

# **SAND SEARCH AND FILL MATERIAL QA/QC PLANS FOR BEACH NOURISHMENT PROJECTS IN FLORIDA**

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## **ABSTRACT**

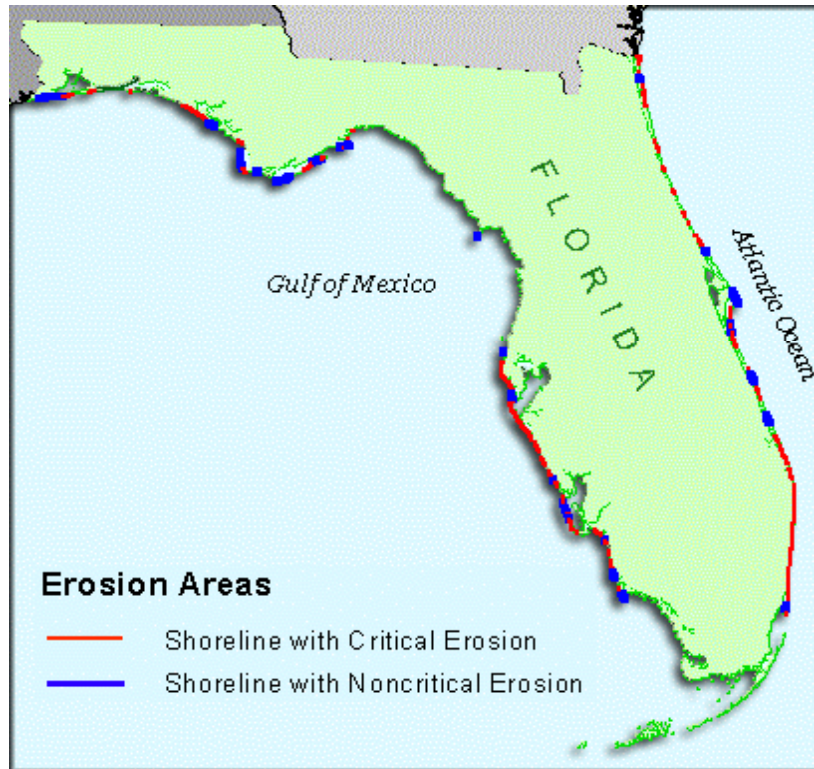
Over 40 beach nourishment projects along approximately 172 miles of Gulf of Mexico and Atlantic Ocean shoreline have been constructed and maintained. The performance and aesthetic expectations of project sponsors and the public, as well as stringent environmental constraints, has led to the need for explicit Quality Assurance/Quality Control (QA/QC) procedures when conducting sand search investigations and during the construction of beach nourishment projects. This is in addition to the incentive to optimize the volume of excavation of beach compatible fill material from borrow areas within an economical transport distance from the beach project site.

The QA/QC procedures are described in the investigators' scope of work for offshore sand searches and in the contract documents for construction. During the sand search phase, it is important to establish precise survey control of the spatial location and elevation of each vibracore. This allows for reduced tolerances between excavation depth of dredging and underlying non-compatible material. By increasing the number of vibracores and decreasing their spacing within the boundaries of the borrow area, confidence in the character of the borrow area is increased. This is especially true, if the vibracore locations are correlated with sediment reflectors detected by seismic sub-bottom acoustic profilers. If high quality data is used to create the borrow area design, then the unidentified risk associated with the borrow area is lessened. The construction phase QA/QC plan is based on the risks of encountering non-compatible material identified during the sand search phase. Each QA/QC plan is tailored to the unique risks associated with each project. These risks can be minimized further by ensuring that the borrow area limits set forth in the design phase are not exceeded in the construction phase and the material adheres to the specifications set forth for the fill material. The QA/QC procedures include dredge position monitoring, telemetry of the dredge position to allow for monitoring of the dredge from another location, real-time sampling of the fill material for a variety of characteristics, and a plan to remediate placement of any unacceptable material. Although the QA/QC plan for each project will differ, each will contain the same basic elements. These plans can be created for every type project to identify and potentially reduce the risk associated with beach nourishment projects.

