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THE RICHARD STOCKTON COLLEGE OF NEW JERSEY

J. Bailey Smith
US Army Corps of Engineers
Philadelphia District (CENAP-PL-PC)
Wanamaker Building
100 Penn Square East
Philadelphia, PA 19107

March 3, 2010

Dear Mr. Smith,

Enclosed with this letter is the electronic report for the *Sediment Characterization and Distribution of Artificial Island Confined Disposal Facility* project supported by the US Army Corps of Engineers, Philadelphia District.

The electronic report found on the associated DVD-ROM, functions similar to a standard webpage, where there are links to various resources and data found within the disc. The report was constructed in this manner to optimize and organize the immense amount of data collected and compiled for Artificial Island CDF (*Note:* If the autorun feature is disabled on your PC, navigate to the DVD-ROM and open "index.htm in your web browser).

The project team would like to thank you for your support and hope you will be pleased with the product generated for Artificial Island. We are confident that this information will no doubt aid in current and future dredged material management in the Delaware River and the state of New Jersey.

Sincerely,

Daniel A. Barone
Chief, Geospatial Analysis
Richard Stockton College Coastal Research Center

CC: Jeffery Gebert, Richard DePasquale

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March 3rd, 2010

Sediment Characterization and Distribution of Artificial Island Salem County, New Jersey

Prepared for:
US Army Corps of Engineers, Philadelphia District
The Wanamaker Building
100 Penn Square East
Philadelphia, PA 19107-3390

INTRODUCTION

Dredging is a fundamental activity for most maintained waterways. It involves the underwater excavation of sand, silt, clay and organic-rich mud that gradually accumulate over time as a result of natural sedimentation processes (upland run-off, redistribution from storms, tides, and currents). Sedimentation is a problem for residential lagoons, marinas, bay waters, and open channels (ICW) alike. The Delaware River is dredged by the US Army Corps of Engineers (USACE). The majority of dredged material is placed in disposal areas alongside the river. One of these disposal areas is Artificial Island. It is estimated that there is a large fraction of sand in this disposal area owing to the dredging in a section of the river which has many sand shoals. There is a need to garner a better understanding of the distribution and quantities of sand at the Artificial Island disposal area for beneficial use purposes and eventual inclusion into the Dredged Material Management System (DMMS).

The Richard Stockton College Coastal Research Center, surveyed Artificial Island disposal site in December 2009. The survey consisted of the collection of piston cores, auger grab samples, Global Positioning System (GPS) elevations at sampling locations, and site photographs Sediment coring locations were strategically located at the base of each of the three discharge areas with corresponding samples radiating outward to visual extent of the sand plume. Analyses of field-collected data included grain size analyses of different vertical sediment horizons sections of the core, and GIS analyses to process all geographically-referenced data to produce 3-dimensional representations of the bare disposal area surface, stratigraphic sediment distributions contained within the disposal area, and calculation of existing sediment volumes at each disposal site.

DREDGED MATERIAL CHARACTERIZATION

Field Data Collection

The Coastal Research Center field crew investigated Artificial Island in December of 2009. It was realized early in the field data collection that there were three distinct discharge areas and that the dredge material found in these areas would have the highest composition of sand. One of

the primary goals of the investigation was determine the vertical and horizontal sand distribution outward from the discharge pipe. This would allow for approximate volume calculations of how much and what types of materials could be found at each discharge area. In order to accomplish the task, a series of sediment cores were taken extending outward from the discharge pipe. At each location a piston coring device was used to penetrate down through the dredge material (approx 6-10ft), giving a detailed stratigraphic log for each boring hole location. Also, sample site photographs were taken in the field to document the sediments further.

In addition to sampling the sediment distribution of each discharge area, sediment samples were taken at each sluice location. A soil augur was used to characterize the different sediment horizons at each location. Penetration depths at sluice boring hole locations ranged from 3 to 6ft. Sediment samples were taken for various depths and at each visual change in sediment types. Additional auger samples were taken sporadically throughout the CDF to increase the sediment characterization area.

Sediment Composition

The sediment samples taken from Artificial Island CDF were analyze at the Coastal Research Center (CRC) sediment lab. These samples were either in the form of a 2-inch diameter lexan tube core of up to 10-foot lengths or bag samples taken with a 6-foot stainless steel 2-inch diameter bucket auger. An in depth analysis was then conducted on each lexan tube core sample to produce a stratigraphic log, sand/silt ratios, and mean grain size of the sand fraction. A visual grain size analysis was performed for the 2-inch diameter bucket auger.

