Monitoring Survey at the Seawolf Disposal Mound
September 2010

Disposal Area Monitoring System DAMOS

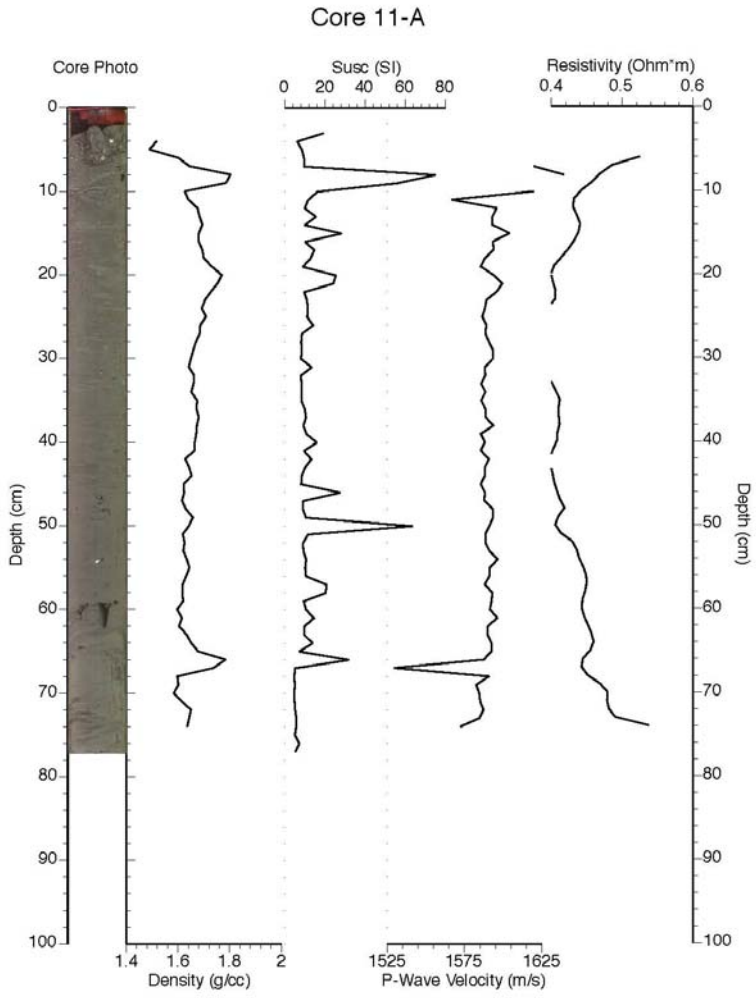

Figure 1. Digital image and core log parameters versus depth for core 11-A

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13. ABSTRACT

The Seawolf Mound, located in the New London Disposal Site within Long Island Sound, was created in 1995/96 from the placement of material dredged from the Thames River, Connecticut that was deemed unsuitable for open water disposal due to trace metal and polycyclic aromatic hydrocarbon (PAH) concentrations. This sediment was then covered with suitable dredged material to form a cap layer and sequester the underlying unsuitable material from the environment. Periodic monitoring of the site has identified a stable layer of capping material over the mound, but a 2006 survey suggested more variable PAH concentrations in the cap layer than previously measured. However, the 2006 survey used a different PAH analytical preparation technique from previous investigations. A monitoring survey was conducted on the Seawolf Mound in September 2010 to compare PAH analytical and extraction methodologies from previous surveys and to further characterize the spatial variability of PAH concentrations in surficial sediments of the mound cap.

A total of 16 vibracores were collected in 2010 from nine stations across the mound and one station in a pre-defined reference area to characterize material within the cap layer of the mound. Two of the mound stations and the one reference station included sets of three co-located cores in order to asses small-scale spatial variability in cap sediments. The upper 0.5 m of each core was homogenized into a single sample and subsequently analyzed for grain size, total organic carbon (TOC), and PAHs. Grain size and TOC results were consistent with previous surveys and documented a surficial layer of relatively fine-grained material with low TOC levels.

PAH analysis was conducted in two phases in order to assess potential variability from different methods used on previous Seawolf monitoring surveys. Phase 1 consisted of two sediment cores with analysis by three different extraction methodologies: microscale extraction (MSE) by Method 3570, pressurized fluid extraction (PFE) by Method 3545A, and Soxhlet extraction by Method 3540C. Following extraction all samples were analyzed via GC/MS SIM (SW-846 Method 8270C). The Soxhlet extraction method achieved the highest PAH surrogate and quality control recoveries, PFE had the next highest recoveries, and MSE exhibited the lowest and most variable results. Based on these results the Soxhlet extraction method was used on the remaining samples to complete the second phase of PAH analysis.

Phase 2 of the PAH study involved analyzing the remaining cores with the Soxhlet extraction method; including assessment of compositional-level heterogeneity of the matrix and assessment of small-scale (10 m or less) spatial variability of field samples. PAH heterogeneity of Seawolf sediments at the matrix level was examined through triplicate sub-sampling of three individual cores that had each been well homogenized. Results from this exercise identified the potential for heterogeneity within a single capping dredged material sample to persist through the small sub-sample mass and homogenization techniques of PAH analytical methods.

The 2010 survey results indicated that PAH concentrations were similar across the Seawolf Mound stations and were consistent with pre-dredge characterization of the capping material. Levels were also below the Sediment Quality Guideline Effects-Range Low (ERL) value indicating that there is a sufficient layer of cap material over the mound. It is likely that different PAH extraction methodologies, compositional-level variability, and small-scale spatial variability have all contributed to observed variations in PAH concentrations throughout the monitoring efforts at the Seawolf Mound. It is recommended that any future sediment investigations use analytical methods with larger sample size, high extraction efficiencies, and thorough homogenization techniques in order to reduce the impact of these factors and that sufficient samples are collected to allow for meaningful comparison of spatial and temporal means rather than comparing concentrations at individual locations.

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Frontispiece

USS Seawolf (SSN-21)

Photo and Badge: US Navy

The Seawolf class submarine was designed to combat the Akula and Typhoon class submarines of the Soviet fleet at the end of the Cold War. The first boat of the class, the USS Seawolf, was christened on 24 June 1995 in Groton, Connecticut. Originally envisioned as a new fleet of 29 submarines, the construction costs of the large vessels, coupled with the end of the Cold War, stopped production at just three boats. All three Seawolf class submarines are currently based out of Naval Base Kitsap in Bremerton, Washington.

Note on units of this report: As a scientific contribution, information and data are presented in the metric system. However, given the prevalence of English units in the dredging industry of the United States, conversions to English units are provided for the general information in Section 1. A table of common conversions can be found in Appendix E.

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EXECUTIVE SUMMARY

The Seawolf Mound, located in the New London Disposal Site within Long Island Sound, was created in 1995/96 from the placement of material dredged from the Thames River, Connecticut that was deemed unsuitable for open water disposal due to trace metal and polycyclic aromatic hydrocarbon (PAH) concentrations. This sediment was then covered with suitable dredged material to form a cap layer and sequester the underlying unsuitable material from the environment. Periodic monitoring of the site has identified a stable layer of capping material over the mound, but a 2006 survey suggested more variable PAH concentrations in the cap layer than previously measured. However, the 2006 survey used a different PAH analytical preparation technique from previous investigations. A monitoring survey was conducted on the Seawolf Mound in September 2010 to compare PAH analytical and extraction methodologies from previous surveys and to further characterize the spatial variability of PAH concentrations in surficial sediments of the mound cap.

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PAH analysis was conducted in two phases in order to assess potential variability from different methods used on previous Seawolf monitoring surveys. Phase 1 consisted of two sediment cores with analysis by three different extraction methodologies: microscale extraction (MSE) by Method 3570, pressurized fluid extraction (PFE) by Method 3545A, and Soxhlet extraction by Method 3540C. Following extraction all samples were analyzed via GC/MS SIM (SW-846 Method 8270C). The Soxhlet extraction method achieved the highest PAH surrogate and quality control recoveries, PFE had the next highest recoveries, and MSE exhibited the lowest and most variable results. Based on these results the Soxhlet extraction method was used on the remaining samples to complete the second phase of PAH analysis.

Phase 2 of the PAH study involved analyzing the remaining cores with the Soxhlet extraction method; including assessment of compositional-level heterogeneity of the matrix and assessment of small-scale (10 m or less) spatial variability of field samples. PAH heterogeneity of Seawolf sediments at the matrix level was examined through triplicate sub-sampling of three individual cores that had each been well homogenized.

Results from this exercise identified the potential for heterogeneity within a single capping dredged material sample to persist through the small sub-sample mass and homogenization techniques of PAH analytical methods.

Variblity of PAHs at the field scale was examined through analysis of three sets of triplicate co-located cores, with cores of each set collected within a 10 m station tolerance. While two of the three stations sampled with co-located cores showed strong agreement between samples, there was considerable variation among cores from the third station. These results further supported the understanding of the potential for small-scale spatial variability among the heterogeneous cap material and suggest limitations on inter-survey comparisons between individual locations.

The 2010 survey results indicated that PAH concentrations were similar across the Seawolf Mound stations and were consistent with pre-dredge characterization of the capping material. Levels were also below the Sediment Quality Guideline Effects-Range Low (ERL) value indicating that there is a sufficient layer of cap material over the mound. It is likely that different PAH extraction methodologies, compositional-level variability, and small-scale spatial variability have all contributed to observed variations in PAH concentrations throughout the monitoring efforts at the Seawolf Mound. It is recommended that any future sediment investigations use analytical methods with larger sample size, high extraction efficiencies, and thorough homogenization techniques in order to reduce the impact of these factors and that sufficient samples are collected to allow for meaningful comparison of spatial and temporal means rather than comparing concentrations at individual locations.

1.0 INTRODUCTION

A monitoring survey was conducted at the Seawolf disposal mound (Seawolf Mound) as part of the U.S. Army Corps of Engineers (USACE) New England District (NAE) Disposal Area Monitoring System (DAMOS). DAMOS is a comprehensive monitoring and management program designed and conducted to address environmental concerns associated with use of aquatic disposal sites throughout the New England region. An introduction to the DAMOS Program and the Seawolf Mound, including a brief description of the formation of the mound and previous monitoring surveys, is provided below.

1.1 Overview of the DAMOS Program

For 35 years, the DAMOS Program has conducted monitoring surveys at aquatic disposal sites throughout New England and evaluated the patterns of physical, chemical, and biological responses of seafloor environments to dredged material disposal activity. The DAMOS Program features a tiered disposal site management protocol designed to ensure that any potential adverse environmental impacts associated with dredged material disposal are promptly identified and addressed (Fredette and French 2004; Germano et al. 1994).

DAMOS monitoring surveys fall into two general categories, confirmatory and focused. Confirmatory studies are designed to test hypotheses related to expected physical and ecological response patterns following placement of dredged material on the seafloor at established, active disposal sites. These surveys typically involve collection of both bathymetry data to characterize the height and spread of discrete dredged material deposits or mounds and sediment-profile imaging (SPI) data to support evaluation of seafloor (benthic) habitat conditions and recovery over time. The data collected during these studies provide confirmation of correct placement of material and confirmation of the recovery of the benthic community following cessation of disposal at active sites and provide input for the longer term management of individual sites.

Focused studies are periodically undertaken within the DAMOS Program to evaluate inactive/historic disposal sites as well as to contribute to the development of dredged material placement, capping, and monitoring techniques. Focused studies may consist solely of records and literature review, involve comparison of analytical techniques, or include field surveys using sediment collection and other imaging and geophysical measurements in addition to standard confirmatory tools. The 2010 Seawolf investigation was a focused study involving the collection of sediment cores and

comparison of analytical techniques that was designed to further investigate the results of previous studies conducted over an inactive mound.

1.2 Seawolf Mound Background

The Seawolf Mound is a historical, capped disposal mound located in the northwest quadrant of the New London Disposal Site (NLDS) (Figures 1-1 and 1-2). NLDS is an active, open-water dredged material disposal site located 5.4 km (3.1 nmi) south of Eastern Point, Groton, Connecticut (Figure 1-1). While dredging and disposal activities in the New England Region have been overseen by the DAMOS Program since its inception in 1977, disposal has taken place in the vicinity of the New London site since 1955 (SAIC 2001a).

The Seawolf Mound was created during the 1995/96 disposal season from the U.S. Navy dredging of the Thames River to accommodate Seawolf class submarines at the Naval Submarine Base in Groton, CT. This project, along with a small-scale (800 m^3 [1,000 yd3]) Mystic River, CT dredging project, resulted in the placement of approximately 306,000 m^3 (400,000 yd3) of material deemed unsuitable for unconfined open water disposal (unsuitable dredged material [UDM]). Later in the 1995/96 disposal season, the UDM was covered by 556,000 m^3 (727,000 yd3) of coarser grained material from the Thames River channel determined to be suitable for unconfined open water disposal (capping dredged material [CDM]) (SAIC 2001a). An additional 15,500 m^3 (20,300 yd3) of sediment suitable for open water disposal from Venetian Harbor, CT and the Mystic River was placed near the edge of the Seawolf Mound in 1995/96, resulting in a total estimated volume of 877,500 m^3 (1,148,000 yd3) of sediment (UDM plus CDM) deposited at the Seawolf Mound in the 1995/96 period (SAIC 2001a).

1.3 Previous Surveys

Given the proximity of Naval Submarine Base New London, located near the mouth of the Thames River, to NLDS the U.S. Navy initiated a comprehensive study of the site in 1973 (SAIC 2001a). With the formal initiation of DAMOS in 1977, the program assumed monitoring responsibility at NLDS as well as at three other active disposal sites in Long Island Sound (Fredette et al. 1993).

Pre-dredging characterization of sediments from the 1995/96 Naval Submarine Base project revealed elevated levels of polycyclic aromatic hydrocarbons (PAHs) and trace metals (Cu, Cr, and Zn), with subsequent biological testing of these contaminated sediments resulting in the UDM classification. As a result, the dredging permit required

that the UDM placed at NLDS be capped with CDM and that a comprehensive disposal site monitoring program be undertaken to ensure adequate capping coverage to isolate the UDM from the environment.

Since formation of the Seawolf Mound during the 1995/96 disposal season, several types of surveys have been conducted at the site to meet the monitoring requirements specified in the original dredging permit for the project (Table 1-1). In addition to bathymetric surveys conducted prior to and during mound formation, bathymetric surveys were conducted at several post-disposal intervals and following passage of an intense coastal storm in October 2002. These surveys documented changes in bottom topography following dredged material placement, post-placement consolidation, and storm events. The results of these surveys demonstrated the continued physical stability of the mound with no evidence of large-scale topographic changes that would indicate continued consolidation, scour, or other disturbance (SAIC 2003, SAIC 2004, AECOM 2011).

Benthic recolonization of the Seawolf Mound was investigated as part of the monitoring program primarily through several SPI surveys which allowed for comparison of mound conditions to three reference areas surrounding NLDS. Results from these surveys were consistent with models of infaunal succession following seafloor disturbance in Long Island Sound with advanced benthic communities present in the five-year post-disposal monitoring survey (SAIC 2004) and overall conditions on the mound mirroring conditions at the reference areas in the ten-year post-disposal monitoring survey (AECOM 2011).

Sediment cores have been collected several times since mound formation to assess the physical and chemical composition of the deposited sediments and to confirm the thickness and integrity of the CDM layer. Surveys conducted in 1997, 1998, and 2001 documented a 1–2 m (3–7 ft) thick layer of CDM over most of the Seawolf Mound footprint (SAIC 2001a, SAIC 2004). Metals and PAH concentrations in short cores (0.5 m [1.6 ft]) from these surveys were consistent with pre-dredge analysis of the capping material with no evidence of incomplete coverage or migration of contaminants from the UDM below (SAIC 2004).

The ten-year post-project coring survey of the mound in 2006 found physical and some chemical sediment characteristics that were consistent with previous findings of a consistent layer of CDM over the surface of the Seawolf Mound with UDM sequestered beneath the CDM (AECOM 2011). Metals concentrations in the 2006 cores were generally consistent with both the pre-mound CDM and UDM characterization data

(Maguire Group, Inc. 1995) as well as the post-mound monitoring data collected in 1997 (SAIC 2001a), 1998 (SAIC 2001b), and 2001 (SAIC 2004).

In contrast, concentrations of PAHs measured in the upper segment of the 2006 sediment cores were consistently higher than those measured in previous surveys of the mound (AECOM 2011). Given the overall physical stability of the mound noted in 2006 along with the consistent metals concentrations, the higher PAH concentrations in the 2006 cores were attributed to two potential causes: 1) The variability that existed in the pre-dredge CDM sediment (Maguire Group, Inc. 1995, AECOM 2011) could translate to heterogeneity at the disposal site at the scale of an individual dredge bucket of material (meter scale). Mechanical dredging and scow disposal does not homogenize the dredged material; rather, it can preserve discreet blocks of sediment with the scale of the heterogeneity dependant on characteristics of the CDM deposit and the sequencing in the dredging and loading of the scow (Fredette et al. 1992). Evidence of this small-scale heterogeneity was supported by variation in PAH concentrations detected between duplicate cores collected in 2006 (AECOM 2011). 2) The higher PAH concentrations could also be related to different analytical approaches among the multiple surveys. A review of historical laboratory reports indicated that the instrumental analysis by Method 8270C by GC/MS-SIM for PAHs was the same for all surveys. However, variations in the amount of sediment removed from a sample for actual analysis (termed the sub-sample mass) and variations in the preparatory methodologies (how the PAHs are extracted from the solid matrix) may have contributed to the higher and more variable PAH concentrations observed in 2006.

1.4 Study Objectives

The presence of somewhat elevated and variable PAH concentrations in 2006 compared to previous surveys led to the recommendation for this follow-up investigation to compare the 2001 and 2006 analytical approaches and to further characterize the physical and chemical variability in the cap layer across the Seawolf Mound. Specifically, the objectives of the survey were to:

1) Use Seawolf Mound sediment samples to compare the PAH analytical approaches used in 2001 and 2006, and;

2) Collect and analyze cap layer sediment samples to further assess variability in PAH concentrations across the Seawolf Mound.

Table 1-1.

Overview of Previous Investigations at the Seawolf Mound since Project Completion in 1996

Date	Purpose of Survey	Bathymetry Area (mxm)	Number of SPI Stations	Number of Sediment Cores	Number of Benthic Grabs	Other Studies	Reference
Sept. 1997	1.5 yr post-cap monitoring	1000 x 1000	Site: 29 Ref: 13	Site: 12 Ref: 1	Site: 6		SAIC 2001a
July 1998	2.5 yr post-cap monitoring	1000 x 1000	Site: 29 Ref: 13	Site: 12 Ref: 1			SAIC 2001a
August 2000	Periodic monitoring	1000 x 1000	Site: 29 Ref: 13				SAIC 2001b
June 2001	5 yr post-cap monitoring		Site: 29 Ref: 13	Site: 12 Ref: 1	Site: 6		SAIC 2004
October 2002	Post-storm monitoring	1000 x 1000	Site: 29 Ref: 13			Side-scan	SAIC 2003
February 2003	Post-storm monitoring	1000 x 1000					SAIC 2003
June/July 2006	10 yr post-cap monitoring	1000 x 1000	Site: 13 Ref: 13	Site: 12 Ref: 1	Site: 6 Ref: 3		AECOM 2011

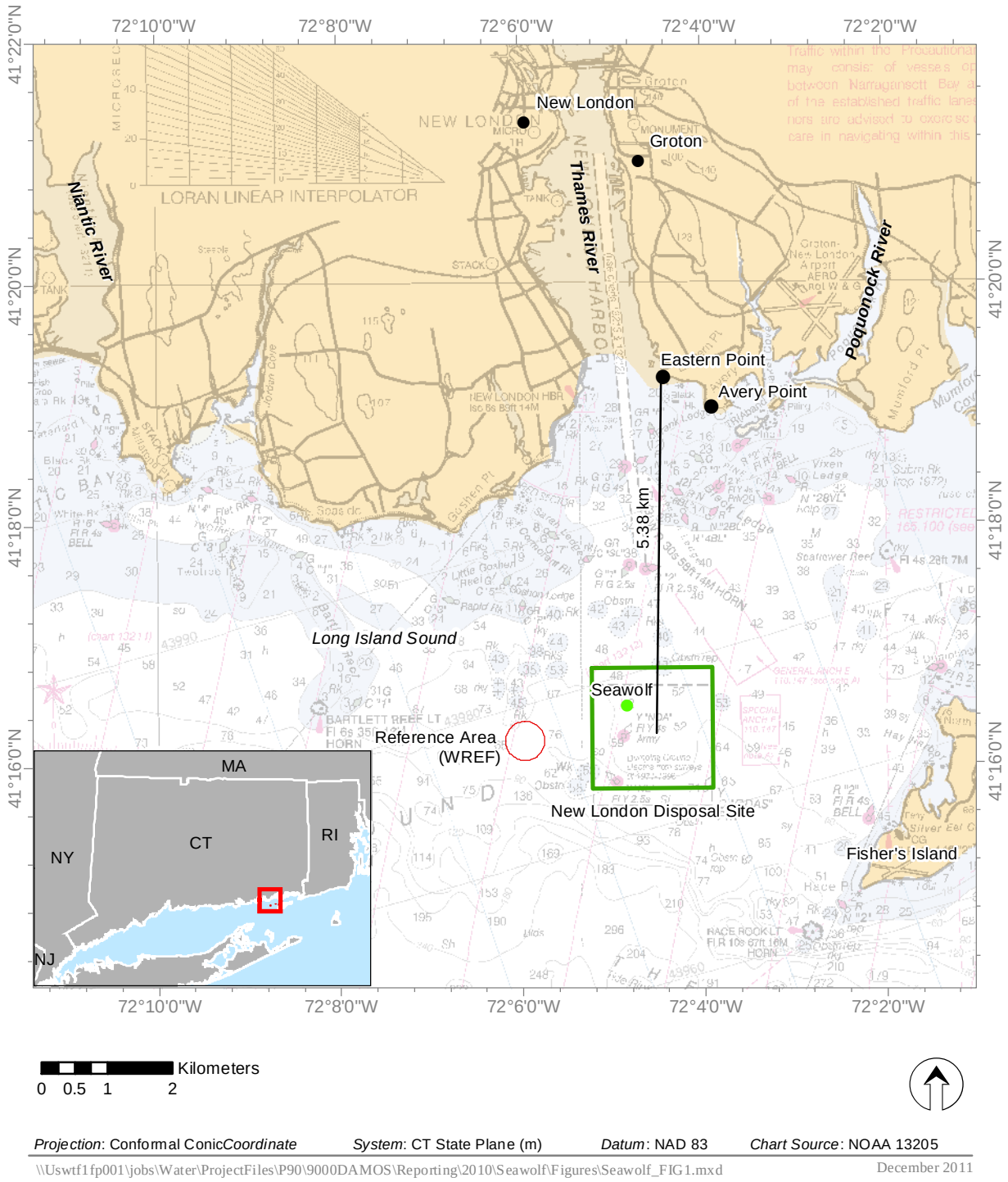

Figure 1-1. Location of the Seawolf Disposal Mound, within the New London Disposal Site, located in the eastern portion of Long Island Sound

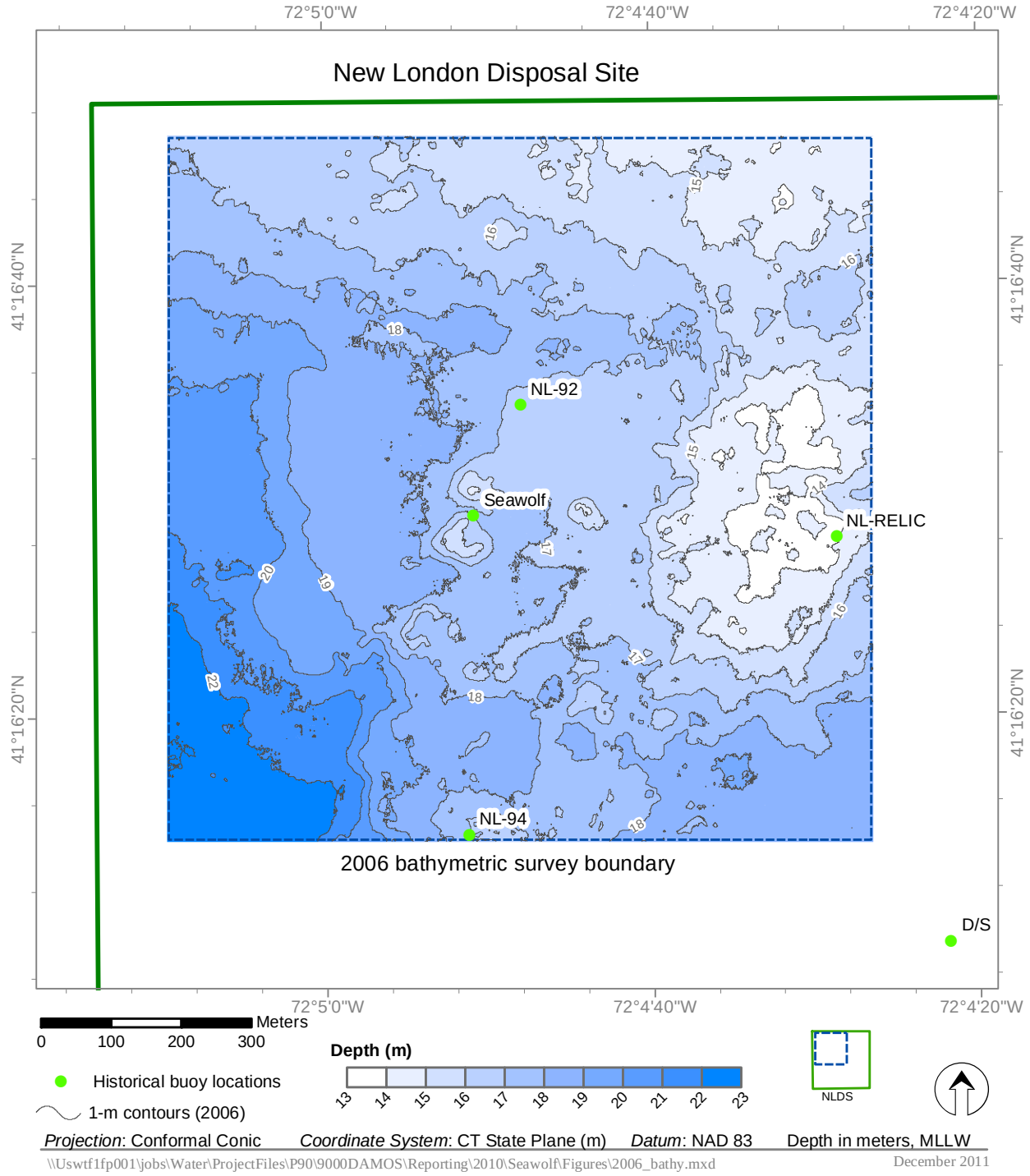

Figure 1-2. Bathymetry of Seawolf Mound and surrounding portion of NLDS, 2006

2.0 METHODS

The September 2010 survey conducted at the Seawolf Mound was performed by AECOM, Ocean Surveys Inc. (OSI), CoastalVision, and a team of laboratories. The sediment coring survey was conducted 13–14 September, cores were sub-sampled and analyzed for physical characteristics 15–16 September, and additional physical and chemical analysis of the cores was performed the following year.

A description of field activities and an overview of the methods used to collect, process, and analyze the survey data are provided below. The details of the approach and methods used to collect the data are presented in the project Sampling and Analysis Plan/ Quality Assurance Project Plan (QAPP, Appendix A).

2.1 Navigation and On-Board Data Acquisition

Positional data, comprised of horizontal positioning (x and y dimensional data) and time (t dimensional data), were obtained using a Trimble Differential Global Positioning System (DGPS). The GPS receiver installed on the survey vessel was interfaced to the onboard navigation computer running HYPACK® software providing the field team with the ability to precisely navigate the vessel throughout the survey area and to the target stations for the coring survey. HYPACK® hydrographic survey software, developed by HYPACK, Inc. was used to acquire, integrate, and store all positional data from the DGPS.

2.2 Sediment Coring

The approach used to collect the sediment cores was detailed in a project Sampling and Analysis Plan/QAPP (Appendix A) originally written to support the 2006 Seawolf Mound surveys. Coring stations for the 2010 survey were selected to support a methods comparison study and to increase understanding of past results. Cores were collected using vibracoring equipment and were subsequently split, imaged, and subsampled at the Marine Geomechanics Lab at the University of Rhode Island (URI). Sediment samples were collected from the cores and prepared for future analysis. Analyses included total organic carbon (TOC) content determined by Alpha Analytical Laboratories; grain size performed by Geo/Plan Associates; and PAH concentrations determined by Battelle.

2.2.1 Core Collection

A total of 16 vibracores were collected over the Seawolf Mound and reference area between 13 and 14 September 2010. Field operations were conducted from the 11 m pontoon coring barge, R/V Candu, (operated by OSI) which was equipped with a Trimble DGPS, a multipoint anchoring system, and central moon pool for accurate positioning of each core (within 10 m of target coordinates).

The 16 vibracore samples were collected from nine stations located across the Seawolf Mound and one reference station. The mound samples were distributed among three zones at various distances from the central position of the mound (inner zone [0 to 200 m radius], middle zone [200 to 400 m radius], and outer zone [400 to 600 m radius]) (Figure 2-1). Six stations (including one with three co-located cores) were sampled in the inner zone, two stations were sampled in the middle zone, and one station (with three co-located cores) was sampled in the outer zone. Three additional co-located cores were collected at a station in a designated NLDS reference area (WEST-REF). All 2010 cores were co-located with stations that were previously sampled during the 1997, 1998, 2001, or 2006 mound surveys.

