

Final Report to
The National Park Service

High-Resolution Bathymetric and Backscatter Mapping in Jamaica Bay

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Introduction

Accurate and detailed information about the benthic environment in Jamaica Bay is needed in order to properly manage this complex and important system. In particular, we need to understand in detail the spatial distribution of different bottom types as well as their physical characteristics and their significance for benthic organisms. While existing information provides important insights into sediment and faunal patterns, many details of the sea bed are not known. Acoustic mapping techniques can provide high-resolution data on sediment topography and characteristics in a range of water depths.

Jamaica Bay is a highly modified coastal estuary located within greater New York Harbor and is the largest estuarine system in Gateway National Recreation Area. It is experiencing rapid and accelerating loss of its remaining salt marsh areas (NYCDEP WAC, 2007). The salt marshes of Gateway NRA are essential habitat for fish, migratory and nesting birds, and other wildlife that use these natural systems that persist among highly urbanized surroundings. Extensive research is underway at the park to determine physical and other processes contributing to the rapid loss of the saltmarsh habitats of the bay and the other estuaries of the park. High quality bathymetric information and characterization of bottom sediments of the bay is lacking. This information would provide critical knowledge for understanding why the marshes are deteriorating and how to mitigate for these habitat losses.

Ongoing research is attempting to identify the causes of and factors affecting wetland loss, and also to gauge the effects of contaminant and nutrient inputs on water quality and sediments. Research includes studies in sediment budget analysis, time series analysis (GIS based) of salt marsh changes over time, and marsh elevation studies, among others. In addition, there are two experimental marsh restoration projects in Jamaica Bay, one conducted by NPS, the other a larger restoration constructed by the U.S. Army Corps of Engineers. Both of the restorations involve addition of sediments to counteract a loss of sediments and lowering of marsh elevation due to several factors, including the extension of the Rockaway Peninsula following construction of a large jetty in the 1930s. New system-wide bathymetric data will help to understand how these kinds of localized restoration projects affect the overall system.

Good bathymetric data and information on sediment characteristics for the entire area, including near salt marsh areas of the park, are fundamental for this research, for management of the current salt marsh restorations, and for planning and design of future mitigation efforts of salt marsh loss. Changes in bathymetry are recognized as a major factor in the status of the salt marsh ecosystems (Blue Ribbon Panel Report, 2001), but since NOAA surveys in the 1950's there has been little specific and comprehensive information on what is occurring in benthic and deep water areas. Bathymetric information is particularly important for the shallow areas of the bay in order to study the underpinnings of the salt marshes and to understand their hydrodynamic and sediment interactions with the deeper, dredged areas. Previous bathymetric data (such as the NOAA charts) have few data points in shallow areas. This precludes real understanding of the morphology and sediment movement within the bay as a whole, knowledge critical to understanding the processes that define the estuarine ecosystem in Jamaica Bay and the other estuaries within the region.

The ultimate goal this study of high-resolution bathymetry and backscatter is to develop benthic habitat maps that extend from nearly shore to shore across Jamaica Bay, with studies in less than 4 m water depths being done primarily west of Cross Bay Boulevard. Important intermediate products are the bathymetric and backscatter maps and the new ground-truth data determined from sampling the sea bed in Jamaica Bay. We (Robert Cerrato and Roger Flood at SoMAS) recently started a project supported by NY Sea Grant on the subject of evaluating

habitat classification schemes and the biological samples collected during this study will be processed under that grant. As a result, no quantitative benthic sample analyses will be presented here.

This Jamaica Bay study was divided into three projects: (1) a mapping project using the R/V Donald W Pritchard collected multibeam bathymetric and backscatter data and side-scan sonar data in the deeper navigation channels (deeper than about 4 m), (2) a mapping project using a SoMAS 16-foot Boston Whaler collected single-beam bathymetry and side-scan sonar data in water depths shallower than 4 m in the vicinity of marshes west of Cross Bay Boulevard, and (3) a sampling project collected grab samples, bottom photographs and bottom penetrometer data at a number of stations in water depths deeper than about 4 m using the vessel R/V Donald W Pritchard. The sediment samples were analyzed for grain size as well as water content and loss on ignition where appropriate. As noted above, the faunal data from these sediment samples is being determined under separate funding from New York Sea Grant and that data is not yet available. These data sets provide the basis for a preliminary acoustic classification of the sea bed that can be used to characterize sediment distribution patterns, sediment processes, and the characterization of benthic fauna (Figures 1 to 4).

Three acoustic mapping techniques were used to survey the Jamaica Bay floor: multibeam swath mapping for water depth and backscatter, single-beam mapping for water depth and side-scan sonar for backscatter. All three of these techniques can be effective in water depths of a few meters (generally limited by the draft of the survey vessel) to the maximum depth of Jamaica Bay (several 10s of meters). However, there are several considerations in assessing the best mix of side-scan sonar and multibeam mapping for a particular task.

A side-scan sonar maps the seabed by transmitting a narrow sound beam perpendicular to the ship track and then recording the returned sound (Johnson and Helferty, 1990). A picture of the sea bed is painted out as the fish moves across the bottom. For highest resolution, the swath width should be about 7 to 10 times the water depth, but a wider swath is often feasible. The strength of the returned signal depends on bottom characteristics (e.g., grain size, shells, vegetation) as well as bottom topography. A side-scan sonar mosaic is created from the digitally

recorded sonar data, giving a map of the side-scan sonar data plotted in its correct geographic position and orientation.

While a side-scan sonar potentially provides high-resolution images of sea-bed objects to the side of the ship, the sea floor directly below the sonar is poorly imaged and our system doesn't collect bathymetric data. Using a side-scan sonar in very shallow water can also be problematic because the sound can reflect off the water surface as well as the sea bed which means that surface water waves and boat wakes can create prominent sonar targets, and near-surface temperature stratification can distort the records. In addition, the strength of the bottom return is related to both the bottom material (e.g., sand, shell, mud) and bottom topography (which can cast shadows). One other possible source of error is that slant range (range from fish to sea bed features) is generally converted to horizontal range (horizontal distance from beneath fish to sea bed feature) assuming a flat sea bed. The topography is often flat and thus this assumption introduces some error in the cross-track positioning of features. Other considerations are that the side-scan sonar records are adversely affected by sea state and wave motion, and, for the side-scan sonars used here, the electronic gain in the sonar system is not calibrated. However, in spite of these difficulties the side-scan sonar remains an effective tool for characterizing the seabed in both deep and shallow water and compliments a multibeam or single-beam mapping effort. We mounted the side-scan sonar on a pole for these survey operations so that we could accurately measure the heading, orientation and water depth of the sidescan sonar transducers.

A multibeam echosounder maps the sea bed in a fashion similar to a side-scan sonar; however, unlike a side-scan sonar, bottom depths can be determined from the returned echo because the angle of the acoustic return is precisely known (Hughes Clarke et al., 1996; Gardner et al., 1998). The echo from each ping can result in up to several hundred depth measurements across the swath depending on the multibeam equipment and there can be from about 4 to 20 pings per second. The results from all the tracks are combined to make a detailed map of seabed topography. The width of the multibeam swath is set by the sonar geometry, and it can range from four to ten times the water depth depending again on the multibeam equipment. For this study we used a dual-head system in order to increase our maximum swath width from about

four times water depth to ten times water depth. The strength of the sonar return (backscatter, which varies with bottom roughness and sediment characteristics) is also measured, giving information about small and large-scale seabed features and sediment type. The detailed depth information is used to construct a digital terrain map (DTM) with a resolution of about 1-2 meters. A synthetic sun can be shined across this high-resolution DTM to generate a "sun-illuminated" bathymetry image, showing what the estuary floor would look like if the water were drained from the region. The multibeam backscatter is processed to create a backscatter image showing in detail the variation of echo strength.

Our multibeam mapping system was mounted on a vessel with a draft of about 4 feet (1.2 m) thus effectively limiting our mapping with the multibeam system to about 4 m water depth. We were also interested in mapping in the shallower water in Jamaica Bay that is between the marshes and so we mounted an acoustic mapping system on a 16-foot Boston Whaler that could operate in water depths of about two feet. We considered mounting our multibeam system on the whaler, but our system is configured for use on a vessel of moderate size with a secure and heated or air-conditioned cabin and thus was too large to be used on our Boston Whaler. For shallow-water work we elected to use a single-beam 200 kHz echosounder that would could be mounted on the bottom of the whaler and that could operate in depths as shallow as one foot. We also had a hull-mounted side-scan sonar on the whaler that was used to map sediment characteristics during the whaler surveys. Our electronics system allowed us to use the echosounder and one side-scan sonar transducer, so we alternated side-scan sonar transducers as we ran the single-beam survey lines to give complete side-scan sonar coverage of the sea floor.

For this study we used both a side-scan sonar and a dual-head multibeam echosounder throughout the study area in deeper water and the single-beam depth profiler and side-scan sonar in shallower water, with the dividing line between the two systems being about 4 meters. The pole-mounted side-scan sonar and multibeam echosounder operate on slightly different frequencies (100 kHz vs. 300 kHz) and the same sea-bed can potentially reflect different amounts of signal at different frequencies. Thus by running both systems together throughout the deeper parts of the survey area we collect information about echo strengths at two different frequencies.

Acoustic Mapping Techniques

Multibeam Mapping System

The multibeam system used consisted of an EM 3000D multibeam echosounder (which operates at 300 kHz), a POS/MV 320 v2 (for attitude, heading and inertially-supplemented DGPS navigation -- accuracy +/- 1 m), a Trimble SPS-651 receiver (position accuracy +/-0.2 m using cellular RTK corrections), sound velocity probe, sound velocity profiler and CTD (for sound velocity profiles), computer hardware and software for data acquisition and logging, and display to assist helmsman to follow planned ship tracks. The EM 3000D utilizes two hull-mounted multibeam transducers each mounted 40 degrees from the horizontal to achieve a wider swath width. The two transducers operate at slightly different frequencies (293 and 307 kHz), but their backscatter records appear to be identical. Ship speed and line spacing was adjusted so that we collected at least one to two depth points per square meter in the across-track and along-track directions. Data was collected using the 28-foot MSRC research vessel R/V Pritchard.

Side-scan sonar system

The side-scan sonar system used during the multibeam survey was a pole-mounted Edgetech 272TD side-scan sonar fish, and the sonar data was logged on a topside computer using Isis software. The side-scan sonar was used along with the multibeam echosounder, so ship orientation, position, and water depth are recorded by the multibeam system. The Edgetech 272TD sonar fish can operate at either 100 kHz or 400 kHz (historically advertised as 500 kHz). We collected data using the 100 kHz setting because this resulted in a wider swath width because of the lower attenuation of 100 kHz vs. 400 kHz sound in seawater.

Single-beam echosounder and side-scan sonar system

We used a Knudsen 1612 dual-frequency echosounder system along with a dual-frequency 28/200 kHz single-beam transducer and 200 kHz side-scan sonar transducers mounted

on the hull of a 16-foot Boston Whaler. In this configuration there are four channels of available acoustic data (two echosounder frequencies and two side-scan channels) although we only had the ability to record two channels of acoustic data. For this study we recorded the 200 kHz echosounder frequency and one of the side-scan sonar channels. During the survey we selected which side of the side-scan sonar channel that was recorded so as to cover the study area as we ran parallel tracks. Sound velocity measurements and a bar check was used to correct echosounding depths to bottom depths. We ran single-beam echosounder tracks spaced 50 m apart in a grid pattern with cross-lines spaced every 200 m. The side-scan sonar swaths were run on a 50 m scale which did reach between lines spaced at 50 m. This proved to be quite far with the best data coming from the inner 20 to 25 m of the swath. We accepted this side-scan sonar coverage as being adequate because we could observe patterns across the swath and because our survey plan only called for using side-scan sonar if it could be done at little or no cost to the project.

Water-level measurements

Multibeam and single-beam depth measurements were measured with respect to their respective transducers and it is necessary to determine the elevation of the transducers in order to determine water depth. Water elevation referenced to NGVD29 was measured by water-level gauges operated by the USGS at Rockaway Inlet near Floyd Bennett Field (Station 01311875) and at Jamaica Bay at Inwood (Station 1311850). We also deployed a water-level gauge at Canarsie Pier for the duration of our 2008 multibeam and 2009 single-beam studies to ensure we had a complete water-level record during our surveys. The records from these gauges demonstrate that there are small changes in timing and water level throughout Jamaica Bay as the tide wave propagates through the bay, but the changes appeared small enough so that we only used the Rockaway Inlet gauge in our studies. We also measured vertical elevations of the sonar transducers accurate to about 0.02 m using a RTK GPS receiver (Trimble SPS651) using cellular corrections provided by the New York State Department of Transportation. Our GPS results during 2008 were not adequate to get elevations, perhaps because of station locations. However, we got good results in 2009 and were able to use GPS elevations to calculate the sea-floor bathymetry. Depths in all surveys were reported to NAVD88. According to the NOAA Vdatum

program (<http://vdatum.noaa.gov>), the charting datum mean lower low water (MLLW) is 0.9 to 0.95 m lower than the zero elevation of NAVD88 in Jamaica Bay, thus water depths reported relative to NAVD88 appear to be 0.9 to 0.95 m greater than those reported relative to MLLW. Since we are not using the NOAA charting datum, the depth data and charts reported by this study should not be used for navigation. The datum NAVD88 was chosen because water depths referenced to NAVD88 more correctly indicate the average water level than do those referenced to MLLW. Also, the elevation of MLLW changes spatially and will change over time as a result of sea-level rise or changes to local morphology and it can be more difficult to follow sea-bed changes if the vertical datum is also changing.

Data Processing

Bathymetry and side-scan sonar data were processed using a suite of software programs developed at the University of New Brunswick (SwathEd) for both multibeam and side-scan sonar processing. Navigation and depth data were displayed and edited so that any bad depths or navigation fixes could be removed, and water-level corrections were applied to the depth data. Local sound-velocity refraction corrections were also made in some areas. The multibeam depth data was gridded at 1 m and sun-illuminated bathymetry images illuminated from the northwest and northeast were also created. The single-beam depth data was binned at 2 m and then gridded at 5 m using triangular interpolation followed by Gaussian smoothing. The vertical datum for the project is North Atlantic Vertical Datum 1988 (NAVD88). The multibeam backscatter data and side-scan sonar records were corrected for beam pattern effects by averaging along track. However, the acoustic levels are not precisely consistent from year to year. New processing algorithms are now available that may resolve this problem. The backscatter and side-scan sonar data collected along with the multibeam data was gridded at 1 m and plotted with stronger echoes as lighter colors and weaker echoes as darker colors. Side-scan data recorded along with the single-beam data was gridded at 5 m. All grids were referenced to UTM Zone 18 (meters), NAD83.

Digital Map Data Files

The gridded depth data were imported into ArcView 3.1 as a binary grid (.flt and .hdr files). The sun-illuminated bathymetry and the backscatter data grids were converted to geotiff images and loaded into ArcView 3.1. Shape files of bathymetric contours at 1 and 5 m were made for each survey. Point shape files in latitude and longitude were also created showing the locations of the bottom samples. See the Appendix for more information about the files being provided.

Sediment sampling and analysis

Given the large size of Jamaica Bay we planned to sample at a relatively high density in a few areas rather than to collect samples in all areas of the bay during this study. We chose to concentrate our sampling primarily in three areas: in Reynolds Channel west of the Gil Hodges Bridge, at the western end of Runway Channel in Jamaica Bay, and in Grassy Bay. This sample data set was collected to help provide ground truth for the depth and backscatter data sets, and the sampling data consist of grab samples, bottom video and bottom penetrometer. A total of 86 stations were occupied (Table 1), and sample sediment data is reported on Tables 2 to 5. Sampling was conducted aboard the R/V Donald W Pritchard operated by Stony Brook University in June 2009 and station locations were determined by GPS.

Grab Samples

Bottom samples were collected using a modified Van Veen grab (0.04 m²). Sediment samples with sufficient fine-grained material were processed for loss on ignition (LOI, a proxy for organic carbon content) and water content. Water content (percent wet weight, corrected for salt at 35 psu) was measured by weighing a sediment sample before and after drying for at least 24 hours at 80°C. LOI (percent of initial dry sample weight) was calculated by weighing samples before and after dry sediment samples were combusted at 450° C for at least 4 hours. Water content and LOI measurements were generally not made on coarse sand-size sediment because water drained out of the sediment on recovery and those sediments contained little organic matter.

Sediment samples were processed for grain-size including the percent composition by weight of major size-fractions (gravel, sand, silt, clay) as well as the detailed grain-size distribution reported to 0.5 phi intervals. We used a combination of sieve, settling column, and sedigraph analyses for the gravel, sand, and silt-clay fractions, respectively. Samples were initially partitioned into four size fractions by wet sieving with distilled water through a combination of 2 mm, 1 mm, and 63 micron sieves. The >2 mm, 1 mm-2 mm, and 1 mm-63 micron fractions were placed in a drying oven at 60° C to 85° C for at least 24 hours to obtain dry weights. The dry weight for the >2 mm sediment was the gravel fraction. The dry weight of the 2 mm-63 micron sediment was the sand fraction, but only the 1 mm-63 micron fraction was analyzed by settling tube as described below. The <63 micron (mud or fine) fraction was analyzed by sedigraph as described below, and following that analysis, the sample was captured, dried and weighed to get the weight of the fine fraction. The weight was corrected for sodium hexametaphosphate added for the sedigraph analysis.

The grain-size distribution of the 1 mm-63 micron fraction was determined by settling column analysis. The settling column consisted of a 193.5 cm tall PVC tube with an internal diameter of 15.2 cm filled with distilled water. Samples were introduced at the top of the column and a collecting pan connected to an analytical balance registered weight as particles landed on the pan. A computer connected to the balance recorded cumulative weight with time for each sample. Weight-time data were converted to sedimentation diameter using an empirical equation in Gibbs et al. (1971). A particle roughness correction, the gibbs velocity, suggested by Baba and Komar (1981) was also applied.

A Micromeritics SediGraph 5100 was used to analyze the <63 micron (silt-clay) fraction. Water containing the <63 micron fraction was centrifuged for approximately ten minutes. For a few samples, the settling process was sped up by putting the jars of suspended fine particles in the water in a oven at 35° to 40° C for a few days. Water was decanted from the sample, and the sedimented material was rinsed with a 0.5% sodium hexametaphosphate solution to reduce coagulation of clay particles. Samples were run using standard techniques obtained from the manufacturer. As a final step in the sediment analysis, results from the dry sieve, settling column, and sedigraph analyses were combined and grain-size distribution was reduced to ½ phi

intervals. As the grain-size results were combined, the sedigraph size distribution was extended to 14 phi (in the colloid size range) to allow grain-size distribution parameters to be calculated; however, the ½ phi data was truncated at 11 phi. Standard size data included percent gravel, sand, mud (silt+clay), silt and clay and the sand percentages coarser and finer than 1 mm (0 phi) are also reported. The grain-size parameters median grain size, mean grain size, sorting (standard deviation), _skewness (third moment), and _kurtosis (fourth moment) are also reported for the combined settling tube and sedigraph fraction following Folk and Ward (1957). The combined settling tube and sedigraph fraction is generally finer than about 1 mm although some sediment in the 1 mm-2 mm fraction did pass through the sieve and is included in the settling tube and sedigraph fraction.

The general character of the sand and mud-sized material recovered in the grab samples is shown in Figures 5 and 6. Figure 5 shows the percent of material in each size range for all samples. Figure 5 shows that many of the samples have a peak in the sand size range (phi size of 4 or less). This peak is often fairly well defined with a width of about one phi size, and the sand component is mixed with a fine-grained mud component to give the final size range. This grain size structure would be consistent with current transport of the sand-sized fraction and dilution by a muddy component. Figure 6 shows the same grain size data, but this time plotted as cumulative percent finer than the phi size indicated. The median sediment size is where the curve crosses the 50% line. This plot again suggests that many samples have a well defined sand component (the steeper the line on this plot, the better sorted the sand fraction is) mixed with a finer component, but there are definitely some sediments with little or no sand component. These muddy sediments appear to accumulate in areas where currents are very low.

Bottom Videos

The sea bed was photographed with a Deep Blue underwater video camera from Ocean Systems, Inc. which transmitted the video signals over wire the ship. The bed was illuminated by small lights when sunlight did not provide enough lumination. The video signals were recorded onto DVD and then copied to a computer where they were viewed. The video data are summarized in Table 6 and some example photographs are shown in Figure 7. The camera has a

resolution of 640x480 and a fixed focal length. We got good photographs by essentially lying the camera on the sea bed and keeping it still for several minutes. This approach was made possible by anchoring the vessel. This also ensured that the video, grab sample and bottom penetrometer were all from essentially the same location.

Bottom Penetrometer

We deployed a free-fall penetrometer at each sample site to provide additional information about sea-bed sediments. A free-fall penetrometer is an instrumented probe that falls through the water column and impacts the sea bed. The deceleration of the probe as it hits the bed is recorded on the ship. This deceleration record provides important information about the sea bed. In particular, the probe can penetrate quite far into the bottom in fine-grained sediments but it stops abruptly in coarse-grained sediments. The rate of slowing (the deceleration, given in units of the gravitational acceleration g which is $980 \text{ cm}^2/\text{s}$) is related to sea-bed physical properties such as water content or shear strength. This kind of probe has been developed and is being evaluated in an expendable form (Stoll and Akal, 1999; Aubeny and Shi, 2006; Stark and Wever, 2009). We have used a non-expendable form of this instrument as part of our studies in Port Jefferson Harbor and elsewhere in coastal waters. Since the probe quickly provides information about surface sediment properties, it has the potential to become an important tool for classifying shallow-water environments. The bottom penetrometer results are given in Table 7 and a plot of all penetrometer impacts in Jamaica Bay is shown in Figure 8.

The area beneath the deceleration-time curve of the probe is proportional to the terminal velocity of the probe, so a probe that stops abruptly in sandy sediments penetrates only a short distance into the sediment while a probe that slows gradually in muddy sediments can travel a greater distance. As a result the maximum deceleration and penetration depth are not independent measures and maximum deceleration is used in preference to penetration depth in describing results. In Jamaica Bay, probe drops with a maximum deceleration of less than about $3g$ tended to indicate very soupy sediments. Maximum probe decelerations of about $4g$ to $10g$ tended to indicate more normally consolidated fine-grained sediments and maximum probe

decelerations over about 10g tended to indicate better consolidated sediments, shell beds or, for the largest decelerations, clean sand beds.

Operations

This study has required 40 ship days to complete, one third more time than anticipated. In addition, data acquisition occurred over a 10 month period rather than the approximately one month allowed in the implementation plan. Indeed, the entire implementation plan proved to be overly optimistic.

Multibeam bathymetry and side-scan sonar were collected primarily during a 12 day study in August and September 2008. During the study our vessel was berthed at Kingsboro Community College. Survey data was collected on August 15, 19, 20, 21, 22, 25, 26, 27, 28, and 29 and on September 3 and 8. We were unable to obtain permission to enter the security zone at JFK Airport at the eastern edge of our study area during the planned survey. However, we were able to do our mapping in that area as part of our 2009 sampling cruise.

Small-boat bathymetric and side-scan sonar mapping in the shallower areas of Jamaica Bay west of Cross Bay Boulevard was undertaken on 20 days in late winter and in spring in 2009. During this time our vessel was stored at the Hempstead Town West Marina and the boat was launched from the Nassau County boat ramp in Inwood. Survey data was collected on February 28, March 5, 6, 19, 20, 26 and 31, April 1, 9, 10, 14, 24, 27, 28, 29 and 30, and May 8, 12, 13, and 15. The irregular survey schedule was necessitated by our need to wait for good weather and our need to survey only on the high half of the tidal cycle.

Sediment sampling was undertaken during 8 days in June 2009 and during the study our vessel was berthed at Kingsboro Community College. Sampling was conducted on June 17, 18, 19, 23, 24, 25, 26, and 30. We also conducted the bathymetric mapping near JFK Airport during one of these days that was not done in 2008.

Project Results

Our mapping project revealed a tremendous amount of detail and complexity, too much to be discussed and illustrated within this report. Thus while some examples of the items being discussed are presented as figures, it is intended that the user of this document will have the project results available in GIS or similar format.