In the lab, stratigraphic logs were prepared on each sample. The core material was combined with any auger samples associated with that specific bore hole, and a composite of that material was created for grain size analysis. A sub-sample of this composite is wet-sieved to separate the sand (>.0625mm, 4.0 phi) from the silt/clay (<.0625mm, 4.0 phi). The resulting sand portion was then used to describe statistical parameters such as color and mean grain size.

Sediment Distribution

Based on the piston core and auger samples analyzed from Artificial Island, a CDF sediment distribution map was created to display the percentage of sand and mud throughout the CDF. This information is valuable for determining where desirable dredged material is located. The map was created from the sediment samples collected by The Richard Stockton College Coastal Research Center in December 2009. The percentage of sand and mud were calculated for each sample and were attached to the sample locations in ArcGIS. A raster was then interpolated from the sample points using an inverse distance weighted method in the spatial analyst extension of ArcGIS.

Volume Calculations

Utilizing GIS and collected GPS field data, the Coastal Research Center was able to calculate the volume of material contained in Artificial Island CDF. The volume calculation process consisted of a three step process to yield a final volume in cubic yards. The first part of the process was compiling existing elevation data collected by the USACE and then the collection of GPS data on the CDFs. The CRC used survey quality Real Time Kinematic GPS equipment to obtain data. This ensured that the data had a high degree of vertical accuracy (plus or minus 2 cm.) which is essential to calculating sediment volumes.

At Artificial Island, GPS elevation data was collected at each sediment sample location. The second step involved downloading, checking and manipulating the data in a GIS. CRC staff analyzed the data to make sure that the GPS were able to be integrated into the USACE elevation

data so that a TIN (Triangular Irregular Network) could be created. A TIN is a three dimensional surface created from elevation data in GIS. Environmental Systems Research Institute's (ESRI) ArcGIS was used for editing the data and viewing the TIN in a three dimensional representation. Using ArcGIS Spatial Analyst, CDF volumes were calculated from the TIN above the compressed salt marsh elevation (beneath the CDF). Salt marsh compression was calculated using the base contact elevation data from sediment cores that penetrated to the salt marsh layer beneath the CDF sediments.

SUMMARY

This sediment characterization and management of Artificial Island was a reconnaissance-level study to compile site data for a comprehensive database for which coastal zone managers, coastal engineers, and scientists can better manage New Jersey's navigable waterways and dredging projects, as well as promote the reuse of dredged material (DM) contained in existing placement sites. Artificial Island is a relatively large Confined Disposal Facility (CDF) located in Salem, New Jersey adjacent to the Salem Nuclear Power Generating Station. The site is owned by the US Army Corps of Engineers (USACE) and is used as a dredged material placement site for maintenance dredging along the Delaware River. The site is approximately 312 acres and consists of 3 adjoining cells, each containing a discharge area where the DM from the river bottom was pumped into the site hydraulically.

Sediment Analysis

In order to properly characterize the CDF based on sediment types and volumes, the CRC strategically collected a total of 21 samples at Artificial Island (7 piston cores, 14 augers samples). The piston core samples were collected proximal to each discharge area (two in each of the three, and one on the northern end). Grain size and percent sand/silt ratios were determined using the Folk methodology (Folk, p. 25) for each of the piston core samples collected at the discharge areas. Additional analyses were performed on the samples due to the focus on sandier sediments near the discharge areas. The auger samples were analyzed visually for percent sand/silt ratios and photographs were taken of the samples as well. Stratigraphic logs of all samples taken at Artificial Island were created to document the various sediment layers within each sediment sample.

Geographic Information Systems (GIS) Analysis

Data collected at Artificial Island was the basis for a GIS-based analysis to calculate sediment volumes for the entire site as well as each discharge area based on digital elevation models (DEMs) derived from field collected data by the CRC and data provided by the USACE, Philadelphia District. In addition, percent sand/silt ratios we attached to GPS point locations collected at each sample site. From this, a sediment distribution map was generating in ArcGIS using the Inverse Distance Weighting method.

At Artificial Island, numerous datasets were collected and compiled to:

- Analyze sediment within the CDF for generating in-situ sediment distribution maps.
- Characterize various sediment types within the CDF to locate variations in grain sizes.
- Estimate sediment volumes using 3-dimensional Geographic Information Systems Software.

Field work at Artificial Island was conducted the CRC in December 2009 over a 2-day period. At the site, RTK-GPS spot elevations were collected at each sample site in order to calculate the elevation of the salt marsh contact below the CDF.

