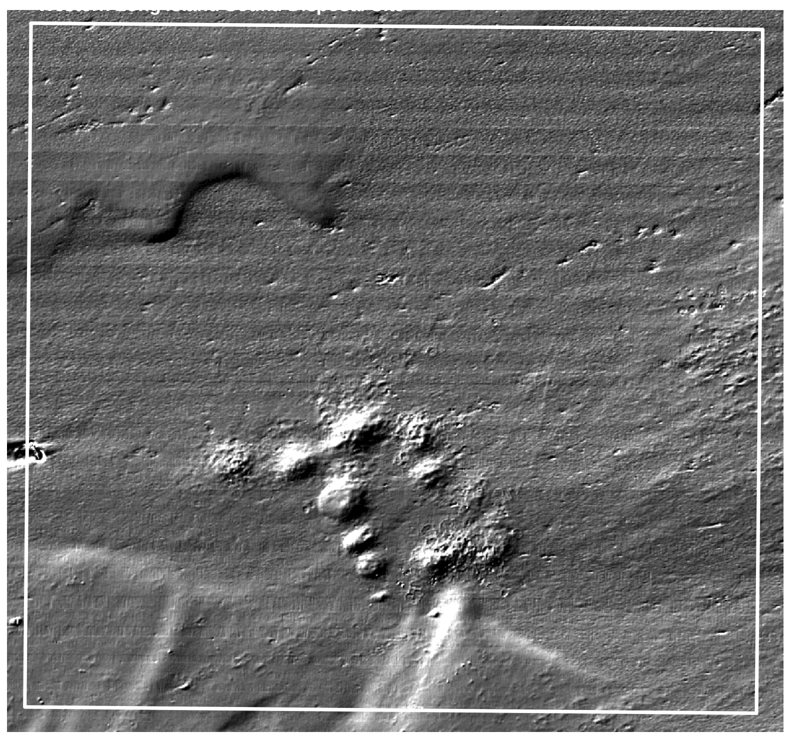
Baseline Bathymetric Surveys at the Central and Western Long Island Sound Disposal Sites
July 2005

Disposal Area Monitoring System DAMOS

Contribution 177
November 2007



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13. ABSTRACT

Bathymetric surveys were conducted in July 2005 at the Central Long Island Sound Disposal Site (CLDS) and the Western Long Island Sound Disposal Site (WLDS) as part of the Disposal Area Monitoring System (DAMOS). In May 2005, the USEPA designated both CLDS and WLDS as long-term open water disposal sites for dredged material. The July 2005 field effort consisted of a multi-beam bathymetric survey designed to establish a detailed baseline bathymetric dataset for the newly designated sites against which future bathymetric surveys will be compared. The July 2005 surveys provided data to explore the formation of the various sedimentary features observed at the sites and to document any significant consolidation and/or accumulation of dredged material at CLDS and WLDS since the previous surveys.

In addition to new mounds formed as expected and previously observed mounds, which showed little change over time, several types of sedimentary features were identified and grouped based on their morphology and causal processes. Several types of ring-like features were identified and were all interpreted as disposal traces. The size distribution of material disposed, the level of consolidation of the bottom, and the age of the disposal trace were all considered to have contributed to the observed form of the disposal trace. The persistence of both the man-made and ambient features further supported previous conclusions that bottom sediments at CLDS and WLDS are stable.

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EXECUTIVE SUMMARY

Bathymetric surveys were conducted in July 2005 at the Central Long Island Sound Disposal Site (CLDS) and the Western Long Island Sound Disposal Site (WLDS) as part of the Disposal Area Monitoring System (DAMOS). In May 2005, the USEPA designated both CLDS and WLDS as long-term open water disposal sites for dredged material. Both sites have been monitored by the DAMOS Program for over 20 years, and the 2005 surveys provide site-wide, baseline bathymetric data following site designation and a slight shift in the site boundaries.

The July 2005 field effort consisted of a multi-beam bathymetric survey designed to establish a detailed baseline bathymetric dataset for the newly designated sites against which future bathymetric surveys will be compared. At CLDS, the 2005 survey, together with a side-scan survey in 1997 and a multi-beam survey in 2000, formed a set of three site-wide high-resolution acoustic surveys which provided a time-series data set used to evaluate the stability of sedimentary features. At WLDS, the 2005 survey was the first site-wide high-resolution bathymetric survey. The July 2005 surveys provided data to explore the formation of the various sedimentary features observed at the sites and to document any significant consolidation and/or accumulation of dredged material at CLDS and WLDS since the previous surveys.

In addition to new mounds formed as expected and previously observed mounds, which showed little change over time, several types of sedimentary features were identified and grouped based on their morphology and causal processes. Several types of ring-like features were identified and were all interpreted as disposal traces. The features had varying expressions in either or both the side-scan and the multi-beam images, and many observed at CLDS persisted over the eight year span from the first to most recent high-resolution survey. The size distribution of material disposed, the level of consolidation of the bottom, and the age of the disposal trace were all considered to have contributed to the observed form of the disposal trace. The persistence of both the man-made and ambient features further supported previous conclusions that bottom sediments at CLDS and WLDS are stable.

The high-resolution bathymetric data can support site management by aiding identification of location and spatial extent of historical disposal activities and assessment of the stability of sedimentary features. A detailed analysis of the sedimentary features and a comparison of these features over time provides insight into the causal dredged material disposal processes. It is recommended that future surveys employ high-resolution survey techniques to further the understanding of the sedimentary features within CLDS and WLDS and their relationship to site management goals.

1.0 INTRODUCTION

Bathymetric surveys were conducted at the Central Long Island Sound Disposal Site (CLDS) and the Western Long Island Disposal Site (WLDS) in July 2005 as part of the U.S. Army Corps of Engineers (USACE) New England District (NAE) Disposal Area Monitoring System (DAMOS). DAMOS is a comprehensive monitoring and management program designed and conducted to address environmental concerns associated with the use of open-water disposal sites throughout the New England region. The multi-beam bathymetric surveys of July 2005 provide detailed baseline bathymetry of CLDS and WLDS following their designation as long-term dredged material disposal sites by the U.S. Environmental Protection Agency (USEPA) in June 2005 (40 CFR Part 228). Both sites have been monitored by the DAMOS Program for over 20 years, and the 2005 surveys provide site-wide, baseline bathymetric data following site designation and a slight shift in the site boundaries. An introduction to the DAMOS Program and the Central Long Island Sound and Western Long Island Sound Disposal Sites, including a summary of the history of each site, is provided below.

1.1 Overview of the DAMOS Program

For nearly 30 years, the DAMOS Program has collected and evaluated disposal site data throughout New England. Based on these data, patterns of physical, chemical, and biological responses of seafloor environments to dredged material disposal activity have been documented (Fredette and French 2004). The DAMOS Program features a tiered management protocol designed to ensure that any potential adverse environmental impacts associated with dredged material disposal activities are promptly identified and addressed (Germano et al. 1994).

DAMOS monitoring surveys are designed to test hypotheses related to expected physical and ecological response patterns following placement of dredged material on the seafloor at established disposal sites. The data collected during DAMOS monitoring surveys serve as hypothesis tests, providing answers to strategic management questions. The results of each monitoring survey are evaluated to determine the next step in the disposal site environmental management process.

1.2 Regulatory Authority

Under the Marine Protection, Research and Sanctuaries Act (MPRSA), the USACE and the USEPA share the authority to manage and regulate dredged material disposal in open water. The authority to designate ocean disposal sites for long-term use rests uniquely with the USEPA under Section 102(c) of MPRSA. In June 2005, the USEPA officially designated both CLDS and WLDS for long-term use for the disposal of dredged material from harbors and navigation channels in the vicinity of Long Island Sound (40 CFR Part 228).

CLDS and WLDS are two of four regional dredged material disposal sites in Long Island Sound (Figure 1-1). They had both been used for dredged material disposal prior to the designation under either the USACE short-term site selection authority under MPRSA Section 103(b) or under the Clean Water Act (CWA) Section 404 permitting authority. These sites were identified as preferred alternatives for dredged material disposal in an Environmental Impact Statement to serve the dredging needs of the surrounding areas (USEPA 2004a).

The boundaries of the designated sites do not coincide exactly with the historical boundaries. During the site designation process, CLDS was enlarged and WLDS was shifted to the northwest. The boundary of CLDS was extended approximately 200 m to the north and 400 m to the east to encompass historical mounds. These historic mounds were created at a time when CLDS was represented by a slightly different boundary position than had been used more recently. The boundary of WLDS was shifted 337 m north and 185 m west to avoid a shallow area near the southeast boundary of the historical disposal site.

Designation of CLDS and WDLS provides potential future government and private dredging projects with the alternative to dispose of dredged material in long-term, open-water, disposal sites. Designation of a site does not automatically authorize the disposal of dredged material at that site. Rather, designation makes the site an alternative location for the disposal of dredged material from a specific project. Prior to disposal, an alternative analysis must conclude that there are no environmentally preferable, practicable alternatives for managing that dredged material, and that analysis of the dredged material indicates that it is suitable for open-water disposal.

1.3 Central Long Island Sound Disposal Site

1.3.1 History of CLDS

The Central Long Island Sound Disposal Site (CLDS, historically referred to as CLIS) is situated approximately 10.4 km south of South End Point, East Haven, Connecticut (Figure 1-2). The recent site designation of CLDS resulted in an enlargement of the site from its previous dimensions (USEPA 2004a). The boundaries of CLDS were expanded in the northern and eastern directions in order to encompass historical disposal mounds CS-2 and FVP. As a result, CLDS, centered at 41° 08.95' N, 72° 52.95' W (NAD 83), occupies 8.2 km^2 and is defined as a 4.1 km x 2.0 km area on the seafloor (Figure 1-2).

The natural seafloor at Central Long Island Sound Disposal Site gently slopes from a depth of 18 m mean lower low water (MLLW) in the northwest to a depth of 22 m (MLLW) in the southeast (Figure 1-3). Previous bathymetric surveys indicated localized shallow areas of historical dredged material disposal mounds concentrated in the central and northern portion of the site. Water depths above the disposal mounds typically ranged from 15 m to 17 m (MLLW).

Disposal and monitoring records indicate that the area around present-day CLDS has been receiving dredged material since at least 1941 and has been monitored extensively by the USACE since 1979 (ENSR 1998). Over 26 individual disposal mounds have been formed at CLDS between 1982 and 2003 following the placement of over 5.6 million m^3 of dredged material from waterways in Connecticut and New York (Figure 1-3, Table 1-1). The mounds are described briefly below, grouped into three general categories: New Haven Harbor maintenance projects, experimental capping projects, and containment cell development projects.

The New Haven Harbor maintenance project is one of the largest navigation projects continually contributing dredged material to CLDS. Over 1.2 million m^3 of dredged material from New Haven Harbor has been placed at CLDS since 1982. Three large maintenance dredging activities at New Haven Harbor conducted primarily in 1974, 1983 and 1993 resulted in the formation of three mounds, NHAV 74, NHAV 83, and NHAV 93 (Table 1-1, Figure 1-3).

In the late 1970s and the early 1980s, several experimental capping projects were initiated to determine the feasibility and effectiveness of isolating unacceptably contaminated dredged material (UDM) from the marine environment. Coarse-grained material and/or fine-grained material acceptable for unconfined open water disposal was placed on top of disposal mounds of UDM. The benthic recovery of the seven capped mounds of UDM (NHAV 74, Norwalk, STNH-N, STNH-S, MQR, CS-1 and CS-2) was compared to the benthic recovery of the one uncapped mound of UDM (FVP). These experimental cap site mounds remain visible within the CLDS bathymetry (Table 1-1, Figure 1-3).

Prior to 1984, the management strategy at CLDS involved the controlled placement of small to moderate volumes of sediment to form individual disposal mounds. These mounds were monitored to assess stability, thickness of dredged material, and benthic recolonization status relative to previous survey results and in comparison to nearby reference areas. The management strategy was later modified to develop multiple rings of disposal mounds on the CLDS seafloor to form containment cells that could subsequently be used for large-scale confined aquatic disposal (CAD) operations. The containment cells aid in limiting the lateral spread of UDM that was placed and capped at the site (Fredette 1994). The first containment cell developed at CLDS was used to confine the New Haven 1993 (NHAV 93) Mound, and a second containment cell was completed in 1999. Additional containment cells are currently being developed for future use. A summary of the mounds forming the boundaries of the containment cells is found in Table 1-1. A schematic diagram of the approximate containment cell boundaries is presented in Figure 1-4.

The formation of five mounds, CLIS 00 (SAIC 2003b), CLIS 01, CLIS 02 (ENSR 2004a), and CLIS 03 (ENSR 2005a) at CLDS has been documented since the previous multi-beam bathymetric survey was completed in September 2000 (SAIC 2002b). These mounds have formed as a result of the placement of dredged material from New Haven Harbor and other small regional projects between September 2000 and June 2004. With the exception of CLIS 03, the mounds form the eastern edge of a third containment cell currently under development.

1.3.2 Previous Monitoring Events at CLDS

CLDS has been the focus of numerous monitoring investigations conducted by the USACE since 1978. A summary of all DAMOS monitoring events at CLDS occurring since 1990 is presented in Table 1-2. The most recent CLDS monitoring event (prior to the present survey) was conducted in June 2004 and included a single-beam bathymetric survey and a sediment-profile imaging survey (ENSR 2005a). The June 2004 survey was performed over a 1200 m x 1200 m area (1.44 km^2) in the northeast portion of CLDS. The results of the 2004 survey confirmed the formation of a new mound, CLIS 03, approximately 300 m west of the CLIS 99 Mound (ENSR 2005a). Various historic mounds were also present within the survey area including, CLIS 99, CLIS 00, CLIS 01, CLIS 02, NHAV 74, STNH-N and CS-90. SPI monitoring to assess the physical distribution of dredged material and the persistence of an algal/detrital layer first observed during September 2003 indicated that benthic recovery at CLDS was occurring as expected.

1.3.3 Recent Dredged Material Disposal Activity at CLDS

Since the June 2004 survey, approximately 58,500 m^3 of dredged material has been placed at the disposal buoy located first at 41° 8.72' N, 72° 53.91' W and second at 41° 8.71' N, 72° 53.92' W (NAD 83) (Figure 1-5, Table 1-3). The dredged material deposited at the buoy positions originated primarily from the Branford River and Harbor (28,000 m^3). A detailed record of barge disposal activity at CLDS for the period from June 2004 to July 2005, including the origin of dredged material, the volume deposited, and the disposal location is provided in Appendix A-1.

1.4 Western Long Island Sound Disposal Site

1.4.1 History of WLDS

The Western Long Island Sound Disposal Site (WLDS, historically referred to as WLIS) is situated approximately 5 km south of Long Neck Point, Noroton, Connecticut (Figure 1-6). During the site designation process, it was decided that the dimensions of WLDS would remain the same (2.2 km x 2.4 km), but that the center of the site would be shifted 337 m west and 185 m north to avoid a relatively shallow area to the south. WLDS, centered at 40° 59.50' N, 73° 28.95' W (NAD 83), occupies 5.3 km^2 on the seafloor.

WLDS has been used regularly as a regional disposal site since 1982, receiving a total of over 1.1 million m^3 of dredged material. The management strategy at WLDS is similar to that of CLDS and has involved the controlled placement of sediment to form individual disposal mounds arranged in a ring on the seafloor. These mounds have been monitored individually to assess stability, thickness of dredged material, and benthic recolonization status relative to previous survey results and in comparison with nearby reference areas. The ring of disposal mounds forms a containment cell that could subsequently be used for large-scale confined aquatic disposal (CAD) operations.

Water depths within WLDS generally range from 26 m mean low water (MLW) along a ridge on the southern boundary to 34 m near the center of the site. Twelve distinct mounds (WLIS A through L Mounds, Table 1-4, Figure 1-7) have been created on the seafloor in the south-central quadrant of WLDS. Placement of dredged material at WLDS between 1986 and 2004 resulted in the formation of a ring of disposal mounds enclosing a containment cell approximately 0.3 km^2 in area. Although mounds ring the containment cell, the defining ridge line of the ring is discontinuous and future disposals may be placed between disposal mounds to minimize the existing gaps.

1.4.2 Previous Monitoring Events at WLDS

The most recent WLDS monitoring survey (prior to the present survey) was conducted in June 2004 and included a single-beam bathymetric and sediment-profile imaging survey. The June 2004 WLDS bathymetric survey was performed over a 1200 m x 1200 m (1.44 km^2) area, in the southwest portion of WLDS. The results of the 2004 survey indicated that placement of 70,000 m^3 of dredged material at WLDS between 2001 and 2004 near the WLIS J Mound spread and settled onto the nearby WLIS H Mound, causing the two small mounds to coalesce into one oblong-shaped mound (Figure 1-7). The height of the resulting WLIS J/H Mound Complex was approximately 1.5 m above the surrounding seafloor (ENSR 2005b). A summary of all WLDS monitoring events occurring since 1990 is presented in Table 1-5.

1.4.3 Recent Dredged Material Disposal Activity at WLDS

Since the June 2004 survey, approximately 78,500 m^3 of dredged material has been placed at the disposal buoy located at 40° 57.83' N, 73° 28.80' W (Figure 1-8, Table 1-6). The dredged material originated primarily from Southport Harbor (73,000 m^3). A detailed record of barge disposal activity at WLDS for the period from June 2004 to July 2005, including the origin of dredged material, the volume deposited, and the disposal location is provided in Appendix A-2.

1.5 Survey Objectives

The July 2005 bathymetric surveys at CLDS and WLDS were designed to provide detailed, comprehensive baseline bathymetric data over the full area of the newly designated dredged material disposal sites using multi-beam bathymetry as well as documenting the distribution of dredged material around the 2004-05 disposal locations. The design of the July 2005 surveys allowed assessment of the following expectations:

- The placement of 58,500 m^3 of dredged material at the CLDS buoy during the 2004-05 disposal season will result in an observable disposal mound.

- The placement of 78,500 m^3 of dredged material at the WLDS buoy during the 2004-05 disposal season will result in an observable disposal mound.

- Existing mounds will retain the general location and shape observed in previous surveys with stable surface features.

Table 1-1.
Summary of Mounds at CLDS

Mound Name	Season(s) Created	Volume Disposed[a] (m^3)	Reference Source DAMOS Contribution No.	Containment Cell Identifier[c]
New Haven Harbor Maintenance Projects				
NHAV 74	1973 – 1977	1,200,045	Supplement H, 57, 63	2
NHAV 83	1983	253,000 [b]	46	2
NHAV 93	1993/1994	1,159,557	111, 117, 118	1[d]
Experimental Capping Projects				
STNH-N	1979	59,002	1 – 7, 57, 63, 95	3
STNH-S	1979	264,710	1 – 7, 57 ,63 ,95	-
Norwalk	1980/1981	598,223	15, 57, 63, 95	1, 2
MQR	1981-1983 & 1993	902,234	46, 57, 63, 95	-
CS-1	1982/1983	86,903	38, 46, 57, 63, 95	-
CS-2	1982/1983	80,102	38, 46, 57, 95	-
FVP	1982	55,002	46, 25, 38, 57, 63	-
Confined Aquatic Disposal (CAD) Cell Development Projects				
CLIS 86	1985/1986	237,453 [b]	63, 68	1
CLIS 87	1986/1987	71,325	72, 94	1

Table1-1. (continued)
Summary of Mounds at CLDS

Mound Name	Season(s) Created	Volume Disposed[a] (m^3)	Reference Source / DAMOS Contribution No.	Containment Cell Identifier[c]
Confined Aquatic Disposal (CAD) Cell Development Projects (continued)				
CLIS 88	1988/1989	336,963	94	1
CLIS 89	1989/1990	152,172	94	1
CLIS 90	1990/1991	59,002	97	1
CS-90-1	1989-1991	116,000	94, 97	3
CLIS 91	1991/1992	57,856	Database[b]	1, 3
CLIS 92	1992/1993	40,028	Database[b]	-
CLIS 94	1994/1995	397,281	118, 94, 120	1, 3
CLIS 95/96	1995-1997	327,589	135, 139	2
CLIS 97/98	1997-1999	516,331	139	2
CLIS 99	1999/2000	85,973	139	3
CLIS 00[e]	2000/2001	71,000	142	3
CLIS 01[e]	2001/2002	53,000	159	3
CLIS 02[e]	2002/2003	312,000	159	3
CLIS 03[e]	2003/2004	426,000	163	3

a. Barge volumes referenced from USEPA 2004b.

b. Barge volumes referenced from the DAMOS scow log database.

c. The containment cell identifier indicates the cell or cells for which the indicated mound forms a boundary.

d. NHAV 93 Mound became the first deposit of UDM placed in a CAD cell at CLDS

e. Mounds formed and documented after the SAIC bathymetric survey of 2000.

Table 1-2.
Previous Monitoring Events at CLDS, 1990 to Present

Date (Mo-Year)	Purpose of Survey	Bathymetry Area (m x m)	SPI Stations Location: Quantity	Additional Studies	Sediment Analysis	DAMOS Contribution No.
Jul-90	Periodic Monitoring	1200x1200	CLIS 90: 66 REF: 39	CTD, DO, Sediment Chemistry		94
Jun-91	Periodic Monitoring	1200x1200	CLIS 90: 66 CS-90-1: 13 MQR: 13 NHAV 74: 13 CS-1: 13 FVP: 13 CLIS 88: 13 REF: 39	CTD, DO, Sediment Chemistry	Grain Size, TOC, Metals, PAHs	97
Aug-91	Sediment Core Chemistry data from MQR			Sediment Cores	Grain size, PCBs, Metals, PAHs, VOCs	103
Aug-92	Benthic recolonization of MQR		MQR: 21	Amphipod Bioassay		104
Sep-93	NHAV 93 Capping Project –Baseline	1600x1600	30	Geotechnical Coring		111
Oct-93	NHAV 93 Capping Project –Disposal	1600x1600		Sediment Grabs	Metals, PCBs, PAHs, Bioassay	111

Table1-2. (continued)
Previous Monitoring Events at CLDS, 1990 to Present

Date (Mo-Year)	Purpose of Survey	Bathymetry Area (m x m)	# SPI Stations Location: Number	Additional Studies	Sediment Analysis	DAMOS Contribution No.
Nov-93	NHAV 93 Capping Project - Precap	1600x1600	43	Geotechnical Coring		111
Nov-93	NHAV 93 Capping Project --Interim Cap	1600x1600		Sediment Grab	Metals, PCBs, PAHs s	111
Jan-94	NHAV 93 Capping Project - Interim Cap 2	1600x1600				111
Mar-94	NHAV 93 Capping Project – Postcap	1600x1600		Geotechnical Coring		111
Jul-94	Periodic Monitoring	2553x2225	NHAV 93: 13 MQR: 13 REF: 13	DO, Subbottom Profiling (1600m x 525m), Geotechnical Coring, Sediment chemistry	Sediment Toxicity, TOC, PAH, Metals, Grain size	117
Sept-95	Periodic Monitoring	NHAV93: 1600x1600 CLIS 94: 1000x1000	NHAV 93: 13 CLIS 94: 13 FVP: 13 REF: 13	Geotechnical Coring		118

Table1-2. (continued)
Previous Monitoring Events at CLDS, 1990 to Present

Date (Mo-year)	Purpose of Survey	Bathymetry Area (m x m)	# SPI Stations	Additional Studies	Sediment Analysis	DAMOS Contribution No.
Jul-96	Precision Bathymetry	2100x2100	CLIS 95: 13 NHAV 93: 5 CLIS 94: 5 REF: 13	DO, Hypoxia		120
Sept-97	Periodic Monitoring	1200x1200	CLIS95/96:41 NHAV 93: 5 REF: 14			135
Mar-98	Benthic Monitoring		CLIS 95/96:8 NHAV93: 5 REF: 9	Side-scan 600x000m		135
Sept-99	Periodic Monitoring	1000x1000	CLIS 97/98 & CLIS95/96:57 NHAV93: 5 FVP: 13 MQR: 13 REF: 13			139
Sept-00	Precision Bathymetry	2100x4100				139
Jun-01	Periodic Monitoring	1000x1000	CLIS 99: 10 CLIS 00: 15 CLIS97/98:21 NHAV 93: 5 REF: 13			142

Table1-2. (continued)
Previous Monitoring Events at CLDS, 1990 to Present

Date (Mo-Year)	Purpose of Survey	Bathymetry Area (m x m)	# SPI Stations	Additional Studies	Sediment Analysis	DAMOS Contribution No.
Sept-03	Periodic Monitoring	1300x1000	CLIS 00: 15 CLIS 99: 10 NHAV 93: 5 MQR: 13 CLIS95/96:25 REF:14			159
Jun-04	Periodic Monitoring	1200x1200	CLIS95/96:15 2500WREF: 5 4500EREF: 5 CLISREF: 5			163

Table 1-3.
Overview of Recent (2004-05) Disposal Activity at CLDS

Source Project Permitee	Estimated Scow Volume Disposed (m^3)
	2004-05 Season
Bayhead Group	3,700
Tilcon Connecticut, Inc.	15,000
Goodsell Point Marina	3,100
Town of Guilford	7,300
Town of Guilford	9,200
Harbor Point Marina	800
Brewer's Bruce & Johnson's Marina	10,100
Guilford Yacht Club	9,400
Season Total	**58,500**

Table 1-4.
Summary of Mounds at WLDS

Mound Name	Season(s) Created	Volume Disposed[a] (m^3)	Reference/DAMOS Contribution No.	Containment Cell Identifier[b]
WLIS A	1982	40,000	27	1
WLIS B	1986/1988	73,800	55	-
WLIS C	1985/1986	73,230	61	1
WLIS D	1989/1990	185,000	138	1
WLIS E	1990/1991	86,462	99	1
WLIS F	1991-1994	80,300	119	1
WLIS G	1994/1995	52,500	119	1
WLIS H	1995/1996	15,300	125	1
WLIS I	1996/1997	35,000	125	1
WLIS J	1997/1998, 2001-2004	10,700	161	1
WLIS K	1998/1999	33,500	161	1
WLIS L	1999/2000	40,000	161	1

a. Barge volumes referenced from USEPA 2004b.

b. The containment cell identifier indicates the cell or cells for which the indicated mound forms a boundary.

