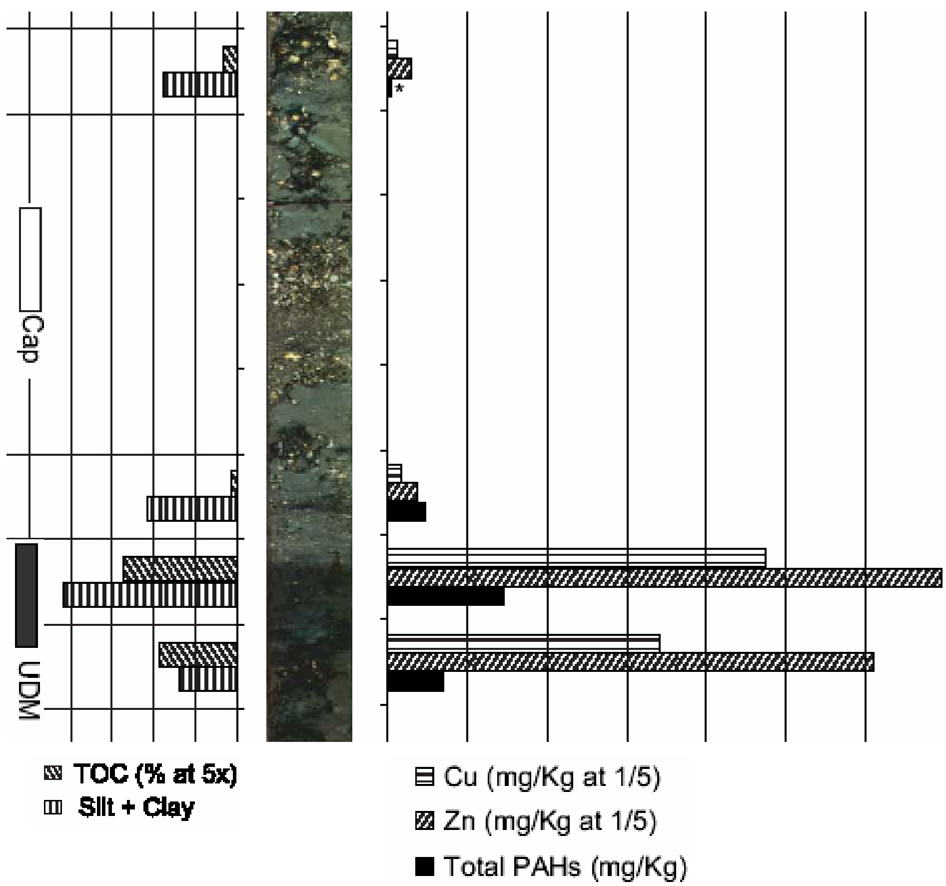
Stamford-New Haven North/Cap Site 2 Investigation
May 2004

Disposal Area Monitoring System DAMOS



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13. ABSTRACT

An investigation was conducted in May 2004 as part of the Disposal Area Monitoring System (DAMOS) to assess the physical distribution of sediments and chemical profiles in two engineered mounds in Long Island Sound, Stamford New Haven-North (STNH-N) and Cap Site 2 (CS-2). The STNH-N mound is one of two capped mounds created in 1979 as the first engineered open water caps in the United States. The CS-2 mound was created in 1983 as part of an extensively monitored follow-up capping project. Investigations performed during and following formation of these mounds revealed that the unacceptably contaminated dredged material (UDM) had been successfully capped at both sites. In the 2004 investigation, visual observations and analytical data were applied to classify horizons into surficial sediments, capping dredged material (CDM), UDM, historic dredged material, and native base sediments. Data from the 2004 investigation was compared to historic data to evaluate the integrity of the caps and assess the continued isolation of chemicals within the UDM horizon.

The cores collected in the 2004 study at STNH-N and CS-2 provided clear and consistent data showing that the CDM over UDM sequence remained intact with a well-defined interface between the intervals at both mounds. At both sites, a surficial layer was noted above the CDM, indicating net deposition since formation of the mounds. The maintenance of the CDM thickness over time and the overlying net deposition provide evidence that the UDM interval remained physically isolated from the overlying waters and unaffected by potential erosive events or other surface disturbances. The sediment chemistry data supported classification of sediments into the observed horizons in the cores. Concentrations for all constituents were generally at least an order of magnitude higher in the UDM than in the other horizons. Comparison of 1990 and 2004 analytical data indicated similar concentrations were observed in both surveys. The 2004 analytical results did not suggest any vertical migration of chemicals from the UDM into the CDM, supporting previous studies indicating chemical isolation within the UDM.

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TABLE OF CONTENTS

Page

LIST OF TABLES iii
LIST OF FIGURES iv
EXECUTIVE SUMMARY vii

1.0 INTRODUCTION AND BACKGROUND 1
- 1.1 Overview of the DAMOS Program 1
- 1.2 Introduction to Stamford-New Haven North/Cap Site 2 1
- 1.3 Previous Monitoring of STNH-N and CS-2 4
- 1.4 Survey Objectives 4

2.0 APPROACH AND METHODS 7
- 2.1 Coring Survey 7
- 2.2 Core Processing 10
- 2.3 Core Descriptions 10
- 2.4 Core Imaging 11
- 2.5 Core Chemistry 11
- 2.6 Mound Sediment Classifications 12

3.0 RESULTS 14
- 3.1 Results Overview 14
  - 3.1.1 Field Collection 14
  - 3.1.2 Core Data Summaries 14
  - 3.1.3 Data Quality 40
- 3.2 Stamford-New Haven North 43
  - 3.2.1 Physical Characteristics and Observations 43
  - 3.2.2 Sediment Chemistry 44
  - 3.2.3 Mound Sediment Classification Summary 45
- 3.3 Cap Site 2 46
  - 3.3.1 Physical Characteristics and Observations 46
  - 3.3.2 Sediment Chemistry 47
  - 3.3.3 Mound Sediment Classification Summary 48
- 3.4 P-Wave 48

4.0 DISCUSSION 51
- 4.1 Review of Mound Formation 52
  - 4.1.1 STNH-N History 52
  - 4.1.2 CS-2 History 56

Page

4.2 Physical Distribution of Mound Sediments 61
4.2.1 STNH-N 61
4.2.2 CS-2 70
4.2.3 Sediment Distribution Summary 74
4.3 Chemical Distribution within Mound Sediments 75
4.3.1 Comparison with Chemistry of Previous Investigation 75
4.3.2 STNH-N 77
4.3.3 CS-2 84
4.3.4 Sediment Chemistry Summary 84

5.0 CONCLUSIONS 91

6.0 REFERENCES 93

APPENDICES

A QUALITY ASSURANCE AND METHOD DOCUMENTS

B DATA QUALITY

C DETAILED CORE INFORMATION

INDEX

LIST OF TABLES

Page

Table 3-1. Summary of Cores Collected in May 2004 15

Table 3-2. STNH-N 2004 Sediment Chemistry and Grain Size Results 16

Table 3-3. CS-2 2004 Sediment Chemistry and Grain Size Results 22

Table 3-4. 2004 STNH-N Layer Summary Statistics 41

Table 3-5. 2004 CS-2 Layer Summary Statistics 42

Table 4-1. Capped Mound Layer Thickness Estimates Observed in 2004 (thickness in cm) 64

Table 4-2. Capped Mound Layer Thickness Observed in 1990 (thickness in cm) 66

Table 4-3. Surface Sediment Comparisons – 2000 CLDS Reference Sediments vs 2004 Capped Mound Sediments 78

LIST OF FIGURES

Page

Figure 2-1. May 2004 coring locations at the Stamford New Haven North capped mound 8

Figure 3-1a. STNH-N Core 1-1 characteristics and horizon classification 28

Figure 3-1b. STNH-N Core 1-2 characteristics and horizon classification 29

Figure 3-1c. STNH-N Core 1-3 characteristics and horizon classification 30

Figure 3-1d. STNH-N Core 1-4 characteristics and horizon classification 31

Figure 3-1e. STNH-N Core 1-5 characteristics and horizon classification 32

Figure 3-1f. STNH-N Core 1-6 characteristics and horizon classification 33

Figure 3-2a. CS-2 Core 2-1 characteristics and horizon classification 34

Figure 3-2b. CS-2 Core 2-2 characteristics and horizon classification 35

Figure 3-2c. CS-2 Core 2-3 characteristics and horizon classification 36

Figure 3-2d. CS-2 Core 2-4 characteristics and horizon classification 37

Figure 3-2e. CS-2 Core 2-5 characteristics and horizon classification 38

Figure 3-2f. CS-2 Core 2-6 characteristics and horizon classification 39

Figure 3-3. P-wave velocity profiles from Cores 2-3 and 2-4 49

Figure 4-1. Composite depth difference map of UDM at STNH-N 54

Figure 4-2. Composite depth difference map of CDM at STNH-N 55

Page

Figure 4-3. Recent STNH-N bathymetric contour map showing 1990 and 2004 coring locations 57

Figure 4-4. Composite depth difference map of UDM thickness at CS-2 58

Figure 4-5. Composite depth difference map of CDM dredged material thickness at CS-2 60

Figure 4-6. Recent CS-2 bathymetry showing 1990 and 2004 coring locations 63

Figure 4-7. Ternary grain size plots of the STNH-N mound layers 67

Figure 4-8. Ternary grain size plots of the CS-2 mound layers 71

Figure 4-9. STNH-N TOC content in mound horizons 79

Figure 4-10. STNH-N Copper content in mound horizons 80

Figure 4-11. STNH-N Zinc content in mound horizons 81

Figure 4-12. STNH-N PAH content in mound horizons 82

Figure 4-13. STNH-N Copper content in mound horizons 83

Figure 4-14. CS-2 TOC content in mound horizons 85

Figure 4-15. CS-2 Copper content in mound horizons 86

Figure 4-16. CS-2 Zinc content in mound horizons 87

Figure 4-17. CS-2 Total PAH content in mound horizons 88

EXECUTIVE SUMMARY

An investigation was conducted in May 2004 as part of the Disposal Area Monitoring System (DAMOS) to assess the physical distribution of sediments and chemical profiles in two engineered mounds in Long Island Sound, Stamford New Haven-North (STNH-N) and Cap Site 2 (CS-2). Seven cores were collected from each mound, visually inspected and subsampled for selected metals, PAHs, TPHs and total organic carbon. Visual observations and analytical data were applied to classify horizons into surficial sediments, capping dredged material (CDM), unacceptably contaminated dredged material (UDM), historic dredged material, and native base sediments.

The STNH-N mound is one of two capped mounds created in 1979 as the first engineered open water caps in the United States. The CS-2 mound was created in 1983 as part of an extensively monitored follow-up capping project. Extensive investigations performed during and following formation of these mounds revealed that the contaminated UDM had been successfully capped at both sites. Data from the 2004 investigation was compared to historic data to evaluate the integrity of the caps and assess the continued isolation of chemicals within the UDM horizon.

The cores collected in the 2004 study at STNH-N and CS-2 provided clear and consistent data showing that the CDM over UDM sequence remained intact with a well-defined interface between the intervals at both mounds. At STNH-N, the thickness of the CDM interval compared well with the distribution of the CDM mapped following the original formation of the mound, taking into account the expected long-term consolidation of the hydraulically dredged CDM. At CS-2, the thickness of the CDM was more variable, reflecting the intermittent disposal associated with mechanical dredging that was used in the project, but there was no apparent reduction of CDM thickness over time. At both sites, a surficial layer was noted above the CDM, indicating net deposition since formation of the mounds. The maintenance of the CDM thickness over time and the overlying net deposition provide evidence that the UDM interval remained physically isolated from the overlying waters and unaffected by potential erosive events or other surface disturbances.

The sediment chemistry data supported classification of sediments into the observed horizons in the cores. Concentrations for all constituents were generally at least an order of magnitude higher in the UDM than in the other horizons. Comparison of 1990 and 2004 analytical data indicated similar concentrations were observed in both surveys. The 2004 analytical results did not suggest any vertical migration of chemicals from the UDM into the CDM, supporting previous studies indicating chemical isolation within the UDM.

1.0 INTRODUCTION AND BACKGROUND

An investigation of previously capped sediment mounds was conducted at the Central Long Island Sound Disposal Site in May 2004 as part of the U.S. Army Corps of Engineers (USACE) New England District (NAE) Disposal Area Monitoring System (DAMOS). The two mounds investigated in this study, Stamford-New Haven North and Cap Site 2, were formed more than 20 years ago with the initial placement of dredged material containing elevated levels of contaminants and subsequent capping with dredged material that was suitable for open water disposal. These two capped mounds were among the earliest engineered disposal mounds in the United States and have been investigated periodically to assess their long-term effectiveness at sequestering contaminants. An introduction to the DAMOS program under which this investigation was performed is provided below as well as background information on the formation and previous studies of the disposal mounds.

1.1 Overview of the DAMOS Program

DAMOS is a comprehensive monitoring and management program designed and conducted to ensure environmental protection at open-water disposal sites throughout the New England region. For over 25 years, the USACE NAE has collected and evaluated disposal site data throughout New England. Patterns of physical, chemical, and biological responses of seafloor environments to dredged material disposal activity have been documented based on these data. The DAMOS program features a tiered management protocol designed to ensure that any potential adverse environmental impacts associated with dredged material disposal activities are promptly identified and addressed (Germano et al. 1994).

Disposal site monitoring surveys are designed to collect data that will allow evaluation of the environmental status of each disposal site relative to conditions after recent disposal of dredged material and to conditions in nearby reference areas unaffected by disposal activities. The results of each monitoring survey are evaluated to determine the next step in the process of managing each specific disposal site. Focused studies are periodically undertaken within the DAMOS Program to evaluate inactive/historic disposal sites. This investigation represents the next step in a series of focused studies of two capped disposal mounds which have now been inactive for more than 20 years.

1.2 Introduction to Stamford-New Haven North/Cap Site 2

In 1977, with the formal beginning of the DAMOS Program, a discussion of approaches to management and monitoring of dredged material disposal in New England led to advancements in the design of disposal projects within Long Island Sound. These discussions resulted in a series of projects designed to sequester contaminated dredged materials from inner harbor areas beneath layers of cleaner outer harbor materials, a process known as “capping” (Fredette and French 2004, SAIC 1995, Fredette et al. 1993). The material containing the elevated contaminant levels was termed unsuitably contaminated dredged material (UDM) because it was unsuitable for unconfined open ocean disposal. The cleaner material that was suitable for open ocean disposal was termed capping dredged material (CDM).

One of the earliest capping projects arose from concerns about the disposal of metal-contaminated Stamford Harbor (CT) Channel sediments proposed for dredging (SAI 1980b). Interagency discussions resulted in a decision to place a volume of UDM dredged from Stamford Harbor channel at two sites within the Central Long Island Sound Disposal Site (CLDS, historically referred to as CLIS), termed Stamford-New Haven North (STNH-N) and South (STNH-S) (Figure 1-1). As part of the project, the two deposits were capped with different types of material; CDM consisting primarily of sands was used at STNH-N, and CDM consisting primarily of silts was used at STNH-S (see SAIC 1995 for a detailed summary of the overall project).

Between 23 April and 15 June, 1979, STNH-N received approximately 31,000 m^3 of silty material (UDM) dredged with a clamshell bucket from the east branch of the Stamford Harbor channel. This material was placed at a taut-wire moored buoy to form a compact mound. From 16 to 21 June, 1979, a hopper dredge was used to remove sandy, shelly material from the channel outside the breakwater of New Haven Harbor for use as CDM at STNH-N. Approximately 65,000 m^3 of the CDM was placed near the center of the UDM mound, and approximately 67,000 m^3 was disposed 100 to 300 m from the center of the mound to form a cap, providing full coverage to isolate the UDM from contact with the marine environment (SAIC 1995).

In 1983, a similar project was initiated as part of a larger study jointly managed by U.S. Environmental Protection Agency (USEPA) and USACE Waterways Experiment Station, entitled the Field Verification Program (FVP). The FVP included laboratory and field investigations of the fate and effects of contaminated dredged material from Black Rock Harbor, CT placed at capped and uncapped subaqueous mounds, confined aquatic disposal sites, and upland (Peddicord 1988, Rogerson et al. 1985). As part of this project UDM from Black Rock Harbor was placed at two sites within CLDS, termed Cap Site 1 (CS-1) and Cap Site 2 (CS-2) (Figure 1-1). The two sites were capped with different types of CDM dredged from New Haven Harbor; CDM consisting primarily of silts was

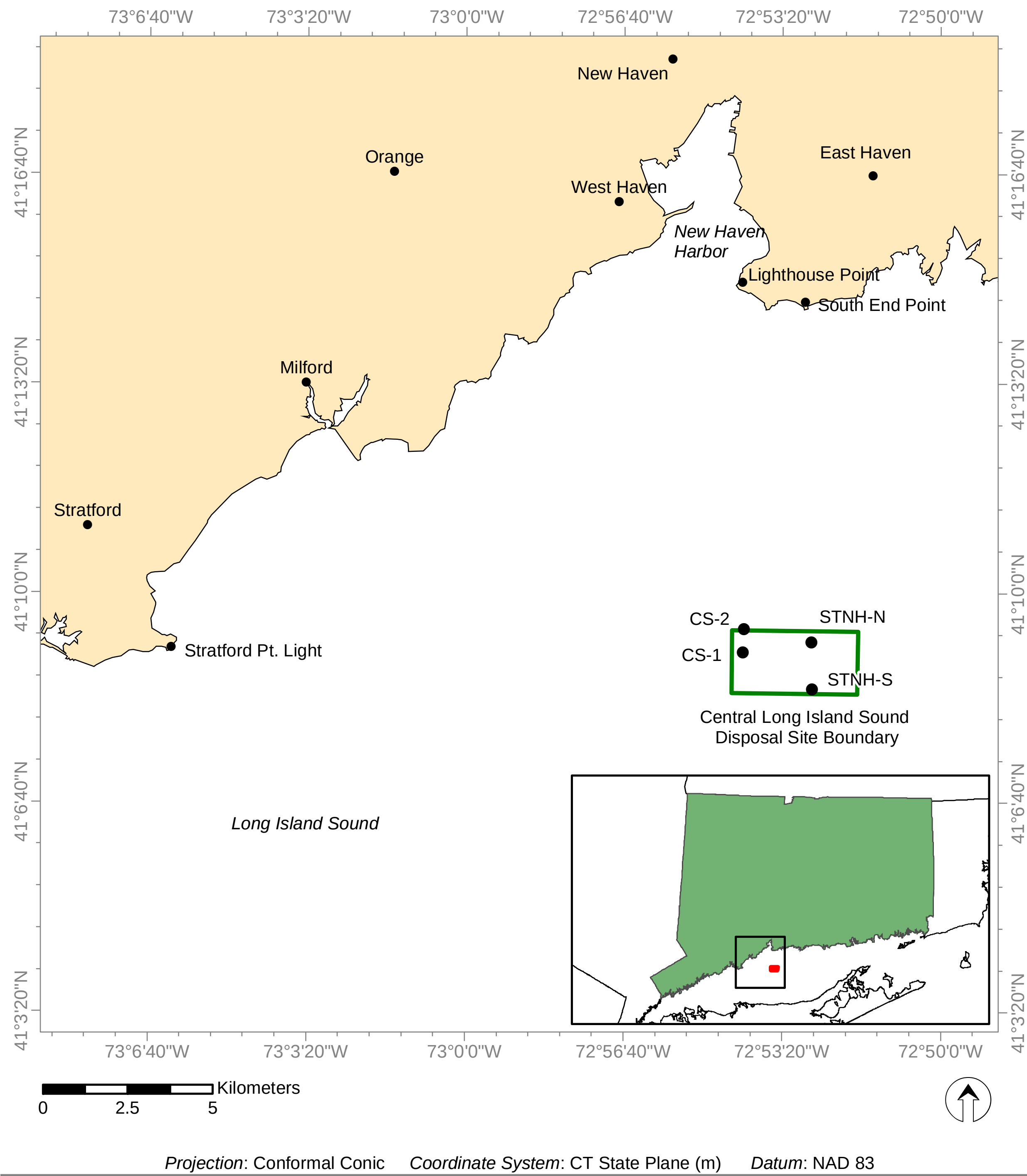


Figure 1-1. Location of the Central Long Island Sound Disposal Site and the capped mounds Stamford-New Haven North, Stamford-New Haven South, Cap Site 1, and Cap Site 2.

used at CS-1 and CDM consisting primarily of sands was used at CS-2 (see SAIC 1995 for a detailed summary of the overall project).

CS-2 received approximately 38,000 m^3 of UDM from Black Rock Harbor from 18 April to 18 May 1983, with disposal occurring in two distinct phases. CS-2 was capped with approximately 42,000 m^3 of sand from New Haven Harbor between 30 May and 3 June 1983.

1.3 Previous Monitoring of STNH-N and CS-2

Because STNH-N and CS-2 were among the earliest experimental capping projects, they were extensively studied during their development. At STNH-N, monitoring surveys were among the first to sequentially document the development and formation of a subaqueous capped mound (SAI 1979 a-f, 1980 a,b). At CS-2, the monitoring surveys were part of a much larger comparative study of the placement of UDM and different management options (Peddicord, 1988). The results of these surveys provide a good record of the initial nature and distribution of UDM and CDM at these two sites (summarized in SAIC 1995).

Follow-up investigations were also performed at both sites to examine the mounds after the deposits had consolidated and weathered for several years. At STNH-N surface grabs were collected in 1983 on an E-W transect across the mound, and in 1986 grabs were collected in a cross-shaped grid over the top of the mound (SAIC 1990). Subsurface cores were collected in 1990 from five locations (SAIC 1995). At CS-2, surface grabs were collected in June 1983, and subsurface cores were collected in July 1983 and July 1990 (SAIC, 1995).

CLDS has remained an active disposal site since the creation of the STNH-N and CS-2 capped mounds, with the creation of additional disposal mounds across the site (Figure 1-2). As such, CLDS has been included in other DAMOS investigations providing bathymetry and reference site data for comparison (SAIC 2002, Fredette and French 2004)

1.4 Survey Objectives

It has been over 25 years since the formation of capped mound STNH-N and 21 years since the formation of capped mound CS-2. Evaluation of the long-term stability of these mounds provides important information for the design and management of current and future dredged material disposal projects. The May 2004 survey was designed to collect deep cores over both STNH-N and CS-2 to allow for assessment of contaminant

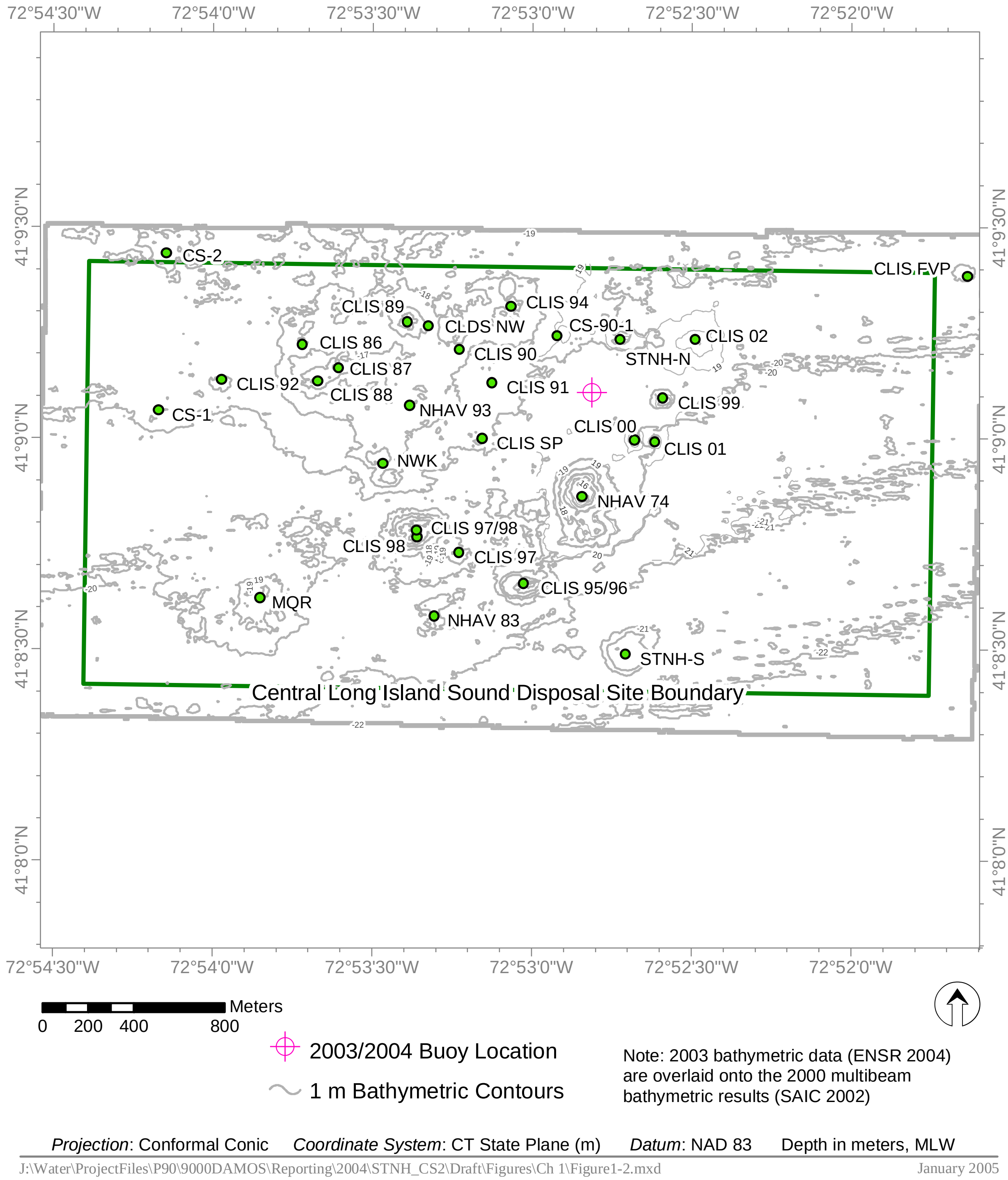


Figure 1-2. CLDS mounds

distribution within the mounds and comparison with the results of prior studies. An ancillary objective of the survey was to identify mound variability over a short (meters) distance scale.

2.0 APPROACH AND METHODS

The May 2004 coring at STNH-N and CS-2 and subsequent analyses were performed by ENSR International, Ocean Surveys Inc. (OSI), CoastalVision, and a team of laboratories. The approach and methods used to collect and analyze the cores were detailed in a project Sampling and Analysis Plan/Quality Assurance Project Plan (QAPP, Appendix A). Cores were collected using vibracoring equipment and were subsequently split, imaged, and subsampled at the University of Rhode Island Department of Ocean Engineering. Analyses included total organic carbon (TOC), total petroleum hydrocarbons (TPH), and polycyclic aromatic hydrocarbons (PAHs) performed by Katahdin Analytical Services Inc.; metals (copper and zinc) performed by STL-Pittsburgh; and grain size performed by Geo\Plan Associates.

2.1 Coring Survey

Five vibracores plus one replicate were collected at both the STNH-N and CS-2 capped disposal mounds on 24-25 May 2004 (Figures 2-1, 2-2). Pneumatic vibracoring was performed at the selected stations using OSI's VC 1500 coring unit outfitted with a 10-cm (4-inch) steel barrel and stainless steel cutter head. The sediment samples were collected in new, clear lexan liners (8.9 cm (3.5 inch) ID). OSI's coring barge (R/V *Candu*) was equipped with differential global positioning system (DGPS), multipoint anchoring system, and central moon pool for accurate positioning of cores.

For shipboard storage and subsequent transport of the collected cores, water overlying the sediment was drained by drilling a hole near the sediment water interface followed by cutting the lexan liner to within 1 cm of the sediment surface using a hack saw. The entire 2 to 3 meter long core was labeled, logged, and cut into manageable subsections of approximately 1 to 2 meters in length. Each subsection was capped, sealed with tape, and secured in an upright position.

The initial set of 12 cores, subsequently split in the field into shorter sections for transport and storage, resulted in a set of more than 30 core sections. At the end of each day, the core sections were off-loaded upright into insulated boxes and iced for storage. Following completion of the field effort, the cores were transported to the Marine Geomechanics Laboratory (MGL) at the University of Rhode Island (URI) and stored upright in a walk-in refrigerator.

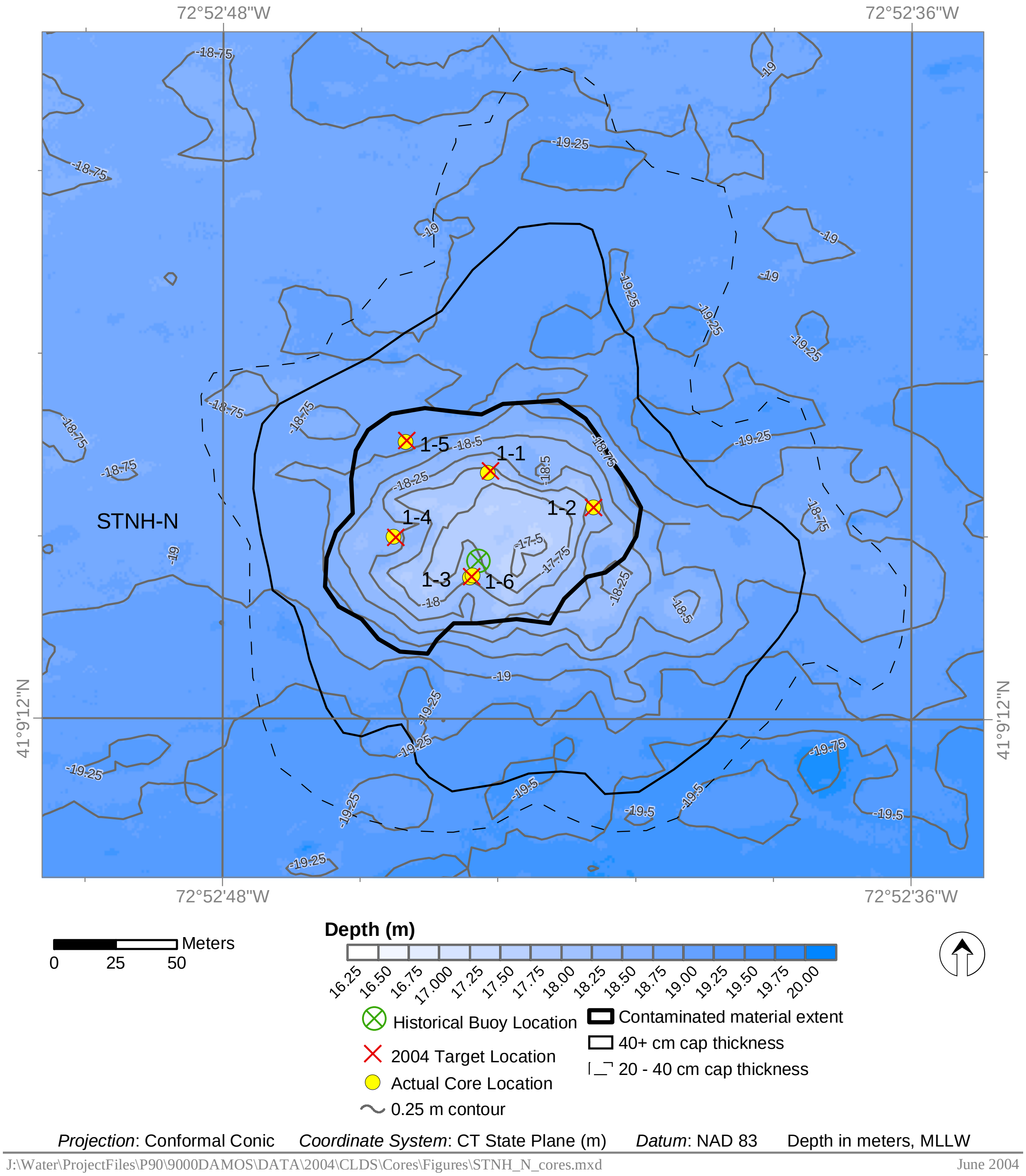


Figure 2-1. May 2004 coring locations at the Stamford New Haven North capped mound

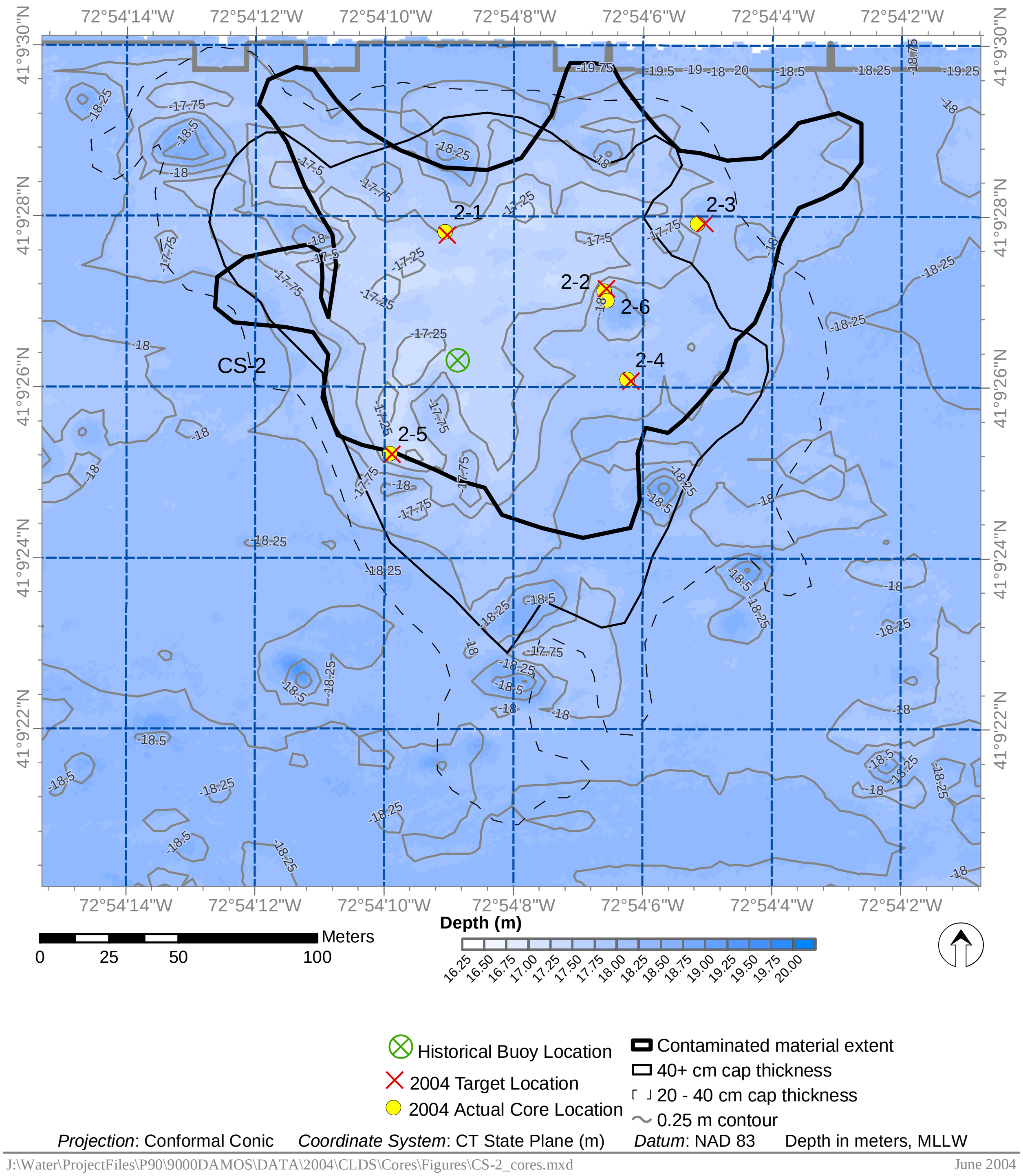


Figure 2-2. May 2004 coring locations at the Cap Site 2 mound

2.2 Core Processing

Processing of the cores was performed at MGL. Before splitting commenced, any void existing above the sediment water interface was filled with a high density, low permeability foam material to prevent sediment/water migration and to maintain the core configuration and shape during the splitting process. This prevented loss of material from the uppermost surface sediment slurry. Each core tube was labeled at intervals from the sediment water interface before splitting.

Core sections were split length-wise using a device designed to cut the hard plastic liner without disturbing the sediment core. This device cut each core liner axially, using a set of laterally adjustable routers, pushed along the core using an electric motor and wire/pulley system. To avoid disturbance, the routers did not cut through the entire liner. Straight blades were then used to manually finish the cut. Following the splitting of the lexan core liner, each sediment core section was split lengthwise by hand by pulling a titanium wire through the core beginning at the uppermost sediment surface and continuing down through each successive (lower) sediment layer.

After each core was split lengthwise (resulting in two core halves), one half was transferred to the imaging laboratory for high-resolution filming, subsampling for grain size analysis, and p-wave analysis. Because the imaging process required surface smoothing that could have caused chemical cross contamination along the length of the core, only grain size subsamples were collected from the imaged core splits. The remaining half of the core was described by examining the open surface of the core, labeled, and subsampled for chemical analysis.

Subsamples collected for grain size were transferred to plastic zip-lock bags, labeled, and delivered to the physical testing laboratory for homogenization and analysis. Details of sample handling and containerization are provided in the project QAPP (Appendix A).

2.3 Core Descriptions

Core descriptions were conducted by MGL staff with oversight by ENSR and CoastalVision. Each core was examined to document surface texture, odor, coloration, stratigraphic changes, and unique features or anthropogenic materials (e.g., plastic) on log forms (Appendix C). Details of selected split core sections were also photographed. Based on this examination, select 10-cm horizons were identified in each core for subsampling and chemical analysis, and 20-cm horizons were identified for quality control analyses. Each subsample was homogenized before containerization and transfer to the analytical laboratory. Details of sample handling and containerization are provided in the project QAPP (Appendix A). Appendix C also provides a list of the sections selected for analysis and archive within each sediment core.

2.4 Core Imaging

Core imaging was performed at URI by MGL staff using a GeoTek GeoScan III, digital video camera mounted on a core logger. The sediment surface along the core split was smoothed laterally with a plastic plate to minimize changes in focal length, prior to imaging. Selected cores were covered with plastic film and stored for analysis of p-wave velocity. However, core logger malfunctions caused a delay in p-wave testing, and 10 cores dried out to the extent that they could not be accurately logged. P-wave velocity profiles were acquired for two cores (CS-2 cores 2-3, 2-4).

2.5 Core Chemistry

As indicated earlier, several laboratories were involved in analyzing project samples. A full set of project specifications in the QAPP were provided to the laboratories (Appendix A). The intent of this section is to provide a brief overview of the analytical methods employed, a basic understanding of the analytical constraints, and the comparability to other data sets.

Sediments were prepared for PAH analysis according to EPA SW-846 method 3550B and analyzed using method 8270C modified to utilize selected ion mass spectrometer mode. Method 3550B is an ultrasonic extraction method incorporating acetone and methylene chloride as extraction solvents. Samples designated for TPH analysis were prepared using EPA SW-846 method 3540C (Soxlet) and analyzed using method 8015B (GC/FID).

Copper and zinc were selected for metals analysis to complement available historical information that largely focused on these two metals as reliable tracers of UDM. Metals that are typically used in describing sediment geochemical terms (such as Al or Fe) were not included because the horizons of interest are man-made features largely consisting of UDM or older dredged material overlain by coarse-grained cap material. Metals samples were prepared according to EPA SW-846 method 3050B and analyzed using method 6010B (ICP/AES). The preparation method (3050B) is a rigorous acid digestion method using HNO_3 and H_2O_2 followed by an HCl acid reflux step. TOC measurements were analyzed using a combustion method (Lloyd Kahn, 1988) which is preferred for TOC analysis in marine sediments.

Sediment grain size analysis was performed on the sample set according to Folk (1974) which combines sieving and pipetting methods. The resulting data tables provided in Section 3 include the major sediment classes (as gravel, sand, silt and clay).

All data were provided in electronic format for direct transfer into the project database. Data supporting graphics and tables were directly exported.

2.6 Mound Sediment Classifications

To evaluate large scale mound characteristics, the predominant layers observed within each core were classified as:

Surface – Material that has deposited on top of the cap.
CDM – Coarse grained dredged material that was used to cap the mound.
UDM – Dredged material unsuitable for unconfined aquatic disposal that created the original mound.
DM – Dredged material previously disposed at CLDS that was beneath the STNH-N and CS-2 mounds.
Native Sediment – Native Long Island Sound sediments in place prior to disposal at CLDS.

Classification into the categories listed above relied primarily on the following characteristics:

- Sediment color and texture,
- Overall appearance (uniform versus disturbed),
- Unusual material contained within the sediment (anthropogenic material), and
- Cross-core marker horizons.

The most prominent core features were related to basic color and appearance and provided strong evidence for classification of a core section. The understanding of mound creation (e.g., coarse CDM placement above UDM) provided clues during the classification process. Some layers were quite uniform, indicative, for example, of native sediments underlying the mound. The existence of anthropogenic material (plastic, foil, etc.) or biological material (preserved plant material) at depth provided a clear indication that the sediment section was within one of the disturbed dredged material layers. A distinctive thin horizon of coarse, red sand observed within multiple cores provided a useful marker for assessing cross-mound core layers. The fact that many cores penetrated native sediments also aided the classification process by providing a point of reference between cores across the mounds.

3.0 RESULTS

3.1 Results Overview

3.1.1 Field Collection

Sediment cores were successfully collected in May 2004 at the five target and two replicate locations at each of the two capped mounds. At STNH-N recovered sediment cores ranged in length from 282 to 296 cm (Table 3-1) and were distributed across the mound within the area assumed to contain underlying UDM material based on bathymetric studies conducted prior to and following mound formation (Figure 2-1). Core 1-1 was collected from the northern edge of the upper mound surface; Core 1-2 was collected from the eastern mound slope; Cores 1-3 and 1-6 were collected as field replicates from the southern slope; and Cores 1-4 and 1-5 were collected from the western and northwestern mound flank, in outer, thinner mound areas.

The cores recovered from the CS-2 mound ranged in length from 235 to 289 cm (Table 3-1) and were distributed across the more irregular CS-2 mound footprint (Figure 2-2). Core 2-1 and 2-2 and field replicate 2-6 were collected across the thickest area of the mound; Cores 2-3 and 2-4 were collected along the eastern slope of the mound; and Core 2-5 was collected along the southwestern margin of the mound where a thick UDM layer had been noted during the 1990 survey (Core "CS-2 Center", SAIC, 1995).

3.1.2 Core Data Summaries

Physical and chemical laboratory test results are provided in Tables 3-2 and 3-3 (for STNH-N and CS-2, respectively). Silt and clay sediment fractions were summed in the tables to provide a "percent fines" value. The individual priority pollutant PAH compounds have been summed to provide a total PAH value. Any compound undetected in a particular sample was included in the sum at a value of one-half the laboratory reporting limit. Chemical concentrations that fall between the laboratory reporting limit and method detection limit were reported with a "J" qualifier and were considered to be an estimate.

Photographs of each core are presented in Figures 3-1 for STNH-N and 3-2 for CS-2 along with a scale representing the actual core length in centimeters. Physical and chemical analytical results have been plotted along the core images as well as observations of note. To provide a better overall graphical presentation, selected parameter scales have been amplified or reduced. The TOC results, which were all less

Table 3-1.

Summary of Cores Collected in May 2004

Site	Core	Coordinates[1] Latitude (N)	Longitude (W)	Recovered Core Length (cm)[2]	No. of Core Sections Submitted for Phys/Chem Analysis	No. of Core Sections Archived
STNH-N	1-1	41°9.253'	72°52.722'	296	8	14
	1-2	41°9.246'	72°52.691'	292	9	15
	1-3	41°9.23'	72°52.727'	282	9	14
	1-4	41°9.239'	72°52.749'	284	8	14
	1-5	41°9.260'	72°52.746'	295	8	5
	1-6	41°9.231'	72°52.726'	290	10	16
CS-1	2-1	41°9.463'	72°54.15'	289	9	10
	2-2	41°9.451'	72°54.109'	273	9	13
	2-3	41°9.465'	72°54.085'	245	7	6
	2-4	41°9.434'	72°54.103'	250	9	6
	2-5	41°9.420'	72°54.164'	264	7	6
	2-6	41°9.450'	72°54.108'	231	9	10

[1]NAD 83 Coordinate System

[2]Field length estimates differ from final laboratory measurements by 1 to 8 cm.

Table 3-2.

STNH-N 2004 Sediment Chemistry and Grain Size Results

	Site	STNH-N	STNH-N	STNH-N	STNH-N	STNH-N	STNH-N	STNH-N	STNH-N
	Station	1-1	1-1	1-1	1-1	1-1	1-1	1-1	1-1
	Sample ID	1-1(A)	1-1(B)	1-1(C)	1-1(D)	1-1(E)	1-1(F)	1-1(G)	1-1(H)
	Start Depth (cm)	10	50	70	120	130	140	160	220
	End Depth (cm)	20	60	80	130	140	150	170	230
Analysis	Unit								
GRAINSIZE									
GRAVEL	percent	1.0	4.9	27.7	4.7	11.8	70.8	9.5	35.5
SAND	percent	82.9	64.0	54.7	73.6	46.2	15.1	45.6	23.1
SILT	percent	8.9	23.7	14.1	16.8	31.4	9.1	33.5	26.6
CLAY	percent	7.1	7.4	3.5	4.8	10.5	5.1	11.4	14.8
SILT+ CLAY(a)	percent	16.0	31.0	17.6	21.7	41.9	14.2	44.9	41.4
TOC									
TOC	percent	0.4	0.6	0.7	0.3	5.5	3.7	4.2	2.4
PAH									
ACENAPHTHENE	mg/kg	0.0019 J	0.0091 J	0.0022 J	0.056	0.17	0.34 J	1.7 J	0.023 J
ACENAPHTHYLENE	mg/kg	0.0076 J	0.02 J	0.005 J	0.042	0.21	0.13	2.9 U	0.1
ANTHRACENE	mg/kg	0.018 J	0.032	0.01 J	0.12	0.8 J	0.4 J	2.2 J	0.09
BENZO(A)ANTHRACENE	mg/kg	0.06	0.29	0.053	0.97	2.4	1.1	4.4	0.41
BENZO(A)PYRENE	mg/kg	0.083	0.38	0.084	0.76	2.5	1.2	4.9	0.55
BENZO(B)FLUORANTHENE	mg/kg	0.11	0.37	0.096	0.75	2.4	1	3.9	0.47
BENZO(K)FLUORANTHENE	mg/kg	0.082	0.35	0.08	0.51	2.2	1	4.3	0.48
BENZO[G,H,I]PERYLENE	mg/kg	0.03	0.1	0.026 J	0.34 J	1.5	0.67 J	2.7 J	0.3 J
CHRYSENE	mg/kg	0.066	0.29	0.058	0.8	3	1.4	5.9	0.56
DIBENZO(A,H)ANTHRACENE	mg/kg	0.026 U	0.036	0.0086 J	0.038	0.46 J	0.19 J	1.3 J	0.1
FLUORANTHENE	mg/kg	0.092	0.4	0.077	1.5	5.2	2.3	10	0.66
FLUORENE	mg/kg	0.0074 J	0.011 J	0.027 U	0.04	0.18	0.13	0.54 J	0.034
INDENO(1,2,3-CD)PYRENE	mg/kg	0.043	0.44	0.045	0.7	1.4	0.68	2.7 J	0.32
NAPHTHALENE	mg/kg	0.0029 J	0.011 J	0.0049 J	0.047	0.15	0.19 J	0.74 J	0.037
PHENANTHRENE	mg/kg	0.054	0.096	0.027 J	0.36 J	0.92 J	0.85	5.2	0.22 J
PYRENE	mg/kg	0.14	0.93	0.3	2.4	5.6	2.5	9.9	0.82
Total PAHs (b)	mg/kg	0.81	3.8	0.89	9.4	29	14	62	5.2
TPH									
TPH	mg/kg	32	85	51	140	12000	3100	7500	490
METALS									
COPPER	mg/kg	11.2	35.0	11.2	18.6	474	340	289	143
ZINC	mg/kg	29.0	38.6	30.4	36.2	696	610	381	172

Note: Start and end depths are based on measurements from the top of the core and represent depths below the sediment-water interface.
(a) Sum of Silt plus Clay
(b) Sum of individual PAHs; 1/2 the reporting limit has been substituted for undetected data.
J: Estimated value
U: Undetected Value; result represents the laboratory reporting limit.

Table 3-2 (continued)

Analysis	Site Station Sample ID Start Depth (cm) End Depth (cm) Unit	STNH-N 1-2 1-2(A) 10 20	STNH-N 1-2 1-2(B) 50 60	STNH-N 1-2 1-2(C) 110 120	STNH-N 1-2 1-2(D) 134 144	STNH-N 1-2 1-2(E) 144 154	STNH-N 1-2 1-2(F) 160 170	STNH-N 1-2 1-2(G) 180 190	STNH-N 1-2 1-2(H) 230 250	STNH-N 1-2 1-2(I) 270 280
GRAINSIZE										
GRAVEL	percent	8.4	5.6	4.9	7.9	11.9	7.8	1.2	0.6	2.1
SAND	percent	41.8	91.7	55.3	45.4	59.2	41.4	14.4	10.4	12.5
SILT	percent	33.1	1.6	34.3	37.8	20.7	34.5	68.9	64.0	76.7
CLAY	percent	16.7	1.2	5.4	8.8	8.2	16.3	15.4	25.0	8.7
SILT+ CLAY(a)	percent	49.8	2.7	39.8	46.6	28.9	50.8	84.4	89.0	85.4
TOC										
TOC	percent	1.8	0.2	1.4	1.3	11.0	8.3	8.0	2.8	3.0
PAH										
ACENAPHTHENE	mg/kg	0.0074 J	0.025 U	0.056	0.021 J	1.5 J	3.6 J	4.6 J	0.012 J	0.016 J
ACENAPHTHYLENE	mg/kg	0.012 J	0.4 J	0.06	0.061	0.48 J	0.8 J	16 U	0.052	0.068
ANTHRACENE	mg/kg	0.034	1.6	0.14	0.086	2.7 J	4.8 J	11 J	0.06	0.067
BENZO(A)ANTHRACENE	mg/kg	0.18	1.2 J	0.73	0.5 J	9	11	23	0.23	0.22
BENZO(A)PYRENE	mg/kg	0.21	1.2 J	0.81	0.48 J	9	12	19	0.26	0.34
BENZO(B)FLUORANTHENE	mg/kg	0.22	0.98 J	0.7	0.4 J	8	11	17	0.19	0.25
BENZO(K)FLUORANTHENE	mg/kg	0.21	0.99 J	0.84	0.4 J	7.9	10	17	0.26	0.31
BENZO[G,H,I]PERYLENE	mg/kg	0.096	0.74 J	0.53 J	0.28 J	5.6 J	6.8 J	11 J	0.15	0.19
CHRYSENE	mg/kg	0.22	1.3	0.79	0.56	12	14	26	0.26	0.28
DIBENZO(A,H)ANTHRACENE	mg/kg	0.03 U	1.3 U	0.12	0.054	5.6 U	6.8 U	16 U	0.092	0.068
FLUORANTHENE	mg/kg	0.44	4.4	1.8	1.1	21	31	61	0.34	0.4
FLUORENE	mg/kg	0.012 J	0.88 J	0.065	0.021 J	1.5 J	2.1 J	4.7 J	0.02 J	0.031 J
INDENO(1,2,3-CD)PYRENE	mg/kg	0.093	0.62 J	0.46 J	0.26 J	4.9 J	6 J	10 J	0.18	0.16
NAPHTHALENE	mg/kg	0.0088 J	0.037	0.052	0.043	0.55 J	1.1 J	3.2 J	0.014 J	0.043
PHENANTHRENE	mg/kg	0.11	4.3	0.74	0.19 J	7.3	13	40	0.087	0.18
PYRENE	mg/kg	0.41	3.3	2.1	1.1	22	29	53	0.43	0.46
Total PAHs (b)	mg/kg	2.3	23	10	5.6	120	160	320	2.6	3.1
TPH										
TPH	mg/kg	110	12	660	350	7400	140	9400	180	130
METALS										
COPPER	mg/kg	35.2	3.6	40.2	20.1	384	634	471	72.9	85.2
ZINC	mg/kg	67.5	14.2	76.5	47.9	641	1030	709	117	157

Note: Start and end depths are based on measurements from the top of the core and represent depths below the sediment-water interface.
(a) Sum of Silt plus Clay
(b) Sum of individual PAHs; 1/2 the RL has been substituted for undetected data.
J: Estimated value
U: Undetected Val U: Undetected Value; result represents the laboratory reporting limit.

