget.

6.3 DETAILED SURVEY PLAN AND PRELIMINARY BORROW AREA DESIGN

Following analysis of the data collected in Phase II, a plan to conduct detailed investigations over a smaller area should be prepared. Detailed investigation plans should strive to obtain enough information to define sand quality for specific quantities and to map the vertical and horizontal continuity of sand layers. This level of investigation also provides sufficient information to identify layers or zones of undesirable sediments that should be avoided during borrow area design. The detailed investigations usually consist of detailed bathymetry, sidescan sonar and seismic reflection profile surveys on 200 to 300 foot grids with vibracores obtained on 1000 foot centers. Analysis of the information obtained in detailed surveys permits preliminary design of offshore borrows and mapping of surface features (*i.e.* environmental resources, possible obstructions to dredging) that occur in or near the borrow. Tools that assist in the visualization of deposit morphology, sediment thickness, and general characteristics of the borrow area include geological cross-sections and fence diagrams, three-dimensional isopach maps and bathymetric charts, color-coded interpretation of seismic records, *etc.*

Although these detailed investigations allow for preliminary borrow area design, they are usually not adequate to meet final engineering requirements of complete borrow area design. It must be appreciated that characteristics of sand resources even in geologically well-known sites are still subject to interpretive errors that are linked to spatial and temporal variability of natural environments.

6.3.1 Cultural Resource Investigations

Detailed geophysical investigations are required to determine whether cultural resources occur within the boundary limits of a proposed borrow. Geophysical surveys are usually conducted on a grid with tracklines spaced 98 feet apart (Note: Cultural resource surveys are conducted on metric grids). The cultural resource surveys generally consist of magnetometer, sidescan sonar and seismic reflection profile surveys. Because these investigations must be conducted at 98 ft intervals, other geophysical Phase III investigations are generally conducted along multiple trackline spacings at 196 feet and 294 ft. These multiple-spaced grids are so spaced so that cultural resource investigations can make use of data from Phase III by nesting additional tracklines between lines of prior Phase III geophysical surveys. It is desirable that the cultural resource investigations be conducted using the same type of geophysical equipment deployed in other Phase III geophysical surveys. In this way, borrow design can be refined using the additional (cultural resource) data obtained, making for efficient use of separate surveys. Presence of cultural resources (*i.e.* shipwrecks, large cultural artifacts, *etc.*) requires modification of the borrow design to avoid disturbing the mapped features. The addition of 200-foot no-dredge buffers around the cultural resource feature satisfies this requirement. The margins of the borrow area (when the cultural resource features occur near the borders of the borrow area) may also be modified to meet cultural resource requirements.

6.3.2 Borrow Area Impact Analysis (Environmental Investigation and Numerical Modeling)

Data from Phases III and IV may be used to map sensitive environmental resource (*e.g.* hardbottom) occurring near the proposed borrow site. If sensitive environmental resources occur near the proposed dredge site, the borrow area design is modified.

In addition to cultural resources and a consideration of environmental impacts, there is a need to evaluate whether the proposed borrow sites will adversely affect the nearshore wave climate to cause additional erosion of adjacent beaches. This evaluation is preferably accomplished by using a range of numerical models that simulate wave transformation over the borrow sites. These models can also simulate wave-induced currents, sediment transport, shoreline change, and variation in beach morphology. Several wave models evaluate borrow area impacts on nearshore wave climates. In order to properly evaluate borrow area impact on nearshore waves, spectral wave models that incorporate most of the relevant physical processes of wave transformation (*e.g.* wave refraction, bottom friction and to a lesser extent diffraction) are recommended. Even though proposed borrows may induce changes in the nearshore wave climate, these changes may not necessarily cause additional erosion of adjacent beaches. To evaluate whether the impacts of borrow areas on nearshore waves is significant in terms of beach erosion and deposition patterns, shoreline change models or beach morphology change models can be used.

These models can be either empiric (*i.e.* sediment transport is calculated based on the output of a wave transformation model that feeds empirical sediment transport formulas) or process-based (output from a wave transformation model is used to calculate wave-induced currents and these are in turn used to calculate bed-load and suspended load sediment transport). Simulations are run for scenarios with and without the proposed dredging. By comparing the with/without dredging scenarios, the investigator can evaluate the impact of dredging on the beach deposition and erosion patterns. If numerical modeling indicates that significant undesirable impacts are expected on adjacent beaches due to borrow area dredging, borrow design modifications may be required.

6.3.3 Final Borrow Area Design

Final borrow designs, plans, and specifications are prepared when all concerns regarding sediment quality, cultural resource potential, potential environmental impacts, and physical considerations are addressed. Due to implementation of no-dredge buffers that reduce negative impacts from dredging, final shape and cut depths may differ significantly from the design prepared at the end of Phase III.

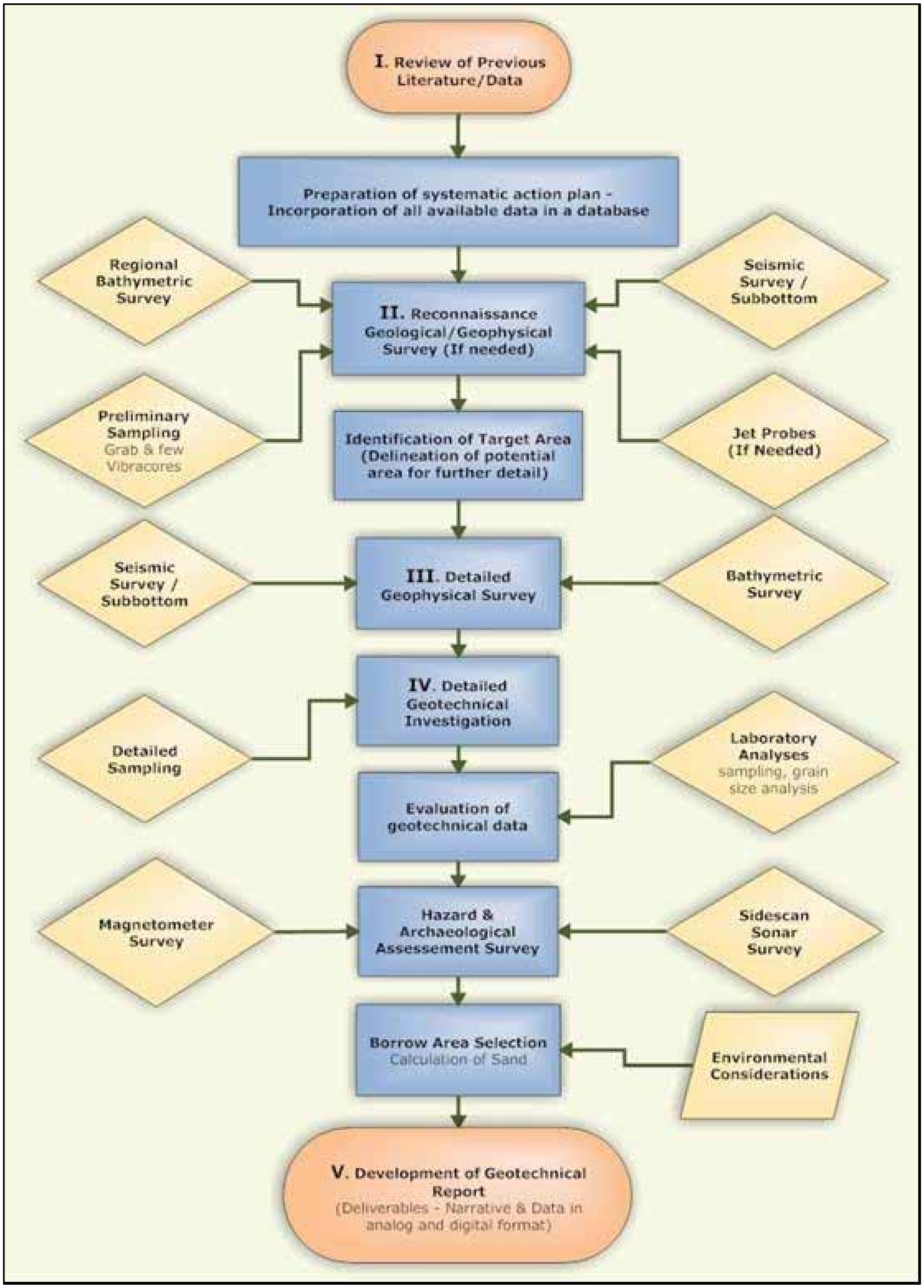

Figure 6-1. Flow diagram showing systematic approaches to offshore sand searches, based on major steps that incorporate a range of subset activities that are restrained by local circumstances. Each task is meant to direct the course of subsequent actions so that sand searches along sandy coasts proceed following a logical strategy that produces an efficient exploration methodology.

