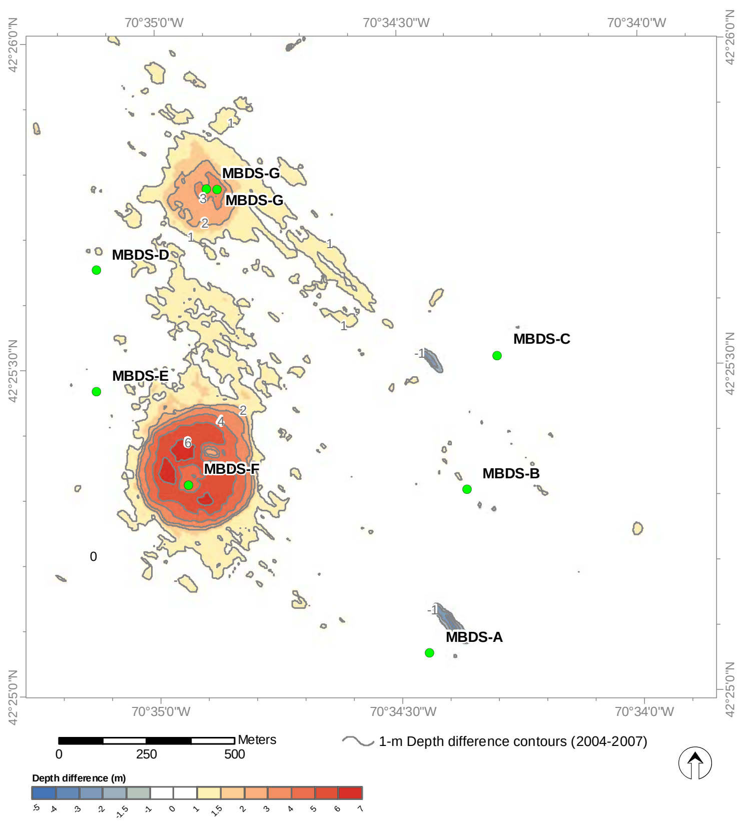
Monitoring Survey at the Massachusetts Bay Disposal Site
August 2007

Disposal Area Monitoring System DAMOS



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13. ABSTRACT

A monitoring survey was conducted in August 2007 at the Massachusetts Bay Disposal Site (MBDS) as part of the Disposal Area Monitoring System (DAMOS). The 2007 field effort consisted of bathymetric and sediment-profile imaging (SPI) surveys and the collection of sediment box cores. The objectives of the surveys were to document the distribution of dredged material across MBDS at historic and recent disposal mounds, to assess the benthic recolonization status of historic disposal mounds MBDS-E and MBDS-F, and to assess baseline sediment characteristics over the southeastern portion of MBDS where a capping demonstration is planned (termed the barrel cap demonstration area or BCDA).

The 2007 multi-beam bathymetric survey covered a 2100 x 3200 m area encompassing the disposal mounds in the northern portion of MBDS and the BCDA in the southeastern portion of MBDS. Since the previous survey in 2004, the MBDS-F Mound received approximately 1.5 million m^3 of dredged material, resulting in an increase in mound height from 4 to 7 m above the seafloor. The disposal of approximately 550,000 m^3 of dredged material since September 2006 at the newly located disposal buoy resulted in the formation of a seventh distinct mound at the site, MBDS-G. The new mound measured 250 m in diameter and 3 m in height.

The 2007 SPI survey was performed at historical disposal mounds MBDS-E and MBDS-F, along with the BCDA and three MBDS reference areas. The results of the SPI survey indicated that recolonization at the MBDS-E Mound had continued as expected, and recolonization at the MBDS-F Mound had proceeded faster than expected, with mature, Stage III communities found at almost every station on both of these mounds and habitat conditions similar to those found at the reference stations. SPI data from the BCDA indicated that overall, it was very similar to the reference areas in terms of sediment composition and physical characteristics as well as benthic community composition.

Sediment box cores were collected at the BCDA to further assess baseline sediment characteristics. Sediment collected from the two cores located closer to the disposal areas were considerably coarser than those near the southeastern boundary of the site that are assumed more similar to native sediments. All cores contained a surficial layer of soft, light-colored clay or elastic silt, underlain by dense and darker material.

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EXECUTIVE SUMMARY

A monitoring survey was conducted in August 2007 at the Massachusetts Bay Disposal Site (MBDS) as part of the Disposal Area Monitoring System (DAMOS). The 2007 field effort consisted of bathymetric and sediment-profile imaging (SPI) surveys and the collection of sediment box cores. The objectives of the surveys were to document the distribution of dredged material across MBDS at historic and recent disposal mounds, to assess the benthic recolonization status of historic disposal mounds MBDS-E and MBDS-F, and to assess baseline sediment characteristics over the southeastern portion of MBDS where a capping demonstration is planned (termed the barrel cap demonstration area or BCDA).

The 2007 multi-beam bathymetric survey covered a 2100 x 3200 m area (approximately 6.7 km^2) encompassing the disposal mounds in the northern portion of MBDS and the BCDA in the southeastern portion of MBDS. Since the previous survey in 2004, the MBDS-F Mound received approximately 1.5 million m^3 of dredged material, resulting in an increase in mound height from 4 to 7 m above the seafloor. Despite nearly doubling in height, the observed diameter of the MBDS-F Mound did not change significantly since the 2004 survey. The disposal of approximately 550,000 m^3 of dredged material since September 2006 at the newly located disposal buoy resulted in the formation of a seventh distinct mound at the site, MBDS-G. The new mound measured 250 m in diameter and 3 m in height. Overall, there were no major differences in bathymetry over the historical mounds compared with the 2004 survey, and no other significant bathymetric changes were observed between 2004 and 2007.

The 2007 SPI survey was performed at historical disposal mounds MBDS-E and MBDS-F, along with the BCDA and three associated MBDS reference areas. The results of the SPI survey indicated that recolonization at the MBDS-E Mound had continued as expected, and recolonization at the MBDS-F Mound had proceeded faster than expected, with mature, Stage 3 communities found at almost every station on both of these mounds and habitat conditions similar to those found at the reference stations. SPI data from the BCDA indicated that overall, it was very similar to the reference areas in terms of sediment composition and physical characteristics as well as benthic community composition. Disposed dredged material was identified in some of the SPI images, particularly at the stations closer to the recent and active disposal areas in the northern portion of MBDS.

Sediment box cores were collected at the BCDA to further assess baseline sediment characteristics. Samples were collected from four stations, including two stations closer to the recent and active disposal areas and two stations near the southeastern boundary of MBDS farther from recorded disposal activity. Sediment collected from the two cores located closer to the disposal areas were considerably coarser than those near the southeastern boundary of the site that are assumed more similar to native sediments. All cores contained a surficial layer of soft, light-colored clay or elastic silt, underlain by dense and darker material.

1.0 INTRODUCTION

A monitoring survey was conducted at the Massachusetts Bay Disposal Site (MBDS) in August 2007 as part of the U.S. Army Corps of Engineers (USACE) New England District (NAE) Disposal Area Monitoring System (DAMOS). DAMOS is a comprehensive monitoring and management program designed and conducted to address environmental concerns associated with use of open-water disposal sites throughout the New England region. An introduction to the DAMOS Program and MBDS, including a brief description of previous dredged material disposal activities and previous monitoring surveys, is provided below.

1.1 Overview of the DAMOS Program

For over 30 years, the DAMOS Program has conducted monitoring surveys at open-water disposal sites throughout New England and evaluated the patterns of physical, chemical, and biological responses of seafloor environments to dredged material disposal activity. The DAMOS Program features a tiered disposal site management protocol designed to ensure that any potential adverse environmental impacts associated with dredged material disposal are promptly identified and addressed (Fredette and French 2004; Germano et al. 1994).

DAMOS monitoring surveys are designed to test hypotheses related to expected physical and ecological response patterns following placement of dredged material on the seafloor at established disposal sites. The data collected and evaluated during DAMOS monitoring surveys provide answers to strategic management questions in determining the next step in the disposal site environmental management process.

Two primary goals of DAMOS monitoring surveys are to document the physical location of dredged material placed on the seafloor and to evaluate the environmental impact of placement of the dredged material. Sequential bathymetric measurements are made to characterize the height and spread of discrete dredged material deposits or mounds created at disposal sites, and sediment-profile imaging (SPI) surveys are performed to support evaluation of seafloor (benthic) habitat conditions and recovery over time. Each type of data collection activity is conducted periodically at disposal sites, and data are evaluated to determine the next step in the disposal site management process. The conditions found after a defined period of disposal activity are compared with the long-term data set at a specific site (Germano et al. 1994). DAMOS monitoring surveys may also feature additional types of data collection activities, such as side-scan sonar, sediment coring, or grab sampling, as deemed appropriate to achieve specific survey objectives.

1.2 Introduction to the Massachusetts Bay Disposal Site

The Massachusetts Bay Disposal Site (MBDS) is centrally located within Massachusetts Bay accessible from Boston Harbor as well as harbors along the northern and southern shorelines of the Bay (Figure 1-1). MBDS was officially designated an ocean dredged material disposal site by the U.S. Environmental Protection Agency (EPA) in 1992 (USEPA 1992; DeAngelo and Murray 1997). MBDS is situated approximately 22.2 km southeast of Gales Point, Manchester, Massachusetts and receives sediments from dredging projects along coastal Massachusetts. The site is circular in shape and occupies a 10.75 km^2 area on the seafloor (Figure 1-1). The site was relocated from the interim disposal site (Foul Area Disposal Site (FADS)), used for the disposal of dredged material from 1977 to 1993, to its current position centered at 42° 24.106' N, 70° 34.969' W (NAD 83) (Figure 1-2). The current location was also selected to avoid the northern part of the Industrial Waste Site (IWS), closed by EPA in 1977, where past disposal of barrels containing low-level radioactive waste and other types of debris and industrial waste had occurred (SAIC 1997a and 1997b).

Water depths at MBDS slope gradually from approximately 82 m along the southwestern boundary towards a shallow depression (approximately 92 m in depth) in the northeast quadrant of the site. North of the depression and outside of the MBDS boundary is a distinct topographic high (approximately 67 m in depth), thought to be a remnant glacial deposit (SAIC 1997a; Figure 1-3).

Since January 1994, the management strategy at MBDS has involved the controlled placement of small to moderate volumes of sediment to form individual disposal mounds arranged around the natural seafloor depression in the northeast quadrant of the site. The goal of this approach is to construct the boundary of a containment cell over time. Once complete, the containment cell may be used to limit the lateral spread of future dredged material or be employed as part of confined aquatic disposal. To date, six dredged material disposal mounds have been constructed within MBDS (MBDS-A through MBDS-F; Figure 1-3). A brief description of the mounds and their origin is provided below in Section 1.3.

The USEPA Region 1 and USACE New England District considered the potential use of sediments from the planned Boston Harbor deepening project to aid in the physical isolation of historical disposed sediments and barreled waste at the old IWS (USACE and MassPort 2008). In order to test the feasibility of such a project, a capping demonstration project was performed at MBDS using sediment from another ongoing Boston Harbor dredging project. The dredging project generated sediments from the creation of additional confined aquatic disposal (CAD) cells in the harbor and additional

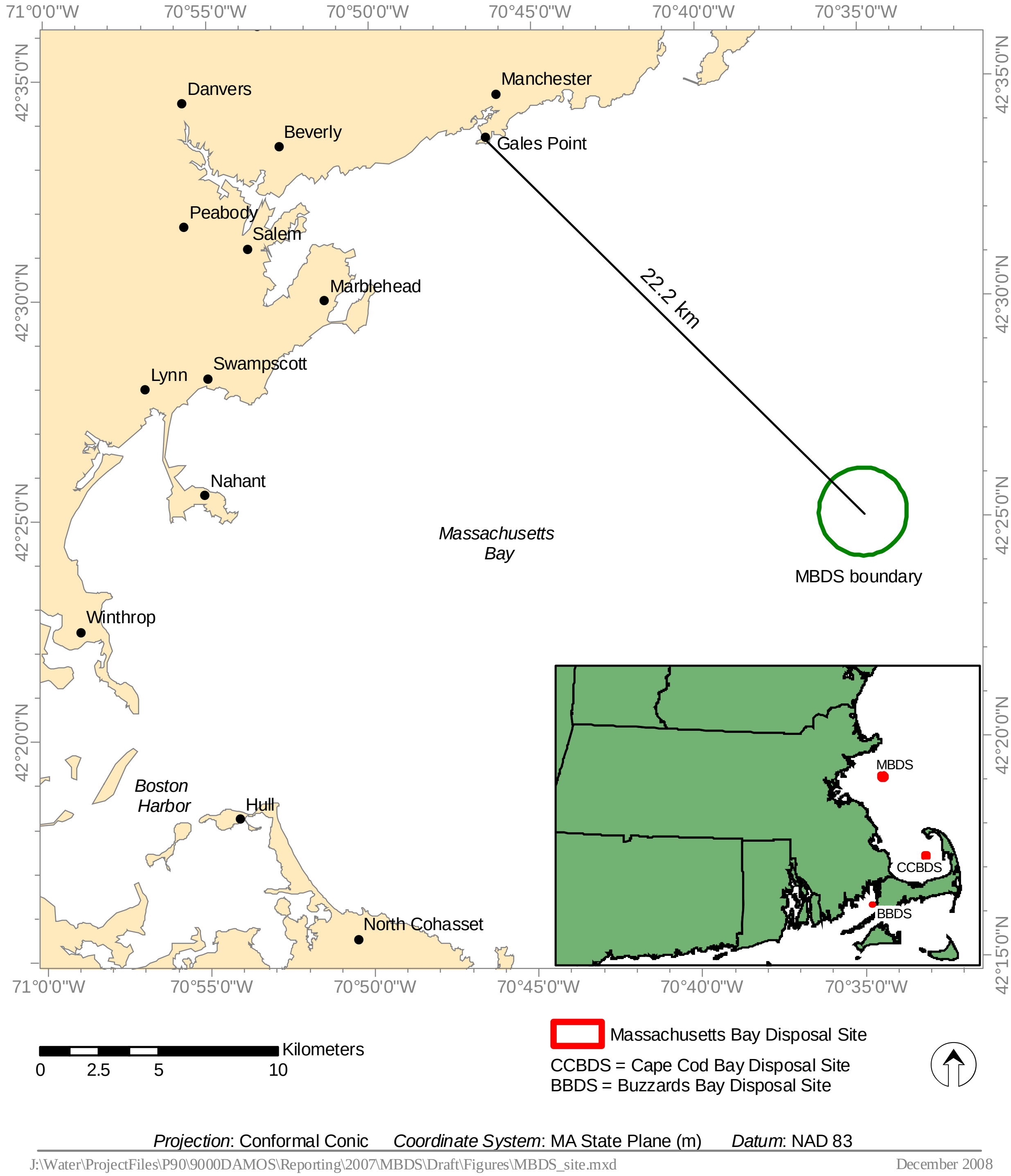

Figure 1-1. Location of the Massachusetts Bay Disposal Site

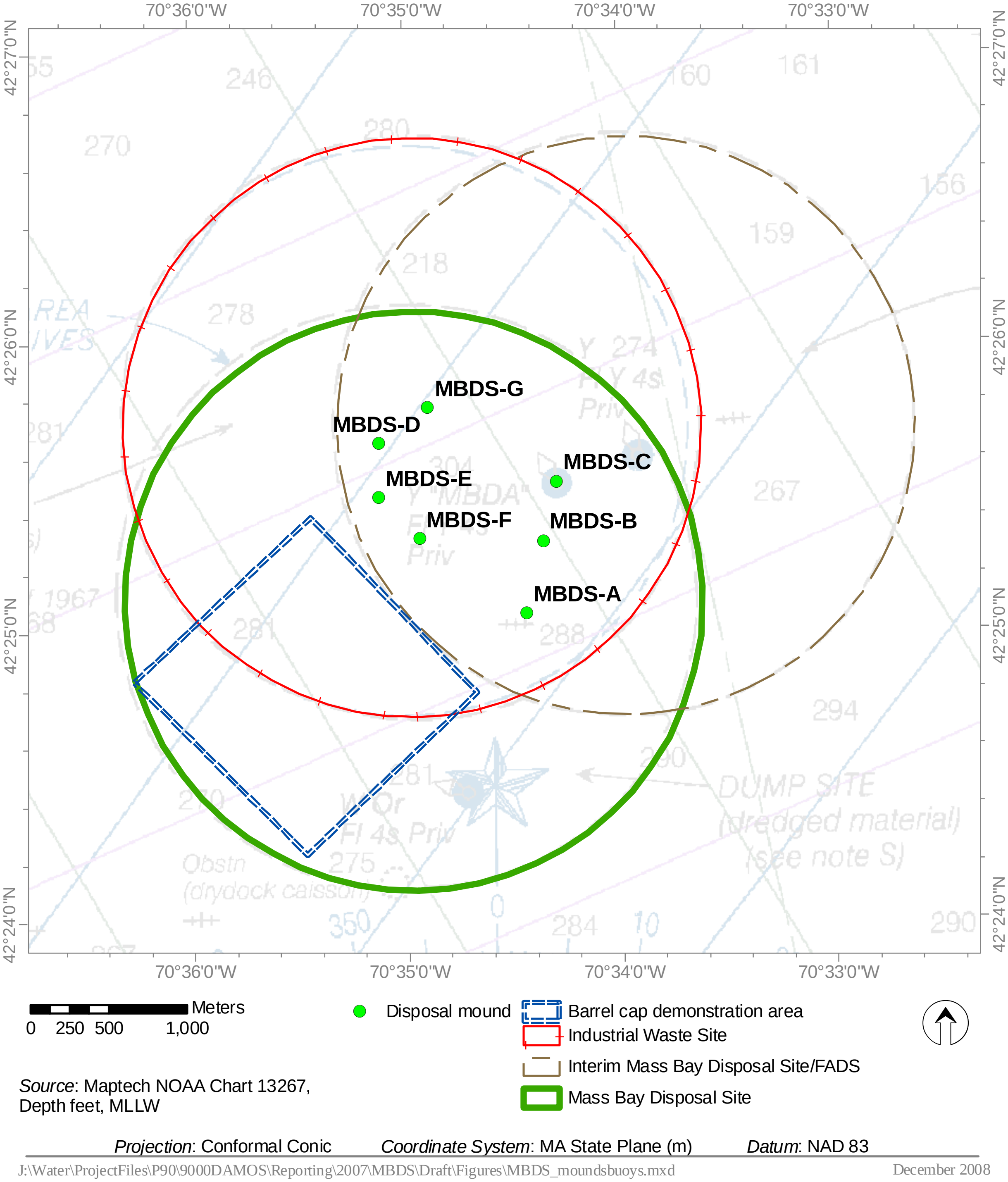

Figure 1-2. MBDS with historical site boundaries, disposal mounds, and BCDA

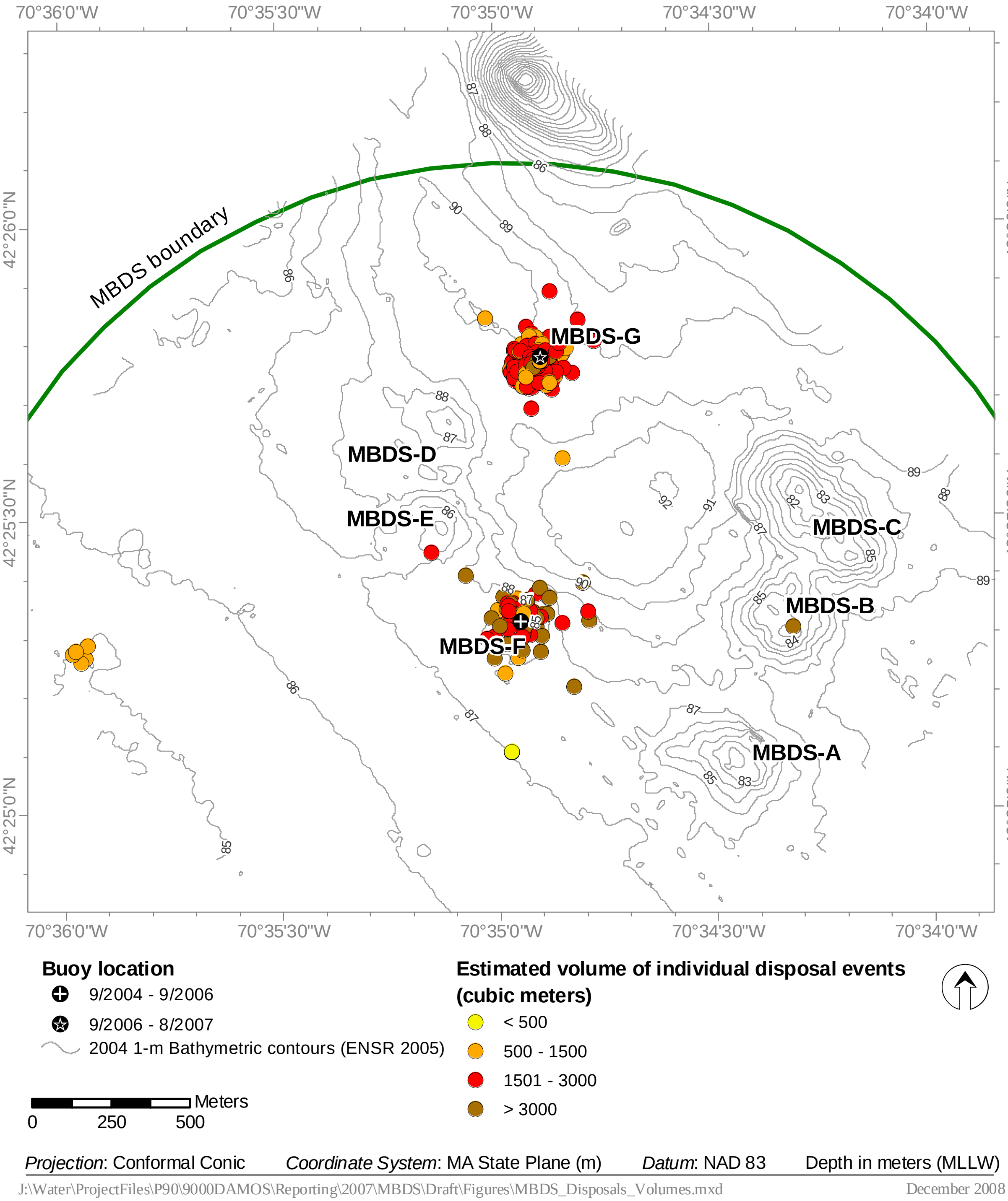

Figure 1-3. MBDS with reported 2004-2007 dredged material disposal events and disposal buoy locations indicated

maintenance material that was determined to be suitable for disposal at MBDS. The southern portion of MBDS was identified as a demonstration area, named the barrel cap demonstration area (BCDA), for developing techniques for capping the historical waste at the IWS (Figure 1-2).

MBDS accepts dredged material year-round; however, most dredging activities occur from September through February. In general, a disposal marker buoy (MDA) is used to identify the current disposal location within the disposal site. The placement of the buoy for each disposal season is based on the amount of material deposited during the previous season and the morphology of the mounds identified during periodic surveys.

The disposal site boundaries of MBDS and other New England disposal sites have been established to provide a management objective for placement of dredged material on the seafloor. Barge operators are given specific coordinates (and often visible lighted buoys) within the disposal boundaries to navigate to and release their cargo of dredged material. In practice, it is expected that disposal will occur in a cluster around the designated disposal location and that some dredged material will be suspended in the water column during release. The Clean Water Act Section 404(b)(1) provides guidelines for the discharge of dredged material and defines the “discharge point” as the point within the disposal site (the bottom surface area and overlying volume of water) at which the dredged material is released. The Marine Protection, Research and Sanctuaries Act Section 102 defines the release zone as a locus of points 100 m around the barge from beginning to end of the discharge. Monitoring surveys are designed with the recognition that the site boundary is a target area for release at the water’s surface, and that during placement and descent some dredged material may extend across the boundary on the seafloor.

1.3 Historical Dredged Material Disposal Activity

MBDS has been used regularly as a regional disposal site for 15 years, receiving over 8.5 million m^3 of dredged material. Six distinct disposal mounds have been developed on the seafloor in the northern half of MBDS (MBDS-A through MBDS-F; Figure 1-3). Development of the sixth mound, MBDS-F, was confirmed during the most recent survey in 2004 (ENSR 2005).

The MBDS-A Mound was formed from the disposal of fine-grained material, including consolidated clay, originating from the Third Harbor Tunnel Project between 1992 and 1994. The MBDS-B Mound was formed from the disposal of sediment dredged from channels and harbors in the region from December 1994 through November 1998. The three subsequent disposal mounds (MBDS-C, MBDS-D and MBDS-E) were constructed over a short period of time (1998-2000), consisting primarily of Boston Blue Clay (BBC) dredged as part of the Boston Harbor Navigation Improvement Project. The MBDS-C Mound is the largest of the disposal mounds, formed by the placement of nearly 1.4 million m^3 of dredged material between November 1998 and August 1999. The MBDS-D Mound is the smallest mound, formed by the disposal of approximately 386,000 m^3 of dredged material from Boston Harbor placed at the site over a 2.5-month period (August – October 1999). The fifth mound, MBDS-E, resulted from the disposal of over 750,000 m^3 of dredged material from October 1999 through June 2000. A sixth mound, MBDS-F, was initiated in September 2000, and received just over 2.0 million m^3 of dredged material between September 2000 and August 2007. There has also been approximately 550,000 m^3 of dredged material deposited 400 m to the northeast of mound MBDS-D since September 2006 (Figure 1-3).

1.4 Previous MBDS Monitoring Events

Monitoring surveys have been conducted at or near the site that is currently known as MBDS since 1987. A list of monitoring events that have occurred since MBDS was designated by EPA in 1992 is presented in Table 1-1. Mounds at MBDS have been monitored individually to assess stability, thickness of dredged material, and benthic recolonization status relative to previous survey results and in comparison with nearby reference areas.

Previous DAMOS monitoring surveys at MBDS were conducted in 2004 (ENSR 2005), 2000 (SAIC 2002), 1998/1999 (SAIC 2003), 1994 (SAIC 1997a) and 1993 (SAIC 1997b). The 1993 survey was the baseline survey for the reconfigured MBDS, conducted to delineate the topography and sediment composition of the site for DAMOS management. Bathymetry, side-scan sonar, and sediment acoustic characterization surveys were performed in addition to sediment collection for grain size and chemical analyses. Results of the 1993 baseline survey indicated that the newly designated MBDS could be separated into two distinct areas: the southwestern area where no documented disposal had occurred and the northeastern portion where dredged material had been disposed and one dredged material disposal mound was already evident (MBDS-A).

Previous chemistry data collected during a 1989 survey of the interim MBDS indicated that elevated levels of PAHs were present in the sediments near the center of the current MBDS (Murray 1994). Results from the 1993 survey confirmed the presence of relatively high levels of metal and organic contaminants at the center of the site and that concentrations decreased with radial distance away from the center (SAIC 1997b).

Table 1-1
Overview of Survey Activities at MBDS since 1993

Date	Purpose of Survey	Bathymetry Area (m x m)	# SPI Stations	Sediment Grabs (#) and Analyses	Additional Studies	DAMOS Contribution No.
9/1993	Baseline of reconfigured site	4000 x 4075 Single beam		Grain size, metals, PAHs, pesticides, PCBs, TOC (26)	Side-scan	115
8/1994	Periodic site monitoring		76			116
9/1998	Capping demonstration – baseline	800 x 800 Single beam	91	Grain size, color, consistency, other (13)	Side-scan	147
12/1998	Capping demonstration - single-barge	800 x 800 Single beam	82		Side-scan	147
3/1999	Pre-capping demonstration	800 x 800 Single beam	30	Grain size, color, consistency, other (13)	Side-scan	147
9/2000	Post-capping demonstration	800 x 800 Single beam	33	Grain size, tracers	Side-scan, sediment cores (12)	147
Fall 2000	Periodic site monitoring	2400 x 2400 Single beam	39			134
9/2004	Periodic site monitoring	2400 x 2400 Multi-beam	45			162

The 1994 survey at MBDS included sediment-profile and plan-view image collection to assess the recolonization status of recently disposed material, determine the areal extent of historical dredged material, and investigate the successional status and benthic conditions around the area where elevated levels of PAHs and other contaminants were found in 1989 and 1993. Results of the 1994 survey at MBDS indicated that the area of recent disposal (MBDS-A) was supporting a relatively advanced benthic community with Stage 1 organisms at the surface and burrowing Stage 3 organisms at depth. Furthermore, although some sediments did show signs of organic eutrophication (high sediment oxygen demand [SOD] and thin redox potential discontinuity [RPD] intervals), overall results indicated a highly developed Stage 3 community (SAIC 1997a).

The 1998/1999 MBDS survey was focused over the southern portion of MBDS, away from areas of active disposal, as part of the Massachusetts Bay Disposal Capping Demonstration Project. The objective was to evaluate the feasibility of effectively capping a discrete mound of sediment at a deep water site (90 m). Dredging needs analyses at the time indicated that large volumes of sediment would need to be dredged in the near future, a percentage of which was expected to be considered unsuitable for unconfined open water disposal due to elevated levels of contaminants. Subaqueous capping had proven to be an environmentally and economically sound method of managing large volumes of unacceptably-contaminated dredged material (UDM) in the shallow waters of Long Island Sound (20 m) and the moderate water depths of Portland Disposal Site (65 m) (Fredette 1994). However, capping at deeper water disposal sites (>65 m) remained unexplored. Sediments from Cohasset Harbor and Chelsea River, both considered suitable for unconfined open water disposal, were deposited at MBDS as part of the Capping Demonstration Project. Dredged material from Cohasset Harbor was deposited to form the base and was capped with dredged material from the Chelsea River. The dredged material from these two different sources (Cohasset and Chelsea) displayed sufficient visual distinction to identify the source of the material after disposal and capping activities were complete. Single-beam bathymetry, side-scan sonar, sediment profile imaging (SPI), sediment grabs, and core surveys were conducted to document the development of a layered deposit consisting of distinct sediment strata on the MBDS seafloor. Overall, the project showed that dredged material could be effectively placed, capped, and monitored in the deeper waters of MBDS (SAIC 2003).

The 2000 survey at MBDS centered on the northern extent of the disposal area and included a single-beam bathymetric survey and SPI survey. Analysis of the 2000 bathymetric data confirmed the formation of four new mounds (MBDS-B, MBDS-C, MBDS-D, and MBDS-E) from the disposal of dredged material between 1993 and 2000. The objective of the SPI survey was to evaluate benthic habitat conditions over two disposal mounds (MBDS-B and MBDS-C) and two reference areas (FG23 and SEREF). Results indicated that both mounds were recovering as expected, supporting Stage 1 organisms at the sediment surface and Stage 3 organisms at depth. The benthic community at the MBDS-B Mound was slightly more advanced than that found at the more recently formed MBDS-C Mound, suggesting that conditions over the surface of the MBDS-B Mound were more conducive for burrowing infauna given the increased time following disturbance. It was concluded that benthic recovery and establishment of Stage 3 deposit-feeding communities took somewhat longer than expected in response to disturbance due to the cohesive nature and lower organic carbon content of the BBC (Rhoads et al. 1978). It was anticipated that as time progressed, benthic conditions at the MBDS-C Mound would show continued improvement. Future monitoring at MBDS-C Mound was recommended in order to track the continued recovery of benthic habitat conditions.

The most recent monitoring survey conducted at MBDS was in September 2004 and included a multi-beam bathymetric survey and sediment-profile imaging survey (ENSR 2005). The 2004 survey was focused on the northern portion of the disposal site and was conducted to document changes in seafloor topography, assess the benthic recolonization status of historical disposal mounds MBDS-C and MBDS-D, and confirm the formation of the MBDS-F Mound. The 2004 multi-beam bathymetric survey covered a 2400 X 2400 m area and confirmed the formation of a new mound (MBDS-F) from the disposal of 560,000 m^3 of dredged material between 2000 and 2004. The 2004 SPI survey evaluated benthic habitat conditions over two historical disposal mounds (MBDS-C and MBDS-D) and three reference areas (FG23, SEREF, and MBDREF). The SPI survey results indicated that both mounds exhibited benthic community structures similar to reference area conditions and had fully recovered in the five years since the most recent disposal activities.

1.5 Recent Dredged Material Disposal Activity

Since the September 2004 survey, a total of approximately 2.0 million m^3 of dredged material has been placed at two disposal buoy locations within MBDS. The majority of this material (1.5 million m^3) was placed between September 2004 and September 2006 to further the development of the MBDS-F Mound. The material deposited during the 2004–2006 disposal seasons originated primarily from maintenance dredging in Boston Harbor with small contributions from the Marina Bay & Dorchester Yacht Club (approximately 13,000 m^3), Weymouth Fore River (approximately 13,000 m^3) and the Point of Pines Yacht Club (approximately 1,000 m^3). The remainder of the material (approximately 550,000 m^3) was deposited between September 2006 and August 2007 at the disposal buoy, which was repositioned approximately 350 m to the northeast of the MBDS-D Mound (Figure 1-3, Table 1-2). The material deposited during the 2006–2007 disposal season originated from dredging in the Weymouth and Weymouth Fore Rivers (approximately 288,000 m^3), Salem Harbor (approximately 259,000 m^3), Dorchester Bay (approximately 13,000 m^3) and the Annisquam River (approximately 7,000 m^3). A detailed record of barge disposal activity at MBDS for the period from September 2004 to August 2007, including the origin of dredged material, the volume deposited, and the disposal location, is provided in Appendix A.

1.6 Survey Objectives

The objectives of the August 2007 MBDS survey were to:

- Document the distribution of dredged material across a 2100 x 3200 m area of MBDS using multi-beam bathymetry,
- Assess the benthic recolonization status of disposal mounds MBDS-E and MBDS-F using sediment-profile imaging, and
- Provide a baseline description of sediments at the BCDA prior to the planned capping demonstration project using multi-beam bathymetry, sediment-profile imaging, and collection of sediment box cores for evaluation of the impact of the capping demonstration material on ambient sediment.

The design of the August 2007 survey allowed assessment of the following expectations:

- The placement of approximately 1.5 million m^3 of dredged material at the disposal buoy between September 2004 and September 2006 will result in the continued development of the MBDS-F Mound;
- The placement of approximately 550,000 m^3 of dredged material at the repositioned disposal buoy between September 2006 and August 2007 will result in the formation of a new mound to the northeast of the MBDS-D Mound;
- Mounds created in past years will show limited change in elevation except for the most recently created mounds, which should show some evidence of continued consolidation;
- As the MBDS-E Mound has not received significant dredged material in more than six years (only 5,000 m^3 since January 2001), it is expected that the benthic community will include Stage 3 taxa and will display conditions comparable to those found at the reference areas;
- Due to the high volume of dredged material recently disposed at the MBDS-F Mound, early community assemblages (Stage 1 or 2) will dominate; and
- Because disposals have not been directed to the BCDA since the establishment of specific disposal points in Massachusetts Bay in 1979, the benthic biological status and sediment composition of the BCDA will be similar to those found at the reference areas.

Table 1-2
Overview of Recent Disposal Activity at MBDS (9/16/2004 – 8/7/2007)

Source Project	**Estimated Scow Volume Disposed (m^3)**			
	9/16/04 - 12/31/04	2005	2006	1/1/07 - 8/7/07
Annisquam River	--	--	6,830	--
Boston Harbor	459,983	1,041,527	--	--
Dorchester Bay	--	--	--	12,539
Marina Bay & Dorchester Yacht Club	--	13,304	--	--
Point of Pines Yacht Club	841	--	--	--
Salem Harbor	--	--	195,871	63,385
Weymouth Fore River	12,692	--	--	3,869
Weymouth River	--	--	109,369	174,336
Total	473,516	1,054,831	312,070	254,129
Grand Total	2,094,546			

2.0 METHODS

A team of investigators from AECOM, CR Environmental, and Germano and Associates performed the August 2007 survey at MBDS. The bathymetry survey was conducted 7 August 2007 to assess dredged material distribution at MBDS. The sediment profile imaging (SPI) survey was conducted 22-24 August 2007 to assess benthic conditions at the MBDS-E and MBDS-F Mounds and the BCDA. Sediment box cores were collected on 24 August 2007 to document sediment characteristics within the BCDA. Field activities are summarized in Table 2-1, and an overview of the methods used to collect, process, and analyze the survey data is provided below. A more detailed description of methodology and the related terminology can be found in ENSR (2004).

2.1 Navigation and On-Board Data Acquisition

Positional data, comprised of horizontal positioning (x- and y-dimensional data) and time (t-dimensional data), were collected using a Trimble AG-132 Differential Global Position System (DGPS) unit. This system received and processed satellite and land-based beacon data and provided real-time vessel position, typically to sub-meter accuracy. HYPACK® hydrographic survey software, developed by HYPACK®, Inc. (formerly Coastal Oceanographics, Inc.), was used to acquire, integrate, and store all positional data from the DGPS as well as bathymetric and station data. The GPS receiver installed on the survey vessel was interfaced with the onboard navigation computer running HYPACK® software providing the field team with the ability to precisely navigate the vessel throughout the survey area and along the pre-selected survey tracklines for the bathymetry survey and to the target stations for the SPI survey.

2.2 Bathymetry

Bathymetric surveys provide measurements of water depth that, when processed, can be used to map the seafloor topography. The processed data can also be compared with previous surveys to track changes in the size and location of seafloor features. This technique is the primary tool in the DAMOS Program for mapping the distribution of dredged material at disposal sites.

2.2.1 Bathymetric Data Collection

The 2007 multi-beam bathymetric survey was designed to cover a 2100 x 3200 m area representing approximately 6.7 km^2 of the northern portion of MBDS and the BCDA (Figure 2-1). The survey was conducted 7 August 2007 aboard the F/V *Shanna Rose*.

Table 2-1
August 2007 MBDS Field Activities Summary

Survey Type	Date	Summary
Multi-beam Bathymetry and Acoustic Backscatter	7 August 2007	Area: 2100 x 3200 m Lines: 16 Spacing: 125 m
Sediment-Profile Imaging	22-24 August 2007	Stations: 63 MBDS-E: 15 MBDS-F: 15 BCDA: 18 FG23 Reference: 5 MBDREF Reference: 5 SEREF Reference: 5
Sediment Box Coring	24 August 2007	Box Cores: 4

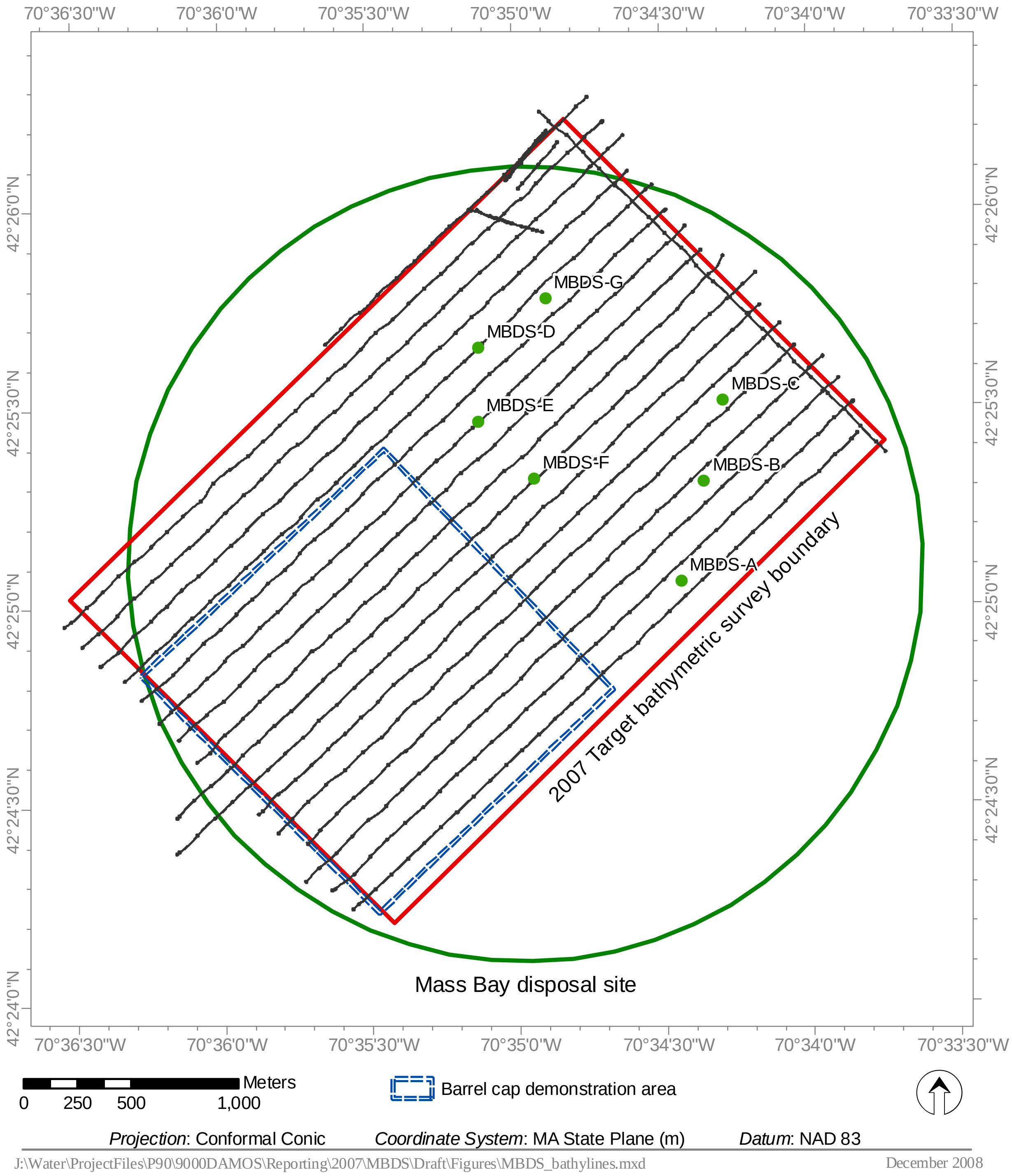

Figure 2-1. MBDS with bathymetric survey boundary and survey lines indicated, August 2007

A total of 16 survey lines, each approximately 125 m apart and oriented in a northeast-southwest direction, were occupied as part of the survey. One additional line was run in a northwest-southeast direction to assess data quality.