Vibracoring was performed at the selected stations using a VC 1500 pneumatic coring unit outfitted with a 10 cm inner diameter (ID), 1.5 m long steel barrel and stainless steel cutter head with a new, clear Lexan liner (8.9 cm ID) per sample. The goal of the coring survey was to recover the top 50 cm of sediment, which was assumed to represent the overlying cap material. If the recovered sediments within the core liner were observed to be consistent material throughout (i.e., no significant changes in stratigraphy), then the top 76 cm of the core was retained to provide additional logging data, and the remaining material was disposed overboard at the site. Samples with substantial variation in stratigraphy were retained as whole cores. After collection, each core was secured vertically, and the excess liner was removed using a clean saw blade to cut the tube within 1 cm of the sediment surface, and the water overlying the sediment was siphoned off the top. Each core was capped, sealed with tape, labeled, logged, and secured in an upright position in the on-board ice locker.

Following the completion of the field effort, the 16 cores were transported on ice to the Marine Geomechanics Laboratory at URI and stored upright in a walk-in refrigerator.

2.2.2 Core Processing

Core splitting, imaging, and sub-sampling were performed at the Marine Geomechanics Lab at URI. Prior to splitting, any void existing above the sediment-water interface was filled with a high density, low permeability foam material to maintain the original condition of the core and prevent sediment/water migration or the loss of fluidized surficial sediments when the cores were positioned horizontally during the splitting process. In addition, an index tape (labeled along graduated intervals) was affixed to each core tube to maintain the comparable orientation between the two halves of the core subsequent to 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 from top to bottom, using a set of laterally adjustable routers, maneuvered along the length of the core by an electric motor and wire/pulley system. To avoid disturbing the sediments, the depth of the two routers was carefully adjusted to obtain the maximum depth of cut without fully penetrating the core liner. Once the router cut was complete, the intact core was relocated to a cutting table where a straight bladed razor knife was used to manually finish cutting the residual thickness of liner material along the router cut.

With the two halves of the liner manually held together, a titanium wire was drawn from top to bottom of each sediment sample, along the gap opening in the liner, to split the sample into two individual halves. One half was immediately wrapped in clear cellophane and transferred to the URI imaging laboratory for high-resolution filming and physical characterization. The remaining half of the core was photographed and examined to evaluate surface texture, odor, color, and changes in stratigraphy as documented on individual log forms (Appendix B).

Sediment from the top 50 cm of each core was sampled, except for sample NLDS-42-3B which consisted of material from 50 cm to the end of the core. All samples were manually homogenized using a stainless steel spoon and a stainless steel bowl for five minutes to form a single composite sample. The sample was then transferred to labeled jars for chemical analysis and grain size determinations. Details of sample handling and containerization are provided in the project QAPP (Appendix A).

2.2.3 Core Imaging

Core imaging was performed by URI staff using a GeoTek Multi-Sensor Core Logging System. A digital photograph was first acquired followed by measurement of physical properties in a subsequent scan. The exposed sediment surface was cleaned and manually smoothed to provide a fresh, unaltered sediment surface for high resolution imaging. Core images along with associated sediment properties are provided in Appendix C.

2.2.4 Core Analysis

Ten stations were sampled during the 2010 survey of the Seawolf Mound (Table 2-1), and the resulting 16 cores were analyzed for the full suite of parameters (TOC, grain size, and PAHs).

TOC and Grain Size Analysis

Samples for TOC and PAH analysis were preserved on ice and delivered to Alpha Analytical for archiving, TOC analysis, and shipment to Battelle for subsequent PAH analysis. Sediment samples for grain size determination were transferred to Geo/Plan Associates for archiving and analysis. TOC samples were analyzed in accordance with the Lloyd Kahn Method (USEPA 1988), and grain size was determined following ASTM D422.

PAH Analysis

An analytical approach recommendation memorandum was prepared detailing the number of recommended splits and specifics of laboratory PAH preparation/extraction and analytical methods to be assessed as well as the recommended samples for assessment of spatial variability based on the visual and physical characterization (Appendix D). Individual PAH analytes were selected based on the United States Environmental Protection Agency's (USEPA) 16 priority pollutant compounds; of these PAHS, six are low molecular weight (LMW) and ten are high molecular weight (HMW) compounds. PAH data were subsequently evaluated as groups (total, LMW, or HMW) because the differing structures exhibit differing toxicity characteristics.

The PAH analysis was performed in 2 phases to assess three extraction method efficiencies (Phase 1) and to further assess variability in PAH concentrations across the Seawolf Mound using a single extraction technique (Phase 2). Prior to extraction each

sample was homogenized a second time using a blender to diminish any settling that may have occurred during sample transport or storage; PAH subsamples were then removed simultaneously for analysis. Phase 1 consisted of the analysis of sediment collected from two stations (NLDS-42 and NLDS-48, each consisting of three co-located cores) plus quality control (QC) samples to assess three PAH extraction methods. Following an initial review of the extraction method comparison results, the remaining samples from the site were analyzed using a single PAH extraction method (Phase 2). Table 2-2 details the station numbers, QC samples, and relevant analytical methods for both phases of PAH analysis.

The PAH method comparison study (Phase 1) was performed with two EPA extraction methods used on previous Seawolf Mound monitoring studies (microscale extraction [MSE, SW-846 Method 3570] and pressurized fluid extraction [PFE, SW-846 Method 3545 using a 33 mL ASE cell]) as well as a third method not previously used for Seawolf samples (Soxhlet extraction [Method 3540]). The microscale extraction method uses the smallest sample amount of the three techniques (2–2.5 g of wet sediment) and minimizes solvent usage, pressurized fluid extraction uses a larger sample (6-8 g) and proceeds at elevated temperatures and pressures in an attempt to achieve higher analyte recoveries or better extraction efficiencies, while Soxhlet extraction uses the largest sample size of the three techniques (10-15 g) and consequently requires the largest solvent volumes. All PAH extracts were subsequently analyzed using GC/MS SIM (SW-846 Method 8270C). Additional method details are provided in Appendix A.

Following a review of Phase 1 data it was determined that the Soxhlet extraction method rendered the most acceptable QC results and was therefore selected as the most efficient extraction method for Phase 2 analyses. Phase 2 involved analysis of the remaining samples including analysis of the other triplicate core station (NLDS-52) to better characterize concentrations and small-scale spatial variability within the cap layer of the Seawolf Mound.

In addition, homogenized samples from three stations were sub-sampled and analyzed in triplicate to investigate potential variability introduced from the small sample mass used for the PAH extraction techniques (Soxhlet: 10–15 g, PFE: 6–8 g, MSE: 2–2.5 g). Triplicate sub-sampling and analysis via a single method (Soxhlet) was performed on two stations in the inner zone that represented the higher and lower ranges of total PAH concentrations (NLDS-46 and NLDS-47) along with one sample from below the surficial segment of an outer zone core that represented near background concentrations (NLDS-42 3B) (Table 2-1).

Quality Control

The Seawolf samples were collected in 2010, frozen for long-term storage, and then analyzed in 2011 to accommodate the DAMOS Program's budget schedule. While freezing samples is often accepted for long-term PAH sample storage, the standard protocol for PAH sample extraction is based on unfrozen samples and specifies a 14-day holding time from the sample collection date. For this reason, PAH analytical results were "T" qualified by the laboratory to convey that sample processing occurred outside of the 14-day period.

Each batch of sediment samples analyzed for PAHs and TOC were prepared with a routine set of QC samples. For the PAH analysis, standard QC included a method blank (MB) and a laboratory control sample (LCS). Additional QC was added to the Phase 1 method comparison study including one certified reference material (CRM [SRM 1944]) and one matrix spike (MS) sample with each sediment sample per extraction method, as indicated on Table 2-2. A matrix spike duplicate sample was not included for budgetary reasons, but a laboratory control sample duplicate was analyzed to assess precision. For TOC, all samples were analyzed in duplicate per the method requirements and QC samples included one MB and a LCS. Grain size samples did not require additional QC for this study.

Table 2-1.

Seawolf Sediment Core Target Sampling Locations

Station	Latitude (N)	Longitude (W)
Seawolf Mound as Part of NLDS		
11A	41° 16.435'	72° 04.802'
20A	41° 16.604'	72° 04.925'
24A	41° 16.488'	72° 04.786'
NLDS-42	41° 16.455'	72° 05.161'
NLDS-46	41° 16.549'	72° 04.822'
NLDS-47	41° 16.519'	72° 04.742'
NLDS-48	41° 16.461'	72° 04.771'
NLDS-50	41° 16.425'	72° 04.969'
NLDS-51	41° 16.464'	72° 04.874'
Reference Area		
NLDS-52	41° 16.206'	72° 05.970'

Notes: Coordinate system NAD83

Table 2-2.

PAH Sample Analysis Approach

	PAH Phase 1			Phase 2
Method	3540[1]	3545[1]	3570[1]	3540[1]
Station IDs	-	-	-	11A
	-	-	-	24A
	-	-	-	NLDS-46
	-	-	-	NLDS-47
	-	-	-	NLDS-50
	-	-	-	NLDS-51
	-	-	-	20A
	NLDS-42-1	NLDS-42-1	NLDS-42-1	-
	NLDS-42-2	NLDS-42-2	NLDS-42-2	-
	NLDS-42-3A	NLDS-42-3A	NLDS-42-3A	-
	NLDS-48-1	NLDS-48-1	NLDS-48-1	-
	NLDS-48-2	NLDS-48-2	NLDS-48-2	-
	NLDS-48-3	NLDS-48-3	NLDS-48-3	-
	-	-	-	NLDS-52-1
	-	-	-	NLDS-52-2
	-	-	-	NLDS-52-3
QC Samples	MB	MB	MB	MB
	MS-1	MS-2	MS-3	LCS
	CRM-1	CRM-2	CRM-3	LCSD

[1]Full Method Reference: EPA SW-846 Method 3540/3545/3570
MB: Method Blank
MS: Matrix Spike (in addition to LCS)
LCS: Laboratory Control Sample
CRM: Certified Reference Material

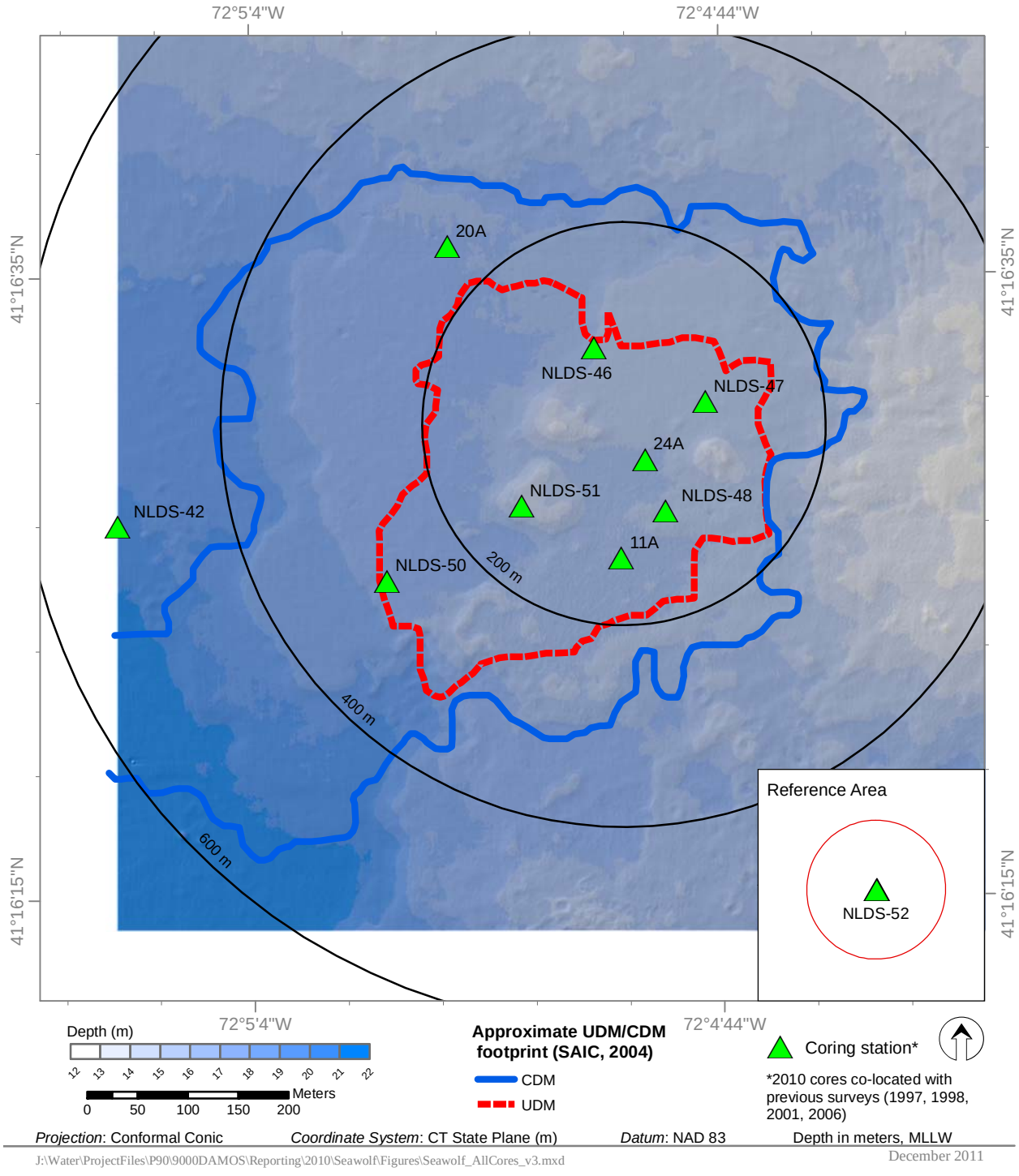

Figure 2-1. Sediment coring locations

3.0 RESULTS

A total of 16 sediment cores were collected from the Seawolf Mound on 13–14 September 2010, and samples were subsequently analyzed for physical and chemical properties including grain size, TOC, and PAHs. The results from these analyses are presented in the following sections with additional datasets compiled in Appendices B, C, and D.

3.1 Grain Size and Total Organic Carbon on the Seawolf Mound

Based on the surface (0.5 m) sample set collected in 2010, the Seawolf Mound cap is dominated by fine-grained sediments with a patchy distribution of coarser material (Figure 3-1). The inner zone samples were typically 55–90% fine-grained (silt and clay) material with moderate TOC (1.2–2.1%, Table 3-1). However, station NLDS-51 in the inner zone was less than 20% fine-grained material. The middle zone was sampled at two locations in 2010 (20A and NLDS-50) and both stations were more than 80% fine-grained material with moderate TOC (1.5–1.9%). The outer zone, represented by a single station in the 2010 survey (NLDS-42), was less than 20% fine-grained material with low TOC (<0.5%).

3.2 PAH Method Study

Mean total PAH concentrations varied by over a factor of three for station NLDS-48 and nearly a factor of three for station NLDS-42 for the three extraction methodologies (Table 3-2). Surrogate standard recovery results were highest when samples were processed using the Soxhlet extraction method and exceeded 80% for all analytes. Recoveries were lower when using the PFE extraction method (57–85%) and only 20–21% when the MSE extraction method was employed (Table 3-2). The Soxhlet method also rendered the most accurate CRM, LCS, and MS results with recoveries between 73% and 100%. The PFE QC sample results were less accurate (42–73%), and the MSE method again rendered the least accurate QC sample results (1–32%). The QC sample results include the 16 target PAHs and surrogate recoveries in the MB, LCS, and MS QC samples. Summary statistics from the method comparison study are provided in Table 3-2, and additional QC information is listed in Table 3-3.

Based on the QC results of the method comparison study, the Soxhlet method was selected to analyze PAH concentrations in the remaining sediment samples. Data presented in the following results sections, and the subsequent discussion on Seawolf Mound PAH concentrations, refer to results from the Soxhlet extraction method only.

3.3 Composite-Scale Variability or Heterogeneity

To evaluate possible variability introduced by the small mass needed for the three PAH extraction methods, single homogenized samples from three separate stations were sub-sampled in triplicate and analyzed for PAH concentrations via Soxhlet extraction. Results from station NLDS-47 were consistent with a Total PAH relative standard deviation of only 9.4% between the triplicates (Table 3-4). Sub-samples from stations NLDS-42 B and NLDS-46 were less consistent resulting in relative standard deviations of 166% and 109% respectively (Table 3-4).

3.4 Localized Spatial Variability

Triplicate co-located cores were collected at three stations during the 2010 Seawolf survey to document small-scale PAH variability in surface sediments. Each of the triplicate cores was collected within 10 m of the target station location. Total PAH results from the co-located cores collected from the reference area (NLDS-52) varied by almost a factor of two with concentrations ranging from 183 to 343 ng/g (Figure 3-2). Total PAH concentrations from the outer zone station NLDS-42 were more consistent (902–1239 ng/g), but results from co-located cores from the inner zone station NLDS-48 varied by almost a factor of three and ranged from 1132 to 2807 ng/g.

3.5 PAH Concentrations on the Seawolf Mound

Total PAH concentrations across the Seawolf Mound stations ranged from 846 to 3960 ng/g in the upper 0.5 m of sediment (Table 3-5). There was no specific pattern of PAH distribution in relation to station location although there was limited sampling in the middle and outer zones of the mound (Figure 3-2). Total PAH concentrations in the reference area (NLDS-52) were lower than mound stations (Table 3-5).

Table 3-1.

Seawolf Mound Grain Size and TOC Results (dry units)

Site	Station	% Fines[1]	% TOC[2]
Seawolf Mound	11A	76	1.8
	20A	81	1.5
	24A	85	1.9
	NLDS-42-1	19	0.4
	NLDS-42-2	17	0.5
	NLDS-42-3	16	0.5
	NLDS-46	90	1.8
	NLDS-47	68	1.8
	NLDS-48-1	55	1.6
	NLDS-48-2	72	2.1
	NLDS-48-3	64	1.8
	NLDS-50	84	1.9
	NLDS-51	19	1.5
WEST REF	NLDS-52-1	14	0.3
	NLDS-52-2	14	0.3
	NLDS-52-3	14	0.3

[1] % Fines calculated as sum of % clay and % silt
[2] % TOC represents the mean of 2 replicates

Table 3-2.

PAH Method Comparison Study Summary Results

		Station NLDS-42 PAH Sum			Station NLDS-48 PAH Sum			*Method*
	Units	Mean[1]	SD[2]	RSD[3]	Mean	SD	RSD	*Blank*
Field Samples								
Soxhlet[4]	ng/g	1057	170	16%	1770	906	51%	*3.3*
PFE[5]	ng/g	980	746	76%	1842	774	42%	*5.3*
MSE[6]	ng/g	2687	3704	138%	479	121	25%	*3.6*
		QC Sample - Rec%[7]			QC Sample - SD			
QC Accuracy		CRM[8]	LCS[9]	MS[10]	CRM	LCS	MS	
Soxhlet	% Rec	99	88	110	10	8	19	-
PFE	% Rec	92	74	57	11	10	13	-
MSE	% Rec	107	*17*	*27*	11	8	3	-

[1]Mean represents the average value for the 3 co-located cores associated with the station
[2]SD: Standard Deviation; SD associated with individual compound recovery
[3]RSD: Relative Standard Deviation
[4]Soxhlet: Soxhlet Extraction Method (EPA Method 3540)
[5]PFE: Pressurized Fluid Extraction Method (EPA Method 3545 - 33 mL cell)
[6]MSE: Microscale Extraction Method (EPA Method 3570)
[7]Rec%: Recovery Percent; Value represents mean of individual compounds
[8]CRM: Certified Reference Material
[9]LCS: Laboratory Control Sample
[10]MS: Matrix Spike

Table 3-3.

PAH Method Surrogate Standard Recovery Values (% Recovery)

Station (NLDS-)	42-1	42-2	42-3A	48-1	48-2	48-3
Soxhlet[1]						
Naphthalene-d8	72	75	73	82	80	80
Acenaphthene-d10	80	83	79	93	90	88
Phenanthrene-d10	79	83	80	92	88	88
Benzo(a)pyrene-d12	91	92	90	102	98	97
PFE[2]						
Naphthalene-d8	51	51	61	56	57	54
Acenaphthene-d10	58	62	71	70	72	65
Phenanthrene-d10	60	64	75	75	76	71
Benzo(a)pyrene-d12	68	73	83	84	85	77
MSE[3]						
Naphthalene-d8	52	38	56	21	21	37
Acenaphthene-d10	53	39	58	20	21	37
Phenanthrene-d10	50	38	56	20	20	35
Benzo(a)pyrene-d12	55	38	57	20	20	35

		CRM[4] SIS			LCS[5] SIS	
SIS Accuracy	**Soxhlet**	**PFE**	**MSE**	**Soxhlet**	**PFE**	**MSE**
Naphthalene-d8	77	64	30	73	68	1
Acenaphthene-d10	86	70	32	73	72	5
Phenanthrene-d10	82	69	31	78	73	13
Benzo(a)pyrene-d12	89	67	32	82	42	13

		Sample SIS[6]			MS[7] SIS	
	Soxhlet	**PFE**	**MSE**	**Soxhlet**	**PFE**	**MSE**
Naphthalene-d8	80	57	21	83	54	22
Acenaphthene-d10	90	72	21	92	60	22
Phenanthrene-d10	88	76	20	90	61	21
Benzo(a)pyrene-d12	98	85	20	100	71	23

[1]Soxhlet: Soxhlet Extraction Method (EPA Method 3540);
[2]PFE: Pressurized Fluid Extraction Method (EPA Method 3545 - 33 mL cell);
[3]MSE: Microscale Extraction Method (EPA Method 3570); [4]CRM: Certified Reference Material;
[5]LCS: Laboratory Control Sample; [6]Sample SIS: Unspiked sample used for Matrix Spike; [7]MS: Matrix Spike

Table 3-4.

PAH Triplicate Analysis of Single Samples

Station	PAH Concentration (ng/g dry weight) NLDS-42-3B			NLDS-46			NLDS-47		
	Initial	Duplicate	Triplicate	Initial	Duplicate	Triplicate	Initial	Duplicate	Triplicate
Naphthalene	0.25 (J)	0.46 (J)	0.34 (J)	23.9	8.84	19.0	26.0	21.3	29.3
Acenaphthylene	0.12 (J)	4.82	0.08 (J)	14.3	12.7	180	28.7	38.9	32.5
Acenaphthene	0.42 (J)	1.34 (J)	0.5 (J)	8.47	6.64	6.84	5.84	6.76	7.14
Fluorene	0.24 (J)	1.42 (J)	0.24 (J)	55.3	8.49	7.69	10.6	13.3	13.0
Anthracene	0.08 (J)	5.88	0.16 (J)	16.7	15.0	96.8	35.4	43.7	42.3
Phenanthrene	2.03 (B)	19.7	1.75 (J)	112	43.8	47.0	69.2	88.1	75.0
Fluoranthene	1.43 (J)	20.2	1.36 (J)	66.5	78.4	506	141	166	146
Pyrene	1.24 (J)	25.9	1.58 (J)	80.9	91.1	649	212	239	219
Benzo(a)anthracene	0.22 (J)	21.9	0.25 (J)	39.9	34.4	538	95.8	129	106
Chrysene	0.28 (J)	16.3	0.43 (J)	52.4	43.2	464	106	137	111
Benzo(b)fluoranthene	0.27 (J)	10	0.36 (J)	45.0	47.4	294	116	138	132
Benzo(k)fluoranthene	0.2 (J)	12.7	0.25 (J)	43.1	46.5	288	108	131	113
Benzo(a)pyrene	0.17 (J)	19.1	0.26 (J)	46.3	43.2	385	107	136	117
Indeno(1,2,3-cd)pyrene	0.21 (J)	9.54	0.26 (J)	38.8	41.4	234	98.9	114	108
Dibenz(a,h)anthracene	0.11 (U)	2.11	0.11 (U)	7.78	7.74	60.3	21.1	23.7	23.0
Benzo(g,h,i)perylene	0.2 (J)	8.54	0.24 (J)	37.6	34.6	184	85.3	96.0	91.0
Sum LMWPAH	3.14	33.6	3.1	231	95.4	357	176	212	199
Sum HMWPAH	4.3	146	5.10	458	468	3600	1090	1310	1170
Total PAH	7.5	180	8.2	689	563	3960	1270	1520	1360
Mean Total PAH (%RSD)		60 (166%)			1740 (109%)			1380 (9.4%)	

All samples were archived frozen and exceeded holding time established for unfrozen samples; NLDS-46 and NLDS-47 surficial samples, NLDS-42-3B from >50 cm deep
All results based on Soxhlet extraction method (Method 3540) of a single sample fully homogenized and sub sampled three times
B: Analyte concentration <5x the level found in the procedural blank, J: Analyte detected above method-detection limit and below the sample-specific reporting limit
U: Analyte not detected above method detection limit; MDL shown in table

Table 3-5.

Seawolf Mound PAH Results

	PAH Concentration (ng/g dry weight)															
Station (NL-)	**11A**	**20A**	**24A**	**42-1**	**42-2**	**42-3A**	**46**	**47**	**48-1**	**48-2**	**48-3**	**50**	**51**	**52-1**	**52-2**	**52-3**
Naphthalene	40.2	21.8	13.8	15.3	12.6	26.4	19.0	26.0	21.1	27.0	23.8	20.9	16.9	2.86	2.98	2.50 (B)
Acenaphthylene	49.8	27.0	19.1	33.1	23.5	27.0	180	28.7	20.1	32.3	26.0	27.0	19.5	6.68	3.73	4.94
Acenaphthene	10.4	10.9	4.60	2.30	3.17	3.32	6.84	5.84	53.2	7.22	8.08	5.50	5.04	0.74 (J)	0.14 (U)	0.14 (U)
Fluorene	18.3	14.8	7.66	9.78	5.40	5.22	7.69	10.6	50.1	13.1	12.9	9.73	9.60	1.66 (J)	1.27 (J)	1.23 (J)
Phenanthrene	109	77.4	48.0	47.0	60.7	39.2	47.0	69.2	327	71.9	76.3	57.1	52.1	14.9	8.69	8.34
Anthracene	61.3	36.3	25.6	166	31.1	36.3	96.8	35.4	93.8	43.6	49.0	32.2	29.5	8.77	3.74	3.77
Fluoranthene	195	140	97.4	115	99.4	104	506	141	509	148	124	112	129	38.1	19.5	16.3
Pyrene	351	178	132	172	145	139	649	212	430	240	237	191	187	53.9	21.6	21.6
Benzo(a)anthracene	177	86.2	66.0	103	65.8	102	538	95.8	238	101	74.9	96.7	80.8	30.0	13.0	13.0
Chrysene	179	88.4	67.4	118	73.8	95.6	464	106	191	114	95.9	97.2	88.6	30.1	13.2	13.6
Benzo(b)fluoranthene	210	103	77.9	84.5	70.8	82.8	294	116	197	112	84.2	112	100	28.7	19.4	20.2
Benzo(k)fluoranthene	180	86.5	70.6	97.2	75.6	93.6	288	108	197	120	85.3	98.3	82.3	31.6	18.9	18.7
Benzo(a)pyrene	205	89.8	75.2	116	90.1	111	385	107	205	129	86.1	108	83.5	33.9	17.0	19.4
Indeno(1,2,3-cd)pyrene	180	89.7	69.8	72.9	66.6	75.2	234	98.9	129	97.7	68.4	97.9	76.9	29.3	20.0	21.1
Dibenz(a,h)anthracene	37.5	17.4	13.0	17.9	15.1	20.1	60.3	21.1	34.6	23.3	16.3	19.7	16.5	5.61	3.4	3.82
Benzo(g,h,i)perylene	150	72.7	58.0	68.9	62.9	67.7	184	85.3	112	92.3	63.4	80.8	64.3	25.9	16.6	18.0
Sum LMWPAH	289	188	119	274	136	137	357	176	565	195	196	152	133	35.6	20.6	20.9
Sum HMWPAH	1860	952	728	965	765	892	3600	1090	2240	1180	936	1010	909	307	163	166
Total PAH	2150	1140	846	1240	902	1030	3960	1270	2810	1370	1130	1170	1040	343	183	187

All samples were archived frozen and exceeded holding time established for unfrozen samples; subsurface sample NL-42-3B not shown

All results based on Soxhlet extraction method (Method 3540)

B: Analyte concentration found in the sample at a concentration < 5x the level found in the procedural blank

J: Analyte detected above method-detection limit and below the sample-specific reporting limit

