Monitoring Surveys of the New Haven Capping Project, 1993 - 1994

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13. ABSTRACT

Dredging of the New Haven Harbor Channel and five private marine terminals occurred between October 1993 and February 1994. These projects involved removal of an estimated barge volume of 500,000m3 of unacceptably contaminated dredged material (UDM) from the inner portion of the federal channel and about 90,000 m3 from the five private terminals. The UDM was approved for open water disposal and sediment capping at Central Long Island Sound Disposal Site (CLIS). A total barge volume of 569,000 m3 (506,000m3 federal and 63,000m3 private) of cap dredged material (CDM) was used to establish a sediment cap over the UDM deposit.

A taut-wired, moored Disposal Area Monitoring System (DAMOS) disposal buoy "NHAV" was deployed in the center of a basin-like feature created by a ring of seven historical disposal mounds. The ring of mounds, which requried ten years to construct, would serve as a lateral containment measure, limiting the spread of the initial UDM deposit and facilitating efficient capping operations. Capping material was placed at various points surrounding the NHAV buoy to ensure sufficient coverage of the UDM mound. The end result of disposal activity at CLIS was the development of a flat, stable, confined aquatic disposal (CAD) mound.

Science Applications International Corporation (SAIC) completed five precesion bathymetric surveys (baseline, interim disposal, precap, interim cap, and postcap), two Remote Monitoring of the Seafloor (REMOTS) surveys, and three geotechnical coring surveys of the NHAV 93 mound. The strategic repetition of the survey activity over the NHAV 93 mound has given the SAIC and NED an excellent perspective on CAD mound development and insight toward the disposal and oceanographic processes that affect the bottom feature. The bathymetric data provided "snapshots" of the developing mounds, allowing time-series comparisons of the various stages of CAD mound construction. The REMOTS photographs were used to determine relative shear strength of the containment ring as well as the areal extent of the UDM deposit. Geotechnical cores and grab samples were used to define the physical characteristics, document the bulk density, and estimate the consolidation of the NHAV93 mound.

Comparisons between the baseline, interim disposal, and precap monitoring surveys revealed a UDM deposit 510m in diameter and 2.5m in height, containing a volume of 312,000m3 of new material. A significant amount of consolidation was detected over the apex of the disposal mound before capping operations commenced. The NHAV 93 mound was then capped to a thickness of 0.5 to 1.0m with CDM from the outer harbor, resulting in a total mound diameter of 600-800m and height of 2.5 at the apex. Volume difference calculations based on the baseline, precap, interim cap, and the postcap surveys detected 402,000m3 of cap material overlying the initial UDM deposit and a total mound volume of 714,000m3.

Although 402,000m3 of CDM was placed over the initial UDM mound, there was no increase in net mound height at the apex. It has been determined through precision bathymetric surveying and geotechnical coring that consoildation of the UDM deposit and compaction of the basement sediments had occurred during the middle stages of CAD mound construction. As a result, no apparent changes in the mound height were detected after the completion of capping operations over the NHAV 93 mound.

Monitoring of NHAV 93 mound has continued through 1995. The long-term focus of these operations has pertained to mound stabilty and compaction/consoildation of the NHAV 93 mound; REMOTS sediment-profile surveys have determined the recolonization rate of the mound; and additional sediment cores and grab samples investigated the potential for migration of contaminents into overlying cap material. The results of these datasets have been submitted to NED under seperate DAMOS report titles.

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EXECUTIVE SUMMARY

Dredging of the New Haven Harbor Channel and five private marine terminals occurred between October 1993 and February 1994. These projects involved removal of an estimated barge volume of 500,000 m^3 of unacceptably contaminated dredged material (UDM) from the inner portion of the federal channel and about 90,000 m^3 from the five private terminals. The UDM was approved for open water disposal and sediment capping at the Central Long Island Sound Disposal Site (CLIS). A total barge volume of 569,000 m^3 (506,000 m^3 federal and 63,000 m^3 private) of cap dredged material (CDM) was used to establish a sediment cap over the UDM deposit.

A taut-wired, moored Disposal Area Monitoring System (DAMOS) disposal buoy "NHAV" was deployed in the center of a basin-like feature created by a ring of seven historic disposal mounds. The ring of mounds, which required ten years to construct, would serve as a lateral containment measure, limiting the spread of the initial UDM deposit and facilitating efficient capping operations. Deposition of UDM from the federal project was completed at the NHAV buoy, while the privately dredged UDM was disposed at a point to the southwest of the buoy. Capping material was placed at various points surrounding the NHAV buoy to ensure sufficient coverage of the UDM mound. The end result of disposal activity at CLIS was the development of a flat, stable, confined aquatic disposal (CAD) mound.

The decision to cap the material was based on the results of the *Ampelisca* bioassay test using the sediments sampled from the federal channel project. Biological testing of the private marine terminal projects was not pursued due to a cooperative plan for capping both the federal and private projects, providing a cost-efficient method of disposal.

Science Applications International Corporation (SAIC) completed five precision bathymetric surveys (baseline, interim disposal, precap, interim cap, and postcap), two Remote Monitoring of the Seafloor (REMOTS®) surveys, and three geotechnical coring surveys of the NHAV 93 mound. The strategic repetition of survey activity over the NHAV 93 mound has given SAIC and NED an excellent perspective on CAD mound development and insight toward the disposal and oceanographic processes that affect the bottom feature. The bathymetric data provided "snapshots" of the developing mounds, allowing time-series comparisons of the various stages of CAD mound construction. The REMOTS® photographs were used to determine the relative shear strength of the containment ring as well as the areal extent of the UDM deposit. Geotechnical cores and grab samples were used to define the physical characteristics, document the bulk density, and estimate the consolidation of the NHAV 93 mound.

Comparisons between the baseline, interim disposal, and precap monitoring surveys revealed a UDM deposit 510 m in diameter and 2.5 m in height, containing a volume of 312,000 m^3 of new material. A significant amount of consolidation was detected over the apex of the disposal mound before capping operations commenced. The NHAV 93 mound was then capped to a thickness of 0.5 to 1.0 m with CDM from the outer harbor, resulting in a total mound diameter of 600-800 m and height of 2.5 m at the apex. Volume difference calculations based on the baseline, precap, interim cap, and postcap surveys detected 402,000 m^3 of cap material overlying the initial UDM deposit and a total mound volume of 714,000 m^3.

Although 402,000 m^3 of CDM was placed over the initial UDM mound, there was no increase in net mound height at the apex. It has been determined through precision bathymetric surveying and geotechnical coring that consolidation of the UDM deposit and compaction of the basement sediments had occurred during the middle stages of CAD mound construction. As a result, no apparent changes in mound height were detected after the completion of capping operations over the NHAV 93 mound.

Monitoring of the NHAV 93 mound has continued through 1995, including additional precision bathymetric surveys, subbottom profiling, REMOTS® sediment-profile photography, sediment surface grab samples for chemical analysis, and geotechnical coring. The long-term focus of these operations has pertained to mound stability and compaction/consolidation of the NHAV 93 mound; REMOTS® sediment-profile surveys have determined the recolonization rate of the mound; and additional sediment cores and grab samples investigated the potential for migration of contaminants into the overlying cap material. The results of these datasets have been submitted to NED under separate DAMOS report titles.

1.0 INTRODUCTION

From October 1993 to February 1994, the New Haven Harbor was dredged to improve navigational access within the federal channel and operations efficiency at five area marine terminals (Figure 1-1). As part of the Dredged Material Management Plan, formulated by the New England Division (NED) of the US Army Corps of Engineers (USACE), the federal channel project sediments were sampled and subjected to a variety of tests to determine their physical and chemical properties. The results of a standard *Ampelisca* bioassay test indicated that the federal channel project material was not suitable for unconfined open water disposal and required capping. Capping is a subaqueous containment method which uses dredged material determined to be suitable for unconfined open water disposal to overlay and isolate the unacceptably contaminated dredged material (UDM) from the environment (Fredette 1994). The process was introduced to the Central Long Island Sound Disposal Site (CLIS) in 1979 with the formation of the Stamford-New Haven mounds (STNH-N and STNH-S; SAIC 1995).

Subaqueous capping is the most cost effective and environmentally sound approach to manage large volumes of UDM. Results of the Stamford-New Haven Project suggested that careful navigational controls and point deposition techniques at a taut-wired buoy could be used to form a discrete mound of UDM (SAIC 1995). In addition, these results suggested that precise deposition of cap dredged material (CDM), both at the center and at the flanks of the UDM mound, could be accomplished with tight navigational control and project planning. As a result of the operational success of the 1979 capping project, additional capping projects were conducted at CLIS. These include the Mill-Quinnipiac River mound (MQR), Norwalk mound (NORWALK), and two Experimental Cap Sites (CS-1 and CS-2). Physical monitoring of the mounds indicates that they have been stable even after the passage of three hurricanes (SAIC 1995).

A successful capping project requires an effective monitoring program in addition to predisposal planning and well-organized dredging and disposal operations (SAIC 1995). Science Applications International Corporation (SAIC) conducted a series of five environmental surveys including the collection of various types of data at each stage of the dredging project (Table 1-1). The data collected at CLIS includes precision bathymetry, Remote Ecological Monitoring of the Seafloor (REMOTS®) sediment-profile photographs, sediment grab samples, and geotechnical cores (Figure 1-2). The strategic repetition of survey operations over the disposal site during the New Haven Capping Project provided SAIC and NED a wealth of information on the developing mound.

The baseline survey conducted from 19 to 20 September 1993 was intended to define the predisposal conditions at the site to provide a baseline for comparison to the future survey

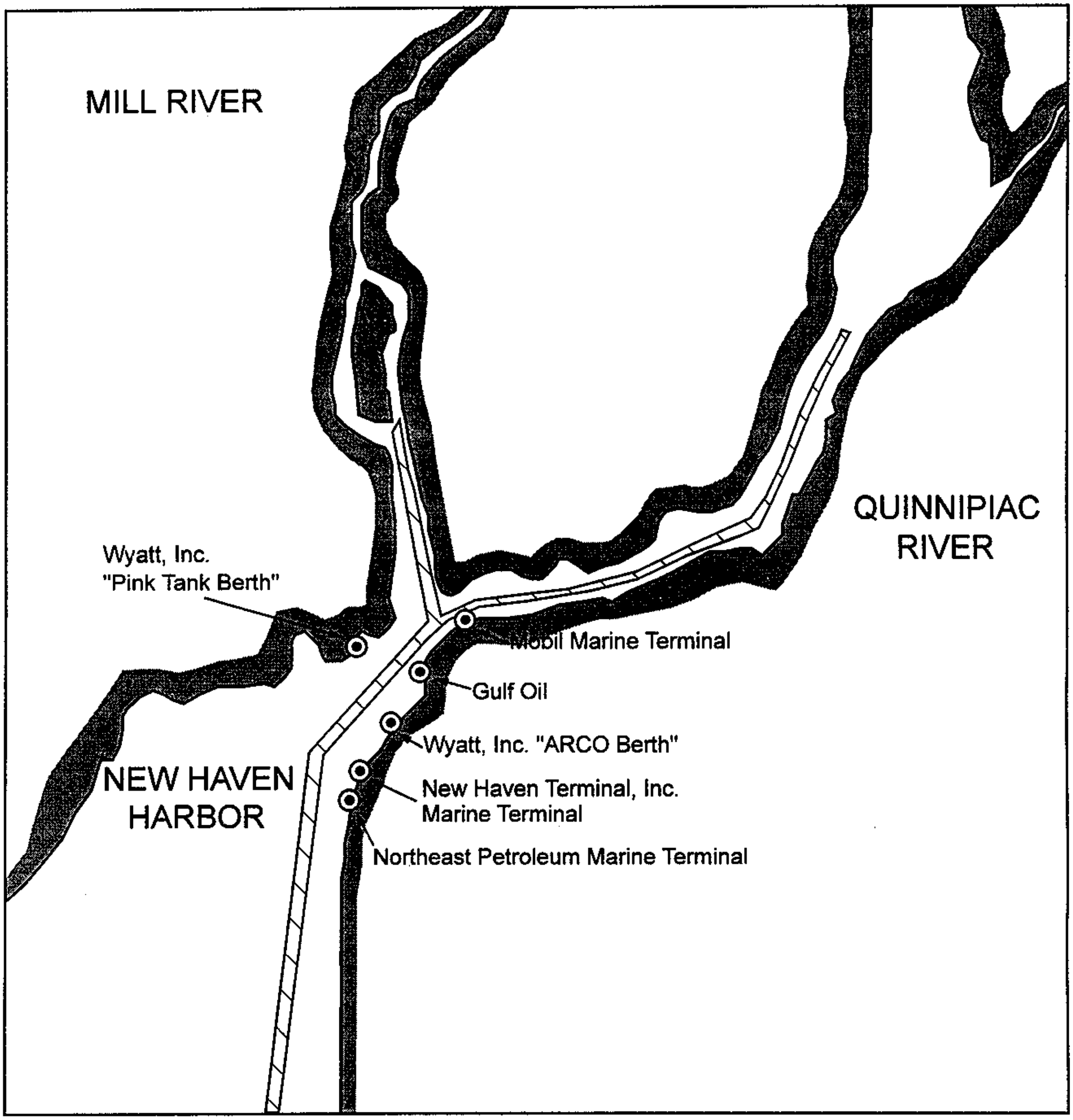

Figure 1-1. Location of the federal navigation channel, Gulf Oil, Mobil Oil Corporation, the New Haven Terminal, Northeast Petroleum, and Wyatt Incorporated in New Haven Harbor (adapted from HMM Associates, Inc. 1993)

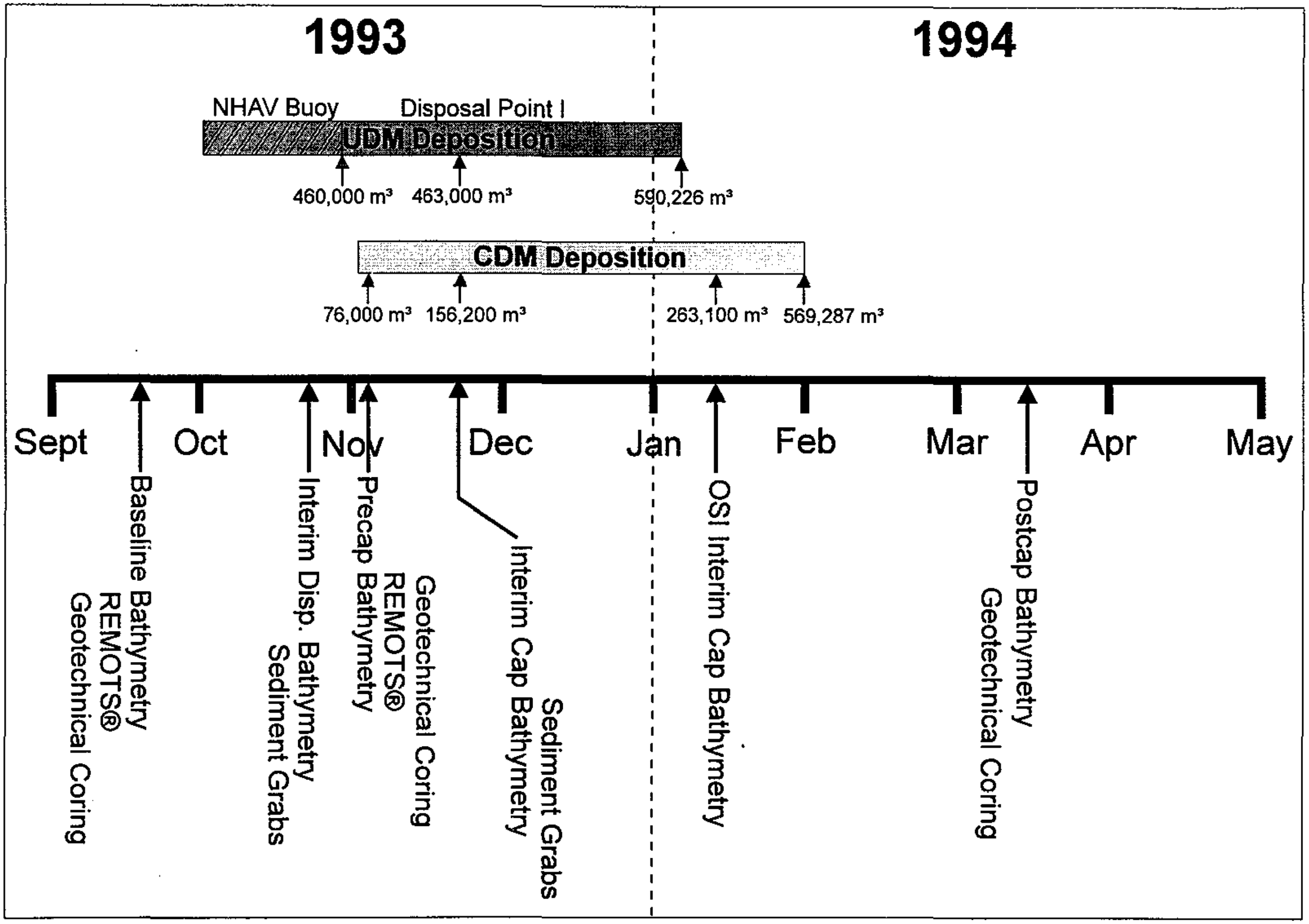

Figure 1-2. Timeline of disposal and environmental monitoring activity during the New Haven Capping Project 1993-1994

Table 1-1

Summary of Monitoring Surveys for the New Haven Capping Project, September 1993 to March 1994

Event	Baseline (Predisposal)	Interim Disposal	Precap*	Interim Cap	Interim Cap+	Postcap
Precision Bathymetry	9/19-20/93	10/23-25/93	11/2-3/93	11/23-24/93	1/12-13/94	3/13-14/94
REMOTS® Sediment Profile	9/21-22/94		11/4/93			
Sediment Cores	9/21/93		11/10/93			3/15/94
Sediment Grabs		10/25/93		11/24/93		
Vessel	M/V *Beavertail*	R/V *UCONN*	R/V *UCONN*	M/V *Beavertail*		M/V *Beavertail*

*This survey also included 76,000 m^3 of cap material deposited at the northeast corner of the mound.

+ Survey conducted by Ocean Surveys Incorporated.

data. The baseline survey included bathymetry, REMOTS®, and geotechnical cores. The interim disposal survey, completed after 50% of the UDM dredged from the federal channel was disposed (23-25 October 1993), included bathymetry and sediment grab samples.

Bathymetry, REMOTS®, and geotechnical cores were collected during the precap survey, performed following the completion of the federal inner harbor dredging (2-3 November 1993). This survey was designed to provide an accurate map of the distribution of UDM to facilitate complete cap coverage. An interim capping survey was completed from 23 to 24 November 1993 using bathymetry and sediment grab samples to document the distribution of cap material. A final survey was conducted following the completion of all dredging activities to evaluate the coverage of the UDM deposit by the outer harbor CDM. This postcap survey included bathymetry and geotechnical cores and was completed from 13 to 15 March 1994.

The geotechnical cores were collected by SAIC and University of Rhode Island (URI) scientists in close proximity to the NHAV disposal buoy and within the central portion of the dredged material mound. Results provided an estimate of consolidation within the basement sediments and inner harbor dredged material. In addition, the geotechnical coring results were used to verify the completion of the cap material thickness requirements established by NED.

A sediment plume study was conducted during the initial phase of dredging (25 October to 18 November 1993) to monitor the potential for material dispersion (Bohlen et al. 1994). Nine plume tracking surveys were conducted by Dr. W.F. Bohlen of the University of Connecticut while Great Lakes Dredging Company was operating in New Haven Harbor; results will be provided under a separate report. Further survey activity over CLIS during the New Haven Capping Project included bathymetric and sediment-profile photography surveys (12–13 January 1994). Ocean Surveys, Incorporated completed these field tasks following the disposal of UDM generated from the private marine terminal projects in the harbor.

Since 1977, monitoring cruises have been conducted at CLIS as part of the Disposal Area Monitoring System (DAMOS) Program for the US Army Corps of Engineers, NED (NUSC 1979). These surveys assessed both the stability of the dredged material disposed at the site and any potential for adverse long-term environmental effects, particularly in terms of the postdisposal recovery of benthic ecosystems. The objectives of these surveys included documenting and monitoring the location and physical characteristics of dredged material mounds, as well as any postdepositional dispersion of material. A total of eighteen inactive disposal mounds currently exist within the 6.85 km^2 area of CLIS.

CLIS, located approximately 5.6 nautical miles (nmi) south of South End Point, East Haven, Connecticut, continues to be one of the most active containment sites in New England (Figure 1-3). The 2 nmi long by 1 nmi wide rectangular area, centered at 41°08.950' N, 72°52.850' W, receives sediments dredged from the New Haven, Stamford, and Norwalk Harbors as well as adjacent coves and embayments. In addition, the large volumes of material deposited at CLIS have been subject to a variety of dredged material management strategies.

The strategy at CLIS during the 1993 New Haven Harbor Capping Project was to form a large scale, stable confined aquatic disposal (CAD) mound. A CAD mound is a dredged material disposal mound constructed in conjunction with artificial or natural containment measures. The containment measures are structures that surround a given area limiting the lateral spread of UDM to facilitate efficient sediment capping operations. The taut-wire moored buoy "NHAV" was deployed at 41°09.122' N and 72°53.453' W, over the center of a basin created by the planned placement of seven historic disposal mounds: CLIS-87, CLIS-88, CLIS-89, CLIS-90, CLIS-91, SP, and NORWALK (Figure 1-4). The basin region was utilized for the disposal of a total volume of 1,159,513 m^3 of material; 590,229 m^3 of UDM and 569,287 m^3 of CDM (Table 1-2). The precision disposal and capping operations performed by the Great Lakes Dredging Company and the technical support provided by SAIC aided NED in forming a stable CAD mound with a diameter of 550 m, a height of 2.5 m, and a CDM to UDM ratio of 0.96 to 1.0.

The successful completion of the NHAV 93 mound represents the end of a ten-year dredging cycle in the central Long Island Sound region. NED estimates that major maintenance dredging of New Haven Harbor must be conducted every ten years to provide adequate water depths for commercial, military, and private vessels utilizing the harbor. Thoughtful management of smaller volumes of dredged material over the last decade not only facilitated the safe disposal of over a million cubic meters of dredged material, but also demonstrated a management strategy that can serve to maximize the site capacity of CLIS as well as other DAMOS disposal sites.

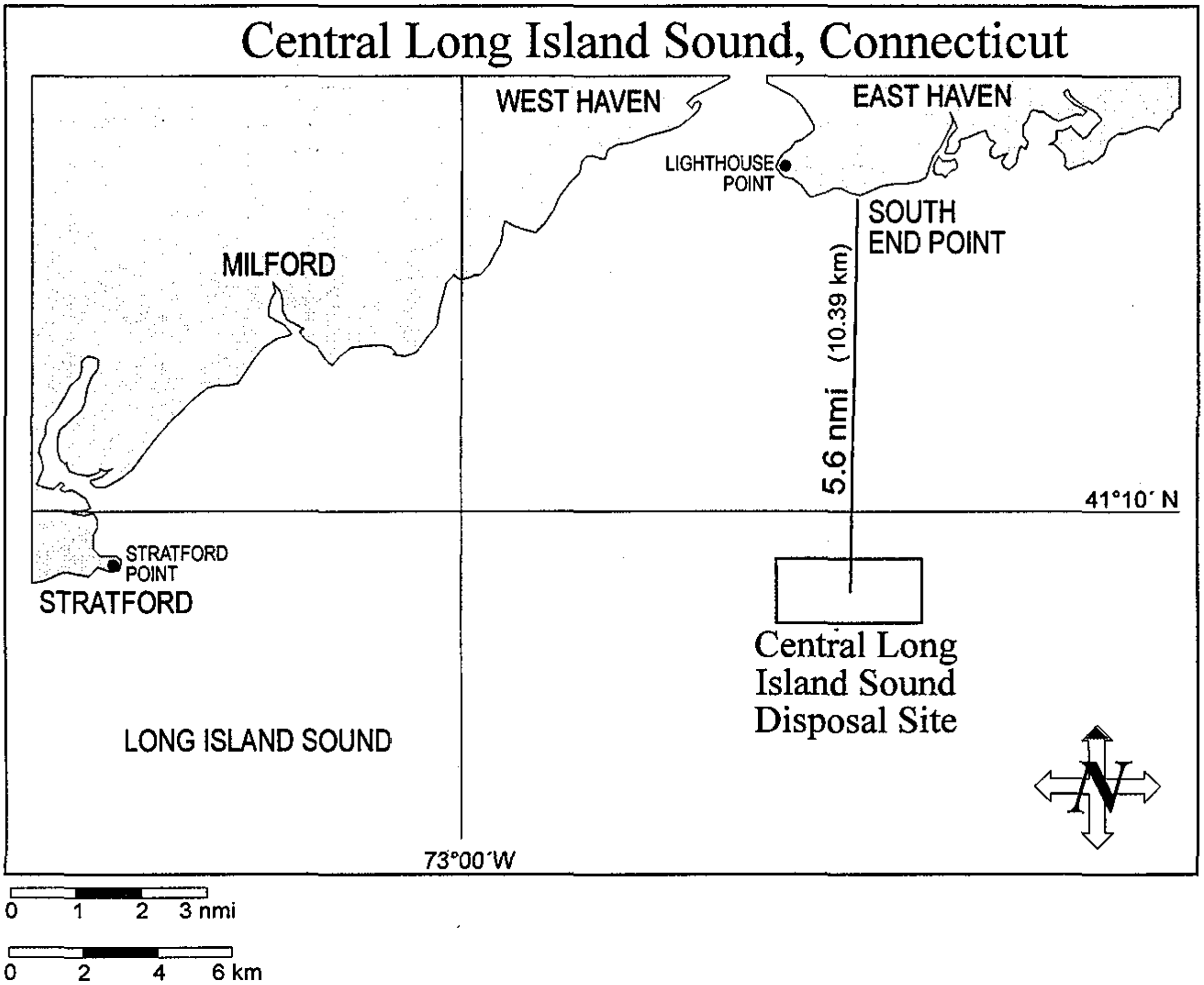

Figure 1-3. Location of the Central Long Island Sound Disposal Site (CLIS)

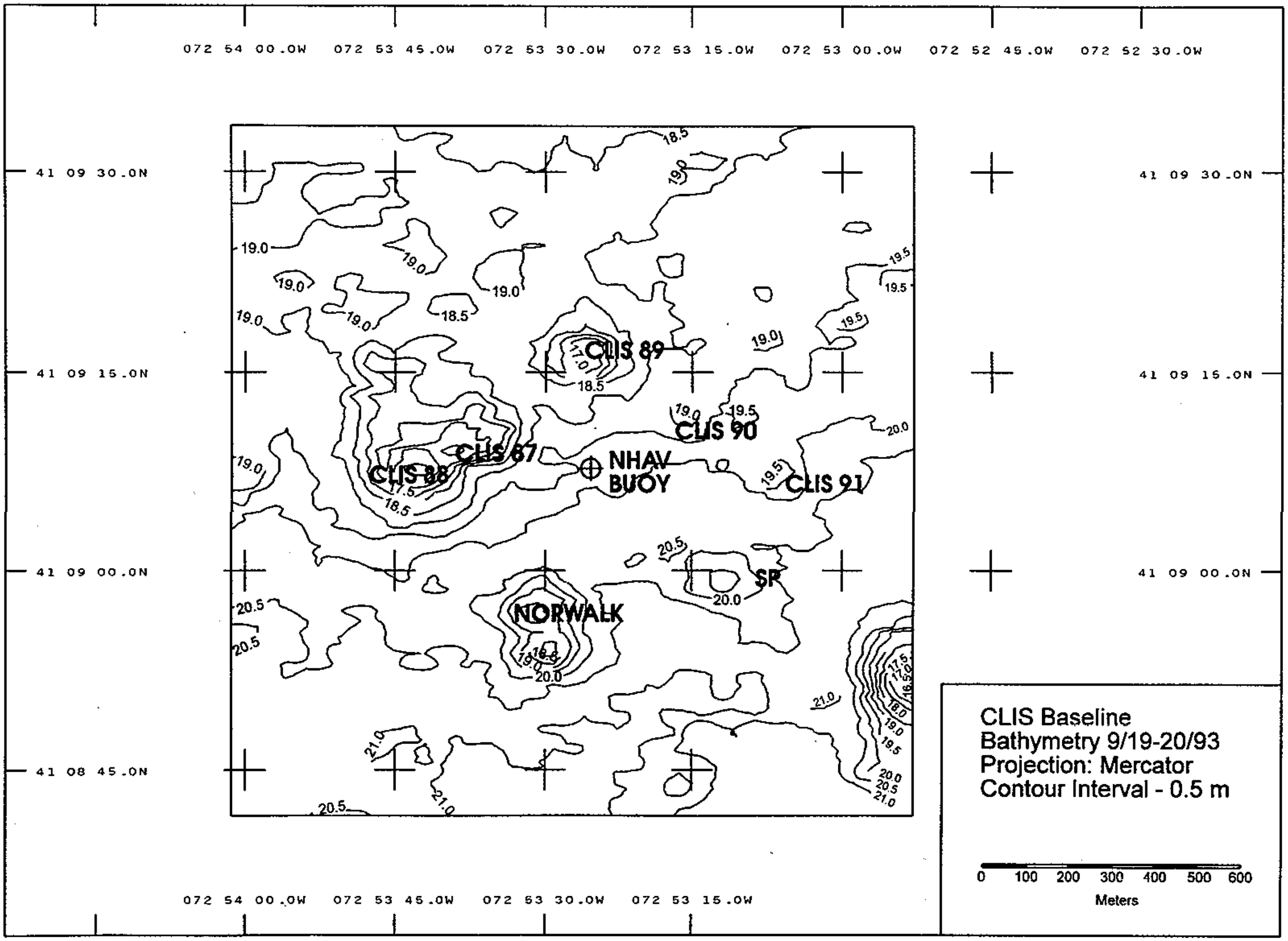

Figure 1-4. Location of the NHAV buoy over the basin created by seven historic disposal mounds. The contoured bathymetric chart shows the results of the baseline survey conducted in September 1993 (depth in meters).

Table 1-2

Amounts of Sediments Dredged from New Haven Harbor,
October 1993 to February 1994 (Source: DAMOS Disposal Barge Logs)

A. CONTAMINATED SEDIMENTS

Disposal Location	Source	Volume (m^3)
NHAV buoy	inner federal channel	460,083
Disposal Point I	inner federal channel	40,286
Total from the inner federal channel		**500,369**
Disposal Point I		
	New Haven Terminal	25,327
	Wyatt Incorporated	20,873
	NE Petroleum	11,927
	Gulf Oil	28,901
	Mobil Oil	2,829
Total from private dredging projects		89,857
	TOTAL VOLUME	**590,226**

B. CAP SEDIMENTS

Disposal Location	Source	Volume (m^3)
Multiple Points	outer federal channel	505,848
K, L, V-Z, A1	NE Petroleum	48,338
G	Lex Atlantic/Gateway	12,272
J	Wyatt Incorporated	2,829
	TOTAL VOLUME	**569,287**

2.0 DECISION PROCESS FOR THE DREDGING OF NEW HAVEN HARBOR

The decision to dispose and cap dredged material is made through a formal, tiered decision matrix which is used as a guide for monitoring and managing disposal sites in New England (EPA/USACE 1991). Federal maintenance projects and private applicants are approved for open-water disposal when all practicable alternatives to ocean or estuarine/riverine disposal have been determined to be unavailable according to federal and state guidelines (EPA/USACE 1991).

Once these criteria are met, the dredged material is evaluated for potential environmental impacts based on laboratory analytical results. After NED completes the evaluation process, all permits are subject to review and comment by federal agencies such as EPA Region I, the National Marine Fisheries Service, and the US Fish and Wildlife Service. Approval to dredge the inner federal navigation channel of New Haven Harbor was given in October 1993. During the dredging of the inner channel, permits were granted for the following five private dredging projects within New Haven Harbor: Northeast Petroleum (two projects approved 5 and 30 November 1993), Mobil Oil and the New Haven Terminal (24 November 1993), Wyatt Incorporated (1 December 1993), and Gulf Oil (17 December 1993).

2.1 Physical Testing of Sediment

As part of the evaluation process, samples of dredged material are analyzed for grain size, total organic carbon, and water content. Sediments proposed for disposal may be excluded from further testing according to the tiered protocol if the majority of the material is predominantly composed of sand-sized particles or larger (EPA/USACE 1991). Sand and larger diameter particles are chemically inert and relatively free from contaminants. Therefore, they pose no environmental impact from a chemical or biological standpoint (other than a possible change in the type of community that develops on a substratum of a particular grain size).

Results of the grain size analysis for the federal navigation channel showed that the sediments contained little sand and were predominantly silt/clay (inner channel Stations A-D were 93 to 97% silt/clay and outer channel Stations E-J were 77 to 99% silt/clay) (Figure 2-1; Appendix A Tables 1 and 2). The sand fractions at the New Haven Terminal ranged from 57 to 66%, Mobil Oil 66 to 82%, and Wyatt Incorporated from 34 to 87%. Sediments dredged from Gulf Oil were almost equal in the percentage of sands and silt/clay. The majority of samples from Northeast Petroleum consisted of 87 to 93% silt/clay; only three samples contained 70 to 98% sands (Appendix A Tables 1 through 7).