Bathymetry

Jamaica Bay has a complex morphology in part due to more than a century of modification and nearby urban development. The present-day inlet channel has a limiting depth at Rockaway Point of about 6.5 m NAVD88 and then deepens to about 10 m at about the southwestern limit of our survey when the channel turns towards the northeast near Breezy Point (Figure 9). With some exceptions, the depth is 10 m or more in Reynolds Channel to and past the Gil Hodges Memorial Lift Bridge, in Island Channel along the western side of Jamaica Bay and in North Channel on the northern side of Jamaica Bay to about Old Mill Creek which is almost as far as the Cross Bay Boulevard. Depths over 10 m are also found in parts of Beach Channel along the south side of Jamaica Bay, especially near where the channel narrows west of the Cross Bay Boulevard Memorial Bridge. Indeed, the deepest depths found during our survey were in a scoured area in a narrow section of Beach Channel that is nearly 22 m deep. The second deepest area is a dredged depression in North Channel that is nearly 20 m deep. Channels approaching and east of about Cross Bay Boulevard are generally shallower than those to the west of Cross Bay Boulevard with water depths of 6 to 9 m. The sea floor deepens again as JFK Airport (JFK) is approached, apparently due to dredging for fill for the airport and other construction projects. The northern part of Winhole Channel and the eastern part of Grass Hassock Channel are notably deeper and wider than the southern or western parts, respectively, of those channels. Grassy Bay immediately west of JFK has maximum depths of 15 m which is considerably deeper than the channels through which it drains and fills. The area between JoCo Marsh and JFK south of the runway extension has depths as deep as 13.3 m which are similar to those in Grassy Bay but shallower than those in the adjacent Grass Hassock Channel which are as deep as 18.7 m.

The marsh area of central Jamaica Bay, west of Cross Bay Boulevard, contains two major channels, Pumpkin Patch Channel (actually the combination of Pumpkin Patch Channel and Big Fishkill Channel) which crosses the marsh and The Raunt which terminates near Beach Haven. These channels range from about 3 to over 5 m deep but with portions that are as deep as 9.5 m at the mid point of Pumpkin Patch Channel and as deep as about 12.5 m at the northern end of The Raunt. These deeper depths may be the result of past dredging. These larger channels connect with a network of smaller channels with depths of 1 to 3 m that go between the various marshes and act as conduits for water to and from the marsh areas as the tide rises and falls. Some of the water flowing through this channel network crosses the marsh area entirely and flows into and out of Grassy Bay. The major channels and most of the smaller channels flow near to marsh edges, e.g., the channels near Stony Creek Marsh, Yellow Bar Hassock, and flow in the channels may contribute to the erosion of marsh edges. A small moat-like depression is also observed on the northwest corner of Canarsie Pol which may result from the current flowing near the edge of the island as the tide ebbs and floods. In some cases these channels are also used for small-boat traffic and boat wakes, especially when combined with currents, may also contribute to marsh erosion. In a later section we will discuss the implications of the south end of Pumkin Patch Channel ending at the very edge of the marsh platform.

Seabed Morphology

The sun-illuminated multibeam and single-beam bathymetric data provide important information about the nature of the processes that have formed and modified the present-day Jamaica Bay. While the bed in many areas of Jamaica Bay has been smoothed by current flow, the most common feature on the sea bed in deeper water is the pattern left by dredging. This pattern consists of a series of arcuate mounds and troughs that cover a swath about 80 m wide that can extend for an arbitrary distance (Figure 11). We observe swaths of up to about 2 km long in Runway Channel, but many swaths extend for a shorter distance. The individual mounds and troughs can be spaced from about 10 to 40 m apart and the mounds can be from 0.1 to over 1.0 m higher than the troughs. In some areas this morphology is quite subdued as a result of subsequent sedimentation and modification by currents, but the lateral swath boundaries appear to be recognizable for some time after the individual mounds and troughs are difficult to

identify. In some areas more clearly defined swaths are located adjacent to swaths where the topography is more subdued. This suggests that dredging has occurred at several times in the past. It needs to be noted that multibeam bathymetric data is also collected in swaths that often run parallel to the channel. Also, sand-wave trains are natural features with along-channel extension that are unrelated to dredging. Thus not all along-channel lineations shown by sun-illuminated bathymetry can be ascribed to past dredging activity and further investigations may be needed, including more careful study of the existing multibeam data, in areas where features are subtle.

West of Cross Bay Boulevard this dredging pattern is observed in Island Channel north of the southern tip of Nova Scotia Bar, in Runway Channel, and in North Channel, with the patterns that look the most recent occurring between about Fresh Creek and Elders Point Marsh. The depression at the midpoint of Pumpkin Patch Channel also has the dimensions of a dredged area being a U-shaped swath which is about 80 m wide, 600 m long and with a subdued arcuate mound-and-trough morphology on the floor of the trough (Figure 10). The depression off Beach Haven appears also to have a dredging origin based on the overall horizontal dimensions of 80 m wide by 280 m long, but no arcuate features were observed on the bottom here. A possible dredging pattern is observed on the southeast flank of Nova Scotia Bar in that there are somewhat linear features with widths of about 80 m and lengths of about 1.2 km, but the lineations are not as regular as in other areas where features created by dredging have been identified. If these features southeast of Nova Scotia Bar were formed by dredging, then they have been heavily modified by subsequent current transport of sediment.

East of Cross Bay Boulevard a somewhat subdued dredging pattern can be identified in the northern half of Winhole Channel while clear dredging patterns of likely different ages are identified throughout Grassy Bay and in Grass Hassock Channel as far east as JFK (Figure 9). Dredging has also occurred under the bridge at the north end of Cross Bay Boulevard and under the adjacent railway bridge.

The general morphology and depths in Grassy Bay (Figure 12) depicted on the current NOAA chart and discernable in NOAA bathymetry survey data available online suggest that

Grassy Bay was dredged to its present form earlier than about 1950. Given the amount of time that has passed since dredging occurred here (about 60 years at the time of the bathymetric survey) and the relatively high accumulation rates thought to occur in the fine-grained sediments in Grassy Bay it is somewhat surprising that this dredging topography is still observable. There are some reasons why this could be the case. First, sedimentation in Grassy Bay appears to have occurred uniformly as there is no evidence of current scour or preferential deposition on our bathymetric records. If sedimentation is uniform, then it is perhaps not surprising that features with relief in excess of 1 m over a distance of 40 m are still visible after the uniform deposition of at least an equal amount of sediment. Second, our studies confirm that the fine-grained sediments here are very gassy in addition to being very soupy, and that this gas extends to the sediment surface. This gassy sediment makes a good acoustic reflector. If our system was not reliably tracking the sediment-water interface then we would expect to see the depths jump when passing over a gassy interval. This is not the case, and as a result we feel the multibeam data is providing a true representation of the sea-bed morphology.

The second major on the sea-floor pattern is the sand wave, and sand waves are observed in many of the channels that have not been made too deep by dredging. A link is made here between sand waves and dredging simply to express the idea that the flow speed in a channel decreases as the cross-sectional area increases, and that deepening or widening a channel by dredging may reduce flow speeds to the point where sand waves do not continue to form. Certainly sand waves can form in dredged channels should flow speeds be appropriate and sufficient material to form sand waves be available. Sand waves observed on our study area range in size with the largest features being in Reynolds Channel with heights over 3 m and wavelengths of about 75 m. Sand waves are observed at a number of places in Reynolds Channel both east and west of the Gil Hodges Memorial Bridge and at several places along Beach Channel. Several sets of sand waves, some with heights over 2 m, also occur immediately west of Nova Scotia Bar (Figure 11). In many areas these sand waves are two dimensional in form with wave crests that are parallel to one another. However, in some areas the sand waves have a more complex three dimensional pattern. The three dimensional pattern may be occurring in areas where flow speeds are somewhat stronger and more turbulent. The sand waves observed are generally asymmetric with the steeper slope occurring in the direction of the flood tide

although in some areas the sand waves are more symmetric. The asymmetric sand waves appear to be primarily active on flood tide which would be consistent with an estuarine circulation pattern while more symmetric waves indicate areas where both flood and ebb tides are able to move sand-size sediment.

Samples from sand waves showed well-sorted, clean sands with mean sizes in the medium to fine sand range. Penetrometer impacts in areas of sand waves generally have high maximum decelerations, almost always over 20-30g.

Sand waves were also observed during the small-boat study north of Runway Channel at its eastern end and along the southern portion of Nova Scotia Bar. These waves are not well represented on the bathymetry gridded at 5 m but they are visible on the side-scan sonar mosaic from the small-boat study.

There is a scoured morphology that has formed beneath the Cross Bay Boulevard Memorial Bridge, under the railway bridge immediately to the east of that bridge and, to a lesser extent, under Gil Hodges Memorial Bridge (Figure 13). These scours suggest that the flow near the bridge pilings is fast enough to transport sediment away from the bridge pilings. At Gil Hodges Memorial Bridge this transport is primarily in the direction of the flood current at the south end of the bridge while it is in both flood and ebb directions at the north end of that bridge and at the other two bridges. The scours at Gil Hodges Memorial Bridge can be as deep as 6 m and can affect the sea floor for perhaps two hundred meters from the bridge. The scour morphology at Cross Bay Boulevard Memorial Bridge and at the railroad bridge consists of both deeper areas between pilings and sediment ridges both extending in the flow directions. Thus while the relief between the trough and ridge can be as much as 3 m, some of that relief is related to the ridges rather than to the depressions. A more complete analysis will be needed to understand whether this level of scour has any affect on the stability of these bridges.

Acoustic Backscatter

Acoustic backscatter as measured by the multibeam system and by side-scan sonar varies

in a complex fashion. Some of the areas mapped in 2008 were revisited in 2009 during the sampling cruise, and the comparison of data in the two years suggests that backscatter patterns in most areas are stable whereas patterns in other areas can change significantly.

The backscatter patterns in Reynolds Channel appear to be similar in both 2008 and 2009 (Figure 14). While one can make few generalities, it appears that areas with higher backscatter are more likely to have more shell on the bed and that areas with fine sand and ripples or dunes are more likely to have lower backscatter. One exception to this is at station 3a where the bottom penetrometer showed a weak in a depression with low backscatter near the entrance to Sheepshead Bay. While no grain size measurements were made at that station, the visual description notes that the sample was mud with mussel shells and a lot of black tubes.

Comparison between samples and backscatter patterns in the vicinity of Runway Channel, Island Channel and Nova Scotia Bar continue the above pattern with higher backscatter in areas of abundant shell and lower backscatter in areas with fine sand and ripples or dunes. We also see several examples of low backscatter in areas with lower-speed currents and the bed in those areas is often muddy with mats of amphipod tubes. One exception to this general rule is at the southern end of Pumpkin Patch Channel where there is a region of quite high backscatter, although this area is somewhat larger in August 2008 than in June 2009. Bottom photographs from this area at stations 28 and 51 show that ulva is abundant near the bottom at 7.5 to 8 m. Some of this ulva is relatively fresh which much of it is quite degraded, and it appears that the ulva has been trapping gas bubbles of biogenic origin that apparently originate in the underlying sediment. It may be the bubbles trapped beneath the ulva that lead to the highest backscatter values. There are also many shelled organisms (snails and hermit crabs) crawling on the plant material that may also contribute to the high backscatter here. It is unclear if the ulva is actively growing at this site or if it is accumulating along the edge of the deeper channel. Ulva is present in nearby Pumpkin Patch and Runway Channels at about depths of 4.5 to 5.5 m. Close examination of the 2008 and 2009 backscatter data show that in 2008 there were numerous small areas with very high backscatter at depth in Island Channel while none were observed in 2009. Those small areas of very high backscatter might be places where ulva is resting on the bed and trapping gas from the sediments. We targeted a station in one of these deep high backscatter

anomalies based on the 2008 data, but that anomaly was not present in 2009. There are other small areas of intermediate to high backscatter at depth in Island Channel that also had a different character in 2009 than in 2008. These changing patterns might alternatively represent changing distributions of amphipod mats from year to year.

The dredged depression at the midpoint of Pumpkin Patch Channel (Figure 15) also shows an area of high backscatter in the 2008 data that the bottom camera at station 61 shows to be a region of degraded ulva. However, in this case trapped gas bubbles are not as apparent as at stations 28 and 51 and the backscatter in 2009 does not appear to be as high as the backscatter in 2008. The penetrometer at station 61 had a very low maximum deceleration value of 3.6g, constant with the soupy sediments.

Four stations at the eastern end of North Channel confirm the observation that areas with abundant shell have higher backscatter than do areas with little or no shell. At station 84 in a water depth of 4.5 m we photographed a hard clam with an open shell and extended siphon at the sediment surface. The chart in this area shows a water depth of 34 feet, much deeper than we observed, and this shallow area is apparently a remnant left after dredging the area.

Sixteen bottom sampling stations were occupied in Grassy Bay (Figure 16). Thirteen of these stations were in the central portion of the bay and three were near the northern entrance to the bay. The backscatter and topographic data suggest that the central part of the basin can be broken into four categories: shallower with high backscatter, shallow with low backscatter, deeper with high backscatter and deeper with low backscatter. We collected samples from all of these settings and came to the following conclusion. In the shallower water (water depths less than about 6 or 7 m) backscatter appears most affected by the presence or absence of shell. Thus shallower areas with high backscatter were likely to have shell, and bottom photographs at three of these stations (station 67 at 5.7 m, nearby station 72 at 7.1 m, and at station 79 at 6.2 m) showed the presence of live hard clams at the sites. In contrast, station 80 at 5.7 m and station 68 at 7.3 m have low backscatter and no shell material. In the deeper water, high backscatter in general indicates rotting ulva and presumably gas trapped by the ulva vegetation (e.g., stations 66 at 10.9 m, station 83 at 11.3 m and station 71 at 11.1 m) while low backscatter areas have

little or no ulva but often has amphipod tubes (e.g., station 73 at 7.2 m) . Sediments are soupy in both high and low backscatter areas the penetrometer reports low deceleration values (less than 4 g and as low as 2.4 g) and high penetrations (usually over 35 cm and as high as 81 cm). However, there are exceptions to every rule and station 78 at 11.2 m is in a depression with high backscatter but no ulva is visible on the bottom video.

Stations 82 and 86 were located on the side of the channel about 1.2 and 1.6 km east of the Gil Hodges Bridge. These stations targeted 3 m deep holes that have existed in the region since at least our multibeam study in 2000. The video from the sites showed steep slopes on the bed with some sand or pockmarks bottom and the grab samples collected a concretion in sand at one site and sand over mud at the other. The origin of these holes has been unclear because there is no obvious structure in the area which could initiate scour here. One hypothesis has been that there is periodic ground-water discharge from these sites, but as of yet there is no evidence to support that suggestion.

Comparisons with NOAA Chart 12350

The bathymetric data collected by this project were compared in general terms with the charted depths on the 60th edition of NOAA Chart 12350 "Jamaica Bay and Rockaway Inlet" dated August 2011. The raster version of the chart was downloaded from the NOAA charting website and converted to a georeferenced .tif image using the program NOAA Chart Reprojector also available on the web. The comparison was made by creating contours of our 5 m gridded data set that included our entire survey area that matched the levels MLLW (-0.9 m NAVD88), -6 ft MLLW (-2.78 m NAVD88), -12 ft MLLW (-4.61 m NAVD88), -18 ft MLLW (-6.44 m NAVD88), and -30 ft MLLW (-10.10 m NAVD88). These levels were chosen because they are the submerged contour lines drawn on NOAA charts. These contour lines were then visually compared with the NOAA chart (Figure 17). In making this comparison one needs to take into account that the data on the NOAA chart was collected over a number of years and that the level of the tidal datum has changed with time as a result of sea-level rise and modification of the basin bathymetry. Also, one needs to allow for changes in navigational accuracy over time.

Overall the agreement is quite good in Reynolds Channel west of the Gil Hodges Bridge, although the contours derived from this survey sometimes plot shallower than the contours on the NOAA chart. This good agreement is to be expected because the chart in this area is based on a high-resolution NOAA survey conducted in 2006. There is somewhat less good agreement east of Gil Hodges Bridge, and differences in this area appear to represent long-term changes in Jamaica Bay morphology.

While there are many small differences, we will discuss a few of the important points at this time. First, the areas surrounding the marshes west of Cross Bay Boulevard appear to be systematically deeper than on the NOAA chart (Figure 17). The MLLW contour is an important one as it shows the average extent of the area that dries at low tide and this affects the near-shore beach slope as well as the amount of area potentially available for marsh colonization. The deeper depths near the marsh islands also allow for faster currents to develop during ebb and flood.

There are fairly large changes in the charted depths in the vicinity of Nova Scotia Bar at the southwest corner of Jamaica Bay in that the depths at the top of the bar are now deeper and the shallow area to the east of the bar is considerably reduced in size (A, Figure 18). In addition, Yankee Channel has moved laterally up to 100 m to the east and shoaled (B, Figure 18). The northwestern flank of Nova Scotia Bar along with adjacent Runway Channel has been changed significantly through dredging activity that occurred since the surveys for the chart were conducted (C, Figure 18). This dredging has removed about 500 m of Runway Channel floor and the adjacent shallow areas and marshes. This dredging has also created the situation where the south end of Pumpkin Patch Channel now is adjacent to water 9 m deep rather than to water 4.5 m deep in Runway Channel. As a result, sediment transported to the end of Pumpkin Patch Channel will drop into quite deep water and potentially be lost to the marsh system.

There are two other areas of significant depth change along Runway Channel that should also be mentioned. First, the southern edge of Runway Channel has moved up to 100 m farther north than it was at the time the chart was made (D, Figure 18). This shifting is due to sediment being moved from deeper to shallower water as the tide floods. However, rather than reaching

the marsh surface, this sediment is being trapped in Runway Channel. Thus one natural process of bringing sediment to the marsh surface, current transport on the flood tide, is effectively interrupted by the presence of the channel. Second, The Raunt runs north-south and intersects Runway Channel on its north side about 1/2 way along Runway Channel (E, Figure 18). While the eastern edge of The Raunt in this location matches that on the chart quite well, the western edge of the channel is offset about 90 to 100 m towards the east from the charted position. This offset most likely has occurred as sediment has moved southeast from Ruffle Bar towards Little Egg Marsh. Again the channel has served to trap sediment moving near the marshes, potentially removing the sediment from the marsh system. Similar patterns can be observed along Pumpkin Patch Channel and Big Fishkill Channel where the channel has narrowed and moved towards the east near the site of Fishkill Hassocks (F, Figure 18) and where it has narrowed and moved to the southeast and east along Pumpkin Patch Marsh. Both of these offsets and narrowings may be due to sediment being washed from the marsh platform (the area between the marshes) into the channel. The potential loss of sediment from the system by the filling of local channels is potentially only made worse by the presence of the post-chart dredged area at the bend of Pumpkin Patch Channel. This depression will also be filled with sediment washed from the marsh or marsh platform.

One other change between the NOAA chart and the present-day morphology needs to be noted at this time. The south edge of North Channel east of Canarsie Pier has been cut back about 200 m in several places through dredging. As mentioned previously, increasing the water depth adjacent to a marsh will inevitably result in increased flow speeds, and perhaps greater wave heights, near the marsh.

Cultural Features

A detailed bathymetric survey such as the one conducted here will, especially in an urban setting, image many man-made features on the sea bed that are of potential cultural interest. This survey is no exception and Figure 19 shows two examples of likely man-made features as shown on side-scan sonar records. Such underwater cultural resources are a sensitive matter, and NPS needs to be aware that the raw multibeam bathymetric and side-scan sonar data files, as well as

the multibeam depth and backscatter data gridded at 1 m, do show the locations of these kinds of features. The single-beam bathymetric and gridded side-scan sonar data do not appear to show these kinds of features. We have worked in the Hudson River where there are similar kinds of concerns regarding cultural features being revealed on multibeam bathymetric data. In that study and in discussions with NYS-DEC it was determined that depth data gridded at 30 m could safely be released to the public along with depth contours derived from depths gridded at 10 m. NPS may wish to consider a similar strategy with this data set.

Acoustic Classification and Sediment Distribution Patterns

Note -- this section is being finalized and, along with Figure 20, has been purposely removed from this draft.

Conclusions

This initial report of our mapping studies in Jamaica Bay show that side-scan sonar and multibeam echosounding techniques can provide new and useful information about the nature of the sea bed over a range of time and distance scales. Understanding the larger-scale as well as the smaller-scale patterns of sediment distribution and sediment processes and will help us understand the importance of additional factors such as the overall history of the area to the modern environment. Such variations in sediments and processes are two of the important contributors to benthic habitat. While some initial results and observations are reported here, additional insights and results are anticipated during a current N.Y. Sea Grant program that will

One major observation of this study is that dredging of Jamaica Bay has had a long-term and detrimental impact on the bay. While this is not the first study to suggest such a conclusion, the evaluation of detailed bathymetric data has allowed us to demonstrate specific areas where sediment is being trapped by areas that have been dredged thus making it unlikely that the sediment being trapped could be used to build up marsh land. The long-term loss of sediment from marsh areas is thought to be one of the key factors in the decline of Jamaica Bay marshes.

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APPENDIX A

GIS Layers

The following list describes in general terms the GIS layers being provided as the results of the study. The horizontal coordinates of the files are either in UTM (meters, NAD 83 Zone 18N) for the maps or in decimal degrees for the station data. Bathymetry grids are provided as in ArcView .flt/.hdr format and images are provided in .tif/.tfw format. Depths are in meters and referenced to NAVD88.

Summary maps combining 2008 and 2009 bathymetry data:

- 2008 depths, 2009 depths and whaler depths combined into one 5-m grid.
- sun-illuminated image of above
- MLLW contour intervals in feet.