Table 3-2 (continued)

Analysis	Site Station Sample ID Start Depth (cm) End Depth (cm) Unit	STNH-N 1-3 1-3(A) 10 20	STNH-N 1-3 1-3(B) 60 70	STNH-N 1-3 1-3(C) 115 125	STNH-N 1-3 1-3(D) 125 135	STNH-N 1-3 1-3(E) 135 145	STNH-N 1-3 1-3(F) 145 155	STNH-N 1-3 1-3(G) 190 200	STNH-N 1-3 1-3(H) 220 230	STNH-N 1-3 1-3(I) 250 270
GRAINSIZE										
GRAVEL	percent	0.0	15.1	5.2	17.4	58.6	15.8	1.3	0.0	6.6
SAND	percent	8.3	77.1	58.1	77.0	28.4	53.7	30.9	3.8	25.9
SILT	percent	57.7	4.5	21.9	3.3	8.3	21.3	50.8	64.7	42.9
CLAY	percent	34.0	3.3	14.8	2.3	4.6	9.3	16.9	31.4	24.5
SILT+ CLAY(a)	percent	91.7	7.8	36.7	5.6	13.0	30.6	67.8	96.2	67.5
TOC										
TOC	percent	2.9	0.7	1.3	0.7	5.7	5.0	8.2	1.6	2.9
PAH										
ACENAPHTHENE	mg/kg	0.055 J	0.024 U	0.12 J	0.0019 J	2.6 U	1.7 J	2.4 J	0.032 J	0.072
ACENAPHTHYLENE	mg/kg	0.061 J	0.024 U	1.4 U	0.0072 J	2.6 U	0.12 J	0.24 J	0.016 J	0.13
ANTHRACENE	mg/kg	0.12	0.024 U	0.57 J	0.012 J	1 J	2.5 J	5 J	0.034 J	0.19 J
BENZO(A)ANTHRACENE	mg/kg	0.4	0.0046 J	2.6	0.04	3.5	6.6	14	0.11	0.73
BENZO(A)PYRENE	mg/kg	0.43	0.0083 J	2.8	0.049	3.5	6.7	14	0.12	0.61 J
BENZO(B)FLUORANTHENE	mg/kg	0.5	0.0082 J	2.2	0.06	3.1	5.2	13	0.12	0.62 J
BENZO(K)FLUORANTHENE	mg/kg	0.42	0.0082 J	2.8	0.051	3.4	6.7	13	0.11	0.42 J
BENZO[G,H,I]PERYLENE	mg/kg	0.18	0.0062 J	1.4 J	0.017 J	2.3 J	3.9	8.5	0.069	0.27 J
CHRYSENE	mg/kg	0.46	0.0073 J	2.9	0.036	3.7	8.8	19	0.13	0.62 J
DIBENZO(A,H)ANTHRACENE	mg/kg	0.11 U	0.024 U	0.38 J	0.023 U	0.64 J	1 J	2.1 J	0.022 J	0.13
FLUORANTHENE	mg/kg	1.1	0.0081 J	5	0.064	10	14	30	0.24	1.7
FLUORENE	mg/kg	0.063 J	0.024 U	1.4 U	0.0031 J	0.22	0.78 J	1.7 J	0.019 J	0.15
INDENO(1,2,3-CD)PYRENE	mg/kg	0.22	0.0068 J	1.3 J	0.02 J	2.2 J	3.6	7.8	0.072	0.34 J
NAPHTHALENE	mg/kg	0.086 J	0.0012 J	0.28 J	0.0033 J	0.23	0.67 J	1.3 J	0.028 J	0.054
PHENANTHRENE	mg/kg	0.26	0.0036 J	2	0.017 J	1.4 J	6.3	12	0.084	0.89
PYRENE	mg/kg	0.85	0.013 J	6.3	0.092	8	15	30	0.23	1.7
Total PAHs (b)	mg/kg	5.3	0.14	32	0.49	46	84	170	1.4	8.6
TPH										
TPH	mg/kg	540	10	2200	31	16000	8000	18000	140	2300
METALS										
COPPER	mg/kg	110	3.8	68.5	3.3	780	322	587	25.7	282
ZINC	mg/kg	179	15.0	113	12.5	1220	618	1080	87.9	383

Note: Start and end depths are based on measurements from the top of the core and represent depths below the sediment-water interface.
(a) Sum of Silt plus Clay
(b) Sum of individual PAHs; 1/2 the RL has been substituted for undetected data.
J: Estimated value
U: Undetected Val U: Undetected Value; result represents the laboratory reporting limit.

Table 3-2 (continued)

Analysis	Site Station Sample ID Start Depth (cm) End Depth (cm) Unit	STNH-N 1-4 1-4(A) 10 20	STNH-N 1-4 1-4(B) 50 60	STNH-N 1-4 1-4(C) 60 70	STNH-N 1-4 1-4(D) 80 90	STNH-N 1-4 1-4(E) 90 100	STNH-N 1-4 1-4(F) 100 110	STNH-N 1-4 1-4(G) 160 170	STNH-N 1-4 1-4(H) 220 230
GRAINSIZE									
GRAVEL	percent	0.0	8.2	26.3	18.9	11.7	10.0	32.5	2.8
SAND	percent	5.6	70.9	59.7	63.3	42.9	38.5	29.6	12.2
SILT	percent	60.7	13.3	8.5	11.3	32.4	37.2	28.4	56.7
CLAY	percent	33.7	7.6	5.4	6.6	13.0	14.4	9.4	28.2
SILT+ CLAY(a)	percent	94.4	20.9	14.0	17.8	45.4	51.5	37.9	84.9
TOC									
TOC	percent	3.2	0.5	0.5	0.3	3.2	7.5	2.9	2.6
PAH									
ACENAPHTHENE	mg/kg	0.012 J	0.0018 J	0.0011 J	0.052	1.1 J	3.6 J	0.15	0.019 J
ACENAPHTHYLENE	mg/kg	0.026 J	0.0068 J	0.0048 J	0.022 J	0.37 J	0.06 U	0.083	0.05
ANTHRACENE	mg/kg	0.055 J	0.01 J	0.0055 J	0.17 J	1.2 J	4.5 J	0.39 J	0.087
BENZO(A)ANTHRACENE	mg/kg	0.23	0.043	0.025 J	0.44 J	4.7	12 J	1.3 J	0.53 J
BENZO(A)PYRENE	mg/kg	0.35	0.066	0.038	0.46 J	3.7	11 J	1.6 J	0.84
BENZO(B)FLUORANTHENE	mg/kg	0.48	0.085	0.038	0.5	5.3	10 J	2.2	0.83
BENZO(K)FLUORANTHENE	mg/kg	0.23	0.066	0.036	0.47 J	2.6 J	8.3 J	1.1 J	0.72 J
BENZO[G,H,I]PERYLENE	mg/kg	0.14	0.032	0.019 J	0.14 J	1.6 J	4.9 J	0.67 J	0.39 J
CHRYSENE	mg/kg	0.28	0.051	0.03	0.42 J	4.3	12 J	1.4 J	0.65 J
DIBENZO(A,H)ANTHRACENE	mg/kg	0.046 J	0.0087 J	0.0056 J	0.046	0.26	1.6 J	0.22	0.06
FLUORANTHENE	mg/kg	0.75	0.072	0.043	0.66	8.4	27	4.2	0.82
FLUORENE	mg/kg	0.021 J	0.0038 J	0.026 U	0.061	2.8 U	1.7 J	0.13	0.036 J
INDENO(1,2,3-CD)PYRENE	mg/kg	0.22	0.048	0.031	0.3 J	2.8 J	11 J	1.6 J	0.58 J
NAPHTHALENE	mg/kg	0.026 J	0.0055 J	0.0034 J	0.046	0.43 J	1.5 J	0.06	0.08
PHENANTHRENE	mg/kg	0.18	0.036	0.019 J	0.52	3	12	0.51 J	0.37 J
PYRENE	mg/kg	0.57	0.11	0.059	1.1	9.3	23	2.7	1.5
Total PAHs (b)	mg/kg	3.6	0.65	0.37	5.4	50	140	18	7.6
TPH									
TPH	mg/kg	64	27	26	220	1600	8300	2600	200
METALS									
COPPER	mg/kg	93.6	17.2	14.7	25.0	223	523	363	114
ZINC	mg/kg	180	44.4	38.6	39.8	294	879	917	184

Note: Start and end depths are based on measurements from the top of the core and represent depths below the sediment-water interface.
(a) Sum of Silt plus Clay
(b) Sum of individual PAHs; 1/2 the RL has been substituted for undetected data.
J: Estimated value
U: Undetected Value; result represents the laboratory reporting limit.

Table 3-2 (continued)

Analysis	Site Station Sample ID Start Depth (cm) End Depth (cm) Unit	STNH-N 1-5 1-5(A) 10 20	STNH-N 1-5 1-5(B) 47 57	STNH-N 1-5 1-5(C) 57 67	STNH-N 1-5 1-5(D) 67 77	STNH-N 1-5 1-5(E) 77 87	STNH-N 1-5 1-5(F) 90 100	STNH-N 1-5 1-5(G) 120 130	STNH-N 1-5 1-5(H) 270 280
GRAINSIZE									
GRAVEL	percent	0.0	5.4	2.3	6.3	9.4	1.0	0.4	0.1
SAND	percent	24.9	85.4	48.2	71.0	27.0	36.7	13.3	2.1
SILT	percent	46.4	2.9	36.7	11.6	34.6	42.2	50.9	63.0
CLAY	percent	28.7	6.2	12.9	11.0	28.9	20.1	35.4	34.8
SILT+ CLAY(a)	percent	75.1	9.1	49.5	22.7	63.5	62.2	86.3	97.8
TOC									
TOC	percent	1.4	0.1	2.3	0.9	4.0	6.8	1.8	1.3
PAH									
ACENAPHTHENE	mg/kg	0.0074 J	0.0038 J	0.088	0.037	0.35 J	0.45 J	0.062	0.036 U
ACENAPHTHYLENE	mg/kg	0.022 J	0.0081 J	0.12	0.078	0.23	0.58 J	0.036	0.036 U
ANTHRACENE	mg/kg	0.029 J	0.034	0.57 J	0.11	0.71 J	1.1 J	0.58 J	0.036 U
BENZO(A)ANTHRACENE	mg/kg	0.16	0.087	2.5	1	2.9	5.2 J	2.1	0.0022 J
BENZO(A)PYRENE	mg/kg	0.26	0.087	2.5	0.87	2.5	7.5	2	0.036 U
BENZO(B)FLUORANTHENE	mg/kg	0.32	0.072	2.5	0.77	2.8	9	2.2	0.036 U
BENZO(K)FLUORANTHENE	mg/kg	0.26	0.062	1.8 J	0.56	2.4	6.3 J	1.3 J	0.036 U
BENZO[G,H,I]PERYLENE	mg/kg	0.13 J	0.043	1.6 J	0.43 J	1.1 J	3.2 J	0.83 J	0.036 U
CHRYSENE	mg/kg	0.17	0.075	2.3	0.88	2.5	5.2 J	1.9	0.0023 J
DIBENZO(A,H)ANTHRACENE	mg/kg	0.04	0.023 U	0.5 J	0.093	0.34 J	1.1 J	0.15	0.036 U
FLUORANTHENE	mg/kg	0.25	0.14	5.1	1.3	6	17	2.9	0.0041 J
FLUORENE	mg/kg	0.014 J	0.016 J	0.1	0.04	0.3 J	0.32	0.065	0.036 U
INDENO(1,2,3-CD)PYRENE	mg/kg	0.16	0.05	1.9 J	0.43 J	1.8	6 J	2	0.036 U
NAPHTHALENE	mg/kg	0.026 J	0.0069 J	0.097	0.035	0.13	0.27	0.048	0.036 U
PHENANTHRENE	mg/kg	0.16	0.099	0.87 J	0.32 J	1.8	3.6 J	0.99 J	0.036 U
PYRENE	mg/kg	0.32	0.2	3.8	1.8	5.3	13	5.2	0.0068 J
Total PAHs (b)	mg/kg	2.3	1.0	26	8.8	31	80	22	0.23
TPH									
TPH	mg/kg	110	35	2600	490	3600	7200	68	12
METALS									
COPPER	mg/kg	53.1	5.8	73.1	112	572	531	95.8	10.5
ZINC	mg/kg	112	18.1	121	122	914	834	150	60.2

Note: Start and end depths are based on measurements from the top of the core and represent depths below the sediment-water interface.
(a) Sum of Silt plus Clay
(b) Sum of individual PAHs; 1/2 the RL has been substituted for undetected data.
J: Estimated value
U: Undetected Value; result represents the laboratory reporting limit.

Table 3-2 (continued)

Analysis	Site Station Sample ID Start Depth (cm) End Depth (cm) Unit	STNH-N 1-6 1-6(A) 10 20	STNH-N 1-6 1-6(B) 60 80	STNH-N 1-6 1-6(C) 130 140	STNH-N 1-6 1-6(D) 140 150	STNH-N 1-6 1-6(E) 150 160	STNH-N 1-6 1-6(F) 160 170	STNH-N 1-6 1-6(G) 190 200	STNH-N 1-6 1-6(H) 230 240	STNH-N 1-6 1-6(I) 240 250	STNH-N 1-6 1-6(J) 260 270
GRAINSIZE											
GRAVEL	percent	0.0	15.6	7.2	8.0	61.3	8.1	4.2	3.8	13.4	0.6
SAND	percent	19.2	73.6	65.1	57.6	27.1	33.0	56.2	31.5	23.2	43.9
SILT	percent	49.5	6.0	17.1	29.0	8.1	37.3	31.8	47.4	45.5	47.4
CLAY	percent	31.2	4.8	10.6	5.5	3.6	21.6	7.8	17.4	17.9	8.0
SILT+ CLAY(a)	percent	80.8	10.8	27.7	34.5	11.6	58.9	39.6	64.7	63.4	55.4
TOC											
TOC	percent	4.4	1.1	2.3	1.7	4.2	4.8	4.7	2.5	2.5	2.7
PAH											
ACENAPHTHENE	mg/kg	0.064	0.023 U	0.0018 J	0.014 J	14 U	1.9 J	1.6 J	0.34 J	0.074	0.016 J
ACENAPHTHYLENE	mg/kg	0.042 J	0.023 U	0.0019 J	0.03	14 U	0.03 U	7.3 U	0.087	0.05	0.052
ANTHRACENE	mg/kg	0.12	0.023 U	0.0055 J	0.053	1.6 J	2.5 J	3.3 J	1 J	0.39 J	0.091
BENZO(A)ANTHRACENE	mg/kg	0.71	0.0023 J	0.019 J	0.29	8.7 J	5 J	6.9 J	2.4 J	1.2 J	0.5
BENZO(A)PYRENE	mg/kg	0.77	0.023 U	0.035	0.39	14 U	5 J	8	2.3 J	1.1 J	0.6
BENZO(B)FLUORANTHENE	mg/kg	0.78	0.023 U	0.032	0.43	14 U	5.1 J	6.7 J	2.4 J	1.4 U	0.54
BENZO(K)FLUORANTHENE	mg/kg	0.75	0.023 U	0.031	0.3	14 U	3.9 J	7.7	1.8 J	1.4 U	0.57
BENZO[G,H,I]PERYLENE	mg/kg	0.28 J	0.023 U	0.016 J	0.16 J	14 U	6.1 U	7.3 U	2.8 U	1.4 U	0.29 J
CHRYSENE	mg/kg	0.82	0.0048 J	0.028	0.32	11 J	5.9 J	8.7	2.9	1.3 J	0.57
DIBENZO(A,H)ANTHRACENE	mg/kg	0.096	0.023 U	0.026 U	0.079	14 U	6.1 U	7.3 U	2.8 U	0.095	0.084
FLUORANTHENE	mg/kg	1.3	0.0045 J	0.027	0.57	27	12	14	6.6	3.1	0.84
FLUORENE	mg/kg	0.072	0.023 U	0.026 U	0.021 J	14 U	6.1 U	7.3 U	2.8 U	0.097	0.03 J
INDENO(1,2,3-CD)PYRENE	mg/kg	0.4 J	0.023 U	0.024 J	0.23	14 U	6.1 U	7.3 U	2.8 U	1.4 U	0.43
NAPHTHALENE	mg/kg	0.094	0.00095 J	0.0036 J	0.018 J	14 U	6.1 U	7.3 U	2.8 U	0.046	0.026 J
PHENANTHRENE	mg/kg	0.33 J	0.023 U	0.015 J	0.14 J	3.2 J	7.9	7.4	3	0.82 J	0.17
PYRENE	mg/kg	1.3	0.0089 J	0.12	0.92	69	12	21	6	3	1.2
Total PAHs (b)	mg/kg	7.9	0.15	0.39	4.0	190	76	110	36	14	6.0
TPH											
TPH	mg/kg	410	4.3 J	40	560	9700	5100	5500	5100	2200	870
METALS											
COPPER	mg/kg	99.8	3.7	7.0	24.8	305	325	238	234	214	256
ZINC	mg/kg	179	13.8	26.0	53.5	724	413	380	450	394	303

Note: Start and end depths are based on measurements from the top of the core and represent depths below the sediment-water interface.
(a) Sum of Silt plus Clay
(b) Sum of individual PAHs; 1/2 the RL has been substituted for undetected data.
J: Estimated value
U: Undetected Value; result represents the laboratory reporting limit.

Table 3-3.

CS-2 2004 Sediment Chemistry and Grain Size Results

	Site	CS-2	CS-2	CS-2	CS-2	CS-2	CS-2	CS-2	CS-2	CS-2
	Station	2-1	2-1	2-1	2-1	2-1	2-1	2-1	2-1	2-1
	Sample ID	2-1(A)	2-1(B)	2-1(C)	2-1(D)	2-1(E)	2-1(F)	2-1(G)	2-1(H)	2-1(I)
	Start Depth (cm)	10	55	75	85	95	105	135	155	235
	End Depth (cm)	20	75	85	95	105	115	145	165	245
Analysis	Unit									
GRAINSIZE										
GRAVEL	percent	1.8	1.9	4.0	3.5	0.7	4.2	2.7	0.3	0.1
SAND	percent	48.4	92.3	79.2	58.8	52.7	40.8	25.6	5.3	55.2
SILT	percent	27.7	1.3	8.3	21.5	30.7	33.0	51.2	50.0	26.9
CLAY	percent	22.0	4.5	8.5	16.2	15.8	22.0	20.4	44.5	17.8
SILT+ CLAY(a)	percent	49.7	5.8	16.8	37.7	46.5	55.0	71.7	94.4	44.6
TOC										
TOC	percent	1.3	0.6	0.9	2.8	2.5	2.5	0.8	8.6	1.5
PAH										
ACENAPHTHENE	mg/kg	0.007 J	0.0018 J	0.0066 J	0.05	0.56 J	1.1 J	0.076	18 J	0.038 U
ACENAPHTHYLENE	mg/kg	0.01 J	0.0034 J	0.018 J	0.083	1.6 U	0.4 J	0.027 U	18 U	0.038 U
ANTHRACENE	mg/kg	0.019 J	0.0066 J	0.017 J	0.12	1.3 J	2.2 J	0.021 J	24	0.0029 J
BENZO(A)ANTHRACENE	mg/kg	0.1	0.024	0.12	0.68	1.4 J	3.7	0.0046 J	18	0.0054 J
BENZO(A)PYRENE	mg/kg	0.14	0.042	0.16	0.85	1.4 J	3.6	0.027 U	16 J	0.038 U
BENZO(B)FLUORANTHENE	mg/kg	0.15	0.027	0.11	0.74	0.94 J	2.7 J	0.027 U	10 J	0.038 U
BENZO(K)FLUORANTHENE	mg/kg	0.13	0.026	0.1	0.76	1 J	3.1 J	0.027 U	11 J	0.038 U
BENZO[G,H,I]PERYLENE	mg/kg	0.076	0.016 J	0.049	0.31 J	0.37 J	0.72 J	0.027 U	18 U	0.038 U
CHRYSENE	mg/kg	0.13	0.028	0.12	0.76	1.5 J	3.8	0.0053 J	21	0.0044 J
DIBENZO(A,H)ANTHRACENE	mg/kg	0.034 U	0.024 U	0.02 J	0.08	0.11	3.4 U	0.027 U	18 U	0.038 U
FLUORANTHENE	mg/kg	0.14	0.021 J	0.1	1.6	2.5	7.2	0.011 J	37	0.0061 J
FLUORENE	mg/kg	0.0081 J	0.024 U	0.0077 J	0.05	1.6 U	0.58 J	0.03	11 J	0.038 U
INDENO(1,2,3-CD)PYRENE	mg/kg	0.11	0.018 J	0.061	0.46 J	1.6 U	1.2 J	0.027 U	18 U	0.038 U
NAPHTHALENE	mg/kg	0.0095 J	0.0036 J	0.0077 J	0.047	0.11	3.4 U	0.1	16 J	0.038 U
PHENANTHRENE	mg/kg	0.066	0.012 J	0.044	0.42 J	3	5.2	0.05	65	0.038 U
PYRENE	mg/kg	0.26	0.19	0.36	1.5	2.8	8.3	0.019 J	44	0.038 U
Total PAHs (b)	mg/kg	1.4	0.44	1.3	8.5	19	47	0.41	330	0.25
TPH										
TPH	mg/kg	52	22	53	280	860	1300	31	20000	35
METALS										
COPPER	mg/kg	32.2	4.7	16.1	378	319	442	10.7	3210	11.3
ZINC	mg/kg	74.9	10.2	27.1	271	213	283	29.3	1370	64.6

Note: Start and end depths are based on measurements from the top of the core and represent depths below the sediment-water interface.
(a) Sum of Silt plus Clay
(b) Sum of individual PAHs; 1/2 the RL has been substituted for undetected data.
J: Estimated value
U: Undetected Value; result represents the laboratory reporting limit.

Table 3-3 (continued)

Analysis	Site Station Sample ID Start Depth (cm) End Depth (cm) Unit	CS-2 2-2 2-2(A) 10 20	CS-2 2-2 2-2(B) 40 50	CS-2 2-2 2-2(C) 50 60	CS-2 2-2 2-2(D) 80 90	CS-2 2-2 2-2(E) 100 110	CS-2 2-2 2-2(F) 120 130	CS-2 2-2 2-2(G) 140 150	CS-2 2-2 2-2(H) 160 170	CS-2 2-2 2-2(I) 220 230
GRAINSIZE										
GRAVEL	percent	0.9	15.9	16.4	2.6	0.4	1.2	2.0	2.4	0.1
SAND	percent	51.6	60.8	63.1	94.6	46.7	40.1	29.3	76.9	8.0
SILT	percent	28.1	15.1	11.5	1.1	35.2	36.7	42.1	15.1	55.9
CLAY	percent	19.5	8.3	9.0	1.7	17.7	22.0	26.6	5.6	36.0
SILT+ CLAY(a)	percent	47.5	23.4	20.5	2.8	52.9	58.7	68.7	20.7	91.9
TOC										
TOC	percent	1.2	1.1	2.7	0.8	2.8	4.5	6.9	3.2	2.8
PAH										
ACENAPHTHENE	mg/kg	0.043	0.048	0.031	0.0036 J	2.4	7.7	15 J	30	0.15
ACENAPHTHYLENE	mg/kg	0.11	0.14 J	0.14	0.0094 J	1.8 U	7.6 U	20 U	27 U	0.06
ANTHRACENE	mg/kg	0.15	0.13	0.087	0.011 J	2.2	7.6	15 J	18 J	0.097
BENZO(A)ANTHRACENE	mg/kg	0.46	0.54 J	0.45 J	0.076	2.7	11	21	22 J	0.32 J
BENZO(A)PYRENE	mg/kg	0.48	0.92	0.78	0.063	2.4	11	17 J	20 J	0.55 J
BENZO(B)FLUORANTHENE	mg/kg	0.24	0.42 J	0.39 J	0.039	1.2 J	6.5 J	10 J	11 J	0.4 J
BENZO(K)FLUORANTHENE	mg/kg	0.35	0.7	0.59 J	0.04	2	6.8 J	12 J	13 J	0.38 J
BENZO[G,H,I]PERYLENE	mg/kg	0.16	0.4 J	0.37 J	0.028	0.97 J	3.1 J	20 U	27 U	0.18 J
CHRYSENE	mg/kg	0.49	0.7	0.58 J	0.055	3	13	27	25 J	0.44 J
DIBENZO(A,H)ANTHRACENE	mg/kg	0.078	0.1	0.14 J	0.0095 J	0.2 J	7.6 U	20 U	27 U	0.095
FLUORANTHENE	mg/kg	0.62	0.58	0.48 J	0.046	4.2	15	27	30	0.53 J
FLUORENE	mg/kg	0.023 J	0.03	0.018 J	0.0029 J	0.59 J	4.3 J	9 J	17 J	0.076
INDENO(1,2,3-CD)PYRENE	mg/kg	0.2	0.37 J	0.28 J	0.025	0.94 J	7.6 U	20 U	27 U	0.28 J
NAPHTHALENE	mg/kg	0.027 J	0.056	0.048	0.0022 J	0.38 J	4.3 J	16 J	89	2.6
PHENANTHRENE	mg/kg	0.43	0.31 J	0.12	0.019 J	2.3	21	41	53	0.39 J
PYRENE	mg/kg	0.83	2	1.9	0.16	4.8	24	52	53	0.75 J
Total PAHs (b)	mg/kg	4.7	7.4	6.4	0.59	31	150	300	440	7.3
TPH										
TPH	mg/kg	110	390	280	24	1500	12000	19000	6600	370
METALS										
COPPER	mg/kg	36.5	123	74.4	5	542	1320	2220	536	116
ZINC	mg/kg	81	99	67.4	9.9	344	644	1240	471	190

Note: Start and end depths are based on measurements from the top of the core and represent depths below the sediment-water interface.
(a) Sum of Silt plus Clay
(b) Sum of individual PAHs; 1/2 the RL has been substituted for undetected data.
J: Estimated value
U: Undetected Value; result represents the laboratory reporting limit.

Table 3-3 (continued)

Analysis	Site / Station / Sample ID / Start Depth (cm) / End Depth (cm) / Unit	CS-2 / 2-3 / 2-3(A) / 10 / 20	CS-2 / 2-3 / 2-3(B) / 40 / 50	CS-2 / 2-3 / 2-3(C) / 60 / 70	CS-2 / 2-3 / 2-3(D) / 70 / 80	CS-2 / 2-3 / 2-3(E) / 80 / 90	CS-2 / 2-3 / 2-3(F) / 90 / 100	CS-2 / 2-3 / 2-3(G) / 120 / 130
GRAINSIZE								
GRAVEL	percent	5.7	2.4	1.7	11.9	13.0	9.7	0.0
SAND	percent	32.8	85.0	12.7	39.1	62.0	62.3	8.5
SILT	percent	40.7	5.5	60.9	34.2	14.6	19.0	78.8
CLAY	percent	20.8	7.1	24.7	14.8	10.4	9.0	12.7
SILT+ CLAY(a)	percent	61.5	12.6	85.6	49.0	25.0	28.0	91.5
TOC								
TOC	percent	1.7	0.7	1.9	1.6	1.4	2.2	1.8
PAH								
ACENAPHTHENE	mg/kg	0.01 J	0.0017 J	0.016 J	0.032 U	0.031 U	0.031 U	0.041 U
ACENAPHTHYLENE	mg/kg	0.056	0.0089 J	0.076	0.14 J	0.096 J	0.0099 J	0.041 U
ANTHRACENE	mg/kg	0.047	0.0089 J	0.12	0.11	0.11 J	0.009 J	0.0028 J
BENZO(A)ANTHRACENE	mg/kg	0.18	0.022 J	0.45 J	1.8	2.7	0.052	0.028 J
BENZO(A)PYRENE	mg/kg	0.39	0.047	0.54 J	1.9	2	0.095	0.043
BENZO(B)FLUORANTHENE	mg/kg	0.21	0.034	0.5 J	0.77 J	0.82 J	0.086	0.029 J
BENZO(K)FLUORANTHENE	mg/kg	0.28	0.029	0.44 J	0.99 J	0.96 J	0.07	0.041
BENZO[G,H,I]PERYLENE	mg/kg	0.12	0.015 J	0.29 J	0.84 J	0.46 J	0.033	0.013 J
CHRYSENE	mg/kg	0.35	0.027 J	0.46 J	2.6	1.5	0.073	0.034 J
DIBENZO(A,H)ANTHRACENE	mg/kg	0.045	0.0074 J	0.1	1.6 U	1.2 U	0.017 J	0.0061 J
FLUORANTHENE	mg/kg	0.31	0.024 J	0.66 J	3	2.6	0.045	0.044
FLUORENE	mg/kg	0.0051 J	0.028 U	0.046	0.04	0.059	0.031 U	0.041 U
INDENO(1,2,3-CD)PYRENE	mg/kg	0.13	0.017 J	0.33 J	0.64 J	0.57 J	0.037	0.017 J
NAPHTHALENE	mg/kg	0.023 J	0.0045 J	0.076	0.05	0.073	0.0062 J	0.0044 J
PHENANTHRENE	mg/kg	0.12	0.018 J	0.34 J	0.074	0.14	0.028 J	0.02 J
PYRENE	mg/kg	0.47	0.081	1.4	5	6.2	0.19	0.077
Total PAHs (b)	mg/kg	2.7	0.36	5.8	19	19	0.78	0.42
TPH								
TPH	mg/kg	2200	24	140	120	390	87	58
METALS								
COPPER	mg/kg	41.4	10.9	97.3	31.3	56.2	19.2	19.4
ZINC	mg/kg	97.8	23.1	128	46.8	64.1	43.4	74.1

Note: Start and end depths are based on measurements from the top of the core and represent depths below the sediment-water interface.
(a) Sum of Silt plus Clay
(b) Sum of individual PAHs; 1/2 the RL has been substituted for undetected data.
J: Estimated value
U: Undetected Value; result represents the laboratory reporting limit.

Table 3-3 (continued)

Analysis	Site Station Sample ID Start Depth (cm) End Depth (cm) Unit	CS-2 2-4 2-4(A) 10 20	CS-2 2-4 2-4(B) 40 50	CS-2 2-4 2-4(C) 56 66	CS-2 2-4 2-4(D) 66 76	CS-2 2-4 2-4(E) 76 86	CS-2 2-4 2-4(F) 86 96	CS-2 2-4 2-4(G) 96 106	CS-2 2-4 2-4(H) 106 116	CS-2 2-4 2-4(I) 146 156
GRAINSIZE										
GRAVEL	percent	0.3	3.1	2.6	2.5	1.9	3.7	7.5	11.1	0.05
SAND	percent	34.7	56.7	73.4	84.4	91.2	53.8	47.1	49.8	6.4
SILT	percent	52.3	26.6	14.9	7.4	3.7	29.6	33.4	33.9	78.6
CLAY	percent	12.6	13.6	9.0	5.7	3.2	12.9	11.9	5.2	14.9
SILT+ CLAY(a)	percent	65.0	40.2	23.9	13.1	6.9	42.5	45.4	39.1	93.5
TOC										
TOC	percent	1.8	2.1	1.5	1.8	1.2	2.1	1.8	1.7	1.7
PAH										
ACENAPHTHENE	mg/kg	0.074	0.053	0.02 J	2.7 U	0.093 J	0.14	1.9 J	0.48 J	0.04 U
ACENAPHTHYLENE	mg/kg	0.16	0.32 J	0.099	0.07	0.15 J	0.24 J	0.99 J	3.2 U	0.04 U
ANTHRACENE	mg/kg	0.26 J	0.14	0.064	1.9 J	0.3 J	0.41 J	8.4	1.1 J	0.013 J
BENZO(A)ANTHRACENE	mg/kg	1.2	2.4	0.71	4.5	1	2.2	8.1	2.2 J	0.011 J
BENZO(A)PYRENE	mg/kg	1.2	2	0.86	3.6	0.88	2.1	6.2	3.2 U	0.014 J
BENZO(B)FLUORANTHENE	mg/kg	0.55 J	0.97 J	0.4 J	2.6 J	0.4 J	1.3 J	2.7 J	3.2 U	0.04 U
BENZO(K)FLUORANTHENE	mg/kg	0.77	0.98 J	0.44 J	2.6 J	0.5 J	1.2 J	3.6	3.2 U	0.04 U
BENZO[G,H,I]PERYLENE	mg/kg	0.46 J	0.86 J	0.39 J	1.5 J	0.33 J	0.94 J	1.9 J	3.2 U	0.04 U
CHRYSENE	mg/kg	1.2	2.2	0.68	4.4	0.87	2.1	7.7	2.7 J	0.0099 J
DIBENZO(A,H)ANTHRACENE	mg/kg	0.11	0.24 J	0.081	0.58 J	0.098	0.23 J	0.77 J	0.15	0.04 U
FLUORANTHENE	mg/kg	1.2	2.1	0.51 J	7.2	0.88	2.1	10	3.5	0.017 J
FLUORENE	mg/kg	0.075	0.046	0.022 J	0.069 J	0.087	0.1	0.45 J	3.2 U	0.04 U
INDENO(1,2,3-CD)PYRENE	mg/kg	0.41 J	0.66 J	0.28 J	1.4 J	0.27 J	0.82 J	1.6 J	3.2 U	0.04 U
NAPHTHALENE	mg/kg	0.048	0.11	0.06	0.12	0.051	0.18 J	0.39 J	3.2 U	0.04 U
PHENANTHRENE	mg/kg	0.74 J	0.12	0.058	5.8	0.7	0.62 J	0.9 J	0.96 J	0.0076 J
PYRENE	mg/kg	1.9	5.3	2	8.7	1.9	4.9	17	6.9	0.021 J
Total PAHs (b)	mg/kg	10	18	6.7	46	8.5	20	73	31	0.27
TPH										
TPH	mg/kg	130	220	140	220	170	860	790	570	23
METALS										
COPPER	mg/kg	67.8	49.3	29	21.7	26	278	353	267	17.2
ZINC	mg/kg	124	65.5	36.7	22.6	28.0	256	225	209	69.1

Note: Start and end depths are based on measurements from the top of the core and represent depths below the sediment-water interface.
(a) Sum of Silt plus Clay
(b) Sum of individual PAHs; 1/2 the RL has been substituted for undetected data.
J: Estimated value
U: Undetected Value; result represents the laboratory reporting limit.

Table 3-3 (continued)

Analysis	Site Station Sample ID Start Depth (cm) End Depth (cm) Unit	CS-2 2-5 2-5(A) 10 20	CS-2 2-5 2-5(B) 30 40	CS-2 2-5 2-5(C) 50 60	CS-2 2-5 2-5(D) 70 80	CS-2 2-5 2-5(E) 80 90	CS-2 2-5 2-5(F) 90 100	CS-2 2-5 2-5(G) 130 150
GRAINSIZE								
GRAVEL	percent	4.1	5.7	0.6	0.3	0.0	10.0	0.0
SAND	percent	75.0	49.2	15.4	7.9	3.3	23.3	3.0
SILT	percent	13.4	27.7	53.5	57.0	56.2	38.4	61.7
CLAY	percent	7.6	17.4	30.5	34.9	40.4	28.3	35.3
SILT+ CLAY(a)	percent	20.9	45.1	84.0	91.8	96.7	66.7	97.0
TOC								
TOC	percent	1.1	1.3	1.4	0.9	2.1	1.5	1.5
PAH								
ACENAPHTHENE	mg/kg	0.025 U	0.032 U	0.0058 J	0.0057 J	0.0028 J	0.0043 J	0.038 U
ACENAPHTHYLENE	mg/kg	0.0068 J	0.003 J	0.035	0.03	0.0087 J	0.0069 J	0.038 U
ANTHRACENE	mg/kg	0.0074 J	0.0038 J	0.029 J	0.024 J	0.0091 J	0.0071 J	0.038 U
BENZO(A)ANTHRACENE	mg/kg	0.038	0.015 J	0.15 J	0.081	0.038	0.059	0.038 U
BENZO(A)PYRENE	mg/kg	0.06	0.022 J	0.26	0.098	0.045	0.064	0.038 U
BENZO(B)FLUORANTHENE	mg/kg	0.025 U	0.032 U	0.2	0.03 U	0.027 J	0.037 J	0.038 U
BENZO(K)FLUORANTHENE	mg/kg	0.025 U	0.032 U	0.13	0.066	0.035	0.045	0.038 U
BENZO[G,H,I]PERYLENE	mg/kg	0.018 J	0.032 U	0.13	0.06	0.017 J	0.025 J	0.038 U
CHRYSENE	mg/kg	0.034	0.012 J	0.12	0.066	0.045	0.048	0.038 U
DIBENZO(A,H)ANTHRACENE	mg/kg	0.025 U	0.032 U	0.071	0.027 J	0.03 U	0.037 U	0.038 U
FLUORANTHENE	mg/kg	0.045	0.018 J	0.2	0.087	0.045	0.022 J	0.038 U
FLUORENE	mg/kg	0.025 U	0.0044 J	0.016 J	0.0068 J	0.0033 J	0.0045 J	0.038 U
INDENO(1,2,3-CD)PYRENE	mg/kg	0.025 U	0.032 U	0.15 J	0.068	0.014 J	0.018 J	0.038 U
NAPHTHALENE	mg/kg	0.0043 J	0.029 J	0.36	0.011 J	0.0063 J	0.0053 J	0.038 U
PHENANTHRENE	mg/kg	0.013 J	0.0042 J	0.081	0.046	0.021 J	0.0091 J	0.038 U
PYRENE	mg/kg	0.084	0.035	0.47	0.26	0.12	0.087	0.038 U
Total PAHs (b)	mg/kg	0.39	0.24	2.4	0.95	0.45	0.46	0.30
TPH								
TPH	mg/kg	25	24	84	38	29	25	20
METALS								
COPPER	mg/kg	8.4	11.2	38.4	17.6	14.8	13.1	11.4
ZINC	mg/kg	21.5	45.7	65.0	42.2	55.4	66.9	71.5

Note: Start and end depths are based on measurements from the top of the core and represent depths below the sediment-water interface.
(a) Sum of Silt plus Clay
(b) Sum of individual PAHs; 1/2 the RL has been substituted for undetected data.
J: Estimated value
U: Undetected Value; result represents the laboratory reporting limit.

Table 3-3 (continued)

Analysis	Site Station Sample ID Start Depth (cm) End Depth (cm) Unit	CS-2 2-6 2-6(A) 10 20	CS-2 2-6 2-6(B) 30 40	CS-2 2-6 2-6(C) 40 50	CS-2 2-6 2-6(D) 50 60	CS-2 2-6 2-6(E) 60 70	CS-2 2-6 2-6(F) 80 90	CS-2 2-6 2-6(G) 100 110	CS-2 2-6 2-6(H) 120 130	CS-2 2-6 2-6(I) 190 200
GRAINSIZE										
GRAVEL	percent	2.0	0.3	0.2	6.0	10.2	4.2	5.2	14.0	0.2
SAND	percent	49.4	9.0	14.2	56.8	68.2	73.9	73.9	65.2	5.8
SILT	percent	32.6	56.8	56.5	27.0	14.6	13.5	14.9	15.1	65.0
CLAY	percent	16.1	33.9	29.1	10.2	7.1	8.4	6.0	5.7	29.0
SILT+ CLAY(a)	percent	48.7	90.7	85.6	37.2	21.6	21.9	20.9	20.8	94.0
TOC										
TOC	percent	1.5	1.5	1.7	3.2	2.2	3.2	4.5	3.8	1.8
PAH										
ACENAPHTHENE	mg/kg	0.009 J	0.015 J	0.057	27 J	76	43	20	28	0.012 J
ACENAPHTHYLENE	mg/kg	0.015 J	0.029 J	0.064	0.035 U	0.16 U	31 U	0.033 U	0.14 U	0.0064 J
ANTHRACENE	mg/kg	0.032 J	0.052	0.74 J	0.035 U	0.16 U	27 J	17	17	0.016 J
BENZO(A)ANTHRACENE	mg/kg	0.2	0.31	0.7 J	20 J	36	33	27	19	0.054
BENZO(A)PYRENE	mg/kg	0.29	0.33	0.62 J	35 U	28 J	26 J	21	14 J	0.06
BENZO(B)FLUORANTHENE	mg/kg	0.22	0.17 J	0.34 J	35 U	10 J	11 J	9.9 J	9 J	0.04 U
BENZO(K)FLUORANTHENE	mg/kg	0.14	0.12	0.35 J	35 U	18 J	18 J	14	8.9 J	0.04 U
BENZO[G,H,I]PERYLENE	mg/kg	0.079	0.072	0.11	35 U	9.1 J	11 J	7.3 J	5.5 J	0.023 J
CHRYSENE	mg/kg	0.24	0.29	0.68 J	35 J	37	34	27	19	0.044
DIBENZO(A,H)ANTHRACENE	mg/kg	0.034 U	0.047	0.032 J	35 U	2.9 J	2.2 J	2.8 J	2.2 J	0.04 U
FLUORANTHENE	mg/kg	0.29	0.3	1.1	38	48	40	30	29	0.065
FLUORENE	mg/kg	0.0084 J	0.016 J	0.036 J	8 J	24 J	22 J	12 J	15	0.012 J
INDENO(1,2,3-CD)PYRENE	mg/kg	0.12	0.15	0.22 J	35 U	7.7 J	8.1 J	6.8 J	5.1 J	0.05
NAPHTHALENE	mg/kg	0.015 J	0.026 J	0.077	35 U	3.5 J	62	29	54	0.075
PHENANTHRENE	mg/kg	0.098	0.064	0.16	62	130	84	45	50	0.036 J
PYRENE	mg/kg	0.49	0.65	2	100	85	68	50	38	0.11
Total PAHs (b)	mg/kg	2.3	2.6	7.3	410	520	500	320	310	0.62
TPH										
TPH	mg/kg	72	29	52	2400	2000	7400	8100	4600	43
METALS										
COPPER	mg/kg	42.6	25.9	42.5	582	275	676	874	689	27.5
ZINC	mg/kg	103	73.2	92.9	376	236	524	739	696	77.5

Note: Start and end depths are based on measurements from the top of the core and represent depths below the sediment-water interface.
(a) Sum of Silt plus Clay
(b) Sum of individual PAHs; 1/2 the RL has been substituted for undetected data.
J: Estimated value
U: Undetected Value; result represents the laboratory reporting limit.