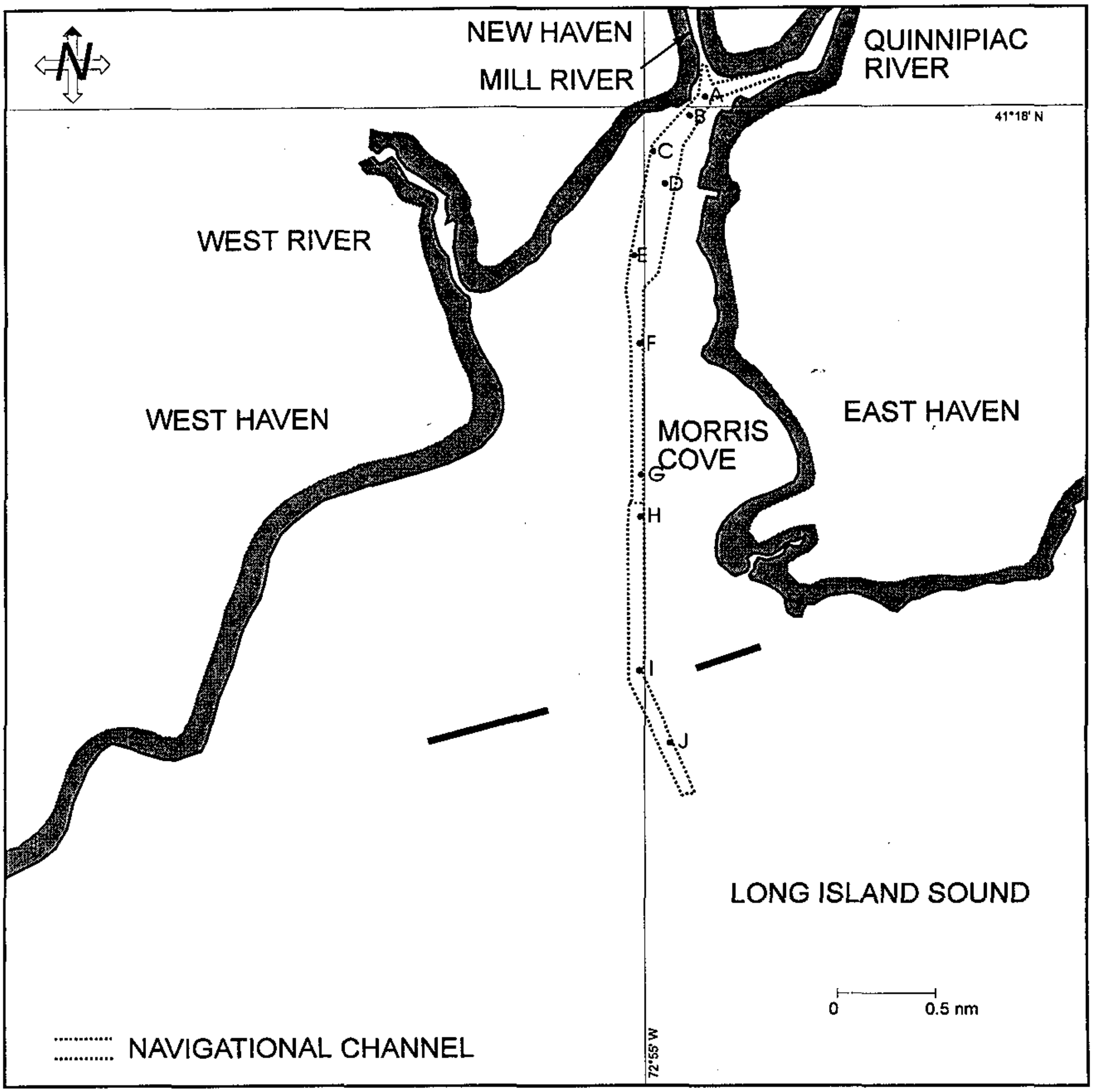

Figure 2-1. Sediment and benthic sampling locations in the federal navigation channel, New Haven Harbor. Stations A-D were located in the inner harbor (UDM), and Stations E-J were located in the outer channel (CDM).

2.2 Chemical Testing of Sediment

Sediments which are not predominantly sand require bulk sediment analyses for eight metals, total polychlorinated biphenyls (PCBs), chlorinated pesticides, and polynuclear aromatic hydrocarbons (PAHs) according to EPA guidance (EPA/USACE 1991). All project areas in New Haven Harbor including the outer channel required chemical analyses.

2.2.1 Metals

The metals required for analysis included arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), mercury (Hg), nickel (Ni), lead (Pb), and zinc (Zn). Sediments from the inner federal channel contained moderate levels of all metals except Hg and Pb (present in low levels) when compared to the classification guidelines provided by the New England River Basins Commission (NERBC) (Table 2-1; Appendix A Tables 1 through 7). Zn was high in one sample (595 ppm). Low to moderate levels of As, Cd, Cr, Cu, Ni, and Zn were present in sediments sampled from the outer channel with only one value of Zn classified as high (440 ppm). Metal concentrations were low in sediments sampled from Mobil Oil and the New Haven Terminal. Moderate levels of Cr (117 to 123 ppm), Pb (110 to 158 ppm), and Zn (264 to 350 ppm) were detected in some sediments collected from Gulf Oil; Wyatt Incorporated, Zn (213 to 265 ppm) and Pb (105 to 168 ppm); and Northeast Petroleum, moderate to high levels of Zn (235 to 919 ppm) and a moderate level of Pb (144 ppm).

2.2.2 Organic Compounds

Pesticides were below the detection limit for all compounds in the inner channel and outer channel sediments except for heptachlor epoxide which ranged from 0.46 to 1.94 ppm in the inner channel and from less than the detection limit to 0.82 ppm in the outer channel sediments. Pesticides were below the detection limit for all five terminal project areas.

Total PCBs for the inner and outer channel sediments were less than the laboratory's reported detection limit of 100 ppb. Total PCBs were detected by another laboratory in sediments collected from Mobil Oil (less than unreported detection limit to 56 ppb), Wyatt Incorporated (22 to 68 ppb), and Gulf Oil (140 to 280 ppb).

For the permitting process PAH values were normalized to percent organic carbon and compared to the carbon normalized PAH values for the CLIS Reference area. The concentrations of PAHs in some sediments from the inner federal channel and the five

Table 2-1

New England River Basins Commission (NERBC)
Classification of Dredged Sediment (NERBC 1980)

	Class I	Class II	Class III
Percent oil and grease (hexane extract)	<0.2	0.2-0.75	>0.75
Percent volatile solids (NED method)	<5	5-10	>10
Percent water	<40	40-60	>60
Percent silt/clay	<60	60-90	>90

LEVEL OF CONTAMINATION

	LOW	MODERATE	HIGH
As	<10	10-20	>20
Cd	<3	3-7	>7
Cr	<100	100-300	>300
Cu	<200	200-400	>400
Hg	<0.5	0.5-1.5	>1.5
Ni	<50	50-100	>100
Pb	<100	100-200	>200
V	<75	75-125	>125
Zn	<200	200-400	>400

private project areas (as well as elevated levels of Zn in some samples collected from NE Petroleum) indicated that sediments were not suitable for open water disposal unless capped or subjected to biological testing (Appendix A Tables 1 through 7; ranges of PAHs reported here have not been normalized to TOC). The concentrations of individual PAHs in the inner channel sediments ranged from <0.03 to 2.39 ppm; outer channel sediments ranged from <0.02 to 1.07 ppm. Sediments from Wyatt Incorporated had higher concentrations of individual PAHs in the Pink Tank berthing area, up to 8.70 ppm, requiring the capping of all sediments in comparison to sediments sampled from the Arco berthing area which contained concentrations of PAHs ranging from 0.08 to 3.71 ppm. Approximately 3,800 m^3 from this area were considered suitable for open-water disposal. Other ranges for individual PAH compounds present above the detection limit were 1) Gulf Oil, 0.12 to 8.75 ppm; 2) Mobil Oil, 0.05 to 11.4 ppm; 3) Northeast Petroleum, 0.03 to 4.66 ppm; and 4) the New Haven Terminal, 0.09 to 6.52 ppm.

2.3 Bioaccumulation/Bioassay Tests

If sediment chemistry data indicate elevated levels of contaminants, bioassay and bioaccumulation testing are required. Permittees can, at this point, opt to select capping as opposed to paying for this expensive testing procedure which may indicate the need to cap anyway (EPA/USACE 1991). Whole sediment bioassays must include three species from three different phyla: a crustacean, a polychaete, and a bivalve, and bioaccumulation testing must use the survivors of the bioassay test. Data are used to determine whether or not capping need be imposed as a permit restriction (EPA/USACE 1991).

The Tier III benthic-bioaccumulation tests provide for the determination of bioavailability through 10-day exposure tests if all contaminants of concern are metals or 28-day exposure tests if any contaminants of concern are organic or organometallic compounds (EPA/USACE 1991). The decision to cap sediments from the inner harbor federal channel was based on the results of the 28-day *Ampelisca* bioassay which had a significant mortality compared to the reference samples.

Results of the *Ampelisca* bioassay showed survival in the inner harbor was 51%, which was 36% lower than the reference survival of 87%. This suitability determination was conservative based on the current understanding of the *Ampelisca* toxicity test. Survival of *Nereis* and *Macoma* in test sediments (28 days) was not significantly different from reference results based on analysis of preliminary laboratory data. Bioaccumulation in *Nereis* and *Macoma* was also not significantly different from reference samples based on analysis of preliminary data (Lawless 1991). Biological testing was not pursued for the private projects because of the availability of capping material if dredging was completed in conjunction with the federal navigation channel project.

Additional sediment chemistry data are available through NED for the core samples and replicate sample data. Sampling and analytical work were contracted to HMM Associates, Incorporated, Concord, Massachusetts. Methods used for grain size, TOC, and metals were not provided; however, PAHs were analyzed by EPA Method 8270, and chlorinated pesticides and total PCBs by EPA Method 8080. Bioassay studies were conducted by SP, Incorporated, Salem, MA. Skinners and Sherman, Waltham, MA, conducted the bioaccumulation tissue analysis. Cadmium, copper, and zinc were analyzed in the tissue following EPA Methods 3051, 6010, and 7131. Pesticides were analyzed by Method 8080 and PAHs by Method 8270.

2.4 Disposal and Capping Operations

The Great Lakes Dredge and Dock Company conducted the dredging operations in New Haven Harbor with Clamshell Dredge 54. Disposal and capping at CLIS were achieved with the use of Great Lakes' 4000 yd^3 disposal barges 32 and 33 and Towing Vessels (T/V) *Arthur F. Zeman, Jr. and Delmur C. Lynn*. Additional disposal work was performed by Gateway Towing, Inc. *T/V Outrageous* and United Towing, Inc. *T/V Terror* during the New Haven Capping Project.

2.4.1 Disposal of UDM

Of the total volume of UDM (590,226 m^3), approximately 500,369 m^3 was dredged from the inner federal navigation channel. During the month of October 1993, approximately 460,083 m^3 from the inner channel was deposited at the NHAV buoy (Appendix B Table 1). The remaining 40,286 m^3 were deposited at disposal point I, located southwest of the buoy (41°09.000' N and 72°53.525' W) (Figure 2-2). UDM from the private dredging projects totaling 89,857 m^3 was also deposited at disposal point I from 3 December 1993 to 8 January 1994 (Appendix B Table 1). This allowed capping to begin on the northern side of the mound while contaminated sediments were disposed on the southern side of the mound.

2.4.2 Capping Operations

In addition to the use of the DAMOS capping model (which was not designed for large volume dredged material projects such as the New Haven capping project because it has a tendency to create unrealistically high central mound heights) capping operations were designed using a simple geometric analysis of volume and potential cap thickness. It was predicted that the dredged material would be placed in a berm-shaped mound approximately 5 m high, 250 m wide, and 608 m long including the thin flanks. The total areas to be covered by the cap material would need to extend 50 m beyond these

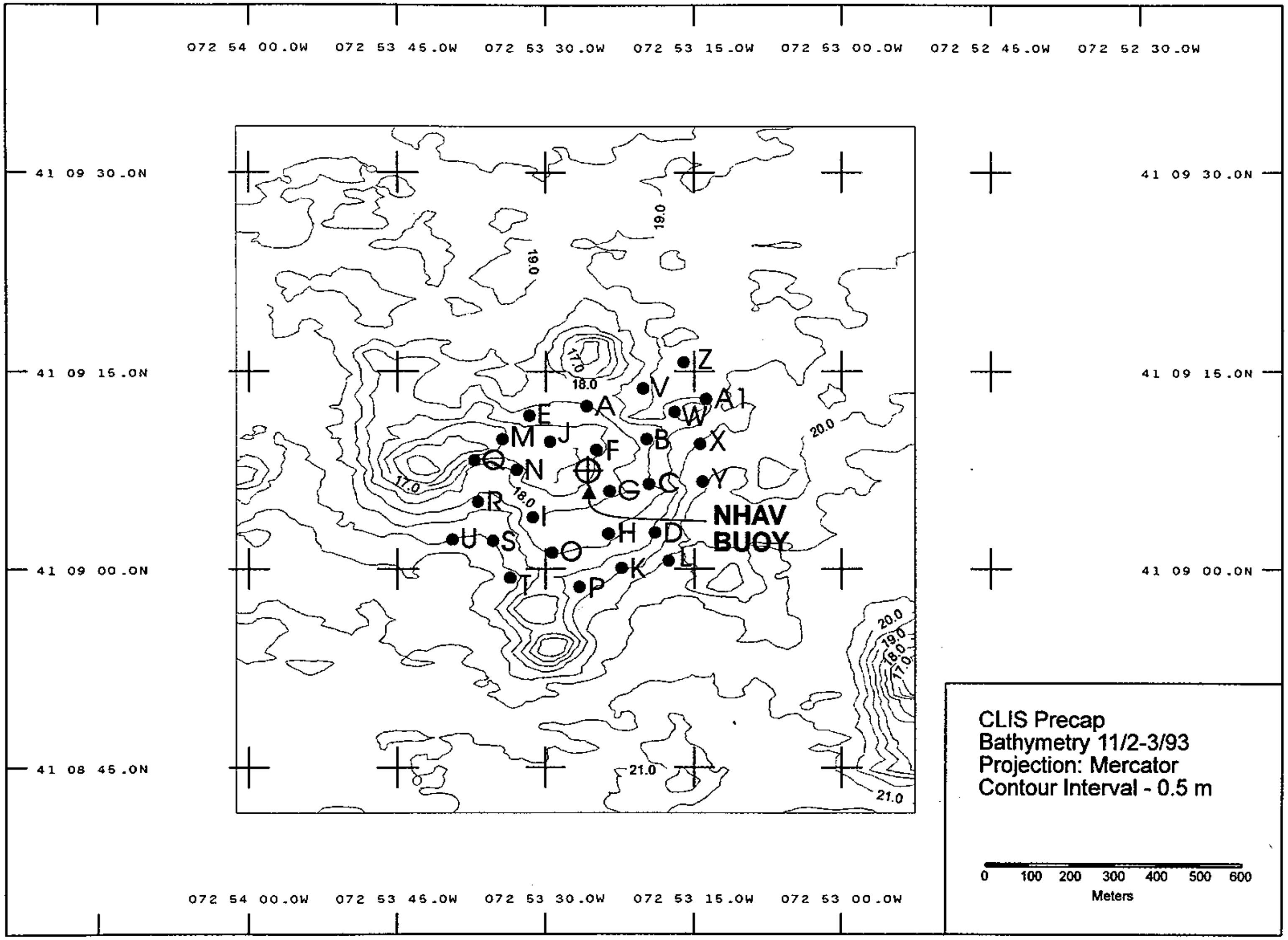

Figure 2-2. Cap placement locations at CLIS, 1993

dimensions with a designated cap thickness of 50 cm to 1 m. These calculations were based on estimated amounts of 539,800 m^3 of contaminated dredged material and 397,000 m^3 of cap material. Prior experience in the construction of capped sediment mounds at CLIS (STNH-N, STNH-S, MQR, CS-1, CS-2, and NORWALK) was also incorporated into the NHAV 93 mound capping design (SAIC 1995).

CDM dredged from the outer New Haven Harbor provided the bulk of the cap material, 505,848 m^3. Additional CDM was also obtained from sediments dredged from NE Petroleum, Lex Atlantic/Gateway, and Wyatt Incorporated terminals. This volume amounted to 63,439 m^3. The total volume of available cap material was 569,287 m^3.

Capping of the UDM deposit took place in several stages using a series of cap placement points (Figure 2-2; Appendix B Table 2) designed for complete coverage of the UDM mound. Prior to the precap survey, approximately 76,000 m^3 of CDM was deposited near points A, F, and J (Figure 2-2). The directed cap disposal began with depositing outer channel sediments at disposal points A-E on a rotating basis (3 November 1993). Additional UDM from the federal channel and private terminals was deposited at point I during this stage.

The second stage of capping began on 18 November 1993 when disposal was directed to points F, G, H, J, K, and L, again on a rotating basis. UDM continued to be disposed at point I. Beginning on 10 December 1993, capping operations were directed to points G, K, L, V, W, X, Y, Z, and A1. Disposal at eight of the nine points (excluding G) was completed on a rotating basis for cap sediments from the federal project and Northeast Petroleum. Point G was used for placement of Lex Atlantic/Gateway sediments. Location I was maintained for further disposal of UDM. A fourth revision in distribution of the cap material occurred on 22 December 1993. This stage began with disposal of cap material at and around point I (five trips) and the NHAV buoy (five trips). Additional cap material was then placed at points N, R, S, and O (three trips each). Once these trips were completed, capping was carried out on a rotating basis at the NHAV buoy and points G, I, M, N, O, P, Q, R, S, T, and U. This was intended to cap the most recently disposed contaminated material.

3.0 METHODS

SAIC conducted five monitoring surveys from September 1993 to March 1994: 1) baseline, 2) interim disposal, 3) precap, 4) interim cap, and 5) postcap (Figure 1-2) (Table 1-2). In addition to the comprehensive dataset generated by the strategic repetition of SAIC's survey activity, Ocean Surveys Incorporated conducted an interim cap survey in January 1994 to fulfill a contract with the marine terminals involved in the dredging project. Results of this survey are reported in Section 4.1.4.

The SAIC Integrated Navigation and Data Acquisition System (INDAS) provided the precision navigation required for all SAIC field operations. This system uses a Hewlett-Packard 9920® series computer to collect position, depth, and time data for later analysis, as well as provide real-time navigation. A Del Norte Microwave Trisponder® System provided positioning to an accuracy of ±3 m. Shore stations were established in Connecticut at known benchmarks at Stratford Point (41°09.112' N, 73°06.227' W) and Lighthouse Point (41°14.931' N, 72°54.255' W). A detailed description of the navigation system and its operation can be found in SAIC Report No. 290 (Murray and Selvitelli 1993).

3.1 Precision Bathymetric Surveys

The five precision bathymetric surveys that documented the stages of mound development were all centered at 41°09.125' N, 72°53.450' W, and conducted over a 1600 m × 1600 m area. The surveys were oriented east to west using 25 m lane spacing and requiring 65 lanes to fully cover the 2.56 km^2 area. An ODOM DF3200 Echotrac® Survey Fathometer with a narrow-beam 208 kHz transducer measured individual depths to a resolution of 3.0 cm (0.1 feet) as described in SAIC Report No. 290 (Murray and Selvitelli 1993). Depth values transmitted to the computer were adjusted for transducer depth. The acoustic records reliably detect changes in depth on the order of 20 cm due to the accumulation of errors introduced by the positioning system, tidal corrections, the calibration of the fathometer (speed of sound through the water column), the slope of the bottom, and the vertical motion of the vessel.

During each bathymetric survey, tidal variations at the disposal site were recorded using a Seabird Instruments, Inc. SBE 26-03 Sea Gauge wave and tide recorder. Pressure readings were collected at 6 minute intervals for the duration of the survey. After conversion to water depths, the readings provided a constant record of tidal variations over the survey area. The observed tidal data were later used to correct the bathymetric survey data.

Sound velocity measurements were obtained before and after the bathymetric survey using a Seabird Instruments, Inc. SEACAT SBE 19-01 Conductivity, Temperature, and Depth probe (CTD). The CTD was lowered over the side and allowed to equilibrate in ambient seawater for one to two minutes before initiating the cast. The CTD provided a profile of temperature, depth, salinity, and sound velocity in the water column. A mean sound velocity was then calculated and applied to the bathymetric data.

The data collected during each of the five bathymetric surveys were analyzed using SAIC's Hydrographic Data Analysis System v. 1.03 (HDAS). During analysis, raw bathymetric data were corrected for sound velocity and standardized to Mean Tidal Level. The corrected bathymetric data were then used to construct depth models of the surveyed area. Depth difference calculations were performed using the HDAS volume differencing routines. In order to assist NED in achieving its goal, SAIC supplied detailed contour and depth difference plots of the survey area 48 hours after each survey in order to modify the disposal or capping activity to ensure proper containment and coverage. A detailed discussion of the bathymetric analysis technique is given in SAIC Report No. 290 (Murray and Selvitelli 1993).

3.2 REMOTS® Sediment-Profile Surveys

Actual REMOTS® station locations (latitude and longitude) occupied during the surveys are provided in Appendix C along with analytical results. REMOTS® sediment-profile surveys were conducted prior to disposal to assess baseline conditions and after UDM disposal (precap survey) (Figure 1-2). Designed to obtain *in situ* profile images of the top 20 cm of the sediment, the REMOTS® sediment-profile camera has been used to detect and map the distribution of thin (0.1-20 cm) dredged material layers, and document seafloor processes and organism-sediment relationships as they occur naturally on the seafloor and on the disposal site (Rhoads and Germano 1990). Specific measurement/ observational techniques for determining REMOTS® parameters include sediment grain size major mode and range, prism penetration depth, surface boundary roughness, presence/absence and size of mud clasts, apparent redox potential discontinuity (RPD) depth, apparent presence/absence of sedimentary methane, infaunal successional stage, and calculation of the REMOTS® Organism-Sediment Index (OSI).

3.2.1 Baseline Survey

During the September 1993 baseline survey, REMOTS® sediment-profile photographs were obtained in triplicate from 30 stations surrounding the NHAV buoy (Figure 3-1; Appendix C Table 1). A series of six-station transects were occupied, over five surrounding sediment mounds (CLIS 87-88 complex, CLIS 89, CLIS 90, NORWALK,

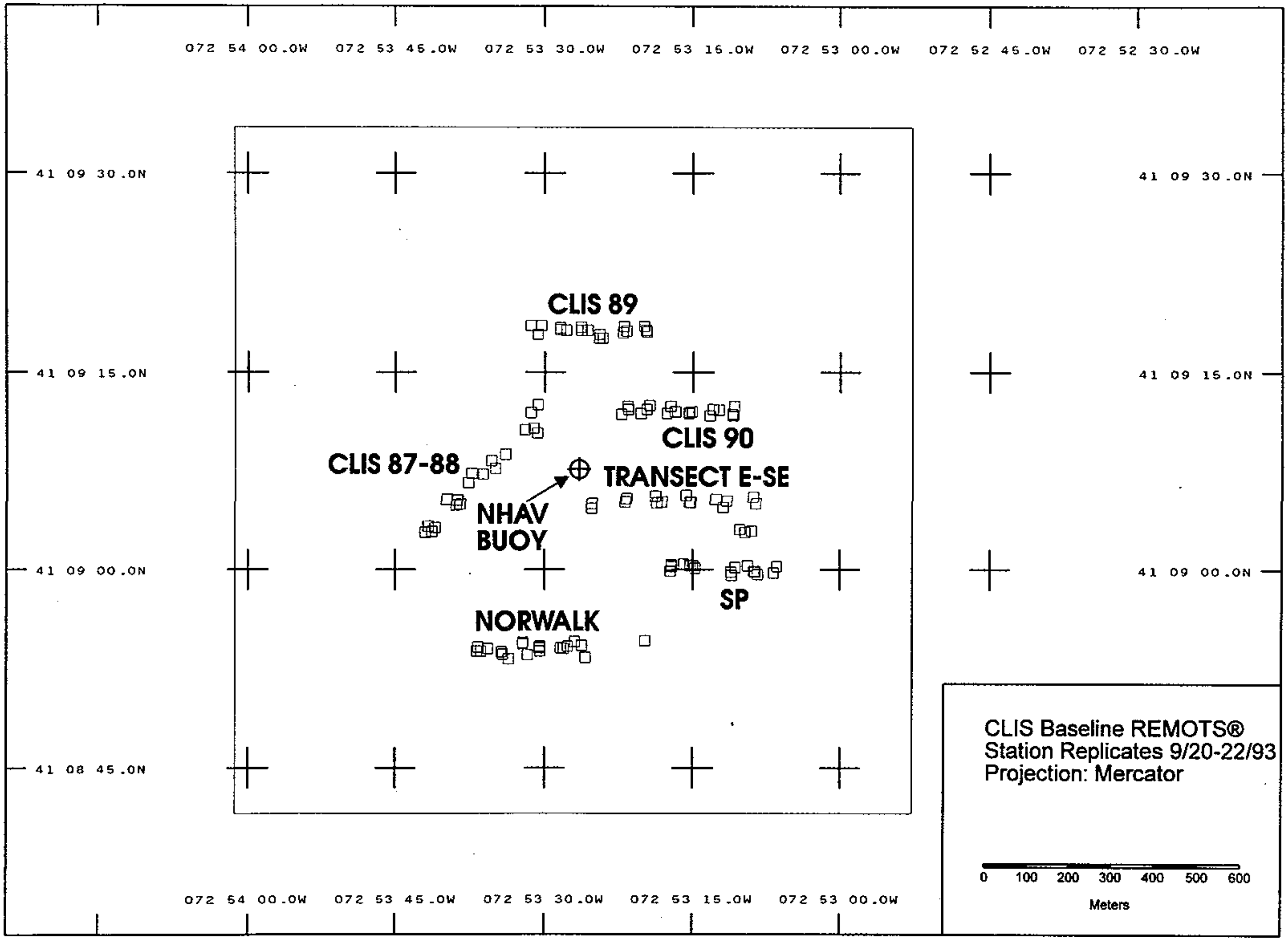

Figure 3-1. Station replicate locations for the baseline REMOTS® sediment-profile survey conducted 21-22 September 1993

and SP) and along the east-southeast valley area to determine recolonization status and relative shear strength of the sediments (Figure 3-2; Appendix C Table 2).

3.2.2 Precap Survey

SAIC conducted a second REMOTS® survey on 3-4 November 1993 following the completion of the inner harbor dredging. Transects were oriented in the eight major compass directions (N, NE, E, SE, S, SW, W, NW) to delineate the apron of the disposal mound for capping. The survey was conducted from the center of the mound (41°09.100' N, 72°53.442' W) as determined by the interim disposal survey. Each transect began 325 m from the center and consisted of four stations spaced 75 m apart extending a total of 550 m from the center. Three replicate samples were taken at each station. The presence and/or absence of dredged material was determined for each REMOTS® sediment-profile photograph (Figure 3-2).

In addition to the eight directional transects, two other stations in the southwest quadrant were also sampled, 400 m SSW and 400 m WSW, during the precap survey (Appendix C Table 2). The southwest quadrant may be selected as a site for future disposal operations, and information from these stations was used to provide greater detail on the distribution of dredged material and status of the benthic community. A nine-station cross-shaped grid was conducted over the historic FVP mound in the northeast corner of the disposal site. The REMOTS images were used to determine whether excess cap material should also be directed to the FVP mound (Appendix C Table 3).

3.3 Geotechnical Cores/Surface Grabs

Geotechnical cores were obtained in a joint effort between SAIC and the University of Rhode Island (URI) using the PVC version of the Marine Geotechnical Laboratory (MGL) Large-diameter Gravity Corer (LGC) (Appendix D Table 1, and Figures 1 through 3) (Silva et al. 1994a). The core barrel consisted of a 3 m (10 ft) section of Schedule 40 PVC with a 10.2 cm (4.0 in) inside diameter. The PVC core barrel included a nose cone and core catcher at the bottom. Basement sediments were cored during the baseline and precap surveys to establish geotechnical characteristics before loading by any additional layers of material. During each interim survey (i.e., disposal and capping) sediment grabs were collected from the vicinity of the NHAV buoy and the center of the disposal mound to characterize the surface sediments (Figure 1-2; Appendix D Table 2).

Basement material, UDM, and CDM were cored immediately following completion of the CAD mound to establish the initial geotechnical characteristics of the completed mound (Figure 1-2). These data will be used as a reference for future geotechnical

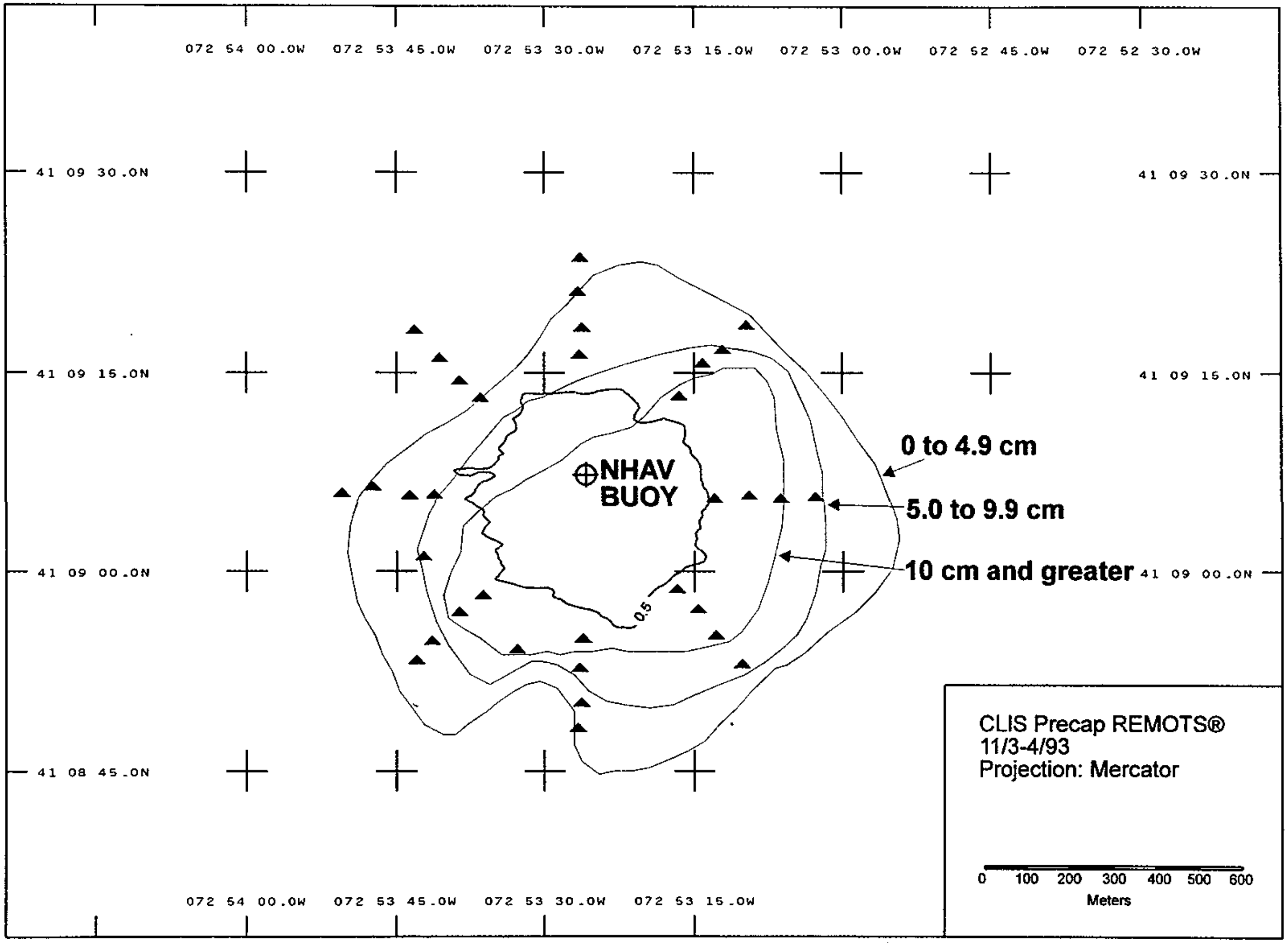

Figure 3-2. Station locations for the precap REMOTS® sediment-profile survey conducted 4 November 1993 with dredged material thickness seen in REMOTS® analysis and 0.5 m contour from bathymetry. Contour lines indicate thickness of dredged material.

and bathymetric surveys over the NHAV 93 mound and to carry out numerical computations of settlement and volume changes.

Results of URI's analysis of the sediment cores and surface grabs have been submitted in a separate report (Silva et al. 1994b). Twenty good quality cores with lengths from 69 cm to 302 cm were recovered during the baseline, precap, and postcap surveys using the LGC system (Appendix D). Before splitting the cores (core liners), a Multi-Sensor Core Logger (MSCL) was used to obtain profiles of sediment bulk density. Visual descriptions (and photographs) were recorded and subsamples extracted for analysis of the physical properties (grain size, water content, Atterberg limits, and specific gravity). Consolidation behavior was measured through analysis (void ratio versus effective stress, compression index, and consolidation stress) and permeability data (direct and indirect measurements).

4.0 RESULTS

4.1 Repetitive Bathymetric Surveys

CLIS is located in a depositional area of Long Island Sound, characterized by mild bottom current regimes and subject to shallow, wind-driven waves. Since 1984, the DAMOS site management strategy at CLIS has been to create a ring of disposal mounds for the deposition of large volumes of dredged material. The New Haven Capping Project marks the first instance that an artificial containment measure was designed and utilized for the deposition of dredged material. The entire CAD mound development process was observed, scrutinized, and documented by SAIC in support of the DAMOS Program. Results of the precision bathymetry and depth difference analyses for the five surveys conducted at CLIS between September 1993 and March 1994 are presented below including 1) baseline (predisposal), 2) interim disposal, 3) precap, 4) interim cap, and 5) postcap.

4.1.1 Baseline Survey (19-20 September 1993)

Results of the baseline bathymetry indicate, with the exception of shallower water depths over the mounds, water depths in the area range from 19 m in the northern half of the surveyed area to 21 m in the southern portion (Figure 1-1). Water depths over the mound centers were as follows: CLIS-87 and CLIS-88 16 m, CLIS-89 17 m, CLIS-90 19 m, CLIS-91 19 m, NORWALK 18.5 m, and SP 19.5 m. The historic NHAV-74 mound is visible in the southeast corner of the bathymetric chart with a minimum depth of 17.0 m before extending beyond the survey area.

4.1.2 Interim Disposal Survey (23-25 October 1993)

The interim disposal survey was completed when the federal inner harbor dredging was 50% complete. Development of the mound is readily apparent in the bathymetric analysis of the interim survey (Figure 4-1) when compared to the baseline survey (Figure 1-1). The water depth at the center of the NHAV 93 UDM mound was 17.0 m. The depth difference comparison between the baseline and interim disposal surveys (Figure 4-2) showed a mound approximately 400 to 450 m in diameter and 3 m in height. The total volume of the mound based on successive bathymetric surveys was 238,000 m^3 (Table 4-1).