## **INTRODUCTION**

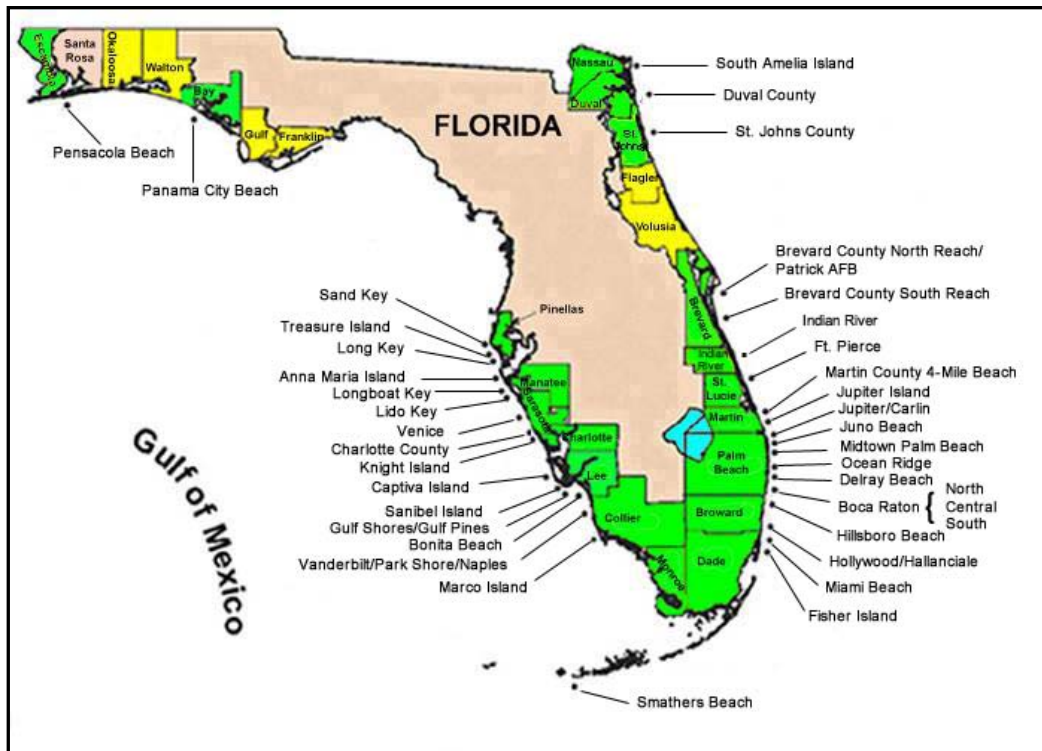
The first shore protection measures constructed to reduce erosion along Florida's coast were hard structures such as bulkheads, seawalls, jetties, and groins. Today, beach restoration

with periodic nourishment is the primary method employed. Beach nourishment is the process of placing sand on an eroding beach to provide a protective buffer against storm and wave damage and to enhance the recreational value of the beach. A beach nourishment project is typically designed to last 8-10 years once complete. Its lifetime is dependent on the site, project plan, and number and intensity of storms. Beach erosion threatens the very resource that Florida's residents and visitors enjoy. At present, about 365 of the state's 825 miles of sandy beaches are critically eroded (Figure 1), a level of erosion which threatens substantial development, recreational, cultural, and environmental interests.



**Figure 1:** Critical erosion areas throughout Florida.

The importance of Florida's beaches was recognized in 1986 when the Florida Legislature adopted a policy of protecting and restoring the state's beaches through a comprehensive beach management program. Under this program, the Department of Environmental Protection's Bureau of Beaches and Coastal Systems (BBCS) evaluates beach erosion problems throughout the state seeking viable solutions to these problems. Beach nourishment is one solution. The department actively monitors and evaluates the performance of over 40 beach nourishment projects along approximately 172 miles of Gulf of Mexico and Atlantic Ocean Shoreline (Figure 2).



**Figure 2:** Beach nourishment projects monitored and analyzed throughout the state (figure from the Beaches and Shores Resource Center website: <http://beach15.beaches.fsu.edu/>).