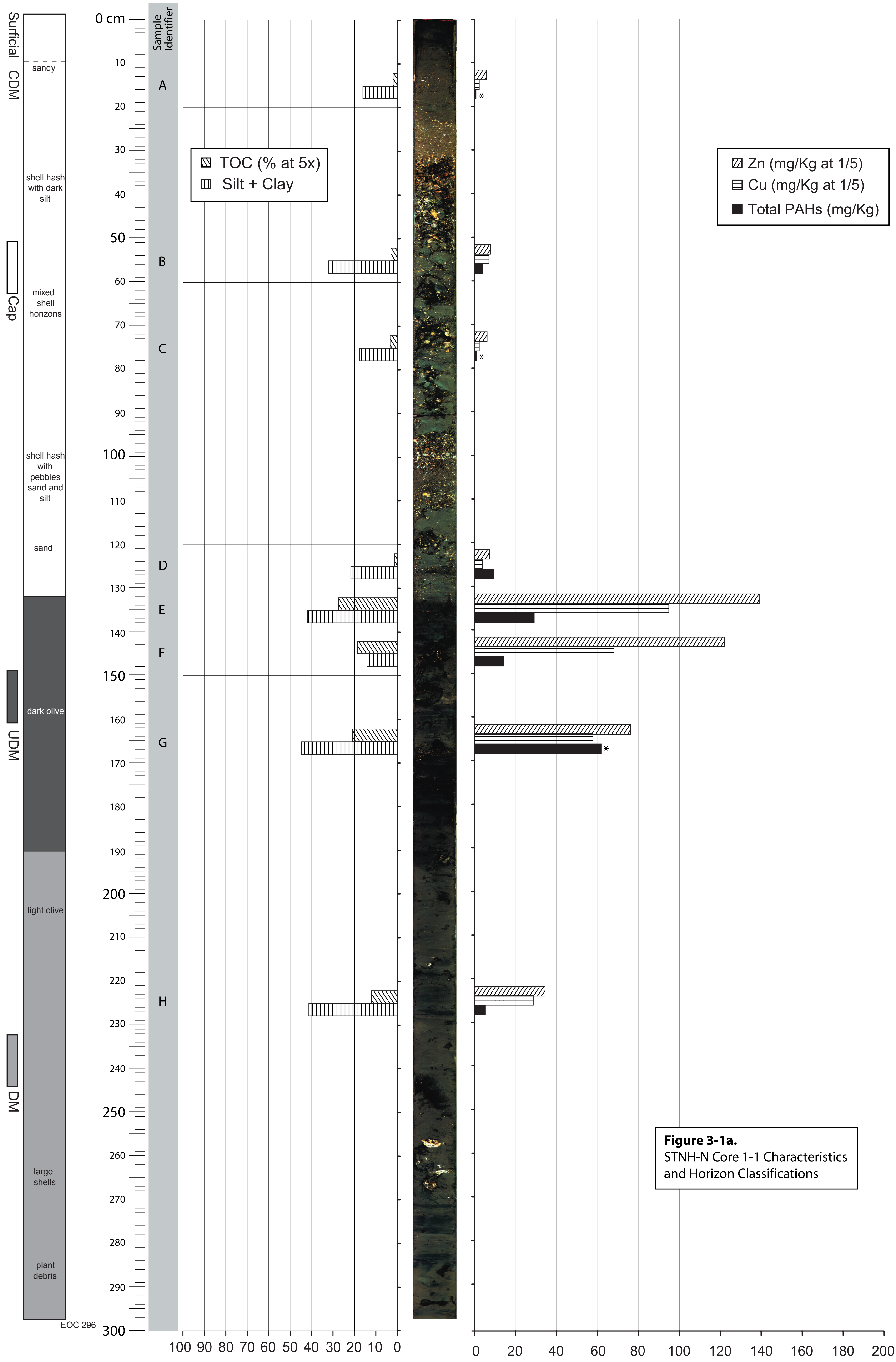


Figure 3-1a.
STNH-N Core 1-1 Characteristics and Horizon Classifications

* One or more compound ND is included in the PAH sum at 1/2 the RL

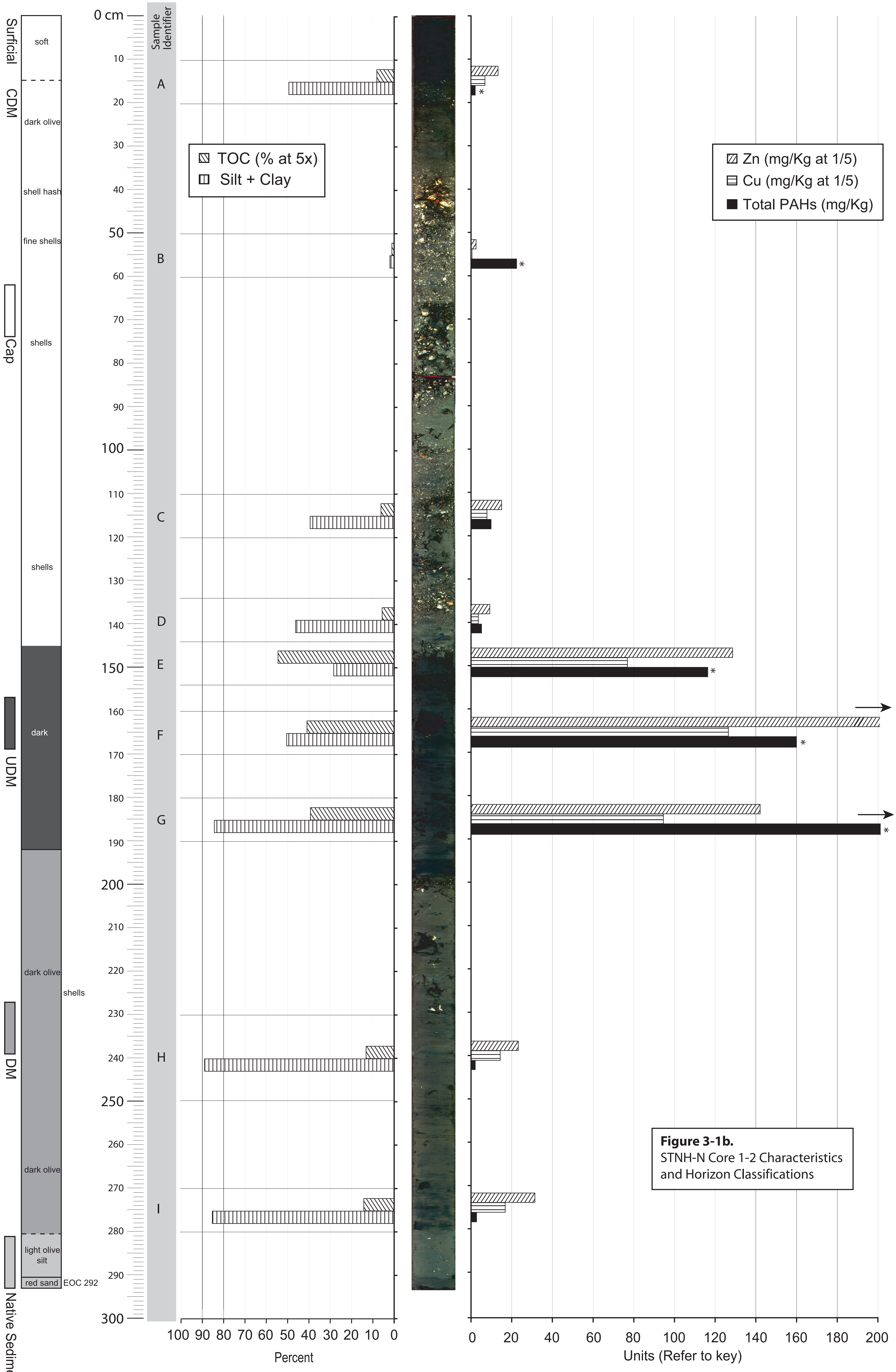


Figure 3-1b.
STNH-N Core 1-2 Characteristics and Horizon Classifications

* One or more compound ND is included in the PAH sum at 1/2 the RL

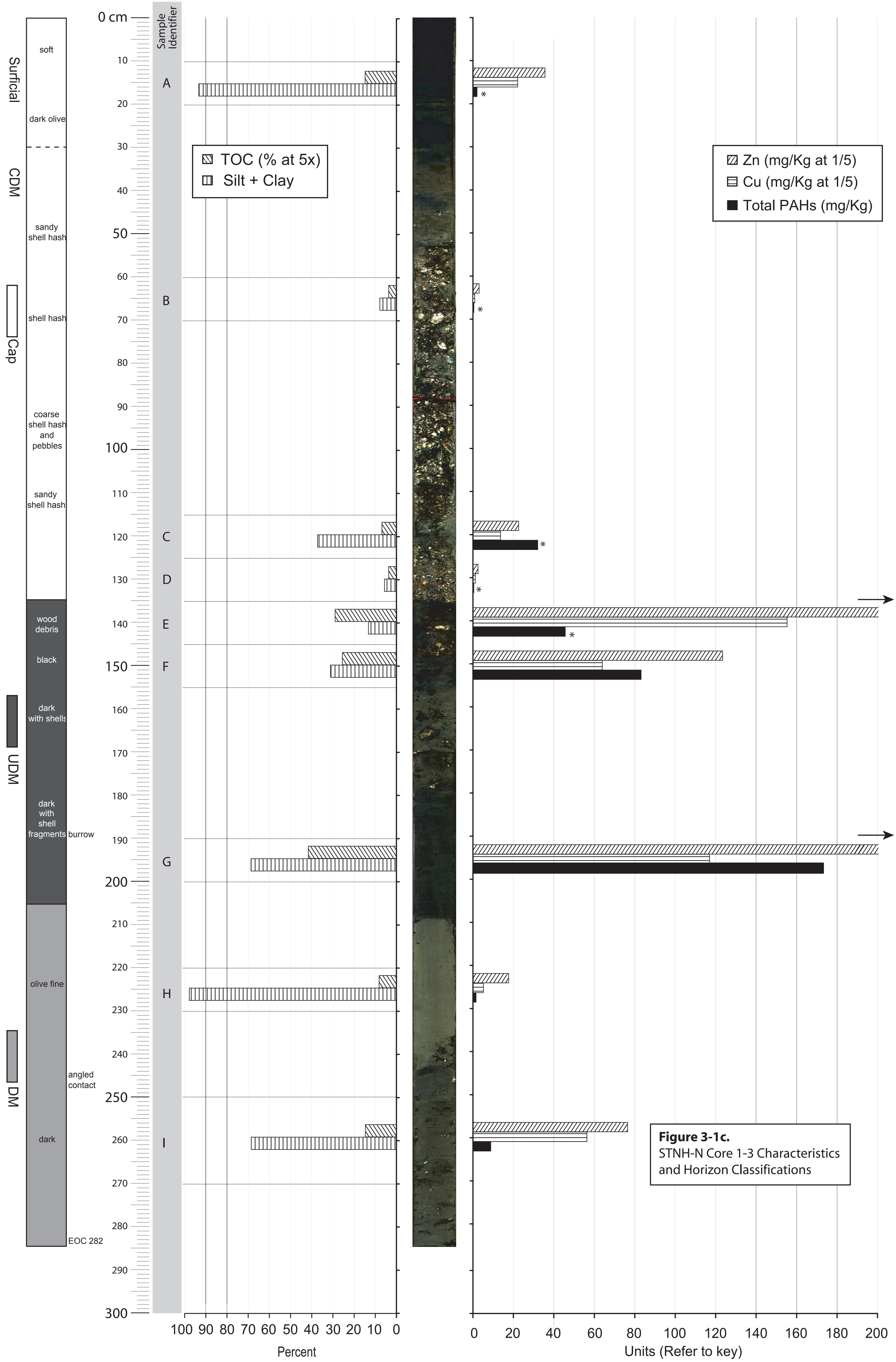


Figure 3-1c.
STNH-N Core 1-3 Characteristics and Horizon Classifications

* One or more compound ND is included in the PAH sum at 1/2 the RL

Figure 3-1d.
STNH-N Core 1-4 Characteristics and Horizon Classifications

* One or more compound ND is included in the PAH sum at 1/2 the RL

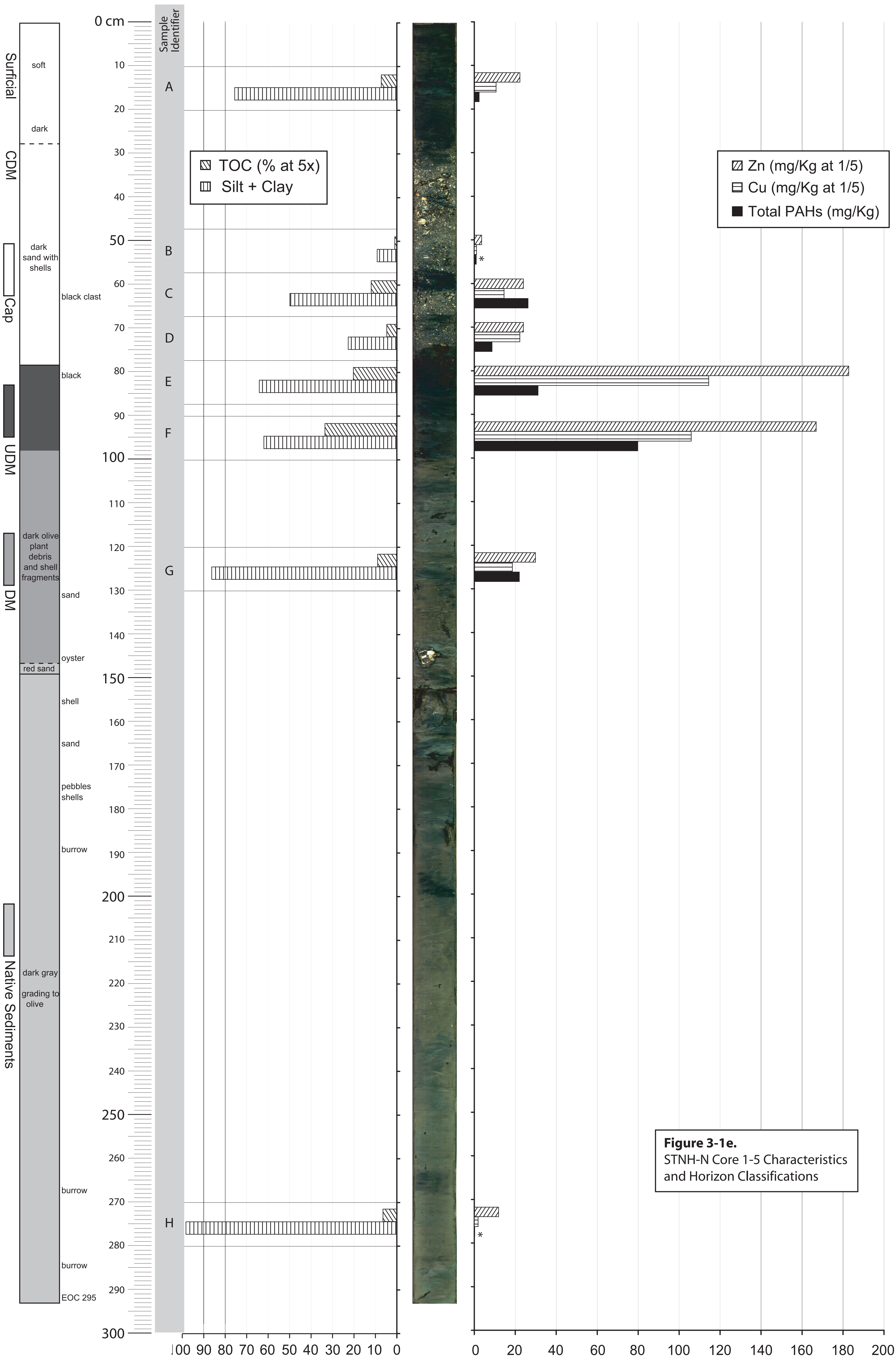


Figure 3-1e.
STNH-N Core 1-5 Characteristics and Horizon Classifications

* One or more compound ND is included in the PAH sum at 1/2 the RL

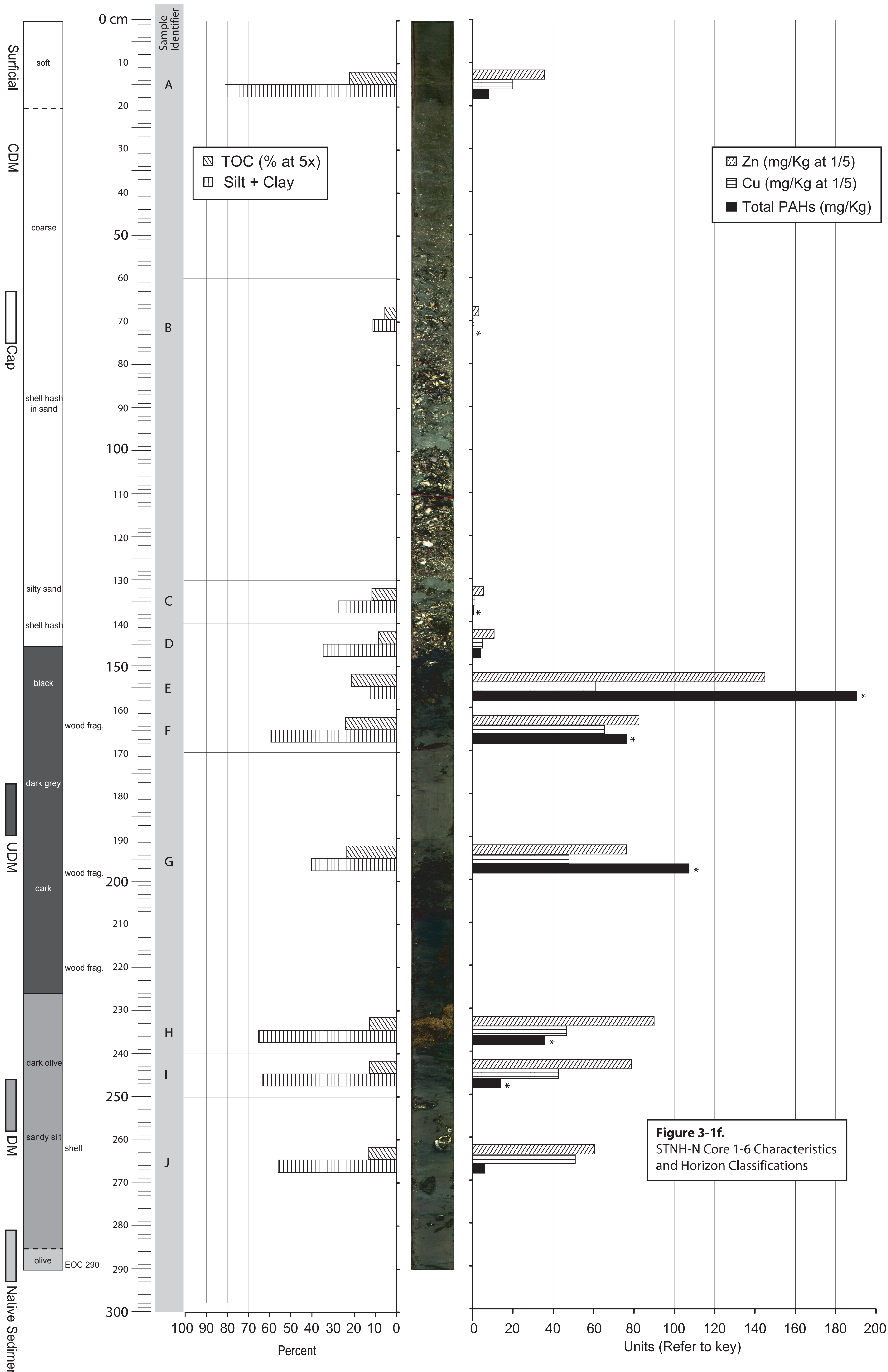


Figure 3-1f.
STNH-N Core 1-6 Characteristics and Horizon Classifications

* One or more compound ND is included in the PAH sum at 1/2 the RL

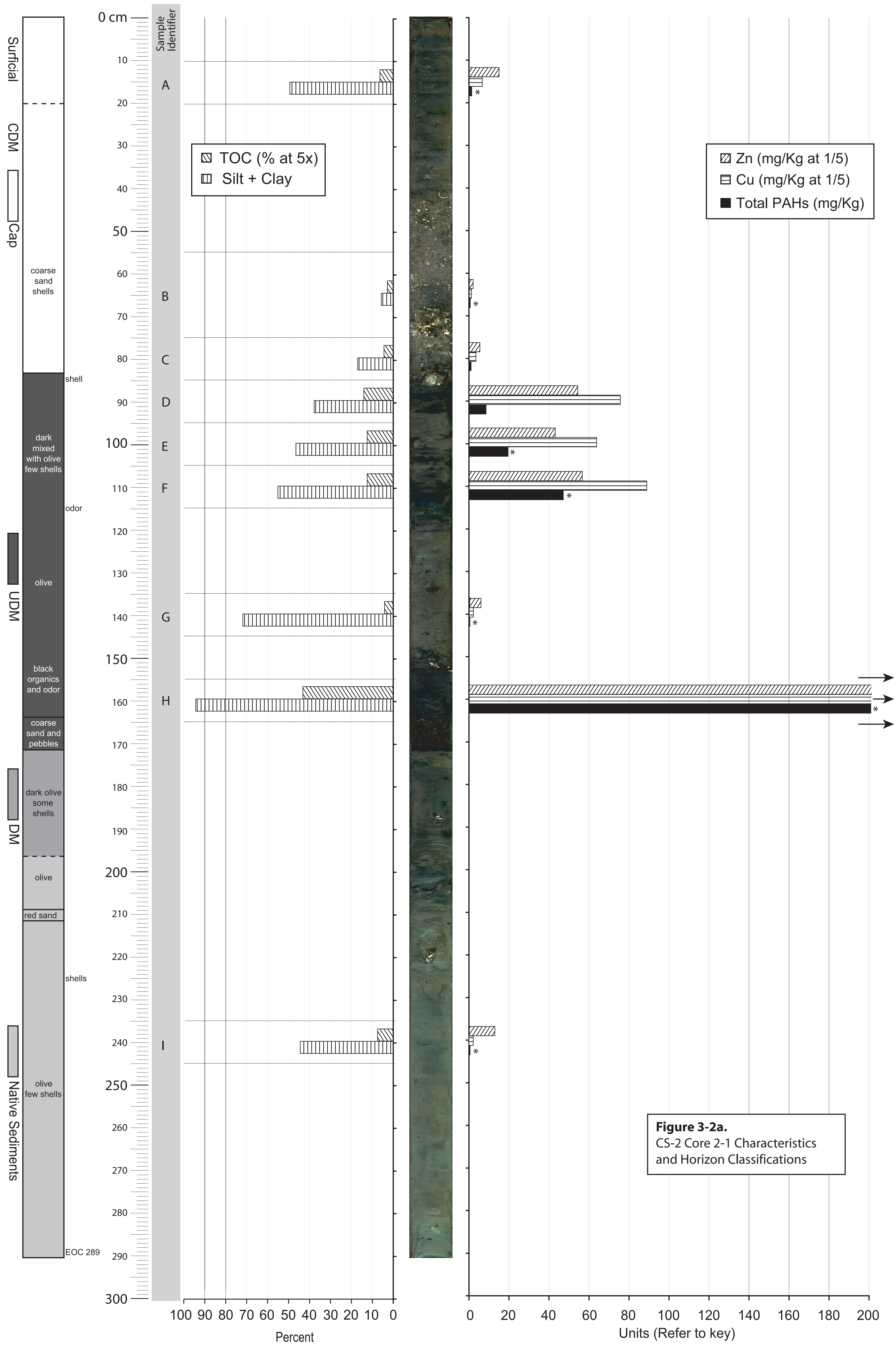


Figure 3-2a.
CS-2 Core 2-1 Characteristics and Horizon Classifications

* One or more compound ND is included in the PAH sum at 1/2 the RL

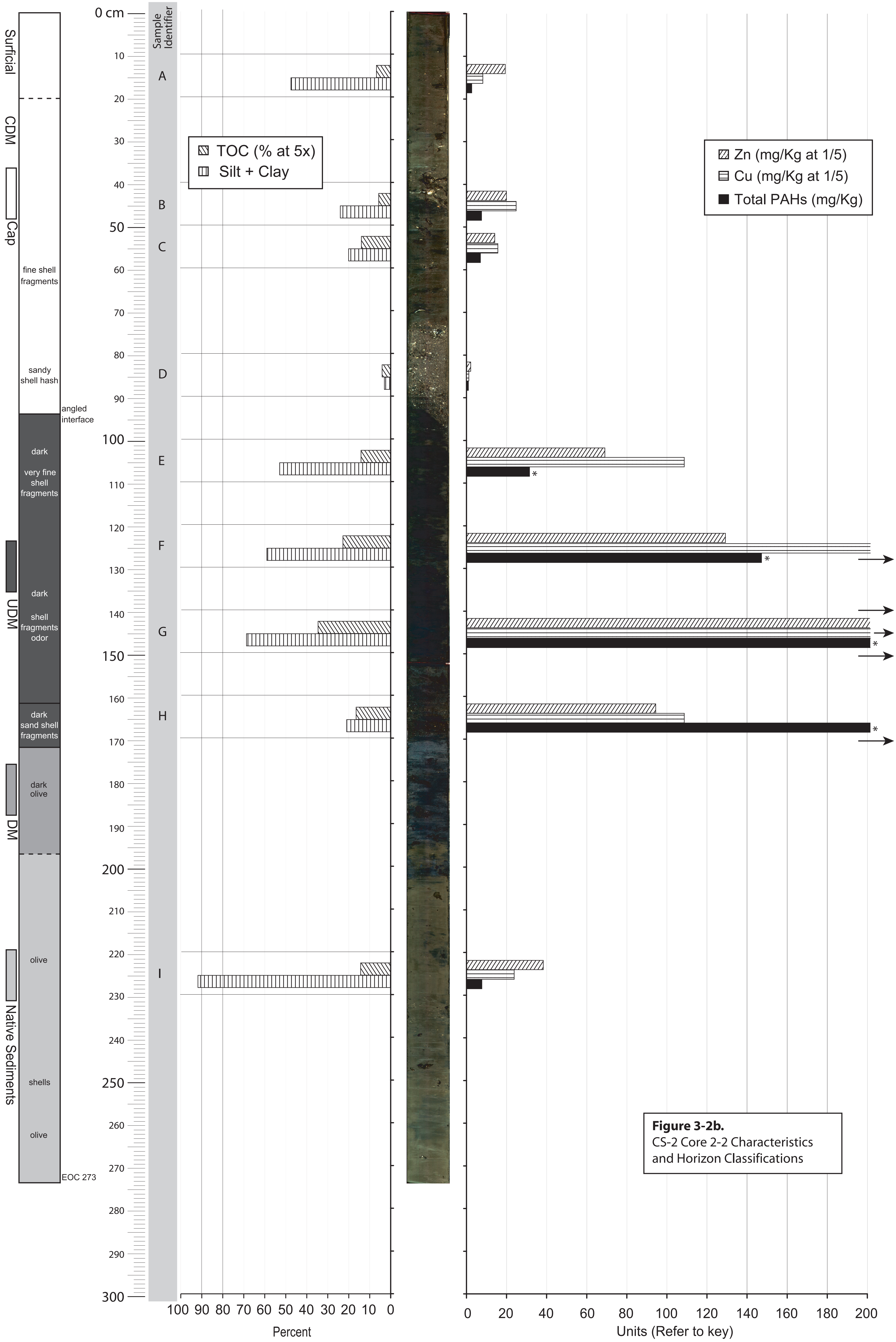


Figure 3-2b.
CS-2 Core 2-2 Characteristics and Horizon Classifications

* One or more compound ND is included in the PAH sum at 1/2 the RL

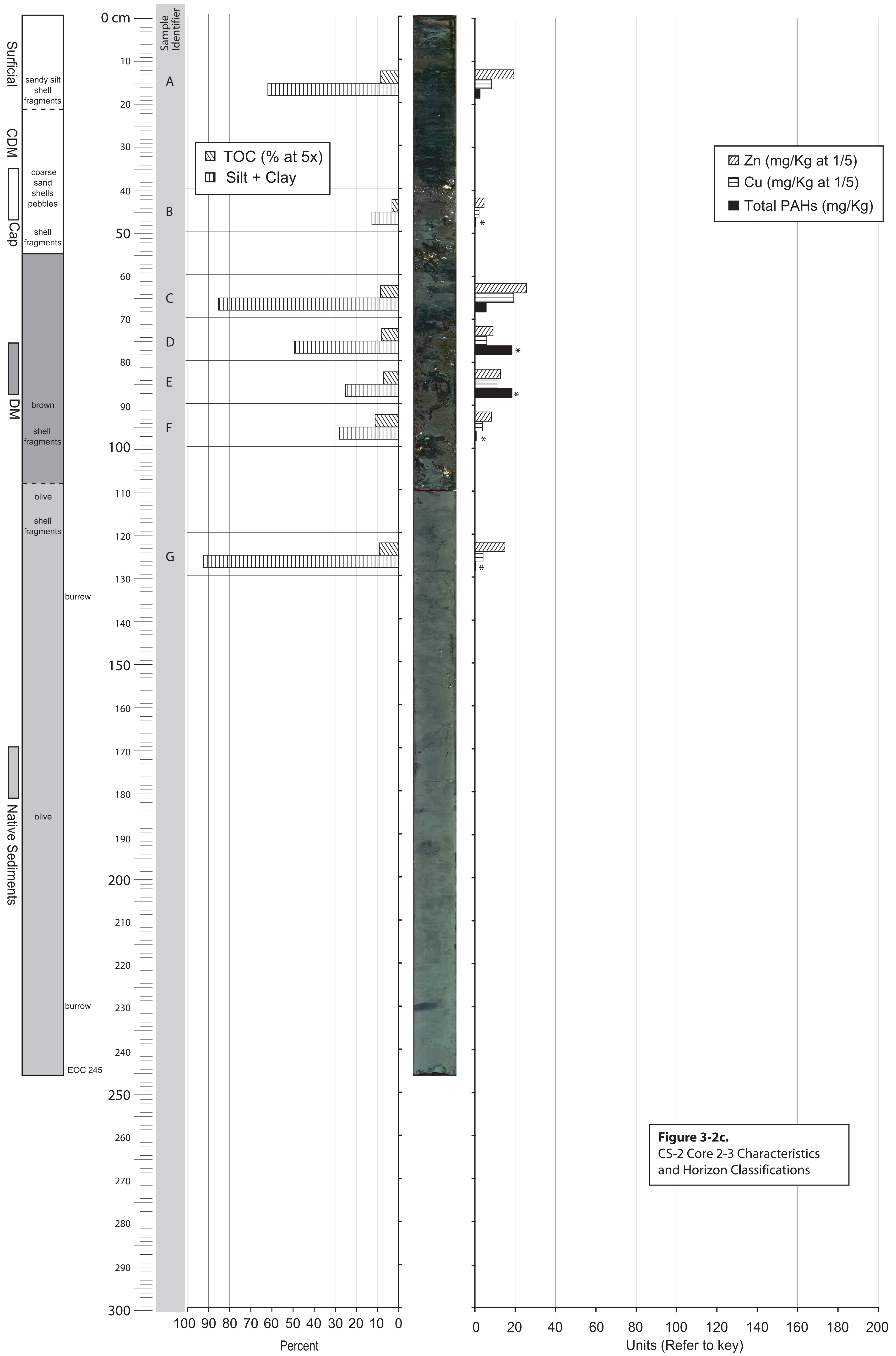


Figure 3-2c.
CS-2 Core 2-3 Characteristics
and Horizon Classifications

* One or more compound ND is included in the PAH sum at 1/2 the RL

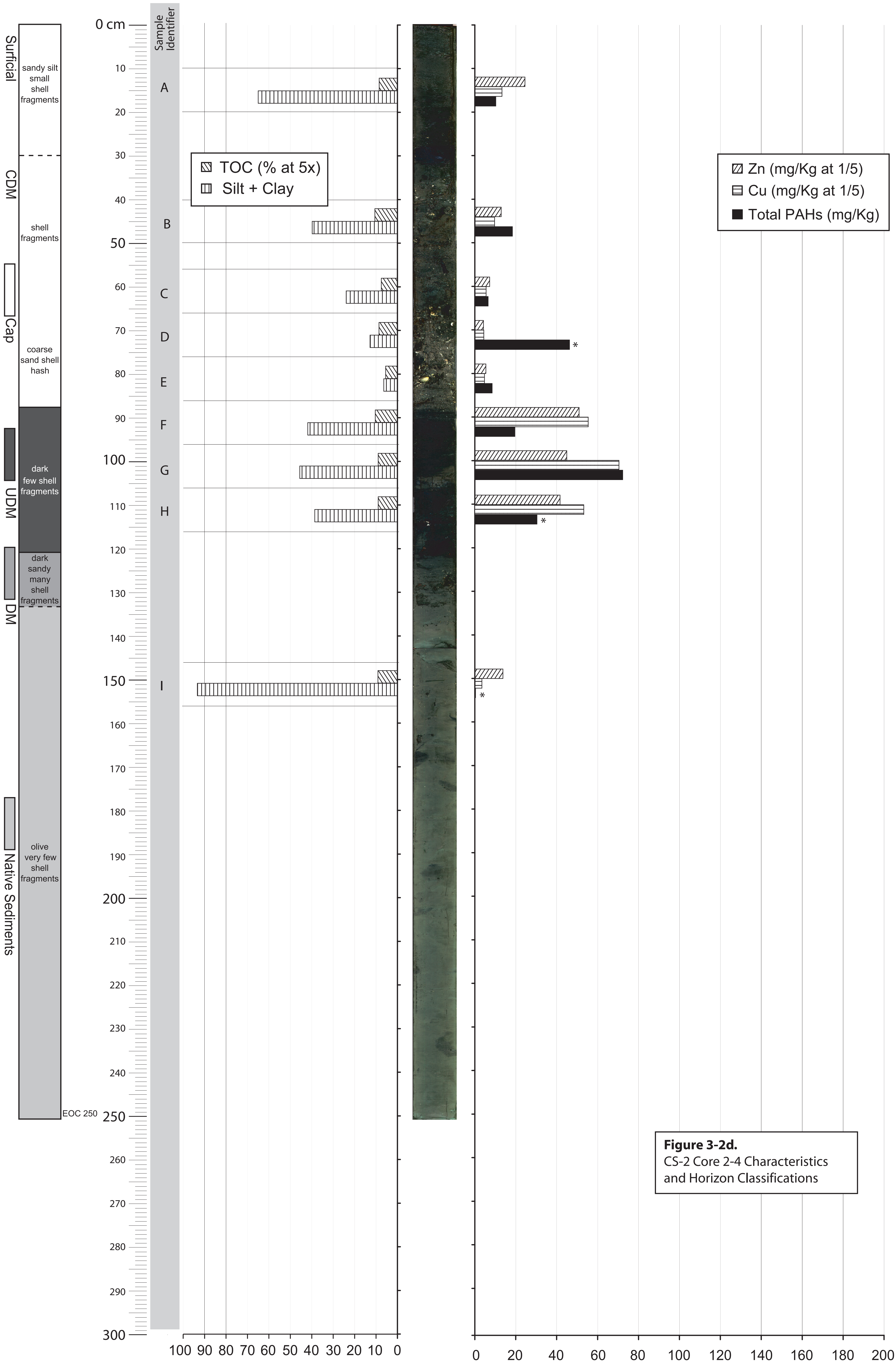


Figure 3-2d.
CS-2 Core 2-4 Characteristics and Horizon Classifications

* One or more compound ND is included in the PAH sum at 1/2 the RL

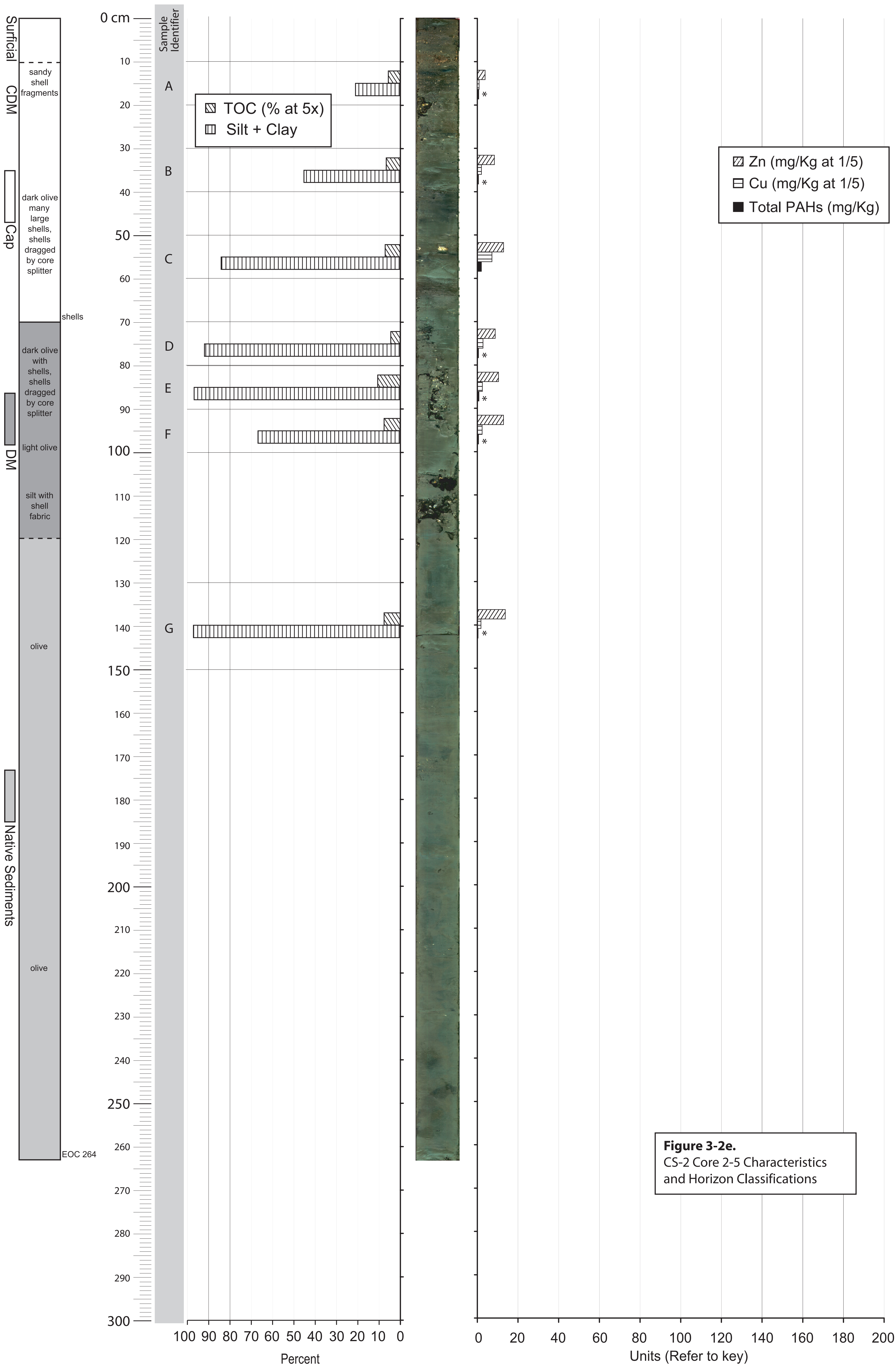


Figure 3-2e.
CS-2 Core 2-5 Characteristics and Horizon Classifications

* One or more compound ND is included in the PAH sum at 1/2 the RL

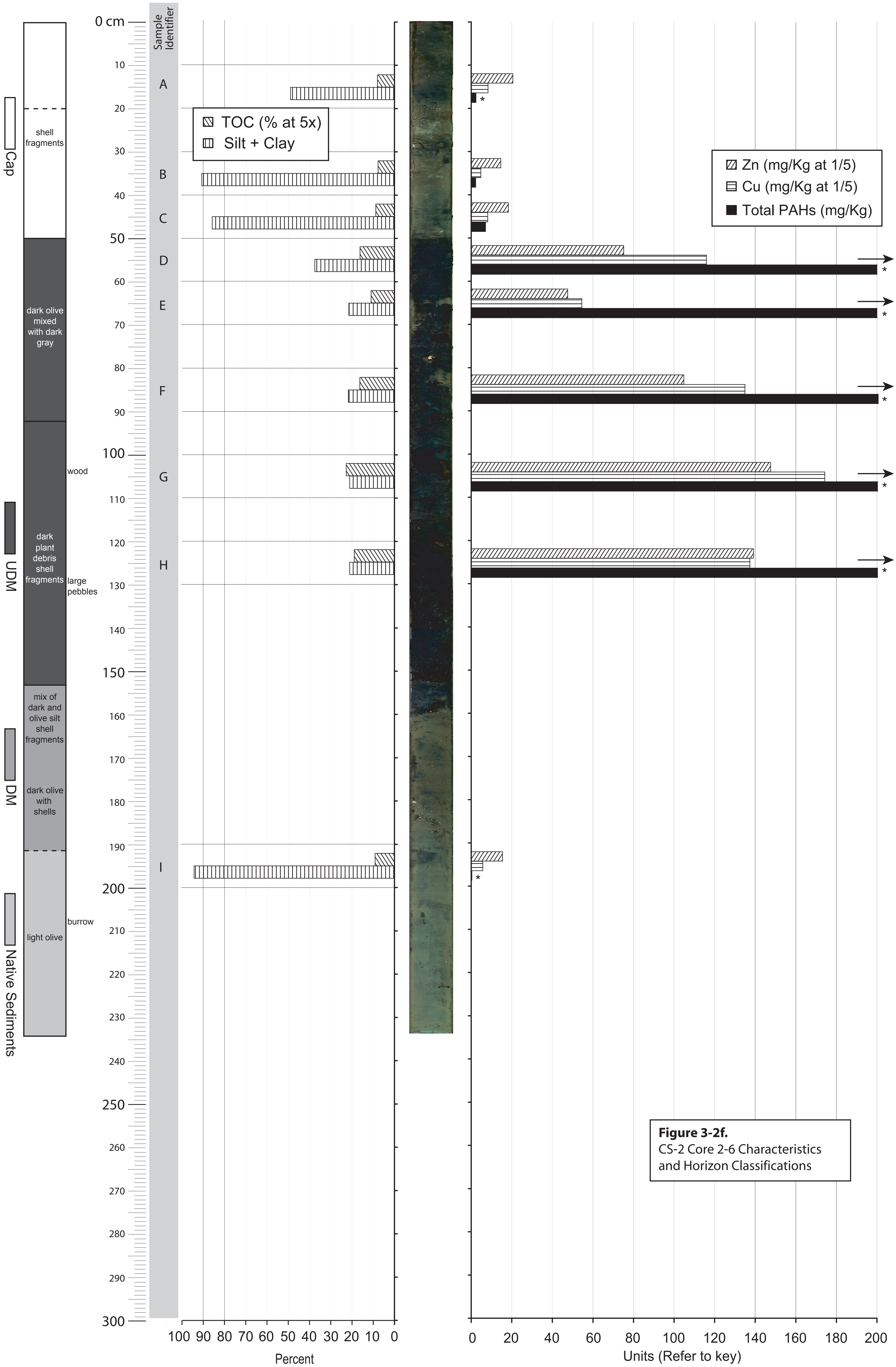


Figure 3-2f.
CS-2 Core 2-6 Characteristics and Horizon Classifications

* One or more compound ND is included in the PAH sum at 1/2 the RL

than 10%, have been amplified by a factor of five to better distinguish sediment concentrations since they are plotted on a scale with percent fines (silt/clay) which often exceed 90%. Copper and zinc values were reduced by a factor of five to plot on the same scale as total PAHs.

Classification of core intervals as surficial sediment, capping dredged material (CDM), mound dredged material (UDM), older dredged material (DM), and native sediment is also presented in Figures 3-1 and 3-2. In order to consistently characterize the upper sediment interval contained in each core, while avoiding what was sometimes a slurry-like material at the very top of the core, the section from 10-20 cm of each core was analyzed. Subsequent sections were selected from various depths within each core; pre-selected depths were not consistently analyzed among all cores to allow investigators the flexibility of capturing unique features within each core and so as to not cross obvious interval boundaries. Based on these observations, some cores were sampled more intensively than others, i.e., a greater number of core sections were selected for analysis (Table 3-1). Summary statistics for the analytical results for samples collected in the each interval are provided in Table 3-4 for STNH-N and Table 3-5 for CS-2.

The results presented in the Tables 3-2 through 3-5 and Figures 3-1 and 3-2 as well as information on texture, coloration, and odor noted during logging of the cores are summarized below in Sections 3.3 and 3.4 for STNH-N and CS-2, respectively. For the purpose of describing sediment textures, the nomenclature developed by Shepard (1954) has been used. For example, material containing 30 percent sand, 30 percent silt, and 40 percent clay is termed "sand, silt, clay" whereas material that is 40 percent silt, 5 percent clay, and 55 percent sand is termed "silty sand". A more detailed description of each core and the associated core logs are presented in Appendix C.

3.1.3 Data Quality

Analytical data quality was assessed according to the *Region I, EPA-NE Data Validation Guidelines for Evaluation of Environmental Analyses* (EPA 1996) and the *USEPA Region I Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses* (EPA 1991). A single data package for each of the measured chemical parameters was subjected to a Tier II validation. Additionally, the quality control criteria specified in the Quality Assurance Project Plan (Appendix A), and the quality assurance and quality control criteria specified in the analytical methods were used to assess the data during the data validation. No significant issues were noted during this data review. A summary of the data review is presented in Appendix B.

Table 3-4.

2004 STNH-N Layer Summary Statistics

Layer	n[1]	Sample IDs	Parameter	Unit (dry)	Average	Minimum	Maximum	Median	Std Dev
Surface	5	1-2(A)	Silt/Clay	percent	78	50	94	81	18
		1-3(A)	TOC	percent	2.7	1.4	4.4	2.9	1.2
		1-4(A)	Total PAHs	mg/kg	4.3	2.3	7.9	3.6	2.4
		1-5(A)	TPH	mg/kg	247	64	540	110	214
		1-6(A)	Cu	mg/kg	78	35	110	94	32
			Zn	mg/kg	144	68	180	179	52
CDM	19	1-1(A, B, C, D)	Silt/Clay	percent	23	2.7	50	21	14
		1-2(B, C, D)	TOC	percent	0.9	0.1	2.3	0.7	0.7
		1-3(B, C, D)	Total PAHs	mg/kg	7.0	0.1	32	3.8	9.6
		1-4(B, C, D)	TPH	mg/kg	399	4.3	2600	51	737
		1-5(B, C, D)	Cu	mg/kg	26	3.3	112	17	29
		1-6(B, C, D)	Zn	mg/kg	47	13	122	39	36
UDM	17	1-1(E, F, G)	Silt/Clay	percent	44	12	84	45	20
		1-2(3, F, G)	TOC	percent	5.7	2.9	11	5.0	2.2
		1-3(E, F, G)	Total PAHs	mg/kg	100	14	317	80	78
		1-4(3, F, G)	TPH	mg/kg	7361	140	18000	7400	4804
		1-5(E, F)	Cu	mg/kg	433	223	780	384	155
		1-6(E, F, G)	Zn	mg/kg	726	294	1220	709	265
Historic DM	9	1-1(H)	Silt/Clay	percent	72	41	96	67	18
		1-2(H, I)	TOC	percent	2.5	1.6	3.0	2.5	0.5
		1-3(H, I)	Total PAHs	mg/kg	11	1.4	36	6.0	11
		1-5(G)	TPH	mg/kg	1275	68	5100	490	1680
		1-6(H, I, J)	Cu	mg/kg	157	26	282	143	92
			Zn	mg/kg	246	88	450	172	137
Native Sediment	2	1-4(H)	Silt/Clay	percent	91	-	-	-	9.1
		1-5(H)	TOC	percent	2.0	-	-	-	0.9
			Total PAHs	mg/kg	3.9	-	-	-	5.2
			TPH	mg/kg	106	-	-	-	133
			Cu	mg/kg	62	-	-	-	73
			Zn	mg/kg	122	-	-	-	88

[1]n=the sample quantity included in the layer statistics

Table 3-5.

2004 CS-2 Layer Summary Statistics

Layer	n[1]	Sample IDs	Parameter	Unit (dry)	Average	Minimum	Maximum	Median	Std Dev
Surface	6	2-1(A)	Silt/Clay	percent	49	21	65	49	16
		2-2(A)	TOC	percent	1.4	1.1	1.8	1.4	0.3
		2-3(A)	Total PAHs	mg/kg	3.6	0.4	10	2.5	3.6
		2-4(A)	TPH	mg/kg	432	25	2200	91	867
		2-5(A)	Cu	mg/kg	38	8.4	68	39	19
		2-6(A)	Zn	mg/kg	84	22	124	89	35
CDM	14	2-1(B, C)	Silt/Clay	percent	34	2.8	91	22	31
		2-2(B, C, D)	TOC	percent	1.4	0.6	2.7	1.4	0.6
		2-3(B)	Total PAHs	mg/kg	8	0.2	46	5	12
		2-4(B, C, D, E)	TPH	mg/kg	124	22	390	69	117
		2-5(B, C)	Cu	mg/kg	34	4.7	123	26	32
		2-6(B, C)	Zn	mg/kg	48	9.9	99	41	30
UDM	17	2-1(D, E, F, G, H)	Silt/Clay	percent	44	21	94	43	21
		2-2(E, F, G, H)	TOC	percent	3.4	0.8	8.6	2.8	1.9
		2-4(F, G, H)	Total PAHs	mg/kg	206	0.4	520	150	192
		2-6(D, E, F, G, H)	TPH	mg/kg	5194	31	20000	2000	6363
			Cu	mg/kg	763	11	3210	536	809
			Zn	mg/kg	478	29	1370	344	366
Historic DM	7	2-3(C, D, E, F)	Silt/Clay	percent	63	25	97	67	30
		2-5(D, E, F)	TOC	percent	1.7	0.9	2.2	1.6	0.5
			Total PAHs	mg/kg	6.6	0.5	19	1.0	8.6
			TPH	mg/kg	118	25	390	87	128
			Cu	mg/kg	36	13	97	19	31
			Zn	mg/kg	64	42	128	55	30
Native Sediment	6	2-1(I)	Silt/Clay	percent	85	45	97	93	20
		2-2(I)	TOC	percent	1.9	1.5	2.8	1.8	0.5
		2-3(g)	Total PAHs	mg/kg	1.5	0.2	7.3	0.4	2.8
		2-4(I)	TPH	mg/kg	92	20	370	39	137
		2-5(G)	Cu	mg/kg	34	11	116	18	41
		2-6(I)	Zn	mg/kg	91	65	190	73	49

[1]n=the sample quantity included in the layer statistics

3.2 Stamford-New Haven North

3.2.1 Physical Characteristics and Observations

Distinct and consistent strata were observed in the six cores from STNH-N. A dark, fine-grained surface layer was observed at the top of all the cores. This layer ranged from approximately 20 to 30 cm in thickness, with up to 94% fines and TOC ranging from 1.4 to 4.4%. Core 1-1, collected on the upper portion of the mound was the exception, where the upper fine-grained layer appeared less than 10 cm in thickness and was not captured in the first sampling interval.

The dark, fine-grained surface layer graded into an interval of much lighter and coarser grained material, assumed to be the New Haven CDM placed at the site. This interval ranged in thickness from approximately 50 cm for the cores located closer to the mound edge (Cores 1-4, 1-5) to over 100 cm near the top of the mound (Core 1-1). This interval was quite variable in appearance with numerous shells, shell hash, and pockets of fine material. Three 10-cm sections were sampled in this interval for most cores. Sand was the dominant grain size, with the sand and shell fraction generally over 70%. TOC was low, ranging from 0.1 to 2.3% with a median of 0.7%.

Beneath the lighter colored, coarse-grained material there was a sharp transition to a very dark gray-black silt and sand which gave off a strong petroleum odor in four cores. This interval ranged in thickness from approximately 20 to 80 cm and was assumed to be the Stamford Harbor UDM placed at the site. The dark sand and silt was interspersed with pockets of gravel and shell and occasionally interlayered with lighter olive silt. Two or three 10-cm sections were sampled in this interval for each core. Silt and clay content ranged from 12 to 84%, with a median of 45%. Samples from this interval consistently had the highest TOC of each core, ranging from 2.9 to 11%, with a median of 5.0%.

The dark UDM horizon was underlain by a layer that was predominantly a lighter olive silt and clay but had pockets of sand and gravel as well as shell and wood fragments. Some layering of darker material was apparent, as were some irregular contact angles between sediment types. The mixed properties and disturbed nature of this material indicated older dredged material disposed at the site prior to the STNH-N mound formation. One or two 10-cm sections were sampled in this interval for most cores. In addition to the lighter color and texture change, analysis revealed that this interval was further distinguished from the overlying UDM by moderate TOC content, ranging from 1.6 to 3%. This older dredged material interval ranged in thickness from approximately

10 cm at Core 1-4 on the outer flank of the mound to >100 cm at Core 1-1 (interval extended to the bottom of the core).

In four cores, layers of what appeared to be native Long Island Sound sediments were identified below the older dredged material. This material was generally logged as a light olive clay silt. A distinctive thin sand lens was embedded within the silt in three of the cores. There appeared to be a gradation from the overlying older dredged material to the native sediment rather than a sharp transition. The two samples collected from this interval had very high silt and clay content (85-98%) and lower TOC (1.3-2.6%).

3.2.2 Sediment Chemistry

Although sediment chemistry profiles for the STNH-N cores varied significantly with depth, there was strong consistency within the strata identified by the physical characteristics noted above. For the dark, fine-grained surface layer, zinc concentrations ranged from 68 to 180 mg/kg, with a median of 179 mg/kg. Copper concentrations ranged from 35 to 110 mg/kg, with a median of 74.9 mg/kg. TPH concentrations were more variable and ranged from 64 to 540 mg/kg, with a median of 110 mg/kg. Total PAH concentrations ranged from 2.3 to 7.9 mg/kg, with a median of 3.6 mg/kg.

Concentrations of all constituents were generally lower in the coarse-grained CDM interval, although similar to the physical characteristics, there was a larger degree of variability within this interval. Zinc concentrations ranged from 13 to 122 mg/kg, with a median of 39 mg/kg. Copper concentrations ranged from 3 to 112 mg/kg, with a median of 17 mg/kg. TPH concentrations ranged from 4 to 2600 mg/kg. Most values were at the low end of this range, and the median was 51 mg/L. Total PAH concentrations ranged from 0.1 to 32 mg/kg. Again, most values were at the low end, and the median was 3.8 mg/kg.

Highest concentrations for all constituents were found in the dark UDM interval. Zinc concentrations ranged from 294 to 1220 mg/kg, with a median of 709 mg/kg. Copper concentrations ranged from 223 to 780 mg/kg, with a median of 384 mg/kg. TPH concentrations ranged quite widely from 140 to 18,000 mg/kg (nearly 2%), with a median of 7400 mg/kg, contributing to the strong odor noted in some samples. Total PAH concentrations also varied widely, ranging from 14 to 317 mg/kg, with a median of 80 mg/kg.

In the assumed historic dredged material beneath the UDM, concentrations of all constituents were much lower than in the UDM, with zinc concentrations ranging from 88 to 450 mg/kg, and copper concentrations ranging from 26 to 282 mg/kg. TPH continued to vary widely, ranging from 68 to 5100 mg/kg. Total PAH were also lower than the UDM, ranging from 1.4 to 36 mg/kg.

Only two samples were analyzed from what was logged as the native Long Island Sound sediments. One sample collected near the bottom of Core 1-5 had very low concentrations of all constituents (1-5(H) in Table 3-2). The other sample collected in the lower half of Core 1-4 (1-4(H) in Table 3-2) had constituent concentrations similar to those found in the overlying historic dredged material and may have been collected from a transition zone between the two intervals.

3.2.3 Mound Sediment Classification Summary

The Stamford Harbor UDM was identified as a distinct interval in all six cores collected at STNH-N. A minimum UDM thickness of approximately 20 cm was found in Core 1-5, collected near the edge of the original mapped mound. The thickness of the UDM interval increased in cores collected farther up the mound, with a maximum of approximately 80 cm in Cores 1-4 and 1-6. Although the UDM was generally dark in appearance and contained elevated contaminant concentrations, there was some variability both between and within individual cores. This variability is best characterized in the field replicate Cores 1-3 and 1-6, collected within several meters of each other. The overall thickness of the UDM interval was similar for the two cores, but in Core 1-6, the interval contained a much larger component of a lighter olive silt (Figures 3-1c and 3-1f).

Above the UDM, there was a sharp transition to the overlying cap in all cores. The cap consisted of distinct, coarse-grained CDM directly above the UDM with a surficial interval of finer-grained material worked into the CDM. The overall cap thickness ranged from approximately 80 cm on the mound flank to nearly 150 cm near the top of the mound.

Lighter colored material with increased fines and occasional shells and gravel was found beneath the UDM in all six cores. Given the disturbed nature of this sediment and slightly elevated contaminant levels, it was considered to be older dredged material historically disposed at the site prior to STNH-N mound formation. A gradual transition to apparent native Long Island Sound sediments was noted beneath the older dredged material in four cores. The native material consisted of a relatively uniform olive to gray silt, with occasional imbedded coarser horizons.

3.3 Cap Site 2

3.3.1 Physical Characteristics and Observations

Distinct vertical strata were observed in the six cores from CS-2. However, consistency of these strata among cores was not as strong as for STNH-N. The surficial interval was typically dark olive-gray with a nearly even sand-silt content. TOC for the 10-20 cm interval was low, ranging from 1.1 to 1.7%. This sand and silt surficial interval extended to 30 to 40 cm in all cores except Core 2-5 where surficial sediments were coarser.

In four cores (2-1, 2-2, 2-3, 2-4) the surficial interval was underlain by a sharp transition to coarser material with shells and shell hash, ranging from 20 to 50 cm in thickness. Cores 2-5 and 2-6 transitioned to finer, lighter colored material beneath the surficial interval. This finer material was approximately 40 cm thick with imbedded shells in Core 2-5 and was approximately 20 cm thick in Core 2-6. All of this material was classified as CDM, with the variability in grain size consistent with the source of the cap material (New Haven) and method of removal (mechanical dredging). Two 10-cm sections were sampled in this CDM interval for most cores, with a median sand and shell fraction of 78% and median TOC of 1.4%.

Beneath the varied CDM, there was a sharp transition to a very dark mixture of silty sand and sandy silt in four cores (2-1, 2-2, 2-4, 2-6). This interval contained some horizons of lighter olive silt, and a strong petroleum odor was noted in two cores. This interval ranged in thickness from approximately 35 to 100 cm and was assumed to be the Black Rock Harbor UDM placed at the site. Three or four 10-cm sections were sampled in this UDM interval in each core. Silt and clay content ranged from 21 to 94%, with a median of 43%. TOC was lowest (0.8% minimum) in the lighter horizons and highest (8.6%) in the darker sections, with a median of 2.8%.

The UDM interval was not apparent in two cores (2-3, 2-5). In these cores the CDM transitioned to a chaotic mixture of silt, sand, and shells that was lighter in color than the UDM and assumed to be older dredged material disposed at the site prior to the CS-2 mound formation. This interval was approximately 50 cm in length in both cores. A total of seven 10-cm sections were sampled in this interval for the two cores. Silt and clay content ranged from 25 to 97%, with a median of 67%. TOC was low, ranging from 0.9 to 2.2%. This older dredged material was apparent beneath the UDM in the other four cores, ranging in thickness from approximately 15 to 35 cm.

In all six cores, native Long Island Sound sediments were apparent below the older dredged material. Similar to the STNH-N cores, this material was generally logged as a light olive clay silt, but evidence of episodic deposition of coarser sediments was not as apparent beneath CS-2. In general, the exact boundary between the older dredged material and underlying native material was difficult to discern, with a gradual transition from the disturbed and heterogeneous older dredged material to the more uniform native material below. One 10-cm interval was sampled within this interval for each core. Silt and clay content was over 90% for all but one sample, and TOC ranged from 1.5 to 2.8%.

3.3.2 Sediment Chemistry

Similar to STNH-N, sediment chemistry profiles varied significantly with depth for the CS-2 cores but displayed consistency within the strata identified by the physical characteristics noted above. For the dark, sand and silt surface layer, zinc and copper concentrations were low, with medians of 78 and 34 mg/kg, respectively. TPH concentrations were more variable and ranged from 29 to 2200 mg/kg, with a median of 62 mg/kg. Total PAH concentrations were low, with a median of 1.8 mg/kg.

Concentrations of all constituents in the varied CDM interval were generally similar to the surface interval. The median zinc concentration was 41mg/kg, and the median copper concentration was 26 mg/kg. TPH concentrations ranged from 22 to 390 mg/kg, with a median of 69 mg/kg, and the median total PAH was 4.5 mg/kg.

Similar to the STNH-N cores, highest concentrations for all constituents were found in the dark UDM interval in CS-2 cores, although there was a greater degree of variability. Zinc concentrations ranged from 29 to 1370 mg/kg, with a median of 344 mg/kg. Copper concentrations ranged from 11 to 3210 mg/kg, with a median of 536 mg/kg. TPH concentrations ranged quite widely from 31 to 20,000 mg/kg, with a median of 2000 mg/kg, contributing to the strong odor noted in some samples. Total PAH concentrations also varied widely, ranging from <0.1 to 515 mg/kg, with a median of 147 mg/kg.

Relative to the UDM described above, concentrations of all constituents were much lower in the assumed historic dredged material that was found in Cores 2-3 and 2-5. Median zinc and copper concentrations were 55 and 19 mg/kg, respectively. TPH varied over a smaller range, from 25 to 390 mg/kg. Total PAH concentrations were also lower than the UDM, ranging from 0.5 to 19 mg/kg.

Of the six samples analyzed from what was logged as the native Long Island Sound sediments, five had generally low concentrations of all constituents. One sample collected near the bottom of Core 2-2 (sample 2-2(I) in Table 3-3) had constituent concentrations similar to those found in the overlying historic dredged material and may have been collected from a transition zone between the two intervals.

3.3.3 Mound Sediment Classification Summary

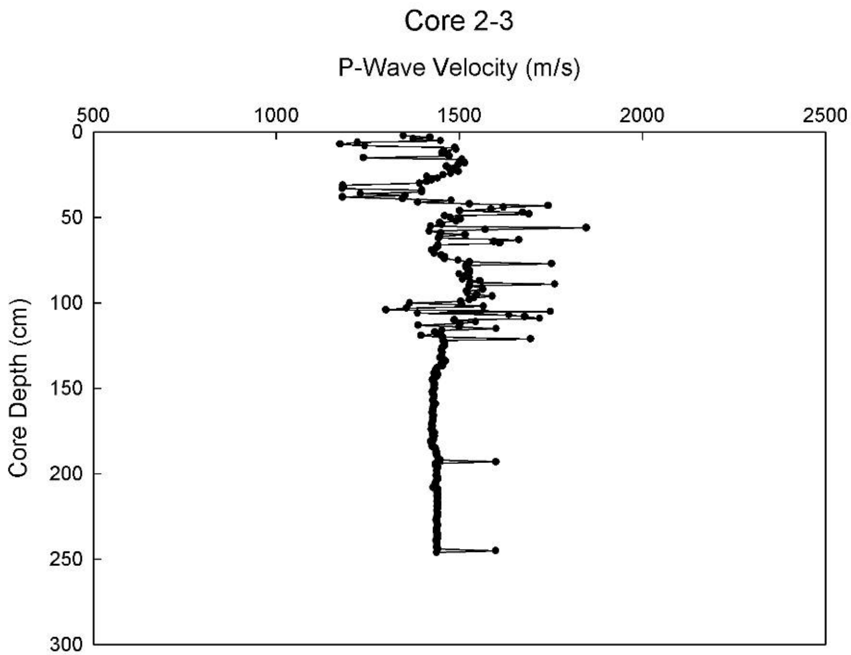
The Black Rock Harbor UDM was identified as a distinct interval in four cores collected closer to the top of the CS-2 mound, with thicknesses ranging from approximately 35 to 100 cm. Although the UDM was generally dark in appearance and contained elevated contaminant concentrations, there was some interlayering of lighter, finer-grained, and less contaminated material.