Table 1-5.
Previous Monitoring Events at WLDS, 1990 to Present

Date (Mo-Year)	Purpose of Survey	Bathymetry Area (m x m)	SPI # Stations	Additional Studies	Sediment Grab (#)	DAMOS Contribution No.
Jul-90	Monitoring	800x800 3000x2500	77	CTD, DO	Chemical, Grain size (4)	85
Jul-91	Monitoring	1200x800	77	CTD, DO	Grain size, TOC, Metals, PAH (3)	99
Jul-92	Monitoring, Reference area investigation	1200x1000	64	CTD, DO, Toxicity	Grain size, TOC, Metals, PAH, Pesticides, PCBs (2)	102
Jul-96	Monitoring, Reference area investigation	1400x1000	41			119
Sept-97	Monitoring	800x800	39	Side-scan		125
Mar-98	Reference area investigation	1500x4000	60	Side-scan	Grain size, TOC, PAH, PCBs, Pesticides, Metals (10)	125
Jun-01	Monitoring	1000x1000	47			138
Jun-04	Monitoring	1200x1200	60			161

Table 1-6.
Overview of Recent (2004-05) Disposal Activity at WLDS

Source Project Permittee	**Estimated Scow Volume Disposed (m^3) 2004-05 Season**
Bayhead Group	5,500
COE – Town of Fairfield	73,100
Season Total	**78,600**

Figure 1-1. Dredged material disposal sites in Long Island Sound

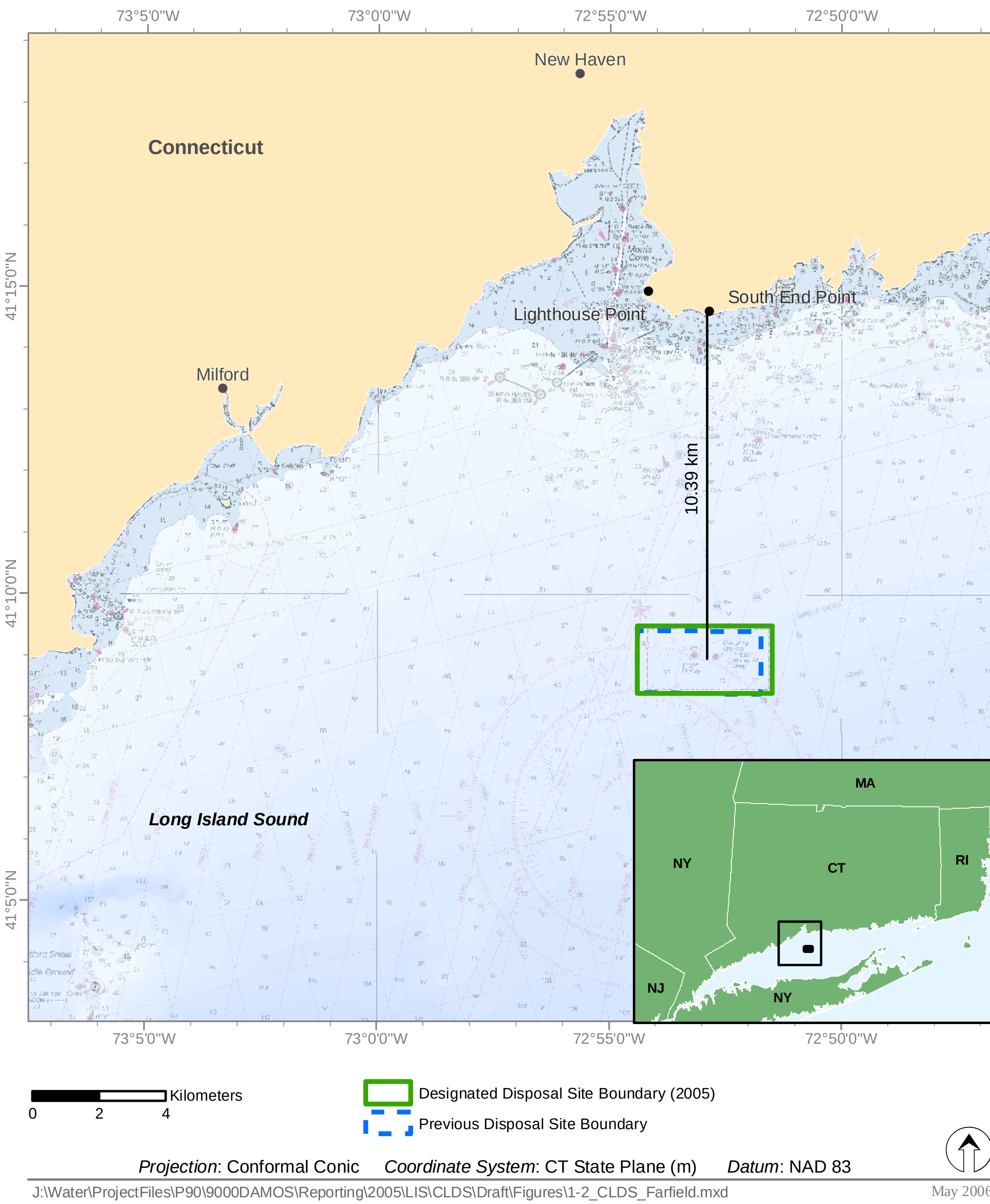


Figure 1-2. Location of the Central Long Island Sound Disposal Site

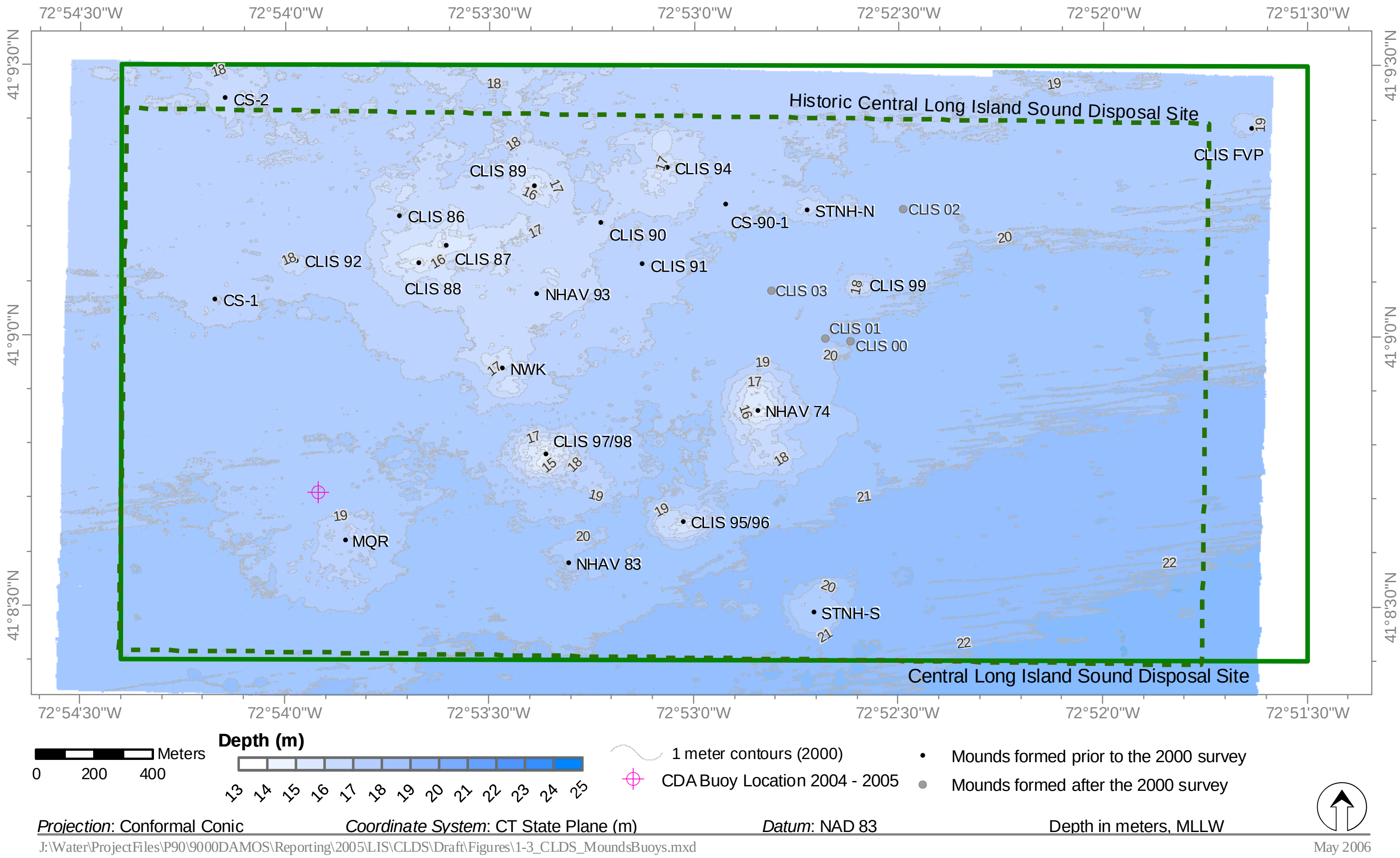


Figure 1-3. CLDS 2000 bathymetry with disposal mounds and buoy indicated

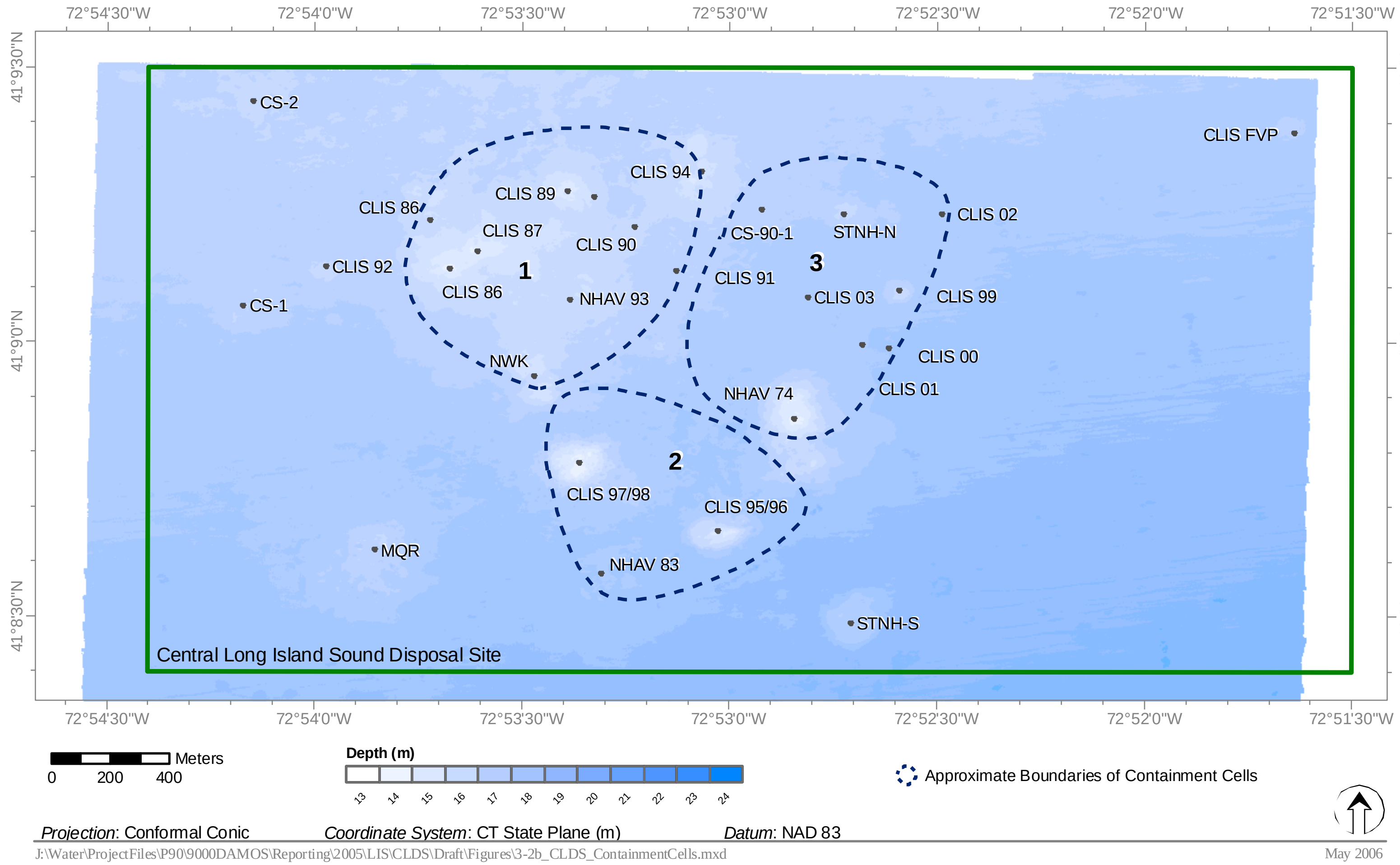


Figure 1-4 Approximate boundaries of confined aquatic disposal areas at CLDS

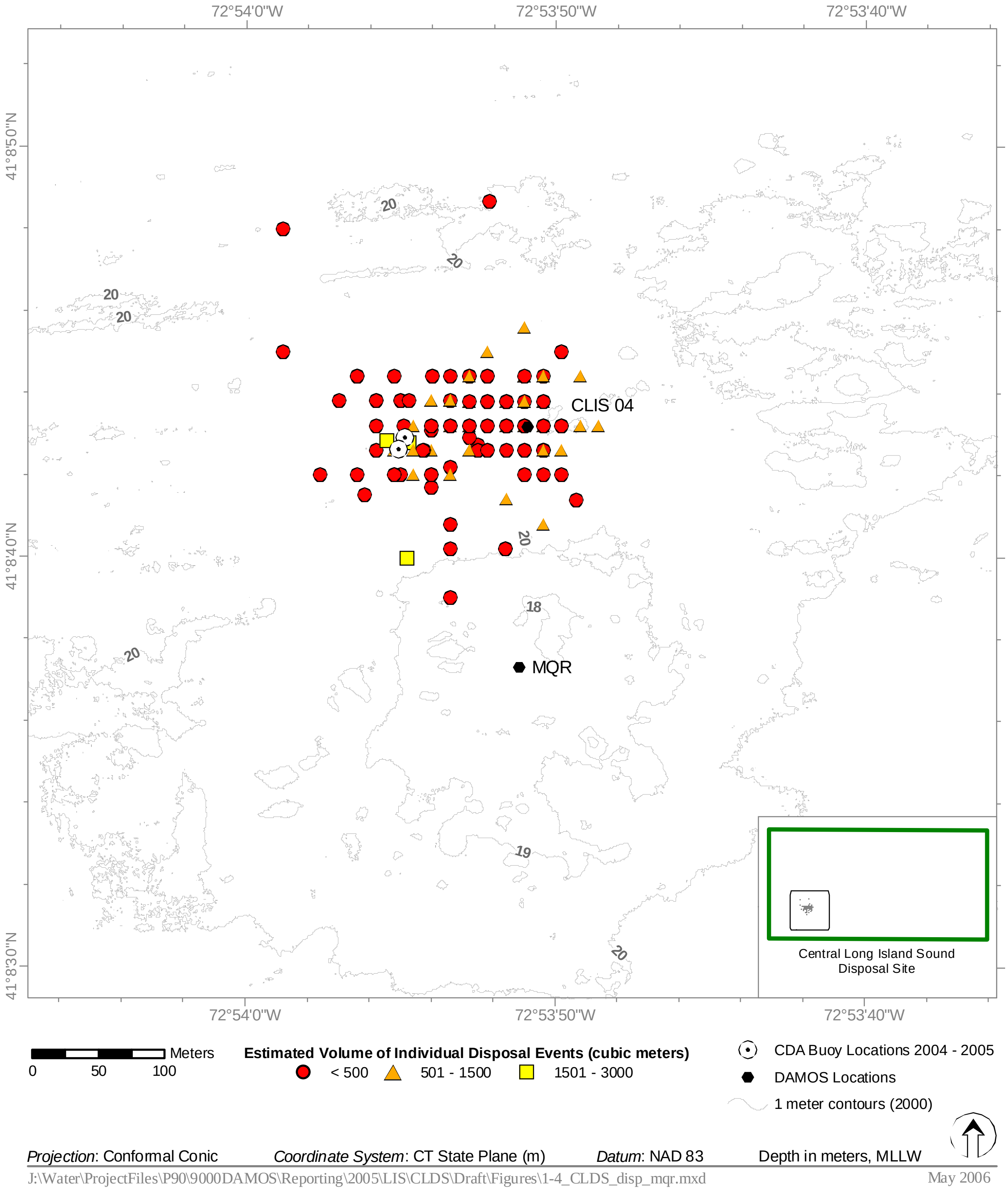


Figure 1-5. CLDS with recent dredged material disposal locations indicated (Oct. 2004 – May 2005)