The bathymetric data were collected using a Reson 8125 Ultra High Resolution Echo Sounder outfitted with a 0.5°, 455-kHz transducer. Sediment acoustic backscatter data, in the form of side-scan imagery, were also collected. A gyro compass was used to provide accurate measurement of heave, pitch and roll. The system was calibrated for local water mass speed of sound by performing conductivity-temperature-density (CTD) casts at frequent intervals throughout the day with a Seabird SBE-19 Seacat CTD profiler.

Water depths over the survey area were recorded in meters and referenced to mean lower low water (MLLW) based on local tidal data recorded at a project benchmark established at Boston Harbor Light using an In-Situ, Inc. Mini-Troll pressure transducer. Bathymetric data were recorded and stored within Hysweep®, a module of HYPACK®, used to collect, display, and edit data from multi-beam echosounder systems. Hysweep® also recorded acoustic backscatter, depth, vessel heave, heading, position, and time along each survey transect line.

2.2.2 Bathymetric Data Processing

The bathymetric data were processed using the HYPACK® software program and included corrections for tidal conditions, local speed of sound, and spurious data points. Tidal correction consisted of transforming the raw measurements of depth below the transducer to seafloor elevation measurements relative to MLLW using the locally collected tidal elevation data. Heave data supplied by the vessel's motion reference unit (MRU) were incorporated into the raw data to minimize the effects of vessel motion. The bathymetric data were also reviewed for spurious data points (clearly unrealistic measurements resulting from signal interference), and these points were removed. The final data set was averaged into 1.0-m^2 bins. All soundings located within a given bin were averaged, and the average value was assigned to the coordinates at the center of the bin.

2.2.3 Bathymetric Data Analysis

Bathymetric data were analyzed to document the distribution of dredged material at MBDS and evaluate changes in seafloor topography in comparison with previous surveys. The corrected bathymetric data were analyzed using a combination of the contouring and surface plotting software program, Surfer® 8.0 and the geographic information system software program, ArcGIS Desktop® 9.2. The processed bathymetric data were converted into grids using Surfer®, and bathymetric contour lines were generated and displayed using ArcGIS Desktop®.

Surfer® was also used to calculate a depth difference grid based on the September 2004 and August 2007 bathymetric data sets. The depth difference grid was calculated by subtracting the 2004 interpolated depth estimates from the 2007 survey depth estimates at each point throughout the grid. The resulting depth differences were contoured and displayed using ArcGIS Desktop®.

2.3 Sediment-Profile Imaging

Sediment-profile imaging (SPI) is a monitoring technique used to provide data on the physical characteristics of the seafloor as well as the status of the benthic biological community. The technique involves deploying an underwater camera system that photographs a cross section of the sediment-water interface. Acquisition of high-resolution sediment-profile images was accomplished using a Nikon D100 digital single-lens reflex camera mounted inside an Ocean Imaging Model 3731 pressure housing system. The pressure housing sat a top a wedge-shaped prism with a front faceplate and a back mirror. The mirror was mounted at a 45° angle to reflect the profile of the sediment-water interface. As the prism penetrated the seafloor, a trigger activated a time-delay circuit that fired an internal strobe to obtain a cross-sectional image of the upper 15 to 20 cm of the sediment column. The camera remained on the seafloor for approximately 20 sec to ensure that a successful image had been obtained.

Test exposures of the Kodak® Color Separation Guide (Publication No. Q-13) were made on deck at the beginning and end of each survey to verify that all internal electronic systems were working to design specifications and to provide a color standard against which final images could be checked for proper color balance. After deployment of the camera at each station, the frame counter was checked to ensure that the requisite number of replicates had been obtained. In addition, a prism-penetration depth indicator on the camera frame was checked to verify that the optical prism had actually penetrated the bottom to a sufficient depth. If images were missed or the penetration depth was insufficient, the camera frame stop collars were adjusted and/or weights were added or removed, and additional replicate images were taken. Changes in prism weight amounts, the presence or absence of mud doors (to limit over-penetration in soft sediments), and frame stop collar positions were recorded for each replicate image.

Each image was assigned a unique time stamp in the digital file attributes by the camera's data logger and cross-checked with the time stamp in the navigational system's computer data file. In addition, the field crew kept redundant written sample logs. Images were downloaded periodically to verify successful sample acquisition and/or to assess the type of sediment/depositional layer present at a particular station. Digital image files were re-named with the appropriate station name immediately after downloading as a further quality assurance step.

2.3.1 SPI Data Collection

The sediment-profile imaging survey was conducted 22-24 August 2007 aboard the F/V *Shanna Rose*. At each station, the vessel was positioned at the target coordinates, and the camera was deployed within a defined station tolerance of 10 m. Three replicate images were collected at each of the 63 stations.

The 2007 SPI survey design included 63 stations: 30 stations located over MBDS disposal mounds, 15 stations distributed within three reference areas, and 18 stations within the BCDA (Table 2-2, Figure 2-2, Figure 2-3). The 30 stations located over MBDS mounds were distributed as follows: 15 stations at the MBDS-E Mound and 15 stations at the MBDS-F Mound. Stations were randomly distributed across each of these mounds. Three previously established reference areas (FG23, MBDREF, and SEREF), located south and southeast of the disposal site, were also surveyed to provide a basis of comparison between MBDS sediment conditions and the ambient sediment conditions in Massachusetts Bay. Five reference stations were selected randomly within a 300-m radius of the centers of each of the three references areas (Table 2-2, Figure 2-3). Fifteen stations were also established in a grid pattern within the BCDA. Three additional stations were surveyed in areas of expected historical disposal activity based on previous survey data (Figure 2-2).

2.3.2 SPI Data Analysis

Computer-aided analysis of the resulting images provides a set of standard measurements that can be compared between different locations and different surveys. The DAMOS Program has successfully used this technique for over 30 years to map the distribution of disposed dredged material and to monitor benthic recolonization at disposal sites.

Following completion of data collection, the digital images were analyzed using Bersoft Image Measurement© software version 3.06 (Bersoft, Inc.). Images were first adjusted in Adobe Photoshop® to expand the available pixels to their maximum light and dark threshold range. Linear and area measurements were recorded as number of pixels and converted to scientific units using the Kodak® Color Separation Guide for measurement calibration. Detailed records of all SPI results are included in Appendix B.

Table 2-2

MBDS SPI Target Sampling Locations

Station	Latitude (N)	Longitude (W)	Station	Latitude (N)	Longitude (W)
MBDS-F-1	42° 25.373'	70° 34.954'	FG23-1	42 22.723'	70° 34.624'
MBDS-F-2	42° 25.297'	70° 35.000'	FG23-2	42° 22.663'	70° 34.613'
MBDS-F-3	42° 25.350'	70° 34.850'	FG23-3	42° 22.698'	70° 34.479'
MBDS-F-4	42° 25.328'	70° 34.932'	FG23-4	42° 22.779'	70° 34.536'
MBDS-F-5	42° 25.298'	70° 34.896'	FG23-5	42° 22.671'	70° 34.541'
MBDS-F-6	42° 25.330'	70° 34.847'	MBDREF-1	42° 22.715'	70° 30.307'
MBDS-F-7	42° 25.388'	70° 34.898'	MBDREF-2	42° 22.679'	70° 30.319'
MBDS-F-8	42° 25.316'	70° 34.861'	MBDREF-3	42° 22.745'	70° 30.341'
MBDS-F-9	42° 25.409'	70° 34.967'	MBDREF-4	42° 22.711'	70° 30.170'
MBDS-F-10	42° 25.329'	70° 34.983'	MBDREF-5	42° 22.677'	70° 30.354'
MBDS-F-11	42° 25.315'	70° 34.919'	SEREF-1	42° 19.967'	70° 28.028'
MBDS-F-12	42° 25.391'	70° 34.972'	SEREF-2	42° 20.042'	70° 27.892'
MBDS-F-13	42° 25.273'	70° 34.949'	SEREF-3	42° 19.994'	70° 27.871'
MBDS-F-14	42° 25.361'	70° 34.900'	SEREF-4	42° 19.955'	70° 27.919'
MBDS-F-15	42° 25.388'	70° 34.943'	SEREF-5	42° 19.990'	70° 27.877'
MBDS-E-1	42° 25.467'	70° 35.179'	DEMO-1	42° 24.577'	70° 35.818'
MBDS-E-2	42° 25.473'	70° 35.167'	DEMO-2	42° 24.834'	70° 35.068'
MBDS-E-3	42° 25.479'	70° 35.097'	DEMO-3	42° 25.006'	70° 35.157'
MBDS-E-4	42° 25.491'	70° 35.068'	DEMO-11	42° 25.357'	70° 35.435'
MBDS-E-5	42° 25.526'	70° 35.121'	DEMO-12	42° 25.226'	70° 35.636'
MBDS-E-6	42° 25.510'	70° 35.141'	DEMO-13	42° 25.086'	70° 35.845'
MBDS-E-7	42° 25.548'	70° 35.126'	DEMO-14	42° 25.952'	70° 36.046'
MBDS-E-8	42° 25.505'	70° 35.089'	DEMO-15	42° 24.818'	70° 36.243'
MBDS-E-9	42° 25.520'	70° 35.077'	DEMO-21	42° 25.068'	70° 35.061'
MBDS-E-10	42° 25.531'	70° 35.197'	DEMO-22	42° 25.931'	70° 35.262'
MBDS-E-11	42° 25.463'	70° 35.119'	DEMO-23	42° 24.797'	70° 35.467'
MBDS-E-12	42° 25.456'	70° 35.137'	DEMO-24	42° 24.660'	70° 35.668'
MBDS-E-13	42° 25.474'	70° 35.138'	DEMO-25	42° 24.523'	70° 35.869'
MBDS-E-14	42° 25.443'	70° 35.166'	DEMO-31	42° 24.773'	70° 34.687'
MBDS-E-15	42° 25.503'	70° 35.144'	DEMO-32	42° 24.636'	70° 34.888'
			DEMO-33	42° 24.502'	70° 35.085'
			DEMO-34	42° 24.368'	70° 35.290'
			DEMO-35	42° 24.231'	70° 35.491'

Notes: Coordinate system NAD 83

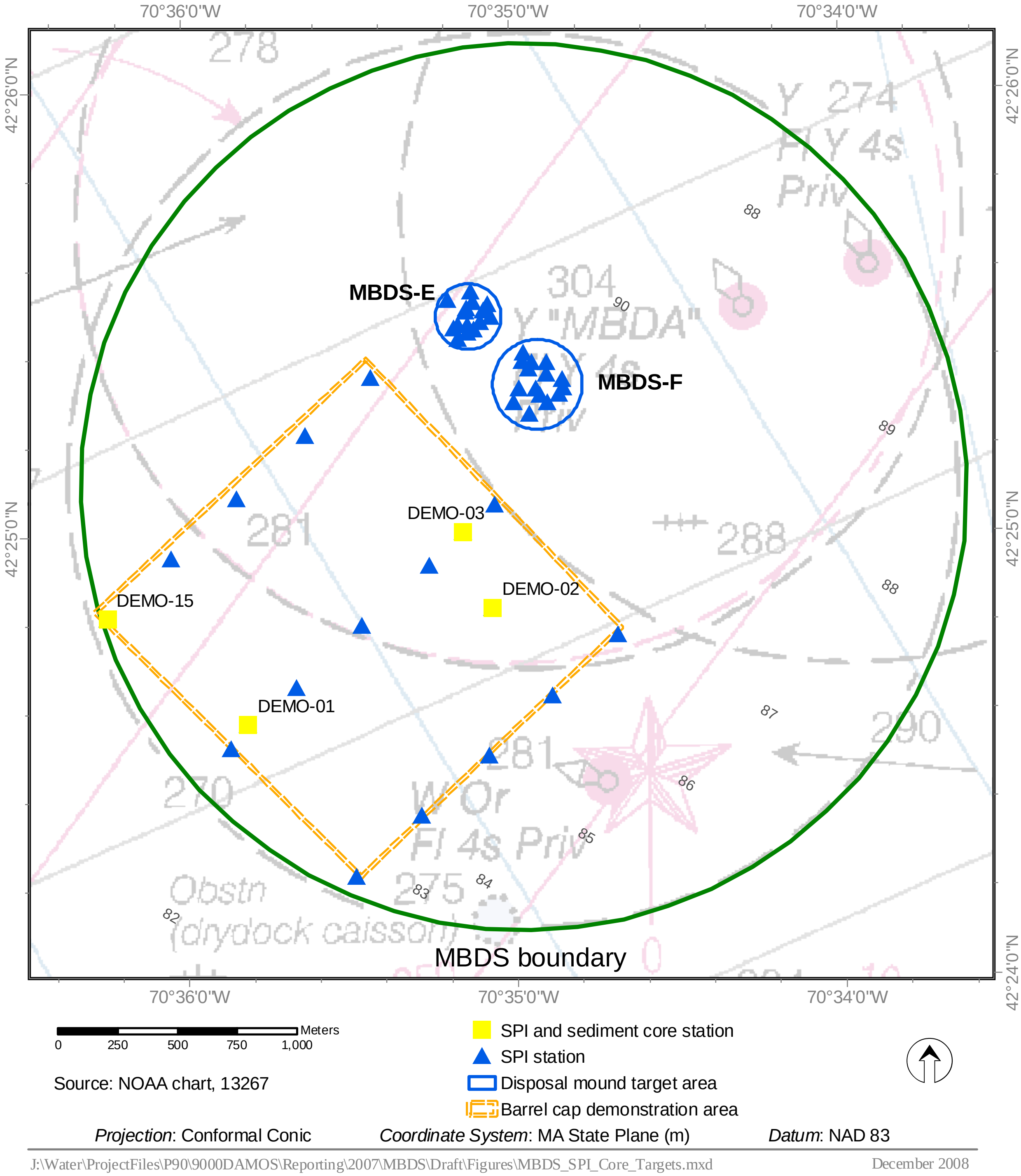

Figure 2-2. MBDS with target SPI and sediment core stations indicated, August 2007

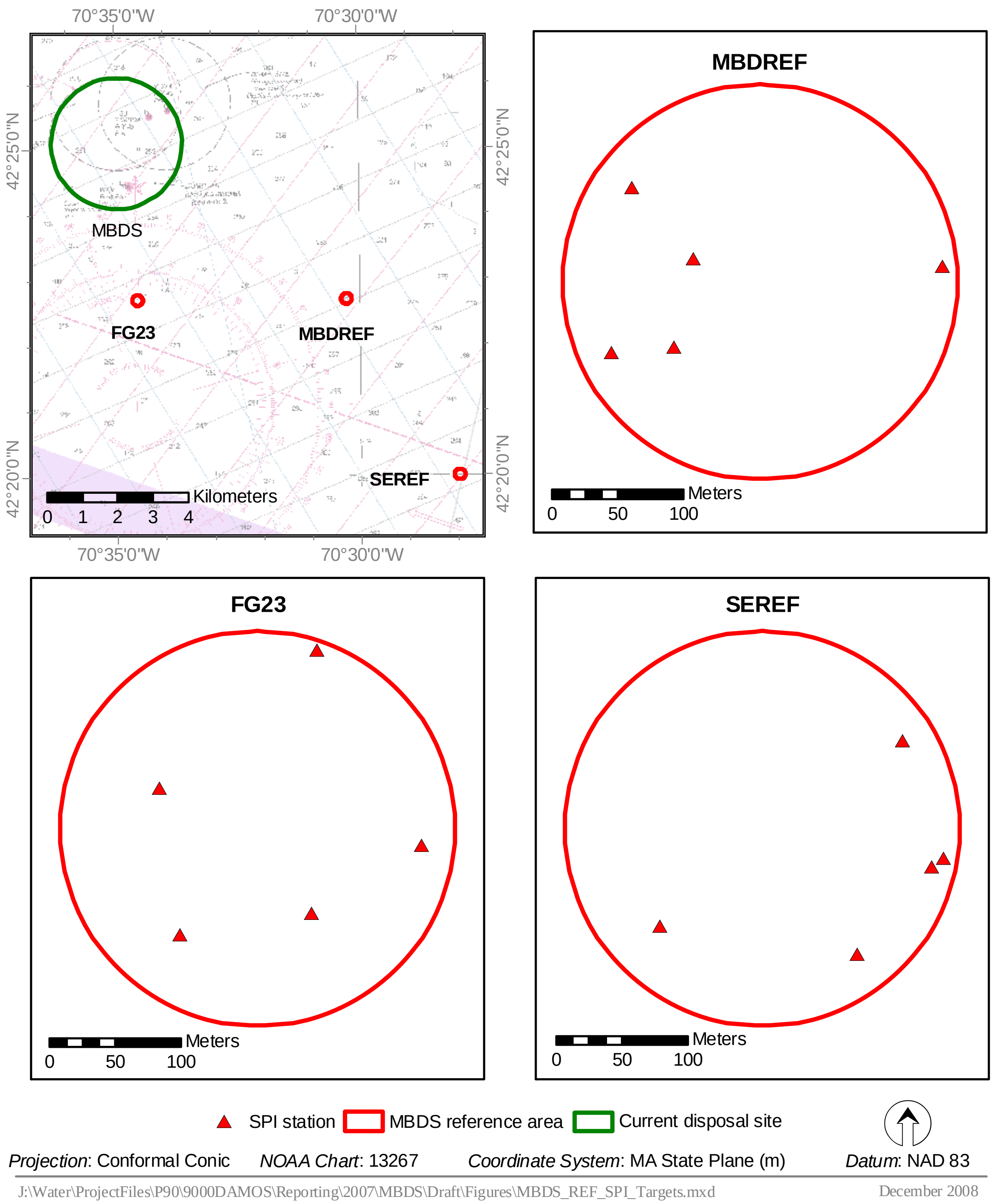

Figure 2-3. MBDS reference areas with target SPI stations indicated, August 2007

Analysis of each SPI image was performed to provide measurement of the following standard set of parameters:

- *Sediment Type* — The sediment grain size major mode and range were estimated visually from the images using a grain size comparator at a similar scale. Results were reported using the phi scale. Conversion to other grain size scales is provided in Appendix B. The presence and thickness of disposed dredged material were also assessed by inspection of the images.

- *Penetration Depth* — The depth to which the camera penetrated into the seafloor was measured to provide an indication of the sediment density or bearing capacity. The penetration depth can range from a minimum of 0 cm (i.e., no penetration on hard substrates) to a maximum of 20 cm (full penetration on very soft substrates).

- *Surface Boundary Roughness* — Surface boundary roughness is a measure of the vertical relief of features at the sediment-water interface in the sediment-profile image. Surface boundary roughness was determined by measuring the vertical distance between the highest and lowest points of the sediment-water interface. The surface boundary roughness (sediment surface relief) measured over the width of sediment-profile images typically ranges from 0 to 4 cm, and may be related to physical structures (e.g., ripples, rip-up structures, mud clasts) or biogenic features (e.g., burrow openings, fecal mounds, foraging depressions). Biogenic roughness typically changes seasonally and is related to the interaction of bottom turbulence and bioturbational activities.

- *Apparent Redox Potential Discontinuity (RPD) Depth* — RPD provides a measure of the integrated time history of the balance between near surface oxygen conditions and biological reworking of sediments. Sediment particles exposed to oxygenated waters oxidize and lighten in color to brown or light grey. As the particles are moved downwards by biological activity or buried, they are exposed to reduced oxygen concentrations in subsurface pore waters and their oxic coating slowly reduces, changing color to dark grey or black. When biological activity is high, the RPD depth increases; when it is low or absent, the RPD depth decreases. The RPD depth was measured by assessing color and reflectance boundaries within the images.

- *Infaunal Successional Stage* — Infaunal successional stage is a measure of the biological community inhabiting the seafloor. Current theory holds that organism-sediment interactions in fine-grained sediments follow a predictable sequence of development after a major disturbance (such as dredged material disposal), and this sequence has been divided subjectively into three stages (Rhoads and Germano 1982, 1986). Successional stage was assigned by assessing which types of species or organism-related activities were apparent in the images.

Additional components of the SPI analysis included calculation of means and ranges for the parameters listed above and mapping of station-averaged values.

2.3.3 Statistical Analysis

The objective of the SPI survey at MBDS was to assess the benthic recolonization status of the MBDS-E and MBDS-F Mounds relative to reference conditions and to establish a baseline description of the benthic community structure at BCDA prior to the planned capping demonstration project. Traditionally, the DAMOS Program used point-null hypothesis testing to evaluate this type of objective. This approach postulates the null hypothesis that there is no difference in benthic conditions between the mean values of the reference area and the mean values of the disposal mound; if the p-value is less than the accepted Type I error risk ($\alpha = 0.05$), it is concluded that the sites are different (e.g., Underwood 1990, 1997; Fairweather 1991). As such, p-values are treated as evidence for or against rejecting the null hypotheses.

As limitations have been identified with this approach (e.g., Carver 1978; Tukey 1991; McBride et al. 1993; Germano 1999; McBride 1999; Nelder 1999; Cole et al. 2001), equivalence tests (also known as interval hypothesis tests) have been employed by the DAMOS Program to analyze SPI data. Statistical analysis of the 2007 MBDS SPI data included equivalence tests to compare biological conditions at the MBDS mounds with those at the reference stations.

Equivalence tests can examine either 1) the equivalence hypothesis, where the true difference between means is postulated to lie within a prescribed equivalence interval, or 2) the inequivalence hypothesis, in which the true difference between means is postulated to lie beyond that interval. These two approaches provide a framework for demonstrating proof of hazard (equivalence tests), or proof of safety (inequivalence tests). It is the latter approach that is particularly appropriate for the evaluation of disposal mounds relative to nearby reference areas for the DAMOS Program. In this application of bioequivalence (interval) testing, the null hypothesis chosen was one that presumes the difference between parameter values measured within a disposal site relative to reference areas is great, i.e., an inequivalence hypothesis (e.g., McBride 1999). This is recognized as a ‘proof of safety’ approach because rejection of this inequivalence null hypothesis requires sufficient proof that the difference is actually small. The null and alternative hypotheses to be tested were:

H_0: $d \le -\delta$ or $d \ge \alpha$ (presumes the difference is great)

H_A: $-\delta < d < \delta$ (requires proof that the difference is small)

Where:

d = the actual difference between reference mean and site mean for a particular parameter, and

δ = the maximum difference expected for that parameter considering background information.

If the null hypothesis is rejected, then it can be concluded that the two means are equivalent to one another within ± δ units. The size of δ should be determined from historical data and/or best professional judgment to identify a maximum difference that is within background variability/noise and is therefore not ecologically meaningful. To determine the expected difference (δ) between an undisturbed seafloor (i.e., reference area) and a recently disturbed disposal site (i.e., disposal mound) for RPD and successional stage rank, both the mean and range of values in historical DAMOS SPI monitoring data were considered. Based on these historical data, it was determined that realistic δ for RPD and successional stage rank values would be 1 and 0.5 (on a scale of 0–3), respectively. These difference values were based on the typical spread of RPD and successional stage rank values observed at the reference areas and were representative of a background range.

The test of this interval hypothesis was broken down into two one-sided tests (TOST) (McBride 1999 after Schuirmann 1987) which are based on Student's *t*-distribution. The statistics used to test the interval hypotheses shown here are based on such statistical foundations as the Central Limit Theorem (CLT) such that the mean of any random variable is normally distributed, and linear combinations of normal random variables are also normal. As a result, the *t*-distribution can be used to construct a confidence interval around any linear function of means.

In this sampling design, there are actually six distinct areas, three of which are categorized as reference locations, so the difference equation of interest is defined as the average of the 3 reference means minus each mound or BCDA mean, or

$$[(\text{Mean}_{\text{MBDREF}} + \text{Mean}_{\text{SEREF}} + \text{Mean}_{\text{FG23}})/3 - \text{Mean}_{\text{Mound or BCDA}}]$$

The three reference areas collectively represent ambient conditions, and, if appropriate, were pooled into a single reference group. However, if there are mean differences among these three areas, then pooling them into a single reference group would increase the variance beyond true background variability. Differences among the three reference areas were evaluated prior to comparison with the mound data to determine if pooling the reference areas was appropriate.

The difference equations, $\hat{d}$, for the comparisons of interest are:

$\hat{d}_1$ = ⅓ ($\text{Mean}_{\text{MBDREF}}$+$\text{Mean}_{\text{SEREF}}$+$\text{Mean}_{\text{FG23}}$) – $\text{Mean}_{\text{MBDS}}$-E or $\text{Mean}_{\text{Pooled Refs}}$ – $\text{Mean}_{\text{MBDS-E}}$

$\hat{d}_2$ = ⅓ ($\text{Mean}_{\text{MBDREF}}$+$\text{Mean}_{\text{SEREF}}$+$\text{Mean}_{\text{FG23}}$) – $\text{Mean}_{\text{MBDS}}$-F or $\text{Mean}_{\text{Pooled Refs}}$ – $\text{Mean}_{\text{MBDS-F}}$

$\hat{d}_3$ = ⅓ ($\text{Mean}_{\text{MBDREF}}$+$\text{Mean}_{\text{SEREF}}$+$\text{Mean}_{\text{FG23}}$) – $\text{Mean}_{\text{BCDA}}$ or $\text{Mean}_{\text{Pooled Refs}}$ – $\text{Mean}_{\text{BCDA}}$

The standard error of each difference was calculated from the fact that the variance of a sum is the sum of the variances for independent variables, or

$$SE(\hat{d}) = \sqrt{\sum_j \left(S_j^2 c_j^2 / n_j\right)}$$

Where:

c_j = coefficients for the *j* means in the difference equation, $\hat{d}$ (i.e., for the difference equation shown above, the coefficients are 1/3, 1/3, 1/3, and –1 for areas MBDREF, SEREF, FG23, and each disposal mound or BCDA, respectively; or they would be 1, -1 for reference and mound or BCDA, respectively, if the three reference areas can be pooled).

S_j^2 = variance for the j^{th} area. If we can assume equal variances, a single pooled variance estimate can be substituted for each group, equal to the mean square error from an ANOVA.

n_j = number of replicates for the j^{th} area (5, 5, 5, for each of the reference areas; and 15, 15, 18, for MBDS-E, MBDS-F, and BCDA).

The inequivalence null hypothesis was rejected (and equivalence is concluded) if the confidence interval on the difference of means, $\hat{d}$, was fully contained within the interval [–δ , + δ]. Thus the decision rule is to reject H_0 if:

$$D_L = \hat{d} - t_{\alpha,\upsilon} se(\hat{d}) > -\delta \qquad \text{and} \qquad D_U = \hat{d} + t_{\alpha,\upsilon} se(\hat{d}) < \delta$$

Where:

$\hat{d}$ = observed difference in means between the reference area and mound/BCDA

$t_{\alpha,\upsilon}$ = upper 100 α percentile of a Student's *t*-distribution with υ degrees of freedom

$se(\hat{d})$ = standard error of the difference.

υ = degrees of freedom for the standard error. If a pooled variance estimate was used, the degrees of freedom was equal to the sum of the sample sizes for all groups included in the $\hat{d}$ minus the number of groups; if separate variance estimates were used, degrees of freedom were calculated based on the Brown and Forsythe estimation (Zar 1996).

Equality of the reference areas was graphically evaluated using boxplots and summary statistics. Validity of the normality and equal variance assumptions was tested using Shapiro-Wilk's test for normality on the area residuals (α =0.05) and Levene's test for equality of variances among the four areas (α =0.05). If normality was not rejected but equality of variances was rejected, then the variance for the difference equation was based on separate variances for each group. If systematic deviations from normality were identified, then the data were transformed to approximate normality, if possible. Otherwise, a non-parametric bootstrapped interval was used.

2.4 Sediment Collection

In order to further describe sediments in the BCDA, box cores were collected for sediment characterization and analysis.

2.4.1 Sediment Collection

Sediment box cores were collected at four stations within the BCDA on 24 August 2007 aboard the F/V *Shanna Rose* (Figure 2-2). For data comparison purposes, two of the stations were located in areas of acoustically-detectable historical disposal activity while two stations were located in areas where no historical disposal had been identified. A 0.0625-m^2 Gray O'Hara Box corer was used to collect the sediment samples. The vessel was positioned at the target coordinates, and the equipment was deployed within a defined station tolerance of 10 m.

Once the box core was retrieved, the core was examined for acceptability, and residual water was removed using a length of silicone tubing. The sample was visually examined for penetration depth, sediment color and texture, odor, and observed biota. Two clear, plastic, 5-cm diameter core tubes were manually driven into the box core sample until refusal, with core compaction documented by measuring the difference between the original sediment surface and the sediment surface inside the plastic core barrel. Grab samples were also collected from the top, middle and bottom sections of the core using stainless steel utensils and then transferred to labeled plastic zip-top bags. Visual observations of sediment color and density were recorded for each grab sample. Once the grab samples were collected, the tubes were removed from the box core, capped, taped, and labeled. All samples were then stored on ice and retained under chain of custody for future laboratory analysis.

2.4.2 Sediment Analysis

All sediment samples were stored at 4°C at AECOM's Westford, Massachusetts facility until January 2008 when the bagged samples were transferred to GeoTesting Express for analysis. The sub-cored samples were logged but were not sent for further laboratory analysis. The grab samples were analyzed for grain size, moisture content, and Atterberg limits following methods ASTM D 422, ASTM D 2216, and ASTM D 4318, respectively.

3.0 RESULTS

3.1 Bathymetry

The general bathymetry of MBDS is characterized by a gradual slope from approximately 84 m depth in the southwestern portion of the site to a natural depression in the north-central portion of the site with depths up to 92 m. The 2007 bathymetric survey confirmed the presence of seven disposal mounds (MBDS-A through MBDS-G) (Figure 3-1). Six of the mounds had been previously identified; however, placement of approximately 2.0 million m^3 of material at the MDA buoy since 2004 resulted in the enhancement of the MBDS-F Mound and the formation of a new mound, identified as MBDS-G (Figure 3-1). Limited survey artifacts were also apparent in the general bathymetry (Figure 3-1) related to a combination of sea conditions and strong/complex water column stratification at the time of the survey.

The five oldest existing mounds (MBDS-A through MBDS-E) have changed little in shape since the 2004 survey (Figure 3-2). The oldest and most southern mound, MBDS-A, was elongated in an east-west orientation, approximately 500 m in length and 5 m in height (Figure 3-3). The MBDS-B Mound, located to the northeast of MBDS-A, had a diameter of approximately 350 m and a height of approximately 6 m. The MBDS-C Mound was the largest, with an elongated shape oriented along a northwest-southeast axis that was approximately 600 m in length and rising to a peak height of approximately 8 m above the surrounding seafloor. The MBDS-C Mound was partially conjoined with the MBDS-B Mound to the south. To the west, the MBDS-D and MBDS-E Mounds were much smaller, each with a diameter of approximately 250 m and height of approximately 3 m (Figure 3-3).

The MBDS-F Mound, which was first identified in September 2004, was located between the MBDS-E and MBDS-A Mounds. The placement of approximately 1.5 million m^3 of dredged material at MBDS-F since September 2004 led to a substantial increase in size of the mound. MBDS-F had a footprint of approximately 350 m and extended approximately 7 m above the seafloor (Figure 3-3).

The 2007 bathymetry survey overlapped with much of the previous 2004 survey area, allowing for generation of a depth difference map, plotted at a 1-m contour interval (Figure 3-4). The depth difference map clearly shows the increased size of the MBDS-F Mound. The depth difference map also highlights the formation of a new mound, MBDS-G, to the northeast of the MBDS-D Mound. The MBDS-G Mound had a slightly elongated footprint, with a northwest-southeast axis approximately 300 m in length, and a

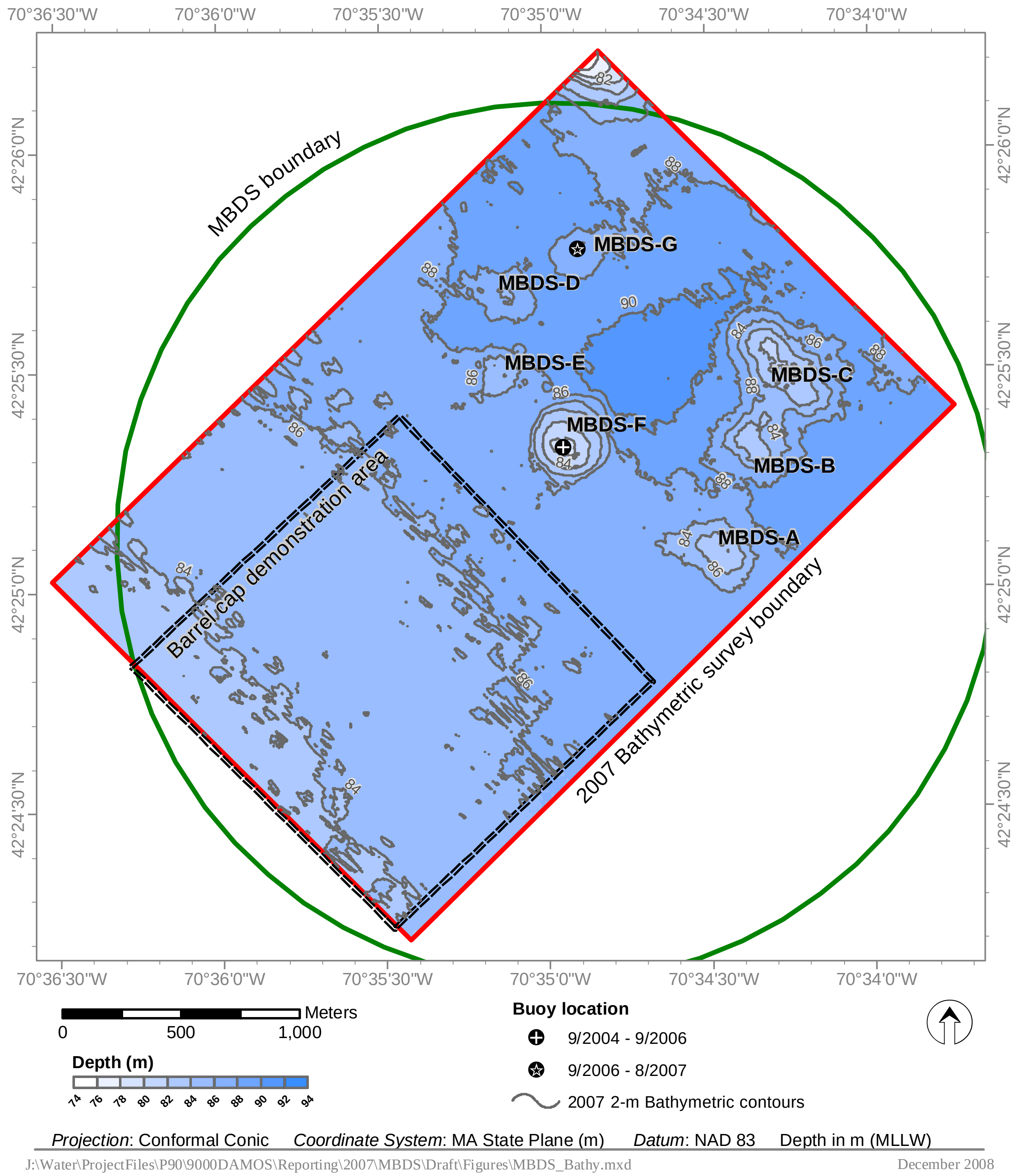

Figure 3-1. Bathymetric contour map of MBDS survey area, August 2007 (2-m contour interval)

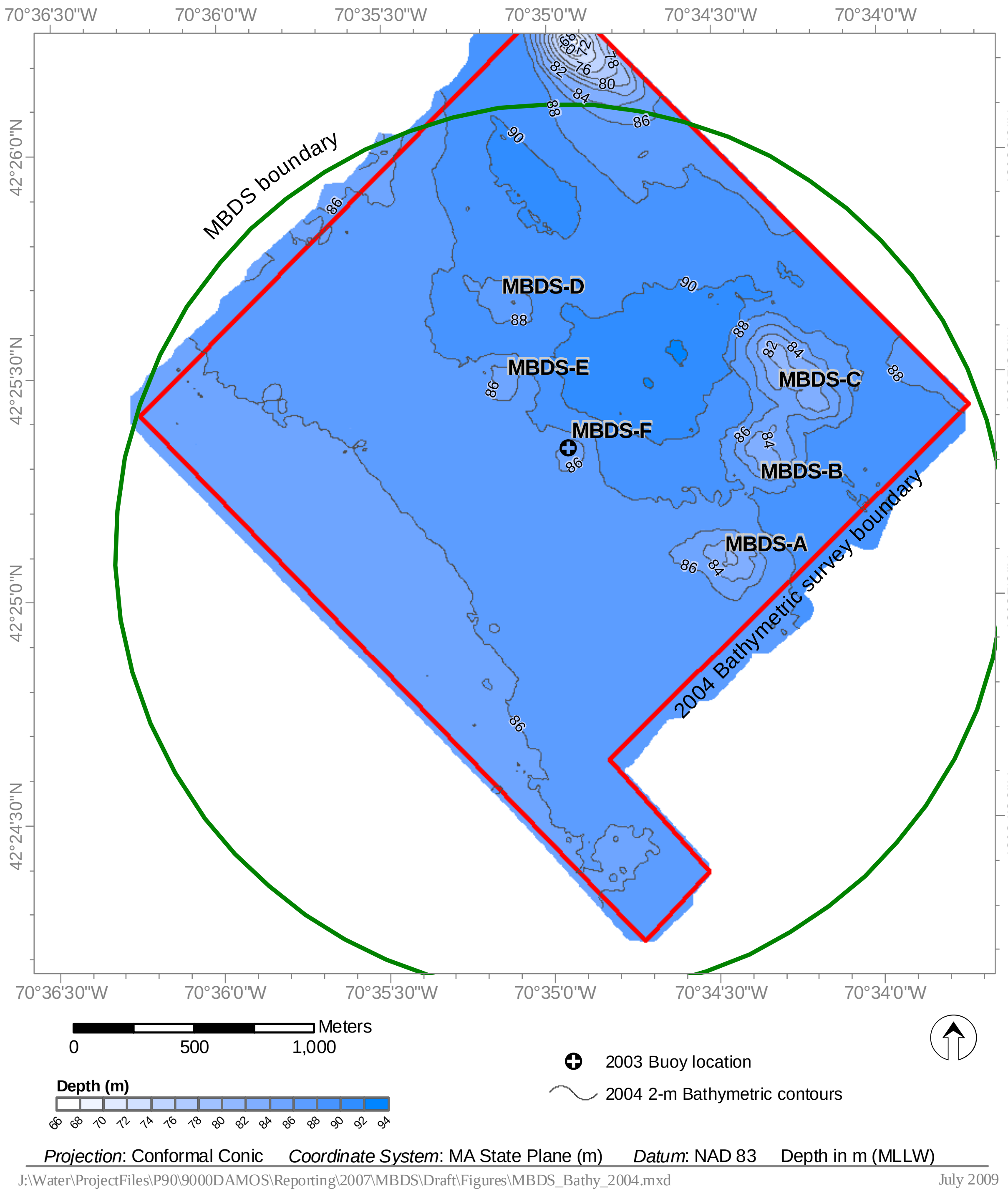

Figure 3-2. Bathymetric contour map of MBDS survey area, September 2004 (2-m contour interval)