2009 sampling cruise:

- multibeam bathymetry gridded at 1 m
- sun illuminated bathymetry of above grid
- multibeam backscatter gridded at 1 m
- side-scan sonar backscatter gridded at 1 m
- shape file with station locations (maybe more than one)
- video files (appx 46 GB, try to reformat to smaller size)

2009 shallow-water mapping cruise:

- depths as xyz file
- single-beam depth gridded at 5 m
- side-scan sonar backscatter gridded at 5 m

2008 multibeam cruise:

- multibeam bathymetry gridded at 1 m
- sun illuminated bathymetry of above grid
- multibeam backscatter gridded at 1 m
- side-scan sonar backscatter gridded at 1 m

2003 multibeam cruise:

- multibeam bathymetry gridded at 1 m
- sun illuminated bathymetry of above grid
- multibeam backscatter gridded at 1 m

2000 multibeam cruise:

- multibeam bathymetry gridded at 1 m
- sun illuminated bathymetry of above grid
- multibeam backscatter gridded at 1 m

Table 1. Station Summary and Sediment Sample Descriptions

Survey Area	Station ID	Time (GMT)	Latitude	Longitude	Water Depth (NAVD88, m)	Visual Description of Grab Sample	Comments
JamaicaBay	JB09-01	06/17/2009 19:09	40.570288	-73.925688	9.1	muddy sand with mussel shells and tubes	
JamaicaBay	JB09-02	06/17/2009 18:37	40.571772	-73.926227	3.8	muddy sand with a lot of shells	
JamaicaBay	JB09-03	06/17/2009 17:56	40.572847	-73.927090	5.9	muddy sand with a lot of shells	
JamaicaBay	JB09-03a	06/17/2009 19:29	40.573120	-73.926288	9.0	mud with mussel shells and a lot of black tubes	
JamaicaBay	JB09-04	06/17/2009 16:52	40.574353	-73.927033	7.2	sandy with shells and some mud	
JamaicaBay	JB09-05	06/18/2009 15:00	40.567755	-73.923778	3.5	fine sand with shell (mussels) above black mud	
JamaicaBay	JB09-06	06/18/2009 15:45	40.566272	-73.919750	14.0	coarse sand, mussels, broken shell, lots of crabs, baby mussels and a clam	
JamaicaBay	JB09-07	06/18/2009 16:09	40.566132	-73.913892	10.4	sand with many large broken shells	
JamaicaBay	JB09-08	06/19/2009 14:33	40.574395	-73.919500	4.4	sand with many animals (amphipods, snails, thin worms, tiny crabs)	
JamaicaBay	JB09-09	06/19/2009 13:39	40.575205	-73.923753	8.4	sand, lots of hermit crabs	
JamaicaBay	JB09-10	06/18/2009 17:08	40.569470	-73.919747	6.4	sand with some mud and shell	
JamaicaBay	JB09-11	06/18/2009 16:37	40.567763	-73.917833	12.0	coarse sand with some blue shell, sand eel	
JamaicaBay	JB09-12	06/19/2009 15:57	40.574948	-73.904028	8.0	muddy sand with tubes	
JamaicaBay	JB09-13	06/19/2009 16:24	40.574168	-73.904688	5.1	muddy sand with many mussels	
JamaicaBay	JB09-14	06/19/2009 16:45	40.573837	-73.905745	8.0	muddy sand with tubes	
JamaicaBay	JB09-15	06/19/2009 17:13	40.573188	-73.907192	6.7	fine sand with mud and lots of shell	
JamaicaBay	JB09-16	06/18/2009 19:58	40.571647	-73.905685	9.4	medium fine sand	
JamaicaBay	JB09-17	06/18/2009 19:28	40.569198	-73.904232	9.6	medium sand	
JamaicaBay	JB09-18	06/18/2009 18:57	40.567890	-73.904863	11.8	medium sand	
JamaicaBay	JB09-19	06/18/2009 17:50	40.566417	-73.904447	7.7	medium sand	anchor dragged in strong current, started at 20 and dragged to 19, then returned to 20
JamaicaBay	JB09-20	06/18/2009 18:19	40.565717	-73.904673	6.6	medium sand	
JamaicaBay	JB09-21	06/19/2009 15:01	40.572710	-73.920825	8.3	muddy sand with many animals (amphipods, tiny crabs, scale worm)	
JamaicaBay	JB09-22	06/19/2009 14:09	40.576330	-73.923842	2.9	muddy sand, razor clam	
JamaicaBay	JB09-23	06/19/2009 17:31	40.573782	-73.908937	4.2	sand with mussels	
JamaicaBay	JB09-24	06/19/2009 17:57	40.572308	-73.908650	10.8	muddy sand, tiny moon snail, lots of animals and tubes	
JamaicaBay	JB09-25	06/19/2009 15:32	40.574710	-73.901305	5.8	muddy sand with mussels, lots of mud crabs, mud underneath sandy surface	
JamaicaBay	JB09-26	06/19/2009 18:23	40.572300	-73.914587	4.0	muddy sand	

JamaicaBay	JB09-27	06/25/2009 17:08	40.595943	-73.867402	4.9	muddy sand, crab in old clam shell, a few large shells (one buried)
JamaicaBay	JB09-28	06/25/2009 16:30	40.595805	-73.868890	7.4	sandy mud with black mud underneath, ulva, many animals
JamaicaBay	JB09-29	06/25/2009 16:05	40.596503	-73.870768	9.9	mud, big hermit crab (at least 5 cm), tubes
JamaicaBay	JB09-30	06/25/2009 15:42	40.594790	-73.870028	9.5	sandy mud, tubes, hermit crabs
JamaicaBay	JB09-31	06/25/2009 14:09	40.595868	-73.877960	12.6	sandy mud, lots of snails and a few amphipods
JamaicaBay	JB09-32	06/25/2009 13:41	40.602412	-73.873473	8.3	mussel shell over sand, some snails and crabs
JamaicaBay	JB09-33	06/25/2009 13:14	40.601452	-73.873478	11.3	sandy mud, caught two snails
JamaicaBay	JB09-34	06/24/2009 18:34	40.592157	-73.860578	4.9	sandy mud with hermit crabs and a few tubes
JamaicaBay	JB09-35	06/24/2009 18:56	40.592795	-73.862735	5.5	muddy sand
JamaicaBay	JB09-36	06/24/2009 20:57	40.589693	-73.871937	11.5	muddy sand with some shell and tubes
JamaicaBay	JB09-37	06/24/2009 20:17	40.598220	-73.867082	5.7	sand with a large burrow
JamaicaBay	JB09-38	06/25/2009 18:18	40.587097	-73.871800	7.4	sand with some shell
JamaicaBay	JB09-39	06/24/2009 19:20	40.592740	-73.865760	4.8	sandy mud
JamaicaBay	JB09-40	06/25/2009 14:38	40.593692	-73.875583	13.2	muddy sand (sand over mud), lots of snails
JamaicaBay	JB09-41	06/24/2009 17:51	40.591005	-73.857903	4.5	muddy sand
JamaicaBay	JB09-42	06/25/2009 17:34	40.591775	-73.868365	10.7	sandy mud
JamaicaBay	JB09-43	06/25/2009 17:55	40.591493	-73.870122	10.0	sandy mud
JamaicaBay	JB09-44	06/24/2009 13:13	40.587862	-73.861445	2.8	sand
JamaicaBay	JB09-45	06/24/2009 13:46	40.588325	-73.860022	2.3	sand
JamaicaBay	JB09-46	06/24/2009 14:08	40.586395	-73.857960	7.7	muddy sand, moon snail, hard clam, hermit crabs, snails, old tubes, stinky
JamaicaBay	JB09-47	06/24/2009 14:34	40.587438	-73.855403	3.4	muddy sand (shell and sand over mud)
JamaicaBay	JB09-48	06/24/2009 17:28	40.590305	-73.854203	4.8	muddy sand with flattened tubes, snail, hermit crab, small clam
JamaicaBay	JB09-49	06/24/2009 16:08	40.589163	-73.852055	5.0	muddy sand with shells
JamaicaBay	JB09-50	06/24/2009 18:12	40.591093	-73.861542	4.9	muddy sand with some tubes
JamaicaBay	JB09-51	06/24/2009 19:54	40.595262	-73.868133	8.0	sandy mud, ulva
JamaicaBay	JB09-52	06/24/2009 16:58	40.592692	-73.850298	5.8	muddy sand with clam, amphipods, scale worm, bloodworm, hermit crabs, tubes
JamaicaBay	JB09-53	06/24/2009 16:37	40.592805	-73.848992	7.3	sand with hermit crabs, polychetes, some shell pieces
JamaicaBay	JB09-54	06/24/2009 15:28	40.588125	-73.847720	5.1	sand with a little mud
JamaicaBay	JB09-55	06/24/2009 15:04	40.585917	-73.842230	5.1	muddy sand with a lot of shells
JamaicaBay	JB09-56	06/25/2009 18:35	40.586618	-73.872900	13.7	sand, live small bivalves, worms, some old shell

JamaicaBay	JB09-57	06/25/2009 17:06	40.585950	-73.874105	14.5	sand with live hard clam and bits of shell
JamaicaBay	JB09-58	06/25/2009 19:30	40.585232	-73.875292	15.8	sand with old shells, crabs, small red shrimps
JamaicaBay	JB09-59	06/30/2009 16:09	40.640940	-73.858675	9.4	sand, tubes
JamaicaBay	JB09-60	06/30/2009 15:46	40.640805	-73.859950	12.5	muddy sand, amphipod tubes, several hard clams
JamaicaBay	JB09-61	06/30/2009 14:26	40.620348	-73.840075	5.9	muddy sand, lots of ulva, gassy, marsh fibers
JamaicaBay	JB09-62	06/30/2009 14:00	40.619218	-73.838922	5.3	muddy sand
JamaicaBay	JB09-63	06/30/2009 13:39	40.619668	-73.843617	3.2	muddy sand, some shell, lots of snails and amphipod tubes, some ulva
JamaicaBay	JB09-64	06/30/2009 17:11	40.643777	-73.821470	10.5	muddy sand, amphipod tubes
JamaicaBay	JB09-65	06/30/2009 18:00	40.643202	-73.819978	9.4	sandy mud, two hard clams and one soft clam
JamaicaBay	JB09-66	06/26/2009 18:46	40.639188	-73.814553	10.9	soupy sandy mud
JamaicaBay	JB09-67	06/26/2009 17:58	40.638323	-73.812957	5.7	muddy sand, lots of amphipods and tubes, snails, hard clams, soft clam
JamaicaBay	JB09-68	06/26/2009 17:32	40.638898	-73.811397	7.3	sandy mud, amphipods, stringy material
JamaicaBay	JB09-69	06/26/2009 14:51	40.636293	-73.802355	10.1	sandy mud, live worm, buried shell
JamaicaBay	JB09-70	06/30/2009 18:15	40.643293	-73.817540	7.3	sandy mud, amphipod tubes
JamaicaBay	JB09-71	06/26/2009 19:05	40.635820	-73.816705	11.1	sandy mud, old black tubes, gassy, ulva on sides of grab
JamaicaBay	JB09-72	06/26/2009 18:23	40.639030	-73.813722	7.1	sandy mud, tubes, one shell
JamaicaBay	JB09-73	06/26/2009 19:28	40.634722	-73.812497	7.2	sandy mud, threads, stiffer
JamaicaBay	JB09-74	06/26/2009 19:48	40.633923	-73.814552	10.8	sandy mud
JamaicaBay	JB09-76	06/30/2009 18:44	40.625335	-73.810223	9.3	sandy mud, some ulva, tubes, live amphipods
JamaicaBay	JB09-77	06/26/2009 16:30	40.628375	-73.794530	8.6	sandy mud, some threads, piece of ulva
JamaicaBay	JB09-78	06/26/2009 16:08	40.627600	-73.793882	11.2	sandy mud, gas bubbles, threads
JamaicaBay	JB09-79	06/26/2009 15:44	40.634128	-73.802638	6.2	muddy sand, live clams, lots of snails, old shell
JamaicaBay	JB09-80	06/26/2009 17:02	40.635835	-73.806570	5.7	sandy mud, stiffer on top, with some amphipods, shells, snails, small bivalve
JamaicaBay	JB09-81	06/30/2009 16:50	40.643835	-73.827425	9.4	muddy sand with shells
JamaicaBay	JB09-82	06/30/2009 20:08	40.575458	-73.871577	13.3	sand and a concretion
JamaicaBay	JB09-83	06/26/2009 15:14	40.636375	-73.803378	11.3	sandy mud, gassy
JamaicaBay	JB09-84	06/30/2009 15:26	40.640252	-73.855585	2.5	muddy sand with amphipods, snails
JamaicaBay	JB09-85	06/30/2009 15:00	40.642637	-73.842180	3.7	sand over mud layers with many amphipod tubes, hermit crabs.
JamaicaBay	JB09-86	06/30/2009 19:48	40.577068	-73.866520	12.9	muddy sand (sand over mud)

Table 2. Bulk Sediment Parameters

Survey Area	Station ID	% Gravel	% Sand	% Mud (Silt+Clay)	% Sand 1-2 mm	% Sand < 1 mm	%Silt	%Clay	Water Content (% wet weight)	% Loss on Ignition (% dry weight)
JamaicaBay	JB09-01	9.7	53.4	36.9	0.5	53.0	15.9	21.0		
JamaicaBay	JB09-02	18.6	68.8	12.6	3.3	65.6	5.0	7.6		
JamaicaBay	JB09-03	51.6	42.1	6.3	0.1	42.0	2.4	3.9		
JamaicaBay	JB09-03a	23.1	6.1	70.8						
JamaicaBay	JB09-04	1.9	94.7	5.2	0.4	94.3	2.1	3.0		
JamaicaBay	JB09-05	19.1	72.0	8.9	3.9	68.2	3.3	5.6		
JamaicaBay	JB09-06	15.4	83.5	1.1	7.6	75.9	0.3	0.7		
JamaicaBay	JB09-07	19.5	75.8	4.8	1.8	74.0	1.6	3.2		
JamaicaBay	JB09-08	21.6	75.8	2.6	0.5	75.3	0.9	1.8		0.6
JamaicaBay	JB09-09	0.5	84.8	14.7	0.2	84.6	6.3	8.4		1.2
JamaicaBay	JB09-10	2.6	90.9	6.5	0.9	89.9	2.4	4.0		
JamaicaBay	JB09-11	2.1	97.0	0.9	5.6	91.4	0.3	0.6		
JamaicaBay	JB09-12	0.3	58.0	41.8	0.4	57.5	15.8	26.0	64.1	5.5
JamaicaBay	JB09-13	0.6	60.9	38.4	2.0	58.9	15.3	23.1	45.9	3.6
JamaicaBay	JB09-14	0.0	71.3	28.7	0.2	71.1	12.5	16.2	59.9	5.3
JamaicaBay	JB09-15	12.3	77.6	10.2	1.6	75.9	3.1	7.0		1.8
JamaicaBay	JB09-26	0.1	99.6	0.3	0.1	99.5	0.2	0.1		
JamaicaBay	JB09-17	14.6	81.8	3.6	0.3	81.5	1.3	2.2		
JamaicaBay	JB09-18	0.7	99.0	0.3	1.0	98.0	0.1	0.1		
JamaicaBay	JB09-19	0.0	99.5	0.4	0.0	99.5	0.2	0.3		
JamaicaBay	JB09-20	2.2	96.9	1.0	0.4	96.5	0.4	0.6		
JamaicaBay	JB09-21	1.0	77.8	21.1	0.2	77.6	7.9	13.2	46.9	3.8
JamaicaBay	JB09-22	0.0	84.2	15.8	0.0	84.2	8.1	7.7		1.1
JamaicaBay	JB09-23	0.1	99.4	0.5	0.2	99.3	0.2	0.3		0.3
JamaicaBay	JB09-24	0.0	90.2	9.8	0.0	90.2	4.0	5.8		4.1
JamaicaBay	JB09-25	0.0	65.5	34.5	2.6	62.9	13.9	20.6	45.8	4.1
JamaicaBay	JB09-26	0.0	99.9	0.1	99.7	0.1	0.1	0.1		0.3
JamaicaBay	JB09-27	3.4	86.3	10.3	0.0	86.3	5.8	4.5		1.9
JamaicaBay	JB09-28	0.0	42.0	58.0	0.0	42.0	28.4	29.6		
JamaicaBay	JB09-29	0.0	5.2	94.8	0.0	5.2	36.9	57.9	70.3	9.4
JamaicaBay	JB09-30	0.0	26.1	73.9	0.0	26.1	30.2	43.7	70.4	9.9
JamaicaBay	JB09-31	0.0	36.9	63.1	0.0	36.9	26.9	36.2	67.0	8.7
JamaicaBay	JB09-32	9.0	87.8	3.1	1.1	86.7	1.6	1.5		0.6
JamaicaBay	JB09-33	0.0	36.8	63.2	3.2	33.6	25.7	37.4	69.0	9.9
JamaicaBay	JB09-34	0.0	48.5	51.5	0.0	48.5	20.9	30.6	51.0	5.0
JamaicaBay	JB09-35	0.0	65.4	34.6	0.0	65.4	19.9	14.7	47.0	3.5
JamaicaBay	JB09-36	0.6	87.3	12.1	0.3	87.0	4.2	7.9		1.0
JamaicaBay	JB09-37	0.7	94.9	4.4	0.2	94.8	2.2	2.2		0.9
JamaicaBay	JB09-38	0.0	98.0	2.0	0.0	98.0	0.8	1.1		0.4
JamaicaBay	JB09-39	0.0	35.0	65.0	0.0	35.0	33.0	32.0	64.0	7.9
JamaicaBay	JB09-40	0.0	74.2	25.8	0.0	74.2	11.3	14.4	57.6	6.5
JamaicaBay	JB09-41	0.1	63.0	36.9	0.4	62.6	19.4	17.4	53.1	4.7
JamaicaBay	JB09-42	0.0	13.5	86.5	0.0	13.5	39.7	46.8	71.9	11.3
JamaicaBay	JB09-43	0.0	32.1	67.9	0.1	31.9	29.2	38.7	68.8	10.1
JamaicaBay	JB09-44	0.4	97.1	2.5	0.3	96.9	1.1	1.4		0.4
JamaicaBay	JB09-45	0.0	98.1	1.9	0.2	97.9	0.8	1.1		0.6
JamaicaBay	JB09-46	0.1	64.1	35.7	0.4	63.7	14.8	20.9	65.6	6.2
JamaicaBay	JB09-47	26.1	56.5	17.4	2.5	54.0	6.4	11.0		3.8

JamaicaBay	JB09-48	0.0	73.7	26.3	0.4	73.3	12.4	13.9	45.1	3.6
JamaicaBay	JB09-49	6.6	83.1	10.4	1.2	81.9	4.6	5.7		1.8
JamaicaBay	JB09-50	0.0	64.1	35.9	0.0	64.1	18.7	17.2	50.2	4.8
JamaicaBay	JB09-51	0.0	38.9	61.1	0.0	38.9	29.6	31.5	77.1	12.2
JamaicaBay	JB09-52	0.0	63.0	37.0	0.0	63.0	18.5	18.5	57.3	5.9
JamaicaBay	JB09-53	0.1	98.9	1.0	0.1	98.8	0.5	0.5		0.4
JamaicaBay	JB09-54	1.8	92.6	5.7	0.5	92.1	2.9	2.8		1.4
JamaicaBay	JB09-55	26.0	65.4	8.6	2.3	63.1	4.0	4.6		2.0
JamaicaBay	JB09-56	0.0	99.5	0.5	0.4	99.1	0.2	0.3		0.3
JamaicaBay	JB09-57	0.2	98.3	1.4	0.2	98.1	0.7	0.7		0.4
JamaicaBay	JB09-58	8.7	85.9	5.4	1.0	84.9	2.1	3.4		1.4
JamaicaBay	JB09-59	1.3	94.5	4.3	4.7	89.8	1.9	2.4		0.7
JamaicaBay	JB09-60	0.0	19.4	80.6	0.2	19.2	38.5	42.1	69.8	9.5
JamaicaBay	JB09-61	0.0	25.4	74.6	0.0	25.4	50.2	24.4	84.3	12.9
JamaicaBay	JB09-62	3.8	15.2	81.0	0.0	15.2	47.6	33.4	69.0	10.8
JamaicaBay	JB09-63	1.5	86.8	11.7	0.1	86.7	7.5	4.2		1.1
JamaicaBay	JB09-64	0.0	60.1	39.9	0.4	59.7	18.3	21.6	59.5	5.9
JamaicaBay	JB09-65	0.0	23.6	76.4	0.0	23.6	34.6	41.9	74.9	11.7
JamaicaBay	JB09-66	0.0	8.4	91.6	0.0	8.3	44.3	47.3	80.6	14.0
JamaicaBay	JB09-67	0.9	56.4	42.7	0.4	56.0	21.0	21.7	56.2	6.3
JamaicaBay	JB09-68	0.0	24.9	75.1	0.4	24.5	36.1	39.1	78.3	12.8
JamaicaBay	JB09-69	0.0	7.0	93.0	0.0	7.0	36.3	56.7	80.4	13.3
JamaicaBay	JB09-70	0.0	22.3	77.7	0.7	21.6	41.2	36.5	76.2	11.6
JamaicaBay	JB09-71	0.0	3.9	96.1	0.0	3.9	47.7	48.4	87.1	14.9
JamaicaBay	JB09-72	0.0	11.6	88.4	0.0	11.6	43.4	45.0	72.0	12.1
JamaicaBay	JB09-73	0.0	6.3	93.7	0.0	6.3	39.9	53.8	75.7	13.3
JamaicaBay	JB09-74	0.0	3.4	96.6	0.0	3.4	41.7	54.9	83.1	13.6
JamaicaBay	JB09-76	0.0	7.3	92.7	0.1	7.3	53.2	39.4	80.2	13.1
JamaicaBay	JB09-77	0.0	13.6	86.4	0.0	13.6	37.8	48.6	84.8	13.2
JamaicaBay	JB09-78	0.0	10.5	89.5	0.0	10.4	39.9	49.7	85.8	13.3
JamaicaBay	JB09-79	0.0	92.0	8.0	0.7	91.2	3.7	4.4		1.6
JamaicaBay	JB09-80	0.0	9.5	90.5	0.2	9.3	47.4	43.1	73.0	12.9
JamaicaBay	JB09-81	96.0	4.0	0.0	0.4	3.7	0.0	0.0		
JamaicaBay	JB09-82	2.6	96.9	0.4	1.7	95.2	0.1	0.3		0.2
JamaicaBay	JB09-83	0.0	3.8	96.2	0.2	3.6	33.3	63.0	89.3	15.4
JamaicaBay	JB09-84	1.3	88.1	10.6	1.6	86.5	6.7	3.9		0.9
JamaicaBay	JB09-85	4.8	92.6	2.6	2.6	90.0	0.8	1.8		0.5
JamaicaBay	JB09-86	2.6	75.1	22.3	3.2	71.9	8.2	14.1	43.2	2.4

Table 3. Grain-Size Parameters of the Sand and Mud Fraction Calculated for Sediment Finer Than 1 mm