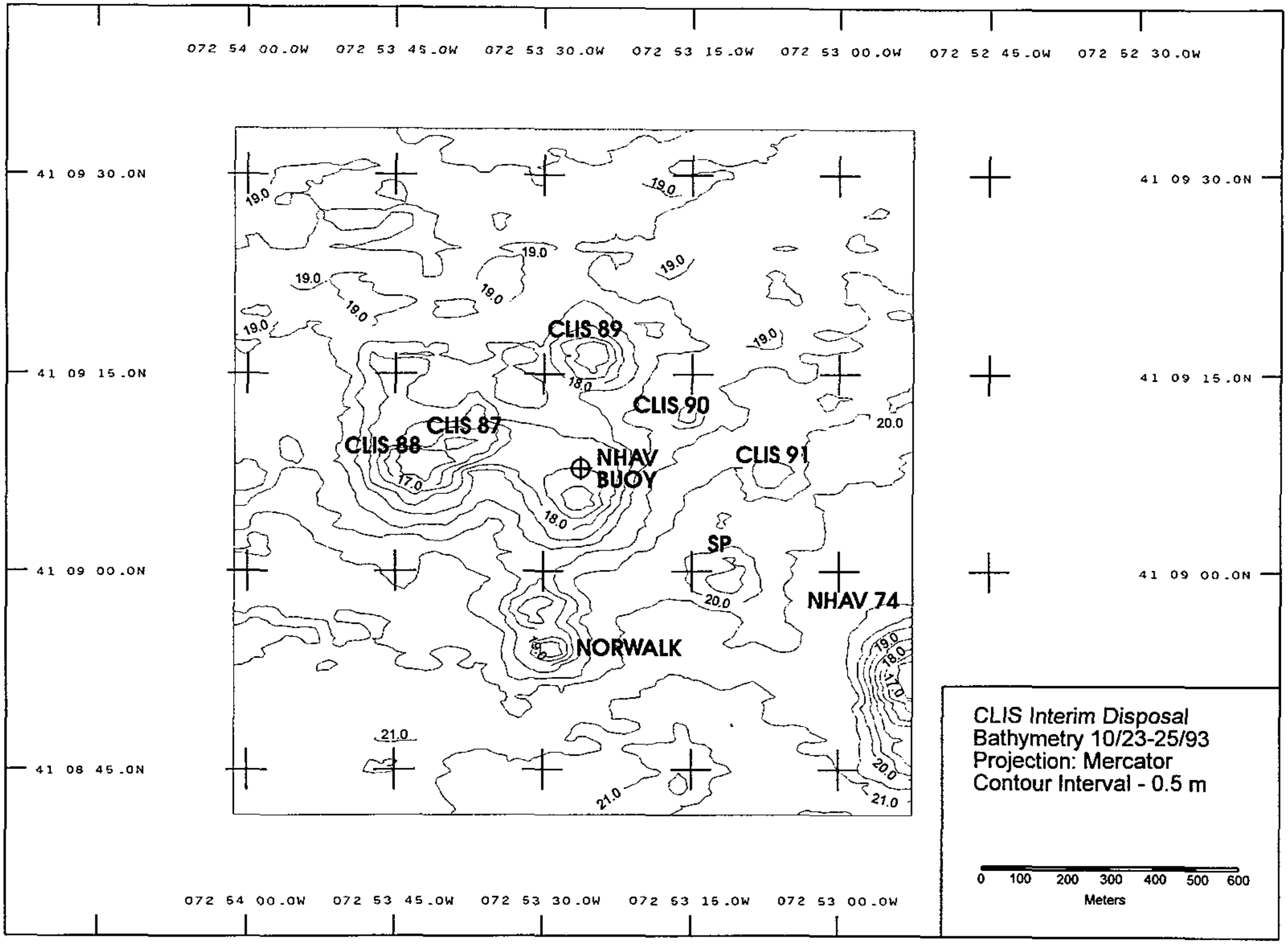

Figure 4-1. Contoured bathymetric chart around the disposal point following disposal of 50% of the sediments for the federal inner harbor dredging project, October 1993 (depth in meters)

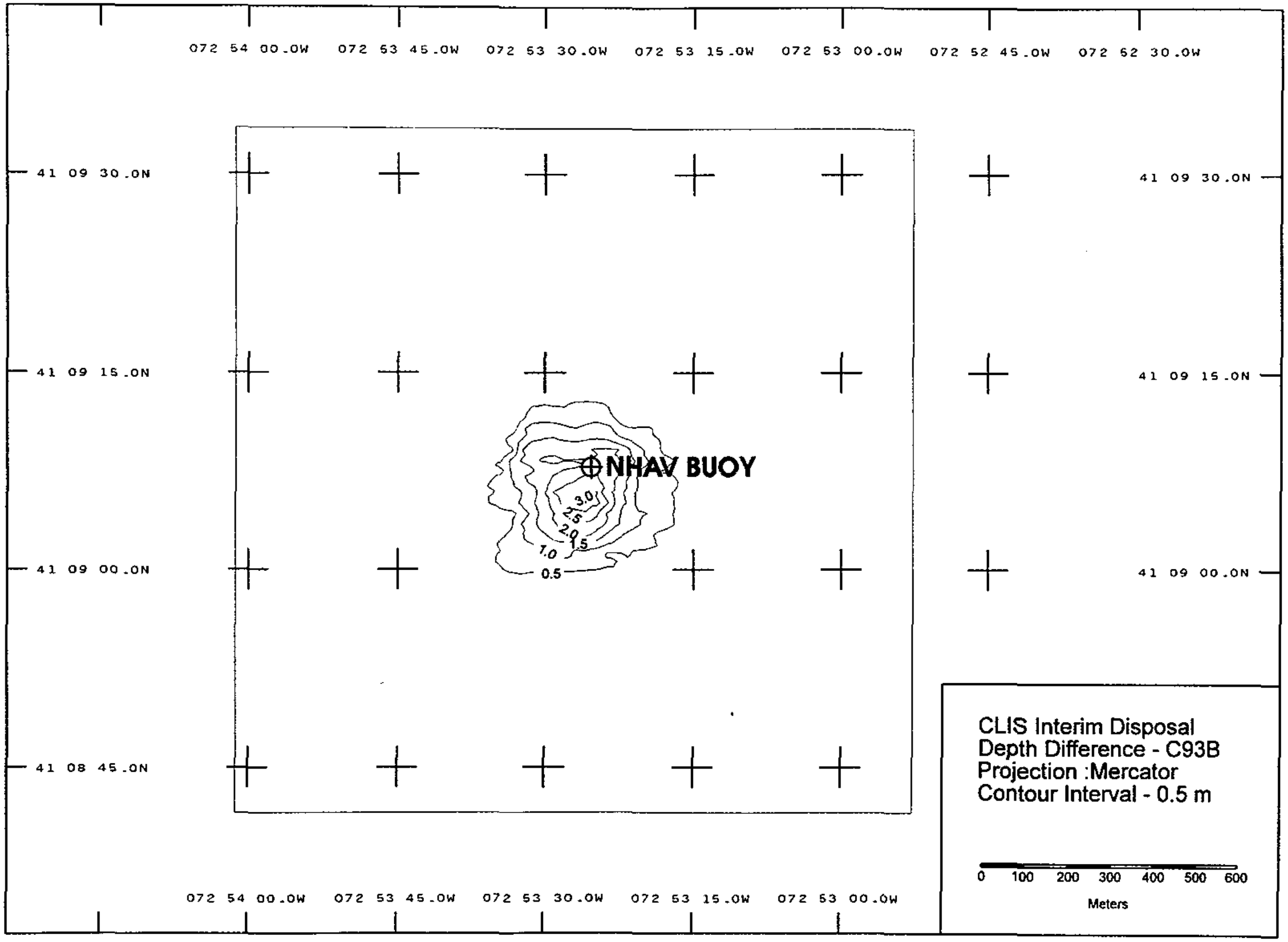

Figure 4-2. Depth difference contour chart (in meters) based on the comparison of the interim disposal (October 1993) and baseline (September 1993) bathymetric surveys

Table 4-1

Summary of Volume Difference Calculations for the
New Haven Capping Project, September 1993 to March 1994

	m^3
Baseline/Interim Disposal	238,000
Interim Disposal/Precap	74,000
TOTAL DREDGED MATERIAL	**312,000**
Precap/Interim Cap	124,000
Interim Cap/Postcap	278,000
TOTAL CAP	**402,000**
TOTAL VOLUME	**714,000**

4.1.3 Precap Survey (2-3 November 1993)

This survey measured the NHAV 93 mound following the completion of the federal inner harbor dredging and UDM deposition, as well as the disposal of 76,000 m^3 of cap material at the northwest capping locations. Disposal of UDM from the private dredging operations continued over the southwestern flank of the disposal mound. (Figure 2-2, point I). The analysis of bathymetric data from the precap survey (Figure 4-3) indicated a loss in mound height (0.5 m) from the interim disposal survey (Figure 4-1). An interesting result of the bathymetric comparison is evidence of a large amount of consolidation or slumping of the dredged material. The depth difference contours between the interim disposal and precap survey (Figure 4-4) show the loss at the mound peak due to structural failure of the apex. The profile plot comparing survey lane 35 from the interim and the precap survey (Figure 4-5) is included to show the evidence of slumping of the mound peak and the movement of material towards the northeast. Results of the depth difference between the baseline and precap operations (Figure 4-6) show the size of the mound to be approximately 510 m in diameter and 2.5 m in height. The calculated total volume of the mound based on the baseline and precap bathymetric surveys is 312,000 m^3. The volume shown by the depth difference model between the interim disposal survey and the precap survey is 74,000 m^3.

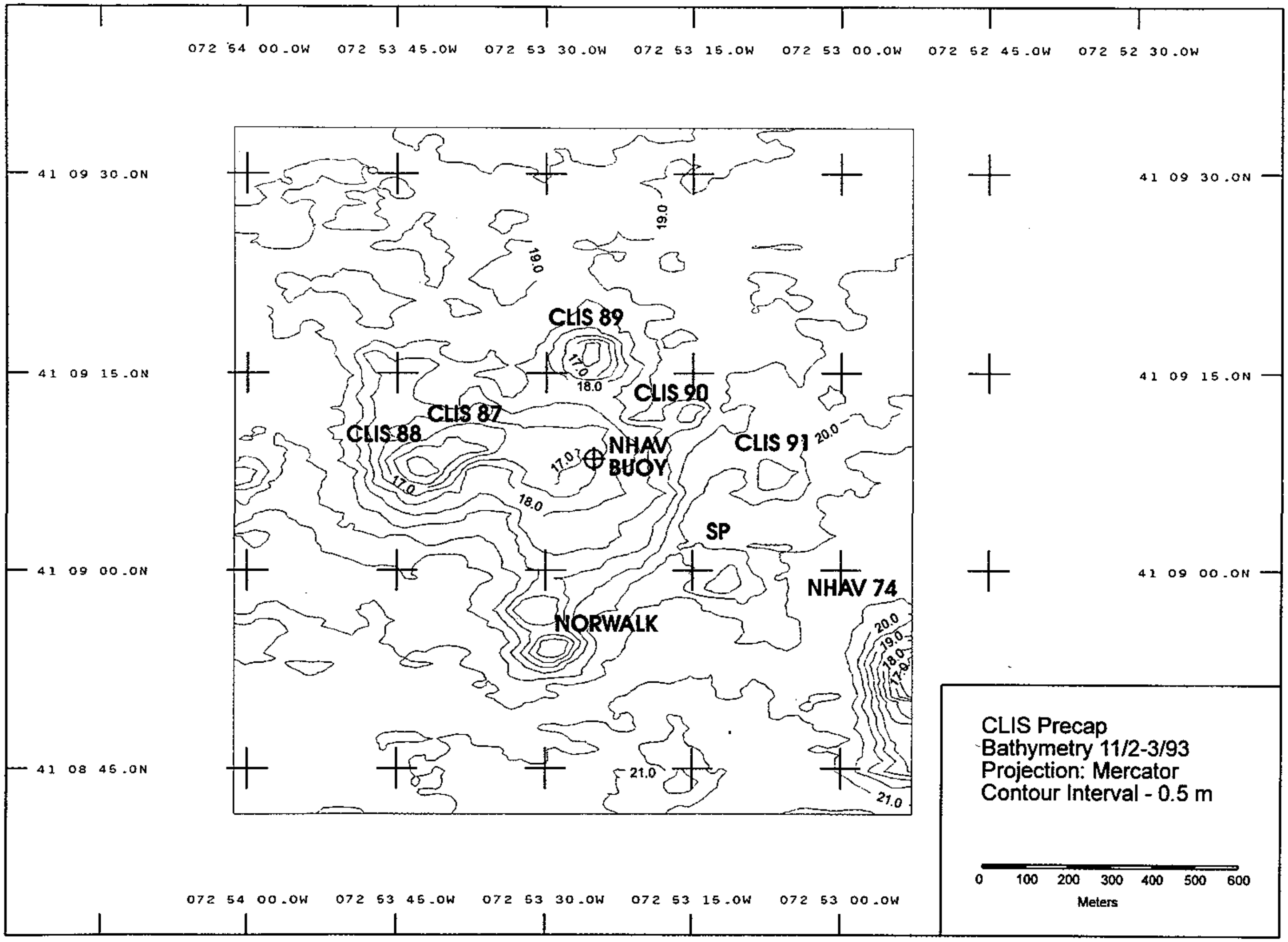

Figure 4-3. Contoured bathymetric chart of the mound complex at precap status or 100% completion of the dredging of the inner harbor sediments plus approximately 76,000 m^3 of cap material, 2 November 1993 (depth in meters)

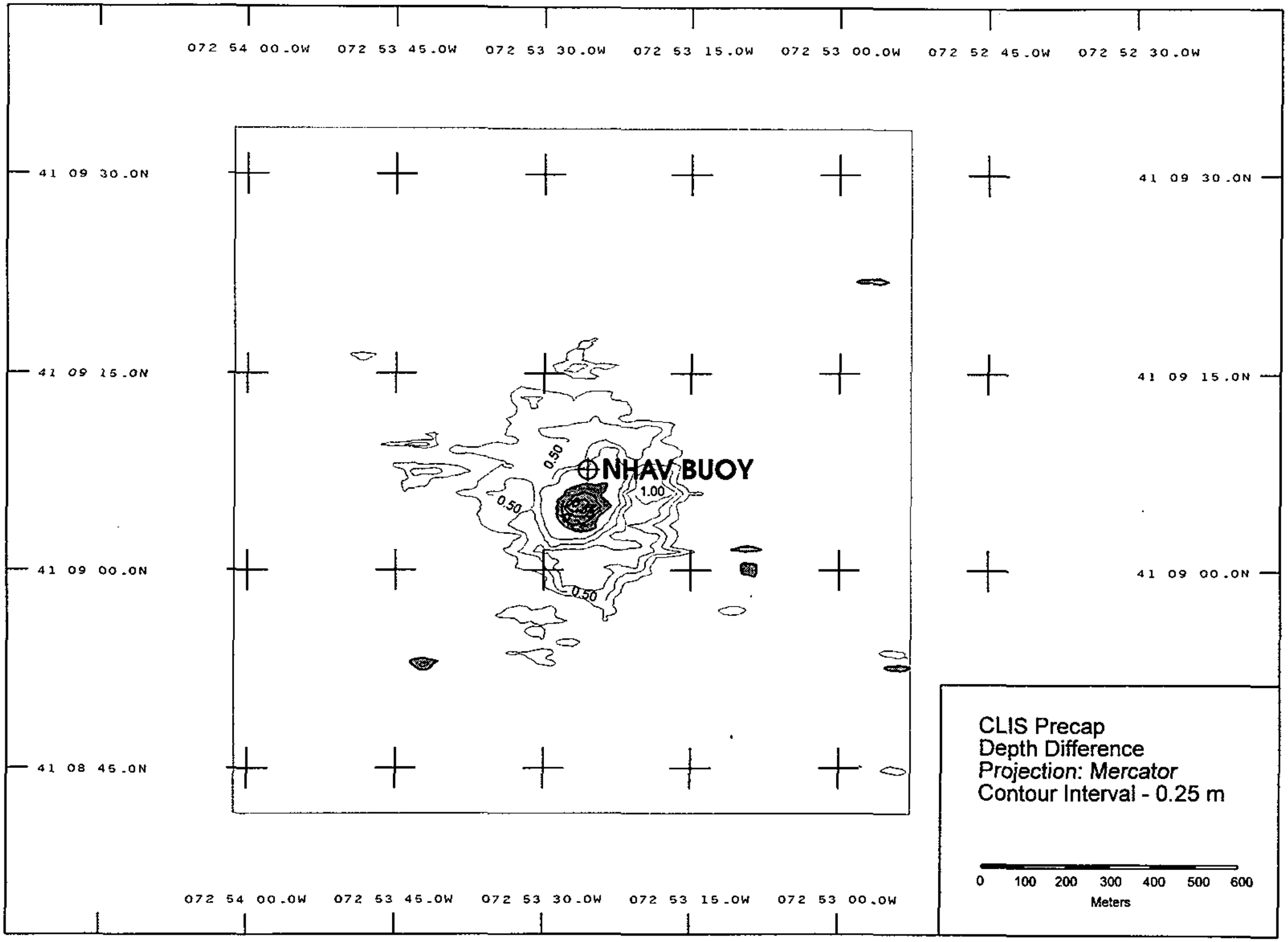

Figure 4-4. Depth difference contour chart (in meters) based on the comparison of interim disposal (October 1993) and precap (November 1993) bathymetric surveys. Negative depth differences showing the loss in mound height are shaded.

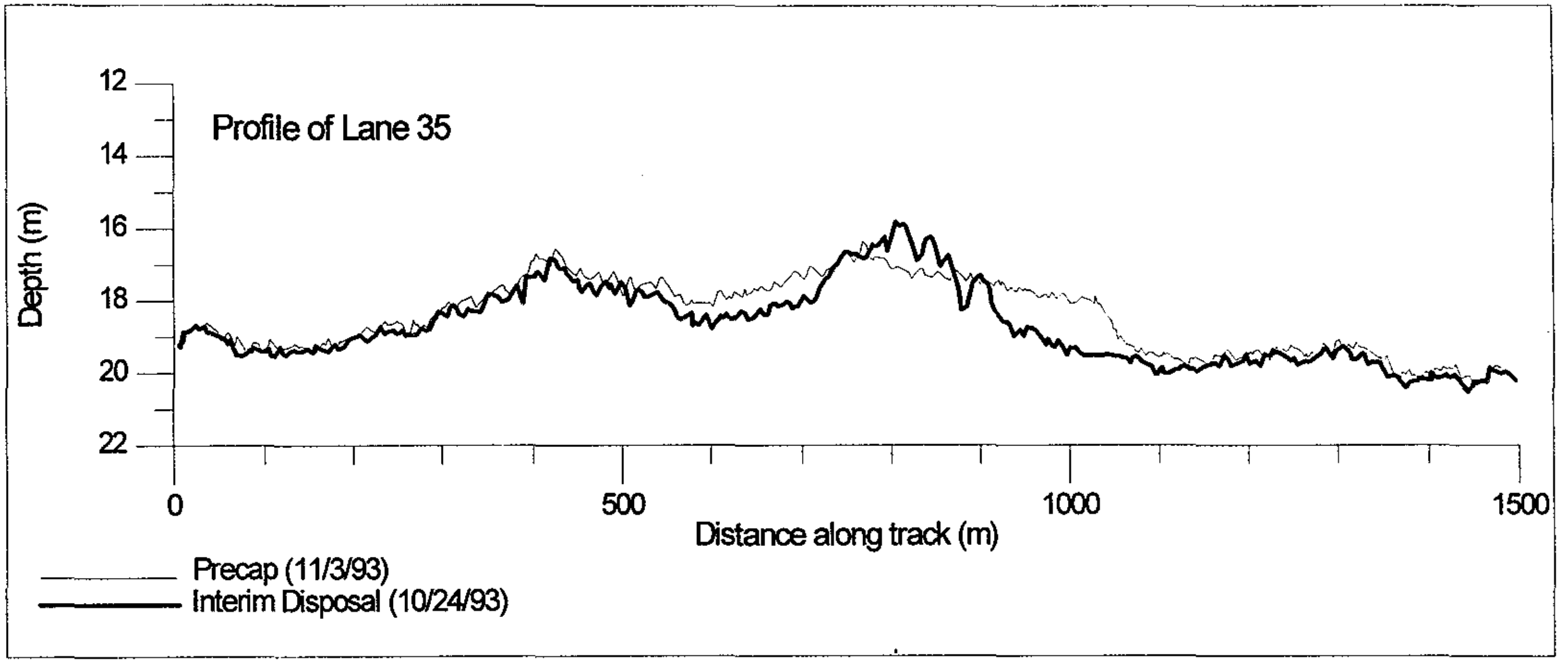

Figure 4-5. Bathymetric profile plots of survey lane 35 from the interim disposal survey (October 1993) and precap survey (November 1993)

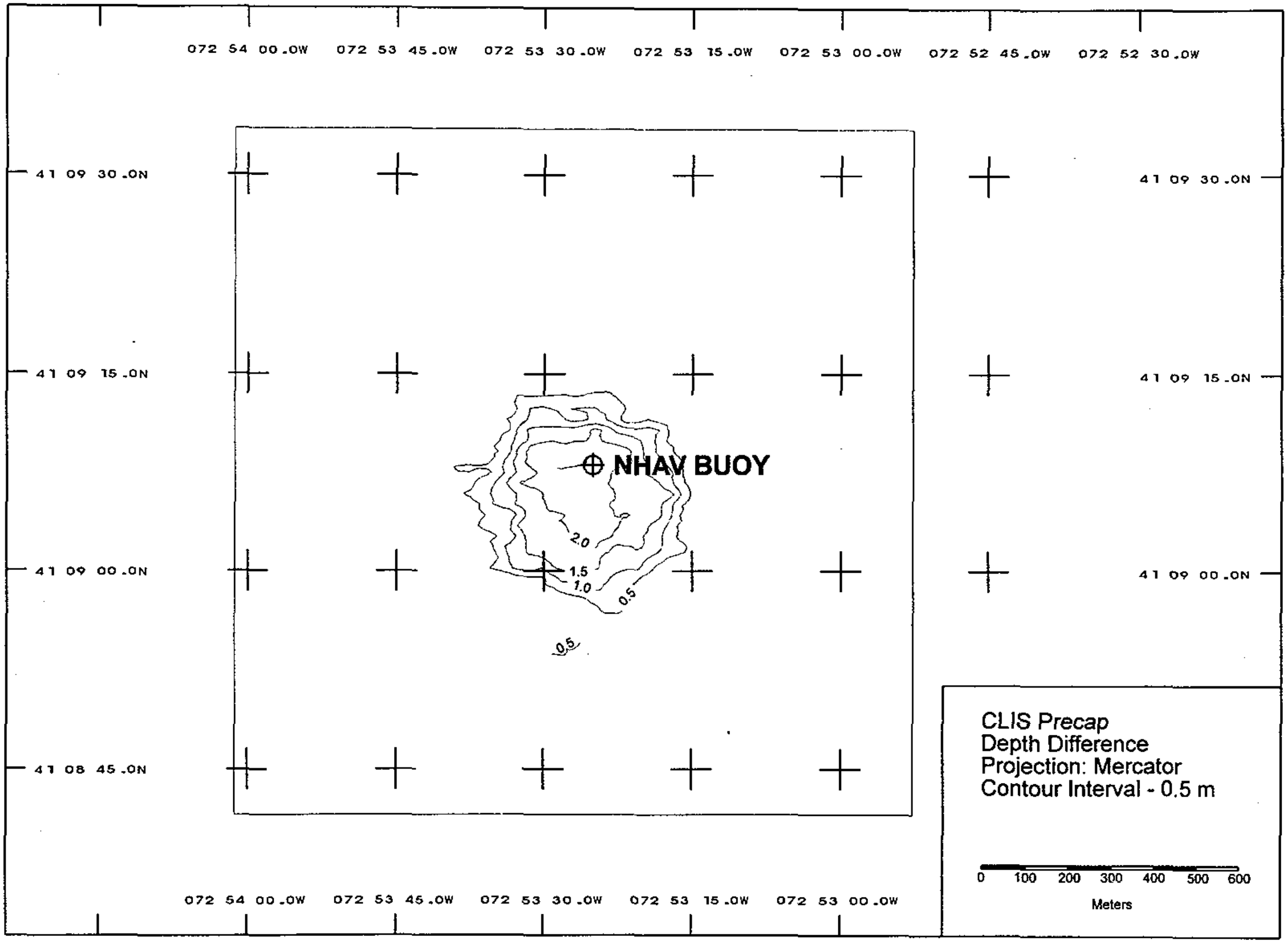

Figure 4-6. Depth difference contour chart (in meters) based on the comparison of the precap (2 November 1993) and baseline (September 1993) bathymetric surveys

4.1.4 Interim Cap Surveys (23-24 November 1993 and 12-13 January 1994)

Two interim cap bathymetric surveys were conducted, one by SAIC in late November (Figure 4-7) when the federal capping operations were 50% complete and another by Ocean Surveys Incorporated on 12-13 January 1994 (Figure 4-8) following the completion of the dredging of contaminated sediment from the private terminals. Results of the depth difference comparing the 2-3 November precap survey to the 23-24 November interim cap survey (Figure 4-9) showed that the volume added to the mound was 124,000 m^3 to the east and southeast of the buoy. Most of the capping activity following the interim cap survey was concentrated in the southwestern portion of the mound where the UDM originating from the private terminals was deposited. The height of the mound was 2.5 m, and the diameter of the mound was approximately 550 m. The depth difference comparing the November interim cap survey to the September baseline survey showed the total volume of the mound to be 435,000 m^3.

In comparing the data from the Ocean Surveys Incorporated survey (Figure 4-8) to the SAIC baseline survey (Figure 1-1) there was an average overall discrepancy of 0.92 m. This difference was the result of comparing datasets corrected to dissimilar vertical datums used for tidal corrections. SAIC data is referenced to observed Mean Tide Level (MTL) over the survey area, while Ocean Surveys Incorporated used tidal corrections based on Mean Lower Low Water (MLLW) predictions. After correcting the Ocean Surveys Incorporated data to previous SAIC surveys, two depth difference plots were generated. The first plot shows the thickness of material added since the baseline survey (Figure 4-10). This represents a total mound volume of about 593,000 m^3. The second depth difference shows the material added between the January and precap (November 2-3) surveys (Figure 4-11). The volume from this comparison, 281,000 m^3, includes all of the privately dredged contaminated sediments and some of the federal capping sediments. This plot illustrates that the deposition of dredged material during this period was mostly over the southeast flank of the NHAV 93 mound in accordance with the direction from NED.

4.1.5 Postcap Survey (13-14 March 1994)

Comparison of the postcap (Figure 4-12) and baseline (Figure 1-1) bathymetric surveys shows the formation of a well-developed mound centered 125 m to the south of the NHAV buoy. The water depth at the center of the mound is 17.5 m. The depth difference comparison of the postcap survey versus the baseline survey (Figure 4-13) shows the height of the mound to be 2.5 m and the mound diameter to be 600-800 m. The final volume of the capped NHAV mound based on that comparison is approximately 714,000 m^3. Differencing the postcap survey to the precap survey (Figure 4-14) shows the total volume of cap material and privately dredged sediments to be approximately

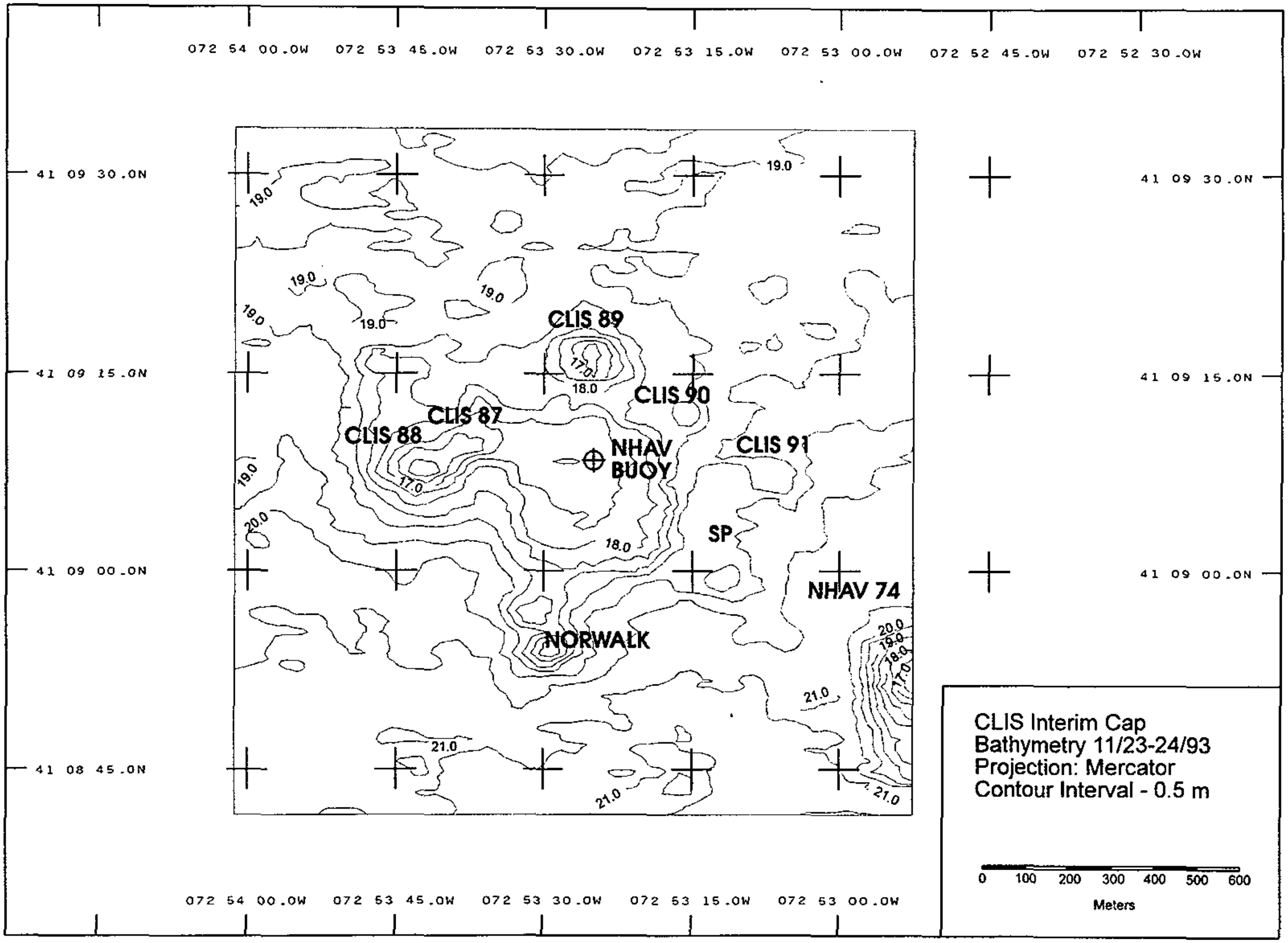

Figure 4-7. Contoured bathymetric chart of the mound complex following completion of 50% of the capping operations, 23 November 1993 (depth in meters)

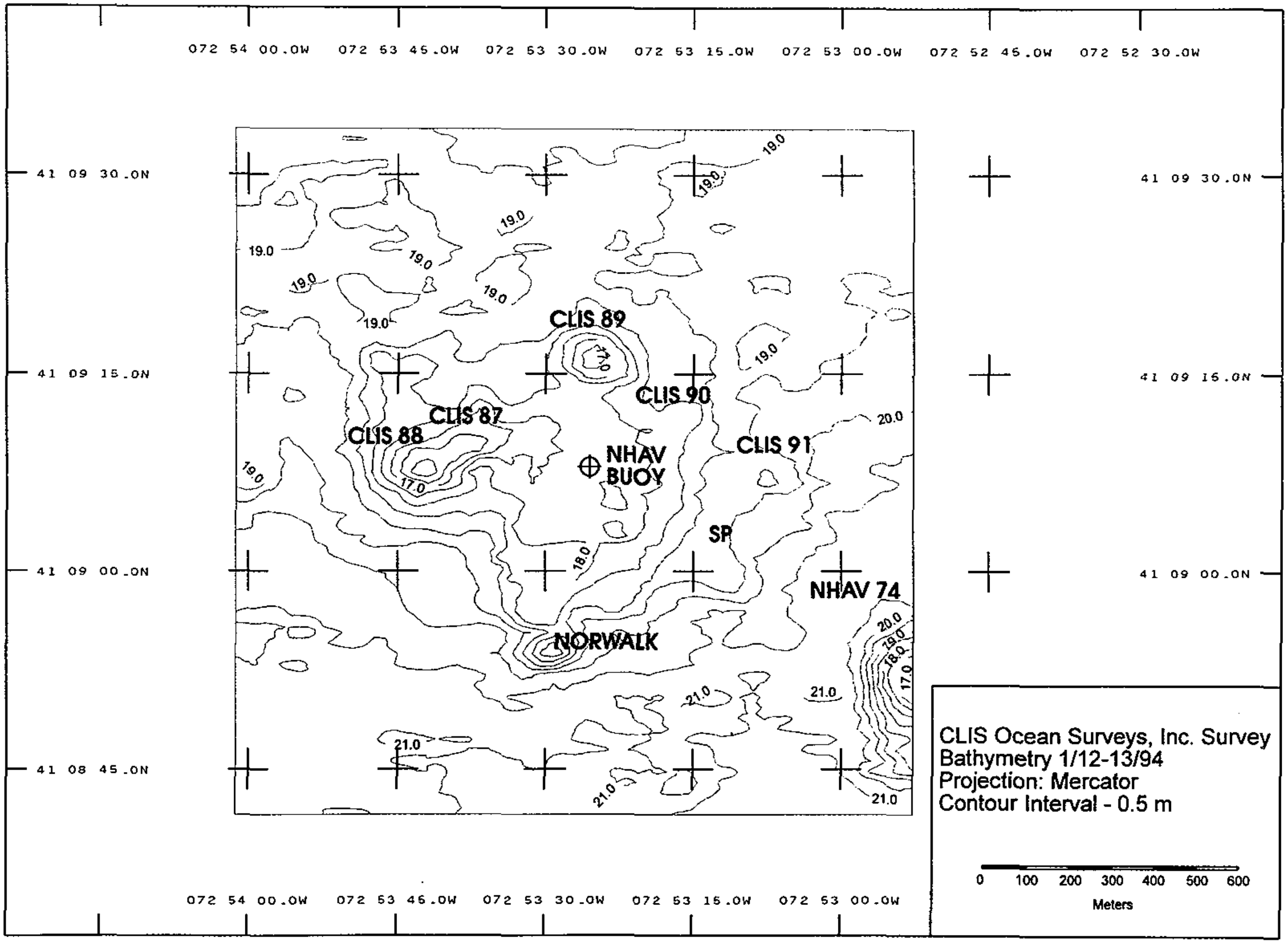

Figure 4-8. Contoured bathymetric chart based on data collected by Ocean Surveys, Inc. at the completion of the private dredging operations, January 1994 (depth in meters)