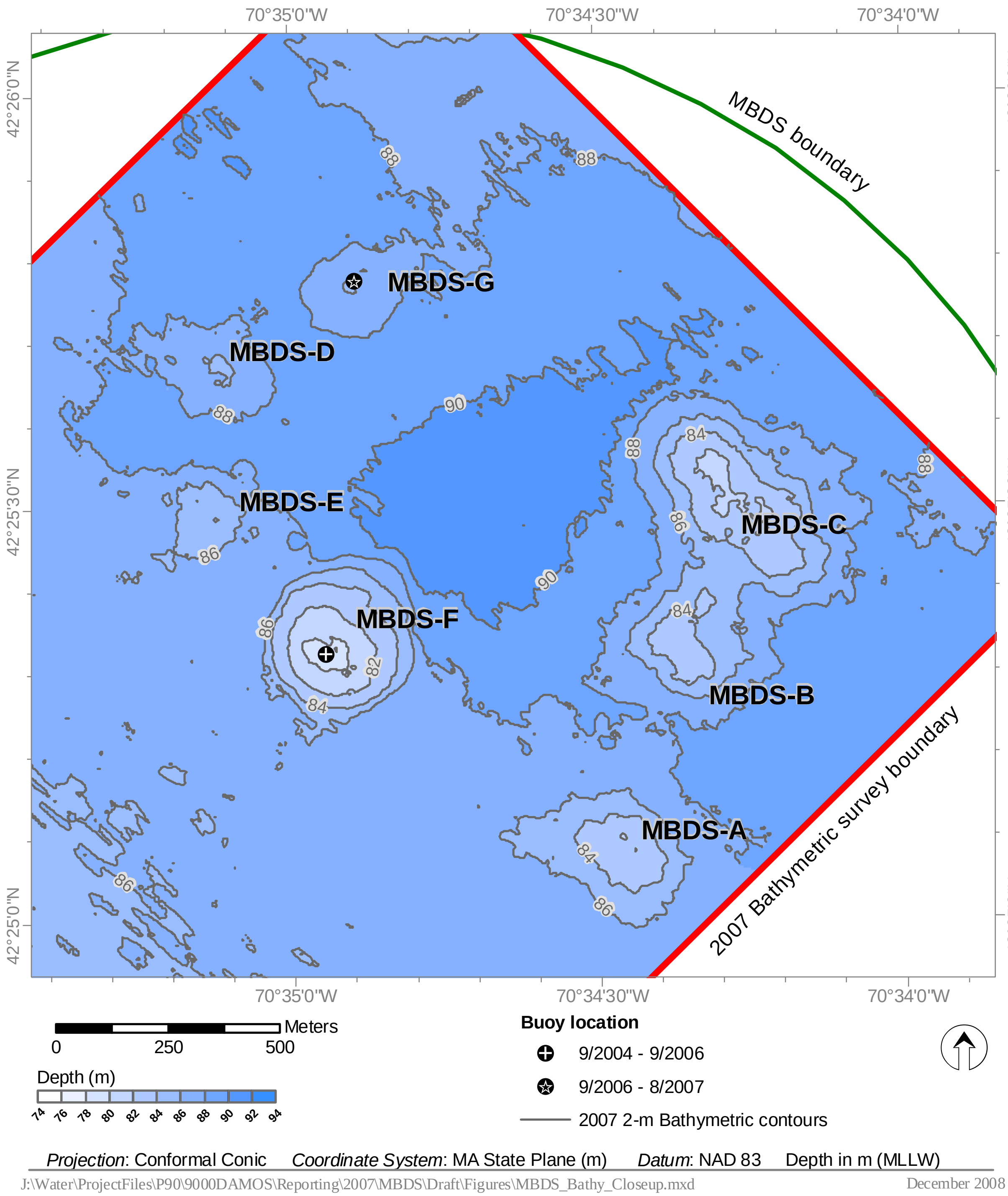

Figure 3-3. Bathymetric contour map of MBDS disposal area, August 2007 (2-m contour interval)

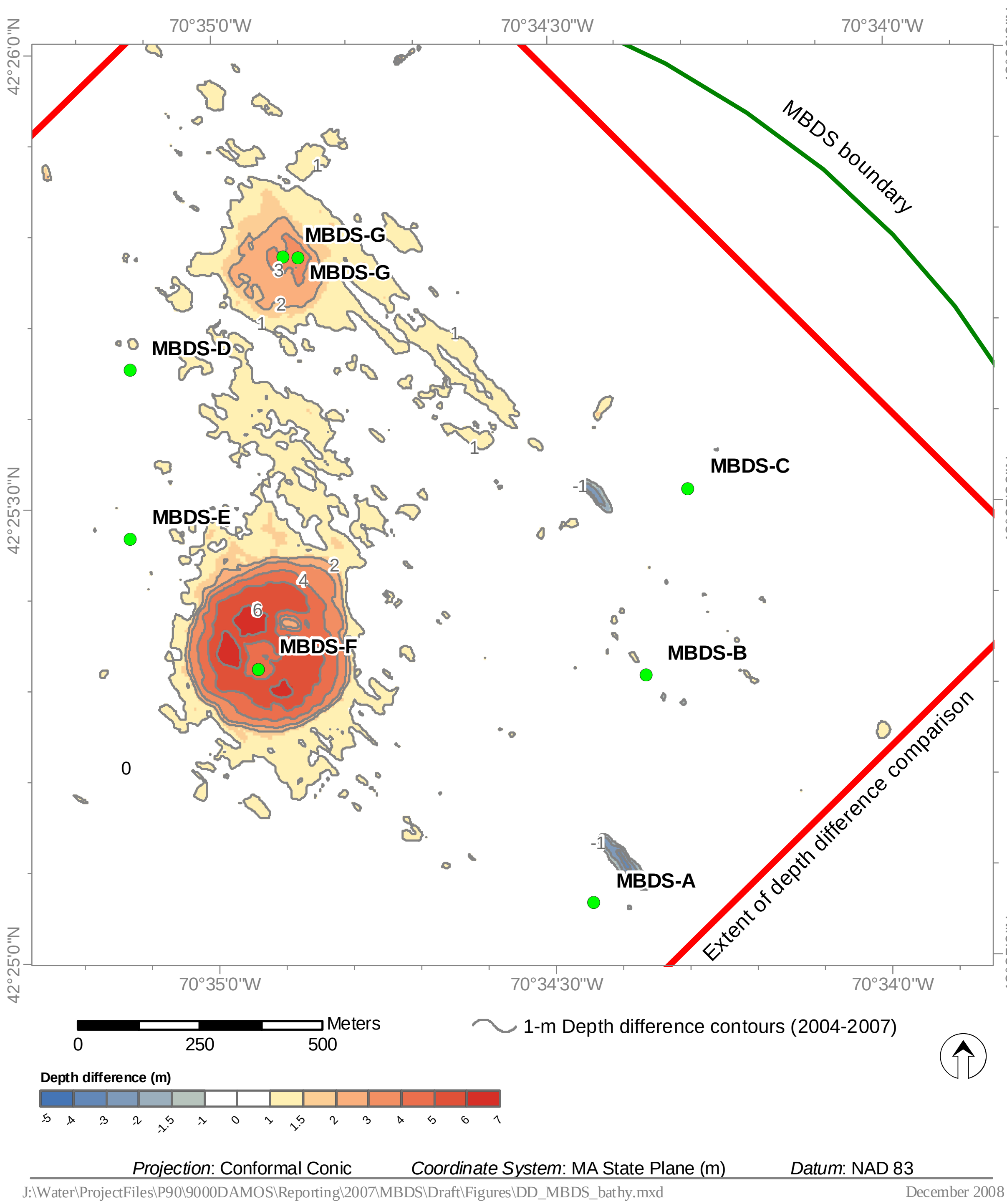

Figure 3-4. Depth difference contour map of MBDS disposal area, September 2004 vs. August 2007 survey results (1-m contour interval)

height of approximately 3 m. There was also a small area of depth increase on the northeastern edge of the MBDS-A Mound since the September 2004 survey potentially indicative of limited compaction or material loss or related to artifacts of the 2007 data set due to conditions at the time of the survey.

3.2 Sediment-Profile Imaging

The primary objective of the SPI survey was to assess the recolonization status and benthic habitat characteristics of representative areas on the two disposal mounds and at the reference areas. A secondary objective was to evaluate the habitat and sediment conditions across the surface of the BCDA for baseline assessment of an area planned for experimental disposal.

The 2007 SPI data from MBDS consisted of three distinct reference areas (FG23, MBDREF, SEREF) with five stations at each reference area; 15 stations at each of the two disposal mounds (MBDS-E – last disposal in 2000; MBDS-F – last disposal in 2005); and 18 stations in a grid at the BCDA. At each of the stations, there are results for three replicate drops of the SPI camera. The three replicate observations were combined to get one value per station: the average of replicates was used for the station RPD, and the maximum among replicates was used as the successional stage rank for the station. A summary of SPI results from the two disposal mounds (MBDS-E, and MBDS-F), the BCDA, and the three reference areas (FG23, MBDREF, and SEREF) can be found in Tables 3-1 through 3-4, and the complete set of all SPI results can be found in Appendix B.

3.2.1 Reference Areas

Physical Sediment Characteristics

As described in previous monitoring surveys at MBDS (ENSR 2005, SAIC 2003, 2002, Murray 1994, DeAngelo and Murray 1997), the sediments at the reference areas were nearly uniform light brown silt clay (Figure 3-5). Although the grain size major mode for all stations was similar, Station MBDREF-4 had mud-covered rocks present on top of the silt substratum in every replicate (Figure 3-6).

Station-averaged camera prism penetration depth at the reference stations ranged from 3.2 to 18.0 cm (Figure 3-7), with an overall average reference station penetration depth of 14.9 cm (Table 3-1). The stop collar settings and number of weights were kept nearly constant (stop collar settings of 34 or 38 cm, and one or two weights per carriage; Appendix B), so the camera penetration depth was a good measure of the sediment shear strength within the reference areas. The apparent shear strength of reference area sediments was generally low with the exception of two stations at MBDREF (MBDREF-1 and MBDREF-4; Figure 3-7).

Table 3-1

Summary of SPI Results for MBDS Reference Stations, August 2007

Station	Grain Size Major Mode (phi)	Mean Prism Penetration Depth (cm)	Mean Boundary Roughness (cm)	Mean RPD Depth (cm)	Dredged Material Present?	Methane Present?	Low Dissolved Oxygen Apparent?	Station Average Void Depth (cm)	Successional Stages Present (Number of Duplicates)
FG23-1	>4	16.1	1.2	3.3	No	None	No	5.7	1 on 3 (3)
FG23-2	>4	16.9	1.1	3.6	No	None	No	6.3	1 on 3 (3)
FG23-3	>4	16.5	1.0	3.6	No	None	No	6.4	1 on 3 (3)
FG23-4	>4	15.6	0.9	3.2	No	None	No	6.4	1 on 3 (3)
FG23-5	>4	16.3	2.1	3.0	No	None	No	8.9	1 on 3 (2), 3 (1)
SEREF-1	>4	18.0	1.1	3.9	No	None	No	9.9	1 on 3 (1), 3 (2)
SEREF-2	>4	17.5	1.3	4.0	No	None	No	8.2	1 on 3 (2), 3 (1)
SEREF-3	>4	16.9	1.5	3.6	No	None	No	7.8	1 on 3 (2), 1 (1)
SEREF-4	>4	16.5	1.3	2.9	No	None	No	7.9	1 on 3 (3)
SEREF-5	>4	17.2	1.2	3.3	No	None	No	9.5	1 on 3 (3)
MBDREF-1	>4	7.0	2.5	2.9	No	None	No	5.5	1 on 3 (3)
MBDREF-2	>4	15.7	1.0	3.0	No	None	No	10.5	1 on 3 (2), 3 (1)
MBDREF-3	>4	12.8	1.5	3.2	No	None	No	6.9	1 on 3 (3)
MBDREF-4	>4	3.2	3.7	2.6	No	None	No	3.7	1 on 3 (1), Ind. (2)
MBDREF-5	>4	17.1	1.5	3.3	No	None	No	4.9	1 on 3 (3)
Average		14.9	1.5	3.3				7.2	
Median		16.5	1.3	3.3				6.9	
Minimum		3.2	0.9	2.6				3.7	
Maximum		18.0	3.7	4.0				10.5	

Table 3-2

Summary of SPI Results for MBDS-E Mound Stations, August 2007

Station	Grain Size Major Mode (phi)	Mean Prism Penetration Depth (cm)	Mean Boundary Roughness (cm)	Mean RPD Depth (cm)	Dredged Material Present?	Methane Present?	Low Dissolved Oxygen Apparent?	Station Average Void Depth (cm)	Successional Stages Present (Number of Duplicates)
MBDS-E-1	>4	13.8	1.1	2.2	Yes	None	No	8.9	1 on 3 (3)
MBDS-E-2	>4	13.9	1.4	1.4	Yes	None	No	8.7	1 on 3 (3)
MBDS-E-3	>4	12.1	0.8	1.2	Yes	None	No	9.0	1 on 3 (3)
MBDS-E-4	>4	14.2	1.1	2.1	Yes	None	No	6.9	1 on 3 (3)
MBDS-E-5	>4	16.9	1.3	2.5	Yes	None	No	14.1	1 on 3 (3)
MBDS-E-6	>4	13.2	1.8	1.7	Yes	None	No	10.4	1 on 3 (3)
MBDS-E-7	>4	20.0	0.9	2.5	Yes	None	No	16.0	1 on 3 (3)
MBDS-E-8	>4	18.7	0.8	1.8	Yes	None	No	12.8	1 on 3 (2), 2 (1)
MBDS-E-9	>4	17.8	0.8	2.3	Yes	None	No	11.5	1 on 3 (2), 2 (1)
MBDS-E-10	>4	19.4	1.5	3.0	Yes	None	No	10.1	1 on 3 (3)
MBDS-E-11	>4	8.5	0.8	1.5	Yes	None	No	6.0	1 on 3 (3)
MBDS-E-12	>4	9.1	1.1	1.6	Yes	None	No	7.3	1 on 3 (3)
MBDS-E-13	>4	12.0	1.7	1.5	Yes	None	No	9.9	1 on 3 (3)
MBDS-E-14	>4	12.4	1.3	1.9	Yes	None	No	8.6	1 on 3 (2), 2 (1)
MBDS-E-15	>4	11.5	1.4	1.4	Yes	None	No	6.4	1 on 3 (3)
Average		14.2	1.2	1.9				9.8	
Median		13.8	1.1	1.8				9.0	
Minimum		8.5	0.8	1.2				6.0	
Maximum		20.0	1.8	3.0				16.0	

Table 3-3

Summary of SPI Results for MBDS-F Mound Stations, August 2007

Station	Grain Size Major Mode (phi)	Mean Prism Penetration Depth (cm)	Mean Boundary Roughness (cm)	Mean RPD Depth (cm)	Dredged Material Present?	Methane Present?	Low Dissolved Oxygen Apparent?	Station Average Void Depth (cm)	Successional Stages Present (Number of Duplicates)
MBDS-F-1	>4	9.9	1.1	2.0	Yes	None	No	4.2	1 on 3 (2), 2 (1)
MBDS-F-2	>4	12.8	0.7	2.5	Yes	None	No	8.1	1 on 3 (3)
MBDS-F-3	>4	10.1	1.2	1.6	Yes	None	No	7.0	1 on 3 (3)
MBDS-F-4	>4	7.1	1.7	1.3	Yes	None	No	10.5	1 on 3, 2, Ind.
MBDS-F-5	>4	10.7	1.2	1.2	Yes	None	No	6.2	1 on 3 (3)
MBDS-F-6	>4	9.7	1.3	1.7	Yes	None	No	6.0	1 on 3 (3)
MBDS-F-7	>4	11.2	1.5	2.0	Yes	None	No	8.1	1 on 3 (3)
MBDS-F-8	>4	12.5	0.6	2.3	Yes	None	No	9.1	1 on 3 (3)
MBDS-F-9	>4	10.6	2.8	1.2	Yes	None	No	5.8	3 (1), 1 on 3 (2)
MBDS-F-10	>4	15.2	0.9	2.4	Yes	None	No	9.6	1 on 3 (3)
MBDS-F-11	>4	9.8	0.8	2.0	Yes	None	No	4.8	1 on 3 (3)
MBDS-F-12	>4	10.7	2.0	2.7	Yes	None	No	3.1	1 on 3 (3)
MBDS-F-13	>4	12.4	0.6	2.2	Yes	None	No	8.8	1 on 3 (3)
MBDS-F-14	>4	6.1	2.0	1.8	Yes	None	No	5.1	1 on 3 (3)
MBDS-F-15	>4	9.5	1.5	2.3	Yes	None	No	6.6	1 on 3 (3)
Average		10.5	1.3	1.9				6.9	
Median		10.6	1.2	2.0				6.6	
Minimum		6.1	0.6	1.2				3.1	
Maximum		15.2	2.8	2.7				10.5	

Table 3-4

Summary of SPI Results for MBDS Barrel Cap Demonstration Area Stations, August 2007

Station	Grain Size Major Mode (phi)	Mean Prism Penetration Depth (cm)	Mean Boundary Roughness (cm)	Mean RPD Depth (cm)	Dredged Material Present?	Methane Present?	Low Dissolved Oxygen Apparent?	Station Average Void Depth (cm)	Successional Stages Present (Number of Duplicates)
DEMO-1	>4	16.4	2.2	2.6	No	None	No	8.9	3 (1), 1 on 3 (2)
DEMO-2	>4	17.3	1.8	3.0	Yes	None	No	4.8	3 (2), 1 on 3 (1)
DEMO-3	>4	17.8	0.7	3.6	Yes	None	No	7.7	3 (1), 1 on 3 (2)
DEMO-11	>4	14.6	1.2	3.3	Yes	None	No	7.2	1 on 3 (3)
DEMO-12	>4	14.9	1.2	3.2	Yes	None	No	9.5	1 on 3 (3)
DEMO-13	>4	15.7	2.8	2.1	Yes	None	No	4.1	3 (1), 1 on 3 (2)
DEMO-14	>4	17.5	1.3	3.0	No	None	No	3.7	1 on 3 (3)
DEMO-15	>4	17.9	1.9	3.1	No	None	No	9.5	3 (1), 1 on 3 (2)
DEMO-21	>4	20.8	1.0	3.7	Yes	None	No	3.8	3 (2), Ind. (1)
DEMO-22	>4	15.2	3.3	2.8	No	None	No	6.4	3 (1), 1 on 3 (2)
DEMO-23	>4	17.3	1.4	3.1	No	None	No	7.4	3 (2), 1 on 3 (1)
DEMO-24	>4	14.5	1.1	3.0	No	None	No	4.7	1 on 3 (3)
DEMO-25	>4	14.8	0.7	3.0	No	None	No	2.5	3 (2), 1 on 3 (1)
DEMO-31	>4	18.9	0.8	3.5	No	None	No	4.8	3 (1), 1 on 3 (2)
DEMO-32	>4	16.9	1.1	3.5	No	None	No	8.0	3, 1 on 3, 2-3
DEMO-33	>4	18.3	2.2	2.8	No	None	No	5.3	3 (1), 1 on 3 (2)
DEMO-34	>4	15.5	0.6	3.4	No	None	No	11.8	3 (2), 1 on 3 (1)
DEMO-35	>4	13.8	1.4	3.1	No	None	No	7.0	3 (3)
Average		16.6	1.5	3.1				6.5	
Median		16.7	1.2	3.1				6.7	
Minimum		13.8	0.6	2.1				2.5	
Maximum		20.8	3.3	3.7				11.8	

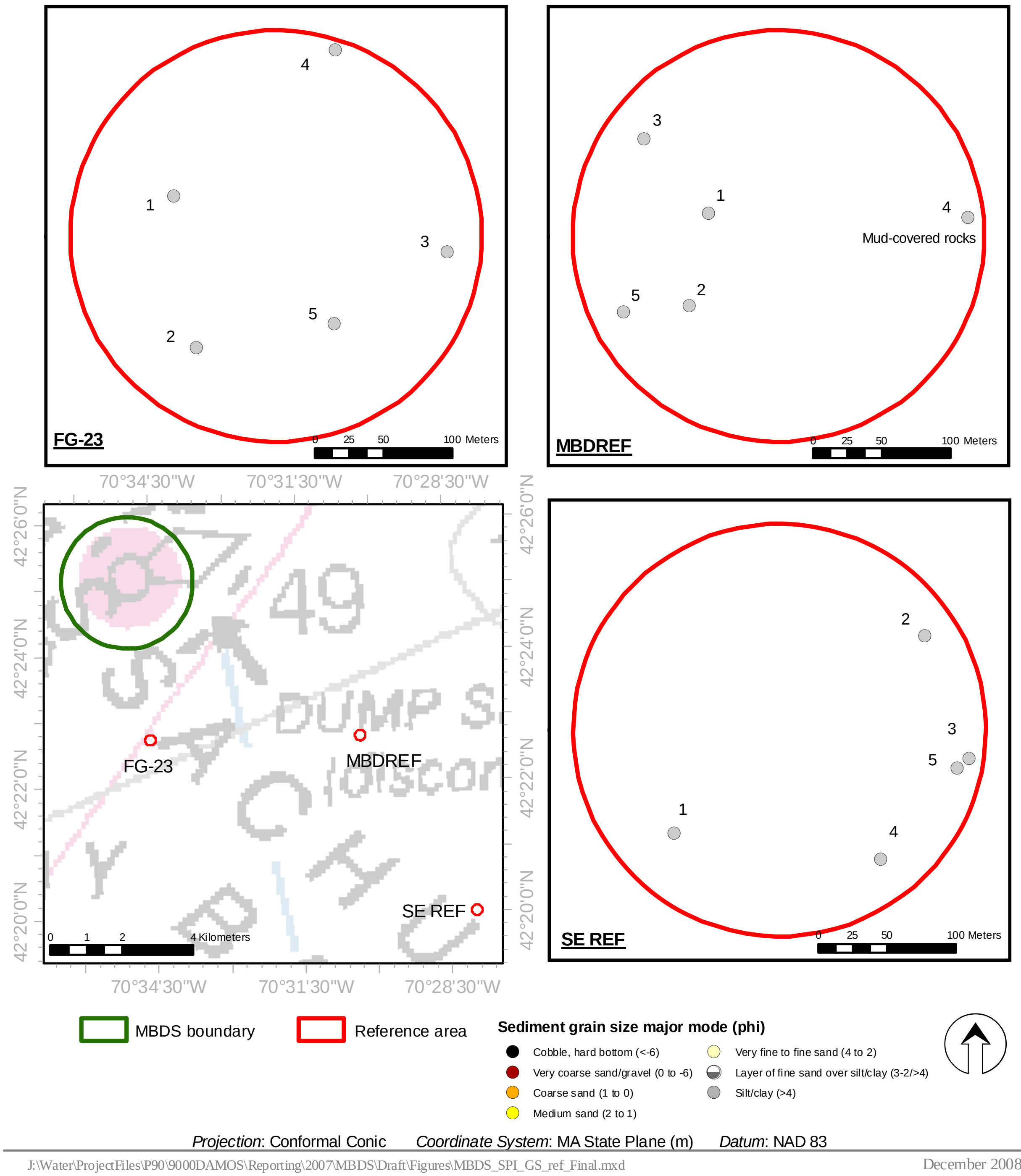

Figure 3-5. Distribution of sediment grain size major mode (phi units) found at MBDS reference areas

Figure 3-6. Station FG23-2 (left) has a deep well-mixed silt/clay horizon and a feeding void. This image from Station MBDREF-4 (right) had mud-covered rocks on the surface of a silt/clay horizon.

Figure 3-7. Distribution of station-averaged camera prism penetration depth (cm) at MBDS reference areas

MBDREF-4 had rocks on the surface (Figure 3-6) and MBDREF-1 appeared to have compact silt and perhaps burrowing animals that limited camera penetration.

Average small-scale boundary roughness values at the reference stations ranged from 0.9 to 3.7 cm, with an overall average value of 1.5 cm for the ambient seafloor (Figure 3-8). The small-scale surface roughness elements were divided between physical and biological origins, with more biological origins (26 out of 45 replicates; Appendix B). SEREF had lower average roughness values than the other reference areas, with a preponderance of biological origins.

Biological Conditions and Benthic Recolonization

The average depth of the apparent RPD at the stations surveyed on the ambient seafloor ranged from 2.6 to 4.0 cm (Figure 3-9), with an overall average of 3.3 cm (Table 3-1).

All of the reference area stations showed benthic assemblages in the late stages of colonization (Stage 3) with evidence of deposit feeding activity (Figure 3-6). The average depth of subsurface feeding voids (when present) ranged from 3.7 to 10.5 cm below the sediment surface (Appendix B). Most of the stations showed evidence of surface disturbance (Stage 1 on 3) (Figure 3-10).

3.2.2 MBDS-E

The MBDS-E Mound received approximately 750,000 m^3 of dredged material between October 1999 and June 2000, primarily from the Boston Harbor Navigation Improvement Project (ENSR 2005). Dredged material was still evident in each image and extended beyond the depth of prism penetration (Table 3-2). Even though there had been no disposal at this location for over eight years, the evidence of multiple disposal events was still preserved in many of the sediment cross-sectional images (Figure 3-11).

Sediment Physical Characteristics

All fifteen stations surveyed at the MBDS-E Mound were comprised of fine-grained sediments with a grain size major mode of >4 phi (Figure 3-12, Appendix B). Although clay fabric was visible in some replicates, the majority of images showed dark reduced dredged material and layers of dredged material over older surface material (Figure 3-11).

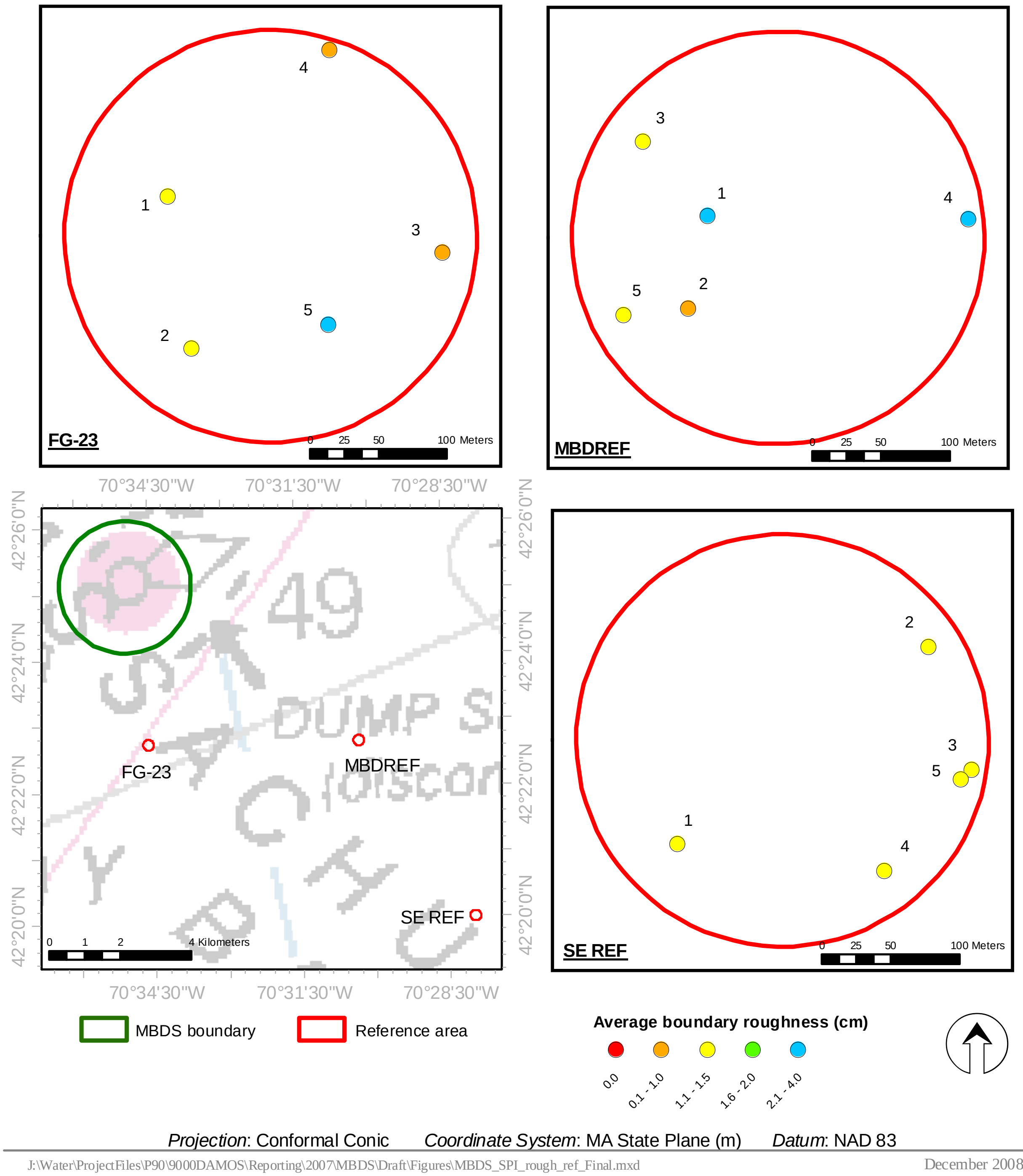

Figure 3-8. Distribution of station-averaged surface boundary roughness (cm) at MBDS reference areas

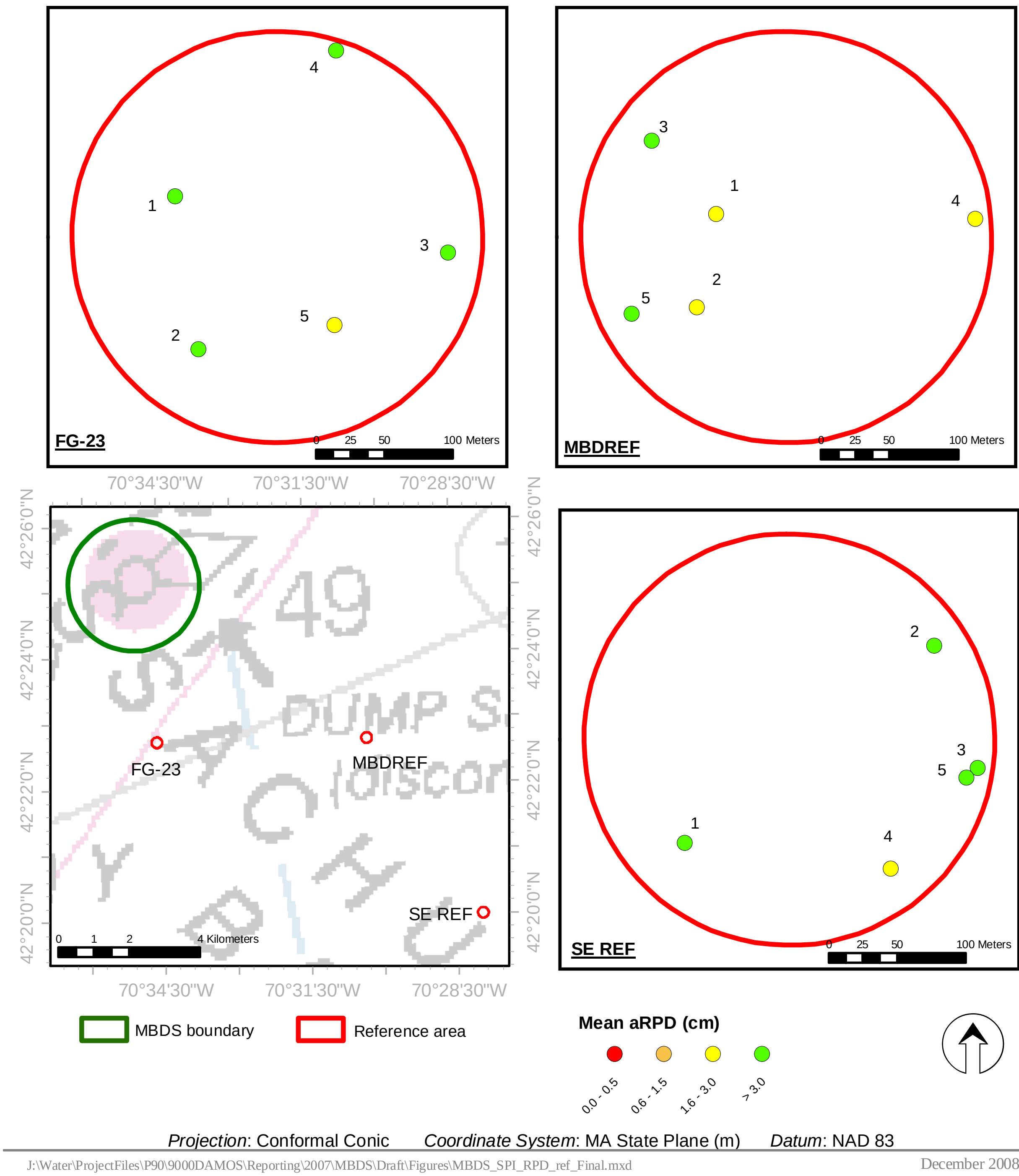

Figure 3-9. Distribution of station-averaged aRPD (cm) at MBDS reference areas

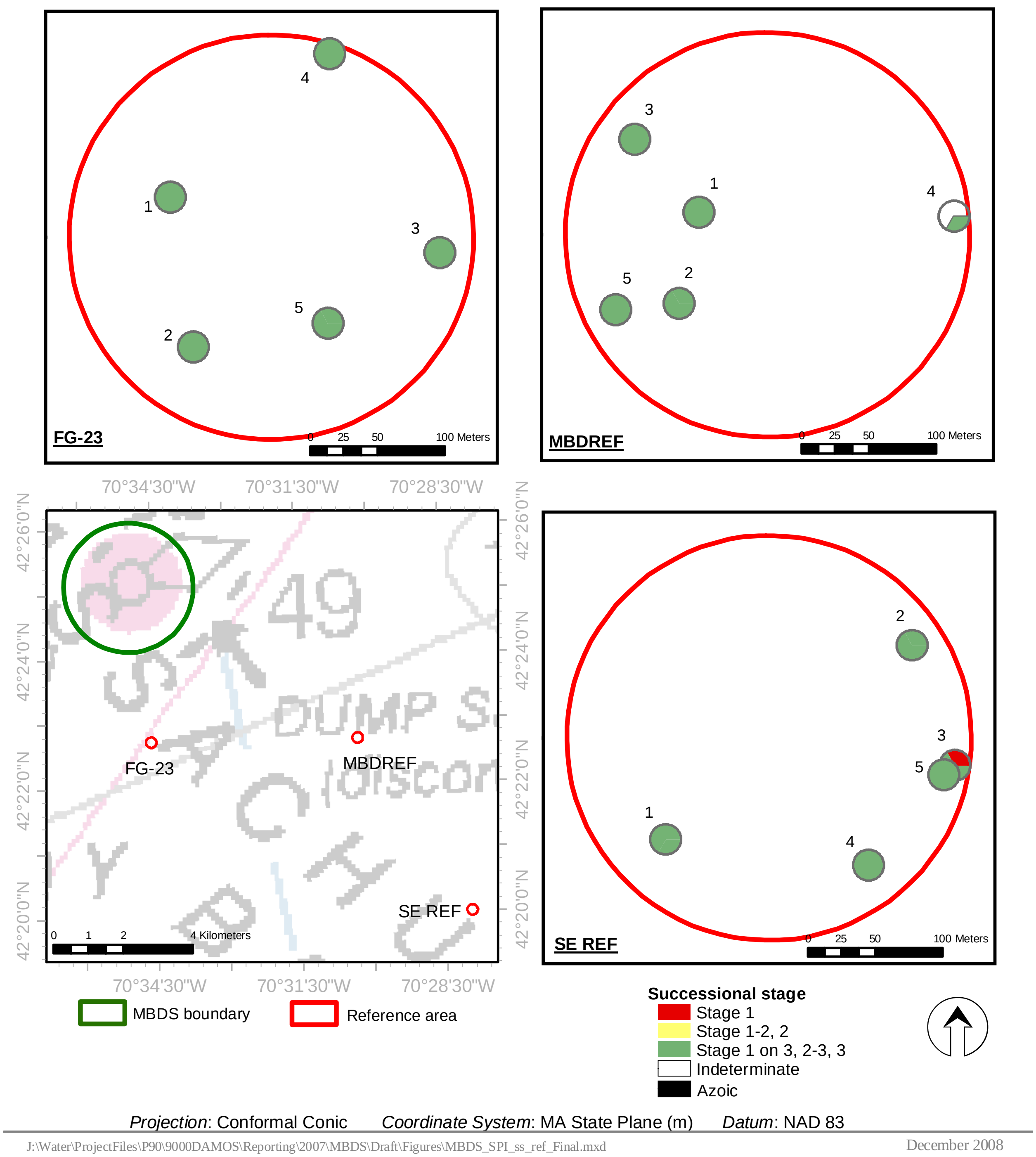

Figure 3-10. Distribution of infaunal successional stages at MBDS reference areas

Figure 3-11. SPI image from Station MBDS-E-09 showing multiple depositional horizons from past disposal activity.

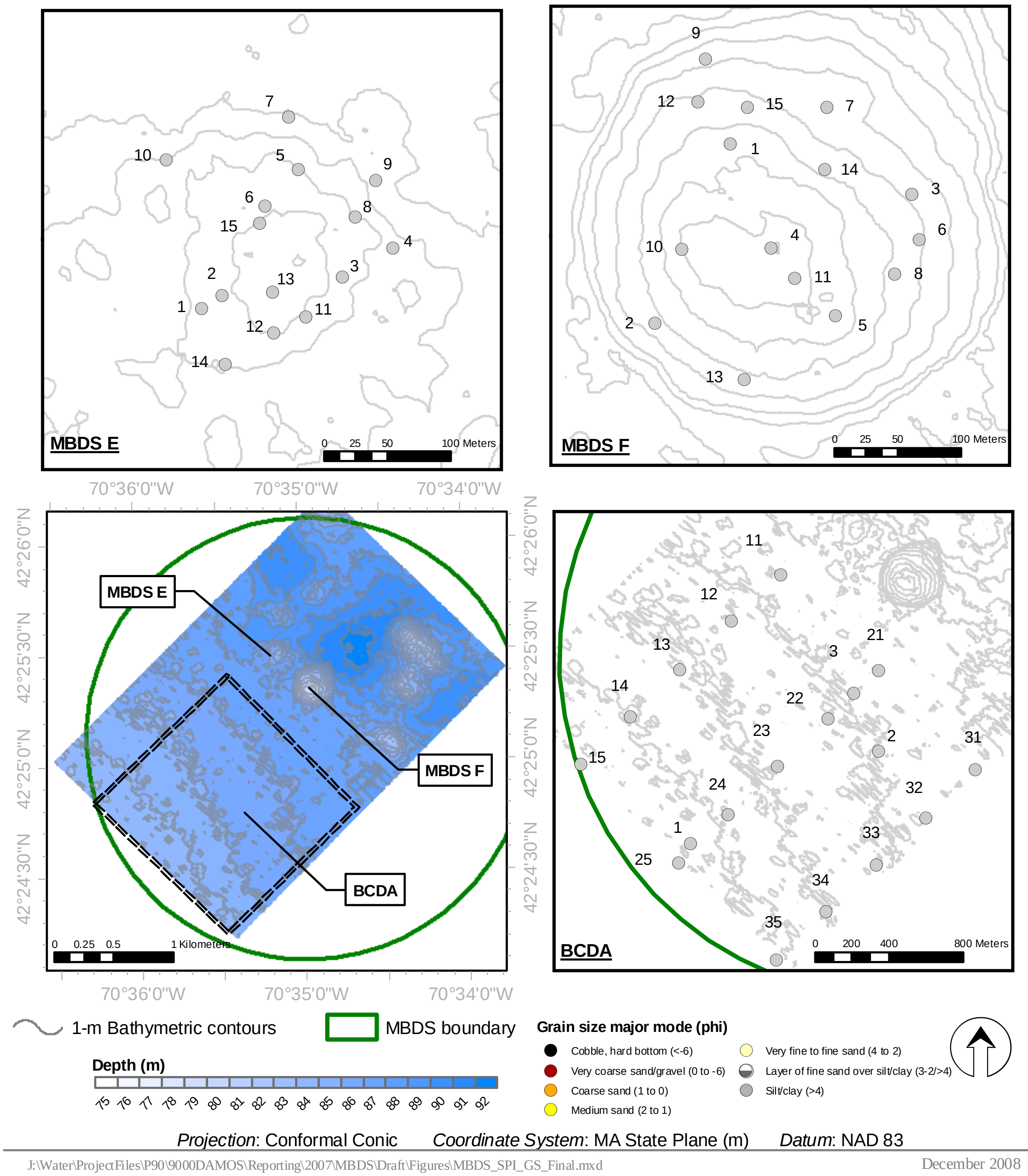

Figure 3-12. Distribution of sediment grain size major mode (phi units) found at MBDS

Average camera prism penetration depth ranged from 8.5 to 20.0 cm (Figure 3-13), with an overall mound average penetration depth of 14.2 cm. Although the stop collar settings varied from 28 to 36 cm and the number of weights per carriage varied from zero to two (Appendix B), the variation in camera prism penetration depth was still an indicator of relative sediment shear strength from varying amounts of cohesive clay present at each station (the adjustments were made mainly to prevent over penetration of the prism). Sediment shear strength was greater than that of the references areas. Even though all the stations sampled on this mound showed dredged material thickness in excess of the prism penetration depth (Table 3-2), there was no evidence of organic enrichment, low oxygen concentrations in the overlying water, or presence of sub-surface methane gas in any of the images collected on the MBDS-E Mound.