Station ID	Median Size (phi)	Graphic Mean (phi)	Inclusive Graphic Standard Deviation (sorting)	Inclusive Graphic Skewness	Graphic Kurtosis	% Very Coarse and Medium Sand (-1 to 2 phi and sieved at 1 mm)	% Fine and Very Fine Sand (2 to 4 phi and sieved at 1 mm)	% Sand (gravel-free and sieved at 1 mm)	% Silt (gravel-free and sieved at 1 mm)	% Clay (gravel-free and sieved at 1 mm)	% Mud (silt + clay, gravel-free and sieved at 1 mm)
JB09-01	3.4	5.2	3.0	54.0	18.7	1.4	56.6	58.0	17.7	24.3	42.0
JB09-02	3.0	3.5	1.8	20.0	2.1	9.4	73.5	82.9	6.5	10.6	17.1
JB09-03	3.0	3.2	1.4	22.2	1.6	4.1	81.1	85.3	5.4	9.3	14.7
JB09-04	2.9	2.9	0.6	1.4	0.6	5.4	88.8	94.3	2.3	3.4	5.7
JB09-05	2.9	3.0	1.3	16.0	1.5	6.4	80.4	86.8	4.7	8.5	13.2
JB09-06	0.9	0.9	0.6	0.8	0.6	93.1	4.8	97.9	0.6	1.5	2.1
JB09-07	2.1	2.2	1.3	14.7	2.0	43.0	50.5	93.5	2.1	4.4	6.5
JB09-08	2.1	2.1	0.7	0.3	0.8	43.0	53.6	96.5	1.1	2.4	3.5
JB09-09	3.1	3.2	1.3	18.6	1.5	1.3	83.7	85.0	6.2	8.8	15.0
JB09-10	2.9	2.9	1.0	12.8	1.0	2.1	90.0	92.1	2.9	5.0	7.9
JB09-11	1.0	1.0	0.5	-0.1	0.4	96.2	2.6	98.8	0.4	0.8	1.2
JB09-12	3.5	5.6	3.5	67.9	23.0	2.0	55.3	57.3	15.9	26.9	42.7
JB09-13	3.3	4.9	3.1	53.1	20.9	3.3	55.6	58.8	16.0	25.2	41.2
JB09-14	3.2	4.8	2.7	49.7	9.9	1.7	68.4	70.1	12.8	17.1	29.9
JB09-15	3.0	3.0	1.4	16.2	1.8	10.0	77.6	87.7	3.6	8.7	12.4
JB09-16	1.8	1.8	0.4	0.1	0.2	78.4	21.0	99.4	0.3	0.3	0.6
JB09-17	1.8	1.8	0.6	0.8	0.6	70.9	24.8	95.7	1.5	2.8	4.3
JB09-18	1.3	1.3	0.4	-0.1	0.3	94.7	4.8	99.5	0.2	0.3	0.5
JB09-19	2.1	2.1	0.3	0.0	0.1	27.0	72.6	99.6	0.1	0.3	0.4
JB09-20	2.2	2.2	0.5	0.2	0.4	27.5	71.5	99.0	0.4	0.6	1.0
JB09-21	3.2	4.6	2.4	33.1	3.1	3.6	72.5	76.1	8.7	15.2	23.9
JB09-22	3.1	3.4	1.6	26.1	1.9	0.9	80.2	81.1	9.6	9.3	18.9
JB09-23	1.9	1.9	0.4	0.0	0.2	61.0	38.5	99.5	0.2	0.3	0.5
JB09-24	3.0	3.0	1.2	18.0	1.2	1.5	87.2	88.7	4.6	6.7	11.3
JB09-25	3.3	4.8	3.1	51.4	19.4	6.3	56.8	63.1	14.5	22.4	36.9
JB09-26	2.1	4.3	3.6	73.0	25.8	48.6	4.1	52.7	24.5	22.8	47.3
JB09-27	2.3	2.5	1.4	15.5	2.9	26.7	62.2	88.9	6.1	4.9	11.1
JB09-28	5.3	6.1	3.3	29.0	22.2	1.4	40.3	41.7	28.2	30.1	58.3
JB09-29	8.6	8.8	3.1	2.7	18.9	0.0	5.0	5.1	36.3	58.6	94.9
JB09-30	7.3	7.5	3.7	10.6	28.9	0.4	25.0	25.4	30.1	44.5	74.6
JB09-31	6.2	6.9	3.6	25.4	27.3	2.0	34.5	36.6	26.6	36.8	63.4
JB09-32	1.7	1.9	0.8	1.9	1.1	68.8	27.1	95.9	2.1	2.0	4.1
JB09-33	6.6	7.1	3.7	21.0	29.7	1.7	32.7	34.3	26.3	39.3	65.7
JB09-34	4.3	6.1	3.5	57.2	25.1	2.0	45.9	48.0	20.9	31.2	52.1
JB09-35	3.4	4.7	2.5	36.5	8.5	2.8	62.6	65.4	19.7	14.9	34.6
JB09-36	2.2	2.4	1.7	28.7	3.9	37.7	50.0	87.6	4.2	8.2	12.4
JB09-37	2.3	2.4	0.7	2.2	0.7	21.9	72.3	94.3	2.9	2.9	5.7
JB09-38	2.3	2.3	0.4	0.2	0.2	18.3	79.9	98.2	0.7	1.0	1.8
JB09-39	5.7	6.6	3.4	32.2	23.3	0.7	32.9	33.6	33.3	33.1	66.4
JB09-40	3.1	4.4	2.6	41.5	6.3	2.0	72.1	74.1	11.3	14.6	25.9
JB09-41	3.4	4.9	2.7	44.2	12.7	1.4	60.6	61.9	19.9	18.2	38.1
JB09-42	7.7	8.0	3.3	7.7	21.1	0.7	12.3	13.0	39.4	47.6	87.0
JB09-43	6.6	7.1	3.7	19.2	28.6	1.6	30.1	31.6	29.0	39.4	68.4
JB09-44	2.5	2.4	0.7	-0.2	1.0	27.0	70.4	97.4	1.1	1.5	2.6
JB09-45	2.2	2.2	0.6	0.4	0.5	36.0	62.1	98.1	0.8	1.1	1.9
JB09-46	3.3	5.2	3.3	63.0	18.7	4.0	59.0	63.0	15.1	21.9	37.0
JB09-47	3.1	4.5	3.1	51.7	7.9	10.5	63.2	73.7	9.5	16.8	26.3
JB09-48	3.3	4.6	2.8	47.7	6.9	4.2	67.1	71.3	13.4	15.3	28.7
JB09-49	2.9	2.9	1.3	15.1	1.9	5.5	83.3	88.8	4.9	6.3	11.2
JB09-50	3.6	5.1	2.9	48.9	12.2	2.6	59.6	62.3	19.4	18.3	37.7
JB09-51	5.5	6.5	3.5	35.2	24.5	1.9	34.7	36.5	30.4	33.1	63.5
JB09-52	3.3	4.9	3.0	54.0	13.9	1.2	61.8	63.0	18.3	18.7	37.0
JB09-53	2.2	2.2	0.4	0.4	0.2	24.8	73.6	98.4	0.7	0.8	1.6
JB09-54	2.8	2.8	0.9	5.3	1.3	5.3	86.9	92.2	3.9	3.9	7.8
JB09-55	2.8	2.8	1.6	18.4	3.1	16.7	69.0	85.7	6.6	7.7	14.3
JB09-56	1.6	1.6	0.5	0.1	0.3	82.1	17.3	99.4	0.2	0.3	0.6
JB09-57	2.0	2.1	0.5	1.1	0.4	46.3	50.0	96.3	1.9	1.8	3.7
JB09-58	2.8	2.7	1.1	8.6	1.4	9.8	83.5	93.3	2.5	4.2	6.7
JB09-59	1.9	1.8	1.0	0.7	1.7	56.6	38.6	95.2	2.1	2.7	4.8
JB09-60	7.4	7.6	3.7	6.1	24.7	4.3	13.5	17.8	38.7	43.5	82.2
JB09-61	5.4	6.1	2.7	20.8	13.7	0.9	24.0	24.9	50.0	25.1	75.1

JB09-62	6.5	7.1	3.1	18.9	17.7	1.4	13.9	15.3	49.2	35.4	84.7
JB09-63	2.7	3.0	1.6	21.2	3.2	9.8	72.9	82.7	11.1	6.2	17.3
JB09-64	3.2	5.0	3.6	62.9	22.5	13.7	45.5	59.3	18.5	22.2	40.7
JB09-65	7.2	7.4	3.8	6.3	26.7	5.8	16.5	22.3	34.7	43.1	77.7
JB09-66	7.8	8.0	3.0	7.4	16.6	0.9	6.5	7.4	44.3	48.3	92.6
JB09-67	3.6	5.2	3.5	55.5	21.3	11.4	45.0	56.3	21.2	22.5	43.7
JB09-68	7.4	7.5	3.5	5.4	23.7	1.2	20.2	21.5	37.1	41.5	78.5
JB09-69	8.5	8.9	3.1	1.7	19.1	3.6	3.1	6.7	35.8	57.5	93.3
JB09-70	6.7	6.9	3.4	8.7	22.2	5.4	15.9	21.3	41.2	37.5	78.7
JB09-71	7.9	8.1	2.6	8.8	13.3	1.0	2.0	3.0	47.5	49.5	97.0
JB09-72	7.6	8.0	3.3	11.4	20.7	1.4	9.5	10.9	43.3	45.7	89.1
JB09-73	8.4	8.7	3.3	5.8	22.5	1.1	4.9	6.0	39.5	54.5	94.0
JB09-74	8.4	8.8	2.9	9.0	16.8	0.5	2.8	3.3	41.2	55.5	96.7
JB09-76	7.5	7.9	3.0	12.5	16.3	0.9	5.9	6.9	52.8	40.4	93.2
JB09-77	7.9	8.2	3.3	7.1	21.4	1.0	11.8	12.8	37.6	49.5	87.2
JB09-78	8.0	8.4	3.2	6.8	20.2	0.5	8.9	9.4	40.0	50.6	90.6
JB09-79	2.9	2.9	1.0	10.9	1.1	3.0	88.3	91.3	3.9	4.8	8.7
JB09-80	7.5	7.7	2.9	6.1	16.1	2.5	6.1	8.6	47.2	44.2	91.4
JB09-81	2.6	2.6	0.9	0.3	1.4	22.2	70.2	92.4	5.6	2.0	7.6
JB09-82	1.7	1.6	0.5	-0.3	0.4	78.7	20.8	99.6	0.1	0.3	0.4
JB09-83	9.4	9.4	2.9	-0.5	17.3	0.8	2.4	3.2	33.0	63.8	96.8
JB09-84	2.8	2.8	1.3	8.1	2.4	17.4	71.3	88.7	7.1	4.2	11.3
JB09-85	1.6	1.6	0.7	1.5	0.8	78.9	18.1	97.0	0.9	2.1	3.0
JB09-86	2.9	4.4	3.0	55.0	6.8	8.4	66.3	74.7	9.2	16.1	25.3

Notes:

Results for samples sieved at 1.0 mm

Graphic grain-size statistics calculated following Folk and Ward, 1957

Table 4. Grain-Size Percentages by Phi Interval for Sediment Samples Sieved at 1 mm

Station ID	Phi Size	-1	-0.5	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	>11
JB09-01	0.00	0.00	0.01	0.02	0.13	0.38	0.88	1.92	19.82	28.46	6.38	1.53	1.29	1.58	1.68	2.72	2.16	3.53	3.17	3.45	2.83	2.55	2.69	2.63	2.06	8.12	
JB09-02	0.00	0.00	0.00	0.00	0.38	2.79	6.24	10.44	34.73	24.76	3.57	0.68	0.22	0.51	0.68	0.47	0.87	1.25	1.85	2.85	2.38	1.34	0.97	0.65	0.73	1.65	
JB09-03	0.00	0.23	0.25	0.33	0.66	0.44	2.23	4.38	38.04	32.77	5.96	0.87	0.29	0.51	0.38	0.62	0.61	0.93	1.17	1.57	1.48	0.91	0.80	0.92	0.62	3.04	
JB09-04	0.00	0.10	0.26	0.34	0.08	0.90	3.76	11.26	47.67	26.38	3.52	0.59	0.21	0.16	0.21	0.19	0.13	0.31	0.51	0.68	0.47	0.25	0.21	0.21	0.21	1.39	
JB09-05	0.00	0.13	0.09	0.00	0.21	1.88	4.08	8.89	46.88	21.31	3.34	0.86	0.14	0.13	0.24	0.26	0.41	0.84	1.81	2.73	2.08	1.13	0.58	0.33	0.30	1.36	
JB09-06	0.00	0.15	3.05	17.62	38.07	27.97	6.19	2.82	1.92	0.10	0.00	0.01	0.03	0.04	0.07	0.09	0.07	0.09	0.24	0.28	0.28	0.18	0.12	0.09	0.08	0.41	
JB09-07	0.00	0.00	0.00	0.16	1.81	8.43	32.64	29.74	13.32	5.91	1.52	0.20	0.07	0.15	0.21	0.26	0.23	0.27	0.73	0.84	0.87	0.55	0.36	0.27	0.25	1.22	
JB09-08	0.00	0.00	0.00	0.41	4.61	15.43	22.53	34.66	11.08	6.40	1.43	0.06	0.04	0.08	0.11	0.14	0.13	0.14	0.40	0.46	0.47	0.29	0.20	0.14	0.14	0.66	
JB09-09	0.00	0.00	0.00	0.12	0.21	0.35	0.64	3.59	32.20	40.83	7.11	0.97	0.61	0.63	0.59	0.60	0.55	0.82	1.43	1.76	1.45	0.95	0.68	0.65	0.57	2.71	
JB09-10	0.00	0.00	0.00	0.04	0.18	0.34	1.56	9.26	54.87	22.57	3.29	0.62	0.17	0.26	0.21	0.24	0.20	0.37	0.82	1.11	0.85	0.49	0.36	0.27	0.30	1.63	
JB09-11	0.00	0.00	2.04	14.11	33.83	41.10	5.12	1.50	0.02	0.42	0.71	0.00	0.02	0.04	0.04	0.04	0.03	0.06	0.13	0.18	0.13	0.08	0.06	0.04	0.05	0.26	
JB09-12	0.00	0.00	0.00	0.00	0.11	0.39	1.47	6.22	15.15	27.06	6.87	1.76	1.43	1.56	1.49	1.93	2.57	2.61	2.56	2.50	1.98	2.21	2.07	1.90	2.07	14.14	
JB09-13	0.00	0.00	0.06	0.07	0.16	0.52	2.47	11.94	18.59	20.59	4.44	1.37	0.90	1.39	1.68	1.79	1.99	3.08	3.74	4.81	4.32	2.75	1.93	1.85	1.61	7.94	
JB09-14	0.00	0.15	0.07	0.00	0.12	0.53	0.85	2.40	22.52	36.40	7.08	2.10	1.42	1.12	1.40	1.55	1.83	1.79	1.61	2.06	1.32	1.48	1.74	1.58	1.46	7.42	
JB09-15	0.00	0.00	0.26	0.53	0.67	2.69	5.88	6.55	32.33	34.31	4.43	0.15	0.23	0.26	0.23	0.36	0.44	0.71	1.26	1.94	2.02	1.37	0.86	0.58	0.46	1.48	
JB09-16	0.00	0.03	0.11	0.61	2.57	18.20	56.89	16.66	2.40	1.10	0.82	0.16	0.00	0.01	0.01	0.02	0.02	0.03	0.07	0.12	0.08	0.04	0.03	0.01	0.02	0.00	
JB09-17	0.00	0.02	0.17	2.19	6.21	17.20	45.14	17.12	4.55	3.09	0.00	0.00	0.00	0.09	0.11	0.15	0.17	0.34	0.67	1.05	0.80	0.34	0.25	0.17	0.14	0.05	
JB09-18	0.00	0.06	0.63	3.31	15.96	49.05	25.67	4.58	0.24	0.00	0.02	0.09	0.00	0.00	0.01	0.02	0.01	0.03	0.07	0.09	0.08	0.03	0.02	0.02	0.01	0.00	
JB09-19	0.00	0.06	0.06	0.34	0.33	0.61	25.65	63.49	9.07	0.00	0.00	0.00	0.01	0.00	0.02	0.02	0.01	0.03	0.04	0.05	0.06	0.04	0.03	0.02	0.02	0.05	
JB09-20	0.00	0.00	0.00	0.25	1.19	5.16	20.86	49.96	14.53	5.16	1.89	0.04	0.06	0.05	0.04	0.03	0.04	0.05	0.08	0.09	0.08	0.06	0.04	0.06	0.05	0.24	
JB09-21	0.00	0.00	0.05	0.18	0.44	0.85	2.07	4.28	21.73	36.44	10.05	1.22	0.30	0.50	0.94	0.94	0.80	1.72	2.31	2.96	2.96	2.31	1.64	1.29	0.97	3.08	
JB09-22	0.00	0.00	0.00	0.00	0.08	0.41	0.42	4.19	32.67	38.70	4.64	3.30	1.67	0.85	0.63	0.72	0.60	0.93	0.88	1.31	1.08	0.84	0.72	0.62	0.70	4.05	
JB09-23	0.00	0.02	0.01	0.09	0.89	11.43	48.51	33.70	2.88	1.31	0.62	0.02	0.05	0.02	0.02	0.02	0.01	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.11	
JB09-24	0.00	0.01	0.01	0.03	0.48	0.97	4.77	47.02	31.95	3.43	1.08	0.58	0.40	0.48	0.38	0.46	0.51	0.69	0.91	0.77	0.63	0.55	0.54	0.50	2.82		
JB09-25	0.00	0.00	0.00	0.06	0.37	0.85	5.01	10.79	17.56	22.06	6.37	1.69	0.85	1.14	1.29	1.93	1.92	2.61	3.06	3.88	3.30	2.30	2.19	1.87	1.54	7.38	
JB09-26	0.00	0.14	0.28	0.29	1.32	15.87	30.71	2.60	0.69	0.41	0.38	3.46	4.78	4.00	3.33	2.28	2.33	2.07	2.31	2.56	2.48	2.38	2.58	2.72	2.33	7.71	
JB09-27	0.00	0.00	0.00	0.24	0.72	4.50	21.26	30.45	15.19	12.43	4.15	1.58	1.03	0.87	0.73	0.49	0.51	0.45	0.50	0.55	0.54	0.52	0.56	0.59	0.51	1.67	
JB09-28	0.00	0.00	0.00	0.00	0.00	0.21	1.18	3.76	11.63	18.87	6.05	3.34	2.73	2.89	4.20	3.76	3.39	4.28	3.59	3.74	3.81	3.05	3.16	3.38	2.79	10.19	
JB09-29	0.00	0.00	0.01	0.01	0.00	0.01	0.33	1.26	2.43	1.02	3.36	3.54	1.56	4.46	4.60	4.52	5.92	6.07	4.82	6.52	5.77	4.16	4.42	4.38	4.59	28.79	
JB09-30	0.00	0.00	0.02	0.05	0.02	0.01	0.27	1.89	5.76	12.22	5.16	3.31	3.48	3.13	3.41	3.88	4.07	4.79	4.02	3.60	4.30	3.28	3.12	3.59	3.63	23.01	
JB09-31	0.00	0.04	0.15	0.17	0.10	0.04	1.55	1.57	8.24	18.33	6.38	2.41	2.59	3.10	3.43	3.38	3.41	4.31	4.02	3.62	3.61	3.11	2.83	3.05	2.84	17.77	
JB09-32	0.00	0.00	0.10	2.58	8.13	23.71	34.24	11.27	9.06	4.93	1.85	0.62	0.24	0.17	0.19	0.17	0.16	0.26	0.29	0.32	0.28	0.20	0.23	0.19	0.16	0.66	
JB09-33	0.00	0.00	0.09	0.33	0.08	0.43	0.74	1.95	8.96	16.22	5.53	2.38	2.68	2.91	2.85	3.90	3.60	3.69	4.35	3.60	2.85	3.06	3.43	2.79	3.07	20.55	
JB09-34	0.00	0.03	0.09	0.15	0.25	0.55	0.95	1.98	8.17	25.21	10.57	2.97	2.31	2.46	2.60	2.57	2.21	2.87	2.86	2.54	2.55	2.54	2.44	2.64	2.73	15.76	
JB09-35	0.00	0.08	0.24	0.33	0.30	0.29	1.58	4.39	13.37	33.75	11.10	3.70	2.99	2.80	2.29	1.79	1.79	1.75	2.56	1.69	1.95	1.46	1.60	1.88	1.45	4.87	
JB09-36	0.00	0.08	0.21	0.64	2.27	8.07	26.39	27.88	11.79	7.81	2.47	0.39	0.32	0.44	0.49	0.55	0.55	0.61	0.87	1.11	0.94	0.76	0.60	0.59	0.60	3.59	
JB09-37	0.00	0.12	0.21	0.16	0.47	2.59	18.37	45.52	17.41	7.28	2.14	0.78	0.32	0.33	0.29	0.28	0.24	0.29	0.33	0.24	0.25	0.25	0.26	0.29	0.26	1.31	
JB09-38	0.00	0.00	0.00	0.00	0.10	1.82	16.38	55.69	19.68	3.90	0.66	0.01	0.12	0.11	0.10	0.10	0.09	0.10	0.12	0.08	0.09	0.09	0.09	0.10	0.10	0.46	
JB09-39	0.00	0.02	0.00	0.01	0.12	0.13	0.40	1.52	5.10	15.64	10.63	5.19	4.96	4.32	4.19	3.47	3.55	3.91	3.73	3.80	3.10	2.56	3.26	2.94	2.69	14.74	
JB09-40	0.00	0.00	0.00	0.02	0.01	0.61	1.37	7.96	31.19	27.59	5.35	0.70	1.05	1.19	1.38	1.35	1.64	2.04	1.92	1.56	1.79	1.44	1.33	1.44	1.06	5.22	
JB09-41	0.00	0.00	0.09	0.16	0.24	0.36	0.53	3.50	17.37	30.54	9.15	3.19	2.82	2.31	2.16	2.35	1.97	2.35	2.71	2.07	2.05	1.70	2.22	2.18	1.78	6.20	
JB09-42	0.00	0.04	0.08	0.08	0.18	0.21	0.14	0.49	1.98	6.03	3.83	3.08	3.99	5.20	4.92	5.54	5.79	5.54	5.35	5.23	5.06	3.83	3.89	3.94	3.86	21.78	
JB09-43	0.00	0.00	0.00	0.08	0.11	0.42	0.94	3.30	6.57	14.63	5.56	2.74	3.13	3.70	3.70	3.89	3.90	3.59	4.36	4.16	3.53	3.34	2.99	2.99	3.08	19.28	
JB09-44	0.00	0.23	0.54	0.59	1.30	7.10	17.27	24.71	23.43	19.26	3.01	0.13	0.12	0.13	0.14	0.15	0.14	0.14	0.16	0.16	0.13	0.13	0.11	0.11	0.12	0.72	
JB09-45	0.00	0.00	0.00	0.00	0.95	7.08	28.00	37.21	16.17	7.40	1.30	0.07	0.08	0.11	0.10	0.11	0.11	0.10	0.12	0.12	0.09	0.10	0.08	0.08	0.09	0.54	
JB09-46	0.00	0.03	0.12	0.40	0.53	1.53	1.42	4.12	20.58	27.87	6.44	2.07	1.61	1.57	1.80	1.56	1.75	2.28	2.42	2.04	1.62	1.61	1.81	1.69	1.57	11.56	
JB09-47	0.00	0.16	0.34	0.40	0.92	3.00	5.65	14.24	19.72	23.12	6.12	1.54	0.60	0.78	1.09	1.36	0.89	1.38	1.87	2.39	1.99	1.36	1.11	0.89	1.08	8.00	
JB09-48	0.00	0.17	0.37	0.48	0.90	0.72	1.52	6.78	18.84	32.02	9.47	3.24	1.67	1.54	1.21	1.35	1.62	1.53	1.26	1.43	1.58	1.16	0.89	1.05	1		

Table 5. Cumulative Grain-Size Percentages by Phi Interval for Sediment Samples Sieved at 1 mm