CONCLUSIONS

At Artificial Island, is was found that of the 21 sediment samples (7 piston cores, 14 auger samples) collected, only 1 piston core (Piston Core Sample ID #2) made contact with the salt marsh surface below the CDF. This was mainly due to the high density of stones and pebbles blocking the piston core within the 3 discharge areas as it penetrated deeper into the CDF's sediments. However, since the elevation at the CDF surface was known due to RTK-GPS data collected at each sample site, the salt marsh elevation was able to be calculated, therefore allowing for a CDF sediment volume calculation. The salt marsh elevation was calculated to be 1.12 feet NAVD88 elevation beneath the CDF. From this, using the derived DEM, the CRC calculated that there is approximately ***6,431,781 cubic yards*** of dredged material in the entire Artificial Island CDF.

Discharge Area	Plane Hght (NAVD88)	Elevation Contour	Area 2D (sq ft)	Area 2D (acres)	Surface Area 3D	Volume (GIS)	Dredge Material (cb yds)	Average Sand Volume (cb yds)
D1	1.12	16	192241	4.41	193553	3440904.59	127440.9	D1
D1	1.12	17	152763	3.5	154073	2833874	104958.3	103,698.63
D1	1.12	18	109628	2.5	110915	2124810.57	78696.7	
D2	1.12	16	540689	12.41	543661	10760535.36	398538.3	D2
D2	1.12	17	476492	10.9	479397	9766095.97	361707.3	1,342,418.46
D2	1.12	18	392705	9	395585	8378604	310318.7	
D2	1.12	19	333115	7.64	335944	7340063	271854.2	
D3	1.12	11	896129.7	20.57	906755	13908025.43	515112.1	D3
D3	1.12	12	748090.71	17.17	757849	12290525	455204.6	460,493.36
D3	1.12	13	644527.17	14.79	654106	11101412	411163.4	
								Total Sand Volume
Whole Site	1.12		13620661		13697044.1	173658103	6431781.6	1,802,911.82

Table 1. Artificial Island Volume Calculations

Within each of the three discharge areas (D1, D2, D3), the sediment volumes were calculated based on various contour elevations spreading out from the discharge pipe location (in other words, as you move away from the discharge pipe, the elevation becomes lower - See Table 1). This was due to the USACE's desire to calculate the amount of sandy dredged material within each of the discharge areas to the extent where vegetation is overgrown and siltier material becomes dominant. These contour extents were determined from aerial photography and the DEM (see Figure 1). It was determined from the sediment samples within the discharge areas that extents analyzed were mostly if not all sand. A large amount of sediment was characterized as pebbles/gravel in addition to the sandy discharge areas. This should be taken into account if further sediment analyses are to be conducted at Artificial Island CDF. Through our GIS volume analysis, it was determined that there is approximately ***1,802,912 cubic yards of sand total*** (Table 1) within the 3 discharge areas. This was calculated by averaging the values derived from each contour boundary in each discharge area and then taking the sum of the 3 values. This gives a general sand volume, but avoids over estimating or under estimating by a large factor.