## BEACH NOURISHMENT USING OFFSHORE BORROW AREAS

The material used in beach nourishment projects can come from a number of sources, including inlets (new work or maintenance dredging), upland sources, or offshore borrow areas. For the purposes of this paper, we will be considering only offshore borrow areas. In order to permit an offshore borrow area for a beach nourishment project, a large amount of data must be collected in order for BBCS to feel confident that the material being placed on the beach meets the Department Rule set forth for beach nourishment activities. The majority of the information is collected during the sand search process, which will be discussed below. Once an offshore source is identified, BBCS reviews the borrow area for compatibility with the native beach material and compliance with the Department Rule (to be discussed below). As part of every review, the type and relative risk of encountering non-compatible material is identified for the borrow area. The degree of risk depends on a number of factors, is different for every pairing of a beach with a borrow area, and can change based on the previous performance of a borrow area and/or any new information obtained within the borrow area during/since the initial review. Once this risk is identified, a sediment Quality Assurance/Quality Control (QA/QC) construction plan is created and reviewed by BBCS as part of the permit application and review process.

## PHASES OF THE SAND SEARCH PROCESS

A typical sand search consists of two basic phases, an office study and a field investigation. The office study includes the collection and interpretation of historical data sets. This data includes bathymetric, seismic, geotechnical, and environmental data. A literature search is often completed to aid in the gathering of this data. One resource in the State of Florida to initiate the office study is the Reconnaissance Offshore Sand Search (ROSS) Database, which can be found via the BBCS, Coastal Engineering section homepage (<http://www.dep.state.fl.us/beaches/programs/coasteng.htm>). ROSS contains a collection of geotechnical (vibracore and grab samples), seismic, and bathymetric data, as well as an annotated bibliography of the available data throughout the State of Florida. QA/QC protocols begin in the first phase of a sand search. At the beginning of a sand search, a set of criteria are often set for the sediment being sought. These criteria can be set for a region or for a specific beach, depending on the scope of the investigation. Sites are chosen as preliminary targets based on any information that is available that could lead the investigator to a source of beach compatible sand. Areas of silty or rocky material are omitted from the investigation. This may come at the beginning of the investigation with knowledge of the geology and paleogeography of the area, past vibracore and seismic investigations, or initial reconnaissance field information collected in the area. At the conclusion of the office study, a borrow area (or areas) that meets the criteria set out in the project is identified for further investigation.

After a potential borrow area has been identified a reconnaissance-level field investigation can be planned based on the results of the office study. Reconnaissance field investigations are conducted over a larger area in order to focus on the most promising deposits for further detailed investigations. The reconnaissance field investigations can include a bathymetric survey, a side scan sonar survey, a sub-bottom profile (seismic) survey, jet probes and vibracores. Based on the results of the reconnaissance investigations, the sand search area can be further refined to the most promising sand deposits and the design-level field investigation can be planned. The design-level field investigation can include more detailed (closely spaced) sub-bottom profile (seismic) surveys and vibracores collected on 1000-foot centers throughout the refined borrow area. Often, a dynamic vibracoring plan is used to allow the investigator to follow the most compatible material, rather than being held to a rigid plan set forth before the field investigation begins. The immediate response to knowledge gained in the field is invaluable to the QA/QC of the material because it can favor the identification of compatible material. The vibracoring plan can be set with primary and secondary targets. The primary cores are taken, split and field logged. The seismic information can be reviewed again taking into account the additional information provided by the primary vibracores. The secondary vibracore locations are then selected to pursue the most compatible material. Dynamic vibracoring plans, therefore, allow areas to be deemed incompatible fairly quickly and the investigation to focus more cores and time in areas with more potential, furthering the QA/QC of the material.

The next stage in the sand search process is vibracore sedimentological data analysis. The purpose of vibracore analysis is to log, sample and photograph the vibracores collected from within each potential borrow area. Upon completion of the field investigation, the vibracores are

transferred to a laboratory where they are analyzed and logged according to the FDEP guidelines (to be discussed below). Samples are extracted from the cores and analyzed for their Munsell color, carbonate content and grain size distribution.