Station ID	Phi Size																	10.5	11	>11
	-1	-0.5	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7			
JB09-01	0.00	0.00	0.01	0.03	0.16	0.54	1.42	3.33	23.15	51.62	58.00	59.53	60.81	62.39	64.07	66.79	68.95	72.49	75.66	79.11
JB09-02	0.00	0.00	0.00	0.00	0.38	3.17	9.41	19.85	54.59	79.35	82.92	83.60	83.82	84.32	85.00	85.47	86.34	87.58	89.44	92.29
JB09-03	0.00	0.23	0.48	0.81	1.47	1.91	4.14	8.52	46.56	79.32	85.28	86.15	86.44	86.95	87.33	87.95	88.56	89.49	90.66	92.23
JB09-04	0.00	0.10	0.36	0.70	0.78	1.68	5.44	16.70	64.37	90.76	94.27	94.86	95.07	95.23	95.44	95.63	95.76	96.07	96.58	97.26
JB09-05	0.00	0.13	0.22	0.22	0.43	2.31	6.39	15.29	62.17	83.48	86.81	87.67	87.81	87.94	88.18	88.44	88.85	89.68	91.49	94.22
JB09-06	0.00	0.15	3.21	20.83	58.90	86.87	93.06	95.88	97.80	97.90	97.90	97.91	97.94	97.98	98.05	98.14	98.21	98.31	98.55	98.83
JB09-07	0.00	0.00	0.00	0.16	1.97	10.40	43.04	72.78	86.10	92.01	93.53	93.72	93.79	93.94	94.15	94.41	94.64	94.91	95.64	96.48
JB09-08	0.00	0.00	0.00	0.41	5.02	20.45	42.98	77.63	88.72	95.12	96.55	96.61	96.65	96.73	96.84	96.98	97.11	97.25	97.65	98.10
JB09-09	0.00	0.00	0.00	0.12	0.33	0.68	1.32	4.90	37.11	77.93	85.05	86.02	86.62	87.25	87.84	88.44	88.99	89.81	91.24	93.00
JB09-10	0.00	0.00	0.00	0.04	0.22	0.56	2.12	11.38	66.25	88.82	92.11	92.73	92.90	93.16	93.37	93.61	93.80	94.17	94.99	96.10
JB09-11	0.00	0.00	2.04	16.14	49.97	91.07	96.20	97.69	97.71	98.13	98.84	98.84	98.86	98.90	98.94	98.98	99.01	99.07	99.20	99.38
JB09-12	0.00	0.00	0.00	0.00	0.11	0.50	1.97	8.19	23.34	50.40	57.27	59.02	60.45	62.01	63.50	65.42	67.99	70.59	73.15	75.64
JB09-13	0.00	0.00	0.06	0.13	0.29	0.81	3.28	15.21	33.80	54.39	58.83	60.21	61.11	62.50	64.18	65.98	67.97	71.05	74.79	79.60
JB09-14	0.00	0.15	0.22	0.22	0.34	0.86	1.72	4.12	26.64	63.04	70.12	72.22	73.64	74.76	76.16	77.71	79.54	81.33	82.94	85.00
JB09-15	0.00	0.00	0.26	0.79	1.46	4.15	10.03	16.58	48.91	83.22	87.65	87.80	88.03	88.29	88.52	88.88	89.32	90.03	91.29	93.23
JB09-16	0.00	0.03	0.14	0.75	3.31	21.52	78.40	95.07	97.46	98.56	99.38	99.54	99.54	99.55	99.56	99.58	99.60	99.63	99.70	99.82
JB09-17	0.00	0.02	0.19	2.38	8.58	25.78	70.92	88.04	92.59	95.67	95.67	95.67	95.67	95.67	95.67	95.67	95.67	95.67	95.67	95.67
JB09-18	0.00	0.06	0.69	4.00	19.95	69.00	94.67	99.25	99.50	99.50	99.52	99.61	99.61	99.61	99.62	99.64	99.65	99.68	99.75	99.84
JB09-19	0.00	0.06	0.12	0.46	0.79	1.40	27.05	90.53	99.60	99.60	99.60	99.60	99.61	99.61	99.63	99.65	99.66	99.69	99.73	99.78
JB09-20	0.00	0.00	0.00	0.25	1.44	6.59	27.46	77.42	91.95	97.10	98.99	99.03	99.09	99.14	99.18	99.21	99.25	99.30	99.38	99.47
JB09-21	0.00	0.00	0.05	0.23	0.67	1.52	3.58	7.86	29.59	66.03	76.08	77.30	77.59	78.09	79.03	79.97	80.77	82.49	84.79	87.75
JB09-22	0.00	0.00	0.00	0.00	0.08	0.49	0.91	5.10	37.76	76.47	81.11	84.41	86.08	86.93	87.55	88.27	88.87	89.80	90.68	91.99
JB09-23	0.00	0.00	0.02	0.21	1.10	12.53	61.03	94.74	97.62	98.93	99.54	99.56	99.61	99.63	99.65	99.67	99.68	99.71	99.74	99.77
JB09-24	0.00	0.00	0.01	0.02	0.05	0.53	1.50	6.28	53.30	85.25	88.68	89.76	90.34	90.75	91.23	91.61	92.07	92.58	93.27	94.18
JB09-25	0.00	0.00	0.00	0.06	0.43	1.28	6.29	17.08	34.65	56.70	63.08	64.77	65.61	66.75	68.04	69.97	71.89	74.50	77.55	81.43
JB09-26	0.00	0.14	0.42	0.72	2.04	17.90	48.61	51.21	51.90	52.31	52.70	56.15	60.03	64.93	68.26	70.54	72.87	74.93	77.24	79.80
JB09-27	0.00	0.00	0.00	0.24	0.96	5.45	26.72	57.17	72.36	84.78	88.93	90.51	91.53	92.40	93.13	93.62	94.13	94.58	95.07	95.62
JB09-28	0.00	0.00	0.00	0.00	0.00	0.21	1.39	5.15	16.79	35.66	41.71	45.05	47.77	50.66	54.86	58.63	62.01	66.30	69.89	73.64
JB09-29	0.00	0.00	0.01	0.02	0.02	0.03	0.04	0.37	1.63	4.06	5.08	7.44	10.99	15.44	20.04	24.56	30.48	36.56	41.38	47.90
JB09-30	0.00	0.00	0.02	0.07	0.09	0.10	0.37	2.26	8.02	20.24	25.39	28.70	32.18	35.31	38.72	42.60	46.67	51.46	55.48	59.08
JB09-31	0.00	0.04	0.19	0.36	0.46	0.50	2.05	3.62	11.86	30.19	36.57	38.98	41.56	44.66	48.09	51.46	54.87	59.17	63.19	66.81
JB09-32	0.00	0.00	0.10	2.68	10.81	34.51	68.76	80.02	89.08	94.01	95.86	96.48	96.72	96.89	97.08	97.25	97.41	97.67	97.96	98.28
JB09-33	0.00	0.00	0.09	0.42	0.50	0.93	1.67	3.62	12.58	28.80	34.33	36.70	39.38	42.29	45.14	49.04	52.63	56.32	60.67	64.27
JB09-34	0.00	0.03	0.12	0.27	0.52	1.07	2.02	4.00	12.17	37.38	47.95	50.92	53.23	55.69	58.29	60.86	63.07	65.94	68.80	71.34
JB09-35	0.00	0.08	0.32	0.65	0.95	1.24	2.82	7.21	20.58	54.33	65.43	69.13	72.12	74.92	77.21	79.00	80.79	82.54	85.10	86.79
JB09-36	0.00	0.08	0.29	0.93	3.20	11.27	37.66	65.54	77.33	85.15	87.62	88.01	88.33	88.77	89.25	89.80	90.35	90.96	91.83	92.93
JB09-37	0.00	0.12	0.33	0.49	0.96	3.55	21.92	67.44	84.84	92.12	94.26	95.04	95.37	95.70	95.99	96.27	96.51	96.80	97.13	97.37
JB09-38	0.00	0.00	0.00	0.00	0.10	1.92	18.31	74.00	93.69	97.59	98.24	98.25	98.37	98.48	98.58	98.68	98.77	98.87	98.99	99.07
JB09-39	0.00	0.02	0.02	0.03	0.15	0.28	0.68	2.20	7.30	22.94	33.58	38.77	43.73	48.05	52.25	55.72	59.28	63.19	66.92	70.73
JB09-40	0.00	0.00	0.00	0.02	0.03	0.64	2.01	9.96	41.15	68.74	74.10	74.79	75.84	77.04	78.42	79.77	81.41	83.44	85.36	86.92
JB09-41	0.00	0.00	0.09	0.25	0.49	0.85	1.38	4.88	22.25	52.79	61.94	65.13	67.95	70.26	72.42	74.77	76.74	79.09	81.80	83.87
JB09-42	0.00	0.04	0.12	0.20	0.38	0.59	0.73	1.22	3.20	9.22	13.05	16.13	20.11	25.31	30.23	35.76	41.55	47.08	52.43	57.65
JB09-43	0.00	0.00	0.00	0.08	0.19	0.61	1.56	4.86	11.43	26.06	31.62	34.36	37.50	41.19	44.89	48.77	52.67	56.26	60.61	64.77
JB09-44	0.00	0.23	0.77	1.35	2.66	9.75	27.02	51.73	75.16	94.42	97.42	97.56	97.67	97.80	97.94	98.09	98.23	98.37	98.53	98.69
JB09-45	0.00	0.00	0.00	0.00	0.95	8.03	36.03	73.24	89.41	96.81	98.11	98.18	98.26	98.37	98.47	98.58	98.69	98.79	98.91	99.03
JB09-46	0.00	0.03	0.15	0.55	1.08	2.61	4.03	8.15	28.73	56.60	63.04	65.11	66.72	68.29	70.09	71.65	73.40	75.68	78.10	80.14
JB09-47	0.00	0.16	0.50	0.90	1.82	4.82	10.47	24.71	44.43	67.55	73.67	75.21	75.81	76.59	77.68	79.04	79.93	81.31	83.18	85.57
JB09-48	0.00	0.17	0.54	1.02	1.92	2.64	4.16	10.94	29.78	61.80	71.27	74.51	76.18	77.72	78.93	80.28	81.90	83.43	84.69	86.12
JB09-49	0.00	0.17	0.57	1.07	1.52	1.67	5.46	25.00	59.23	84.33	88.77	89.32	89.99	90.57	91.08	91.39	91.90	92.54	93.67	95.02
JB09-50	0.00	0.08	0.23	0.57	1.17	1.80	2.63	5.14	14.82	47.03	62.27	66.55	69.14	71.48	73.55	75.96	77.57	79.52	81.68	83.38
JB09-51	0.00	0.07	0.25	0.41	0.50	0.73	1.88	3.02	11.22	29.67	36.55	40.64	45.22	49.65	53.30	56.84	59.88	63.39	66.93	70.61
JB09-52	0.00	0.08	0.10	0.11	0.11	0.17	1.22	9.99	34.09	55.45	63.03	66.25	69.04	71.68	74.07	75.70	77.62	79.56	81.35	82.98
JB09-53	0.00	0.00	0.01	0.26	0.88	2.47	24.80	82.16	93.38	96.87	98.40	98.82	98.85	98.89	98.91	98.96	99.02	99.08	99.15	99.22
JB09-54	0.00	0.13	0.35	0.53	0.55	0.97	5.32	30.56	64.96	87.30	92.23	93.73	94.22	94.58	94.89	95.19	95.50	95.79	96.12	96.43
JB09-55	0.00	0.02	0.04	0.43	1.89	7.28	16.75	35.63	63.62	80.84	85.70	87.31	88.13	88.70	89.33	89.84	90.33	91.16	92.26	93.62
JB09-56	0.00	0.01	0.09	1.35	7.30	35.58	82.08	94.63	98.13	99.14	99.43	99.59	99.59	99.54	99.56	99.58	99.60	99.62	99.67	99.73
JB09-57	0.00	0.03	0.19	0.55	1.62	6.43	46.32	83.23	92.46	94.52	96.35	97.31	97.42	97.52	97.63	97.73	97.85	97.96	98.21	98.55

Table 6. Bottom Video File Summary

Station	Latitude	Longitude	Video Time Start (GMT)	Video Time End (GMT)	Video File Name	General Description
1	40.570367	-73.925637	6/17/2009 19:03	6/17/2009 19:08	Sta_01_VTS_04_1.VOB	
2	40.571761	-73.926240	6/17/2009 18:32	6/17/2009 18:36	Sta_02_VTS_03_1.VOB	
3	40.572870	-73.927100	6/17/2009 17:41	6/17/2009 17:47	Sta_03_VTS_02_1.VOB	
3a	40.572923	-73.925917	6/17/2009 19:21	6/17/2009 19:27	Sta_03a_VTS_05_1.VOB	
4	40.574320	-73.927060	6/17/2009 16:58	6/17/2009 17:11	Sta_04_VTS_01_1.VOB	
5	40.567760	-73.923790	6/18/2009 14:39	6/18/2009 14:43	Sta_05-1_VTS_01_1.VOB	
5	40.567760	-73.923790	6/18/2009 15:04	6/18/2009 15:08	Sta_05-2_VTS_02_1.VOB	
6	40.566230	-73.919710	6/18/2009 15:21	6/18/2009 15:34	Sta_06_VTS_03_1.VOB	
7	40.566150	-73.913900	6/18/2009 16:04	6/18/2009 16:08	Sta_07_VTS_04_1.VOB	
8	40.574414	-73.919499	6/19/2009 14:25	6/19/2009 14:31	Sta_08_VTS_03_1.VOB	
9	40.575265	-73.923771	6/19/2009 13:21	6/19/2009 13:34	Sta_09_VTS_01_1.VOB	
10	40.569470	-73.919750	6/18/2009 17:02	6/18/2009 17:06	Sta_10_VTS_06_1.VOB	
11	40.567800	-73.917690	6/18/2009 16:32	6/18/2009 16:36	Sta_11_VTS_05_1.VOB	
12	40.574939	-73.903768	6/19/2009 15:45	6/19/2009 15:50	Sta_12_VTS_06_1.VOB	
13	40.574182	-73.904688	6/19/2009 16:12	6/19/2009 16:20	Sta_13_VTS_07_1.VOB	
14	40.573865	-73.905770	6/19/2009 16:35	6/19/2009 16:42	Sta_14_VTS_01_1.VOB	
15	40.573124	-73.907170	6/19/2009 17:01	6/19/2009 17:07	Sta_15_VTS_02_1.VOB	
16	40.571642	-73.905733	6/18/2009 19:46	6/18/2009 19:54	Sta_16_VTS_03_1.VOB	
17	40.569152	-73.904150	6/18/2009 19:15	6/18/2009 19:26	Sta_17_VTS_02_1.VOB	
18	40.567845	-73.904805	6/18/2009 18:40	6/18/2009 18:48	Sta_18_VTS_01_1.VOB	
19	40.566410	-73.904410	6/18/2009 17:35	6/18/2009 17:48	Sta_19_VTS_07_1.VOB	
20	40.565720	-73.904740	6/18/2009 18:08	6/18/2009 18:13	Sta_20_VTS_08_1.VOB	
21	40.572709	-73.920842	6/19/2009 14:49	6/19/2009 14:56	Sta_21_VTS_04_1.VOB	
22	40.576237	-73.923804	6/19/2009 14:00	6/19/2009 14:06	Sta_22_VTS_02_1.VOB	
23	40.573763	-73.908936	6/19/2009 17:23	6/19/2009 17:29	Sta_23_VTS_03_1.VOB	
24	40.572343	-73.908529	6/19/2009 17:44	6/19/2009 17:53	Sta_24_VTS_04_1.VOB	
25	40.574780	-73.901270	6/19/2009 15:20	6/19/2009 15:29	Sta_25_VTS_05_1.VOB	
26	40.572229	-73.914583	6/19/2009 18:15	6/19/2009 18:21	Sta_26_VTS_05_1.VOB	
27	40.596053	-73.867383	6/25/2009 16:55	6/25/2009 17:03	Sta_27_VTS_01_1.VOB	
28	40.595817	-73.868937	6/25/2009 16:17	6/25/2009 16:27	Sta_28_VTS_07_1.VOB	
29	40.596497	-73.870776	6/25/2009 15:56	6/25/2009 16:02	Sta_29_VTS_06_1.VOB	
30	40.594592	-73.870011	6/25/2009 15:33	6/25/2009 15:40	Sta_30_VTS_05_1.VOB	
31	40.595850	-73.877979	6/25/2009 13:57	6/25/2009 14:03	Sta_31_VTS_03_1.VOB	
32	40.602580	-73.873478	6/25/2009 13:32	6/25/2009 13:39	Sta_32_VTS_02_1.VOB	
33	40.601457	-73.873503	6/25/2009 13:02	6/25/2009 13:13	Sta_33_VTS_01_1.VOB	
34	40.592175	-73.860523	6/24/2009 18:25	6/24/2009 18:32	Sta_34_VTS_07_1.VOB	
35	40.592814	-73.862638	6/24/2009 18:44	6/24/2009 18:52	Sta_35_VTS_08_1.VOB	
36	40.589701	-73.871908	6/24/2009 20:42	6/24/2009 20:49	Sta_36_VTS_04_1.VOB	
37	40.598336	-73.867212	6/24/2009 20:04	6/24/2009 20:14	Sta_37_VTS_03_1.VOB	
38	40.587093	-73.871720	6/25/2009 18:07	6/25/2009 18:12	Sta_38_VTS_04_1.VOB	
39	40.592712	-73.865780	6/24/2009 19:09	6/24/2009 19:16	Sta_39_VTS_01_1.VOB	
40	40.593693	-73.875700	6/25/2009 14:33	6/25/2009 14:31	Sta_40_VTS_04_1.VOB	
41	40.590971	-73.857861	6/24/2009 17:41	6/24/2009 17:48	Sta_41_VTS_05_1.VOB	
42	40.591683	-73.868343	6/25/2009 17:23	6/25/2009 17:30	Sta_42_VTS_02_1.VOB	
43	40.591329	-73.870020	6/25/2009 17:45	6/25/2009 17:52	Sta_43_VTS_03_1.VOB	
44	40.587858	-73.861401	6/24/2009 12:57	6/24/2009 13:08	Sta_44_VTS_01_1.VOB	
45	40.588326	-73.860018	6/24/2009 13:36	6/24/2009 13:43	Sta_45_VTS_02_1.VOB	
46	40.586450	-73.858008	6/24/2009 13:59	6/24/2009 14:06	Sta_46_VTS_03_1.VOB	
47	40.587333	-73.855453	6/24/2009 14:24	6/24/2009 14:31	Sta_47_VTS_04_1.VOB	
48	40.590287	-73.854330	6/24/2009 17:17	6/24/2009 17:25	Sta_48_VTS_04_1.VOB	
49	40.589156	-73.852051	6/24/2009 15:45	6/24/2009 15:53	Sta_49-1_VTS_07_1.VOB	
49	40.589156	-73.852051	6/24/2009 16:02	6/24/2009 16:05	Sta_49-2_VTS_01_1.VOB	
50	40.591162	-73.861410	6/24/2009 18:04	6/24/2009 18:10	Sta_50_VTS_06_1.VOB	
51	40.595317	-73.868066	6/24/2009 19:31	6/24/2009 19:46	Sta_51-1_VTS_02_1.VOB	
51	40.595317	-73.868066	6/24/2009 19:46	6/24/2009 19:47	Sta_51-2_VTS_02_2.VOB	
52	40.592692	-73.850293	6/24/2009 16:49	6/24/2009 16:55	Sta_52_VTS_03_1.VOB	
53	40.592806	-73.848999	6/24/2009 16:23	6/24/2009 16:34	Sta_53_VTS_02_1.VOB	
54	40.588123	-73.847721	6/24/2009 15:17	6/24/2009 15:24	Sta_54_VTS_06_1.VOB	
55	40.585966	-73.842236	6/24/2009 14:50	6/24/2009 15:01	Sta_55_VTS_05_1.VOB	

56	40.586609	-73.872876	6/25/2009 18:26	6/25/2009 18:31	Sta_56_VTS_05_1.VOB
57	40.585718	-73.874007	6/25/2009 18:47	6/25/2009 19:01	Sta_57-1_VTS_06_1.VOB
57	40.585718	-73.874007	6/25/2009 19:01	6/25/2009 19:04	Sta_57-2_VTS_06_2.VOB
58	40.585242	-73.875277	6/25/2009 19:19	6/25/2009 19:26	Sta_58_VTS_07_1.VOB
59	40.640910	-73.858590	6/30/2009 15:58	6/30/2009 16:02	Sta_59_VTS_12_1.VOB
60	40.640800	-73.859940	6/30/2009 15:36	6/30/2009 15:40	Sta_60_VTS_09_1.VOB
61	40.620349	-73.840039	6/30/2009 14:16	6/30/2009 14:21	Sta_61_VTS_05_1.VOB
62	40.619230	-73.838880	6/30/2009 13:53	6/30/2009 14:01	Sta_62_VTS_04_1.VOB
63	40.619674	-73.843612	6/30/2009 13:32	6/30/2009 13:36	Sta_63_VTS_03_1.VOB
64	40.643940	-73.821470	6/30/2009 17:02	6/30/2009 17:04	Sta_64_VTS_17_1.VOB
65	40.643220	-73.819960	6/30/2009 17:49	6/30/2009 17:51	Sta_65_VTS_02_1.VOB
66	40.639193	-73.814567	6/26/2009 18:35	6/26/2009 18:43	Sta_66_VTS_02_1.VOB
67	40.638330	-73.812931	6/26/2009 17:46	6/26/2009 17:54	Sta_67_VTS_09_1.VOB
68	40.638904	-73.811377	6/26/2009 17:18	6/26/2009 17:25	Sta_68_VTS_08_1.VOB
69	40.636308	-73.802262	6/26/2009 14:41	6/26/2009 14:46	Sta_69_VTS_01_1.VOB
70	40.643220	-73.817440	6/30/2009 18:10	6/30/2009 18:12	Sta_70_VTS_03_1.VOB
71	40.635850	-73.816640	6/26/2009 18:59	6/26/2009 19:06	Sta_71_VTS_03_1.VOB
72	40.639030	-73.813737	6/26/2009 18:13	6/26/2009 18:23	Sta_72_VTS_01_1.VOB
73	40.634721	-73.812492	6/26/2009 19:21	6/26/2009 19:26	Sta_73_VTS_04_1.VOB
74	40.633930	-73.814550	6/26/2009 19:38	6/26/2009 19:46	Sta_74_VTS_05_1.VOB
76	40.625410	-73.810200	6/30/2009 18:36	6/30/2009 18:40	Sta_76_VTS_04_1.VOB
77	40.628447	-73.794523	6/26/2009 16:22	6/26/2009 16:27	Sta_77_VTS_06_1.VOB
78	40.627600	-73.793864	6/26/2009 15:59	6/26/2009 16:04	Sta_78_VTS_05_1.VOB
79	40.634131	-73.802661	6/26/2009 15:28	6/26/2009 15:41	Sta_79_VTS_04_1.VOB
80	40.635824	-73.806690	6/26/2009 16:51	6/26/2009 16:58	Sta_80_VTS_07_1.VOB
81	40.643840	-73.827440	6/30/2009 16:37	6/30/2009 16:42	Sta_81_VTS_14_1.VOB
82	40.575680	-73.871610	6/30/2009 20:01	6/30/2009 20:05	Sta_82_VTS_06_1.VOB
83	40.636377	-73.803369	6/26/2009 15:05	6/26/2009 15:09	Sta_83_VTS_02_1.VOB
84	40.640260	-73.855590	6/30/2009 15:13	6/30/2009 15:20	Sta_84_VTS_08_1.VOB
85	40.642640	-73.842200	6/30/2009 14:50	6/30/2009 14:55	Sta_85_VTS_07_1.VOB
86	40.577090	-73.866450	6/30/2009 19:41	6/30/2009 19:45	Sta_86_VTS_05_1.VOB

Table 7. Bottom Penetrometer Summary

Station	Original XBP file name	Corrected XBT drop ID	Time (GMT)	Latitude	Longitude	Terminal Velocity (cm/s)	Maximum Deceleration (g)	Calculated Probe Penetration Depth (cm)	Comments
1	17jn1914	17jn1914	06/17/2009 19:14	40.570367	-73.925637	407	6.3	18.0	
2	17jn1851	17jn1851	06/17/2009 18:51	40.571761	-73.926240	410	36.1	5.1	
3	17jn1808	17jn1808	06/17/2009 18:08	40.572870	-73.927100	409	17.1	7.2	
3a	17jn1945	17jn1945	06/17/2009 19:45	40.572923	-73.925917	377	3.6	41.6	
4	17jn1726	17jn1726	06/17/2009 17:26	40.574320	-73.927060	414	33.8	10.1	
5	18jn1510	18jn1510	06/18/2009 15:10	40.567760	-73.923790	405	14.2	7.4	
6	18jn1553	18jn1553	06/18/2009 15:53	40.566230	-73.919710				no bottom impact recorded
7	18jn1619	18jn1619	06/18/2009 16:19	40.566150	-73.913900	425	25.3	6.5	
8	19jn1440	19jn1440	06/19/2009 14:40	40.574414	-73.919499	357	43.7	3.1	
9	19jn1351	19jn1351	06/19/2009 13:51	40.575265	-73.923771	422	43.8	3.5	
10	18jn1719	18jn1719	06/18/2009 17:19	40.569470	-73.919750	539	25.6	8.2	
11	18jn1645	18jn1645	06/18/2009 16:45	40.567800	-73.917690	303	37.3	2.1	
12	19jn1604	19jn1604	06/19/2009 16:04	40.574939	-73.903768	423	5.4	23.8	
13	19jn1626	19jn1626	06/19/2009 16:26	40.574182	-73.904688	438	29.2	10.1	
14	19jn1650	19jn1650	06/19/2009 16:50	40.573865	-73.905770	406	6.0	19.4	
15	19jn1714	19jn1714	06/19/2009 17:14	40.573124	-73.907170	431	17.9	9.8	
16	18jn2004	18jn2004	06/18/2009 20:04	40.571642	-73.905733	273	57.9	1.4	
17	18jn1934	18jn1934	06/18/2009 19:34	40.569152	-73.904150	103	12.7	4.5	
18	18jn1901	18jn1901	06/18/2009 19:01	40.567845	-73.904805	159	55.7	0.7	
19	18jn1757	18jn1757	06/18/2009 17:57	40.566410	-73.904410	146	58.1	0.6	
20	18jn1825	18jn1825	06/18/2009 18:25	40.565720	-73.904740	252	56.5	1.4	
21	19jn1504	19jn1504	06/19/2009 15:04	40.572709	-73.920842	439	6.1	18.7	
22	19jn1415	19jn1415	06/19/2009 14:15	40.576237	-73.923804	382	42.3	3.7	
23	19jn1735	19jn1735	06/19/2009 17:35	40.573763	-73.908936	208	44.8	1.3	
24	19jn1802	19jn1802	06/19/2009 18:02	40.572343	-73.908529	407	42.7	4.2	
25	19jn1537	19jn1537	06/19/2009 15:37	40.574780	-73.901270	355	12.6	13.7	
26	19jn1829	19jn1829	06/19/2009 18:29	40.572229	-73.914583	234	59.0	1.8	
27	25jn1313	25jn1713	06/25/2009 17:13	40.596053	-73.867383	436	48.5	6.4	computer on EDT not GMT
28	25jn1243	25jn1643	06/25/2009 16:43	40.595817	-73.868937	440	2.6	76.7	computer on EDT not GMT
29	25jn1208	25jn1608	06/25/2009 16:08	40.596497	-73.870776	463	5.3	32.3	computer on EDT not GMT
30	25jn1146	25jn1546	06/25/2009 15:46	40.594592	-73.870011	402	5.1	24.8	computer on EDT not GMT
31	25jn1011	25jn1411	06/25/2009 14:11	40.595850	-73.877979	398	5.2	24.4	computer on EDT not GMT
32	25jn0945	25jn1345	06/25/2009 13:45	40.602580	-73.873478	453	42.6	6.3	computer on EDT not GMT
33	25jn0920	25jn1320	06/25/2009 13:21	40.601457	-73.873503	440	5.3	29.4	computer on EDT not GMT
34	24jn1837	24jn1837	06/24/2009 18:37	40.592175	-73.860523	411	6.4	19.6	
35	24jn1858	24jn1858	06/24/2009 18:58	40.592814	-73.862638	425	7.9	16.8	
36	24jn2102	24jn2102	06/24/2009 21:02	40.589701	-73.871908	213	42.9	1.3	
37	24jn2025	24jn2025	06/24/2009 20:25	40.598336	-73.867212	393	43.1	3.6	
38	25jn1417	25jn1817	06/25/2009 18:17	40.587093	-73.871720	207	45.5	1.3	computer on EDT not GMT
39	24jn1921	24jn1921	06/24/2009 19:21	40.592712	-73.865780	445	5.9	26.8	
40	25jn1044	25jn1444	06/25/2009 14:44	40.593693	-73.875700	400	7.1	23.2	computer on EDT not GMT
41	24jn1754	24jn1754	06/24/2009 17:54	40.590971	-73.857861	409	6.5	22.4	
42	25jn1336	25jn1736	06/25/2009 17:36	40.591683	-73.868343	501	5.9	33.3	computer on EDT not GMT
43	25jn1357	25jn1757	06/25/2009 18:57	40.591329	-73.870020	467	5.5	32.4	computer on EDT not GMT
44	31de1316	24jn1316	06/24/2009 13:16	40.587858	-73.861401	201	35.4	2.9	computer date not set
45	24jn1349	24jn1349	06/24/2009 13:49	40.588326	-73.860018	359	39.1	3.6	
46	24jn1414	24jn1414	06/24/2009 14:14	40.586450	-73.858008	130	19.5	0.8	
47	24jn1438	24jn1438	06/24/2009 14:38	40.587333	-73.855453	396	12.8	11.5	
48	24jn1732	24jn1732	06/24/2009 17:32	40.590287	-73.854330	393	5.9	20.6	
49	24jn1612	24jn1612	06/24/2009 16:12	40.589156	-73.852051	407	25.9	5.2	
50	24jn1816	24jn1816	06/24/2009 18:16	40.591162	-73.861410	390	6.0	21.1	
51	24jn1956	24jn1956	06/24/2009 19:56	40.595317	-73.868066	392	5.4	26.5	
52	24jn1704	24jn1704	06/24/2009 17:04	40.592692	-73.850293	386	6.0	22.6	
53	24jn1641	24jn1641	06/24/2009 16:41	40.592806	-73.848999	326	61.2	2.4	
54	24jn1533	24jn1533	06/24/2009 15:33	40.588123	-73.847721	350	43.7	2.8	
55	24jn1508	24jn1508	06/24/2009 15:08	40.585966	-73.842236	467	21.4	9.2	
56	25jn1433	25jn1833	06/25/2009 18:33	40.586609	-73.872876	287	37.8	2.5	computer on EDT not GMT
57	25jn1509	25jn1909	06/25/2009 19:09	40.585718	-73.874007	266	75.6	1.1	computer on EDT not GMT
58	25jn1528	25jn1928	06/25/2009 19:28	40.585242	-73.875277	420	23.8	5.6	computer on EDT not GMT
59	30jn1610	30jn1610	06/30/2009 16:10	40.640910	-73.858590	399	44.7	7.9	
60	30jn1548	30jn1548	06/30/2009 15:48	40.640800	-73.859940	402	5.3	25.8	
61	30jn1429	30jn1429	06/30/2009 14:29	40.620349	-73.840039	397	3.6	72.4	
62	30jn1407	30jn1407	06/30/2009 14:07	40.619230	-73.838880	525	6.1	41.1	
63	30jn1343	30jn1343	06/30/2009 13:43	40.619674	-73.843612	413	42.1	6.8	
64	30jn1712	30jn1712	06/30/2009 17:12	40.643940	-73.821470	395	12.0	20.3	
65	30jn1759	30jn1759	06/30/2009 17:59	40.643220	-73.819960	405	5.1	25.5	
66	26jn1850	26jn1850	06/26/2009 18:50	40.639193	-73.814567	472	4.0	49.7	