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Appendix 1

Online Query Builder Users Manual

Reconnaissance Offshore Sand Search

Online Database Query Builder

Building a Custom Query

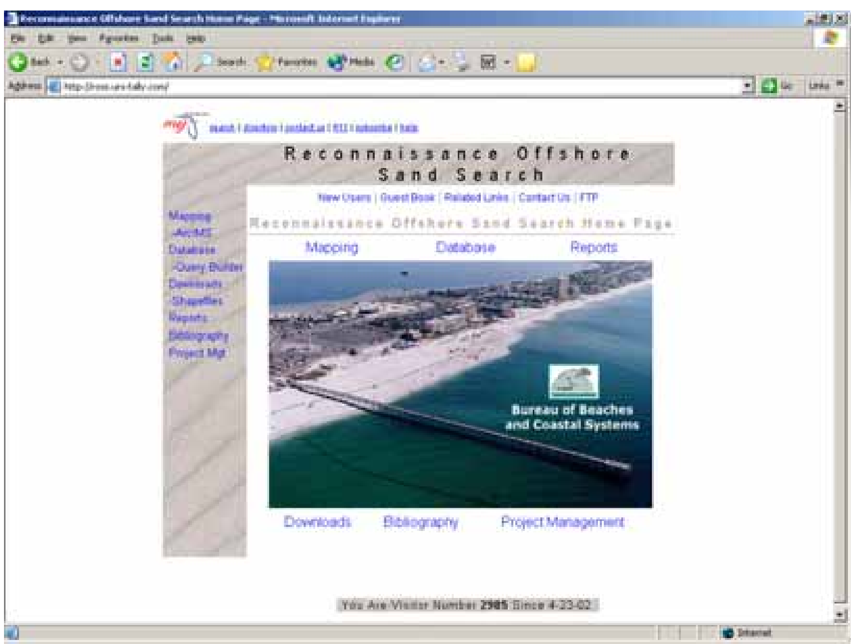
Introduction:

The query builder works by allowing you to create a "where" clause that is added to an SQL (Structured Query Language) selection statement. This selection statement tells the database to retrieve rows where the conditions you have set are true.

The query is made against one of two database views that join together data from several different database tables. Because of the structure of the database, you must specify whether the query should be run against the samples or core view. The sample view includes all data in the samples data, plus related data in the core table. The core view includes all data in the core table plus related data in the samples table. They appear to be very similar, but they are different representations of the data.

Creating a custom query

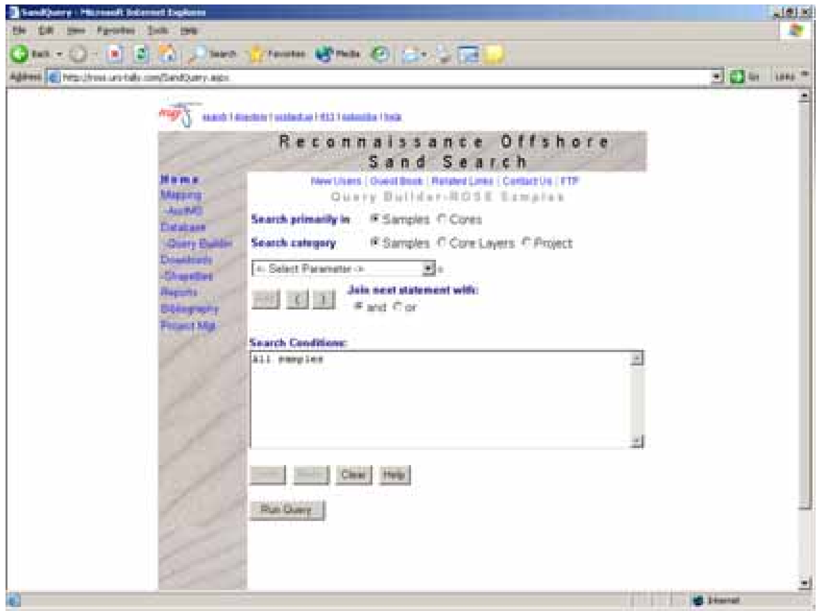
First you need to get to the Query Builder page.



Click on the link titled ‘Query Builder’ on the ROSS Main page.

You should now see the Online Query Builder page. From this page you can select the query criteria you want to use to filter the data.

The query parameters are categorized into three different groups. The Sample group, which provides parameters associated with the samples table. The Cores group, which provides parameters associated with the cores and core layers tables, and the Project group, which provides parameters associated with the project table.



Depending on which parameter you choose, the screen will change to allow you to enter an appropriate value.

If you choose a numeric or date parameter (such as Mean Grain Size, or Sample Date), the screen will change to show you a drop-down list of relational operators ("=", ">", "<", etc.) and a text box into which you can enter a number or date, as appropriate.

If you choose a text parameter, the screen will change to show you a different set of relational operators ("=", "<>", "like" and "not like"). The first two operators allow you to search for a specific text value, while the latter two operators allow you to search using a wildcard character ("*") to represent any text. The following examples demonstrate the difference between the relational operators:

For example, searching for a sample record that contains the word "island" in the project location field yields the following results based on the relational operator

- The “=” operator requires an EXACT match to return any results
- The “like” and “not like” require the use of the ‘wildcard character’ (‘*’, an asterisk) placed in the appropriate location within the search criteria for example
    - Choose “like” then enter “*island*” this will return ANY Project location that has the word island anywhere in the location
        - Captiva **Island**

        - Sanibel and Captiva **Island**s
        - Captiva **Island**, Lee County, Florida
    - Choose “like” then enter “*island” this will return results where the word “island” is at the end of the project location.
        - Captiva **Island**
    - Choose “like” then enter “island*” this will return results where the word “island” is at the beginning of the project location.
        - Currently there are no Project Locations that begin with the word “island”

There are several parameters (such as Layer Structure) you can use that provide you with a lookup list. If you choose one of these parameters, a drop-down list containing the acceptable values will appear.

There are other parameters that provide an even more customized query interface. These include Munsell color, named descriptive color, and core layer qualifiers. These screens are described in more detail below.

Search by range of dates or numbers

If you choose one of the numeric or date parameters, you will see the "between" relational operator appear in the drop-down list. This allows you to enter two values in the textbox and return records whose values fall between the two numbers (or dates). For example, to search for samples with a mean grain size greater or equal to -1 and less than or equal to 2, you would select the "between" relational operator and enter "-1 and 2" in the textbox.