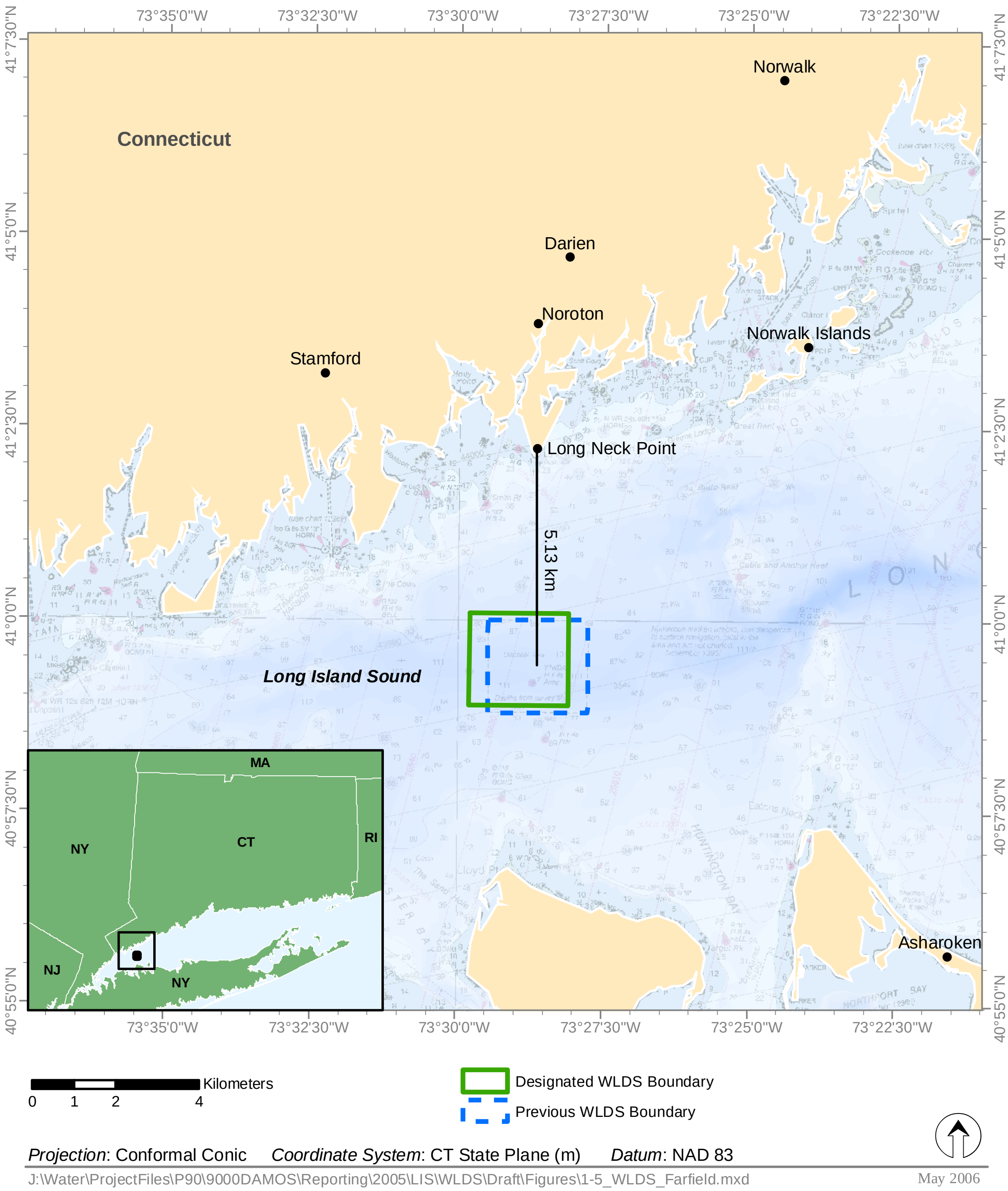


Figure 1-6. Location of the Western Long Island Sound Disposal Site

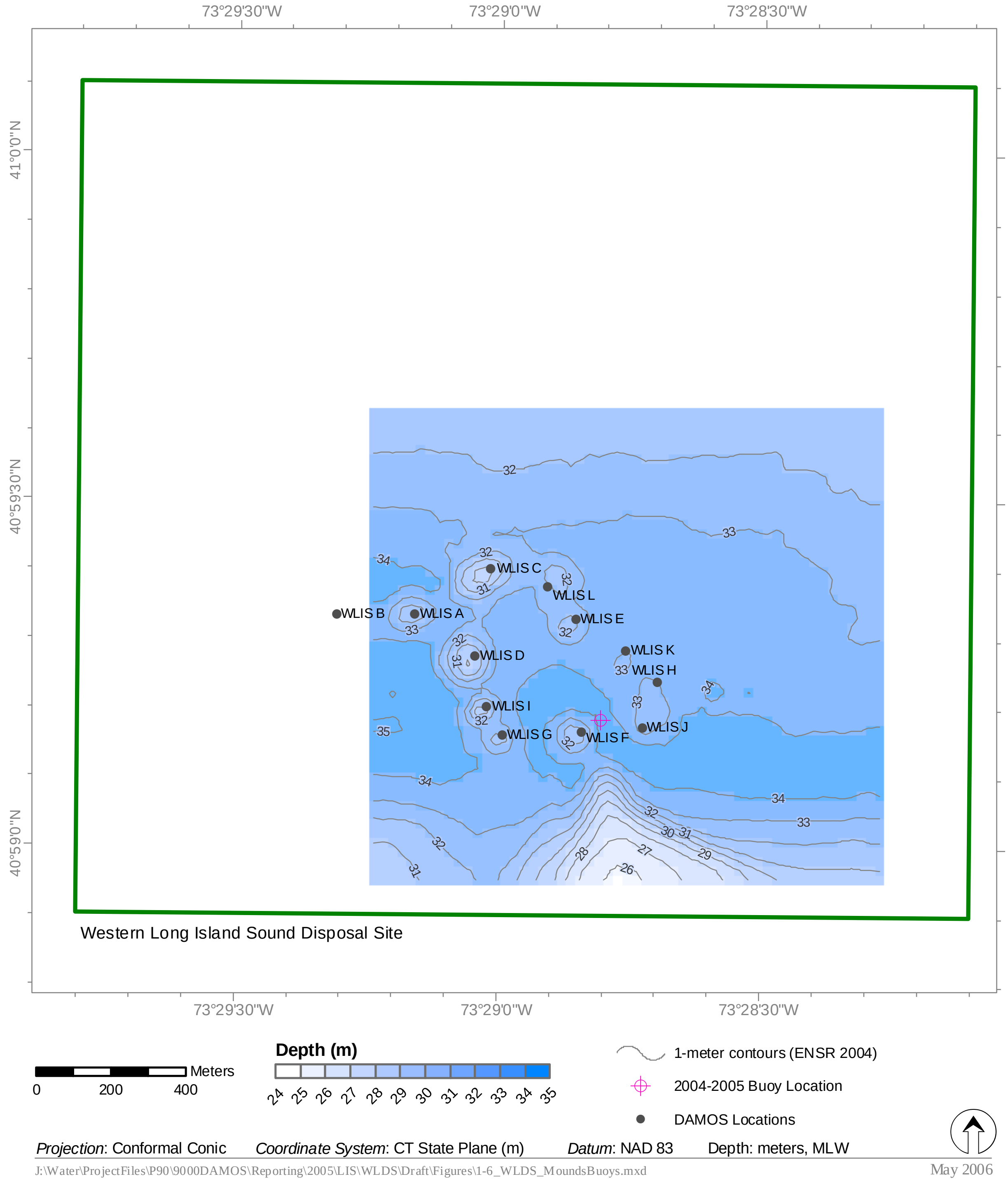


Figure 1-7. WLDS 2004 bathymetry with disposal mounds and buoy indicated

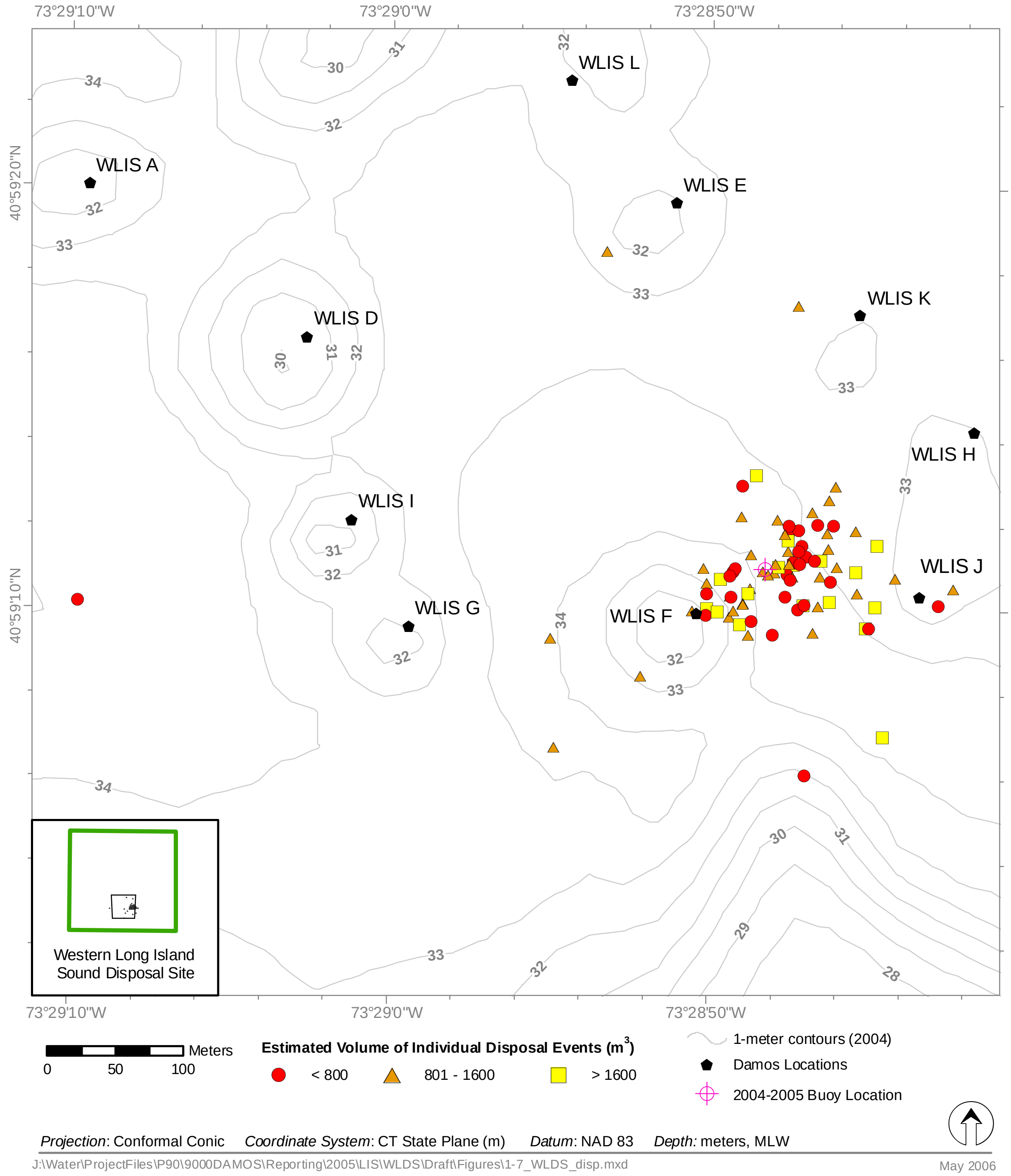


Figure 1-8. WLDS with recent dredged material disposal locations indicated (Nov 2004 – May 2005)

2.0 METHODS

A team of investigators from ENSR Corporation and Ocean Surveys, Inc. performed the July 2005 surveys at CLDS and WLDS. Bathymetric surveys were conducted 6-15 July 2005 at CLDS and 16-20 July 2005 at WLDS to establish a detailed baseline of the seafloor topography and to assess dredged material distribution. Field activities are summarized in Table 2-1 and an overview of the methods used to collect, process, and analyze the survey data is provided below. A more detailed description of methodology and the related terminology can be found in ENSR (2004b).

2.1 Navigation and On-Board Data Acquisition

Positional data, comprised of horizontal positioning (x- and y-dimensional data) and time (t-dimensional data), were collected using a Trimble MS750 series Global Positioning System (GPS) receiver interfaced with a Trimble Probeacon differential beacon receiver. This system received and processed satellite and land-based beacon data and provided real-time vessel position, typically to sub-meter accuracy. Coastal Oceanographics, Inc. HYPACK™ hydrographic survey software was used to acquire, integrate, and store all positional data from the differential global positioning system (DGPS) as well as bathymetric and station data. The HYPACK® software also displayed real-time vessel position and bathymetric data over a background electronic chart of the study area, thus enabling survey scientists to review and evaluate survey data on a real-time basis.

2.2 Bathymetry

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

2.2.1 Bathymetric Data Collection

The 2005 multi-beam bathymetric survey at CLDS covered a 2500 x 4500 m area, approximately 11.25 km^2 (Figure 2-1). The survey area encompassed the entire disposal site as defined by the new boundaries specified by the USEPA site designation (USEPA 2004a). The bathymetric survey was conducted 6-15 July 2005 aboard the R/V *Willing II*. A total of 100 survey lines, each 45 m apart and oriented in a north-south direction, were occupied as part of the survey (Figure 2-1). Additional tie-lines were occupied perpendicular to the main survey lines to assess data quality.

The 2005 multi-beam bathymetric survey at WLDS covered a 2600 x 2800 m area, approximately 7.28 km^2 (Figure 2-2). The survey area encompassed the entire disposal site as defined by the new boundaries specified by the USEPA site designation (USEPA 2004a). The bathymetric survey was conducted 16-20 July 2005 aboard the R/V *Willing II*. A total of 59 survey lines, each 45 m apart and oriented in an east-west direction, were occupied as part of the survey (Figure 2-2). Additional tie-lines were occupied perpendicular to the main survey lines to assess data quality.

The bathymetric data were collected using a Reson 8125 Ultra High Resolution Echo Sounder outfitted with a 0.5°, 455-kHz transducer. The multi-beam sounding system was also equipped with a TSS DMS 2-05i motion sensor for measuring heave, pitch, and roll and a TSS Meridian gyro compass to provide accurate heading guidance. The system was calibrated for local water mass speed of sound by performing conductivity-temperature-density (CTD) casts at frequent intervals throughout the day with a Seabird SBE-19 Seacat CTD profiler. Data recorded at a rate of 7 soundings per second, combined with boat speeds between 4 to 4.5 knots, resulted in soundings spaced at less than 0.3 meter intervals along each line. Additional calibration information was obtained from a bar check.

Water depths at CLDS and WLDS were recorded in meters and referenced to mean lower low water (MLLW) based on local tidal information. The CLDS data were referenced to MLLW based on the NOAA Tide Station located in New Haven, Connecticut, and the WLDS data were referenced to MLLW based on the NOAA Tide Station located in Eatons Neck, New York. Bathymetric data were recorded by means of a high-resolution trace on a thermal printer in addition to the digital data stored within Hypack®. Hypack® managed data acquisition and storage of data from the echosounder and the Trimble DGPS. Hypack® also recorded depth, vessel heave, heading, position, and time along each survey transect line.

2.2.2 Bathymetric Data Processing

The bathymetric data were processed using the HYPACK® software program and included corrections for tidal conditions, local speed of sound, and spurious data points. Tidal correction consisted of transforming the raw measurements of depth below the transducer to seafloor elevation measurements relative to MLLW using the locally collected tidal elevation data. Heave data supplied by the vessel's motion reference unit

(MRU) was incorporated into the raw data to minimize the effects of vessel motion. The bathymetric data were also reviewed for spurious data points (clearly unrealistic measurements resulting from signal interference), and these points were removed. The final data set was averaged into 2.0-meter square bins. All soundings located within a given bin were averaged, and the average value was assigned to the coordinates at the center of the bin.

2.2.3 Bathymetric Data Analysis

Bathymetric data were analyzed to establish a baseline of the existing conditions at each site and to document changes in seafloor topography in comparison with previous surveys. The corrected bathymetric data were processed for display using a combination of the contouring and surface plotting software program, Surfer® 8.0 and the GIS-based software package ArcView® 9.1. Using Surfer®, the processed CLDS and WLDS data were converted into grids. Once gridded, bathymetric contour lines were generated and displayed using ArcView®.

Surfer® was also used to generate depth-difference grids based on prior baseline surveys and the July 2005 bathymetric data sets. At CLDS, the September 2000 multi-beam survey and the 2005 dataset were used to create the depth difference grid. The 2000 bathymetry dataset was selected instead of the more recent 2004 data to allow development a depth-difference map of the whole site. At WLDS, the June 2004 single-beam bathymetric dataset covering the southeast quadrant of the site and the July 2005 dataset were used to create the depth difference grid. The depth difference grids were calculated by subtracting the July 2005 interpolated depth estimates from the prior surveys depth estimates at each point throughout the grid. The resulting depth differences were contoured and displayed using ArcView®.

Three-dimensional hillshaded renderings of the bathymetric data were created using the ArcView® 9.1 3-D Analyst toolbox. A simulated light source with an azimuth of 315° and an altitude of 45° was applied to the grids to provide a shaded-relief image of the disposal sites. Several figures in Sections 3 and 4 of this report (See Figures 3-2, 3-14) were enhanced with the hillshade grids, which are used to illustrate the three-dimensional qualities of the multi-beam bathymetric data.

Table 2-1.
July 2005 CLDS and WLDS Field Activities Summary

Survey	Date	Summary
Bathymetry at CLDS	6-15 July 2005	Area: 2500 x 4500 m Lines: 100 and 4 tie-lines Orientation: north-south Spacing: 45 m
Bathymetry at WLDS	16-20 July 2005	Area: 2600 x 2800 m Lines: 59 and 2 tie-lines Orientation: east-west Spacing: 45 m

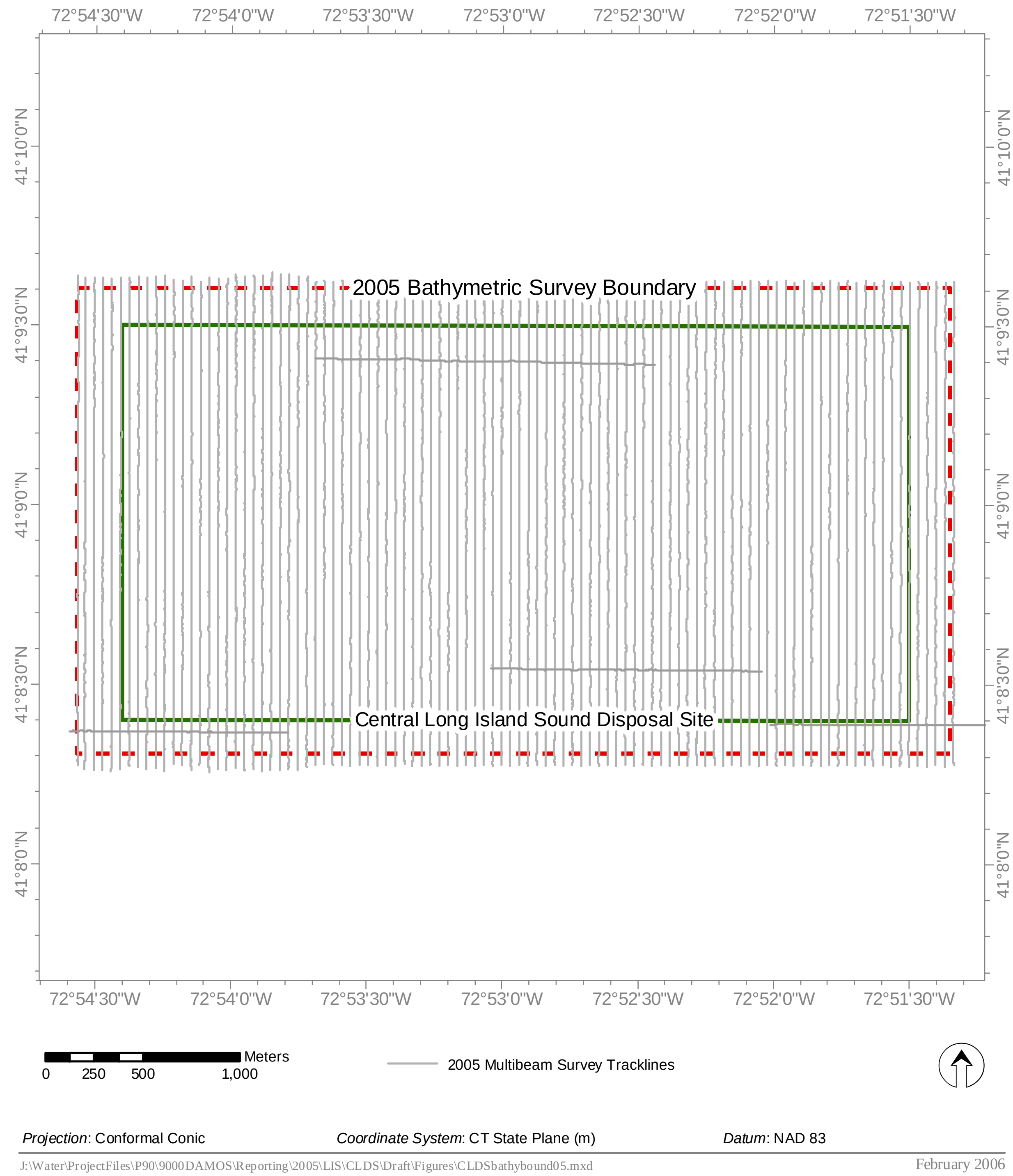


Figure 2-1. Bathymetric survey lines at CLDS, July 2005

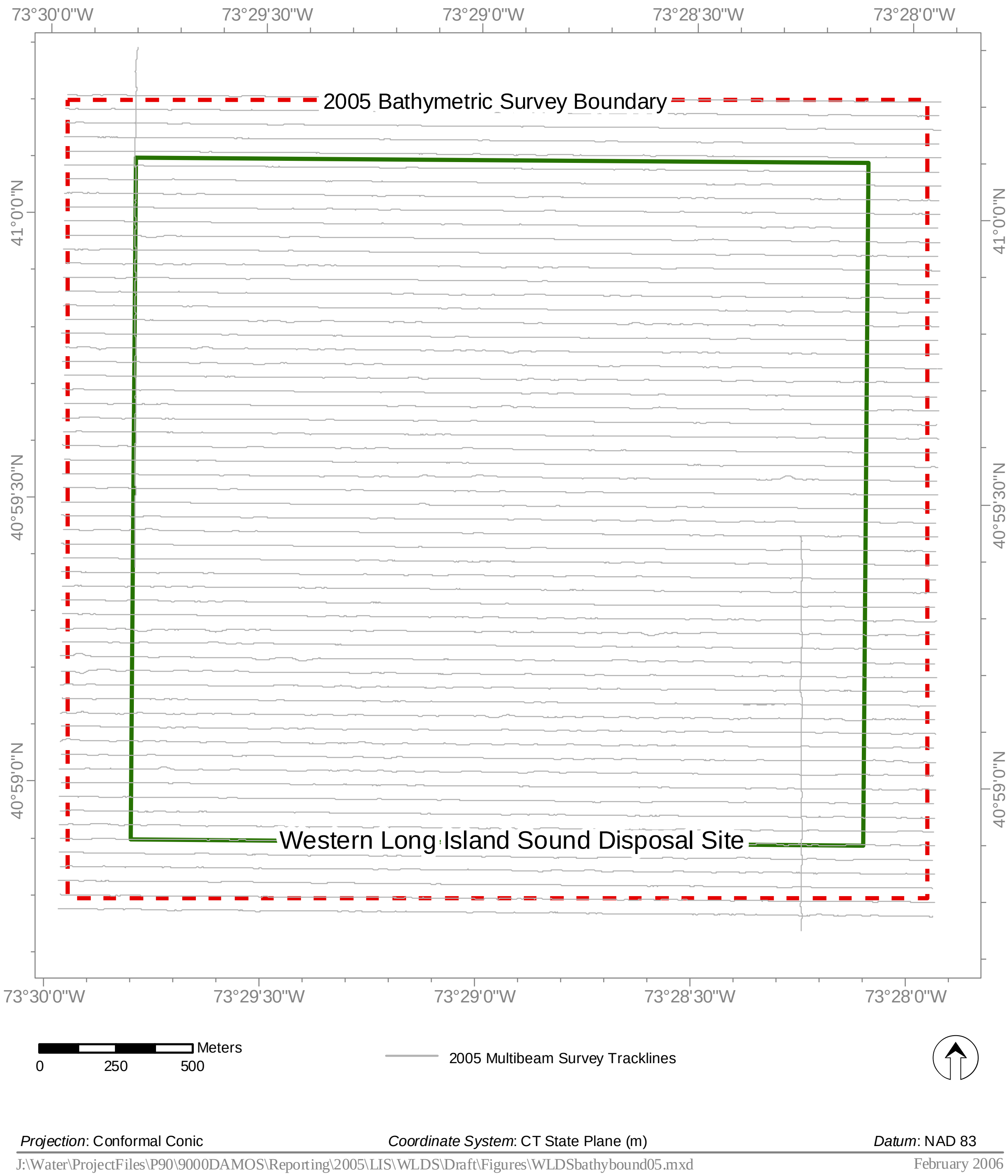


Figure 2-2. Bathymetric survey lines at WLDS, July 2005

3.0 RESULTS

3.1 CLDS

3.1.1 General Bathymetry

Dredged material disposal mounds and several distinct types of sedimentary features were identified in the July 2005 multi-beam survey at CLDS. These features are described below, and their likely origins and implications are discussed further in Section 4. The survey area (2500 x 4500 m) overlapped the disposal site boundary and extended beyond the boundaries of the 2000 multi-beam survey (2100 x 4100 m) and the 2004 single-beam survey (Figure 3-1). This overlap allowed comparison of topographic changes between disposal seasons and some assessment of the stability of natural and anthropogenic features. The documentation of disposal activities and management practices after 1974 (when discrete mounds were first formed) permitted identification of topographic features associated with specific disposal seasons based on buoy position or scow log records.

The July 2005 multi-beam bathymetric survey results for CLDS were consistent with earlier survey results (Table 1-1, SAIC 2002a, ENSR 2004a). The natural seafloor sloped gradually from a depth of 18 m (MLLW) in the northwest to a depth of 22 m (MLLW) in the southeast (Figure 3-2). The central and western sections of CLDS were marked with irregular, roughly circular mounds of varying shapes and heights. The eastern section of CLDS was a relatively smooth slope marked by small pits and longitudinal furrows (Figure 3-3). Across the northwestern margin of the disposal site, the seafloor was relatively flat, but marked by numerous circular, ring-shaped deposits ranging in size from 10 to 25 m which extended to the northern edge of the survey boundary.

3.1.2 Dredged Material Disposal Mounds

Twenty-seven historic mounds were observed during the 2005 survey (Figure 3-4). The mounds were the product of over thirty years of dredged material disposal at CLDS. A list of the mounds with their 2005 height and footprint morphology is presented in Table 3-1. Many of these mounds have coalesced into mound complexes as a result of several seasons of disposal activities (Figure 3-4, Figure 3-5).

The largest mound complex found in CLDS was located in the northwestern central section of the site and formed the first containment cell at CLDS. The adjacent mounds CLIS 86, CLIS 87, CLIS 88, CLIS 89 formed the containment ring which was completed in 1989. The containment cell was utilized for New Haven Harbor UDM in 1993, the disposal of which formed NHAV 93. The central region of the NHAV 93 Mound Complex was smooth and flat with relatively few ring-shaped deposits. CLIS 86, CLIS 87, and CLIS 88 formed a triangle to the northwest with the shallowest areas of the complex over CLIS 87 and CLIS 88. CLIS 89 was on the northern margin of the complex, and the Norwalk Mound with two distinct adjacent peaks was located on the southern margin of the NHAV 93 Mound Complex. Farther south the CLIS 97/98 Mound Complex formed one broad, rounded peak covered with small rings (Figures 3-4 and Figure 3-5).

The oldest capped disposal mound at CLDS (NHAV 74) was located in the center of the disposal site. The mound continued to be a prominent feature on the seafloor due to its size. Other older capped mounds were smaller including Norwalk, STNH-S, STNH-N, MQR, CS-1, and CS-2. These older mounds had a smoother appearance with few visible disposal rings on the surface as noted in previous surveys (SAIC 2002a). One exception to this was the small capped mound at CS-2 which last received capping material in 1983 and still showed apparent disposal features.

The STNH-S Mound, located in the southeastern central area of the site, continued to have a broad, flat surface with steep sides. In contrast, the STNH-N Mound retained a more peaked shape. The broad flat expanse of the MQR Mound was located to the west of the 97/98 Mound Complex. A large number of ring-like features were present on the northern margin of this mound where the most recent disposals of the 2004-05 disposal season occurred. The FVP Mound, a small uncapped deposit of UDM, was located at the far northeastern corner of the disposal site in the region dominated by furrows.

Disposal activity since the September 2000 multi-beam survey had produced five new mounds (CLIS 00, CLIS 01, CLIS 02, CLIS 03, and CLIS 04) and fresh deposits over the MQR Mound. The CLIS 00 and CLIS 01 Mounds were small, relatively steep mounds to the northwest of NHAV 74 (ENSR 2004a). The CLIS 02 Mound was a broad flat mound with a flat peak in the center directly to the east of STNH-N (Figure 3-4, Figure 3-5). The CLIS 03 Mound, located immediately north of the NHAV 74 Mound, appeared to have a large broad base and a flat top.

The CLIS 04 Mound formed at the location of the 2004-05 disposal buoy, approximately 175 meters north of the historical MQR Mound, from the disposal of approximately 58,500 m^3 of material. The mound, which rose approximately 2.5 meters above the surrounding seafloor, was approximately 175 meters along the major axis oriented in the east-west direction and 100 meters along the minor axis oriented in the north-south direction (Figure 3-6).