Above the UDM, there was a sharp transition to the overlying cap in all four of the cores. The cap consisted of CDM with variable appearance and grain size directly above the UDM with a more uniform surficial interval of finer-grained material worked into the CDM. The variable nature of the CDM was highlighted by the replicate cores collected at CS-2. Core 2-2 had the greatest overall cap thickness (approximately 90 cm) with an extended sequence of coarse-grained material (Figure 3-2b). Replicate Core 2-6, collected several meters away had the least overall cap thickness (approximately 50 cm) with very limited coarse-grained material (Figure 3-2f).

Cap material was also present at the two cores with no identified UDM interval. Beneath the cap material, both cores had an approximately 50-cm thick interval of heterogeneous and/or disturbed material that was apparently older dredged material historically disposed at the site prior to CS-2 mound formation. Shorter sequences of this older dredged material were apparent beneath the UDM at the other four cores. A gradual transition to apparent native Long Island Sound sediments was noted beneath the older dredged material in all six cores. Similar to STNH-N, the native material consisted of a relatively uniform olive to gray silt, but with limited imbedded coarser material.

3.4 P-Wave

P-Wave velocity measurements were made in two of the cores collected during the 2004 survey (Figure 3-3). Sharp excursions in the profile should be discounted as measurement noise and/or error, but the underlying p-wave variability measured in upper layers was indicative of heterogeneous sediment mixtures and consistent with general CDM and UDM characteristics. Below the 120 cm core depth of Core 2-3, p-wave measurements were very uniform which was consistent with the uniformly fine-grained, olive colored sediment observed in this region of the core.



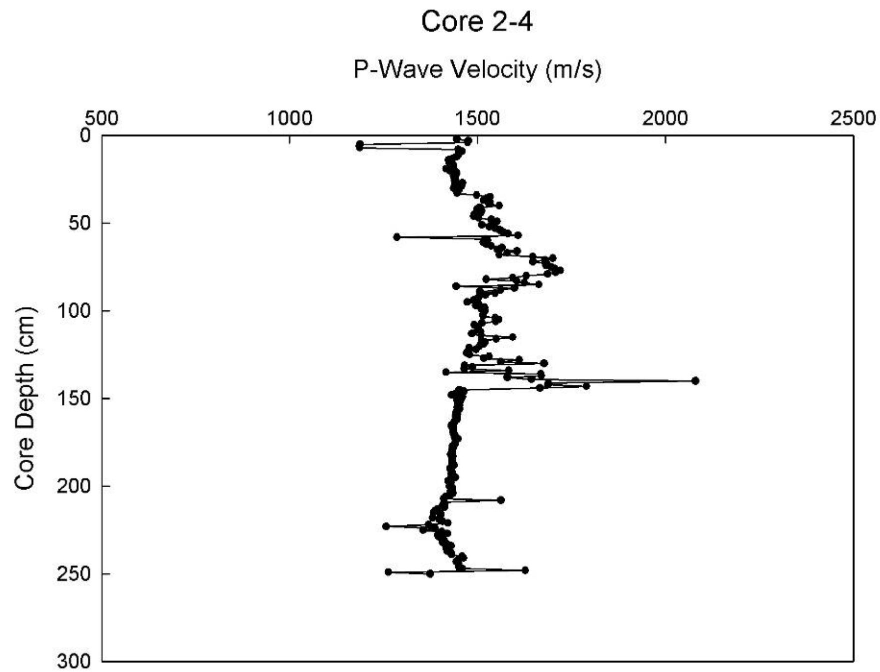


Figure 3-3. P-wave velocity profiles from Cores 2-3 and 2-4

P-Wave measurements made within Core 2-4 were also variable in upper layers, although increasing overall within the CDM layer with depth as the material became coarser to about 85 cm. This was followed by a decrease in velocity within the 85 to 135 cm horizon. Below this depth, p-wave measurements increased dramatically within a relatively short interval, which may have been the result of an increase in core liner thickness. The thicker core liner is expected in this area since the core was cut laterally at about 142 cm and contained a plastic end cap.

Below about 150 cm, the p-wave measurements were very uniform with few exceptions throughout the remaining core length, consistent with the uniform, fine-grained sediment character observed in that region of the core.

4.0 DISCUSSION

The STNH-N and CS-2 capped mounds at CLDS are among the earliest engineered open-water caps. As such, they have been studied periodically to assess the long-term stability of this dredged material management technique. There are two sets of processes governing the movement of contaminants within buried sediments and into to overlying waters where they might be available to the ecosystem. Physical processes, such as scouring of bottom sediments by tidal or storm-related currents, disturbance by trawling, or mixing resulting from burrowing of organisms, can cause redistribution of sediments. This is of potential concern for capped mound settings where the sediment redistribution could result in UDM at or near the sediment-water interface. Chemical processes, such as dissolution of contaminants into surrounding pore water, can allow previously sediment-bound contaminants to move into the pore space of the sediment. If pore waters can actively exchange with near-surface pore water or overlying water, contaminants might become available to biota. This type of pore water exchange process has been shown to be virtually non-existent for a capped mound setting where there is no mechanism for active flux of water through the mound, such as exists at STNH-N and CS-2 (Murray et al. 1994).

Previous investigations have shown both the STNH-N and CS-2 mounds to be stable, with no evidence of physical disturbance of mound components or chemical migration (Fredette et al. 1992). The May 2004 coring investigation was designed to provide additional assurance of mound stability 20+ years after formation of the STNH-N and CS-2 mounds with the following objectives:

- Compare the physical distribution of sediment intervals within the cores with expected values based on core location on the mound and on previous data to assess the physical integrity of the caps.

- Compare the chemical profiles within the cores to previous data to assess the maintenance of chemical isolation of contaminants within the UDM interval.

To provide a context for discussing STNH-N and CS-2 mound physical condition and chemical profiles, a review of the formation of the mounds is presented in Section 4.1. Maps of mound configuration, generated as part of the original mound construction, were used to select coring locations in the May 2004 study and as a context to evaluate the resulting data. The mound horizons and chemical profiles delineated in Section 3 were evaluated as an independent data set and compared with historical data to address the above objectives. These data also allowed addressing an ancillary objective, identifying mound variability over a short (meters) distance scale.

4.1 Review of Mound Formation

The distribution and characteristics of sediment at each capped mound represent the net product of a series of events, both natural and anthropogenic. Some of these events took many years (e.g., natural deposition of fine-grained sediment), and others were completed within a single day (e.g., disposal of a barge load). Natural transport and accumulation of sediments occur throughout Long Island Sound and would have occurred before, during, and after discrete dredged material disposal events. Disposal of dredged material in the vicinity of CLDS took place throughout much of the twentieth century, prior to detailed record keeping of dredging and disposal activities. Hence, the presence of historic dredged material from a number of potential sources was expected in the vicinity of both cap sites. The disposal events for the STNH-N and CS-2 capping projects were grouped around taut-wire moored buoys or specified disposal targets, and the dates, sources, and volumes of disposed material are reasonably well-known. Subsequent deposition and reworking of surface material is assumed to have occurred following the completion of disposal activity (1979 for STNH-N and 1983 for CS-2) until the present. Recently, during the 2003-2004 season, disposal at the CDA03 buoy, located approximately 300 m to the southwest of the STNH-N mound, could have resulted in accumulation of dredged material on top of the cap.

For interpretation and discussion, the depositional stratigraphy identified in the 2004 cores was grouped into presumed horizons: base material of native Long Island Sound sediment, older dredged material (DM) with unknown source characteristics, dredged material unsuitable for unconfined open ocean disposal (UDM), capping dredged material (CDM) placed at the sites to sequester the contaminated UDM, and surface sediment representing recent deposition and reworked upper CDM. Our knowledge of the characteristics and distribution of material in each of these horizons is uneven given the lack of records for the historic DM and given the heterogeneous nature of the UDM and CDM, which were collected from several harbors, depths, and locations and deposited in bulk on the seafloor over existing historical deposits. The following provides a review of the chronology of mound formation and the known characteristics of materials used in the two capping projects.

4.1.1 STNH-N History

The Stamford-New Haven project was the first planned open water capping operation performed in the United States. The seafloor of the area was surveyed prior to mound development to establish depths across the intended site (SAI 1979a). The seafloor had some irregular topography, likely the result of historical disposal, but the preplacement surveys were not designed to document the older dredged material. Development and capping of the STNH-N mound was performed in 1979 and is summarized below.

UDM Placement – Approximately 31,000 m^3 of UDM was deposited at a taut-wire marker buoy at STNH-N in April-June 1979. The material was mechanically dredged from Stamford Harbor and transported and disposed at STNH-N using split-hulled barges. Pre-dredging sediment sampling characterized this UDM as predominantly silts and clays with elevated levels of oil and grease, volatile organics, and metals.

Following placement of the UDM, a bathymetric survey revealed a well-defined mound rising approximately 2 m off the bottom with some elongation of the peak to the southwest and a more extensive mound apron extending to the east and southeast (Figure 4-1 from SAI 1979d). Comparison of the post-disposal survey results with the pre-disposal bathymetry allowed for mapping of the UDM thickness (Figure 4-1). Note that the outer 20-cm contour in the figure has been dashed given the presumed accuracy of the bathymetry measurements in 1979. Diver and grab sampling surveys identified the mound surface as gray cohesive clay clumps 20-30 cm in diameter scattered within a matrix of black oily silt and watery clay (SAI 1979d,e). These surveys provided a more reliable assessment of the full extent of the mound. The black silty material was spread as a thin layer over oxidized sediment at the margin of the mound. The apron of UDM rapidly thinned from approximately 50 cm thick at the mound margin to 3-6 cm thick at a distance of 50 m and to 1-3 cm thick at a distance of 100 m beyond the mound margin (SAI 1979d).

CDM Placement – Following placement of the UDM, approximately 112,000 m^3 of coarse-grained CDM was deposited over the STNH-N mound in June 1979. The material was hydraulically dredged from the mouth of New Haven Harbor and transported and disposed at STNH-N using a hopper dredge. The CDM was not analyzed for chemistry but was characterized as a silty, clayey, fine-medium sand with shell fragments (Fredette et al. 1992). Approximately 65,000 m^3 of the CDM was placed near the center of the mound, and the remainder was placed within a band approximately 100 to 300 m from the mound center. Comparison of a bathymetric survey performed after cap placement with the pre-cap survey indicated an estimated cap thickness of 1-2 m over the majority of the mound (Figure 4-2).

Comparison of the bathymetry survey performed following STNH-N formation (SAI 1979e) with a follow-up survey performed 12 years later (Silva et al. 1991) revealed that the overall morphology of the mound remained the same, but that the height above

Figure 4-1. Composite depth difference map of UDM at STNH-N based on the bathymetric surveys conducted on March 22 and May 21, 1979 (SAI 1979d) with 2004 core locations indicated

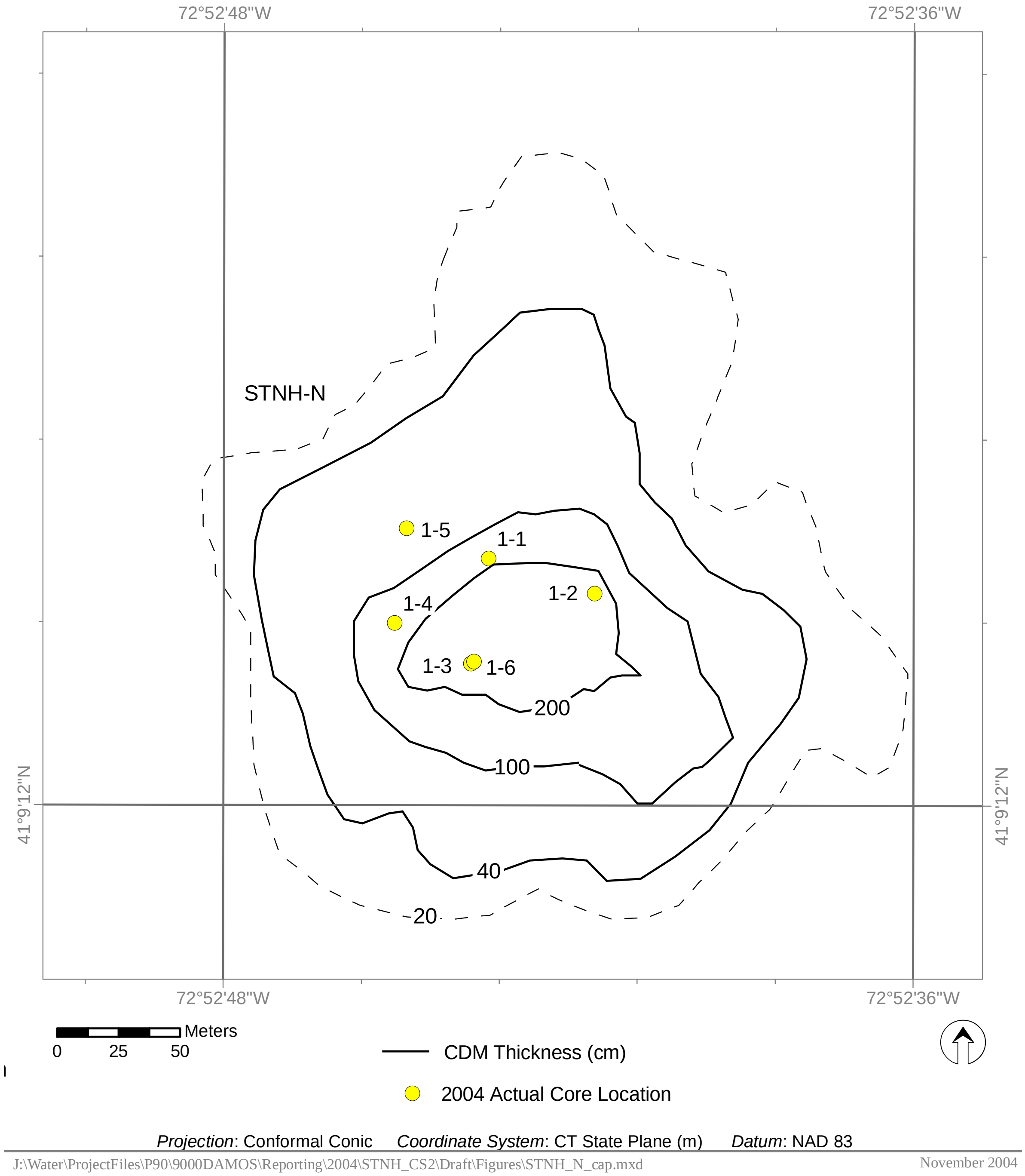


Figure 4-2. Composite depth difference map of CDM at STNH-N based on the bathymetric surveys conducted on May 21 and June 19, 1979 and interpolation of bathymetric survey on June 22, 1979 (SAI 1979e) with 2004 core locations indicated

the seafloor was reduced by approximately 1 m. Given that cores recovered from the mound during the 1990 survey revealed an intact cap layer, the reduction in mound height was attributed to consolidation of mound components and the underlying seafloor (Silva et al. 1991, Fredette et al. 1992, Silva et al. 1994). The results of a 2000 bathymetric survey (SAIC 2002) are presented in Figure 4-3 along with overlays of the previously mapped primary UDM mound extent and CDM cap thickness. This survey, performed 21 years after the formation of STNH-N, is similar to the 1991 survey; the mound retained its original morphology of a nearly 2 m rise above the surrounding seafloor.

4.1.2 CS-2 History

The CS-2 mound was formed in 1983, four years after STNH-N, as part of an extensively monitored follow-up capping study. Baseline surveys at CS-2 prior to mound formation included bathymetry, sediment-profile imaging (SPI), side-scan sonar, and diver observations. The bathymetric survey indicated complex topography with relief of approximately 1 m and apparent coarse dredged material in the northeast portion of the survey area (Morton 1983). SPI survey data indicated habitat disturbance at several stations on the eastern margin of the survey area (200 and 400 m east of the disposal buoy) consistent with older dredged material. Diver surveys conducted near the center of the site reported a cohesive oxygenated silt with very few shell fragments and no evidence of recent dredged material disposal (Morton et al. 1984). The side-scan survey revealed large patches of high reflectance material consistent with older dredged material deposits in the eastern portion of the survey area (Morton et al. 1984). Development and capping of the CS-2 mound was performed in 1983 and is summarized below.

<u>UDM Placement</u> – Approximately 30,000 m^3 of UDM was placed at CS-2 in April 1983. The material was mechanically dredged from Reach 1 in Black Rock Harbor and transported and disposed at CS-2 using split-hulled barges (Morton et al. 1984). Pre-dredging sampling characterized the Black Rock material as highly contaminated with both organic and inorganic compounds, including oil and grease, PAH, copper, and zinc (Rogerson et al. 1985 and Fredette et al. 1992).

Following UDM placement, a bathymetric survey documented the presence of an elliptical shallow mound, approximately 200 m east-west and 100 m north-south with a maximum elevation of 1 m above the surrounding sea floor (Figure 4-4 from Morton et al. 1984). This mound contrasted with the initial UDM deposit at STNH-N (which had a similar volume of UDM) with a lower height and broader dimensions indicating that the Black Rock material was less cohesive than Stamford Harbor material, and tended to

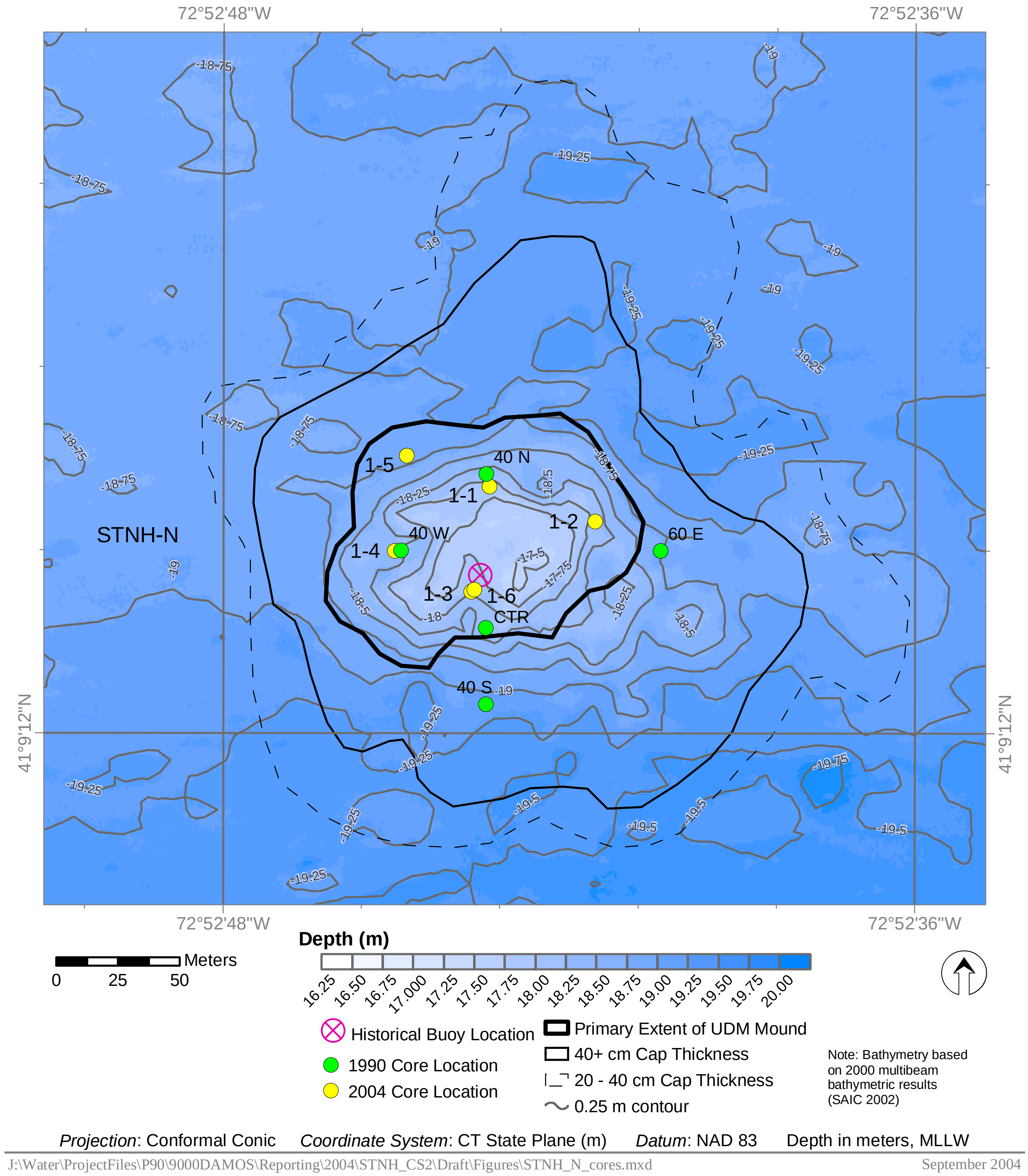


Figure 4-3. Recent STNH-N bathymetric contour map showing 1990 and 2004 coring locations

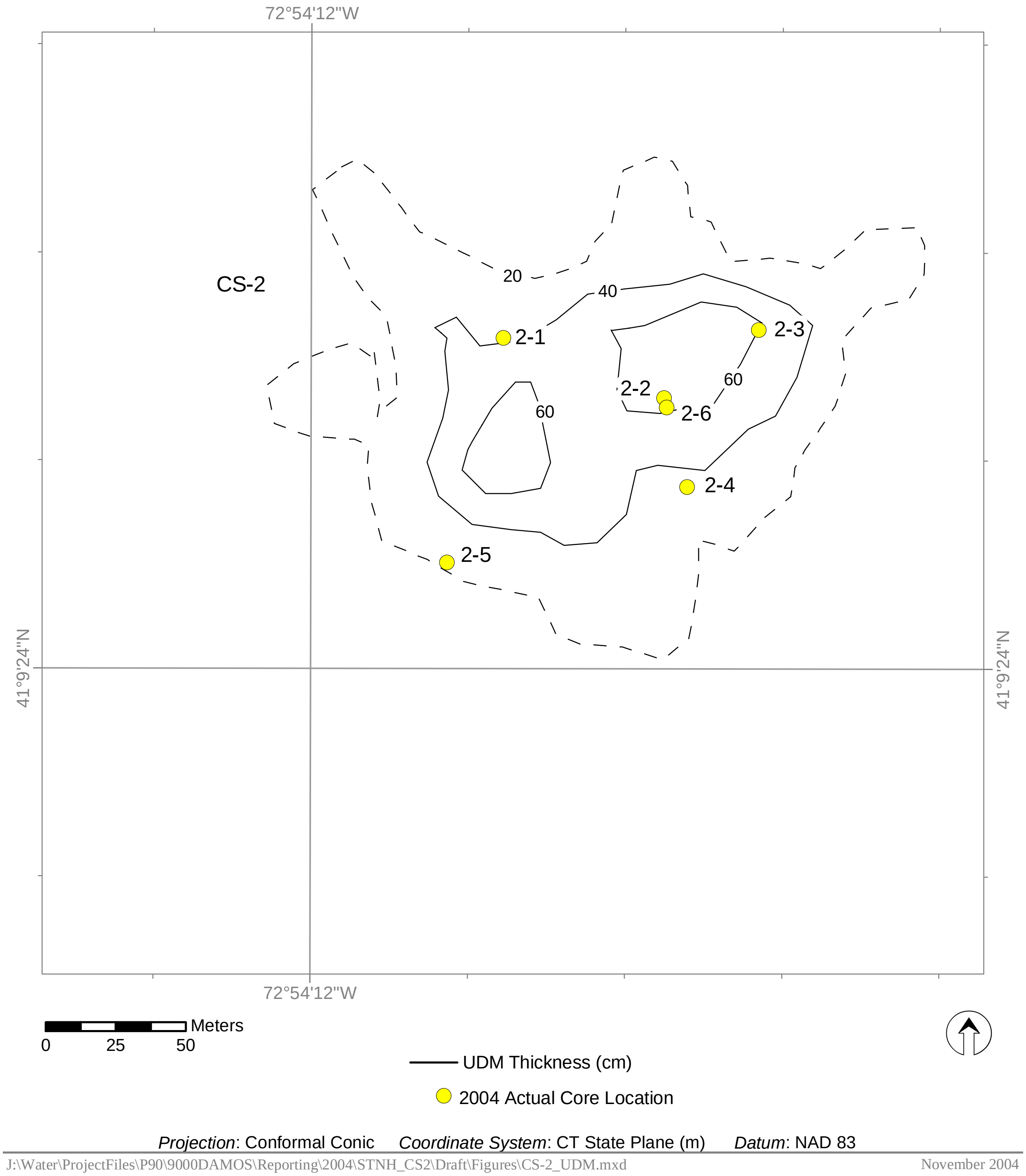


Figure 4-4. Composite depth difference map of UDM thickness at CS-2 based on the bathymetric surveys conducted on April 7 and 28, 1979 (Morton et al. 1984) with 2004 core locations indicated

spread out more following placement on the sea floor. Diver observations and a side-scan sonar survey noted a flat deposit of dredged material with clay clumps, wood fragments, shells and coarse-grained material centered on the disposal buoy. Following characterization of the CS-2 UDM mound, an additional 8000 m^3 of material from Reach 3 in Black Rock Harbor was placed at CS-2 in May 1983.

CDM Placement – Following placement of the UDM, approximately 42,000 m^3 of coarse-grained CDM was deposited over the CS-2 mound in May-June 1983. The material was mechanically dredged from outside the New Haven Harbor breakwater and transported and disposed at CS-2 using split-hulled barges. The material was characterized as dark grey coarse sand (Fredette et al. 1992). A bathymetric survey conducted to assess the distribution of CDM over CS-2 indicated that most of the capping material was placed south and west of the disposal buoy, while the UDM was more closely centered and slightly to the east. During capping operations at CS-2, there were some problems with the operation of the Loran receivers used for locating capping points, and tug operators instead used the buoy as a reference point for most of the barge loads (Morton et al. 1984). The resulting cap layer varied in thickness from 20 to 140 cm and formed roughly an equilateral triangle pointing south with sides approximately 250 m long (Figure 4-5). The thickest deposits were over the southern point of the triangle, but the cap at the center of the mound was at least 80 cm thick over a broad area (Morton et al. 1984).

Following the completion of the cap, the surface of the mound was surveyed extensively with side-scan, SPI, and divers. Side-scan results showed high reflectance material centered on the mound and evidence of cratering from individual barge loads (Morton et al. 1984). Divers observed a 2-cm layer of fine sand over sandy gravel with ripples and patchy distribution of shell fragments, clay clumps and wood debris at the center of the mound. They also observed rapid changes in elevation of 1-2 m over the surface of the mound in the recently-deposited dredged material. The results of the SPI survey indicated that the CDM was thicker than camera penetration from the center of the site to the margin of the bathymetrically observable mound. Beyond the margin of the mound, the thickness of the CDM decreased quickly to thin layers (1 to 4 cm) over thin layers of UDM (1 to 9 cm) (Morton et al. 1984).

Another round of surveys was performed one to two months following completion of the cap, which included collection of sediment cores, bathymetry, SPI, and diver observations. The bathymetric survey indicated consolidation in the thickest portion of the mound, and divers noted a 2-cm deposit of flocculent soft sediment over the CDM

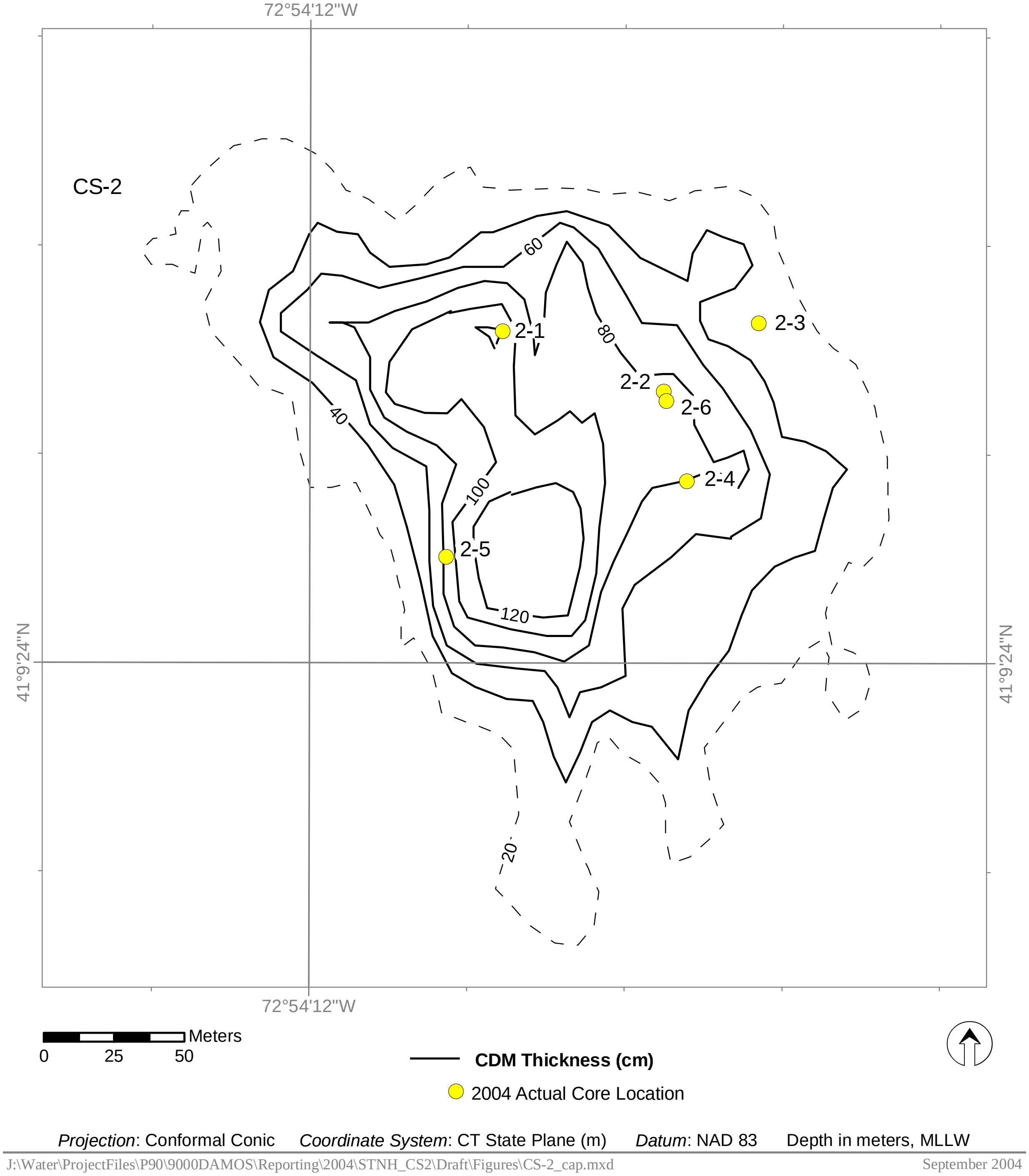


Figure 4-5. Composite depth difference map of CDM dredged material thickness at CS-2 based on depth difference between bathymetric surveys conducted on April 28 and June 8, 1979 (Morton et al. 1984) with 2004 core locations indicated

and relatively flat topography compared with the previous survey. The surface was scattered with clay clumps with some peat, and the western region was littered with chunks of wood, fishing gear and rope (Morton et al. 1984). The SPI survey also reported a 2-cm layer of silt on top of the CDM and a similar distribution of CDM and UDM compared to the previous SPI survey. The flanks of the mound had thin layers of UDM (<2 cm) covered by thin layers of sand that were beginning to be mixed by bioturbation (Morton et al. 1984).

Comparison of the bathymetry from the survey performed following CS-2 formation (Morton et al. 1984) with a follow-up survey performed eight years later (Silva et al. 1991) revealed that the overall morphology of the mound remained the same. Similar to STNH-N, cores recovered from the CS-2 during the 1990 survey revealed an intact cap layer (Fredette et al. 1992). The results of a 2000 bathymetric survey (SAIC 2002) are presented in Figure 4-6 along with overlays of the previously mapped primary UDM mound extent and CDM cap thickness. This survey, performed 17 years after the formation of CS-2, was similar to the 1990 survey; the mound still retained its original morphology of approximately a 0.75 m rise above the surrounding seafloor.

4.2 Physical Distribution of Mound Sediments

The physical characteristics of the CDM generally differed from those of the UDM at both STNH-N and CS-2. These characteristics (color, texture, organic content, odor) were used to classify the layering within the 2004 cores as described in Section 3 and to assess the physical integrity of the CDM over UDM mound structure 20+ years after formation. The earlier investigations that characterized the mound structure following formation were used to select a range of locations over the mounds for coring in the 2004 study to ensure representative coverage. Cores were of sufficient length to capture the full mound stratigraphy at each location.

4.2.1 STNH-N

All six of the STNH-N cores showed clearly differentiable CDM and UDM intervals. The overall cap thickness ranged from approximately 75 cm to 145 cm (Table 4-1). The cap was made up primarily of CDM, but also contained a surficial layer ranging in thickness from 10 to 30 cm and consisting of fine sediment grading into CDM. This surficial layer was assumed to be the result of deposition occurring since mound formation that has been reworked into the CDM through biological activity and surface disturbance.

The 2004 core locations are shown on the original cap thickness map prepared following mound formation/capping (Figure 4-2). Taking into account the overall mound consolidation that was documented following formation, the thickness of the CDM

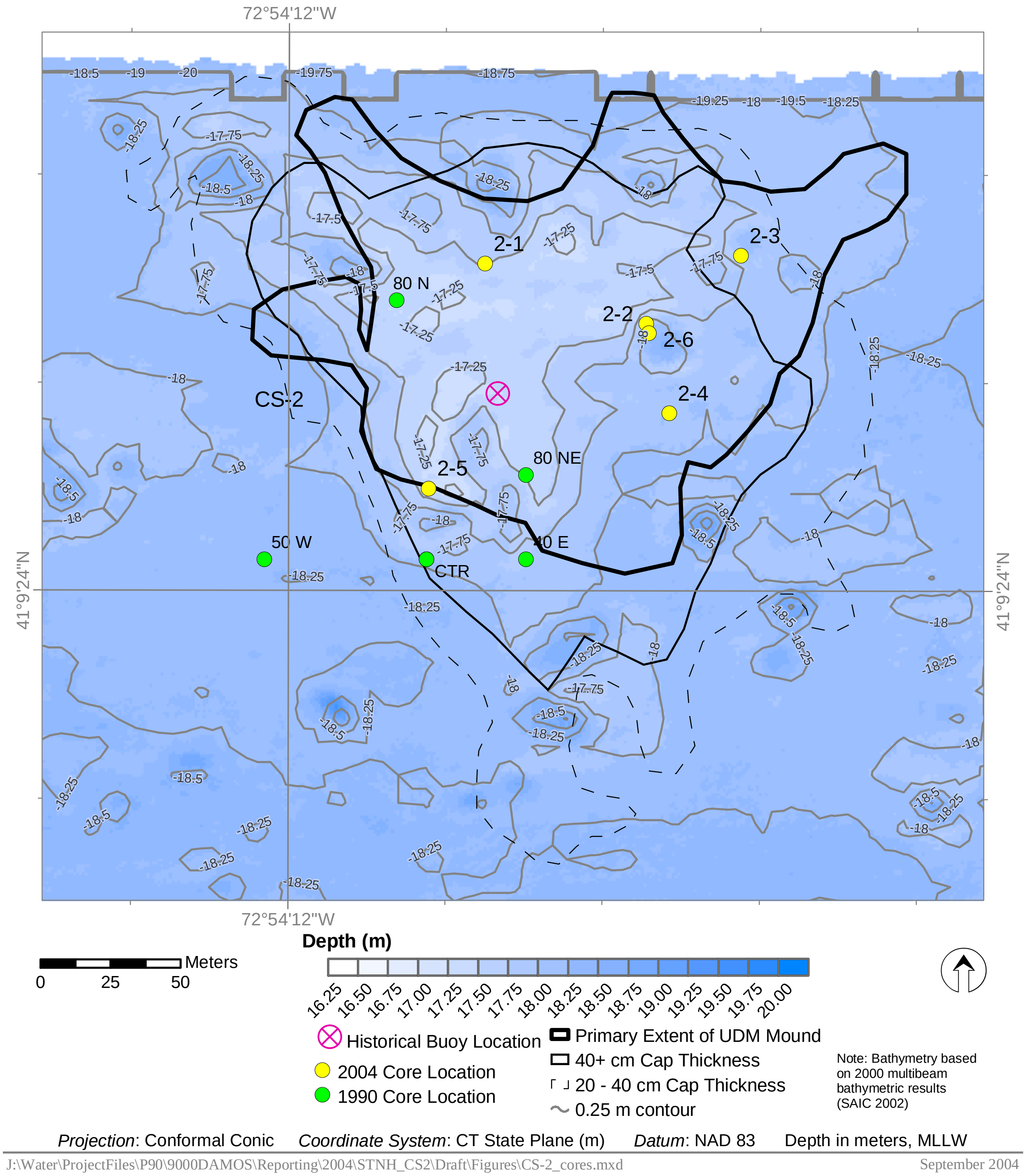


Figure 4-6. Recent CS-2 bathymetry showing 1990 and 2004 coring locations

Table 4-1.

Capped Mound Layer Thickness Estimates Observed in 2004 (thickness in cm)

Mound	Layer	Core ID/Layer thickness					
		1-1	**1-2**	**1-3^R**	**1-4**	**1-5**	**1-6^R**
STNH-N	CAP-Surficial	10	15	30	30	30	20
	CAP-CDM	120	130	105	60	45	125
	UDM	60	55	75	85	20	80
	DM	105	80	75	10	50	60
	Native Sediment	0	10	0	95	145	5
		2-1	**2-2^R**	**2-3**	**2-4**	**2-5**	**2-6^R**
CS-2	CAP-Surficial	20	20	20	30	10	20
	CAP-CDM	65	75	35	55	60	30
	UDM	85	75	0	35	0	100
	DM	25	30	55	15	50	35
	Native Sediment	95	70	135	115	145	45

^{R}Field Replicate

recorded in the 2004 cores (ranging from 45 at Core 1-5 to 130 at Core 1-2) was in good agreement with the original estimated CDM thickness at each location (ranging from just under 100 cm at Core 1-5 to just over 200 cm at Core 1-2). For 2004 cores collected in close proximity to cores from the 1990 study (see 1-1/40N and 1-4/40W in Figure 4-3), a thicker CDM layer was recorded in both of the 2004 cores relative to the 1990 cores (Tables 4-1 and 4-2). This may have been due to recent dredged material that may have accumulated on the mound during the 2003-2004 disposal season, when the CDA03 disposal buoy was located approximately 300 m to the southwest of the STNH-N mound. Minor differences in CDM thickness may also be due to natural variation within the intervals or to differences in vibracore equipment or techniques between the two studies that resulted in increased compaction of the 1990 cores. The lack of a trend toward reduced CDM thickness in 2004 coupled with the record of deposition of fine-grained sediment over the CDM provided evidence that surficial erosion and disturbances had not occurred at a level that would affect the CDM layer.

The transition from CDM to underlying UDM was visually quite distinct in all six of the cores based on color and texture (Figures 3-1 and 4-7). Banding of CDM and UDM, indicating potential interlayering or mixing at the time of formation, was only noted in the lower cap interval of Core 1-5 (Figure 3-1e). Although the fines content was similar between the CDM and UDM in some samples, the CDM had a larger fraction of shells and very coarse material. The UDM was generally dark in color and uniform in appearance, but with some variability of color and texture within the interval. The transition from UDM to underlying historic dredged material was generally less defined than the UDM-CDM interface.

The UDM interval was identified in all of the 2004 cores and ranged in thickness from approximately 20 cm in Core 1-5 to 85 cm in Core 1-4 (Table 4-1). Once again taking mound consolidation into account, these UDM thicknesses were in good agreement with the original estimated UDM thickness at each location (ranging from just over 60 cm at Core 1-5 to 120 cm at Core 1-4 in Figure 4-1). For 2004 cores collected in close proximity to cores from the 1990 study (see 1-1/40N and 1-4/40W in Figure 4-3), a thicker UDM layer was recorded in both of the 2004 cores relative to the 1990 cores (Tables 4-1 and 4-2), again potentially due to natural variation or greater compaction of the 1990 cores during collection.

Historic dredged material was identified beneath the UDM in all six of the cores. Four of the cores penetrated through the dredged material into base material of native Long Island Sound sediments. The boundary between the historic dredged material and

Table 4-2.

Capped Mound Layer Thickness Observed in 1990 (thickness in cm)

Mound	Layer	Station ID/Thickness				
		40N	40W	CTR	60E	40S
	CDM	80	50	110	75	140
STNH-N	UDM	40	40+	50	20-40	20
	Core Length	125	160	160	110	180
		80N	CTR	80 NE	40E	50W
	CDM	60	40	80	65	25
CS-2	UDM	0	40-80[1]	35	0	0
	Core Length	130	120	125	120	140

[1]The bottom 40 cm from the core may be historic dredged material

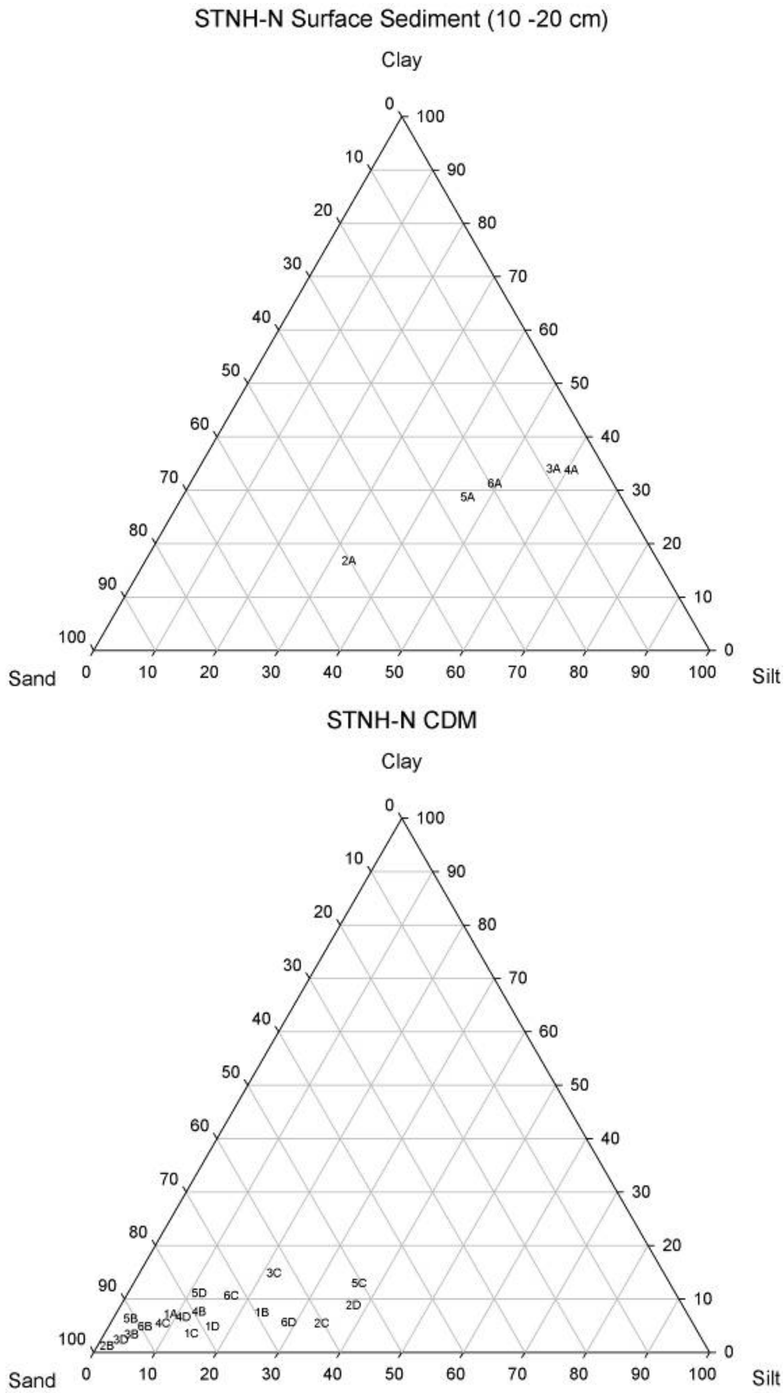


Figure 4-7. Ternary grain size plots of the STNH-N mound layers

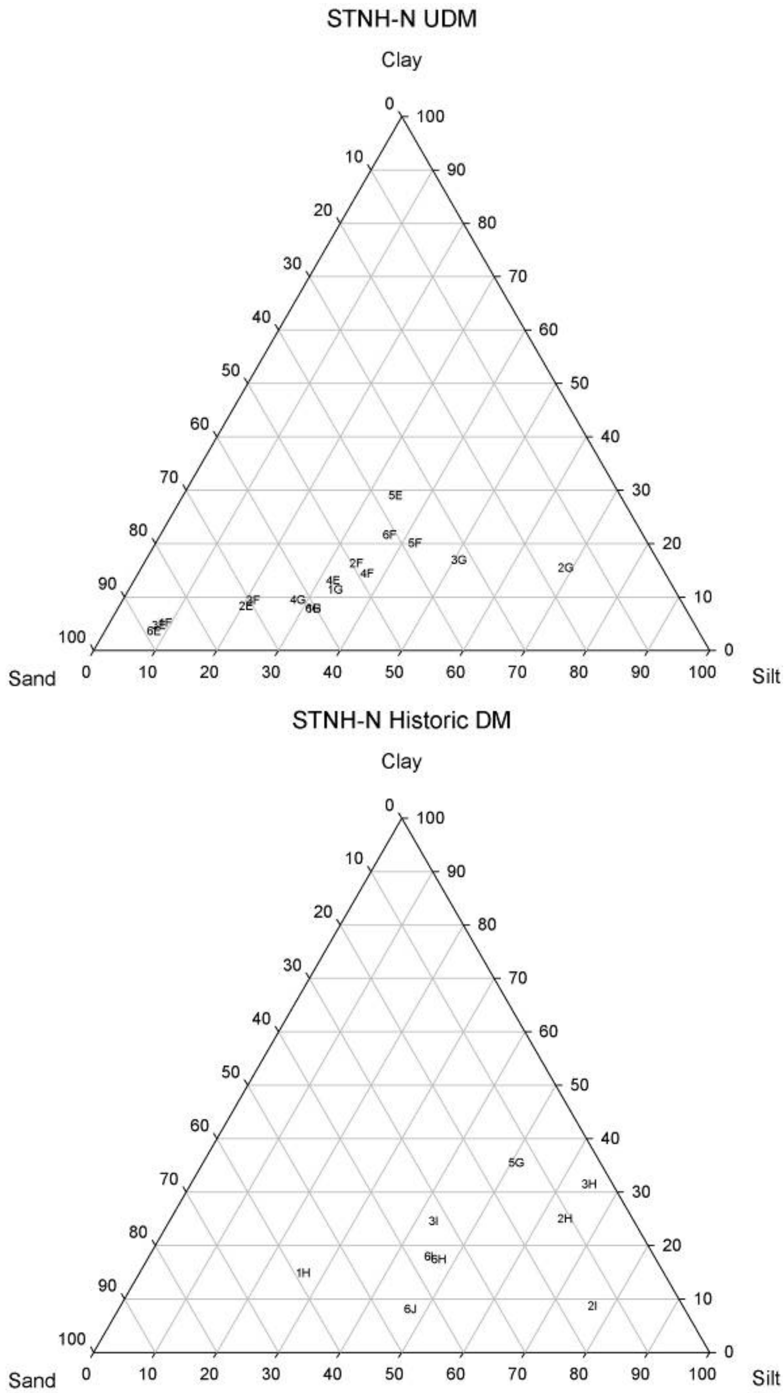


Figure 4-7 (continued). Ternary grain size plots of the STNH-N mound layers

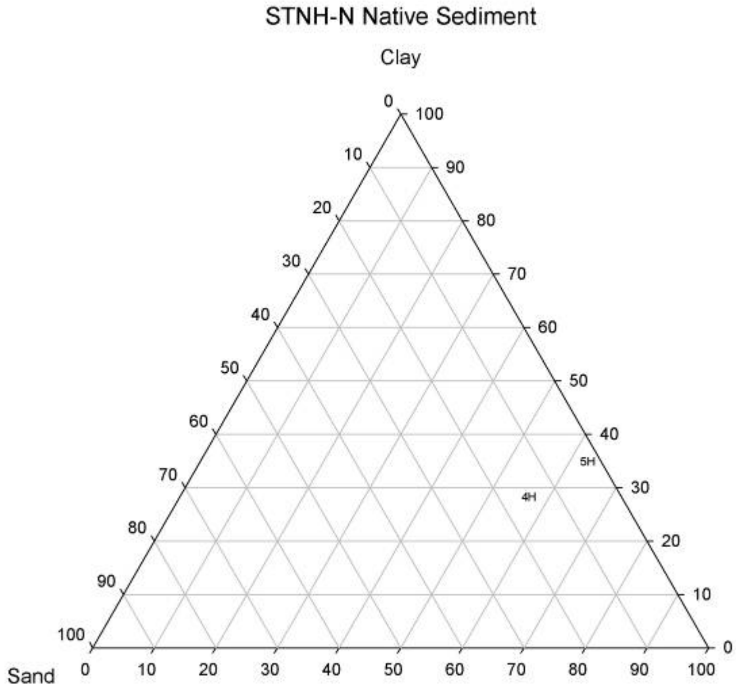


Figure 4-7 (continued). Ternary grain size plots of the STNH-N mound layers underlying native sediment was not well-defined, likely because the disposal of historic dredged material occurred intermittently over an extended period of time (decades).

Cores 1-3 and 1-6 were collected as replicates within several meters of each other. Overall, the cores were quite similar in profile and interval thickness. There was some variation within the UDM; an intact sequence of lighter grey silt was identified in Core 1-6, while the interval was more mixed in Core 1-3. As discussed in Fredette et al. (1992), variability at this scale is to be expected given the mechanical dredging/split-hulled barge techniques used to place the UDM.

4.2.2 CS-2

The CDM over UDM sequence was identified in four of the six CS-2 cores. In the remaining two cores, a CDM interval was identified with no apparent underlying UDM interval. The overall cap thickness ranged from approximately 50 to 95 cm (Table 4-1). Similar to STNH-N, the cap was made up primarily of CDM, but also contained a surficial layer, ranging in thickness from approximately 10 to 30 cm. The surficial layer was coarser in texture than at STNH-N, consisting of nearly even sand and silt-clay content (Figure 4-8). In addition, the CDM layer at CS-2 showed more variability in color and texture than at STNH-N, making it harder to differentiate from the surficial material (Figure 3-2).

The 2004 core locations are shown on the original cap thickness map prepared following mound formation/capping (Figure 4-5). Comparison of the thickness of the CDM recorded in the 2004 cores (Table 4-1) with the original mapped CDM thickness (Figure 4-5) revealed greater variability but no consistent trend, i.e., there was no observable trend toward reduced CDM thickness in the 2004 cores relative to the original estimates. None of the 2004 cores were collected in close proximity to those in the 1990 study (Figure 4-6), and a direct comparison of CDM thickness cannot be made.

The transition from CDM to underlying UDM was visually distinct in the four cores in which UDM was present based on color and texture (Figures 3-2 and 4-8). Similar to STNH-N, the fines content in the UDM was sometimes similar to the CDM, but the CDM had a larger fraction of shells and very coarse material. Also similar to STNH-N, there was some variability of color and texture within the UDM interval, and the transition to underlying historic dredged material was generally less defined than the UDM-CDM interface.