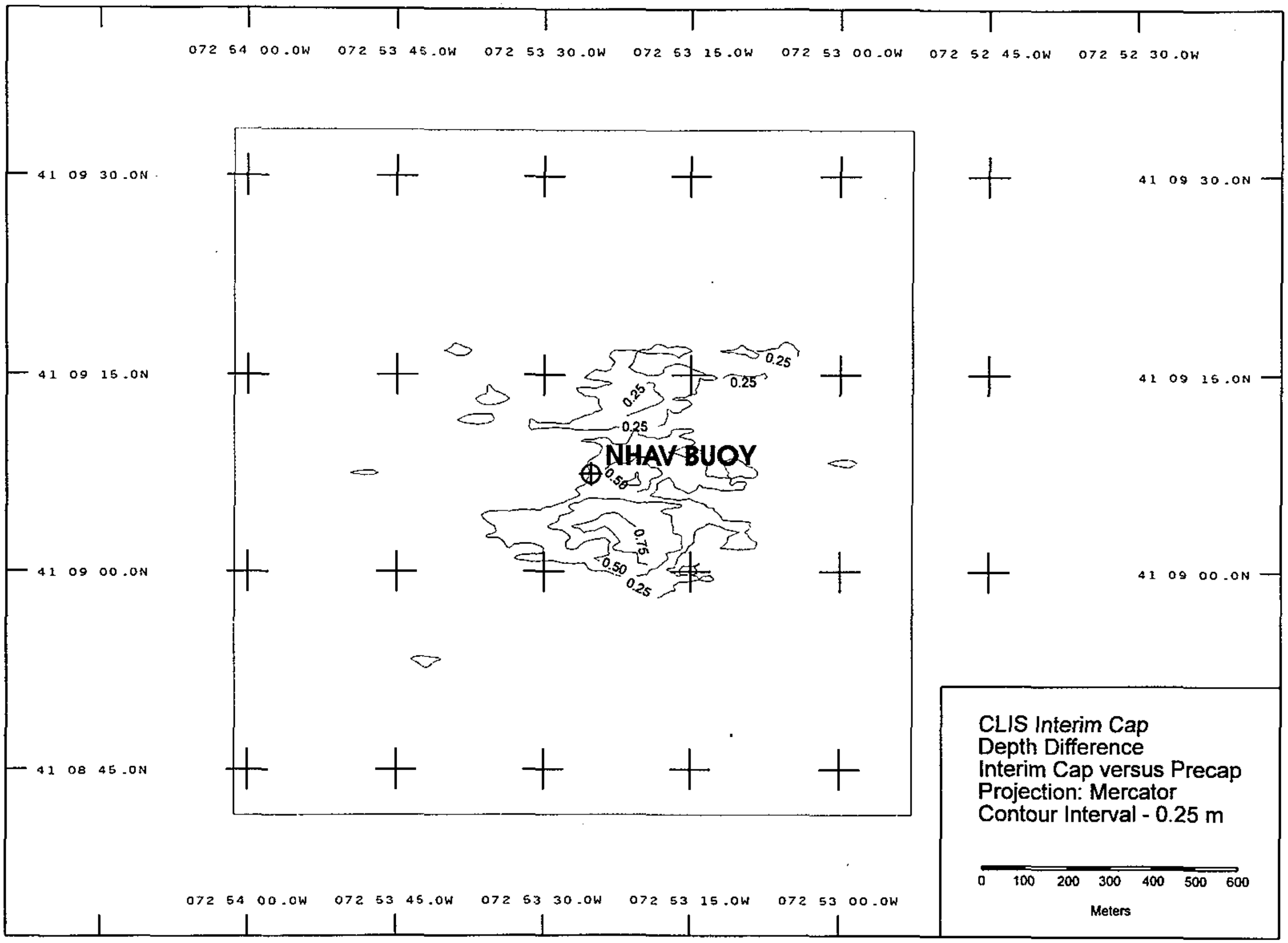

Figure 4-9. Depth difference contour chart (in meters) based on the comparison of the interim cap (23 November 1993) and precap (2 November 1993) bathymetric surveys

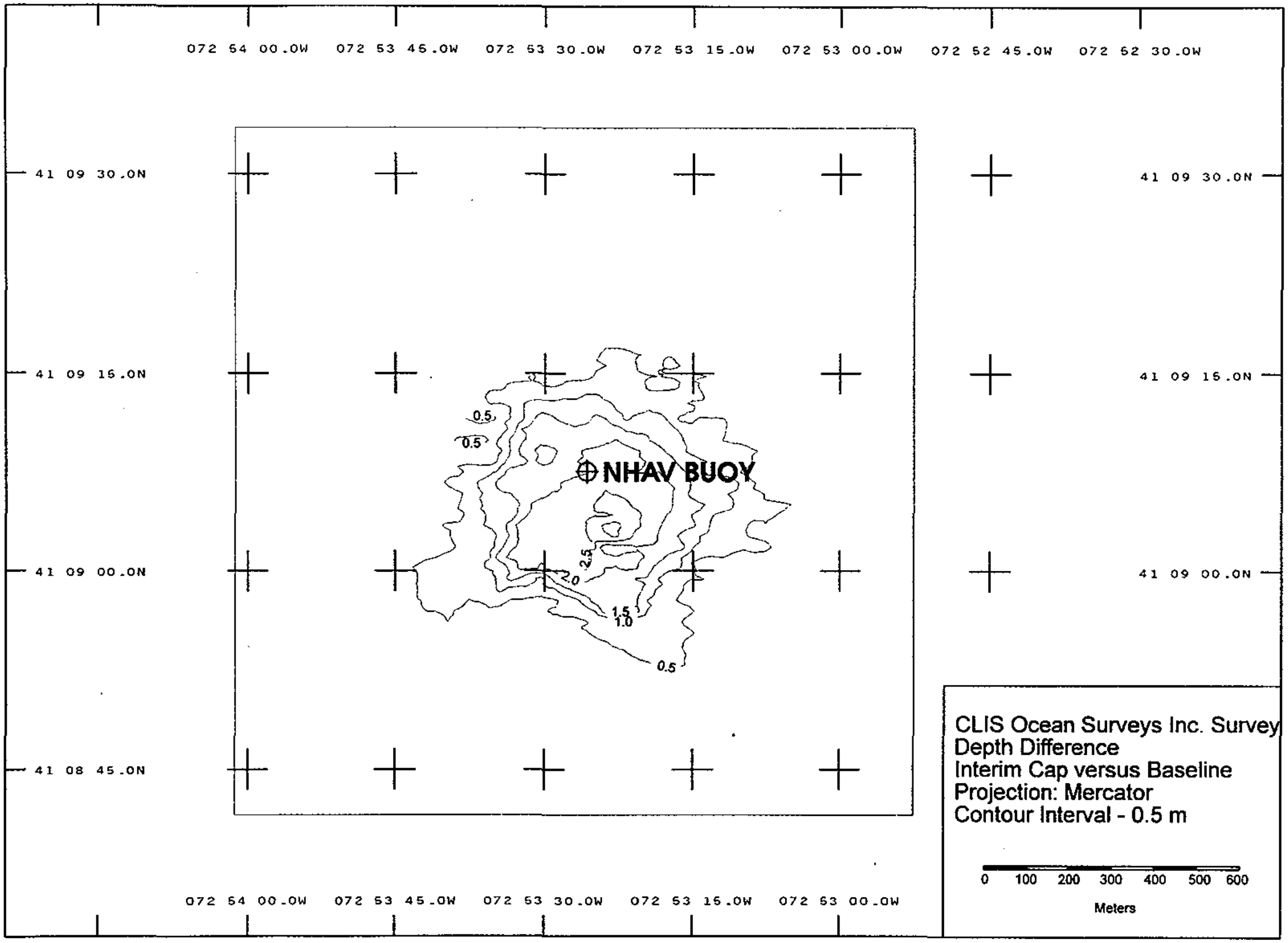

Figure 4-10. Depth difference contour chart (in meters) based on the comparison of the Ocean Surveys, Inc. interim cap (January 1994) and SAIC baseline (September 1993) bathymetric surveys

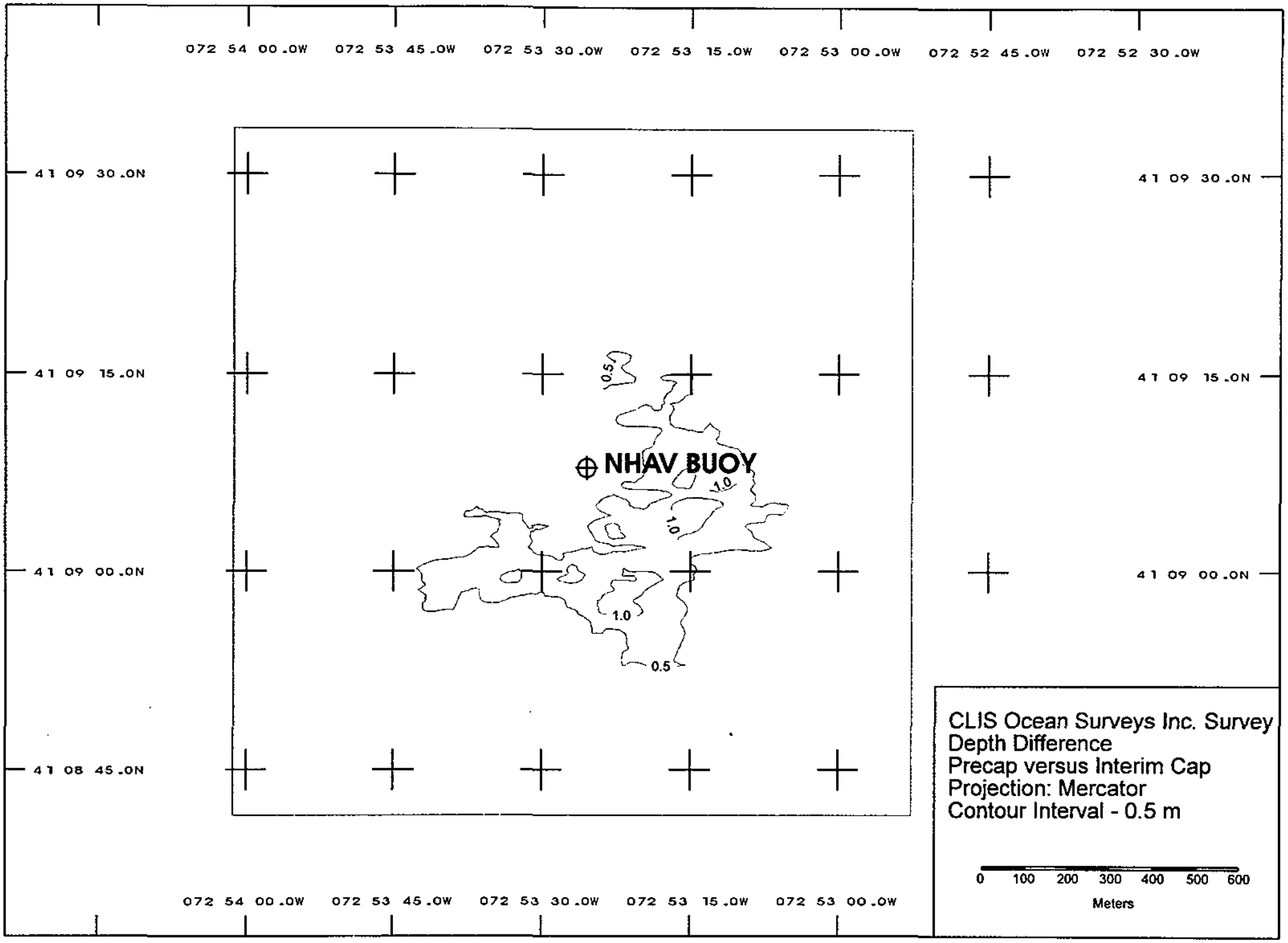

Figure 4-11. Depth difference contour chart (in meters) based on the comparison of the SAIC precap survey (2 November 1993) and the Ocean Surveys, Inc. interim cap survey (January 1994)

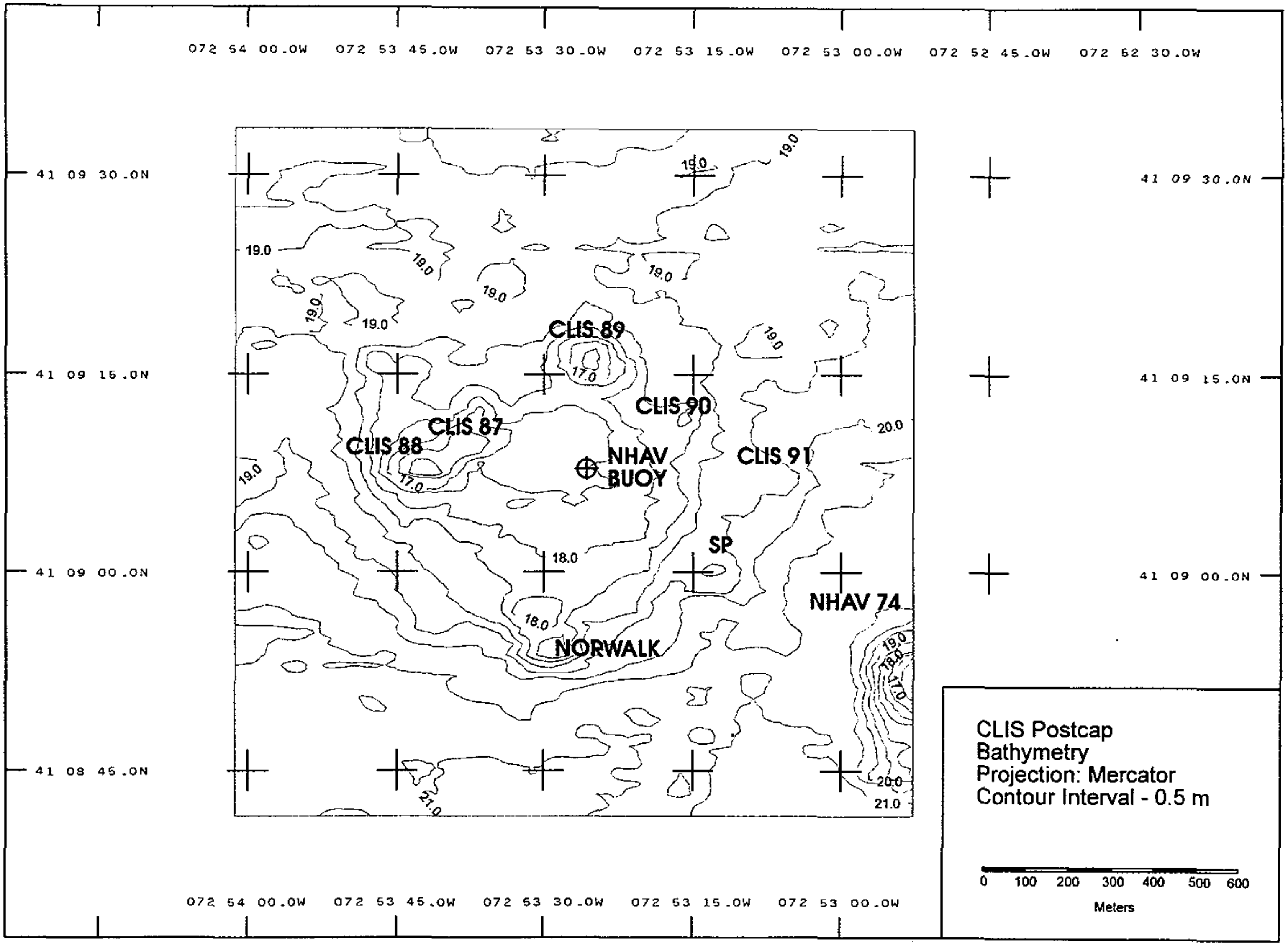

Figure 4-12. Contoured bathymetric chart of the mound complex following completion of the capping operations (postcap), March 1994

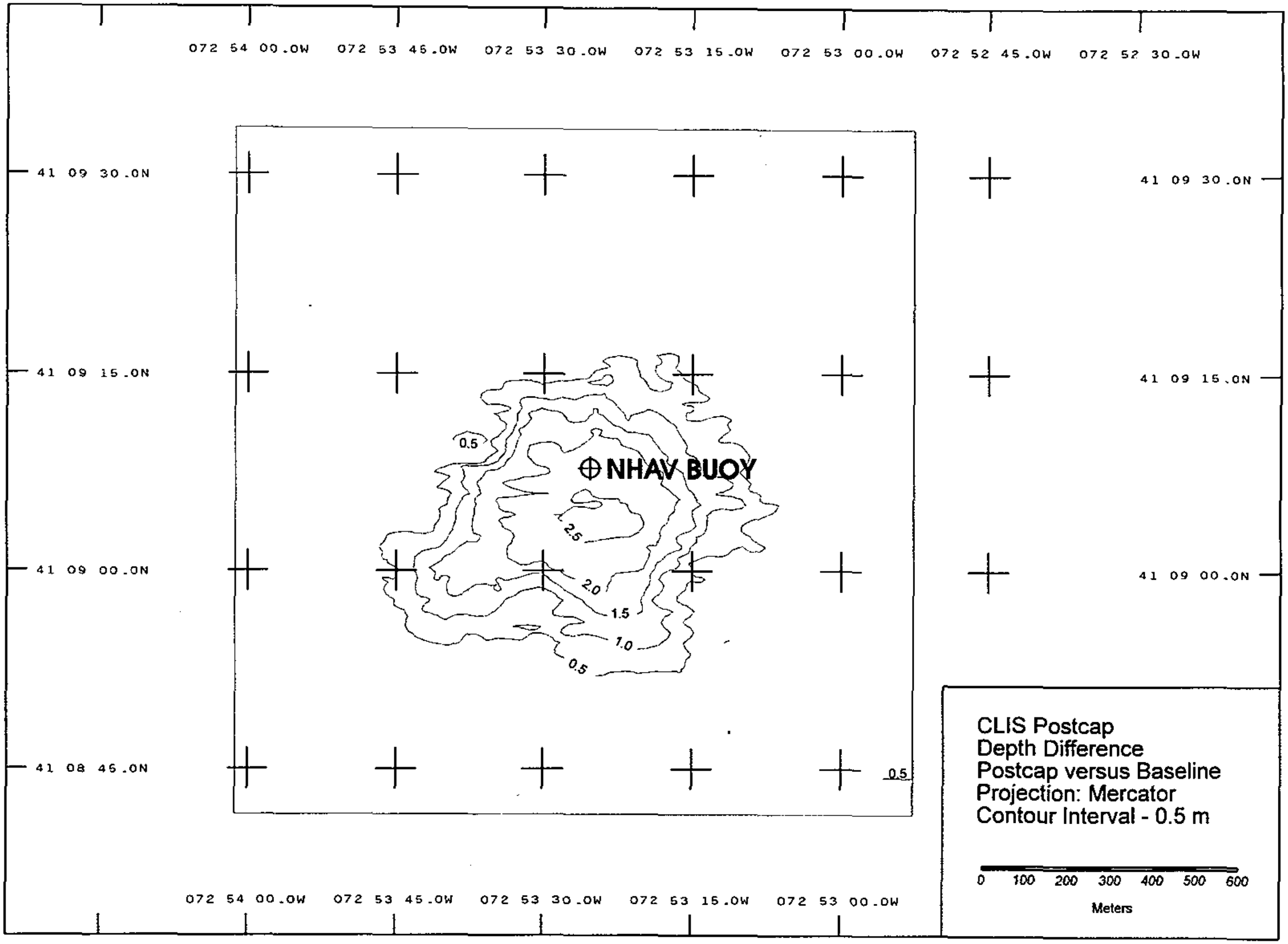

Figure 4-13. Depth difference contour chart (in meters) based on the comparison of the postcap (March 1994) versus baseline (September 1993) bathymetric surveys

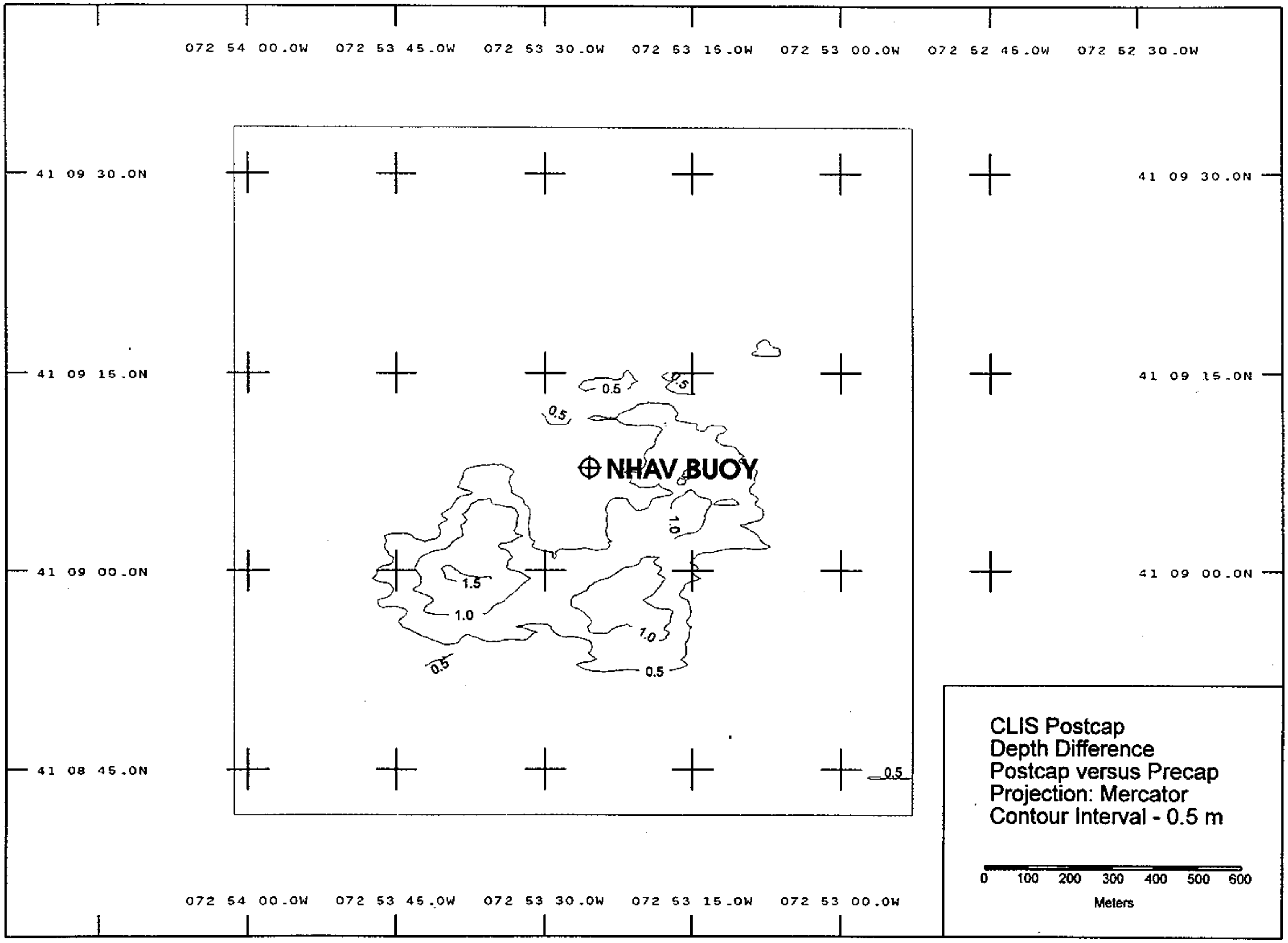

Figure 4-14. Depth difference contour chart showing apparent cap material thickness (in meters) based on the comparison of the postcap (March 1994) versus precap (2 November 1993) surveys

278,000 m³. The comparison shows that federal cap material and the privately funded disposal and cap material were deposited on the southern side of the mound. The 76,000 m³ barge volume of additional federal cap material that was disposed to the northwest of the NHAV buoy location prior to the precap survey could not be accounted for in this comparison due to its deposition prior to the completion of the precap bathymetry.

4.2 REMOTS® Sediment-Profile Surveys

The REMOTS® baseline survey was conducted over the following inactive disposal mounds: NORWALK, CLIS-87, CLIS-88, CLIS-89, CLIS-90, SP, and the east-southeast valley. The results were used to assess the stability of the disposal mounds, allow accurate placement of dredged material in the basin formed by these mounds, and to document the status of the benthic community. In addition, NED planned to place a sediment cap over the experimental FVP mound in the northeast quadrant of CLIS using any excess CDM generated by the New Haven Capping Project. Therefore, triplicate photographs were also obtained at the historic FVP mound during the precap survey to allow comparisons in the event that excess CDM was available for deposition.

4.2.1 Grain Size Distribution

The major modal grain sizes over the majority of the mounds were very fine sand (4-3 phi) and some silt/clay (≥4 phi) sediments at the CLIS-87 and CLIS-88 mounds. Fine sands (3-2 phi) were the major mode at a few of the stations located on the CLIS-89 and SP mounds. Several stations had surface layers of coarse sands and gravel. The major modal grain sizes at the FVP mound were very fine sands (4-3 phi); some silt/clay (≥4 phi) sediments were present at stations 50E, 50W, 100W, and 100S. The range in grain size included gravel and very coarse sands to silt/clay.

4.2.2 Prism Penetration Depth

Dredged material often has different shear strengths and bearing capacities than ambient bottom sediments. The prism penetration depth into the bottom sediments depends on the force exerted by the optical prism and bearing strength of the sediment. The optical prism of the REMOTS® camera penetrates the bottom sediment under a static driving force imparted by the weight of the descending optical prism, camera housing, supporting mechanism, and weight packs. Soft silt/clay sediments will generally produce photographs showing two-thirds to full penetration (15-20 cm), while coarser grained material yields lesser penetration values (sands 8-12 cm; gravel 3-10 cm).

During the baseline survey, penetration depths of individual replicates over the five sediment mounds (CLIS 87-88 complex, CLIS 89, CLIS 90, NORWALK, and SP) ranged from 5.50 cm to 20.70 cm. The replicate-averaged mean penetration depths at the CLIS 87-88 mound complex ranged from 7.6 to 13.88 cm; CLIS 89 7.80 to 17.64 cm; CLIS 90 11.42 to 16.72 cm; NORWALK 9.83 to 17.35 cm; and SP 5.65 to 17.52 cm. The penetration depths from individual replicates on the FVP mound ranged from 5.76 cm (sediments with a surface layers of gravel and coarse sands over very fine sands) to 15.83 cm (sediments with a surface layer of coarse and medium sands over silt/clay sediments).

4.2.3 Mean Apparent Redox Potential Discontinuity (RPD) Depth

Aerobic near-surface marine sediments typically have higher reflectance values relative to underlying hypoxic or anoxic sediments. Surface sands washed free of mud also have higher optical reflectance than underlying muddy sands. These differences in optical reflectance are readily apparent in REMOTS® images; the oxidized surface sediment contains particles coated with ferric hydroxide (an olive color associated with particles), while reduced and muddy sediments below this oxygenated layer are darker, generally gray to black. The boundary between the colored ferric hydroxide surface sediment and underlying gray to black sediment is called the apparent redox potential discontinuity (RPD). The replicate averaged RPD over the project area ranged from 1.10 cm to 3.06 cm during the baseline survey (Figure 4-15). The RPD values for the FVP mound during the precap survey ranged from 1.09 cm to 2.72 cm.

4.2.4 Infaunal Successional Stage

The mapping of successional stages is based on the theory that organism-sediment interactions follow a predictable sequence after a major seafloor perturbation such as the disposal of dredged material (Rhoads and Germano 1990). All stations occupied during the baseline REMOTS® survey showed evidence of Stage I pioneering polychaetes (Figure 4-16). Stage I on Stage III communities were present at CLIS-87 and CLIS-88, CLIS-90, SP, and the east-southeast valley transect. Stage III taxa represent high-order successional stages typically found in low disturbance regimes. Evidence of Stage II taxa was present at CLIS-89, NORWALK, SP, and the east-southeast valley transect. Stage II organisms represent a transitional stage to Stage III and are characterized by tubicolous amphipods which can form extensive tube mats on the surface.

All stations occupied over the FVP mound during the NHAV 93 precap survey were characterized by presence of Stage I organisms. One replicate at FVP station 50W showed signs of Stage III activity, and was designed as Stage I on III. These results

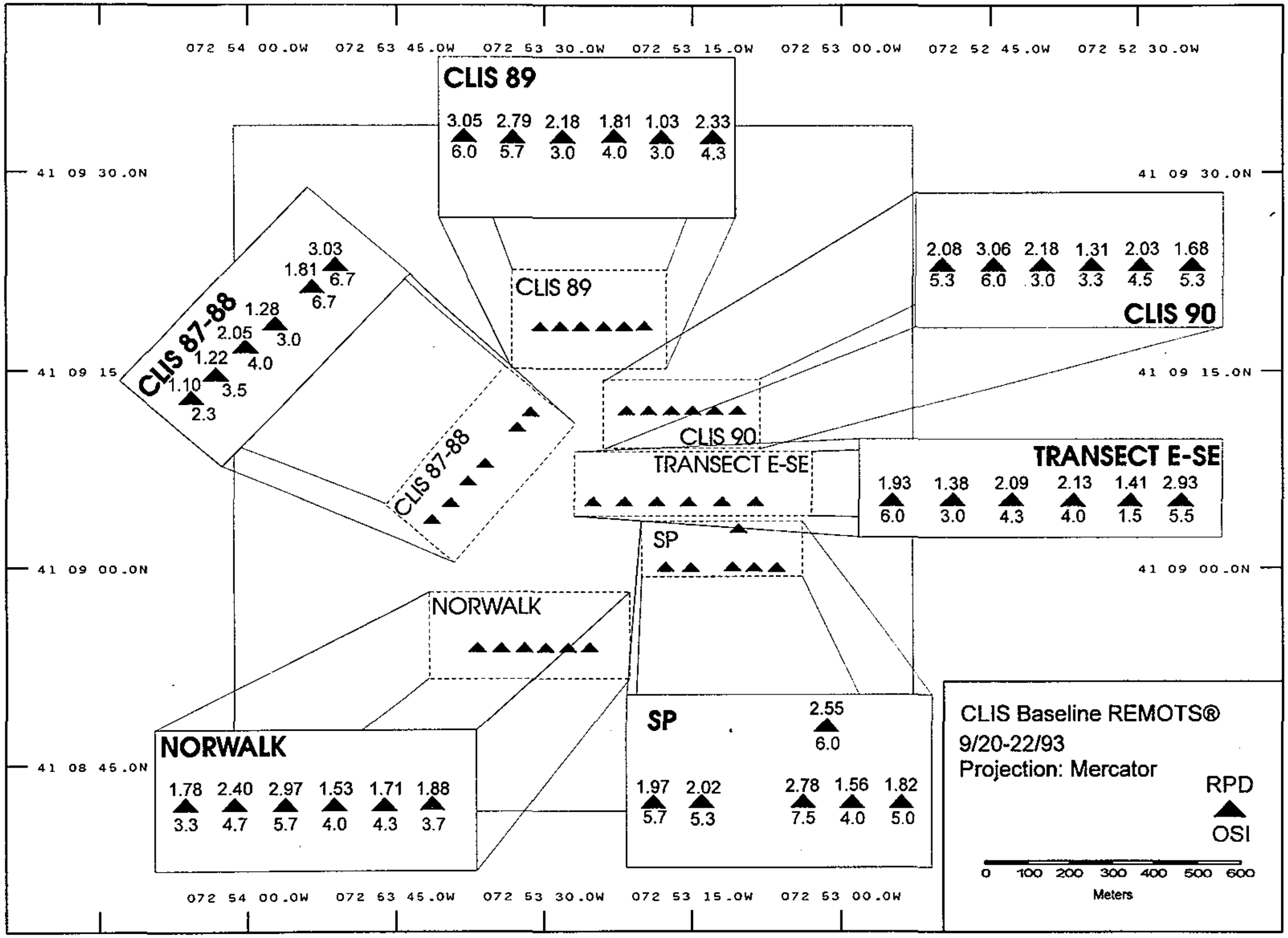

Figure 4-15. Mean RPD and OSI values for the five disposal mounds and the east-southeast valley feature during the baseline REMOTS® survey

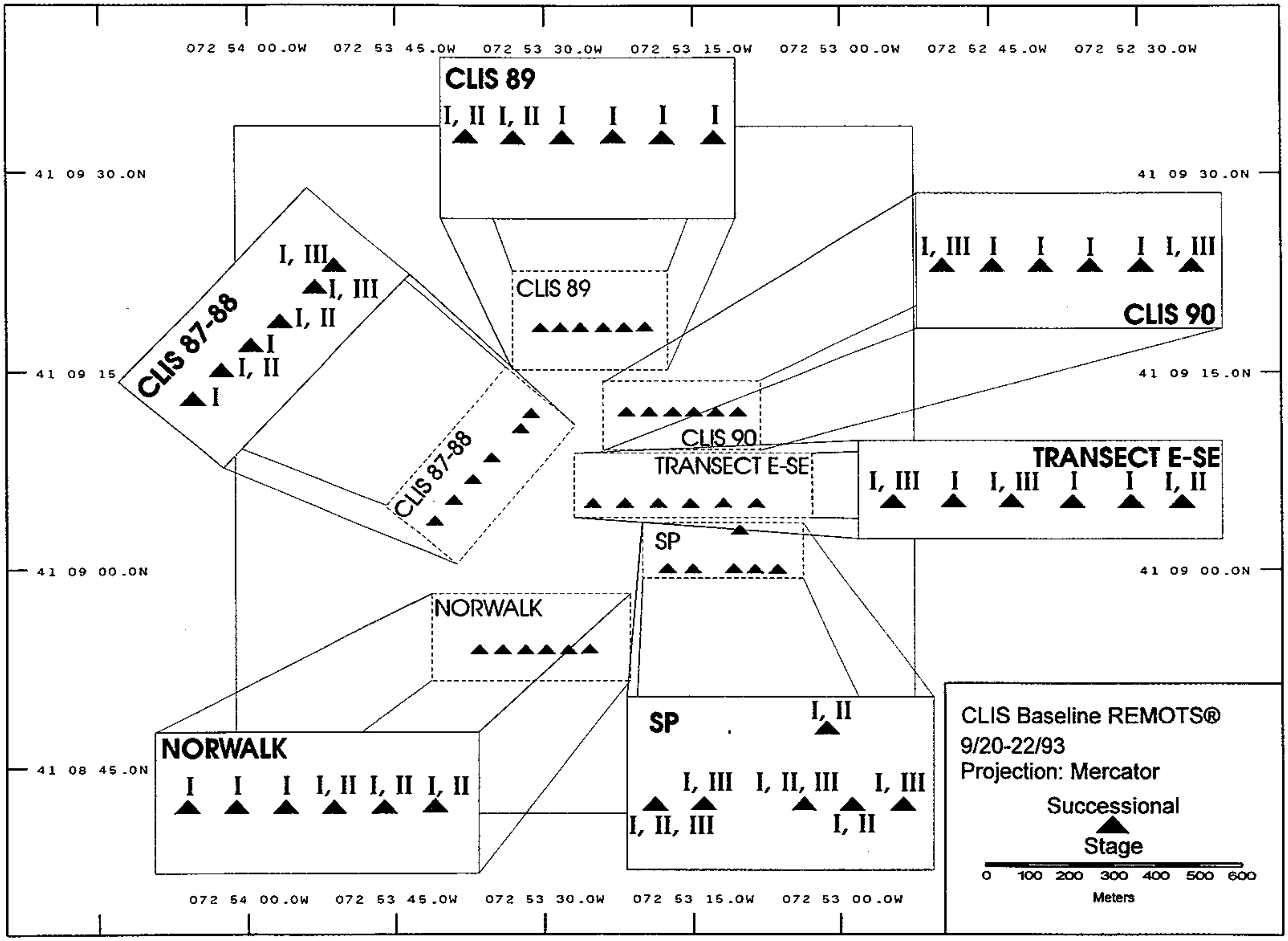

Figure 4-16. Infaunal successional stages at the five disposal mounds and east-southeast valley feature during the baseline REMOTS® survey

indicate a continued lack of a stable, benthic infaunal population over the entire FVP mound.