Average small-scale boundary roughness values ranged from 0.8 to 1.8 cm over the disposal mound, with an overall average of 1.2 cm (Figure 3-14, Table 3-2). The small-scale topographic roughness elements at the MBDS-E Mound were generally biogenic in origin (Appendix B), caused by feeding pits, tubes, or mounds (Figure 3-15, left); however, 13 out of the 45 replicates had mud clasts, and 17 of the 45 replicates had primarily physical boundary roughness elements (Figure 3-15, right). Small, rounded, oxidized mud clasts on the surface are generally the result of some physical surface disturbance, although biological origins are possible. The larger reduced mud clasts were likely caused by sampling artifacts from the camera frame or wiper blade and not due to any transport processes occurring at the disposal site.

<u>Biological Conditions and Benthic Recolonization</u>

The average depth of the apparent RPD ranged from 1.2 to 3.0 cm over the MBDS-E Mound (Appendix B, Figure 3-16), with an overall average RPD depth for the mound of 1.9 cm (Table 3-2). Only three replicates lacked clear evidence of Stage 3 infauna (Figure 3-17; these images lacked feeding voids, but deep RPD depths suggested that the presence of Stage 3 infauna was likely; see Appendix B). All of the stations had benthic assemblages in the late stages of colonization (Stage 2 or 3) with evidence of deposit feeding activity and evidence of biological response to surface disturbance (Stage 1 on 3; Figure 3-18). The average depth of subsurface feeding voids ranged from 6.0 to 16.0 cm below the sediment surface (Appendix B). Infaunal density and bioturbational activity was intense at this older mound, quite typical for the response eight years after cessation of disposal.

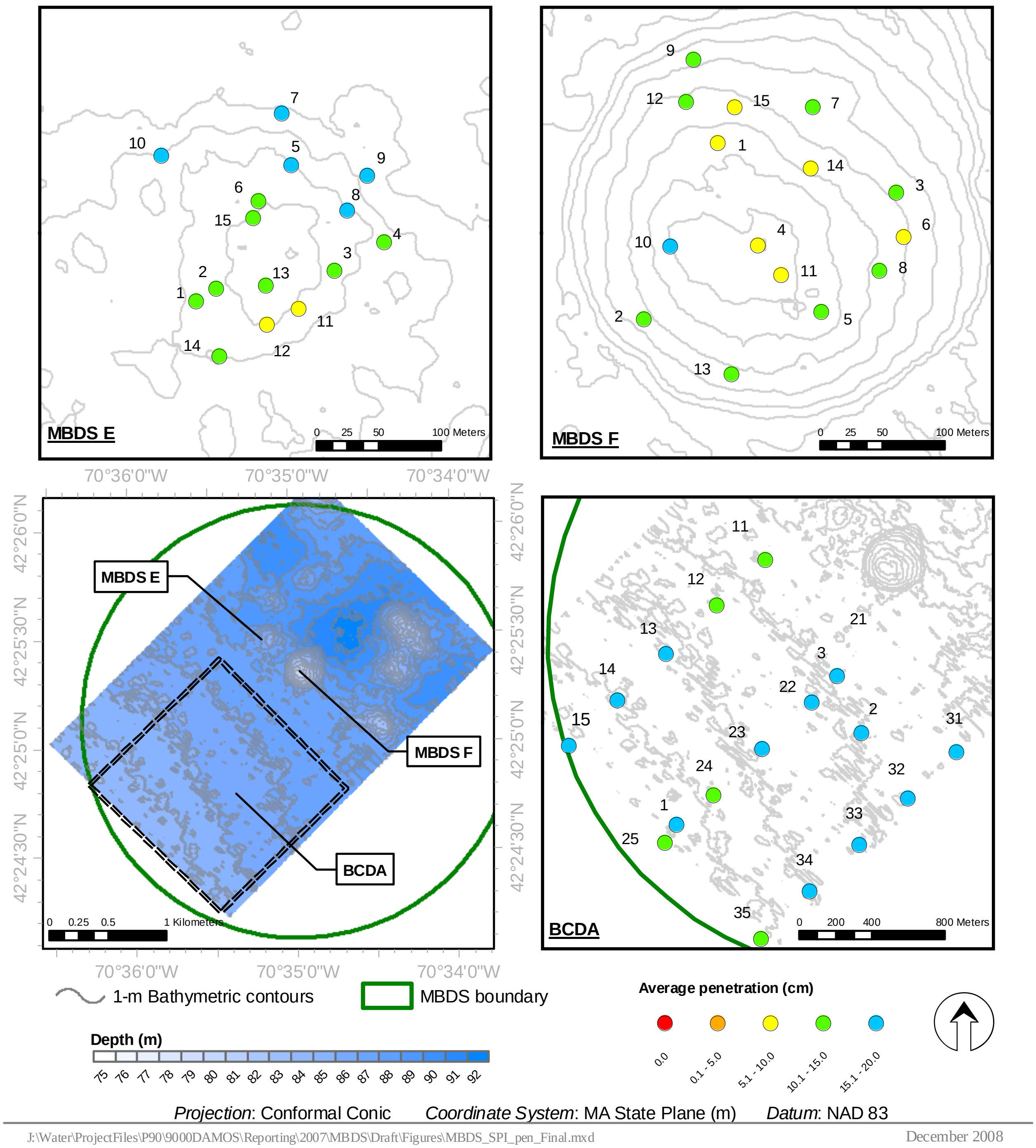

Figure 3-13. Distribution of station-averaged camera prism penetration depth (cm) at MBDS

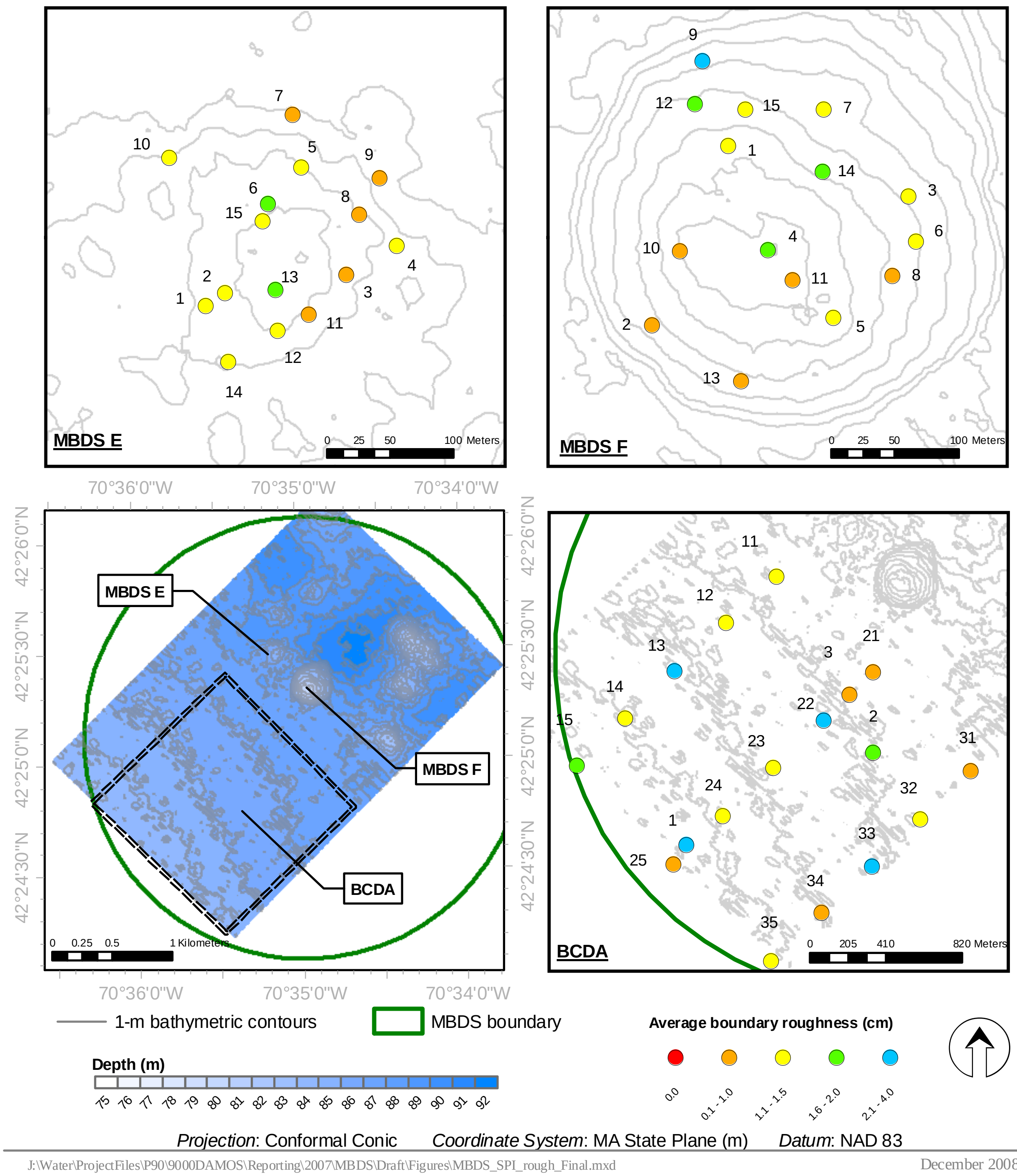

Figure 3-14. Distribution of station-averaged boundary roughness (cm) at MBDS

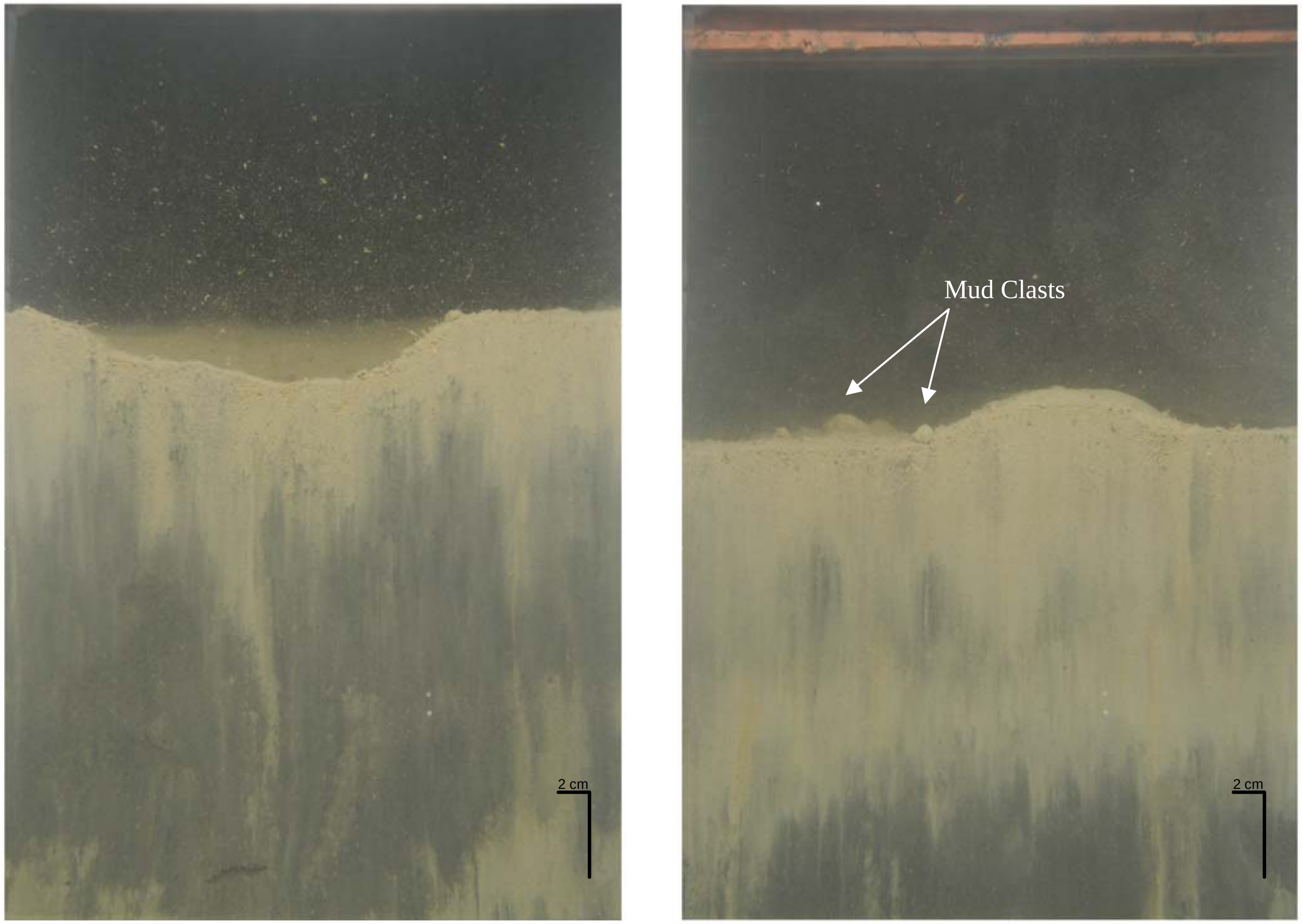

Figure 3-15. The small-scale surface boundary roughness elements seen in the profile image from Station MBDS-5 (left) were of biological origin, caused by macrofaunal bioturbation. The mud clasts in the profile image from Station MBDS-E-13 (right) are rounded and oxidized, indicating some surface disturbance prior to sampling.

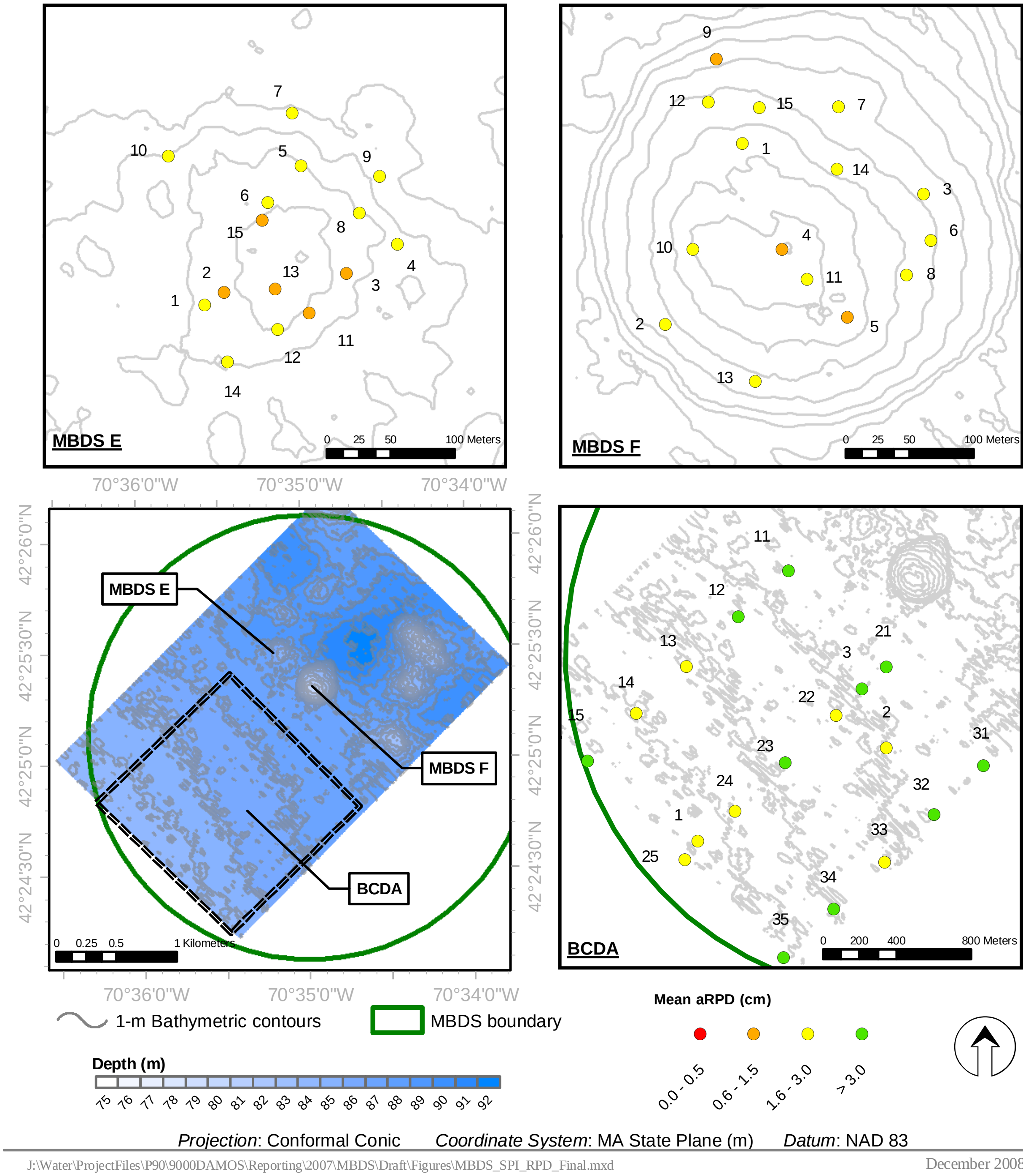

Figure 3-16. Distribution of station-averaged apparent RPD (cm) at MBDS

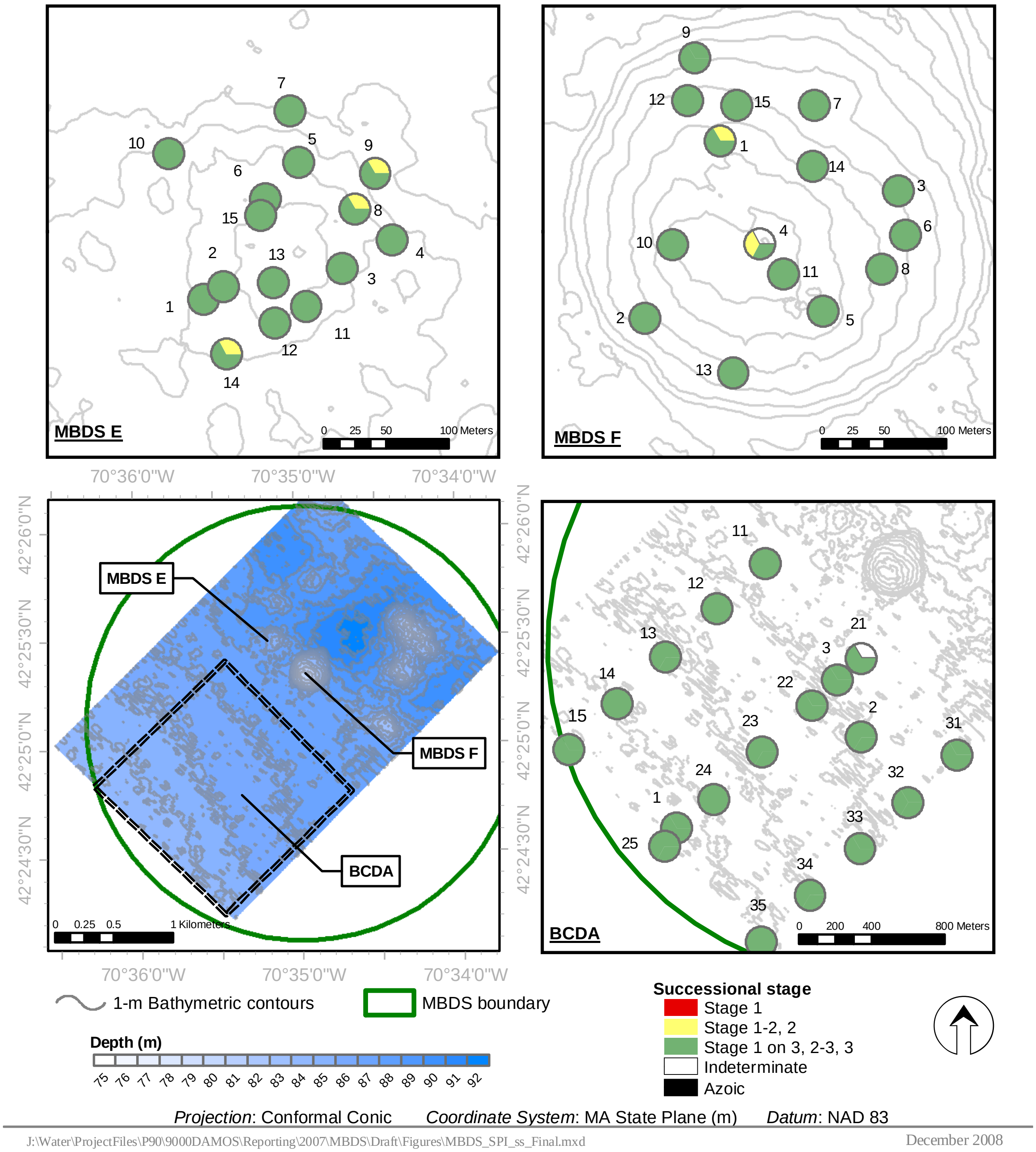

Figure 3-17. Distribution of infaunal successional stages at MBDS

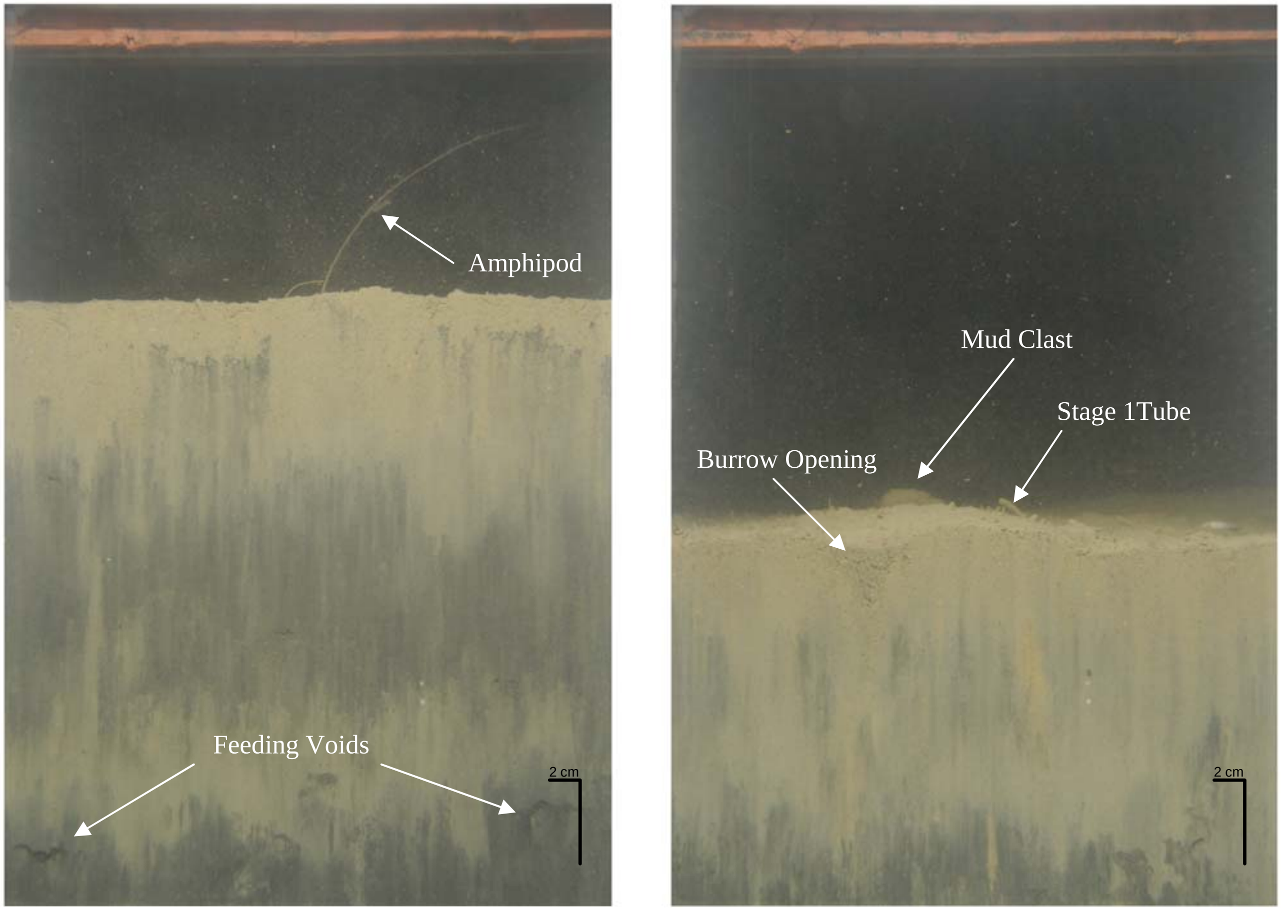

Figure 3-18. The biological conditions at the MBDS-E Mound represented clear evidence of sustained recovery with some disturbance of the surface layers. This image from Station MBDS-E-6 (left) has deep feeding voids, a buried RPD horizon, and Stage 1 animals including a podocerid amphipod clinging to a proteinaceous "whip". This image from Station MBDS-E-12 (right) shows dense clay with a burrow opening filled with fecal pellets, oxidized mud clasts, Stage 1 tubes, and a feeding void.

3.2.3 MBDS-F Mound

The MBDS-F Mound received just over 2.0 million m^3 of dredged material between September 2000 and August 2007, primarily from the Boston Harbor Navigation Improvement Project. Dredged material was evident in each image and extended beyond the depth of prism penetration, apart from one replicate (Appendix B). Even though there had been no disposal at this location for over two years, clayey dredged material was still visible near the surface in most of the sediment cross-sectional images (Figure 3-19).

Sediment Physical Characteristics

All fifteen stations surveyed at the MBDS-F Mound were comprised of fine-grained sediments with a grain size major mode of >4 phi (Figure 3-12). The sediment texture was more complex than the layers of reworked dredged material at the MBDS-E Mound because of the presence of fresh clayey dredged material in many of the images (Figure 3-19).

Average camera prism penetration depth ranged from 6.1 to 15.2 cm (Figure 3-13), with an overall mound average penetration depth of 10.5 cm. Although stop collar settings varied 5 cm among stations and the number of weights per carriage ranged from one to three (Appendix B) the variation in camera prism penetration depth was still an indicator of relative sediment shear strength from varying amounts of cohesive clay present at each station (the adjustments were made mainly to prevent over penetration of the prism). The sediments on this mound were generally firmer compared with those on the MBDS-E Mound, particularly near the center of the mound (Table 3-3 and Figure 3-13), reflecting a greater proportion of fresh clayey dredged material and indicating that sediment shear strength was greater than that of the references areas. Even though all the stations sampled on this mound showed dredged material thickness in excess of the prism penetration depth (Table 3-3), there was no evidence of organic enrichment, low oxygen concentrations in the overlying water, or presence of sub-surface methane gas in any of the images collected on the MBDS-F Mound.

Average small-scale boundary roughness ranged from 0.6 to 2.8 cm over this disposal mound, with an overall mound average of 1.3 cm (Appendix B). The majority of the surface roughness elements were of physical origin; 26 of the 45 replicates had physical surface roughness elements consisting of mud clasts and physical reworking at the sediment surface (Figure 3-20, left). Biogenic boundary roughness features were dominant in 19 replicates due to the presence of burrow openings, feeding pits, or fecal mounds at the sediment-water interface (Figure 3-20, right).

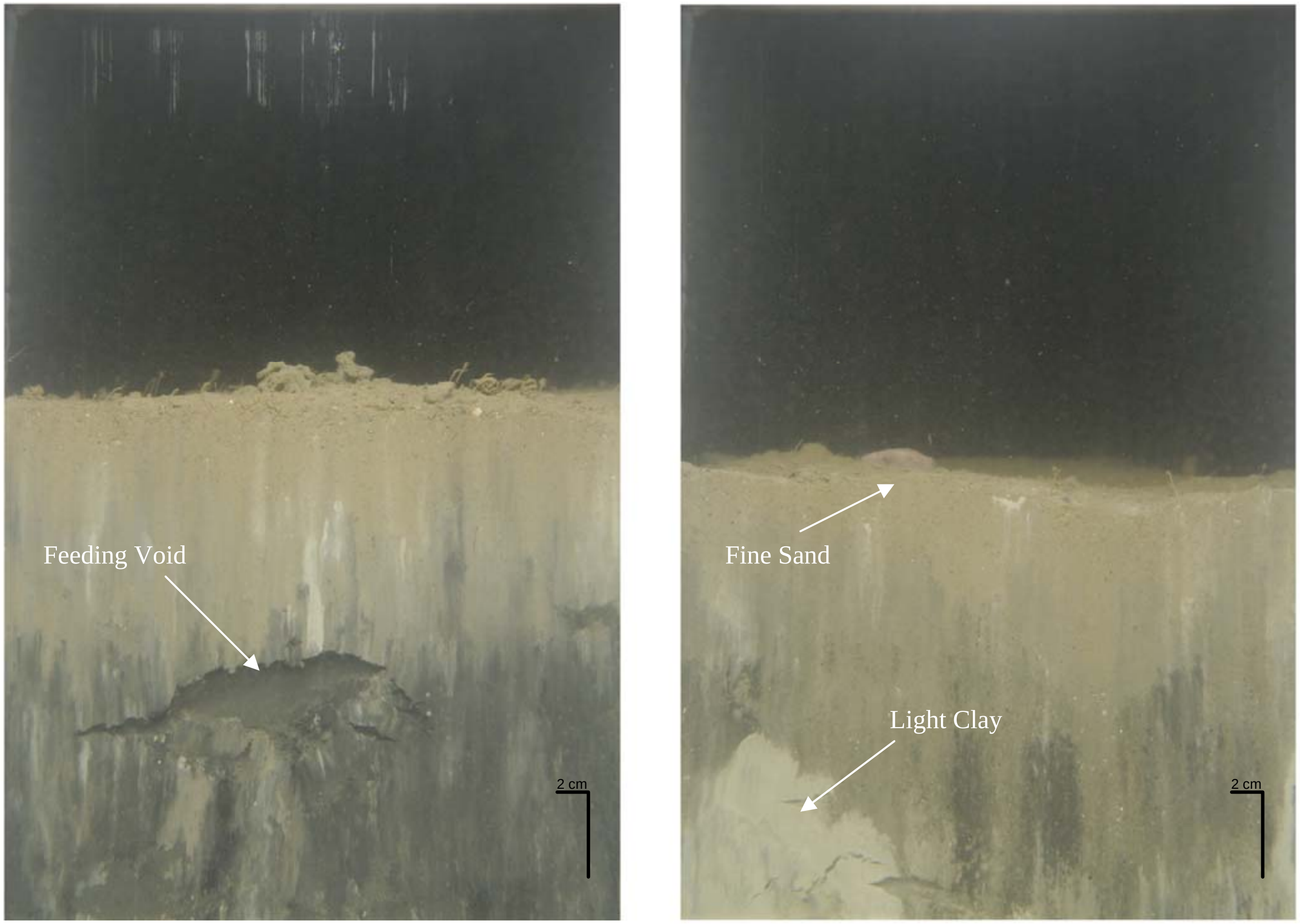

Figure 3-19. Fresh clayey dredged material and fine sandy silt were typical of the surface conditions at the MBDS-F Mound in August 2007. Light brown silt overlies dense light and dark clay with fractures and feeding voids at Station MBDS-F-13 (left). In this image from Station MBDS-F-7 (right) the large clump of light clay at the lower left is overlain by a fine sand layer and light brown silt at the surface.

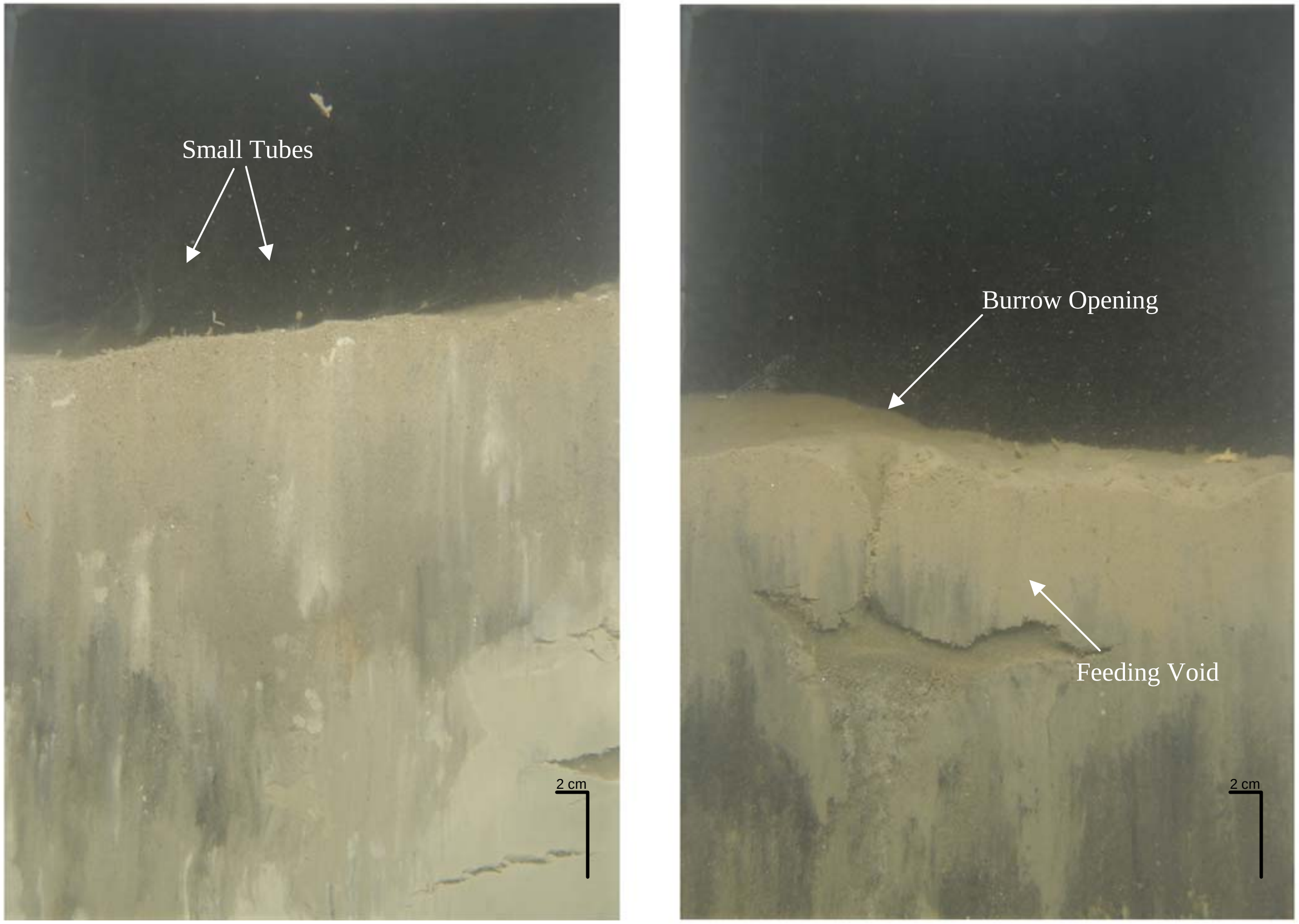

Figure 3-20. These representative sediment-profile images from the MBDS-F Mound show the range of surface roughness characteristics. Station MBDS-F-4 (left) has numerous small tubes at the surface in a layer of sandy silt with clay clumps. Station MBDS-F-15 (right) has a large burrow creating a pit and mound structure with a subsurface feeding void.

Biological Conditions and Benthic Recolonization

The average depth of the apparent RPD measured at the stations surveyed on the MBDS-F Mound ranged from 1.2 to 2.7 cm (Figure 3-16), with an overall mound average of 1.9 cm (Table 3-3). All but two of the replicates showed benthic assemblages in the late stages of colonization (Stage 2 or 3) with evidence of deposit feeding activity (Figure 3-20, right). The average depth of subsurface feeding voids ranged from 3.1 to 10.5 cm below the sediment surface (Appendix B). Most of the stations showed evidence of biological response to surface disturbance (Stage 1 colonizing animals on Stage 3 textures; Figure 3-20, left). In the year since the last disposal event, the site was completely recolonized by a mature, equilibrium, deposit-feeding community, but had subsurface sediments that were largely unchanged since deposition (Figures 3-19, 3-20, 3-21).

Many images had distinctive small rounded mud clasts on the end of thin tubes (Figure 3-21). The tubes were thicker than podocerid proteinaceous whips and are assumed to be polychaete tubes with biologically collected mud on the tube tip.

3.2.4 Barrel Cap Demonstration Area

Sediment Physical Characteristics

The 18 locations sampled within the BCDA were dominated by soft tan mud and were similar to those found at the reference areas; all stations had a sediment grain size major mode of >4 phi (silt-clay) (Figure 3-12). Eighteen of the 56 replicates sampled in this area showed dredged material thickness in excess of the prism penetration depth (Table 3-4 and Figure 3-22). However, there was no evidence of organically enriched sulfidic sediments at the surface or of the presence of sub-surface methane gas in any replicates. Some of the dredged material appeared to be the light colored clay typical of CAD cell construction (Figure 3-22, middle), and one station displayed strongly reduced dredged material below the surface sediments (Figure 3-22, right).

Average camera prism penetration depth ranged from 13.8 to 20.8 cm, with an overall mound average penetration depth of 16.6 cm (Figure 3-13 and Appendix B). The stop collars and weight settings were only changed at two stations on this mound (stop collar settings were varied from 41 to 43 cm, and either three or four weights were used in each carriage), so the measured penetration is a very good indication of relative shear strength of the ambient sediments in the BCDA. Sediment shear strength was comparable to that of the reference areas.

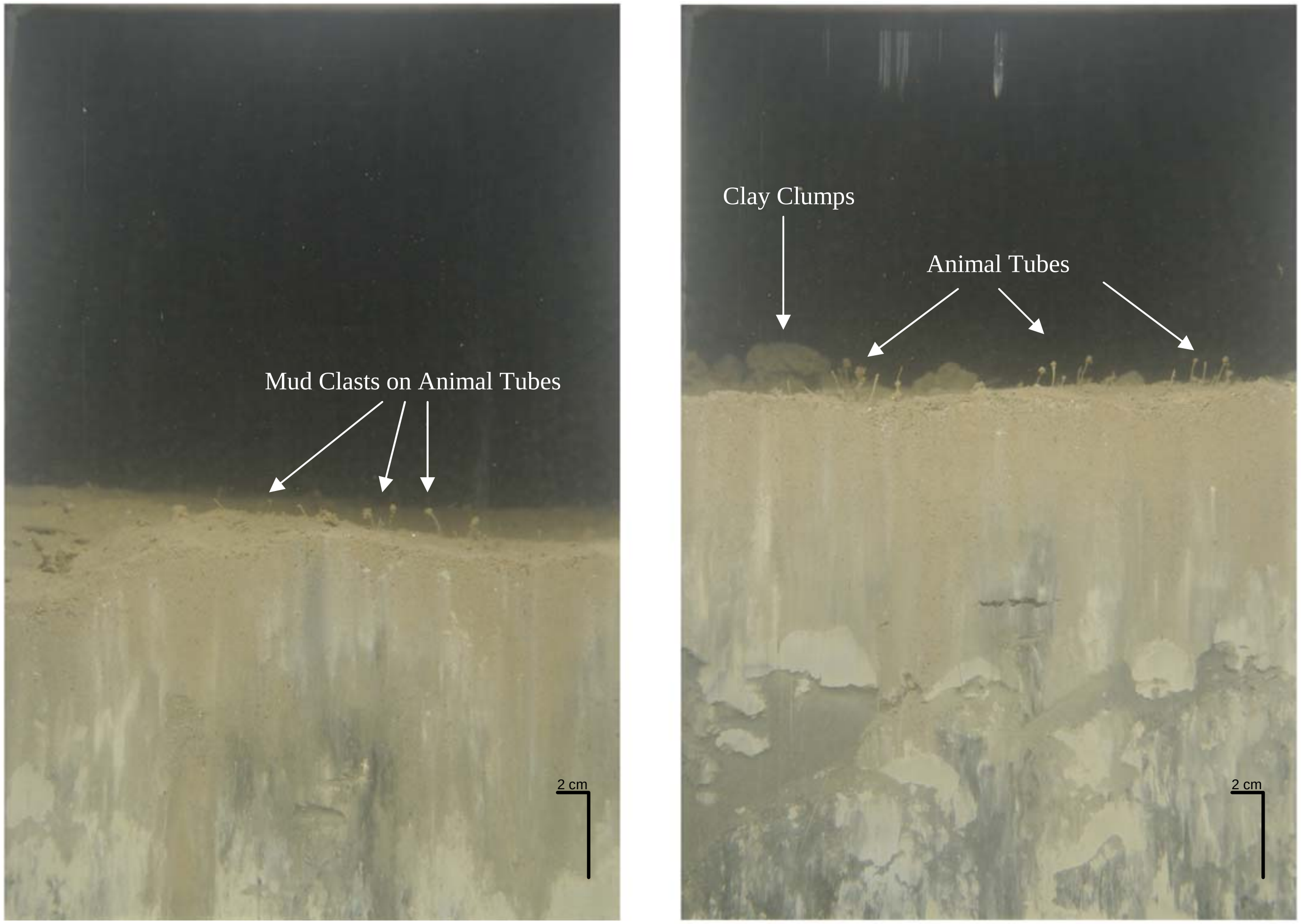

Figure 3-21. Distinctive rounded mud clasts on the tips of animal tubes are visible on the surface at many MBDS-F Mound stations. Station MBDS-F-3 (left) shows a cluster of tubes at the margin of a large burrow opening. Station MBDS-F-8 (right) shows three clusters of tubes near burrows with clay clumps in the background.