67	26jn1802	26jn1802	06/26/2009 18:02	40.638330	-73.812931	402	9.1	16.2
68	26jn1736	26jn1736	06/26/2009 17:36	40.638904	-73.811377	410	5.2	25.7
69	26jn1454	26jn1454	06/26/2009 14:54	40.636308	-73.802262	425	3.0	35.5
70	30jn1819	30jn1819	06/30/2009 18:19	40.643220	-73.817440	486	8.0	25.6
71	26jn1911	26jn1911	06/26/2009 19:11	40.635850	-73.816640	418	2.9	65.6
72	26jn1827	26jn1827	06/26/2009 18:27	40.639030	-73.813737	408	6.4	21.5
73	26jn1930	26jn1930	06/26/2009 19:30	40.634721	-73.812492	406	6.2	19.7
74	26jn1950	26jn1950	06/26/2009 19:50	40.633930	-73.814550	428	3.6	50.7
76	30jn1846	30jn1846	06/30/2009 18:46	40.625410	-73.810200	425	4.8	30.4
77	26jn1635	26jn1635	06/26/2009 16:35	40.628447	-73.794523	459	3.6	48.9
78	26jn1612	26jn1612	06/26/2009 16:12	40.627600	-73.793864	428	3.1	59.0
79	26jn1547	26jn1547	06/26/2009 15:47	40.634131	-73.802661	583	42.4	11.7
80	26jn1708	26jn1708	06/26/2009 17:08	40.635824	-73.806690	472	6.4	35.5
81	30jn1651	30jn1651	06/30/2009 16:51	40.643840	-73.827440	407	29.8	4.9
82	30jn2011	30jn2011	06/30/2009 20:11	40.575680	-73.871610	356	41.8	2.7
83	26jn1516	26jn1516	06/26/2009 15:16	40.636377	-73.803369	463	2.4	81.2
84	30jn1526	30jn1526	06/30/2009 15:26	40.640260	-73.855590	413	35.0	4.5
85	30jn1500	30jn1500	06/30/2009 15:00	40.642640	-73.842200	398	46.9	3.1
86	30jn1951	30jn1951	06/30/2009 19:51	40.577090	-73.866450	404	14.6	11.5

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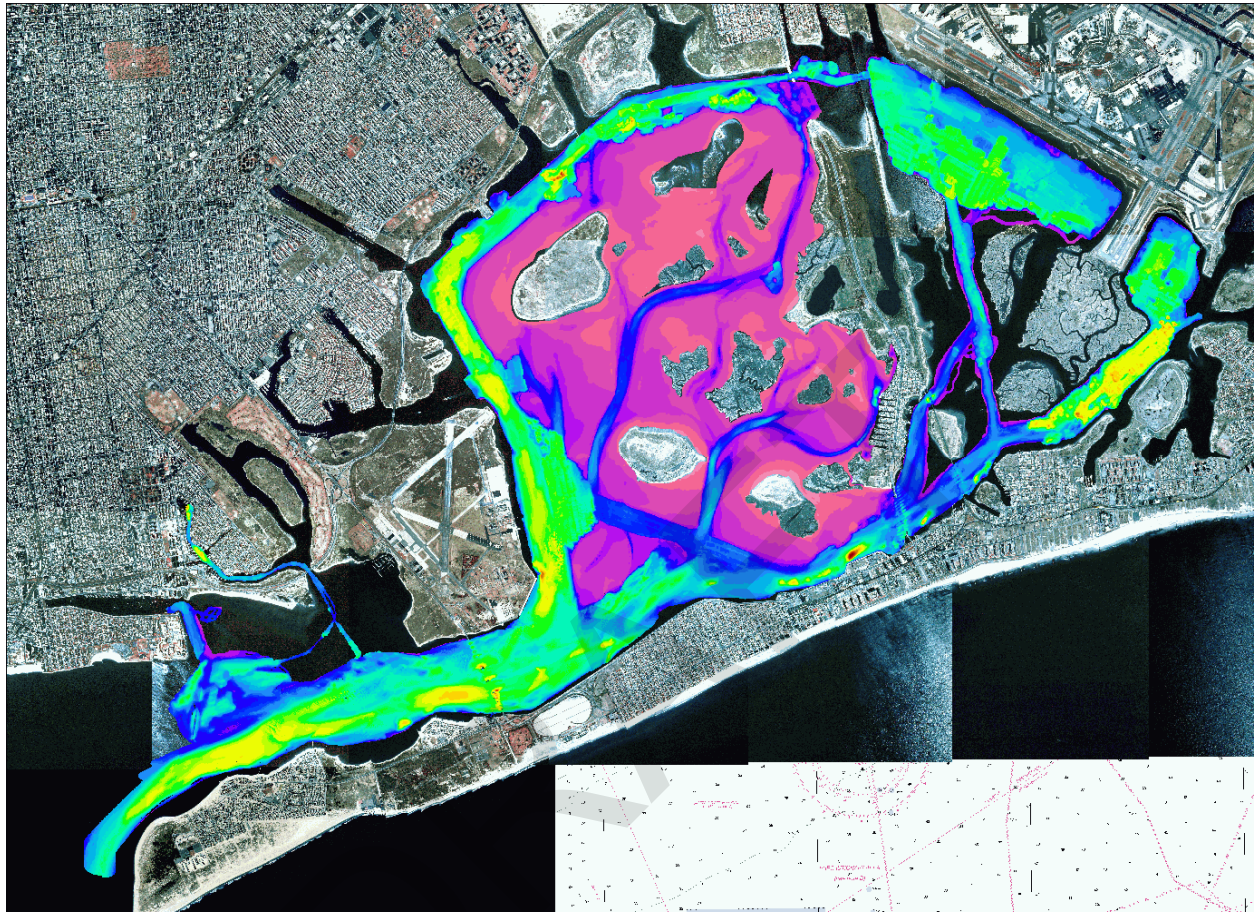


Figure 1.

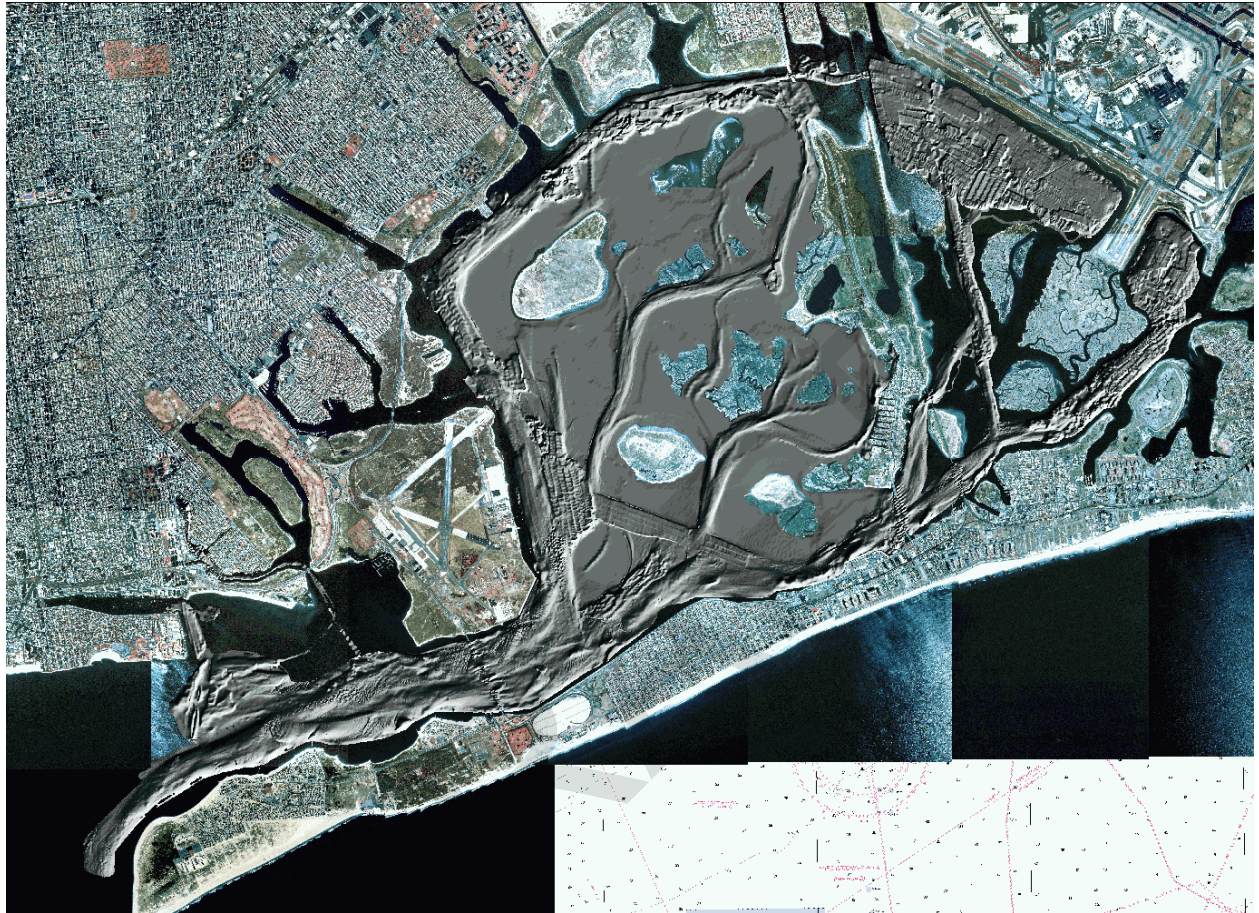


Figure 2.

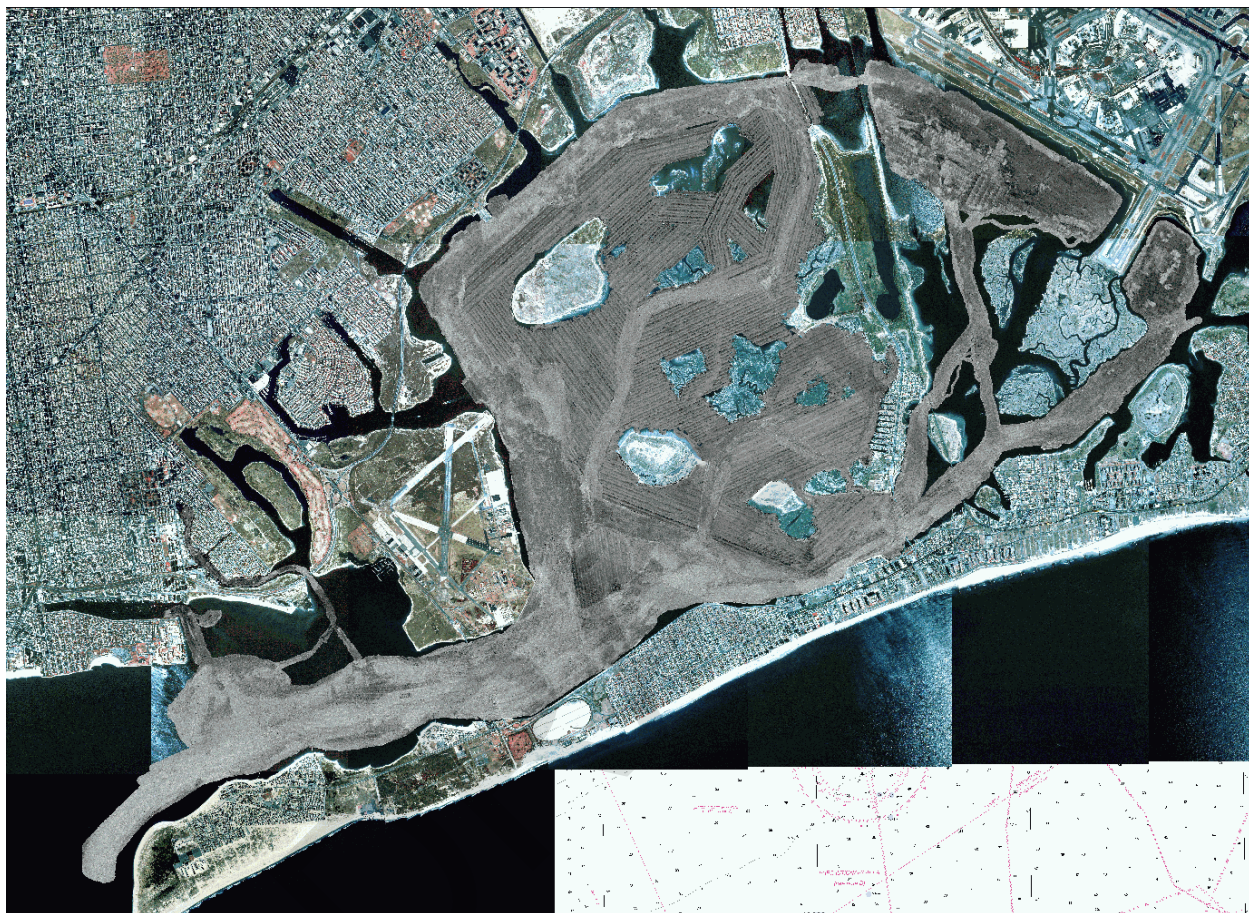


Figure 3.

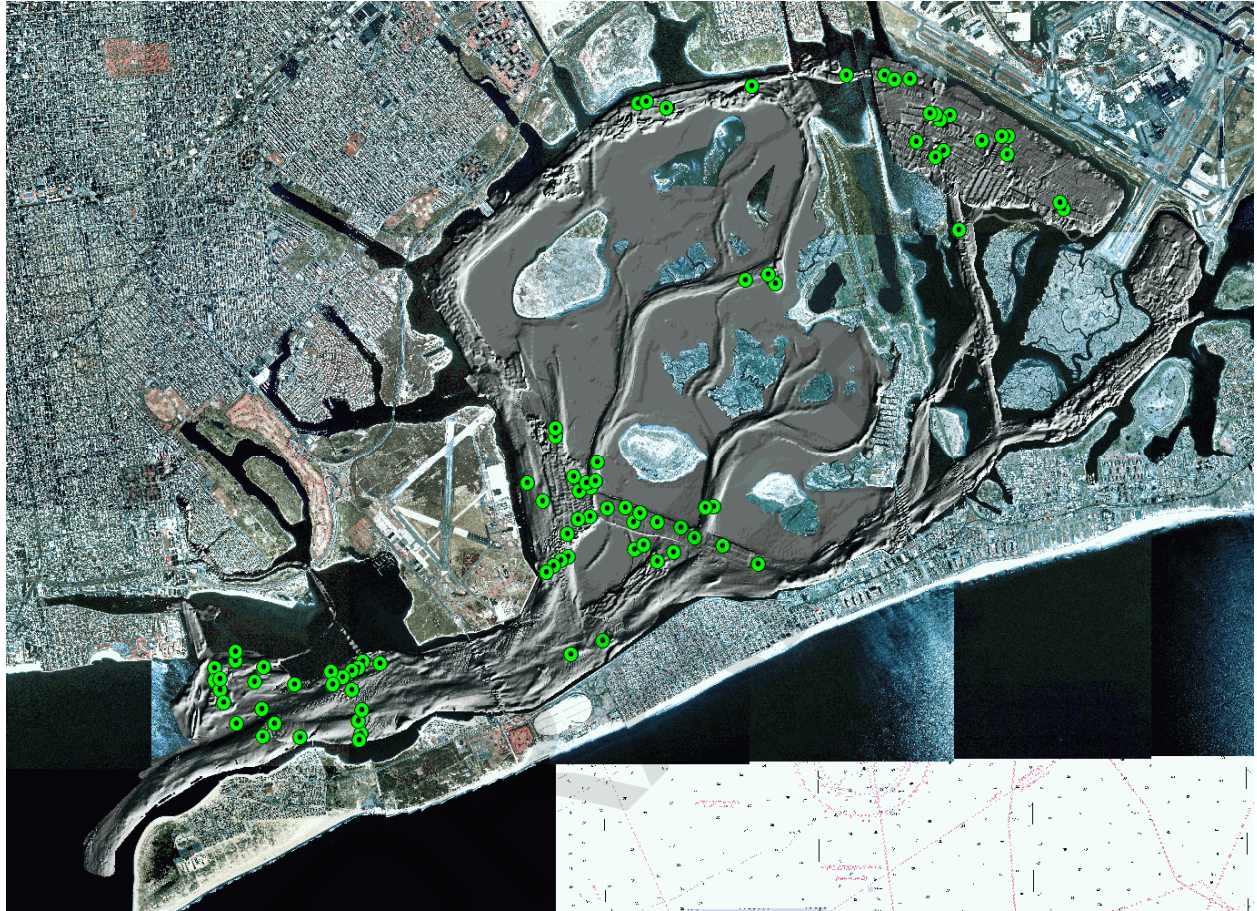


Figure 4.

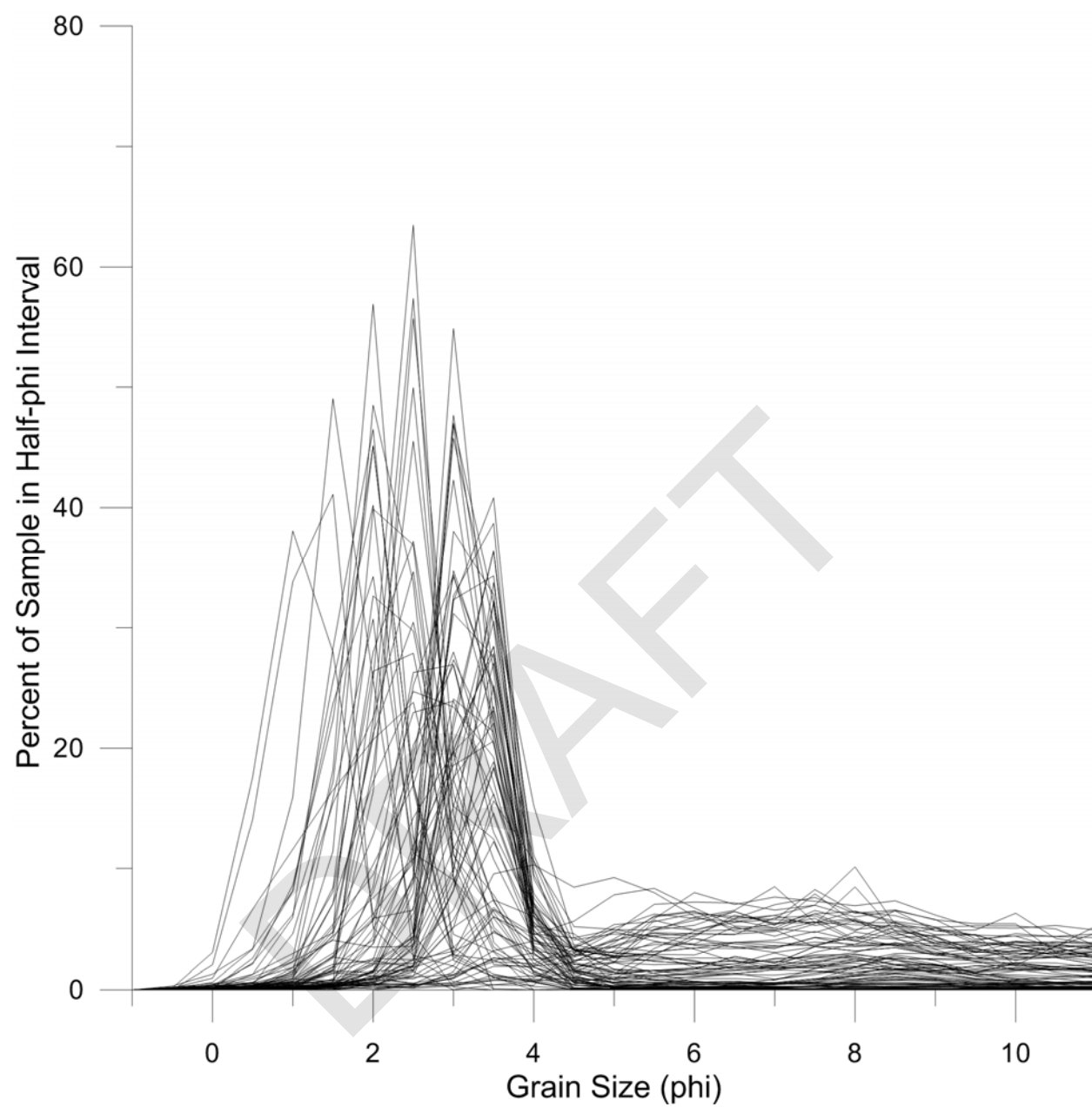


Figure 5.