Acceptable date formats

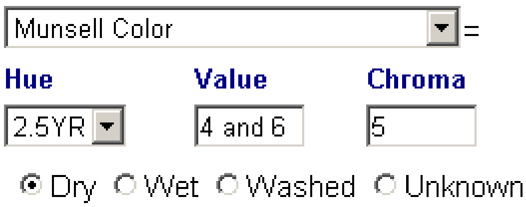
The query builder allows you to enter a date in a variety of formats, including:

Format	Example
mm/dd/yyyy	12/31/2003
mm dd yyyy	12 31 2003
mm-dd-yyyy	12-31-2003
mm.dd.yyyy	12/31/2003
mm/dd/yyyy	12/31/2003
dd month yyyy	3 May 2004
month dd yyyy	May 3 2004
dd mon yyyy	3 Jan 2006
mon dd yyyy	Jan 3 2006

If you leave the year off, it will assume you mean the current year. Enter the date in whatever format you are most comfortable with, and the query builder will reformat the date into a standard MM/DD/YYYY format for you.

Searching by Munsell color

If you choose the Munsell color parameter, the screen will change to show a drop-down list and two textboxes. To enter a Munsell color, select the hue from the drop-down list, and enter numbers in the value and chroma text boxes.



You can also search by a range of Munsell values or chromas. To do this, enter the lower and upper limits of the range you wish to search in the value or chroma textboxes. For example, to search for Munsell colors with a range of values between 2 and 5, enter "2 and 5" in the value textbox.

Searching by named color

If you choose Named Color as the parameter, the screen will display three drop-down lists. These allow you to enter a descriptive color name.

Undo and Redo

If you make a mistake and enter a query condition accidentally, you can "undo" the mistake simply by clicking the Undo button. You can undo as many changes as you like. If you undo one too many changes, hit the Redo button to reapply the last change.

Joining Query Conditions

The conditions you enter must be joined together by a combinatorial operator, either "and" or "or". "And" signifies that all conditions must be true to return a record, while "or" signifies that only one must be true. You can group conditions together to clarify how the "or" operator is to be applied. For example, to search for samples with a mean grain size of -1 phi with a color of 2.5yr 5/6 or 5yr 5/6, you should group the color conditions together within parentheses. To do this:

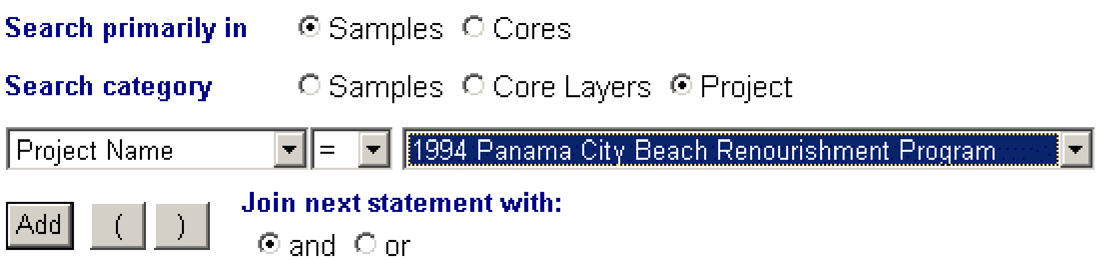
1. Enter the grain size condition
2. Change the join operator to "and"
3. Click the "(" button
4. Enter the first color
5. Change the join operator to "or"
6. Enter the second color
7. Click the ")"

Example

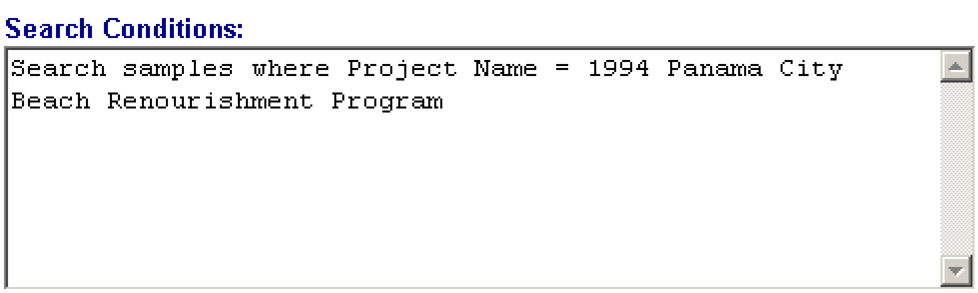
Now that you know how to provide the information to the Query Builder, Its time to put that knowledge to the test and create a query. Let's say that you want to run a query for All Samples in the 1994 Panama City Beach Renourishment Program that contain at least 80% Fine Sand (as determined by the Unified Soils Classification) that are found within 2 feet of the bottom*. You would open the Query Builder page and select the following:

Part 1: Add project condition

1. Select the Project search category.
2. Select the Project Name parameter.
3. Select 1994 Panama City Beach Renourishment Program from the drop-down list that appears after you select the project name.
4. Click the Add button.

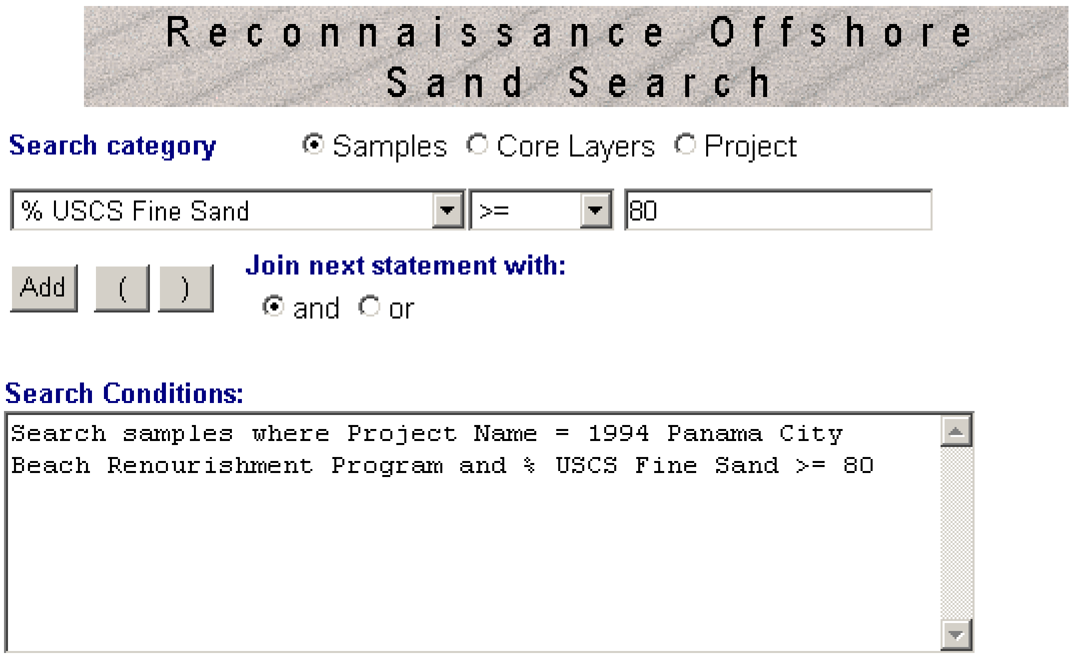


You will see the first query condition appear in the Search Conditions textbox.