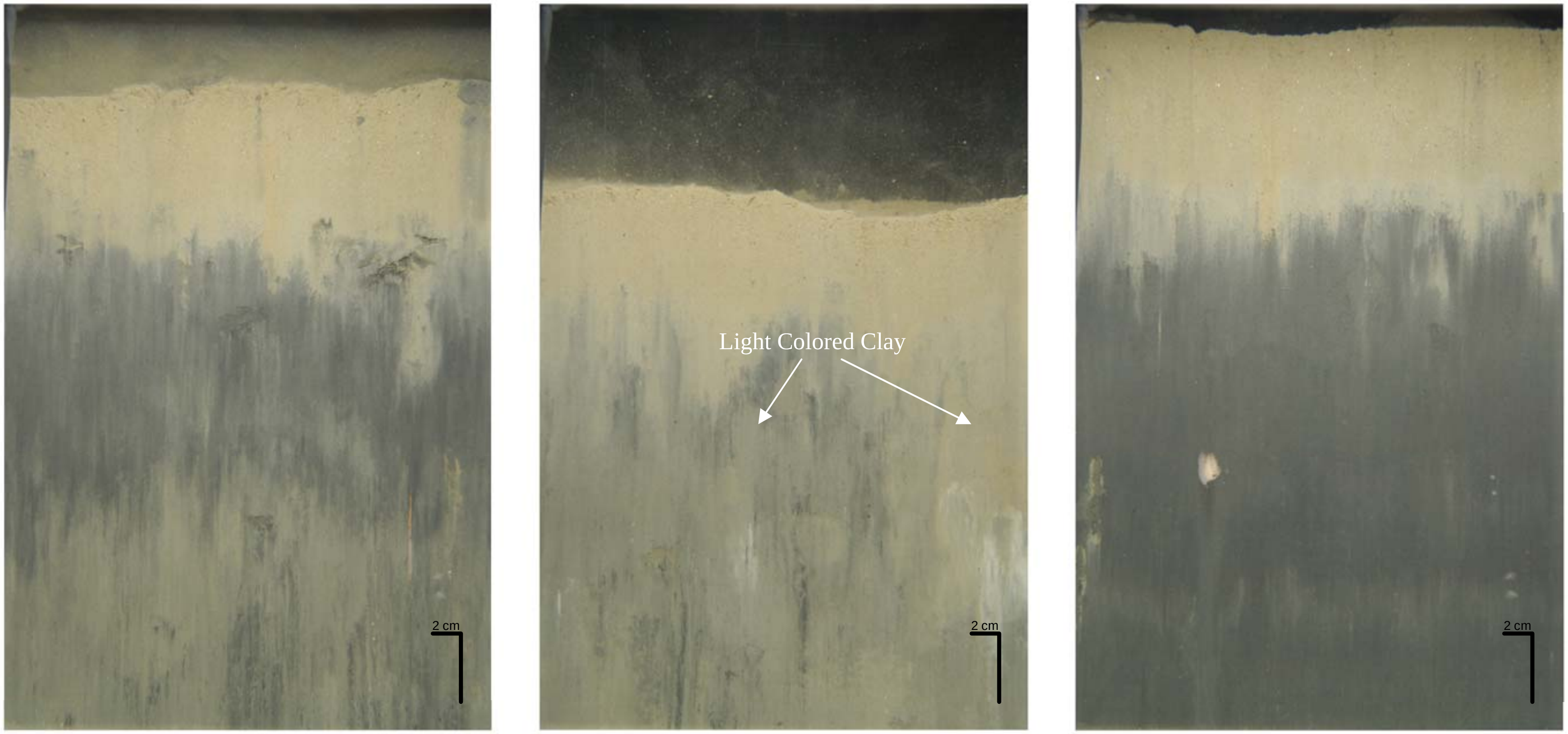

Figure 3-22. Evidence of dredged material can be seen in these profile images from the BCDA. Station DEMO-3 (left) displayed multiple layers of dredged material that are still distinct despite deep bioturbation. This image from Station DEMO-12 (middle) has several clumps of light colored clay about 10 cm below the surface. The dredged material layers in this image from Station DEMO-21 (right) are highly reduced but support Stage 3 animals.

Average small-scale boundary roughness values ranged from 0.6 to 3.3 cm, with an overall average value for BCDA of 1.5 cm (Figure 3-14). The majority of the surface roughness elements were of biological origin and due to the presence of burrows and tubes at the sediment-water interface (Figure 3-23).

Biological Conditions and Benthic Recolonization

The average depth of the apparent RPD at the stations surveyed in the BCDA ranged from 2.1 to 3.7 cm (Figure 3-16), with an overall average of 3.1 cm (Table 3-4). All of the stations showed benthic assemblages in the late stages of colonization (Stage 3) with evidence of deposit feeding activity (Figure 3-17). The average depth of subsurface feeding voids (when present) ranged from 2.5 to 11.8 cm below the sediment surface (Appendix B). Many of the stations showed evidence of biological response to surface disturbance (Stage 1 on 3). All BCDA stations were colonized by a mature, equilibrium, deposit-feeding community, with extensively bioturbated subsurface sediments (Figure 3-23).

3.2.5 Statistical Results of SPI Data Analysis

As noted previously, there are results for three replicate drops of the SPI camera at each station, and these three replicate observations were combined to get one value per station. The average of replicates was used for the station RPD, and the maximum among replicates was used as the successional stage rank for the station. Successional stage ranks have possible values between 0 (no fauna present) and 3 (Stage 3); half ranks are also possible for the "in-between" stages (e.g., Stage 1-2 has value 1.5). A summary of the mean RPD and successional stage rank values for the station means are shown in Table 3-5 and Figure 3-24.

Mean RPD Variable

The three reference areas were fairly similar, though the SEREF had slightly higher mean and variance for the RPD values (Table 3-5, Figure 3-24). Pooling stations across all reference areas was expected to increase the estimate of residual variability beyond what is probably the true within-group variance. Consequently, the three reference areas were maintained as separate locations in the following analysis.

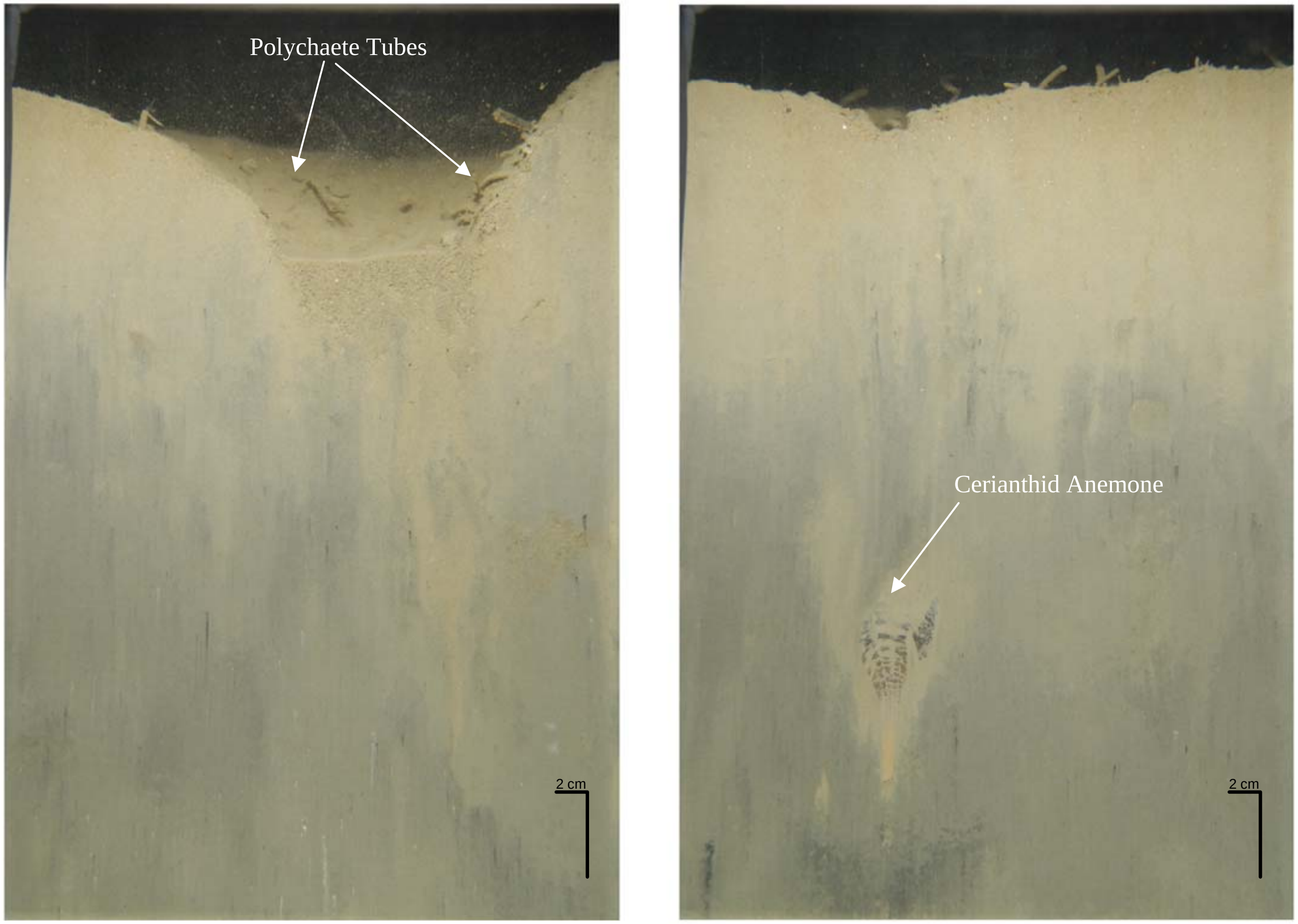

Figure 3-23. Small-scale boundary roughness was generally the result of biological activities. Station DEMO-33 (left) has a large burrow opening surrounded by polychaete tubes. Station DEMO-14 (right) also has a large burrow but with a retracted Cerianthid anemone below the surface.

Table 3-5

Summary of Station Means by Sampling Location

		Mean RPD (cm)		Successional Stage Rank	
Area	**N**	**Mean**	**Standard Deviation**	**Mean**	**Standard Deviation**
Reference Locations					
MBDREF	5	3	0.28	3	0
SEREF	5	3.6	0.44	3	0
FG23	5	3.3	0.24	3	0
Mean:		3.3		3	
Disposal Mounds/Cap Demonstration Area					
MBDS-E	15	1.9	0.52	3	0
MBDS-F	15	1.9	0.48	3	0
BCDA	18	3.1	0.39	3	0

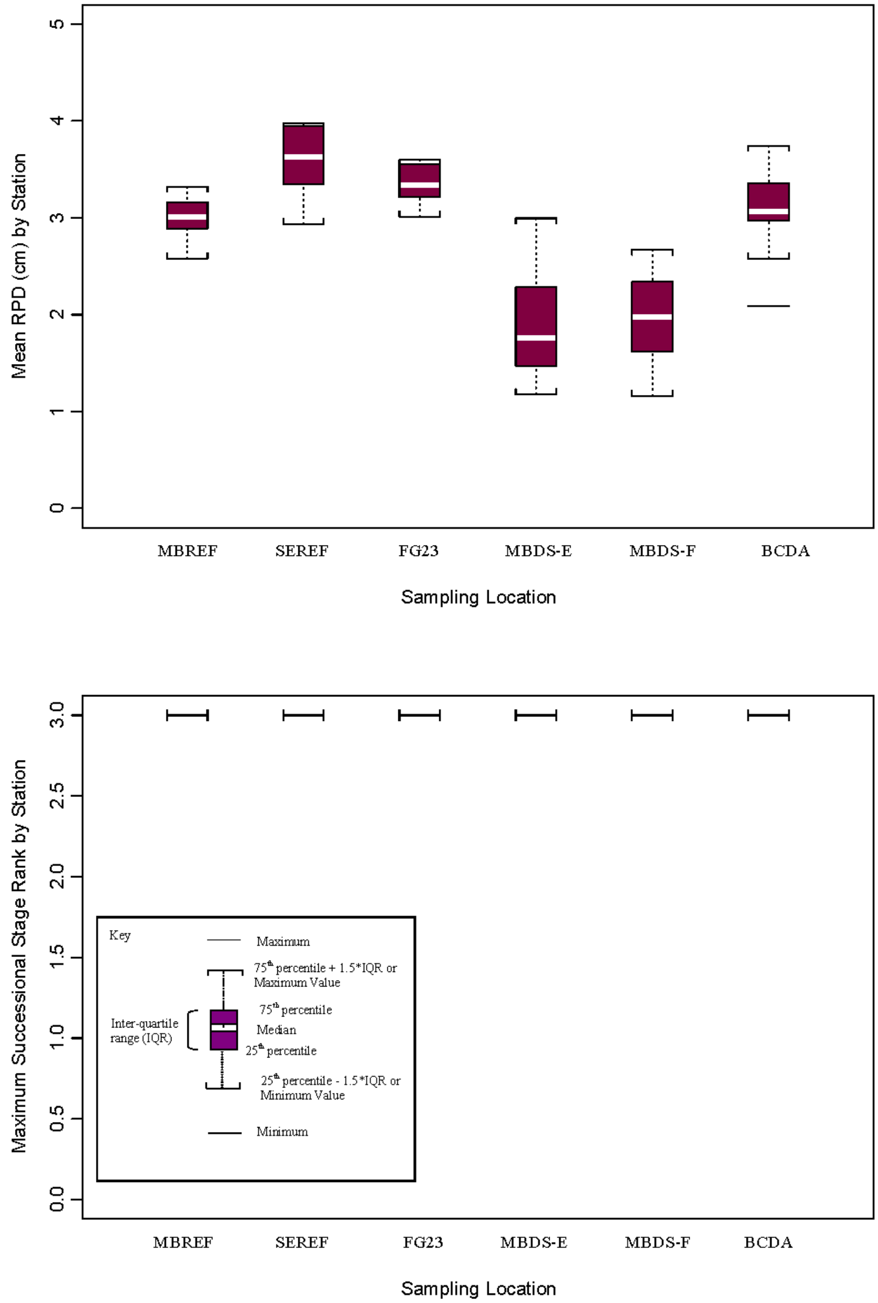

Figure 3-24. Boxplots showing distribution of station mean RPD and successional stage rank values for 2007 MBDS survey

Results for the Shapiro-Wilk's test indicate that the area residuals (i.e., each observation minus the area mean) were normal (p=0.98). The assumption of equal variances was not rejected by Levene's test (p=0.27), so a single pooled residual variance estimate was used to compute the variance for the difference equations (Table 3-6).

The specified δ values of ± 1 were outside of the 95% lower and upper confidence bounds for the shaded comparisons (Table 3-6). The difference in apparent mean RPD depth between BCDA and the reference areas was significantly less than 1 cm. Therefore, RPD depths at BCDA were not different from the reference areas within the pre-determined definition of what is "ecologically meaningful" for apparent RPD depths. The differences in apparent mean RPD depth between MBDS-E and MBDS-F Mounds and the reference areas were significantly greater than 1 cm. Thus, RPD depths at these mounds were not equivalent (within the pre-determined definition of "ecologically meaningful") to those found at the reference areas.

<u>Successional Stage Rank Variable</u>

Every station on MBDS-E and MBDS-F Mounds, the BCDA, and reference areas received a successional stage rank value of 3 (Stage 3 or equivalent). Hence, no statistics are needed to conclude that there are no differences among areas.

3.3 Sediment Box Cores

Four sediment box cores were collected within the BCDA. SPI data from the 2007 survey confirmed targeting assumptions that stations DEMO-2 and DEMO-3 were in areas that received dredged material in the past and that stations DEMO-1 and DEMO-15 did not show any evidence of past disposal activity (Table 3-4). Field descriptions of the four cores are presented in Appendix C.

3.3.1 Core Characteristics

Sub-cores collected from the box cores had a recovery that ranged from 17 to 38 cm with compaction measurements between 2.5 and 5.1 cm. Field observations revealed a uniform light-colored, soft layer in the upper 3.8 to 5.1 cm in each core (Appendix C). Below that interface the sediment was dense and darker than the overlying material with shale fragments visible in cores DEMO-2 and DEMO-15. The bottom segment was also dense and dark but exhibited a sticky texture in cores DEMO-1, DEMO-3, and DEMO-15. A square-style clothespin was recovered from the bottom layer of core DEMO-2.

Table 3-6

Summary Statistics and Results of Bioequivalence Testing for RPD Values

Difference Equation	**Observed Difference ($\hat{d}$)**	**SE ($\hat{d}$)**	**Degrees of Freedom for SE ($\hat{d}$)**	**95% Lower Confidence Bound**	**95% Upper Confidence Bound**
All REF – MBDS-E	1.4	0.16	57	1.1	1.7
All REF – MBDS-F	1.4	0.16	57	1.1	1.6
All REF – BCDA	0.2	0.15	57	-0.05	0.46

Note: Shading indicates that the two groups were "statistically equivalent".

3.3.2 Sediment Analysis

A grab sample from the top, middle, and bottom segment of each core was analyzed for grain size, moisture content, and Atterberg limits.

3.3.3 Grain Size

The grain size analysis confirmed the SPI data at the four stations, with an average major mode of >4 phi (silt-clay) at each location (Table 3-4). However, grain size varied among the samples; only 38% of the middle layer of DEMO-2 was silt and clay size sediments, while 98% of the top layer of DEMO-1 consisted of these fine-grained materials (Table 3-7). The two cores collected closer to the main disposal areas of MBDS were considerably coarser than the cores collected from native sediments. Average percent fines for the three segments from each of the two stations with evidence of past disposal ranged from 58.1 to 84.5%, while average percent fines for the three segments from the two stations near the boundary of MBDS (and farther from the main disposal areas) were all above 94% (Table 3-8).

3.3.4 Moisture Content and Atterberg Limits

Moisture content ranged from 77 to 205% in the samples (Table 3-7). There was an overall decrease in moisture content with depth at each station with the exception of the middle layer of core DEMO-15 and the bottom layer of DEMO-1. Plastic limits were consistently between 32 and 42% for each sample and showed no trends across depth or location (Table 3-7). The liquid limits were more varied and ranged from 82 to 121% (Table 3-7). Liquid limits at the stations with evidence of past disposal were lower than those of the western-most stations. The average for the three segments from the two stations with dredged material ranged from 79 to 94%, while the averages from the two western locations were all above 110% (Table 3-8).

Table 3-7

Box Core Sediment Analysis Results from the August 2007 Survey

Station ID	Segment	Laboratory Description	Moisture Content (%)	Percent Fines	Atterberg Limits (%)	
					Liquid Limit	**Plastic Limit**
DEMO-1	Top	Wet, dark grayish brown clay	206	97.8	110	34
	Middle	Wet, very dark grayish brown clay	129	97.5	121	37
	Bottom	Wet, very dark gray clay	130	97.5	116	38
DEMO-2	Top	Wet, olive silt with sand	152	79.2	82	38
	Middle	Moist, very dark grayish brown clayey gravel with sand	105	38	84	36
	Bottom	Moist, dark olive gray clay with sand	77	70.5	74	33
DEMO-3	Top	Wet, olive brown clay	186	89.7	105	36
	Middle	Wet, dark greenish gray clay with sand	115	78.2	80	32
	Bottom	Wet, very dark gray clay with sand	106	81.3	83	30
DEMO-15	Top	Wet, very dark grayish brown clay	116	96.6	111	39
	Middle	Wet, olive brown silt	139	96.8	101	42
	Bottom	Moist, very dark gray clay	88	92.1	107	36

Table 3-8

Comparison of Sediment Analysis Results from Disposal and Non-Disposal Locations

				Atterberg Limits (%)	
Area	**Segment**	**Average Moisture Content (%)**	**Average Percent Fines**	**Average Liquid Limit**	**Average Plastic Limit**
Apparent Disposal Activity (DEMO-2, DEMO-3)	Top	169	84.5	94	37
	Middle	110	58.1	82	34
	Bottom	92	75.9	79	32
No Apparent Disposal Activity (DEMO-1, DEMO-15)	Top	161	97.2	111	37
	Middle	134	97.2	111	40
	Bottom	109	94.8	112	37

4.0 DISCUSSION

The objectives of the August 2007 survey efforts at MBDS were to characterize the distribution of dredged material at historical disposal mounds, document the formation of an expanded disposal mound (MBDS-F) and a new disposal mound (MBDS-G), assess the benthic recolonization status of MBDS-E and MBDS-F, and describe the sediment composition and benthic biological status of the BCDA. These objectives were met through bathymetric, SPI, and box core survey techniques.

4.1 Dredged Material Distribution

The August 2007 survey was designed to document the distribution of recent disposal activity around MBDS-F and the newly formed mound at MBDS-G as well as assess changes in historical mounds and provide baseline seafloor topography for the BCDA. Since the MBDS-F Mound was first observed during the 2004 bathymetric survey (ENSR 2005), it has received approximately 1.5 million m^3 of dredged material. This new material resulted in an increase in mound height from 4 to 7 m above the seafloor. Despite nearly doubling in height, the bathymetrically observable diameter of MBDS-F had not changed significantly since the 2004 survey.

The disposal of approximately 550,000 m^3 of dredged material at the disposal buoy since September 2006 resulted in the formation of a seventh distinct mound at the site, MBDS-G. The mound measured 250 m in diameter and 3 m in height.

Overall, there were no major changes in bathymetry over the historical mounds compared with the 2004 survey. A few small areas of water depth increases were observed over the older mounds between 2004 and 2007, indicative of potential limited consolidation or material loss. These areas may also have been artifacts related to sea conditions and water column stratification during the 2007 survey. Regardless of the cause, these areas were limited in extent and do not represent significant erosion or compaction events.

Bathymetric data from the BCDA revealed relatively uniform seafloor topography, with a gradual decrease in depth with increasing distance from the active disposal portion of MBDS. No obvious historical disposal mounds were observed within the BCDA, but minor irregularities in the bathymetry suggested the presence of limited historical disposal activity over the area.

4.2 Biological Conditions and Benthic Recolonization

The results of this SPI survey confirmed the recolonization predictions made at the outset of the survey for the disposal mounds and were consistent with observations of the reference area conditions noted in previous monitoring surveys at MBDS (SAIC 1997a and 2002, ENSR 2005).

Recolonization at MBDS-E and MBDS-F Mounds has continued as expected, with mature, Stage 3 communities found at every station on both of these mounds. Infaunal burrowers and deposit feeders were evident in the SPI images from these two mounds, and both mounds displayed habitat conditions similar to those found at the reference stations.

The most intriguing result of the survey was the presence of mud clasts or mud balls at the top of a large number of tubes at the MBDS-F Mound (Figure 3-21). These distinctive features were not observed at all stations, or even at all replicates at a station, nor were they observed at the MBDS-E Mound, the BCDA or the reference areas. The structures below the mud clasts appear to be small polychaete tubes (most likely of the family Spionidae), but the clasts may not be formed by the tube constructors. Small polychaetes have been observed in the laboratory to collect organically rich detritus into balls (S.A. Woodin, personal communication, September 2008), but this has rarely been observed under field conditions except in deep sea polychaetes (Cirratulidae in oxygen minimum zones, Levin 2003). Some small amphipods (*Erichthonius* spp.) are surface deposit feeders that have been observed to collect mud aggregations and raise them off the seafloor (L. Watling, personal communication, September 2008). These amphipods may be living in spionid tubes or forming their own tubes. The presence of the mud clasts appears specific to profile images with biological roughness features rather than any physical features (ripples, physical reworking). The mud clasts may represent a brief settlement of mud-aggregating amphipods at this one site.

The MBDS-E Mound received 750,000 m^3 of dredged material from October 1999 to January 2001. The 2007 survey was conducted six years after the last disposal activity at MBDS-E, providing ample time for recolonization of this relatively small mound. Although the RPD depths at the mound were shallower than reference area values (Tables 3-5 and 3-6), the successional stage conditions were comparable with those of the reference areas, indicating advanced recolonization. Indeed, all MBDS stations displayed advanced successional stages with extensive burrowing and feeding voids (Figure 3-17).

The MBDS-F Mound received approximately 1.6 million m^3 of dredged material between October 1999 and September 2006, primarily from the Boston Harbor Navigation Improvement Project. The 2007 survey was conducted 11 months after the last disposal activity at this mound, but substantial recolonization activity had already occurred (Figure 3-17). All stations displayed advanced stages of recolonization despite the presence of coherent clumps of dense clay material below the surface (Figure 3-19). As expected, the RPD measurements of stations on the mound were shallower than reference areas (Tables 3-5 and 3-6) but were indistinguishable from or slightly deeper than the RPD depths of the MBDS-E Mound.

The BCDA has not received large volumes of recent dredged material. The 2007 survey was designed to provide a baseline description of sediments in the area prior to the planned capping demonstration disposal to enable evaluation of the impact of the demonstration project on ambient material. It was expected that the area selected for the demonstration project might have small amounts of historical dredged material. Prior to the establishment of specific disposal points in Massachusetts Bay in 1979, barge loads of dredged material were directed not only to specific areas but also to compass headings or LORAN lines, which can be less precise methods of directing disposal. In addition, barges may lose small amounts of material during transit, which could also result in limited dredged material outside of a specific target disposal area.

The BCDA was very similar to the reference areas in sediment composition, successional status, and shear strength. Several stations displayed clear evidence of historical dredged material and some trace amounts of apparent Boston Blue Clay. The general area in and near the historical IWS is expected to have sediment and geotechnical properties similar to those of the BCDA and reference areas based on the similarity of its physical setting (proximity and bathymetry). The existing reference areas should provide adequate comparative analysis for the planned demonstration project at BCDA, as well as any future capping operations at the IWS, provided sufficient ground truth data are collected at IWS prior to disposal.

4.3 Sediment Analysis

Box cores were collected during the August 2007 survey to further document the sediment characteristics of the BCDA. The two cores collected from areas of suspected historical disposal activity were substantially coarser than the two cores collected from the area considered more representative of native sediments (Table 3-8). This difference in grain size likely reflects the locally impacted nature of the sediments in the BCDA due to undocumented disposals prior to DAMOS management of the site (1977).

All four cores exhibited a 3.8 to 5.0 cm surficial layer of clay or elastic silt (Appendix C). Sediments at the IWS are expected to show similar stratification near the sediment-water interface, and the geotechnical results from the four BCDA cores will aid in planning and interpreting the results of the capping evaluation at the BCDA.

5.0 CONCLUSIONS

The August 2007 survey provided a means to assess changes in seafloor topography and the benthic recolonization status of one historical mound (MBDS-E) and one mound that received additional, more recent material (MBDS-F). The survey also enabled characterization of a new disposal mound, MBDS-G, that received approximately 550,000 m3 of dredged material between September 2006 and August 2007. The BCDA, for which future plans involved its use for a capping demonstration project, was also surveyed to provide a baseline for seafloor topography, benthic community status, and sediment composition.

The 2007 survey was designed to assess the following expectations:

- The placement of approximately 1.5 million m^3 of dredged material at the disposal buoy between September 2004 and September 2006 will result in the continued development of the MBDS-F Mound;

- The placement of approximately 550,000 m^3 of dredged material at the repositioned disposal buoy between September 2006 and August 2007 will result in the formation of a new mound, MBDS-G, to the northeast of the MBDS-D Mound;

- Mounds created in past years will show limited change in elevation except for the most recently created mounds, which should show some evidence of continued consolidation;

- As the MBDS-E Mound has not received significant dredged material in more than six years (only 5,000 m^3 since January 2001), it is expected that the benthic community will include Stage 3 taxa and will display conditions comparable to those found at the reference areas;

- Due to the high volume of dredged material recently disposed at the MBDS-F Mound, early community assemblages (Stage 1 or 2) will dominate; and

- Since disposals have not been directed to the BCDA since the establishment of specific disposal points in Massachusetts Bay in 1979, the benthic biological status and sediment composition will be similar to those found at the reference areas.

The MBDS-F Mound increased in height by approximately 3 m since the 2004 survey. Despite nearly doubling in height, the observable diameter of the MBDS-F Mound had not changed significantly since the 2004 survey. The new mound, MBDS-G, measured 250 m in diameter and 3 m in height. No significant changes in bathymetry were noted at the MBDS-E Mound or elsewhere in the survey area.

Recolonization at MBDS-E Mound continued as expected, with mature, Stage 3 communities found at every station. MBDS-F Mound recolonization progressed more rapidly than anticipated; Stage 3 communities were also found at every station of this mound. Both mounds displayed habitat conditions similar to those found at the reference stations.

The topography at the BCDA was relatively uniform, with a gradual decrease in depth with increasing distance from the active disposal portion of MBDS. The BCDA was very similar to the reference areas in sediment composition, successional status, and shear strength. Several BCDA SPI stations displayed clear evidence of historical dredged material and some trace amounts of apparent Boston Blue Clay. The box cores revealed a soft, light-colored layer comprised of clay or elastic silt in the upper 3.8 to 5.0 cm in each core, followed by dense and darker material. The existing MBDS reference areas should provide an adequate comparison for the planned capping demonstration project at the BCDA, as well as for any future capping operations at the IWS, provided sufficient ground truth data are collected from the IWS prior to disposal.

Based on the findings of the 2007 MBDS survey, the following recommendations are proposed:

R1) Unless future dredged material is directed to the MBDS-E and MBDS-F Mounds, there is no need to regularly monitor these areas of advanced recolonization;

R2) Following the cessation of disposal at the MBDS-G Mound, a SPI survey should be conducted to confirm that a normal pattern of benthic recolonization is occurring; and

R3) The existing MBDS reference areas should be used as a comparison of recolonization for both the capping demonstration project and any future capping operations at the IWS.

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Appendix A

Disposal Barge Log Summary for MBDS
September 2004 to August 2007

Appendix A
Disposal Barge Log Summary MBDS – September 2004 to August 2007

Project Name: WEYMOUTH FORE RIVER
Permittee: METROPOLITAN YACHT CLUB
Permit Number: 199700038

Disposal Date	Volume (yd^3)	Volume (m^3)	Disposal Latitude (degrees)	Disposal Longitude (degrees)	Approximate Distance from Buoy (ft)	Approximate Direction from Buoy
10/13/2004	1,300	994	42.42227	-70.58240	50 - 75	NEW
10/14/2004	1,375	1,051	42.42208	-70.58250	150	SWE
11/1/2004	1,400	1,070	42.42175	-70.58240	100	
11/2/2004	1,400	1,070	42.42208	-70.58240	150	
11/4/2004	1,475	1,128	42.42233	-70.58242	125	
11/6/2004	1,350	1,032	42.42217	-70.58240	no buoy	
11/9/2004	1,350	1,032	42.42225	-70.58240	no buoy	
11/10/2004	1,350	1,032	42.42225	-70.58240	no buoy	
11/11/2004	1,400	1,070	42.42225	-70.58240	no buoy	
11/16/2004	1,400	1,070			no buoy	
11/17/2004	1,400	1,070			no buoy	
11/18/2004	1,400	1,070			no buoy	
Total Dredged Material Volume	16,600	12,692				

Project Name: YACHT CLUB
Permittee: POINT OF PINES YACHT CLUB
Permit Number: 200002894

Disposal Date	Volume (yd^3)	Volume (m^3)	Disposal Latitude (degrees)	Disposal Longitude (degrees)	Approximate Distance from Buoy (ft)	Approximate Direction from Buoy
9/16/2004	1,100	841	42.42248	-70.58230	75-100	N?
Total Dredged Material Volume	1,100	841				

Project Name: BOSTON HARBOR
Permittee: COE - BOSTON HARBOR FED. PROJECT
Permit Number: 2004C0006

Disposal Date	Volume (yd^3)	Volume (m^3)	Disposal Latitude (degrees)	Disposal Longitude (degrees)	Approximate Distance from Buoy (ft)	Approximate Direction from Buoy
9/25/2004	5,100	3,899	42.42212	-70.58321	no buoy	
9/26/2004	3,300	2,523	42.42182	-70.58234	110	
9/27/2004	5,400	4,129	42.42356	-70.58450	250	
9/28/2004	2,800	2,141	42.42175	-70.58373	200	
9/30/2004	3,500	2,676			150	
10/1/2004	4,500	3,441	42.42122	-70.58344	150	
10/2/2004	3,600	2,753	42.42254	-70.58288	150	
10/3/2004	5,600	4,282	42.42255	-70.58283	100	
10/3/2004	3,450	2,638	42.42270	-70.58287	300	S
10/4/2004	5,700	4,358	42.42139	-70.58165	400	S
10/4/2004	3,100	2,370	42.42203	-70.58295	100	

Appendix A
Disposal Barge Log Summary MBDS – September 2004 to August 2007

Project Name: BOSTON HARBOR
Permittee: COE - BOSTON HARBOR FED. PROJECT
Permit Number: 2004C0006

Disposal Date	Volume (yd^3)	Volume (m^3)	Disposal Latitude (degrees)	Disposal Longitude (degrees)	Approximate Distance from Buoy (ft)	Approximate Direction from Buoy
10/5/2004	3,300	2,523	42.42227	-70.58278	100	N
10/6/2004	5,600	4,282	42.42210	-70.58229	5	S
10/7/2004	3,600	2,753	42.42248	-70.58268	100	S
10/7/2004	5,700	4,358	42.42265	-70.58290	125	S
10/7/2004	3,000	2,294	42.42260	-70.58253	150	N
10/8/2004	5,500	4,205	42.42277	-70.58279	200	N
10/8/2004	3,200	2,447	42.42240	-70.58259	60	N
10/9/2004	5,600	4,282	42.42231	-70.58242	50	N
10/9/2004	3,200	2,447	42.42276	-70.58291	300	N
10/9/2004	5,300	4,052	42.42246	-70.58277	100	N
10/9/2004	3,100	2,370	42.42197	-70.58232	50	S
10/10/2004	5,500	4,205	42.42247	-70.58254	100	N
10/10/2004	3,450	2,638	42.42228	-70.58290	50	N
10/10/2004	5,600	4,282	42.42233	-70.58258	50	N
10/10/2004	3,500	2,676	42.42181	-70.58345	150	N
10/11/2004	5,800	4,435	42.42260	-70.58254	125	N
10/11/2004	3,500	2,676	42.42219	-70.58258	100	N
10/13/2004	5,700	4,358	42.42286	-70.58218	200	N
10/13/2004	3,000	2,294	42.42256	-70.58208	100	S
10/13/2004	5,650	4,320	42.42160	-70.58293	200	S
10/14/2004	3,200	2,447	42.42423	-70.58582		
10/14/2004	5,300	4,052	42.42250	-70.58270	150	N
10/14/2004	3,100	2,370	42.42256	-70.58227		
10/15/2004	5,400	4,129	42.42233	-70.58353		
10/15/2004	3,100	2,370	42.42277	-70.58271		
10/15/2004	5,800	4,435	42.42236	-70.58283		
10/15/2004	3,250	2,485	42.42261	-70.58271		
10/16/2004	5,400	4,129	42.42262	-70.58296		
10/16/2004	3,100	2,370	42.42217	-70.58249		
10/16/2004	3,000	2,294	42.42196	-70.58272		
10/17/2004	5,700	4,358	42.42241	-70.58259		
10/17/2004	3,250	2,485	42.42238	-70.58238		
10/17/2004	5,800	4,435	42.42291	-70.58133		
10/18/2004	3,100	2,370	42.42229	-70.58263		
10/18/2004	5,600	4,282	42.42142	-70.58236		
10/18/2004	3,250	2,485	42.42240	-70.58249		
10/19/2004	5,600	4,282	42.42250	-70.58251		
10/19/2004	4,600	3,517	42.42263	-70.58246		
10/19/2004	3,250	2,485	42.42252	-70.58277	80	N
10/19/2004	5,500	4,205	42.42235	-70.58230	30	N
10/20/2004	3,250	2,485	42.42242	-70.58208	30	NNE
10/25/2004	5,400	4,129	42.42242	-70.58242	40	NW
10/26/2004	5,650	4,320	42.42232	-70.58180	20	W
10/26/2004	3,500	2,676	42.42235	-70.58230	20	N
10/27/2004	5,600	4,282	42.42238	-70.58227	40	NE

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Disposal Date	Volume (yd^3)	Volume (m^3)	Disposal Latitude (degrees)	Disposal Longitude (degrees)	Approximate Distance from Buoy (ft)	Approximate Direction from Buoy
10/27/2004	3,380	2,584	42.42227	-70.58218	80	N
10/27/2004	5,400	4,129	42.42265	-70.58288	90	NW
10/28/2004	3,400	2,600	42.42242	-70.58228	40	N
10/28/2004	3,510	2,684	42.42242	-70.58240	40	NE
10/29/2004	5,450	4,167	42.42252	-70.58208	50	N
10/29/2004	3,380	2,584	42.42240	-70.58215	40	NE
10/29/2004	5,450	4,167	42.42248	-70.58248	70	N
10/29/2004	3,320	2,538	42.42215	-70.58227	40	ENE
10/30/2004	5,450	4,167	42.42037	-70.58042	100	ENE
10/30/2004	3,450	2,638	42.42248	-70.57983	50	E
10/31/2004	5,450	4,167	42.42333	-70.58002	60	N
10/31/2004	3,250	2,485	42.42237	-70.58167	10	N
10/31/2004	5,450	4,167	42.42317	-70.58167	300	NE
10/31/2004	3,300	2,523	42.42190	-70.58230	20	S
11/1/2004	5,450	4,167	42.42222	-70.58228	20	N
11/1/2004	3,250	2,485	42.42250	-70.58232	70	N
11/1/2004	5,300	4,052	42.42225	-70.58232	30	N
11/2/2004	3,300	2,523	42.42242	-70.58227	43	N
11/2/2004	5,600	4,282	42.42243	-70.58228	30	NNE
11/2/2004	3,300	2,523	42.42242	-70.58222	35	N
11/25/2004	3,920	2,997	42.42300	-70.58183	300	NE
11/25/2004	4,405	3,368	42.42200	-70.57200	50	S
11/25/2004	3,627	2,773	42.42217	-70.58083	15	S
11/26/2004	4,921	3,763	42.42217	-70.58215	40	E
11/26/2004	3,722	2,846	42.42238	-70.58228	20	E
11/26/2004	4,576	3,499	42.42215	-70.58235	40	SE
11/26/2004	3,800	2,905	42.42238	-70.58232	0	
11/27/2004	4,500	3,441	42.42225	-70.58223	40	SE
11/27/2004	4,233	3,237	42.42232	-70.58230	10	S
11/27/2004	4,500	3,441	42.42253	-70.58213	60	NE
11/28/2004	3,555	2,718	42.42235	-70.58252	70	W
11/29/2004	3,891	2,975	42.42183	-70.58208	40	SE
11/29/2004	3,800	2,905	42.42220	-70.58225	0	
11/30/2004	4,500	3,441	42.42218	-70.58207	50	SE
11/30/2004	3,722	2,846	42.42237	-70.58233	10	NW
11/30/2004	4,062	3,106	42.42210	-70.58208	80	SSE
12/1/2004	3,800	2,905	42.42228	-70.58227	20	SE
12/2/2004	4,576	3,499	42.42182	-70.58163	100	SE
12/2/2004	3,925	3,001	42.42217	-70.58213	90	SE
12/2/2004	4,233	3,237	42.42238	-70.58228	0	
12/3/2004	3,891	2,975	42.42228	-70.58233	40	SSW
12/3/2004	4,576	3,499	42.42243	-70.58185	80	ENE
12/3/2004	3,825	2,925	42.42205	-70.58210	65	SE
12/4/2004	4,921	3,763	42.42213	-70.58210	70	SE
12/4/2004	3,891	2,975	42.42232	-70.58232	0	