U: Analyte not detected above method detection limit; MDL shown in table

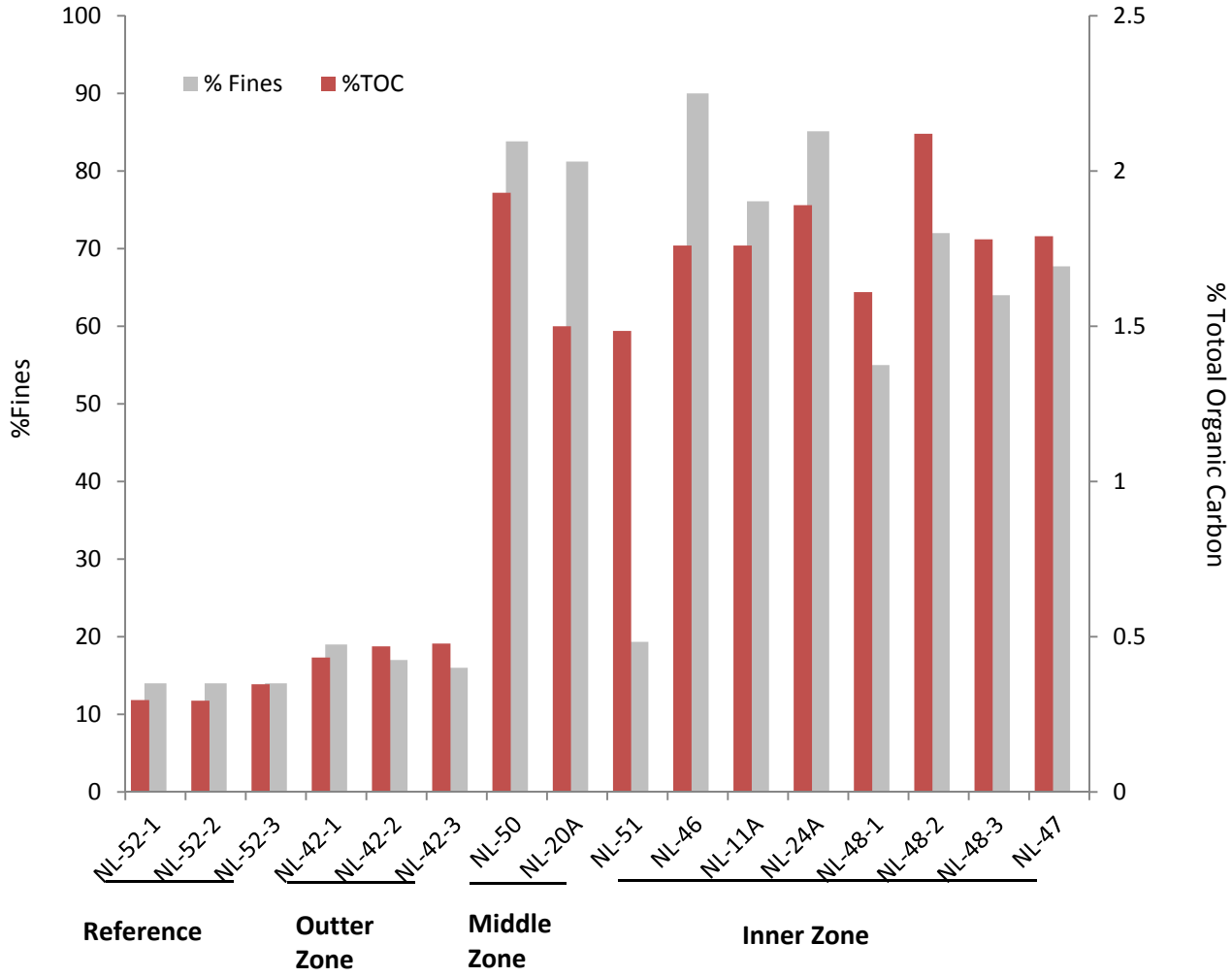

Figure 3-1. Distribution of grain size and TOC results on the Seawolf Mound, 2010

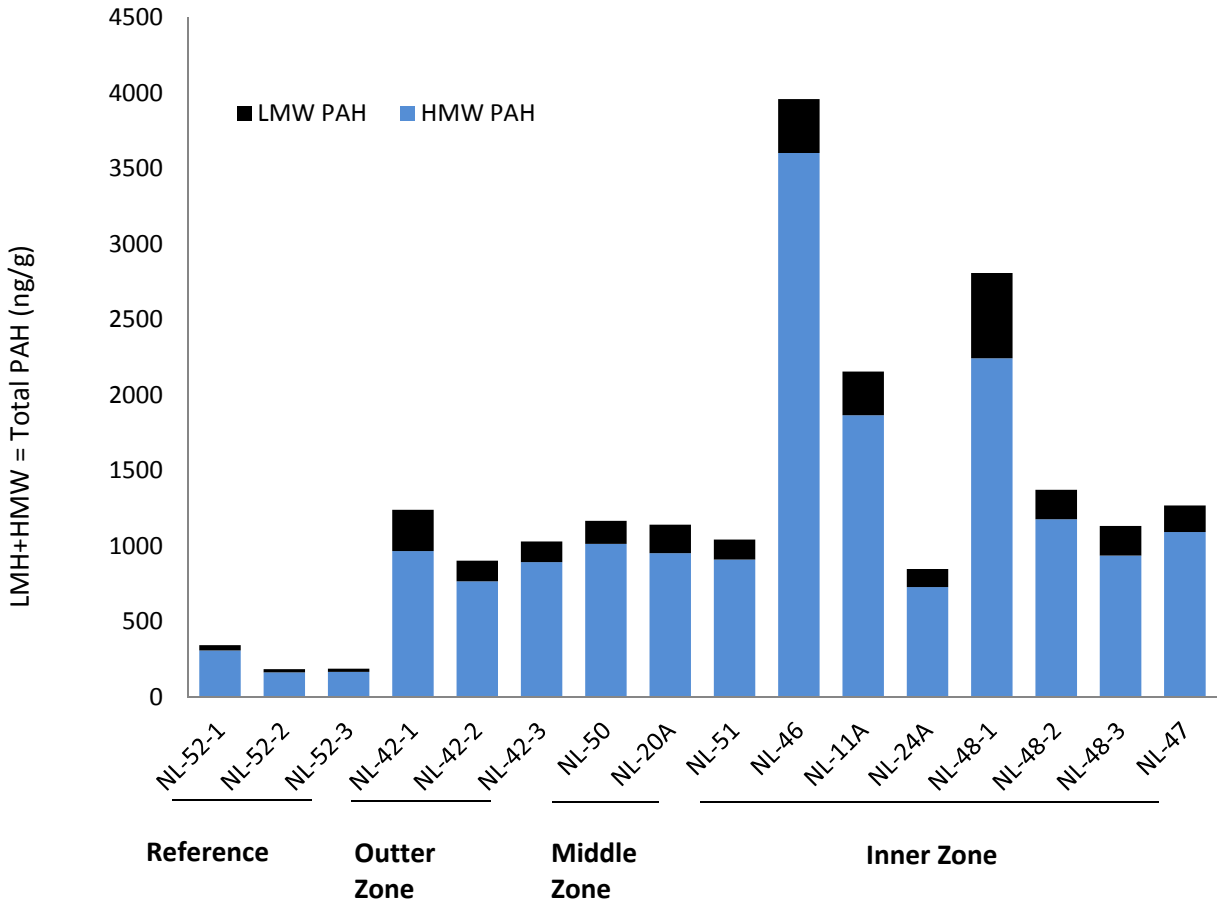

Figure 3-2. Distribution of PAH results on the Seawolf Mound, 2010

4.0 DISCUSSION

The Seawolf Mound, located in the northwest quadrant of the New London Disposal Site (NLDS) in Long Island Sound, covers an area measuring about 1,200 m in diameter. The unsuitable dredged material (UDM) placed at the site in 1995/96 was mainly deposited within a 400 m zone, with some material extending to the southwest an additional 200 m. The capping dredged material (CDM) placed on top of the UDM followed this same distribution and extended beyond the UDM placement boundaries, particularly to the west and southwest of the central mound area. For this reason, sediment investigations of the Seawolf Mound have focused on the central and western areas of the deposit (see Figure 2-1 for UDM/CDM boundaries and sediment coring locations).

Sediment cores were collected from these areas of the mound in 1997, 1998, 2001, and 2006 to characterize the physical and chemical composition of the cap layer and underlying UDM to ensure adequate coverage and integrity of the cap. The first three surveys documented a 1–2 m thick layer of CDM over the majority of the Seawolf footprint with metals and polycyclic aromatic hydrocarbon (PAH) concentrations consistent with pre-dredge characterization of the capping material (SAIC 2001a, SAIC 2004).

While measured metal concentrations from the 2006 sediment investigation of the Seawolf Mound confirmed previous findings of a thick layer of CDM, the PAH levels from this survey were measured at higher concentrations than previously measured in the inner and outer mound areas and were variable across the site (AECOM 2011). Although the PAH concentrations were not high enough to cause ecological concern, potential causes were evaluated to determine if the higher values were indicative of a longer term trend. Further evaluation of the 2006 data attributed the higher concentrations to two potential causes, a change in the analytical methodology for PAH analysis in 2006 and the underlying variable distribution of PAHs within the cap material that was placed over the mound. The 2010 coring survey presented in this report was designed to provide further insight into both of these potential causes, and the results are discussed separately in the sections below.

4.1 Evaluation of Three PAH Extraction Techniques

Details on the extraction methodologies from pre-2001 surveys were not readily available, but there was a shift from pressurized fluid extraction (PFE, EPA Method 3545) in 2001 to microscale extraction (MSE, EPA Method 3570) in 2006. This switch to MSE was an adjustment laboratories were making to reduce the amount of solvent

required for the extraction process. While samples from both surveys were analyzed via GC/MS SIM (SW-846 Method 8270C), the change in extraction methodologies may have influenced survey results. Sediments from the 2010 survey were prepared using both PFE and MSE techniques along with the more robust Soxhlet extraction method (EPA Method 3540) which requires the most solvent volume of all three techniques.

The Soxhlet method performed the best from a quality control (QC) sample recovery perspective including certified reference material, laboratory control sample, matrix spike sample, and surrogate recovery (Tables 3-2 and 3-3). In contrast, QC measures for PFE indicated lower accuracy while MSE produced the least accurate results. The low performance observed from the MSE method for many of the QC samples, and the low surrogate spike recoveries, may have been related to the way sample moisture is addressed in this preparation. Specifically, while the drying agent NaSO4 is added to the extraction vessel early in the process, it is not mixed with the wet sample until after surrogate spikes, matrix spikes, and extracting solvents are added. MSE did perform well when analyzing certified reference material, perhaps owing to the fact that this material is pre-dried and not influenced by the MSE drying process.

For the two stations analyzed by all three extraction techniques there was general agreement between the Soxhlet and PFE results while there was substantial variability with the MSE results (Figure 4-1). The mean MSE concentration for station NLDS-42 was more than double the mean Soxhlet or PFE concentration while results for station NLDS-48 were reversed with the mean MSE concentration more than three times lower than the mean Soxhlet and PFE concentrations. Based on these results, differences between the PFE and MSE methods likely contributed to the inter-survey PAH variability at Seawolf identified when the 2006 data (MSE method) and the 2001 data (PFE method) were compared. The heterogeneity of the matrix could have also affected the PAH precision.

Findings from a recent inter-laboratory study of PAH method performance conducted by the National Institute of Standards and Technology (NIST) also highlighted the high level of PAH analysis accuracy and precision that can be attained when sediments are processed using the Soxhlet apparatus (NIST 2011). While this study supports the selection of Soxhlet as a robust and highly efficient extraction method, it also suggests that the National Oceanic and Atmospheric Administration's National Status and Trends (NOAA's/NS&T) shaker table/tumbler extraction method can achieve results of equal quality (NIST 2011). Based on the recent NIST results, the DAMOS Program should consider both the Soxhlet and NOAA/NS&T extraction methods as options in future monitoring programs. The use of these methods would have an added benefit of allowing direct sediment data comparisons to the large NS&T sediment database.

4.2 Variability in PAH Distribution

In addition to potential error from extraction methodology there also appears to be variation introduced by the compositional heterogeneity of PAH compounds within the matrix of the Seawolf Mound capping material and the small sample mass used by all three PAH methods. While cores were thoroughly homogenized prior to sub-sampling, the relative standard deviation of Total PAHs between triplicate sub-samples exceeded 100% for two of the three analyzed cores (Table 3-4). Therefore, PAH sub-sampling methodology served to highlight persistent heterogeneity that is inherent in the Seawolf CDM.

The CDM heterogeneity also contributed to localized spatial variation in PAH concentrations that were observed in co-located cores from the 2010 survey. One station (NLDS-48) exhibited a Total PAH range of 1132–2807 ng/g between cores collected from within 10 meters of the target location (Figure 3-2). It should then be expected that this small-scale spatial variation also affected PAH concentrations in co-located cores between surveys and inhibited accurate comparison of results at individual stations. It may then be useful to increase future sampling stations within each zone to allow for meaningful comparisons of PAH results between surveys on a zonal mean basis instead of examining trends at individual locations.

The complex sediment matrix of the Seawolf Mound capping material presents a challenge for accurate characterization and monitoring. Results from this study provide tools that could aid in monitoring program design for the Seawolf Mound and other sites with heterogeneous capping material. Subsequent PAH monitoring efforts should take the potential for extraction method efficiency, sub-sampling mass, and small-scale heterogeneity into consideration to maximize the statistical strength and comparability between data sets.

4.3 Evaluation of Current PAH Concentrations on the Seawolf Mound

In general the PAH results from the 2010 survey of the Seawolf Mound were consistent with previous findings, indicating that there is at least a 0.5 m layer of CDM over the extent of the UDM. While PAH concentrations remain elevated relative to reference area cores they reflect the use of coastal harbor sediments as capping material and do not suggest any failure in the capping material to sequester the underlying UDM. Sediment Quality Guidelines (SQGs) are often useful as a first level screening exercise for sediment contaminants. The guidelines developed for the National Status and Trends (NS&T) program include the priority pollutant PAH compounds and may be instructive for Seawolf Mound sediment concentrations (Buchman 1999). Since the CDM used at

the Seawolf Mound originated from a coastal harbor, it is reasonable to expect that sediment concentrations would be elevated above undisturbed reference stations within Long Island Sound. Therefore, instead of using reference areas as a baseline, a comparison with SQG screening-levels may provide an important environmental context for the Seawolf Mound.

For this first level screening exercise, Effects Range-Low (ERL) and Effects Range-Median (ERM) values have been included in Table 4-1. With the exception of HMW PAHs from the 2006 survey, none of the PAH mean concentrations from the Seawolf Mound surveys have exceeded the lower ERL benchmark, suggesting that adverse effects from sediment PAH concentrations are unlikely. For the 2006 samples (analyzed using the MSE extraction method that was assessed as less reliable in this study), the HMW PAHs exceeded the ERL by only 30% and was well below the ERM. Based on these consistent findings of low potential for harmful PAH exposure from Seawolf Mound sediments, additional sediment sampling and analysis is not recommended at the mound unless future bathymetric surveys of the New London Disposal Site suggest instability or disturbance of the mound surface.

Table 4-1.
Comparison of Means from the 2010 and Previous Seawolf Surveys

	Seawolf Mound					Reference Area (WREP)[4]					SQG[5]	
Coring Survey Year	2010	2006	2001	1998	1997	2010	2006	2001	1998	1997	ERL	ERM
Extraction Method	Soxhlet	MSE	PFE	UNK	UNK	Soxhlet	MSE	PFE	UNK	UNK		
%TOC[1]	1.5	0.9	2.7	2.9	2.1	0.3	0.2	0.7	1.6	0.5		
% Fines[2]	57	69	78	87	81	14	31	27	32	28		
Mean PAHs (ng/g)[3]												
Naphthalene	22	27	18	13	6	2.8	5.3 U	6.5 U	8	4 J		
Acenaphthylene	39	55	12	16	8	5.1	20	6.5 U	13	3 J		
Acenaphthene	10	13	11	9	8	0.3	5.3 U	6.5 U	4 J	5 U		
Fluorene	13	12	12	9	8	1.4	5.3 U	6.5 U	4 J	5 U		
Phenanthrene	83	147	42	26	20	11	13	7.4	38	9		
Anthracene	57	161	19	16	9	5.4	9	6.5 U	14	4 J		
Sum of LMW PAHs	**224**	**415**	**114**	**89**	**59**	**26**	**58**	**40**	**81**	**30**	**552**	**3160**
Fluoranthene	186	398	84	44	49	25	31	15	65	21		
Pyrene	251	481	97	69	55	32	39	18	88	25		
Benz[a]anthracene	140	249	56	29	27	19	26	9.3	32	14		
Chrysene	137	257	57	35	25	19	28	9.7	41	12		
Benzo[b]fluoranthene	126	154	56	23	27	23	29	14	34	14		
Benzo[k]fluoranthene	122	179	35	25	17	23	30	7.1	29	8		
Benzo[a]pyrene	138	254	52	32	28	23	36	11	37	14		
Indeno[1,2,3-cd]pyrene	104	110	32	20	19	23	23	7.6	25	9		
Dibenz[a,h]anthracene	24	33	13	8	7	4.3	7	6.5 U	4 J	5 U		
Benzo[g,h,i]perylene	89	124	27	23	18	20	26	6.6	27	9		
Sum of HMW PAHs	**1318**	**2240**	**509**	**308**	**271**	**212**	**275**	**105**	**382**	**131**	**1700**	**9600**
Total PAHs	**1543**	**2655**	**623**	**397**	**330**	**237**	**333**	**145**	**463**	**161**	**4022**	**44792**

Units are ng/g dry weight; MDL used in statistical calculations for U and J qualified data

[1]USEPA Method 9060 (1997, 1998, 2001 samples), Lloyd Kahn (2006, 2010 samples); [2]ASTM D422 (1997 [with pipette], 1998, 2001, 2006, 2010 samples);

[3]USEPA (extraction/analysis): 3550A/8270C (1997, 1998, 2001 samples), 3550B/8270C (2006 samples) 3540/8270C (2010 samples);

[4]Data is not averaged; single station only; MDL used in sum for U and J qualified data;

[5]SQG=Sediment Quality Guidelines: ERL=Effect Range-Low: ERM=Effects Range-Medium (Buchman 1999)

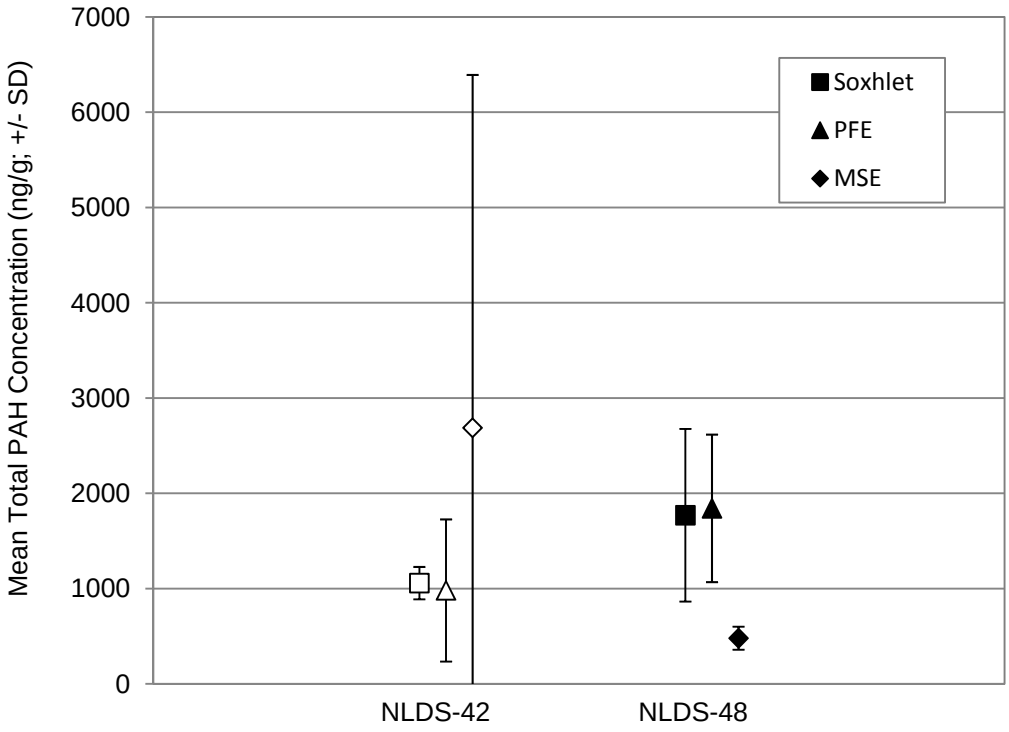

Figure 4-1. Total PAH concentrations per extraction method

5.0 CONCLUSIONS

The September 2010 survey at the Seawolf Mound was performed to collect and analyze surface sediments of the mound cap. The survey design included elements to allow for determination of variability at three levels: laboratory variability (different extraction methods), sampling-scale variability (heterogeneity within the composition of an individual sample), and field-scale variability (spatial heterogeneity of co-located cores meters apart).

Three PAH extraction techniques (PFE, MSE, and Soxhlet) were used to analyze Seawolf Mound sediments in order to compare analytical method performance. The Soxhlet extraction technique yielded the most accurate and precise results from a quality control perspective, PFE results were the next most reliable, while the MSE results were highly variable. Differences in method performance also contributed to comparison issues between datasets, reflected in the higher PAH results from the 2006 survey of the Seawolf Mound when the MSE method was used. To eliminate this source of data variation, it is recommended that PAH methods with high extraction efficiencies and larger sample masses (i.e. Soxhlet or NS&T shaker table/tumbler) be used on any future sediment investigations of the Seawolf Mound. These methods should also be considered for all future PAH investigations within the DAMOS Program to ensure consistency between disposal site surveys.

The small sample mass used for all three PAH extraction methods, including Soxhlet, provided another pathway for data variability. While every effort was made to thoroughly homogenize the sample prior to analysis it may be necessary to review the preparation technique to develop a more robust mixing method for these highly heterogeneous sediments. Sub-sampling each homogenized sample three times would allow for determination of a station mean and would also reduce the influence of compositional-level heterogeneity and should be considered for future efforts. As this sub-sampling variability is likely a common characteristic of dredged material placed at most disposal sites monitored through the DAMOS Program, it should be evaluated for other locations as well.

Localized PAH spatial variability was assessed through three sets of co-located sediment cores. While two stations showed very good agreement among cores, there was considerable variation among the co-located cores from the third station. This highlights the potential for small-scale variability among the heterogeneous Seawolf cap material and indicates the need for collection of sufficient samples to generate summary statistics to allow for accurate zonal and temporal comparisons between surveys.

Overall the PAH concentrations measured in the 2010 Seawolf Mound sediment coring survey were consistent with pre-dredge characterization of the CDM and indicate that there is at least 0.5 m of cap material over the extent of the UDM with PAH levels below the ERL. Method performance issues, sub-sampling variability, and small-scale spatial variability all likely contributed to the variation in PAH results observed in different investigations at the Seawolf Mound, including the higher concentrations noted in 2006. Subsequent sediment investigations of the mound are not necessary unless there are indications of mound instability through regular monitoring efforts of the New London Disposal Site.

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Appendix A

Sampling and Analysis Plan/QAPP

QUALITY ASSURANCE PROJECT PLAN

for

Seawolf Disposal Mound Survey

New London Disposal Site

LONG ISLAND SOUND

JUNE 2006

Prepared by:

ENSR

Prepared for:

Oak Environmental Engineering

Prepared By:	Don Boyé	Date:	June 2006
Approved By:	Steve Wolf Technical Reviewer	Date:	June 2006
Approved By:	Debra McGrath QA Reviewer	Date:	June 2006

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1.0 Project Description

1.1 Introduction

The Seawolf 2006 Field Survey will be an investigation of a capped dredged material disposal mound located at the New London Disposal Site (NLDS) in Long Island Sound outside New London, Connecticut (Figure 1). The Seawolf disposal mound is a historic, capped disposal mound developed during the 1995/96 disposal season from material generated by dredging operations at the Groton Submarine Base and in the Thames River channel on behalf of the US Navy. This mound was last characterized in February 2003 with a multi-beam bathymetry survey and in June 2001 with the collection of sediment-profile imagery (SPI). The proposed 2006 monitoring will be conducted to satisfy the permit issued for the dredging project and will include precision multi-beam bathymetry, sediment profile imagery, sediment grab sampling for benthic community characterization, and vibracore sampling for the analysis of specific parameters.

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 EPA requirements, regulations, guidance, and applicable technical standards.

1.2 Site Name, Location, and Description

The New London Disposal Site (NLDS) is located 5.38 km (3.1 nm) south of Eastern Point, Groton, Connecticut and is centered at 41deg 16.306'N, 72deg 04.571'W (NAD-83). The disposal site covers a 3.42 km2 area of seafloor, with water depths ranging from 14 to 24 meters. Currently, this site is utilized for the unconfined disposal of suitable sediments, as well as sub-aqueous capping of sediments deemed unsuitable for open water disposal.

The Seawolf Mound is a capped dredged material disposal mound developed in the northwestern quadrant of NLDS in 1995-1996 as the product of a large improvement dredging project in the Thames River. The disposal and capping of material generated from improvement dredging associated with home-porting the Seawolf class submarines in Groton, CT. and other smaller maintenance dredging projects, resulted in a total estimated volume of 877,500 m3 of sediment deposited at the Seawolf Mound.

1.3 Objectives

The purpose of this study is to evaluate the long term stability of the Seawolf Mound by examining the thickness of capping material, investigating for any potential migration of underlying unsuitable dredged material from under the cap, and evaluating the assimilation of capping material to the natural background conditions of indigenous sediment. This study will also document the continued recovery of surface sediments

at the Seawolf Mound by assessing benthic conditions and infaunal successional status in comparison to the conditions observed by the concomitant sampling of three DAMOS reference areas surrounding NLDS.

1.4 Project Approach

The continued investigative monitoring of the project disposal mound is being conducted to comply with the monitoring plan prepared in accordance with the permit issued for the Seawolf dredging project. Monitoring specified in the plan includes a precision multi-beam bathymetric survey, sediment profile imaging, benthic community grab sampling, and collecting sediment vibracores to be analyzed for selected parameters.

To accomplish the specified objectives of the project, the signature boundaries of the Seawolf disposal mound will be characterized by collecting multi-beam bathymetry data over a 1000 x 1000-meter area of the mound and evaluating depth differences and comparing surface features of the mound with those determined by the previous multi-beam bathymetry survey conducted in 2003.

Further characterization of the integrity of the cap will be determined by the collection and analysis of sediment vibracores at 12 stations on the Seawolf Mound. Sediment vibracores, ranging in length from 50 centimeters to 3 meters will be split lengthwise, visually described/documented, sub-sampled, and analyzed to determine vertical grain size and selected chemical parameters including Total Organic Carbon (TOC), metals, and poly-aromatic hydrocarbons (PAHs) found on the Priority Pollutant List. The physical and chemical data obtained from the core samples at the Seawolf Mound will be compared to those obtained from a designated reference station (WEST-REF) to determine whether unsuitable dredged material has migrated from underneath the capping materials atop the disposal mound. Table 1-1 summarizes the target parameters and corresponding detection limit requirements selected for the Project.

Sediment profile images or a cross-sectional photograph of the top 20 centimeters of sediment, along with sediment sampling for the characterization of benthic community structure will be collected from 13 stations and appropriate reference stations. The results of these two investigations will determine the extent of discernable differences in benthic conditions between the Seawolf Mound and ambient sediments.

The target positions for filed sampling are summarized and depicted in the Field Sampling Plan.

1.5 Schedule of Activities and Deliverables

The project schedule is presented in the following table.

Project Task	Schedule (2006)
Field Program (SPI / benthic grabs)	13/14 June
Field Program (bathymetry)	26 June
Field Program (sediment vibracoring)	11 July
Draft Bathymetry Map	14 July
Core Splitting	17/18 July
Physical Testing Complete	31 July
Chemical Analysis Complete	31 July
Benthic Enumeration Complete	18 August
SPI Images Reviewed	18 August
Data Validation	18 August
Draft Synthesis Report	29 September

2.0 Project Organization and Responsibilities

Under contract to Oak Environmental, ENSR and participating sub-contractors will be performing the field investigation. Sub-contractors include Ocean Surveys Incorporated (OSI) for multi-beam bathymetry and vibracoring support, Germano and Associates for the performance of Sediment Profile Imaging (SPI) and CR Environmental Incorporated which will be providing a survey vessel to assist in the SPI study and benthic community sampling. ENSR will oversee sample analysis, and evaluate/discuss the results in a draft synthesis report. Laboratory services will be provided under subcontract to ENSR.

The various management, QA, field, and laboratory responsibilities of key project personnel are defined below.

2.1 Management Responsibilities

Contract Technical Manager

The Oak Environmental Project Manager is Bruce Newman.

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 coordinating all field and laboratory task activities, communications, reports, technical reviews and other support functions, and for facilitating sampling activities as needed to achieve the technical requirements of the Project, and for
- Maintaining the Project files.

ENSR Health and Safety Officer

The ENSR Project Health and Safety Officer, Ms. Kathy Harvey will serve as a health and safety advisor to the project including reviewing field sampling plans, recommending appropriate personal protective equipment (PPE) to protect ENSR personnel from any potential hazards, and conducting accident investigations in the unlikely event an injury has occurred during the completion of this Project.

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, challenges, and any potential data quality issues to the ENSR Project

Manger. The Task Managers are also responsible for contributing to the preparation of the Field Summary Report. The Task Managers are as follows:

Field Task Manager – Mr. Don Boyé will be responsible for implementing the field program in accordance with the Field Sampling Plan, QAPP, and Site Safety Health Plan, arranging the required sub-contract services and, managing the overall field budget.

Analytical Task Manager – Mr. Dion Lewis will be responsible for developing the sub-contracts for laboratory services, acting as the liaison between field and laboratory personnel, and for assessing the quality of the analytical data submitted by the laboratories.

Data Manager – Ms. Heather Wayne will be responsible for managing project data information systems including 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 for quality assurance oversight. The ENSR Project QA Officer communicates directly to the ENSR Project Manager. Specific responsibilities include:

- Reviewing and approving the SAP/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 SAP/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 support to the physical and chemical testing of field samples are listed below.