3.1.3 Sedimentary Features

Two distinct types of sedimentary features were identified in the multi-beam data at CLDS: long, narrow, linear features and circular or sub-circular features in the form of rings or pits. The features were both natural and anthropogenic, and their likely origins are discussed in Section 4.

3.1.3.1 Linear Features

The multi-beam bathymetric survey documented sets of long, linear furrows with low relief and widths of 2 to 10 m, depths of 0.4 m, and lengths on the order of hundreds of meters. The sedimentary furrows were oriented parallel with the prevailing tidal current (running slightly south of west and north of east) and were most clearly visible in the southeast section of the disposal site (Figure 3-7). The furrows were observed throughout the disposal site in areas of little or no mantling of dredged material, and were not present in fresh dredged material or on any of the surfaces of historical mounds. Furrows were observed in the margin of the FVP Mound, and appeared to be buried under the Mound (Figure 3-8A). The sedimentary furrows have been described previously and are discussed further in Section 4.

Irregular faint linear features in an otherwise smooth seafloor were observed periodically throughout the site. The irregular linear features were of two distinct forms: a continuous thin linear mark (Figure 3-9) and several shorter linear features with small nodes at regular intervals (Figure 3-8B). The nodes were spaced 20 to 70 m apart and appeared to be reflections of acoustic energy rather than textural features of the seafloor. Several linear features appeared as paired, symmetrical traces, suggesting that the feature was above the seafloor or oscillating between the nodes during the bathymetric survey (see inset in Figure 3-8).

3.1.3.2 Rings and Pits

Recent disposal mounds had distinctive ring features on their surface, especially noticeable on the CLIS 03 and MQR Mounds (Figures 3-9 and 3-10). The ring features varied in size from 10 to 25 m in diameter on these newer mounds, but similar ring features were observed throughout the disposal site. The rings appeared either as depressions, flat areas with a shallow rim 10 to 20 cm high, or with a small central knob or raised area. Some of the rings had softer relief than others. As noted previously, the rings were frequently distributed in linear arrays and overlapped one another (SAIC 2002b). In some instances, the rings appeared flat and draped over sediment topography, conforming to the underlying bathymetric relief (Figure 3-10C).

In the areas dominated by furrows there were widely dispersed pits, many in linear arrays of two to five pits oriented north-south. Some of the pits intersected furrows and appeared to have a cuspate form whereas other pits were circular with a rough floor (Figures 3-7, 3-8). The circular pits were similar in scale to the ring features, on the order of 10 to 25 m in size, and resembled the ring depressions found on the disposal mounds. They did not have raised margins but appeared to be depressions with rounded edges. Few of them were as distinctly circular as the rings.

In addition to the north-south oriented linear arrays of pits, there were several similar linear depressions scattered throughout the survey area. These depressions were wide (10 to 20 m), shallow, elongated (70 to 200 m long) pits with curved edges oriented NE-SW at a distinctive 45° from the horizontal. One linear depression appeared to continue over the CLIS 95/96 Mound linking a series of four pits with the same orientation (Figure 3-11). These small linear depressions may have been composed of a string of circular pits, rather than a continuous feature.

3.1.4 Comparison with Previous Bathymetry at CLDS

The data from the September 2000 multi-beam bathymetric survey (Figure 1-3) and the July 2005 multi-beam bathymetric survey (Figure 3-2) were used to generate a depth-difference map (Figure 3-12). The depth-difference map was plotted at 0.5-m contour intervals.

The depth-difference map (Figure 3-12) generally indicated little change in bathymetry across the site. There was a small amount (up to 0.5 m) of apparent depth difference of the CLIS 95/96 and CLIS 97/98 Mound Complexes. This apparent decrease in height may be due to consolidation of dredged material over time. A progression of consolidation documented in the historical survey data is discussed in Section 4. However, some of the apparent decrease in height was likely due to changes in data capture and processing techniques. Both CLIS 95/96 and CLIS 97/98 Mounds had steep sides; a small variation in location of survey track lines can make a large difference in the apparent height of the mound. The depth-difference map indicated the formation of the CLIS 00, CLIS 01, CLIS 02, and CLIS 03 Mounds, which were documented following the June 2004 single-beam bathymetric survey of CLDS (ENSR 2005a). The depth-difference map also indicated the formation of the CLIS 04 Mound in the southwestern quadrant of the site, with up to 2.5 m of sediment accumulation between 2000 and 2005 (Figure 3-12).

3.2 WLDS

3.2.1 General Bathymetry

The July 2005 bathymetric survey results for WLDS were consistent with earlier survey results (Table 1-2, Myre and Saffert 1999, SAIC 2002a, ENSR 2005b). The site was centered over a broad trough trending east-west and narrowing to the east (Figure 3-13). This trough had an average depth of 33 m (MLLW) and was bounded on the northern side by the edge of a plateau with a scalloped edge and on the southern side by the edge of an incised platform. These platforms on the margin of the trough were not terminal moraines of glaciers as previously thought, but eroded margins of pre-glacial, glacial, and post-glacial deposits (Lewis and DiGiacomo-Cohen 2000). The moraines in this region of LIS are on the northern shore of Long Island and well north of the disposal site amongst the Norwalk Islands (Figure 1-6) (Lewis and Stone 1991). The western region of LIS is marked by the presence of the Norwalk Shoal, a shallow area east of WLDS composed of two promontories mantled with deltaic fan deposits and later marine sediments. The promontories have been shown to be bedrock on the north and coastal plain deposits in the south. The eroded margins of the trough are likely to be similar but less dramatic expressions of these underlying geologic formations now mantled by fine-grained deposits (Knebel and Poppe 2000, Poppe et al. 2000).

The shallowest area within the disposal site boundary was on the northwest margin with a depth of 23 m (MLLW). The southern platform had an average depth of 24 to 26 m (MLLW) within the disposal site and continued to decrease in depth to the shoreline of Lloyd Harbor (Figure 3-13).

3.2.2 Dredged Material Disposal Mounds

The south central area of the trough contained a ring of dredged material disposal mounds (Figure 3-14). Twelve historic mounds were evident during the 2005 survey. The largest mounds (WLIS A, C, and D) are located on the northwestern margin of the ring, and a smaller older mound (WLIS B) is located outside the ring to the west. The larger mounds have a relatively smooth surface with soft-edged rings (see descriptions from CLDS above). The most distinct mound was the WLDS D Mound, which rose approximately 4 meters above the surrounding seafloor. The newer and smaller mounds (including WLIS B) had surfaces marked with craters and rings with sharper, more distinct outlines (Figure 3-14). A list of the mounds with their current observed height and footprint morphology is presented in Table 3-2.

3.2.3 Sedimentary Features

The high-resolution multi-beam bathymetric data revealed small, subtle features of the seafloor as described above. Ring features of various forms, similar to the rings and pits described at CLDS, were visible on the mounds and along the southern and eastern margin of the disposal site (Figure 3-15, Figure 3-16, Inset C). There were lines of rings oriented NE-SW particularly in the southeast corner of WLDS extending to and along the southern margin of the disposal site (Figure 3-16, Inset A). No sedimentary furrows were observed in the WLDS region, and the seafloor had a smooth appearance particularly in the northern part of the trough and along the scalloped northern margin. Along the western margin of WLDS, a large object and an associated scour pattern were observed protruding above the seafloor (Figure 3-16 Inset B). There were faint linear markings extending north-northeast from the area of disposal mounds (Figure 3-15).

3.2.4 Comparison with Previous Bathymetry at WLDS

The data from the June 2004 single-beam bathymetric survey (Figure 3-17) and the 2005 multi-beam bathymetric survey (Figure 3-13) were used to generate a depth-difference map (Figure 3-18). The depth-difference map was plotted at 0.5-m contour intervals.

A new mound, designated as WLIS M, was formed approximately 60 meters northeast of WLIS F Mound and 120 meters northwest of WLIS J Mound (Figure 3-14, Figure 3-16 Inset C). These mounds are sufficiently close to merge into a mound complex with overlapping margins. This new mound resulted from the disposal of approximately 78,000 m^3 of material during the 2004-05 disposal season. The base of the mound was approximately 150 m in diameter. The minimum water depth at the apex of the two peaks was approximately 32 m, and the surrounding water depths averaged about 33.5 m, indicating that the mound was approximately 1.5 meters above the surrounding seafloor (Figure 3-18).

Table 3-1.
CLDS Disposal Mounds, July 2005 Multi-Beam Bathymetric Survey

Mound Name	Height of Mound in 2005 (m)	Dimensions or Diameter of Mound Footprint in 2005 (m)
NHAV 74	5	380 x 300
STNH-N	1	100
STNH-S	1.5	200
Norwalk	1.5	200 x 150
MQR	1	300
CS-1	0.5	150 x 70
CS-2	0.5	180
FVP	1	126
NHAV 83	0.5	90 x 100
CLIS 86[a]	-	-
CLIS 87	4	500 x 400
CLIS 88 [a]	-	-
CLIS 89	1.5	215
CLIS 90	0.5	60
CS-90-1 [a]	-	-
CLIS 91	0.5	80
CLIS 92	1	100
NHAV 93	1	60
CLIS 94	2	235 x 150
CLIS 95/96	3.5	300 x 175
CLIS 97/98	4.5	358 x 250
CLIS 99	1	120
CLIS 00	2	70
CLIS 01	1.5	90
CLIS 02	1	300
CLIS 03	1.5	350
CLIS 04	2.5	175 x 100

[a] *the individual mound is not distinguished in the bathymetric image*

Table 3-2.
WLDS Disposal Mounds, July 2005 Multi-Beam Bathymetric Survey

Mound Name	Height of Mound in 2005 (m)	Dimensions or Diameter of Mound Footprint in 2005 (m)
WLIS A	2.5	150
WLIS B	1.5	130
WLIS C	3	160
WLIS D	3.5	160
WLIS E	2	120
WLIS F	3.5	130
WLIS G	2	120
WLIS H [a]	-	-
WLIS I	2.5	100
WLIS J	1.5	162
WLIS K	0.5	100
WLIS L	2	120
WLIS M	1.5	150

[a] *the individual mound is not distinguished in the bathymetric image*

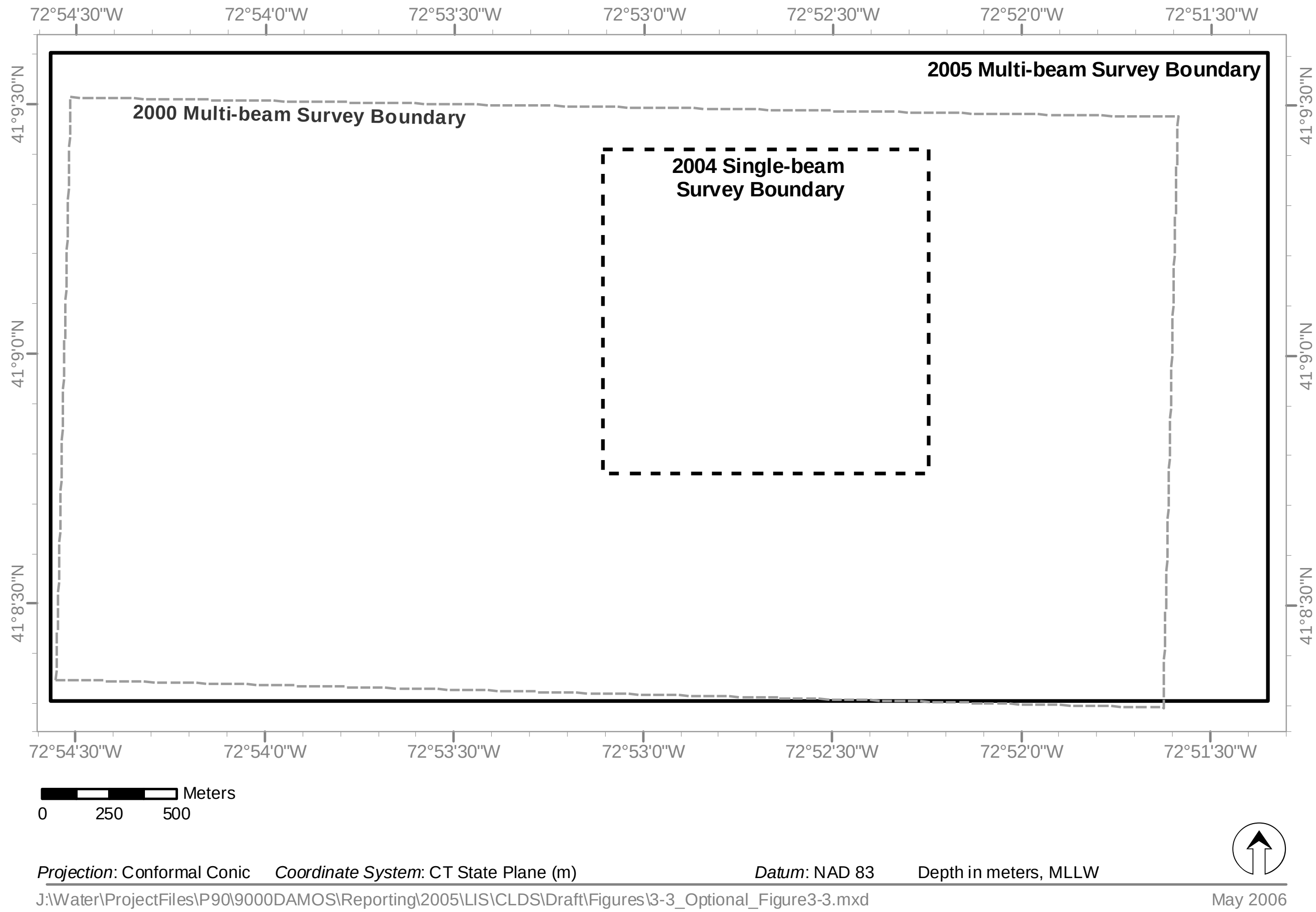


Figure 3-1. Locus map of recent surveys at CLDS including the boundaries of the multi-beam surveys of 2000 and 2005 and the single-beam survey of 2004.

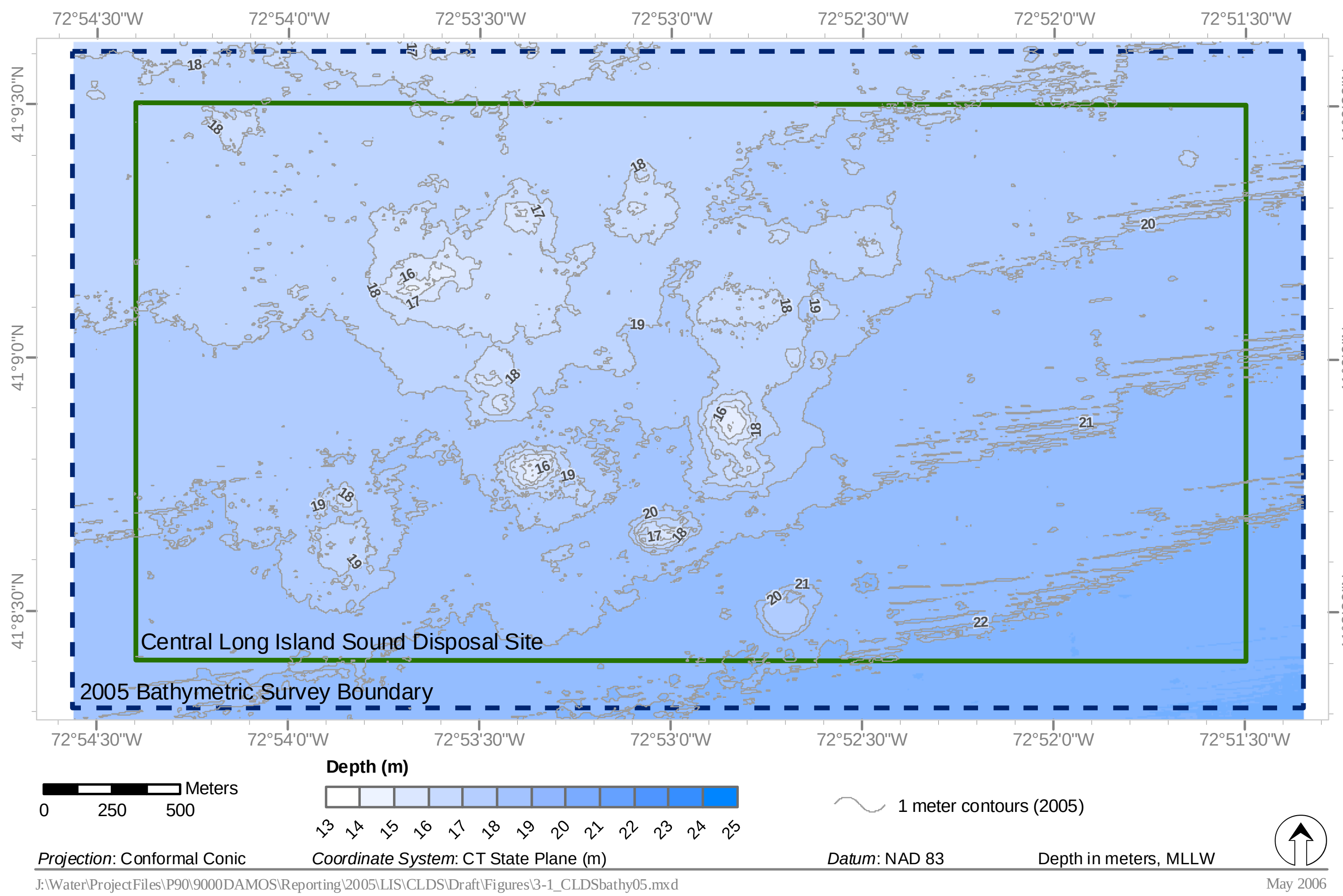


Figure 3-2. Bathymetric contour map of CLDS survey area, July 2005 (1-m contour interval)

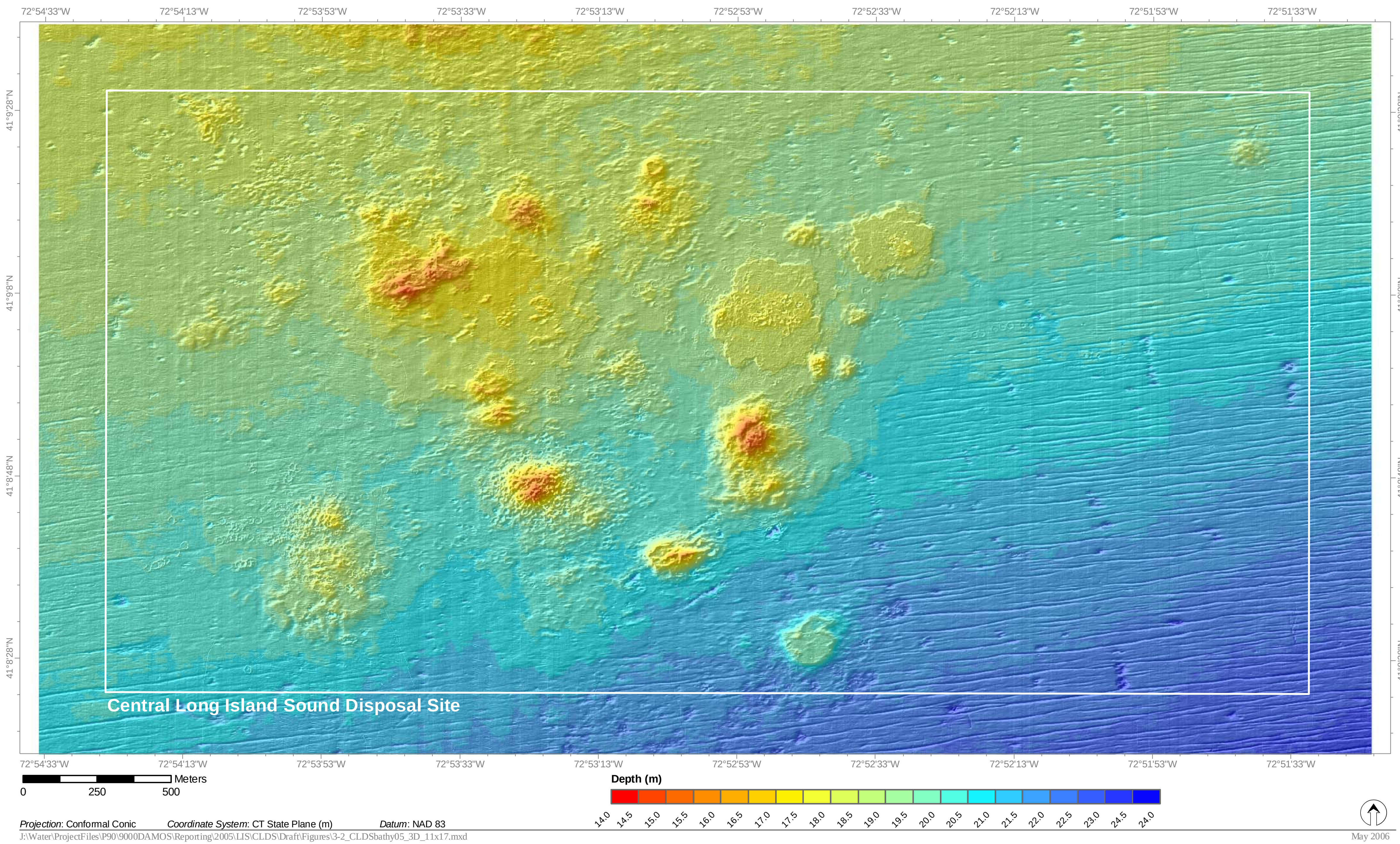


Figure 3-3. Bathymetric relief map of CLDS survey area, July 2005

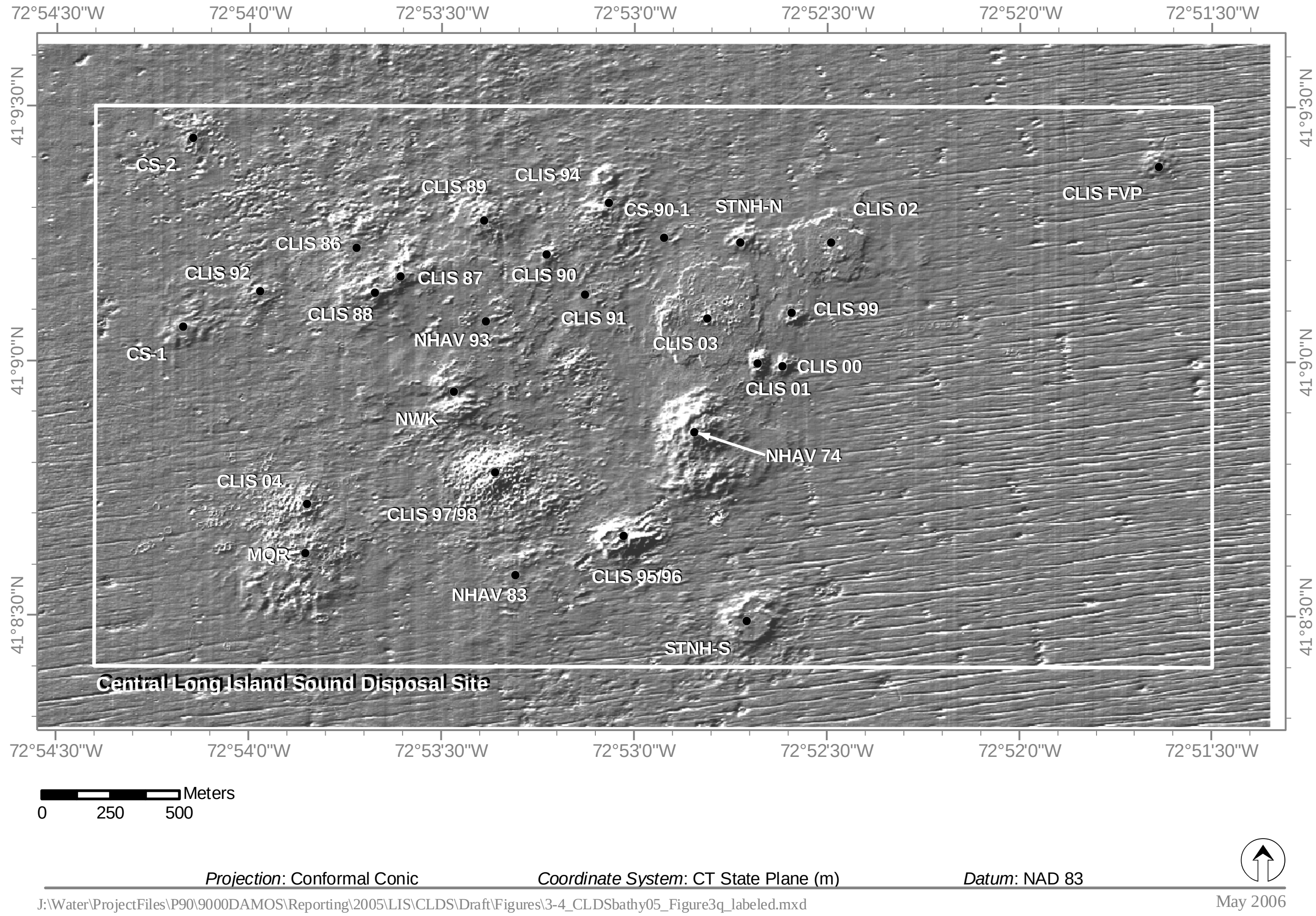


Figure 3-4. Multi-beam bathymetry data of CLDS, July 2005. Hillshaded to highlight topographic features. Disposal mounds identified by project or year of disposal activity.