The data resulting from the previous tasks is reviewed, interpreted and evaluated. Borrow area design cuts that contain beach compatible sand are developed from these interpretations. The borrow area limits are dictated by the area of influence of the cores containing beach compatible material. The expected characteristics (mean grain size, sorting, color, carbonate content, etc.) are composite values calculated from the samples from the cores and core layers within the area of influence (within the design limits). Once potential borrow areas have been defined, a sand compatibility analysis is performed using standard industry procedures for design fill volumes and comparative procedures for environmental compatibility. The beach compatible sediment identified in the cores is compared to native beach samples, with respect to textural and compositional parameters, including color similarity. The compatibility assessment includes the identification of unsuitable sediment horizons and considerations of potential borrow area material performance after project construction. Based on these results, the vertical and horizontal limits of the borrow area(s) are identified and mapped.

At the conclusion of the sand search, the QA/QC protocols have allowed the investigator and the State to be confident in the material to be taken from the borrow area and to determine if it is compatible with the beach to be nourished. This process also reveals any risk associated with the borrow area. Determination of risk will be discussed in the following section.

Borrow area delineation is often refined after the completion of cultural and biological resource investigations. This involves mapping and delimiting any potential cultural resources, hardbottom, or seagrasses within the borrow areas. This is generally done through sidescan sonar and magnetometer surveys. Buffers are then created around the resource and excluded from the borrow area design and volume.

## **BEACH COMPATIBLE FILL MATERIAL STANDARDS AND GUIDELINES**

To protect the environmental functions of Florida's beaches, the Department has adopted standards and guidelines for determining the compatibility of beach fill material with the existing sediments in the coastal system. These standards and guidelines have been incorporated into Rule 62B-41.007(2)(j), Florida Administrative Code.

The objective is to use beach fill material that maintains the general character and functionality of the material occurring on the beach and in the adjacent dune and coastal system. Characteristics include the sediment properties of grain size distribution, color and mineral composition (quartz and carbonate) and bulk properties of cementation and compaction. The functionality of the material is primarily related to suitability as nesting substrate for marine turtles, as well as maintenance of water quality standards (turbidity) and littoral transport performance.

The rule provides specific grain size parameters that may not be exceeded. Beach compatible fill material shall not contain:

1. Greater than 5 percent, by weight, silt, clay or colloids passing the #230 sieve (4.0 $\phi$ );
2. Greater than 5 percent, by weight, fine gravel retained on the #4 sieve (-2.25 $\phi$ );
3. Coarse gravel, cobbles or material retained on the 3/4 inch sieve in a percentage or size greater than found on the native beach;

The rule allows for discreet placement of rocks or other non-specific material in excess of 50% of background in any 10,000 square foot area. If this construction tolerance is exceeded in amount or area, then remediation is required.

Once a deposit of sand is identified that does not exceed the grain size parameters specified in the rule, then similarity in color and grain size distribution (sand grain frequency, mean and median grain size and sorting value) to the material in the existing coastal system at the disposal site is the determining factor in the acceptability of the borrow area sediment. The character of the material within the existing dry beach berm is used to define the material within the existing coastal system, since suitability for marine turtle nesting is the primary consideration with regard to environmental functionality of the beach sediment. While marine turtles successfully nest in a variety of beach sediments, the Department Rule establishes similarity between the proposed beach fill material and the material in the existing coastal system at the disposal site as the principle criterion for compatibility.

Strict compliance with the similarity criterion is rarely achieved. Typically, proposed fill material obtained from offshore borrow areas is poorly sorted or has a bimodal grain size distribution as compared to the well-sorted sediment within the beach berm. Most of the offshore deposits contain carbonate sand or shell fragments with a mean and median grain size greater than the beach sediments. General compliance with the similarity criterion also involves avoidance of borrow area sediments containing a high percentage of fine carbonate sands and/or shell fragments. Material with these sediment properties can create a beach fill that exceeds acceptable bulk properties for compaction and cementation. Compaction has been limited to 500 psi through permit conditions to protect marine turtles. Cementation is not permitted.

The text of the Rule 62B-41.007(2)(j), F.A.C. is provided below and can be found on the BBSC General Publications homepage (<http://www.dep.state.fl.us/beaches/publications/gen-pub.htm#Rules>).