Organization	Contact	Tasks
Alpha Woods Hole Group 375 Paramount Drive Suite 2 Raynham, MA. 02767-5154	Edie Hutchinson 508-822-9300	Analysis of sediment TOC, metals, and PAH compounds.
GeoPlan Associates 1145 Massachusetts Avenue Boxborough, MA 01719	Peter Rosen (978) 635-0424	Measurement of sediment grain size and moisture content (biology samples).
University Of Rhode Island Geo-Mechanics Lab		Lab support for splitting, photographing, and sub-sectioning sediment core samples (core grainsize).

Laboratory Manager

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

- Implementing and adhering to the laboratory QA manual and all corporate policies and standard procedures within the laboratory,
- Approving the standard operating procedures (SOPs),
- Maintaining adequate staffing to meet the schedule for the delivery of data, and
- Implementing all 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 non-conformances within the laboratory,
- Performing QA assessments, and
- Reviewing and approving corrective action plans for non-conformances, tracking trends of non-conformances to detect systematic problems, and initiating additional corrective actions as needed.

Laboratory Project Manager

The Laboratory Project Manager will serve as 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 ENSR and laboratory staff,
- Reviewing project data packages and electronic data deliverables (EDDs) for completeness and compliance to the agreed upon format for the data package, and
- Monitoring, reviewing, and evaluating the progress and performance of assigned analyses.

2.4 Field Responsibilities

ENSR Field Task Manager

The ENSR Field Task Manager, Mr. Don Boyé, has the overall responsibility for completing all field activities in accordance with the Survey Plan, QAPP, and Health and Safety Plan (HASP) and will facilitate communications between ENSR project management and the field team. Specific responsibilities for the ENSR Field Task Manager will include:

- Planning and coordinating field survey and sampling activities,
- Establishing sub-contracts for support services
- Briefing ENSR and sub-contract personnel on the Project HASP before field operations,
- Briefing ENSR personnel on guidelines for proper recordkeeping and field documentation,
- Mobilizing and demobilizing the field team and subcontractors,
- Assigning specific duties and directing ENSR and sub-contract personnel in the field,
- Resolving logistical challenges which may potentially affect field activities, including equipment malfunctions or availability, personnel conflicts, or safety issues stemming from weather and/or sea conditions, and
- Implementing field QC procedures for the collection of field measurements and records and for ensuring that field samples are properly collected, labeled, preserved, and handled and/or shipped in accordance with accepted chain-of-custody procedures,

ENSR Field Survey Personnel

ENSR field survey personnel report directly to the ENSR Field Task Manager.

The responsibilities of the field team include:

- The collection of data and field samples in accordance with the methods and quality assurance procedures specified in the Field Survey Plan and Project 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 Task Leader.

Sub-contracted Field Support Services

Field support services will be provided by the following organizations:

Organization	Contact	Tasks
Ocean Surveys Inc. 91 Sheffield Street Old Saybrook, CT 06475 (860) 388-4631	George Reynolds	Marine logistical support: Providing a survey vessel, licensed captain, qualified hydrographer and all necessary equipment to perform multi-beam bathymetry survey. Providing a specialty sampling platform, licensed captain, qualified crew, and all necessary equipment and supplies to conduct vibracoring.
CR Environmental Inc. 639 Boxberry Hill Road East Falmouth, MA. 02536 (508) 564-4121	Chip Ryther	Marine logistical support: Providing a survey vessel, and licensed captain to assist in conducting SPI survey and collect benthic community samples.
Germano and Associates 12100 SE 46th Place Bellevue, WA. 98006 (425) 865-0199	Joe Germano	Providing the SPI camera, qualified operators and necessary supplies required conduct SPI survey.

2.5 Training

All personnel performing work on this study will be qualified to perform their assigned tasks. Prior to starting work, the Chief Scientist or Project QA Officer will review specific instructions, covering the following areas:

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

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

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 methods, and reporting. Field station positioning must be highly accurate to locate specific sampling sites on the seafloor. Subsequent laboratory analysis must be precise so that measured chemical concentrations are representative of the in-situ conditions in order to accurately evaluate capping efficiency.

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

Twelve core samples will be collected from the Seawolf Mound, four cores in each of three designated zones around the center of the mound. The replicate sampling within each individual zone should be sufficient to assess lateral variability around the disposal mound. A low degree of variability is anticipated since previous surveys conducted in 2003 confirmed the integrity of the cap.

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 30% 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

Sub-meter accurate vessel positioning is a fundamental aspect of field surveying and will be accomplished using a Differential Global Positioning System (DGPS) and confirmed with a real-time display of vessel

position on an electronic nautical chart. 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 the Collection of Representative Field Data

To ensure that the data generated during the project will 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, 12 cores (plus a comparative reference site core) will be collected from the Seawolf Mound to ensure that the final data set adequately represents the condition of the cap.

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 Field 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 greater than 90 percent. The equation for completeness is presented in Section 12.3 of this FSP/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 FSP/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 FSP/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 Survey and Sampling Program

The field program details are defined in the project survey plan. A specialized 37-foot coring vessel (R/V Can-do) with 4'x5' moon-pool will be utilized for the coring effort at the Seawolf Mound and a 35-foot survey vessel will be used for the multi-beam survey; these two vessels will be operated by Ocean Surveys Incorporated. SPI images and the collection of sediment grab samples for benthic community characterizations will be completed from the 42-foot survey vessel R/V Shanna Rose equipped with a hydraulic A-frame and winch, operated by CR Environmental. As indicated, accurate vessel positioning is essential for the successful collection of site sediments and field data. Navigational positioning will be accomplished using a Trimble 4000 RS DGPS receiver (or equal) interfaced with HYPACK hydrographic software or the OSI Maretrack Navigation and Data Logging System. Site depth will be monitored using both an echo sounder and a checked with a weighted sounding line. The target coring locations and collection procedures are fully detailed in the survey plan. Laboratory handling details are further defined in the following sections.

4.1 Multi-beam Bathymetry Survey

A multi-beam bathymetry survey shall be conducted in a 1000 x 1000 meter survey area over the Seawolf disposal mound covering the same area previously surveyed in 2001 as shown in Figure 2.

The bathymetric data will be collected by a Reson 8125 Ultra High Resolution Echo Sounder outfitted with a 0.5º 455-kHz transducer (or equal system). The multi-beam sounding system will be equipped with a TSS DMS 2-05i Motion Sensor for measuring heave, pitch, and roll and a TSS Meridian Gyro Compass to provide accurate heading guidance. The data collected will be calibrated for local water speed of sound by performing conductivity-temperature-density (CTD) casts at frequent intervals throughout the day with a Seabird SBE-19 Seacat CTD profiler. The accuracy of the bathymetry data will be determined by a bar check. Water depths at Seawolf will be recorded in meters and referenced to mean lower low water (MLLW) based on local tidal information obtained from the NOAA Tide Station located in New London, Connecticut.

Bathymetric data will be stored electronically in HYPACK, a hydrographic surveying software package that will manage data acquisition and the storage of data from the echosounder, the Trimble DGPS navigation system, and MRU, resulting in a record of depth, position, vessel heave, pitch and roll, vessel heading, and the time along each survey transect line. A redundant back-up of bathymetry data will also be recorded on a high-resolution trace on a thermal printer.

4.1.1 Bathymetric Data Processing

Bathymetric data processing will be accomplished using the HYPACK software program to correct data for local tidal conditions, vessel motion, and local speed of sound. All spurious data points (clearly unrealistic measurements resulting from signal interference) will be removed from the record during data processing. Tidal correction will consist of transforming the raw measurements of depth below the transducer to seafloor elevation measurements relative to MLLW using the locally collected tidal elevation data. Heave data supplied by the vessels motion reference unit (MRU) will be applied to the raw data to minimize the effects of vessel motion during data acquisition. The final data set will be "binned" into 0.5-meter square bins. The average

value of all data collected within each bin will be determined and this value will be assigned to the coordinates at the center of the bin for plotting purposes.

4.1.2 Bathymetric Data Analysis

Corrected bathymetric data will be displayed the contouring and surface plotting software program, Surfer® 8.0 and the GIS-based software package ArcView® 9.1. Bathymetry data will be gridded in Surfer® and then contoured and plotted using ArcView®.

Data will be compared to previous to the multi-beam survey conducted in 2003 to evaluate changes in seafloor topography. This will be completed in Surfer® by calculating depth-difference grids based on prior baseline surveys. Three-dimensional hill-shaded renderings of the bathymetric data will also be created using the ArcView® 9.1 3-D Analyst toolbox. The hill-shade grid will enhance the three-dimensional qualities of the multi-beam bathymetric data by simulating a light source with an azimuth of 315 degrees and an altitude of 45 degrees illuminating the seafloor.

4.2 Sub-Sampling Procedures for Core Samples

Sediment cores collected from the stations shown on Figure 3 will be maintained on ice (4oC) from the time of collection until actual processing in the lab at the University of Rhode Island (URI) Geo-Mechanics Lab. Short core samples (50 centimeters in length) will be transported intact from the field to the processing laboratory; long cores (3 meters in length) may be cut into equal halves to facilitate shipping and handling. At the URI lab, core samples will split, photographed, characterized for sediment stratigraphy, and sub-sampled. Cores will be handled in the following manner:

1) A single core will be placed on a covered laboratory bench, accurately measured, and cut in half length-wise using a clean stainless steel shearing device (since Lexan liners are going to be used), exposing the sediment material.

2) The sediment core will then be split into two equal halves down the horizontal centerline of the core. The core 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, odor, location of visual transitions in sediment properties) will be noted on a log form and then the core shall be photographed.

4) Sediment cores will be sub-sectioned to obtain the appropriate sampling material, defined as follows: For short core samples, the top 50 centimeters will be sub-sectioned in its entirety resulting in the generation of one single composite sample. For long cores, the core will be sub-sectioned into the following segments (measured from the top of core) – 0.0 to 0.5 meters, 0.5 to 0.75 meters, 0.75 to 1.0 meters, 1.0 to 2.0 meters, and 2.0 to 3.0 meters, resulting in the generation of five composite samples. (NOTE: The location of segment boundaries shall be adjusted as needed to account for any visual transitions). Each individual composite segment shall be transferred to a stainless steel container and thoroughly homogenized prior to actually collecting materials in glass sample containers. A newly decontaminated knife shall be used in cutting each segment boundary. A

dedicated stainless steel bowl and set of utensils shall be used in handing sediment materials from each segment.

5) Each discrete sample taken from the prepared homogenate shall be containerized in the appropriate sample container provided by the analytical laboratory (summarized in Table 4-1) for subsequent analysis. All sample containers will be properly labeled with the core ID, the appropriate ID for the segment length, the date and time of collection at the URI lab, and the intended parameter for analysis. (NOTE: The 0.0 to 0.5 meter and 2.0 to 3.0 meter segments from the long cores are to be archived at the analytical laboratory).

6) Samples shall be packed in protective bubble-wrap bags and maintained on ice (4°C) from the time of collection until actual analysis. Samples shall be shipped to the appropriate destination laboratory within 48 hours of collection. Grain size samples must not be frozen, but may be stored either chilled (4°C) or at ambient temperature in airtight containers.

All sample handling tools used during the splitting, segment transferring, segment homogenization, and sample collection will be constructed of stainless steel and will be decontaminated with lab detergent, DIW, and solvents between the processing of each core as described in Section 4.2.2.

4.2.1 Sediment Sample Preservation, Containerization, and Holding Times

Upon completing the processing of core samples, individual sediment samples will be transferred to the appropriate sample jars listed in Table 4-1 for subsequent storage and chemical analysis.

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.

4.2.2 Equipment Decontamination – Processing Sediment Cores

All bowls and utensils used in the processing of core samples will be decontaminated using the following procedure:

1) Remove all adhering sediment with lab soap and DIW mixture

2) Rinse with DIW

3) Rinse with DCM

4) Rinse with Acetone

5) Seal the utensils in Al foil unless they are to be reused immediately

4.2.3 Sediment QC Sample Collection

As indicated in the field survey plan, a replicate core will be collected for field QC purposes from a select Seawolf station. For laboratory QC (replicate and spiking exercises), one segment horizon per 20 will be

selected. These "QC horizons" must not be collected near cap/mound interfaces to avoid "gradient smearing" in the vicinity of the visual interface.

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

4.2.4 Sediment Sample Labeling

The Seawolf Mound will have 12 coring locations (NLDS-40 through NLDS-51) plus a reference station WEST-REF. For labeling purposes, the field sample ID will consist of SD06 indicating a sediment sample collected in 2006, followed by the coring location (as listed above), plus any pertinent information regarding any core splitting conducted in the field for the long 3-meter core samples to facilitate shipping ex. SD06-NL51-0 to 1.5 meters and SD06-NL51-1.5 to 3.0 meters for the two halves of the 3 meter core collected from station NLDS-51. The label applied to the field core samples shall also carry the following information: Project-SEAWOLF, date and time of collection, initials of sample collector, and preservation methods.

Further segmentation of the field core, conducted at the University of Rhode Island Geo-Mechanics Lab for purpose of preparing the required sample homogenate, will require the following labeling convention. For the short cores (NLDS-40 through NLDS-48), the segment length will simply be 50 centimeters therefore an example sample ID for station NLDS-40 would be SD06-NL40-50. For the long cores (NLDS-49 through NLDS-51), the proposed segment lengths are 0.0 to 0.5 meters, 0.5 to 0.75 meters, 0.75 to 1.0 meters, 1.0 to 2.0 meters, and 2.0 to 3.0 meters; a sample ID for the top two samples at station NLDS-51 would be SD06-NL51-0.0-0.5, and SD06-NL51-0.5-0.75, respectively. Lab duplicates will have –DUP appended to the end of each respective duplicate sample. The label applied to each of the sample jar used to collect an aliquot of sediment intended for lab analysis shall also carry the following information: Project-SEAWOLF, date and time of collection, initials of sample collector, preservation methods, and the intended analysis (metals, PAH, TOC, grain size, etc.).

4.2.5 Sediment Sample Transfer/Shipments

Sediment samples that are shipped from URI to supporting laboratories for chemical analysis shall be packaged in protective plastic to prevent breakage and preserved on ice; samples intended for grain size analysis shall be shipped without ice. Custody seals are to be applied to shipping coolers and sample receipt forms must be filled out upon receipt at the laboratory.

4.3 SPI Survey

Sediment-profile imaging (SPI) is a monitoring technique used to provide data on the physical characteristics of the seafloor as well as the status of the benthic biological community. The technique involves deploying an underwater camera system that photographs a cross section of the sediment-water interface. Computer-aided analysis of the resulting images provides a set of standard measurements that can be compared between different locations and different surveys. The DAMOS Program has successfully used this technique for over 20 years to map the distribution of disposed dredged material and to monitor benthic recolonization at disposal sites

4.3.1 SPI Data Acquisition

The 2006 SPI survey of the Seawolf Mound includes 13 stations located within the boundaries of the Seawolf site and 13 stations distributed within three reference areas. A cross-sectional image of the top 20 cm (8 inches) of sediment shall be collected at each station.

Seawolf stations are identified as CTR, 75E, 150N, 150W, 300SE, and 300WSW plus 7 additional stations SW01 through SW07 placed randomly around a 150-meter radius of the central point of the Seawolf mound (Figure 4). Three images shall be collected at each of 13 stations (39 images total). The three designated reference areas associated with the New London Disposal Site are identified as NLON-REF, NE-REF, and WEST-REF on Figure 5. Reference area data will provide information on benthic conditions within the ambient sediments and represent a basis for comparison with data collected from the project mound. Reference SPI stations were randomly located within a 300 meter radius of the central location for each reference area as follows: four stations will be occupied at each of two selected reference areas and five stations will be occupied at the third reference area. Three images shall be collected at each of 13 reference stations (39 images total).

At each survey location, the survey vessel will be positioned at the designated target coordinates to within a tolerance of 10 meters. Three replicate sediment-profile images will be collected at each of the 26 stations for characterization of small-scale (i.e. within-station) spatial variability.

Acquisition of high-resolution SPI images will be accomplished by Germano and Associates using an Ocean Imaging Model 3731 pressure housing system with a Nikon D100 digital single-lens reflex camera (or equal). The system is comprised of a camera installed inside a pressure housing mounted atop a wedge-shaped prism with a clear front faceplate and a mirror mounted at a 45° angle to reflect the profile of the sediment-water interface. As the prism penetrates the seafloor, a trigger activated time-delay circuit will fire an internal strobe to obtain a cross-sectional image of the upper 15 to 20 centimeters of the sediment column. Once in position, the camera will remain on the seafloor for approximately 20 seconds to ensure that a successful image had been obtained. After each deployment of the camera, the frame counter will be checked to ensure that the requisite number of replicates was obtained. In addition, the prism penetration depth indicator on the camera frame will be checked to verify that the optical prism has penetrated sufficiently into the bottom.

Two types of adjustments to the SPI system are typically made in the field: (1) Physical adjustments to the frame stop collars and/or adding/subtracting lead weights to the frame to control penetration in harder or softer sediments. If images were missed or the penetration depth was insufficient, the camera frame stop collars will be adjusted and/or the payload weight adjusted accordingly, and additional replicate images collected until a satisfactory image set has been obtained. Changes in prism weight amounts, the presence or absence of mud doors, and frame stop collar positions will be recorded for each replicate image. (2) Electronic software adjustments to the Nikon D100 to control camera settings.

Each image will be assigned a unique time stamp in the digital file attributes by the camera's data logger and cross-checked with the time stamp in the navigational system's computer data file. In addition, redundant hand-written sample log sheets will be maintained by survey personnel. Digital images will be downloaded periodically to verify successful sample acquisition or to assess what type of sediment/depositional layer was present at a particular station. Digital images will be promptly re-named with the appropriate station name immediately upon downloading as a further quality assurance step.

Test exposures of the Kodak® Color Separation Guide (Publication No. Q-13) will be made on deck at the beginning and end of each survey to verify that all internal electronic systems are working to design specifications and to obtain a color standard against which final images can be checked for proper color balance.

4.3.2 SPI Data Analysis

Each SPI image will be subjected to a computer-aided analysis to determine a value for each of the following standard parameters:

- Sediment Type: The sediment grain size (major mode and range) will be estimated visually from the images using a grain-size comparator at a similar scale and results will be reported using the phi scale. The presence and thickness of any apparent disposed dredged material will also be assessed by inspection of the images.
- Penetration Depth: The depth to which the camera penetrated the seafloor will be measured to provide an indication of the sediment density or bearing capacity and will be expressed as a value ranging from a minimum of zero (i.e., no penetration on hard substrates) to a maximum of 20 centimeters (full penetration on very soft substrates).
- Surface Boundary Roughness: Surface boundary roughness, a measure of the vertical relief of features at the sediment-water interface, will be determined for each sediment-profile image. Surface boundary roughness will be determined by measuring the vertical distance between the highest and lowest points of the sediment-water interface. The surface boundary roughness (sediment surface relief) measured over the width of sediment-profile images should reside in the range of 0.02 to 3.8 centimeters, as influenced by physical structures (e.g., ripples, rip-up structures, mud clasts) or biogenic features (e.g., burrow openings, fecal mounds, foraging depressions).
- Apparent Redox Potential Discontinuity (RPD) Depth: RPD provides a measure of the integrated time history of the balance between near surface oxygen conditions and biological reworking of sediments. Sediment particles exposed to oxygenated waters oxidize and lighten in color to brown or light grey. The RPD depth will be measured by assessing color and reflectance boundaries within each image.
- Infaunal Successional Stage: Infaunal successional stage is a measure of the biological community inhabiting the seafloor. Current theory holds that organism-sediment interactions in fine-grained sediments follow a predictable sequence of development after a major disturbance (such as dredged material disposal), and this sequence has been divided subjectively into three stages (Rhoads and Germano 1982, 1986). Successional stage will be determined by assessing species or organism-related activities apparent in each image.
- Organism-Sediment Index (OSI): OSI is a summary parameter incorporating the apparent mean RPD depth, successional stage, and presence of methane or low oxygen and reflects the seafloors' response to natural or anthropogenic disturbance. This parameter will be determined for each image in accordance with accepted characterization methods (Revelas et al. 1987).

4.4 Benthic Community Characterization

One benthic grab sample will be taken at six stations using a stainless-steel 0.04m^2 Ted-Young grab sampler deployed from a boat using a hydraulic winch and A-frame. The sampler is slowly lowered through the water column so as not to generate a pressure wave ahead of the sampler which would flush organisms away from the underside of sampler prior to impact. A counterweighted latch holds the jaws of the grab sampler in the opened set position during deployment. This configuration is held static until the grab sampler impacts the bottom and lifting cable tension is lost, at which point the latch mechanism drops clear and the sampler is ready to collect a sediment sample. The action of hauling back on the lifting cable mechanically closes the jaws of the sampler thereby capturing a sediment sample within the bucket.

Upon recovery, the grab sampler is placed on a stand, at which point, the inspection panels on top of the grab are opened and the condition of the sample inspected for quality. The criteria for an acceptable benthic sample are outlined in the following section.

4.4.1 Acceptance Criteria for Benthic Samples

The Chief Scientist shall inspect the condition of the grab sampler and sediment contents to determine whether a benthic sample can be accepted. Acceptance criteria include:

- Sediment surface is more or less level and intact over the entire surface area of the grab
- Depth of the sediment retained is approximately 7 cm as measured at the center of the grab
- The grab should be tightly closed; little or no water should be leaking from the sample
- Shell hash or coarse material visible on the surface is acceptable as long as all the criteria stated above have been satisfied.
- Grabs that are only partially filled, or obviously slumped or pitched due to the grab hitting at an angle are not acceptable.
- If the grab is filled to the top, it is considered acceptable unless sediment has a dimpled appearance indicating contact with the underside of the inspection panels or if sediment is lost when the doors are opened; such samples will have penetrated too deep.

The field team will adjust their sampling to account for local sediment conditions including adding or removing weight to control depth of penetration and possibly adding pads (boards) to the underside of the grab frame to prevent over-penetration in very soft sediments. During the course of sampling a station, it may become obvious that the sediment conditions are not suitable for successful grab sampling. The most common situation is the presence of sediments that contain rocks and shell hash. Such sediments prevent the jaws of the grabs from closing and retention of suitable samples. Before abandoning a station, the Chief Scientist shall attempt to reposition the boat to locate more suitable sediments. The minimum criterion for abandoning such a station is five sequential unsuccessful sampling attempts, or a 70% failure rate. The Chief Scientist may elect to attempt further sampling, but will use his/her judgment given the time limitations and priorities of the field program.

4.4.2 Processing Benthic Samples

Prior to processing, the sample will be visually inspected and descriptive information such as surface texture, color, smell, and visible fauna or debris recorded. By visual observation and the use of a small ruler, the depth of the apparent redox RPD potential discontinuity (RPD) layer will be determined and recorded. The sediment depth in the grab will also be measured and recorded as the penetration depth of the grab.

Each biology sample will then be processed as follows.

- The grab will be opened and the contents dumped into a collecting bucket (containing a pore spout) placed under the stand on which the grab rests. Any sediment remaining in the grab will be washed directly into the bucket.
- The bucket will be transferred to a sample-processing table where it will be elutriated. This technique involves washing the sample with filtered seawater until the water flows from the bucket through the pore spout and onto the 0.5-mm mesh sieve. Lightweight particles are carried out of the bucket with the flow of water; silt passes through the sieve while the organisms that are floated onto the sieve are retained. Heavier sediment particles and organisms (i.e., molluscs and starfish) concentrate at the bottom of the bucket. Elutriation continues until the water flowing from the bucket is clear, indicating that all of the fine sediments have been removed.
- The material retained on the sieve is carefully washed through a funnel into a pre labeled sample jar where it will be preserved in 10% buffered (borax) formalin. An extra spoonful of borax will be added to the sample jar prior to use.
- The heavy fraction remaining in the bucket will likewise be transferred to separate labeled jar and similarly preserved. The light and heavy fractions may be combined if appropriate. This technique completely eliminates direct sieving of the animals and minimizes specimen fragmentation.

The Seawolf Mound will have six sediment grab sample locations for benthic community assessment, CTR, 75E, 150N, 150W, 300SE, and 300WSW, plus three designated reference stations. For labeling purposes, the sample ID will consist of SD06 indicating a sediment sample collected in 2006, followed by the sampling location (as listed above), and completed with a suffix of BIO; a biology sample obtained from station CTR would be SD06-CTR-BIO. The label applied to each sample jar shall also carry the following information: Project-SEAWOLF, date and time of collection, initials of sample collector, and preservation methods.

Prior to processing another sample, the sieves will be carefully inspected to ensure that all organisms were removed. All equipment including buckets, sieves, and funnels used in the above process will be thoroughly cleaned prior to processing the next sample in order to preclude cross contamination. Equipment will be rinsed with seawater and will be examined thoroughly to ensure that there are no adhering organisms. Sieves will be cleaned using a pressurized jet of water and scrubbing with a stiff brush.

After 48 hours, but within 2 weeks, the samples will be reopened and the formalin decanted into a storage container. The samples shall be sieved again with seawater and then rinsed with freshwater. This process removes remaining sediment particles and salt from the samples. These samples will then be preserved in 80% ethanol and re-sealed. These samples will then be shipped to the sorting laboratory for further processing. The formalin residue will be stored as hazardous and disposed of in an appropriate manner.

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 samples will be identified with sample numbers, sampling locations and date/time of collection. The sample numbering system is presented in Section 4.4.
- 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 FSP/QAPP Addendum. 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.; and
- All custody documentation (forms, air bills, 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. The multi-beam bathymetry system will be calibrated and tested in accordance with the procedures outline in the US Army Corps of Engineers Manual "Engineering and Design – Hydrographic Surveying", document EM 1110-2-1003, dated January 2002. 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.

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 detection limits, and analytical methods are listed in Table 1-1. Laboratory specific SOPs are provided in the following table.

Analyte Group	Laboratory SOP No.	Equivalent Method No.
PAHs	O-007, Analysis of Polynuclear Aromatic Hydrocarbons by Gas Chromatography/Mass Spectrometry with Selected Ion Monitoring	SW-846 3550B (EPA, 1986) SW-846 8270c Modified (EPA, 1996)[1]
ICP/AES Metals	*Metals Prep:* MP-001, Acid Digestion of Solid Samples for Metals Analysis MP-003, Microwave Assisted Acid Digestion of Sediments, Soils, Tissues and Waters *Metals:* M-001, Inductively Coupled Plasma-Mass Spectrometry M-006, Mercury Determination in Solids by Cold Vapor Atomic Absorption	SW-846 3051 (EPA, 1986) SW-846 6010B (EPA, 1986)
TOC	W-028, Total Organic Carbon in Soil, Sediment and Water	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

Two additional cores will be collected from the Seawolf mound, one from each of two randomly selected stations, as a field QC measure. Additionally:

- All activities will be performed by appropriately trained personnel,
- Work will be conducted in conformance with project-specific protocols.

8.2 Laboratory Quality Control

The laboratories utilized for this study have existing QC programs which 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 and validated 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

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.

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 Chief 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 non-conformances 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 non-conformances, 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, although formal data validation is beyond the scope of this project. All reported data, however, will provide full backup so that a data validation can be performed at some future date if needed.

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 developed for this purpose.

9.3.2 Statistics

ENSR will review the data when available and evaluate the best statistical approach. 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

AWHG, GeoPlan, and University of Rhode Island Geo-Mechanics Lab 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.

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, result presentation, and a discussion.

9.5.4 Final Report

One round of comments will be accepted after 30-day review period, at which time, a final report will be prepared. The final report will be submitted 2 weeks after the receipt of comments.

9.6 Data Management

ENSR will maintain validated laboratory data in an Access database during the course of this study.

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 FSP/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 (AWHG) has 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 vibracore sampler and a 0.04m2 Ted-Young sediment sampler. Field instruments will include a DGPS, Motion Reference Unit (MRU) and a multi-beam transducer. The ENSR Chief Scientist will be responsible for ensuring that all field sampling equipment and are free from obvious defects, damage, and contamination and are properly functioning. At a minimum, this will entail checking the equipment prior to commencing the survey and performing daily operational checks and calibration as described in the manufacturer's instructions. OSI will have the responsibility for ensuring that the bathymetric survey instrumentation is operating correctly and has been properly calibrated prior to the collection of field data.

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 will 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.

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 in a review meeting before preparation of a synthesis report. The (draft) report will include a description of the analytical procedures and additional information useful for interpreting the data. The report will include stratigraphic comparisons across the disposal mound and an assessment of any vertical chemical contaminant migration through the cap.

The data quality indicators (DQI) reviewed during the conduct of these studies includes 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), matrix spikes, and SRMs. Percent recovery will be determined according to the following equation:

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

Method blank results will be compared to reporting limit (RL) concentrations to ensure that data are free from contamination.

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:

$$Completeness = \frac{(number\ of\ valid\ measurements)}{(number\ of\ measurements\ planned)}\,x\,100$$

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. If corrective action is necessary, the ENSR Chief Scientist will first notify the ENSR Project Manager. The ENSR Project Manager, in consultation with the Contract/Technical Manager and the ENSR Project QA Officer, will approve the corrective measure. No staff member will initiate corrective action without prior communication of findings through the proper channels. However, if this communication protocol cannot be completed in a timely fashion, the ENSR Chief Scientist has authorization to approve corrective action and to ensure proper measures are 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.