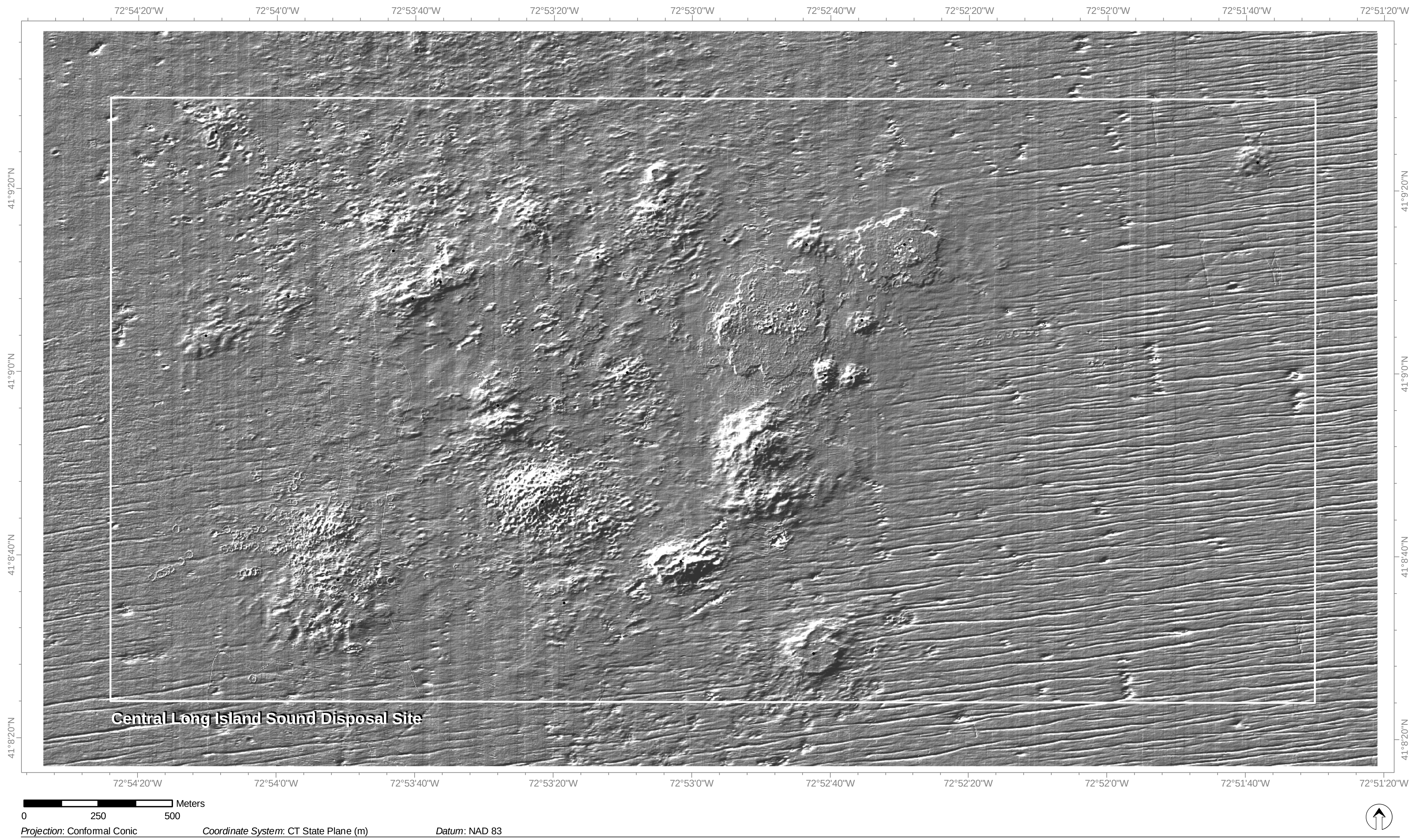


Figure 3-5. Multi-beam bathymetry data of CLDS, July 2005. Hillshaded to highlight topographic features. Disposal mounds unlabelled to allow view of distribution of features described in the text.

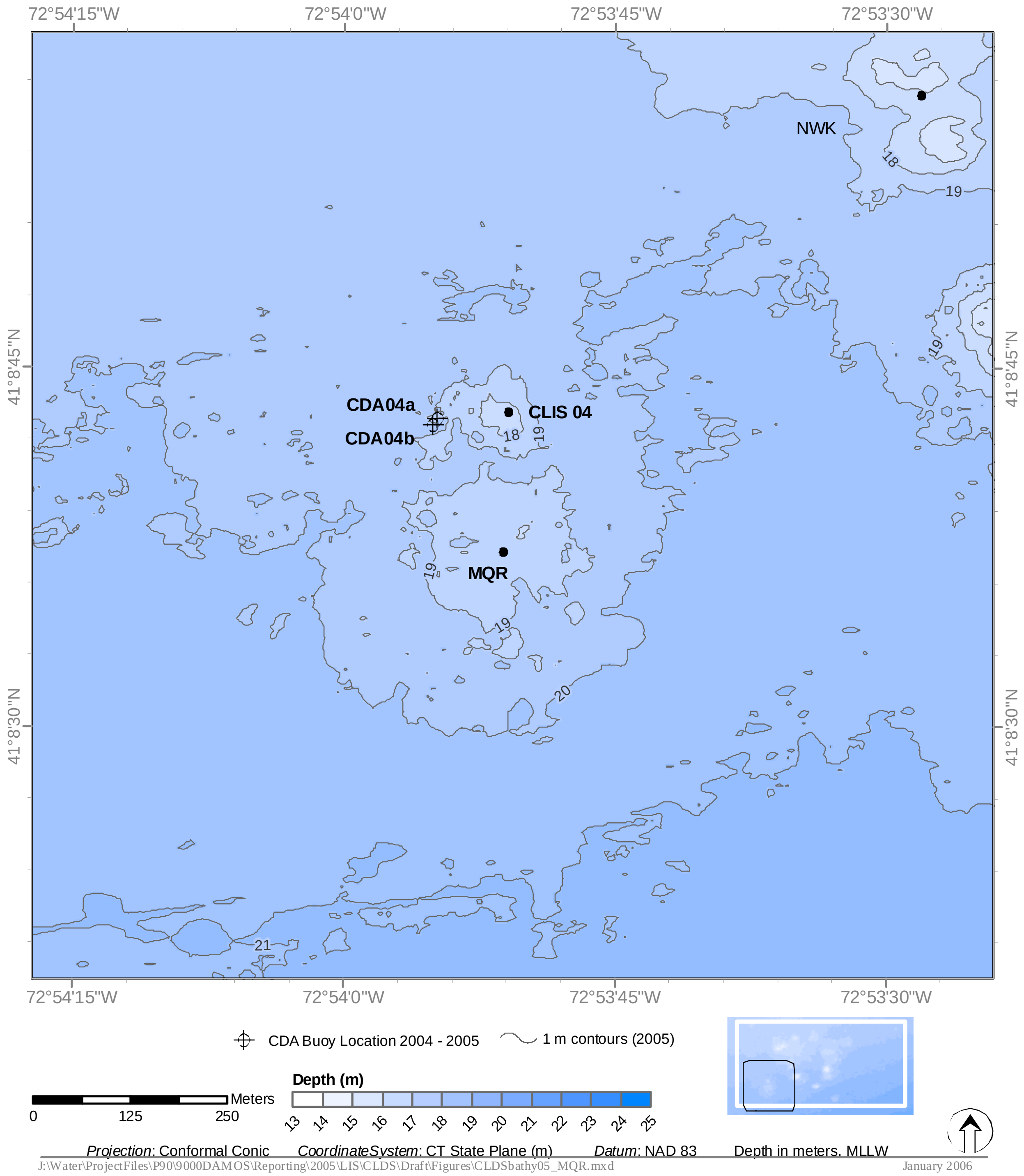


Figure 3-6. Bathymetric contour map of CLIS 04, July 2005.

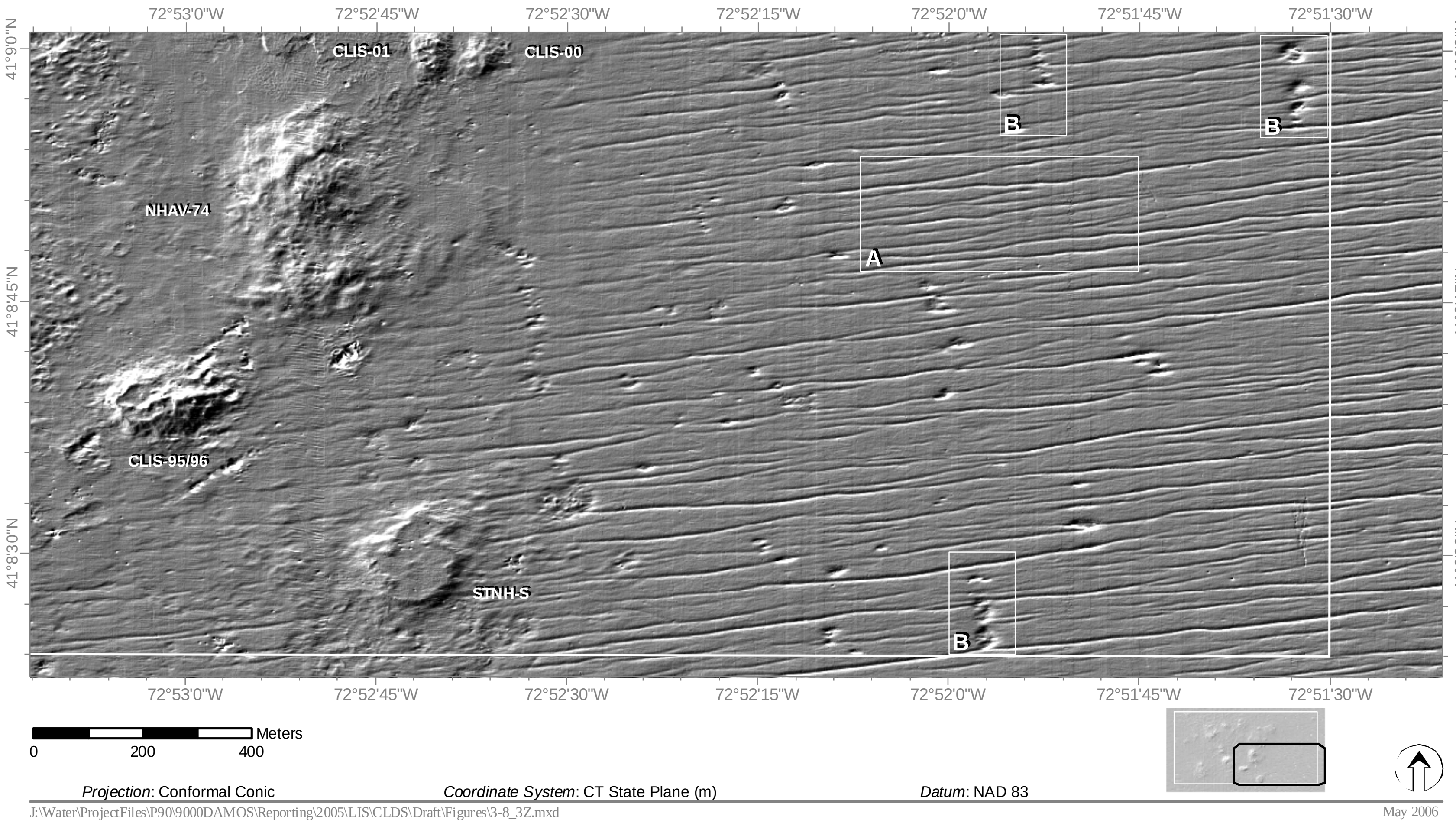


Figure 3-7. Sedimentary furrows (A) and pits (B) in the southeastern section of CLDS.

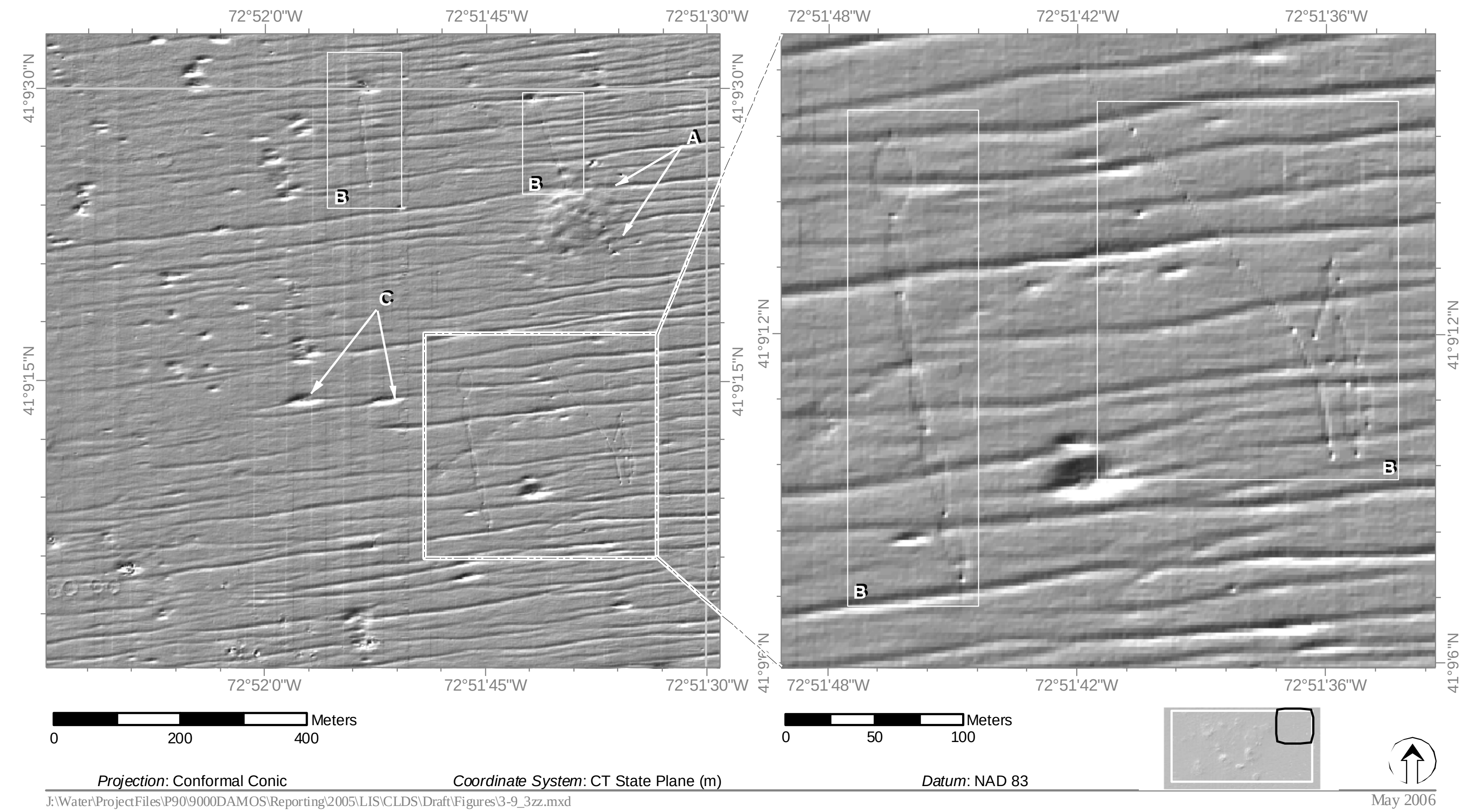


Figure 3-8. Multi-beam record of the northeastern corner of CLDS. A. Shows furrows around margin of the FVP Mound. B. Shows paired symmetrical linear traces with circular nodes. The image on the right is an enlargement of the area in the black rectangle. C. Cuspate pits associated with furrows.

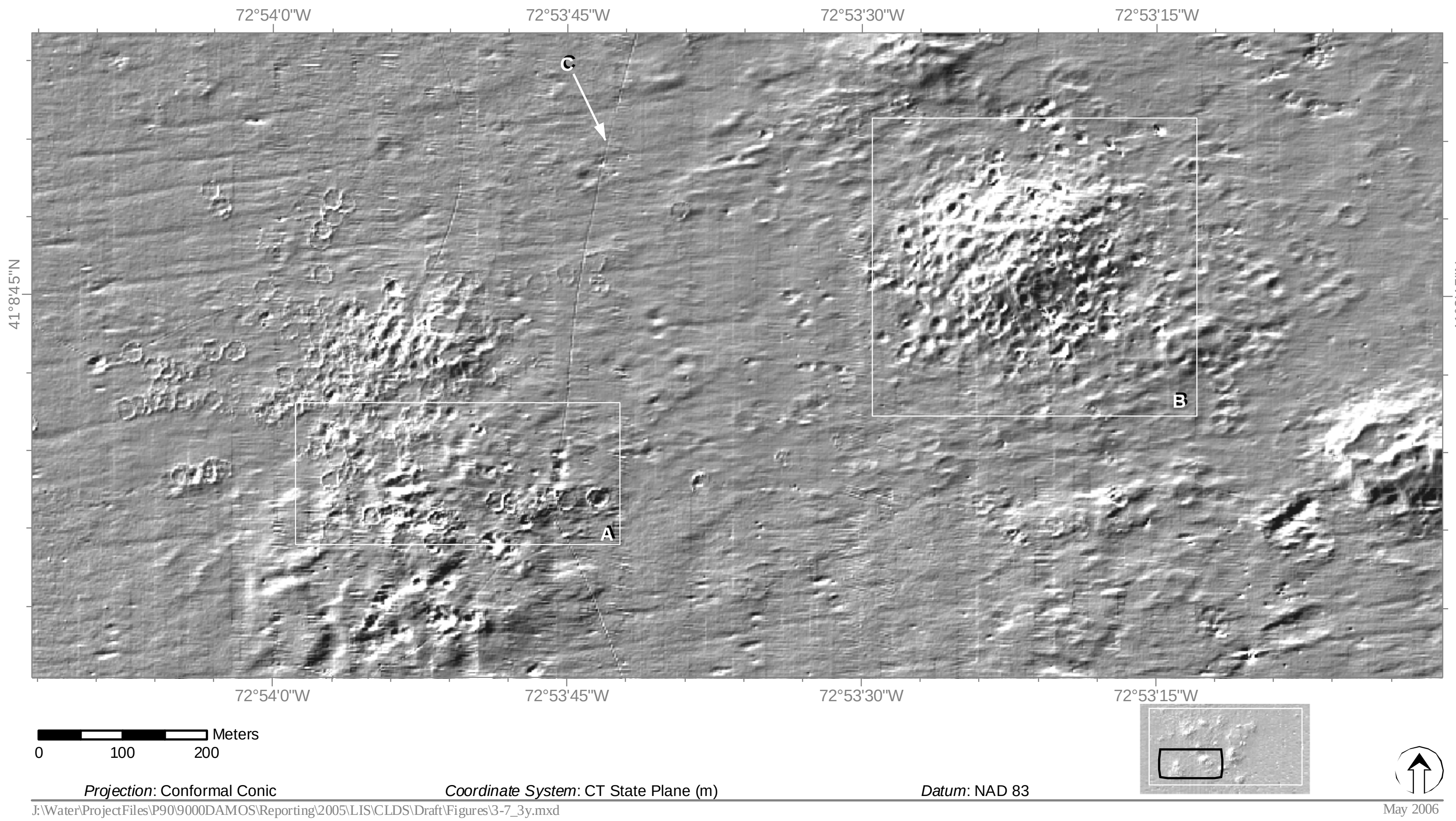


Figure 3-9. Rings from disposal activities on MQR Mound and CLIS 97/98 Mound Complex. A. Rings from recent disposal at MQR. B. Rings from historic disposals over seven years old at CLIS 97/98 Mound Complex. C. Linear scar or trace on seafloor.

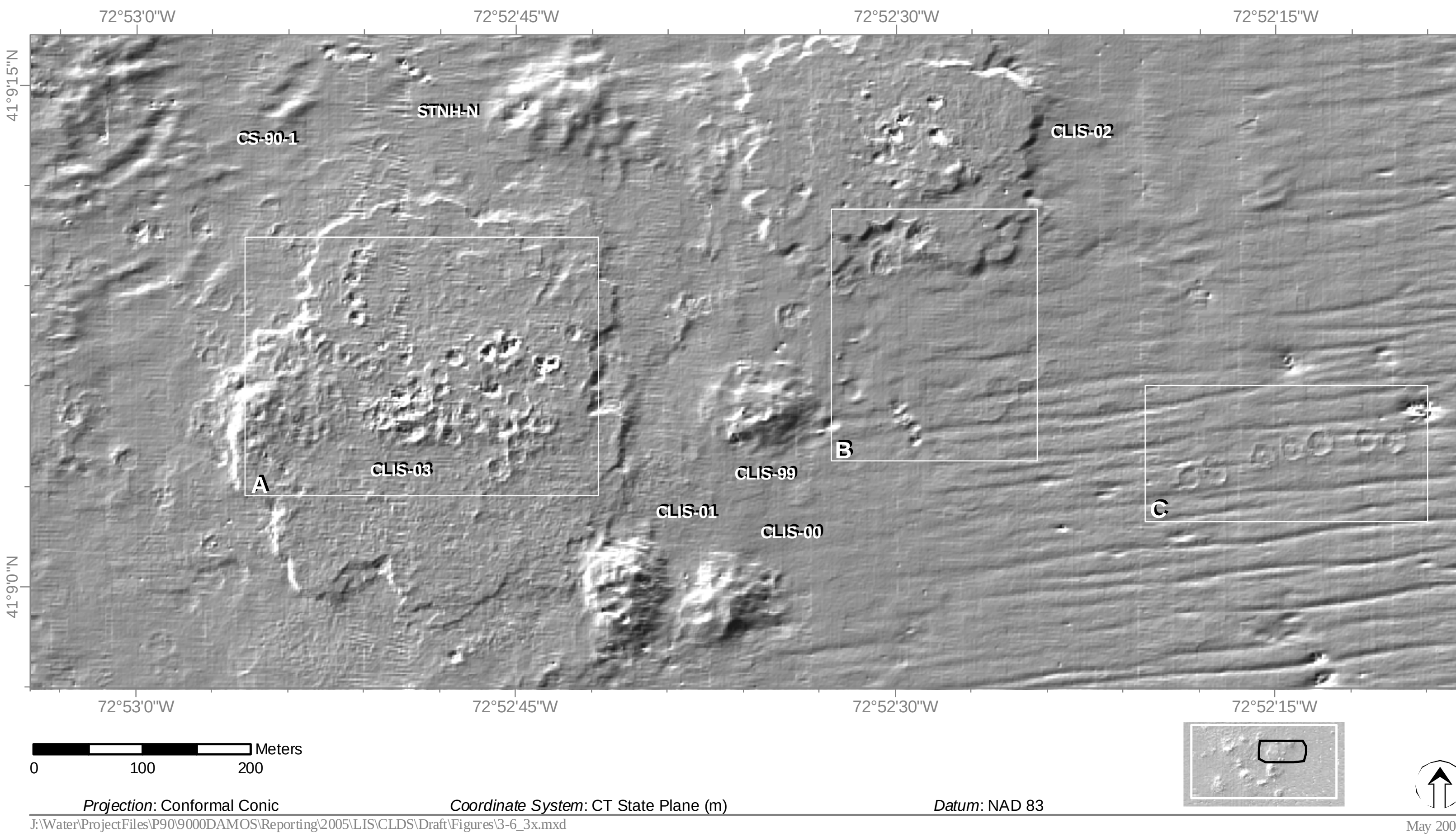


Figure 3-10. Examples of rings from disposal activities at CLDS. A. Recent disposal rings on CLIS 03, note sharp relief. B. Rings described in 2000 multi-beam survey, note soft relief and overlap. C. Rings in furrow area of eastern section of site, note soft relief, some with raised center and conformation to topographic relief.