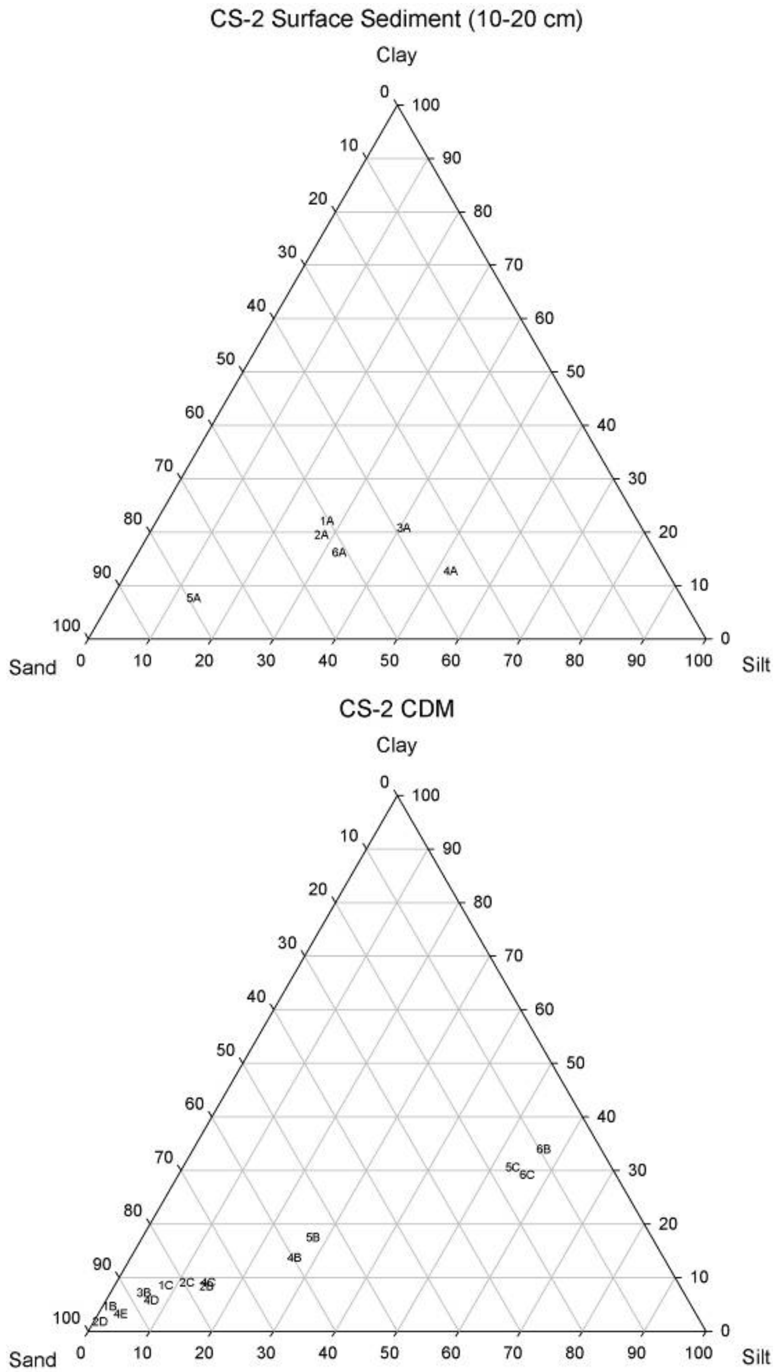
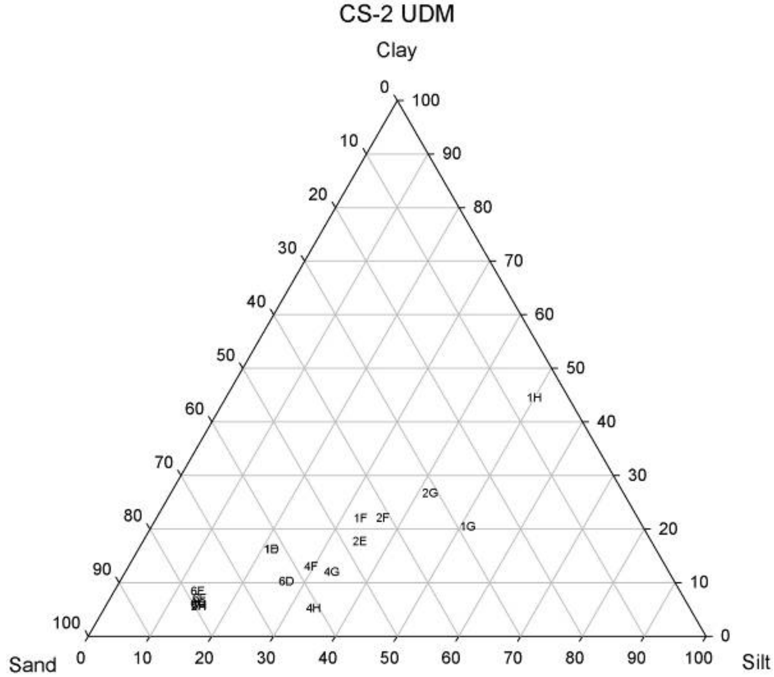


Figure 4-8. Ternary grain size plots of the CS-2 mound layers



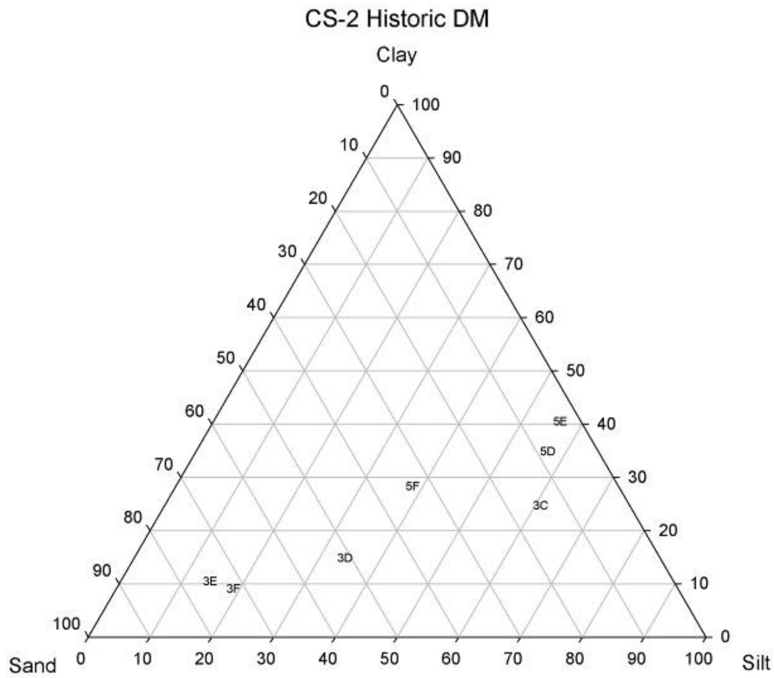


Figure 4-8 (continued). Ternary grain size plots of the CS-2 mound layers

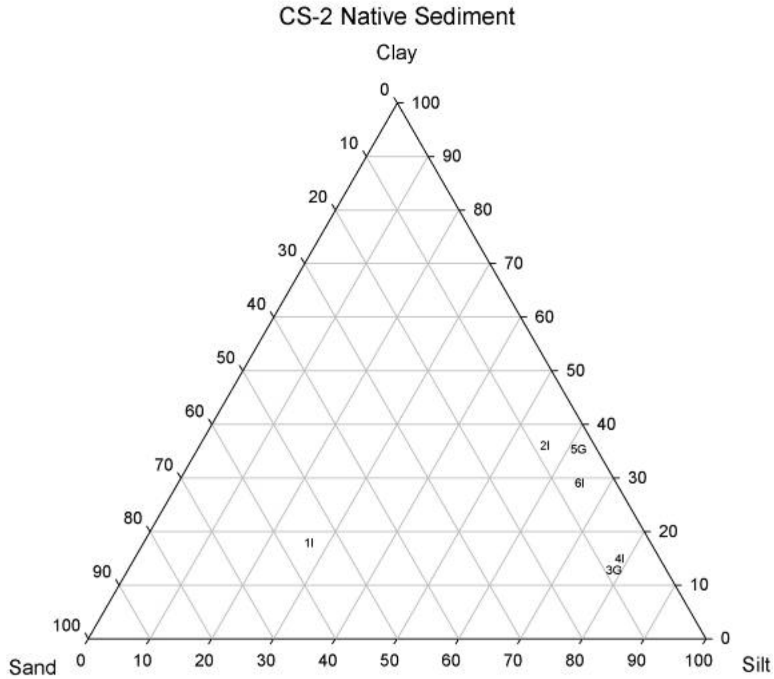


Figure 4-8 (continued). Ternary grain size plots of the CS-2 mound layers

The UDM interval identified in the four cores ranged in thickness from 35 cm in Core 2-4 to 100 cm in Core 2-6 (Table 4-1). Similar to the CDM, these interval lengths showed more variability than the STNH-N cores when compared to the original estimated UDM thickness at each location (Figure 4-4). This variability was highlighted by comparison of the 2004 replicate cores and comparison with the 1990 core data. Cores 2-2 and 2-6 were collected within several meters of each other (Figure 4-2), but the UDM thickness measured in the two cores varied by about 25 cm (Table 4-1, Figures 3-1b and 3-2f). Core 2-5 was positioned in the general direction of the 1990 Core CTR but closer to the mound center (Figure 4-6). A relatively thick, 40+ cm layer of UDM was recorded for Core CTR, and a similar or greater thickness was expected at Core 2-5, positioned closer to the mound center. However, no UDM interval was found in Core 2-5.

Historic dredged material was identified beneath the UDM or CDM in all six of the cores, varying in thickness from 15 to 50 cm (Table 4-1). As expected, this material was variable in texture (Figure 4-8). All six of the cores penetrated into base material of native Long Island Sound sediments. Similar to STNH-N, the transition from the overlying historic dredged material to the underlying native sediment was not well-defined.

Cores 2-2 and 2-6 were collected as replicates within several meters of each other. In addition to the variability in the UDM intervals for the two cores noted above, the overall cap thickness varied by 45 cm between the two cores (Table 4-1, Figures 3-2b and 3-2f). This variability was expected given that both the CDM and UDM at CS-2 were placed using mechanical dredging/split-hulled barge disposal (Fredette et al. 1992).

4.2.3 Sediment Distribution Summary

The cores collected in the 2004 study at STNH-N and CS-2 provide clear and consistent data showing that the CDM over UDM sequence remains intact with a well-defined interface between the intervals at both mounds. At STNH-N, the thickness of the CDM interval compared well with the distribution of the CDM mapped following the original formation of the mound, taking into account the expected long-term consolidation of the hydraulically dredged CDM. At CS-2, the thickness of the CDM was more variable, reflecting the mechanical dredging that was used in the project, but there was no apparent reduction of CDM thickness over time. At both sites, a surficial layer was noted above the CDM, indicating net deposition since formation of the mounds. This layer was more distinct and thicker at STNH-N, potentially the result of its location near the center of CLDS, with significant dredged material disposal over the past 25 years (see disposal mounds noted on Figure 1-2). In the 2003-2004 disposal season, the disposal buoy was located approximately 300 m to the southwest of STNH-N, and depth-difference maps calculated from subsequent bathymetric surveys indicated a thin layer (up to 0.25 m) of deposition over at least the southern portion of the mound. Taken together, the maintenance of the CDM thickness over time and the overlying net deposition provide evidence that the UDM interval remains physically isolated from the overlying waters and unaffected by potential erosive events or other surface disturbances.

4.3 Chemical Distribution within Mound Sediments

Following classification of the distinct horizons within the 2004 cores, subsamples from each of the horizons were submitted for chemical analyses. Specific analyses included total petroleum hydrocarbons (TPH), polycyclic aromatic hydrocarbons (PAH), copper, zinc, and total organic carbon (TOC). The analytical results for the different intervals were compared with each other and compared with the results of previous studies, looking for evidence of consistency of chemical distributions within and between horizons in the context of relatively heterogeneous sediments. The overall goal was to assess the effectiveness of the mound/cap structure at chemically isolating contaminants over time.

As presented in Fredette et al. (1992), chemistry within the UDM and, to a lesser extent, the CDM of STNH-N and CS-2 was expected to display wide variations spatially as a result of the techniques used for dredging and placement. Given this variability, a large dataset would be required for statistical comparison within a given interval. However, given the relatively large difference in chemical concentrations between the UDM and the other intervals, simple statistics have been used to summarize and compare the chemical data presented in Section 3.

4.3.1 Comparison with Chemistry of Previous Investigation

Given the experimental nature of the STNH-N and CS-2 projects, a number of investigations were performed before, during, and after mound formation, many of which included sediment sampling and analysis (see SAIC 1995, Appendix C for a partial list). Data from previous investigations which have been reviewed and used in comparison to the 2004 data include the following:

- Pre-mound formation data characterizing the UDM and CDM sediments as summarized in Fredette et al. (1992) and SAIC (1995).

- Analysis of core samples collected from both mounds in 1990 and summarized in Fredette et al. (1992) and SAIC (1995).

- Analysis of grab samples collected at the CLDS reference area in 2000 as part of disposal site designation (ENSR 2001).

Some analytical methods from the 1990 investigation compared well with those specified for the 2004 investigation while others did not. The analytical methods used in 2004 are detailed in Appendix A-1; 1990 method details are provided in Appendix A-2. Metals processing and analysis methods were exactly the same for the two investigations, using an acid leaching procedure followed by ICP/AES analysis. The methods in 1990 for TPH, TOC, and PAHs were generally less definitive than the methods employed for the 2004 investigation, and the resulting datasets are less comparable than the metals datasets. Method references in this discussion refer to the SW-846 method series (EPA, 1986) with the exception of the 1990 TPH method (418.1). This earlier TPH method was selected from *Methods for Chemical Analysis of Water and Wastes* (EPA, 1979).

The 1990 TPH data were generated by EPA methods 9071 (extraction) and 418.1 (analysis), using n-hexane as the extraction solvent followed by IR instrumentation. This method results in an operationally defined TPH result. Furthermore, petroleum products more volatile than fuel oil #2 may have been lost during the extraction process, and heavy crude and fuel oils would not have been fully extracted. Overall, the methods used to generate the 1990 dataset could have resulted in a low bias in the data, with the degree of bias dependent on the range of compounds that actually existed. The 2004 sample set was analyzed using a acetone and methylene chloride extraction, according to Method 3550, which are more effective over a broader range of compounds. The resulting extract was then analyzed using a GC method (EPA Method 8015B) providing more definitive results. The TPH results generated in 2004 are therefore not directly comparable to the 1990 TPH results.

For TOC, the 1990 investigation employed a wet combustion method, whereas in 2004, the samples were analyzed using a pyrolytic combustion method. While the 2004 combustion method is considered to be the method of choice for marine sediments, the methods are not considered equivalent and the two sets of results are not directly comparable.

Finally, the PAH method used in 1990 (EPA Method 8310) is more prone to interferences and less definitive than the GC/MS method specified for the 2004 investigation (EPA Method 3550/8270C). Baseline and retention shifts are common when using the 8310 HPLC method which typically results in a low bias, but in some cases false positives are also possible. Unfortunately, it is not possible to predict the degree of bias without an in-depth study of the potential interferants relative to instrumentation that is now dated. It is necessary to keep in mind these method differences when comparing the 2004 dataset with the 1990 dataset.

Historical method details for the 1983 samples (summarized in Morton et al. 1984, Fredette et al. 1992 and SAIC 1995) were not available to fully assess data comparability, although it is believed that sediments were not dissolved for metals analysis (R. Valente, pers. comm.). Thus, the leaching procedure used in 1983 is likely comparable to those used in the 1990 and 2004 investigations, as are the metals data generated. Information relating to the analysis of PAH compounds and TPH was also not available for these earliest measurements and no assessment of data comparability could be performed.

The comparisons made to surface sediments from a CLDS reference area (Table 4-3; ENSR 2001) also warrant comment regarding data comparability. The methods used to generate the CLDS reference results are detailed in a QAPP prepared for a larger Long Island Sound study (ENSR 2000) and the same methods were specified for the analysis of sediment TOC, metals, and PAHs. The 2000 and 2004 data tabulated in Table 4-3 should be directly comparable.

4.3.2 STNH-N

The analytical results presented in Section 3 for each core horizon at STNH-N (surface, CDM, UDM, older dredged material, native sediment) were pooled, and the summary statistics have been presented in Figures 4-9 through 4-13 for each of the analytical constituents. Also presented in the plots are pooled UDM and CDM data from the 1990 coring study. Mean surface sediment values at the CLDS reference site from a 2000 investigation (ENSR 2001) and global mean sediment values for copper and zinc (Bowen 1979) have also been plotted on the figures for reference.

Concentrations within the UDM interval dominate the plots for all constituents and remained at the same overall levels reported for the Stamford Harbor sediments prior to dredging (Fredette et al. 1992). For TOC (Figure 4-9), the UDM was clearly organic carbon enriched, while organic carbon in the coarse-grained CDM was relatively lower. TOC for the surface sediment and older dredged material intervals were slightly higher than at the CLDS reference site. For copper and zinc, the 1990 and 2004 data sets were similar (Figures 4-10 and 4-11); median UDM values were approximately an order of magnitude higher than for the CDM with little or no overlap of the two data sets. Copper and zinc were moderately elevated within the older dredged material interval. There was

Table 4-3. Surface Sediment Comparisons – 2000 CLDS Reference Sediments vs 2004 Capped Mound Sediments

	% Fines	TOC (%)	Copper (mg/kg)	Zinc (mg/kg)	Total PAH (ug/kg)
CLDS Ref (n=8)[1]					
Minimum Value	90	1.6	31.5	88.5	488
Maximum Value	94	2.3	55.0	121	1481
Median	93	1.8	46.2	110	739
Mean	92	1.9	44.0	107	867
Standard Dev.	1	0.3359	10.0	13.2	390
Cap Site 2 (n=6)					
Minimum Value	21	1.1	8.4	21.5	387
Maximum Value	65	1.8	67.8	124	10357
Median	49	1.4	40.0	89.4	2505
Mean	49	1.4	38.2	83.7	3636
Standard Dev.	16	0.00003	19.1	35.1	3.6
STNH-N (n=6)					
Minimum Value	16	0.4	11.2	29.0	811
Maximum Value	94	4.4	110	180	7928
Median	78	2.4	73.4	146	2972
Mean	68	2.4	67.2	124	3704
Standard Dev.	30	0.0001	39.9	65.6	2.6

[1]From ENSR (2001).

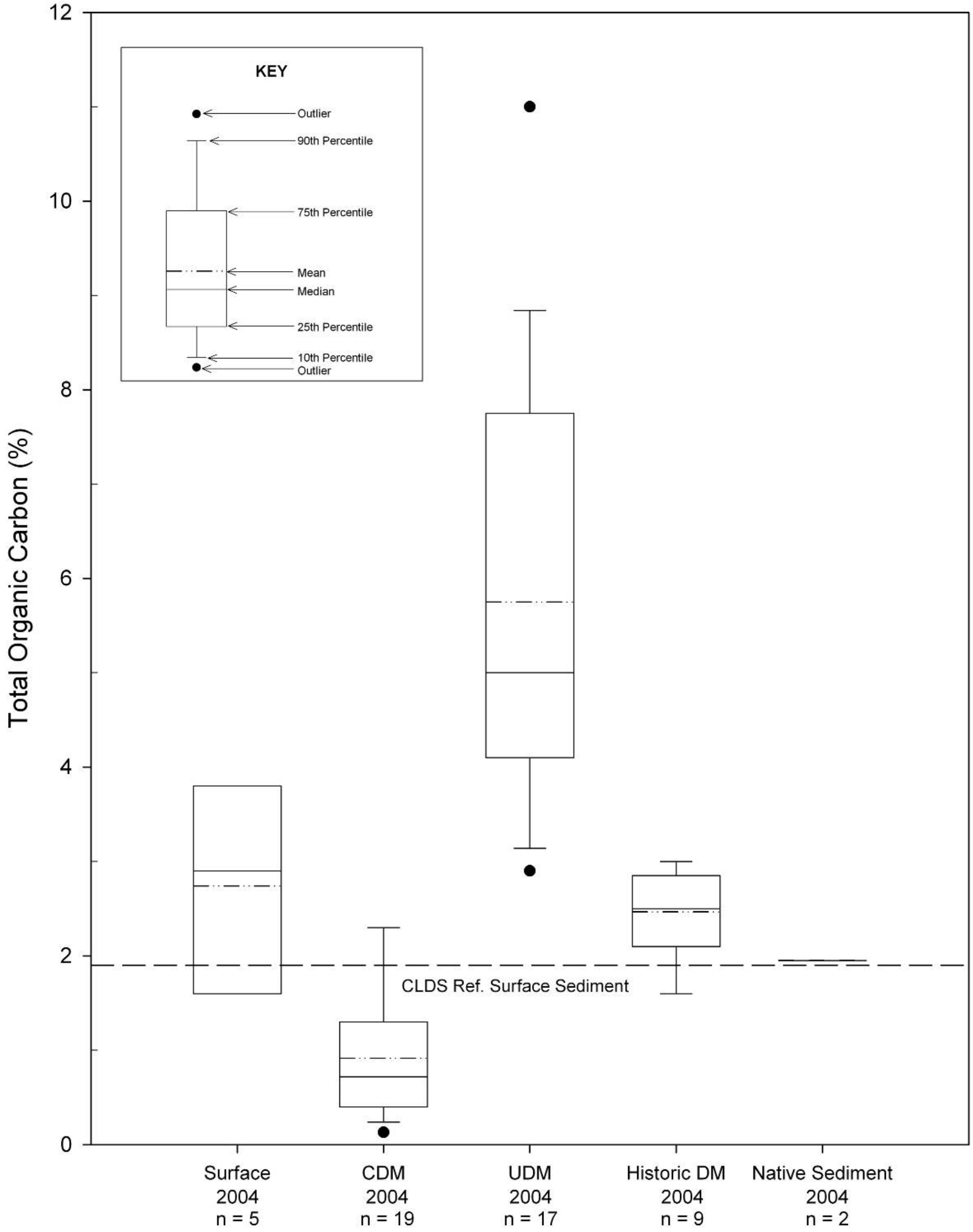


Figure 4-9. STNH-N TOC content in mound horizons

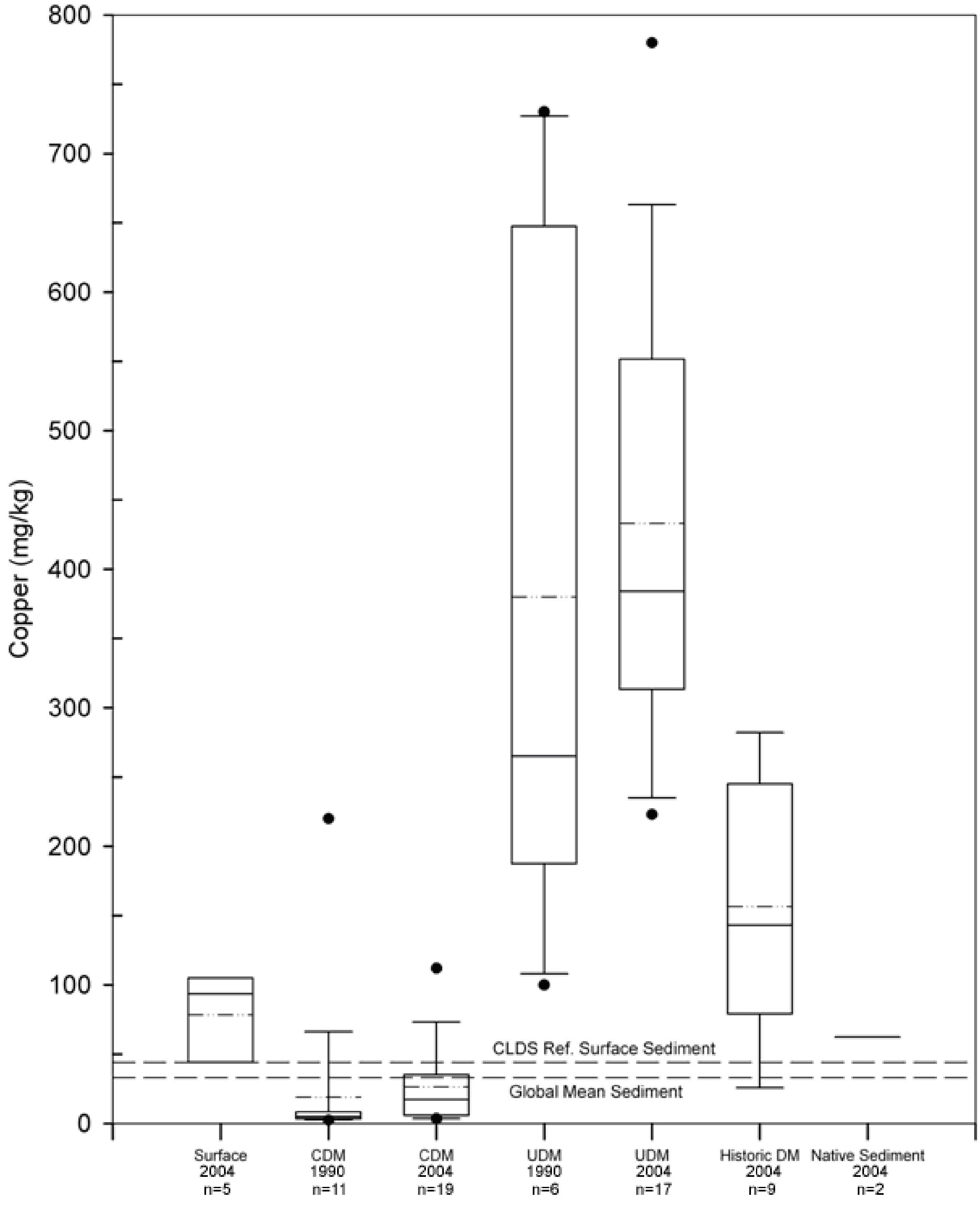


Figure 4-10. STNH-N Copper content in mound horizons

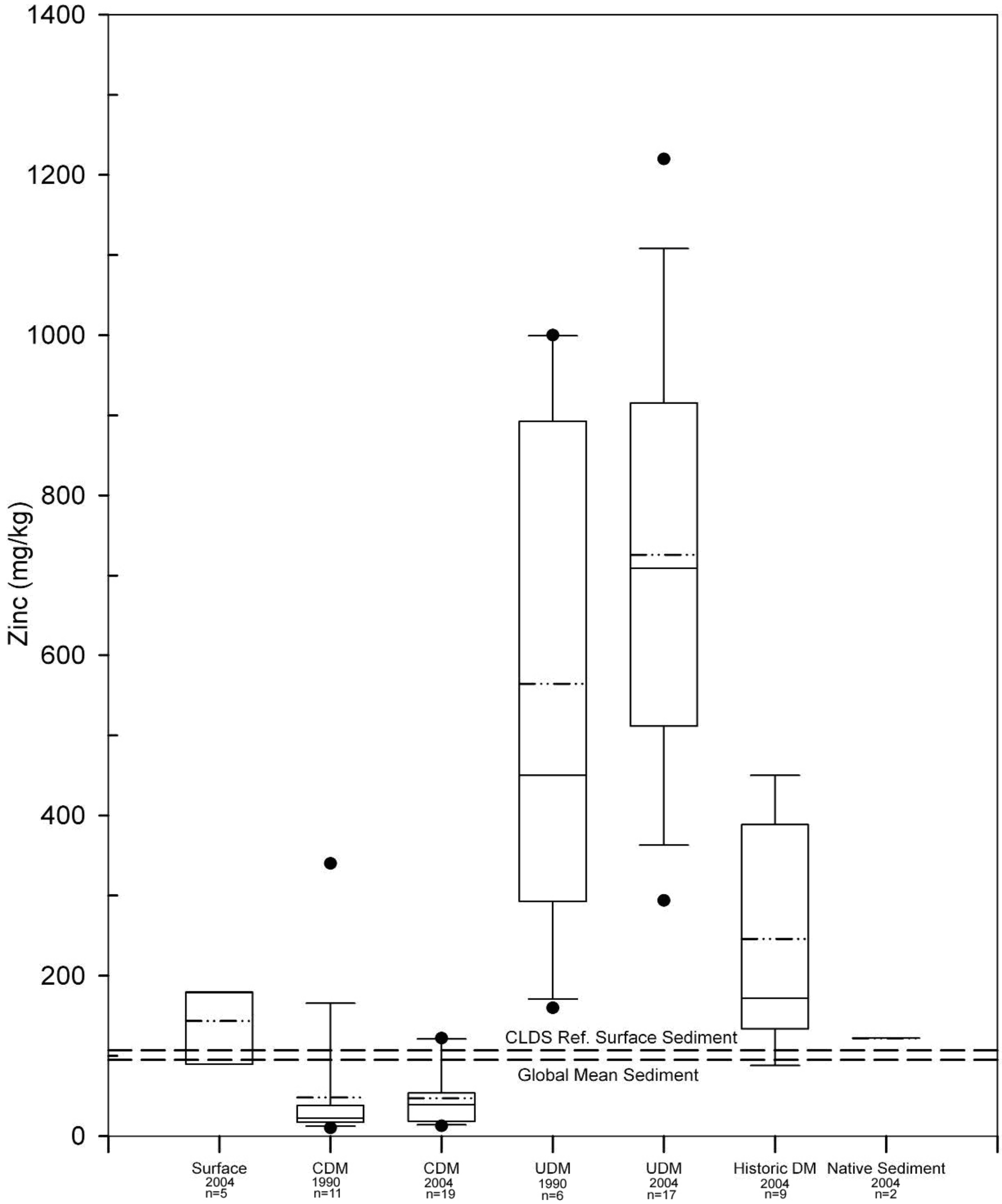


Figure 4-11. STNH-N Zinc content in mound horizons

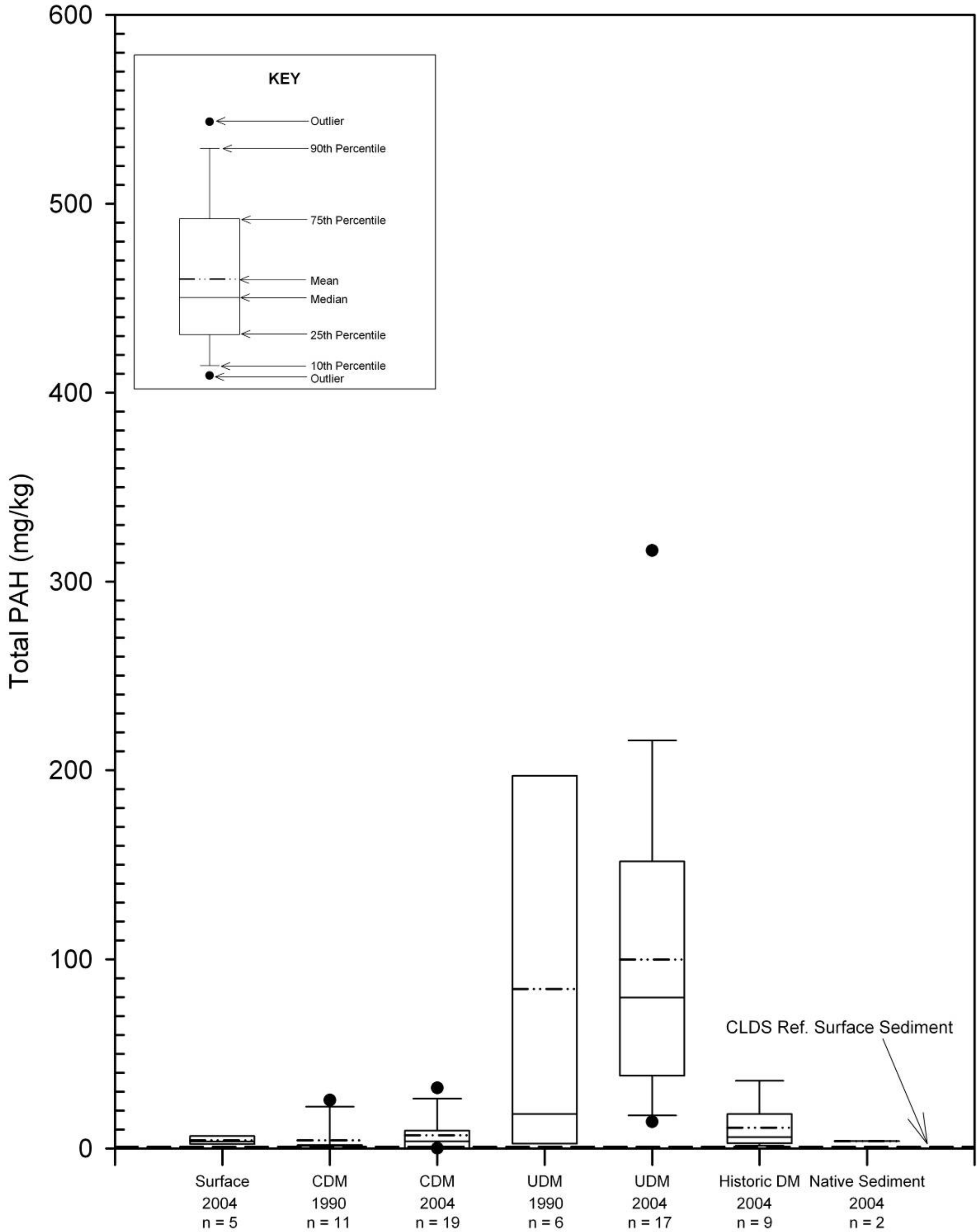


Figure 4-12. STNH-N PAH content in mound horizons

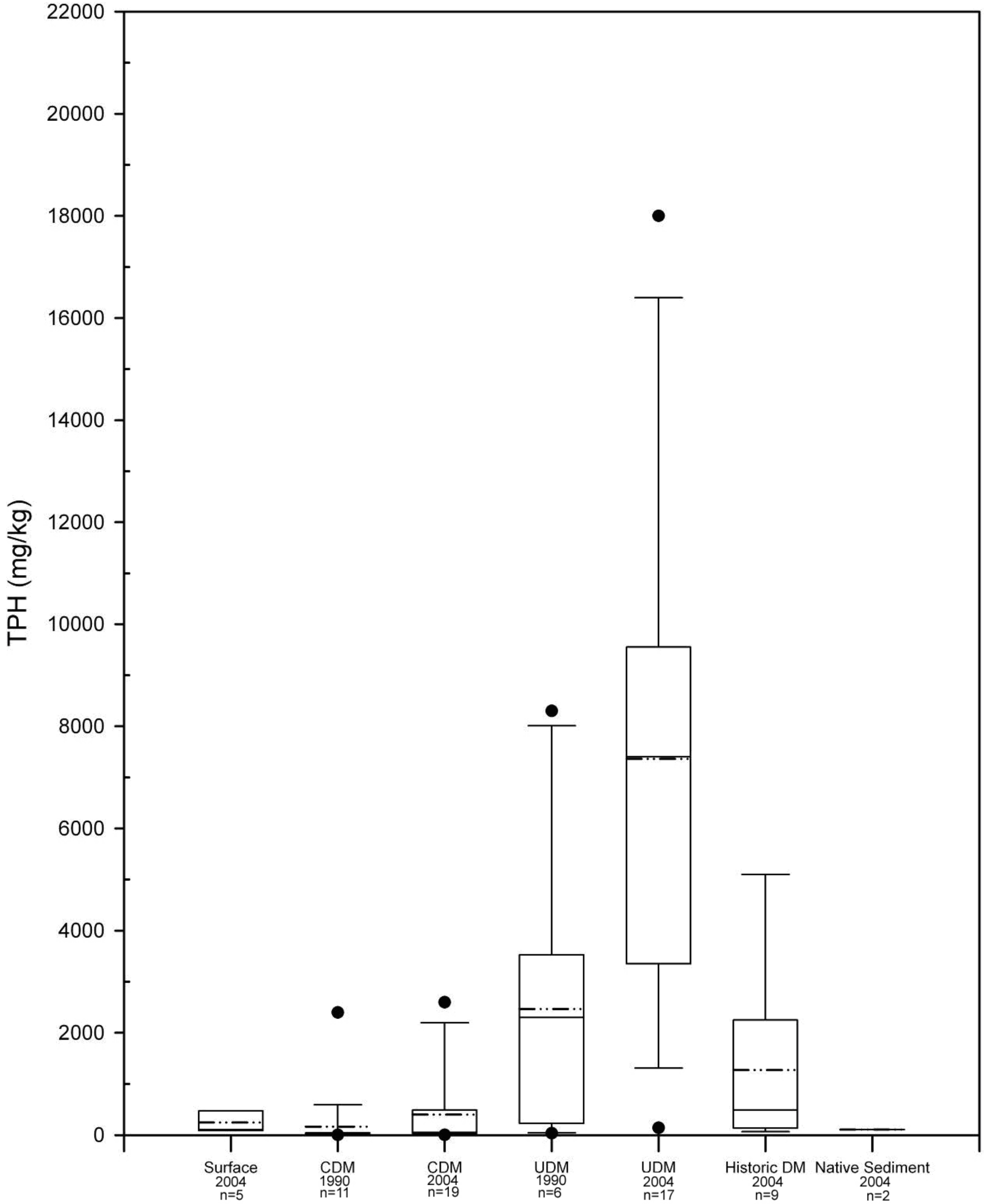


Figure 4-13. STNH-N Copper content in mound horizons

slightly more overlap in the UDM and CDM data sets for total PAH and TPH (Figures 4-12 and 4-13), but median values remained approximately an order of magnitude higher in the UDM interval. For the organics, there was less comparability between the 1990 and 2004 data sets, particularly for TPH. As noted in Section 4.3.1, this was likely due to a difference in analytical methods between the two studies which had a tendency to bias the 1990 data low.

4.3.3 CS-2

The analytical results for CS-2 core intervals were pooled and plotted in Figures 4-14 through 4-18. Similar to STNH-N, concentrations within the UDM interval dominate the plots for all constituents and remain at the same overall levels reported for the Black Rock Harbor sediments prior to dredging (Fredette et al. 1992). For TOC, the UDM remains organic carbon enriched relative to the other intervals (Figure 4-14). For copper and zinc, the 1990 and 2004 data sets are similar (Figures 4-15 and 4-16), and the elevated copper to zinc ratio noted in previous investigations remains (SAIC 1995). The median UDM values remained approximately an order of magnitude higher than for the CDM with little or no overlap of the two data sets. Similar to STNH-N, there was slightly more overlap in the UDM and CDM data sets for total PAH and TPH (Figures 4-17 and 4-18), but median values remained approximately an order of magnitude higher in the UDM interval. Also similar to STNH-N, there was less comparability between the 1990 and 2004 organics data sets, particularly for TPH, attributed to a difference in analytical methods. The historic dredged material at CS-2 had consistently lower concentrations of all constituents relative to STNH-N.

4.3.4 Sediment Chemistry Summary

The sediment chemistry data supported the visual classification of sediments into the observed horizons in the cores. Concentrations for all constituents were generally at least an order of magnitude higher in the UDM than in the other horizons. Chemical differences between historic dredged material and native base material were less pronounced, particularly at CS-2. Comparison of 1990 and 2004 analytical data (where appropriate, and accounting for expected biases) indicated similar concentrations were observed in both surveys.

Previous investigations have demonstrated that the sediment chemistry results from UDM horizons within capped mounds at CLDS are consistent with pre-disposal contaminant inventories (Fredette et al. 1992, SAIC 1995). Despite the heterogeneity of

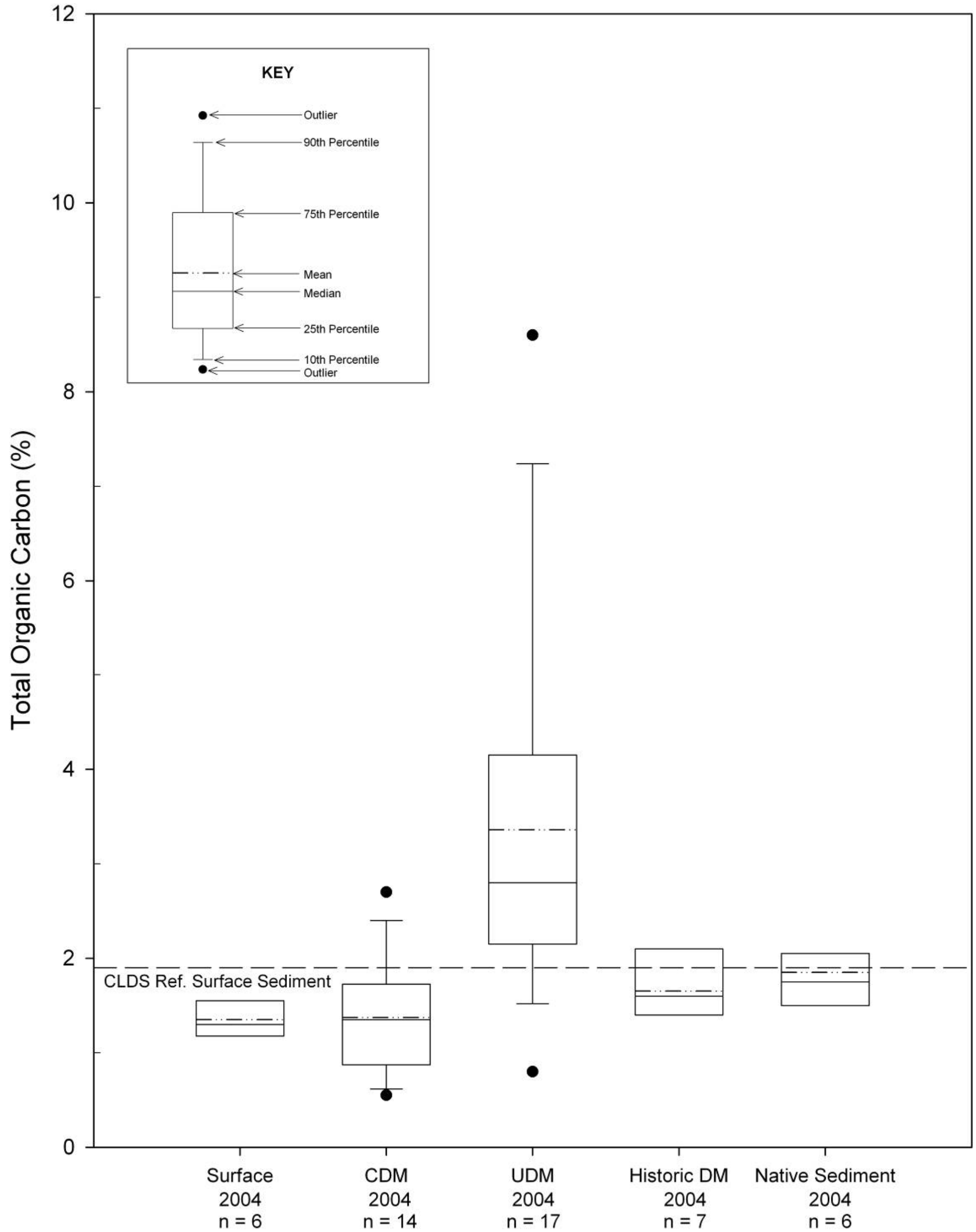


Figure 4-14. CS-2 TOC content in mound horizons

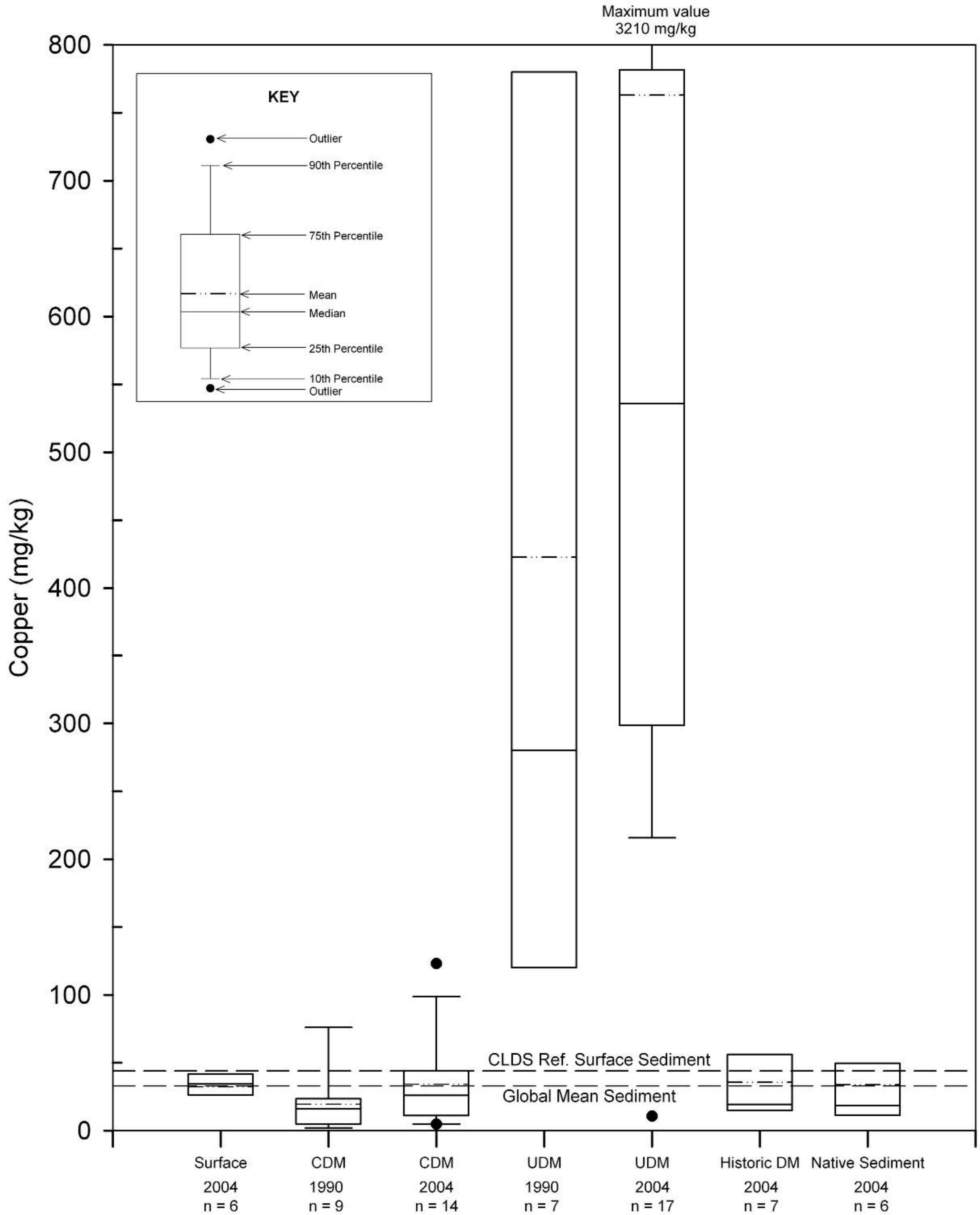


Figure 4-15. CS-2 Copper content in mound horizons

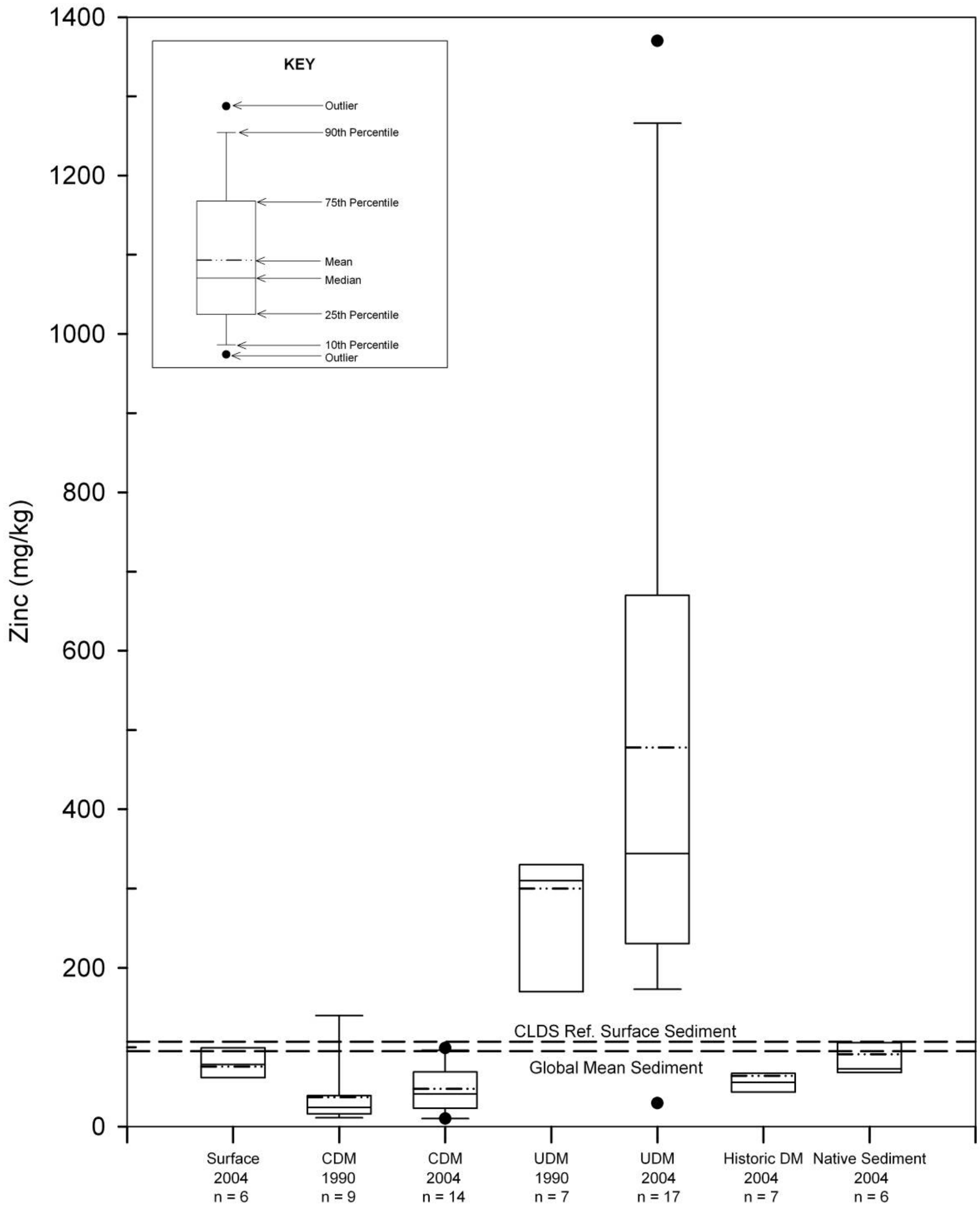


Figure 4-16. CS-2 Zinc content in mound horizons

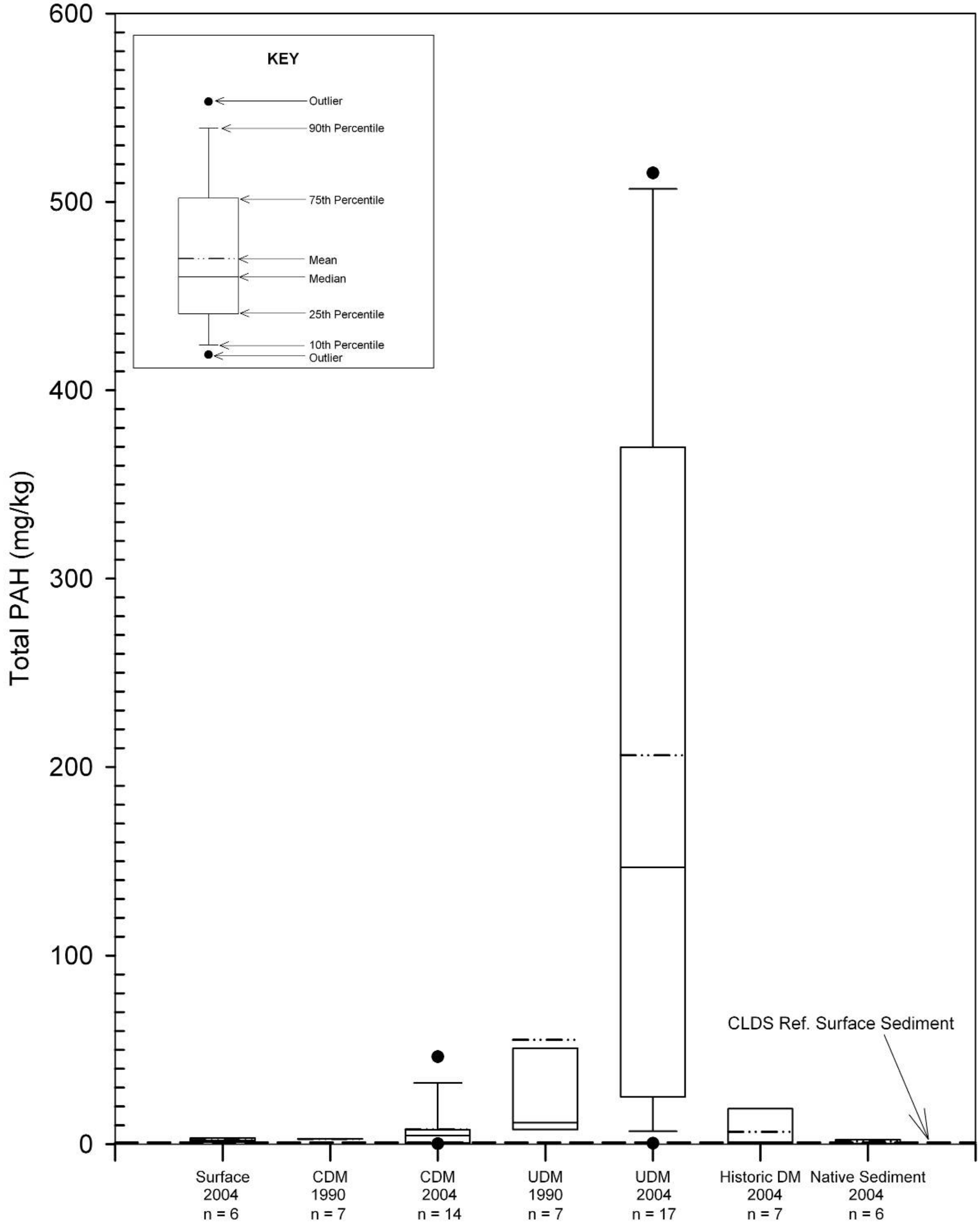


Figure 4-17. CS-2 Total PAH content in mound horizons

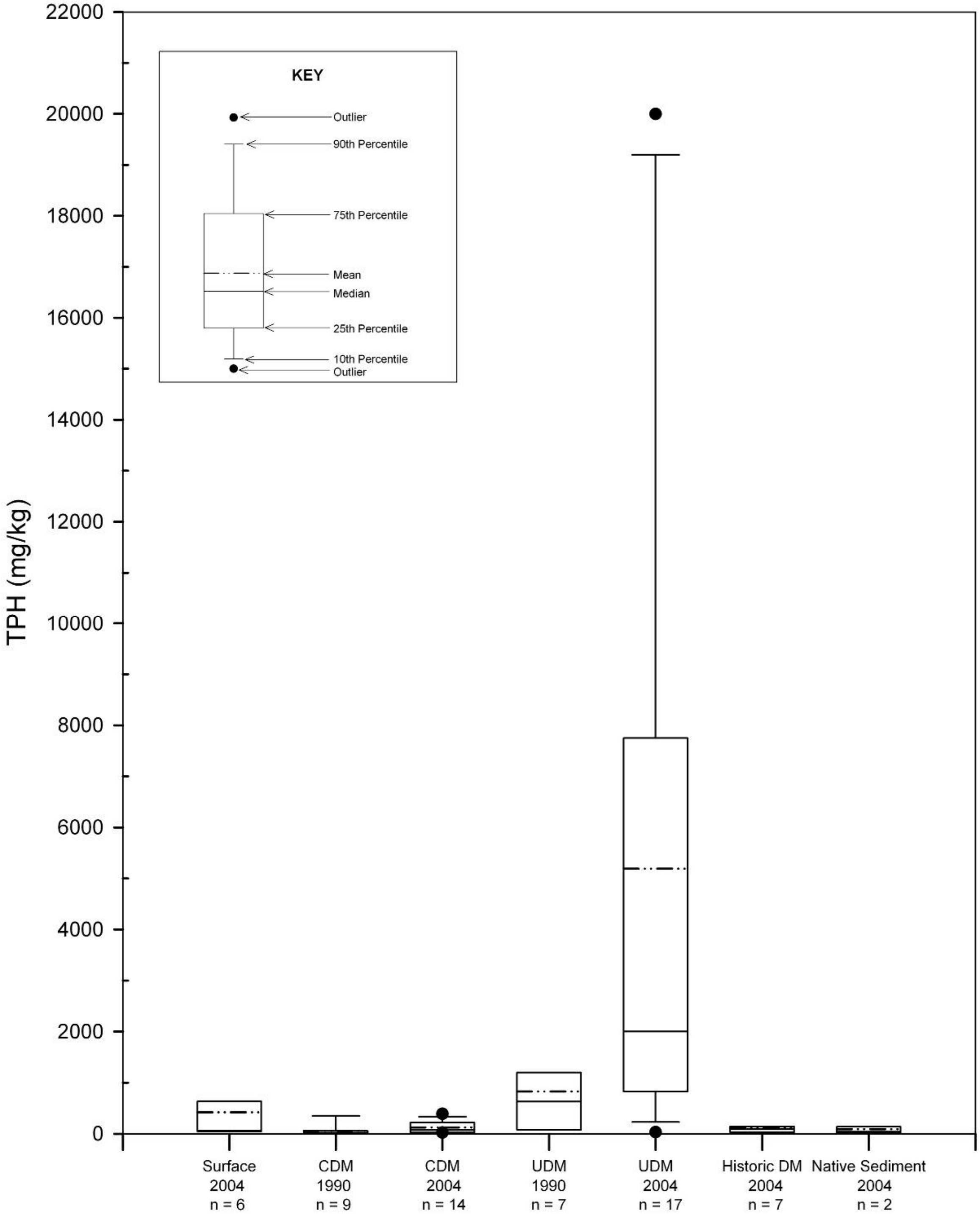


Figure 4-18. CS-2 TPH content in mound horizons

these source sediments, the episodic placement events, consolidation of the mounds after capping and spatial complexity of the horizons, the chemical signatures of UDM and CDM horizons have remained comparable over the history of the projects. The apparent chemical stability of each horizon is consistent with the demonstrated physical stability of the mounds and model results of potential contaminant migration (Murray et al. 1994).