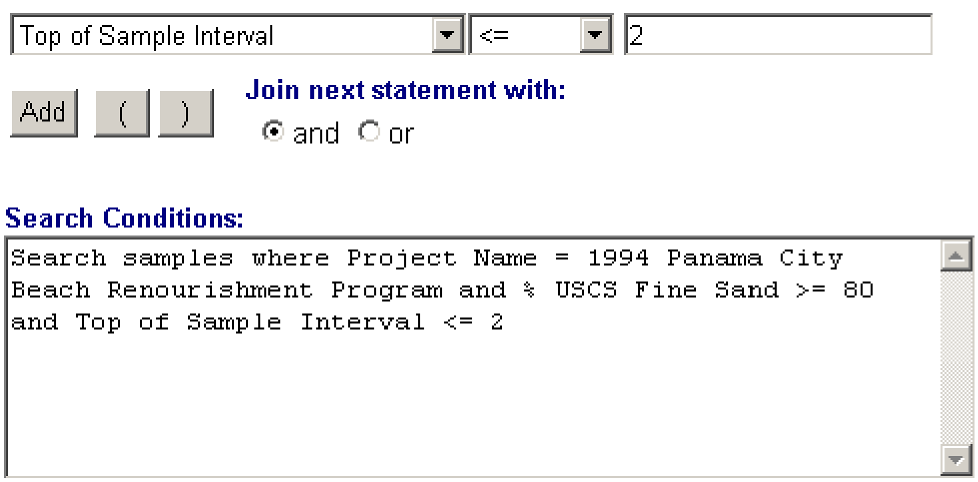
Part 2: Add the USCS Find Sand condition

1. Select the Samples search category
2. Select the % USCS Fine Sand parameter
3. Change the relational operator to ">="
4. Enter 80 in the text box.
5. Click the Add button.



Part 3: Add the depth condition

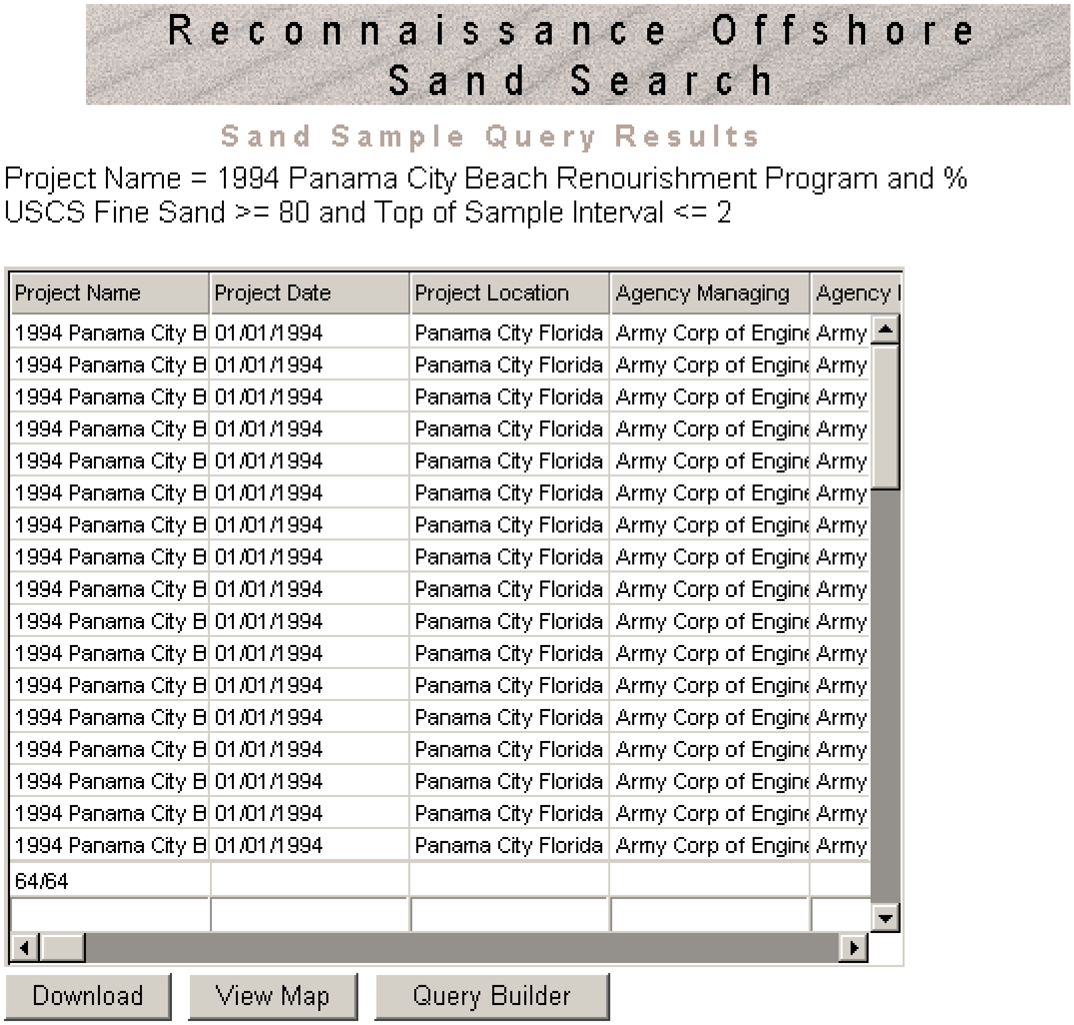
1. Select the Top of Sample Interval parameter
2. Enter 2 in the text box.
3. Click the Add button.



Now that you have entered all of the search conditions, click the Run Query button.

Query Results

The next screen that appears shows you a table of the results of your query.



Reconnaissance Offshore Sand Search

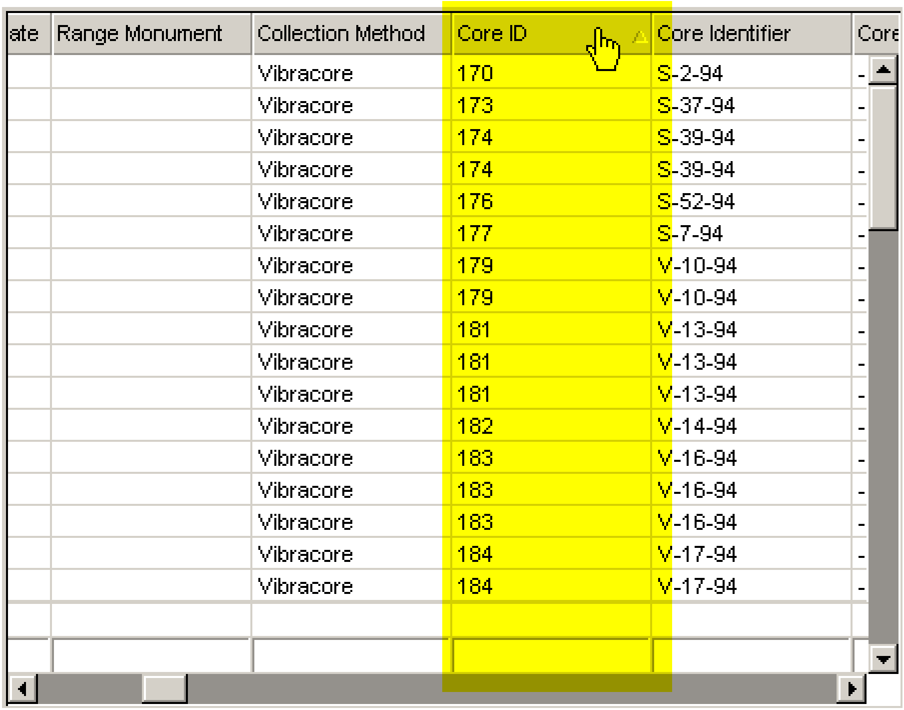
Sand Sample Query Results

Project Name = 1994 Panama City Beach Renourishment Program and % USCS Fine Sand >= 80 and Top of Sample Interval <= 2