4.2.5 Organism-Sediment Indices (OSI)

The multiparameter Organism-Sediment Index (OSI), used to characterize gradients in habitat disturbance, can only be calculated at those stations where RPD and infaunal successional stage are also determined. The OSI is calculated automatically by the image analysis system after completion of all measurements from each REMOTS® image. Based on the compiled results of REMOTS® surveys during the past 10 years, OSI values of less than or equal to +6 are considered indicative of chronically stressed benthic habitats and/or those which have experienced recent disturbance such as disposal (Rhoads and Germano 1986). OSI values greater than +6 tend to represent relatively undisturbed habitats or habitats that have experienced a long period of recovery relative to bottom areas more recently disturbed. The replicate averaged OSI values over the disposal site ranged from 2.3 to 7.5 and were indicative of a patchy benthic environment in varying states of recovery (Figure 4-15). The NORWALK and SP mounds showed the most uniform values of OSI. Values at the FVP mound ranged from 3 to 5 with one value of 9; this was at the station with a Stage I on III community.

5.0 DISCUSSION

The subaqueous capping of dredged material was introduced as a disposal technique to the DAMOS Program in 1979. The practices behind this disposal technique were improved during the early-1980s and continue to be employed in the successful completion of capping projects at CLIS, the New London Disposal Site (NLDS), and Portland Disposal Site (PDS; SAIC 1995). Over the years, data have shown that both sand and silt are effective capping materials. The low permeability and chemically adsorptive properties of silt constitute good capping material. Although sand caps provide greater resistance to erosion during storm events, a 0.5 to 1.0 m layer of silt was used as capping material at CLIS due to its similarity to the ambient grain size, relative abundance, and availability to the New Haven Capping Project.

The NHAV 93 disposal mound received an estimated barge volume of 1,159,000 m^3 of material dredged from New Haven Harbor and the surrounding area as part of the New Haven Capping Project. The capping project conducted at CLIS during the 1993-1994 disposal season was atypical in several ways: 1) Dredged material was deposited in a depression formed by a ring of seven historic mounds to restrict the lateral spread of the UDM apron; 2) The resulting disposal mound was successfully capped with quantities of CDM less than the total volume of the UDM deposit; 3) A remarkable sequence of five precision bathymetric, two REMOTS® sediment-profile, and three geotechnical coring surveys were conducted by SAIC at various stages of NHAV 93 mound development, creating a comprehensive time-series dataset documenting the construction of the CAD mound.

The data collected over the NHAV 93 mound indicate that lateral containment of the UDM deposit was critical in the completion of the New Haven Capping Project. Utilization of the basin-like feature, created by the ring of disposal mounds, to receive large volumes of UDM for environmentally sound and cost-effective disposal is the culmination of many years of thoughtful planning and disposal. Since the inception of the DAMOS Program, a ten-year cycle of dredging and disposal operations has been established in the central Long Island Sound region. With the development of the NHAV 74, NHAV 83, and NHAV 93 mounds, NED has estimated that large scale dredging operations must be conducted in New Haven Harbor and the Quinnipiac River every ten years to maintain adequate depths for commercial, military, and private vessels (Morris 1994).

The ten-year time frame allows for the completion of many small dredging operations in regional harbors, channels, and docking facilities. The disposal of modest volumes of material aids in the preparation for large scale projects with the magnitude of the New Haven Capping Project. Dredged material generated by those smaller projects is now used to develop containment rings that concentrate deposition of large volumes of UDM and facilitate efficient capping. By continuing to build rings of closely spaced disposal mounds over the 6.85 km^2 area of CLIS, a network of containment cells, similar to honeycombs, will be produced (Figure 5-1). Over time, this network of cells will minimize the surface area occupied by each dredged material deposit and therefore maximize the overall capacity of the site.

In the past, the management strategy at CLIS and other DAMOS disposal sites was to build many independent mounds over the given area of the disposal site. Each mound could be monitored individually, assessing mound stability, cap thickness, recolonization status, etc. Although this practice was highly successful, the overall capacity of the disposal site was reduced due to the unusable area between the discrete sediment mounds. This strategy changed at CLIS in 1983 with the placement of the SP mound to the northeast of the historic NORWALK mound (SAIC 1984). As dredging and disposal practices continued to improve, advancements in precision navigation and point deposition helped concentrate sediment mounds in smaller areas. By repositioning a taut-wire moored disposal buoy at the start of each disposal season, a ring of disposal mounds was formed and eventually completed in 1992 with the development of the CLIS 91 mound. At this time project plans for the large-scale New Haven Capping Project were being finalized.

The reported volumes provided by the DAMOS Disposal Barge Logs state that approximately 590,000 m^3 of UDM was deposited at the NHAV buoy, followed by an estimated volume of 569,000 m^3 of CDM. The wealth of data collected over the NHAV 93 project area suggests that the resulting mound is broad, stable, adequately capped, and exhibiting a CDM to UDM ratio of 0.96 to 1.0 (Morris 1994). In the past, CDM to UDM ratios varied from 2:1 to 6:1 when initiating a capping operation on a flat or gently sloping area of seafloor without natural (i.e., rock outcrops, glacial troughs) or artificial (i.e., disposal mound ring, geotextile fabrics) means of restricting the lateral dispersion of a UDM deposit (SAIC 1995). Lacking means of containment, the apron of UDM is free to spread into a wide, thin layer of material, increasing the amount of CDM required to completely cover the flanks of the mound.

The NHAV 93 capping project was the first in the New England region to utilize an artificial containment cell to control the spread of UDM. The use of the disposal mound ring at CLIS significantly reduced the outward migration of the UDM mound apron. As a result, cap material was distributed over a much smaller area, decreasing the total volume of CDM required to cap the inner harbor sediments. Dredging operations in urbanized areas may not produce an abundance of CDM for use in capping operations. However, the

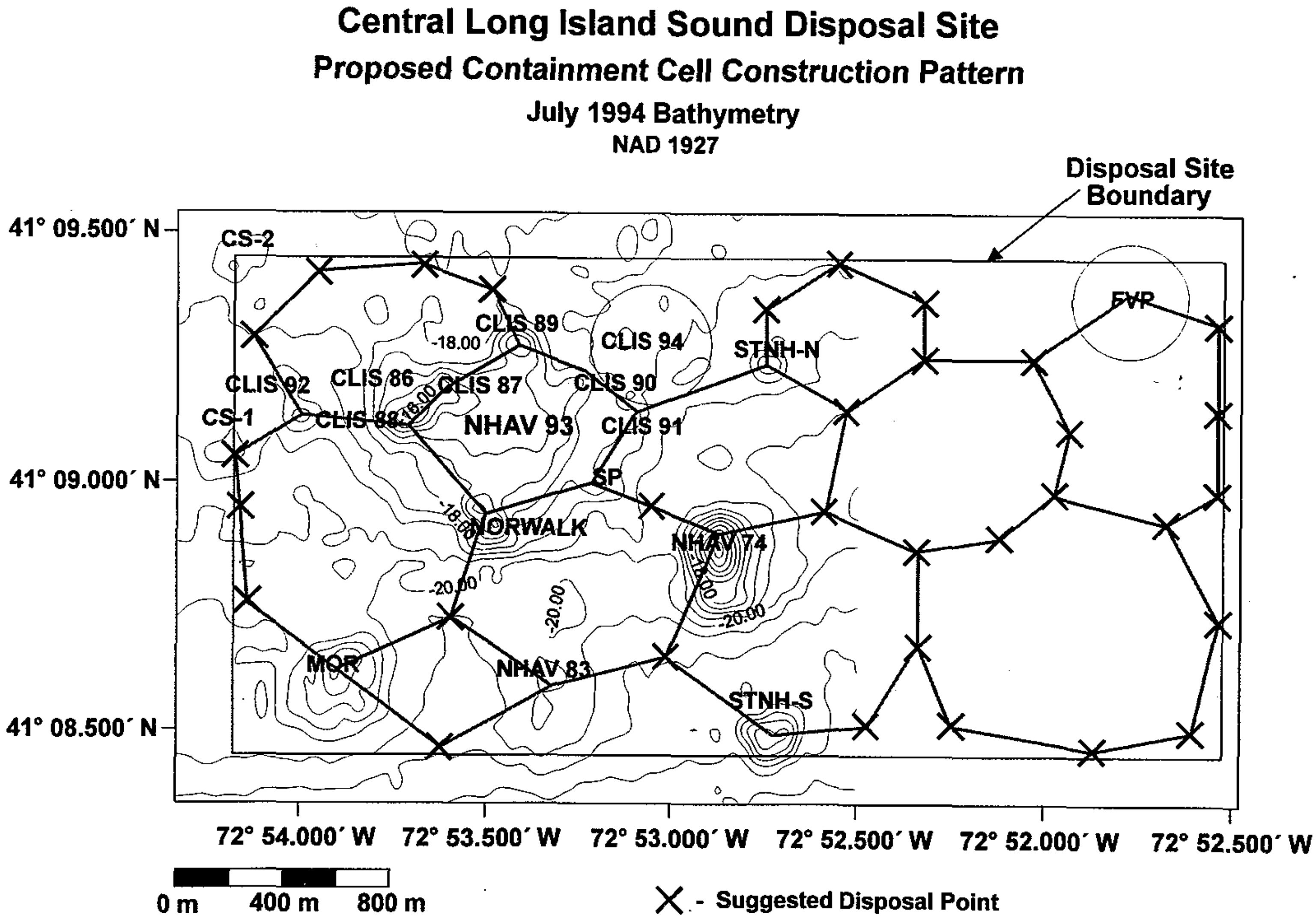

Figure 5-1. Suggested pattern of future disposal at CLIS to maximize site capacity and construct a network of containment cells

perfection of this disposal and containment technique allows NED to deposit moderate to large volumes of UDM, while requiring a minimum investment of CDM.

The strategic repetition of precision bathymetric, REMOTS®, and geotechnical coring surveys was invaluable during the New Haven Capping Project. The five separate datasets allowed SAIC to document the progression of CAD mound development and advise NED upon the best course of action to achieve its ultimate goal. The results of each bathymetric survey provided a "snapshot" in time, allowing comparisons with previous surveys to document and quantify central mound consolidation, calculate overall growth of the CAD mound, and identify areas requiring additional cap material deposition. This comprehensive dataset also facilitates revisiting the various stages of the capping project to chronicle how disposal and oceanographic processes affected the dredged material, as well as to explore what knowledge of CAD mound construction was gained.

During the baseline survey, REMOTS® sediment-profile photography was used to estimate the shear strength, as well as document the successional status of the containment ring. The flanks of the UDM mound were mapped by REMOTS® within the containment basin during the precap survey of the NHAV 93 mound. These data were used to ensure accurate placement of the dredged material during disposal operations and permit the calculation of target capping points along the mound apron (Figure 4-6). REMOTS® photography continues to be used to detect changes in various physical and biological parameters on the surface of the NHAV 93 mound.

The surface layer shear strengths of the five mounds sampled during the baseline survey indicated that significant de-watering and consolidation had occurred in the surface sediments. The larger grain-sized and densely packed sediment deposits displayed higher shear strengths, indicating the potential to contain a ridge of new dredged material while maintaining the mound integrity. No structural failure was detected within the seven-mound containment ring during any of the five bathymetric surveys.

URI estimated the relative consolidation of sediments occurring between the precap, interim cap, and postcap surveys using both theoretical models and data from the geotechnical cores. These estimates were required to determine cap material requirements; actual cap thickness was masked by consolidation of both the basement material (ambient sediments and historic dredged material) and the UDM deposit. Cores collected immediately following the construction of the mound included the basement material, UDM, and CDM. Results were used to establish the initial geotechnical characteristics of the completed mound. These data were used as a reference for future geotechnical and bathymetric surveys. Numerical computations will also be performed on settlement and volume changes.

Following UDM disposal, the mound was 2.5 m in height and 510 m in diameter with a calculated volume of 312,000 m^3 based on comparisons of the baseline and precap bathymetric surveys. The final CAD mound is centered approximately 125 m to the south of the NHAV buoy location (Figure 4-13). The total volume of cap material accounted for by bathymetry was 402,000 m^3, the diameter of the mound expanded to 800 m, and the mound height remained at 2.5 m due to significant consolidation of the underlying UDM deposit. According to DAMOS barge disposal logs, the total volume of dredged material was 1,159,000 m^3; however, the total volume accounted for by bathymetry was 714,000 m^3 (62% of the estimated barge volume).

Results of previous DAMOS monitoring surveys have shown that accumulations of dredged material less than 20 cm thick in the flanks of a disposal mound are typically deposited in layers too thin to be detected by standard bathymetric techniques. The 38% difference in final volumes between bathymetric analysis and disposal logs is accounted for by consolidation of the underlying UDM deposit and the limits of the acoustic survey. Due to the complex scheduling of disposal activities during this project, it is difficult to determine what volumes of contaminated and cap material were present during each survey.

The depth difference comparison between the precap and the postcap surveys provides the best indication of the overall distribution of cap material. This comparison indicates an apparent lack of cap material in the northwestern quadrant of the final disposal mound (Figure 4-14). However, disposal records indicate that 76,000 m^3 of cap material was disposed in this quadrant prior to the precap survey making it undetectable in the precap/postcap comparisons. In addition, subbottom profiling data and geotechnical cores collected over the NHAV 93 mound in July 1994 detected 0.5 to 0.75 m of silt cap material over the northwestern flank (Figures 5-2 and 5-3; Morris 1994).

Results of the REMOTS® baseline survey showed that recolonization of the bottom invertebrate community from the disturbance of historic disposal operations has proceeded at a rate typical for open-water dredged material sites. Successional stages were dominated by pioneering Stage I polychaetes with evidence of more mature taxa in the Stage I to Stage II and Stage I on Stage III communities. Stage II taxa represent a transitional sere between Stage I and III and are associated with recovery of a disturbed benthic habitat (Rhoads and Germano 1986). Stage III taxa generally represent high-order successional stages typically found in low disturbance regimes. Organism-Sediment Indices were variable and indicative of a patchy benthic environment.

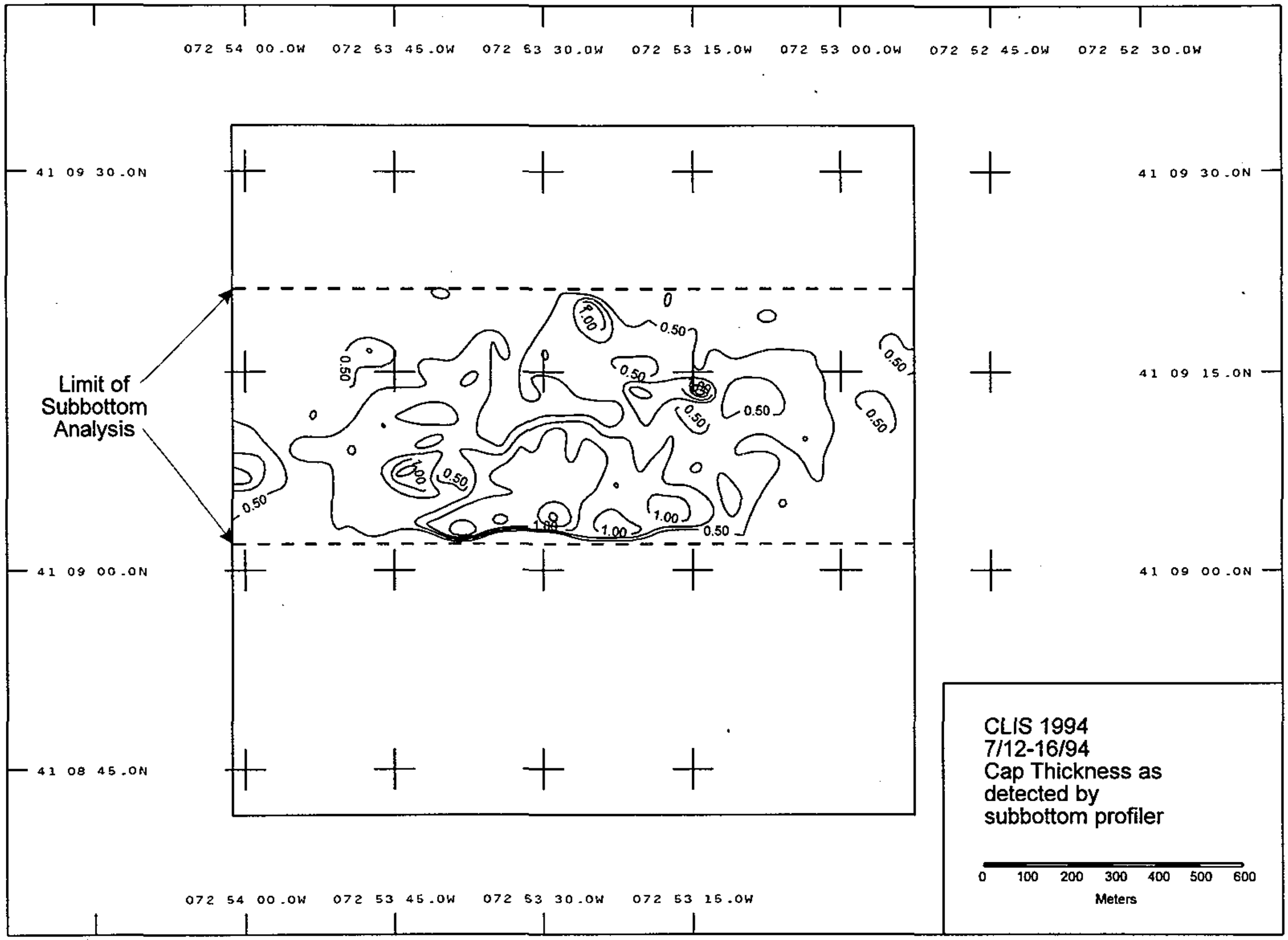

Figure 5-2. July 1994 subbottom data. Contour plot of subbottom layer 1 (cap thickness) 1600 × 525 m analysis area over the NHAV 93 mound, 0.25 m contour interval.

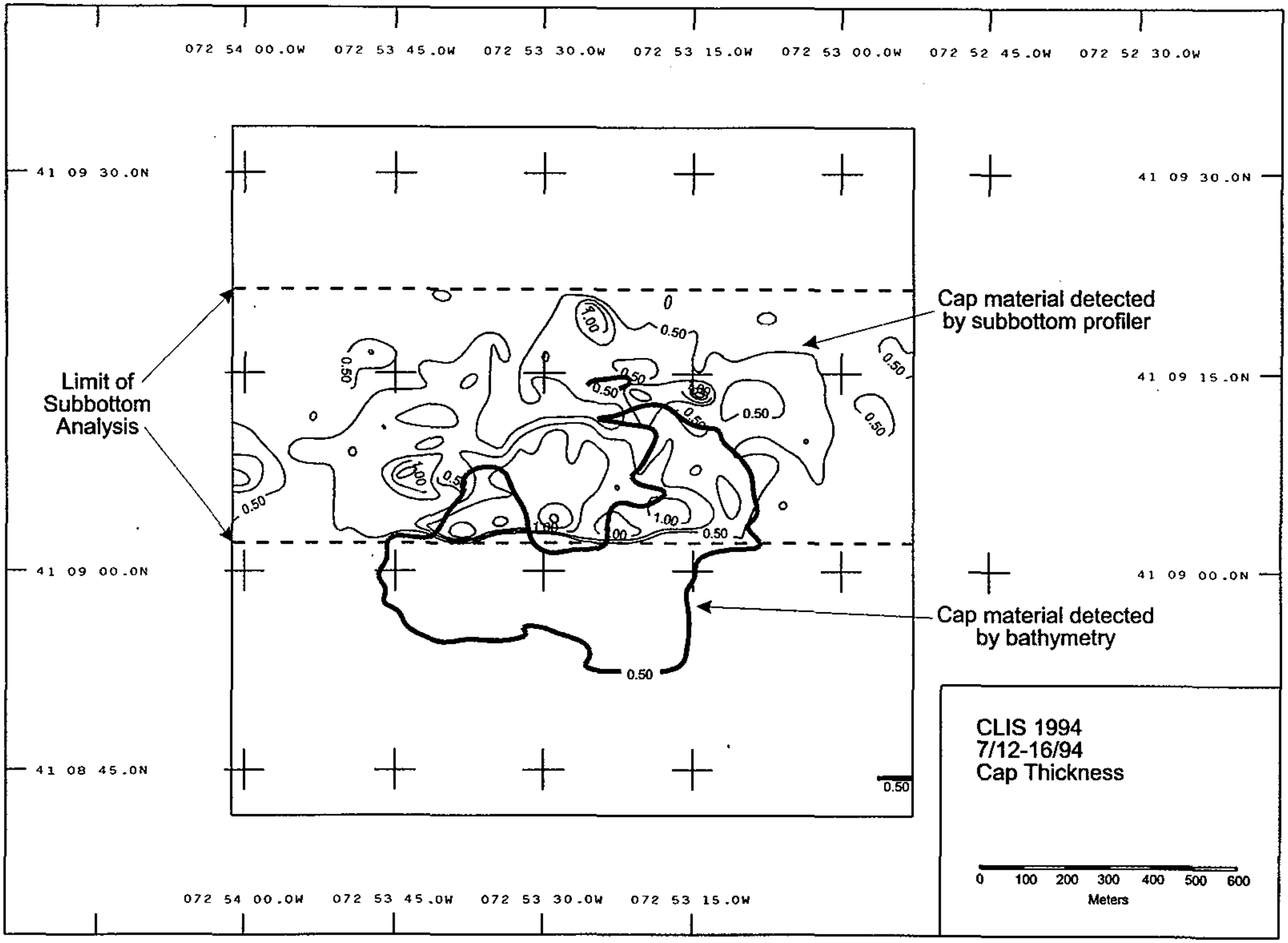

Figure 5-3. July 1994 subbottom data. Contour plot of subbottom layer 1 (cap thickness) overlaid onto cap material footprint plot of March 1994, 1600 × 525 m analysis area over the NHAV 93 mound.

During the November 1993 precap REMOTS® survey of the FVP mound, there was a noticeable lack of Stage II and Stage III benthic infaunal activity. Although plans were made to cap the historic UDM mound, no excess CDM was available from the New Haven Capping Project to begin the placement of a sediment cap over the FVP mound. Another series of REMOTS® photographs collected in September 1995 indicate an increase in Stage III individuals within the surface sediments (Morris and Murray 1995). A total of ten stations displayed evidence of Stage III assemblages, compared to the single replicate of station 50W in 1993. However, the majority of those ten stations lie 200 to 300 m from the center of the mound, correlating to previous observations regarding the patchy benthic infaunal community near the center of the FVP mound.

The original objective of FVP was to field verify existing predictive techniques for evaluating the environmental consequences of dredged material disposal under aquatic, intertidal (wetland), and upland conditions (Murray and Carey 1993). The mound is an uncapped UDM deposit formed by the placement of Black Rock Harbor sediments placed in the northeast corner of CLIS during the 1982-83 disposal season. Designed as a six-year, cooperative research project between the US Army Corps of Engineers, Waterways Experiment Station (WES) and the US Environmental Protection Agency (EPA), the UDM sediments have been monitored periodically for changes in benthic infaunal population and contaminant content.

Now that the WES/EPA experimentation has concluded, plans have been made to cap the mound in order to isolate the UDM from the marine environment. Without the deposition of cap material during the New Haven Capping Project, an opportunity still exists to conduct a comprehensive physical, chemical, and biological assessment of the experimental mound 13 years post-disposal. An intensive bioaccumulation study on the invertebrate species inhabiting the sediments could determine the current amount of chemical uptake within the benthic infauna, as well as explore the stress and susceptibility levels of the organisms occupying the various domains of the mound.

6.0 CONCLUSIONS

Based on acoustically detected changes in depth at the NHAV buoy location, disposal and capping operations formed a CAD mound with a diameter of 800 m and height of 2.5 m. Depth difference calculations between the interim disposal and precap surveys detected a 100 m wide pocket of consolidation over the mound apex. It was determined that the majority of the material shifted to the northeast, forming a 150 m wide plateau at the top of the UDM mound. The primary factor causing the structural failure of the apex was likely to be the initial placement of CDM over the northwest quadrant of the NHAV 93 mound, building the apex beyond the critical angle of repose, causing redistribution of material downslope. A contributing factor to the collapse of the mound apex could have been the subsurface consolidation of the UDM deposit due to de-watering.

A question had existed concerning the coverage of UDM in the northwestern quadrant of the NHAV 93 mound due to conflicts in the schedule of capping and survey operations. However, DAMOS disposal logs indicate an estimated barge volume of 76,000 m^3 was released over cap placement points A, F, and J before the completion of the precap survey. In addition, subbottom and geotechnical core data collected over the northern portion of the NHAV 93 mound in July 1994 indicate that 0.5 to 0.75 m of cap material is present northwest of the buoy location. Recolonization over the entire surface of the new CAD mounds is expected to progress at a rate typical of open-water dredged material disposal sites.

This capping project demonstrated the successful execution of a long-term management strategy at the most active disposal site in New England. The strategy included the thoughtful placement of small to moderate volumes of dredged material in order to support the containment of large volumes of UDM and effectively isolate it from further interaction with the marine environment. Also, the continued use of this management approach will concentrate disposal into the formation and subsequent filling of containment cells, maximizing the finite capacity of the 6.85 km^2 disposal site. Although all primary indications suggest the attainment of all of NED's goals, monitoring at the NHAV 93 mound should continue for the next several years to assess biological recovery and long-term cap integrity (Morris 1994; Germano et al. 1994).

The wealth of data generated by the repetitive survey operations during CAD mound construction and annual monitoring are providing a great deal of insight into the processes that continue to affect this and other dredged material mounds. The inspection of cap integrity and quantification of overall consolidation could lead to answers pertaining to dredged material mass balance, consolidation rates, material slumping, material de-watering, and physical changes in basement material.

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APPENDIX A

Sediment Chemistry Results

Appendix A Sediment Chemistry Results

Appendix A Table 1

Sediment Chemistry Results (Dry Weight) for the Inner Federal Navigation Channel, New Haven Harbor 1993

INNER HARBOR	A	B	C	D
Station Latitude Station Longitude	42°17.94' 72°54.50'	42°17.73' 72°54.60'	41°17.45' 72°54.75'	41°17.23' 72°54.69'
GRAIN SIZE				
%Silt/clay	93	97	96	96
% TOC	1.20	0.96	0.82	0.55
METALS (ppm)				
As	13.8	0.6	0.9	0.1
Cd	7.7	0.9	3.1	2.9
Cr	163	168	168	266
Cu	109	99	111	279
Hg	0.15	0.02	0.18	0.10
Ni	45	75	82	71
Pb	67	98	32	47
Zn	595	174	136	81
PESTICIDES (ppm)				
Aldrin	<0.01	<0.01	<0.01	<0.01
Chlordane	<0.40	<0.40	<0.40	<0.40
pp-DDT,DDE,DDD	<0.02	<0.02	<0.02	<0.02
Dieldrin	<0.01	<0.01	<0.01	<0.01
Endosulfan I,II	<0.01	<0.01	<0.01	<0.01
Endosulfan sulfate	<0.04	<0.04	<0.04	<0.04
Endrin	<0.01	<0.01	<0.01	<0.01
Endrin aldehyde	<0.04	<0.04	<0.04	<0.04
Heptachlor	<0.01	<0.01	<0.01	<0.01
Heptachlor epoxide	0.46	1.42	1.79	1.94
Toxaphene	<0.50	<0.50	<0.50	<0.50
alpha-BHC	<0.01	<0.01	<0.01	<0.01
beta-BHC	<0.01	<0.01	<0.01	<0.01
gamma-BHC	<0.01	<0.01	<0.01	<0.01
Total BHC	<0.01	<0.01	<0.01	<0.01
PCBs (ppb)	<100	<100	<100	<100

Appendix A Table 1 (cont.)

PAHs (ppm)	A	B	C	D
Low Molecular Weight				
Napthalene	0.20	0.18	0.31	0.19
Acenapthene	0.11	0.05	0.05	0.03
Acenaphthylene	< 0.03	< 0.03	< 0.04	< 0.04
Fluorene	0.17	0.09	0.10	< 0.04
Phenanthrene	0.69	0.34	0.55	0.29
Anthracene	0.27	0.11	0.13	0.08
High Molecular Weight				
Fluoranthene	1.52	0.82	1.31	0.82
Pyrene	2.39	1.12	1.38	0.87
Benzo(a)anthracene	0.71	0.32	0.47	0.28
Chrysene	0.73	0.41	0.60	0.36
Benzo(b)fluoranthene	0.63	0.36	0.70	0.39
Benzo(k)fluoranthene	0.62	0.36	0.46	0.38
Benzo(a)pyrene	0.47	0.32	0.45	0.27
Benzo(g,h,i)perylene	< 0.03	< 0.03	0.31	0.19
Dibenzo(a,h)anthracene	< 0.03	< 0.03	< 0.04	< 0.04
Indeno(1,2,3-cd)pyrene	< 0.03	< 0.03	< 0.04	< 0.04

Appendix A Table 2

Sediment Chemistry Results (Dry Weight) for the Outer Federal Navigation Channel, New Haven Harbor 1993

OUTER HARBOR	E	F	G	H	I	J
Station Latitude Station Longitude	41°16.94' 72°54.80'	42°16.39' 72°54.69'	41°15.60' 72°54.81'	41°15.16' 72°54.97'	41°14.50' 72°54.97'	41°13.54' 72°54.69'
GRAIN SIZE						
% Silt/clay	95	97	97	99	98	77
% TOC	0.60	0.64	0.40	0.68	0.76	0.50
METALS (ppm)						
As	<0.03	12.6	3.9	1.4	1.5	1.9
Cd	4.2	1.1	3.9	1.1	0.76	0.62
Cr	320	220	278	318	162	151
Cu	260	340	258	420	149	153
Hg	0.19	0.22	0.24	0.24	0.28	0.38
Ni	36	76	96	181	60	63
Pb	90	100	80	98	106	112
Zn	101	440	117	218	321	334
PESTICIDES (ppm)						
Aldrin	<0.01	0.13	<0.01	<0.01	<0.01	0.21
Chlordane	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40
pp-DDT,DDE,DDD	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Dieldrin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Endosulfan I,II	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Endosulfan sulfate	<0.04	<0.04	<0.04	<0.04	<0.04	0.04
Endrin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Endrin aldehyde	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
Heptachlor	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Heptachlor epoxide	1.39	0.62	0.82	<0.01	0.53	0.59
Toxaphene	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
alpha-BHC	<0.01	0.18	<0.01	<0.01	<0.01	<0.01
beta-BHC	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
gamma-BHC	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total BHC	<0.01	0.11	0.22	<0.01	<0.01	<0.01
PCBs (ppb)	<100	<100	<100	<100	<100	<100

Appendix A Table 2 (cont.)