*To protect the environmental functions of Florida's beaches, only beach compatible fill shall be placed on the beach or in any associated dune system. Beach compatible fill is material that maintains the general character and functionality of the material occurring on the beach and in the adjacent dune and coastal system. Such material shall be predominately of carbonate, quartz or similar material with a particle size distribution ranging between 0.062mm (4.0 $\phi$ ) and 4.76mm (-2.25 $\phi$ ) (classified as sand by either the Unified Soils or the Wentworth classification), shall be similar in color and grain size distribution (sand grain frequency, mean and median grain size and sorting coefficient) to the material in the existing coastal system at the disposal site and shall not contain:*

1. Greater than 5 percent, by weight, silt, clay or colloids passing the #230 sieve (4.0φ);
2. Greater than 5 percent, by weight, fine gravel retained on the #4 sieve (-2.25φ);
3. Coarse gravel, cobbles or material retained on the 3/4 inch sieve in a percentage or size greater than found on the native beach;
4. Construction debris, toxic material or other foreign matter; and
5. Not result in cementation of the beach.

*If rocks or other non-specified materials appear on the surface of the filled beach in excess of 50% of background in any 10,000 square foot area, then surface rock should be removed from those areas. These areas shall also be tested for subsurface rock percentage and remediated as required. If the natural beach exceeds any of the limiting parameters listed above, then the fill material shall not exceed the naturally occurring level for that parameter.*

## **GEOLOGICAL INFORMATION REQUIREMENTS**

A description of the information and analysis required by the Department to demonstrate the character of the proposed beach fill material and its compatibility with naturally occurring beach sediment is provided in Rule 62B-41.008(1)(k)4, Florida Administrative Code, and the Department's application form for a Joint Coastal Permit.

As stated in the application form, permit applications for excavation or fill activities shall include the following detailed information concerning the material to be excavated:

- a. Core boring logs and sediment grain size analyses from representative points throughout the area to be excavated. Logs should extend at least two feet below the proposed bottom elevation. The depth of each visible horizon in the log should be reported relative NGVD and the material in each stratum classified according to grain size.
- b. Particle size analysis to the sediment and a measure of the percent organics by dry weight. Gradation curves should be produced from sieve analysis of each stratum in the core. Grain size distribution must be determined down to the standard unit 230 sieve size.
- c. Chemical analysis shall be required if there is reason to suspect that the sediments are contaminated.

The Department has pending rule revisions to require submittal of geological information in a format and media conducive for incorporation in the Department's Reconnaissance Offshore Sand Search (ROSS) database. The data may be submitted in Access or gINT files. The MS Access Front End Loader is available on the ROSS website <http://ross.urs-tally.com/>. Please visit the gINT website <http://www.gintsoftware.com/> for downloads necessary for the ROSS data structure. Also requested are any shapefiles and PDF files suitable for inclusion in ROSS, including but not limited to seismic images with time stamp annotations, seismic tracklines, seismic time stamps, seismic shot points, and borrow areas.

The JCP Application states, among other things, that the vibracores (and therefore the vibracore logs) should extend at least 2 feet below the proposed bottom elevation. This gives us assurance that the material immediately below the dredge depth is not horribly incompatible. This is one QA/QC procedure that is used to reduce risk. There is no assurance of what is beyond the bottom of a core. If the dredge were to accidentally dredge material from below the approved maximum dredge depth, the Department wants to be assured that noncompatible material (too silty or too dark or too shelly) will not be placed on the beach, resulting in remediation that could have been avoided.

This information allows the Department to be assured that we are placing compatible material on the beach includes the sieve data sheets, grain size curves, and the vibracore logs. The sieve data sheets and the grain size curves allow us to easily look at the grain size distribution and the moment method statistics and compare it to the same information for the beach. The vibracore logs allow us to further review what we expect to come out of a particular borrow area within the dredge depth, but also to see what material is found outside the cut. Reviewing this information, along with color and carbonate data, is another QA/QC procedure.