Project Name	Project Date	Project Location	Agency Managing	Agency I
1994 Panama City B	01/01/1994	Panama City Florida	Army Corp of Engine	Army
1994 Panama City B	01/01/1994	Panama City Florida	Army Corp of Engine	Army
1994 Panama City B	01/01/1994	Panama City Florida	Army Corp of Engine	Army
1994 Panama City B	01/01/1994	Panama City Florida	Army Corp of Engine	Army
1994 Panama City B	01/01/1994	Panama City Florida	Army Corp of Engine	Army
1994 Panama City B	01/01/1994	Panama City Florida	Army Corp of Engine	Army
1994 Panama City B	01/01/1994	Panama City Florida	Army Corp of Engine	Army
1994 Panama City B	01/01/1994	Panama City Florida	Army Corp of Engine	Army
1994 Panama City B	01/01/1994	Panama City Florida	Army Corp of Engine	Army
1994 Panama City B	01/01/1994	Panama City Florida	Army Corp of Engine	Army
1994 Panama City B	01/01/1994	Panama City Florida	Army Corp of Engine	Army
1994 Panama City B	01/01/1994	Panama City Florida	Army Corp of Engine	Army
1994 Panama City B	01/01/1994	Panama City Florida	Army Corp of Engine	Army
1994 Panama City B	01/01/1994	Panama City Florida	Army Corp of Engine	Army
1994 Panama City B	01/01/1994	Panama City Florida	Army Corp of Engine	Army
1994 Panama City B	01/01/1994	Panama City Florida	Army Corp of Engine	Army
1994 Panama City B	01/01/1994	Panama City Florida	Army Corp of Engine	Army
64/64				

Sorting Query Results

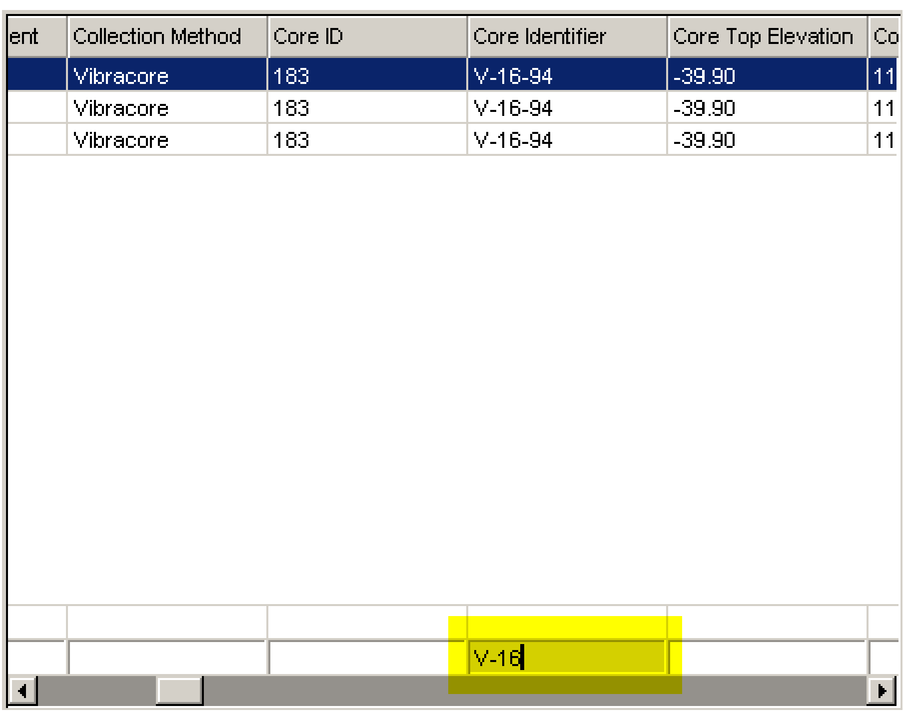
You can sort the results that appear in this table by clicking on one of the column headings Click the column heading again to reverse the sort order.



ate	Range Monument	Collection Method	Core ID	Core Identifier	Core
		Vibracore	170	S-2-94	-
		Vibracore	173	S-37-94	-
		Vibracore	174	S-39-94	-
		Vibracore	174	S-39-94	-
		Vibracore	176	S-52-94	-
		Vibracore	177	S-7-94	-
		Vibracore	179	V-10-94	-
		Vibracore	179	V-10-94	-
		Vibracore	181	V-13-94	-
		Vibracore	181	V-13-94	-
		Vibracore	181	V-13-94	-
		Vibracore	182	V-14-94	-
		Vibracore	183	V-16-94	-
		Vibracore	183	V-16-94	-
		Vibracore	183	V-16-94	-
		Vibracore	184	V-17-94	-
		Vibracore	184	V-17-94	-

Filtering Query Results

You can further narrow the results of your search by either clicking the Query Builder button to go back to the query builder, or you can filter the results on the fly using the filter bar.



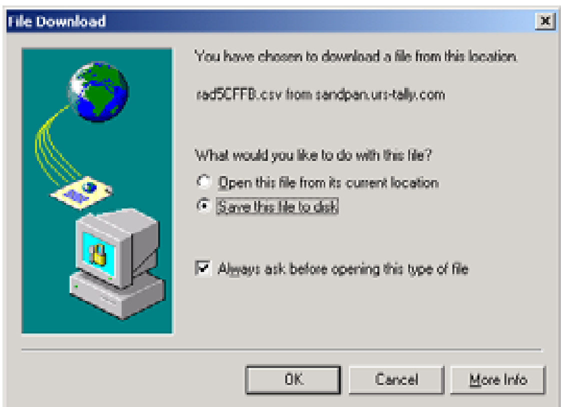
ent	Collection Method	Core ID	Core Identifier	Core Top Elevation	Co
	Vibracore	183	V-16-94	-39.90	11
	Vibracore	183	V-16-94	-39.90	11
	Vibracore	183	V-16-94	-39.90	11
			V-16		

To query using the filter bar, simply start typing a pattern in the column of data you want to filter. In this example, only samples from cores with a core identifier like "V-16" are shown. It's important to note that the filter bar does not requery the database, so you cannot use it to add results to your output.

Downloading Query Results

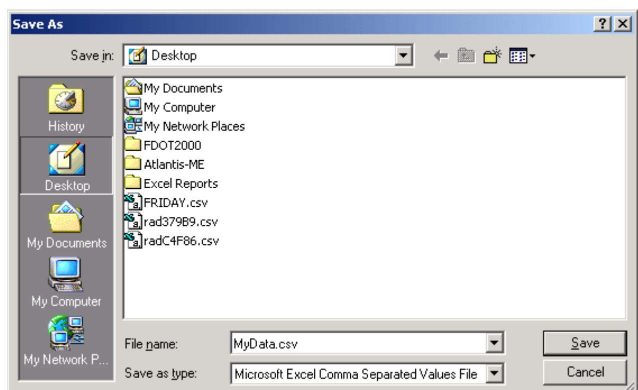
To export the filtered data from the table into a tab-delimited format suitable for import into a spreadsheet program, click the Download button. This will open up a new browser window.