PAHs (ppm)	E	F	G	H	I	J
Low Molecular Weight						
Napthalene	0.03	< 0.02	0.14	0.48	0.06	0.05
Acenapthene	< 0.05	< 0.02	< 0.05	0.26	< 0.06	< 0.03
Acenapthylene	< 0.05	< 0.02	< 0.05	< 0.05	< 0.06	< 0.03
Fluorene	< 0.05	< 0.02	0.08	0.47	< 0.06	< 0.03
Phenanthrene	0.07	0.11	0.36	1.07	0.18	0.21
Anthracene	< 0.05	0.03	0.08	0.22	< 0.06	0.06
High Molecular Weight						
Fluoranthene	0.16	0.54	0.83	0.94	0.43	0.35
Pyrene	0.16	0.58	0.78	0.93	0.43	0.37
Benzo(a)anthracene	0.06	0.39	0.28	0.31	0.19	0.15
Chrysene	0.06	0.29	0.38	0.30	0.19	0.14
Benzo(b)fluoranthene	< 0.05	0.29	0.34	0.37	0.13	0.16
Benzo(k)fluoranthene	< 0.05	0.25	0.32	0.35	0.13	0.11
Benzo(a)pyrene	< 0.05	0.27	0.31	0.35	0.13	0.13
Benzo(g,h,i)perylene	< 0.05	0.19	0.30	0.29	< 0.06	< 0.03
Dibenzo(a,h)anthracene	< 0.05	< 0.02	< 0.05	< 0.05	< 0.06	< 0.03
Indeno(1,2,3-cd)pyrene	< 0.05	0.31	< 0.05	< 0.05	< 0.06	< 0.03

Appendix A Table 3

Sediment Chemistry Results (Dry Weight) for Gulf Oil,
New Haven Harbor 1993

GULF OIL	B1	B2 A/B*	B3	B4	B5	B6 A/B*	B7
GRAIN SIZE							
% Gravel	0	0	0	0	0.2	0	0
% Sand	52.5	32.4	58.4	61.5	59.6	47.5	53.8
% Silt/clay	46.6	36.8	42.3	38.4	40.1	55.7	46.6
%TOC	5.3	3.2	4.2	3.7	4.8	3.9	3.5
METALS(ppm)							
As	ND	ND	ND	ND	ND	ND	ND
Cd	5.91	4.9	5.36	4.76	5.87	6.55	6.65
Cr	12	87.3	91.4	84.8	94.8	117	123
Cu	200	130	150	135	156	200	217
Pb	140	95	110	100	120	142	158
Hg	ND	ND	ND	ND	ND	ND	ND
Ni	49.9	30.5	38.4	33.5	39	41.9	46.2
Zn	350	200	200	190	265	264	276
PESTICIDES(ppm)							
Aldrin	ND	ND	ND	ND	ND	ND	ND
Chlordane	ND	ND	ND	ND	ND	ND	ND
pp-DDT,DDE,DDD	ND	ND	ND	ND	ND	ND	ND
Dieldrin	ND	ND	ND	ND	ND	ND	ND
Endosulfan I,II	ND	ND	ND	ND	ND	ND	ND
Endosulfan sulfate	ND	ND	ND	ND	ND	ND	ND
Endrin	ND	ND	ND	ND	ND	ND	ND
Endrin aldehyde	ND	ND	ND	ND	ND	ND	ND
Heptachlor	ND	ND	ND	ND	ND	ND	ND
Heptachlor epoxide	ND	ND	ND	ND	ND	ND	ND
Hexachlorocyclohexane (total)	ND	ND	ND	ND	ND	ND	ND
Methoxychlor	ND	ND	ND	ND	ND	ND	ND
Toxaphene	ND	ND	ND	ND	ND	ND	ND
PCBs (ppb)	190	210	250	280	250	140	150

Appendix A Table 3 *(cont.)*

PAHs (ppm)	B1	B2 A/B*	B3	B4	B5	B6 A/B*	B7
Low Molecular Weight							
Napthalene	ND	ND	ND	ND	ND	ND	ND
1-Methylnapthalene	ND	ND	ND	ND	ND	ND	ND
Biphenyl	ND	ND	ND	ND	ND	ND	ND
2,6-Dimethylnapthalene	ND	ND	ND	ND	ND	ND	ND
Acenapthene	ND	ND	ND	ND	ND	ND	ND
Acenapthylene	ND	ND	ND	ND	ND	ND	ND
Fluorene	2.78	ND	ND	ND	ND	ND	ND
Phenanthrene	ND	0.2	ND	0.13	0.22	0.43	ND
1-Methylphenanthrene	ND	ND	ND	ND	ND	ND	ND
Anthracene	0.15	ND	0.27	0.2	0.35	0.71	ND
High Molecular Weight							
Fluoranthene	ND	0.99	0.58	0.66	1.38	2.56	1.22
Pyrene	2.49	0.89	0.54	0.6	1.09	2.09	0.99
Benzo(a)anthracene	8.75	4.36	0.16	2.49	4.10	8.33	4.07
Chrysene	1.47	0.73	0.4	0.44	0.70	1.41	0.72
Benzo(b)fluoranthene	2.09	1.29	0.83	0.73	1.09	1.75	1.1
Benzo(k)fluoranthene	1.97	1.22	ND	0.7	ND	0.12	ND
Benzo(a)pyrene	2.79	0.56	0.43	0.27	0.63	0.78	0.54
Benzo(e)pyrene	ND	ND	ND	ND	ND	ND	ND
Benzo(g,h,i)perylene	ND	ND	0.96	0.53	ND	ND	ND
Dibenzo(a,h)anthracene	0.54	ND	ND	0.29	ND	0.2	ND
Indeno(1,2,3-cd)pyrene	ND	ND	ND	0.29	ND	0.28	ND
Perylene	ND	ND	ND	ND	ND	ND	ND

* Composites of two samples

Appendix A Table 4

Sediment Chemistry Results (Dry Weight) for Northeast Petroleum, New Haven Harbor 1993

NORTHEAST PETROLEUM	T1	T2	B1	B2	B3	B3	B3
GRAIN SIZE							
%Gravel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%Sand	9.5	10.7	10.3	8.35	7.82	12.6	97.7
%Silt/clay	90.54	89.3	89.7	91.65	92.18	87.4	2.3
%TOC	3.4	3.6	4.8	3.1	2.6	0.9	0.07
METALS (ppm)							
As	0.604	0.612	1.01	1.05	1.17	0.386	0.431
Cd	ND	ND	ND	0.065	0.505	ND	ND
Cr	71.4	61.2	71.3	92.8	128.0	5.56	32.0
Cu	107.0	92.7	100.0	60.2	73.4	46.3	4.08
Pb	69.9	61.0	75.0	77.3	122.0	10.7	29.0
Hg	0.093	0.099	0.136	0.098	0.036	0.006	0.086
Ni	18.7	19.9	25.1	24.1	32.4	6.3	10.9
Zn	156.0	159.0	182.0	188.0	235.0	16.2	57.2
PESTICIDES (ppm)							
Aldrin	ND	ND	ND	ND	ND	ND	ND
Chlordane	ND	ND	ND	ND	ND	ND	ND
pp-DDT,DDE,DDD	ND	ND	ND	ND	ND	ND	ND
Dieldrin	ND	ND	ND	ND	ND	ND	ND
Endosulfan I,II	ND	ND	ND	ND	ND	ND	ND
Endosulfan sulfate	ND	ND	ND	ND	ND	ND	ND
Endrin	ND	ND	ND	ND	ND	ND	ND
Endrin aldehyde	ND	ND	ND	ND	ND	ND	ND
Heptachlor	ND	ND	ND	ND	ND	ND	ND
Heptachlor epoxide	ND	ND	ND	ND	ND	ND	ND
Hexachlorocyclohexane (total)	ND	ND	ND	ND	ND	ND	ND
Methoxychlor	ND	ND	ND	ND	ND	ND	ND
Toxaphene	ND	ND	ND	ND	ND	ND	ND
PCBs (ppb)	ND	ND	ND	ND	ND	ND	ND

ND = Not Detected

Appendix A Table 4 (cont.)

PAHs (ppm)	T1	T2	B1	B2	B3	B3	B3
Low Molecular Weight							
Napthalene	ND	ND	ND	ND	ND	0.06	ND
1-Methylnapthalene	ND	ND	ND	ND	ND	ND	ND
2-Methylnapthalene	ND	ND	ND	ND	ND	ND	ND
Biphenyl	ND	ND	ND	ND	ND	ND	ND
2,6-Dimethylnapthalene	ND	ND	ND	ND	ND	ND	ND
Acenapthene	ND	0.24	ND	ND	ND	ND	ND
Acenapthylene	ND	ND	ND	ND	0.03	ND	ND
Fluorene	ND	0.23	ND	ND	ND	ND	ND
Phenanthrene	ND	0.94	ND	ND	0.06	ND	ND
1-Methylphenanthrene	ND	ND	ND	ND	ND	ND	ND
Anthracene	ND	ND	ND	ND	0.04	ND	ND
High Molecular Weight							
Fluoranthene	0.43	4.66	ND	ND	0.11	0.44	ND
Pyrene	0.31	2.54	ND	ND	ND	0.26	ND
Benzo(a)anthracene	ND	0.25	ND	ND	0.03	ND	ND
Chrysene	0.14	ND	ND	ND	ND	0.14	ND
Benzo(b)fluoranthene	ND	0.21	ND	ND	0.45	0.05	ND
Benzo(k)fluoranthene	ND	0.22	ND	ND	0.58	0.07	ND
Benzo(a)pyrene	ND	0.27	ND	ND	ND	0.1	ND
Benzo(e)pyrene	ND	ND	ND	ND	ND	ND	ND
Benzo(g,h,i)perylene	ND	ND	ND	ND	ND	ND	ND
Dibenzo(a,h)anthracene	ND	ND	ND	ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene	ND	ND	ND	ND	ND	ND	ND
Perylene	ND	ND	ND	ND	ND	ND	ND

ND = Not Detected

Appendix A Table 4 (cont.)

NORTHEAST PETROLEUM	B4	B4	B5	B5	B6	B7	B8
GRAIN SIZE							
%Gravel	0	0	0	0	0	0	1.67
%Sand	11.4	6.82	7.43	10.4	11.2	69.7	74.5
%Silt/clay	88.6	93.18	92.57	89.6	88.8	26.7	21.6
%TOC	3.2	1.6	3.5	2	2.2	0.46	0.26
METALS (ppm)							
As	0.894	0.751	1.4	1.13	1.35	NA	NA
Cd	ND	ND	1.22	0.864	ND	NA	NA
Cr	73.4	91.5	1.56	101	72.5	NA	NA
Cu	130	54.2	98.4	64.7	88.1	NA	NA
Pb	78.4	81	144	98.7	73.9	NA	NA
Hg	0.136	0.183	0.203	0.109	0.086	NA	NA
Ni	25.7	23.4	40.3	24.8	22.7	NA	NA
Zn	166	306	919	543	149	4.22	7.62
PESTICIDES (ppm)							
Aldrin	ND	ND	ND	ND	ND	ND	ND
Chlordane	ND	ND	ND	ND	ND	ND	ND
pp-DDT,DDE,DDD	ND	ND	ND	ND	ND	ND	ND
Dieldrin	ND	ND	ND	ND	ND	ND	ND
Endosulfan I,II	ND	ND	ND	ND	ND	ND	ND
Endosulfan sulfate	ND	ND	ND	ND	ND	ND	ND
Endrin	ND	ND	ND	ND	ND	ND	ND
Endrin aldehyde	ND	ND	ND	ND	ND	ND	ND
Heptachlor	ND	ND	ND	ND	ND	ND	ND
Heptachlor epoxide	ND	ND	ND	ND	ND	ND	ND
Hexachlorocyclohexane (total)	ND	ND	ND	ND	ND	ND	ND
Methoxychlor	ND	ND	ND	ND	ND	ND	ND
Toxaphene	ND	ND	ND	ND	ND	ND	ND
PCBs (ppb)	ND	ND	ND	ND	ND	ND	ND

ND = Not Detected NA = Not Given

Appendix A Table 4 (cont.)

PAHs (ppm)	B4	B4	B5	B5	B6	B7	B8
Low Molecular Weight							
Napthalene	0.12	0.14	0.04	0.6	ND	ND	ND
1-Methylnapthalene	ND	ND	ND	ND	ND	ND	ND
2-Methylnapthalene	ND	ND	ND	ND	ND	ND	ND
Biphenyl	ND	ND	ND	ND	ND	ND	ND
2,6-Dimethylnapthalene	ND	ND	ND	ND	ND	ND	ND
Acenapthene	ND	ND	0.14	ND	ND	ND	ND
Acenapthylene	ND	0.09	ND	ND	ND	ND	ND
Fluorene	ND	0.14	ND	0.08	ND	ND	ND
Phenanthrene	0.09	0.28	0.13	0.07	ND	ND	ND
1-Methylphenanthrene	ND	ND	ND	ND	ND	ND	ND
Anthracene	ND	0.06	0.46	ND	ND	ND	ND
High Molecular Weight							
Fluoranthene	1.6	3.13	2.3	1.27	0.9	ND	ND
Pyrene	1	2.3	1.46	0.78	0.55	ND	ND
Benzo(a)anthracene	0.13	0.24	0.14	0.08	0.09	ND	ND
Chrysene	ND	0.05	ND	ND	ND	ND	ND
Benzo(b)fluoranthene	0.17	0.38	0.12	0.13	0.12	ND	ND
Benzo(k)fluoranthene	0.24	0.52	0.21	0.17	0.15	ND	ND
Benzo(a)pyrene	0.31	0.49	ND	0.22	0.15	ND	ND
Benzo(e)pyrene	ND	ND	ND	ND	ND	ND	ND
Benzo(g,h,i)perylene	ND	ND	ND	ND	ND	ND	ND
Dibenzo(a,h)anthracene	ND	0.05	ND	ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene	ND	ND	ND	ND	ND	ND	ND
Perylene	ND	ND	ND	ND	ND	ND	ND

ND = Not Detected

Appendix A Table 5

Sediment Chemistry Results (Dry Weight) for the New Haven Terminal, New Haven Harbor 1993

NEW HAVEN TERMINAL	B1	B2	B3	B5	B6
GRAIN SIZE					
%Gravel	23.1	13.8	2.13	13.4	3.58
%Sand	57.0	63.8	62.4	60.4	66.5
%Silt/clay	20.6	18.5	32.1	26.9	26.3
%TOC	2.4	1.6	1.4	1.2	3.3
METALS (ppm)					
As	ND	ND	ND	ND	ND
Cd	ND	ND	ND	ND	ND
Cr	50.9	30.4	38	46.8	77.3
Cu	80	43.1	57.7	63.5	105
Pb	69.6	32.4	49.8	59.5	90.3
Hg	ND	ND	ND	ND	ND
Ni	21.6	11.7	15.8	19.9	25.4
Zn	139	92.6	98.3	121	181
PESTICIDES (ppm)					
Aldrin	ND	ND	ND	ND	ND
Chlordane	ND	ND	ND	ND	ND
pp-DDT,DDE,DDD	ND	ND	ND	ND	ND
Dieldrin	ND	ND	ND	ND	ND
Endosulfan I,II	ND	ND	ND	ND	ND
Endosulfan sulfate	ND	ND	ND	ND	ND
Endrin	ND	ND	ND	ND	ND
Endrin aldehyde	ND	ND	ND	ND	ND
Heptachlor	ND	ND	ND	ND	ND
Heptachlor epoxide	ND	ND	ND	ND	ND
Hexachlorocyclohexane (total)	ND	ND	ND	ND	ND
Methoxychlor	ND	ND	ND	ND	ND
Toxaphene	ND	ND	ND	ND	ND
PCBs (ppb)	ND	ND	ND	ND	ND

Appendix A Table 5 (cont.)

PAHs (ppm)	B1	B2	B3	B5	B6
Low Molecular Weight					
Napthalene	ND	ND	ND	ND	ND
1-Methylnapthalene	ND	ND	ND	ND	ND
2-Methylnapthalene	ND	ND	ND	ND	ND
Biphenyl	ND	ND	ND	ND	ND
2,6-Dimethylnapthalene	ND	ND	ND	ND	ND
Acenapthene	ND	ND	ND	ND	ND
Acenapthylene	ND	ND	ND	ND	ND
Fluorene	ND	ND	ND	ND	ND
Phenanthrene	0.29	0.3	0.09	0.55	0.79
1-Methylphenanthrene	ND	ND	ND	ND	ND
Anthracene	ND	ND	ND	0.48	ND
High Molecular Weight					
Fluoranthene	0.2	1.79	1.52	2.43	6.52
Pyrene	ND	1.19	ND	1.75	4.49
Benzo(a)anthracene	ND	ND	0.34	ND	0.13
Chrysene	0.11	0.57	0.43	1.12	ND
Benzo(b)fluoranthene	0.14	0.68	0.62	ND	0.14
Benzo(k)fluoranthene	0.17	0.88	ND	0.14	0.18
Benzo(a)pyrene	ND	0.08	ND	ND	0.35
Benzo(e)pyrene	ND	ND	ND	ND	ND
Benzo(g,h,i)perylene	ND	ND	ND	ND	ND
Dibenzo(a,h)anthracene	ND	ND	ND	ND	0.51
Indeno(1,2,3-cd)pyrene	ND	ND	ND	ND	ND
Perylene	ND	ND	ND	ND	ND

Appendix A Table 6

Sediment Chemistry Results (Dry Weight) for Mobil Oil,
New Haven Harbor 1993

MOBIL OIL	B1	B2	B3
GRAIN SIZE			
% Gravel	3.89	28.3	14.5
% Sand	81.9	66.4	82.0
% Silt/clay	14.2	5.5	3.68
% TOC	4.9	3.5	0.65
METALS (ppm)			
As	ND	ND	ND
Cd	1.25	ND	ND
Cr	10.7	7.09	2.18
Cu	18.7	0.944	2.24
Pb	38.4	21.8	5.97
Hg	ND	ND	ND
Ni	7.83	4.8	2.66
Zn	87.5	58.3	12.3
PESTICIDES (ppm)			
Aldrin	ND	ND	ND
Chlordane	ND	ND	ND
pp-DDT,DDE,DDD	ND	ND	ND
Dieldrin	ND	ND	ND
Endosulfan I,II	ND	ND	ND
Endosulfan sulfate	ND	ND	ND
Endrin	ND	ND	ND
Endrin aldehyde	ND	ND	ND
Heptachlor	ND	ND	ND
Heptachlor epoxide	ND	ND	ND
Hexachlorocyclohexane (total)	ND	ND	ND
Methoxychlor	ND	ND	ND
Toxaphene	ND	ND	ND
PCBs (ppb)	56	23	ND

Appendix A Table 6 (cont.)

PAHs (ppm)	B1	B2	B3
Low Molecular Weight			
Napthalene	ND	ND	ND
1-Methylnapthalene	ND	ND	ND
2-Methylnapthalene	ND	ND	ND
Biphenyl	ND	ND	ND
2,6-Dimethylnapthalene	ND	ND	ND
Acenapthene	0.42	ND	ND
Acenapthylene	0.40	0.11	ND
Fluorene	0.24	ND	ND
Phenanthrene	0.74	0.24	ND
1-Methylphenanthrene	ND	ND	ND
Anthracene	5.39	1.66	ND
High Molecular Weight			
Fluoranthene	1.86	1.44	0.05
Pyrene	11.20	7.02	0.23
Benzo(a)anthracene	0.65	4.79	ND
Chrysene	1.61	0.68	0.03
Benzo(b)fluoranthene	11.40	5.05	0.44
Benzo(k)fluoranthene	1.37	0.56	0.56
Benzo(a)pyrene	1.57	0.54	0.04
Benzo(e)pyrene	ND	ND	ND
Benzo(g,h,i)perylene	4.88	0.60	0.05
Dibenzo(a,h)anthracene	2.47	1.04	ND
Indeno(1,2,3-cd)pyrene	ND	ND	ND
Perylene	ND	ND	ND

Appendix A Table 7

Sediment Chemistry Results (Dry Weight) for Wyatt Incorporated, New Haven Harbor 1993

WYATT INCORPORATED	B1	B2	B3	B4	B4-A	B5	B6	A1
	Arco berth			Pink Tank berth				
GRAIN SIZE								
% Gravel	12.7	8.98	18.4	11.3	0.0	3.43	0.5	0.0
% Sand	67.6	70.2	56.3	72.6	69.5	68.3	87.1	34.1
% Silt/clay	19.3	21.6	26.9	16.9	30.8	28.3	12.3	65.9
%TOC	3.8	3.4	4.8	2.0	3.9	3.1	0.64	4.3
METALS (ppm)								
As	ND	ND	ND	ND	ND	ND	ND	ND
Cd	ND	ND	2.54	2.18	3.51	2.87	0.596	1.2
Cr	89.1	44.8	87.0	64.7	101.0	77.2	23.5	10.9
Cu	148.0	67.0	144.0	190.3	206.0	171.0	68.6	ND
Pb	168.0	59.3	105.0	113.0	131.0	106.0	4.48	24.4
Hg	ND	ND	ND	ND	ND	ND	ND	ND
Ni	45.4	21.1	26.5	19.8	29.9	25.1	8.46	8.19
Zn	ND	139.0	214.0	149.0	265.0	213.0	82.8	61.9
PESTICIDES (ppm)								
Aldrin	ND	ND	ND	ND	ND	ND	ND	ND
Chlordane	ND	ND	ND	ND	ND	ND	ND	ND
pp-DDT,DDE,DDD	ND	ND	ND	ND	ND	ND	ND	ND
Dieldrin	ND	ND	ND	ND	ND	ND	ND	ND
Endosulfan I,II	ND	ND	ND	ND	ND	ND	ND	ND
Endosulfan sulfate	ND	ND	ND	ND	ND	ND	ND	ND
Endrin	ND	ND	ND	ND	ND	ND	ND	ND
Endrin aldehyde	ND	ND	ND	ND	ND	ND	ND	ND
Heptachlor	ND	ND	ND	ND	ND	ND	ND	ND
Heptachlor epoxide	ND	ND	ND	ND	ND	ND	ND	ND
Hexachlorocyclohexane (total)	ND	ND	ND	ND	ND	ND	ND	ND
Methoxychlor	ND	ND	ND	ND	ND	ND	ND	ND
Toxaphene	ND	ND	ND	ND	ND	ND	ND	ND
PCBs (ppb)	25	22	27	53	68	59	47	49

Appendix A Table 7 (cont.)

PAHs (ppm)	B1	B2	B3	B4	B4-A	B5	B6	A1
	Arco berth			Pink Tank berth				
Low Molecular Weight								
Napthalene	ND	ND	ND	ND	0.41	ND	ND	ND
1-Methylnapthalene	ND	ND	ND	ND	ND	ND	ND	ND
Biphenyl	ND	ND	ND	ND	ND	ND	ND	ND
2,6-Dimethylnapthalene	ND	ND	ND	ND	ND	ND	ND	ND
Acenapthene	ND	ND	ND	ND	ND	ND	ND	ND
Acenapthylene	ND	ND	ND	ND	ND	ND	ND	ND
Fluorene	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	ND	0.11	0.18	0.30	0.80	0.53	ND	0.16
1-Methylphenanthrene	ND	ND	ND	ND	ND	ND	ND	ND
Anthracene	ND	ND	0.19	ND	0.07	ND	ND	0.06
High Molecular Weight								
Fluoranthene	1.31	0.54	1.09	2.87	8.70	3.22	1.44	1.35
Pyrene	ND	0.51	0.97	2.51	6.95	2.69	1.21	6.51
Benzo(a)anthracene	ND	ND	0.51	0.14	0.17	0.13	0.07	5.37
Chrysene	1.44	0.34	0.52	1.68	2.88	2.29	0.97	0.77
Benzo(b)fluoranthene	2.88	0.88	2.01	2.79	2.36	4.34	1.73	7.45
Benzo(k)fluoranthene	3.71	0.08	2.58	0.29	0.17	0.35	0.18	0.56
Benzo(a)pyrene	ND	ND	0.21	0.40	0.60	0.48	0.29	0.65
Benzo(e)pyrene	ND	ND	ND	ND	0.30	ND	ND	ND
Benzo(g,h,i)perylene	ND	ND	ND	0.31	ND	0.72	0.07	2.10
Dibenzo(a,h)anthracene	ND	ND	0.43	0.54	0.84	0.70	0.34	0.87
Indeno(1,2,3-cd)pyrene	ND	ND	ND	ND	ND	ND	ND	ND
Perylene	ND	ND	ND	ND	ND	ND	ND	ND

APPENDIX B

Disposal and Capping Operations

Appendix B Disposal and Capping Operations

Appendix B Table 1.	Summary of Disposal Operations of Contaminated Sediments Dredged from New Haven Harbor, October 1993 to January 1994 (Source: Great Lakes Dredging Company)
Appendix B Table 2.	Summary of Capping Operations at the NHAV93 Mound, November 1993 to February 1994 (Source: Great Lakes Dredging Company)

Appendix B Table 1

Summary of Disposal Operations of Contaminated Sediments Dredged
from New Haven Harbor, October 1993 to January 1994 (Source: DAMOS Disposal Logs)

Disposal Location	Trip Date	Source	Volume m^3	Volume yd^3
NHAV93 buoy	10/3/93-10/31/93	inner federal channel	460,083	601,730
I	11/5/93-11/18/93	inner federal channel	2,752	3,600
I	11/18/93-12/3/93	inner federal channel	35,240	46,090
I	1/8/94	inner federal channel	2,294	3,000
		Total from the inner federal channel	**500,369**	**654,420**
I	12/3/93-12/7/93	New Haven Terminal		
		Total	**25,327**	**33,125**
I		Wyatt Incorporated		
	12/7/93-12/9/93	Pink Tank	16,362	21,400
	12/13/93-12/14/93	Arco Berth	4,511	5,900
		Total	**20,873**	**27,302**
I	12/11/93-12/13/93	NE Petroleum	9,710	12,700
	12/13/93-12/15/93	NE Petroleum	2,217	2,900
		Total	**11,927**	**15,600**
I	12/25/93-12/28/93	Gulf Oil	25,767	33,700
	1/7/94-1/8/94	Gulf Oil	2,752	3,600
	1/8/94	Gulf Oil	382	500
		Total	**28,901**	**37,801**
I	1/7/94	Mobil		
		Total	**2,829**	**3,700**
		Total from private dredging projects	**89,857**	**117,533**
		TOTAL VOLUME	**590,226**	**771,949**
		Total deposited at NHAV93 buoy	460,083	601,730
		Total deposited at location I	130,143	117,529

Appendix B Table 2

Summary of Capping Operations at the NHAV93 Mound,
November 1993 to February 1994 (Source: DAMOS Disposal Logs)

DISPOSAL POINT	LAT DEG		LONG DEG		DATE INITIATED	DATE COMPLETED	SOURCE OF CAP MATERIAL	VOLUME (yd^3)	VOLUME (m^3)
A-Cap	41	9.200	72	53.425	11/3/93	11/18/93	federal channel	43,185	33,019
B-Cap	41	9.158	72	53.333	11/3/93	11/18/93	federal channel	43,575	33,317
C-Cap	41	9.108	72	53.325	11/3/93	11/18/93	federal channel	38,400	29,361
D-Cap	41	9.050	72	53.317	11/3/93	11/18/93	federal channel	39,440	30,156
E-Cap	41	9.192	72	53.525	11/3/93	11/18/93	federal channel	39,680	30,339
F-Cap	41	9.150	72	53.417	11/18/93	12/10/93	federal channel	14,800	11,316
G-Cap	41	9.100	72	53.400	11/18/93	1/31/94	federal channel & Lex Atlantic/ Gateway	60,700	46,411
H-Cap	41	9.042	72	53.392	11/18/93	12/10/93	federal channel	14,320	10,949
J-Cap	41	9.163	72	53.488	11/18/93	12/10/93	federal channel & Wyatt Incorporated	18,000	13,763
K-Cap	41	9.000	72	53.375	11/18/93	12/22/93	federal channel & NE Petroleum	26,615	20,350

Appendix B Table 2 (cont.)

DISPOSAL POINT	LAT DEG		LONG DEG		DATE INITIATED	DATE COMPLETED	SOURCE OF CAP MATERIAL	VOLUME (yd^3)	VOLUME (m^3)
L-Cap	41	9.008	72	53.300	11/18/93	12/22/93	NE Petroleum	15,140	11,576
V-Cap	41	9.235	72	53.340	12/10/93	12/22/93	NE Petroleum	10,210	7,806
W-Cap	41	9.200	72	53.300	12/10/93	12/22/93	federal channel & NE Petroleum	12,550	9,596
X-Cap	41	9.163	72	53.275	12/10/93	12/22/93	NE Petroleum	7,400	5,658
Y-Cap	41	9.100	72	53.250	12/10/93	12/22/93	NE Petroleum	7,450	5,696
Z-Cap	41	9.265	72	53.265	12/10/93	12/22/93	NE Petroleum	6,000	4,588
A1-Cap	41	9.230	72	53.230	12/10/93	12/22/93	NE Petroleum	7,300	5,582
I-Cap	41	9.067	72	53.525	1/10/94	1/31/94	federal channel	42,350	32,381
M-Cap	41	9.163	72	53.583	1/14/94	1/31/94	federal channel	25,200	19,268
N-Cap	41	9.115	72	53.550	1/8/93	1/31/94	federal channel	35,000	26,761
O-Cap	41	9.023	72	53.483	1/13/94	1/31/94	federal channel	35,700	27,296
P-Cap	41	8.975	72	53.435	1/14/94	1/31/94	federal channel	20,400	15,598
Q-Cap	41	9.125	72	53.625	1/14/94	2/1/94	federal channel	24,900	19,038
R-Cap	41	9.088	72	53.613	1/10/94	2/1/94	federal channel	32,350	24,735
S-Cap	41	9.038	72	53.583	1/10/94	1/30/94	federal channel	34,250	26,187
T-Cap	41	8.992	72	53.565	1/14/94	1/30/94	federal channel	24,950	19,077

Appendix B Table 2 (cont.)

DISPOSAL POINT	LAT DEG		LONG DEG		DATE INITIATED	DATE COMPLETED	SOURCE OF CAP MATERIAL	VOLUME (yd³)	VOLUME (m³)
U-Cap	41	9.040	72	53.660	1/17/94	1/30/94	federal channel	22,560	17,249
NHAV 93 Buoy	41	11.083	72	53.750	1/8/94	1/30/94	federal channel	42,130	32,213
				Total Volume of Capped Sediments				744,555	569,287
				Total Volume from federal channel				661,585	505,845
				Total Volume from NE Petroleum				63,220	48,338
				Total Volume from Lex Atlantic/Gateway				16,050	12,272
				Total Volume from Wyatt Incorporated				3,700	2,829

APPENDIX C

REMOTS® Sediment-Profile Surveys

Appendix C REMOTS® Sediment-Profile Surveys

Appendix C Table 1

Station Locations and Results of the REMOTS® Baseline Survey Conducted in September 1993

STATION & REP		LAT		LONG		SUCC	GRAIN SIZE			MUD CLAST		PENETRATION				DREDGED MATERIAL				REDOX REBOUND			REDOX POTENTIAL DISCONTINUITY			
		DEG	MIN	DEG	MIN	STAGE	MIN	MAX	MAJ MOD	COUN	AVG DIA	MIN	MAX	RANG	MEAN	AREA	MIN	MAX	MEAN	MIN	MAX	MEAN	AREA	MIN	MAX	MEAN
CLIS 87-88																										
C87-88 NEC	A	41	9.199	72	53.524	ST_I	1	>4	4 to 3	0	0	14.19	14.44	0.25	14.32	0	0	0	0	0	0	0	37.312	1.57	3.33	2.75
C87-88 NEC	B	41	9.209	72	53.512	ST_I	2	>4	>4	0	0	10.91	13.48	2.58	12.20	0	0	0	0	0	0	0	35.246	1.16	3.74	2.63
C87-88 NEC	C	41	9.309	72	53.506	ST_I_ON_II	2	>4	4 to 3	0	0	14.29	14.95	0.66	14.62	0	0	0	0	0	0	0	50.025	2.12	4.60	3.71
C87-88 50SW	A	41	9.179	72	53.519	ST_I_ON_II	2	>4	>4	0	0	8.03	10.20	2.17	9.12	0	0	0	0	1.06	6.72	3.89	24.011	0.61	2.37	1.76
C87-88 50SW	C	41	9.173	72	53.513	ST_I_ON_II	2	>4	>4	0	0	10.86	11.36	0.50	11.11	0	0	0	0	1.01	5.46	3.24	27.265	0.10	2.68	2.10
C87-88 50SW	D	41	9.177	72	53.534	ST_I	2	>4	>4	0	0	9.19	10.30	1.11	9.75	0	0	0	0	0.91	2.58	1.74	20.377	0.45	2.37	1.57
C87-88 150SW	A	41	9.146	72	53.567	ST_I	-1	>4	4 to 3	15	2.52	5.15	7.17	2.02	6.16	0	0	0	0	0	0	0	6.685	0.05	1.25	0.51
C87-88 150SW	B	41	9.138	72	53.591	ST_I	2	>4	>4	0	0	6.52	8.28	1.77	7.40	0	0	0	0	0.1	4.19	2.15	17.788	0.15	2.73	1.32
C87-88 150SW	C	41	9.128	72	53.584	ST_I	1	>4	>4	0	0	8.54	9.95	1.41	9.24	0	0	0	0	0.4	2.93	1.67	27.055	1.11	2.53	2.00
C87-88 225SW	B	41	9.110	72	53.630	ST_I	1	>4	>4	0	0	12.53	13.03	0.51	12.78	0	0	0	0	0	0	0	26.937	0.05	2.88	2.01
C87-88 225SW	C	41	9.121	72	53.605	ST_I	1	>4	>4	0	0	13.79	14.39	0.61	14.09	0	0	0	0	0	0	0	25.836	0.81	2.53	1.91
C87-88 225SW	D	41	9.122	72	53.624	ST_I	1	>4	>4	0	0	14.50	15.05	0.55	14.77	0	0	0	0	0	0	0	30.447	1.36	3.59	2.24
C87-88 300SW	A	41	9.088	72	53.648	INDET	-1	>4	4 to 3	0	0	9.09	11.01	1.92	10.05	0	0	0	0	0	0	0	99	99.00	99.00	99.00
C87-88 300SW	B	41	9.083	72	53.643	ST_I_TO_II	1	>4	>4	0	0	11.16	12.47	1.31	11.82	0	0	0	0	0	0	0	14.133	0.66	1.31	1.00
C87-88 300SW	D	41	9.082	72	53.649	ST_I	0	>4	>4	15	1.11	15.15	16.01	0.86	15.58	0	0	0	0	0	0	0	7.458	0.51	2.68	1.44
C87-88 300SW	E	41	9.089	72	53.665	INDET	-1	>4	>4	0	0	0.05	0.05	0.00	0.05	0	0	0	0	0	0	0	99	99.00	99.00	99.00
C87-88 375SW	A	41	9.047	72	53.700	ST_I	-1	>4	>4	5	1	3.99	7.02	3.03	5.50	0	0	0	0	0	0	0	5.165	0.05	1.26	0.79
C87-88 375SW	B	41	9.055	72	53.695	ST_I	1	>4	>4	0	0	13.99	14.30	0.31	14.14	0	0	0	0	0	0	0	9.522	0.05	1.46	0.93
C87-88 375SW	C	41	9.048	72	53.689	ST_I	0	>4	>4	0	0	12.68	13.48	0.81	13.08	0	0	0	0	0	0	0	20.349	0.66	2.42	1.51
C87-88 375SW	D	41	9.053	72	53.684	ST_I	-1	>4	>4	0	0	10.00	11.57	1.57	10.78	0	0	0	0	0	0	0	16.559	0.68	1.72	1.18
CLIS 89																										
C89 100E	A	41	9.301	72	53.326	ST_I	2	>4	4 to 3	0	0	10.96	11.46	0.51	11.21	0	0	0	0	0	0	0	22.769	0.10	3.79	1.80
C89 100E	B	41	9.308	72	53.331	ST_I	2	>4	4 to 3	0	0	13.28	14.14	0.86	13.71	0	0	0	0	0	0	0	39.898	1.31	3.54	2.95
C89 100E	C	41	9.303	72	53.328	ST_I	1	>4	4 to 3	0	0	13.28	13.84	0.56	13.56	0	0	0	0	0	0	0	30.23	0.30	2.98	2.24
C89 50E	A	41	9.302	72	53.361	INDET	0	>4	3 to 2	20	1.26	8.94	11.57	2.63	10.25	0	0	0	0	0	0	0	99	99.00	99.00	99.00
C89 50E	B	41	9.308	72	53.365	ST_I	1	>4	4 to 3	0	0	3.03	6.41	3.38	4.72	0	0	0	0	0	0	0	11.391	0.25	1.67	0.97
C89 50E	C	41	9.300	72	53.367	ST_I	1	>4	3 to 2	15	2.29	7.43	9.44	2.02	8.43	0	0	0	0	0	0	0	14.263	0.25	1.87	1.08
C89 CTR	A	41	9.293	72	53.402	ST_I	1	>4	3 to 2	10	2.1	9.14	12.78	3.64	10.96	0	0	0	0	0	0	0	17.887	0.05	3.59	1.68
C89 CTR	B	41	9.298	72	53.407	ST_I	1	>4	>4	0	0	8.84	10.76	1.92	9.80	0	0	0	0	0	0	0	24.902	1.11	2.73	1.85
C89 CTR	C	41	9.293	72	53.408	ST_I	2	>4	4 to 3	0	0	6.97	8.28	1.31	7.63	0	0	0	0	0	0	0	25.864	0.40	2.78	1.89
C89 50W	B	41	9.303	72	53.428	ST_I	2	>4	3 to 2	30	0.76	14.80	16.01	1.21	15.40	0	0	0	0	0	0	0	45.054	1.26	4.85	3.36
C89 50W	C	41	9.307	72	53.439	ST_I	2	>4	3 to 2	0	0	11.87	14.65	2.78	13.26	0	0	0	0	0	0	0	46.216	2.22	4.34	3.40
C89 50W	D	41	9.303	72	53.438	ST_I	0	>4	3 to 2	0	0	13.54	16.87	3.33	15.20	0	0	0	0	0	0	0	19.884	0.25	2.58	1.94
C89 100W	A	41	9.303	72	53.464	ST_I_TO_II	2	>4	4 to 3	0	0	17.02	17.93	0.91	17.47	0	0	0	0	0	0	0	50.324	0.45	5.45	3.74
C89 100W	B	41	9.306	72	53.474	ST_I	2	>4	4 to 3	3	9.47	16.26	17.83	1.57	17.05	0	0	0	0	0	0	0	16.263	0.30	2.53	1.49
C89 100W	C	41	9.304	72	53.474	ST_I_TO_II	2	>4	>4	0	0	17.32	19.49	2.17	18.41	0	0	0	0	0	0	0	41.923	1.06	4.70	3.13
C89 150W	A	41	9.309	72	53.524	ST_I	2	>4	>4	3	10.01	3.13	13.48	10.35	8.31	0	0	0	0	0	0	0	21.393	1.16	3.18	2.34
C89 150W	B	41	9.298	72	53.512	ST_I	1	>4	4 to 3	0	0	17.32	17.98	0.66	17.65	0	0	0	0	0	0	0	47.42	1.92	4.85	3.50
C89 150W	C	41	9.309	72	53.506	ST_I_TO_II	2	>4	4 to 3	0	0	16.46	17.32	0.86	16.89	0	0	0	0	0	0	0	44.213	1.92	4.44	3.32
CLIS 90																										
C90 100E	A	41	9.207	72	53.181	ST_I	-1	>4	4 to 3	0	0	15.15	15.95	0.80	15.55	0	0	0	0	0	0	0	23.371	0.90	2.85	1.74
C90 100E	B	41	9.197	72	53.184	ST_I	-1	>4	4 to 3	0	0	12.15	12.65	0.50	12.40	0	0	0	0	0	0	0	23.352	0.35	4.00	1.76
C90 100E	C	41	9.195	72	53.183	ST_I_ON_II	1	>4	>4	0	0	5.35	7.25	1.90	6.30	0	0	0	0	0	0	0	20.646	0.50	2.30	1.55
C90 50E	A	41	9.203	72	53.217	ST_I	1	>4	>4	0	0	12.25	13.50	1.25	12.87	0	0	0	0	0	0	0	30.936	1.20	2.85	2.32
C90 50E	B	41	9.202	72	53.207	ST_I	3	>4	4 to 3	0	0	12.25	13.50	1.25	12.87	0	0	0	0	0	0	0	17.163	0.30	2.40	1.73
C90 50E	C	41	9.195	72	53.222	INDET	1	>4	4 to 3	30	1.81	20.70	20.70	0.00	20.70	0	0	0	0	0	0	0	99	99.00	99.00	99.00
C90 CTR	A	41	9.200	72	53.252	ST_I	0	>4	>4	0	0	13.03	13.48	0.45	13.26	0	0	0	0	0	0	0	13.056	0.25	2.53	1.01
C90 CTR	B	41	9.199	72	53.256	ST_I	-1	>4	4 to 3	0	0	13.13	13.89	0.76	13.51	0	0	0	0	0	0	0	26.122	0.10	2.98	1.96
C90 CTR	C	41	9.198	72	53.257	ST_I	0	>4	3 to 2	0	0	7.53	11.36	3.84	9.44	0	0	0	0	0	0	0	11.789	0.15	1.62	0.97
C90 50W	A	41	9.207	72	53.287	ST_I	-1	>4	4 to 3	0	0	13.59	14.44	0.86	14.01	0	0	0	0	0	0	0	29.224	0.35	2.83	2.20
C90 50W	B	41	9.200	72	53.280	ST_I	1	>4	4 to 3	0	0	15.71	16.31	0.61	16.01	0	0	0	0	0	0	0	28.963	1.01	2.78	2.16
C90 50W	C	41	9.198	72	53.293	ST_I	2	>4	4 to 3	0	0	0.05	4.80	4.75	2.42	0	0	0	0	0	0	0	99	99.00	99.00	99.00
C90 100W	A	41	9.203	72	53.327	ST_I	2	>4	4 to 3	10	2.33	13.64	15.10	1.46	14.37	0	0	0	0	0	0	0	55.234	0.10	6.62	4.34
C90 100W	B	41	9.198	72	53.337	INDET	0	>4	4 to 3	100	1.07	17.27	18.53	1.26	17.90	0	0	0	0	0	0	0	20.231	0.20	3.38	1.86
C90 100W	C	41	9.208	72	53.322	ST_I	0	>4	4 to 3	30	0.57	17.27	18.53	1.26	17.90	0	0	0	0	0	0	0	40.487	1.21	4.09	2.97
C90 150W	A	41	9.197	72	53.370	ST_I	-1	>4	4 to 3	0	0	15.76	16.31	0.56	16.04	0	0	0	0	0	0	0	34.984	1.57	3.18	2.56
C90 150W	B	41	9.207	72	53.359	ST_I_ON_II	1	>4	4 to 3	5	5.24	9.19	14.09	4.90	11.64	0	0	0	0	0	0	0	8.845	0.20	2.45	0.74
C90 150W	C	41	9.203	72	53.358	ST_I	0	>4	>4	10	1.52	9.55	15.15	5.61	12.35	0	0	0	0	0	0	0	38.707	0.91	4.49	2.93