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Disposal Date	Volume (yd^3)	Volume (m^3)	Disposal Latitude (degrees)	Disposal Longitude (degrees)	Approximate Distance from Buoy (ft)	Approximate Direction from Buoy
12/4/2004	4,233	3,237	42.42222	-70.58228	30	S
12/5/2004	4,100	3,135	42.42203	-70.58205	90	SSE
12/5/2004	4,576	3,499	42.42233	-70.58195	100	E
12/6/2004	4,749	3,631	42.42215	-70.58230	60	S
12/6/2004	4,835	3,697	42.42223	-70.58228	20	E
12/7/2004	4,062	3,106	42.42232	-70.58233	20	SW
12/8/2004	4,980	3,808	42.42232	-70.58228	20	SE
12/8/2004	3,555	2,718	42.42228	-70.58227	40	SE
12/9/2004	4,749	3,631	42.42253	-70.58215	60	NNE
12/9/2004	3,722	2,846	42.42233	-70.58220	10	E
12/10/2004	4,110	3,143	42.42235	-70.58228	0	
12/10/2004	3,891	2,975	42.42235	-70.58233	20	NNW
12/11/2004	5,093	3,894	42.42233	-70.58202	60	E
12/11/2004	3,645	2,787	42.42210	-70.58225	60	SE
12/12/2004	4,319	3,302	42.42238	-70.58227	30	SW
12/12/2004	3,638	2,782	42.42223	-70.58230	20	E
12/12/2004	4,663	3,565	42.42203	-70.58193	90	SE
12/13/2004	3,830	2,928	42.42217	-70.58203	95	SE
12/14/2004	4,749	3,631	42.42225	-70.58228	40	SSE
12/14/2004	3,555	2,718	42.42235	-70.58238	20	W
12/15/2004	4,576	3,499	42.42217	-70.58212	80	SSE
12/15/2004	3,722	2,846	42.42220	-70.58237	60	SW
12/15/2004	4,490	3,433	42.42235	-70.58227	0	
12/16/2004	3,976	3,040	42.42237	-70.58252	70	WNW
12/16/2004	4,576	3,499	42.42185	-70.58240	90	SSW
12/17/2004	3,891	2,975	42.42238	-70.58232	0	
12/17/2004	4,405	3,368	42.42230	-70.58223	20	SW
12/17/2004	3,722	2,846	42.42212	-70.58222	70	SE
12/18/2004	4,319	3,302	42.42203	-70.58243	90	SE
12/18/2004	3,976	3,040	42.42225	-70.58218	60	SE
12/19/2004	4,405	3,368	42.42222	-70.58217	80	SE
12/20/2004	4,233	3,237	42.42248	-70.58233	40	NW
12/21/2004	4,921	3,763	42.42240	-70.58213	20	NE
12/21/2004	3,222	2,464	42.42222	-70.58193	80	SE
12/22/2004	4,233	3,237	42.42247	-70.58193	20	S
12/22/2004	3,638	2,782	42.42248	-70.58227	20	W
12/22/2004	3,057	2,337	42.42252	-70.58218	70	NE
12/23/2004	3,722	2,846	42.42237	-70.58228	20	NE
12/31/2004	5,500	4,205	42.42293	-70.58310		
12/31/2004	4,200	3,211	42.42242	-70.58259		
1/1/2005	5,200	3,976	42.42196	-70.58284		
1/1/2005	4,200	3,211	42.42217	-70.58257		
1/1/2005	5,300	4,052	42.42206	-70.58182		
1/2/2005	5,300	4,052	42.42206	-70.58182		
1/2/2005	5,500	4,205	42.42208	-70.58233		

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Disposal Date	Volume (yd^3)	Volume (m^3)	Disposal Latitude (degrees)	Disposal Longitude (degrees)	Approximate Distance from Buoy (ft)	Approximate Direction from Buoy
1/2/2005	4,100	3,135	42.42213	-70.58233		
1/3/2005	5,300	4,052	42.42221	-70.58218		
1/3/2005	4,100	3,135	42.42219	-70.58237		
1/3/2005	5,400	4,129	42.42236	-70.58184		
1/3/2005	4,100	3,135	42.42230	-70.58227		
1/4/2005	5,000	3,823	42.42260	-70.58283		
1/5/2005	4,200	3,211	42.42213	-70.58216		
1/6/2005	5,300	4,052	42.42221	-70.57981		
1/6/2005	4,300	3,288	42.42236	-70.58242	75	NE
1/6/2005	5,500	4,205	42.42236	-70.58238	50	N
1/7/2005	4,300	3,288	42.42218	-70.58221	100	S
1/7/2005	5,400	4,129	42.42243	-70.58262	150	N
1/7/2005	4,200	3,211	42.42231	-70.58255	100	S
1/8/2005	5,400	4,129	42.42245	-70.58253	75	S
1/8/2005	4,200	3,211	42.42224	-70.58244	125	S
1/8/2005	5,600	4,282	42.42213	-70.58252	175	S
1/9/2005	4,200	3,211	42.42225	-70.58243	100	NW
1/9/2005	5,400	4,129	42.42227	-70.58250	75	S
1/10/2005	4,200	3,211	42.42238	-70.58239	75	NW
1/10/2005	5,500	4,205	42.42197	-70.58207	175	S
1/11/2005	4,100	3,135	42.42240	-70.58244	100	N
1/11/2005	5,600	4,282	42.42251	-70.58239	75	NW
1/11/2005	4,300	3,288	42.42244	-70.58237	75	N
1/12/2005	5,100	3,899	42.42247	-70.58216	125	N
1/13/2005	3,800	2,905	42.42229	-70.58228	75	S
1/15/2005	5,700	4,358	42.42247	-70.58227	100	N
1/15/2005	4,300	3,288	42.42251	-70.58219	75	N
1/16/2005	5,500	4,205	42.42236	-70.58256	125	N
1/18/2005	5,500	4,205	42.42241	-70.58228	75	N
1/18/2005	4,200	3,211	42.42227	-70.58236	50	S
1/19/2005	5,700	4,358	42.42242	-70.58248	25	S
1/20/2005	4,300	3,288	42.42213	-70.58219	125	S
1/21/2005	5,800	4,435	42.42246	-70.58213	75	N
1/21/2005	4,000	3,058	42.42229	-70.58221	50	S
1/22/2005	5,200	3,976	42.42224	-70.58219	100	S
1/25/2005	4,200	3,211	42.42237	-70.58209	100	S
1/25/2005	5,400	4,129	42.42234	-70.58230	125	N
1/26/2005	4,100	3,135	42.42249	-70.58201	150	N
1/26/2005	5,200	3,976	42.42231	-70.58211	100	NE
1/26/2005	4,100	3,135	42.42224	-70.58213	75	N
1/27/2005	5,500	4,205	42.42241	-70.58228	125	N
1/28/2005	4,300	3,288	42.42239	-70.58238	100	N
1/28/2005	5,400	4,129	42.42238	-70.58228	100	N
1/28/2005	3,976	3,040	42.42235	-70.58233	20	E
1/29/2005	4,319	3,302	42.42235	-70.58232	30	NE

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Disposal Date	Volume (yd^3)	Volume (m^3)	Disposal Latitude (degrees)	Disposal Longitude (degrees)	Approximate Distance from Buoy (ft)	Approximate Direction from Buoy
1/29/2005	3,400	2,600	42.42265	-70.58227	80	N
1/29/2005	4,710	3,601	42.42238	-70.58207	15	NE
1/29/2005	3,710	2,837	42.42235	-70.58228	0	
1/30/2005	4,749	3,631	42.42243	-70.58217	70	NE
1/30/2005	3,555	2,718	42.42232	-70.58228	10	E
1/30/2005	4,576	3,499	42.42237	-70.58220	20	E
1/31/2005	3,800	2,905	42.42235	-70.58237	30	W
1/31/2005	4,500	3,441	42.42232	-70.58227	25	W
1/31/2005	3,976	3,040	42.42238	-70.58227	20	NE
1/31/2005	4,576	3,499	42.42227	-70.58215	40	NE
2/1/2005	3,638	2,782	42.42238	-70.58228	10	N
2/1/2005	4,576	3,499	42.42250	-70.58218	80	N
2/2/2005	4,490	3,433	42.42193	-70.58240	10	S
2/2/2005	3,976	3,040	42.42262	-70.58213	75	NNE
2/2/2005	3,976	3,040	42.42237	-70.58217	90	N
2/2/2005	4,233	3,237	42.42237	-70.58192	100	E
2/2/2005	3,807	2,911	42.42252	-70.58232	75	N
2/3/2005	4,490	3,433	42.42248	-70.58223	70	NE
2/3/2005	3,807	2,911	42.42242	-70.58233	70	NE
2/3/2005	4,921	3,763	42.42232	-70.58222	40	E
2/4/2005	3,891	2,975	42.42247	-70.58228	30	N
2/4/2005	4,576	3,499	42.42232	-70.58220	40	E
2/5/2005	4,663	3,565	42.42272	-70.58248	80	NW
2/6/2005	3,638	2,782	42.42240	-70.58235	100	ENE
2/6/2005	4,835	3,697	42.42215	-70.58225	75	NE
2/6/2005	3,555	2,718	42.42242	-70.58243	50	NE
2/6/2005	4,405	3,368	42.42230	-70.58203	75	NE
2/7/2005	3,976	3,040	42.42220	-70.58238	100	ENE
2/7/2005	4,663	3,565	42.42243	-70.58218	100	ENE
2/7/2005	3,750	2,867	42.42240	-70.58217	120	ENE
2/8/2005	4,749	3,631	42.42238	-70.58223	100	E
2/8/2005	3,891	2,975	42.42222	-70.58222	120	E
2/8/2005	4,749	3,631	42.42238	-70.58218	140	ENE
2/9/2005	3,638	2,782	42.42230	-70.58237	30	N
2/10/2005	6,180	4,725	42.42245	-70.58218	70	NE
2/10/2005	3,807	2,911	42.42240	-70.58240	90	ENE
2/10/2005	4,405	3,368	42.42263	-70.58240	90	NE
2/11/2005	3,807	2,911	42.42233	-70.58228	200	N
2/11/2005	4,576	3,499	42.42232	-70.58255	50	E
2/11/2005	3,638	2,782	42.42257	-70.58217	200	NE
2/11/2005	4,319	3,302	42.42233	-70.58212	150	ENE
2/12/2005	3,638	2,782	42.42218	-70.58208	20	N
2/12/2005	4,749	3,631	42.42245	-70.58213	100	E
2/12/2005	3,638	2,782	42.42242	-70.58228	75	NE
2/12/2005	4,405	3,368	42.42217	-70.58217	75	ENE

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Disposal Date	Volume (yd^3)	Volume (m^3)	Disposal Latitude (degrees)	Disposal Longitude (degrees)	Approximate Distance from Buoy (ft)	Approximate Direction from Buoy
2/13/2005	3,722	2,846	42.42210	-70.58233	40	E
2/13/2005	4,576	3,499	42.42227	-70.58245	40	N
2/13/2005	3,722	2,846	42.42230	-70.58225	90	ENE
2/14/2005	4,576	3,499	42.42230	-70.58228	100	E
2/14/2005	3,722	2,846	42.42240	-70.58242	50	NE
2/14/2005	4,233	3,237	42.42245	-70.58238	60	E
2/15/2005	4,700	3,594	42.42213	-70.58233	15	NE
2/15/2005	4,490	3,433	42.42240	-70.58235	50	N
2/16/2005	3,891	2,975	42.42233	-70.58237	75	NE
2/16/2005	4,749	3,631	42.42245	-70.58222	80	NE
2/16/2005	3,891	2,975	42.42233	-70.58223	85	ENE
2/17/2005	4,490	3,433	42.42215	-70.58217	100	E
2/17/2005	3,800	2,905	42.42218	-70.58240	75	ENE
2/17/2005	4,576	3,499	42.42230	-70.58220	50	SSE
2/17/2005	3,722	2,846	42.42218	-70.58237	70	SW
2/18/2005	4,649	3,555	42.42225	-70.58227	25	S
2/18/2005	3,722	2,846	42.42210	-70.58227	50	S
2/18/2005	4,405	3,368	42.42230	-70.58223	40	SE
2/18/2005	3,555	2,718	42.42243	-70.58230	40	N
2/19/2005	4,405	3,368	42.42228	-70.58230	30	S
2/19/2005	3,722	2,846	42.42218	-70.58225	50	SE
2/19/2005	4,490	3,433	42.42248	-70.58230	90	N
2/19/2005	3,638	2,782	42.42238	-70.58232	40	WNW
2/20/2005	4,576	3,499	42.42233	-70.58232	10	W
2/20/2005	4,576	3,499	42.42223	-70.58217	50	SE
2/20/2005	4,576	3,499	42.42223	-70.58228	60	SSE
2/20/2005	3,722	2,846	42.42237	-70.58232	20	NNW
2/21/2005	4,749	3,631	42.42240	-70.58142	290	E
2/21/2005	3,807	2,911	42.42237	-70.58243	40	WNW
2/23/2005	4,576	3,499	42.42238	-70.58238	30	WNW
2/23/2005	3,638	2,782	42.42213	-70.58223	70	SE
2/23/2005	4,576	3,499	42.42233	-70.58183	75	E
2/24/2005	4,405	3,368	42.42240	-70.58213	80	ENE
2/24/2005	4,100	3,135	42.42220	-70.58225	60	SSE
2/25/2005	3,976	3,040	42.42245	-70.58228	40	NNE
2/26/2005	4,490	3,433	42.42247	-70.58213	70	NE
2/26/2005	3,891	2,975	42.42243	-70.58232	25	N
2/26/2005	4,360	3,334	42.42242	-70.58230	40	N
2/26/2005	4,100	3,135	42.42232	-70.58210	20	E
2/27/2005	4,749	3,631	42.42233	-70.58257	75	W
2/27/2005	3,891	2,975	42.42223	-70.58225	50	SE
2/27/2005	4,062	3,106	42.42232	-70.58217	50	NE
2/27/2005	3,891	2,975	42.42228	-70.58217	65	SE
2/28/2005	4,576	3,499	42.42233	-70.58207	60	E
2/28/2005	4,400	3,364	42.42228	-70.58232	75	E

Project Name: BOSTON HARBOR
Permittee: COE - BOSTON HARBOR FED. PROJECT
Permit Number: 2004C0006

Disposal Date	Volume (yd^3)	Volume (m^3)	Disposal Latitude (degrees)	Disposal Longitude (degrees)	Approximate Distance from Buoy (ft)	Approximate Direction from Buoy
3/2/2005	4,500	3,441	42.42268	-70.58287	135	SW
3/2/2005	4,900	3,747	42.42222	-70.58212	135	SE
3/2/2005	5,800	4,435	42.42217	-70.58205	135	SE
3/3/2005	4,000	3,058	42.42210	-70.58227	100	S
3/3/2005	5,800	4,435	42.42252	-70.58228	60	N
3/4/2005	4,500	3,441	42.42230	-70.58202	75	E
3/4/2005	5,200	3,976	42.42222	-70.58208	80	SE
3/4/2005	4,400	3,364	42.42212	-70.58230	100	SE
3/4/2005	5,800	4,435	42.42233	-70.58230	0	
3/5/2005	4,400	3,364	42.42215	-70.58212	75	SE
3/5/2005	5,400	4,129	42.42230	-70.58225	0	
3/5/2005	4,400	3,364	42.42230	-70.58225	0	
3/6/2005	5,800	4,435	42.42225	-70.58232	0	
3/6/2005	4,400	3,364	42.42215	-70.58222	60	S
3/6/2005	5,700	4,358	42.42243	-70.58228	0	
3/6/2005	4,600	3,517	42.42228	-70.58222	0	
3/7/2005	5,700	4,358	42.42238	-70.58218	0	
3/7/2005	4,500	3,441	42.42223	-70.58227	0	
3/7/2005	5,800	4,435	42.42252	-70.58232	70	N
3/7/2005	4,500	3,441	42.42233	-70.58222	0	
3/8/2005	5,800	4,435	42.42220	-70.58215	80	SE
3/8/2005	4,700	3,594	42.42233	-70.58230	0	
3/8/2005	5,900	4,511	42.42208	-70.58210	110	SE
3/9/2005	4,400	3,364	42.42235	-70.58213	0	
3/10/2005	5,600	4,282	42.42227	-70.58212	0	
3/10/2005	4,600	3,517	42.42243	-70.58230	0	
3/10/2005	5,900	4,511	42.42235	-70.58228	0	
3/11/2005	4,800	3,670	42.42242	-70.58247	60	W
3/11/2005	5,800	4,435	42.42248	-70.58232	0	
3/11/2005	4,600	3,517	42.42230	-70.58227	0	
3/12/2005	5,700	4,358	42.42227	-70.58235	0	
3/12/2005	4,400	3,364	42.42240	-70.58232	0	
3/13/2005	5,600	4,282	42.42215	-70.58232	120	S
3/13/2005	4,500	3,441	42.42207	-70.58218	120	S
3/14/2005	5,600	4,282	42.42213	-70.58218	110	S
3/14/2005	4,400	3,364	42.42238	-70.58237	0	
3/14/2005	5,700	4,358	42.42233	-70.58230	0	
3/14/2005	4,600	3,517	42.42242	-70.58230	0	
3/15/2005	5,600	4,282	42.42230	-70.58225	0	
3/15/2005	4,400	3,364	42.42252	-70.58230	40	N
3/15/2005	5,700	4,358	42.42240	-70.58235	0	
3/15/2005	4,500	3,441	42.42230	-70.58215	0	
3/16/2005	5,700	4,358	42.42227	-70.58222	0	
3/16/2005	4,500	3,441	42.42243	-70.58223	0	
3/16/2005	5,800	4,435	42.42233	-70.58228	0	

Appendix A
Disposal Barge Log Summary MBDS – September 2004 to August 2007

Project Name: BOSTON HARBOR
Permittee: COE - BOSTON HARBOR FED. PROJECT
Permit Number: 2004C0006

Disposal Date	Volume (yd^3)	Volume (m^3)	Disposal Latitude (degrees)	Disposal Longitude (degrees)	Approximate Distance from Buoy (ft)	Approximate Direction from Buoy
3/16/2005	4,600	3,517	42.42225	-70.58227	0	
3/17/2005	5,700	4,358	42.42207	-70.58223	70	S
3/17/2005	4,800	3,670	42.42233	-70.58232	0	
3/17/2005	5,800	4,435	42.42248	-70.58225	0	
3/18/2005	4,600	3,517	42.42217	-70.58217	70	SE
3/18/2005	4,000	3,058	42.42245	-70.58222	50	NE
3/19/2005	4,600	3,517	42.42232	-70.58217	0	
3/19/2005	5,700	4,358	42.42238	-70.58248	0	
3/19/2005	4,400	3,364	42.42243	-70.58218	0	
3/19/2005	5,800	4,435	42.42242	-70.58225	0	
3/20/2005	4,700	3,594	42.42215	-70.58210	80	SE
3/20/2005	5,700	4,358	42.42245	-70.58233	0	
3/20/2005	4,700	3,594	42.42215	-70.58222	0	
3/21/2005	4,300	3,288	42.42217	-70.58223	60	S
3/21/2005	4,700	3,594	42.42233	-70.58217	0	
3/22/2005	4,300	3,288	42.42232	-70.58210	0	
3/22/2005	4,700	3,594	42.42257	-70.58225	90	N
3/22/2005	4,300	3,288	42.42233	-70.58230	0	
3/22/2005	4,700	3,594	42.42235	-70.58228	0	
3/23/2005	4,400	3,364	42.42227	-70.58210	80	SE
3/23/2005	4,700	3,594	42.42203	-70.58235	100	S
3/23/2005	4,300	3,288	42.42232	-70.58235	0	
3/23/2005	4,800	3,670	42.42227	-70.58223	0	
3/24/2005	4,300	3,288	42.42248	-70.58217	0	
3/24/2005	4,500	3,441	42.42235	-70.58157	200	E
3/24/2005	4,300	3,288	42.42235	-70.58212	0	
3/25/2005	4,500	3,441	42.42235	-70.58242	0	
3/25/2005	4,200	3,211	42.42212	-70.58220	80	S
3/25/2005	4,300	3,288	42.42220	-70.58228	0	
3/25/2005	4,500	3,441	42.42250	-70.58222	30	N
3/26/2005	4,300	3,288	42.42247	-70.58232	0	
3/26/2005	4,600	3,517	42.42235	-70.58232	0	
3/26/2005	4,300	3,288	42.42220	-70.58233	0	
3/26/2005	4,500	3,441	42.42233	-70.58230	0	
3/27/2005	4,200	3,211	42.42250	-70.58228	30	N
3/27/2005	4,300	3,288	42.42233	-70.58237	0	
3/27/2005	4,400	3,364	42.42220	-70.58223	0	
3/28/2005	4,500	3,441	42.42233	-70.58230	0	
3/28/2005	4,400	3,364	42.42227	-70.58250	50	N
3/29/2005	4,500	3,441	42.42230	-70.58227	55	N
3/29/2005	4,300	3,288	42.42238	-70.58210	50	NW
3/29/2005	4,500	3,441	42.42219	-70.58232	35	S
3/30/2005	4,300	3,288	42.42231	-70.58241	30	NW
3/30/2005	4,400	3,364	42.42228	-70.58231	25	N
3/30/2005	4,400	3,364	42.42254	-70.58229	65	N

Appendix A
Disposal Barge Log Summary MBDS – September 2004 to August 2007

Project Name: BOSTON HARBOR
Permittee: COE - BOSTON HARBOR FED. PROJECT
Permit Number: 2004C0006

Disposal Date	Volume (yd^3)	Volume (m^3)	Disposal Latitude (degrees)	Disposal Longitude (degrees)	Approximate Distance from Buoy (ft)	Approximate Direction from Buoy
3/31/2005	4,200	3,211	42.42228	-70.58236	45	N
3/31/2005	4,200	3,211	42.42253	-70.58223	50	N
3/31/2005	4,500	3,441	42.42238	-70.58231	60	NE
3/31/2005	4,550	3,479	42.42243	-70.58216	55	N
4/1/2005	4,300	3,288	42.42237	-70.58234	30	N
4/1/2005	4,500	3,441	42.42234	-70.58221	25	N
4/1/2005	4,475	3,422	42.42236	-70.58240	35	N
4/1/2005	4,400	3,364	42.42240	-70.58213	75	N
4/2/2005	4,400	3,364	42.42234	-70.58230	50	N
4/2/2005	4,500	3,441	42.42249	-70.58235	75	N
4/2/2005	4,300	3,288	42.42252	-70.58244	100	N
4/4/2005	4,200	3,211	42.42233	-70.58210	50	S
4/4/2005	4,400	3,364	42.42220	-70.58230	60	NE
4/4/2005	4,500	3,441	42.42232	-70.58238	25	S
4/5/2005	4,100	3,135	42.42216	-70.58220	25	N
4/5/2005	4,500	3,441	42.42233	-70.58241	35	N
4/5/2005	4,275	3,269	42.42222	-70.58249	20	N
4/6/2005	4,350	3,326	42.42242	-70.58219	75	N
4/6/2005	4,500	3,441	42.42237	-70.58230	60	N
4/6/2005	4,500	3,441	42.42244	-70.58237	80	N
4/6/2005	4,500	3,441	42.42257	-70.58236	100	N
4/7/2005	4,400	3,364	42.42229	-70.58225	50	N
4/7/2005	4,500	3,441	42.42245	-70.58235	75	N
4/7/2005	4,500	3,441	42.42245	-70.58234	100	N
4/7/2005	4,500	3,441	42.42220	-70.58236	55	N
4/8/2005	4,325	3,307	42.42217	-70.58215	100	S
4/8/2005	4,500	3,441	42.42229	-70.58251	100	S
4/8/2005	4,150	3,173	42.42256	-70.58250	75	N
4/9/2005	4,500	3,441	42.42238	-70.58251	75	S
4/9/2005	4,400	3,364	42.42234	-70.58251	50	S
4/9/2005	4,500	3,441	42.42236	-70.58237	25	N
4/10/2005	4,250	3,250	42.42229	-70.58221	50	N
4/10/2005	4,500	3,441	42.42222	-70.58256	75	N
4/10/2005	3,000	2,294	42.42228	-70.58203	75	N
4/13/2005	4,500	3,441	42.42208	-70.58239	75	N
4/14/2005	4,400	3,364	42.42229	-70.58265	75	N
4/14/2005	4,500	3,441	42.42212	-70.58238	60	N
4/14/2005	4,400	3,364	42.42231	-70.58252	100	N
4/14/2005	4,300	3,288	42.42227	-70.58223	85	N
4/15/2005	4,475	3,422	42.42238	-70.58221	50	N
4/15/2005	4,500	3,441	42.42227	-70.58182	125	S
4/15/2005	4,500	3,441	42.42232	-70.58238	65	N
4/15/2005	4,500	3,441	42.42223	-70.58215	75	S
4/16/2005	4,500	3,441	42.42224	-70.58234	55	N
4/16/2005	4,500	3,441	42.42235	-70.58232	100	N

Appendix A
Disposal Barge Log Summary MBDS – September 2004 to August 2007

Project Name: BOSTON HARBOR
Permittee: COE - BOSTON HARBOR FED. PROJECT
Permit Number: 2004C0006

Disposal Date	Volume (yd^3)	Volume (m^3)	Disposal Latitude (degrees)	Disposal Longitude (degrees)	Approximate Distance from Buoy (ft)	Approximate Direction from Buoy
4/16/2005	4,550	3,479	42.42194	-70.58237	130	S
4/17/2005	4,500	3,441	42.42201	-70.58238	125	S
4/17/2005	4,500	3,441	42.42227	-70.58241	75	N
4/18/2005	4,500	3,441	42.42223	-70.58243	70	N
4/18/2005	4,400	3,364	42.42223	-70.58235	65	S
4/19/2005	4,500	3,441	42.42230	-70.58219	75	N
4/19/2005	4,400	3,364	42.42219	-70.58224	75	N
4/20/2005	4,475	3,422	42.42198	-70.58213	125	S
4/21/2005	4,500	3,441	42.42225	-70.58219	100	S
4/22/2005	4,350	3,326	42.42236	-70.58221	60	N
4/22/2005	4,500	3,441	42.42240	-70.58235	40	N
4/23/2005	4,375	3,345	42.42231	-70.58254	65	N
4/23/2005	4,350	3,326	42.42222	-70.58225	50	N
4/24/2005	3,800	2,905	42.42227	-70.58233	45	N
4/24/2005	4,425	3,383	42.42231	-70.58239	70	N
4/25/2005	4,400	3,364	42.42227	-70.58222	30	N
4/25/2005	4,500	3,441	42.42232	-70.58225	40	N
4/26/2005	4,500	3,441	42.42268	-70.58237	130	N
4/27/2005	4,425	3,383	42.42244	-70.58209	100	N
4/27/2005	4,500	3,441	42.42247	-70.58274	110	N
4/28/2005	4,500	3,441	42.42219	-70.58233	75	N
4/29/2005	4,500	3,441	42.42245	-70.58235	85	N
4/29/2005	0	0	42.42233	-70.58230	50	N
4/30/2005	4,500	3,441	42.42239	-70.58240	60	N
5/1/2005	3,850	2,944	42.42220	-70.58226	75	S
5/6/2005	3,900	2,982	42.42237	-70.58249	35	N
Total Dredged Material Volume	1,963,785	1,501,510				

Appendix A
Disposal Barge Log Summary MBDS – September 2004 to August 2007

Project Name: WEYMOUTH RIVER
Permittee: COE-WEYMOUTH/FORE RIVER
Permit Number: 2006C0001

Disposal Date	Volume (yd^3)	Volume (m^3)	Disposal Latitude (degrees)	Disposal Longitude (degrees)	Approximate Distance from Buoy (ft)	Approximate Direction from Buoy
11/17/2006	1,700	1,300	42.42952	-70.58160	30	S
11/18/2006	2,300	1,759	42.42952	-70.58160	10	N
11/18/2006	1,500	1,147	42.43075	-70.58368	264	N
11/19/2006	4,000	3,058	42.42952	-70.58160	40	W
11/19/2006	2,600	1,988	42.42952	-70.58160	40	W
11/19/2006	1,300	994	42.42890	-70.58125	158	
11/20/2006	4,000	3,058	42.42952	-70.58160	20	NW
11/20/2006	2,600	1,988	42.42952	-70.58160	20	W
11/20/2006	1,400	1,070	42.42906	-70.58213	15-20	SE
11/21/2006	4,000	3,058	42.42952	-70.58160	70	NW
11/21/2006	2,600	1,988	42.42952	-70.58160	20	NW
11/22/2006	4,000	3,058	42.42952	-70.58160	20	W
11/27/2006	3,000	2,294	42.43002	-70.58085	75	NW
11/27/2006	2,000	1,529	42.43149	-70.58118	20	N
11/28/2006	2,700	2,064	42.42979	-70.58096	50	NE
11/28/2006	4,000	3,058	42.42933	-70.58184	15	SE
11/29/2006	2,100	1,606	42.42967	-70.41534	25	SE
11/30/2006	2,600	1,988	42.42987	-70.41512	20	SW
12/1/2006	2,500	1,912	42.42946	-70.49754	50	NE
12/3/2006	2,100	1,606	42.42892	-70.58164	50	S
12/3/2006	3,050	2,332	42.42953	-70.58152	100	SW
12/4/2006	2,200	1,682	42.42896	-70.58126	150	SW
12/4/2006	3,059	2,339	42.42971	-70.58119	100	SW
12/5/2006	2,019	1,544	42.42982	-70.58115	N/A	
12/6/2006	3,210	2,454	42.42923	-70.58098	N/A	
12/6/2006	1,850	1,415	42.42917	-70.58212	N/A	
12/7/2006	3,250	2,485	42.42911	-70.58110	N/A	
12/7/2006	2,109	1,613	42.42881	-70.58208	No buoy	
12/8/2006	3,059	2,339	42.42940	-70.58211	No buoy	
12/9/2006	1,514	1,158	42.42884	-70.58202	No buoy	
12/10/2006	3,059	2,339	42.42922	-70.58247	No buoy	
12/10/2006	908	694	42.42983	-70.58164	No buoy	
12/13/2006	3,059	2,339	42.42876	-70.58188	No buoy	
12/13/2006	1,262	965	42.42921	-70.58187	No buoy	
12/14/2006	3,059	2,339	42.42918	-70.58225	No buoy	
12/14/2006	995	761	42.42881	-70.58228	No buoy	
12/15/2006	3,210	2,454	42.42980	-70.58166	No buoy	
12/16/2006	996	762	42.42894	-70.58165	No buoy	
12/16/2006	3,135	2,397	42.42903	-70.58260	No buoy	
12/17/2006	996	762	42.42909	-70.58229	No buoy	
12/17/2006	3,059	2,339	42.42935	-70.58258	No buoy	
12/18/2006	1,084	829	42.42901	-70.58241	No buoy	
12/18/2006	3,135	2,397	42.42930	-70.58069	0	
12/19/2006	1,084	829	42.42906	-70.58215	20	W
12/19/2006	3,210	2,454	42.42887	-70.58233	30	W

Appendix A
Disposal Barge Log Summary MBDS – September 2004 to August 2007

Project Name: WEYMOUTH RIVER
Permittee: COE-WEYMOUTH/FORE RIVER
Permit Number: 2006C0001

Disposal Date	Volume (yd^3)	Volume (m^3)	Disposal Latitude (degrees)	Disposal Longitude (degrees)	Approximate Distance from Buoy (ft)	Approximate Direction from Buoy
12/20/2006	996	762	42.42912	-70.58256	10	S
12/20/2006	3,210	2,454	42.42896	-70.58253	0	E
12/21/2006	1,262	965	42.42928	-70.58251	10	W
12/21/2006	3,210	2,454	42.42932	-70.58210	2	N
12/22/2006	1,262	965	42.42895	-70.58150	40	W
12/22/2006	3,518	2,690	42.42980	-70.58232	40	N
12/23/2006	1,262	965	42.42976	-70.58235	50	N
12/23/2006	2,606	1,993	42.42979	-70.58254	20	N
12/27/2006	821	628	42.42914	-70.58151	40	S
12/28/2006	1,125	860	42.42907	-70.58129	30	S
12/28/2006	1,173	897	42.42962	-70.58218	25	NW
12/29/2006	3,210	2,454	42.42906	-70.58139	10	S
12/29/2006	1,064	814	42.42963	-70.58148	10	NE
12/30/2006	3,210	2,454	42.42970	-70.58192	10	NW
12/30/2006	1,173	897	42.42998	-70.58151	10	NE
12/31/2006	3,368	2,575	42.42965	-70.58223	25	NW
1/4/2007	3,518	2,690	42.42998	-70.58175	30	N
1/4/2007	1,262	965	42.42879	-70.58135	75	S
1/5/2007	3,518	2,690	42.42889	-70.58168	30	N
1/5/2007	1,262	965	42.42934	-70.58179	<5	
1/6/2007	3,210	2,454	42.42899	-70.58193	10	S
1/6/2007	1,173	897	42.42923	-70.58178	20	SE
1/6/2007	1,173	897	42.42949	-70.58199	10	NW
1/6/2007	3,518	2,690	42.42908	-70.58137	20	SE
1/7/2007	3,673	2,808	42.42992	-70.58209	20	NW
1/7/2007	1,262	965	42.42986	-70.58061	75	SE
1/7/2007	1,262	965	42.42906	-70.58139	15	NW
1/8/2007	3,364	2,572	42.42985	-70.58186	10	N
1/8/2007	1,534	1,173	42.42906	-70.58104	50	SE
1/9/2007	3,364	2,572	42.42950	-70.58120	15	E
1/10/2007	996	762	42.43021	-70.58199	10	NW
1/11/2007	3,364	2,572	42.42876	-70.58221	50	SW
1/11/2007	996	762	42.43016	-70.58174	10	NW
1/12/2007	3,441	2,631	42.42982	-70.58258	50	NW
1/12/2007	1,084	829	42.42966	-70.58078	20	SW
1/13/2007	3,518	2,690	42.42976	-70.58247	50	NW
1/13/2007	1,262	965	42.42875	-70.58203	0	
1/13/2007	3,518	2,690	42.42903	-70.58222	40	W
1/14/2007	1,262	965	42.42909	-70.58228	0	NW
1/14/2007	3,441	2,631	42.42936	-70.58257	0	
1/15/2007	1,173	897	42.42923	-70.58238	0	
1/16/2007	3,441	2,631	42.42930	-70.58236	5	W
1/22/2007	1,262	965	42.42969	-70.58230	100	W
1/23/2007	3,673	2,808	42.42950	-70.58167	100	N
1/23/2007	1,352	1,034	42.42903	-70.58124	150	S

Appendix A
Disposal Barge Log Summary MBDS – September 2004 to August 2007

Project Name: WEYMOUTH RIVER
Permittee: COE-WEYMOUTH/FORE RIVER
Permit Number: 2006C0001

Disposal Date	Volume (yd^3)	Volume (m^3)	Disposal Latitude (degrees)	Disposal Longitude (degrees)	Approximate Distance from Buoy (ft)	Approximate Direction from Buoy
1/24/2007	3,518	2,690	42.42890	-70.58169	125	S
1/25/2007	1,352	1,034	42.42997	-70.58197	75	N
1/25/2007	3,364	2,572	42.42889	-70.58185		
1/27/2007	1,173	897	42.42952	-70.58188	0	
1/27/2007	3,673	2,808	42.42963	-70.58136	25	S
1/30/2007	3,364	2,572	42.42908	-70.58104	50	SE
1/30/2007	2,531	1,935	42.42919	-70.58123	50	S
1/31/2007	3,210	2,454	42.42868	-70.58117	150	S
2/2/2007	3,073	2,350	42.42988	-70.58214	100	NW
2/2/2007	2,014	1,540	42.43065	-70.58013	200	NW
2/3/2007	3,518	2,690	42.42887	-70.58166	< 10	SE
2/3/2007	2,531	1,935	42.43015	-70.58123	100	NW
2/4/2007	3,518	2,690	42.42977	-70.58203	30	NW
2/4/2007	2,531	1,935	42.42951	-70.58196	10	NE
2/5/2007	3,518	2,690	42.42968	-70.58248	30	NE
2/6/2007	2,109	1,613	42.42870	-70.58203	5	W
2/7/2007	3,518	2,690	42.42884	-70.58151	5	E
2/8/2007	2,531	1,935	42.42916	-70.58270	5	S
2/9/2007	3,518	2,690	42.42912	-70.58261	10	SW
2/9/2007	2,875	2,198	42.42813	-70.58193	5	W
2/10/2007	3,364	2,572	42.42943	-70.58110	20	
2/10/2007	2,702	2,066	42.42929	-70.58087	0	
2/11/2007	2,360	1,804	42.42940	-70.58095	10	E
2/11/2007	2,360	1,804	42.42919	-70.58241	50	W
2/11/2007	3,364	2,572	42.42964	-70.58162	0	
2/12/2007	2,199	1,681	42.42989	-70.58152	10	
2/12/2007	3,432	2,624	42.42950	-70.58197	0	
2/13/2007	2,531	1,935	42.42887	-70.58115	125	SE
2/13/2007	3,210	2,454	42.42960	-70.58217	50	NW
2/17/2007	3,364	2,572	42.42992	-70.58199	75	SW
2/17/2007	2,360	1,804	42.43025	-70.58193	100	NW
2/18/2007	1,352	1,034	42.42924	-70.58274	75	NW
2/18/2007	3,378	2,583	42.42990	-70.58151	110	NW
2/18/2007	2,109	1,613	42.43010	-70.58197		
2/19/2007	3,518	2,690	42.42974	-70.58225	75	NW
2/20/2007	2,702	2,066	42.43044	-70.58212	250	W
2/21/2007	3,518	2,690	42.43003	-70.57952	200	E
2/21/2007	2,109	1,613	42.42900	-70.58177	75	S
2/22/2007	3,518	2,690	42.42928	-70.58212	50	S
2/22/2007	2,109	1,613	42.42996	-70.58194	25	NW
2/23/2007	3,210	2,454	42.42887	-70.58197	175	S
2/24/2007	1,262	965	42.42970	-70.58235	75	W
2/25/2007	3,364	2,572	42.42905	-70.58207	150	S
2/25/2007	905	692	42.42927	-70.58238		
2/27/2007	996	762	42.42942	-70.58223	75	W

Project Name: WEYMOUTH RIVER
Permittee: COE-WEYMOUTH/FORE RIVER
Permit Number: 2006C0001

Disposal Date	Volume (yd^3)	Volume (m^3)	Disposal Latitude (degrees)	Disposal Longitude (degrees)	Approximate Distance from Buoy (ft)	Approximate Direction from Buoy
2/28/2007	3,364	2,572	42.42925	-70.58179	75	S
2/28/2007	735	562	42.42996	-70.58227	50	N
3/1/2007	3,364	2,572	42.42969	-70.58235	20	N
3/1/2007	821	628	42.42957	-70.58178	10	N
3/3/2007	821	628	42.43006	-70.58142	30	N
3/3/2007	3,518	2,690	42.42944	-70.58267	0	N
3/3/2007	821	628	42.42949	-70.58229	5	N
3/4/2007	3,364	2,572	42.42913	-70.58249	10	NW
3/4/2007	821	628	42.42971	-70.58072	200	N
3/5/2007	1,428	1,092	42.42973	-70.58257	50	N
3/7/2007	3,518	2,690	42.42916	-70.58269	2	N
3/7/2007	821	628	42.42895	-70.58223	50	W
3/9/2007	3,518	2,690	42.42913	-70.58036	10	S
3/9/2007	1,040	795	42.42931	-70.58154	5	
3/10/2007	1,040	795	42.42926	-70.58093	1	
3/11/2007	2,907	2,223	42.42988	-70.58197	1	
3/11/2007	908	694	42.42961	-70.58197	20	
3/12/2007	3,059	2,339	42.42983	-70.58203	0	
3/19/2007	2,530	1,934	42.42993	-70.58167	10	
Total Dredged Material Volume	371,050	283,705				

Project Name: MAINTENANCE DREDGING
Permittee: COE-SALEM HARBOR
Permit Number: 2007C0002

Disposal Date	Volume (yd^3)	Volume (m^3)	Disposal Latitude (degrees)	Disposal Longitude (degrees)	Approximate Distance from Buoy (ft)	Approximate Direction from Buoy
11/28/2006	4,500	3,441	42.42933	-70.58183		
11/29/2006	4,500	3,441	42.42950	-70.58172	675	NE
11/29/2006	3,300	2,523	42.42945	-70.58192	N/A	
11/30/2006	3,400	2,600	42.42950	-70.58173	N/A	
12/1/2006	3,500	2,676	42.42983	-70.58137	N/A	
12/1/2006	3,700	2,829	42.42932	-70.58178	N/A	
12/1/2006	3,600	2,753	42.42958	-70.58182	N/A	
12/2/2006	3,600	2,753	42.42952	-70.58170	N/A	
12/3/2006	3,500	2,676	42.42925	-70.58187	N/A	
12/3/2006	4,000	3,058	42.42965	-70.58120	N/A	
12/4/2006	3,500	2,676	42.42937	-70.58168	350	
12/4/2006	3,900	2,982	42.42924	-70.58138	350	
12/4/2006	4,000	3,058	42.42955	-70.58175	300	
12/4/2006	3,600	2,753	42.42943	-70.58160	350	
12/5/2006	3,500	2,676	42.42947	-70.58150	350	