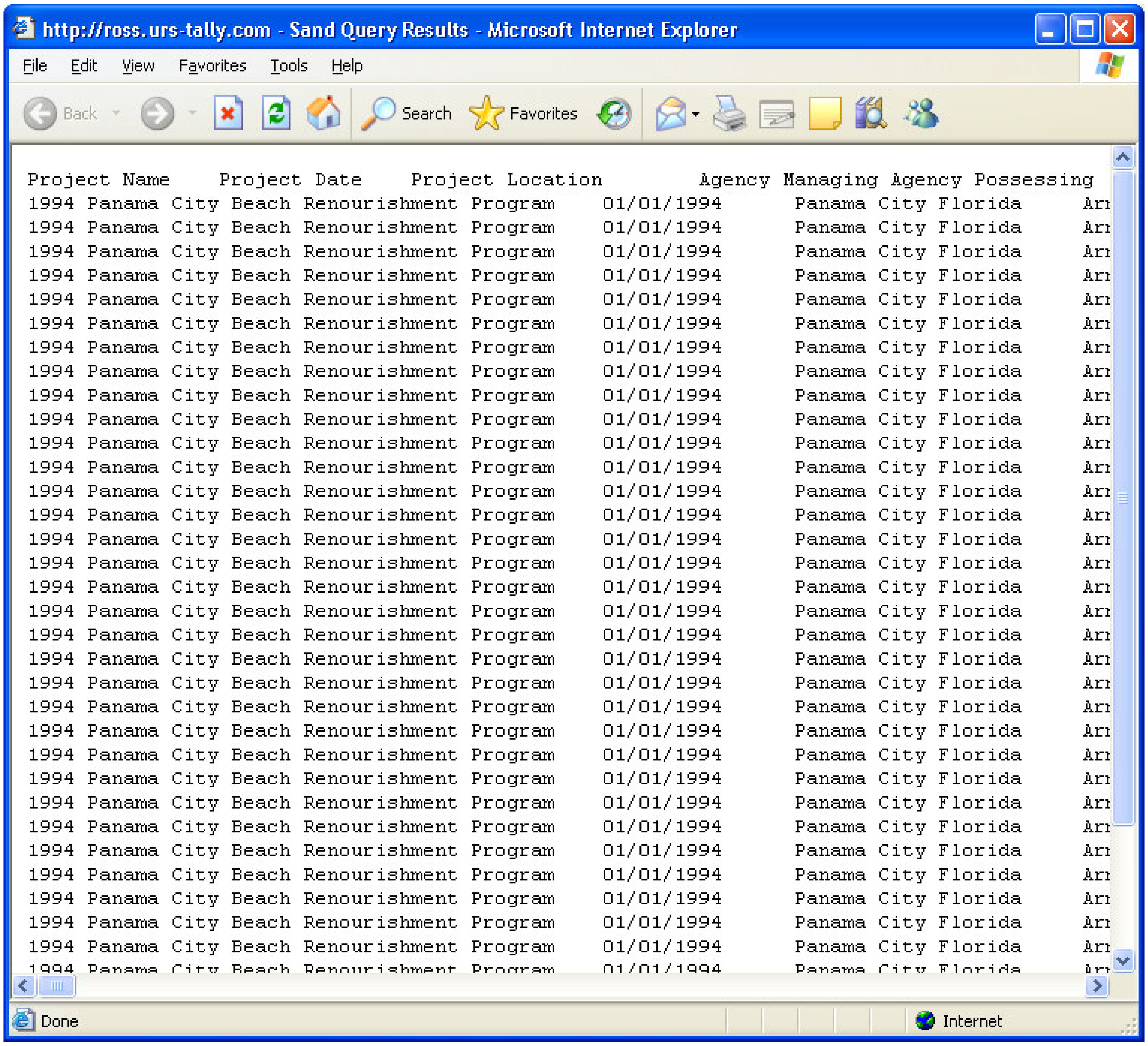
Most browsers, however, will show the data as text in the window. Simply select all of the text and copy and paste it into a blank spreadsheet page. (Hit Ctrl-A, Ctrl-C, switch to your spreadsheet program and hit Ctrl-V).



On some browsers you will be prompted to save the data, or it may open up directly in your spreadsheet program. You may see a window that looks like the one to the left. Select 'Save this file to disk' and click 'OK'

You should see a window that looks like the one to the right. Select the location where you wish to save the file. Rename the file if you wish. Now click 'Save' and the download will begin.





Saving the downloaded File as a .dbf File to use with ArcView

After you download the file, open it using Microsoft Excel. To properly save the file as a .dbf that can be used in ARCview, you will need to format each of the columns for the data type that the column contains. For example, format the State_X and State_Y columns as number columns that have 6 or 8 decimal places. If you do not reformat EVERY COLUMN, the process of saving the file as a .dbf will concatenate each column to 10 characters and you will lose valuable information.

View in ArcView

If you would like to graphically see where the samples you have queried for lie on a map, click the 'View In ArcIMS' button at the bottom of the page. An ArcIMS window will load that will display the area your samples exist and highlight the samples within that area that meet the query criteria you specified.

Appendix 2

Online Mapping Users Manual

Reconnaissance Offshore Sand Search

New Users | Guest Book | Related Links | Contact Us | FTP

Interactive Mapping

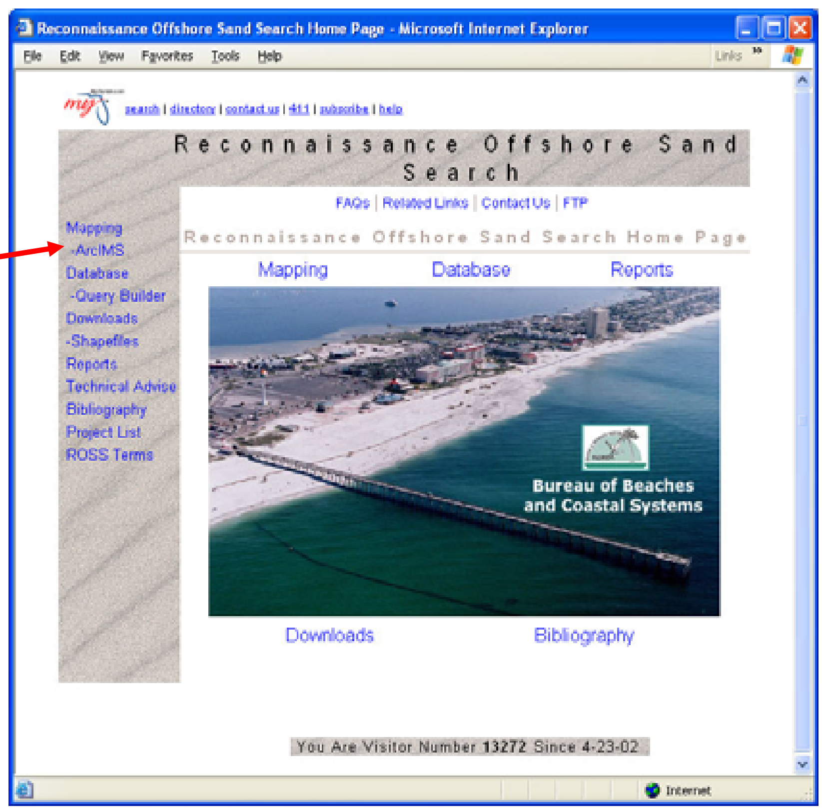
Internet Map Services

What does an Internet Map Service do?

An Internet Map Service (IMS) displays a map image based on an underlying database of spatial information. The map service allows the user to interact with the map display and query the underlying spatial data. The technology used to coordinate the database and map display is ArcIMS. More information on ArcIMS can be found on the web at http://www.esri.com/software/arcims.

Creating an Interactive Map

First you need to get to the Interactive Mapping page.