Appendix C Table 1 (cont.)

STATION & REP		LOW DISS O2	METHANE BUBBLES COUNT	AREA	MIN	MAX	MEAN	OSI	SURFACE TYPE	ADDITIONAL MEASUREMENT COMMENT (NOADDM)	VALUE	COMMENTS
CLIS 87-88												
C87-88 NEC	A	NO	0	0	0	0	0	5	BIOGENIC	NOADDM	0	DM>pen, sand at bottom, chaetopterid? tube, pull-away
C87-88 NEC	B	NO	0	0	0	0	0	5	PHYSICAL	NOADDM	0	DM>pen, pull-away at bottom, burrow, M/S
C87-88 NEC	C	NO	0	0	0	0	0	10	BIOGENIC	depth to feeding void (cm)	5.05	DM>pen, Reduced fecal coil above feeding void, amphipod tubes
C87-88 50SW	A	NO	0	0	0	0	0	8	BIOGENIC	NOADDM	0	DM>pen, amphipod tube on left, Nephthys, camera tipped
C87-88 50SW	C	NO	0	0	0	0	0	8	BIOGENIC	Depth to sm feeding void (cm)	2.79	DM>pen, M/S
C87-88 50SW	D	NO	0	0	0	0	0	4	INDET	NOADDM	0	DM>pen, pull-away
C87-88 150SW	A	NO	0	0	0	0	0	2	PHYSICAL	Depth to bottom sand layer (cm)	7.01	DM>pen, fresh DM, shelter fabric, some lg tubes, max gs shell
C87-88 150SW	B	NO	0	0	0	0	0	3	INDET	NOADDM	0	DM>pen, S/M/S, RPD 0-1 cm
C87-88 150SW	C	NO	0	0	0	0	0	4	BIOGENIC	NOADDM	0	DM>pen, very subtle change from RPD to blue sed, sand at bottom?
C87-88 225SW	B	NO	0	0	0	0	0	4	BIOGENIC	NOADDM	0	DM>pen, burrow,middle lt blue layer betw. ox and sulfitic layers
C87-88 225SW	C	NO	0	0	0	0	0	4	BIOGENIC	NOADDM	0	DM>pen, lt blue mid layer 8-13 cm thick, pull-apart cracks
C87-88 225SW	D	NO	0	0	0	0	0	4	BIOGENIC	NOADDM	0	DM>pen, burrows, sl. pull-away
C87-88 300SW	A	NO	0	0	0	0	0	99	PHYSICAL	NOADDM	0	DM>pen, Nephthys?
C87-88 300SW	B	NO	0	0	0	0	0	4	BIOGENIC	NOADDM	0	DM>pen, burrows
C87-88 300SW	D	NO	0	0	0	0	0	3	PHYSICAL	NOADDM	0	DM>pen, surf. erosion, bivalve, pull-away, sand on bottom?
C87-88 300SW	E	NO	0	0	0	0	0	99	PHYSICAL	NOADDM	0	surf. shot, DM=clumps of roots of marsh grass, fresh DM
C87-88 375SW	A	YES	0	0	0	0	0	-1	PHYSICAL	NOADDM	0	DM>pen, thin RPD, gastropod shell
C87-88 375SW	B	NO	0	0	0	0	0	3	BIOGENIC	Width anemone burrow (cm)	2.02	DM>pen, lg anemone burrow fr surf. to bottom
C87-88 375SW	C	NO	0	0	0	0	0	4	BIOGENIC	NOADDM	0	DM>pen, pull-apart void, sand at bottom?
C87-88 375SW	D	NO	0	0	0	0	0	3	BIOGENIC	NOADDM	0	DM>pen, pull-away, hole at 7 cm depth, gastropod shell
CLIS 89												
C89 100E	A	NO	0	0	0	0	0	4	BIOGENIC	NOADDM	0	DM>pen, lower 1/2 v sulfitic, Nephthys at depth, sl. pull-away, void burrow?
C89 100E	B	NO	0	0	0	0	0	5	BIOGENIC	NOADDM	0	DM>pen, pull-away + pullapart crack, Nephthys, phi 2-1 sand at bottom
C89 100E	C	NO	0	0	0	0	0	4	BIOGENIC	NOADDM	0	DM>pen, M/S/M/S/M/S, pull-away, burrow? in center
C89 50E	A	NO	0	0	0	0	0	99	PHYSICAL	NOADDM	0	DM>pen, wiper dirt obscures RPD, shelter fabric on left, pull-away
C89 50E	B	NO	0	0	0	0	0	3	PHYSICAL	NOADDM	0	DM>pen, phi 4 over phi 2 sand, burrow, pull-apart voids at discontinuity
C89 50E	C	NO	0	0	0	0	0	3	PHYSICAL	NOADDM	0	DM>pen, chaotic ,2 mm thick phi 3 sand, pull-apart cracks
C89 CTR	A	NO	0	0	0	0	0	4	PHYSICAL	NOADDM	0	DM>pen, chaotic + shelter fabric, v sulfitic bet. RPD and bottom sand layer
C89 CTR	B	NO	0	0	0	0	0	4	BIOGENIC	NOADDM	0	DM>pen, S/M/S, pull-away at bottom
C89 CTR	C	NO	0	0	0	0	0	4	BIOGENIC	NOADDM	0	DM>pen, chaotic, S/M/S/M/S
C89 50W	B	NO	0	0	0	0	0	6	PHYSICAL	Thickness phi 3 sand RDSI layer (cm)	0.45	DM>pen, S/M/S, RDSI, mid black cl. layer pull-away, 1 st. I tube
C89 50W	C	NO	0	0	0	0	0	6	PHYSICAL	NOADDM	0	DM>pen, pull-away in black lower layer
C89 50W	D	NO	0	0	0	0	0	4	BIOGENIC	NOADDM	0	DM>pen, S/M/S, pull-away + pull-apart in black middle layer
C89 100W	A	NO	0	0	0	0	0	7	BIOGENIC	NOADDM	0	DM>pen, pull-away at bottom
C89 100W	B	NO	0	0	0	0	0	3	PHYSICAL	NOADDM	0	DM>pen, S/M/S, relic void? pull-away + pull apart cracks
C89 100W	C	NO	0	0	0	0	0	7	BIOGENIC	NOADDM	0	DM>pen, S/M/S, 2 amphipod tubes ?, burrows?, pull-away + pull apart cracks
C89 150W	A	NO	0	0	0	0	0	5	PHYSICAL	NOADDM	0	DM>pen, shelter fabric?
C89 150W	B	NO	0	0	0	0	0	6	BIOGENIC	NOADDM	0	DM>pen, S/M, burrows?, pull-away below discontinuity
C89 150W	C	NO	0	0	0	0	0	7	BIOGENIC	NOADDM	0	DM>pen, S/M, 3 amphipod tubes, pull-away
CLIS 90												
C90 100E	A	NO	0	0	0	0	0	4	BIOGENIC	Depth to 1st discontinuity (cm)	3.35	DM>pen, M/S/M, sand 3-2 phi, sand at bottom artifact fell out of hole
C90 100E	B	NO	0	0	0	0	0	4	BIOGENIC	Min. depth to black layer (cm)	3.15	DM>pen, chaotic fabric, S/M/S/M, mid S 2-3 phi
C90 100E	C	NO	0	0	0	0	0	8	BIOGENIC	NOADDM	0	DM>pen, S/M, pull-apart cracks in lower dark layer
C90 50E	A	NO	0	0	0	0	0	5	BIOGENIC	NOADDM	0	DM>pen, S/M/S, void an artifact
C90 50E	B	NO	0	0	0	0	0	4	INDET	NOADDM	0	DM>pen, voids artifacts, phi 2 sand at depth
C90 50E	C	NO	0	0	0	0	0	99	INDET	NOADDM	0	DM>pen, op. chaotic fabric, jumble of black mud+orange sand (fresh DM)
C90 CTR	A	NO	0	0	0	0	0	3	BIOGENIC	NOADDM	0	DM>pen, S/M/S, top sand layer chaotic, mid black layer 12 cm thick
C90 CTR	B	NO	0	0	0	0	0	4	BIOGENIC	NOADDM	0	DM>pen, S/M/S
C90 CTR	C	NO	0	0	0	0	0	3	PHYSICAL	Thickness of top layer (cm)	1.73	DM>pen, S/M?/S, 3 layers white black dk. gray, camera tipped?
C90 50W	A	NO	0	0	0	0	0	4	BIOGENIC	NOADDM	0	DM>pen, pull-away, Burrow not feeding void?, S/M/S, sand at 13 cm depth
C90 50W	B	NO	1	0.561	8	11.65	9.82	2	BIOGENIC	NOADDM	0	DM>pen, 20 methan bubbles, pull-away, sed. chaotic below 7 cm, S/M/S
C90 50W	C	NO	0	0	0	0	0	99	PHYSICAL	NOADDM	0	DM>pen, camera tipped?
C90 100W	A	NO	0	0	0	0	0	7	PHYSICAL	NOADDM	0	DM>pen, pull-away + pull-apart, sand clast in center
C90 100W	B	NO	0	0	0	0	0	99	PHYSICAL	NOADDM	0	DM>pen, chaotic fabric, dewatering channels lg one on rt
C90 100W	C	NO	0	0	0	0	0	5	BIOGENIC	NOADDM	0	DM>pen, S/M/S/M/S, chaotic fabric, sed. torn below 8 cm, sand at depth
C90 150W	A	NO	0	0	0	0	0	5	BIOGENIC	Depth Nephthys burrow (cm)	5.2	DM>pen, S/M/S/M/S, Nephthys, pull-apart at mid-sand layer
C90 150W	B	NO	0	0	0	0	0	6	PHYSICAL	NOADDM	0	DM>pen, chaotic, pull-away at depth, hole on rt artifact, sm burrow in center
C90 150W	C	NO	0	0	0	0	0	5	PHYSICAL	NOADDM	0	DM>pen, camera on slope (tubes upright), center burrow, pull-away + pull-ap

Appendix C Table 1 (cont.)

STATION & REP		LAT		LONG		SUCC	GRAIN SIZE			MUD CLAST		PENETRATION				DREDGED MATERIAL				REDOX REBOUND			REDOX POTENTIAL DISCONTINUITY			
		DEG	MIN	DEG	MIN	STAGE	MIN	MAX	MAJ MOD	COUN	AVG DIA	MIN	MAX	RANG	MEAN	AREA	MIN	MAX	MEAN	MIN	MAX	MEAN	AREA	MIN	MAX	MEAN
NORWALK																										
NWK 100E	A	41	8.910	72	53.329	ST_I_TO_II	1	>4	4 to 3	0	0	10.10	10.97	0.87	10.54	0	0	0	0	0	0	0	9.073	0.15	1.11	0.63
NWK 100E	B	41	8.904	72	53.437	ST_II	1	>4	4 to 3	0	0	12.69	12.99	0.30	12.84	0	0	0	0	0	0	0	43.396	2.15	4.00	3.22
NWK 100E	C	41	8.889	72	53.431	INDET	-1	>4	4 to 3	0	0	9.04	10.66	1.62	9.85	0	0	0	0	0	0	0	25.257	0.15	3.10	2.02
NWK 100E	F	41	8.909	72	53.449	ST_I	-1	>4	4 to 3	0	0	8.82	14.10	5.28	11.46	0	0	0	0	0	0	0	8.53	0.67	3.03	1.65
NWK 50E	A	41	8.903	72	53.461	ST_II	-1	>4	4 to 3	0	0	10.81	11.78	0.96	11.29	0	0	0	0	0	0	0	22.644	0.76	2.99	1.79
NWK 50E	B	41	8.900	72	53.468	ST_I	-1	>4	4 to 3	15	1.56	11.02	15.53	4.52	13.27	0	0	0	0	0	0	0	11.905	0.61	3.15	1.97
NWK 50E	C	41	8.901	72	53.473	ST_I	0	>4	4 to 3	0	0	13.96	15.48	1.52	14.72	0	0	0	0	0	0	0	16.995	0.20	3.20	1.36
NWK CTR	A	41	8.903	72	53.508	ST_I_TO_II	0	>4	4 to 3	0	0	12.28	15.13	2.84	13.71	0	0	0	0	0	0	0	20.283	0.76	2.84	1.67
NWK CTR	D	41	8.901	72	53.509	ST_I	-1	>4	4 to 3	3	1.52	7.56	8.48	0.91	8.02	0	0	0	0	0	0	0	19.244	0.05	2.84	1.53
NWK CTR	E	41	8.897	72	53.508	ST_I	0	>4	4 to 3	10	3.64	7.46	8.07	0.61	7.77	0	0	0	0	0	0	0	18.16	0.30	2.64	1.38
NWK 50W	2	41	8.907	72	53.537	INDET	1	>4	4 to 3	0	0	20.66	20.66	0.00	20.66	0	0	0	0	0	0	0	99	99.00	99.00	99.00
NWK 50W	A	41	8.906	72	53.537	ST_I	0	>4	4 to 3	0	0	18.93	19.85	0.92	19.39	0	0	0	0	0	0	0	42.751	1.68	4.90	3.18
NWK 50W	B	41	8.908	72	53.537	ST_I	0	>4	4 to 3	0	0	18.26	18.83	0.56	18.55	0	0	0	0	0	0	0	34.88	0.71	3.78	2.60
NWK 50W	D	41	8.892	72	53.529	ST_I	0	>4	4 to 3	0	0	12.81	15.41	2.60	14.11	0	0	0	0	0	0	0	39.745	0.20	4.80	3.14
NWK 100W	A	41	8.896	72	53.573	ST_I	-1	>4	4 to 3	0	0	12.09	12.40	0.31	12.24	0	0	0	0	0	0	0	37.346	1.38	3.93	2.79
NWK 100W	B	41	8.893	72	53.571	ST_I	-1	>4	4 to 3	0	0	12.91	14.13	1.22	13.52	157.9	10.4	13.1	11.6	0	0	0	22.982	0.56	2.55	1.71
NWK 100W	C	41	8.887	72	53.561	ST_I	0	>4	4 to 3	0	0	15.36	16.17	0.82	15.77	0	0	0	0	0	0	0	36.134	1.07	4.03	2.71
NWK 150W	A	41	8.900	72	53.596	ST_I	-1	>4	4 to 3	0	0	7.35	7.81	0.46	7.58	73.27	2.02	7.98	5.91	0	0	0	13.516	0.15	1.63	0.99
NWK 150W	B	41	8.897	72	53.608	ST_I	-1	>4	4 to 3	0	0	10.97	11.22	0.26	11.10	139.3	5.61	11.3	9.94	0	0	0	23.528	0.77	2.45	1.73
NWK 150W	C	41	8.902	72	53.613	ST_I	-1	>4	4 to 3	0	0	13.01	13.27	0.26	13.14	159.5	9.7	13.3	11.76	0	0	0	20.097	0.77	2.19	1.47
NWK 150W	D	41	8.897	72	53.615	ST_I	-1	>4	4 to 3	0	0	15.25	16.17	0.92	15.71	0	0	0	0	0	0	0	12.723	0.46	2.19	1.15
SP																										
SP 100E	A	41	8.996	72	53.114	ST_I	2	>4	4 to 3	0	0	2.49	4.15	1.66	3.32	0	0	0	0	0	0	0	13.802	0.16	2.23	1.44
SP 100E	D	41	9.004	72	53.108	ST_I	2	>4	3 to 2	0	0	1.96	3.04	1.08	2.50	0	0	0	0	0	0	0	15.04	0.25	2.27	1.02
SP 100E	E	41	9.051	72	53.171	ST_I_ON_III	-1	>4	4 to 3	0	0	14.59	16.08	1.49	15.33	0	0	0	0	0	0	0	34.863	0.62	4.07	2.99
SP 50E	A	41	8.998	72	53.147	ST_I	1	>4	4 to 3	0	0	10.26	11.80	1.55	11.03	0	0	0	0	0	0	0	23.814	1.03	3.09	1.78
SP 50E	D	41	8.994	72	53.141	INDET	1	>4	4 to 3	0	0	19.84	20.67	0.82	20.26	0	0	0	0	0	0	0	99	99.00	99.00	99.00
SP 50E	E	41	8.997	72	53.145	ST_I	2	>4	>4	0	0	3.40	4.28	0.88	3.84	0	0	0	0	0	0	0	21.024	1.08	2.27	1.54
SP 50E	F	41	9.005	72	53.158	ST_I_TO_II	2	>4	3 to 2	0	0	1.08	3.08	2.00	2.08	0	0	0	0	0	0	0	10.97	0.10	2.67	1.37
SP CTR	A	41	8.997	72	53.186	ST_II	0	>4	2 to 1	0	0	8.50	9.15	0.65	8.83	0	0	0	0	0	0	0	99	99.00	99.00	99.00
SP CTR	B	41	8.993	72	53.185	ST_I	0	>4	>4	5	5.52	17.25	17.95	0.70	17.60	0	0	0	0	0	0	0	32.3	0.30	3.95	2.43
SP CTR	C	41	9.003	72	53.179	ST_I_ON_III	2	>4	3 to 2	0	0	9.05	10.65	1.60	9.85	0	0	0	0	0	0	0	41.698	0.30	5.15	3.13
SP 50W	A	41	9.049	72	53.151	ST_I	1	>4	4 to 3	0	0	16.70	17.75	1.05	17.22	0	0	0	0	0	0	0	24.323	0.20	3.00	1.86
SP 50W	B	41	9.047	72	53.162	ST_II	1	>4	>4	0	0	17.20	18.45	1.25	17.82	0	0	0	0	0	0	0	43.168	1.95	4.45	3.24
SP 100W	G	41	9.005	72	53.254	ST_I_ON_III	-1	>4	4 to 3	0	0	6.85	8.60	1.75	7.72	0	0	0	0	0	0	0	23.561	0.50	2.30	1.74
SP 100W	I	41	9.002	72	53.246	ST_I	-1	>4	3 to 2	10	2.45	11.60	12.60	1.00	12.10	0	0	0	0	0	0	0	27.584	0.60	3.85	2.19
SP 100W	J	41	9.007	72	53.265	INDET	-1	>4	3 to 2	0	0	1.80	2.50	0.70	2.15	0	0	0	0	0	0	0	99	99.00	99.00	99.00
SP 100W	K	41	9.005	72	53.250	ST_I	1	>4	4 to 3	0	0	13.65	14.20	0.55	13.92	0	0	0	0	0	0	0	28.933	1.30	2.85	2.13
SP 150W	A	41	8.998	72	53.287	ST_I	-1	>4	4 to 3	0	0	10.15	11.60	1.45	10.88	0	0	0	0	0	0	0	20.921	0.10	2.85	1.75
SP 150W	B	41	9.004	72	53.285	ST_I_ON_III	-1	>4	4 to 3	0	0	12.10	13.25	1.15	12.67	0	0	0	0	0	0	0	27.125	0.15	4.80	2.10
SP 150W	C	41	9.006	72	53.285	ST_I_TO_II	-1	>4	4 to 3	0	0	7.60	9.20	1.60	8.40	0	0	0	0	0	0	0	25.964	0.05	3.10	2.05
SOUTHEAST VALLEY																										
VAL 150E	A	41	9.092	72	53.149	ST_I_TO_II	1	>4	4 to 3	0	0	19.95	20.40	0.45	20.18	0	0	0	0	0	0	0	25.447	0.76	3.38	2.17
VAL 150E	B	41	9.084	72	53.144	ST_I	-1	>4	4 to 3	2	12.63	0.12	15.30	15.18	7.71	0	0	0	0	0	0	0	21.864	0.30	5.30	3.69
VAL 75E	A	41	9.089	72	53.212	ST_I	1	>4	4 to 3	10	3.35	0.05	10.40	10.35	5.23	0	0	0	0	0	0	0	99	99.00	99.00	99.00
VAL 75E	B	41	9.079	72	53.199	ST_I	-1	>4	4 to 3	10	1.3	6.92	9.24	2.32	8.08	0	0	0	0	0	0	0	5.605	0.05	1.77	1.14
VAL 75E	C	41	9.087	72	53.193	ST_I	1	>4	4 to 3	0	0	14.44	15.91	1.47	15.18	0	0	0	0	0	0	0	9.219	0.35	2.88	1.67
VAL CTR	A	41	9.094	72	53.262	ST_I	0	4	3 to 2	0	0	4.35	11.01	6.66	7.68	0	0	0	0	0	0	0	99	99.00	99.00	99.00
VAL CTR	B	41	9.086	72	53.255	ST_I	3	>4	>4	0	0	4.24	4.65	0.40	4.44	0	0	0	0	0	0	0	30.536	1.36	2.78	2.22
VAL CTR	C	41	9.085	72	53.253	ST_I	2	>4	4 to 3	0	0	10.45	11.01	0.56	10.73	0	0	0	0	0.91	1.92	1.41	27.405	0.81	3.43	2.04
VAL 75W	A	41	9.093	72	53.312	ST_I_TO_II	2	>4	>4	0	0	10.30	11.11	0.81	10.71	0	0	0	0	0	0	0	18.855	0.45	2.37	1.38
VAL 75W	B	41	9.086	72	53.301	ST_I	2	>4	4 to 3	0	0	11.62	12.17	0.56	11.89	0	0	0	0	1.01	1.41	1.21	36.019	1.52	3.23	2.67
VAL 75W	C	41	9.085	72	53.309	ST_I	1	>4	4 to 3	0	0	11.21	11.62	0.40	11.41	0	0	0	0	0	0	0	30.061	0.96	2.83	2.22
VAL 150W	A	41	9.090	72	53.361	ST_I	-1	>4	>4	0	0	7.63	8.23	0.61	7.93	0	0	0	0	0	0	0	18.954	0.05	2.27	1.41
VAL 150W	B	41	9.086	72	53.363	ST_I	2	>4	>4	0	0	10.00	10.35	0.35	10.18	0	0	0	0	0	0	0	18.202	0.10	2.02	1.34
VAL 225W	A	41	9.084	72	53.420	ST_I	2	>4	4 to 3	0	0	10.00	10.35	0.35	10.18	0	0	0	0	0	0	0	30.166	1.31	3.38	2.21
VAL 225W	B	41	9.078	72	53.420	ST_I_ON_III	-1	>4	4 to 3	0	0	7.73	9.29	1.57	8.51	0	0	0	0	0	0	0	22.017	0.05	2.88	1.65

Appendix C Table 1 (cont.)

STATION & REP		LOW DISS O2	METHANE BUBBLES COUNT	AREA	MIN	MAX	MEAN	OSI	SURFACE TYPE	ADDITIONAL MEASUREMENT COMMENT (NOADDM)	VALUE	COMMENTS
NORWALK												
NWK 100E	A	NO	0	0	0	0	0	3	BIOGENIC	NOADDM	0	DM>pen, lg. animal at 9 cm depth, sl pull-away+pull-apart
NWK 100E	B	NO	0	0	0	0	0	8	BIOGENIC	NOADDM	0	DM>pen, sl. pull-away at bottom, amphipod tubes on surf.
NWK 100E	C	NO	0	0	0	0	0	99	BIOGENIC	NOADDM	0	DM>pen, sl. pull-away, surf. disturbed
NWK 100E	F	YES	0	0	0	0	0	0	PHYSICAL	NOADDM	0	DM>pen, patchy RPD, some pull-away+ pull-apart, some shells
NWK 50E	*A*	*NO*	*0*	*0*	*0*	*0*	*0*	*6*	*INDET*	*NOADDM*	*0*	*DM>pen, amphipods, shelter fabric, lg. sulfitic patch at 5 cm depth, sl. pull-*
NWK 50E	B	NO	0	0	0	0	0	4	PHYSICAL	NOADDM	0	DM>pen, shelter fab, dk sulf. cl. below 5 cm depth, max gastropod shell
NWK 50E	C	NO	0	0	0	0	0	3	PHYSICAL	NOADDM	0	DM>pen
NWK CTR	A	NO	0	0	0	0	0	5	PHYSICAL	Depth of worm (cm)	14.31	DM>pen, pull-away, shelter fabric
NWK CTR	D	NO	0	0	0	0	0	4	PHYSICAL	NOADDM	0	DM>pen, shelter fab, stick on surf, pull-apart voids, few tubes on surf.
NWK CTR	E	NO	0	0	0	0	0	3	PHYSICAL	NOADDM	0	DM>pen, *lg. shelter fabric, few Stage I tubes*
NWK 50W	2	NO	0	0	0	0	0	99	INDET	Min. depth of animal (echinoid?) (cm)	15.46	DM>pen, overpenetrated, min. RPD 0-1 cm, S/M/ pull-away lower 1/2
NWK 50W	A	NO	0	0	0	0	0	6	BIOGENIC	Depth of fat 2 cm long worm (cm)	7.81	DM>pen, pull-away + pull-apart cracks
NWK 50W	B	NO	0	0	0	0	0	5	PHYSICAL	NOADDM	0	DM>pen, S/M, lower 2/3 sl. pull-away
NWK 50W	D	NO	0	0	0	0	0	6	PHYSICAL	NOADDM	0	DM>pen, shell bits to depth, dark sulf. patches deep
NWK 100W	A	NO	0	0	0	0	0	5	BIOGENIC	NOADDM	0	DM>pen, S/M, sl. pull-away + pull-apart cracks
NWK 100W	B	NO	0	0	0	0	0	4	BIOGENIC	Depth to 3 cm diameter echinoid? (cm)	11.07	Depth of old surf? 11 cm
NWK 100W	C	NO	0	0	0	0	0	5	BIOGENIC	NOADDM	0	DM>pen, pull-away in lower 1/2
NWK 150W	A	NO	0	0	0	0	0	3	BIOGENIC	NOADDM	0	gray patches are ambient sediment, pull-apart cracks
NWK 150W	B	NO	0	0	0	0	0	4	BIOGENIC	NOADDM	0	pull-away, sulfitic below RPD except 1 dk gray area ambient sed at 8.5 cm
NWK 150W	C	NO	0	0	0	0	0	3	BIOGENIC	Depth to shallowest part of gray patch (cm)	10.15	S/M, All inc. in DM exc. gray area in lower rt.
NWK 150W	D	NO	0	0	0	0	0	3	BIOGENIC	Depth inj. of ox. material by worm (cm)	6.74	DM>pen, worm tube on left, relic feeding voids in sulfitic layer
SP												
SP 100E	A	NO	0	0	0	0	0	3	PHYSICAL	NOADDM	0	DM>pen
SP 100E	D	NO	0	0	0	0	0	3	PHYSICAL	NOADDM	0	DM>pen, thin RPD outlined by hand, few Stage I tubes
SP 100E	E	NO	0	0	0	0	0	9	BIOGENIC	Depth to worm (cm)	2.89	DM?, pull-away, 2 vert. burrows, max gs shell in deep void
SP 50E	*A*	*NO*	*0*	*0*	*0*	*0*	*0*	*4*	*INDET*	*NOADDM*	*0*	*DM>pen, burrows, some pull-away*
SP 50E	D	NO	0	0	0	0	0	99	INDET	NOADDM	0	DM>pen, mostly op, S/M, pull-apart voids, yellow shell conchiolin
SP 50E	E	NO	0	0	0	0	0	4	BIOGENIC	NOADDM	0	DM>pen, some sm. vert. burrows under RPD layer
SP 50E	F	NO	0	0	0	0	0	4	PHYSICAL	NOADDM	0	DM>pen, amphipods?, shelter fabric voids
SP CTR	A	NO	0	0	0	0	0	99	BIOGENIC	NOADDM	0	DM>pen, RPD>pen, well-washed sand, amphipod tubes
SP CTR	B	NO	0	0	0	0	0	5	PHYSICAL	NOADDM	0	DM>pen, *lg. red. cl.? deep, S/M/S, S at bottom+on top of cl, some pull-away*
SP CTR	C	NO	0	0	0	0	0	10	PHYSICAL	NOADDM	0	DM>pen
SP 50W	A	NO	0	0	0	0	0	4	BIOGENIC	NOADDM	0	DM>pen, 1 shelter fabric void
SP 50W	B	NO	0	0	0	0	0	8	BIOGENIC	Depth to dark sulfitic layer (cm)	9.05	DM>pen, S/M, deep dk sulf. layer c pull-apart voids? Fe rich patch, S patch
SP 100W	G	NO	0	0	0	0	0	8	BIOGENIC	Min. depth to lg. void (cm)	2.95	DM>pen, maldanids? surf. erosion, lg. void camera artifact
SP 100W	I	NO	0	0	0	0	0	4	BIOGENIC	Min. depth to large void (cm)	2.45	DM>pen, S/M/S
SP 100W	J	NO	0	0	0	0	0	99	INDET	NOADDM	0	DM>pen, underpenetrated, RPD>pen, poor sorting
SP 100W	K	NO	0	0	0	0	0	4	BIOGENIC	Min. depth to sand patch (cm)	7.05	DM>pen, chaotic fabric beneath RPD patches of phi 2 sand+dk blue mud
SP 150W	A	NO	0	0	0	0	0	4	BIOGENIC	NOADDM	0	DM? large void type?
SP 150W	B	NO	0	0	0	0	0	8	BIOGENIC	Min. depth to large void (cm)	3.3	DM>pen, feeding voids small, lg. voids clumps pushed by camera
SP 150W	C	NO	0	0	0	0	0	5	BIOGENIC	NOADDM	0	DM? amphipods?
SOUTHEAST VALLEY												
VAL 150E	A	NO	0	0	0	0	0	5	BIOGENIC	NOADDM	0	DM>pen, S/M, some burrows, pull-away + pull apart cracks in mud
VAL 150E	B	NO	0	0	0	0	0	6	PHYSICAL	NOADDM	0	DM>pen, shell scour lag, pull-away on rt
VAL 75E	A	NO	0	0	0	0	0	99	PHYSICAL	NOADDM	0	DM>pen, chaotic fabric
VAL 75E	B	NO	0	0	0	0	0	3	PHYSICAL	NOADDM	0	DM>pen, shell hash, bad pull-away
VAL 75E	*C*	*YES*	*0*	*0*	*0*	*0*	*0*	*0*	*INDET*	*NOADDM*	*0*	*DM>pen, burrows, patchy RPD, pull-away*
VAL CTR	A	NO	0	0	0	0	0	99	PHYSICAL	NOADDM	0	DM>pen, sandy, surf. too dist. to measure RPD, a lot of pull-away
VAL CTR	B	NO	0	0	0	0	0	4	BIOGENIC	NOADDM	0	DM>pen, sm pull-apart crack
VAL CTR	C	NO	0	0	0	0	0	4	BIOGENIC	NOADDM	0	DM>pen, burrows on left (end-on view), pull-apart cracks deep
VAL 75W	A	NO	0	0	0	0	0	4	BIOGENIC	Depth to sm burrow (cm)	1.72	DM>pen, amphipod tubes, sm. burrow, pull-apart cracks deep
VAL 75W	B	NO	0	0	0	0	0	5	BIOGENIC	NOADDM	0	DM>pen, *RPD 1-1.5 cm can't distinguish RPD from rbd, burrows, pull-apart*
VAL 75W	C	NO	0	0	0	0	0	4	BIOGENIC	NOADDM	0	DM>pen, pull-away
VAL 150W	A	NO	0	0	0	0	0	3	INDET	NOADDM	0	DM>pen, max gastropod shell frag, pull-away
VAL 150W	B	NO	0	0	0	0	0	3	BIOGENIC	NOADDM	0	DM>pen, burrow, ox. layer beneath red.
VAL 225W	A	NO	0	0	0	0	0	4	BIOGENIC	NOADDM	0	DM>pen, sm. burrows?, large pull-away cracks?
VAL 225W	B	NO	0	0	0	0	0	8	BIOGENIC	NOADDM	0	DM>pen, burrows, feeding void, pull-away crack