In the absence of active movement of pore water (on a level seafloor there is a constant hydraulic head; pore water is only advected by biological activity or physical mixing) after consolidation, movement of contaminants within capped mounds is limited to the diagenetic process of molecular diffusion (Brannon et al. 1987, Poindexter-Rollings 1990). After the initial consolidation of mounds, further compaction is controlled by sedimentation rates (Berner 1980, Silva et al. 1991). In effect, the pore waters below active biological mixing depths (ca. 50 cm) are a static pool and release of contaminants from this pool is controlled by molecular diffusion rates. Molecular diffusion is a very slow process. While contaminant availability to pore waters is controlled by complex chemical reactions, the rate of diffusion can be modeled based on empirical observations (Wang et al. 1991). For the case of capped mounds in Long Island Sound, the calculated rate of diffusive flux of metals from undisturbed sediments (500 years for 50 cm) is much lower than the average sedimentation rates for the Sound (Murray et al. 1994). It is not surprising that the chemical concentrations within the UDM and CDM have apparently remained stable over the life of the mounds.

As presented in Fredette et al. (1992), chemistry within the UDM of STNH-N and CS-2 was expected to display wide variations spatially given the dredged material placement techniques, which result in a heterogeneous distribution of material over the mound. Results of the 2004 survey supported this expectation, with concentrations varying up to two orders of magnitudes. Data in replicate cores collected within meters of each other resulted in metals concentrations one order of magnitude different from one another. Although considerable variation within a horizon was observed, variation between horizons was far greater, and was consistent with previous studies.

5.0 CONCLUSIONS

The STNH-N mound is one of two capped mounds created in 1979 as the first engineered open water caps in the United States. The CS-2 mound was created in 1983 as part of a follow-up capping project. Extensive investigations performed during and following formation of these mounds revealed that the contaminated UDM had been successfully capped at both sites. The May 2004 survey included collection of six long cores from each of the mounds, covering areas with a range of expected UDM and CDM thicknesses. Follow-up investigations included detailed logging of core stratigraphy and chemical analyses of selected core intervals. The primary objectives of these investigations were to:

- Compare the physical distribution of sediment intervals within the cores with expected values based on core location on the mound and on previous data to assess the physical integrity of the caps.

- Compare the chemical profiles within the cores to previous data to assess the maintenance of chemical isolation of contaminants within the UDM interval.

The cores collected in the 2004 study at STNH-N and CS-2 provide clear and consistent data showing that the CDM over UDM sequence remains intact with a well-defined interface between the intervals at both mounds. At STNH-N, the thickness of the CDM interval compared well with the distribution of the CDM mapped following the original formation of the mound, taking into account the expected long-term consolidation of the hydraulically dredged CDM. At CS-2, the thickness of the CDM was more variable, reflecting the mechanical dredging that was used in the project, but there was no apparent reduction of CDM thickness over time. At both sites, a surficial layer was noted above the CDM, indicating net deposition since formation of the mounds. This layer was more distinct and thicker at STNH-N, where recent dredged material has likely been deposited. Taken together, the maintenance of the CDM thickness over time and the overlying net deposition provide evidence that the UDM interval remains physically isolated from the overlying waters and unaffected by potential erosive events or other surface disturbances.

The sediment chemistry data supported classification of sediments into the observed horizons in the cores. Concentrations for all constituents were generally at least an order of magnitude higher in the UDM than in the other horizons. Chemical differences between historic dredged material and native base material were less pronounced, particularly at CS-2. Comparison of 1990 and 2004 analytical data (where appropriate, and accounting for expected biases) indicated similar concentrations were observed in both surveys. The 2004 analytical results did not suggest any vertical migration of chemicals from the UDM into the CDM, supporting previous study results showing chemical isolation within the UDM.

As the objectives of this study were fully met, no specific follow up investigations are proposed. However, given the long-term interest in capping as a management tool for contaminated sediment, the following recommendations are proposed:

- For future assessment of the physical integrity of the mounds, performance of periodic multi-beam bathymetric and side-scan surveys is proposed as an alternative to coring. These surveys would provide detailed maps of bottom topography capable of resolving even small, 1-meter scale disturbances. The 2000 multi-beam survey (SAIC 2002) could be used as a baseline for future depth-difference plots to assess larger scale processes such as the deposition that appears to be taking place over both mounds.

- To better understand the deposition process taking place over the mounds, the historic chemistry data from grab samples collected from the surface of the mounds throughout the 1980s could be compiled and compared against the reference data collected at CLDS in 1990. If warranted, the upper 5 cm interval of the May 2004 cores (currently archived) could be analyzed as representative of a surface grab for further comparison.

- The sampling and characterization of historic dredged material and native Long Island Sound sediments (including recent deposition) represents a potentially useful insight into the time history of contaminant flux in Long Island Sound. Archived samples should be made available to qualified investigators for further investigations if not required for management of dredged material disposal activities.

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INDEX

barge, 7, 52, 59, 69, 73
baseline, 91, 94
bathymetry, 4, 53, 56, 59, 61, 62
Black Rock Harbor, 2, 4, 46, 48, 56, 59, 83, 94
capping, viii, 1, 2, 4, 40, 52, 56, 59, 61, 69, 89, 90, 91, 93, 95, 96
carbon, viii, 7, 74, 76, 83
confined aquatic disposal (CAD), 2
density, 10
deposition, viii, 47, 52, 61, 64, 73, 90, 91
disposal site, 1, 2, 3, 4, 75, 92, 93, 95
  Central Long Island (CLDS), 1, 2, 3, 93, 95
dredging, 94, 95
Dredging
  clamshell, 94, 95
  hopper, 94, 95
Field Verification Program (FVP), 2
grain size, 7, 10, 12, 16, 22, 43, 46, 48, 66, 67, 68, 70, 71, 72
habitat, 56
Long Island Sound, viii, 1, 12, 44, 45, 47, 48, 52, 64, 73, 76, 89, 91, 92, 93
organics, 53, 83
reference area, 1, 75, 76
sediment
  clay, 12, 14, 40, 43, 44, 46, 47, 53, 59, 69, 95
  sand, 4, 12, 40, 43, 44, 46, 47, 53, 59, 61, 69, 95
  silt, 12, 14, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 40, 41, 42, 43, 44, 45, 46, 47, 48, 53, 56, 61, 69, 95
sediment-profile imaging, 56
side-scan sonar, 56, 59
STNH-S, 3
topography, 52, 56, 59, 91
trawling, 51

APPENDIX A

QUALITY ASSURANCE AND METHOD DOCUMENTS

APPENDIX A1

QUALITY ASSURANCE PROJECT PLAN - 2004

TABLE OF CONTENTS

1.0 PROJECT DESCRIPTION ... 1-1

1.1 Introduction ... 1-1

1.2 Site Name, Location, and Description ... 1-1

1.3 Objectives and Scope ... 1-2

1.4 Project Approach ... 1-2

1.5 Schedule of Activities and Deliverables ... 1-2

2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES ... 2-1

2.1 Management Responsibilities ... 2-1

2.2 Quality Assurance Responsibilities ... 2-2

2.3 Laboratory Responsibilities ... 2-3

2.4 Field Responsibilities ... 2-4

2.5 Training ... 2-5

3.0 DATA QUALITY REQUIREMENTS AND ASSESSMENTS ... 3-1

3.1 Precision ... 3-1
3.1.1 Definition ... 3-1
3.1.2 Field Variability ... 3-1
3.1.3 Laboratory Precision Objectives ... 3-1

3.2 Accuracy ... 3-1
3.2.1 Definition ... 3-1
3.2.2 Field Accuracy Objectives ... 3-2
3.2.3 Laboratory Accuracy Objectives ... 3-2

3.3 Measures to Ensure Representativeness of Field Data ... 3-2

3.4 Completeness ... 3-2
3.4.1 Definition ... 3-2
3.4.2 Field Completeness Objectives ... 3-2
3.4.3 Laboratory Completeness Objectives ... 3-3

3.5 Comparability ... 3-3
3.5.1 Definition ... 3-3
3.5.2 Measures to Ensure Field Comparability ... 3-3
3.5.3 Measures to Ensure Laboratory Comparability ... 3-3

4.0 FIELD PROGRAM ... 4-1

4.1 Sub-Sample Collection Procedures 4-1
4.2 Sample Preservation, Containerization, and Holding Times 4-2
4.3 Equipment Decontamination 4-2
4.4 QC Sample Collection 4-3
4.5 Sample Labeling 4-3
4.6 Sample Transfer/Shipments 4-4

5.0 SAMPLE CUSTODY 5-1

5.1 Field Custody Procedures 5-1
5.2 Laboratory Custody Procedures 5-2
5.3 Project Evidence Files 5-3

6.0 CALIBRATION PROCEDURES 6-1

6.1 Field Instruments 6-1
6.2 Laboratory Instruments 6-1

7.0 ANALYTICAL PROCEDURES 7-1

7.1 Field Analyses 7-1
7.2 Laboratory Analyses 7-1

8.0 INTERNAL QUALITY CONTROL CHECKS 8-1

8.1 Field Quality Control 8-1
8.2 Laboratory Quality Control 8-1
8.2.1 Chemical Analyses 8-1

9.0 DATA REDUCTION, VALIDATION, AND REPORTING 9-1

9.1 Data Reduction 9-1
9.1.1 Field Data Reduction Procedures 9-1
9.1.2 Laboratory Data Reduction Procedures 9-1
9.2 Data Validation 9-3
9.3 Data Analysis 9-4
9.3.1 GIS/Spatial Analysis 9-4
9.3.2 Statistics 9-4
9.4 Meetings 9-4
9.5 Data Reporting 9-4

9.5.1 Laboratory Data Reporting 9-4
9.5.2 Status Reports 9-5
9.5.3 Draft Report 9-5
9.5.4 Final Report 9-5

9.6 Data Management 9-5

10.0 PERFORMANCE AND SYSTEMS AUDITS 10-1

10.1 System Audits 10-1
10.1.1 Field System Audits 10-1
10.1.2 Laboratory System Audits 10-1

10.2 Performance Audits 10-1

11.0 PREVENTIVE MAINTENANCE 11-1

11.1 Field Equipment 11-1

11.2 Laboratory Equipment 11-1

11.3 Inspection/Acceptance Requirements for Supplies and Consumables 11-1

12.0 DATA ASSESSMENT 12-1

12.1 Precision 12-1

12.2 Accuracy 12-1

12.3 Completeness 12-2

12.4 Representativeness and Comparability 12-2

13.0 CORRECTIVE ACTION 13-1

13.1 Field Corrective Action 13-1

13.2 Laboratory Corrective Action 13-1

13.3 Corrective Action During Data Review and Assessment 13-2

14.0 QUALITY ASSURANCE REPORTS 14-1

15.0 REFERENCES 15-1

ATTACHMENT 1 LABORATORY SOPs AND QAMPs (CD)

LIST OF TABLES

Table 1-1 Project Parameters and Reporting Limits (dry weight units) 1-3
Table 6-1 Laboratory Instrument Calibration Frequency and Criterion. 6-2
Table 8-1 Internal QC Checks 8-2

LIST OF FIGURES

Figure 2-1 Project Organization 2-6

1.0 PROJECT DESCRIPTION

1.1 Introduction

Four capped disposal mounds at the Central Long Island Sound Disposal Site (CLDS) are among the earliest engineered open-water dredged material capping projects. The Stamford-New Haven North (STNH-N) and Stamford-New Haven South (STNH-S) mounds were created in 1979 when relatively contaminated sediments from Stanford Harbor were capped with coarse grained sediments from New Haven Harbor. Two additional capped sites, Capped Site-1 (CS-1) and Capped Site-2 (CS-2) were created in 1983 and involved sediments from Black Rock Harbor capped with sediment from New Haven.

A coring study conducted in 1990 (Silva *et al.,* 1990, Fredette *et al.,* 1992 and SAIC, 1995) investigated the textural and chemical characteristics of the sites. The investigators frequently observed distinct transitions and the researchers concluded that the sediment caps, after ca. 10 years, continued to isolate contaminants from the marine environment. Selected CS-2 cores were, however, not located on the main layered mound and associated chemical profiles exhibited different site conditions.

The purpose of the proposed study is to re-examine two of the sites, STNH-N and CS-2, 25 years following the original mound creation. This investigation will provide longer-term evidence regarding cap integrity and complement the earlier (1990) study. This current study will also segment the cores at a greater resolution than the 1990 study (at 10 cm versus 20 cm).

This Quality Assurance Project Plan (QAPP) presents the organization, objectives, planned activities, and specific quality assurance/quality control (QA/QC) procedures associated with the sediment evaluation. Specific protocols for sampling and initial handling are described in accordance with ***Methods for Collection, Storage and Manipulation of Sediments for Chemical and Toxicological Analyses: Technical Manual*** (EPA, 2001). Protocols for sample storage and analysis are in accordance with the specified EPA methods (EPA, 1996). QA/QC procedures have been structured in accordance with applicable technical standards and with EPA requirements, regulations, guidance, and technical standards. The QAPP was prepared in association with the Survey Plan and incorporates that document by reference.

1.2 Site Name, Location, and Description

The two capped sites (STNH-N and CS-2) to be investigated are located within the CLDS. The general mound and cap characteristics associated with these sites have been described by Fredette *et al.* (1992) and are reproduced below:

STAMFORD NEW-HAVEN-NORTH (STNH-N)
Cap Description: Silty/clayey fine to medium sand with shell fragments
Mound Description: Black to grey organic clay silt, sand
CAPPED SITE 2 (CS-2)
Cap Description: Coarse dark grey sands
Mound Description: Dark grey to blank organic clayey silt with oil-like odor

1.3 Objectives and Scope

The purpose of this study is to re-examine two capped disposal sites, STNH-N and CS-2, 25 years following their original creation. The project objective is to examine textural and chemical gradients between mound and cap material at STNH-N and CS-2 as a way to infer long term capping effectiveness. This current study will also segment the cores at a higher resolution than has been done previously.

1.4 Project Approach

This investigation will provide on-going evidence regarding cap integrity and complement an earlier (1990) study.

To accomplish the objective, five vibra-cores (plus one duplicate) measuring 1.6 to 3 m in length will be collected at each of the sites (STNH-N and CS-2). The target positions are summarized in Table 1 and depicted in Figures 1 and 2 of the survey plan. The cores will be split lengthwise, visually described/documented, subsampled, and analyzed to determine vertical grainsize and chemistry characteristics. Table 1-1 summarizes the target parameters and corresponding detection limit requirements selected for the project.

1.5 Schedule of Activities and Deliverables

The project schedule is presented in the following table.

Project Task	**Schedule (2004)**
Field Program	May 24th and 25th (Tentative)
Core Splitting	May 26th and 27th (Tentative)
Letter Cruise Report	June 4th
Physical Testing Complete	July 9th
Chemical Analysis Complete	July 9th
Data Validation/Review Complete	July 30th
Draft Synthesis Report	August 30th

Table 1-1 Project Parameters and Reporting Limits (dry weight units)

Parameter	Method Reference	Method Number	Project Required RL[1]	RL Units
Physical Tests				
Total Solids/Water Content	ASTM	D-2216	1.0	%
Grain Size Analysis Sieve & Hydrometer	ASTM	D-422	1.0	%
Metals				
Copper	SW-846	6020	1.0	ppm
Zinc	SW-846	6020	1.0	ppm
Conventional Analyses				
TOC	Lloyd Kahn	--	0.1	ppm
Total Petroleum Hydrocarbons (C9-C36)	SW-846	8015	5.0	ppm
PAHs (Priority Pollutant List)				
Acenaphthene	SW-846	8270C-SIM	0.02	ppm
Acenaphthylene	SW-846	8270C-SIM	0.02	ppm
Anthracene	SW-846	8270C-SIM	0.02	ppm
Benzo(a)anthracene	SW-846	8270C-SIM	0.02	ppm
Benzo(a)pyrene	SW-846	8270C-SIM	0.02	ppm
Benzo(b)fluoranthene	SW-846	8270C-SIM	0.02	ppm
Benzo(k)fluoranthene	SW-846	8270C-SIM	0.02	ppm
Benzo(g,h,i)perylene	SW-846	8270C-SIM	0.02	ppm
Chrysene	SW-846	8270C-SIM	0.02	ppm
Dibenz(a,h)anthracene	SW-846	8270C-SIM	0.02	ppm
Fluoranthene	SW-846	8270C-SIM	0.02	ppm
Fluorene	SW-846	8270C-SIM	0.02	ppm
Indeno(1,2,3-cd)pyrene	SW-846	8270C-SIM	0.02	ppm
Naphthalene	SW-846	8270C-SIM	0.02	ppm
Phenanthrene	SW-846	8270C-SIM	0.02	ppm
Pyrene	SW-846	8270C-SIM	0.02	ppm
[1]RL: Reporting Limit				

2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

NAE has overall responsibility for the study. NAE's contractor, ENSR, will perform the field investigation, oversee sample analysis, and prepare the cruise and draft synthesis reports. Field and laboratory services will be provided under subcontract to ENSR.

The various management, QA, field, and laboratory responsibilities of key project personnel are defined below. Figure 2-1 presents the lines of authority and communication specific to this study.

2.1 Management Responsibilities

NAE Technical Manager

The NAE Technical Manager, Dr. Tom Fredette, is responsible for project direction and decisions concerning technical issues and strategies.

ENSR Project Manager

The ENSR Project Manager, Mr. Steve Wolf, has responsibility for technical, financial, and scheduling matters. Other duties, as necessary, include:

- Assigning duties and orienting project staff to the specific needs and requirements of the project,
- Ensuring that data assessment activities are conducted in accordance with the QAPP,
- Approving project-specific procedures and internally prepared plans, drawings, and reports,
- Serving as the focus for coordination of all field and laboratory task activities, communications, reports, and technical reviews, and other support functions, and facilitating sampling activities with the technical requirements of the project, and
- Maintaining the project files.

Technical Studies Manager

The Technical Studies Manager, Dr. Drew Carey, will provide technical comment on the project design and assist with the draft synthesis report.

ENSR Health and Safety Officer

The ENSR Project Health and Safety Officer, Ms. Kathy Harvey serves as an advisor to the PM and ENSR staff including:

- Recommending appropriate personal protective equipment (PPE) to protect ENSR personnel from potential hazards,
- Conducting accident investigations.

Additionally, a Boat/Marine Safety briefing will be conducted by the Boat Captain before the survey begins.

ENSR Task Managers

Each ENSR Task Manager is responsible for overseeing the day-to-day activities associated with his/her task and for communicating progress, problems, and any data quality issues to the ENSR Project Manger. The Task Managers will also participate in report preparation. The Task Leaders are as follows:

Project Chemist – Mr. Dion Lewis will be responsible for procuring and managing the laboratory subcontractors, serving as the liaison between field and laboratory personnel, and assessing the quality of the analytical data.

Data Manager – Ms. Heather Wayne will be responsible for managing related project information systems including Electronic Data Deliverable (EDD) specifications, database oversight, documentation of all database related decisions, and output.

2.2 Quality Assurance Responsibilities

ENSR Project QA Officer

The ENSR Project QA Officer, Ms. Debra McGrath, has overall responsibility quality assurance oversight. The ENSR Project QA Officer communicates directly to the ENSR Project Manager. Specific responsibilities include:

- Reviewing and approving the QAPP,
- Reviewing and approving QA procedures, including any modifications to existing approved procedures,
- Ensuring that QA audits of the various phases of the project are conducted as required,
- Providing QA technical assistance to project staff,
- Ensuring that data validation/data assessment is conducted in accordance with the QAPP, and
- Reporting on the adequacy, status, and effectiveness of the QA program to the ENSR Project Manager.

2.3 Laboratory Responsibilities

The laboratories providing project physical and chemical testing services are listed below.

Organization	Contact	Tasks
Katahdin Analytical Services (KASI) 340 County Road Westbrook, ME 04098	Robert Thomas (207) 874-2400	Sediment TOC, TPH, and PAH compound analyses.
GeoPlan Associates 1145 Massachusetts Avenue Boxborough, MA 01719	Peter Rosen (978) 635-0424	Sediment grain size and moisture content measurements.
STL Billerica (splitting) 149 Rangeway Road N. Billerica, MA 01862 STL Pittsburgh (analysis) 450 William Pitt Way Pittsburgh, PA 15238	Rick Carr (781) 455-0653	Core splitting support and sediment metals analysis.

Laboratory Manager

The Laboratory Manager is ultimately responsible for the data produced by the laboratory. Specific responsibilities include:

- Implementing and adhering to the laboratory QA manual and all corporate policies and procedures within the laboratory,
- Approving the standard operating procedures (SOPs),
- Maintaining adequate staffing documented on organization charts
- Implementing corrective actions related to internal/external audit findings

Laboratory QA Coordinator

The Laboratory QA Coordinator reports to the Laboratory Manager. Specific responsibilities include:

- Approving SOPs,
- Assessing and maintaining the laboratory QA manual implementation within the facility operations,
- Recommending resolutions for ongoing or recurrent nonconformances within the laboratory,
- Performing QA assessments,

- Reviewing and approving corrective action plans for nonconformances, tracking trends of nonconformances to detect systematic problems, and initiating additional corrective actions as needed.

Laboratory Project Manager

The Laboratory Project Manager is the primary point of contact between the laboratory and ENSR. Specific responsibilities of the Laboratory Project Manager include:

- Monitoring project requirements for a specified project,
- Acting as a liaison between the client and the laboratory staff,
- Reviewing project data packages and EDDs for completeness and compliance to client needs, and
- Monitoring, reviewing, and evaluating the progress and performance of projects.

2.4 Field Responsibilities

ENSR Field Scientist

The ENSR Field Scientist, Mr. Dion Lewis, has overall responsibility for completion of all field activities in accordance with the Survey Plan and QAPP and is the communication link between ENSR project management and the field team. Specific responsibilities of the ENSR Field Scientist include:

- Coordinating activities in the field,
- Assigning specific duties to field team members,
- Mobilizing and demobilizing the field team and subcontractors,
- Directing the activities of subcontractors in the field,
- Resolving any logistical problems that could potentially hinder field activities, such as equipment malfunctions or availability, personnel conflicts, or weather dependent working conditions, and
- Implementing field QC including issuance and tracking of measurement and test equipment; the proper labeling, handling, storage, shipping, and chain-of-custody procedures used at the time of sampling; and control and collection of all field documentation.

ENSR Field Staff

The field staff report directly to the ENSR Field Scientist. The responsibilities of the field team include:

- Collecting samples, conducting field measurements, and decontaminating equipment according to documented procedures stated in the Survey Plan and QAPP,
- Ensuring that field instruments are properly operated, calibrated, and maintained, and that adequate documentation is kept for all instruments,
- Collecting the required QC samples and thoroughly documenting QC sample collection,
- Ensuring that field documentation and data are complete and accurate, and
- Communicating any nonconformance or potential data quality issues to the ENSR Field Scientist.

Field Service Contractor

Field services will be provided by the following organization:

Organization	Contact	Tasks
OSI 91 Sheffield Street Old Saybrook, CT 06475 Phone 860 388-4631	George Reynolds	To provide the survey vessel, captain, navigation and echo sounding systems, sampling equipment (Vibra cores, liners, caps) and related support staff.

2.5 Training

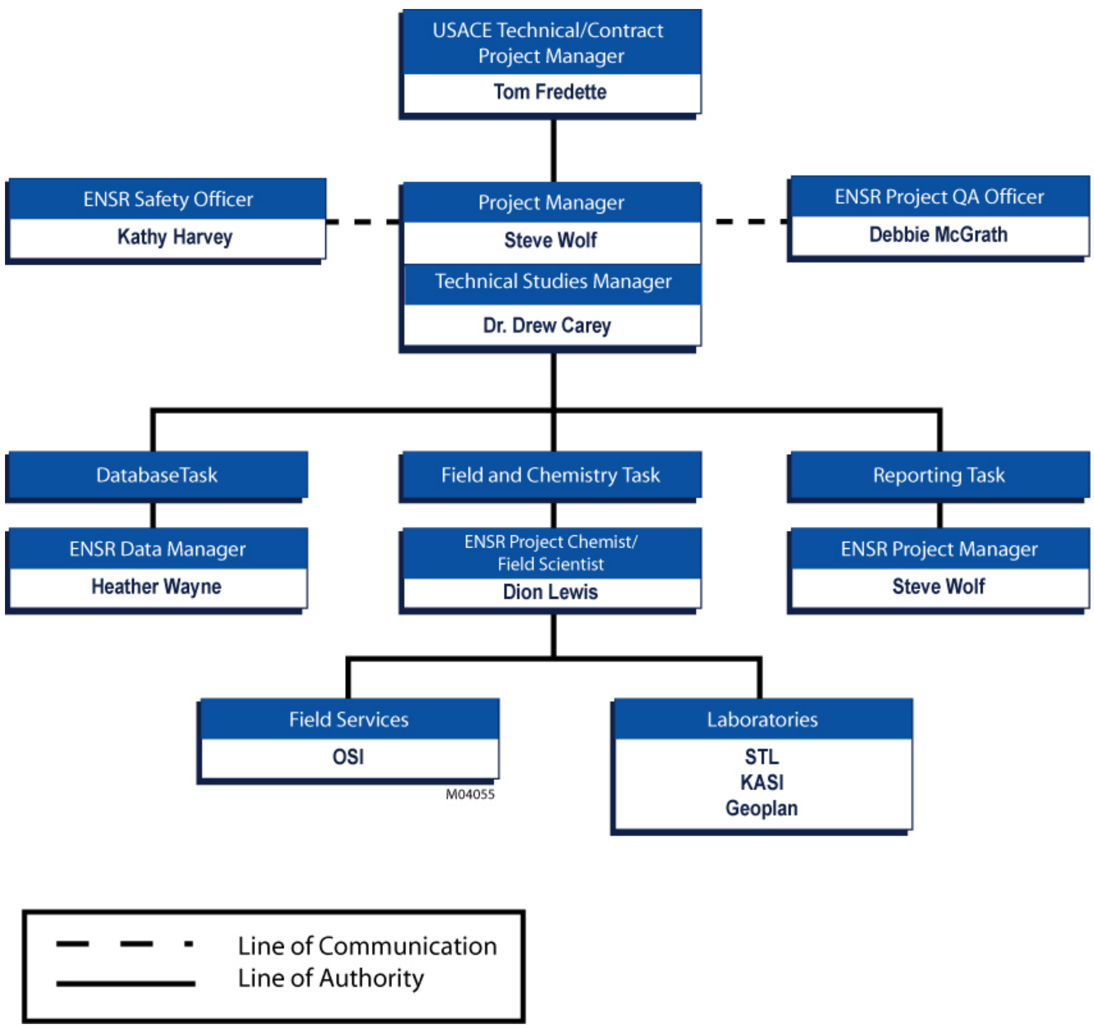
All personnel performing work on this study will be qualified to perform their assigned tasks. Prior to starting work, field personnel will be given instruction specific to the project, covering the following areas:

- Organization and lines of communication and authority,
- Overview of the QAPP,
- QA/QC requirements,
- Equipment documentation requirements, and
- Health and safety requirements.

Instructions will be provided by the Field Scientist and Project QA Officer.

All laboratory sample processing and analysis techniques must be performed by fully trained personnel, for whom training certificates are maintained in QA Department files.

Figure 2-1 Project Organization



3.0 DATA QUALITY REQUIREMENTS AND ASSESSMENTS

The overall QA objective for this study is to develop and implement procedures for accurate field sampling, laboratory analysis, chain of custody, and reporting. Field station positioning must be highly accurate to locate several cores along the relatively small mounds on the seafloor. Subsequent laboratory analysis must be precise so that measured chemical gradients are representative of the in-situ conditions and so that the data can support capping efficiency evaluations.

Specific procedures for sampling, chain of custody, laboratory instrument calibration, laboratory analysis, reporting of data, internal QC, audits, preventive maintenance of field equipment, and corrective action are described in subsequent QAPP sections.

3.1 Precision

3.1.1 Definition

Precision is a measure of the degree to which two or more measurements agree.

3.1.2 Field Variability

One core per site will be collected in duplicate to assess lateral variability at the disposal mounds. A high degree of variability is anticipated since these disposal sites represent disturbed environments. The purpose of this exercise is to evaluate lateral variability, rather than assess collection and measurement precision. Therefore, a field precision objective has not been specified.

3.1.3 Laboratory Precision Objectives

Precision in the laboratory is assessed through the calculation of relative percent difference (RPD) for duplicate samples. The equations to be used for precision can be found in Section 12.1. Precision control limits are provided in Table 8-1. The objective for this project is better than 35% for the chemical constituents that are measured an order of magnitude above the laboratory reporting limit.

3.2 Accuracy

3.2.1 Definition

Accuracy is the degree of agreement between the observed value and an accepted reference or true value.

3.2.2 Field Accuracy Objectives

Vessel positioning accuracy is essential so that several cross-sectional cores can be accurately collected from the small (100-200 m dia.) disposal mounds. Sub-meter accuracy is specified for the survey and will be accomplished using DGPS technology. Accuracy in the field is also assessed through the adherence to all sample handling, preservation, and holding time requirements.

3.2.3 Laboratory Accuracy Objectives

Laboratory accuracy is assessed through the analysis laboratory control samples (LCSs), spiked samples, Standard Reference Materials (SRMs) and surrogate compounds, and the subsequent determination of percent recoveries (%Rs). The equations to be used for accuracy in this project can be found in Section 12.2. Accuracy control limits are listed in Table 8-1.

3.3 Measures to Ensure Representativeness of Field Data

To ensure that the data generated during the project accurately represent field conditions and the mound/cap characteristics it is imperative that the samples be collected in a manner that properly preserves the in-situ chemical and physical conditions. Furthermore, five cores (plus a field replicate) will be collected at each site to enhance the representativeness of the final dataset.

Careful measurement of the core penetration and recovery will be made to gauge any compression that occurs during the coring process. Once collected, sediments will be stored, handled, and analyzed according to the protocols specified in Section 4 and in the Survey Plan.

3.4 Completeness

3.4.1 Definition

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the expected amount under normal conditions. "Normal conditions" are defined as the conditions expected if the sampling plan was implemented as planned.

3.4.2 Field Completeness Objectives

Field completeness as it relates to this investigation is a measure of the amount of valid samples collected. The field completeness objective is 100 percent. The equation for completeness is presented in Section 12.3 of this QAPP.

3.4.3 Laboratory Completeness Objectives

Laboratory completeness is a measure of the amount of valid measurements obtained from all valid samples submitted to the laboratory. The equation for completeness is presented in Section 12.3 of this QAPP. The laboratory completeness objective is greater than 95 percent.

3.5 Comparability

3.5.1 Definition

Comparability expresses the confidence with which one data set can be compared to another.

3.5.2 Measures to Ensure Field Comparability

Comparability is dependent upon the proper design of the sampling program and will be satisfied by ensuring that the QAPP is followed and that proper sampling techniques are used. Maximum comparability with previous data sets is expected because the same field design has been specified.

3.5.3 Measures to Ensure Laboratory Comparability

Comparability is also dependent on the use of nationally recognized EPA or equivalent analytical methods and the reporting of data in standardized units. Table 1-1 lists the recognized EPA methods that have been specified for this project.

4.0 FIELD PROGRAM

The field program details are defined in the Survey Plan. A specialized coring vessel (R/V Can-do) with 4'x5' moon-pool will be utilized for the coring effort at the CLDS. As indicated, accurate vessel positioning is essential for the successful collection of site sediments, particularly given the relatively small size of the study mounds. Navigational positioning will be accomplished using a Trimble 4000 RS DGPS receiver interfaced with an OSI Maretrack Navigation and Data Logging System. Site depth will be monitored using both an echo sounder and a weighted line. The target coring locations and collection procedures are fully detailed in the Survey Plan. Laboratory handling details are further defined in the following section.

4.1 Sub-Sample Collection Procedures

All cores will be transported intact from the field to the fixed processing laboratory for splitting the core liner, documenting stratigraphy, and subsampling. At the fixed laboratory, cores will be handled in the following manner:

1) A single core will be placed on a covered laboratory bench, measured lengthwise, and the outer Lexan sleeve cut in half length-wise using clean shears, exposing the sediment material.
2) Next, the sediment will be cut vertically in two. The cores will be cut from top to bottom so that the cleanest material is encountered first, followed by the more contaminated material. A stainless steel wire will be used to cut each core in half. New wire will be used for each core.

3) A visual description of the stratigraphy (color, texture) will be noted on a log form (Attachment 1) and the core photographed. Sectitoning will take place without crossing stratigraphic boundaries (cap/mounts interface).

4) Sediment (10-cm) horizons will be selected for analysis by the Project Chemist, removed to a stainless bowl, and homogenized.

5) Each sample representing a 10-cm core interval will be containerized in a 2-oz glass jar, a 4-oz glass jar, and a plastic bag (summarized in Table 4-1) for subsequent analysis. Un-used core sections will also be containerized and archived (-20°C) for possible future analysis.

Samples will be transferred to the appropriate destination laboratory within 48 hours. All containers will be labeled with the core and subsection ID as described in Section 4.5. Chemistry samples will be stored chilled (4°C) until ready for laboratory processing. Grain size samples must not be frozen, but may be stored either chilled (4°C) or at ambient temperature in airtight containers.

Sample handling tools during the homogenization, and subsampling process will be constructed of stainless steel and will be decontaminated as described in Section 4.3.

4.2 Sample Preservation, Containerization, and Holding Times

After core samples are split at the processing laboratory, sediment subsamples will be transferred to the appropriate sample jars for subsequent storage and analysis.

Table 4-1 Sample Container, Preservation, and Holding Time Requirements for Sediment Samples

Sediment Parameters[1]	Sample Volume/Mass	Container Material	Preservation	Storage Condition[2]	Holding Times[3]	Receiving Lab[4]
Grain Size, Moisture Content	500 g	Plastic	Airtight	NA	Undetermined	GEO
Grain Size QC (1 per 20)	*1000 g*	*Plastic*	*Airtight*	*NA*	*Undetermined*	*GEO*
TOC Lloyd Kahn	4-oz/120 g	Glass	Chill or Freeze	-20 °/4±2 °C	14 d	KASI
PAHs, TPH					14 d (solid)/ 40 d (extract)	KASI
TOC, PAH, TPH QC (1 per 20)	*8-oz/240 g*	*Glass*	*Chill or Freeze*	*-20 °/4±2 °C*	*14 d*	*KASI*
Metals	2-oz/40 g	Glass	Chill or Freeze	-20 °/4±2 °C	180 d	STL
Metals QC (1 per 20)	*3-oz/60 g*	*Glass*	*Chill or Freeze*	*-20 °/4±2 °C*	*180 d*	*STL*

[1]Shaded QC samples represent quantities required for QC (duplication, spiking) exercises. Amount listed includes the mass needed to make both background and QC measurements.

[2]Holding time corresponds to chilled storage condition. Frozen samples may be held stable for one year (minimum).

[3]Allowable holding time is from the time that samples are collected.

[4]GEO: GeoPlan Associates; KASI: Katahdin Analytical Services Inc; STL: Severn Trent Labs

Storage jars will be cleaned by the manufacturer to meet or exceed U.S. EPA specifications. Certificates of analysis are provided with each bottle lot and maintained on file to document conformance to EPA specifications.

4.3 Equipment Decontamination

All subsampling and homogenization utensils will be decontaminated between horizons using the following soap, water, and solvent rinsing procedure:

1) Remove all adhering sediment with laboratory soap (Alconox or equivalent) and deionized water (DIW) mixture
2) Rinse with DIW

3) Rinse with dichloromethane
4) Rinse with acetone
5) Seal the utensils in aluminum foil unless they are to be reused immediately.

4.4 QC Sample Collection

As indicated in the field survey plan, one duplicate core per site will be collected for field QC purposes. Co-located core replicates will be collected as close as possible under the existing sea conditions. For laboratory QC (replicate and spiking exercises), one subsection per 20 will represent a 20 cm interval to ensure sufficient QC sample mass. These “QC horizons” must not be collected near cap/mound interfaces to avoid “gradient smearing”.

Field rinseate blanks are considered unnecessary for this program because a new, previously unused core liner will be used at each location.

4.5 Sample Labeling

For labeling purposes, the STNH-N site will be designated site 1 and the CS-2 site will be designated site 2. Samples will be labeled with the site number and core number. Using this convention, the first two cores collected at each site will be labeled in the following fashion:

1-1, 1-2 (representing core 1 and 2 collected at the STNH-N site).

2-1, 2-2 (representing core 1 and 2 collected at the CS-2 site).

There will be six unique core IDs at each site, representing the five core locations plus one field duplicate. If a core requires cutting down in the field due to its length, subsections will be labeled with alpha characters. The uppermost section is to be labeled (A), followed by (B) at greater depth.

Example: 1-2 (A) and 1-2 (B).

Core subsections selected for further analysis are to be labeled with the core ID followed by the depth interval in cm. Example: 2-2 (50-70) will represent the 50 to 70 cm section from the second core collected at the CS-2 mound. The sediment/water interface represents “0” in all section labeling.

The full chemical/physical subsample label will provide the following information:

1. Project (DAMOS Task 4)
2. Sample Identification number, incorporating core subsection depth
3. Sample collection date and time

4. Collector name
5. Sample preservation/storage condition
6. Type of analysis (Metals, PAH, TOC, etc.)

4.6 Sample Transfer/Shipments

Sediment samples destined for GeoPlan Associates (grainsize analysis) will be packaged without ice. Samples destined for the chemistry laboratories will be shipped on ice. Custody seals are to be applied to shipping coolers and sample receipt forms must be filled out upon receipt at the laboratory.

5.0 SAMPLE CUSTODY

Data authenticity depends on strict chain-of-custody, which will be adhered to for this study. Sample custody is addressed in three parts: field sample collection, laboratory analysis, and final evidence files.

A sample or evidence file is considered to be under a person's custody if

- the item is in the actual possession of a person;
- the item is in the view of the person after being in actual possession of the person;
- the item was in the actual physical possession of the person but is locked up to prevent tampering;
- the item is in a designated and identified secure area.

5.1 Field Custody Procedures

Field logbooks will provide the means of recording the chronology of data collecting activities performed during the investigation. As such, entries will be described in as much detail as possible so that a particular situation could be reconstructed without reliance on memory.

- All cores and subsamples will be identified with sample numbers, sampling locations and date/time of collection. The sample numbering system is presented in Section 4.5.
- Sample labels will be completed for each sample using waterproof ink unless prohibited by weather conditions. For example, a logbook notation would explain that a pencil was used to fill out the sample label because the pen would not function in wet weather.
- Samples will be accompanied by a properly completed chain-of-custody form. The sample numbers and locations will be listed on the chain-of-custody form. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the record. This record documents the transfer of custody of samples from the sampler to another person, to another laboratory, or to/from a secure storage location.
- All shipments will be accompanied by the chain-of-custody record identifying the contents. The original record will accompany the shipment, and copies will be retained by the sampler and placed in the project files.
- Following the core splitting exercise, samples will be properly packaged for shipment and dispatched to the appropriate laboratory for analysis, with a separate signed custody record enclosed in and secured to the inside top of each sample box or cooler. Shipping containers will be locked and secured with strapping tape and custody seals for shipment to the laboratory. The custody seals will be attached to the front right and back left of the cooler and covered with clear plastic tape after being signed by field personnel. The cooler will be strapped shut with strapping tape in at least two locations.

- If the samples are sent by common carrier, the waybill will be used. Waybills will be retained as part of the permanent documentation. Commercial carriers are not required to sign off on the custody forms since the custody forms will be sealed inside the sample cooler and the custody seals will remain intact.

5.2 Laboratory Custody Procedures

Samples will be received and logged in by a designated sample custodian or his/her designee. Upon sample receipt, the sample custodian will:

- Examine the shipping containers to verify that the custody tape is intact,
- Examine all sample containers for damage,
- Determine if the temperature required for the requested testing program has been maintained during shipment and document the temperature on the chain-of-custody records,
- Compare samples received against those listed on the chain-of-custody,
- Verify that sample holding times have not been exceeded,
- Examine all shipping records for accuracy and completeness,
- Sign and date the chain-of-custody immediately (if shipment is accepted) and attach the waybill,
- Note any problems associated with the coolers and/or samples on the cooler receipt form and notify the Laboratory Project Manager, who will be responsible for contacting the ENSR Chemistry Task Manager,
- Attach laboratory sample container labels with unique laboratory identification and test, and
- Place the samples in the proper laboratory storage.

Following receipt, samples will be logged in according to the following procedure:

- The samples will be entered into the laboratory tracking system. At a minimum, the following information will be entered: project name or identification, unique sample numbers (both client and internal laboratory, type of sample, required tests, date and time of laboratory receipt of samples.
- The Laboratory Project Manager will be notified of sample arrival.
- The completed chain-of-custody, waybills, and any additional documentation will be placed in the final evidence file.

5.3 Project Evidence Files

The final evidence files will be the central repository for all documents that are relevant to sampling and analysis activities as described in this QAPP. ENSR is the custodian of the final evidence files and will maintain the contents of the files, including all relevant records, reports, logs, field notebooks, pictures, subcontractor reports, and data reviews in a secured, limited access area.

The final evidence files will include at a minimum:

- Field logbooks,
- Field data and data deliverables,
- Photographs,
- Drawings,
- Field forms,
- Electronically captured data files,
- Laboratory data deliverables,
- Data validation and assessment reports,
- Progress reports, QA reports, interim project reports, etc.,
- All custody documentation (forms, airbills, etc.)

6.0 CALIBRATION PROCEDURES

This section describes the calibration procedures and frequency at which these procedures will be performed.

6.1 Field Instruments

Field navigation instruments will be checked daily, prior to use. Checking procedures will be consistent with the manufacturer's recommendations. All checking procedures will be documented in the field records. Records will include the checking date/time, name of the person performing the check, and the results.

6.2 Laboratory Instruments

Calibration procedures for laboratory instruments will consist of initial calibrations, initial calibration verifications, and continuing calibration verification. The SOP for each analysis performed in the laboratory describes the calibration procedures, their frequency, acceptance criteria, and the conditions that will require recalibration. This information is summarized in the laboratory QA Manuals included on the CD appended to this QAPP.

The laboratory maintains documentation for each instrument which includes the following information: instrument identification, serial number, date of calibration, analyst, calibration solutions, and the samples associated with these calibrations.

Calibration procedures for laboratory instrumentation will consist of initial calibrations, initial calibration verifications, and continuing calibration verification. Detailed descriptions of the calibration procedures are included in the laboratory SOPs, which describe the calibration, frequency, acceptance criteria, and the conditions that will require recalibration. A summary of this information is provided in Table 6-1.

Table 6-1 Laboratory Instrument Calibration Frequency and Criterion.

Instrument and Parameter	Calibration Frequency	Calibration Standards	Acceptance Criteria
GC/MS PAHs	Initial: As needed	Initial: 5 standards 0.2, 0.5, 1.0, 2.0, 3.0 ug/mL	Initial: %RSD <30 for all CCC[1] analytes; Average %RSD <15% for individual target compounds
	Continuing: Every 12-18 h	Continuing: Mid-point standard 1.0 ug/mL	Continuing: %D <20 for all CCC analytes
GC TPH	Initial: As needed	Initial: 5 standards 50, 200, 500, 1000, 2000 ug/mL	Initial: Correlation Coefficient ≥0.99
	Continuing: daily after every 20 samples, and when CV exceeds criteria	Continuing: Mid-point standard 500 ug/mL	Continuing: %D <20
Combustion Analyzer TOC	Initial: Annually	Initial: 6 standards 0, 400, 2000, 4000, 16000, 24000, ug Carbon	Initial: Correlation Coefficient ≥0.995
	Continuing: Every 12 hours	Continuing: 1 standard within calibration range	Continuing: CCV within 20% of true value.
ICP-MS Metals	Initial: Daily	Initial: Minimum of three standards and calibration blank. ~10, 20, 100 µg/L	Initial: r >0.995
	Continuing: Every 10 samples and at the end of the analytical run	Continuing: Mid-point standard of each metal. ~50 µg/L	Continuing: CCV within 10% of true value.
[1]CCC: Calibration Check Compounds (as defined in SW-846 8270C).			

7.0 ANALYTICAL PROCEDURES

7.1 Field Analyses

There are no field chemical analyses associated with the survey.

7.2 Laboratory Analyses

Samples will be analyzed by the laboratories identified in Section 2. The target analytes, project-required reporting limits, and analytical methods are listed in Table 1-1. Laboratory specific SOPs are identified in the following table and provided as an attachment.

Analyte Group	Laboratory SOP No.	Equivalent Method No.
PAHs	CA-512/526 (preparation) CA-213 (analysis)	SW-846 3550B (EPA, 1986) SW-846 8270C Modified (EPA, 1996)[1]
ICP/AES Metals	3051 (preparation) PITT-MT-0020 (analysis)	SW-846 3051 (EPA, 1986) SW-846 6020 (EPA, 1994)
TPH	CA-527/525/536 (preparation) CA-315 (analysis)	SW-846 3550B/3545 (EPA, 1986) SW-846 8015 (EPA, 1996)
TOC	CA-741 (preparation and analysis)	Lloyd Kahn TOC Method (EPA, 1988)
Grain size	ASTM D422	ASTM D422C-98
[1]EPA Method modified to run in selected ion mass spectrometer mode		

8.0 INTERNAL QUALITY CONTROL CHECKS

8.1 Field Quality Control

For field QC purposes, all activities will be performed by appropriately trained personnel, and work will be conducted in conformance with project-specific protocols.

8.2 Laboratory Quality Control

The laboratories utilized for this study have QC programs in place to ensure the reliability and validity of the measurements performed. Additionally, the following requirements apply to all laboratory analyses:

- All activities will be performed by appropriately trained personnel,
- Work will be conducted in conformance with project-specific protocols and laboratory SOPs,
- All steps of analysis will be documented as described in Section 9.1.2 and the records retained on file,
- Reviews of records will be conducted by supervisory personnel on a routine basis (at least weekly),
- All data will be reviewed by laboratory personnel prior to its release.

8.2.1 Chemical Analyses

The QC requirements for analytical methodologies include the following:

- Method blanks
- Surrogate Internal Standards (PAHs)
- LCS/LCSDs
- MS/MSDs
- SRMs
- Matrix Duplicates (metals)

The QC checks for each parameter and method (frequencies, control limits, and corrective actions) are detailed in the attached laboratory SOPs and summarized in Table 8-1.

Table 8-1 Internal QC Checks

QC Sample*	Units	Grain Size	TOC	TPH	Metals	PAHs	*Corrective Action*
Method Blank	Conc	-	< RL	< RL	< RL	< RL	*1*
Surrogate Spikes	% Rec	-	-	25-95	-	30-150	*2*
Matrix Duplicate	% RPD	20	20	-	30	35	*3*
Matrix Spike	% Rec	-	-	40-100	75-125	30-150	*4*
MSD	% RPD	-	-	35	20	35	*5*
LCS	% Rec	-	80-120	40-100	80-120	30-150	*6*
SRM	% Rec	-	WIL	-	WIL	WIL	*7*

*Frequency: 1 QC sample per batch of 20 samples except for surrogate spikes and SRMs. Surrogate spikes are added to every sample, blank, and standard prior to extraction. One SRM contained in just two of the project batches are sufficient for the program.

WIL = Within limits

Corrective Action Codes:

1 Re-extract and reanalyze samples with concentrations < 20x the method blank result and narrate.

2 Re-extract sample or re-analyze sample if within hold time. Discuss with ENSR Project Chemist immediately.

3 Flag results, narrate and discuss with ENSR Project Chemist.

4 If LCS (and surrogate) are within specifications, flag results. If ND results contain high bias, narrate. Otherwise reprep/analyze affected samples.

5 Investigate, re-analyze or flag results. Organics: per Corrective Action code #4.

6 If other QC sample results are acceptable, flag results. If ND results contain high bias, narrate. Otherwise re-extract/reanalyze and discuss with ENSR Project Chemist.

7 Report, flag results and narrate.

9.0 DATA REDUCTION, VALIDATION, AND REPORTING

All generated data will be reduced and validated prior to reporting. No data will be disseminated by the laboratory until it has been subjected to the procedures summarized below.

9.1 Data Reduction

9.1.1 Field Data Reduction Procedures

Measurements, station location, and sample collection information will be transcribed directly into the field logbook or onto standardized forms. If errors are made, results will be legibly crossed out, initialed and dated by the person recording the data, and corrected in a space adjacent to the original (erroneous) entry. Field data will be reviewed by the Field Scientist to ensure that records are complete, accurate, and legible.

9.1.2 Laboratory Data Reduction Procedures

Laboratory data reduction procedures will be performed according to the following protocol. All information related to analysis will be documented in controlled laboratory logbooks, instrument printouts, or other approved forms. All entries that are not generated by an automated data system will be made neatly and legibly in permanent waterproof ink. Information will not be erased or obliterated. Corrections will be made by drawing a single line through the error and entering the correct information adjacent to the cross out. All changes will be initialed, dated, and, if appropriate, accompanied by a brief explanation. Unused pages or portions of pages will be crossed out to prevent future data entry. Laboratory records will be reviewed by the Section Leaders on a regular basis, and by the Laboratory QA Manager periodically, to verify adherence to documentation requirements.

Analytical results for the sediment samples will be reported on a dry weight basis.