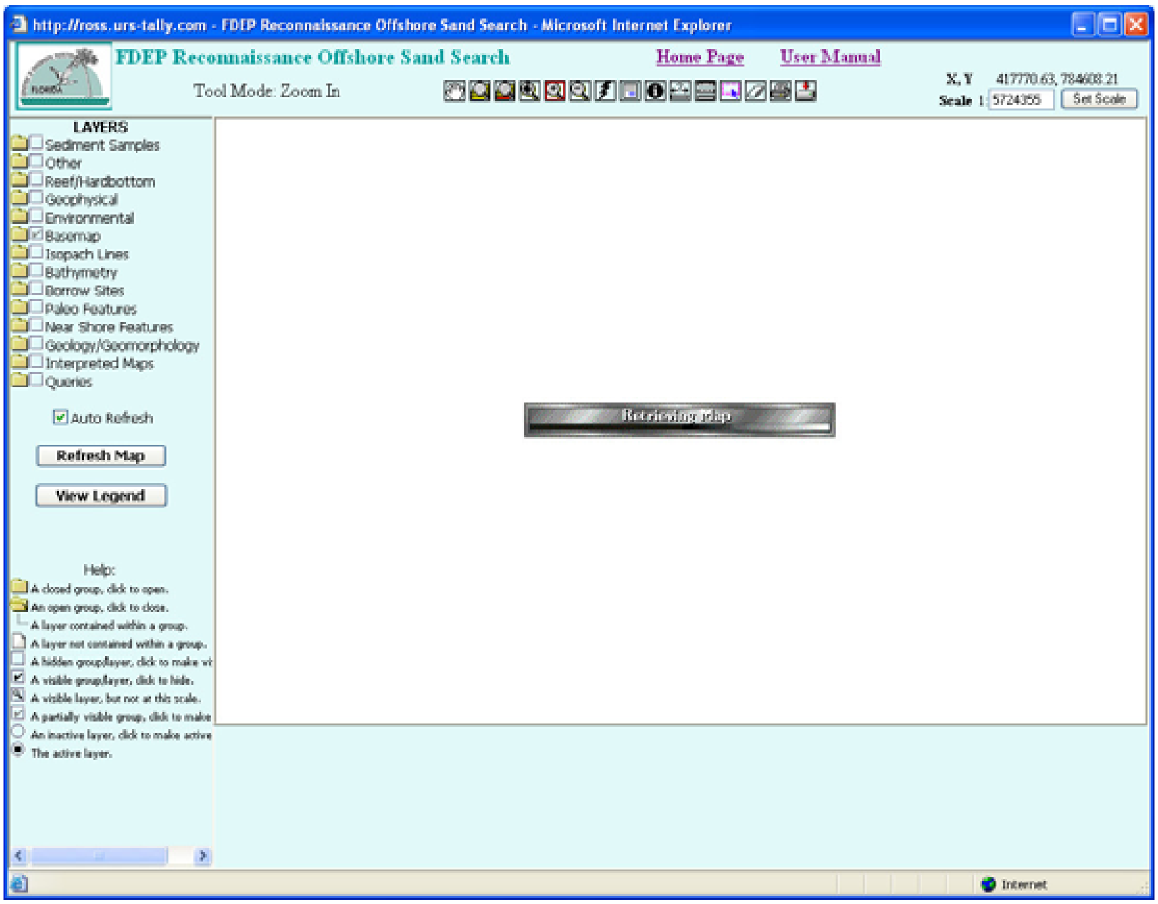


Click on the link titled 'ArcIMS' on the navigation bar of the BBCS Reconnaissance Offshore Sand Search web page.

You should now see the Interactive Mapping page in a new browser window. From this page you can use a variety of tools to navigate the map and query the underlying data.

The map image displays the full extent of the spatial data contained in the database. You may navigate through any part of the map shown in this initial extent. Below the map is an area for displaying responses from the database to your requests.

When you make requests of the map service, a response to your request is generated by the server and sent to your browser for display. The response may be a new map or the results of a query for tabular information. A response may take anywhere from a few seconds to a couple of minutes to process, depending on its complexity. During this processing time, the ArcIMS map viewer will be in Retrieving mode, preventing it from producing further requests until a reply from the server is received.

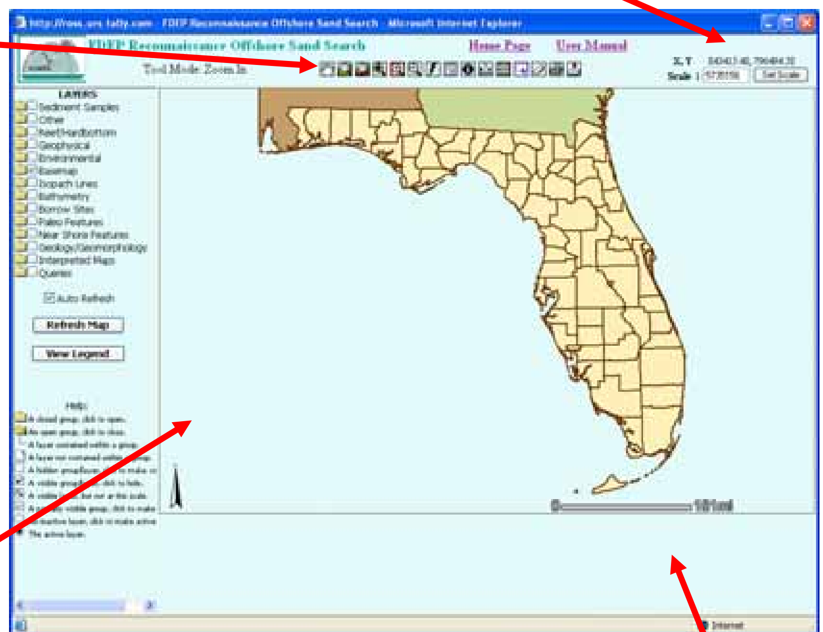


Navigating an Interactive Map

The interactive map page has a variety of tools for manipulating the map and querying the underlying spatial data. Here is a general overview of the Interactive Map page.

Across the top of the interactive map is a toolbar that includes tools for navigating, querying, and printing. A tool mode message next to the tool bar indicates the currently selected tool.

As the mouse cursor moves over the map, the map coordinates under the cursor are displayed in the top right frame, along with the current reference scale.



Appearing in the left-hand frame is the Table of Contents (TOC).

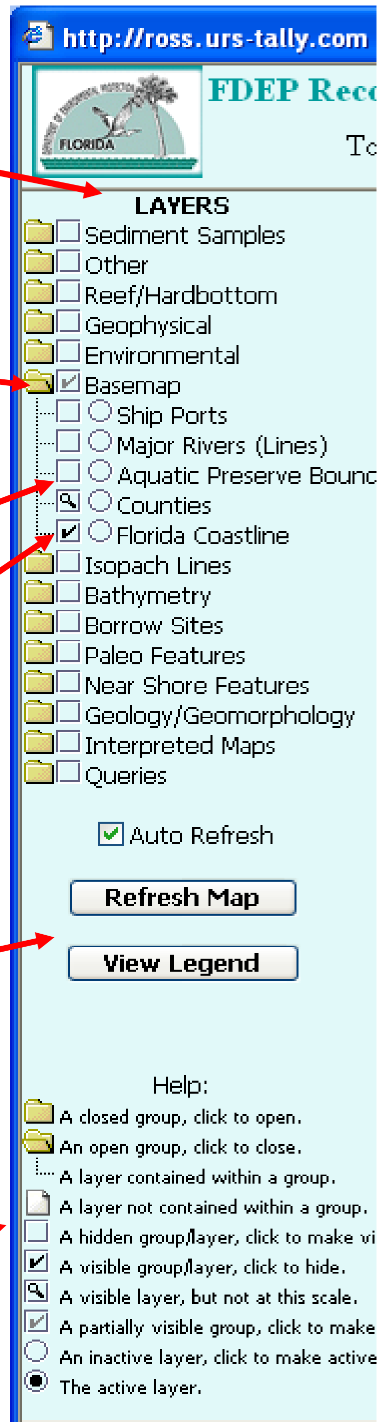
The map frame displays the interactive map.

The results frame below the map displays the records associated with the results of queries and selections, as well as various messages.