Appendix C Table 2

Dredged Material Thickness from REMOTS®
Precap Survey (3-4 November 1993)

Station	Rep	Lat N dg	Lat N min	Long W dg	Long W min	DM LAYER (cm)	Mean DM Layer (cm)
550 E	A	41	9.093	72	53.044	ABSENT	2.0
	C	41	9.094	72	53.050	ABSENT	
	D	41	9.093	72	53.042	6	
475E	B	41	9.091	72	53.103	ABSENT	3.3
	D	41	9.093	72	53.100	3	
	E	41	9.095	72	53.095	7	
400E	A	41	9.095	72	53.157	ABSENT	9.7
	B	41	9.092	72	53.164	9	
	C	41	9.094	72	53.164	20	
325E	A	41	9.091	72	53.215	15	18.3
	D	41	9.091	72	53.210	20	
	E	41	9.092	72	53.207	20	
325W	D	41	9.101	72	53.682	12	12.5
	E	41	9.102	72	53.685	13	
	F	41	9.103	72	53.687	12.5	
400W	A	41	9.095	72	53.727	ABSENT	8.2
	B	41	9.092	72	53.723	6	
	D	41	9.101	72	53.736	9	
	E	41	9.106	72	53.738	9.5	
475W	A	41	9.106	72	53.789	ABSENT	4.3
	B	41	9.107	72	53.789	1	
	C	41	9.108	72	53.786	1	
	D	41	9.096	72	53.782	11	
550W	A	41	9.098	72	53.839	ABSENT	0.3
	B	41	9.094	72	53.839	1	
	C	41	9.098	72	53.836	ABSENT	
550NE	A	41	9.302	72	53.167	ABSENT	
	B	41	9.302	72	53.162	ABSENT	
	C	41	9.309	72	53.162	ABSENT	
475NE	A	41	9.270	72	53.200	10	9.7
	B	41	9.278	72	53.201	12	
	C	41	9.282	72	53.198	7	
400NE	A	41	9.253	72	53.251	20	16.7
	B	41	9.261	72	53.236	15	
	C	41	9.263	72	53.236	15	
325NE	A	41	9.215	72	53.278	20	19.4
	B	41	9.220	72	53.276	20	
	C	41	9.224	72	53.269	17	
	D	41	9.226	72	53.276	20	
	E	41	9.227	72	53.278	20	
325SW	A	41	8.969	72	53.604	11	15.5
	B	41	8.975	72	53.605	20	
	C	41	8.979	72	53.603	20	
	D	41	8.970	72	53.605	11	
400SW	A	41	8.948	72	53.644	8.5	8.2
	B	41	8.943	72	53.630	7	
	C	41	8.945	72	53.637	9	
475SW	A	41	8.912	72	53.691	ABSENT	
	B	41	8.912	72	53.685	ABSENT	
	C	41	8.920	72	53.683	ABSENT	
	D	41	8.917	72	53.682	ABSENT	
550SW	A	41	8.888	72	53.717	ABSENT	
	B	41	8.890	72	53.713	CLUMP	
	C	41	8.893	72	53.710	CLUMP	

Appendix C Table 2 (cont.)

Station	Rep	Lat N dg	min	Long W dg	min	DM LAYER (cm)	Mean DM Layer (cm)
550SE	A	41	8.883	72	53.170	ABSENT	
	B	41	8.881	72	53.163	ABSENT	0.0
	C	41	8.888	72	53.163	ABSENT	
475SE	A	41	8.919	72	53.214	ABSENT	
	B	41	8.922	72	53.210	ABSENT	0.0
	C	41	8.923	72	53.202	ABSENT	
400SE	A	41	8.952	72	53.244	8	
	B	41	8.954	72	53.239	8	8.0
	C	41	8.950	72	53.232	8	
325SE	A	41	8.977	72	53.280	17	
	B	41	8.978	72	53.276	12	13.0
	C	41	8.974	72	53.264	10	
325NW	A	41	9.218	72	53.608	5.5	
	B	41	9.216	72	53.603	10	8.2
	C	41	9.215	72	53.600	9	
400NW	A	41	9.239	72	53.643	4.5	
	B	41	9.245	72	53.647	6.5	4.7
	C	41	9.249	72	53.646	3	
475NW	A	41	9.268	72	53.677	<1	
	B	41	9.276	72	53.685	ABSENT	
	C	41	9.281	72	53.681	ABSENT	
550NW	B	41	9.303	72	53.720	ABSENT	
	C	41	9.310	72	53.719	ABSENT	
	D	41	9.252	72	53.722	ABSENT	
500N	A	41	9.393	72	53.440	CLUMP	
	B	41	9.393	72	53.437	CLUMP	
	C	41	9.393	72	53.435	ABSENT	
475N	A	41	9.351	72	53.444	ABSENT	
	B	41	9.352	72	53.438	PATCHY	
	C	41	9.352	72	53.435	ABSENT	
400N	A	41	9.306	72	53.437	3	
	B	41	9.311	72	53.435	2	2.3
	C	41	9.314	72	53.434	2	
325N	A	41	9.272	72	53.441	4.5	
	B	41	9.272	72	53.440	7	6.2
	C	41	9.271	72	53.440	7	
325S	A	41	8.915	72	53.436	11	
	B	41	8.921	72	53.433	5.5	7.2
	C	41	8.922	72	53.435	5	
400S	A	41	8.878	72	53.441	ABSENT	
	B	41	8.880	72	53.432	6	4.3
	C	41	8.880	72	53.430	7	
475S	A	41	8.834	72	53.438	CLUMP	
	B	41	8.840	72	53.435	ABSENT	
	C	41	8.842	72	53.437	ABSENT	
550S	A	41	8.803	72	53.444	ABSENT	
	B	41	8.802	72	53.441	ABSENT	
	C	41	8.802	72	53.439	ABSENT	
400WSW	A	41	9.018	72	53.705	20	
	B	41	9.021	72	53.709	20	20.0
	C	41	9.021	72	53.699	20	
400SSW	A	41	8.901	72	53.547	ABSENT	
	B	41	8.901	72	53.543	ABSENT	
	C	41	8.904	72	53.546	ABSENT	

Appendix C Table 3

Station Locations and Results of the REMOTS® Postdisposal Survey Conducted 4 November 1993

STATION & REP		LAT		LONG		SUCC	GRAIN SIZE			MUD CLAST		PENETRATION				DREDGED MATERIAL				REDOX REBOUND			REDOX POTENTIAL DISCONTINUITY			
		DEG	MIN	DEG	MIN	STAGE	MIN	MAX	MAJ MODE	COUNT	AVG DIAM	MIN	MAX	RANGE	MEAN	AREA	MIN	MAX	MEAN	MIN	MAX	MEAN	AREA	MIN	MAX	MEAN
FVP																										
FVP 100E	A	41	9.386	72	51.612	ST_I	0	>4	4 to 3	0	0	4.90	6.62	1.72	5.76	0	0	0	0	0	0	0	26.297	0.71	3.13	1.96
FVP 100E	B	41	9.382	72	51.614	ST_I	-1	>4	4 to 3	0	0	10.56	11.41	0.86	10.98	0	0	0	0	0	0	0	25.711	1.01	3.08	1.99
FVP 100E	C	41	9.381	72	51.602	ST_I	-1	>4	4 to 3	5	2.33	11.21	12.83	1.62	12.02	0	0	0	0	0	0	0	10.367	0.05	2.22	1.46
FVP 50E	A	41	9.383	72	51.674	ST_I	-1	>4	>4	0	0	9.44	10.15	0.71	9.80	0	0	0	0	0	0	0	9.289	0.30	2.17	1.42
FVP 50E	B	41	9.380	72	51.648	ST_I	2	>4	>4	0	0	8.08	9.60	1.52	8.84	0	0	0	0	0	0	0	36.634	0.56	3.74	2.72
FVP 50E	C	41	9.381	72	51.652	ST_I	-1	>4	4 to 3	5	2.9	10.56	13.38	2.83	11.97	0	0	0	0	0	0	0	13.725	0.10	2.93	1.95
FVP CTR	A	41	9.386	72	51.682	ST_I	2	>4	4 to 3	0	0	10.30	10.66	0.35	10.48	0	0	0	0	0	0	0	20.718	0.86	2.17	1.50
FVP CTR	B	41	9.383	72	51.693	ST_I	0	>4	4 to 3	0	0	9.80	10.61	0.81	10.20	0	0	0	0	0	0	0	16.954	0.15	2.02	1.49
FVP CTR	C	41	9.379	72	51.692	ST_I	1	>4	4 to 3	0	0	7.47	8.08	0.61	7.78	0	0	0	0	0	0	0	7.904	0.05	1.21	0.71
FVP 50W	A	41	9.387	72	51.718	ST_I	0	>4	>4	0	0	15.45	15.71	0.25	15.58	0	0	0	0	0	0	0	12.146	0.05	1.92	0.88
FVP 50W	B	41	9.380	72	51.716	ST_I_ON_III	1	>4	>4	0	0	15.45	16.21	0.76	15.83	0	0	0	0	0	0	0	31.529	1.41	2.93	2.35
FVP 50W	C	41	9.383	72	51.723	ST_I	2	>4	>4	0	0	14.70	14.85	0.15	14.77	0	0	0	0	0	0	0	30.771	0.45	2.78	2.26
FVP 100W	A	41	9.384	72	51.784	ST_I	1	>4	>4	0	0	11.77	12.42	0.66	12.10	0	0	0	0	0	0	0	21.731	0.05	2.53	1.64
FVP 100W	B	41	9.384	72	51.751	ST_I	1	>4	>4	0	0	14.60	14.75	0.15	14.67	0	0	0	0	0	0	0	25.387	1.06	2.32	1.86
FVP 100W	C	41	9.385	72	51.752	ST_I	1	>4	>4	0	0	10.10	10.96	0.86	10.53	0	0	0	0	0	0	0	11.069	0.10	3.38	1.62
FVP 100N	A	41	9.442	72	51.692	ST_I	2	>4	4 to 3	0	0	12.42	12.83	0.40	12.63	0	0	0	0	4.95	8.23	6.59	14.9	0.35	1.52	1.09
FVP 100N	B	41	9.443	72	51.692	ST_I	0	>4	4 to 3	0	0	13.38	13.94	0.55	13.66	0	0	0	0	4.65	8.03	6.34	22.091	0.15	2.37	1.63
FVP 100N	C	41	9.436	72	51.683	ST_I	0	>4	4 to 3	0	0	13.08	13.89	0.81	13.48	0	0	0	0	7.22	9.34	8.28	33.526	0.61	3.89	2.45
FVP 50N	A	41	9.420	72	51.691	ST_I	-1	>4	4 to 3	0	0	11.62	11.97	0.35	11.79	0	0	0	0	0	0	0	24.45	0.91	2.63	1.80
FVP 50N	B	41	9.410	72	51.682	ST_I	2	>4	4 to 3	0	0	6.72	8.08	1.36	7.40	0	0	0	0	0	0	0	12.01	0.10	2.53	1.80
FVP 50N	C	41	9.400	72	51.681	ST_I	-1	>4	4 to 3	0	0	11.67	12.32	0.66	11.99	0	0	0	0	0	0	0	22.425	0.81	2.63	1.64
FVP 50S	A	41	9.365	72	51.674	ST_I	2	>4	4 to 3	0	0	11.67	12.22	0.56	11.94	0	0	0	0	0	0	0	26.679	0.76	3.33	1.96
FVP 50S	B	41	9.365	72	51.678	ST_I	3	>4	4 to 3	0	0	6.06	6.62	0.56	6.34	0	0	0	0	0	0	0	16.416	0.05	1.72	1.27
FVP 100S	A	41	9.338	72	51.672	ST_I	1	>4	>4	0	0	12.68	13.48	0.81	13.08	0	0	0	0	0	0	0	27.364	0.25	3.13	2.00
FVP 100S	B	41	9.329	72	51.668	ST_I	1	>4	>4	0	0	13.33	14.55	1.21	13.94	0	0	0	0	0	0	0	21.603	0.81	2.88	1.59
FVP 100S	C	41	9.330	72	51.674	ST_I	2	>4	4 to 3	0	0	13.48	14.09	0.61	13.79	0	0	0	0	0	0	0	25.074	0.61	2.78	1.83

Appendix C Table 3 (cont.)

STATION & REP		LOW DISS O2	METHANE BUBBLES COUNT	AREA	MIN	MAX	MEAN	OSI	SURFACE TYPE	ADDITIONAL MEASUREMENT COMMENT (NOADDM)	VALUE	COMMENTS
FVP												
FVP 100E	A	NO	0	0	0	0	0	4	PHYSICAL	NOADDM	0	DM>pen, sm burrows
FVP 100E	B	NO	0	0	0	0	0	4	PHYSICAL	NOADDM	0	DM>pen, some shell hash, S/M/S
FVP 100E	C	NO	0	0	0	0	0	3	PHYSICAL	NOADDM	0	DM>pen, S/M/S, some shell scour lag, shelter fabric
FVP 50E	A	NO	0	0	0	0	0	3	PHYSICAL	NOADDM	0	DM>pen, shell scour lag, sm burrows, S/M/S, relic voids?
FVP 50E	B	NO	0	0	0	0	0	5	PHYSICAL	NOADDM	0	DM>pen, S/M/S, sand at bottom?
FVP 50E	C	NO	0	0	0	0	0	4	PHYSICAL	NOADDM	0	DM>pen, S/M/S
FVP CTR	A	NO	0	0	0	0	0	3	BIOGENIC	NOADDM	0	DM>pen, v sulf. just under RPD, max gastropod, pull-apart cracks in black sed
FVP CTR	B	NO	0	0	0	0	0	3	BIOGENIC	NOADDM	0	DM>pen, chaotic fabric (gray lump on lower left), pull-apart cracks
FVP CTR	C	NO	0	0	0	0	0	2	INDET	NOADDM	0	DM>pen, bad pull-away
FVP 50W	A	NO	0	0	0	0	0	3	BIOGENIC	NOADDM	0	DM>pen, wiper cl, max gastropod shell at depth, S/M/S, sand deep
FVP 50W	B	NO	0	0	0	0	0	9	BIOGENIC	NOADDM	0	DM>pen, sm burrows in ox layer, pull-apart cracks deep, S/M/S
FVP 50W	C	NO	0	0	0	0	0	5	BIOGENIC	NOADDM	0	DM>pen, S/M/S, sand deep, pull-apart crack
FVP 100W	A	NO	0	0	0	0	0	4	BIOGENIC	NOADDM	0	DM>pen, M/S, sand at depth, hor. pull-apart crack
FVP 100W	B	NO	0	0	0	0	0	4	BIOGENIC	NOADDM	0	DM>pen, M/S, sand at bottom, Nephthys + its crescent shaped burrow
FVP 100W	C	NO	0	0	0	0	0	4	BIOGENIC	NOADDM	0	DM>pen, vert. burrow on left
FVP 100N	A	NO	0	0	0	0	0	3	BIOGENIC	NOADDM	0	DM>pen, sl. pull-away, lt blue band betw. RPD + sulfitic layer
FVP 100N	B	NO	0	0	0	0	0	4	BIOGENIC	NOADDM	0	DM>pen, pull-apart cracks
FVP 100N	C	NO	0	0	0	0	0	5	BIOGENIC	NOADDM	0	DM>pen, sl. pull-away at bottom
FVP 50N	A	NO	0	0	0	0	0	4	BIOGENIC	NOADDM	0	DM>pen,lg. void=burrow?
FVP 50N	B	NO	0	0	0	0	0	4	BIOGENIC	NOADDM	0	DM>pen, lg. burrow, lg. shell in background
FVP 50N	C	NO	0	0	0	0	0	4	BIOGENIC	NOADDM	0	DM>pen, void at bottom a pull-apart?, sl. pull-away
FVP 50S	A	NO	0	0	0	0	0	4	BIOGENIC	NOADDM	0	DM>pen, burrow on rt, pull-apart cracks in center + left
FVP 50S	B	NO	0	0	0	0	0	3	BIOGENIC	NOADDM	0	DM>pen, pull-apart cracks
FVP 100S	A	NO	0	0	0	0	0	4	BIOGENIC	NOADDM	0	DM>pen, burrow? inj. ox. material down, pull-away at bottom
FVP 100S	B	NO	0	0	0	0	0	4	BIOGENIC	NOADDM	0	DM>pen, vert. burrow on rt, sm pull-apart cracks
FVP 100S	C	NO	0	0	0	0	0	4	BIOGENIC	NOADDM	0	DM>pen, vert. burrow, S/M/S, sand at very bottom

APPENDIX D

Sediment Cores and Grabs

Appendix D Sediment Cores and Grabs

Appendix D Table 1

Location of Geotechnical Cores Collected for the
New Haven Harbor Capping Project, September 1993 to March 1994

A. Predisposal Survey 21 September 1993

Core	Latitude	Longitude	
CLIS A	41°09.091′ N	72°53.502′ W	
CLIS B	41°08.602′ N	72°53.923′ W	* located outside the designated work area
CLIS C	41°09.181′ N	72°53.401′ W	
CLIS D	41°09.172′ N	72°53.534′ W	
CLIS E	41°09.081′ N	72°53.395′ W	
CLIS F	41°09.098′ N	72°53.442′ W	* unsuccessful, reattempt at CLIS FF
CLIS FF	41°09.142′ N	72°53.438′ W	

B. Postdisposal/Precap Survey 10 November 1993

Core	Latitude	Longitude	
CLIS G	41°09.086′ N	72°53.497′ W	Replicate of Core A
CLIS H	41°08.607′ N	72°53.929′ W	Replicate of Core B (outside designated work area)
CLIS I	41°09.1785′ N	72°53.397′ W	Replicate of Core C
CLIS J	41°09.168′ N	72°53.536′ W	Replicate of Core D
CLIS K	41°09.080′ N	72°53.398′ W	Replicate of Core E
CLIS L	41°09.132′ N	72°53.433′ W	Replicate of Core FF
CLIS II	41°09.061′ N	72°53.520′ W	No replicate for station

Appendix D Table 2

Location of Sediment Grab Samples Collected During
the Interim Disposal and Interim Cap Surveys

A. Grabs Collected During the Interim Disposal Survey, October 25, 1993

200W	41°09.165′ N	72°53.580′ W
100W	41°09.129′ N	72°53.511′ W
CTR	41°09.127′ N	72°53.454′ W
100E	41°09.133′ N	72°53.379′ W
200E	41°09.131′ N	72°53.304′ W
200N	41°09.238′ N	72°53.453′ W
100N	41°09.181′ N	72°53.452′ W
100S	41°09.079′ N	72°53.451′ W
200S	41°09.020′ N	72°53.451′ W

B. Grabs Collected During the Interim Cap Survey, November 24, 1993

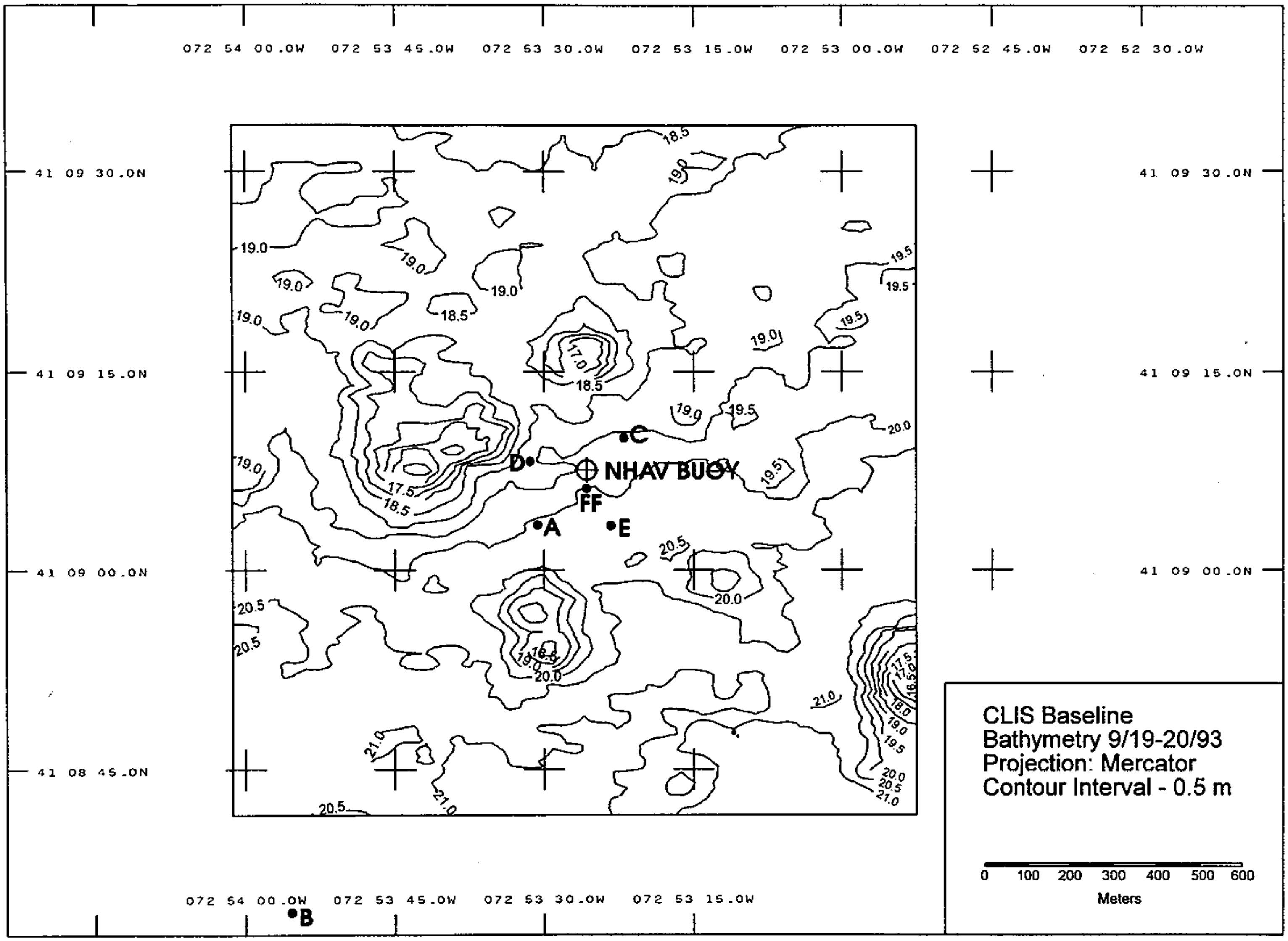
200W	41°09.126′ N	72°53.585′ W
100W	41°09.136′ N	72°53.518′ W
CTR	41°09.132′ N	72°53.443′ W
100E	41°09.117′ N	72°53.366′ W
200E	41°09.122′ N	72°53.284′ W
200N	41°09.229′ N	72°53.454′ W
100N	41°09.182′ N	72°53.436′ W
100S	41°09.067′ N	72°53.452′ W
200S	41°09.008′ N	72°53.437′ W

Appendix D Table 1 (cont.)

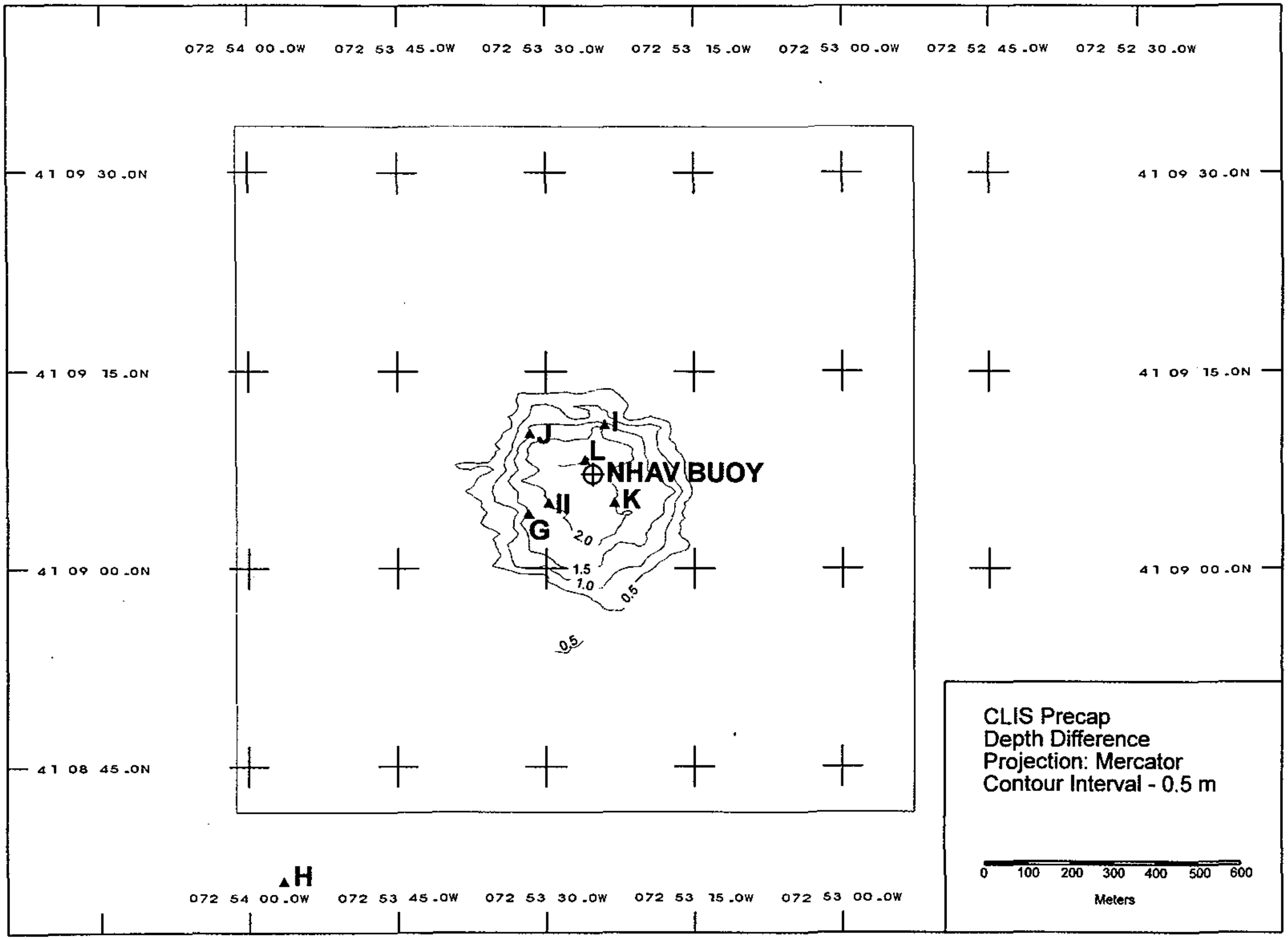
C. Postcap Survey 15 March 1994

Core	Latitude	Longitude	
CLIS-MM	41°09.173′ N	72°53.409′ W	Close to CLIS-C, I
CLIS-N	41°09.141′ N	72°53.441′ W	Same location as CLIS FF, L
CLIS P	41°09.070′ N	72°53.540′ W	Close to CLIS-II
CLIS Q	41°08.990′ N	72°53.633′ W	SW flank of new mound
CLIS R	41°09.254′ N	72°53.322′ W	NE flank of new mound
CLIS-SS	41°09.093′ N	72°53.392′ W	Close to CLIS-E,K
CLIS-T	41°09.177′ N	72°53.516′ W	Same location as CLIS-J

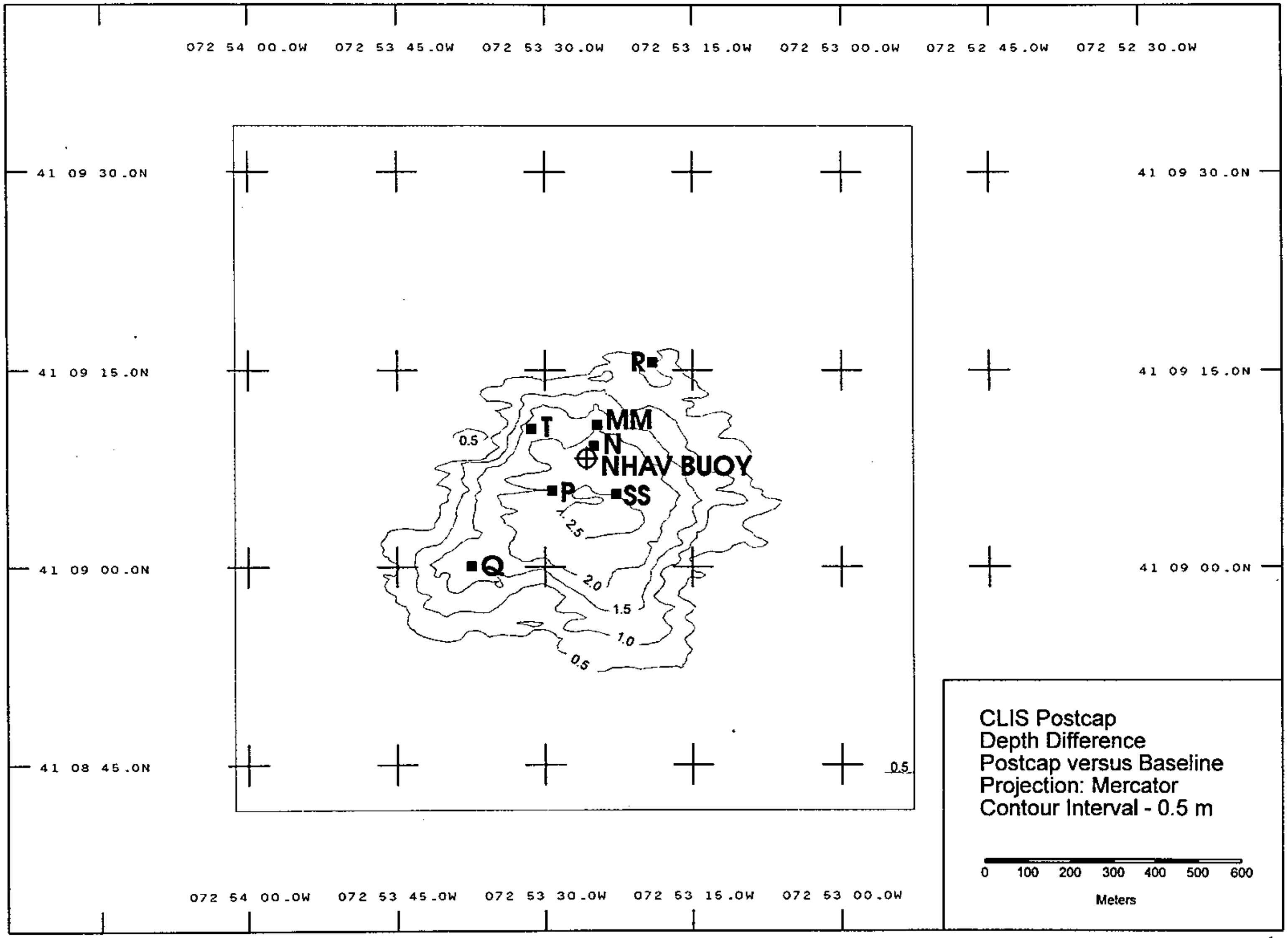
NOTE: Cores CLIS-Q, CLIS-R, and perhaps CLIS-SS penetrated into the base material.



Appendix D Figure 1. Location of the geotechnical cores collected during the predisposal (baseline) survey, 21 September 1993



Appendix D Figure 2. Location of geotechnical cores collected during the precap survey superimposed on the precap mound, 10 November 1993



Appendix D Figure 3. Location of geotechnical cores collected during the postcap survey superimposed on the postcap mound, 15 March 1994