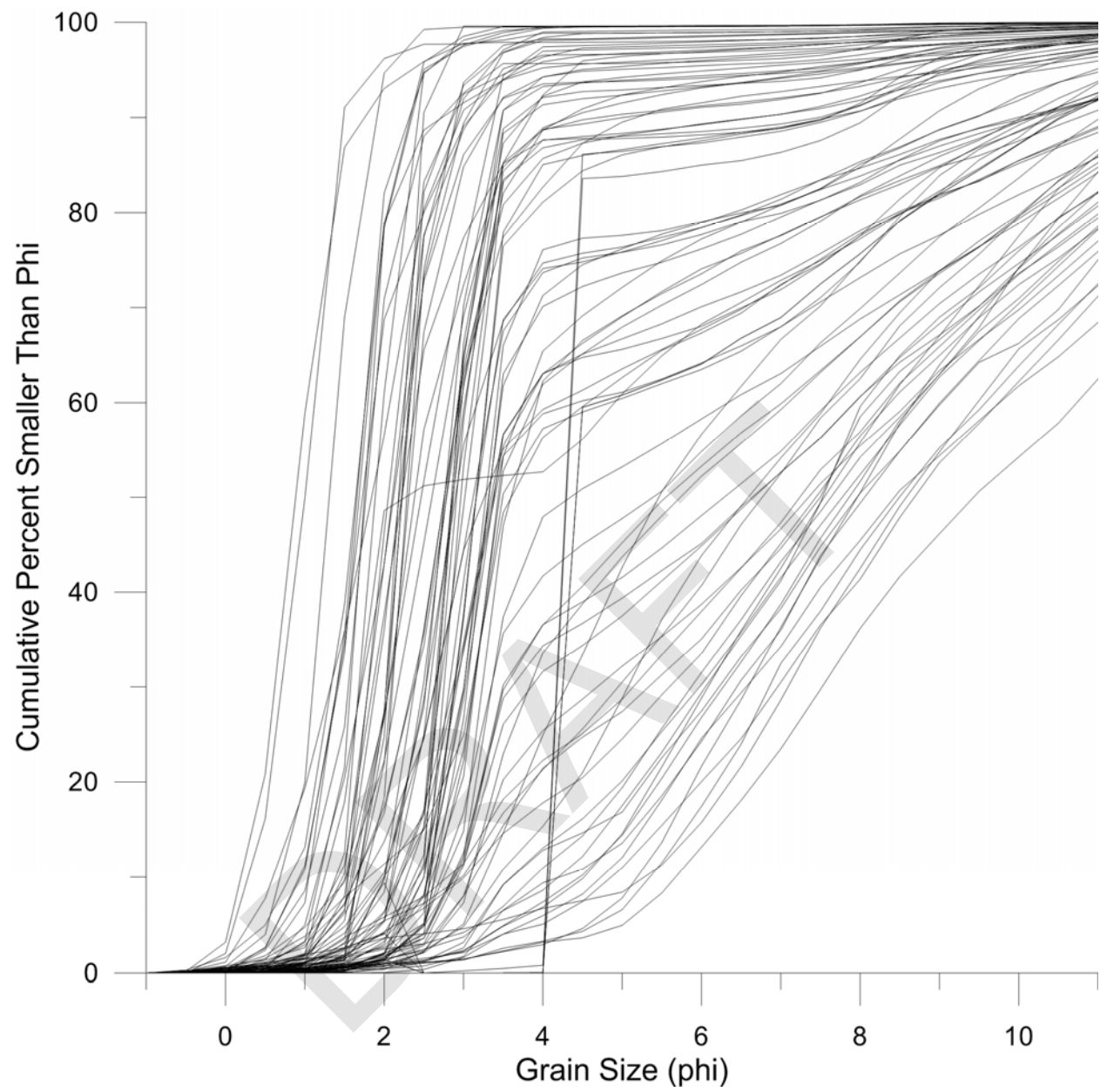


Figure 6.

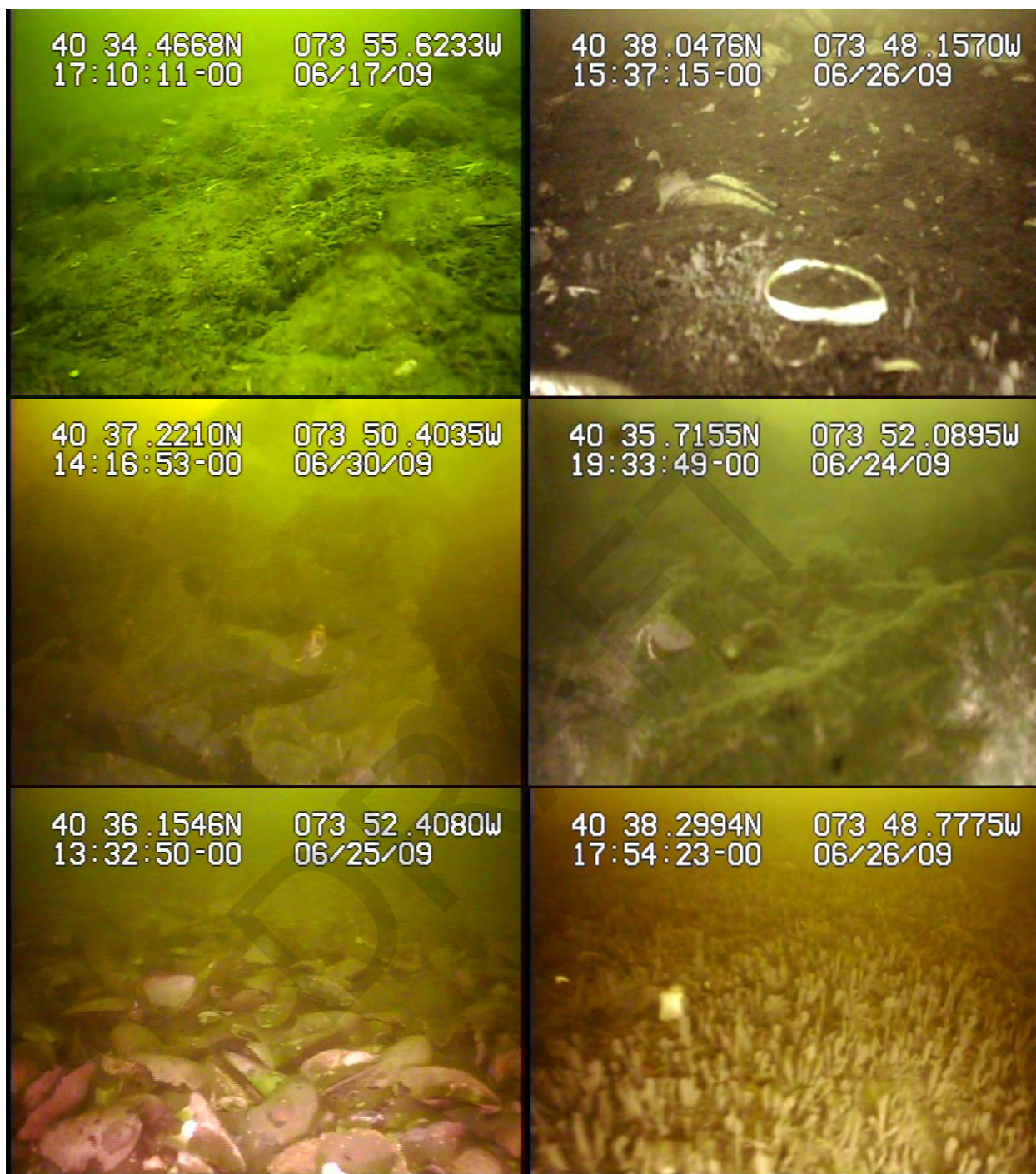


Figure 7.

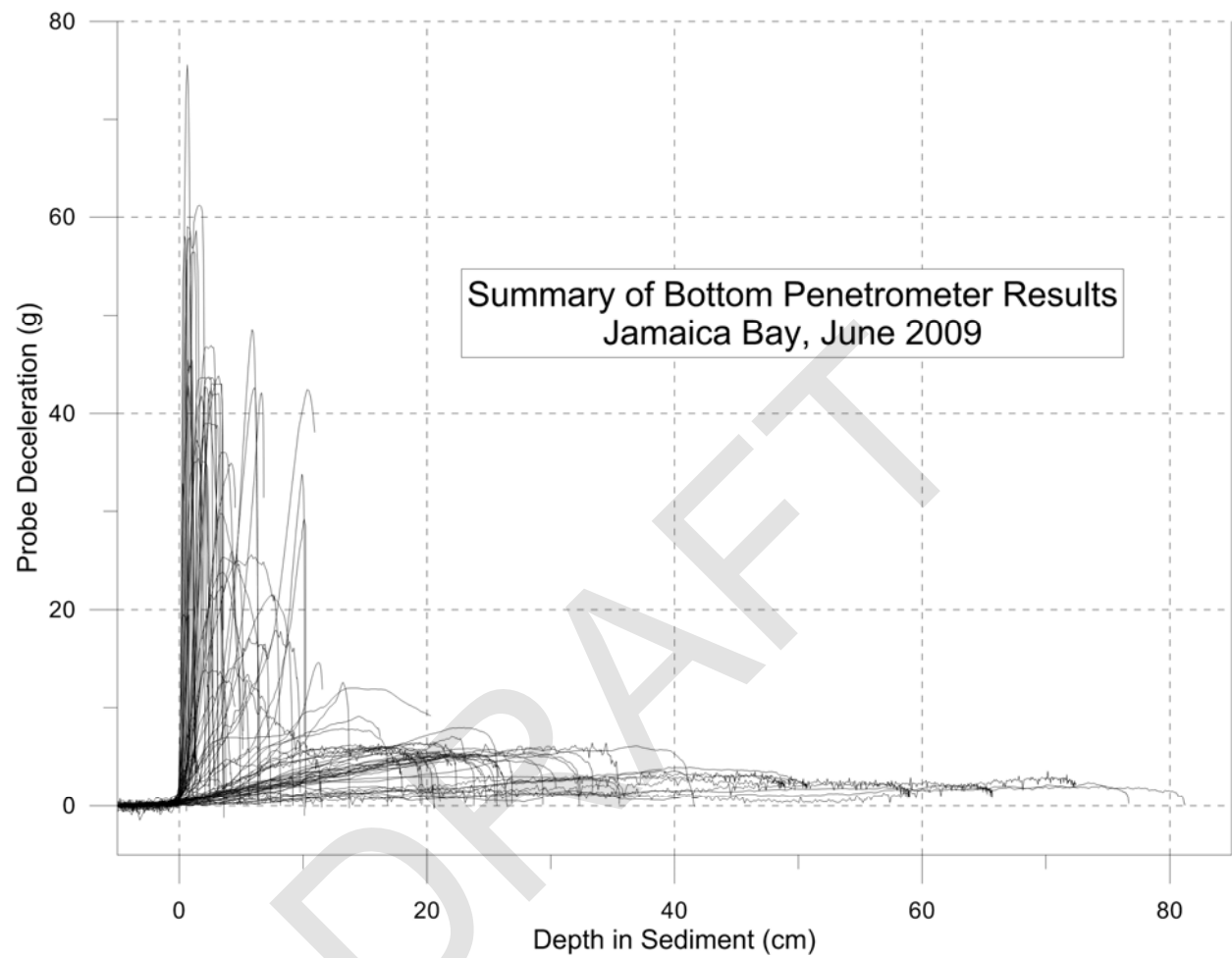


Figure 8.

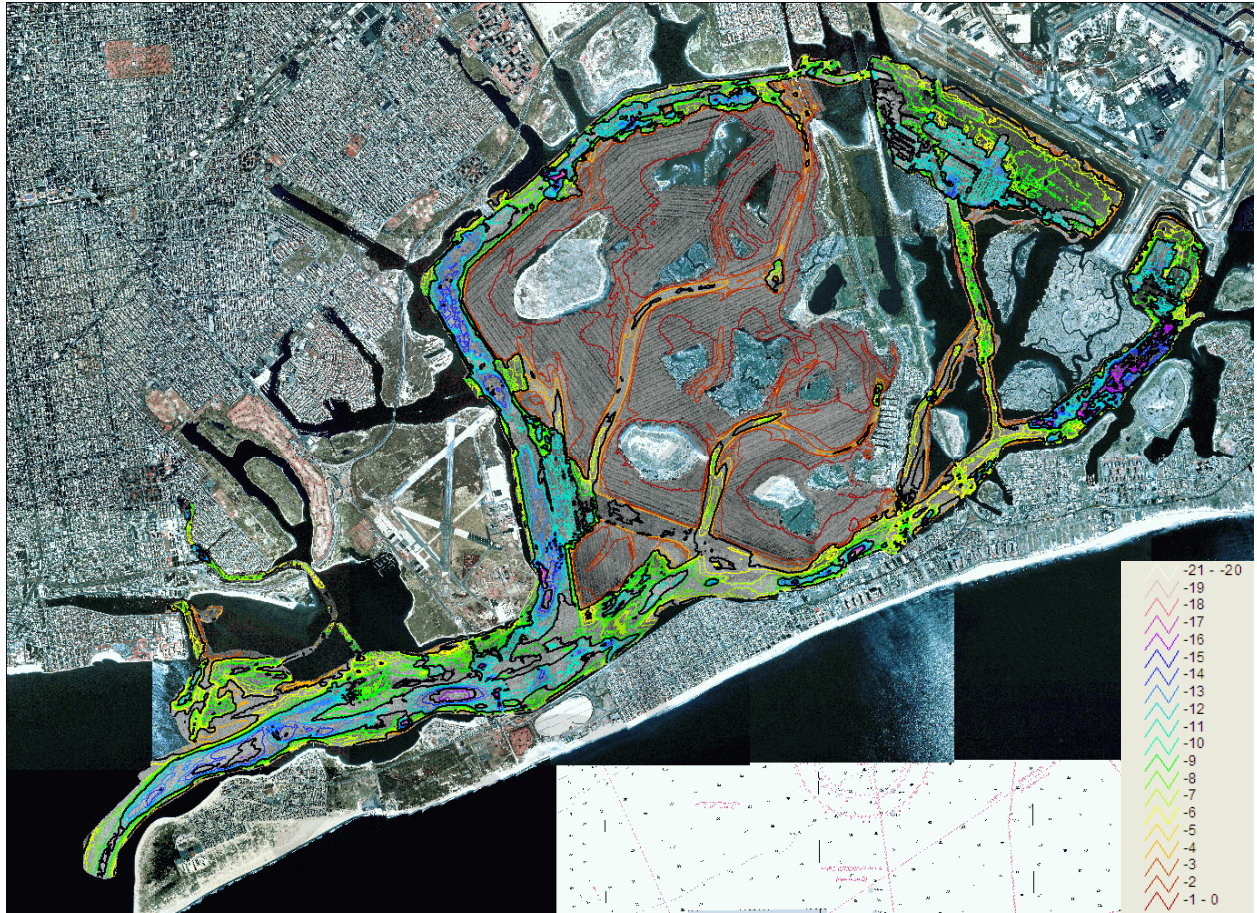


Figure 9.

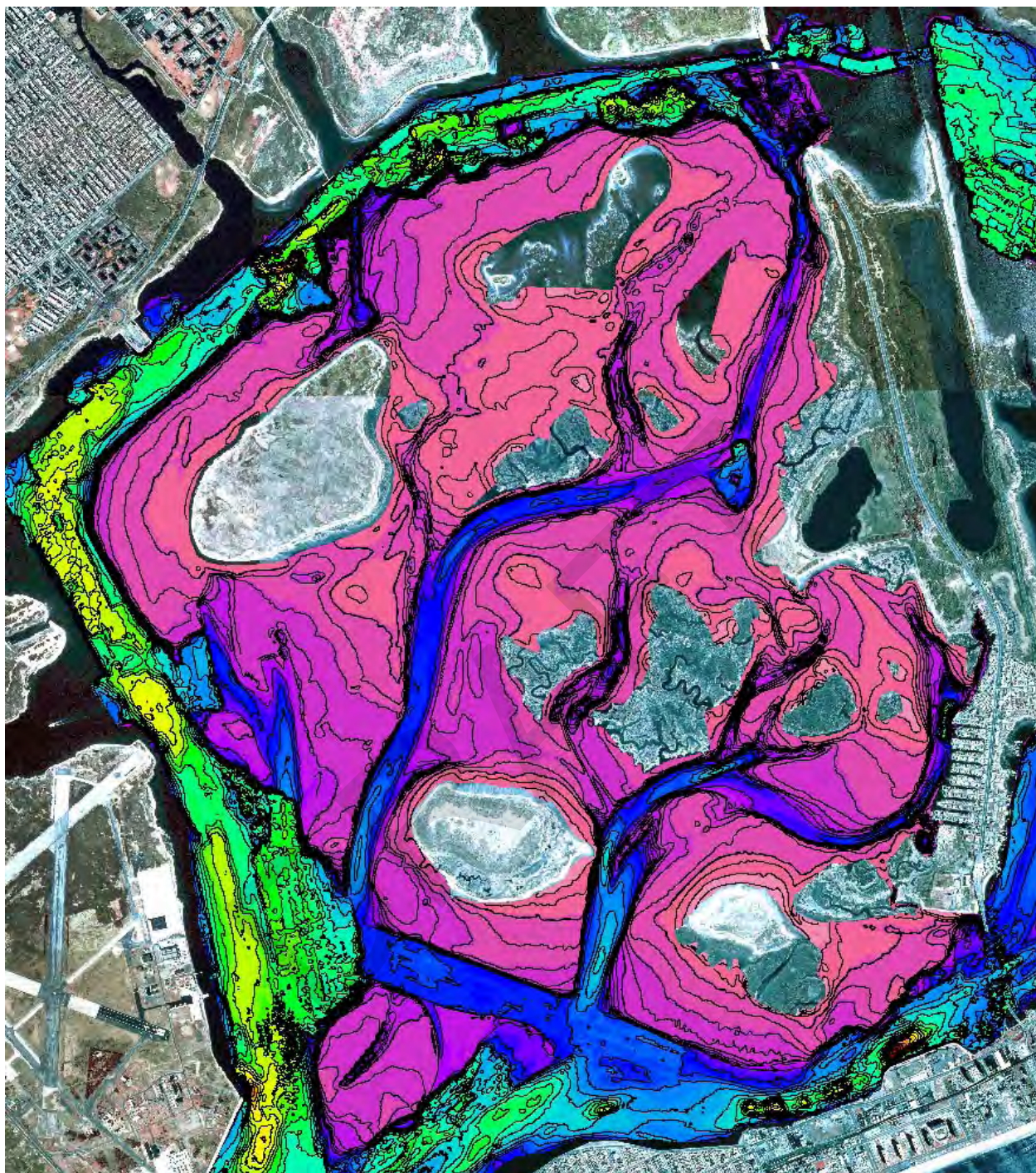


Figure 10.



Figure 11.

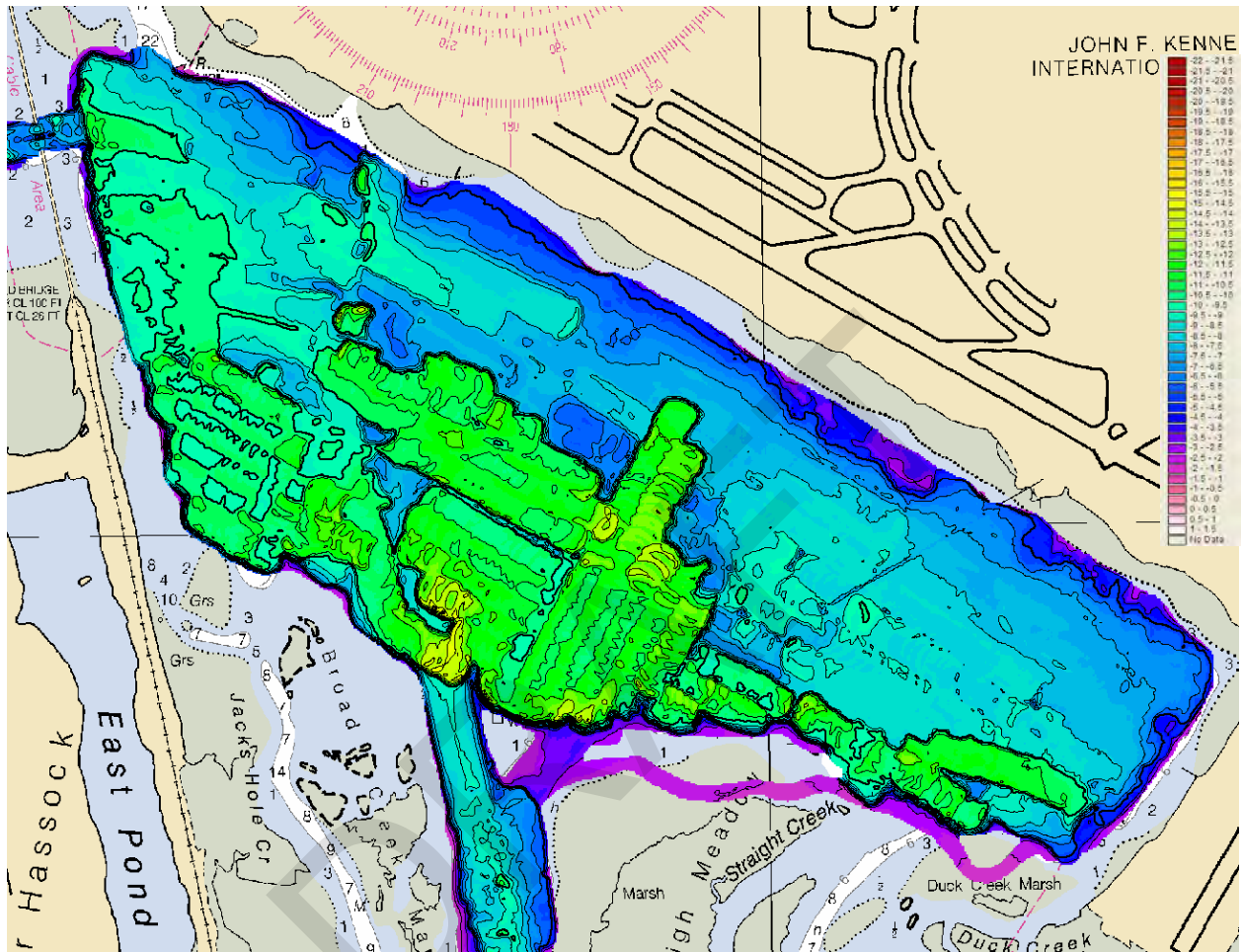


Figure 12.