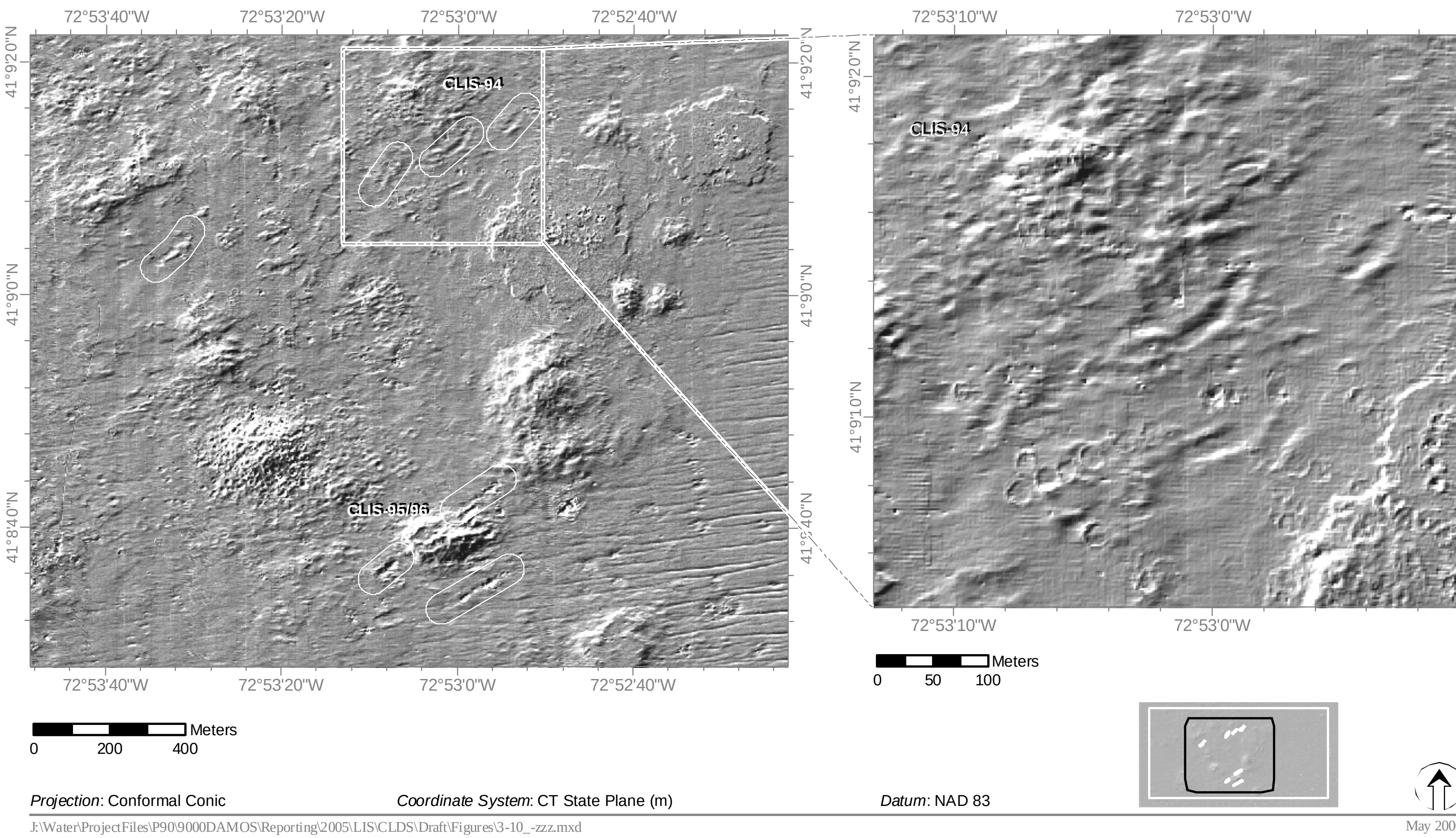


Figure 3-11. Linear depressions near the CLIS 95/96 Mounds apparently formed by a series of circular pits. The image on the left shows linear depressions oriented NE-SW marked by white boundaries. The image on the right is an enlargement of the area indicated on the left and shows the CLIS 94 Mound and a series of linear depressions.

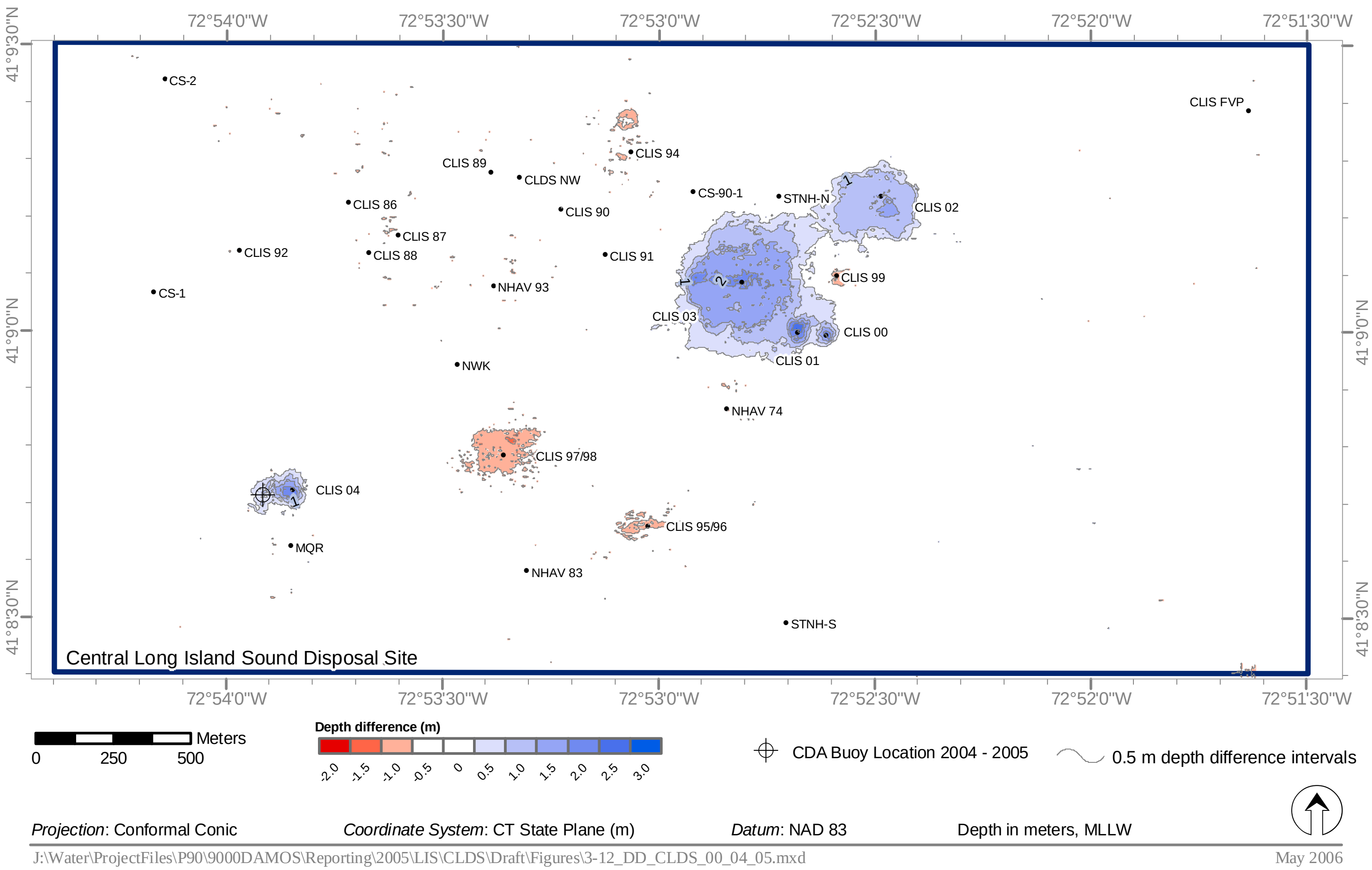


Figure 3-12. Depth difference contour map of CLDS survey area, September 2000 to July 2005 (0.5-m contour interval)

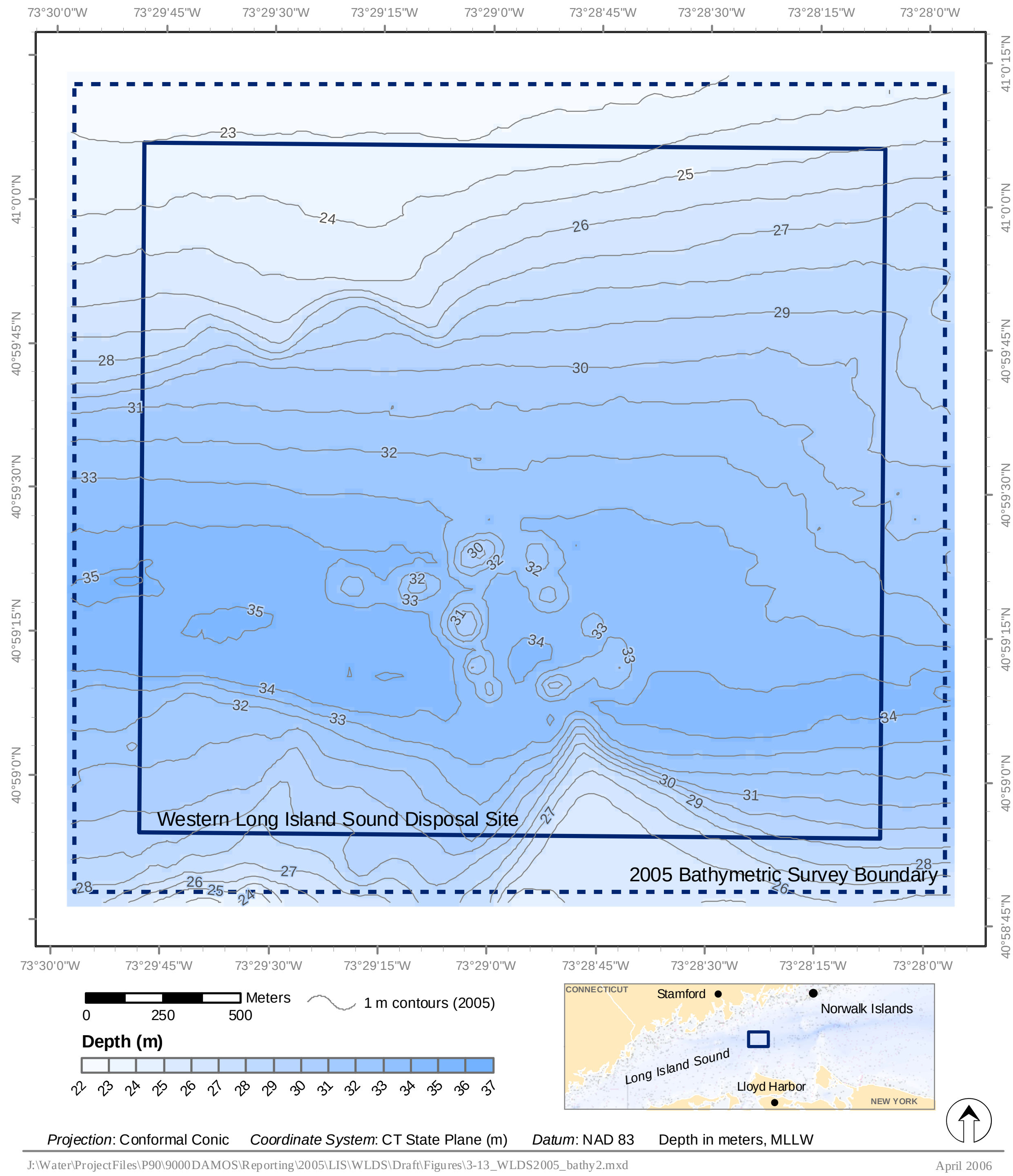


Figure 3-13. Bathymetric contour map of WLDS survey area with inset of Long Island Sound bathymetry locus, July 2005 (1-m contour interval)

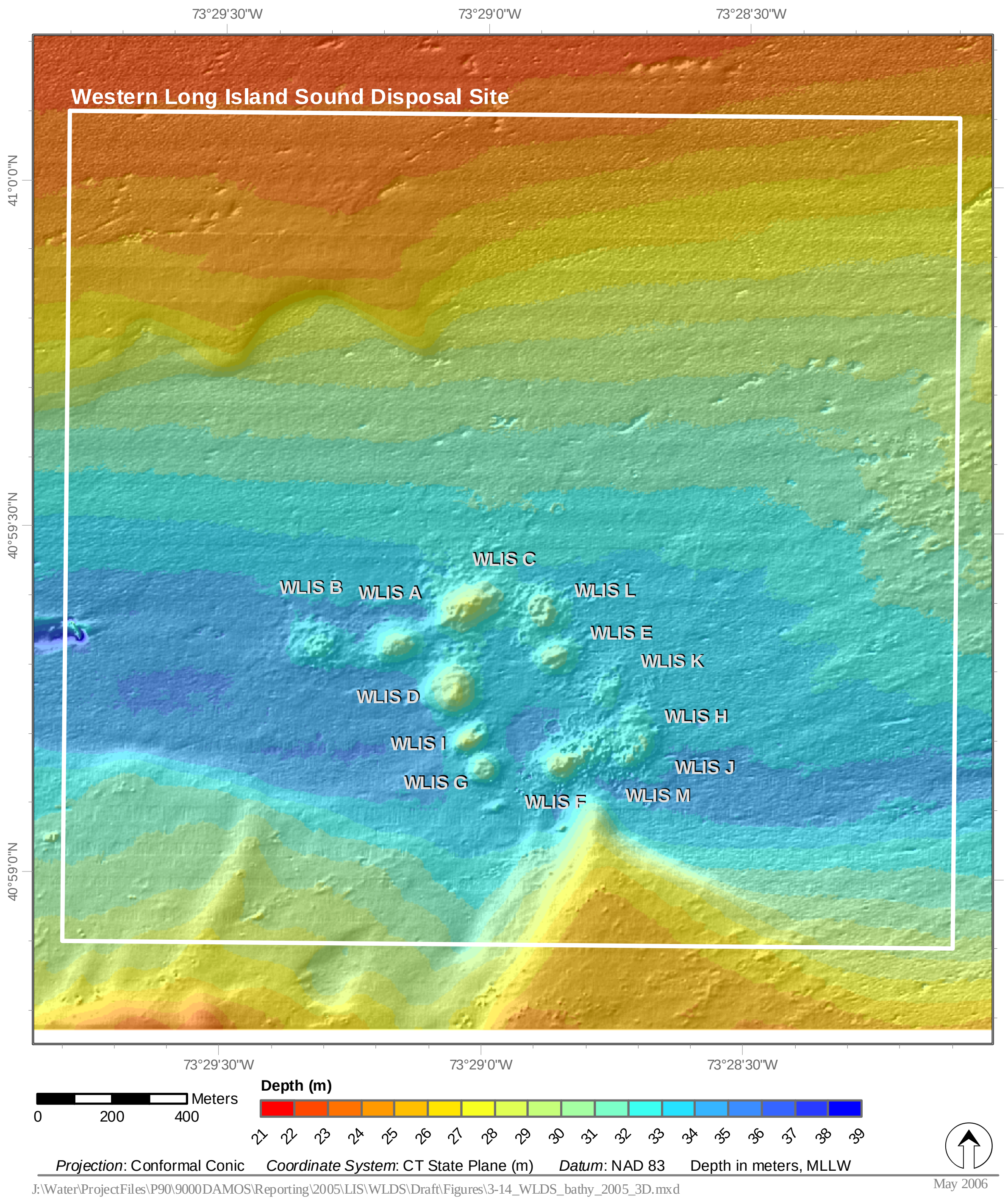


Figure 3-14. Bathymetric relief map of WLDS survey area, July 2005

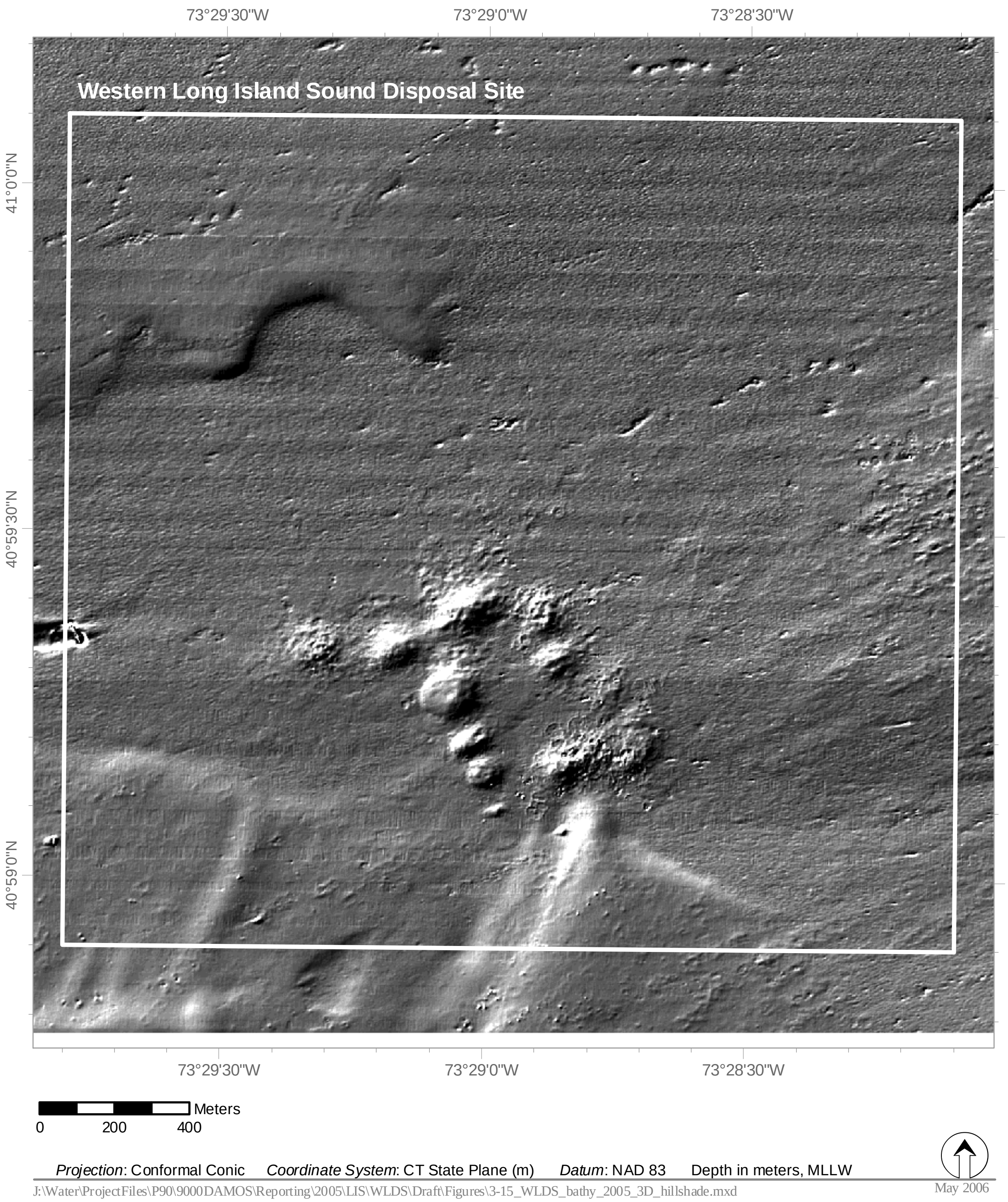


Figure 3-15. Multi-beam hillshade map of WLDS survey area, July 2005

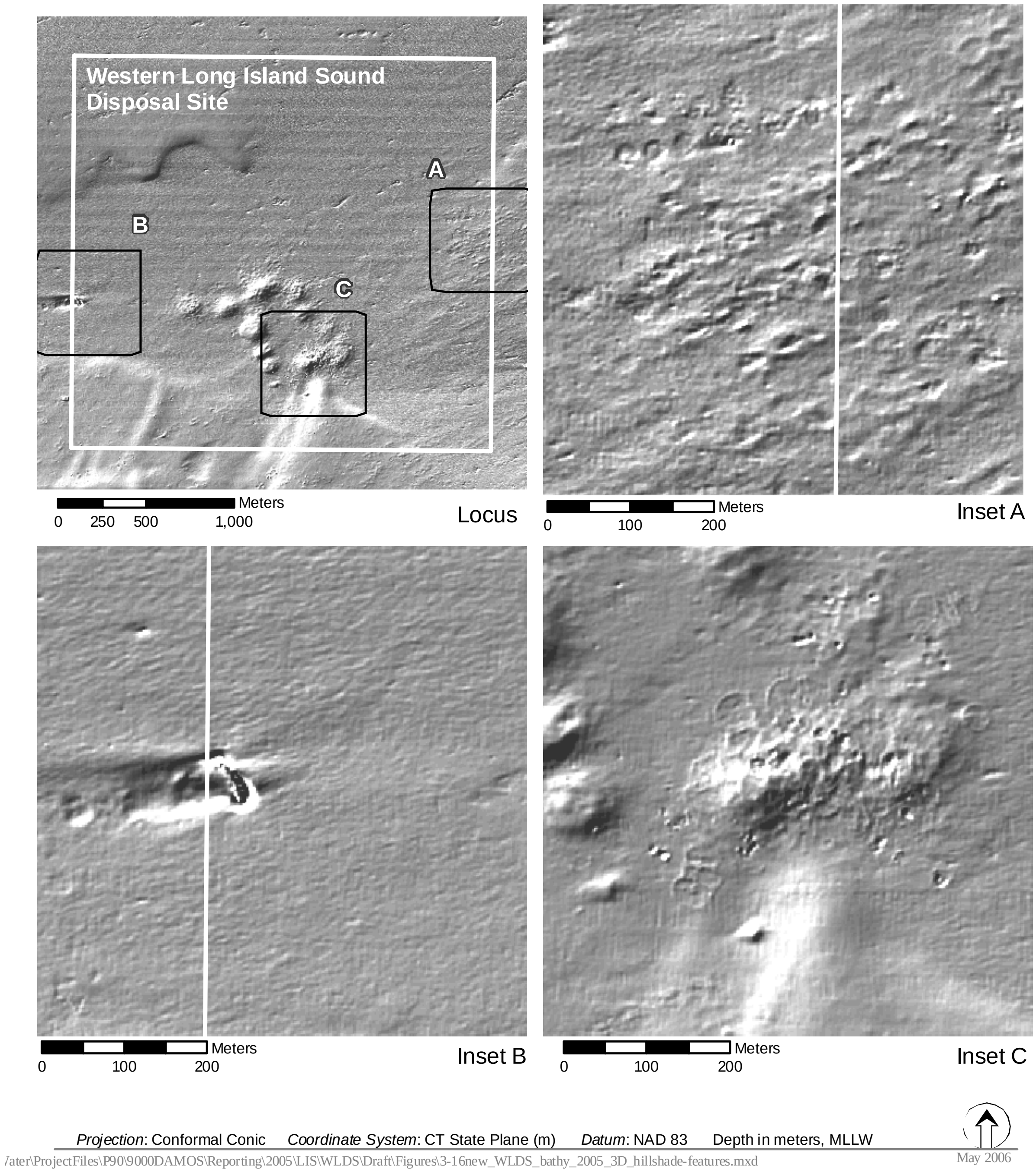


Figure 3-16. Multi-beam hillshade map of sedimentary features at WLDS. Inset A: historic ring features near Eaton's Neck oriented in the NE-SW direction, Inset B: protruding object and scour, Inset C: ring features from recent disposals at Mound M.