Prior to being released as final, laboratory data will proceed through a tiered review process. Data verification starts with the analyst or technician who performs a 100 percent review of the data to ensure the work was done correctly the first time. It is the responsibility of the analyst or technician to ensure that the verification of data in his or her area is complete. The data reduction and initial verification process must ensure that:

- Sample preparation and analysis information is correct and complete,
- Results are correct and complete,
- The appropriate SOPs have been followed and are identified in the project records,
- Proper documentation procedures have been followed,
- All nonconformances have been documented,

- Project-specific requirements have been met,
- The data generated have been reported with the appropriate number of significant figures as defined by the method or otherwise specified by the client.

Following the completion of the initial verification by the analyst or technician, a systematic check of the data will be performed by an experienced peer, Section Leader, or designee. This check will be performed to ensure that initial review has been completed correctly and thoroughly. The second level reviewer will examine the data signed by the analyst or technician. This review will include an evaluation of all items required in the raw data package. Any exceptions noted by the analyst or technician must be reviewed. Included in this review will be an assessment of the acceptability of the data with respect to:

- Adherence of the procedure used to the requested SOP,
- Correct interpretation of data,
- Correctness of numerical input when computer programs are used (checked randomly),
- Correct identification and quantitation of constituents with appropriate qualifiers,
- Numerical correctness of calculations and formulas (checked randomly)
- Acceptability of QC data,
- Documentation that instruments were operating according to method specifications (calibrations, performance checks, etc.),
- Documentation of dilution factors, standard concentrations, etc.,
- Sample holding time assessment.

This review will also serve as verification that the process the analyst or technician has followed is correct in regard to the following:

- The procedure follows the project-required methods and specific instructions,
- Nonconforming events have been addressed by corrective action as defined on a nonconformance memo,
- Valid interpretations have been made during the examination of the data and the review comments of the initial reviewer are correct,
- The package contains all of the necessary documentation for data review and report production and results are reported in a manner consistent with the method used for preparation of data reports.

A third-level review will be performed by the Laboratory Project Manager before results are submitted to the client. This review serves to verify the completeness of the data report and to ensure that project requirements are met for the analyses performed. The items to be reviewed will include:

- Results are present for every sample in the analytical batch, reporting group, or sample delivery group,
- Every parameter or target compound requested is reported with either a value or reporting limit,
- The correct units and correct number of significant figures are utilized,
- All nonconformances, including holding time violations, and data evaluation statements that impact the data quality are accompanied by clearly expressed comments from the laboratory,
- The final report is legible, contains all the supporting documentation required by the project, and is in either the standard format or in the client-required format.

A narrative to accompany the final report will be finalized by the Laboratory Project Manager. This narrative will include relevant comments collected during the earlier reviews.

9.2 Data Validation

ENSR will be responsible for performing an independent review of the analytical data, including a tier II validation of the first sample batch (of 20 samples). The related physical testing and analytical data will be reviewed for the following, as appropriate to the method:

- Completeness of deliverable,
- Technical holding times,
- Laboratory and field blank contamination,
- Surrogate spike recoveries,
- MS/MSD recoveries and relative percent differences (RPDs),
- Laboratory duplicate RPDs, and
- LCS recoveries.

The evaluation will consist of a review of the data package narrative and QC summaries. If data are considered usable, data will not be qualified. In the event that serious deficiencies in data quality are noted, the data may be rejected and considered unusable and additional data packages reviewed.

9.3 Data Analysis

9.3.1 GIS/Spatial Analysis

Vertical mound/cap stratigraphy will be mapped across each site using graphical methods including specialized software.

9.3.2 Statistics

ENSR will review the data when available and evaluate the best statistical approach at that time in consultation with NAE. This may include principal components analysis (PCA) as performed in previous studies to examine vertical gradient inflections.

9.4 Meetings

One review meeting is planned to discuss survey findings before the draft report is prepared. Other meetings may be scheduled as needed.

9.5 Data Reporting

9.5.1 Laboratory Data Reporting

KASI, STL, and GeoPlan will provide analytical results within 45 days following sample receipt. At a minimum, the data packages from the analytical chemistry laboratories will include the following:

- Case narrative, describing any data quality issues,
- Sample results (dry weight units),
- QC results (blanks, laboratory duplicates, SRMs, etc.),
- Internal standard recoveries (PAHs),
- Percent moisture results,
- Electronic Data Deliverable (format detailed in procurement specifications),
- Data qualifier definitions,
- Detection limits,
- Original Chain of Custody,
- Raw data, including chromatograms and quantitation reports.

The physical testing (GeoPlan) data packages should include data summary tables and corresponding grain-size curves (e.g. ENG Form 2087).

9.5.2 Status Reports

Monthly written status reports will accompany the submittal of invoices outlining the work accomplished for that billing period. A monthly record of related phone conversations and written correspondence will also be provided.

9.5.3 Draft Report

A draft report will be prepared that includes results of the survey. The report will discuss the project background, approach, methods, present the results, and provide discussion.

9.5.4 Final Report

A final report is not planned under the current contract.

9.6 Data Management

ENSR will maintain all validated laboratory data in an Access database during the course of this study and will provide NAE with the electronic data in DMSMART format. The data management strategy for this project comprises the following elements:

- Assignment of unique sample codes. This code is used to track the sample from collection, through the analysis, to reporting.
- Verification and validation of data. Verification and validation procedures are described in Sections 9.1 and 9.2 of the QAPP.
- Development of a database. At a minimum, the database will contain the following fields:

  Sample identifier,
  Sample location,
  Sample media type,
  Sampling date,
  Analysis date,
  Laboratory analysis identifier,
  Analyte name,
  Concentration value,
  Measurement units,
  Data qualifiers.

- Temporary vs. final database. Data will be loaded into a "temporary" database until data validation is complete, at which time the database will be finalized. Any changes made to the database after finalization will be documented, including a description of the change, date of change, person responsible, and reason for change.
- Database access. Access to the database will be limited to authorized users and will be controlled by password access.
- Data retention. Data will be retained in the previously established DAMOS data library.

10.0 PERFORMANCE AND SYSTEMS AUDITS

Performance and system audits are conducted as needed to verify that sampling and analysis are performed in accordance with the procedures established in the SAP/QAPP.

10.1 System Audits

10.1.1 Field System Audits

A system audit of field activities is not scheduled.

10.1.2 Laboratory System Audits

Laboratory audits are not planned for this project.

10.2 Performance Audits

Performance audits are not applicable to the field portion of this program. Within the laboratory, performance audits involve the preparation and submittal of blind performance evaluation (PE) samples, which are analyzed as part of the laboratory QA program. The analytical laboratories (KASI, STL) have been approved by the U.S. Corps of Engineers for HTRW project measurements.

11.0 PREVENTIVE MAINTENANCE

11.1 Field Equipment

The field equipment for this project includes a vibra corer. Field instruments will include a DGPS and echosounder. The ENSR Field Scientist will be responsible for ensuring that equipment and instruments are free from obvious defects, damage, and contamination and are properly functioning. At a minimum, this will entail checking the equipment or instrument prior to commencing the survey and performing daily operational checks and calibration as described in the manufacturer's instructions.

11.2 Laboratory Equipment

Routine preventative maintenance is conducted by the laboratory to minimize the occurrence of instrument failure and other system malfunctions. Designated laboratory employees regularly perform routine schedule maintenance and repair of (or coordinate with the vendor for repair of) all instruments. All maintenance that is performed is documented in the laboratory's operating record. All laboratory instruments are maintained in accordance with manufacturer's specifications and laboratory SOPs (on attached CD).

11.3 Inspection/Acceptance Requirements for Supplies and Consumables

For this project, critical supplies will be tracked through ENSR's system in the following manner.

Critical Supplies and Consumables	Inspection Requirements and Acceptance Criteria	Responsible Individual
Sample jars and bottles	Visually inspected upon receipt for cracks, breakage, cleanliness. Must be accompanied by certificate of analysis.	Field Scientist
Field measurement equipment	Functional checks to ensure proper calibration and operating capacity	Field Scientist
Sampling equipment	Visually inspected for obvious defects, damage, and contamination	Field Scientist

Supplies and consumables not meeting acceptance criteria will initiate the appropriate corrective action. Corrective measures may include repair or replacement of measurement equipment, and/or notification of vendor and subsequent replacement of defective or inappropriate materials. All actions will be documented in the project files.

12.0 DATA ASSESSMENT

The project data will be provided to the data users (NAE) in a review meeting before preparation of a synthesis report. The (draft) report will include a description of the sampling and analytical procedures and additional information useful for interpreting the data. The report will include stratigraphic comparisons across the disposal mounds and presentation/assessments of the potential for any vertical chemical contaminant migration.

The data quality indicators (DQIs) reviewed during the conduct of these studies include precision, accuracy, sensitivity, and completeness. Measurement sensitivity (project required detection limits) is defined in Table 1-1 and the fixed laboratories will be required to achieve, or nearly achieve, the minimum levels listed to ensure data usability. Further, Table 8-1 specifies the quality indicator objectives established for the project. The calculations associated with these DQI assessments are detailed below:

12.1 Precision

The RPD between MS/MSD and/or LCS/LCSDs are calculated to compare to precision objectives. The RPD will be calculated according to the following formula.

$$RPD = \frac{(Amount\ in\ Sample\,1 - Amount\ in\ Sample\,2)}{0.5\,(Amount\ in\ Sample\,1 + Amount\ in\ Sample\,2)}\, x\,100$$

12.2 Accuracy

Accuracy will be assessed by determining %Rs for surrogate compounds (PAHs) and SRMs. Percent recovery will be determined according to the following equation:

$$\%R = \frac{Experimental\ Concentration}{Known\ Amount\ \mathrm{Added}}\, x\,100$$

Accuracy will also be assessed by determining %Rs for matrix spikes according to the following formula:

$$\%R = \frac{(Amount\ in\ Spiked\ Sample - Amount\ in\ Sample)}{Known\ Amount\ \mathrm{Added}}\, x\,100$$

12.3 Completeness

Completeness is the ratio of the number of valid sample results to the total number of samples analyzed or processed. Following completion of the testing, the percent completeness will be calculated by the following equation:

$$Completeness = \frac{(number\ of\ valid\ measurements)}{(number\ of\ measurements\ planned)} x100$$

12.4 Representativeness and Comparability

Representativeness is a measure of how well a sample or set of samples represents the population characteristics. Comparability is a measure of how well measured data compare to historical data or other independent sources. Efforts to ensure representativeness and comparability are discussed Sections 3.3 and 3.5.

13.0 CORRECTIVE ACTION

Corrective action is the process of identifying, recommending, approving, and implementing measures to counter unacceptable procedures or out-of-limit QC performance that can affect data quality. Corrective action can occur during field activities, laboratory analyses, data validation, and data assessment.

13.1 Field Corrective Action

Corrective action in the field may be needed if sampling procedures require modification, etc. due to unexpected conditions. The field team may identify the need for corrective action. The ENSR Field Scientist will approve the corrective action and notify the ENSR Project Manager. The ENSR Project Manager, in consultation with the NAE Contract/Technical Manager and ENSR Project QA Officer, will approve the corrective measure. The ENSR Field Scientist will ensure that the corrective measure is implemented by the field team.

Corrective actions will be implemented and documented in the field record book. Documentation will include:

- A description of the circumstances that initiated the corrective action,
- The action taken in response,
- The final resolution, and
- Any necessary approvals.

No staff member will initiate corrective action without prior communication of findings through the proper channels.

13.2 Laboratory Corrective Action

Corrective action in the laboratory may occur prior to, during, and after initial analyses. A number of conditions such as broken sample containers, omissions or discrepancies with chain-of-custody documentation, and potentially high concentration samples may be identified during sample log-in or just prior to analysis. Following consultation with laboratory analysts and Section Leaders, it may be necessary for the Laboratory QA Coordinator to approve the implementation of corrective action. The laboratory SOPs specify some conditions during or after analysis that may automatically trigger corrective action or optional procedures. These conditions may include sample dilutions, additional sample extract cleanup, automatic reinjection/reanalysis when certain QC criteria are not met, loss of sample through breakage or spillage, etc.

The analyst may identify the need for corrective action. The Section Leader, in consultation with the staff, will approve the required corrective action to be implemented by the laboratory staff. The Laboratory QA Coordinator will ensure implementation and documentation of the corrective action. If the nonconformance causes project objectives not to be achieved, the ENSR Project Chemist will be notified. The ENSR Project Manager will contact all levels of project management for concurrence with the proposed corrective action.

These corrective actions are performed prior to release of the data from the laboratory. The corrective action will be documented in both the laboratory's corrective action files, and the narrative data report sent from the laboratory to the ENSR Project Manager. If the corrective action does not rectify the situation, the laboratory will contact the ENSR Project Chemist, who will determine the action to be taken and inform the appropriate personnel.

13.3 Corrective Action During Data Review and Assessment

The need for corrective action may be identified during data review or assessment. Potential types of corrective action may include resampling by the field team or reinjection/reanalysis of samples by the laboratory. These actions are dependent upon the ability to mobilize the field team and whether the data to be collected is necessary to meet the required QA objectives. If the ENSR data reviewer or assessor identifies a corrective action situation, the ENSR Project Manager will be responsible for informing the appropriate personnel. All corrective actions of this type will be documented by the ENSR Project Manager.

14.0 QUALITY ASSURANCE REPORTS

QA reports will be submitted to the ENSR Project Manager by the Project Chemist to ensure that any problems identified during the sampling and analysis programs are investigated and the proper corrective measures taken in response. The QA reports will be prepared for any significant QA/QC problems and describe recommended corrective actions and the outcome of those actions.

15.0 REFERENCES

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SAIC, 1995. Sediment Capping of Subaqueous Dredged Material Disposal Mounds: An Overview of the New England Experience 1979-1993. DAMOS Contribution No. 95. US Army Corps of Engineers, New England Division, Concord, MA.

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United States Army Corps of Engineers, 1997. Chemical Quality Assurance for HTRW Projects. EM 200-1-6. October, 1997.

QUALITY ASSURANCE PROJECT PLAN

STAMFORD-NEW HAVEN HARBOR NORTH/ CAP SITE 2 SURVEY

MAY 2004

(Revision 0)

Prepared by:
ENSR CORPORATION

Prepared for:
U.S. ARMY CORPS OF ENGINEERS
NEW ENGLAND DISTRICT
CONCORD, MASSACHUSETTS

ENSR Project Manager	Date
ENSR Project Quality Assurance Officer	Date
USACE Technical/Contract Manager	Date

QAPP DISTRIBUTION LIST

Tom Fredette, NAE Technical Coordinator
Gail French, NAE Technical Specialist
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Heather Wayne, ENSR Data Task Manager
Rick Carr, STL Project Manager
Rob Thomas, KASI Project Manager
Peter Rosen, GeoPlan Project Manager

ATTACHMENT 1

LABORATORY SOPs AND QAMPs (CD)

APPENDIX A2

1990 SURVEY METHODS AND QA SUMMARY

CENED-ED-GL-E

7 December 1990
Saner/11/928-4711

MEMORANDUM THRU Director, Environmental & Materials Laboratory

Chief, GED

FOR Director of Operations, ATTN: Mr. Fredette

SUBJECT: Transmittal of DAMOS - Cap Site Cores/LIS Reference

1. Enclosed please find analytical results for the DAMOS project along with sample listing with field descriptions, methodologies, and the quality assurance summary.

2. If you have any questions, please call Mr. Saner at 508-928-4238.

Enclosure

RICHARD D. REARDON
Director of Engineering

Quality Assurance Review

Project: DAMOS - Cap Site Cores/LIS Reference

Date: 6 December 1990

Sample Handling:

All samples were collected by SAIC using their own standardized procedures. Samples were received in polyethylene bags with zipper-like closures. While this is acceptable for trace metal samples, it is inappropriate for samples intended for organics analysis. Both a negative bias (from analyte absorption) and contamination from plasticizers (phthalates) can result from this practice. While no phthalates were found in detectable quantities, the question of analyte absorption remains unanswered. It is likely that there was no significant impact on the data due to the limited sample-container interaction and the relatively high detection limits (versus a similar situation with a water sample). Proper chain-of-custody procedures were followed for all samples.

Laboratory Analysis:

Maximum holding times were met for all analyses except for polynuclear aromatic hydrocarbons (PAHs) and semi-volatile organics ("BNAs"). The 14 day maximum holding time before extraction was exceeded by 2-24 days for BNAs, and by 20-25 days for PAHs. Note that the samples were up to 14 days old when received by the Environmental Laboratory, and that the samples had to be shipped to external laboratories for these tests. Exceeding these holding times could have resulted in analyte degradation during storage with a resultant negative bias on the data.

Note that the PAH data is still designated as "preliminary", because a final written report has not been received from the contract laboratory (CEMRD-ED-L). Some of the information is still missing (e.g., extraction and analysis dates for six samples), and much of it was transmitted verbally to expedite the issuance of this data package. Even so, the essential content of the PAH data will probably not change significantly upon receipt of the final report from CEMRD.

Method blanks for PCBs, pesticides, PAHs, TOC, cadmium (Cd), copper (Cu), and vanadium (V), were all free from contamination. Insignificant amounts of zinc (Zn) were found in five of eight blanks for that metal, ranging from 0.06 - 0.12 ppm. Small amounts of total petroleum hydrocarbons (TPH) were found in two of six blanks for that parameter, at 4.2 and 5.9 ppm. All three BNA blanks revealed low levels of three phthalates (diethylphthalate, bis-(2-ethylhexyl)phthalate, and di-n-octylphthalate), and one blank showed traces of phenanthrene and pyrene. All of these minor contaminations are insignificant, and should have no impact on the sample data.

Standard USEPA or AWWA methodologies were used for all analyses with only minor deviations. An in-house developed sulfuric acid cleanup was used for the PCB analysis, and the pesticide extracts were cleaned using a modified Florisil procedure. The trace metal digestion procedure was modified to accommodate microwave energy instead of radiant heat.

All PCB and pesticide surrogate recoveries were within laboratory acceptance limits, with four PCB surrogates being diluted out in the process of quantifying some high PCB levels. 178 out of 180 BNA surrogates fell within acceptable limits, indicating that the extraction/analytical processes were in control and that there were no matrix effects.

All replicate analyses for TOC, Cd, Zn, and V were in control, indicating good analytical precision. Only two PAH spike compounds out of 80 failed the evaluation criteria, showing "good" precision for that test. Note that the maximum differences allowed between replicates are high (RPDs 40-100%), indicating assumed high variability. Two of eight replicates for Cu and three of 10 replicates for TPH were marginally outside of the laboratory control limits, probably the result of the notorious inhomogeneity for this type of sample. All matrix spike duplicates for BNAs and pesticides were in control, indicating good reproducibility for these parameters as well. The precision of the PCB results may be inferred from the performance of the pesticide replicates, since both parameters are analyzed from the same matrix.

Matrix spike recoveries for Cd, V, and TOC were all acceptable, and indicate good accuracy for these tests. Just three of 22 BNA matrix spike results were marginally outside of the laboratory acceptance limits, as was one of seven spike values for Cu. This is not seen as a serious problem. While only one Zn spike value was marginally outside control limits, two more values (out of seven) failed outright (one high and one low). This is either due to sample inhomogeneity, or to some systemic problem with the accuracy of the test. There is insufficient information at this time to draw any definitive conclusions one way or the other. This reviewer, however, feels that the cause is more probably sample inhomogeneity, since the direction and magnitude of the deviant results are inconsistent. Four of the five PAH matrix spike/matrix spike pairs were acceptable, passing 62 of 64 spike compounds. The fifth pair was poor, failing 6 of 13 compounds. An unusual pattern emerged from the pesticide spike data, however. While all 12 of the spike values for heptachlor, aldrin, and DDT passed the evaluation criteria, 10 of 12 values for lindane, dieldrin, and endrin failed marginally on the low side. While dieldrin and endrin are somewhat susceptible to the harsh conditions of sulfur interference removal by activated copper, lindane is not. The low recoveries for dieldrin and endrin could be explained as occurring during the sulfur removal step, however it is unlikely that the lindane was lost during this process as well. Since all three are apparently related, causes other than losses during clean-up (such as matrix effects) are considered more likely. A related issue which confuses this situation is that the evaluation criteria being used here are those published in the EPA method, rather than the preferred internally-generated type. There is some evidence, then, that there could be some minor negative bias to the pesticide values from matrix effects, however that is not conclusive.

The analytical results for these samples mostly appear reasonable and internally consistent. High levels of zinc, copper, and cadmium seemed to correlate with each other and with higher levels of TPH. Of particular note is the comparison between TPH and PAH: of the nine samples with >10 ppm total PAHs, eight (89%) had TPH levels >500 ppm; similarly, of the nine samples with TPH >500 ppm (which also had corresponding PAH results), eight (again 89%) had total PAHs >10 ppm. Two samples, Nos. 10328, and 10346, did not follow this pattern. Six other samples had TPH >460 ppm, but had no matching PAH values, and therefore no comparison could be made for them. Another reassuring observation was that when 4,4′-DDT was detected at levels >20 ppb, one or both of its homologous degradation products (4,4′-DDD and 4,4′-DDE) were also observed as would be expected.

The following analyses were performed in-house:

Analysis	EPA Method (1)
Total Petroleum Hydrocarbons	9071/418.1
PCBs (soil)	3540/8080
Pesticides (soil)	3540/8080
Cd	3050/6010
Cu	3050/6010
Zn	3050/6010
V	3050/6010
Total Organic Carbon	9060

Our validated contract laboratory performed the following analyses:

Polynuclear Aromatic Hydrocarbons	8310
Semi-Volatile Organics	3550/8270

NOTES:
(1) All methods are EPA Methods uless otherwise indicated.

APPENDIX B

DATA QUALITY

STAMFORD-NEW HAVEN NORTH/CAP SITE 2
INVESTIGATION May 2004
Data Quality

To assess of data quality, a single data package for each of the measured parameters was validated according to EPA guidelines (Tier II Validation). During this data review process, no significant issues were noted.

The sample results were assessed according to the Region I, EPA-NE Data Validation Guidelines for Evaluation of Environmental Analyses (12/96) and the USEPA Region I Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses (6/88, modified February 1989 and the proposed modifications August 1991). Additionally, the quality control criteria specified in the Quality Assurance Project Plan (QAPP) (May 2004), and the quality assurance and quality control criteria specified in the analytical methods were used to assess the data during the data validation. An overall assessment of the data is presented below.

The data quality indicators precision, accuracy, and sensitivity are used to describe the overall quality of the data. The data quality indicator objectives are presented in Tables 1-1 and 8-1 of the QAPP. Finally, a brief discussion on blank contamination concludes the overall data quality assessment.

<u>Precision</u>

Laboratory precision was evaluated using the relative percent difference (RPD) values for matrix spike/matrix spike duplicate (MS/MSD) sample results and/or the laboratory control spike/laboratory control spike duplicate (LC/LCSD) sample results. The laboratory precision criteria were met without exception during the metals analysis. Laboratory precision criteria were met during the organic analyses with only minimal exceptions in the PAH, TOC and TPH analyses. Qualification of the PAH data (as estimated) was limited to only a few compounds in the two samples selected for matrix spike analysis. Laboratory precision criteria were slightly exceeded in two instances during the TOC analysis. Laboratory precision criteria were exceeded in one instance during the TPH analysis. Additionally, the PAH sample results required some minimal qualification due to exceeded instrument continuing calibration criteria. However, the data are not considered to be adversely affected by any of the above minor exceedances.

A field precision objective was not specified for the project since a high degree of variability was anticipated, and the field replicates were collected to evaluate the degree of small scale variability at the site, not for data quality evaluations.

Accuracy

Laboratory accuracy was evaluated using the percent recovery (%R) values for the MS/MSD and/or LCS/LCSD sample results as well as spiked sample (surrogate) recoveries. Laboratory accuracy criteria were within specifications without exception during the metals analysis. The TPH results required estimation due to slightly exceeded %R criteria for the surrogate in one laboratory method blank, an exceeded %R in the MSD analysis and a slightly exceeded %R criteria in the LCS analysis. A potential bias for the data cannot be determined since one %R was low and the other two were high. It should be noted however, that all TPH percent surrogate recoveries for the samples met criteria. The data are not adversely affected. The surrogate and MS/MSD %R criteria were slightly exceeded (high) during the PAH analysis. However, all %R criteria were met for the LCS analyses and the data are not adversely affected. The %R criteria were met without exception during the TOC analysis.

Field accuracy is assessed through the evaluation of adherence to all sample handling, preservation, and holding time requirements. Preservation and/or sample handling anomalies were not reported during data validation with the only exception being the TOC analyses being performed outside of the method recommended holding time of 14 days. The samples were analyzed between 21 and 23 days from date of sample collection. However, this is considered a minor concern as it is unlikely that the sediment TOC content would be perceptibly altered during this time interval.

Sensitivity

Measurement sensitivity was assessed by examining the detection limits achieved by the laboratory. Samples did not require dilutions during the metals and TOC analyses and therefore, project required detection limits were achieved in all instances. However, several samples required dilution during the TPH and PAH analyses due to the presence of concentrations that would have exceeded instrument calibration ranges if analyzed undiluted. The laboratory elevated the practical quantitation limits by a factor equivalent to the dilutions. Additionally, a few samples required elevated detection limits due the samples' inability to be concentrated down to the required final volume. The sample volumes were brought to the lowest possible volumes and those values were applied to the sample result calculations. The laboratory was able to achieve, or nearly achieve, the project specified detection limits.

Blank Contamination

Target analytes were not detected in any of the method blanks analyzed for TOC and PAH. One TPH method blank experienced minor TPH contamination, however, the data are not affected since the associated sample concentrations were greater than the action level of 5x the blank concentration. Likewise, copper was detected in one continuing calibration blank during the metals analysis but sample copper concentrations were greater than the blank action level and the data were not affected.

Zinc (2.9 ug/L) and TPH (52 ug/L) were detected in the equipment blank associated with these sediment samples. The lowest sample zinc concentration measured within the project dataset was 9.9 ug/g and so it is unlikely that this small amount of zinc has any effect on the data. The lowest TPH concentration was measured to be 4.3 ug/g, and the laboratory processed a minimum of 10 grams of each sample for analysis. This level of equipment cross-contamination could have had some small impact on samples in the very low concentration range.

APPENDIX C

DETAILED CORE INFORMATION

APPENDIX C1

DETAILED CORE LOGS

Memo

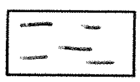
To: Dion Lewis

From: Jennifer Henderson

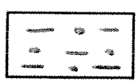
Date: May 28, 2004

Re: Core Descriptions

Attached are the descriptions for the twelve vibra-cores (1-1 to 1-6 and 2-1 to 2-6) brought to the Marine Geomechanics Laboratory at the University of Rhode Island. Two of the cores (1-3 and 1-5) were described my Matt O'Regan, a PhD student of Kate Moran. I described the remaining ten. Below is an explanation of the symbols used in the descriptions. Please call if there are any questions (401-874-6572).

 Silt

 Silty sand/sand

 Sandy silt

EOS End of section

EOC End of core

 Pebble

 Shell fragment

 Intact shell

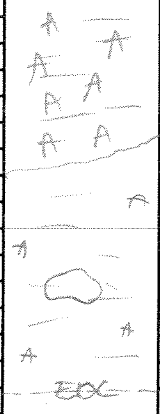
XXX Trash

ENSR			
Client: U.S. ACE			CORE NO: 1-1
Project Number: 9000-340			
Station Location: CLDS -			
GPS Coordinates:			
Geographic Reference: Long Island Sound			Sheet: 1 of 2
Water Depth:	MLW:		Core Size (in.) 4 ID
Weather:		Seas:	Time (Water Depth):
Survey Vessel:	Logged By: J. Henderson	Date: 5/27/04	Time (Coring):
Survey Personnel:			
Sampling Equipment: Vibra-Core			
Estimated Penetration Range:	Project Depth :		
Actual Penetration):	Recovery: 2.96 m	% Recovery:	No. Attempts:

Depth (cm)	SKETCH	DESCRIPTION	
		Soupy at top	
		coarsens downward	
15		dark olive gray sandy silt	
		some shell fragments scattered throughout	
30		med grained sand in brown silt matrix, shell fragments	
		shell hash, light brown quickly becomes dark	
45		olive gray silt	
60		still shell hash, matrix is now dark olive	
		gray silt	
		large oyster shell at 61 cm	
75			
90	EOS		EOS 90cm
		coarse grained sand in black sandy silt (first 2cm)	
		fines downward, black sandy silt, some pebble	
105		+ shells	
120		dark olive gray silt throughout rest of section,	
		appears the black sandy silt was dragged	
135	XXX	down during splitting	
		@ 130cm - trash (plastic + aluminum foil pieces)	
150			
		shells throughout	
165			
180			
195			
		slightly lighter olive gray at bottom of section	
210			EOS @ 212cm
	EOS		
		olive gray silt (upper 2 cm)	
225		few cm of shell hash	
		med grained sand, shell fragments	

XXX - trash

1-1



Depth (cm)	SKETCH	DESCRIPTION	
		olive gray silt, numerous shells & shell fragments	
240			
255		dark gray/black silt STRONG odor shell fragments	
270		med.-coarse grained sand at bottom & plant debris large rock	
285			
			EOC 296cm
300			
315			
330			
345			
360			
375			

NOTES:

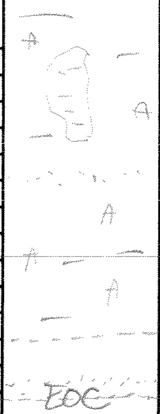
	Core Recovery Calculation:
	Unpenetrated Barrel/Cable Length (A):
	Penetrated Barrel/Cable Length (B):
	Actual Penetration (C) = B-A
	Recovered Core Length (D):
	% Recovery = D/C:

ENSR

Client: U.S. ACE	CORE NO: 1-2
Project Number: 9000-340	
Station Location: CLDS -	
GPS Coordinates:	
Geographic Reference: Long Island Sound	Sheet: 1 of 2
Water Depth: MLW:	Core Size (in.) 4 ID
Weather: Seas:	Time (Water Depth):
Survey Vessel: Logged By: J. Henderson Date: 5/27/04	Time (Coring):
Survey Personnel:	
Sampling Equipment: Vibra-Core	
Estimated Penetration Range: Project Depth :	
Actual Penetration): Recovery: 292m % Recovery:	No. Attempts:

Depth (cm)	SKETCH	DESCRIPTION	
		soupy dark gray sandy silt	
15		couple of shell fragments	
30		dark olive gray sand/silt, sand is med. grained, some shell fragments	
45		shell hash	
60		finer shell hash in olive gray silt	
75	EOS	shells in olive gray silt matrix	EOS @ 83cm
90		dark gray silt	
		olive gray clasts (also silt)	
105		some plant debris + trash at top	
		odor	
		dark brown clast	
120	XX	XX: aluminum foil bits	
135		med grained sand	
		sharp contact w/ light olive gray silt	
		shells in upper cm.	
150		sediment coarsens w/ depth	
		light olive gray silt matrix	
165			
180		med. grained sand + shells – shell hash	
195	EOS	more silt towards bottom of section	EOS 197 cm
210		dark olive gray silt	
225			

1-2

Depth (cm)	SKETCH	DESCRIPTION	
		some areas have dark gray splotches	
240			
		little coarser grained sand at 250 cm	
255			
		few shell fragments scattered throughout	
270			
		becomes light olive gray silt ~280 cm	
285		2 reddish med grained sandy lenses at bottom	
300			EOC 292 cm
315			
330			
345			
360			
375			

NOTES:

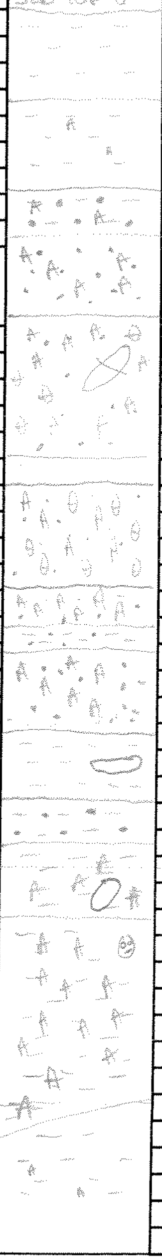
Core Recovery Calculation:
- Unpenetrated Barrel/Cable Length (A):
- Penetrated Barrel/Cable Length (B):
- Actual Penetration (C) = B-A
- Recovered Core Length (D):
- % Recovery = D/C:

ENSR

Client: U.S. ACE			CORE NO: 1-3
Project Number: 9000-340			
Station Location: CLDS -			
GPS Coordinates:			
Geographic Reference: Long Island Sound			Sheet: 1 of 2
Water Depth:	MLW:		Core Size (in.) 4 ID
Weather:		Seas:	Time (Water Depth):
Survey Vessel:	Logged By: M. O'Regan	Date: 5/27/04	Time (Coring):
Survey Personnel:			
Sampling Equipment: Vibra-Core			
Estimated Penetration Range:	Project Depth :		
Actual Penetration):	Recovery: 2.82 m	% Recovery:	No. Attempts:

Depth (cm) | SKETCH | DESCRIPTION

SED TOP 0



Depth (cm): 15, 30, 45, 60, 75, 90, 105, 120, 135, 150, 165, 180, 195, 210, 225

8cm ETHAFOAM FILLS LINER

0-16cm . DARK OLIVE GRAY SOUPY SILT
. LIGHTENS TO OLIVE NEAR BOTTOM

16-34cm . OLIVE SILT LESS SOUPY BUT VERY WET
. DARK GRAY BANDS 26-28cm
. A COUPLE VERY SMALL SHELL FRAGMENTS

34-41cm OLIVE GRAY COARSE SANDY SILT WITH SHELL FRAGMENTS

41-58cm
OLIVE GRAY, WET SANDY SHELL MASH

~~58~~ 84cm
OLIVE GRAY SHELL MASH
LARGE SHELL AT 68-73cm

ENDS AT LAYER OF PEBBLES ⇒ VERY COARSE SHELL MASH

89-108cm
VERY COARSE SHELL MASH

109-117 SANDY SHELL MASH, MORE FINE GRAINED THAN ABOVE
117-122 SANDY-SILT LAYER WITH FEW SHELLS OLIVE GRAY

123-136cm SANDY SHELL MASH

136-147cm DARK BLACK, ODOROUS SILT WITH WOOD DEBRIS
142- LARGE PEBBLE

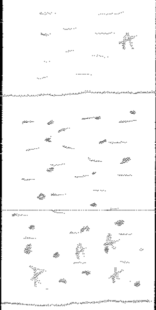
147-156 cm BLACK SANDY-SILT

157-171 DARK OLIVE GRAY SILT
WITH SHELL FRAGMENTS
LARGE PEBBLE 168-169
169-208
SANDCLAST 171
DARK OLIVE GRAY COARSE SILT WITH
SHELL FRAGMENTS

ANGLED CONTACT WITH BLACK STREAKING

210-244cm OLIVE FINE SILT, HOMOGENOUS
WITH A FEW SHELL FRAGMENTS.

1-3

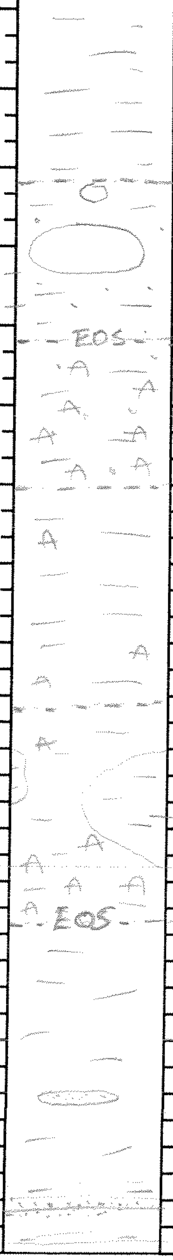
Depth (cm)	SKETCH	DESCRIPTION	
			
240		243 cm	
		SHARP CONTACT W/ DARK GRAY TO BLACK	
		COARSE SILT → SANDY SILT	
255			
		•SLIGHTLY COARSER NEAR BOTTOM WITH OCCASIONAL	
		SHELL FRAGMENTS	
270			
285		EOC 282	
300			
315			
330			
345			
360			
375			

NOTES:

	Core Recovery Calculation:
	Unpenetrated Barrel/Cable Length (A):
	Penetrated Barrel/Cable Length (B):
	Actual Penetration (C) = B-A
	Recovered Core Length (D):
	% Recovery = D/C:

ENSR

Client: U.S. ACE	CORE NO: 1-4
Project Number: 9000-340	
Station Location: CLDS -	
GPS Coordinates:	
Geographic Reference: Long Island Sound	Sheet: 1 of 2
Water Depth: MLW:	Core Size (in.) 4 ID
Weather: Seas:	Time (Water Depth):
Survey Vessel: Logged By: J Henderson Date: 5/27/04	Time (Coring):
Survey Personnel:	
Sampling Equipment: Vibra-Core	
Estimated Penetration Range: Project Depth :	
Actual Penetration): Recovery: 2.44m % Recovery:	No. Attempts:



Depth (cm)	DESCRIPTION	
0	very soupy silt, dark gray, lightens with depth	
15		
30	large pebble	
45	dark olive gray sandy silt, lots of shells, shell fragments, very large rock	
60		EOS @ 63cm
75	brownish to olive gray sandy silt matrix shell hash - shells + shell fragments	
90		
105	dark gray to black silt, odor some shell fragments + organic debris	
120		
135	dark gray mixing w/ dark olive gray silt shell fragments, more abundant w/ depth	
150	dark olive gray silt	
165		EOS @ 173cm
180	dark olive gray silt shell fragments scattered throughout	
195		
210	dark gray sand lens (med. grain)	
225	few linections of olive gray silt sand lens, poorly sorted, coarse sand size to pebble size	

Depth (cm)	SKETCH	DESCRIPTION 1-4	
		dark olive gray silt	
240			
		sand + pebbles same as above	
255		dark olive gray silt	
	A	light olive gray silt	
270		few shell fragments	
	A		
285	EDC		EDC 284cm
300			
315			
330			
345			
360			
375			

NOTES:

	Core Recovery Calculation:
	Unpenetrated Barrel/Cable Length (A):
	Penetrated Barrel/Cable Length (B):
	Actual Penetration (C) = B-A
	Recovered Core Length (D):
	% Recovery = D/C:

ENSR	Client: U.S. ACE	CORE NO: 1-5
	Project Number: 9000-340	
	Station Location: CLDS -	
	GPS Coordinates:	
	Geographic Reference: Long Island Sound	Sheet: 1 of 2
	Water Depth: / MLW:	Core Size (in.) 4 ID
	Weather: / Seas:	Time (Water Depth):

Survey Vessel:	Logged By: J Henderson	Date: 5/27/04	Time (Coring):
Survey Personnel:			
Sampling Equipment: Vibra-Core			
Estimated Penetration Range:	Project Depth :		
Actual Penetration):	Recovery: 2.95m	% Recovery:	No. Attempts:

Depth (cm)	SKETCH	DESCRIPTION	
		soupy olive gray + dark gray mixed silt	
15			
		band of dark gray silt	
30		coarsens downward, shells more abundant w/ depth	
45		dark olive gray, lightens w/ depth silty sand	
60			
		dark black clast, odor	
75			
		sharp contact at 79cm	
		pebbles at 84-88cm	
90		dark gray/black silty sand, fining downward	
		some shell fragment	
105			
		dark olive gray silt	
120		some plant debris + shell fragments	
135			
150		large shell piece at 150, reddish med-coarse grained	
	EOS	sand beneath lens	155 EOS
165			
		dark gray silt, lightens w/ depth	
180		pebbles + shells	
195		bioturbation	
210			
225			

Depth (cm)	SKETCH	DESCRIPTION 1-5	
240		few shell fragments	
255			
270		bioturbation	
285		bioturbation	
300			EOC ~295 cm
315			
330			
345			
360			
375			

NOTES:

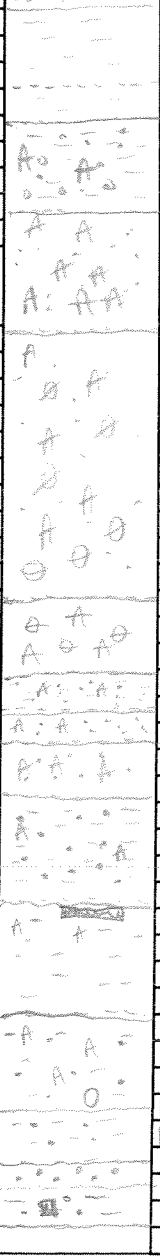
	Core Recovery Calculation:
	Unpenetrated Barrel/Cable Length (A):
	Penetrated Barrel/Cable Length (B):
	Actual Penetration (C) = B-A
	Recovered Core Length (D):
	% Recovery = D/C:

ENSR

Client: U.S. ACE	CORE NO: 1-6
Project Number: 9000-340	
Station Location: CLDS -	
GPS Coordinates:	
Geographic Reference: Long Island Sound	Sheet: 1 of 2
Water Depth: / MLW:	Core Size (in.) 4 ID
Weather: / Seas:	Time (Water Depth):
Survey Vessel: / Logged By: M. ORegan / Date: 5/27/04	Time (Coring):
Survey Personnel:	
Sampling Equipment: Vibra-Core	
Estimated Penetration Range: / Project Depth :	
Actual Penetration): / Recovery: 2.90 m / % Recovery:	No. Attempts:

SKETCH

SED. TOP 0

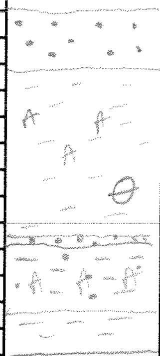


DESCRIPTION

10 CM PIECE OF ETHAFOAM FILLS TOP OF LINER

Depth (cm)	Description	
	DARK, OLIVE GRAY LIGHTENING TO OLIVE AT BOTTOM	
	SOUPY SILT	
15	BROKEN DARK TO LIGHT LAMINATIONS BETWEEN 5-12 CM	
	15-21CM OLIVE GRAY TO DARK OLIVE GRAY SILT	
	21-38CM	
30	SANDY-SILT, DARK GRAY	
	WITH SHELL FRAGMENTS	
45	38-61	
	DARK GRAY SILTY-SAND	
	COARSENING DOWNWARDS WITH INCREASING ABUNDANCE	
60	OF SHELL FRAGMENTS	
	61-112	
75	SHELL HASH IN SAND MATRIX	
	COARSENING DOWN	
	ALL MEDIUM GRAY	
90	WHOLE SHELLS MORE ABUNDANT NEAR BOTTOM	
105		
	112- TOP OF SECTION 2	
120	112-127 CONTINUATION OF SHELL HASH	
	IN COARSE SAND MATRIX, GRAY	
	127-131 LAYER OF FINE SAND AND SHELL FRAGMENTS	
135	131-138 SILTY SAND WITH SILT CLASTS & SHELL FRAGMENTS	
	138-148 END OF SHELL HASH, GRAY SAND MATRIX	
150	SHARP CONTACT	
	148-168 BLACK, SANDY-SILT	
	FEW SHELL FRAGMENTS	
165		
	168 WOOD FRAGMENT	
180	DARK OLIVE GRAY SILT	
195	GRADUAL CHANGE TO DARK GRAY SANDY-SILT	
	WITH SHELL FRAGMENTS	
210	LIGHT BROWN WOODY CLAST AT 203 CM	
	END SECTION AT 207	
	207-217 CONTINUATION OF SANDY SILT	
225	217-223 DARK GRAY SILTY SAND	
	223-230 DARK GRAY SANDY SILT	
	WOODY CLAST, LIGHT BROWN AT 226	

1-6

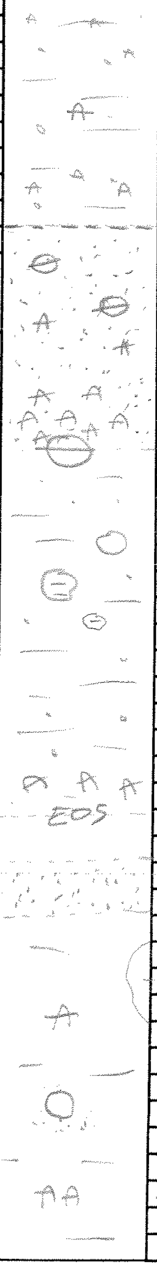
Depth (cm)	SKETCH	DESCRIPTION	
		LIGHT GRAY	
		230 - 237 SILTY SAND	
240		237 - 269	
		DARK OLIVE GRAY SILT	
		A FEW SHELL FRAGMENTS	
255		LARGE SHELL AT 261-263	
270		ENDS WITH A SANDY LENSE	
		OLIVE SANDY-SILT WITH SHELL FRAGMENTS	
285		OLIVE SILT WITH A SINGLE SUBTLE DARK	
		BAND CROSSING ON AN ANGLE	
	END 290		
300			
315			
330			
345			
360			
375			

NOTES:

	Core Recovery Calculation:
	Unpenetrated Barrel/Cable Length (A):
	Penetrated Barrel/Cable Length (B):
	Actual Penetration (C) = B-A
	Recovered Core Length (D):
	% Recovery = D/C:

ENSR

Client: U.S. ACE	**CORE NO:** 2-1
Project Number: 9000-340	
Station Location: CLDS -	
GPS Coordinates:	
Geographic Reference: Long Island Sound	Sheet: 1 of 2
Water Depth: / MLW:	Core Size (in.) 4 ID
Weather: / Seas:	Time (Water Depth):
Survey Vessel: / Logged By: J. Henderson / Date: 5/26/04	Time (Coring):
Survey Personnel:	
Sampling Equipment: Vibra-Core	
Estimated Penetration Range: / Project Depth :	
Actual Penetration): / Recovery: 2.89 m / % Recovery:	No. Attempts:

Depth (cm)	SKETCH	DESCRIPTION	
		dark olive gray sandy silt	
15		much darker if surface is scraped away	
		brownish patches ~30cm depth	
30		shell fragments scattered throughout (few)	
45		sharp transistion to med-coarse grained sand at ~40cm	
60		shells + shell fragments	
75			
		large shell at 86cm	
90		dark olive gray sandy silt throughout section ~few shell fragments	
105		large pebble	
		dark black clast at 107cm, heavy odor + at 115cm	
120			
135			
150	EOS		EOS @ 152cm
		dark gray (almost black beneath surface) silt some organics, strong odor	
165		very poorly sorted coarse grained sand, pebble from 160-170cm, sharp contact at bottom	
180		bioturbation	
195		light olive gray silt throughout rest of section, few shell fragments	
210		large (2cm) red sandstone, thin lens of reddish medium grained sand beneath	
225		shell fragments	

2-1

Sheet: 2 of 2

Depth (cm)	SKETCH	DESCRIPTION	
240			
255			
270			
285		large oyster shell at core base	EOC @ 289cm
300			
315			
330			
345			
360			
375			

NOTES:

	Core Recovery Calculation:
	Unpenetrated Barrel/Cable Length (A):
	Penetrated Barrel/Cable Length (B):
	Actual Penetration (C) = B-A
	Recovered Core Length (D):
	% Recovery = D/C:

ENSR	Client: U.S. ACE		CORE NO: 2-2
	Project Number: 9000-340		
	Station Location: CLDS -		
	GPS Coordinates:		
	Geographic Reference: Long Island Sound		Sheet: 1 of 2
	Water Depth:	MLW:	Core Size (in.) 4 ID
	Weather:	Seas:	Time (Water Depth):
Survey Vessel:	Logged By: J. Henderson	Date: 5/26/04	Time (Coring):
Survey Personnel:			
Sampling Equipment: Vibra-Core			
Estimated Penetration Range:	Project Depth :		
Actual Penetration):	Recovery: 2.73 m	% Recovery:	No. Attempts:

Depth (cm)	SKETCH	DESCRIPTION	
		dark olive gray sandy silt coarsening downward shell fragments	
15			
30			
45		dark olive gray sandy silt mixed w/ shells (whole, fragments - large + small)	
60			
75		gray silty sand (coarse grained) consists largely of shell fragments	
90			
105		dark gray sandy silt, fining downward some shell fragments (very fine)	
120			
135		strong odor at last 20cm of section	
150	EOS		EOS @ 152cm
165		dark gray sandy silt shell fragments more coarse than the previous section	
180			
195			
210		dark olive gray silt dark gray sandy silt (possibly drag down) along liner edges	
225			

2-2

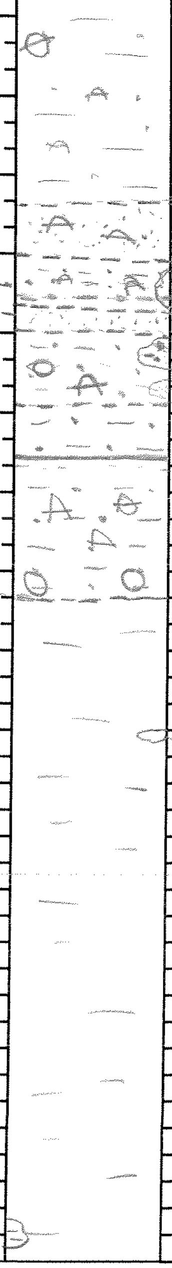
Depth (cm)	SKETCH	DESCRIPTION	
240			
255		dark olive gray silt, lots of shells	
		light olive gray silt	
270			
EOC			~2.73 EOC
285			
300			
315			
330			
345			
360			
375			

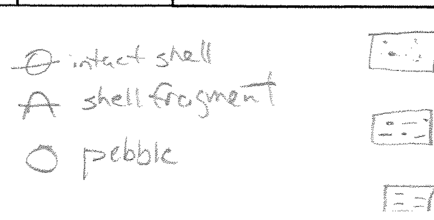
NOTES:

Core Recovery Calculation:
- Unpenetrated Barrel/Cable Length (A):
- Penetrated Barrel/Cable Length (B):
- Actual Penetration (C) = B-A
- Recovered Core Length (D):
- % Recovery = D/C:

ENSR

Client: U.S. ACE			CORE NO: ~~2-4~~ 2-3 (1)
Project Number: 9000-340			
Station Location: CLDS -			
GPS Coordinates:			
Geographic Reference: Long Island Sound			Sheet: 1 of 2
Water Depth:	MLW:		Core Size (in.) 4 ID
Weather:		Seas:	Time (Water Depth):
Survey Vessel:	Logged By: J. Henderson	Date: 5/26/04	Time (Coring):
Survey Personnel:			
Sampling Equipment: Vibra-Core			
Estimated Penetration Range:	Project Depth :		
Actual Penetration):	Recovery: 2.45m	% Recovery:	No. Attempts:

Depth (cm)	SKETCH	DESCRIPTION
15		olive gray sandy silt, w/ faint (1 cm or less) lineations of dark gray sandy silt (possibly due to smearing) shell fragments scattered throughout
30		
45		silty sand, numerous shells + pebbles sand is medium to coarse grained
60		sandy silt, shell fragments, brownish patch
75		silty sand, numerous shells (fragments + whole) pebbles olive gray sandy silt, few dark patches of dark gray sandy silt that has been smeared. Pebbles + shell fragments present
90		brownish gray sandy silt shells, shell fragments, pebbles
105		black lens (<1cm), sandy silt - brownish gray shell fragments + pebbles (some large) becomes more olive gray w/ depth
120		— EOS —
135		Olive gray silt (light) few shell fragments scattered throughout
150		dark gray gray patch (bioturbation)
165		
180		
195		
210		
225		
		dark gray patch (bioturbation)



intact shell

shell fragment

pebble

silty sand

sandy silt

silt

EOS - end of section

EOC - end of core

~~24~~ 2-3 ①

Depth (cm)	SKETCH	DESCRIPTION	
240			
EOC			EOC
255			
270			
285			
300			
315			
330			
345			
360			
375			

NOTES:

	Core Recovery Calculation:
	Unpenetrated Barrel/Cable Length (A):
	Penetrated Barrel/Cable Length (B):
	Actual Penetration (C) = B-A
	Recovered Core Length (D):
	% Recovery = D/C:

① LABEL ERROR (REFER TO 15 SEP 04 EMAIL ATTACHED)

ENSR

Client: U.S. ACE		CORE NO: ~~2-3~~ 2-4 (1)
Project Number: 9000-340		
Station Location: CLDS -		
GPS Coordinates:		
Geographic Reference: Long Island Sound		Sheet: 1 of 2
Water Depth:	MLW:	Core Size (in.) 4 ID
Weather:	Seas:	Time (Water Depth):
Survey Vessel:	Logged By: J. Henderson	Date: 5/26/04	Time (Coring):
Survey Personnel:		
Sampling Equipment: Vibra-Core		
Estimated Penetration Range:	Project Depth :	
Actual Penetration):	Recovery: 2.49m	% Recovery:	No. Attempts:

Depth (cm)	SKETCH	DESCRIPTION
		dark
		olive gray sandy silt
15		very small shell fragments
		← sandier right above black layer
30		black silt
		stronger odor (oil?)
45		olive gray to brownish gray sandy silt, coarsening downward
		shell fragments
60		
75		silty sand (coarse-grained) (shell hash)
		dark gray sandy silt along liner edge
90		
105		lineations of dark gray & olive green-gray sandy silt, however if surface is removed, dark gray sandy silt, few shell fragments
120		
		dark olive gray sandy silt, numerous small shell fragments
135		lighter olive gray silt
	EOS	
150		
		lighter olive gray silt
165		very few shell fragments
		darker olive gray burrows at ~167 cm
180		172
		192
		230-234
195		
210		
225		

~~2-3~~ 2-4[1]

		Sheet: 2 of 2
Depth (cm)	SKETCH	DESCRIPTION
240		
255 EOC		
270		
285		
300		
315		
330		
345		
360		
375		

NOTES:

Core Recovery Calculation:

Unpenetrated Barrel/Cable Length (A):

Penetrated Barrel/Cable Length (B):

Actual Penetration (C) = B-A

Recovered Core Length (D):

% Recovery = D/C:

(1) LABEL ERROR (REFER TO 15 SEP 04 EMAIL - ATTACHED)

ENSR

Client: U.S. ACE		CORE NO: 2-5
Project Number: 9000-340		
Station Location: CLDS -		
GPS Coordinates:		
Geographic Reference: Long Island Sound		Sheet: 1 of 2
Water Depth:	MLW:	Core Size (in.) 4 ID
Weather:	Seas:	Time (Water Depth):
Survey Vessel:	Logged By: J. Henderson	Date: 5/26/04	Time (Coring):
Survey Personnel:		
Sampling Equipment: Vibra-Core		
Estimated Penetration Range:	Project Depth :	
Actual Penetration):	Recovery: 2.64 m	% Recovery:	No. Attempts:

Depth (cm)	SKETCH	DESCRIPTION	
		dark olive gray sandy silt	
		sand is medium grained	
15		slightly more brown from 4-6cm	
		numerous shells + shell fragments	
30			
		dark olive gray silt	
45		numerous shell fragments from 35-40cm	
		core is heavily disturbed from 60-94 + 105-120	
60		(shells dragged down?)	
		silt matrix throughout, large shells + shell fragment	
75			
90			
		"undisturbed" slightly lighter olive gray silt	
105			
		"disturbed" section, shells + shell fragments in silt	
120		matrix	
		light olive gray silt	
135			
	EOS		142cm EOS
150		light olive gray silt	
165			
		shell fragments from 170-174cm	
180		few shell fragments throughout	
195			
210			
225			

2-5

Depth (cm)	SKETCH	DESCRIPTION	
	A		
240		darker olive gray silt clast	
255		darker olive gray inclusion, bioturbation?	
	EOC		EOC @ 264cm
270			
285			
300			
315			
330			
345			
360			
375			

NOTES:

	Core Recovery Calculation:
	Unpenetrated Barrel/Cable Length (A):
	Penetrated Barrel/Cable Length (B):
	Actual Penetration (C) = B-A
	Recovered Core Length (D):
	% Recovery = D/C:

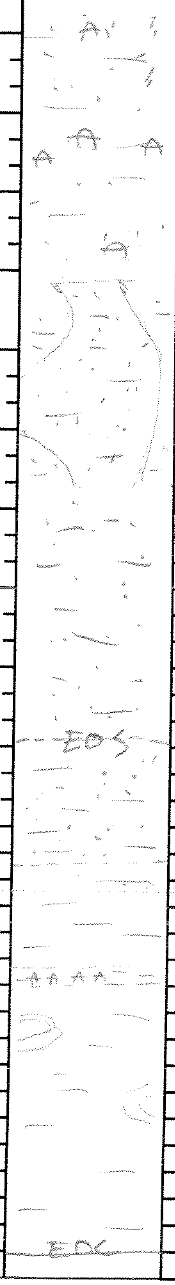
ENSR

Client: U.S. ACE
Project Number: 9000-340
Station Location: CLDS -
GPS Coordinates:
Geographic Reference: Long Island Sound
Water Depth: MLW:
Weather: Seas:

CORE NO: 2-6
Sheet: 1 of 2
Core Size (in.) 4 ID
Time (Water Depth):
Time (Coring):

Survey Vessel: Logged By: J. Henderson Date: 5/26/04
Survey Personnel:
Sampling Equipment: Vibra-Core
Estimated Penetration Range: Project Depth :
Actual Penetration): Recovery: 2.31m % Recovery: No. Attempts:

SKETCH



Depth (cm)	DESCRIPTION	
15	dark olive gray sandy silt fining downward shell fragments, more at top	
30		
45		
60	dark olive gray surrounds dark gray sandy silt	
75		
90		
105	dark gray sand silt 4 cm pieces of wood debris @ 102cm lots of organis (plant life) bits of shells	
120		
135	large pebbles at end of section	EOS 133cm
150	dark gray sandy silt shell fragments	
165	dark olive gray silt	
180	dark olive gray silt, lots of shell fragments	
195	light olive gray silt	
210	two areas of bioturbation	
225		
		EOC @ 231cm

Lewis, Dion

From: jres8015 [jres8015@postoffice.uri.edu]
Sent: Wednesday, September 15, 2004 5:21 PM
To: Lewis, Dion
Cc: jres8015@postoffice.uri.edu
Subject: RE: LIS Core 2-3 vs 2-4

Dion,

Sorry for the confusion. I believe that Jennifer's core description labels are incorrect, such that cores 2-3 and 2-4 are swapped. This is most likely the case for two reasons:

1)
When we concatenate the core section images to form a total core image, the computer suggests the name of the core image, based on the section image names used to make it. For example, if the section name is 2-1, the concatenated image will also be called 2-1. In addition, the concatenated image is written to the same folder that the section images are in.