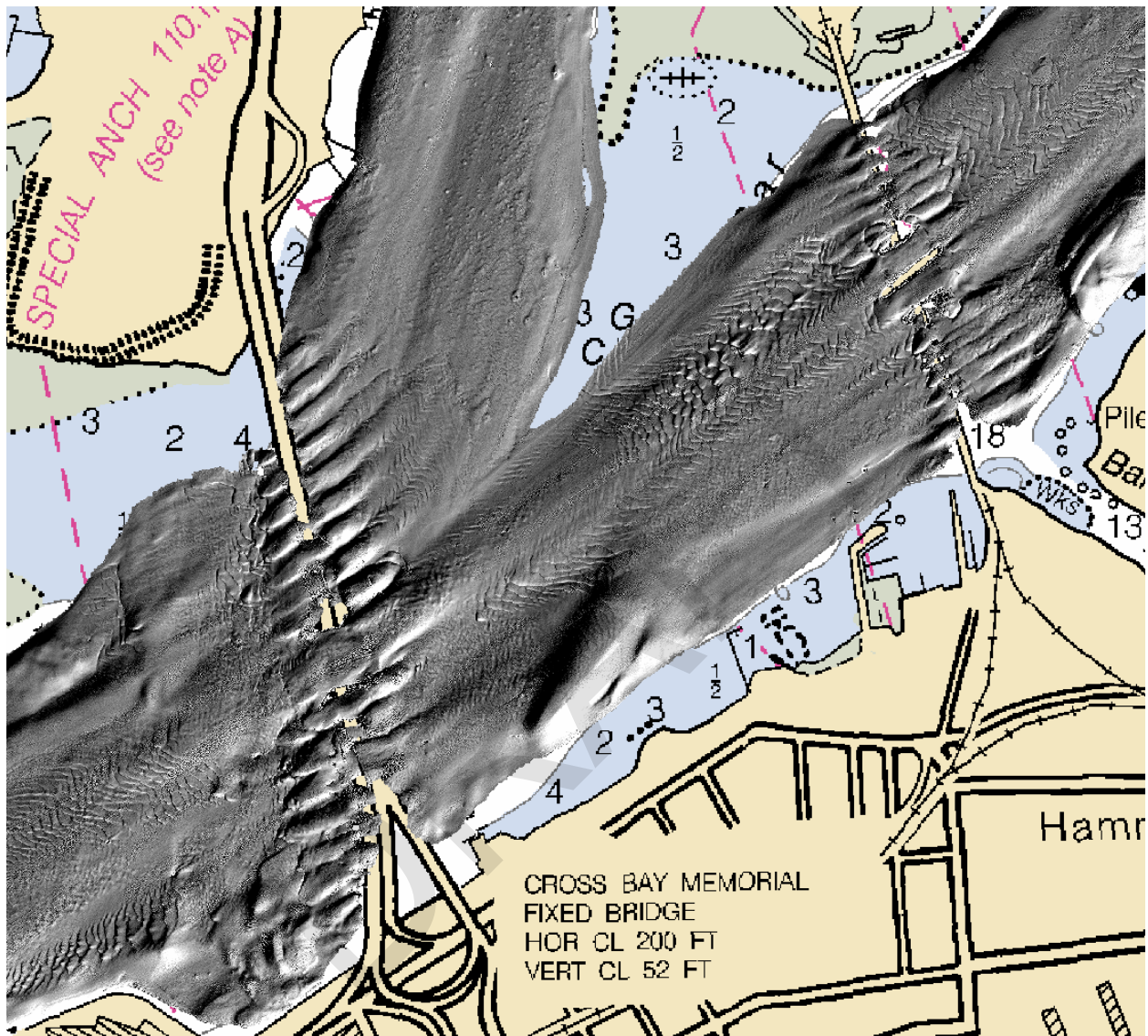


Figure 13.

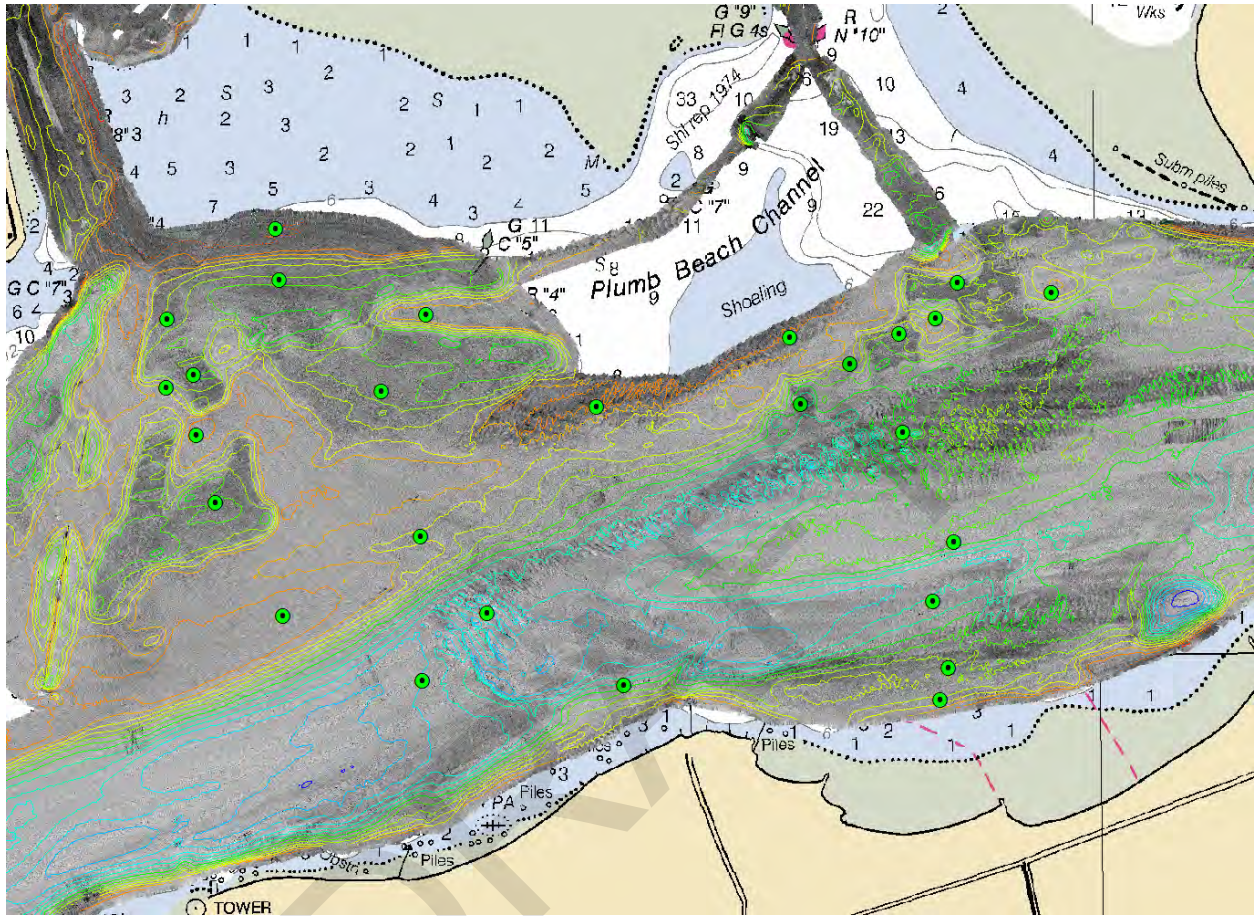


Figure 15.

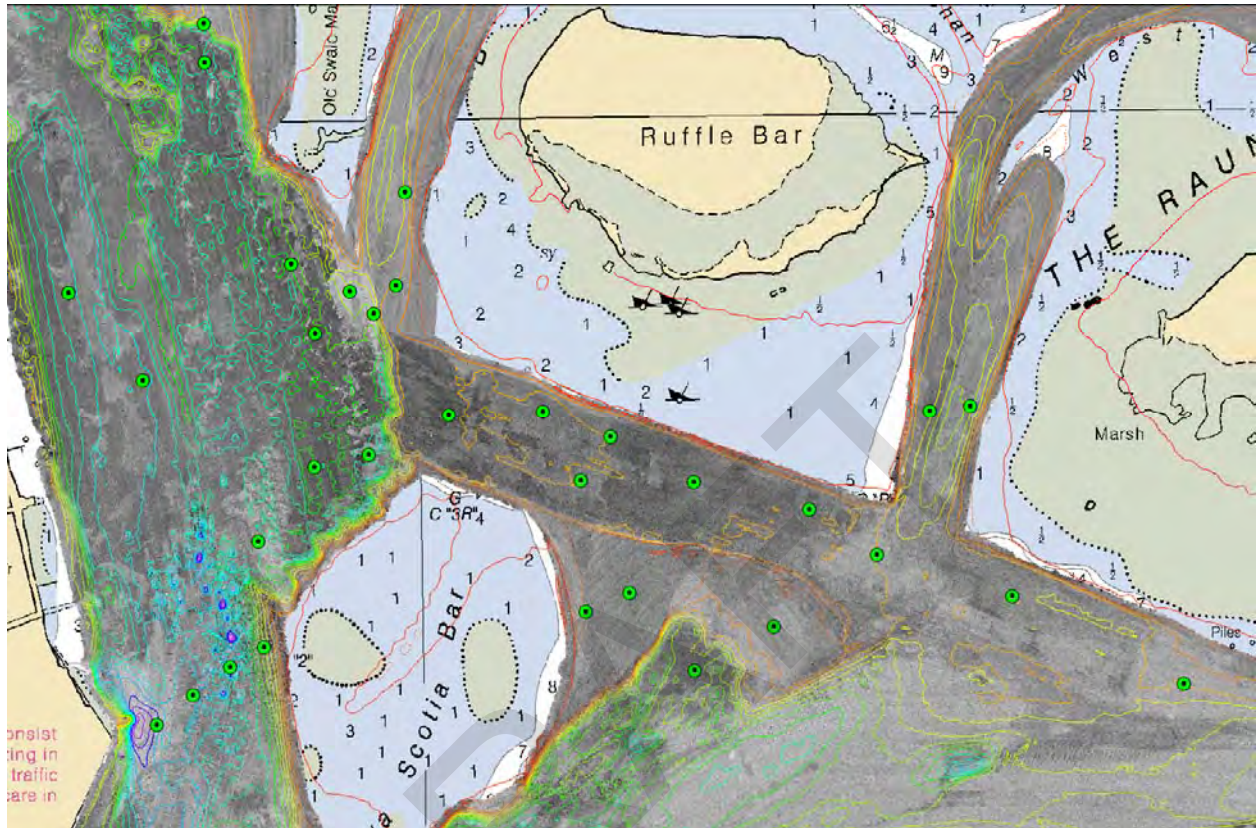


Figure 15.

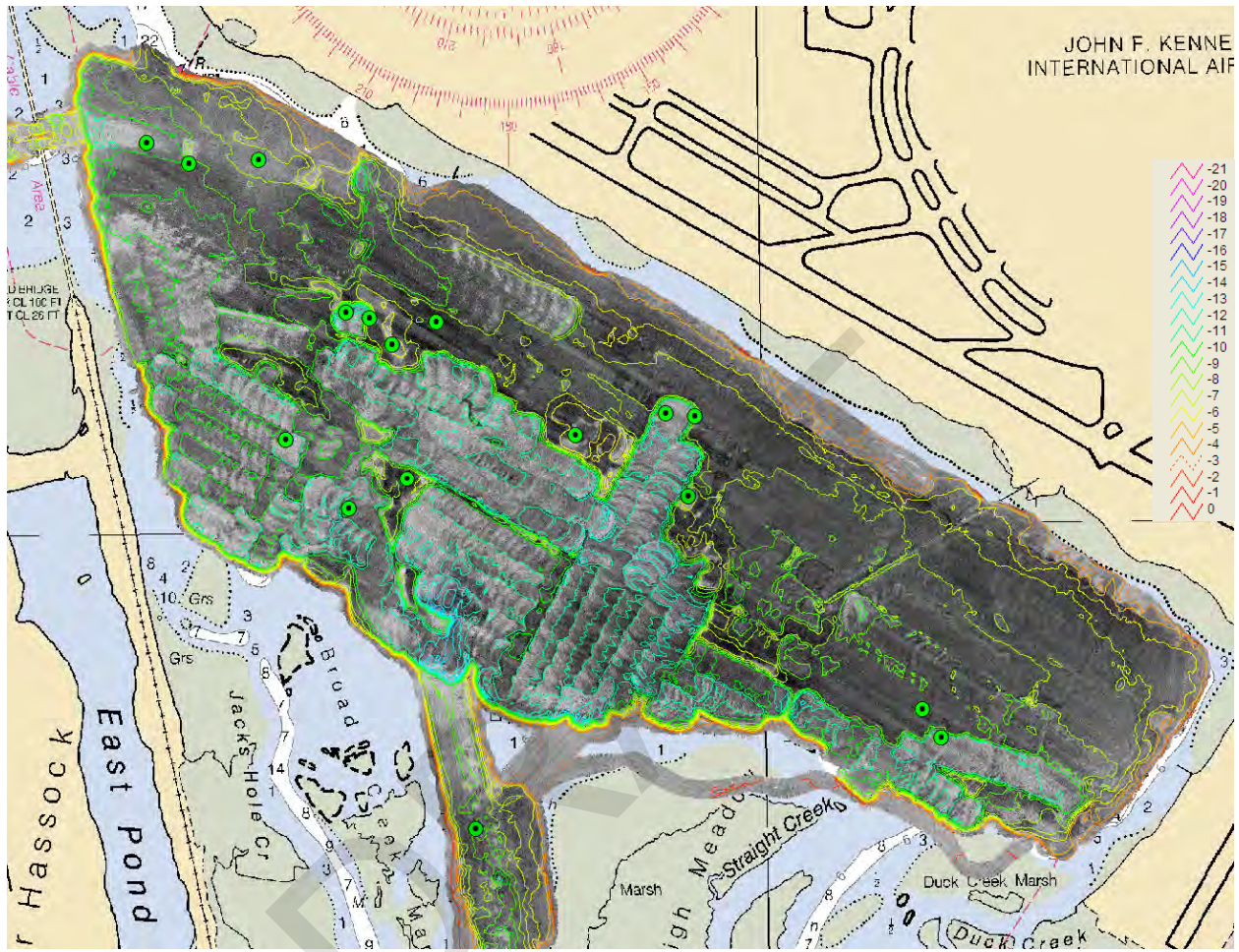


Figure 16.

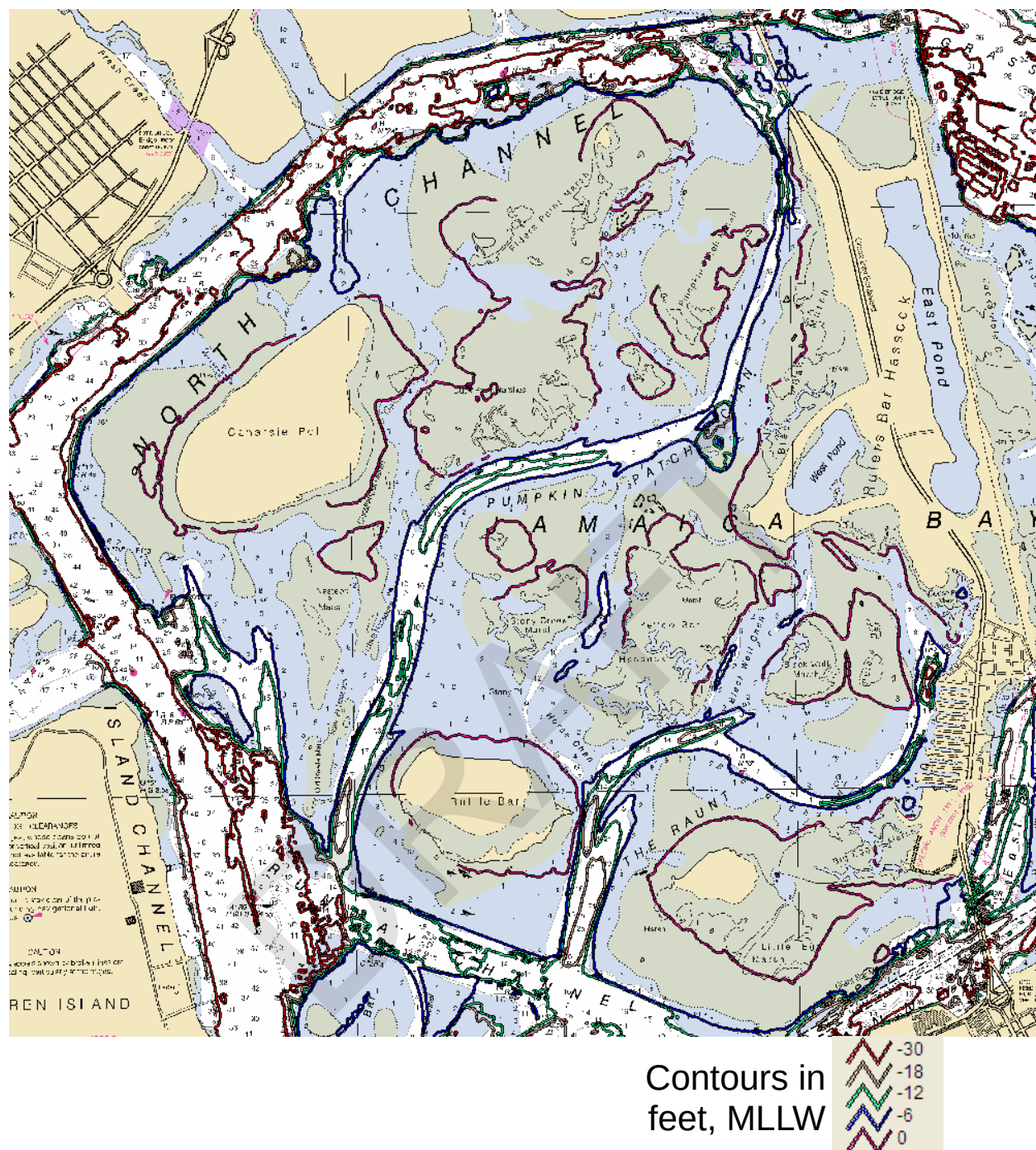


Figure 17.

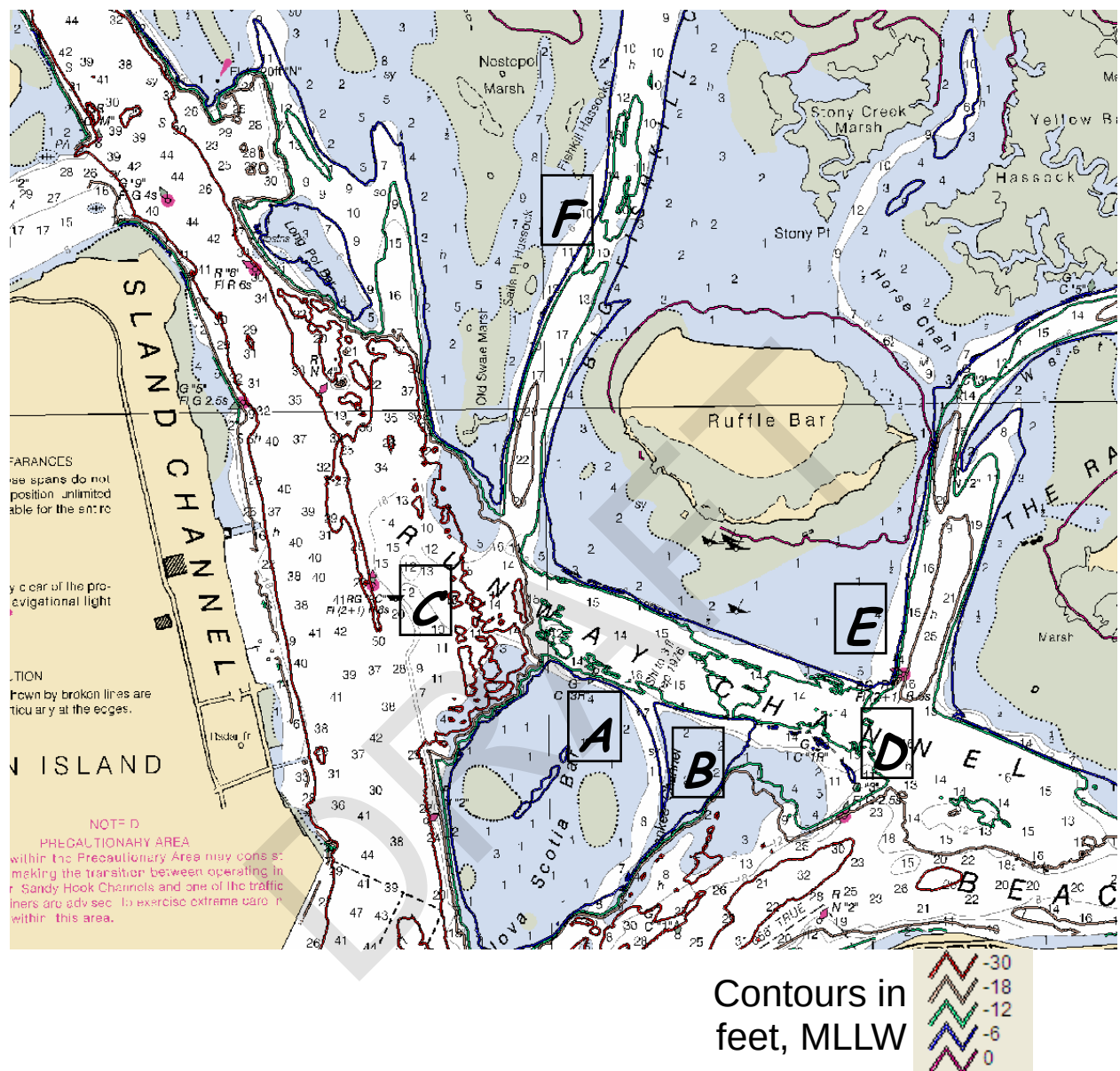


Figure 18.

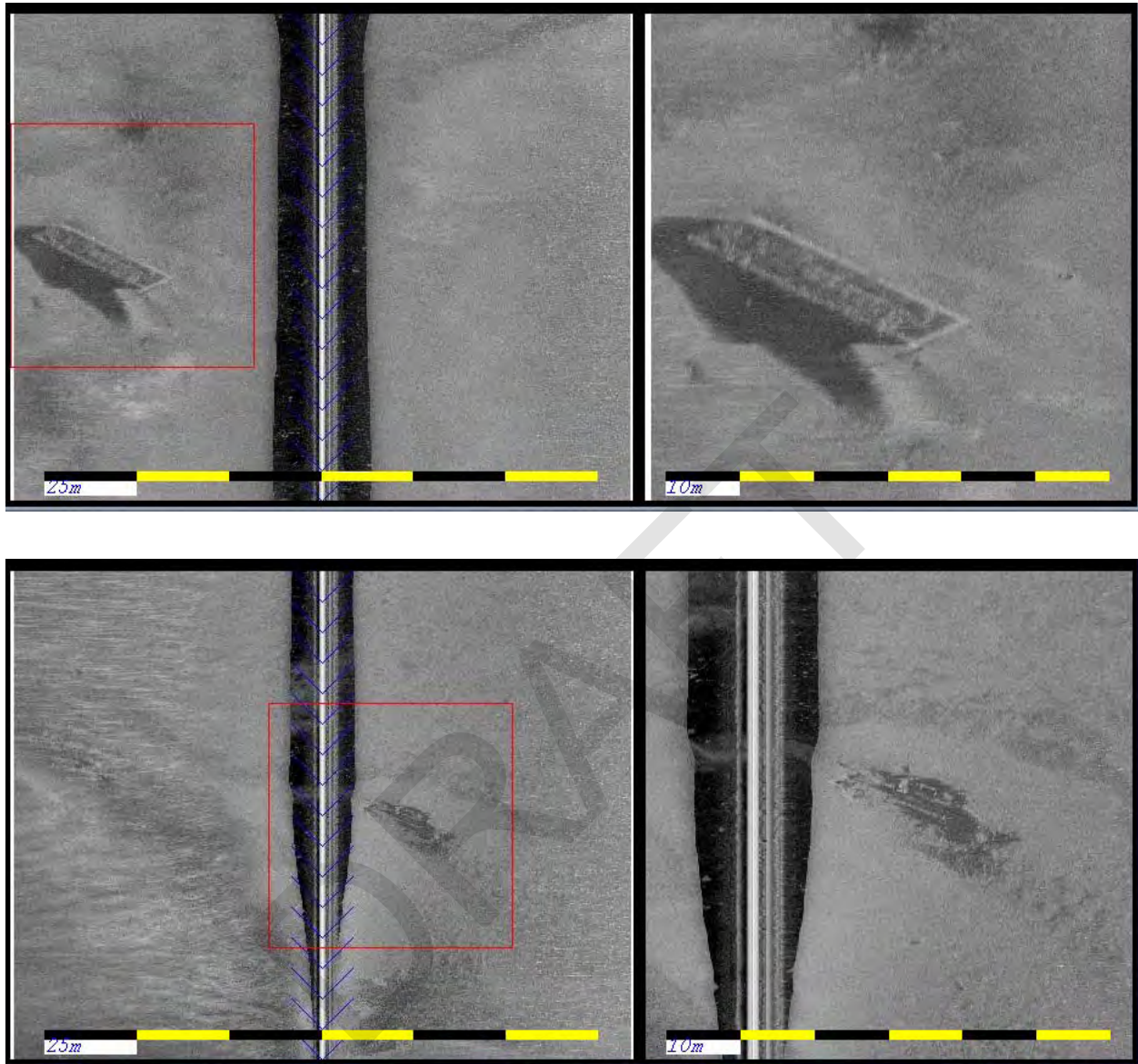


Figure 19.

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Figure 20. Acoustic and Sediment Classification Figure