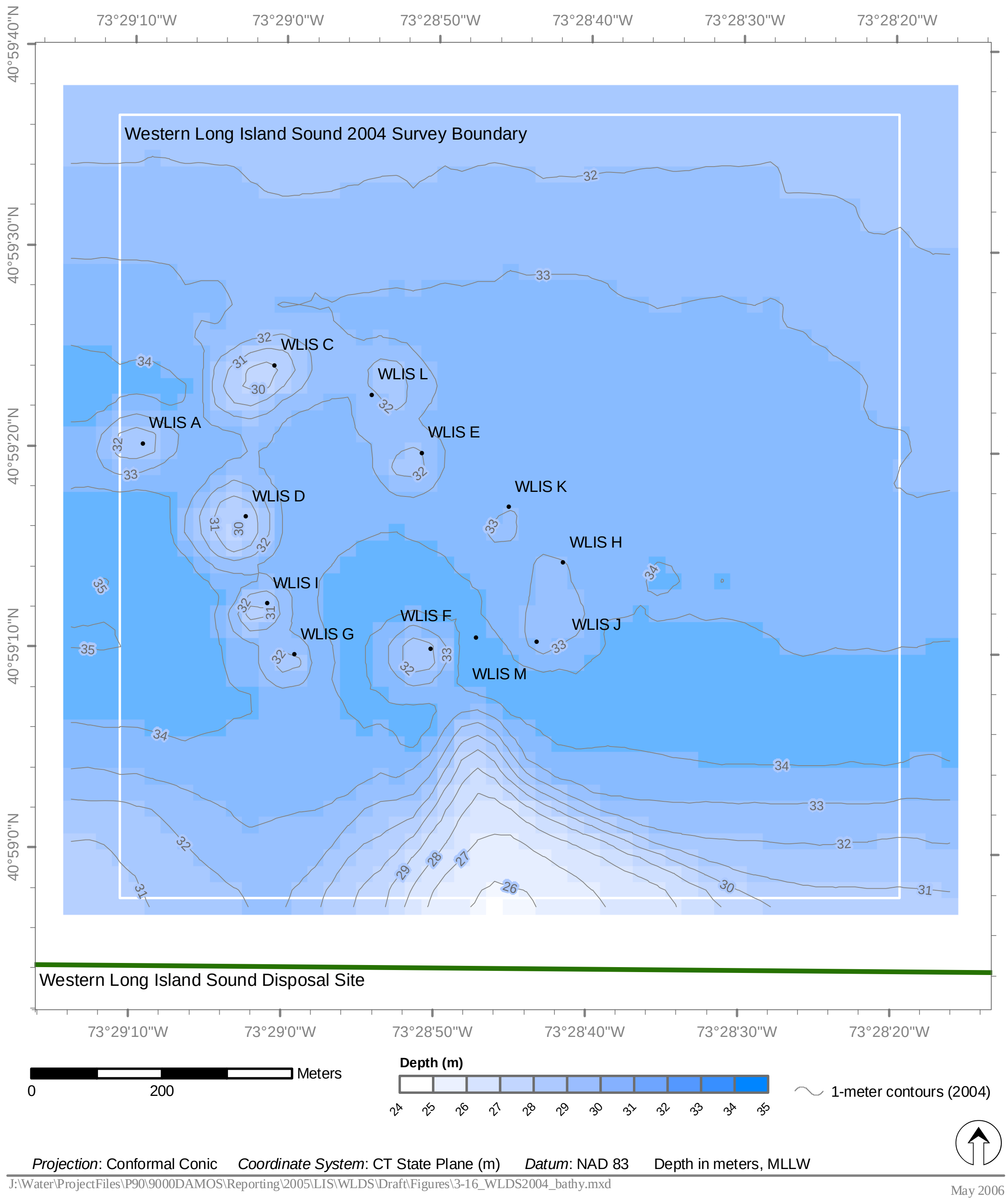


Figure 3-17. Bathymetric contour map of WLDS survey area, June 2004 (1-m contour interval)

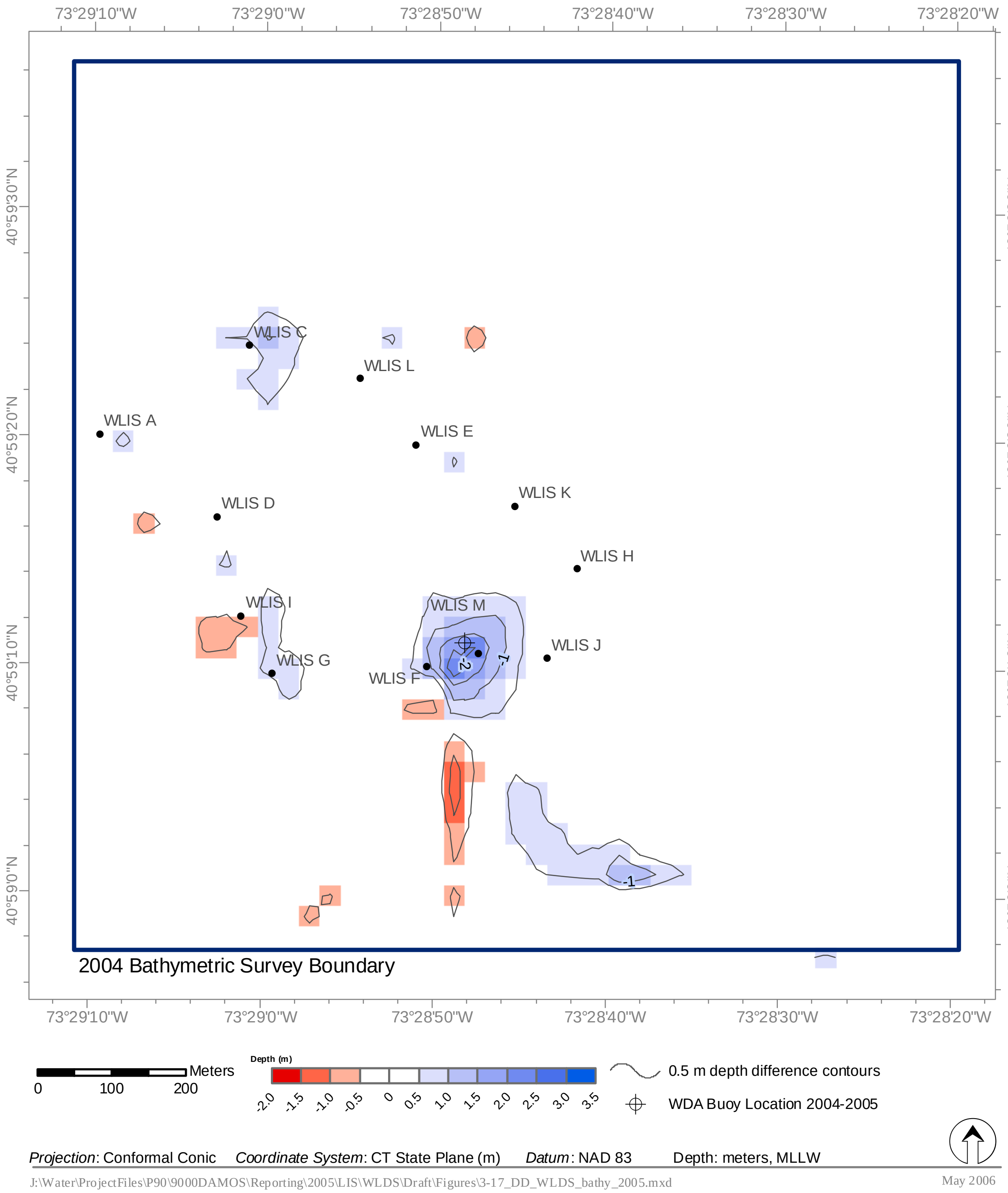


Figure 3-18. Depth difference contour map of WLDS survey area, June 2004 to July 2005 (0.5-m contour interval)

4.0 DISCUSSION

The objectives of the July 2005 surveys at CLDS and WLDS included characterization of the seafloor topography of the newly designated sites and documentation of dredged material distribution. These objectives were accomplished using multi-beam bathymetric survey techniques. The multi-beam imagery of CLDS and WLDS provided high-resolution bathymetric maps of the disposal sites. These maps revealed that measurable bathymetric change at each of the disposal sites can be attributed to placement of dredged material at specific locations within the sites. These results were consistent with the findings of previous DAMOS surveys and established new, comprehensive baseline maps for measuring future changes.

In addition to large-scale changes resulting from placement of dredged material, small topographic variations in the sediment surface (on the order of 10-cm) were apparent across the sites, on dredged material and ambient sediments. The high-resolution bathymetric survey revealed patterns in seafloor topography which can be interpreted to deduce mechanisms of sediment movement from natural forces and human activities not previously identifiable in single-beam survey data (Hughes Clarke et al. 1996). This level of detail in bathymetric data can be obtained from both multi-beam bathymetric surveys and acoustic backscatter data. Acoustic backscatter data measures the angle and relative "reflectiveness" of the acoustic energy off of the seafloor. Hard surfaces, steep microtopography, and coarse sediments have stronger returns than flat surfaces or soft sediments. Variations in backscatter reflectance can be visualized with a gray scale or inverted brown scale color scheme (ENSR 2004b). Through a combination of high-resolution bathymetry and analysis of backscatter it is possible to analyze sedimentary features in more detail and over a wider area than previously possible (Dartnell and Gardner 2004, Lockhart et al. 2002). Expressions of sedimentary features can be observed in only the backscatter or only the multi-beam data, or sometimes in both. The expression of features is a function of how the feature was formed, the sediment composition of the feature (when associated with sediment disposal), and the bottom composition surrounding the feature. A time-series of high-resolution bathymetric data provides a history of sedimentary features and can confirm the bottom stability of a location, an important factor in management of open water dredged material disposal sites.

Three highly detailed bathymetric data sets were available for analysis of CLDS bottom features: the 2005 multi-beam, the 2000 multi-beam (Figure 4-1), and a 1997 side-scan dataset (Figure 4-2) collected by the U.S. Geological Survey (USGS). The juxtaposition of these three images (1997 side-scan, 2000 and 2005 bathymetry) provided a time series that is invaluable in interpretation of the relative stability of bathymetric features (Figure 4-3). Numerous features, both natural and man-made, appear unchanged between each of the datasets (small differences in these images were likely due to differences in data type and processing methodology). A similar time-series of detailed bathymetric data was not available for WLDS, but similar sedimentary features were visible at both sites, and the structure, stability, and formation of the features at WLDS can be inferred from the interpretation of the CLDS datasets. Confirmation of these findings at WLDS will require additional high-resolution surveys in the future.

4.1 CLDS

4.1.1 Ambient Sedimentary Features

The long, linear sedimentary furrows observed at CLDS were first described in detail from 1997 side-scan data (Poppe et al. 1998), but were noted in early DAMOS side-scan surveys (Morton et al. 1984). The scale of the furrows (2 to 10 m wide and 0.4 m deep) made them difficult to detect with single-beam bathymetry or with processed multi-beam data when the dimensions of the gridded pixels are larger than a furrow width. Evidence of the furrows can be seen in the multi-beam data from 2000 and some of the previously presented contour maps (Figure 4-1; SAIC 2002b, Figures 3-1 and 3-2).

Recent publications suggested that the presence of certain sediment bed forms, specifically long (on the order of hundreds of meters), narrow (on average 10 m) and shallow (on average 0.5 m) furrows in fine-grained sediment could result from directionally-stable bottom currents flowing over the fine-grained sediments (Flood 1983, Dellapenna et al. 2001). Furrows of this type have been observed in a wide variety of depths and environments (Dellapenna et al. 2001). The presence of these features at CLDS could be an indication of intermittent sediment resuspension and dispersal in and near CLDS. However, comparison of furrow location, shape, and patterns between 1997, 2000, and 2005 demonstrated a remarkable persistence or stability of the furrows over eight years (Figure 4-3). The processes responsible for formation of the furrows were either not actively modifying these sedimentary features within this eight-year time frame, or not modifying them at a scale observable in the multi-beam bathymetric images.

Flood (1981 and 1983) observed sedimentary furrows under conditions dominated by sediment accretion (where deposition exceeds erosion) where erosional conditions are highly episodic. For example, in an estuarine setting in Southampton Water, England, where furrows similar to those at CLDS were observed, currents strong enough to mobilize sediments and create furrows were observed only 10% of the time, and depositional conditions occurred the remainder of the time. In the vicinity of CLDS, bottom currents are only episodically sufficient to erode sediments, however the typical currents are strong enough to transport sediments in the water column (Poppe et al. 2002). Poppe et al (2002) presented two mechanisms that may have caused the furrows in the non-erosional environment of north-central LIS. The first hypothesis is that resuspended nutclam shells lead to secondary helical flow patterns driven by tidal currents. This helical flow results in convergent flow zones, abrasion and scour, and subsequent furrow formation and elongation. The second mechanism suggests that turbulent wakes form depressions as water flows around disposal mounds, and the non-cohesive grains eroded from the disposal mounds cause abrasion of the depressions, resulting in the elongated furrows. Given that the furrows were typically not associated with disposal mounds or other visible bottom features on the seafloor, this mechanism seems less likely.

The presence of furrows in the region around CLDS may indicate that episodic resuspension occured in defined linear patterns, but does not necessarily indicate that substantive erosion of dredged material deposits has occurred or is expected to occur in the future. Under the DAMOS Program, detailed monitoring of the sediment-water interface at CLDS and WLDS before, during, and after placement of dredged materials does not support a conclusion of systematic dispersion of substantial amounts of sediment, even during major storm disturbances. Data from precision single-beam and multi-beam bathymetric surveys have documented stable volumes of dredged material at the active disposal sites. Moreover, sediment-profile imaging (SPI) surveys have documented a stable interface of biologically mixed sediment across these disposal mounds. Erosion of surface material has been observed during hurricanes (on the order of 5 to 10 cm) but did not result in substantial changes to the mounds (Parker and Revelas 1988). While the recent multi-beam and side-scan sonar surveys revealed the presence of longitudinal sedimentary furrows eastward of the active disposal mounds in an area dotted with individual barge deposits placed prior to 1979, most of the furrows are not associated with disposal mounds (Poppe et al. 2002).

In addition to the DAMOS monitoring surveys, the physical stability of the sediments at CLDS were investigated through direct measurement of near-bottom currents, modeling of sediment transport, and review of monitoring results developed over the past 27 years (USACE 2004). The study results were consistent with conclusions drawn by others that the region in the area of CLDS is “a long-term depositional area characterized by fine-grained, cohesive sediments and relatively weak bottom currents" (Poppe et al. 2002) that are also exposed intermittently to higher currents. Although it is clear from these studies that episodic conditions (e.g., when spring tidal currents are amplified by wind events) can result in resuspension and transport of small amounts of fine-grained sediments, there is strong evidence from more than 25 years of mound-building and monitoring at CLDS and WLDS that disposal mounds are stable over many years.

4.1.2 Dredged Material Disposal Traces

Sedimentary features in varying forms of rings and pits that were observed at CLDS in the high-resolution bathymetric and backscatter data were all interpreted as traces of dredged material disposal. The form of the features provided insight into the causal mechanism; the persistence of the features in the sequential data sets indicated stability of these features over the eight-year time period between 1997 and 2005.

The ring features observed at CLDS appeared as circular patterns of backscatter found over ambient sediment and circular patterns of topography found throughout the site (Types I and II Table 4-1). Circular ring-like features have been observed at many dredged material disposal sites in high-resolution bathymetry, side-scan, and backscatter data (Valentine et al. 1996, Valentine et al. 1998, Torresan and Gardner 2000). High backscatter subcircular markings (10 to 100 m in diameter) without topographic expression have been described from the Massachusetts Bay Disposal Site (MBDS, Valentine et al. 1998) and were identified as individual deposits of dredged material. The relatively large diameter rings are consistent with observed single barge disposal footprints in the water depth at this site (90 m). Similar high backscatter circular deposits were described from the South O'ahu Disposal Site in Mamala Bay, Hawaii (Torresan and Gardner 2000). These deposits exceed 100 m in diameter due to deposition in water depths ranging from 100 to 500 m. The rings at CLDS were smaller (10 to 50 m in diameter, consistent with the shallower water of CLDS) but otherwise matched the characteristics of the rings observed at MBDS.

The size and form of ring-like features resulting from dredged material disposal is a function of disposal operation (e.g., barge type, barge volume), dredged material characteristics (e.g., sand, silty sand, soft mud), and seafloor characteristics. Disposal from a bottom dump scow, hopper barge, or pocket barge descends as a coherent bolus of material which impacts the bottom, flattens out, and spreads as a surge of material. Depending on the size fraction and consolidation of the dredged material, the surge may extend out 50 to 100 m from the impact point in this water depth of 18 to 22 m (SAIC 2003a). If the material is very coarse, the resultant pile will have no surge front and may not look particularly circular. If the material is less coarse, the surge front eventually loses kinetic energy and comes to rest as a circular ridge some distance from the impact center (Type II in Table 4-1). This ridge might be 1 to 15 cm high. With very fine material, the deposit may have a backscatter signature, but no topographic expression on the seafloor. At much greater disposal depths (e.g., 90 m at MBDS and O'ahu at 500 m), the circular patterns of backscatter may have no detectable topography, and fine material extending in rays from the rim has been observed surrounding some disposal rings. After disposal, the deposited material consolidates and may flatten further or may be deformed by additional deposition. One particularly diagnostic attribute of the recent disposal mounds at CLDS was that their margins were marked by flat lobate outlines formed by overlapping circular deposits (Figure 3-5).

When dredged material is deposited on relatively unconsolidated sediments (such as fresh dredged material), the impact can create a depression or impact crater and the surge front must move up a slope and may extend a shorter distance without the distinctive rim formation. Disposal on fresh dredged material may also cause consolidation of the underlying material and result in a smooth depression. Many of the recent disposal mounds (and some of the older mounds) were marked by clusters of circular depressions. The side-scan record distinguished some of these, but the overlapping accumulations of fresh material were more distinct as circular traces in the multi-beam image (compare CLIS 95/96 in Figure 3-11 with Figure 4-4). Dredged material deposited on more consolidated sediments or hard ambient bottom can result in ring-like features with a rim but no central depression (Type I in Table 4-1). In addition to sediment type, the age of the deposited material appeared to affect the topography of the rings. There was an apparent progression of relative sharpness of relief related to the presumed age of the deposit and possibly sediment type (based on disposal records), where older rings had softer relief than more recent rings.

The series of circular depressions that were observed to form linear features 10 to 20 m wide were interpreted as deposition from hopper or pocket barges, based on their size and orientation (Type III in Table 4-1). Hopper or pocket barges approached the disposal site and released dredged material from a series of pockets on the barge, resulting in a tightly clustered sequence of individual disposal events. The barge may have been stationary or moving slowly towards the disposal coordinates, resulting in the closely-spaced deposits. These linear depressions, oriented NE-SW, occurred around CLIS 94, CLIS 95/96, and in the center of NHAV 93. The orientation of the linear depressions may relate to the transit direction of hopper barges coming from New Haven Harbor or harbors to the east. When the barge had completed disposal and began its transit back to the harbor, small amounts of material may have washed out of the barge, evidenced by a distinctive trace on the seafloor with no detectable topography (inset Figure 4-4).

The 2005 multi-beam data revealed a series of small subcircular pits, individual and clustered in linear arrays. Poppe et al. (2000) observed that these features were intersected by sedimentary furrows and described them as "dredge spoil mounds". The pits appeared in the side-scan data as high backscatter areas surrounded by low backscatter haloes, consistent with some type of disposal trace (Type IV in Table 4-1). However, the pits did not exhibit a corresponding topographic expression in the side-scan records. Without the benefit of the multi-beam bathymetry data, the pits were interpreted as mounds based on the backscatter images alone. An overlay of the two data sets demonstrated that the pits in the multi-beam data are congruent with the high backscatter traces in the side-scan image (Figures 4-3, 4-5, 4-7). It is not clear if the high backscatter observed in the side-scan record is solely from the reflective sides of the pits or if it indicated the presence of coarser material. A cross-section of the multi-beam data demonstrated that these pits have a profile consistent with dredged material disposal impact craters seen at a variety of scales and environments (Figure 4-6, Melosh 1989). The profile B-B´ (Figure 4-6) shows the scale of the furrows and three pits. The first pit had an incised margin 1 m below the ambient seafloor and a central mound 0.5 m high. The backscatter record showed a halo of low backscatter material around this pit, high backscatter in the pit and a small circle of low backscatter in the center of the low mound (Figure 4-5).

The pits oriented N-S and observed in the region of the furrows were interpreted as impact craters formed by the deposition of coarse deposits of dredged material dropped from pocket or hopper barges. After impact, the fine sediment resuspended by the impact was deposited in a halo around the pit. The rock, clay, or rubble formed a small knob or pile within the pit and the fine sediment eroded around it, smoothing the outline of the pits. When the pits were intersected by furrows, the pits eroded at either end into the furrow. The persistence and stability of the furrows and their interaction with these pits suggest very old disposal activity and episodic mobilization of the fine ambient sediment around the pits.

4.1.3 Physical Features Associated with Non-dredging Activities

Long, linear grooves traces or scars observed on the seafloor were likely caused by trawl doors or anchors. Shallower grooves such as the long one around MQR did not show in the 1997 backscatter or 2000 bathymetry and might be a more recent trawl mark or a barge tow cable. The 2000 multi-beam data showed a separate curving trace near

MQR (Figure 4-1), and another similar mark is visible in the 1997 side-scan but not in the 2005 bathymetry (Figure 3-4), suggesting that these traces were transient and short-lived.

Several traces appeared in the 2005 multi-beam data that were not detectable in the 1997 or 2000 data (Figures 3-8, inset and 4-7). These linear traces were likely the result of fixed or relic fishing gear of some kind. Most of these traces were oriented N-S (although one trace was E-W) and several "nodes" (7 to 10) were observed sparsely spaced along their length (250 m). Although these features could be interpreted as lobster trawls, it seemed unlikely as most lobster trawls placed in central LIS are oriented parallel to the predominant current (E-W), and the traps would typically be placed closer together than these nodes. An earlier side-scan survey performed in western LIS (SAIC 1999) identified lobster traps placed as close as 10 m apart. Several of these linear features clearly showed a looped and overlapping trace consistent with a tangled line or wire. Along some of these traces, there were apparent shallow depressions or scars in the seafloor. However, the images could be the result of interference in the multi-beam signal from floating and weighted lines. Floating lines might be moved E-W in the current creating the paired symmetrical linear features seen in some traces.

4.1.4 Dredged Material Distribution

Comparison of multi-beam depth data from 2000 and 2005 revealed that all of the mounds formed prior to 2000 were virtually unchanged in surface texture and profile with the exception of CLIS 95/96 and CLIS 97/98. Disposal activities since 2000 have created new mounds (CLIS 01, 02, 03, 04), some of which have coalesced with older mounds to form larger mound complexes.

The apparent depth difference over CLIS 97/98 between 2000 and 2005 suggested a reduction in the overall height of the mound by about 0.5 m with very little change in the surface features (Figure 3-12). The center of the mound seemed to have a smooth depression and some smoothing of surface features (compare Figure 3-9B with Figure 3-2 in SAIC 2002b). The 2000 survey occurred a few years after the formation of this relatively steep mound, and consolidation may account for this change in profile. Data capture and processing techniques, which change over time and are complicated by steep bathymetry, may also contribute to the mapped depth differences.

The CLIS 95/96 Mound had a distinctive depression in the center that coincided with the largest area of depth difference (compare Figures 3-7 and 3-12). This depression seemed more pronounced in the 2005 data than in the 2000 data. However, some suggestion of this feature also appeared in 1997 side-scan image. If consolidation had occurred at this location, it seemed to be continuing a pattern first discernable in 1997. Again, the apparent consolidation may have also been an artifact of resolving steep bathymetry during the survey and changes in processing techniques.

The MQR Mound received two phases of disposal after formation of the original mound. In 1993-94 material from the NHAV 93 capping project was deposited over the mound. These deposits still showed circular ring features but did not change in profile between 2000 and 2005 (Figure 4-1 and Figure 3-9A). The 2003-05 deposits formed a small mound, CLIS 04, to the north of MQR also marked by circular deposits but with a distinct decrease in depth between 2000 and 2005 (Figures 3-12 and 4-8).

4.2 WLDS

Historically, WLDS has been studied in much less detail than CLDS. A detailed historic record of the entire site including multi-beam and side-scan sonar data is not available. The nearest USGS published side-scan data is from Norwalk (Twichell et al., 1997). Previous DAMOS surveys include numerous single-beam bathymetric surveys and “spot” surveys with side-scan (SAIC 1999), but no comprehensive surveys with the resolution and backscatter required to provide a time-series analysis. Despite the limited historical data at WLDS, the sedimentary features observed at WLDS in 2005 can be interpreted based on the analysis of the time-series data at CLDS.