The Department Rule also requires an approved quality control/assurance plan that will ensure that the sediment from the borrow sites to be used in the project will meet the standard in paragraph 62B-41.007(2)(j), F.A.C. This plan is implemented during the construction phase. The protocols provided below are derived from the authors' consultation with practicing coastal engineers in the development of a number of these plans.

The text of Rule 62B-41.008(1)(k)4. F.A.C. is provided below and can be found on the BBCS General Publications homepage.

*Permit applications for inlet excavation, beach restoration, or nourishment shall include:*

- a. An analysis of the native sediment and the sediment at the proposed borrow site(s). The analysis shall demonstrate the nature of the material, quantities available, and its compatibility with the naturally occurring beach sediment pursuant to paragraph 62B-41.007(2)(j), F.A.C. The sediment analysis and volume calculations shall be performed using established industry standards and be certified by a Professional Engineer or a Professional Geologist registered in the State of Florida. Certification shall verify that a quantity of material sufficient to construct the project is available at the borrow site(s) which meets the standard in paragraph 62B-41.007(2)(j), F.A.C., and*
- b. Quality control/assurance plan that will ensure that the sediment from the borrow sites to be used in the project will meet the standard in paragraph 62B-41.007(2)(j), F.A.C.*

## **QA/QC PROTOCOLS DURING SAND SEARCH**

QA/QC protocols are applied throughout the sand search process. Three of the main goals of QA/QC protocols during a sand search are:

- To allow the investigator and State to be confident in the characterization of the material within the borrow area.
- To reveal any risk associated with the borrow area.

- To have complete and adequate data to work with.

In order to meet these goals, there are a number of QA/QC protocols implemented during the sand search process. At the beginning of a sand search, a set of criteria are defined for the sediment being sought. Sites are chosen as preliminary targets based on these criteria. Areas of silty or rocky or dark material based on the available data area are avoided, thus beginning the QA/QC protocols before a field investigation begins.

Dynamic vibracoring plans allow areas to be deemed incompatible fairly quickly. The investigation can therefore focus more cores and time in areas with more potential, furthering the QA/QC of the material. When creating a vibracore site plan, vibracores should be sited along seismic lines. This gives the investigator a better understanding of the underlying geology. If the vibracores are sited along seismic lines it becomes possible to correlate strata observed in the seismic record with strata seen in the vibracores. This data is invaluable when it comes to creating the geologic model.

A further QA/QC protocol involves the application of stringent survey control on the vibracores to ensure accurate horizontal and vertical vibracore locations. Location control on the cores is vital, especially as it relates to top of hole elevation. Real-time tidal corrections allow for better control and eliminate the reliance on published astronomical tide data. This in turn allows the researcher to accurately pinpoint the location of the sedimentary layers within the borrow area. The dredge depths for each borrow area are delineated based on the presence or absence of beach compatible material. Having good survey control on the vibracores allows for tight tolerances above any incompatible material.

Before the field investigation begins, a rough geologic model is often created. Once the reconnaissance field information (seismic and vibracores) has been collected and reviewed, the data should be compared to the geologic model. Any unforeseen differences should be explained and the model refined. The reconnaissance-level vibracore information and its relation to the geologic model eliminate areas from further investigation and refinement of the design-level vibracore plan.

## **RISK**

Risk comes from a number of sources. The two major sources of risk are variability within a borrow area and completeness and accuracy of geologic information. The character of the deposits may be homogeneous, or the deposit may hold discreet strata of noncompatible material. A homogeneous borrow area of compatible material has a much lower risk than a borrow area with known strata of noncompatible material. There is an unknown beyond and between cores, leading to risk due to the completeness of the data and the adequacy of the coverage. This brings forth the question of whether a 4 inch core can adequately characterize the material in its area of influence. Should we have more cores on smaller centers to better characterize the material in order to reduce risk? The borrow area design should minimize the

reliance on interpolated data from between vibracores. Vibracores are typically 4 inch cores but we place a rather large area of influence on them.