Next we will examine in detail the various frames that make up the interactive mapping website.

Table of Contents Frame

The Table of Contents (TOC) contains a list of all the data sets, or layers, that can be viewed and queried in the ROSS database. The data sets and queries are organized in category folders.



The first section of the TOC is the Layer List, which displays all of the spatial data sets that are potentially visible.

Each of the category folders contains a list of layers. Next to the folder icon is a check box for making all of the layers in the folder visible.

Each layer name appears next to a check box and radio button. The check box indicates if the layer is currently visible on the map, and the radio button indicates if the layer is activated for use with the query, select, and identify tools.

A magnifying glass symbol in the checkbox lets you know that the layer is not visible at the present scale. To improve performance by reducing the map drawing speed, some very detailed layers can only be displayed when the map area is small.

Below the Layer List is the Refresh Map and View Legend buttons. Use the Refresh Map buttons to apply changes to the visible layers. The View Legend button loads a map legend that shows the meaning of all the symbols in the map.

At the bottom of the frame is a Help section that describes all of the icons used in the TOC.

Results Frame

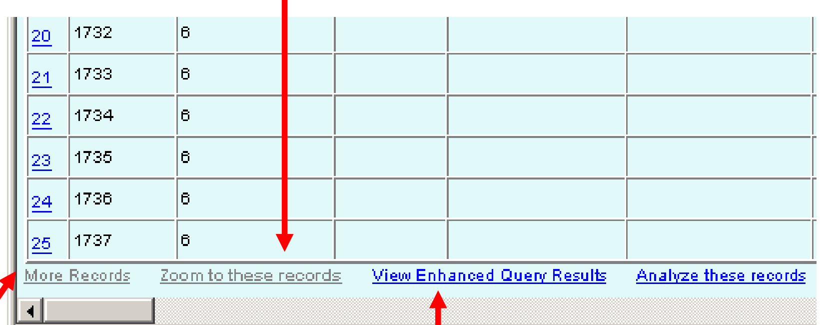
The Results Frame is the area below the map image that is used to display several kinds of textual information, such as:

- Diagnostic messages
- Tabular results from identifying, selecting, and querying features
- Forms for user input
- Hyperlinks to related documents

Below is a screen capture of the results from a selection by rectangle on the All Sand Samples layer. The Select By Rectangle tool is described in detail in the Toolbar Frame section.

Each record has a number that can be used to highlight the feature on the map.

Use the 'Zoom to these records' link to focus the map on the results of the selection.



Identify, query, and selection results records are displayed in the results frame in sets of 25; If there are more than 25 records, a link below the records retrieves the next/previous 25 records.

Features from any of the Sand Samples layers can be analyzed in more depth once they are identified, selected, or returned by a query. See the section on Additional Tools for more details.

Toolbar Frame

The toolbar buttons that appear near the top of the window are used to navigate around the map and query the database for more information about the visible features on the map.

Important Notes:

- Many tools are dependent on whether or not a layer is Visible and/or Active. To make layers visible, check the box next to the layer name, and then click the Refresh Map button at the bottom of the TOC. To make a layer active, click the radio button next to the layer name. Only one layer can be active at a time.

- Tool icons with a red outline are persistent, which means these tools remain enabled until another tool is selected. The name for the currently enabled tool, or Tool Mode, is displayed to the left of the toolbar. When the map page first loads, the Zoom In tool is automatically selected.

Next is a description of how each toolbar button operates.

Pan: Select the pan tool, and then hold the mouse cursor over any part of the map. The mouse cursor will appear as a pair of arrows. By clicking and holding down the left mouse button, you can drag the map image around the map frame. Release the mouse button to re-center the map in a new position.

Zoom to Full Extent: Clicking this button returns the map image to the initial statewide view of Florida.

Zoom to Active Layer: Each spatial data set occupies some region, or extent, on the map. For example, potential borrow areas have been identified off the Florida Panhandle. Clicking the Zoom to Active Layer button will produce the map with the smallest scale at which the selected layer is entirely visible.

Back to Last Extent: This tool returns the map to the previous spatial extent and scale. This button will cycle back through all of the map images that have been viewed, ending with the statewide view of Florida.

Zoom In: There are two ways to use this tool to zoom in on the map:

- **Zoom to Point**: Click anywhere on the map image to re-center the view on that point, and zoom in by a factor of two.

- **Zoom to Box**: Use this mode to define a rectangular region to zoom in on. Hold the mouse cursor over the map image at the top left corner of the new viewing rectangle. Click and hold down the left mouse button, then drag the cursor across the map to create a zoom box. Release the mouse button to complete the rectangle and produce a new map image.

Zoom Out: This button works similarly to the Zoom In tool, allowing you instead to zoom out.

Hyperlink: The hyperlink tool allows you to view documents related to features in some designated layers on the map. There are currently two layers with hyperlinks, Core Locations and Data Buoys. One of these layers must be visible and active to use this tool.

- *Core Locations*: Select the hyperlink tool, and then click on any core location (represented by an orange dot). If there are core logs or photos for that core location, links to these documents will be presented below the map. Click on the links to open these documents.

- *Data Buoys*: Select the hyperlink tool, and then click on the data buoy location (represented by a yellow triangle). If available, a link to the National Data Buoy Center website for the selected buoy will be presented below the map. Click on the link to open the web page containing statistics for the selected buoy.

View Metadata: This button opens a document describing in detail the currently active layer. This document, referred to as the metadata, is presented in Federal Geographic Data Committee (FGDC) format. The information in the metadata file includes a general description of the data set, a description of all the attribute columns that are associated with the data set features, and information about the data set's spatial projection, just to name a few of the available items.

Identify: More than just graphics, features on the map are related to a database record of attribute information. This information can be displayed by using the Identify tool. Any visible map features that are part of the currently active layer can be identified by selecting the identify tool and clicking on a map feature that belongs to the active layer. The database record for that feature will be retrieved and displayed in below the map.

Measure: The measure tool is used to determine the distance along a line segment or series of connected line segments, or path. Select the Measure tool and click once on the map to create a starting point. A new map image will be retrieved showing this starting point. On the new map, click again to mark the ending point of the line segment. A new map will again be retrieved showing the line segment. Continue this process of adding points to create a path. Near the top of the map are two boxes showing the length of the current path, as well as the distance from the last point added to the position of the mouse cursor. The current path may be cleared at any time using the Clear Selection tool, described below.

Set Units: The map units can be changed to feet, miles, meters, or kilometers by selecting this tool and completing the Set Units dialog that appears. A drop-down menu provides the various options for units, and a submit button is provided to apply the changes to the map display units.

Enhanced Query: Use this tool to select points from any of the Sand Samples layers and send the area of interest to the advanced Query Builder. The advanced Query Builder can be used to refine the query, sort the results, and download them for further study. See the section on Additional Tools for more information.

Clear Selection: This button clears the current selected features and compound select areas from the map image, resets the measure tool, and clears any buffers from the map.

Print: Opens the print dialog for printing the current map image. A title can be added before creating the print page. The print page opens in a new browser window, and the File menu of the new window may be used to print the map image.

FTP link: Opens the Regional Offshore Sand Search FTP site in a separate browser window. The FTP site contains the seismic images and GIS shape files for download.

Additional Tools

Enhanced Query

The results from selecting by rectangle or querying can be viewed in the Interactive Query Builder portion of the Sand Search website.

Select the enhanced query tool and draw a rectangle around features of interest on the map. Make sure the sand samples layer you want to query is visible and active.

-OR-

Identify, select, or query any Sand Sample layer, as described in the Toolbar Frame section. Click on the 'View Enhanced Query Results' Link that appears below the table in the Results Frame.