2)
I have looked at the p-wave data to determine sections lengths of each core. The section lengths and core lengths of cores 2-3 and 2-4 found in the p-wave files match those found in the image files.

Therefore the core and section lengths found in the p-wave and image files are correct. The core and section lengths of cores 2-3 and 2-4, in the core descriptions document are swapped.

Core 2-3: Section 1: 0 - 110 cm
Section 2: 110 - 245 cm

Core 2-4: Section 1: 0 - 142 cm
Section 2: 142 - 250 cm

Hope this helps, and sorry about the confusion,

Jason Ressler
University of Rhode Island - Marine Geomechanics Lab
email - jres8015@postoffice.uri.edu

>===== Original Message From "Lewis, Dion" <DLewis@ensr.com> =====
>Jason
>
>I've found what appears to be a "swapping" of core photos/labels. If you
>can check the original image files then perhaps you can find a simple label
>mistake when the images were sliced together or the final concatenated file
>was named.
>
>This is based on Jennifers core descriptions which included end of section
>(EOS) recorded for each core subsection.
>
>In the case of core 2-3, the image shows a break at 110 cm and a total
>length of ca. 245
>
>In the case of core 2-4, the image shows a break at ca 142 and a length of
>ca 250
>
>Jennifers descriptions of these cores are the reverse: 2-3 is marked with an
>EOS at 142 and 2-4 is marked with an EOS at 110. Also core 2-3 was recorded
>to be longer than core 2-4.
>
>If there's anyway you can check this on your end for a possible file naming
>error then that would be a great help.
>
>Dion

APPENDIX C2

DETAILED CORE DESCRIPTIONS

STAMFORD-NEW HAVEN NORTH/CAP SITE 2
INVESTIGATION May 2004
Detailed Core Descriptions

Visual descriptions prepared at the time that cores were cut open have been compared to digital images of the cores and compiled into simplified lithological descriptions with interpretative classifications (CDM, UDM, older dredged material, basement material). Interpretation of layers of dredged material is complicated by the mixing of several processes with indeterminant histories: the original sedimentation processes that deposited sediments in the harbors, the disturbance and mixing of layers during dredging, barge placement and disposal, post-placement consolidation and disturbance. Previous investigations have demonstrated that sediments dredged from harbors can be remarkably heterogeneous and may also survive dredging and placement with original sediment textures intact (Fredette et al. 1993). Cap material may have dark silts, and UDM may have olive silts depending on the dredging process and characteristics of the areas dredged. These visual descriptions and comparisons with images and laboratory data are provided below for each core.

Stamford New Haven – North

Core 1-1

This core had a distinct sandy layer at the top of the core with decreasing silt content with depth. The bottom of the sand layer had higher amounts of shell fragments and graded into shell hash with a silt matrix (shell hash is a bioclastic deposit where the shells, whole and fragments exceed the matrix in volume). This distinctive shell hash layer was also found in Cores 1-2, 1-3, 1-4, 1-6 and to a lesser extent Core 1-5. The shell hash graded at about 50 cm into an olive silt with chaotic layers of shells and sand to the end of the core section (90 cm). Throughout this upper layer, the silt and clay content (by weight) did not exceed 20%. At the top of the next core section a thin layer (2 cm) of coarse sand and black silt graded into dark silt and then into the same chaotic layering of shells, olive silt and sand down to 115 cm. A 15 cm layer of sandy silt with fewer shells (silt and clay >20%) completed the horizon interpreted as New Haven cap material (CDM).

Below the sandy silt was a thick horizon (60 cm) of dark olive silt with high TOC content (3.7-5.5%) interpreted as Stamford Harbor UDM. The silt horizon had irregular layers of lighter olive silt and sandy silt (14% silt/clay at 140-150 cm) and a chaotic fabric with small numbers of shell fragments and some larger shells. This dark silt horizon was present in all of the cores from STNH-N, although thinner in some of the cores.

Below the dark silt horizon was a sequence of light olive silt horizons interspersed with a medium sand layer and a black silt layer with large shells resting on top of a silty sand layer. The last horizon contained a large rock and plant debris. Although olive silt is characteristic of ambient sediments in central LIS, they are also found beneath channel deposits in harbors surrounding the central basin (including New Haven). This entire horizon (106 cm) was tentatively classified as older dredged material due to the presence of distinct, poorly sorted sand horizons, large shells and plant material. This mixed horizon of olive silt and nearshore material was found below the UDM in all other cores from STNH-N. It was distinct from basement in texture but the interface was difficult to discern clearly in many of the cores.

Core 1-2

Core 1-2 was collected on the eastern side of the mound peak. This core had a sandy silt horizon of 35 cm at the top (50% silt & clay) that graded into silty medium sand and shell hash. The shell hash layer was coarse at the top and graded into finer shell fragments in a sandy matrix (3% silt & clay) followed by coarser shells in light olive silt (40% silt & clay). The rest of the horizon classified as CDM was composed of layers of light and dark silt and sand with shells and chaotic fabrics to a depth of 144 cm. This CDM layer resembled the top layer in Core 1-1 except for a higher silt content. The horizon had low TOC (0.24-1.8%) and textures consistent with dredged material.

Below the last layer of olive silt, a layer of shells marked a sharp transition to dark medium silty sand with shells (29% silt & clay) grading into dark silts (51-84% silt & clay). This horizon had high TOC concentrations (8-11%) and extended to the end of the section at 197 cm. This dark silt and sand horizon was classified as Stamford Harbor UDM and corresponded to a similar horizon in Core 1-1.

At the top of the last section a layer of shells marked a transition to olive silts mixed with dark silts and large shells (85-89% silt & clay). This horizon was interpreted as dredged material placed at CLDS prior to the STNH-N project and was comparable to material found in the lower horizon of Core 1-1. The older dredged material extended to a depth of 280 cm.

At the very bottom of the core was a 10 cm section of light olive silt on top of a distinct red medium sand layer with a large scallop shell at 292 cm. This horizon was classified as basement central LIS sediment. The red sand layer was present in several other cores (1-4, 1-5) with basement sediments and had the appearance of a sedimentary layer rather than dredged material. The red sand was well-sorted with very little silt matrix in a distinct horizontal layer.

Core 1-3

Core 1-3 was collected at the southern margin of the mound peak very near the historical buoy location and Core 1-6 (collected as replicates). The top horizon of this core was dark olive silt with some banding of dark grey silt with very few shells (92% silt & clay) which graded into a distinct 5 cm horizon of sandy silt at 35 cm depth. Below the sandy silt, shell fragments increased in a silty sand matrix with large shells appearing at 60 cm (8% silt and clay). This silty-sandy horizon on top of shell hash was similar in composition but thicker than the top horizons in Cores 1-1, 1-2 and 1-5 (which were from the northern margin of the peak) and roughly the same thickness as in 1-4 and 1-6. Below the silty-sandy horizon, layers of shell hash and pebbles with silt and sand matrices alternated from 60 cm to 135 cm. This entire sequence was interpreted as CDM and was similar in thickness and overall composition to the core tops in Cores 1-1, 1-2, and 1-6.

Just below the shell hash layer was a sharp transition to black organic silty sand with wood debris and a large pebble which results in a gravel composition of 59% by weight (13% silt & clay). This silty sand graded into sandy silt and alternating layers of dark and lighter olive silt with chaotic fabric and numerous shell fragments. This horizon was classified as Stamford Harbor CDM. Above the bottom of this horizon (208 cm depth) was a thick layer (38 cm) of coarse organic black silt with shell fragments (68% silt & clay).

The CDM laid on a distinctive layer of light olive silt (96% silt & clay) that at first glance appeared identical with ambient central LIS sediments. However, there was an angled contact between these silts and underlying darker silts with chaotic fabric and shell fragments (67% silt & clay). Based on the fabric, the moderately elevated metals content of the underlying material, the angled contact, and the thickness of this light olive silt horizon (too thick to accumulate in decades of sedimentation) this layer was interpreted as older dredged material placed at CLDS before the STNH-N project. It was similar in character to "maintenance" material (material dredged from below existing channels) from outer New Haven Harbor but it could be from a number of older projects. This material laid on dark coarse silt that graded to sandy silt to the end of the core at 282 cm. The lowest layer was sampled at 250-270 cm with moderate TOC (2.9%) and a silt & clay content of 6%.

Core 1-4

Core 1-4 was collected on the southwestern margin of the mound peak in an area with a slight "shoulder" to the mound peak suggesting a thinner area of the cap based on bathymetric data. The top of the core had soft silt (94% silt & clay) for the first 30 cm, then a layer of silty sand (21% silt & clay) with a pebble and a large rock to the end of the first section (63 cm). At the top of the next section the sand had more shell fragments and graded into shell hash with sand and silt in the matrix (14-18% silt & clay). This overall horizon, which ended at 87 cm was classified as CDM and was thinner than the CDM horizon of any core except 1-5. The upper silty sandy layer was thicker than any other core (63 cm) but it contained a high sand and gravel content toward the bottom (70% sand 8% gravel) at a depth (50-60 cm) occupied by sand and shell hash in other cores. The shell hash at the bottom of the CDM had an angled contact with dark organic sandy silt (45% silt & clay) with an increasing organic content with depth (3.2-7.5% TOC).

At 130 cm depth, the dark organic silt had a sharp contact with lighter organic silts interbedded with dark organic silts from 150-160 cm depth. This entire horizon was interpreted as Stamford Harbor UDM based on fabric and comparison with textures in Core 1-3. The interface at 130 cm was interpreted as a break between separate barge loads with mixtures of Stamford Harbor material. The interface to material below the UDM was less distinct but was likely to be near a horizon with sand and shell fragments (based on interpretation of close-up hand-held photographs of the core section). The core horizon from 160 to 190 cm was a distinctive layer of coarse sand mixed with black silt grading into dark silt with numerous shell fragments. It was unclear if this horizon was older dredged material or part of the UDM.

Below the apparent dredged material horizon, this core penetrated through a thick sequence of apparent basement material. Although there was a visual interface from dark olive silt to light olive silt characteristic of basement material at 190 cm, it was unclear if this represented a true interface or if some of the material below this depth might also be older dredged material. There was a scattered layer of shells at 195 cm and a gray sand lens or layer at 200 cm. Below the sand layer, light olive silt extended to the end of the core with very few shells, interrupted by three distinct sand layers. The olive silt was sampled just above the upper sand layer and was characterized by moderate TOC (2.6%) high silt content (57%) and moderate metals content. The metals content suggested that this horizon was enriched relative to basement material (compared to a similar horizon in Core 1-5). A close examination of the sand layers suggested that they were not likely to be dredged material. The upper layer was at 230 cm depth and appeared to have a silt matrix; the middle layer was at 234 cm depth and was a much coarser, well-sorted sand. A homogeneous layer of light olive silt separated the middle layer from the lower layer. The lower layer was about 3 cm thick beginning at 243 cm depth. The lower layer was a medium sand, well-sorted with distinct red coloration. It is unusual for dredged material to be deposited in a silt environment in such thin layers without mixing of the silt into the sand matrix. At 270 cm, there was a small cluster of shells in a silt matrix.

Core 1-5

Core 1-5 was collected on the northwest shoulder of the STNH-N mound, well off the mound peak but within the footprint of UDM detected by the bathymetric surveys. The top of the core had a 35-cm layer of dark sandy silt (75% silt & clay) with a distinct band of dark silt at 20 cm. This horizon coarsened with depth and mixes with silty sand and shells at 30 cm. This top horizon was similar in thickness to the top horizon in Core 1-2, but was much closer to Core 1-6 in composition (25% sand). Below the silty horizon a layer of sandy shell hash extended from 30-80 cm with high sand content near the top (85% sand at 47-57 cm). This shell hash contained a black silty clast at 65 cm and black silty layers near the bottom that contributed to high silt content in two sampled horizons (37% silt at 57-67 cm; 35% silt at 77-87 cm) with elevated PAHs. An intermediate horizon had high sand content and low PAHs (71% sand at 67-77 cm). The silty and shell hash layers were classified as CDM and were the thinnest layer (80 cm) in any of the cores, reflecting the position of the core off the shoulder of the mound peak.

Below the shell hash, black organic silty sand mixed with pebbles graded to a dark sandy silt. This horizon was classified as Stamford Harbor UDM, and at 20 cm thickness (80-100 cm) represented the thinnest layer of UDM in any of the STNH-N cores. The sandy organic silt was sampled from 90-100 cm depth (TOC 6.8%) and was texturally similar to the sample that overlapped this horizon (77-87 cm) but had higher PAH concentration. This latter sample may represent a mix between CDM and UDM, as it contained 9% gravel and a lower TOC content (4%).

The thin horizon classified as UDM laid over a thick sequence of dark olive silts with wood fragments and shell fragments intermixed with lighter silts and sand lenses. This sequence was consistent with the textures and composition of older dredged material seen in Cores 1-1 and 1-2, but the exact thickness was unclear. It was difficult to definitively distinguish the lower limit of dredged material deposits in this core. There was a sand layer at 135 cm and a large half oyster shell at 145 cm with a layer of red sand beneath. The oyster shell was large enough to cause some disruption of the core during collection and a second half oyster shell was found at 170 cm. This sequence of a sand layer above large shells associated with red sand layers was similar to the sequence in Core 1-2 and Core 1-4 (without the shells). In these cores, the red sand appeared to lack the characteristic texture of dredged material (silt matrix, chaotic bedding). In Core 1-5, this sequence was less clear, in part because of the disturbance from the movement of the oyster shells. If the oyster shell marked the end of the dredged material, the horizon extended from 100-150 cm depth with basement material below. If the disturbed bedding below the oyster shell was also dredged material, the most likely transition to basement was located at 180 cm with the last layer of pebbles and shells. A 50 cm horizon of older dredged material would be most consistent with the horizons observed in Cores 1-2 and 1-4, but much thinner than the apparent dredged material layer in Core 1-1 (106 cm). Only one sample was analyzed from this horizon (120-130 cm), and the characteristics were similar to other samples of older dredged material (low TOC 1.8%, predominately silt 50%, with minor amounts of sand 13%) with relatively low levels of metals and PAHs.

Core 1-6

Core 1-6 was collected as a replicate of Core 1-3 within 3 m of Core 1-3. The cores had similar profiles and thicknesses of CDM and UDM, but the variations in specific lithologies between the cores provided some insight into the heterogeneity of dredged material.

The top of Core 1-6 had a layer of silty sandy material comparable to the layer at the top of Core 1-3. The dark olive silt (silt & clay 81%) graded to sandy silt below 20 cm and silty sand below 35 cm with increasing shell fragments below 50 cm. This silty sandy horizon graded into shell hash (silt & clay 11%) with low organic content (TOC 1.1%) at 60 cm depth. The shell hash continued to 145 cm depth interspersed with layers of silt, fine sand and silty sand. A silty sand layer at 130 cm (sand 65% silt & clay 28%) with moderate TOC (2.3%) was on top of a mixed shell hash and silt layer with 34% silt and clay. This entire sequence (upper silty sandy layer and mixed shell hash) was classified as CDM and was slightly thicker than the CDM in Core 1-3 (148 cm and 135 cm, respectively).

Below the shell hash, a black silt horizon was dominated by the gravel fraction (61%, mixture of pebbles and shells) and a high TOC (4.2%). This horizon had a marked oily smell in both Cores 1-6 and 1-3 and very similar grain size distributions. Wood fragments were present at 165 cm depth where the black silt was mixed with dark gray silt with much lower gravel content (8%). At 190 cm the gray silt mixed into a dark sandy silt with wood fragments (56% sand, 40% silt & clay) followed by layers of silty sand and sandy silt. This sequence of dark silts and sands was classified as Stamford Harbor UDM but it was difficult to distinguish the lower limit of this horizon as it graded into dredged material with similar characteristics. The clearest visual distinction was at 230 cm depth where dark sandy silt had an irregular contact with interbedded coarse sand and silts. If the bottom of Stamford Harbor UDM was at 230 cm, the thickness of this layer was similar to Core 1-3 (82 cm and 73 cm respectively) but they underlying material was quite different in the two cores.

Below the apparent UDM was a series of mixed layers of sand, silts with some large shells. The entire horizon (230-290 cm) was classified as older dredged material with the possibility of 5 cm of basement material at the very bottom. These layers were sampled at three intervals (230-240 cm, 240-250 cm, 260-270 cm), and each sample had distinctly lower TOC than the material classified as UDM (2.5-2.7% for the basement vs. 4.2-4.8% for the UDM) and lower Total PAHs. A 5 cm sand horizon at 265 cm raised the sand fraction of the lowest sample and shell fragments raised the gravel fraction of the middle sample but the silt fraction was very consistent for all three and higher than in the UDM (45-47%). A similar transition occurred in Core 1-3, with the lowest samples depleted in TOC (1.6-2.9%) and Total PAH.

Cap Site 2

Core 2-1

Core 2-1 was collected on the thickest part of CS-2 mound on the northern side of center. The top of the core had 40 cm of silty sand with shell fragments (50% silt & clay). This formed a distinct layer with a sharp transition to a coarse sand horizon with small shell fragments which graded into shell hash with a sand matrix. Near the bottom of the sand horizon, more silt was mixed in to a depth of 85 cm (75-85 cm, 17% silt & clay). This entire sequence was classified as CDM.

A large shell marked the transition to a darker silty sand (85-95 cm, 38% silt & clay) which graded with dark and lighter layers to sandy silt (105-115 cm 55% silt & clay) with moderate organic content (2.5% TOC). From 120 cm to 145 cm there was a distinct light olive sandy silt horizon (72% silt & clay) with low organic content (0.8% TOC) and low metal and PAH concentrations. Below this was black organic silt (94% silt & clay and 8.6% TOC) layer with high metal and PAH concentration and finally a layer of coarse sand and pebbles with dark silt to a sharp transition at 170 cm depth. This sequence of dark sandy silts was classified as Black Rock Harbor UDM. The light olive layer was likely to be material from deep within the harbor below the contaminated sediments.

Below the dark organic sand was a layer of dark olive silt with shells and chaotic fabric mixed with grey silt. This layer was not analyzed but extended from 170 to 195 cm where it graded into olive sandy silt with a red sandstone pebble at 207 cm and a round red sand clast above 210 cm. This layer was most consistent with older dredged material in place before Cap Site 2 material was placed at this site. The transition to basement material was not clear because there was some disturbed fabric below the sand clast and shell fragment at 225 cm. These features were similar to those seen in basement material at STNH-N but may also have resulted from dredged material placement. Below 225 cm there were very few shells and what appeared to be homogeneous olive sandy silt. The sample analyzed at 235-245 cm was actually a silty sand (55% sand, 45% silt & clay) with low organic content (1.5% TOC) and unlike basement sediments from the other CS-2 cores. At the very bottom of the core a large oyster shell was embedded in olive silt. There was at least 20 cm of older dredged material, possibly as much as 55 cm and between 65 and 95 cm of basement material with equivocal evidence of the sediment transport horizons seen at STNH-N.

Core 2-2

Core 2-2 was collected in the thickest part of the mound east and slightly north of center (Core 2-2 was collected as a replicate of Core 2-6). The top of the core had sandy silt that coarsened to silty sand (48% silt & clay at 10-20 cm) very similar in composition to the top of Cores 2-1 and 2-6. This layer graded into a sandy silt with high shell component (silt and clay 20-23%, shelly sand 60-63%, shell gravel 16%). There was a sharp transition at 75 cm to a sandy shell hash with very low organic content (0.8% TOC). This shell hash had an angled sharp interface to underlying dark sandy silt. The sequence of silt and sand at the top of the core was classified as CDM and represented at least 95 cm of cap material after consolidation.

The dark sandy silt below the shell hash had very fine shell fragments and moderate organic content (2.8% TOC). This horizon graded to higher silt content (53-69% silt & clay) and higher organic content (2.8-6.9% TOC) to the end of the core section at 152 cm. At the top of the next section, the silt changed to a dark silty sand with shell fragments and lower organic content (3.2% TOC). This silty sand extended this horizon to 170 cm and marked the lower limit of material classified as Black Rock UDM.

The dark sand had a sharp transition to a mixed layer of lighter olive silt and dark sandy silt from 170 to 195 cm. This horizon had chaotic fabric, some shells and was classified as older dredged material. No samples were analyzed from this horizon which made a sharp transition to olive silts at 195 cm marking the most likely interface to basement or basement material.

The light olive silt extended to the bottom of the core and was sampled at the 220-230 cm depth interval (92% silt & clay, 2.8% TOC) which showed slightly elevated levels of zinc. A thin horizon with dark silt and shells was present at 250 cm which might correlate with sediment transport markers in other cores with basement material.

Core 2-3

Core 2-3 was collected off the peak of the mound on the northeast shoulder. The top of the core was a layer of sandy silt with numerous shell fragments (10-20 cm, silt & clay 61%). This layer had a sharp transition to a coarse sand layer with shells and pebbles at 37 cm interbedded with some sandy silt at 47 cm. A sample from 40-50 cm was dominated by low organic content sand (85% sand, 0.68% TOC). This entire sequence (classified as CDM) was similar to, but thinner than, the CDM layers from Cores 2-1 and 2-2.

At 55 cm, a dark layer of silty sand with shell fragments appeared to mark the transition to older dredged material. There was no evidence of the characteristic Black Rock UDM in this core (black high organic silty sand) which was located within the footprint of UDM deposition but near the margin. Below the silty sand was a series of layers of silt and sand with chaotic fabric and numerous gravel-sized shell fragments and some pebbles. All of the sampled horizons had low to moderate organic content (1.4-2.2% TOC). The top sample (60-70 cm) had 86% silt with little gravel-sized material, but the next three samples had 10-13% gravel and 49-25% silt. The older dredged material layer was the thickest of the six cores (52 cm) and seemed to end quite abruptly at the end of the first core section at 110 cm.

The second core section (110-245 cm) consisted of olive silt with a few shell fragments and burrow mottling classified as basement material. A sample analyzed from 120-130 cm had 91% silt and clay and 1.8% TOC, very similar to basement sediments from the bottom of Core 2-4. What was most striking about this sequence is that there did not appear to be any horizons of sand or large shells as seen in other cores with thick basement layers.

<u>Core 2-4</u>

Core 2-4 was collected within the thicker part of the cap (based on bathymetric surveys) but on the eastern side of the mound center near the margin of the UDM distribution. The top of the core was sandy silt with very small shell fragments (very little gravel-size). The 10-20 cm sample had the highest silt content of any of the CS-2 cores. This layer became sandier toward the bottom. Just below the sandy silt from 27-37 cm was a distinct horizon of black silt with a strong odor. This black silt was not present in any other core but the samples from this horizon were not analyzed so it is unclear whether the odor was due to organic enrichment or contamination. Below the black silt, a layer of dark sandy silt graded to silty sand with numerous sand and gravel sized shell fragments and low organic content (1.5 – 2.1% TOC) but some elevation of PAH (220 mg/kg). This silty sand graded into sandy shell hash layered with sand (91% sand, 1.2% TOC) to a depth of 86 cm. This entire sequence was classified as CDM with a thickness and composition similar to Cores 2-1 and 2-2.

Below the sand layer a sharp transition to dark sandy silt marked the horizon of material classified as Black Rock UDM. The 34 cm of sandy silt had mixed layers of olive and dark grey with a very consistent composition (39-45% silt & clay, 1.7-2.1% TOC). Near the bottom of this sequence the dark silts began to mix with layers of light olive silt.

There was a thin horizon (13 cm) of lighter olive silt with numerous shell fragments that appeared to be older dredged material. Samples of this horizon were not analyzed.

Below the older dredged material the light olive silt had distinct burrow mottling and was been classified as basement material. A sample from 146 – 156 cm had 94% silt and low organic content (1.7% TOC), a composition very similar to basement material from Core 2-3. The basement horizon extended to the core end at 250 cm without any visible evidence of the sediment horizons seen in other cores.

<u>Core 2-5</u>

Core 2-5 was collected on the southeastern edge of the mound at the very margin of UDM distribution but within the 40+ cm CDM distribution. The top of the core was distinct from other cores at CS-2 with silty sand dominated by shell fragments rather than sandy silt. The 10-20 cm horizon had 21% silt and clay and 1.1% TOC. Below 30 cm the sand graded to an olive silty sand and then to olive silt with shells. This was essentially the reverse of the upper sequences of other cores. The lowest part of this sequence had a distinct transition to dark silts with large shells. The total CDM horizon was 70 cm, consistent with other cores collected in the thicker part of the cap.

The dark sandy silt below the CDM was similar to the top of the older dredged material horizon in Core 2-3. From 70-90 cm the material had 92-97% silt and clay and 0.87-2.1% TOC. There was no evidence of Black Rock UDM in this core which is consistent with the location of the core at the margin of bathymetrically detectable UDM. Below the silt layers a horizon of sandy silt (67% silt) alternated with silts and shell accumulations. The entire sequence had large shells that were dragged by the core barrel and contributed to a chaotic fabric. This sequence was classified as older dredged material with a total thickness of 50 cm, similar to Core 2-3.

Below the older dredged material, a nearly featureless horizon of olive silt extended to the bottom of the core. A sample from 130-150 cm had 97% silt and 1.5% TOC. There was a layer of fine shell fragments from 170 – 175 cm that might be evidence of some episodic sediment transport within this sequence.

Core 2-6

Core 2-6 was collected as a replicate of Core 2-2 on the thickest area of the mound but it had different cap layer characteristics. The top of the core was sandy silt that graded to silty sand with very similar material properties as the top of Core 2-2 (49% silt & clay, 1.5% TOC). But below 20 cm, the CDM material was light silt with very little sand content and no shelly gravel (86-91% silt & clay) and extended down to a sharp interface at 50 cm. This sequence was classified as CDM and represented 50 cm of consolidated silt with some sand near the top in contrast to 95 cm of sandy shell hash at the top of Core 2-2.

Below the sharp horizontal interface was a thick horizon of dark silty sand mixed with lighter layers of olive silt with chaotic fabric and shell fragments. Three of the four samples analyzed from this horizon had remarkably consistent silt & clay and TOC content with some variation in the shelly gravel fraction. This horizon extended from 50-150 cm and was classified as a 100 cm thickness of consolidated Black Rock Harbor UDM. This layer was somewhat thicker than the same horizon from Core 2-2 (75 cm) which was primarily composed of sandy silt.

The dark UDM laid above a layer with mixed dark and olive sandy silt with shell fragments that graded into dark olive silt with chaotic fabric and shell horizons. This was classified as older dredged material about 40 cm thick with an indistinct transition to basement at 187 cm. The dredged material horizon was not sampled but the underlying basement olive silt was very similar in physical characteristics to the deepest layers of Core 2-2 (94% silt & clay, 1.8% TOC). The olive silt had distinct burrow mottled textures and extended to the end of the core (231 cm, the shortest of the six cores from CS-2).

APPENDIX C3

CORE SUBSAMPLING

ENSR

Client: U.S. ACE		CORE NO: 1-1
Project Number: 9000-340		
Station Location: CLDS -		
GPS Coordinates:		
Geographic Reference: Long Island Sound		Sheet: 1 of 2
Water Depth:	MLW:	Core Size (in.) 4 ID
Weather:	Seas:	Time (Water Depth):
Survey Vessel:	Logged By:	Date:
Survey Personnel:		Time (Coring):
Sampling Equipment: Vibra-Core		
Estimated Penetration Range:	Project Depth :	
Actual Penetration):	Recovery:	% Recovery:
No. Attempts:		

Depth (cm)	SKETCH	DESCRIPTION: SAMPLE			ARCHIVE
	0-10	∅			
15	10-20	S	1-1 A		
30	20-30	A			1-1 A
	30-40	A			1-1 B
45	40-50	A			1-1 C
60	50-60	S	1-1 B		
	60-70	A			1-1 D
75	70-80	S	1-1 C		
90	80-90	A			1-1 E
	90-100	A			1-1 F
105	100-110	A			1-1 G
120	110-120	A			1-1 H
	120-130	S	1-1 D	INTERFACE @ 130-132 CAP TO DM	
135	130-140	S	1-1 E		
150	140-150	S	1-1 F		
	150-160	A			1-1 I
165	160-170	S	1-1 G		
180	170-180	A			1-1 J
	180-190	A		INTERFACE @ 192 UNK TO BASEMENT	1-1 K
195	190-200	A			1-1 L
210	200-210	A			1-1 M
	210-220	∅			
225	220-230	S	1-1 H		

ENSR

Client: U.S. ACE		CORE NO: 1-1
Project Number: 9000-340		
Station Location: CLDS -		
GPS Coordinates:		
Geographic Reference: Long Island Sound		Sheet: 1 of 2
Water Depth:	MLW:	Core Size (in.) 4 ID
Weather:	Seas:	Time (Water Depth):
Survey Vessel:	Logged By:	Date:	Time (Coring):
Survey Personnel:		
Sampling Equipment: Vibra-Core		
Estimated Penetration Range:	Project Depth :	
Actual Penetration):	Recovery:	% Recovery:	No. Attempts:

Depth (cm)	SKETCH	DESCRIPTION	
	230-240	Ø	
15	240-250		
	250-260		
30	260-270		
45	270-280	A	1-1 N
	280-290	Ø	
60	290-300		
75			
90			
105			
120			
135			
150			
165			
180			
195			
210			
225			

ENSR			
	Client: U.S. ACE		CORE NO: 1-2
	Project Number: 9000-340		
	Station Location: CLDS -		
	GPS Coordinates:		
	Geographic Reference: Long Island Sound		Sheet: 1 of 2
	Water Depth:	MLW:	Core Size (in.) 4 ID
	Weather:	Seas:	Time (Water Depth):

Survey Vessel:	Logged By:	Date:	Time (Coring):
Survey Personnel:			
Sampling Equipment: Vibra-Core			
Estimated Penetration Range:	Project Depth :		
Actual Penetration):	Recovery:	% Recovery:	No. Attempts:

Depth (cm)	SKETCH	DESCRIPTION SAMPLE	ARCHIVE
	0-10		
15	10-20	S 1-2 A	
30	20-30	A	1-2 A
	30-40	A	1-2 B
45	40 50	A	1-2 C
60	50-60	S 1-2 B	
	60-70	A	1-2 D
75	70-80	A	1-2 E
90	80-90	A	1-2 F
	90-100	A	1-2 G
105	100-110	A	1-2 H
120	110-120	S 1-2 C	
	120-130	A	1-2 I
135	134-144	S 1-2 D Note Interval Change	
150	144-154	S 1-2 E	
	160-170	S 1-2 F Note Interval Change	
165	170-180	A	1-2 J
180	180-190	S 1-2 G	
	190-200	A	1-2 K
195	200-210	A	1-2 L
210	210-220	A	1-2 M
	220-230	A	1-2 N
225	230-240	S } 1-2 H	
	240-250	↳ 20CM SECTION FOR QC	

Cont. on next page

ENSR	Client: U.S. ACE Project Number: 9000-340 Station Location: CLDS - GPS Coordinates: Geographic Reference: Long Island Sound	CORE NO: 1-2 cont.
	Water Depth: MLW:	Sheet: 1 of 2
		Core Size (in.) 4 ID
	Weather: Seas:	Time (Water Depth):

Survey Vessel:	Logged By:	Date:	Time (Coring):
Survey Personnel:			
Sampling Equipment: Vibra-Core			
Estimated Penetration Range:	Project Depth :		
Actual Penetration):	Recovery:	% Recovery:	No. Attempts:

Depth (cm)	SKETCH	DESCRIPTION SAMPLE	ARCHIVE
	240-250	NOT SAMPLED	
15	250-260	NOT SAMPLED	
30	260-270	NOT SAMPLED	
	270-280	S 1-2 I	
45	280-290	A	1-2 O
60			
75			
90			
105			
120			
135			
150			
165			
180			
195			
210			
225			

ENSR

Client: U.S. ACE			CORE NO: 1-3
Project Number: 9000-340			
Station Location: CLDS -			
GPS Coordinates:			
Geographic Reference: Long Island Sound			Sheet: 1 of 2
Water Depth:	MLW:		Core Size (in.) 4 ID
Weather:		Seas:	Time (Water Depth):
Survey Vessel:	Logged By:	Date:	Time (Coring):
Survey Personnel:			
Sampling Equipment: Vibra-Core			
Estimated Penetration Range:	Project Depth :		
Actual Penetration):	Recovery:	% Recovery:	No. Attempts:

Depth (cm)	SKETCH	DESCRIPTION		
			SAMPLE	ARCHIVE
	0-10 Ø			
15	10-20	S	1-3 A	
30	20-30	A		1-3 A
	30-40	A		1-3 B
45	40-50	A		1-3 C
60	50-60	A		1-3 D
	60-70	S	1-3 B	
75	70-80	A		1-3 E
90	80-90	Not Sampled		
	90-100	A		1-3 F
105	100-110	A		1-3 G
120	115-125	S	1-3 C	
		Note Interval Change		
	125-135	S	1-3 D	
135	135-145	S	1-3 E	
150	145-155	S	1-3 F	
	160-170	A		1-3 H
165		Note Interval Change		
	170-180	A		1-3 I
180	180-190	A		1-3 J
	190-200	S	1-3 G	
195	200-210	A		1-3 K
210	210-220	A		1-3 L
	220-230	S	1-3 H	
225	230-240	Not Sampled		

ENSR

Client: U.S. ACE		CORE NO: 1-3 cont.
Project Number: 9000-340		
Station Location: CLDS -		
GPS Coordinates:		
Geographic Reference: Long Island Sound		Sheet: 1 of 2
Water Depth:	MLW:	Core Size (in.) 4 ID
Weather:	Seas:	Time (Water Depth):
Survey Vessel:	Logged By: / Date:	Time (Coring):
Survey Personnel:		
Sampling Equipment: Vibra-Core		
Estimated Penetration Range:	Project Depth :	
Actual Penetration):	Recovery: / % Recovery:	No. Attempts:

Depth (cm)	SKETCH	DESCRIPTION	
		SAMPLE	ARCHIVE
	240-250	A	1-3 M
15	250-260	A } S (QC)	~~1-3 N~~ e
30	260-270	S } 1-3 I	
	270-280	A	~~1-3 O~~ 1-3 N
45			
60			
75			
90			
105			
120			
135			
150			
165			
180			
195			
210			
225			

ENSR

Client: U.S. ACE		CORE NO: 1-4
Project Number: 9000-340		
Station Location: CLDS -		
GPS Coordinates:		
Geographic Reference: Long Island Sound		Sheet: 1 of 2
Water Depth:	MLW:	Core Size (in.) 4 ID
Weather:	Seas:	Time (Water Depth):
Survey Vessel: Logged By:	Date:	Time (Coring):
Survey Personnel:		
Sampling Equipment: Vibra-Core		
Estimated Penetration Range:	Project Depth :	
Actual Penetration):	Recovery: % Recovery:	No. Attempts:

Depth (cm)	SKETCH	DESCRIPTION	
	0-10	Ø	
15	10-20	S 1-4 A	
30	20-30	A	1-4 A
	30-40	A	1-4 B
45	40-50	A	1-4 C
60	50-60	S 1-4 B	
	60-70	S 1-4 C	
75	70-80	A	1-4 D
90	80-90	S 1-4 D INTERFACE AT 90 cm	
	90-100	S 1-4 E	
105	100-110	S 1-4 F	
120	110-120	A	1-4 E
	120-130	A	1-4 F
135	130-140	A	1-4 G
150	140-150	A	1-4 H
	150-160	A	1-4 I
165	160-170	S 1-4 G	
180	170-180	A	1-4 J
	180-190	A INTERFACE AT 180 cm UDM TO BASEMENT	1-4 K
195	190-200	A	1-4 L
210	200-210	Ø BAND HORIZON @ 208	
	210-220	Ø	
225	220-230	S 1-4 H	

ENSR	Client: U.S. ACE			CORE NO: 1-4
	Project Number: 9000-340			
	Station Location: CLDS -			
	GPS Coordinates:			
	Geographic Reference: Long Island Sound			Sheet: 1 of 2
	Water Depth:	MLW:		Core Size (in.) 4 ID
	Weather:		Seas:	Time (Water Depth):
Survey Vessel:		Logged By:	Date:	Time (Coring):
Survey Personnel:				
Sampling Equipment: Vibra-Core				
Estimated Penetration Range:		Project Depth :		
Actual Penetration):		Recovery:	% Recovery:	No. Attempts:

Depth (cm)	SKETCH	DESCRIPTION	
	230-240	A	1-4 M
15	240-250	A	1-4 N
30	250-260	∅	
45			
	-280		
60			
75			
90			
105			
120			
135			
150			
165			
180			
195			
210			
225			

ENSR

Client: U.S. ACE			CORE NO: 1-5
Project Number: 9000-340			
Station Location: CLDS -			
GPS Coordinates:			
Geographic Reference: Long Island Sound			Sheet: 1 of 2
Water Depth:	MLW:		Core Size (in.) 4 ID
Weather:		Seas:	Time (Water Depth):
Survey Vessel:	Logged By:	Date:	Time (Coring):
Survey Personnel:			
Sampling Equipment: Vibra-Core			
Estimated Penetration Range:	Project Depth :		
Actual Penetration):	Recovery:	% Recovery:	No. Attempts:

Depth (cm) / SKETCH	DESCRIPTION – SAMPLE	ARCHIVE
0-10 Ø		
10-20	S 1-5 A	
20-30	A	1-5 A
30-40	A	1-5 B
47-57	S 1-5 B	
	Note Interval Change	
57-67	S 1-5 C	
67-77	S 1-5 D	
77-87	S 1-5 E	
90-100	S 1-5 F	
100-110	A	1-5 C
110-120	A	1-5 D
120-130	S 1-5 G	
130-140	A	1-5 E
140-270	NOT SAMPLED	
270-280	S 1-5 H	
280-290	Not Sampled	

ENSR

Client: U.S. ACE		CORE NO: 1-6
Project Number: 9000-340		
Station Location: CLDS -		
GPS Coordinates:		
Geographic Reference: Long Island Sound		Sheet: 1 of 2
Water Depth:	MLW:	Core Size (in.) 4 ID
Weather:	Seas:	Time (Water Depth):
Survey Vessel:	Logged By:	Date:	Time (Coring):

Survey Personnel:			
Sampling Equipment: Vibra-Core			
Estimated Penetration Range:	Project Depth :		
Actual Penetration):	Recovery:	% Recovery:	No. Attempts:

Depth (cm)	SKETCH	DESCRIPTION	
	0-10	∅	
15	10-20	S 1-6 A	
	20-30	A 1	1-6 A
30	30-40	A	1-6 B
45	40-50	A	1-6 C
	50-60	A	1-6 D
60	60-70	S (QC) 1-6 B	
75	70-80		
90	80-90	∅	
	90-100	A	1-6 E
105	100-110	A	1-6 F
	110-120	A	1-6 G
120	120-130	~~A~~ A	1-6 H
135	130-140	S 1-6 C	
	140-150	S 1-6 D	
150	150-160	S 1-6 E	
165	160-170	S 1-6 F	
	170-180	A	1-6 I
180	180-190	A	1-6 J
195	190-200	S 1-6 G	
	200-210	A	1-6 K
210	210-220	A	1-6 L
225	220-230	A	1-6 M

ENSR	Client: U.S. ACE			CORE NO: 1-6
	Project Number: 9000-340			
	Station Location: CLDS -			
	GPS Coordinates:			
	Geographic Reference: Long Island Sound			Sheet: 1 of 2
	Water Depth:	MLW:		Core Size (in.) 4 ID
	Weather:		Seas:	Time (Water Depth):
Survey Vessel:	Logged By:		Date:	Time (Coring):
Survey Personnel:				
Sampling Equipment: Vibra-Core				
Estimated Penetration Range:	Project Depth :			
Actual Penetration):	Recovery:	% Recovery:		No. Attempts:

Depth (cm)	SKETCH	DESCRIPTION	
	230-240	S 1-6 H	
15		240 = UDM/BASEMENT INTERFACE	
	240-250	S 1-6 I	
30	250-260	A	1-6 N
	260-270	S 1-6 J	
45			
	270-280	A	1-6 O
60	280-290	A	1-6 P
75			
90			
105			
120			
135			
150			
165			
180			
195			
210			
225			

ENSR

Client: U.S. ACE	CORE NO: 2-1
Project Number: 9000-340	
Station Location: CLDS -	
GPS Coordinates:	
Geographic Reference: Long Island Sound	Sheet: 1 of 2
Water Depth: MLW:	Core Size (in.) 4 ID
Weather: Seas:	Time (Water Depth):
Survey Vessel: Logged By: Date:	Time (Coring):
Survey Personnel:	
Sampling Equipment: Vibra-Core	
Estimated Penetration Range: Project Depth :	
Actual Penetration): Recovery: % Recovery:	No. Attempts:

Depth (cm)	SKETCH	DESCRIPTION Sample	Archive	
15	10-20	S 2-1A		
30				
45				
60	55-75	SAMPLE QC 2-1B		SANDY HOMOGEN.
75	75-85	S 2-1C	SANDY	MOTTLED FINE
90	85-95	S 2-1D	MOTTLED FINE	
105	95-105	S 2-1E		
	105-115	S 2-1F		
120	115-125	A	2-1 A	
135	125-135	A	2-1 B	
	135-145	S 2-1G		~ HOMOG. GRN
150	145-155	A 2nd CORE ("B")	2-1 C	
165	155-165	S 2-1 H		
	165-175	A	2-1 D	
180	175-185	A	2-1 E	
195	185-195	A	2-1 F	
	195 ~~200~~-205	A	2-1 G	
210	205-215	A	2-1 H	
225	215-225	A	2-1 I	
	225-235	A	2-1 J	

235-245 S 2-1 I

ENSR	Client: U.S. ACE	CORE NO: 2-2
	Project Number: 9000-340	
	Station Location: CLDS -	
	GPS Coordinates:	
	Geographic Reference: Long Island Sound	Sheet: 1 of 2
	Water Depth: MLW:	Core Size (in.) 4 ID
	Weather: Seas:	Time (Water Depth):
Survey Vessel:	Logged By: Date:	Time (Coring):
Survey Personnel:		
Sampling Equipment: Vibra-Core		
Estimated Penetration Range:	Project Depth :	
Actual Penetration):	Recovery: % Recovery:	No. Attempts:

Depth (cm)	SKETCH	DESCRIPTION	SAMPLE	ARCHIVE	
	0-10 Ø				
15	10-20	S	2-2 A		
	20-30	A		2-2 A	
30	30-40	A		2-2 B	
45	40-50	S	2-2 B		
	50-60	S	2-2 C		
60	60-70	A		2-2 C	
75	70-80	A		2-2 D	
90	80-90	S	2-2 D		
	90-100	A		2-2 E	
105	100-110	S	2-2 E		
120	110-120	A		2-2 F	
	120-130	S	2-2 F	~~2-2 G~~ RMC	
135	130-140	A		2-2 G	
150	140-150	S	2-2 G		
	150-160	A		2-2 H	
165	160-170	S	2-2 H		
180	170-180	A		2-2 I	2 BTLS
	180-190	A		2-2 J	2 "
195	190-200	A		2-2 K	2 "
210	200-210	A		2-2 L	2 "
	210-220	A		2-2 M	1 BTL
225	220-230	S	2-2 I		

ENSR			
	Client: U.S. ACE		CORE NO: Z-3
	Project Number: 9000-340		
	Station Location: CLDS -		
	GPS Coordinates:		
	Geographic Reference: Long Island Sound		Sheet: 1 of 2
	Water Depth:	MLW:	Core Size (in.) 4 ID
	Weather:	Seas:	Time (Water Depth):
Survey Vessel:	Logged By:	Date:	Time (Coring):
Survey Personnel:			
Sampling Equipment: Vibra-Core			
Estimated Penetration Range:	Project Depth :		
Actual Penetration):	Recovery:	% Recovery:	No. Attempts:

Depth (cm)	SKETCH	DESCRIPTION		
	0-10			
15	10-20	S	Z-3A	~~Z-3Ac~~
30	20-30	A		Z-3A
	30-40	A		Z-3B
45	40-50	S	Z-3B	
60	50-60	A		Z-3C
	60-70	S	Z-3C	
75	70-80	S	Z-3D	
90	80-90	S	Z-3E	
	90-100	S	Z-3F	
105	100-110	A		Z-3D
120	110-120	A		Z-3E
	120-130	S	Z-3G	
135	130-140	A		Z-3F
150				
165				
180				
195				
210				
225				

ENSR	Client: U.S. ACE Project Number: 9000-340 Station Location: CLDS - GPS Coordinates: Geographic Reference: Long Island Sound	**CORE NO:** 2-4 Sheet: 1 of 2
	Water Depth: MLW:	Core Size (in.) 4 ID
	Weather: Seas:	Time (Water Depth):
Survey Vessel:	Logged By: Date:	Time (Coring):

Survey Personnel:

Sampling Equipment: Vibra-Core

Estimated Penetration Range: | Project Depth :

Actual Penetration): | Recovery: | % Recovery: | No. Attempts:

Depth (cm)	SKETCH	DESCRIPTION		
			Sample	Archive
	φ			
15	10-20	S	2-4 A	
	20-30	A		2-4 A
30	30-40	A		2-4 B
45	40-50	S S	2-4 B	
	φ			
60	56-66	S	2-4 C	
	66-76	S	2-4 D	
75	76-86	S	2-4 E	
90	86-96	S	2-4 F	
	96-106	S	2-4 G	
105	106-116	S	2-4 H	
120	116-126	A		2-4 C
	126-136	A		2-4 D
135	136-146	A		2-4 E
150	146-156	S	2-4 I	
	156-166	A		2-4 F
165				
180				
195				
210				
225				

ENSR	Client: U.S. ACE			CORE NO: 2-5
	Project Number: 9000-340			
	Station Location: CLDS -			
	GPS Coordinates:			
	Geographic Reference: Long Island Sound			Sheet: 1 of 2
	Water Depth:	MLW:		Core Size (in.) 4 ID
	Weather:		Seas:	Time (Water Depth):
Survey Vessel:		Logged By:	Date:	Time (Coring):
Survey Personnel:				
Sampling Equipment: Vibra-Core				
Estimated Penetration Range:		Project Depth :		
Actual Penetration):		Recovery:	% Recovery:	No. Attempts:

Depth (cm)	SKETCH	DESCRIPTION Sample	Archive
	0-10 ∅		
15	10-20	S 2-5 A	
	20-30	A	2-5 A
30	30-40	S 2-5 B	
45	40-50	A	2-5 B
	50-60	S 2-5 C	
60	60-70	A	2-5 C
75	70-80	S 2-5 D (STL QC)	
90	80-90	S 2-5 E	
	90-100	S 2-5 F	
105	100-110	A	2-5 D
120	110-120	A	2-5 E
	120-130	A	2-5 F
A 135	130-140	S 2-5 G	
B 150	*140-150	↳ 20cm section for QC (KAST) (STL 1X only)	
165			
180			
195			
210			
225			

* Top of "B" core contained a "diesel" odor

ENSR

Client: U.S. ACE	CORE NO: 2-6
Project Number: 9000-340	
Station Location: CLDS -	
GPS Coordinates:	
Geographic Reference: Long Island Sound	Sheet: 1 of 2
Water Depth: MLW:	Core Size (in.) 4 ID
Weather: Seas:	Time (Water Depth):
Survey Vessel: Logged By: Date:	Time (Coring):
Survey Personnel:	
Sampling Equipment: Vibra-Core	
Estimated Penetration Range: Project Depth :	
Actual Penetration): Recovery: % Recovery:	No. Attempts:

Depth (cm)	SKETCH	DESCRIPTION	SAMPLE	ARCHIVE
	0-10 ∅			
15	10-20	S	2-6 A	
30	20-30	A		26 A
	30-40	S	2-6 B	
45	40-50	S	2-6 C	
60	50-60	S	2-6 D	
	60-70	S	2-6 E	
75	70-80	A		2-6 B
90	80-90	S	2-6 F	
	90-100	A		2-6 C
105	100-110	S	2-6 G	
120	110-120	A		2-6 D
	120-130	S	2-6 H	
135	130-140	A		2-6 E
150	140-150	A		2-6 F
	150-160	A		2-6 G
165	160-170	A		2-6 H
180	170-180	A		2-6 I
	180-190	A		2-6 J
195	190-200	S	2-6 I	
210				
225				