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 Manager 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 re-injection/re-analysis 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 Manager will ensure implementation and documentation of the corrective action. If the nonconformance causes project objectives not to be achieved, the ENSR Project Manager 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 Manager, 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 re-sampling by the field team or re-injection/re-analysis 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 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

ASTM. Annual Book of ASTM Standards. American Society for Testing and Materials, Philadelphia, Pennsylvania.

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Silva, A.J., W-M Tian, and H.G. Brandes. DAMOS Geotechnical Progam for Summer, 1990. Final Project Report. To SAIC and NED Corps of Engineers prepared by the University of Rhode Island College of Engineering, Marine Geomechanics Laboratory. October, 1990.

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United States Environmental Protection Agency. 2001. Methods for Collection, Storage and Manipulation of Sediments for Chemical and Toxicological Analyses: Technical Manual. EPA-823-B-01-002.

USACE, 1997. Chemical Quality Assurance for HTRW Projects. EM 200-1-6. October, 1997.

Table 1-1 Analytical Methods and Project-Required Detection Limits (dry weight units).

Parameter	Method Reference	Method Number	Project Required RL	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	5	ppm
Arsenic	SW-846	6020	5	ppm
Cadmium	SW-846	6020	0.3	ppm
Chromium	SW-846	6020	5	ppm
Mercury	SW-846	7471A	0.02	ppm
Lead	SW-846	6020	5	ppm
Nickel	SW-846	6020	5	ppm
Zinc	SW-846	6020	5	ppm
Aluminum (Total – HF Digestion)[1]	SW-846	6010B	50	ppm
Conventional Analyses				
TOC	Lloyd Kahn	--	0.1	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]- Total Aluminum using HF Digestion Method (Method 3052), other metals by 3050B

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

Sediment Parameters[1]	Sample Volume/Mass	Container Material	Preservation	Storage Condition	Holding Times[2]	Receiving Lab[3]
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	*AWHG*
PAHs, TPH					14 d (solid)/ 40 d (extract)	AWHG
TOC, PAH, TPH QC (1 per 20)	*8-oz/240 g*	*Glass*	*Chill or Freeze*	*-20 °/4±2 °C*	*14 d*	*AWHG*
Metals	2-oz/40 g	Glass	Chill or Freeze	-20 °/4±2 °C	180 d	*AWHG*
Metals QC (1 per 20)	*3-oz/60 g*	*Glass*	*Chill or Freeze*	*-20 °/4±2 °C*	*180 d*	*AWHG*

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

[3]GEO: GeoPlan Associates; AWHG: Alpha Woods Hole Group

Table 6-1 Calibration Frequency and Criterion for Laboratory Instrumentation

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
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-AES Metals	Initial: Daily	Initial: Minimum of three standards and calibration blank. ~50, 200, 1000μg/L	Initial: r >0.995
	Continuing: Every 10 samples and at the end of the analytical run	Continuing: Mid-point standard of each metal. ~500 μg/L	Continuing: CCV within 10% of true value.

[1]CCC: Calibration Check Compounds (as defined in SW-846 8270C).

Table 8-1 Internal QC Checks

QC Sample*	Units	Grain Size	TOC	Metals	PAHs	*Corrective Action*
Method Blank	Conc	-	< RL	< RL	< RL	*1*
Surrogate Spikes	% Rec	-	-	-	30-150	*2*
Matrix Duplicate	% RPD	20	20	-	35	*3*
Matrix Spike	% Rec	-	-	75-125	30-150	*4*
MSD	% RPD	-	-	20	50	*5*
LCS	% Rec	-	80-120	80-120	30-150	*6*
SRM	% Rec	-	WIL	WIL	WIL	*7*

Corrective Action Codes:

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

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

3 Flag results, narrate and discuss with Project Chemist.

4. If LCS (and SIS) are within specifications, flag results. If ND results contain high bias, narrate, otherwise re-prepare and re-analyze affected samples.

5 Investigate, re-analyze or flag results – organics: per CA code #4.

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

7 Report, flag results and narrate.

Figure 1 NLDS/Seawolf Location

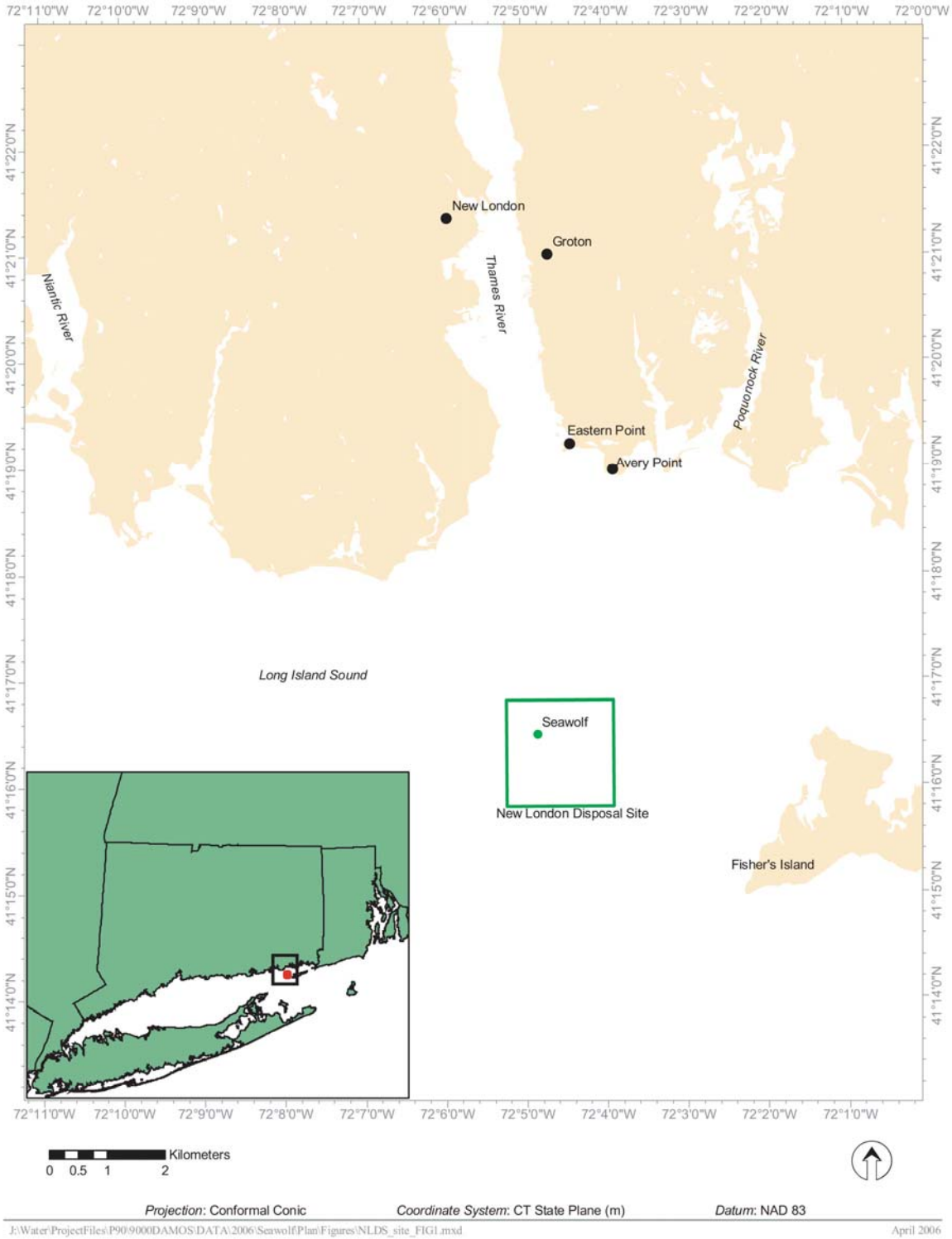


Figure 2 Multi-Beam Survey Boundaries

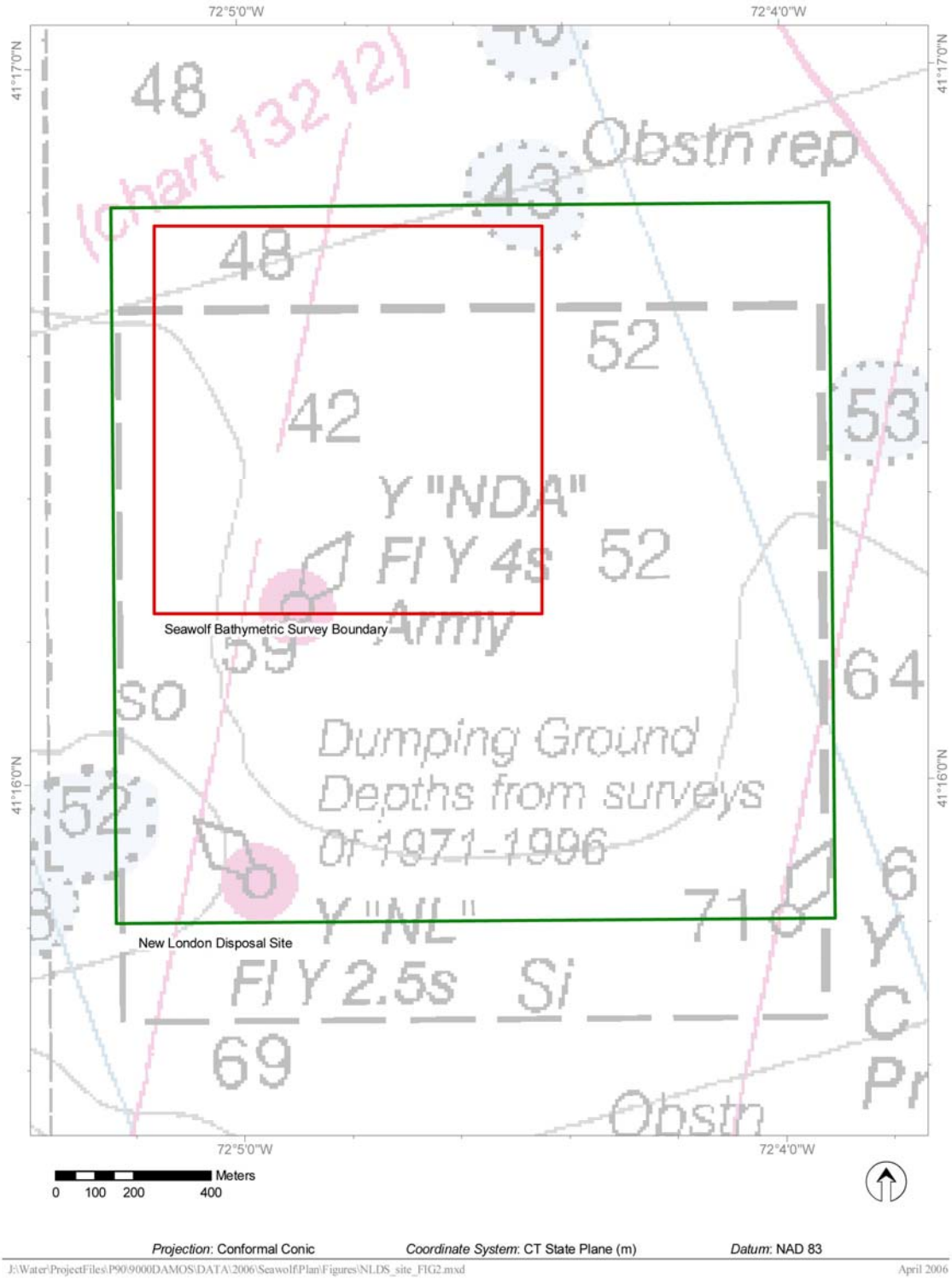


Figure 3 Sediment Coring Locations

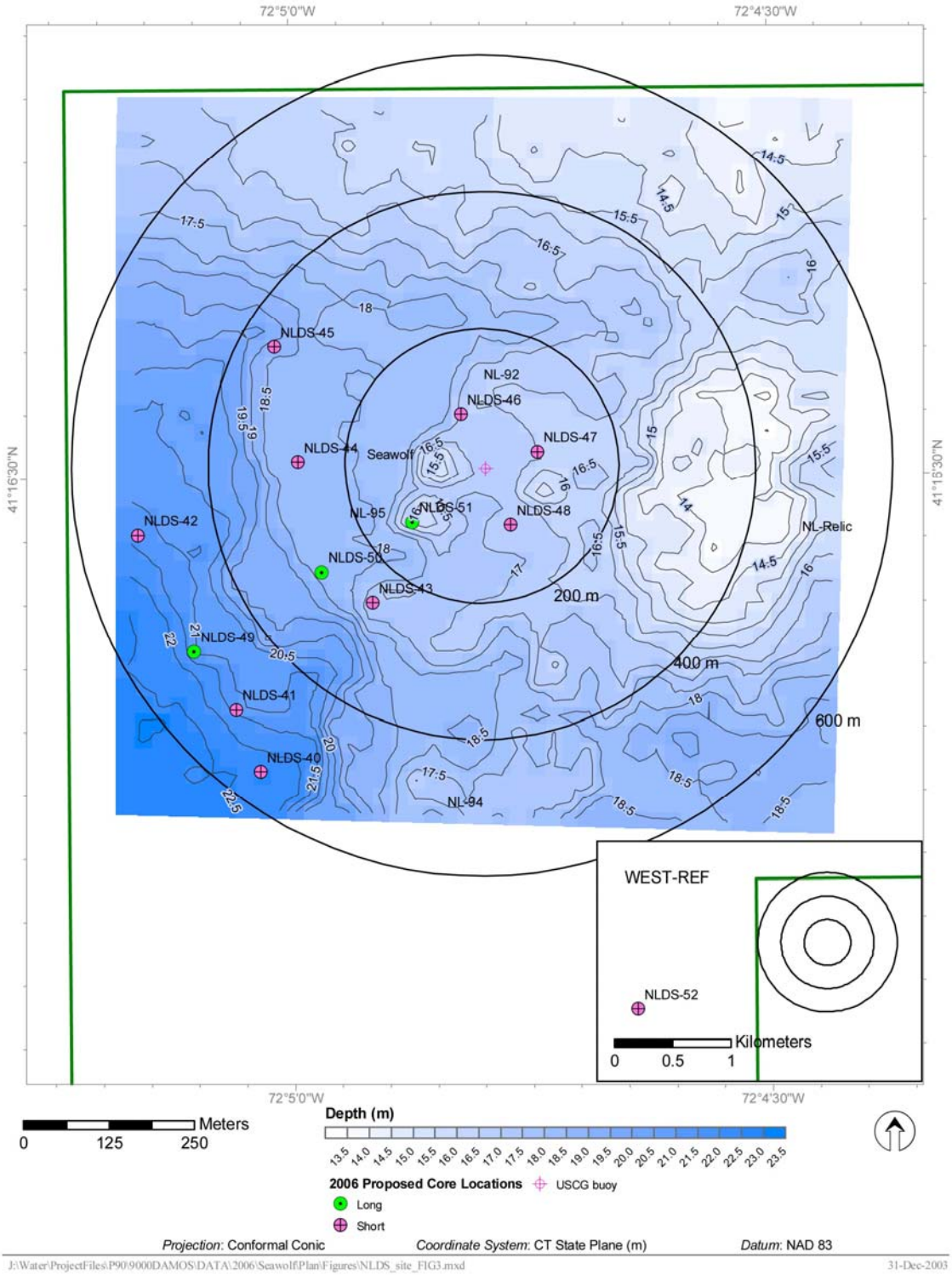


Figure 4 Sediment Profile Imaging Stations – Seawolf

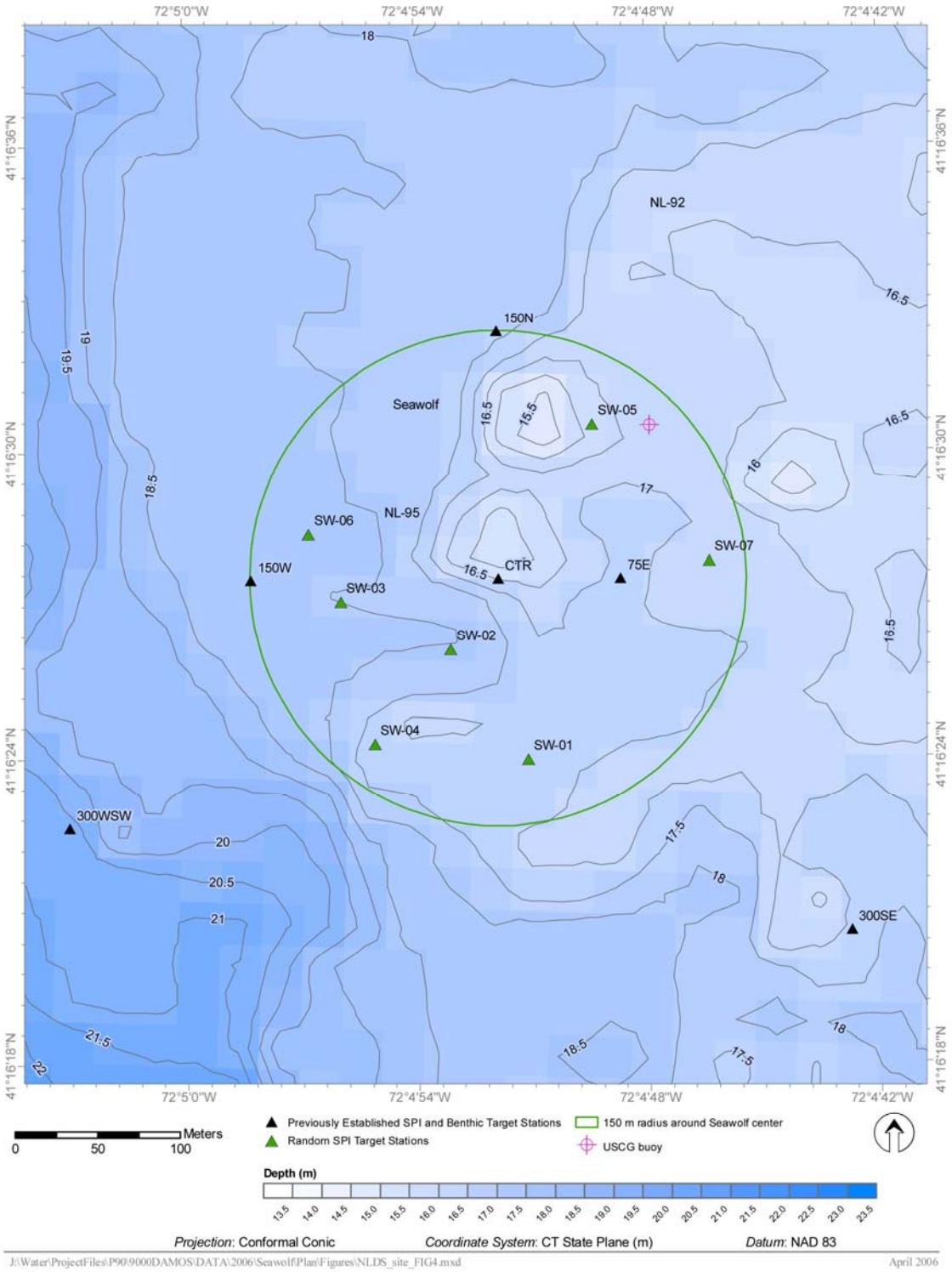
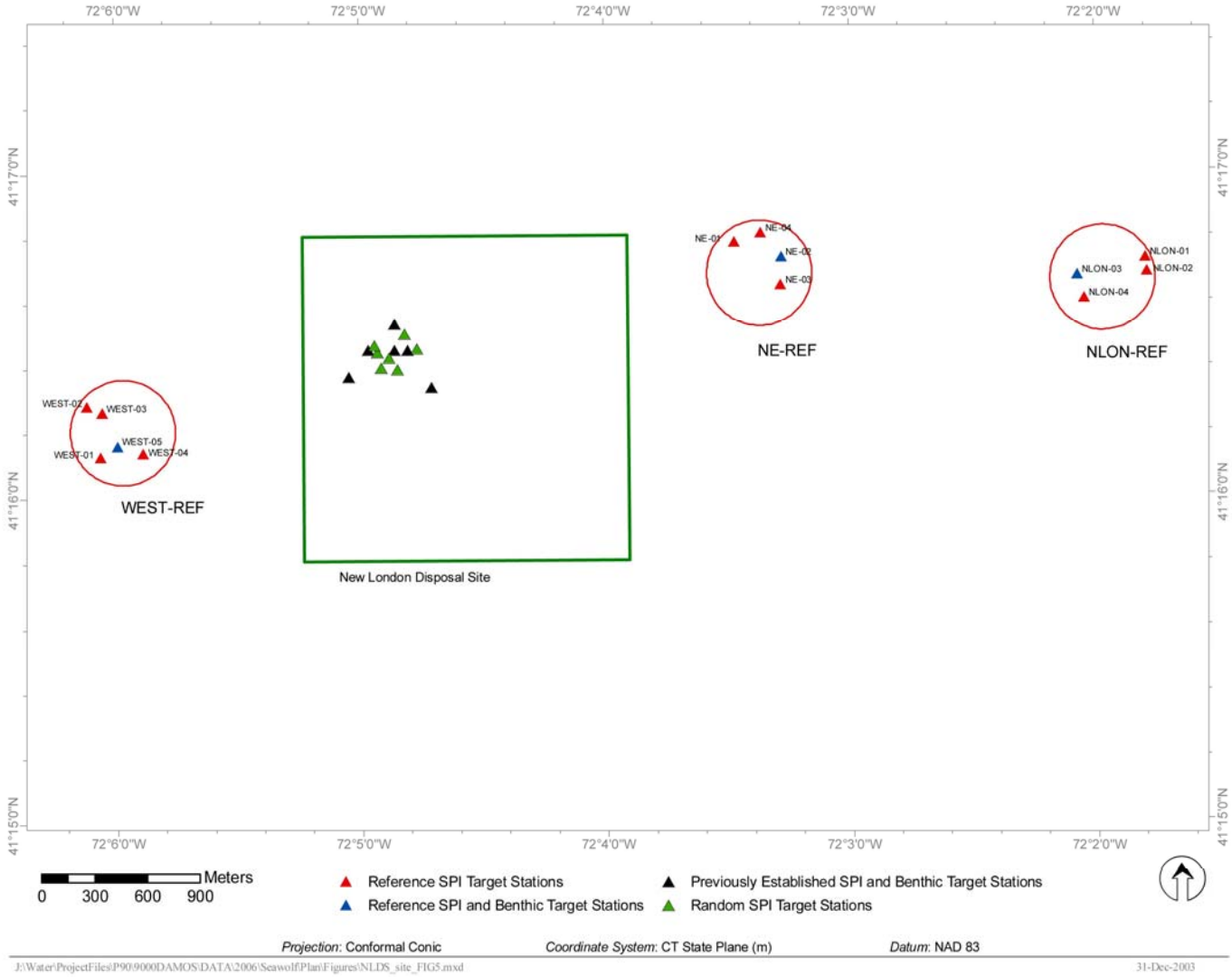


Figure 5 Sediment Profile Imaging Stations – NLDS Reference Stations



Appendix B

Sediment Core Logs

AECOM

Client: USACE		CORE NO: 11-A
Project Number: 60161771-220		
Station Location: SEAWOLF Disposal Mound - NLDS		
GPS Coordinates: 1184158.94 E 661250.52 N		
Geographic Reference: Long Island Sound New London, Connecticut (feet)		Sheet: 1 of 1
Water Depth: 60.6 ft	MLW:	Core Size (in.)
Weather: overcast	Seas:	3 5/8
Survey Vessel: Candu	Logged By: SB	Date: 9/13/10 Time: 1430
Survey Personnel: SB, RM		
Sampling Equipment: Vibracore		
Estimated Penetration Range:	Project Depth :	
Actual Penetration): ~~3.8~~ 4.0'	Recovery: 3.8'	% Recovery: No. Attempts: 1

Depth (cm)	SKETCH	DESCRIPTION
		0-4cm MED. GREY SILT/CLAY w/ SOME FINE SAND, SMALL PEBBLES AND SOME SHELL FRAG
10		4-7cm MED GREY SILT/CLAY w/ SHELL FRAG
		7-16 cm MED. GREY SILT/CLAY w INCREASED MOISTURE
20		16 - 74cm MED GREY SILT/CLAY (DRIER) w/ SPORADIC SHELL FRAG
		3cm MUSSEL SHELL AT 56 cm
30		DARK STREAK AT 71cm
		74 cm EOC
40		
50		
60		

Core Recovery Calculation:		
Starting Barrel Depth (A):		
Final Barrel Depth (B):		
Penetration Depth (C) = (B) – (A)		
Measured Core Recovery (D):		
% Recovery = [(D) / (C)] x 100:		

AECOM	Client: USACE			CORE NO: 20-A
	Project Number: 60161771-220			
	Station Location: SEAWOLF Disposal Mound - NLDS			
	GPS Coordinates: 1183592.70 E 662265.83 N			
	Geographic Reference: Long Island Sound, New London, Connecticut (feet)			Sheet: 1 of 1
	Water Depth: 63.8 ft	MLW:		Core Size (in.)
	Weather: overcast	Seas:		3 5/8
Survey Vessel: Candu	Logged By: SEAB	Date: 9/13/10		Time: 1332
Survey Personnel: SEAB, RM				
Sampling Equipment: Vibracore				
Estimated Penetration Range:	Project Depth :			
Actual Penetration): 4.0 ft	Recovery: 41.5	% Recovery:		No. Attempts: 1

Depth (cm)	SKETCH	DESCRIPTION
		0-3 cm MED. GREY SILT/CLAY w/ MEDIUM SIZED SHELL FRAG AND SOME FINE SAND
		1.5cm WOOD CHUNK AT 5cm
10		
		3-10 cm MED GREY SILT/CLAY w/ SOME FINE SAND
		10 - 72.5cm MED GREY SILT/CLAY
20		
		72.5 EOC
30		
40		
50		
60		

Core Recovery Calculation:		
Starting Barrel Depth (A):		
Final Barrel Depth (B):		
Penetration Depth (C) = (B) – (A)		
Measured Core Recovery (D):		
% Recovery = [(D) / (C)] x 100:		

AECOM

Client: USACE		CORE NO: 24-A
Project Number: 60161771-220		
Station Location: SEAWOLF Disposal Mound - NLDS		
GPS Coordinates: 1184236.30 E 661570.61 N		
Geographic Reference: Long Island Sound New London, Connecticut (feet)		Sheet: 1 of 1
Water Depth: 60.5 ft	MLW:	Core Size (in.)
Weather: overcast	Seas:	3 5/8
Survey Vessel: Canada	Logged By: SEB	Date: 9/13/10 Time: 1300
Survey Personnel: SB, RM		
Sampling Equipment: Vibracore		
Estimated Penetration Range:	Project Depth :	
Actual Penetration): 4.3 ft	Recovery: 44.75" % Recovery:	No. Attempts: 1

Depth (cm)	SKETCH	DESCRIPTION
		0-7 cm VERY FINE SILT CLAY MEDIUM GREY
		2-4cm WOOD CHUNK (4cm) W/ SHELL FRAG
10		(7-10 cm Pocket of FINE SAND) HIGHER MOISTURE CONTENT TO 20cm
		7-21 cm FIRM SILT / CLAY (MED GREY)
20		21-91 FIRM GREY SILT/CLAY W/ SHELL HASH SPORADIC THROUGHOUT SMALL POCKET AT 65cm
		(27-31 DARKER GREY BAND)
30		91-96 DARKER GREY CLAY/SILT SAME TEXTURE AS ABOVE
		96-113 cm MED GREY CLAY/SILT TO EOC
40		
		EOC 113 cm
50		WHEN PROCESSING/HOMOGENIZING, SMALL BROWNISH NODES NOTICED IN SEDIMENT
60		

Below 25 cm sediment dries noticeably

Core Recovery Calculation:		
Starting Barrel Depth (A):		
Final Barrel Depth (B):		
Penetration Depth (C) = (B) – (A)		
Measured Core Recovery (D):		
% Recovery = [(D) / (C)] x 100:		

AECOM

Client: USACE
Project Number: 60161771-220
Station Location: SEAWOLF Disposal Mound - NLDS
GPS Coordinates: 1182519.54 E 661351.97 N
Geographic Reference: Long Island Sound
New London, Connecticut
Water Depth: 71.1' (feet) MLW:
Weather: Sunny, light wind Seas:

CORE NO: SB 42-A (1)
Sheet: 1 of 1
Core Size (in.): 3 5/8

Survey Vessel: Candu | Logged By: SB | Date: 9/14/10 | Time: 836
Survey Personnel: SB, RM
Sampling Equipment: Vibracore
Estimated Penetration Range: | Project Depth :
Actual Penetration): 4' | Recovery: 40" | % Recovery: | No. Attempts: 1

Depth (cm)	SKETCH	DESCRIPTION
		0-3cm FINE GREY SAND w/ SHELL FRAG
		3-11 cm SHELL FRAG MED. GREY CLAY/SILT w/ POCKETS OF FINE-MED SAND AND SHELL FRAG
10		
		11-19 MED GREY SILT/CLAY w/ SOME FINE SAND - INCREASED MOISTURE
		STELLS 1 cm SHELL PEBBLE
		19-28 FINE SAND w/ SOME SILT/CLAY SHELL FRAG
20		28-48cm FINE SAND w/ CLAY SILT DOMINATED BY LARGE SHELL FRAG
30		48-52cm TRANSITION DARK TO LIGHT GREY SAND w/ SHELL FRAG POCKET
		52-94 LIGHT GREY FINE SAND w/ VISIBLE LAYERING
40		
		DARK ~~ORGANIC~~(?) LAYER AT 68cm
		MINERALOGY MICA FLAKES
50		
		94cm EOC
60		