The past performance of a project, whether the borrow area is the same or not, leads to risk, or more accurately, the tolerance of risk. The tolerance of risk is something that is a subjective determination by the project sponsors, and will not be the same from project to project. On a project where the last nourishment event placed unacceptable material (regardless of why it was unacceptable), there can be a lower tolerance to risk in the eyes of the public, the State and other interested parties. These risks lead to varying QA/QC protocols during construction, and the sediment QA/QC plan for the project. The reduction of risk in placement of the non-compatible fill material through greater assurance provided on the character of the proposed beach during the sand search will significantly reduce the cost of construction by eliminating the contingency factor from the dredging contractor's estimate of cost. Hence, the Department recommends and supports comprehensive and thorough sand search investigations.

## **QA/QC PROTOCOLS DURING CONSTRUCTION**

The sediment characteristics of the native beach are identified and reviewed, culminating with the identification of sediment specifications to be met with the borrow area material. The borrow area and native materials are then compared for compatibility. This process often requires portions of the borrow area be avoided and the borrow area redesigned. The goals of this process are to meet the guidelines set by the Department Rule, as well as to address the concerns of the associated agencies. Once the borrow area material is deemed compatible and the risks are identified, a sediment QA/QC plan is developed and submitted to the Department for review, to ensure that the material placed on the beach is compatible and meets State guidelines.

The development of QA/QC protocols to be implemented during construction begins with an assessment of the risk associated with the proposed borrow area. Risk can come from a lack of certain data (most often color or carbonate content), a gap within the collected field data for the borrow area (inadequate core coverage or depth of cores), and the uncertainty that arises from having to interpret between cores. Risk assessment can also be based on identified factors, such as the past performance of adjacent borrow areas, and known strata of non-compatible sediments. The tolerance of risk can also be based on the past performance of a project in the area to be nourished (regardless of the source material) and the sensitivity of the city, county, state, or public to a given characteristic of the beach. In areas where projects in the past have placed darker, shellier, or otherwise marginally compatible or non-compatible material on the beach, these issues will be focused on to ensure that the same issues do not arise, or are handled appropriately through the QA/QC protocols.

The risks associated with a project will vary from sand source to sand source and from project area to project area. For each particular borrow area and beach fill project area, a unique sediment QA/QC plan must be developed. Certain elements, however, will be common to each plan. Each plan, regardless of risk, should include a description of the project, sediment

specifications to be met, dredge and disposal location control, construction monitoring and sampling procedures during and post-construction, material testing procedures, and remediation actions.

The sediment specifications should be included as a table in the plan, and include a combination of allowable/maximum silt content, shell content, carbonate content, mean grain size (often expressed as a range), Munsell color (noted as dry or moist), and shell characteristics/nature of carbonate. This should also be discussed in paragraph form in the plan. An item that is required is a summary table of the sediment parameters for the borrow area and the native/existing beach. The sediment specifications for a project are based on the range of borrow area sediment characteristics that have been deemed compatible with the native beach during the permit application process. These specifications are selected to ensure that the material placed on the beach maintains the general character and functionality of the material occurring on the beach and in the adjacent dune and coastal system.

Two integral components of any QA/QC plan are electronic positioning and dredge depth monitoring and dredge location control. Each QA/QC plan should specify that electronic positioning equipment must be continuously operated to monitor the precise positioning of the excavation device in terms of horizontal location and depth. A Differential Global Positioning System (DGPS) or its equivalent should be used to determine the horizontal position and should be interfaced with an appropriate depth measuring device to determine the vertical position of the bottom of the excavation device. To maintain vertical accuracy near real-time tide corrections should be applied to the vertical position measurements. The purpose of maintaining precise position control is to ensure that all dredging is performed within the permitted vertical and horizontal limits of the borrow area. This reduces the risk of encountering any adjacent non-compatible material and placing this material on the beach.

The monitoring and sampling procedures during and post-construction are the most widely varying portions of the sediment QA/QC plan because they are dependent on the risk associated with each particular project. In general, construction observation is performed 7 days a week, at a variable number of hours per day. For a low risk project, inspection may only be required during daylight hours, with random night-time observations. For a high risk project, round-the-clock observation may be required. Observation involves visually monitoring the material during placement. This assessment consists of handling the material to ensure that it is predominantly sand and to note its physical characteristics (i.e. wet Munsell color, nominal grain size, shell content, silt content, debris). It involves watching for materials such as rock, debris, shell and very silty sediment. If any of these materials exceed the sediment specification contained in the QA/QC plan, then the contractor must put a previously agreed upon remediation plan into effect.