Appendix A
Disposal Barge Log Summary MBDS – September 2004 to August 2007

Project Name: MAINTENANCE DREDGING
Permittee: COE-SALEM HARBOR
Permit Number: 2007C0002

Disposal Date	Volume (yd^3)	Volume (m^3)	Disposal Latitude (degrees)	Disposal Longitude (degrees)	Approximate Distance from Buoy (ft)	Approximate Direction from Buoy
12/5/2006	4,000	3,058	42.42965	-70.58153	150	
12/5/2006	1,900	1,453	42.42965	-70.58122	no buoy	
12/5/2006	3,600	2,753	42.42935	-70.58153	no buoy	
12/6/2006	3,500	2,676	42.42957	-70.58155	no buoy	
12/6/2006	3,900	2,982	42.42962	-70.58153	no buoy	
12/6/2006	3,950	3,020	42.42962	-70.58153	no buoy	
12/7/2006	3,600	2,753	42.42953	-70.58157	no buoy	
12/7/2006	3,500	2,676	42.42933	-70.58142	no buoy	
12/7/2006	3,400	2,600	42.42974	-70.58147	no buoy	
12/8/2006	3,800	2,905	42.42962	-70.58148	no buoy	
12/9/2006	3,600	2,753	42.42965	-70.58194	no buoy	
12/9/2006	3,800	2,905	42.42958	-70.58153	no buoy	
12/9/2006	3,300	2,523	42.42977	-70.58172	no buoy	
12/10/2006	3,900	2,982	42.42957	-70.58163	no buoy	
12/10/2006	4,000	3,058	42.42932	-70.58148	no buoy	
12/10/2006	3,400	2,600	42.42932	-70.58172	no buoy	
12/10/2006	4,100	3,135	42.42952	-70.58165	no buoy	
12/11/2006	4,000	3,058	42.42958	-70.58167	no buoy	
12/11/2006	3,400	2,600	42.42937	-70.58147	no buoy	
12/11/2006	4,125	3,154	42.42950	-70.58193	no buoy	
12/12/2006	3,900	2,982	42.42962	-70.58153	no buoy	
12/13/2006	4,000	3,058	42.42952	-70.58137	no buoy	
12/13/2006	3,500	2,676	42.42948	-70.58137	no buoy	
12/13/2006	3,600	2,753	42.42950	-70.58137	no buoy	
12/14/2006	3,900	2,982	42.42933	-70.58165	no buoy	
12/14/2006	4,300	3,288	42.42962	-70.58163	no buoy	
12/14/2006	3,500	2,676	42.42923	-70.58158	no buoy	
12/14/2006	3,600	2,753	42.42955	-70.58138	no buoy	
12/15/2006	3,400	2,600	42.42932	-70.58172	no buoy	
12/15/2006	4,300	3,288	42.42962	-70.58167	no buoy	
12/15/2006	3,400	2,600	42.42957	-70.58165	no buoy	
12/15/2006	4,100	3,135	42.42967	-70.58150	no buoy	
12/16/2006	3,500	2,676	42.42933	-70.58182	no buoy	
12/16/2006	3,600	2,753	42.42973	-70.58153	no buoy	
12/17/2006	3,400	2,600	42.42950	-70.58178	no buoy	
12/17/2006	4,500	3,441	42.42937	-70.58173	no buoy	
12/18/2006	3,500	2,676	42.42953	-70.58168	no buoy	
12/19/2006	3,300	2,523	42.42960	-70.58173	no buoy	
12/19/2006	3,000	2,294	42.42933	-70.58183	70	
12/20/2006	3,300	2,523	42.42950	-70.58170	40	
12/20/2006	3,500	2,676	42.42932	-70.58187	25	
12/21/2006	3,400	2,600	42.42932	-70.58142		
12/21/2006	3,600	2,753	42.42938	-70.58188		
12/22/2006	3,000	2,294	42.42962	-70.58185	30	
12/22/2006	2,600	1,988	42.42967	-70.58158	5	

Appendix A
Disposal Barge Log Summary MBDS – September 2004 to August 2007

Project Name: MAINTENANCE DREDGING
Permittee: COE-SALEM HARBOR
Permit Number: 2007C0002

Disposal Date	Volume (yd^3)	Volume (m^3)	Disposal Latitude (degrees)	Disposal Longitude (degrees)	Approximate Distance from Buoy (ft)	Approximate Direction from Buoy
12/23/2006	3,000	2,294	42.42948	-70.58187	20	
12/24/2006	3,000	2,294	42.42962	-70.58172	20	
12/25/2006	2,500	1,912	42.42963	-70.58148		
12/26/2006	3,200	2,447	42.42962	-70.58172		
12/27/2006	2,000	1,529	42.42958	-70.58167		
12/27/2006	1,900	1,453	42.42963	-70.58173		
12/28/2006	2,800	2,141	42.42960	-70.58168	50	
12/28/2006	3,300	2,523	42.42950	-70.58153		
12/29/2006	2,200	1,682	42.42953	-70.58167	10	
12/29/2006	3,200	2,447	42.42953	-70.58178	25	
12/30/2006	1,600	1,223	42.42970	-70.58167	25	
12/30/2006	3,300	2,523	42.42972	-70.58145	60	
12/31/2006	2,700	2,064	42.42953	-70.58173	15	
12/31/2006	2,900	2,217	42.42955	-70.58168	35	
1/1/2007	3,500	2,676	42.42972	-70.58150	350	
1/2/2007	3,400	2,600	42.42932	-70.58183	180	
1/2/2007	2,900	2,217	42.42947	-70.58180	60	
1/3/2007	3,900	2,982	42.42913	-70.58180	220	
1/3/2007	3,500	2,676	42.42943	-70.58182	110	
1/4/2007	4,100	3,135	42.42935	-70.58178	90	
1/4/2007	3,500	2,676	42.42950	-70.58168	50	
1/4/2007	3,600	2,753	42.42937	-70.58175	80	
1/5/2007	3,300	2,523	42.42932	-70.58163	160	
1/5/2007	3,600	2,753	42.42943	-70.58182	30	
1/5/2007	3,500	2,676	42.42935	-70.58177	80	
1/6/2007	3,600	2,753	42.42967	-70.58155	50	
1/12/2007	3,600	2,753	42.42957	-70.58145	50	
1/13/2007	3,800	2,905	42.42955	-70.58163	10	
1/14/2007	3,600	2,753	42.42933	-70.58170	90	
1/14/2007	3,800	2,905	42.42937	-70.58163	60	
1/15/2007	3,600	2,753	42.42945	-70.58173	40	
1/15/2007	4,100	3,135	42.42935	-70.58177	90	
1/16/2007	3,600	2,753	42.42968	-70.58165	10	
1/16/2007	3,100	2,370	42.42958	-70.58167	35	
1/18/2007	3,600	2,753	42.42960	-70.58140	120	
1/19/2007	4,200	3,211	42.42965	-70.58148	60	
1/20/2007	3,500	2,676	42.42955	-70.58178	50	
Total Dredged Material Volume	339,075	259,257				

Appendix A
Disposal Barge Log Summary MBDS – September 2004 to August 2007

Project Name: ANNISQUAM RIVER
Permittee: CAPE ANN MARINA
Permit Number: NAE20042673

Disposal Date	Volume (yd^3)	Volume (m^3)	Disposal Latitude (degrees)	Disposal Longitude (degrees)	Approximate Distance from Buoy (ft)	Approximate Direction from Buoy
10/19/2006	600	459	42.41843	-70.58282	2,640	S
10/23/2006	533	408	42.41843	-70.58282	2,640	S
10/24/2006	600	459	42.41843	-70.58282	2,640	S
10/25/2006	600	459	42.41843	-70.58282	2,640	S
10/26/2006	600	459	42.41843	-70.58282	< 5,280	S
10/31/2006	600	459	42.41843	-70.58282	2,640	S
11/1/2006	600	459	42.41843	-70.58282	2,640	S
11/2/2006	600	459	42.41843	-70.58282	2,640	S
11/3/2006	600	459	42.41843	-70.58282	2,640	S
11/6/2006	600	459	42.41843	-70.58282	2,640	S
11/7/2006	600	459	42.41843	-70.58282	2,640	S
11/11/2006	600	459	42.41843	-70.58282	2,640	S
11/18/2006	600	459	42.41843	-70.58282	2,640	S
11/19/2006	600	459	42.41843	-70.58282	2,640	S
11/20/2006	600	459	42.41843	-70.58282	2,640	S
Total Dredged Material Volume	8,933	6,830				

Project Name: MARINA BAY & DORCHESTER Y.C.
Permittee: ENSR INTL. (MARINAS USA)
Permit Number: NAE2004700

Disposal Date	Volume (yd^3)	Volume (m^3)	Disposal Latitude (degrees)	Disposal Longitude (degrees)	Approximate Distance from Buoy (ft)	Approximate Direction from Buoy
1/15/2005	1,200	918	42.42117	-70.58253	missing	
1/19/2005	1,600	1,223	42.42228	-70.58240	missing	
1/21/2005	1,500	1,147	42.42247	-70.58228	missing	
1/28/2005	1,500	1,147	42.42287	-70.58257	missing	
1/29/2005	1,200	918	42.42243	-70.58270	missing	
2/1/2005	1,500	1,147	42.42265	-70.58217	200	N
2/2/2005	1,000	765	42.42072	-70.58305	200	S
2/7/2005	1,000	765	42.42253	-70.58328	200	N
2/8/2005	1,000	765	42.42145	-70.59950	200	S
2/9/2005	1,500	1,147	42.42138	-70.59960	200	S
2/12/2005	1,700	1,300	42.42160	-70.59905	200	S
2/13/2005	1,500	1,147	42.42113	-70.59928	200	S
2/14/2005	1,200	918	42.42123	-70.59913	200	S
Total Dredged Material Volume	17,400	13,304				

Appendix A
Disposal Barge Log Summary MBDS – September 2004 to August 2007

Project Name: WEYMOUTH FORE RIVER
Permittee: CITGO PETROLEUM CORP.
Permit Number: NAE20053746

Disposal Date	Volume (yd^3)	Volume (m^3)	Disposal Latitude (degrees)	Disposal Longitude (degrees)	Approximate Distance from Buoy (ft)	Approximate Direction from Buoy
1/28/2007			42.42964	-70.58197	unknown	
1/28/2007	3,210	2,454	42.42923	-70.58208	75	S
1/29/2007	1,850	1,415	42.42672	-70.58078	950	
Total Dredged Material Volume	5,060	3,869				

Project Name: DORCHESTER BAY
Permittee: UNIVERSITY OF MASS AT BOSTON
Permit Number: NAE2005644

Disposal Date	Volume (yd^3)	Volume (m^3)	Disposal Latitude (degrees)	Disposal Longitude (degrees)	Approximate Distance from Buoy (ft)	Approximate Direction from Buoy
1/23/2007	1,500	1,147	42.42940	-70.58173	25	N
1/24/2007	1,500	1,147	42.42973	-70.58173	35	
1/28/2007	1,500	1,147	42.42922	-70.58132	40	
1/30/2007	1,500	1,147	42.42915	-70.58138	35	
1/30/2007	1,500	1,147	42.42938	-70.58175	40	
1/31/2007	1,500	1,147	42.42980	-70.58175	50	
2/1/2007	1,500	1,147	42.42973	-70.58173	50	N
2/2/2007	1,400	1,070	42.42910	-70.58138	45	N
2/3/2007	1,500	1,147	42.42935	-70.58125	70	N
2/10/2007	1,500	1,147			60	
2/11/2007	1,500	1,147	42.42935	-70.58152	35	
Total Dredged Material Volume	16,400	12,539				

Appendix B

Sediment-Profile Image Results for MBDS
August 2007 Survey

Appendix B-1
Grain Size Scale for Sediments

Phi (Φ) size	Size range (mm)	Size class (Wentworth class)
< -1	> 2	Gravel
0 to −1	1 to 2	Very coarse sand
1 to 0	0.5 to 1	Coarse sand
2 to 1	0.25 to 0.5	Medium sand
3 to 2	0.125 to 0.25	Fine sand
4 to 3	0.0625 to 0.125	Very fine sand
> 4	< 0.0625	Silt/clay

Appendix B-2
Sediment-Profile Image Results for MBDS 2007

Station	Replicate	Date	Time	Penetration Area (sq.cm)	Penetration Mean (cm)	Penetration Minimum (cm)	Penetration Maximum (cm)	Stop Collar Setting (in)	# of Lead Weights per Carriage	Calibration Constant	Boundary Roughness (cm)	Boundary Roughness Type	Grain Size Major Mode (phi)	Grain Size Maximum (phi)	Grain Size Minimum (phi)	Grain Size Range	RPD Area (sq.cm)	Mean RPD (cm)	Mud Clast Number	Mud Clast State (o = oxidized, r = reduced, b = both)	Methane (n = no)	DM Thickness (cm)	Low DO (n = no)	Feeding Void #	Void Minimum Depth (cm)	Void Maximum Depth (cm)	Void Average Depth (cm)	Successional Stage	Comment
MBDS-E Mound																													
MBDS E-1	A	8/23/2007	10:40	184.92	12.8	12.5	13.3	12	0	14.46	0.9	Biological	>4	2	>4	>4 to 2	41.33	2.9	0		n	12.8	n	4	8.69	10.61	9.65	1 on 3	Soft muddy DM>pen; 2 distinct layers w/ relic rpd@depth; black/sulfidic sed@depth; surface tubes+several subsurface feeding voids
MBDS E-1	B	8/23/2007	10:41	184.23	12.7	12.3	13.5	12	0	14.46	1.3	Biological	>4	2	>4	>4 to 2	30.37	2.1	0		n	12.7	n	3	9.23	12.49	10.86	1 on 3	Soft muddy DM>pen; 2 distinct layers w/ relic rpd@depth; rpd smearing; black/sulfidic sed@depth; biogenic mounds; surface tubes+several feeding voids+Stg 3 worms@depth
MBDS E-1	C	8/23/2007	10:42	228.84	15.8	15.2	16.3	12	0	14.46	1.2	Physical	>4	2	>4	>4 to 2	22.09	1.5	0		n	15.8	n	1	6.03	6.07	6.05	1 on 3	Soft muddy DM>pen; highly reduced/black@depth; surf tubes+1 feeding void
MBDS E-2	A	8/23/2007	10:45	170.9	11.8	10.8	12.4	12	0	14.46	1.6	Biological	>4	2	>4	>4 to 2	24.56	1.7	0		n	11.8	n	2	6.14	8.11	7.13	1 on 3	Soft muddy DM>pen; possible (faint) layering w/ relic rpd; reduced sed@depth; dense surf tubes+1-2 subsurface voids
MBDS E-2	B	8/23/2007	10:46	213.54	14.8	14.2	15.6	12	0	14.46	1.4	Physical	>4	2	>4	>4 to 2	23.01	1.6	0		n	14.8	n	4	6.58	12.98	9.78	1 on 3	Soft muddy DM>pen; faint layering w/ relic rpd; several prominent voids/burrows; surf tubes; somewhat shallow rpd w/ weak contrast
MBDS E-2	C	8/23/2007	10:47	217.77	15.1	14.4	15.7	12	0	14.44	1.3	Biological	>4	2	>4	>4 to 2	12.79	0.9	0		n	15.1	n	2	8.73	9.92	9.33	1 on 3	Soft muddy DM>pen; faint layering w/ relic rpd; reduced/black@depth; 2 subsurface voids/burrows.
MBDS E-3	A	8/23/2007	10:51	193.82	13.4	13.0	14.1	12	0	14.46	1.1	Biological	>4	2	>4	>4 to 2	9.94	0.7	0		n	13.4	n	1	9.46	10.37	9.92	1 on 3	Soft muddy DM>pen; 2 layers w/ relic rpd; reduced/black@depth; 1 subsurface voids+several worm-like orgs; very shallow rpd
MBDS E-3	B	8/23/2007	10:53	178.33	12.3	12.3	12.5	12	0	14.46	0.2	Biological	>4	2	>4	>4 to 2	25.45	1.8	8	o+r	n	12.3	n	2	4.59	11.66	8.13	1 on 3	Softy muddy DM>pen; 2 layers w/ relic rpd; 2 partial voids/burrows; surf tubes; mud clasts=camera artifact
MBDS E-3	C	8/23/2007	10:54	154.51	10.7	10.1	11.3	12	0	14.44	1.2	Biological	>4	2	>4	>4 to 2	15.7	1.1	0		n	10.7	n	0				1 on 3	Softy muddy DM>pen; 2 layers w/ relic rpd; numerous surf tubes; transected burrow edges and some bisected burrows at depth
MBDS E-4	A	8/23/2007	10:57	224.94	15.6	14.8	15.9	12	0	14.46	1.1	Biological	>4	2	>4	>4 to 2	36.27	2.5	3	o	n	15.6	n	2	13.23	13.68	13.46	1 on 3	Softy muddy DM>pen; 2 layers w/ relic rpd; surf tubes; 2 deep voids; 2-3 subsurface worm-like orgs
MBDS E-4	B	8/23/2007	10:58	189.57	13.1	12.3	13.7	12	0	14.46	1.4	Physical	>4	2	>4	>4 to 2	26.64	1.8	0		n	13.1	n	3	2.04	3.12	2.58	1 on 3	Softy muddy DM>pen; at least 2 layers maybe 3 w/ relic rpds; several shallow voids; patchy rpd (w/ some minor camera smearing)
MBDS E-4	C	8/23/2007	10:59	203.4	14.1	13.7	14.5	12	0	14.46	0.8	Biological	>4	2	>4	>4 to 2	27.13	1.9	0		n	14.1	n	3	2.98	6.45	4.72	1 on 3	Classic example of multiple DM layers; soft muddy DM>pen; 2 layers w/ relic rpd; several subsurface feeding voids; a few small surf tubes; dark (reduced) sed@depth
MBDS E-5	D	8/23/2007	9:43	195.62	13.5	12.6	14.5	12	0	14.46	1.9	Biological	>4	2	>4	>4 to 2	23.21	1.6	1	o	n	13.5	n	1	11.71	12.11	11.91	1 on 3	Soft muddy DM>pen; 2 layers but relic aRPD disrupted @ depth overlying reduced sediment; 1 deep feeding void; numerous small surf tubes

Station	Replicate	Date	Time	Penetration Area (sq.cm)	Penetration Mean (cm)	Penetration Minimum (cm)	Penetration Maximum (cm)	Stop Collar Setting (in)	# of Lead Weights per Carriage	Calibration Constant	Boundary Roughness (cm)	Boundary Roughness Type	Grain Size Major Mode (phi)	Grain Size Maximum (phi)	Grain Size Minimum (phi)	Grain Size Range	RPD Area (sq.cm)	Mean RPD (cm)	Mud Clast Number	Mud Clast State (o = oxidized, r = reduced, b = both)	Methane (n = no)	DM Thickness (cm)	Low DO (n = no)	Feeding Void #	Void Minimum Depth (cm)	Void Maximum Depth (cm)	Void Average Depth (cm)	Successional Stage	Comment
MBDS E-5	E	8/23/2007	9:44	266.41	18.4	18.1	19.2	12	0	14.45	1.1	Biological	>4	2	>4	>4 to 2	45.29	3.1	0		n	18.4	n	0				1 on 3	Soft muddy DM>pen; 2 layers w/ deep relic rpd; reduced sed@depth; biogenic mound w/ vertical burrow=Stg 3; several vertical oxy burrows
MBDS E-5	F	8/23/2007	9:45	269.08	18.6	18.3	19.2	12	0	14.45	0.9	Physical	>4	2	>4	>4 to 2	40.92	2.8	0		n	18.6	n	1	15.64	16.96	16.30	1 on 3	Soft muddy DM>pen; 2 layers w/ deep relic rpd; reduced sed@depth; deep void+short surf worm tubes; wiper clasts w/ some rpd streaking
MBDS E-6	A	8/23/2007	10:03	210.18	14.5	12.6	14.8	11	0	14.46	2.2	Biological	>4	2	>4	>4 to 2	29.37	2.0	0	0	n	14.5	n	5	4.26	13.3	8.78	1 on 3	Soft muddy DM>pen; 2 layers w/ deep relic rpd; reduced sed@depth; several subsurface voids; Podocerid amphipod stalk w/ animal
MBDS E-6	B	8/23/2007	10:04	153.71	10.6	10.1	12.1	11	0	14.46	2.0	Physical	>4	2	>4	>4 to 2	14.68	1.0	>6	o+r	n	10.6	n	2	8.69	9.76	9.23	1 on 3	Soft muddy DM>pen; sed surf consists of very angular cohesive mud clasts (both oxy+reduced); 2 DM layers w/ relic rpd; surf tubes+2 subsurface voids.
MBDS E-6	C	8/23/2007	10:05	207.13	14.3	13.9	15.1	11	0	14.46	1.3	Biological	>4	2	>4	>4 to 2	30.44	2.1	0		n	14.3	n	2	12.81	13.54	13.18	1 on 3	Soft muddy DM>pen; 2 layers w/ relic rpd; indistinct voids@depth; numerous small surf tubes
MBDS E-7	A	8/23/2007	9:07	295.99	20.5	20.1	20.7	13	1	14.45	0.6	Biological	>4	2	>4	>4 to 2	43.11	3.0	0		n	20.5	n	0				1 on 3	Soft muddy DM>pen; at least 2 layers w/ relic rpd; edge of burrows transected at depth.
MBDS E-7	C	8/23/2007	9:08	282.21	19.5	19.3	20.0	13	1	14.45	0.7	Physical	>4	2	>4	>4 to 2	22.92	1.6	0		n	19.5	n	1	18.67	18.9	18.79	1 on 3	Soft muddy DM>pen; at least 2 layers w/ deep relic rpd; void lower right corner+1 small subsurface worm-like org; some wiper clast smearing of rpd
MBDS E-7	E	8/23/2007	9:49	287.02	19.9	19.1	20.6	12	0	14.43	1.5	Physical	>4	2	>4	>4 to 2	42.52	2.9	0		n	19.9	n	1	13.13	13.31	13.22	1 on 3	Soft muddy DM>pen; at least 2 layers w/ deep relic rpd; very small void@ left+Stg 3 worm-like org in lwr left corner; reduced sed@depth
MBDS E-8	A	8/23/2007	9:22	260.47	18.1	17.6	18.6	13	1	14.43	1.0	Biological	>4	2	>4	>4 to 2	23.4	1.6	0		n	18.1	n	3	4.78	16.66	10.72	1 on 3	Soft muddy DM>pen; at least 2 layers w/ relic rpd; 1 shallow+2 deep voids; long thin surf tubes (too thick for Podocerid stalks); reduced sed@depth
MBDS E-8	B	8/23/2007	9:23	266.65	18.5	18.3	18.8	13	1	14.43	0.5	Physical	>4	2	>4	>4 to 2	22.87	1.6	0		n	18.5	n	3	13.25	16.68	14.97	1 on 3	Soft muddy DM>pen; 2 layers w/ relic rpd; several prominent deep voids; a few long thin surf tubes; reduced sed@depth
MBDS E-8	C	8/23/2007	9:24	280.86	19.4	19.0	19.8	13	1	14.45	0.8	Biological	>4	2	>4	>4 to 2	29.94	2.1	0		n	19.4	n	0				2	Soft muddy DM>pen; 2 layers w/ relic rpd; vertical oxy tubes/burrows indicate Stage 3 most likely present; reduced sed@depth
MBDS E-9	C	8/23/2007	9:19	264.94	18.4	17.9	18.8	13	1	14.43	0.9	Physical	>4	2	>4	>4 to 2	40.24	2.8	2	o+r	n	18.4	n	0				1 on 3	Soft muddy DM>pen; 2 layers w/ deep relic rpd; a few surf tubes+1 subsurface worm-like org@left; red sed@depth
MBDS E-9	D	8/23/2007	9:37	226.34	15.7	15.3	16.0	12	0	14.45	0.7	Physical	>4	2	>4	>4 to 2	18.9	1.3	0		n	15.7	n	0				2	Soft muddy DM>pen; 2 layers w/ deep relic rpd@bottom of image; a few surf tubes; 1 partial/indistinct void@center
MBDS E-9	E	8/23/2007	9:38	282.14	19.5	19.1	20.0	12	0	14.45	0.9	Biological	>4	2	>4	>4 to 2	39.71	2.7	0		n	19.5	n	3	5.34	17.66	11.50	1 on 3	Soft muddy DM>pen; 2 layers w/ deep relic rpd; 1 shallow void+2 very small deep voids; 1-2 subsurface worms; numerous surf tubes; red sed@depth

Appendix B-2
Sediment-Profile Image Results for MBDS 2007

Station	Replicate	Date	Time	Penetration Area (sq.cm)	Penetration Mean (cm)	Penetration Minimum (cm)	Penetration Maximum (cm)	Stop Collar Setting (in)	# of Lead Weights per Carriage	Calibration Constant	Boundary Roughness (cm)	Boundary Roughness Type	Grain Size Major Mode (phi)	Grain Size Maximum (phi)	Grain Size Minimum (phi)	Grain Size Range	RPD Area (sq.cm)	Mean RPD (cm)	Mud Clast Number	Mud Clast State (o = oxidized, r = reduced, b = both)	Methane (n = no)	DM Thickness (cm)	Low DO (n = no)	Feeding Void #	Void Minimum Depth (cm)	Void Maximum Depth (cm)	Void Average Depth (cm)	Successional Stage	Comment
MBDS E-10	B	8/23/2007	8:46	281.88	19.5	18.5	20.6	14	2	14.45	2.0	Biological	>4	2	>4	>4 to 2	32.54	2.3	0		n	19.5	n	3	9.31	15.69	12.50	1 on 3	Soft muddy DM>pen; 2 layers w/ deep relic rpd over reduced (black) DM; 2-3 voids/burrows+2-3 subsurface worm-like orgs; a few surf tubes
MBDS E-10	E	8/23/2007	9:00	295.21	20.5	20.1	20.8	13	1	14.43	0.7	Biological	>4	2	>4	>4 to 2	54.48	3.8	4	o	n	20.5	n	7	2.93	14.26	8.60	1 on 3	Soft muddy DM>pen; 2 layers w/ relic rpd over reduced (black) DM; several voids/burrow complex; a few small surf tubes
MBDS E-10	F	8/23/2007	9:01	263.14	18.2	17.0	18.8	13	1	14.43	1.8	Physical	>4	2	>4	>4 to 2	42.7	3.0	>10	o+r	n	18.2	n	6	5.8	12.89	9.35	1 on 3	Soft muddy DM>pen; 2 layers w/ relic rpd over reduced (black) DM; multiple mud clasts@swi are combination of DM and camera artifact; some rpd streaking; several voids/burrow+1-2 subsurface worm-like orgs; a few small surf tubes
MBDS E-11	A	8/23/2007	10:17	133.49	9.2	8.9	9.6	11	0	14.45	0.7	Biological	>4	2	>4	>4 to 2	17.69	1.2	0		n	9.2	n	1	7.03	7.86	7.45	1 on 3	Somewhat firm muddy/silty DM>pen; slight fine sand content; 2 DM layers w/ relic rpd (very faint); dense surf worm tubes+subsurface void
MBDS E-11	B	8/23/2007	10:18	96.19	6.7	6.2	7.5	11	0	14.45	1.3	Biological	>4	2	>4	>4 to 2	23.8	1.6	0		n	6.7	n	2	4.08	4.89	4.49	1 on 3	Somewhat firm muddy/silty DM>pen; 1-2 distinct subsurface voids/burrows; 1 shallow burrow; dense surf tubes
MBDS E-11	C	8/23/2007	10:19	139.44	9.6	9.5	9.8	11	0	14.45	0.3	Physical	>4	2	>4	>4 to 2	22.25	1.5	2	o	n	9.6	n	0				1 on 3	Somewhat firm muddy/silty DM>pen; 2 layers w/ relic rpd over reduced (black) DM: a few small subsurface orgs+oxy vertical tubes/burrows+dense surf tubes
MBDS E-12	A	8/23/2007	10:21	126.13	8.7	8.4	9.2	11	0	14.44	0.7	Biological	>4	2	>4	>4 to 2	23.45	1.6	1	o	n	8.7	n	3	6.94	8.58	7.76	1 on 3	Somewhat firm muddy/silty DM>pen; faint layering=2 layers w/ relic rpd over more reduced DM@depth; voids/burrow lwr right corner; numerous surf tubes; burrow opening w/ fecal pellets
MBDS E-12	B	8/23/2007	10:22	142.7	9.9	9.4	10.6	11	0	14.46	1.3	Biological	>4	2	>4	>4 to 2	14.99	1.0	0		n	9.9	n	5	5.31	8.35	6.83	1 on 3	Somewhat firm muddy/silty DM>pen; faint layering=2 layers w/ relic rpd over reduced DM@depth; several feeding voids+subsurface worm-like orgs; surf tubes
MBDS E-12	C	8/23/2007	10:23	126.8	8.8	7.9	9.2	11	0	14.46	1.3	Biological	>4	2	>4	>4 to 2	31.53	2.2	0		n	8.8	n	0				1 on 3	Somewhat firm muddy/silty DM>pen; faint layering=2 layers w/ relic rpd over reduced DM@depth; thick short surf tubes; Podocerid amp stalk in farfield; vertical oxy tubes+a few small Stg 3 orgs@depth
MBDS E-13	A	8/23/2007	10:13	171.05	11.8	10.7	12.6	11	0	14.46	1.9	Physical	>4	2	>4	>4 to 2	15.7	1.1	0		n	11.8	n	2	8.53	10.03	9.28	1 on 3	Soft muddy DM>pen; 2 layers w/ relic rpd over black/reduced DM@depth; 2 voids+some surf tubes.
MBDS E-13	B	8/23/2007	10:13	181.4	12.5	11.6	13.5	11	0	14.46	1.9	Physical	>4	2	>4	>4 to 2	33.08	2.3	0		n	12.5	n	3	8.69	12.27	10.48	1 on 3	Soft muddy DM>pen; 2 layers w/ relic rpd over black/reduced DM@depth; several voids/burrows

Appendix B-2
Sediment-Profile Image Results for MBDS 2007

Station	Replicate	Date	Time	Penetration Area (sq.cm)	Penetration Mean (cm)	Penetration Minimum (cm)	Penetration Maximum (cm)	Stop Collar Setting (in)	# of Lead Weights per Carriage	Calibration Constant	Boundary Roughness (cm)	Boundary Roughness Type	Grain Size Major Mode (phi)	Grain Size Maximum (phi)	Grain Size Minimum (phi)	Grain Size Range	RPD Area (sq.cm)	Mean RPD (cm)	Mud Clast Number	Mud Clast State (o = oxidized, r = reduced, b = both)	Methane (n = no)	DM Thickness (cm)	Low DO (n = no)	Feeding Void #	Void Minimum Depth (cm)	Void Maximum Depth (cm)	Void Average Depth (cm)	Successional Stage	Comment
MBDS E-13	C	8/23/2007	10:14	166.54	11.5	10.9	12.3	11	0	14.46	1.4	Biological	>4	2	>4	>4 to 2	18.08	1.3	6	o	n	11.5	n	0				1 on 3	Soft muddy DM>pen; 2 layers w/ relic rpd over black/reduced DM@depth; several vertical oxy burrows/tubes@depth=Stg 3; large biogenic mound
MBDS E-14	A	8/23/2007	10:35	166.14	11.5	11.3	12.0	12	0	14.46	0.7	Physical	>4	2	>4	>4 to 2	40.26	2.8	5	o	n	11.5	n	0				2	Soft muddy DM>pen; no clear subsurface voids, some shallow transected burrows; small oxy mud clasts+worm tubes@sed surf; reduced DM@depth
MBDS E-14	B	8/23/2007	10:36	192.77	13.3	12.1	14.6	12	0	14.46	2.4	Physical	>4	2	>4	>4 to 2	17.92	1.2	8	o	n	13.3	n	8	6.41	14.17	10.29	1 on 3	Soft muddy DM>pen; possible double layer but too faint/indistinct; multiple subsurface voids+organisms+vertical oxy burrows/tubes; dragdown/streaking of rpd by reduced wiper clasts
MBDS E-14	C	8/23/2007	10:37	177.64	12.3	11.9	12.5	12	0	14.46	0.6	Biological	>4	2	>4	>4 to 2	22.43	1.6	0		n	12.3	n	3	6	7.68	6.84	1 on 3	Softy muddy DM>pen; reduced@depth; slight streaking of rpd by reduced wiper clasts; small surf tubes+2-3 subsurface voids+subsurface worm-like orgs
MBDS E-15	A	8/23/2007	10:07	189.35	13.1	12.6	13.5	11	0	14.46	0.9	Biological	>4	2	>4	>4 to 2	9.44	0.7	0		n	13.1	n	4	2.65	5.49	4.07	1 on 3	Softy muddy DM>pen; patches+horizons of reduced sed throughout=shallow rpd; vertical column of red sed expelled on surf; multiple voids/burrows
MBDS E-15	B	8/23/2007	10:08	136.49	9.4	8.5	10.7	11	0	14.46	2.2	Physical	>4	2	>4	>4 to 2	9.27	0.6	6	o+r	n	9.4	n	0				1 on 3	Soft muddy DM>pen; 2 DM layers w/ relic rpd@depth over black/reduced DM; mud clasts+dense worm tubes@swi; vertical oxy burrow@depth@center w/ associated Stg 3 organism
MBDS E-15	C	8/23/2007	10:09	174.4	12.1	11.7	12.8	11	0	14.44	1.1	Biological	>4	2	>4	>4 to 2	40.48	2.8	0		n	12.1	n	2	8.31	9.32	8.82	1 on 3	Soft muddy DM>pen; 2 layers w/ faint relic rpd@depth over black/reduced DM; 2 prominent voids+surf worm tubes; biogenic mounds nearfield and farfield.
MBDS-F Mound																													
MBDS F-1	A	8/23/2007	11:59	133.03	9.2	8.8	10.0	12	0	14.46	1.2	Physical	>4	1	>4	>4 to 1	27.44	1.9	6	o	n	9.2	n	0				2	DM>pen=light brown silty DM over whitish cohesive clay patches@depth; small clay clasts@sed surf; numerous surf tubes; sandy patches@depth
MBDS F-1	B	8/23/2007	12:00	116.8	8.1	7.5	8.6	12	0	14.46	1.1	Physical	>4	2	>4	>4 to 2	32.01	2.2	0		n	8.1	n	2	4.59	6.63	5.61	1 on 3	DM>pen; mostly light brown silty mud w/ streaks/patches of white clay; voids/burrows@depth; surf tubes
MBDS F-1	C	8/23/2007	12:01	180.07	12.5	12.0	13.0	12	0	14.46	1.0	Physical	>4	2	>4	>4 to 2	29.44	2.0	0		n	5.3	n	1	2.69	3.03	2.86	1 on 3	DM/ambient=3 to 9 cm thick surf layer of muddy DM over ambient mud; shallow void+a few surf tubes.
MBDS F-2	A	8/23/2007	13:39	189.68	13.1	12.7	13.5	13	1	14.46	0.8	Physical	>4	2	>4	>4 to 2	33.3	2.3	0		n	13.1	n	1	11.33	11.48	11.41	1 on 3	DM>pen=light brown oxidized mud grading into black/reduced mud w/ white clay streaks=classic DM signature; 1 deep void; dense surf tubes; a few very small subsurface worm-like orgs

Appendix B-2
Sediment-Profile Image Results for MBDS 2007

Station	Replicate	Date	Time	Penetration Area (sq.cm)	Penetration Mean (cm)	Penetration Minimum (cm)	Penetration Maximum (cm)	Stop Collar Setting (in)	# of Lead Weights per Carriage	Calibration Constant	Boundary Roughness (cm)	Boundary Roughness Type	Grain Size Major Mode (phi)	Grain Size Maximum (phi)	Grain Size Minimum (phi)	Grain Size Range	RPD Area (sq.cm)	Mean RPD (cm)	Mud Clast Number	Mud Clast State (o = oxidized, r = reduced, b = both)	Methane (n = no)	DM Thickness (cm)	Low DO (n = no)	Feeding Void #	Void Minimum Depth (cm)	Void Maximum Depth (cm)	Void Average Depth (cm)	Successional Stage	Comment
MBDS F-2	B	8/23/2007	13:40	192.8	13.4	13.0	13.5	13	1	14.44	0.5	Biological	>4	2	>4	>4 to 2	45.29	3.1	0		n	13.4	n	2	5.11	7.57	6.34	1 on 3	DM>pen=light brown oxidized mud grading into black/reduced mud w/ white clay streaks; subsurface worms+feeding voids/burrows; distinctive surf worm tubes
MBDS F-2	C	8/23/2007	13:40	173.02	12.0	11.4	12.2	13	1	14.44	0.8	Physical	>4	2	>4	>4 to 2	28.88	2.0	0		n	12.0	n	3	6.27	6.94	6.61	1 on 3	DM>pen=light brown oxidized silty mud over reduced/black mud w/ patches of white clay; subsurface voids/burrows+worm-like orgs; dense distinctive surf tubes
MBDS F-3	A	8/23/2007	12:20	147.86	10.2	9.4	10.6	12	0	14.46	1.2	Biological	>4	2	>4	>4 to 2	27.91	1.9	0		n	10.2	n	3	4.59	9.54	7.07	1 on 3	DM>pen=light brown oxidized silty mud over cohesive white clay w/ some black streaks; voids/burrows+small worm-like orgs@depth; dense distinctive worm tubes
MBDS F-3	B	8/23/2007	12:21	123.74	8.6	7.6	9.1	12	0	14.46	1.5	Biological	>4	2	>4	>4 to 2	23.42	1.6	0		n	8.6	n	2	5.73	6.67	6.20	1 on 3	DM>pen=light brown oxidized silty mud over cohesive white clay w/ some black streaks; voids/burrows@depth; dense distinctive worm tubes; several different types of surf tubes
MBDS F-3	C	8/23/2007	12:22	166.03	11.5	11.0	11.8	12	0	14.46	0.8	Biological	>4	1	>4	>4 to 1	18.83	1.3	0		n	11.5	n	1	7.28	8.44	7.86	1 on 3	DM>pen=mix of streaky cohesive white clay+brown silt+black/reduced patches@depth; several subsurface worms+at least 1 feeding void; subsurface sand patch; dense surf tubes
MBDS F-4	D	8/23/2007	14:07	54.01	3.7	3.1	4.1	14	3	14.46	1.0	Physical	>4	2	>4	>4 to 2	15.65	1.1	5	o	n	3.7	n	ind				ind	Low pen=DM>pen=thin surface layer of oxidized brown silt over stiff whitish clay; large clay clasts@sed surf; surf tubes; insufficient penetration for successional stage determination
MBDS F-4	E	8/23/2007	14:08	52.14	3.6	2.7	4.7	14	3	14.46	2.0	Physical	>4	2	>4	>4 to 2	14.58	1.0	3	o	n	3.6	n	ind				2	Low pen=DM>pen=thin surface layer of oxidized brown silt over stiff whitish clay; large whitish clay clasts@sed surf (most likely Boston blue clay); 1 subsurface worm-like org+surf tubes, shallow sub-surface burrows
MBDS F-4	F	8/23/2007	14:09	201.04	13.9	12.9	14.8	14	3	14.46	2.0	Physical	>4	1	>4	>4 to 1	24.9	1.7	0		n	13.9	n	3	7.81	13.14	10.48	1 on 3	DM>pen=silty/sandy brown oxidized mud over cohesive whitish/tan clay@depth; voids and stress fractures in clay; subsurface worm@left; surf tubes
MBDS F-5	A	8/23/2007	13:21	169.4	11.7	10.6	12.5	13	1	14.46	1.9	Physical	>4	1	>4	>4 to 1	16.71	1.2	0		n	11.7	n	3	4.26	5.94	5.10	1 on 3	DM>pen=surface layer of brown oxidized silty slightly sandy mud over cohesive whitish clay w/ black streaks; voids/burrows+dense surf tubes.
MBDS F-5	B	8/23/2007	13:22	122.13	8.4	7.9	9.1	13	1	14.46	1.2	Biological	>4	1	>4	>4 to 1	16.84	1.2	0		n	8.4	n	3	4.91	8.04	6.48	1 on 3	DM>pen=surf layer of oxidized silty mud over more cohesive whitish/tan clay w/ black streaks; wiper clasts w/ some rpd streaking; vertical burrow+dense surf tubes