Core Recovery Calculation:

Starting Barrel Depth (A):	
Final Barrel Depth (B):	
Penetration Depth (C) = (B) – (A)	
Measured Core Recovery (D):	
% Recovery = [(D) / (C)] x 100:	

AECOM	Client: USACE			CORE NO: 42 (2)
	Project Number: 60161771-220			
	Station Location: SEAWOLF Disposal Mound - NLDS			
	GPS Coordinates: 1182521.27 E 661350.69 N			
	Geographic Reference: Long Island Sound New London, Connecticut (feet)			Sheet: 1 of 1
	Water Depth: 71.1'	MLW:		Core Size (in.)
	Weather: sunny, light wind	Seas:		3 5/8
Survey Vessel: Candu	Logged By: SB	Date: 9/14/10		Time: 0857
Survey Personnel: SB, RM				
Sampling Equipment: Vibracore				
Estimated Penetration Range:	Project Depth :			
Actual Penetration): 47'	Recovery: 47"	% Recovery:		No. Attempts: 1

Depth (cm)	SKETCH	DESCRIPTION
10		0-60 cm FINE SAND WITH SHELL HASH MEDIUM GREY COLOR THEN HIGHER WATER CONTENT WITH SOME DARKER PARCHES AND PERHAPS
20		INCREASED SILT CONTENT TO 33 cm THEN MORE UNIFORM (MEDIUM) GREY (LESS SILT?) TO 46 cm THEN INCREASED SAND CONTENT (FINE)
30		WITH MUCH LESS MOISTURE TO EOC AT 69.5 cm SOME MICA STRIATIONS ↳ (MICA FINE FRAGMENTS)
40		
50		EOC 69.5 cm
60		

	Core Recovery Calculation:		
	Starting Barrel Depth (A):		
	Final Barrel Depth (B):		
	Penetration Depth (C) = (B) – (A)		
	Measured Core Recovery (D):		
	% Recovery = [(D) / (C)] x 100:		

AECOM

Client: USACE			CORE NO: 42 (3)
Project Number: 60161771-220			
Station Location: SEAWOLF Disposal Mound - NLDS			
GPS Coordinates: 1182525.43 E 661354.79 N			
Geographic Reference: Long Island Sound New London, Connecticut (feet)			Sheet: 1 of 1
Water Depth: 71.1'	MLW:		Core Size (in.)
Weather:		Seas:	3 5/8
Survey Vessel: Candu	Logged By: SB	Date: 9/14/10	Time: 913
Survey Personnel: SB, RM			
Sampling Equipment: Vibracore			
Estimated Penetration Range:	Project Depth :		
Actual Penetration): 4'	Recovery: 44.5"	% Recovery:	No. Attempts: 1

Depth (cm)	SKETCH	DESCRIPTION
		0-2 cm GREY FINE SAND
		2-5 cm GREY FINE SAND w/ SILT/CLAY + SHELL HASH
10		5-12 MED GREY SILT/CLAY w/ SHELL FRAG + INCREASED MOISTURE
		12-37 cm MED GREY SILT/CLAY w FINE SAND AND SHELL HASH. INCREASED MOISTURE
20		37-49 cm FINE SAND w/ SOME SILT/CLAY DOMINATED BY SHELL FRAGMENTS
		49-58 cm DARKER GREY SAND w/ LITTLE SILT SHELL FRAG
30		58-62 TRANSITION ZONE OF DARK GREY TO LIGHT GREY FINE SAND
		62-77 LIGHT GREY FINE SAND w/ SOME DARKER BANDING (SOME SILT)
40		77-83 LIGHT GREY FINE SAND (RED OXIDIZED IRON BAND?)
		83-94 LIGHT GREY FINE SAND w/ SOME SILT DARKER BANDING AND MICA FLAKES PRESENT
		94-98 LIGHT GREY
50		98-106 DARKER GREY FINE SAND w/ SOME SILT EOC
		EOC 106
60		

Core Recovery Calculation:		
Starting Barrel Depth (A):		
Final Barrel Depth (B):		
Penetration Depth (C) = (B) – (A)		
Measured Core Recovery (D):		
% Recovery = [(D) / (C)] x 100:		

AECOM	Client: USACE			CORE NO: 46
	Project Number: 60161771-220			
	Station Location: SEAWOLF Disposal Mound - NLDS			
	GPS Coordinates: 1184069.31 E 661936.12 N			
	Geographic Reference: Long Island Sound New London, Connecticut (feet)			Sheet: 1 of 1
	Water Depth: 58.5'	MLW:		Core Size (in.)
	Weather: sunny		Seas:	3 5/8
Survey Vessel: Conan	Logged By: SB		Date: 9/14/10	Time: 1101
Survey Personnel: SB, RM				
Sampling Equipment: Vibracore				
Estimated Penetration Range:	Project Depth :			
Actual Penetration): 4'	Recovery: 46"		% Recovery:	No. Attempts: 1

Depth (cm)	SKETCH	DESCRIPTION
		0-5 cm DARK GREY SOFT SILT/CLAY W/ SOME FINE SAND SOME SHELL FRAG
10		5-52 cm MED. GREY SILT/CLAY
		BROWN DIME SIZE CIRCLE AT 7 cm
20		52-79 DARKER GREY SILT/CLAY W/ DARK STREAKING + SOME SHELL FRAG EOC
		SOME SHELL FRAG AT DEPTH
30		79 cm EOC
40		
50		
60		

	Core Recovery Calculation:		
	Starting Barrel Depth (A):		
	Final Barrel Depth (B):		
	Penetration Depth (C) = (B) – (A)		
	Measured Core Recovery (D):		
	% Recovery = [(D) / (C)] x 100:		

AECOM

Client: USACE		CORE NO: 47-A SB
Project Number: 60161771-220		
Station Location: SEAWOLF Disposal Mound - NLDS		
GPS Coordinates: 1184432.13 E 661760.12 E		
Geographic Reference: Long Island Sound New London, Connecticut (feet)		Sheet: 1 of 1
Water Depth: 57'	MLW:	Core Size (in.)
Weather: cloudy, some sun	Seas:	3 5/8
Survey Vessel: Condu	Logged By: SB	Date: 9/13/10 Time: 1803
Survey Personnel: SB, RM		
Sampling Equipment: Vibracore		
Estimated Penetration Range:	Project Depth :	
Actual Penetration): < 4' exact UNKNOWN due to stony currents	Recovery: 30"	% Recovery: No. Attempts: 1

Depth (cm)	SKETCH	DESCRIPTION
10		0-3 cm very fine silt/clay medium grey with high water content then firm silt clay (med grey) to 37 cm with large shell pieces at 15cm and 25cm. Also pebble 2x3cm at 35cm
20		(dark striations 20-24 cm)
30		37-65 cm increased dark material contained (heterogeneous) and material breaks apart rather than slicing, smoothly (less water? more clay?)
40		then dark horizon 65-71 cm with some fine shell material (matrix still predominantly fine grained)
50		then medium grey (lighter) clay rich material 71 - EOC at 76.5 cm - large shell piece embedded at 75 cm
60		EOC = 76.5 cm

Core Recovery Calculation:		
Starting Barrel Depth (A):		
Final Barrel Depth (B):		
Penetration Depth (C) = (B) – (A)		
Measured Core Recovery (D):		
% Recovery = [(D) / (C)] x 100:		

AECOM

Client: USACE			CORE NO: SB 48-A (1)
Project Number: 60161771-220			
Station Location: SEAWOLF Disposal Mound - NLDS			
GPS Coordinates: 1184301.94 E 661403.74 N			Sheet: 1 of 1
Geographic Reference: Long Island Sound, New London, Connecticut (feet)			
Water Depth: ~~61.0'~~ 60.0'	MLW:		Core Size (in.)
Weather: sunny w/some clouds		Seas:	3 5/8
Survey Vessel: Candu	Logged By: BB	Date: 9/13/10	Time: 1621
Survey Personnel: SB, RM			
Sampling Equipment: Vibracore			
Estimated Penetration Range:	Project Depth :		
Actual Penetration): 5'	Recovery: 5'	% Recovery:	No. Attempts: 1

Depth (cm)	SKETCH	DESCRIPTION
10		0-4cm MED GREY CLAY/SILT EXTERIOR w/ DARK GREY INTERIOR LARGE MUSSEL SHELL w/ TRACE FINE SAND SHELL FRAG
		4-8 cm DARKER GREY SILT/CLAY w/ SOME SHELL FRAG HIGH MOISTURE CONTENT TO ~ 55CM
20		8-23 MED GREY SILT/CLAY w/ TRACE FINE SAND AND SHELL FRAG 6cm ROCK AT 13cm
30		23-55 MED GREY SILT/CLAY w/ FINE SAND DOMINATED BY CLAM + MUSSEL SHELL FRAG POCKETS OF DARK GREY MATERIAL (AS 0-4cm) w/ VERY 'BRINE-Y' ODOR
40		55-81.5cm MED GREY SILT/CLAY w/ TRACE FINESAND MUSSEL SHELL AT 60cm
50		81.5 EOC
60		

Core Recovery Calculation:		
Starting Barrel Depth (A):		
Final Barrel Depth (B):		
Penetration Depth (C) = (B) – (A)		
Measured Core Recovery (D):		
% Recovery = [(D) / (C)] x 100:		

AECOM	Client: USACE 1184361.97 E			CORE NO: SB 48-A(2)
	Project Number: 60161771-220 / 661413.67 N			
	Station Location: SEAWOLF Disposal Mound - NLDS			
	GPS Coordinates: ~~1184301.97~~ E ~~661463.74~~ N			
	Geographic Reference: Long Island Sound New London, Connecticut (feet)			Sheet: 1 of 1
	Water Depth: 59.5'	MLW:		Core Size (in.)
	Weather: cloudy	Seas:		3 5/8
Survey Vessel: Candu	Logged By: BB	Date: 9/13/10		Time: 1646
Survey Personnel:				
Sampling Equipment: Vibracore				
Estimated Penetration Range:	Project Depth :			
Actual Penetration): 4.0'	Recovery: 39"	% Recovery:		No. Attempts: 1

Depth (cm)	SKETCH	DESCRIPTION
10		0-11 cm MED GREY SILT/CLAY, W/ FINE SAND AND LARGE MUSSEL SHELL FRAG / DARK GREY INTERIOR MATERIAL W/ HIGH MOISTURE CONTENT AND BRINE ODOR
20		11-23 cm MED GREY SILT/CLAY
30		23-73 cm SLIGHTLY DARKER GREY SILT/CLAY W/ SPORADIC SHELL HASH THROUGHOUT DRIER THAN ABOVE HORIZONS 73 cm EOC
40		
50		
60		

Core Recovery Calculation:		
Starting Barrel Depth (A):		
Final Barrel Depth (B):		
Penetration Depth (C) = (B) – (A)		
Measured Core Recovery (D):		
% Recovery = [(D) / (C)] x 100:		

PHOTO TAKEN OF TOP 10 cm TO ILLUSTRATE DARK GREY INTERIOR MATERIAL W/ BRINEY ODOR

AECOM

Client: USACE 1184301.09 E			CORE NO: SB 48-X(3)
Project Number: 60161771-220 661406.65 N			
Station Location: SEAWOLF Disposal Mound - NLDS			
GPS Coordinates: ~~1184301.94 E 661403.74 N~~			
Geographic Reference: Long Island Sound New London, Connecticut (feet)			Sheet: 1 of 1
Water Depth: 59.2'	MLW:		Core Size (in.)
Weather: Overcast		Seas:	3 3/8
Survey Vessel: Candu	Logged By: SB	Date: 9/13/10	Time: 1710
Survey Personnel: SB, RM			
Sampling Equipment: Vibracore			
Estimated Penetration Range:	Project Depth :		
Actual Penetration): 4'	Recovery: 47.5"	% Recovery:	No. Attempts: 1

Depth (cm)	SKETCH	DESCRIPTION
		0-7 cm MED GREY SILT/CLAY W/ FINE SAND AND MUSSEL SHELLS AND HIGH MOISTURE CONTENT
10		7-20 cm MED GREY SILT/CLAY W/ TRACE FINE SAND AND HIGH MOISTURE CONTENT
20		20-36 cm MED GREY SILT/CLAY W/ TRACE FINE SAND
		36-42 cm MED. SAND W/ SILT/CLAY
30		42-48 cm MED GREY SILT/CLAY W/ MED SAND
		48-68 cm MED GREY SILT/CLAY W/ TRACE FINE SAND
40		68-70 cm MED GREY SILT/CLAY W/ MED. SAND + SHELL FRAG
		70-73 cm MED GREY SILT/CLAY W/ SOME SHELL FRAG
50		73-79 cm MED GREY SILT/CLAY W/ FINE SAND + SHELL FRAG
		79 cm EOC
60		

Core Recovery Calculation:		
Starting Barrel Depth (A):		
Final Barrel Depth (B):		
Penetration Depth (C) = (B) – (A)		
Measured Core Recovery (D):		
% Recovery = [(D) / (C)] x 100:		

AECOM	Client: USACE	CORE NO: 50-A SB
	Project Number: 60161771-220	
	Station Location: SEAWOLF Disposal Mound - NLDS	
	GPS Coordinates: 1183397.27 E 661175.79 N	
	Geographic Reference: Long Island Sound New London, Connecticut (feet)	Sheet: 1 of 1
	Water Depth: ~~65.6~~ 64.1' MLW:	Core Size (in.)
	Weather: Cloudy w/ some sun Seas:	3 5/8

Survey Vessel: Candu	Logged By: SB	Date: 9/13/10	Time: 1535
Survey Personnel: SB, RM			
Sampling Equipment: Vibracore			
Estimated Penetration Range:	Project Depth :		
Actual Penetration): 4.0'	Recovery: 44"	% Recovery:	No. Attempts: 1

Depth (cm)	SKETCH	DESCRIPTION
		0-4 cm MED GREY SILT/CLAY W/ SOME FINE SAND AND SHELL FRAG
10		4-73 cm MED GREY SILT CLAY W/ TRACE FINE SAND INTERMITENT SHELL FRAG
		2cm shell at 19cm
20		VERTICAL DARK STREAK AT 14 cm (2cm long)
		73 cm EOC
30		
40		
50		
60		

Core Recovery Calculation:			
Starting Barrel Depth (A):			
Final Barrel Depth (B):			
Penetration Depth (C) = (B) – (A)			
Measured Core Recovery (D):			
% Recovery = [(D) / (C)] x 100:			

AECOM

Client: USACE		CORE NO: 51-X SD
Project Number: 60161771-220		
Station Location: SEAWOLF Disposal Mound - NLDS		
GPS Coordinates: 1183834.63 E 661419.33 N		
Geographic Reference: Long Island Sound New London, Connecticut (Feet)		Sheet: 1 of 1
Water Depth: 56.9'	MLW:	Core Size (in.)
Weather: overcast	Seas:	3 5/8
Survey Vessel: Candu	Logged By: SEB	Date: 9/13/10 Time: 1500
Survey Personnel: SB, RM		
Sampling Equipment: Vibracore		
Estimated Penetration Range:	Project Depth :	
Actual Penetration): ~~4.0'~~ 5.0'	Recovery: 4'10"	% Recovery: No. Attempts: 1

Depth (cm)	SKETCH	DESCRIPTION
10		0-29 cm MED. GREY SILT/CLAY w/ SOME SHELL FRAGMENTS LIGHT MOISTURE CONTENT SOME DARK STREAKING PEBBLE AT 27cm
20		29-40 cm MEDIUM - COARSE SAND w/ LARGE PEBBLES @ 2cm @ ~7cm @ 5cm 40-44 cm DARK GREY SILT/CLAY
30		44-48 cm DARK GREY SILT/CLAY w/ INCREASED MOISTURE AND SOME FINE SAND/SHELLS 48-60 cm MED. GREY SILT/CLAY w/ INCREASED MOISTURE AND SOME FINE SAND
40		60-100 cm MED. GREY SILT/CLAY MUCH DRIER 100-115 cm MED. GREY w/ DARK STREAKING SLIGHT DRIER
50		115-139 DARKER GREY SILT/CLAY PEBBLE AT 118cm w/ FINE SAND SOME SHELL FRAG 139-147 DARK GREY MED. COARSE SAND w/ 1cm PEBBLES DARKER MED. SULFIDE ODOR AT DEPTH EOC
60		

Core Recovery Calculation:		
Starting Barrel Depth (A):		
Final Barrel Depth (B):		
Penetration Depth (C) = (B) – (A)		
Measured Core Recovery (D):		
% Recovery = [(D) / (C)] x 100:		

AECOM

Client: USACE		CORE NO: 52 (1)
Project Number: 60161771-220		
Station Location: SEAWOLF Disposal Mound - NLDS		
GPS Coordinates: 1178825.15 E 659817.72 N		
Geographic Reference: Long Island Sound New London, Connecticut (feet)		Sheet: 1 of 1
Water Depth: 74.0'	MLW:	Core Size (in.)
Weather: Sunny	Seas:	3 5/8
Survey Vessel: Canau	Logged By: SB	Date: 9/14/10 Time: 953
Survey Personnel: SB, RM		
Sampling Equipment: Vibracore		
Estimated Penetration Range:	Project Depth :	
Actual Penetration): >4'	Recovery: SB ~~50.5"~~ 48.0"	% Recovery: No. Attempts: 1

Depth (cm)	SKETCH	DESCRIPTION
10		0-2 cm MEDIUM GREY (5Y5/1) - FINE SAND WITH SHELL HASH THEN SLIGHTLY DARKER MIXED IN TO 12 cm
20		THEN LIGHTER GREY WITH LARGER SHELL PIECES TO 22 cm
30		MOR INCREASED WATER CONTENT 22-44 cm
40		THEN SOME FINER (CLAY?) MATERIAL COMMINGLED TO WITH SHARP ENTHERFACE (I/F) AT 54-58 cm
50		THEN CLAY RICH TO 67 cm WITH NARROW HORIZON OF COARSER MATERIAL & SHELL PIECES ~0.5 cm THICK, THEN CLAY RICH TO EOC AT 73 cm
60		EOC 73 cm

Core Recovery Calculation:		
Starting Barrel Depth (A):		
Final Barrel Depth (B):		
Penetration Depth (C) = (B) – (A)		
Measured Core Recovery (D):		
% Recovery = [(D) / (C)] x 100:		

AECOM	Client: USACE			CORE NO: 52 (2)
	Project Number: 60161771-220			
	Station Location: SEAWOLF Disposal Mound - NLDS			
	GPS Coordinates: 1178828.10 E 659809.33 N			
	Geographic Reference: Long Island Sound New London, Connecticut (feet)			Sheet: 1 of 1
	Water Depth: 74.1'	MLW:		Core Size (in.)
	Weather: sunny		Seas:	3 5/8
Survey Vessel: candu		Logged By: SB	Date: 9/14/10	Time: 1009
Survey Personnel: SB, RM				
Sampling Equipment: Vibracore				
Estimated Penetration Range:		Project Depth :		
Actual Penetration): 5'		Recovery: 4.8'	% Recovery:	No. Attempts: 1

Depth (cm)	SKETCH	DESCRIPTION
		0-4 cm MED-FINE SAND WITH SHELL HASH MEDIUM GREY IN COLOR
10		THEN DARK GREY TO 6 cm
		THEN BACK TO MEDIUM GREY TO 9 cm
		THEN LIGHTER GREY WITH INCREASED WATER CONTENT 9-24 cm
20		THEN SAME MATERIAL WITH LESS MOISTURE
		24-47.5 cm WITH LARGE SHELL PIECES IN ADDITION TO THE SHELL HASH.
30		THEN LINEAR CLAY "LENSES" IN THE VERTICAL WITHIN THE SAND MATRIX ≈ 6 cm LONG x 0.5 cm WIDE AT CORE CENTER & ALONG BARREL EDGE
		47.5-57.5 = SAND MATRIX WITH CLAY FEATURES &
40		THEN CLAY WITH POCKETS OF SAND TO EOC AT 72.5 cm
50		
		EOC 72.5 cm
60		& CLAY APPEARS TO BE NORMALLY LIKELY AFTER EXAMINING - ONLY SURFACE IMPRESSION WAS LINEAR

Core Recovery Calculation:		
Starting Barrel Depth (A):		
Final Barrel Depth (B):		
Penetration Depth (C) = (B) – (A)		
Measured Core Recovery (D):		
% Recovery = [(D) / (C)] x 100:		

AECOM

Client: USACE		CORE NO: 52 (3)
Project Number: 60161771-220		
Station Location: SEAWOLF Disposal Mound - NLDS		
GPS Coordinates: 1178822.81 E 659812.08 N		
Geographic Reference: Long Island Sound, New London, Connecticut		Sheet: 1 of 1
Water Depth: 73.9' (feet)	MLW:	Core Size (in.)
Weather: Sunny	Seas:	3 5/8
Survey Vessel: Candu	Logged By: SB	Date: 9/14/10 Time: 1025
Survey Personnel: SB, RM		
Sampling Equipment: Vibracore		
Estimated Penetration Range:	Project Depth :	
Actual Penetration): 4'	Recovery: 44.5" % Recovery:	No. Attempts: 1

Depth (cm)	SKETCH	DESCRIPTION
10		0-2cm FINE-MEDIUM SAND, MEDIUM GREY WITH SHELL HASH INTERMIXED THEN GREATER SHELL HASH CONTENT TO 6cm THEN CLAY "NODULE" 6-7cm IMBEDDED IN COARSE MATRIX THEN SAND/CLAY MIXTURE TO 12cm THEN INCREASED WATER CONTENT TO ABOUT 30cm (SAND - FINE MATL - SHELL HASH CONTINUED 12-30cm)
20		THEN SIMILAR MATERIAL, ~~AS~~ BUT LESS MOISTURE TO 50cm
30		THEN INCREASED FINES (CLAY?) AND INCREASED MOISTURE TO 66 cm
40		THEN CLAY/FINE INTERMIXED WITH SAND ↳ SOME LAYERING, SOME IN "POCKET" FORM AS IN SKETCH TO 84 cm :: = SAND =:= = CLAY/FINE
50		84-90 cm FINE SAND/SHELL HASH, INCREASED MOISTURE 90-104cm SOME LAYERING/SOME POCKETS AS ABOVE 84cm BIG SHELL AT 97cm 2cm DIAMETER
60		104-110 FINE SAND W/ SILT CLAY SOME SHELL HASH 110cm EOC 2cm SHELL AT DEPTH

Core Recovery Calculation:		
Starting Barrel Depth (A):		
Final Barrel Depth (B):		
Penetration Depth (C) = (B) – (A)		
Measured Core Recovery (D):		
% Recovery = [(D) / (C)] x 100:		