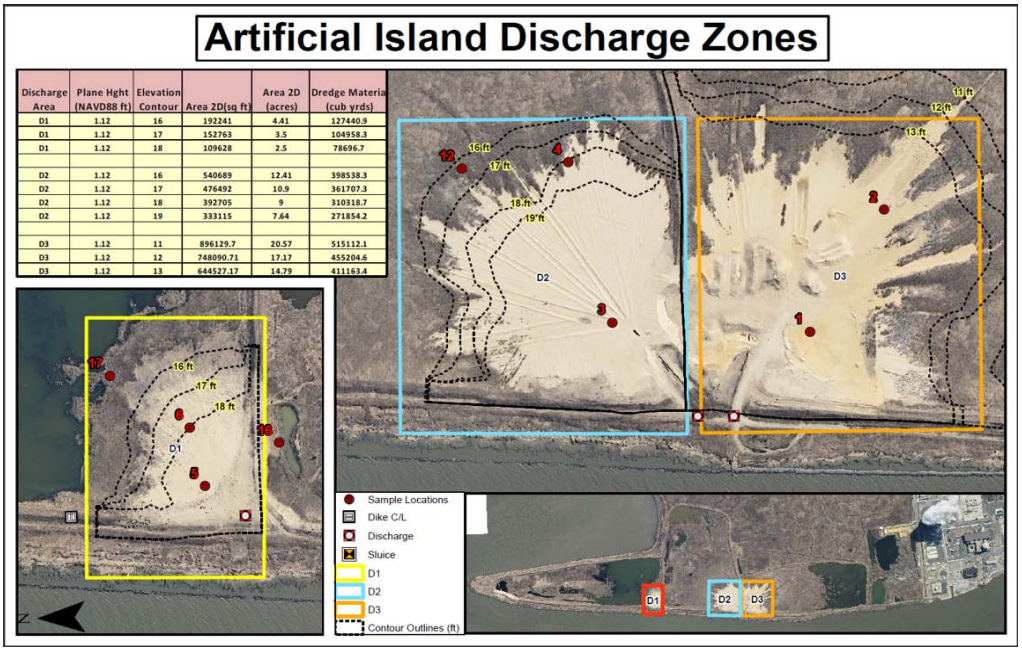

Figure 1. Artificial Island Discharge Zones 1-3

For each of the sediment samples, percent sand/silt ratios were calculated and re-attached to each GPS point in GIS. The CRC then generated a sediment distribution map based on percent sand using an inverse distance weighting method. This, in turn, interpolated sand percentages between sediment sample locations and allow for the visualization of surface sediments found in Artificial Island (Figure 2). It was found that the areas proximal to the discharge pipes were greater than 90 percent sand, and the grain size became finer the further away from the discharge areas. Interestingly, the CDF cell where discharge 2 is located had a fairly sandy auger sample collected near the sluice in that cell. The siltier area in cell 2 was located closer to the discharge area. Similarly, in cell 3, the discharge area was primarily sand, and the area proximal to the sluice was sandy as well. The area between the discharge and the sluice was very silty, as was the southernmost portion for the cell. Cell 1 was the sandiest of all three cells, with the sandiest areas located at the discharge area and at the northwestern most point. The area located next to the sluice was siltier as was the area in between the discharge and the sluice, but still had a significant sand content.

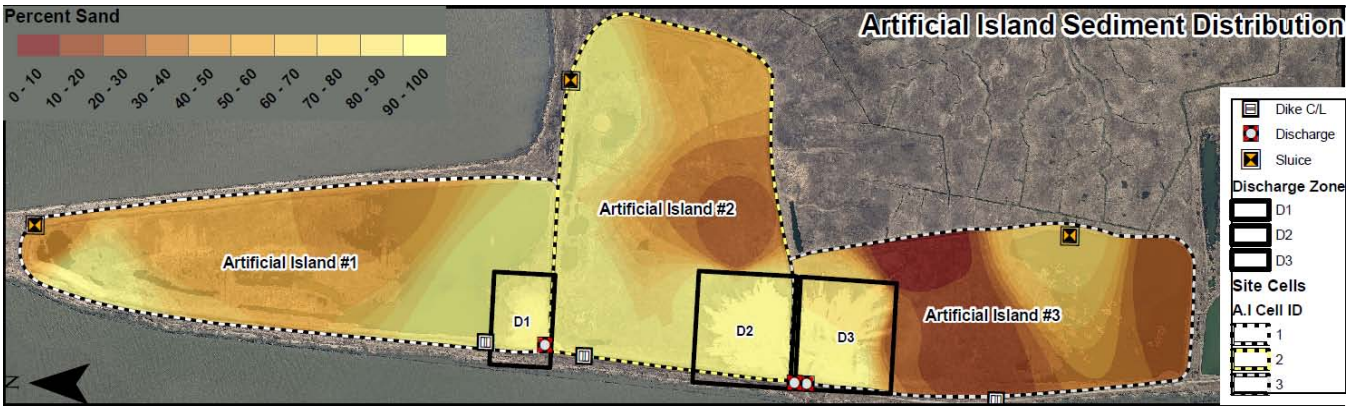

Figure 2. Artificial Island Sediment Distribution Map

RECOMMENDATIONS

Based on the sediment data collected and subsequent analysis at Artificial Island CDF, the project team recommends:

1) Further sediment data collection and analysis in each discharge area, this may include using a device such as a vibra-core to penetrate deeper into the CDF's interior surface (approximately 20ft). Utilizing a virbra-core would increase the accuracy of volume calculations for each of the sediments types.

2) Up-to-date elevation data collection which could include the use of aerial or side-scan LiDAR to provide more detailed topography.

3) Excavation of sandy sediments proximal to the discharge areas for further analysis to determine beneficial uses.

4) Further analysis of phragmites growth in discharge zones 1-3 to determine if the edge of phragmites growth indicates a change in sediment type or another factor that limits phragmite growth (elevation, salinity, etc.).

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