During the observation phase a sample of the placed material should be collected for future reference. The samples should be kept in clear storage bags and catalogued with the date, time, DEP survey reference monument, borrow area and moist Munsell color. A record of sediment quality observations of the samples should be documented in the engineer's daily inspection reports. The sampling interval will be dependent on the risk associated with the

project. Samples can be collected by time interval or volume. For high risk projects sampling is often conducted hourly or every hopper dredge load.

Dependent on the degree of risk associated with the project, qualitative or quantitative assessments of color and sediment grain size characteristics may be periodically made based on samples that have been collected. Assessment of the sand color will consist of a two-step approach. The first step is the visual inspection of the material. Should the inspector note a wet Munsell color value lower than the acceptable range, a second test should be made shortly after the first. If the inspector notes two consecutive wet Munsell color values below the acceptable range, an assessment of the dry Munsell color value shall be made to ensure compliance. Acceptance of the fill will be contingent on the placed material meeting the range of acceptable values within the sediment quality specifications. Assessments of the grain size characteristics will be conducted through mechanical analysis of representative samples. Acceptance of fill will be contingent on the placed material meeting the range of acceptable values within the sediment quality specifications. A mechanical sieve analysis with a sieve set ranging from -2 phi to 4 phi, including the #230 sieve, should be conducted. The silt content and mean grain size should be determined as part of the sieve analysis. If the inspector determines that the color or the grain size and/or silt content of the material is unsuitable based on the sediment quality specifications, actions as discussed in the remediation section of the QA/QC plan will be taken.

Each QA/QC plan should list several remediation options in the event that unacceptable material is encountered and placed on the beach. These options typically include:

- 1) the excavation of the non-specification material and mixing with specification material to achieve a sand mixture that complies with the sediment criteria.
- 2) the excavation or the screening to remove the non-specification material, transportation of the non-specification material to an upland location and replacement with material that complies with the sediment specifications.
- 3) the excavation of the non-specification material, transportation of the material to the submerged portion of the profile and replacement of the material with material that complies with the sediment criteria.

The remediation options selected will depend on a variety of factors related to the characteristics of the beach project location. They will depend on the sensitivity of the nearshore area (i.e., silty material should not be pushed into the nearshore in an area with nearshore hardbottom or seagrasses) and the amount of material deemed unacceptable. For this reason, real-time observation is a vital part of beach nourishment projects. Avoiding unacceptable material being placed on the beach in large quantities will reduce the time and material required to remediate.

Several parties are involved in the execution of a beach project. Each party has a specific role. The project engineer is responsible for approving the electronic positioning equipment and for reviewing all positioning data that is submitted. The engineer is also responsible for proposing to the Owner, the level of construction observation required to reasonably ensure that the contractors work will be in conformance with the required contract and permit condition.

The engineer provides onsite observation by an individual with training or experience in beach nourishment and construction inspection and testing. The individual appointed by the engineer should be knowledgeable of the project design and permit conditions. This field observer is managed by the project manager. The contractor reports to the engineer. The contractor is responsible for establishing controls necessary to ensure that the contract volume of the material is placed on the beach and is responsible for ensuring that excavation of the borrow area does not extend below the allowable depths or beyond the spatial limits shown on the project plans and specs. This involves continuously operating the electronic positioning equipment and applying corrections to the vertical and horizontal positions. One of the main roles of the contractor is to implement the quality control plan. The interaction between the parties involved in a project ensures that QA/QC protocols are maintained.

## **CONCLUSION**

A QA/QC plan is a tool used by the State to minimize the different risks associated with different beach projects. Although QA/QC plans may differ from project to project, they should contain the same basic elements which include a description of the project, dredge location control, disposal location control, an acceptable range of sediment specifications, observation and sampling procedures, lab procedures, and remediation plans. A well constructed QA/QC plan provides confidence that the material being removed from the borrow area is compatible with the beach being nourished. The plan can, therefore, serve as a comprehensive field guide of the QA/QC protocols to be used and lays out the responsibilities of each party involved.