Appendix C

Sediment Core Profiles

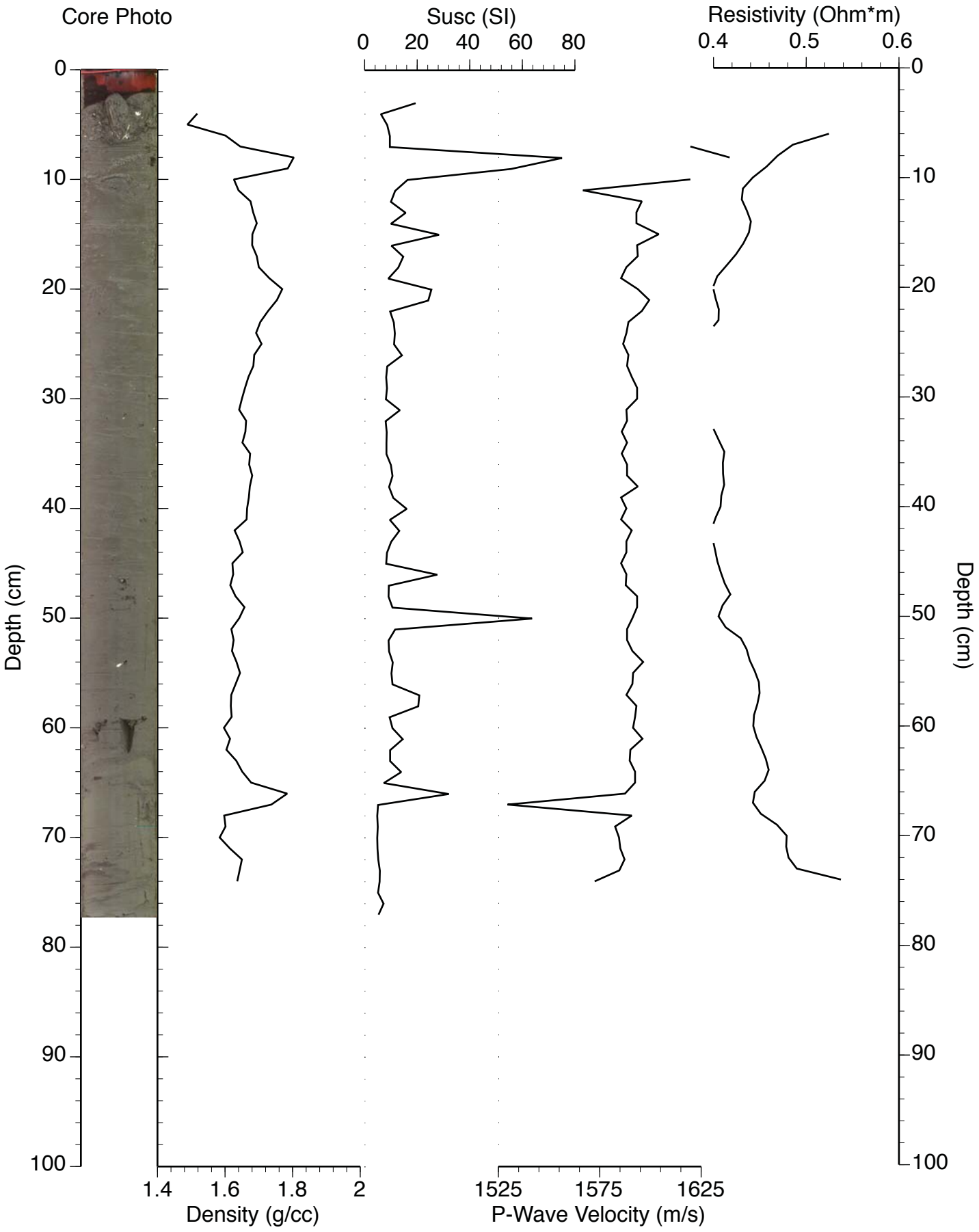


Figure 1. Digital image and core log parameters versus depth for core 11-A

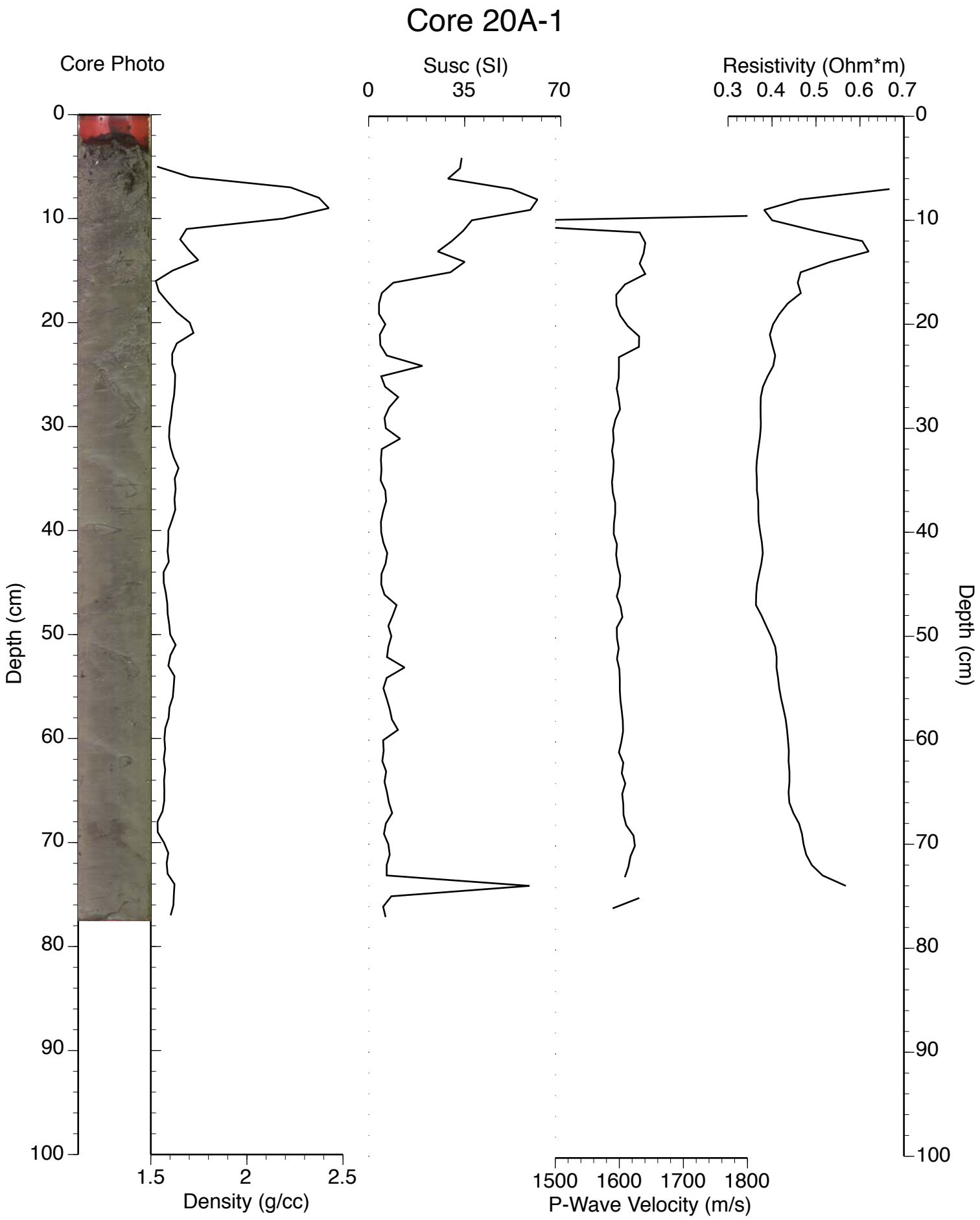


Figure 2. Digital image and core log parameters versus depth for core 20A-1

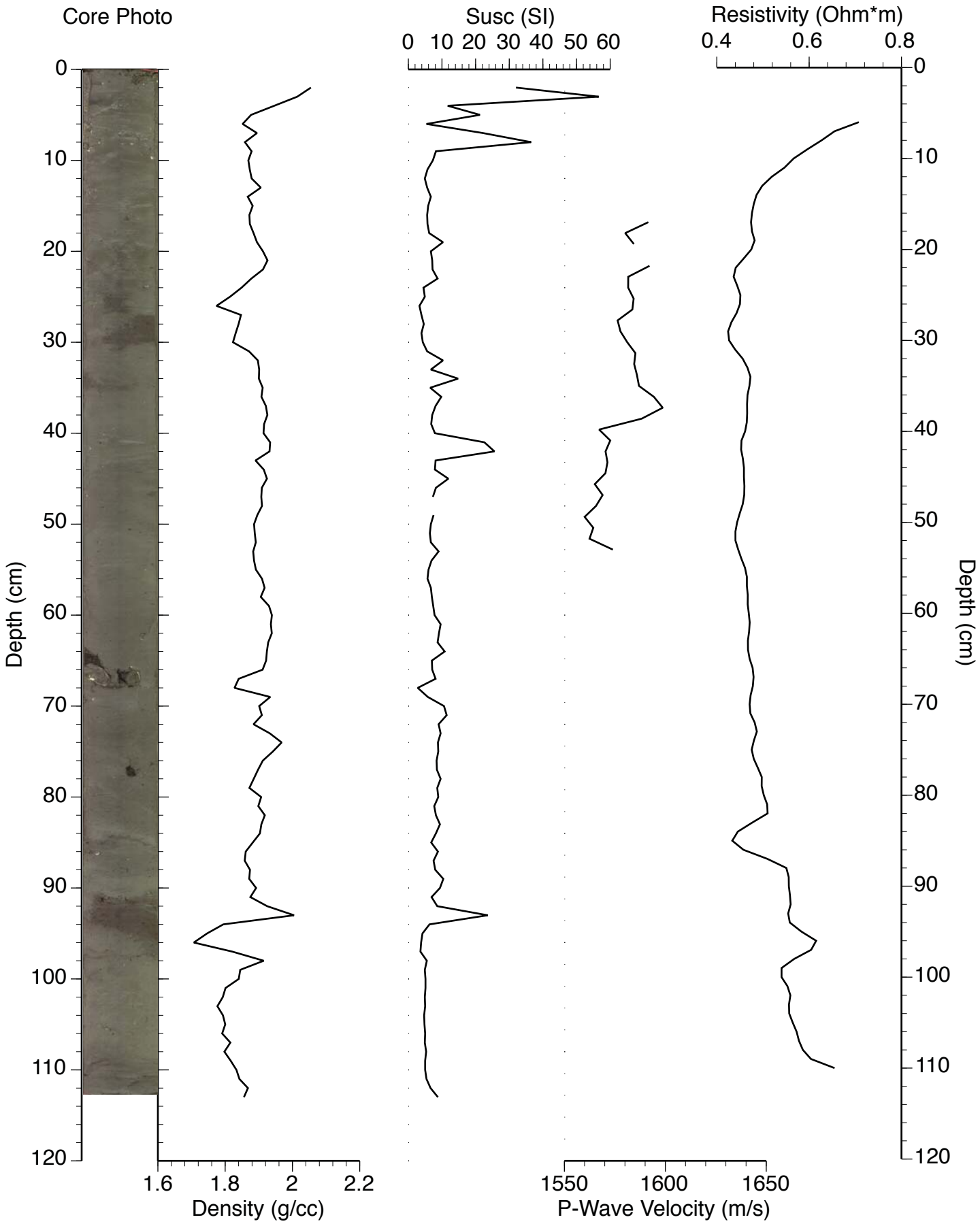


Figure 3. Digital image and core log parameters versus depth for core 24-A

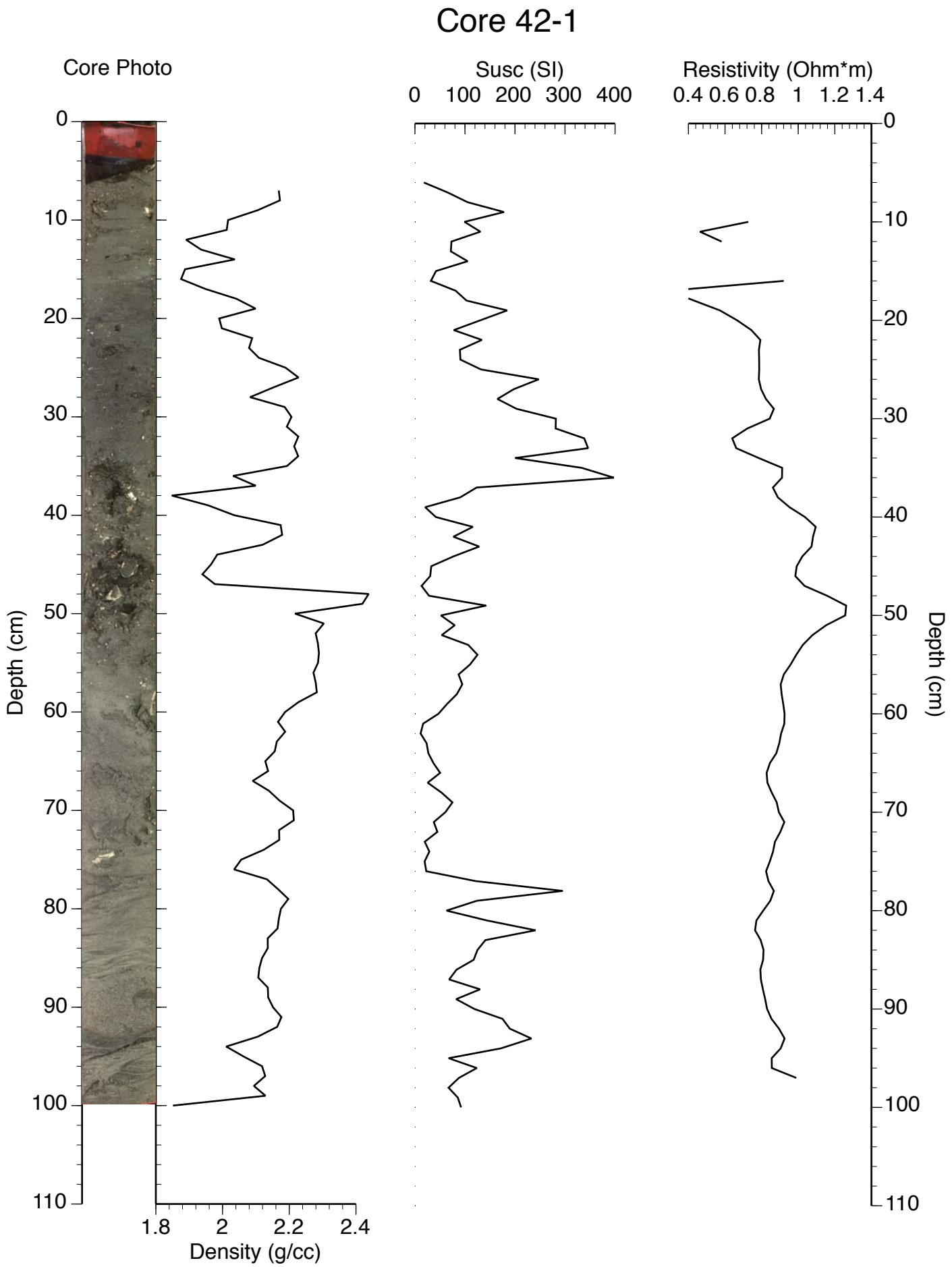


Figure 4. Digital image and core log parameters versus depth for core 42-1

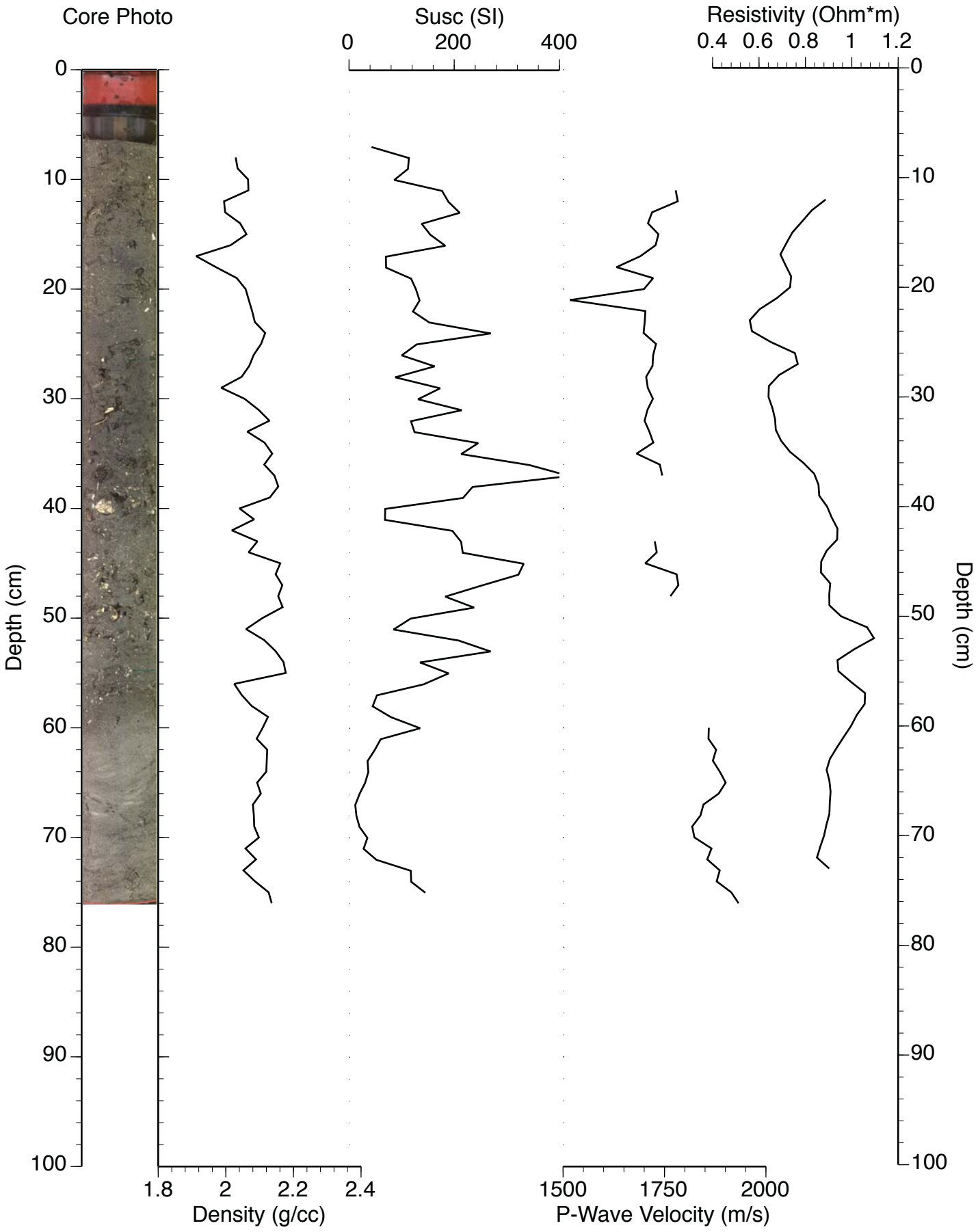


Figure 5. Digital image and core log parameters versus depth for core 42-2

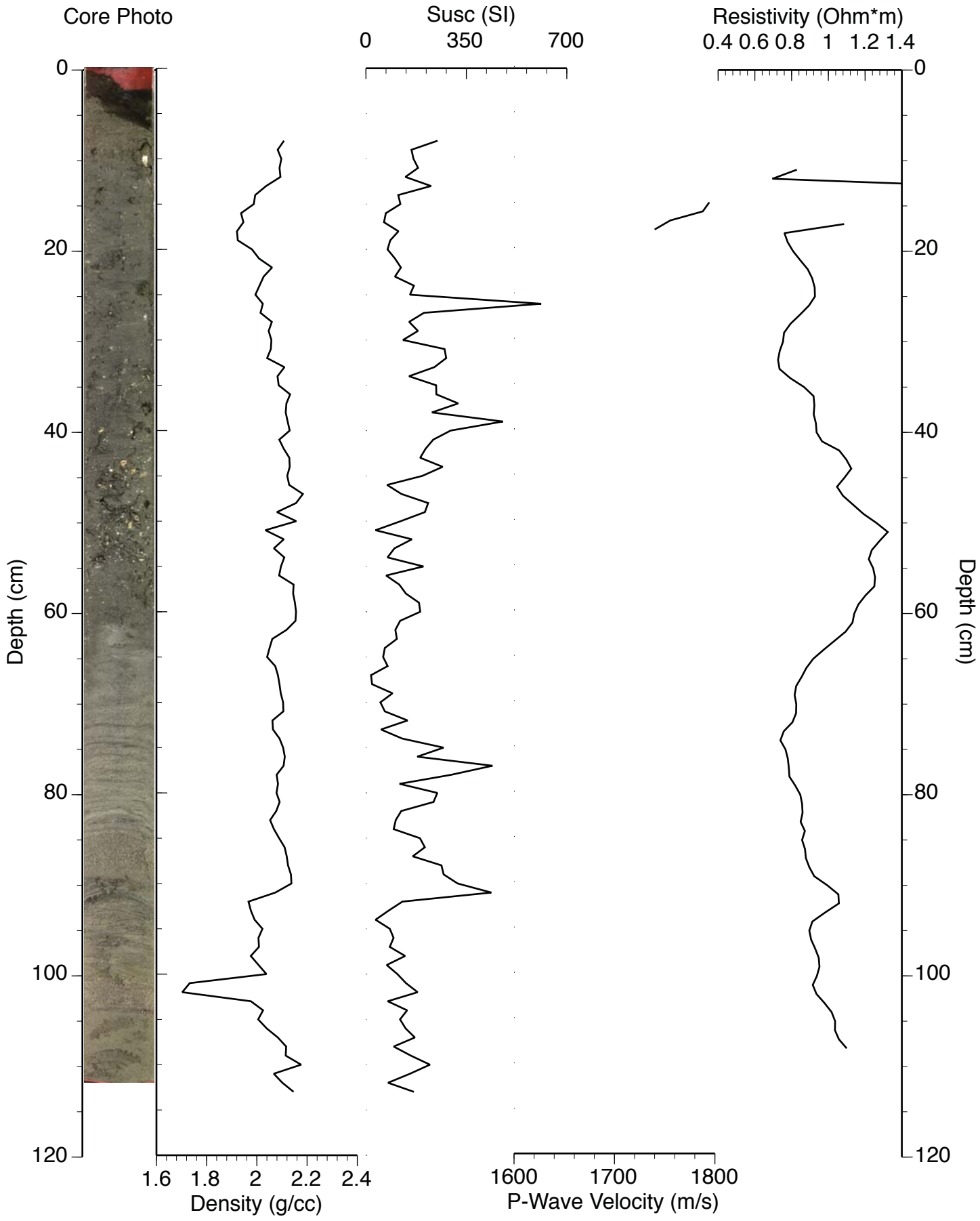


Figure 6. Digital image and core log parameters versus depth for core 42-3

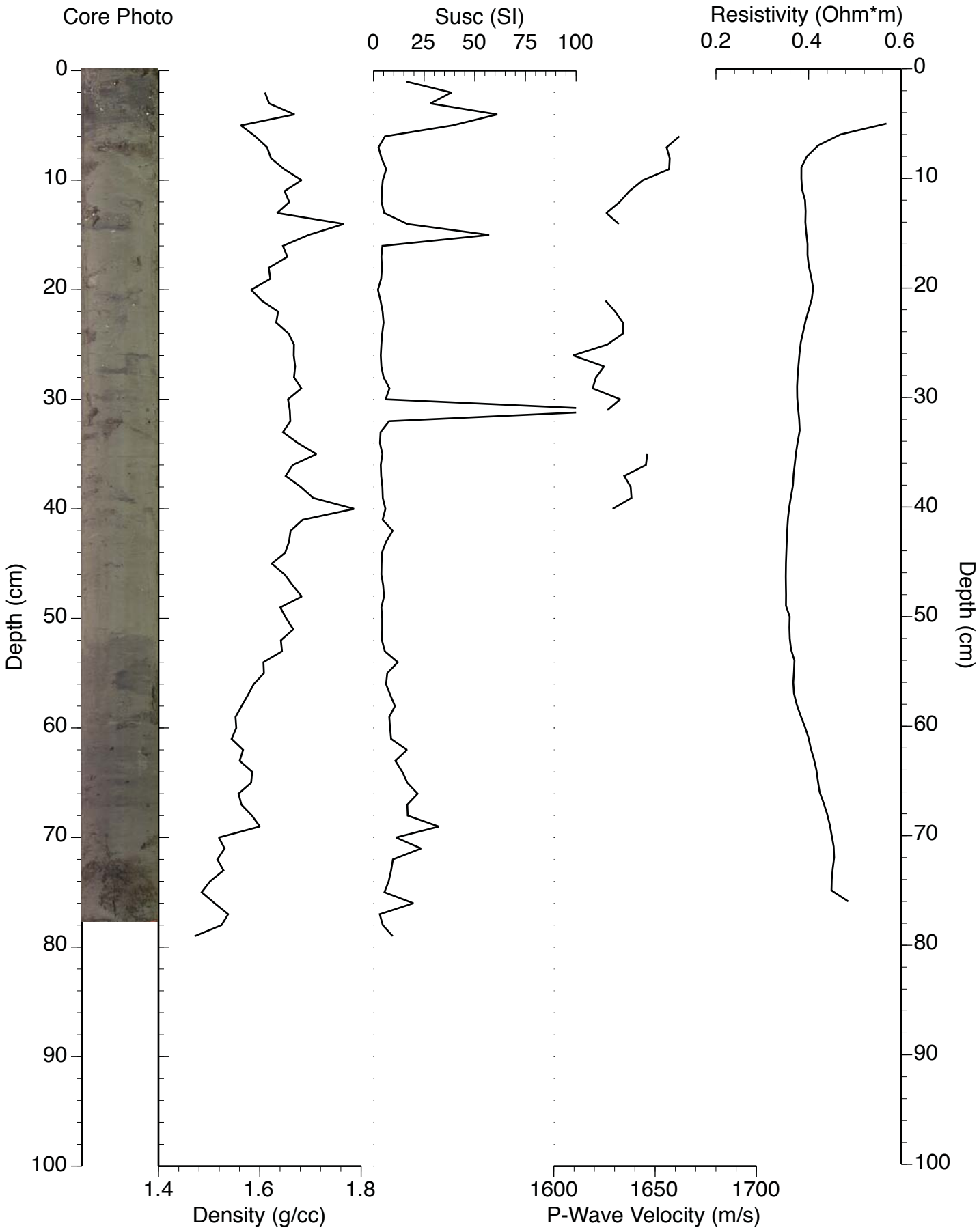


Figure 7. Digital image and core log parameters versus depth for core 46

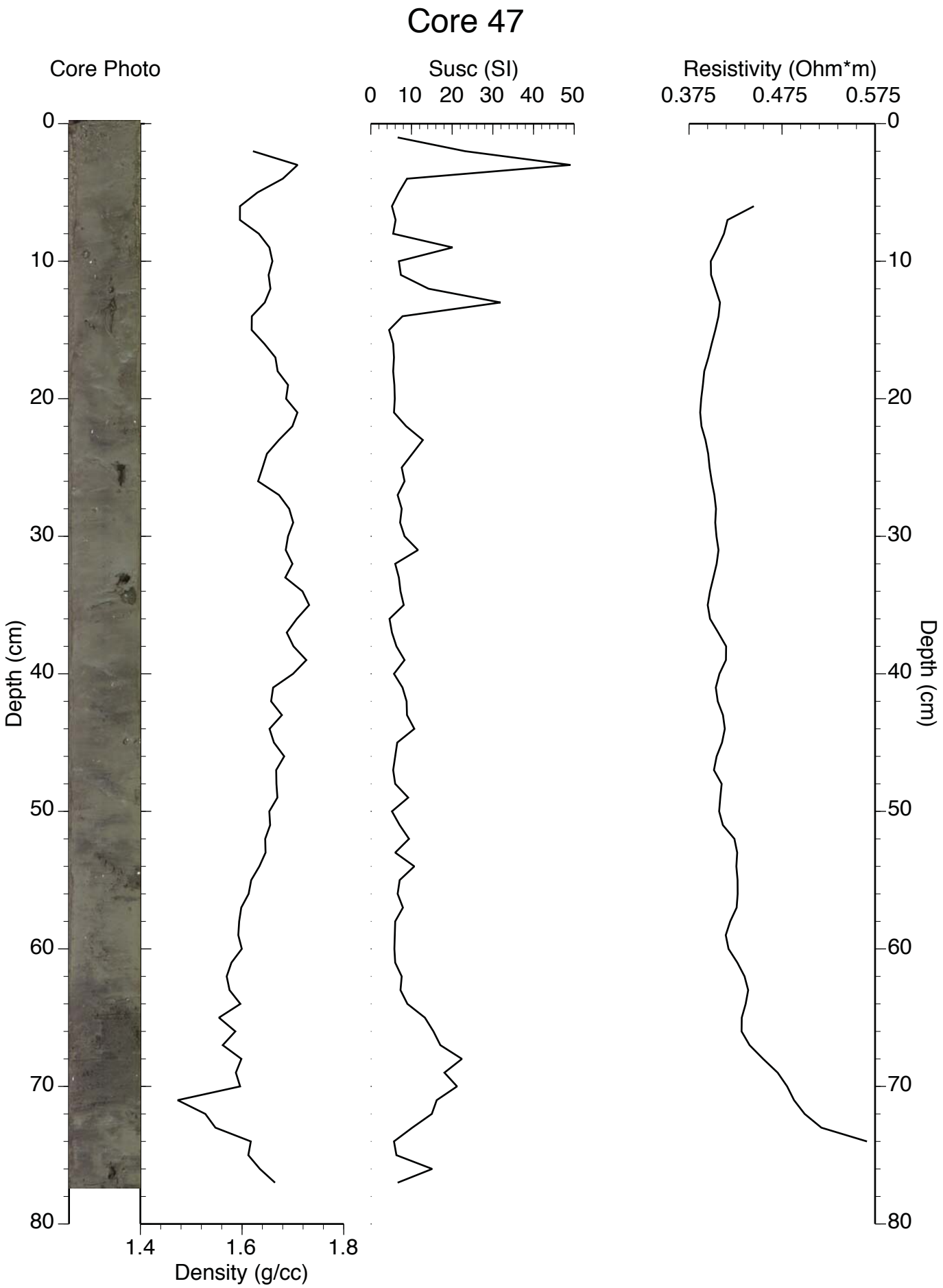


Figure 8. Digital image and core log parameters versus depth for core 47

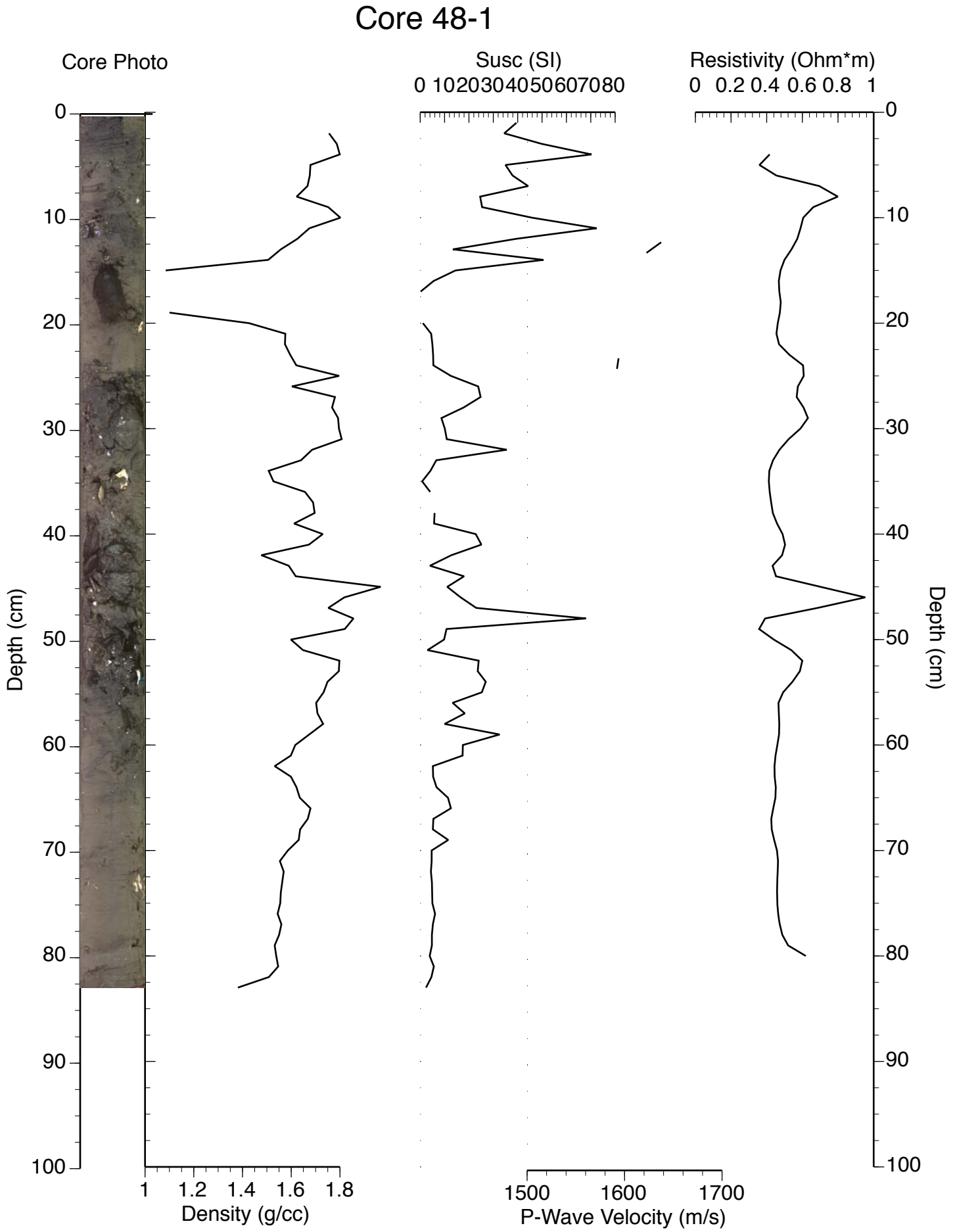


Figure 9. Digital image and core log parameters versus depth for core 48-1

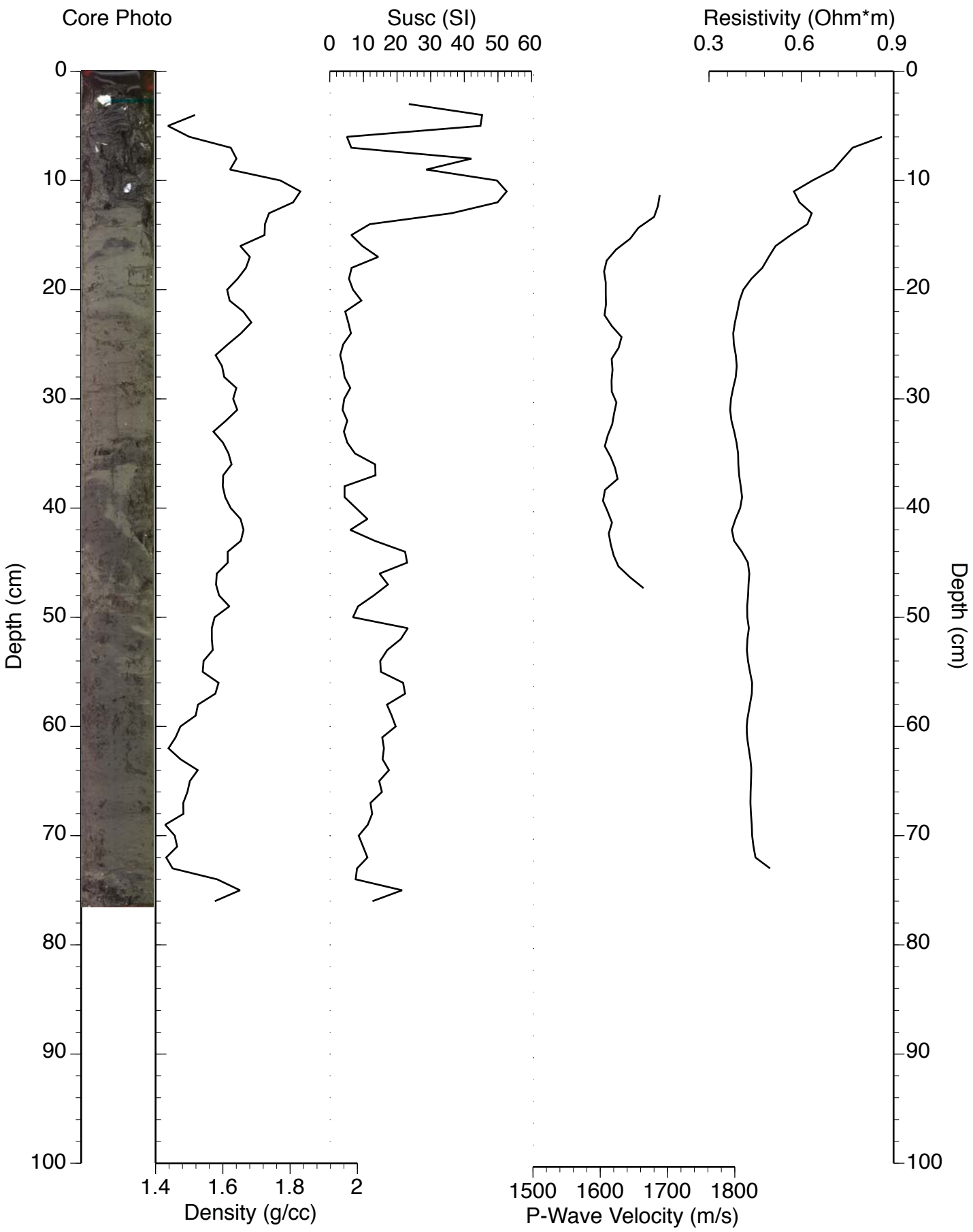


Figure 10. Digital image and core log parameters versus depth for core 48-2

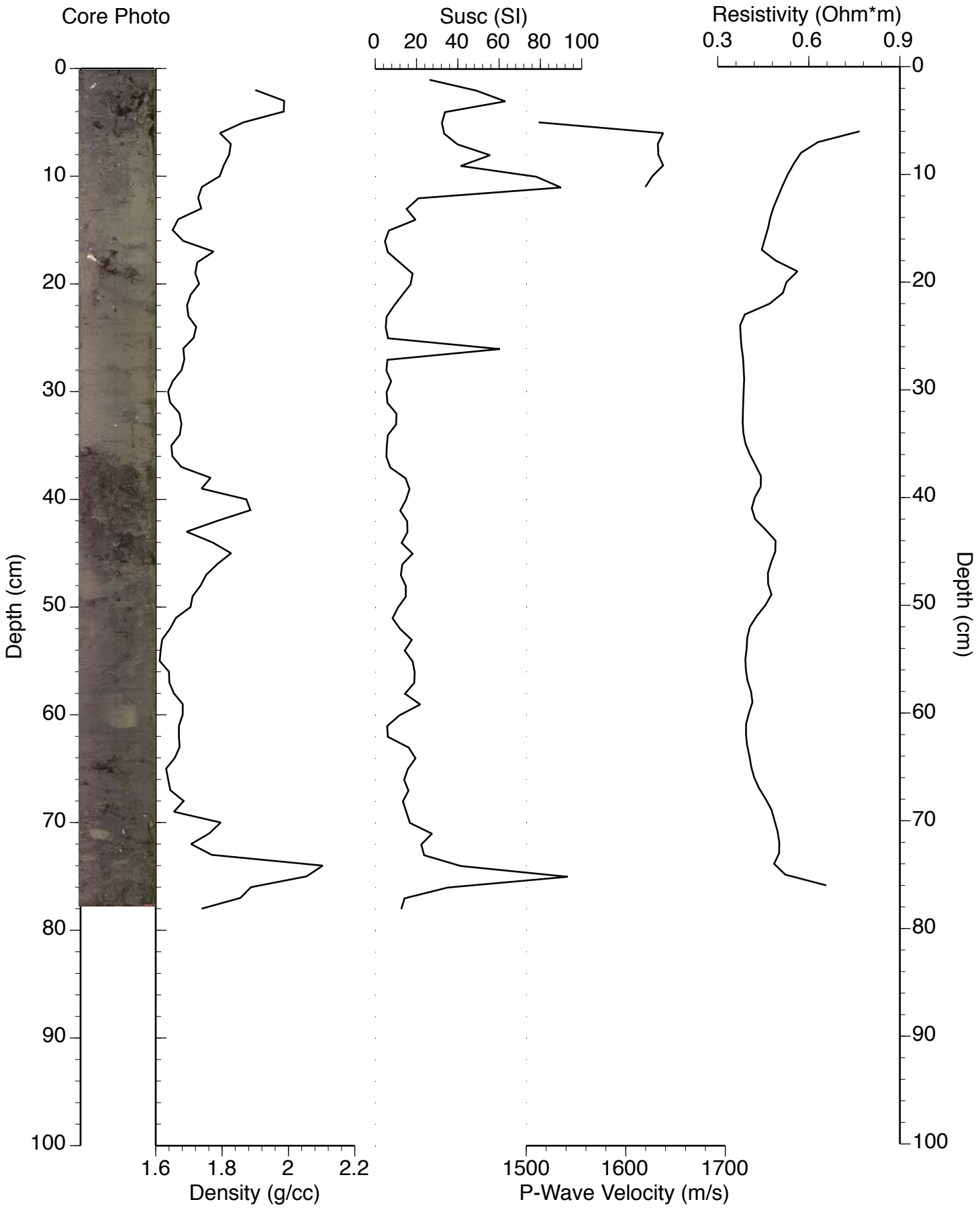


Figure 11. Digital image and core log parameters versus depth for core 48-3

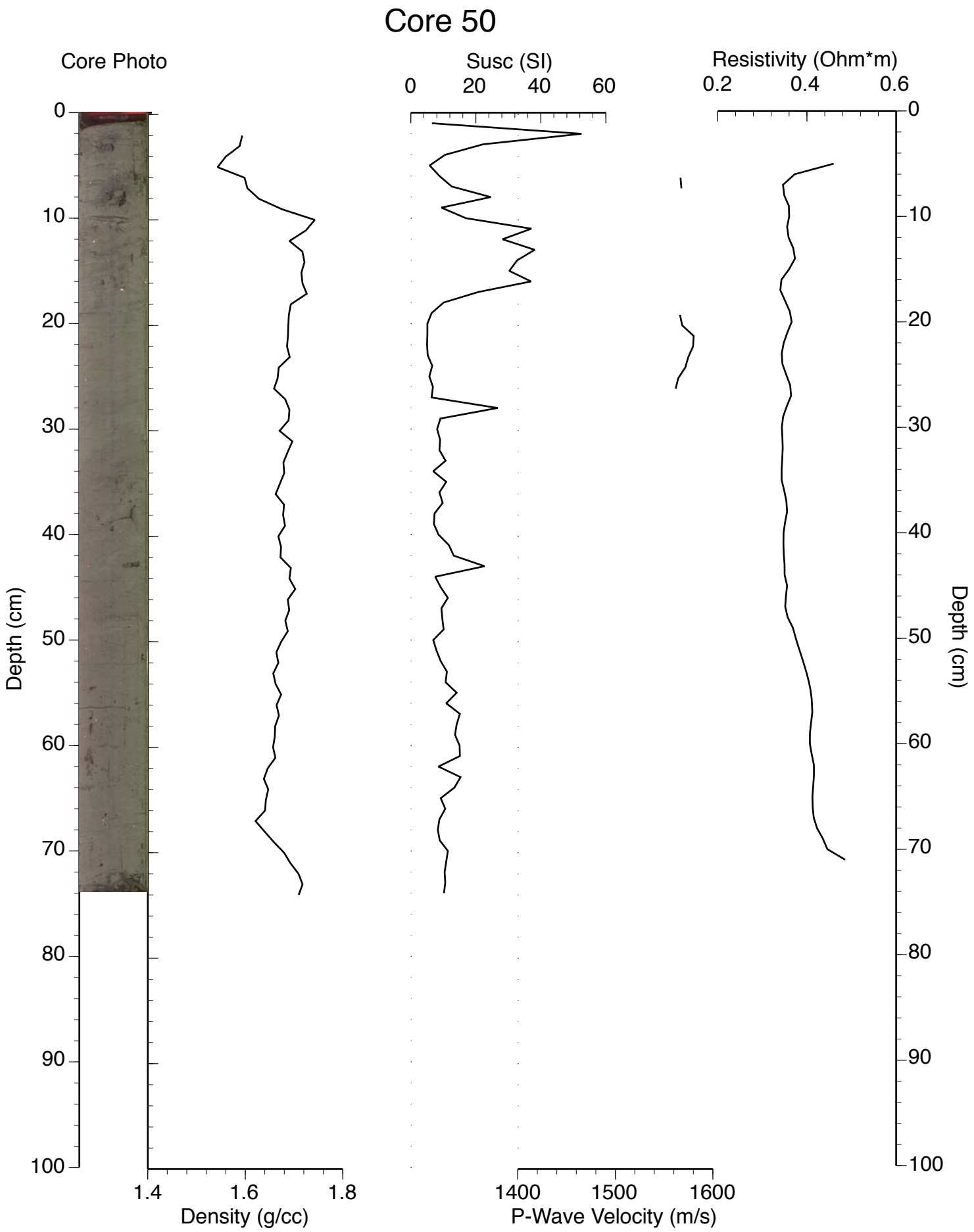


Figure 12. Digital image and core log parameters versus depth for core 50

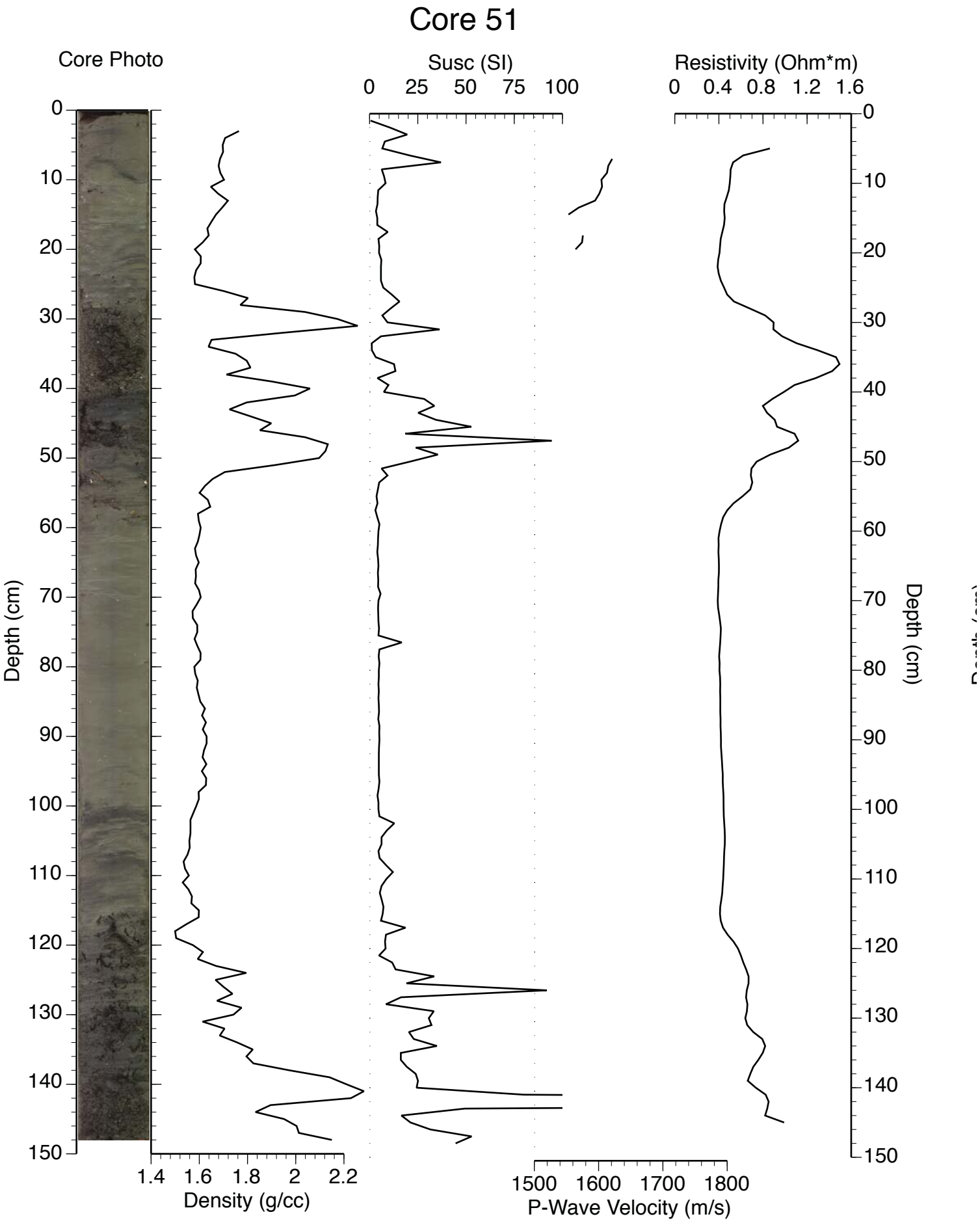


Figure 13. Digital image and core log parameters versus depth for core 51

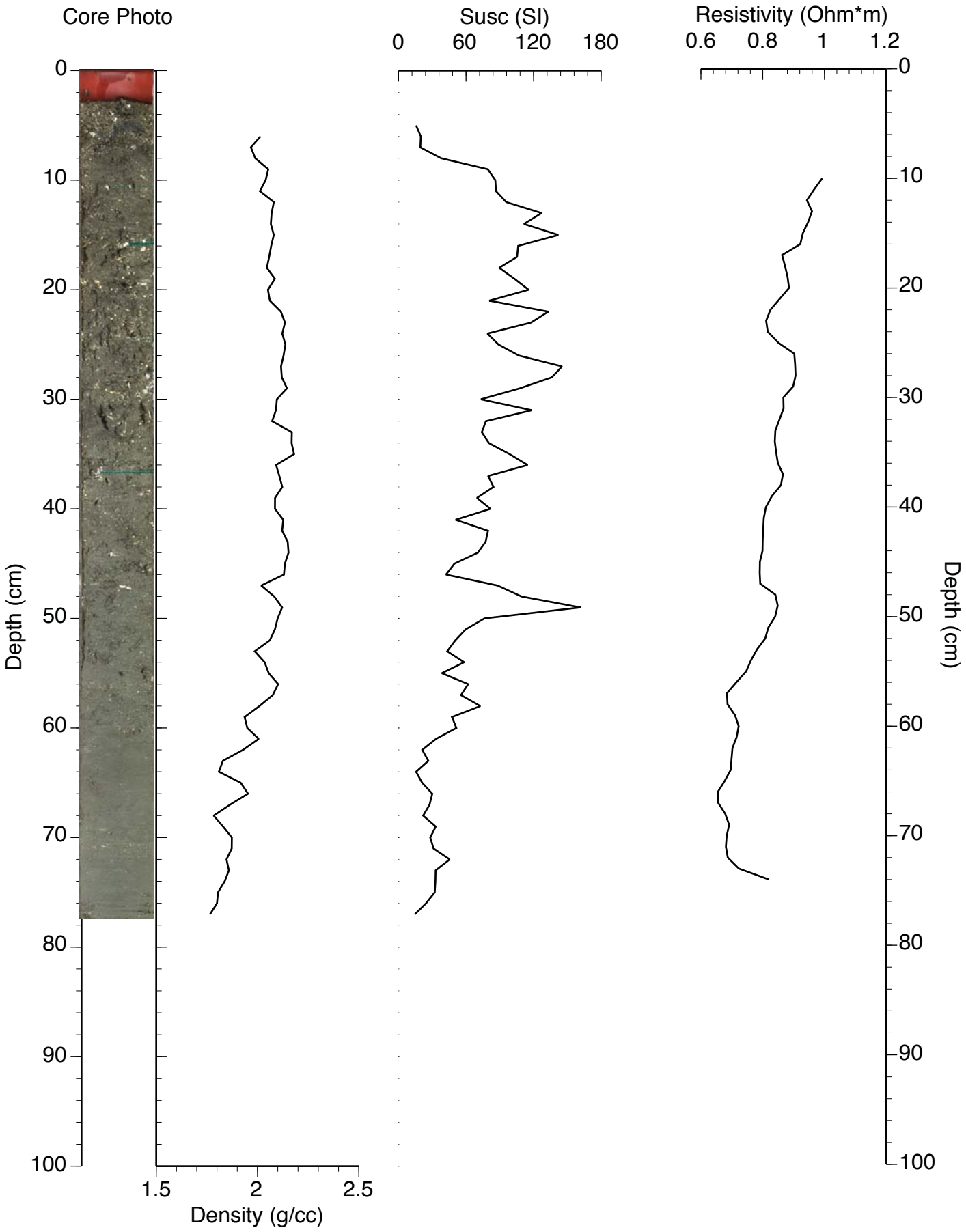


Figure 14. Digital image and core log parameters versus depth for core 52-1

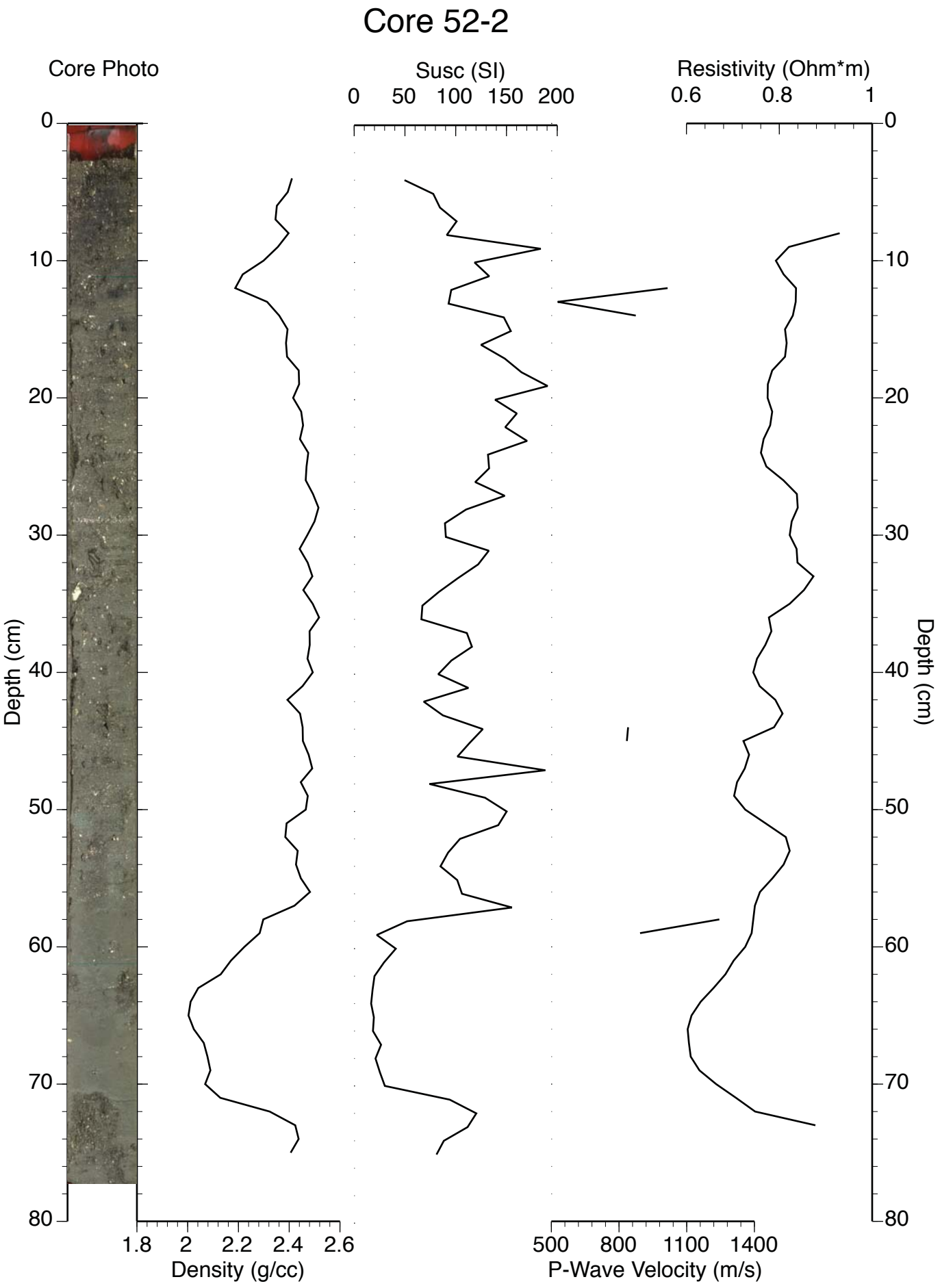


Figure 15. Digital image and core log parameters versus depth for core 52-2

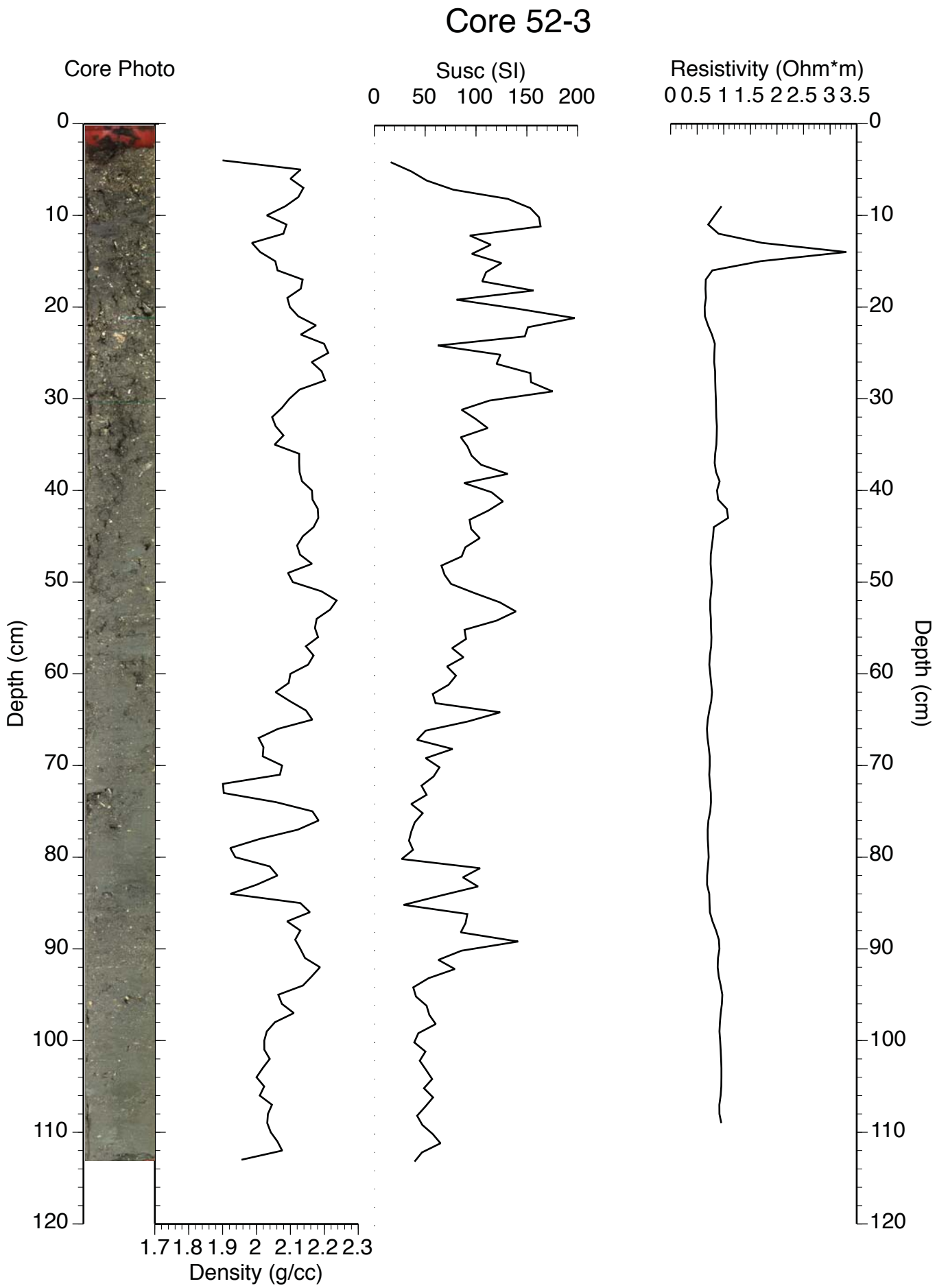


Figure 16. Digital image and core log parameters versus depth for core 52-3

Appendix D

PAH Analytical Approach

PAH Analytical Approach

Background

The Seawolf disposal mound is a capped disposal mound at the New London Disposal Site (NLDS) in Long Island Sound. The mound was formed in 1995-1996 by the initial placement of dredged sediment from the Groton Submarine Base along the Thames River that was unsuitable for unconfined open water disposal followed by the placement of suitable capping sediment as a confining layer. Prior to the September 2010 coring survey (performed by AECOM under DAMOS Task Order 13), the Seawolf Mound was last surveyed in the summer 2006 to fulfill the Year 10 requirement of the monitoring plan prepared as part of the permit issued for the dredging project. The 2006 survey included the performance of multi-beam bathymetry and sediment profile imaging and the collection of both short and long cores for physical and chemical analysis as well as the collection of grabs for biological assessment. The results of the 2006 survey confirmed the biological recovery and physical stability of the Seawolf Mound identified in previous surveys. The physical and chemical profiles in the sediment cores collected over the mound indicated a consistent cap sequestering the underlying unsuitable dredged material. However, consistently higher PAH concentrations identified in 2006 relative to previous data from 2001 (analyzed with a different preparation technique and sample aliquot volume) led to the recommendation for a follow up coring survey to compare the 2001 and 2006 analytical approaches and to further characterize physical and chemical variability in the cap layer across the Seawolf Mound.