Appendix B-2
Sediment-Profile Image Results for MBDS 2007

Station	Replicate	Date	Time	Penetration Area (sq.cm)	Penetration Mean (cm)	Penetration Minimum (cm)	Penetration Maximum (cm)	Stop Collar Setting (in)	# of Lead Weights per Carriage	Calibration Constant	Boundary Roughness (cm)	Boundary Roughness Type	Grain Size Major Mode (phi)	Grain Size Maximum (phi)	Grain Size Minimum (phi)	Grain Size Range	RPD Area (sq.cm)	Mean RPD (cm)	Mud Clast Number	Mud Clast State (o = oxidized, r = reduced, b = both)	Methane (n = no)	DM Thickness (cm)	Low DO (n = no)	Feeding Void #	Void Minimum Depth (cm)	Void Maximum Depth (cm)	Void Average Depth (cm)	Successional Stage	Comment
MBDS F-5	C	8/23/2007	13:23	171.87	11.9	11.7	12.3	13	1	14.46	0.6	Biological	>4	2	>4	>4 to 2	16.84	1.2	0		n	11.9	n	4	3.59	10.62	7.11	1 on 3	DM>pen=surf layer of oxidized silty brown mud over cohesive whitish/tan clay; voids/burrows+dense distintive surf tubes; reduced wiper clast artifacts
MBDS F-6	A	8/23/2007	12:24	167.07	11.6	11.1	12.0	12	0	14.46	0.9	Biological	>4	2	>4	>4 to 2	29.79	2.1	0		n	11.6	n	4	2.78	11.39	7.09	1 on 3	DM>pen=surf layer of oxidized silty brown mud over cohesive whitish/tan clay w/ black patches/streaks; several subsurface voids/burrows+dense distintive surf tubes; clay dragdown artifact
MBDS F-6	B	8/23/2007	12:25	112.1	7.8	6.8	9.1	12	0	14.44	2.3	Physical	>4	2	>4	>4 to 2	9.78	0.7	0		n	7.8	n	1	4.75	4.86	4.81	1 on 3	DM>pen=brown oxidized silt over whitish cohesive clay w/ black patches/streaks; live bivalve partially exposed; surf tubes+void/burrow
MBDS F-6	C	8/23/2007	12:26	141.98	9.8	9.5	10.1	12	0	14.46	0.6	Biological	>4	2	>4	>4 to 2	35.55	2.5	0		n	9.8	n	5	3.5	8.53	6.02	1 on 3	DM>pen=brown oxidized silt over black/reduced silt-clay; multiple feeding voids; dense surface tubes
MBDS F-7	D	8/23/2007	12:46	166.54	11.5	10.8	12.2	13	1	14.46	1.4	Biological	>4	1	>4	>4 to 1	24.53	1.7	0		n	11.5	n	1	9.18	9.27	9.23	1 on 3	DM>pen=light brown oxidized silty/sandy mud over white cohesive clay@depth; sandy horizon; 1 small void@center+dense distinctive tubes.
MBDS F-7	E	8/23/2007	12:47	171.9	11.9	10.8	12.7	13	1	14.46	1.9	Physical	>4	1	>4	>4 to 1	35.41	2.4	7	o+r	n	11.9	n	3	4.66	7.32	5.99	1 on 3	DM>pen=light brown oxidized silty mud over whitish cohesive clay@depth; sandy horizon above clay; several indistinct voids+subsurface orgs
MBDS F-7	F	8/23/2007	12:48	147.12	10.2	9.6	10.8	13	1	14.46	1.2	Biological	>4	1	>4	>4 to 1	25.54	1.8	2	o	n	10.2	n	1	8.52	9.74	9.13	1 on 3	DM>pen=light brown silty oxidized mud over cohesive whitish clay w/ black patches; sandy horizon above clay; both feeding voids and clay fractures; 2 subsurface worms+dense surf tubes
MBDS F-8	A	8/23/2007	13:28	178	12.3	12.0	12.5	13	1	14.46	0.4	Physical	>4	2	>4	>4 to 2	37.12	2.6	8	o	n	12.3	n	3	4.84	10.1	7.47	1 on 3	DM>pen=light brown silty oxy mud over cohesive whitish/tan clay w/ black streaks; both burrows and clay fractures; 2-3 distinct voids; distinctive surf tubes; mud clasts in farfield
MBDS F-8	B	8/23/2007	13:29	170.52	11.8	11.5	12.1	13	1	14.46	0.6	Physical	>4	2	>4	>4 to 2	31.55	2.2	0		n	11.8	n	5	10.63	11.38	11.01	1 on 3	DM>pen=light brown silty oxy mud over whitish/tan cohesive clay w/ black streaks; burrow or deep voids in clay; surface worm tubes; mud-encrusted rock in farfield
MBDS F-8	C	8/23/2007	13:30	192.98	13.3	13.0	13.8	13	1	14.46	0.8	Physical	>4	2	>4	>4 to 2	31.95	2.2	9	o	n	13.3	n	7	4.79	12.92	8.86	1 on 3	DM>pen=light brown silty oxy mud over whitish/tan/black streaky cohesive clay; multiple subsurface voids+pink worm-like org; numerous surf tubes; small mud clasts@sed surf
MBDS F-9	A	8/23/2007	11:28	130.52	9.0	8.2	10.8	12	0	14.44	2.6	Physical	>4	2	>4	>4 to 2	22.74	1.6	0		n	9.0	n	2	1.37	5.13	3.25	1 on 3	DM>pen=light brown silty oxy mud over dark/reduced mud; orange subsurface patch=?; fecal pellets@swi; shallow+deep voids+surf tubes; minor sand fraction@depth

Appendix B-2
Sediment-Profile Image Results for MBDS 2007

Station	Replicate	Date	Time	Penetration Area (sq.cm)	Penetration Mean (cm)	Penetration Minimum (cm)	Penetration Maximum (cm)	Stop Collar Setting (in)	# of Lead Weights per Carriage	Calibration Constant	Boundary Roughness (cm)	Boundary Roughness Type	Grain Size Major Mode (phi)	Grain Size Maximum (phi)	Grain Size Minimum (phi)	Grain Size Range	RPD Area (sq.cm)	Mean RPD (cm)	Mud Clast Number	Mud Clast State (o = oxidized, r = reduced, b = both)	Methane (n = no)	DM Thickness (cm)	Low DO (n = no)	Feeding Void #	Void Minimum Depth (cm)	Void Maximum Depth (cm)	Void Average Depth (cm)	Successional Stage	Comment
MBDS F-9	B	8/23/2007	11:29	163.47	11.3	9.7	12.4	12	0	14.44	2.7	Physical	>4	1	>4	>4 to 1	26.66	1.8	>10	o+r	n	11.3	n	4	1.75	7.75	4.75	1 on 3	DM>pen=light brown silty oxy mud over dark/reduced silt-clay; possibly 2 dm layers; sandy patches@depth; mud clasts@swi=DM; shallow+deep voids
MBDS F-9	C	8/23/2007	11:30	163.84	11.3	9.5	12.8	12	0	14.46	3.2	Physical	>4	1	>4	>4 to 1	diffusional	0.2	>10	o+r	n	11.3	n	2	8.75	9.97	9.36	3	DM>pen=chaotic fabric w/ clast clasts@swi and mix of oxy+reduced streaky sed@depth; diffusional RPD layer on surface, looks like relatively fresh deposit; feeding voids associated with sand patches@depth
MBDS F-10	D	8/23/2007	14:01	214.24	14.8	14.0	15.5	14	3	14.44	1.5	Physical	>4	1	>4	>4 to 1	42.81	3.0	0		n	14.8	n	3	5.24	13.3	9.27	1 on 3	DM>pen=light brown silty-sandy oxidized mud over black/white streaky clay; 2 indistinct voids+1 deeper void in lwr right corner.
MBDS F-10	E	8/23/2007	14:03	212.85	14.7	14.3	15.0	14	3	14.46	0.6	Physical	>4	2	>4	>4 to 2	28.87	2.0	0		n	14.7	n	4	5.98	12.74	9.36	1 on 3	DM>pen=light brown silty mud over black+white streaky silt-clay; several voids+subsurface worm-like orgs+a few surf worm tubes.
MBDS F-10	F	8/23/2007	14:04	232.58	16.1	15.7	16.3	14	3	14.44	0.7	Biological	>4	1	>4	>4 to 1	31.07	2.2	4	o+r	n	16.1	n	4	5.64	14.46	10.05	1 on 3	DM>pen=light brown silty mud over cohesive whitish clay w/ black streaks@depth; voids/burrows+small subsurface worms+surf tubes; some rpd smearing w/ clay
MBDS F-11	A	8/23/2007	13:16	76.82	5.3	4.9	5.5	13	1	14.46	0.6	Biological	>4	1	>4	>4 to 1	28.38	2.0	0		n	5.3	n	3	3.52	4.24	3.88	1 on 3	DM>pen=light brown silty mud w/ streaks of white clay; low pen=cohesive clay@depth; voids+worm-like org@depth+surf tubes
MBDS F-11	B	8/23/2007	13:17	160.92	11.1	10.7	11.5	13	1	14.46	0.9	Biological	>4	2	>4	>4 to 2	25.1	1.7	0		n	11.1	n	3	3.77	7.55	5.66	1 on 3	DM>pen=light brown silty mud over cohesive whitish/tan/dark-grey clay; large burrow/void complex; dense surf tubes=diverse tubes; small rock in farfield
MBDS F-11	C	8/23/2007	13:18	187.3	13.0	12.5	13.4	13	1	14.46	0.9	Physical	>4	2	>4	>4 to 2	32.18	2.2	0		n	13.0	n	0				1 on 3	DM>pen=light brown oxy mud@surf over dark/black reduced mud@depth; 1 subsurface worm@far left+surf worm tubes
MBDS F-12	A	8/23/2007	11:54	180.19	12.5	11.8	12.8	12	0	14.44	1.0	Physical	>4	2	>4	>4 to 2	33.74	2.3	0		n	12.5	n	0				1 on 3	DM>pen; 2 layers=upper layer of soft brown mud over soft brown mud; reduced horizon=bottom of upper layer; surf tubes, worms at depth, transected burrows
MBDS F-12	B	8/23/2007	11:55	167	11.5	9.2	12.6	12	0	14.46	3.4	Biological	>4	2	>4	>4 to 2	36.48	2.5	0		n	11.5	n	1	3.05	3.23	3.14	1 on 3	DM>pen; 2 layers=brown soft mud over reduced horizon over more brown mud; large burrow opening@swi+small subsurface worms+1 indistinct void; surf tubes
MBDS F-12	C	8/23/2007	11:56	116.32	8.1	7.4	9.1	12	0	14.44	1.7	Biological	>4	2	>4	>4 to 2	45.54	3.2	0		n	8.1	n	0				1 on 3	DM>pen; soft brown silty mud w/ reduced sed@depth; 1 fecal pellet@swi; surf tubes, transected burrows at bottom

Station	Replicate	Date	Time	Penetration Area (sq.cm)	Penetration Mean (cm)	Penetration Minimum (cm)	Penetration Maximum (cm)	Stop Collar Setting (in)	# of Lead Weights per Carriage	Calibration Constant	Boundary Roughness (cm)	Boundary Roughness Type	Grain Size Major Mode (phi)	Grain Size Maximum (phi)	Grain Size Minimum (phi)	Grain Size Range	RPD Area (sq.cm)	Mean RPD (cm)	Mud Clast Number	Mud Clast State (o = oxidized, r = reduced, b = both)	Methane (n = no)	DM Thickness (cm)	Low DO (n = no)	Feeding Void #	Void Minimum Depth (cm)	Void Maximum Depth (cm)	Void Average Depth (cm)	Successional Stage	Comment
MBDS F-13	A	8/23/2007	13:34	176.75	12.2	12.5	12.5	13	1	14.46	0.0	Biological	>4	2	>4	>4 to 2	40.5	2.8	3	o	n	12.2	n	2	4.64	7.28	5.96	1 on 3	DM>pen=light brown silty oxidized mud@ surf grading into reduced mud/streaky clay@depth; void/burrow at right, fracture in center; abundant diverse surf tubes; mud clasts
MBDS F-13	B	8/23/2007	13:35	180.32	12.5	12.1	13.0	13	1	14.46	0.9	Biological	>4	2	>4	>4 to 2	32.61	2.3	0		n	12.5	n	2	11.56	11.95	11.76	1 on 3	DM>pen=light brown silty oxidized mud@surf over reduced mud w/ white clay streaks@depth; 2 deep small voids+abundant surf tubes; some clay dragdown over rpd
MBDS F-13	C	8/23/2007	13:35	182.8	12.6	16.9	17.8	13	1	14.46	0.9	Biological	>4	2	>4	>4 to 2	24.16	1.7	0		n	12.6	n	3	7.22	10.32	8.77	1 on 3	DM>pen=light brown silty oxidized mud@surf over reduced mud w/ white clay streaks; extensive large burrow/void complex; wiper clasts@swi+some dragdown; surf tubes
MBDS F-14	D	8/23/2007	12:41	56.27	3.9	2.7	5.1	13	1	14.46	2.4	Physical	>4	2	>4	>4 to 2	21.65	1.5	0		n	3.9	n	0				1 on 3	DM>pen=light brown silty mud w/ black streaks; low pen; numerous surf tubes+1 subsurface org on left
MBDS F-14	E	8/23/2007	12:42	121.36	8.4	7.3	9.2	13	1	14.46	2.0	Physical	>4	1	>4	>4 to 1	24.35	1.7	9	o+r	n	8.4	n	5	4.26	6.05	5.16	1 on 3	DM>pne=light brown silty slightly sandy mud w/ white clay patches; several voids/burrows+dense surf tubes; Podocerid amphipod stalk in farfield; diverse surf tubes.
MBDS F-14	F	8/23/2007	12:43	85.25	5.9	5.3	6.8	13	1	14.46	1.5	Physical	>4	2	>4	>4 to 2	30.08	2.1	4	o	n	5.9	n	4	5.02	5.2	5.11	1 on 3	DM>pen=light brown silty mud w/ 1 white clay patch@depth; large mudclast in farfield; indistinct voids; some surf tubes.
MBDS F-15	A	8/23/2007	12:03	127.38	8.8	7.2	9.3	12	0	14.46	2.1	Physical	>4	2	>4	>4 to 2	39.6	2.7	2	o	n	8.8	n	2	6.49	7.06	6.78	1 on 3	DM>pen=light brown silty mud w/ reduced/black patches/horizon@depth; 2-3 small voids; 2 buried organisms (orange patches)@depth; some surface worm tubes; clasts in farfield
MBDS F-15	B	8/23/2007	12:04	149.95	10.4	9.7	11.2	12	0	14.44	1.4	Biological	>4	2	>4	>4 to 2	27.95	1.9	0		n	10.4	n	1	3.25	5.27	4.26	1 on 3	DM>pen=light brown silty oxidized mud over reduced slightly sandy mud@depth; burrow w/ mounded opening@sed surf; surf tubes
MBDS F-15	C	8/23/2007	12:05	132.87	9.2	8.7	9.7	12	0	14.48	1.0	Physical	>4	1	>4	>4 to 2	33.93	2.3	9	o+r	n	9.2	n	1	8.49	9.12	8.81	1 on 3	DM>pen=light brown mud w/ fine sand and reduced horizon@depth; mud clasts@sed surf; 1 prominent burrow/void@bottom of image.
BCDA																													
DEMO-1	A	8/24/2007	12:44	195.51	13.5	13.0	13.8	17	3	14.46	0.7	Biological	>4	2	>4	>4 - 2	40.32	2.79	0		n		n	3	5.35	6.14	5.75	3	Moderately soft ambient tan mud>pen; low rpd contrast; shallow burrow, subsurface voids
DEMO-1	B	8/24/2007	12:45	245.72	17.0	14.5	19.4	17	3	14.42	4.9	Physical	>4	2	>4	>4 - 2	31.15	2.16	Artifact		n		n	1	8.91	8.91	8.91	1 on 3	Soft ambient tan mud>pen; low rpd contrast; wiper clasts/smears; several small stage 1 tubes; small subsurface void+large polychaete
DEMO-1	C	8/24/2007	12:47	271.56	18.8	18.0	19.1	17	3	14.46	1.1	Biological	>4	2	>4	>4 - 2	40.39	2.79	0		n		n	2	11.14	12.96	12.05	1 on 3	Soft ambient tan mud>pen; low rpd contrast; 2 faint feeding voids; polychaetes@depth

Appendix B-2
Sediment-Profile Image Results for MBDS 2007

Station	Replicate	Date	Time	Penetration Area (sq.cm)	Penetration Mean (cm)	Penetration Minimum (cm)	Penetration Maximum (cm)	Stop Collar Setting (in)	# of Lead Weights per Carriage	Calibration Constant	Boundary Roughness (cm)	Boundary Roughness Type	Grain Size Major Mode (phi)	Grain Size Maximum (phi)	Grain Size Minimum (phi)	Grain Size Range	RPD Area (sq.cm)	Mean RPD (cm)	Mud Clast Number	Mud Clast State (o = oxidized, r = reduced, b = both)	Methane (n = no)	DM Thickness (cm)	Low DO (n = no)	Feeding Void #	Void Minimum Depth (cm)	Void Maximum Depth (cm)	Void Average Depth (cm)	Successional Stage	Comment
DEMO-2	A	8/24/2007	11:31	260.94	18.0	17.8	18.8	17	3	14.46	1.0	Biological	>4	2	>4	>4 - 2	47.52	3.29	0		n	>pen	n	0			0.00	1 on 3	Soft light-tan mud>pen; appears to be old/weathered DM; larger-bodied infauna@depth (including poly in lower right corner); low rpd contrast
DEMO-2	B	8/24/2007	11:32	267.49	18.5	17.7	19.2	17	3	14.46	1.6	Biological	>4	2	>4	>4 - 2	46.92	3.24	3	b	n	>pen	n	4	12.75	16.25	14.50	3	Soft light-tan mud>pen; moderate rpd contrast w/ black streaks appears to =old DM; feeding voids
DEMO-2	C	8/24/2007	11:33	223.32	15.4	13.9	16.9	17	3	14.46	3.0	Biological	>4	2	>4	>4 - 2	36.81	2.55	0		n	>pen	n	0			0.00	3	Soft light-tan mud>pen; low rpd contrast; Maldanid tubes(?)=stg 3; appears to be weathered DM
DEMO-3	A	8/24/2007	11:08	247.63	17.1	16.9	17.7	17	3	14.46	0.8	Biological	>4	2	>4	>4 - 2	53.12	3.67	0		n	13.64	n	1	14.4	14.57	14.49	1 on 3	Soft mud>pen; DM>pen; new DM layer over older layer; 1 subsurface void+1 larger-bodied infauna
DEMO-3	B	8/24/2007	11:09	250.19	17.3	17.1	17.7	17	3	14.43	0.6	Biological	>4	2	>4	>4 - 2	52.81	3.66	Artifact		n	10.34	n	0			0.00	3	Soft tan mud w/ strong rpd contrast>pen; DM>pen; newer DM over older DM lyr; subsurface poly w/ halo of oxy sed around burrow
DEMO-3	C	8/24/2007	11:10	273.64	18.9	18.8	19.4	17	3	14.46	0.6	Biological	>4	2	>4	>4 - 2	48.21	3.33	0		n	11.58	n	6	4.18	12.94	8.56	1 on 3	Soft tan mud w/ strong rpd contrast>pen; DM>pen; newer DM lyr over older layer; multiple feeding voids+Stg 3 poly
DEMO-11	A	8/24/2007	13:40	222.57	15.4	15.0	15.9	17	3	14.46	0.9	Biological	>4	2	>4	>4 - 2	45.35	3.14	0		n	9.39	n	3	4.58	7.27	5.93	1 on 3	Soft tan mud w/ strong rpd contrast>pen; DM>pen; multiple DM layers; feeding voids+stg 1 tubes
DEMO-11	B	8/24/2007	13:41	196.12	13.5	12.7	14.5	17	3	14.48	1.9	Biological	>4	2	>4	>4 - 2	41.39	2.86	1	o	n	10.73	n	6	4.87	12.14	8.51	1 on 3	Soft tan mud w/ moderate rpd contrast>pen; DM>pen; newer DM lyr over older lyr; Maldanid(??) tubes; Stick amphipods; multiple voids
DEMO-11	C	8/24/2007	13:42	215.83	15.0	14.6	15.3	17	3	14.43	0.8	Biological	>4	2	>4	>4 - 2	56.39	3.91	0		n	>pen	n	0			-	1 on 3	Soft tan mud w/ moderate rpd contrat>pen; DM>pen; multiple layers; stage 1 tubes+1 small subsurface poly+oxidized burrow@far left
DEMO-12	B	8/24/2007	13:31	223.25	15.4	15.2	15.8	17	3	14.46	0.6	Biological	>4	2	>4	>4 - 2	43.42	3.00	0		n	>pen	n	1	11.94	12.02	11.98	1 on 3	Soft tan mud>pen; DM>pen; stg 1 tubes; subsurface voids+stg 3 polys
DEMO-12	C	8/24/2007	13:32	194.18	13.4	12.7	14.7	17	3	14.46	2.0	Biological	>4	2	>4	>4 - 2	52.54	3.63	0		n	>pen	n	2	4.57	6.74	5.66	1 on 3	Soft tan mud>pen; old DM>pen; voids+Stage 3 infauna
DEMO-12	D	8/24/2007	13:33	228.27	15.8	15.3	16.2	17	3	14.46	1.0	Biological	>4	2	>4	>4 - 2	41.73	2.89	0		n	>pen	n	1	10.86	10.93	10.90	1 on 3	Soft tan mud>pen; old DM>pen; low rpd contrast; surface tubes and at least 1 partial subsurface void
DEMO-13	A	8/24/2007	13:22	205.35	14.2	13.5	15.1	17	3	14.46	1.6	Biological	>4	2	>4	>4 - 2	28.49	1.97	0		n	>pen	n	2	5.53	10.64	8.09	3	Soft tan mud>pen; DM>pen; moderate rpd contrast; black+white streaks@depth=DM; 2 indistinct voids
DEMO-13	B	8/24/2007	13:23	207.32	14.3	14.0	14.7	17	3	14.46	0.7	Biological	>4	2	>4	>4 - 2	44.93	3.11	0		n	>pen	n	1	4.04	4.15	4.10	1 on 3	Soft tan mud>pen; old DM; moderate rpd contrast; 1 indistinct void
DEMO-13	C	8/24/2007	13:24	268.12	18.6	15.1	21.1	17	3	14.45	6.1	Physical	>4	2	>4	>4 - 2	17.27	1.20	0		n	>pen	n	0			0.00	3	Soft tan mud>pen; old DM>pen; appears to be previous replicate camera divot; large polychaete in background
DEMO-14	A	8/24/2007	13:12	281.45	19.5	18.6	20.2	17	3	14.45	1.6	Biological	>4	2	>4	>4 - 2	44.94	3.11	0		n		n	0			0.00	1 on 3	Ambient soft tan mud>pen; Stg 1 and 3 surf tubes; retracted Cerianthid@depth
DEMO-14	B	8/24/2007	13:13	289.67	20.1	19.8	20.6	17	3	14.42	0.8	Biological	>4	2	>4	>4 - 2	51.02	3.54	2	o	n		n	0			-	1 on 3	Ambient soft tan mud>pen; low rpd contrast; Stage 3 poly@depth

Appendix B-2
Sediment-Profile Image Results for MBDS 2007

Station	Replicate	Date	Time	Penetration Area (sq.cm)	Penetration Mean (cm)	Penetration Minimum (cm)	Penetration Maximum (cm)	Stop Collar Setting (in)	# of Lead Weights per Carriage	Calibration Constant	Boundary Roughness (cm)	Boundary Roughness Type	Grain Size Major Mode (phi)	Grain Size Maximum (phi)	Grain Size Minimum (phi)	Grain Size Range	RPD Area (sq.cm)	Mean RPD (cm)	Mud Clast Number	Mud Clast State (o = oxidized, r = reduced, b = both)	Methane (n = no)	DM Thickness (cm)	Low DO (n = no)	Feeding Void #	Void Minimum Depth (cm)	Void Maximum Depth (cm)	Void Average Depth (cm)	Successional Stage	Comment
DEMO-14	C	8/24/2007	13:14	188.24	13.0	12.3	13.9	17	3	14.44	1.5	Biological	>4	2	>4	>4 - 2	35.84	2.48	0		n		n	1	7.41	7.55	7.48	1 on 3	Ambient soft tan mud>pen; oxy burrows extending below rpd; weak rpd contrast; surface reworking; 1 partial/indistinct void
DEMO-15	A	8/24/2007	13:03	277.46	19.2	18.4	19.9	17	3	14.45	1.6	Biological	>4	2	>4	>4 - 2	27.01	1.87	0		n		n	2	8.34	17.22	12.78	3	Ambient soft tan mud>pen; low rpd contrast; burrows/voids
DEMO-15	B	8/24/2007	13:05	267.17	18.5	18.0	19.1	17	3	14.45	1.1	Biological	>4	2	>4	>4 - 2	48.21	3.34	0		n		n	1	5.21	7.35	6.28	1 on 3	Ambient soft tan mud>pen; white patch= buried bivalve shell with partial dissolution; edge of void transected at depth; Stg 1 surf tubes+subsurface Stg 3 poly
DEMO-15	C	8/24/2007	13:05	231.58	16.0	14.7	17.7	17	3	14.43	3.0	Biological	>4	2	>4	>4 - 2	57.21	3.96	0		n		n	0			-	1 on 3	Ambient soft tan mud>pen; low rpd contrast; biogenic mound in farfield; faint evidence of Stg 3 polys@depth' stg 1 surf tubes
DEMO-21	A	8/24/2007	10:59	302.72	20.9	ind	ind	17	3	14.45	ind	Ind	>4	2	>4	>4 - 2	50.75	3.51	0		n	>pen	n	0			0.00	ind	Overpen=very soft mud>pen=DM>pen; multiple DM layers; indistinct void??; strong rpd contrast; reduced@depth; deep rpd=minimum estimate
DEMO-21	B	8/24/2007	10:59	295.99	20.5	19.5	20.9	17	3	14.45	1.5	Physical	>4	2	>4	>4 - 2	45.25	3.13	0		n	>pen	n	1	11.37	11.51	11.44	3	Slight overpen=very soft mud>pen=DM>pen; DM layering; reduced@depth; 1 feeding void complex; strong rpd contrast
DEMO-21	C	8/24/2007	11:00	300.93	20.8	20.7	21.2	17	3	14.45	0.5	Biological	>4	2	>4	>4 - 2	66.31	4.59	0		n	>pen	n	0			0.00	3	Slight overpen=very soft mud>pen=DM>pen; DM layering; strong rpd contrast; Stg 3 infauna@depth
DEMO-22	A	8/24/2007	11:16	207.68	14.4	11.8	16.1	17	3	14.46	4.3	Physical	>4	2	>4	>4 - 2	31.43	2.17	1	o	n		n	1	14.9	14.94	14.92	1 on 3	Ambient soft tan mud>pen; low rpd contrast; dense surf tubes; feeding void+infaunal organism@depth
DEMO-22	B	8/24/2007	11:17	214.08	14.8	12.3	16.9	17	3	14.46	4.6	Physical	>4	2	>4	>4 - 2	49.11	3.40	Artifact		n		n	0			0.00	3	Ambient soft tan mud>pen; low rpd contrast; edge of subsurface burrows transected at depth
DEMO-22	C	8/24/2007	11:18	236.54	16.4	15.6	16.7	17	3	14.46	1.1	Biological	>4	2	>4	>4 - 2	40.61	2.81	Artifact		n		n	1	4.19	4.32	4.26	1 on 3	Ambient soft tan mud>pen; low rpd contrast; indistinct feeding void + infaunal organism
DEMO-23	A	8/24/2007	12:26	272.06	18.8	18.6	19.6	17	3	14.45	1.0	Biological	>4	2	>4	>4 - 2	44.51	3.08	0		n		n	2	4.68	6.54	5.61	1 on 3	Ambient soft tan mud>pen; low rpd contrast; 2 voids+subsurface poly; vertical oxy tube/burrow; unusual tube @swi
DEMO-23	B	8/24/2007	12:27	275.06	19.1	18.9	19.5	17	3	14.43	0.6	Biological	>4	2	>4	>4 - 2	50.55	3.50	Artifact		n		n	3	3.72	16.71	10.22	3	Ambient soft tan mud>pen; low rpd contrast; subsurface voids
DEMO-23	C	8/24/2007	12:28	202.13	14.0	12.5	15.0	17	3	14.45	2.4	Biological	>4	2	>4	>4 - 2	38.29	2.65	0		n		n	1	6.39	6.54	6.47	3	Ambient soft tan mud>pen; low rpd contrast; prominent vertical burrow w/ oxy halo; biogenic mound associated with burrow
DEMO-24	A	8/24/2007	12:36	280.13	19.3	19.1	20.1	17	3	14.48	1.1	Biological	>4	2	>4	>4 - 2	39.32	2.72	0		n		n	3	5.22	5.54	5.38	1 on 3	Ambient soft tan mud>pen; low rpd contrast; multiple feeding voids and polychaetes@same depth
DEMO-24	B	8/24/2007	12:37	182.21	12.6	12.1	13.4	17	3	14.45	1.3	Biological	>4	2	>4	>4 - 2	47.93	3.32	0		n		n	1	4.43	4.53	4.48	1 on 3	Ambient soft tan mud>pen; low rpd contrast; small Maldanid (?) tubes@swi; feeding void

Appendix B-2
Sediment-Profile Image Results for MBDS 2007

Station	Replicate	Date	Time	Penetration Area (sq.cm)	Penetration Mean (cm)	Penetration Minimum (cm)	Penetration Maximum (cm)	Stop Collar Setting (in)	# of Lead Weights per Carriage	Calibration Constant	Boundary Roughness (cm)	Boundary Roughness Type	Grain Size Major Mode (phi)	Grain Size Maximum (phi)	Grain Size Minimum (phi)	Grain Size Range	RPD Area (sq.cm)	Mean RPD (cm)	Mud Clast Number	Mud Clast State (o = oxidized, r = reduced, b = both)	Methane (n = no)	DM Thickness (cm)	Low DO (n = no)	Feeding Void #	Void Minimum Depth (cm)	Void Maximum Depth (cm)	Void Average Depth (cm)	Successional Stage	Comment
DEMO-24	C	8/24/2007	12:38	168.81	11.7	11.4	12.2	17	3	14.45	0.8	Biological	>4	2	>4	>4 - 2	41.63	2.88	0		n		n	2	3.99	4.5	4.25	1 on 3	Ambient soft tan mud>pen; low rpd contrast; feeding voids+surface worm tubes
DEMO-25	A	8/24/2007	12:52	187.9	13.0	12.9	13.2	17	3	14.48	0.3	Biological	>4	2	>4	>4 - 2	45.69	3.16	0		n		n	2	4.3	5.4	4.85	3	Ambient soft tan mud>pen; feeding voids; low rpd contrast
DEMO-25	B	8/24/2007	12:53	271.68	18.8	18.6	19.1	17	3	14.43	0.5	Biological	>4	2	>4	>4 - 2	45.93	3.18	0		n		n	1	2.65	2.68	2.67	1 on 3	Ambient soft tan mud>pen; low rpd contrast; subsurface feeding voids+multiple polychaetes
DEMO-25	C	8/24/2007	12:54	184.06	12.7	12.3	13.6	17	3	14.45	1.3	Biological	>4	2	>4	>4 - 2	40.14	2.78	0		n		n	0			0.00	3	Ambient soft tan mud>pen; low rpd contrast; surface worm tubes+numerous subsurface polychaetes
DEMO-31	A	8/24/2007	10:39	272.56	18.9	18.2	19.4	17	4	14.45	1.2	Biological	>4	2	>4	>4 - 2	49.26	3.41	0		n		n	0			0.00	1 on 3	Ambient soft tan mud>pen; low rpd contrast; a few small stg 1 surf tubes, edge of oxygenated burrow at depth
DEMO-31	B	8/24/2007	10:40	292.63	20.3	20.1	20.7	17	4	14.43	0.6	Biological	>4	2	>4	>4 - 2	51.08	3.54	0		n		n	5	9.19	19.87	14.53	1 on 3	Ambient very soft tan mud>pen; slight overpen; multiple subsurface voids/burrows
DEMO-31	C	8/24/2007	10:41	251.67	17.4	17.2	17.9	17	4	14.45	0.7	Biological	>4	2	>4	>4 - 2	53.17	3.68	2	o	n		n	0			0.00	3	Ambient soft tan mud>pen; at least subsurface infaunal organism near bottom of frame=Stage 3
DEMO-32	A	8/24/2007	10:22	281.71	19.5	18.9	20.7	16	3	14.43	1.8	Biological	>4	2	>4	>4 - 2	53	3.67	0		n		n	1	19.02	19.09	19.06	3	Ambient soft tan mud>pen; thick tubes@swi=Maldanids??; stick amphipod; 1 deep void; vertical oxy tubes/burrows
DEMO-32	B	8/24/2007	10:23	231.63	16.1	15.5	16.7	16	3	14.43	1.2	Physical	>4	2	>4	>4 - 2	45.68	3.17	0		n		n	0			0.00	2-3	Dark ambient soft tan mud or very old DM>pen; black streaks@depth appears to be old DM; a few small stage 1 tubes
DEMO-32	C	8/24/2007	10:24	217.45	15.0	14.9	15.3	16	3	14.45	0.4	Biological	>4	2	>4	>4 - 2	53.45	3.70	6	o	n		n	2	4.27	5.57	4.92	1 on 3	Ambient soft tan mud>pen; thick surface worm tubes+feeding voids@depth; vertical oxidized burrow
DEMO-33	A	8/24/2007	11:42	251.86	17.4	15.4	20.2	17	3	14.45	4.8	Biological	>4	2	>4	>4 - 2	26.2	1.81	0		n		n	0			-	1 on 3	Ambient soft tan mud>pen; thick surface worm tubes; large burrow opening in nearfield (almost transected)
DEMO-33	B	8/24/2007	11:43	267.11	18.5	18.2	18.9	17	3	14.45	0.8	Biological	>4	2	>4	>4 - 2	47.09	3.26	Artifact		n		n	4	7.25	18.29	-	1 on 3	Ambient soft tan mud>pen; multiple feeding voids+surf tubes
DEMO-33	C	8/24/2007	11:44	275.83	19.1	18.6	19.6	17	3	14.43	1.0	Biological	>4	2	>4	>4 - 2	46.94	3.25	Artifact		n		n	1	5.31	5.3	5.31	3	Ambient soft tan mud>pen; wiper clast artifact@swi; feeding void
DEMO-34	A	8/24/2007	11:52	172.99	12.0	11.8	12.3	17	3	14.45	0.5	Biological	>4	2	>4	>4 - 2	37.22	2.58	0		n		n	4	3.77	8.55	6.16	1 on 3	Ambient soft tan mud>pen; surf worm tubes+multiple voids; low rpd contrast
DEMO-34	B	8/24/2007	11:53	292.23	20.2	20.0	20.4	17	3	14.45	0.5	Biological	>4	2	>4	>4 - 2	69.89	4.84	0		n		n	1	18.42	18.59	18.51	3	Ambient soft tan mud>pen; low rpd contrast; 1 deep feeding void+1 subsurface polychaete
DEMO-34	C	8/24/2007	11:54	204.62	14.2	13.7	14.7	17	3	14.45	1.0	Biological	>4	2	>4	>4 - 2	38.41	2.66	0		n		n	2	8.06	13.35	10.71	3	Ambient soft tan mud>pen; low rpd contrast; thick surf tubes (possible Maldanids); two feeding voids; biogenic mound
DEMO-35	A	8/24/2007	12:02	195.73	13.5	12.3	14.7	17	3	14.45	2.5	Biological	>4	2	>4	>4 - 2	35.82	2.48	0		n		n	0			0.00	3	Ambient soft tan mud>pen; low rpd contrast; one small yellowish subsurface infaunal organism+1 surf tube

Appendix B-2
Sediment-Profile Image Results for MBDS 2007

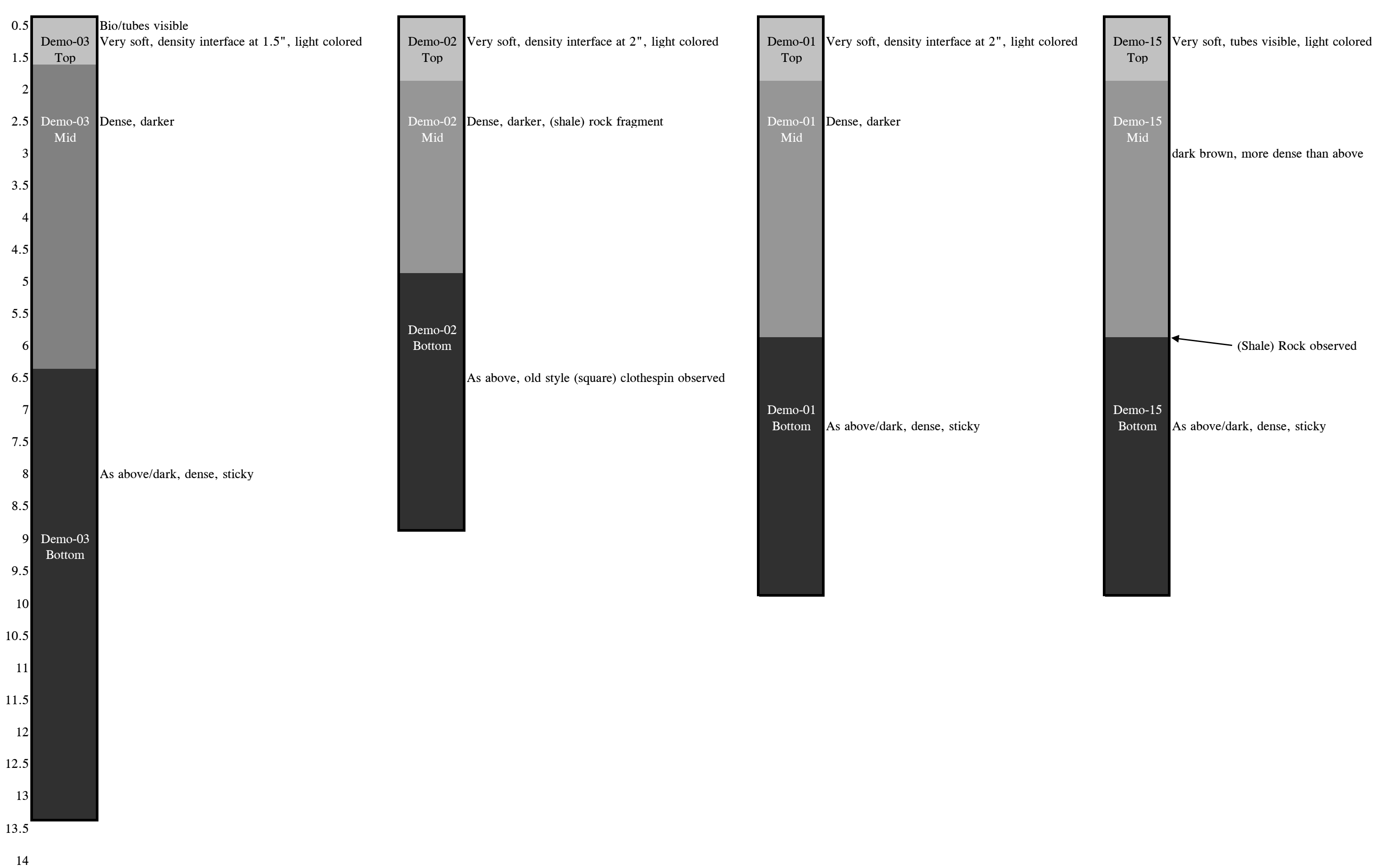
Station	Replicate	Date	Time	Penetration Area (sq.cm)	Penetration Mean (cm)	Penetration Minimum (cm)	Penetration Maximum (cm)	Stop Collar Setting (in)	# of Lead Weights per Carriage	Calibration Constant	Boundary Roughness (cm)	Boundary Roughness Type	Grain Size Major Mode (phi)	Grain Size Maximum (phi)	Grain Size Minimum (phi)	Grain Size Range	RPD Area (sq.cm)	Mean RPD (cm)	Mud Clast Number	Mud Clast State (o = oxidized, r = reduced, b = both)	Methane (n = no)	DM Thickness (cm)	Low DO (n = no)	Feeding Void #	Void Minimum Depth (cm)	Void Maximum Depth (cm)	Void Average Depth (cm)	Successional Stage	Comment
DEMO-35	B	8/24/2007	12:03	189.75	13.1	12.7	13.6	17	3	14.45	0.9	Biological	>4	2	>4	>4 - 2	52	3.60	0		n		n	0			-	3	Ambient soft tan mud>pen; low rpd contrast; subsurface polychaetes=Stg 3; vertical oxy burrows
DEMO-35	C	8/24/2007	12:04	212.47	14.7	14.4	15.1	17	3	14.45	0.7	Biological	>4	2	>4	>4 - 2	48.1	3.33	0		n		n	2	13.41	14.41	13.91	3	Ambient soft tan mud>pen; low rpd contrast; feeding voids@depth

Appendix C

Sediment Core Descriptions for MBDS
August 2007 Survey

Appendix C
Sediment Core Descriptions for MBDS

Time	14:29	15:00	15:50	16:15
Water Depth (ft)	286	285	280	280
Subsample Qty:	3	3	3	3
Core Reps Archived:	2	2	2	2
Site/Core Label	Demo-03	Demo-02	Demo-01	Demo-15



Core Rep	R1	R2	R1	R2	R1	R2	R1	R2
Total Length (in)	11.5	15	7.25	6.75	9.75	9	8.5	9
Compaction (in)	5.5	4	3	3	2.5	2.5	2	1