The following table lists the methods used in the earlier studies:

Table 1. Historical sediment PAH extraction methods used on the Seawolf monitoring program.

Date	Extraction Method	Laboratory
2001	PFE/Method 3545	Alpha Laboratories
2006	MSE/Method 3570	Alpha Laboratories

The 2001 sample set was extracted for PAH compounds using EPA's Pressurized Fluid Extraction (PFE) method, which can produce a negative bias, particularly when extracting wet sediments. The 2006 sample set was extracted using a Microscale Extraction (MSE) method, which requires only 5 grams of sediment.

The 2010 survey was conducted to compare multiple PAH analytical techniques, characterize current PAH concentrations, and assess variability in PAH concentrations across the Seawolf Mound.

Specifically, the objectives of the survey were to:

1) Collect sediment samples that can be used to compare the PAH analytical approaches used in 2001 and 2006 (Phase 1), and;

2) Collect sediment samples that can be used to assess variability in PAH concentrations across the Seawolf Mound (Phase 2).

Approach

Ten stations were sampled at the Seawolf Mound during the 2010 field effort. Analysis of PAH concentrations in triplicate samples collected from two of the stations will be used to compare PAH extraction methods. Further analysis of samples from all ten stations (PAH compounds,

total organic carbon (TOC) and grain size) will be used to assess variability in PAH concentrations across the Seawolf Mound.

A memo detailing the analytical approach was prepared in July 2011. It was proposed that the PAH analysis be performed in two phases. The first phase consisted of a PAH extraction method comparison exercise using sediment collected from two of the sites (each in triplicate for a total of six samples) plus quality control (QC) samples. The PAH method comparison study was performed using three EPA methods representing microscale extraction (SW-846 Method 3570), pressurized fluid extraction (SW-846 Method 3545 using a 33 mL ASE cell), and soxhlet extraction (Method 3540). All PAH extracts were analyzed using GC/MS SIM (SW-846 Method 8270C). The microscale extraction method was designed to minimize sample size and solvent usage. Pressurized fluid extractions proceed at elevated temperatures and pressures in an attempt to achieve analyte recoveries equivalent to Soxhlet extractions. Soxhlet extractions use larger sample sizes and solvent volumes.

Following review of the extraction method comparison results (Phase 1), the remaining (10) samples will be analyzed under Phase 2, using the most appropriate method, as determined from the Phase 1 results.

To complement the PAH dataset, we also recommend analyzing the sample set for total organic carbon (TOC) and grainsize. These are useful parameters when assessing sediment chemistry and will help determine if the apparent (20% relative) increases in fines observed in 2006 represent another method bias. TOC measurements will be analyzed following the Lloyd Kahn method for measuring TOC in marine sediments. Grainsize measurements will be made following ASTM Method 422 (Sieve/Hydrometer). This grainsize method also differs from the approach used in 2006 but matches the earlier method approaches.

Appendix E

Common Unit Conversions

Metric	English
Length	
1 Kilometer (km)	0.62 Miles (mi)
1 Kilometer (km)	0.54 Nautical Miles (nmi)
1 Meter (m)	3.28 Feet (ft)
1 Centimeter (cm)	0.39 Inches (in)
Volume	
1 Cubic Meter (m^3)	35.31 Cubic Feet (ft^3)
1 Cubic Meter (m^3)	1.31 Cubic Yards (yd^3)
Velocity	
1 Meter per Second (m/s)	3.28 Feet Per Second