4.2.1 Sedimentary Features

Ring-like features, similar to those observed at CLDS, were the dominant sedimentary feature observed at WLDS. The ring-like features at WLDS were interpreted as disposal impact craters and associated surge deposits, as described above. The ring-like features had sharper relief around the more recent disposal mounds (e.g., WLIS J and WLIS M), and softer relief around the older disposal mounds (e.g., WLIS A and WLIS C) (Figures 3-14 and 3-15).

Lines of rings oriented NE-SW, located in the northeastern quadrant of WLDS were likely historical dredged material deposits from Eaton’s Neck Disposal Area, located to the east of WLDS (Figure 3-16 Inset A and Figure 4-9). Traces of historic disposal activity were previously identified to the east of WLDS boundary in a side-scan survey performed to evaluate potential reference areas (SAIC 1999). The Eaton’s Neck Disposal Area has not been used for dredged material disposal since 1977, therefore the ring-like sedimentary features were likely formed over 30 years ago. The object that appeared as sharp relief along the western edge of the WLDS boundary was believed to be a sunken disposal barge (Figure 3-16 Inset B).

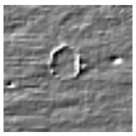
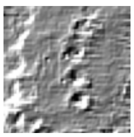
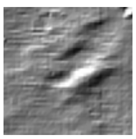
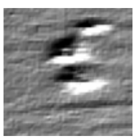
The long, linear furrows dominating the eastern portion of CLDS were not observed in the 2005 survey data at WLDS. Sedimentary furrows have been mapped in several distinct areas in the Long Island Sound (Poppe et al. 2001, 2005, 2006b) and are best developed in two longitudinal areas in the central Sound. Well developed furrows have been observed in areas with recurring, directionally stable, and occasionally strong currents (Dyer 1970, Lonsdale et al. 1973, Hollister et al. 1974, Flood 1983). Furrows are not present in areas where sediments are even slightly coarser than those in the central Sound or with slightly higher energy levels (Poppe et al. 2006b). Furrows are not present in the Bridgeport area or near the Stratford Shoal (Beaulieu et al. 2005, Poppe et al. 2006a, Twichell et al. 1997). The lack of furrows in the vicinity of WLDS may reflect the more complex topography and lack of directionally stable currents more than a distinct grain size difference. The presence of shoal areas surrounding the disposal site may contribute to variations in current direction and intensity influenced by wind and density effects (USEPA 2001).

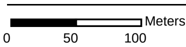
The origin of the faint linear markings observed to the north-northeast of the disposal mounds (Figure 4-10) is unknown. One of these linear features was about 400 m in length and about 10 m in width, and the other feature was a similar width but about 1200 m in length. The linear markings converged at the northern end of the shorter feature. These linear features were oriented in NE-SW directions roughly perpendicular to the survey tracklines. The orientation of the features suggest that they were not artifacts of multi-beam data collection processes. Collection of acoustic backscatter data from a side-scan sonar survey would be useful to determine the causative mechanism of these features. Possible origins include trace disposal by barges returning to the harbor of origin or fishery activities.

4.2.2 Dredged Material Distribution

At WLDS, a new mound, WLIS M, was observed approximately 60 m northeast of WLIS F Mound and 120 m northwest WLIS J Mound. The relatively small mound was formed primarily from the disposal of approximately 78,500 m^3 of material during the 2004-2005 disposal season. The new mound has merged with adjacent mounds, forming the WLIS H/J/M mound complex.

Table 4-1.
Circular Disposal Features Identified in Multi-beam and Side-scan Data from CLDS.

Image	Type	Location	High Backscatter	Depression	Rim	String[a]	Orientation
	I	Mound/ Ambient	Yes	No	Yes	Both	None
	II	Mound	No	Yes	Yes	No	None
	III	Mound	No	Yes	No	Yes	Some NE-SW
	IV	Ambient	In center, low halo outside	Yes	No	Yes	N-S



a. String refers to whether or not the feature may occur in a series or a linear string as a result of an individual disposal event.

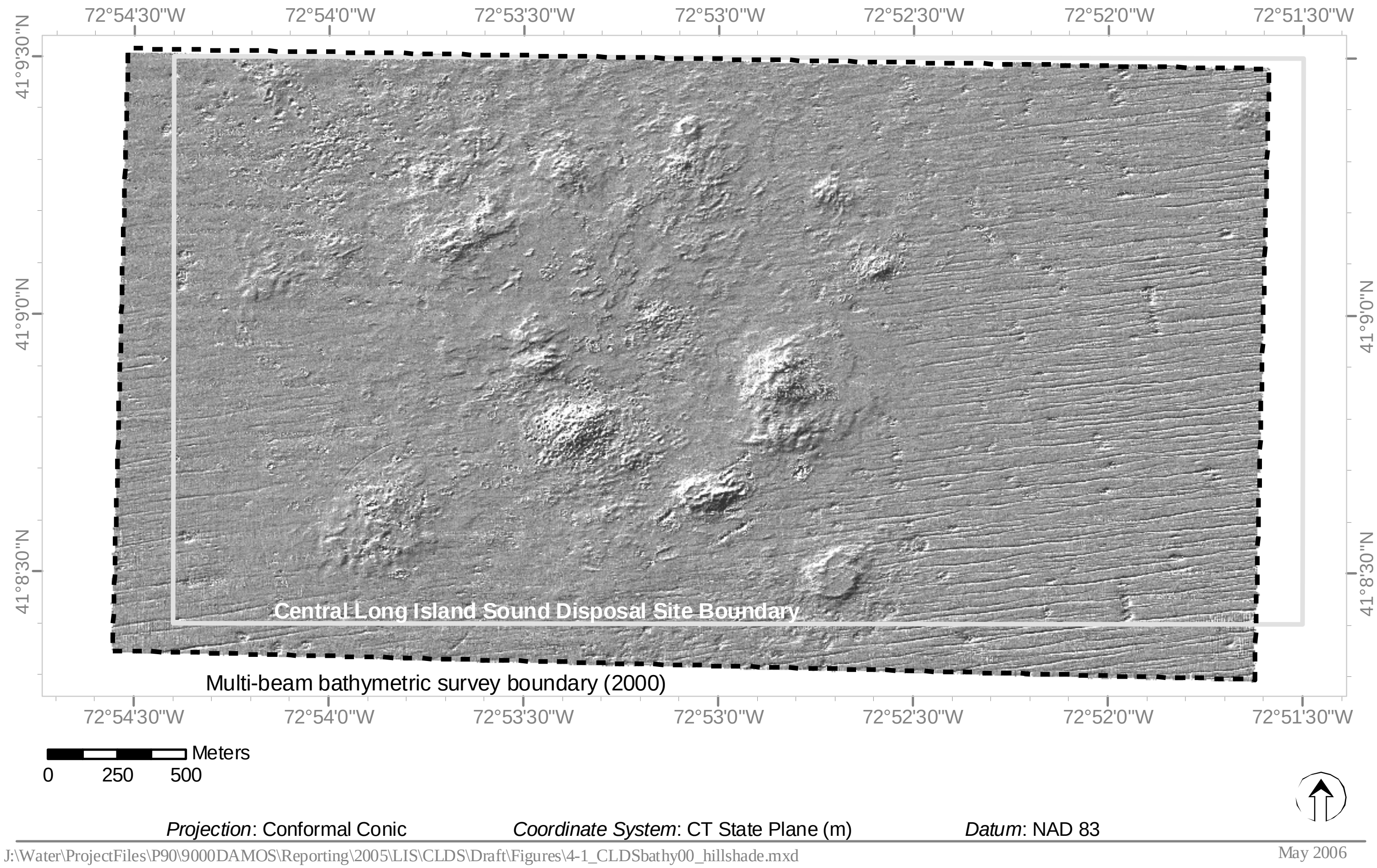


Figure 4-1. Multi-beam bathymetric data from 2000 survey. Hillshaded to compare with 2005 data.

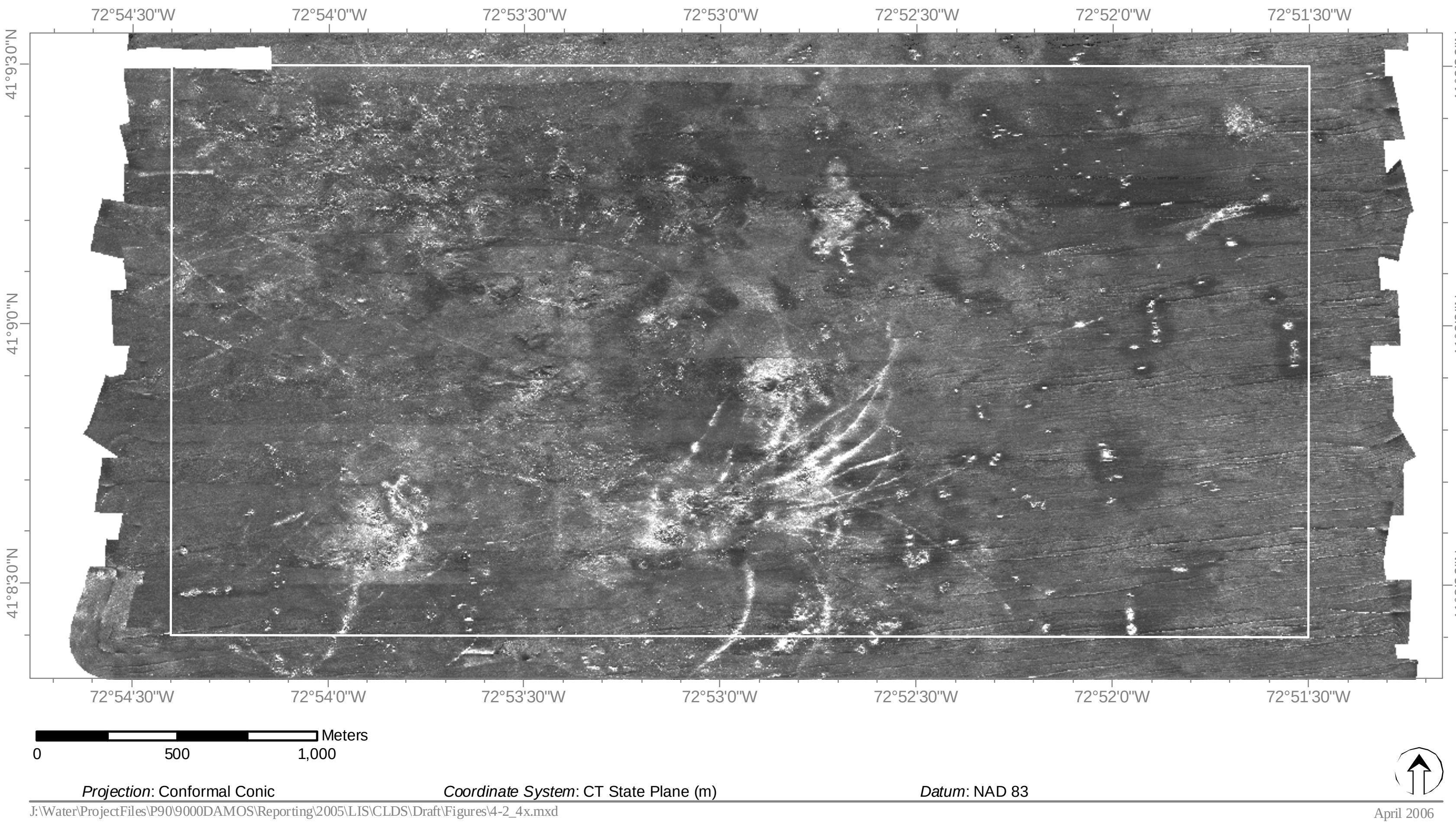


Figure 4-2. U.S. Geological Survey (USGS) side-scan mosaic from 1997 survey. Reprojected to Conformal Conic, CT State Plane, NAD 83 Datum. Histogram stretched from original raster grid to emphasize high backscatter results. Data from Poppe et al. 2000.

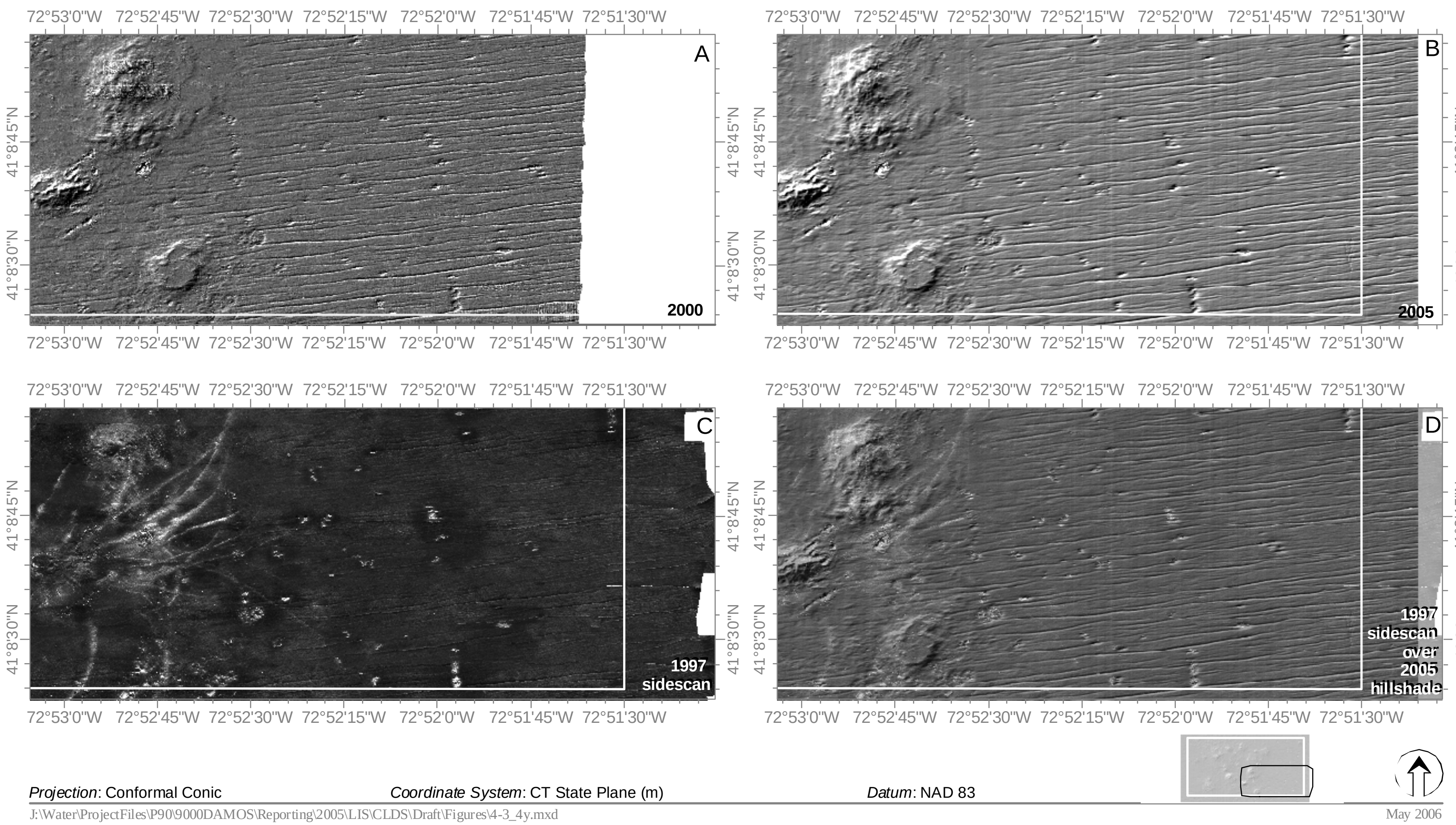


Figure 4-3. CLDS survey data. A. Hillshade multi-beam data from 2000. B. Multi-beam data from 2005. C. Side-scan data from USGS 1997 (Poppe et al. 2000). D. Side-scan data from 1997 draped over 2005 hillshaded multi-beam bathymetry.

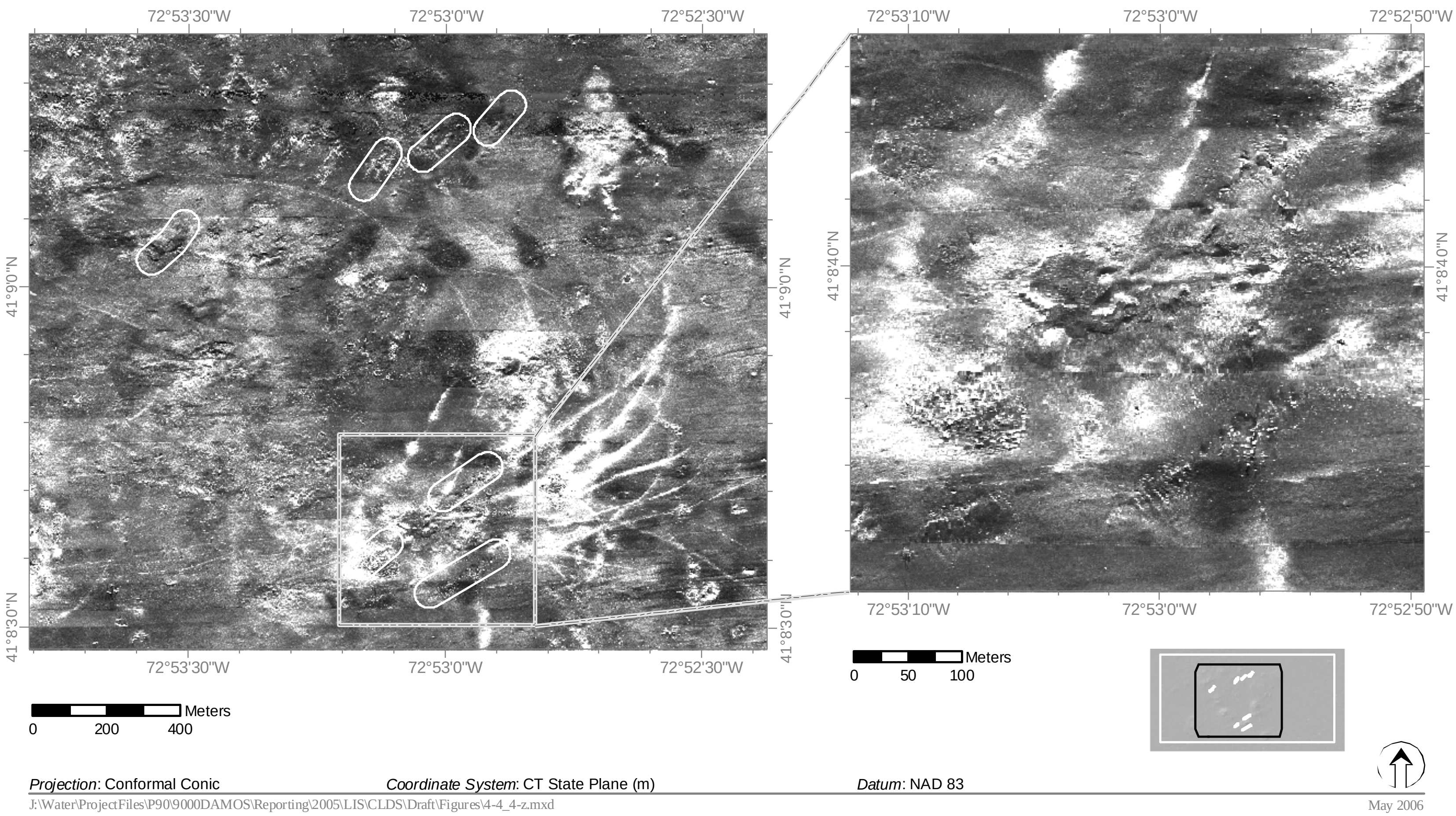


Figure 4-4. USGS side-scan detail. Left image shows linear depressions apparently formed by a series of circular pits marked by white outlines (compare to Figure 3-10). Note trails of high backscatter interpreted to be dredged material disposal traces. Rectangle denotes area of enlargement shown on the right. Note correspondence of high backscatter trails and surface disturbance as well as series of circular pits across top of mound.

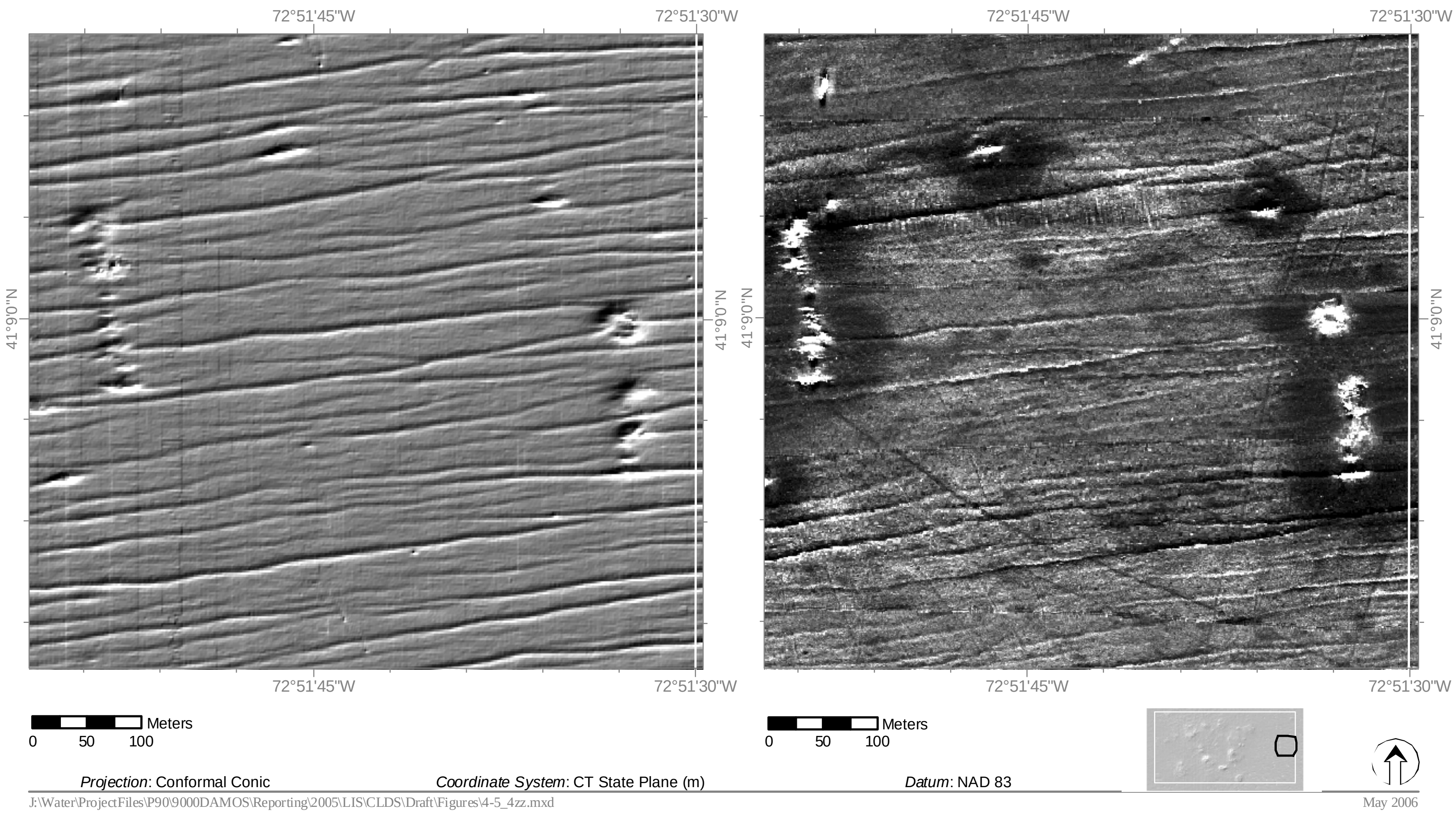


Figure 4-5. Pits and sedimentary furrows in eastern margin of CLDS. The image on the left shows the 2005 hillshaded multi-beam record with two linear arrays of pits. The image on the right shows the USGS 1997 side-scan record draped over the 2005 multi-beam data. Note haloes of low backscatter around pits and correspondence of furrow size and orientation between surveys.

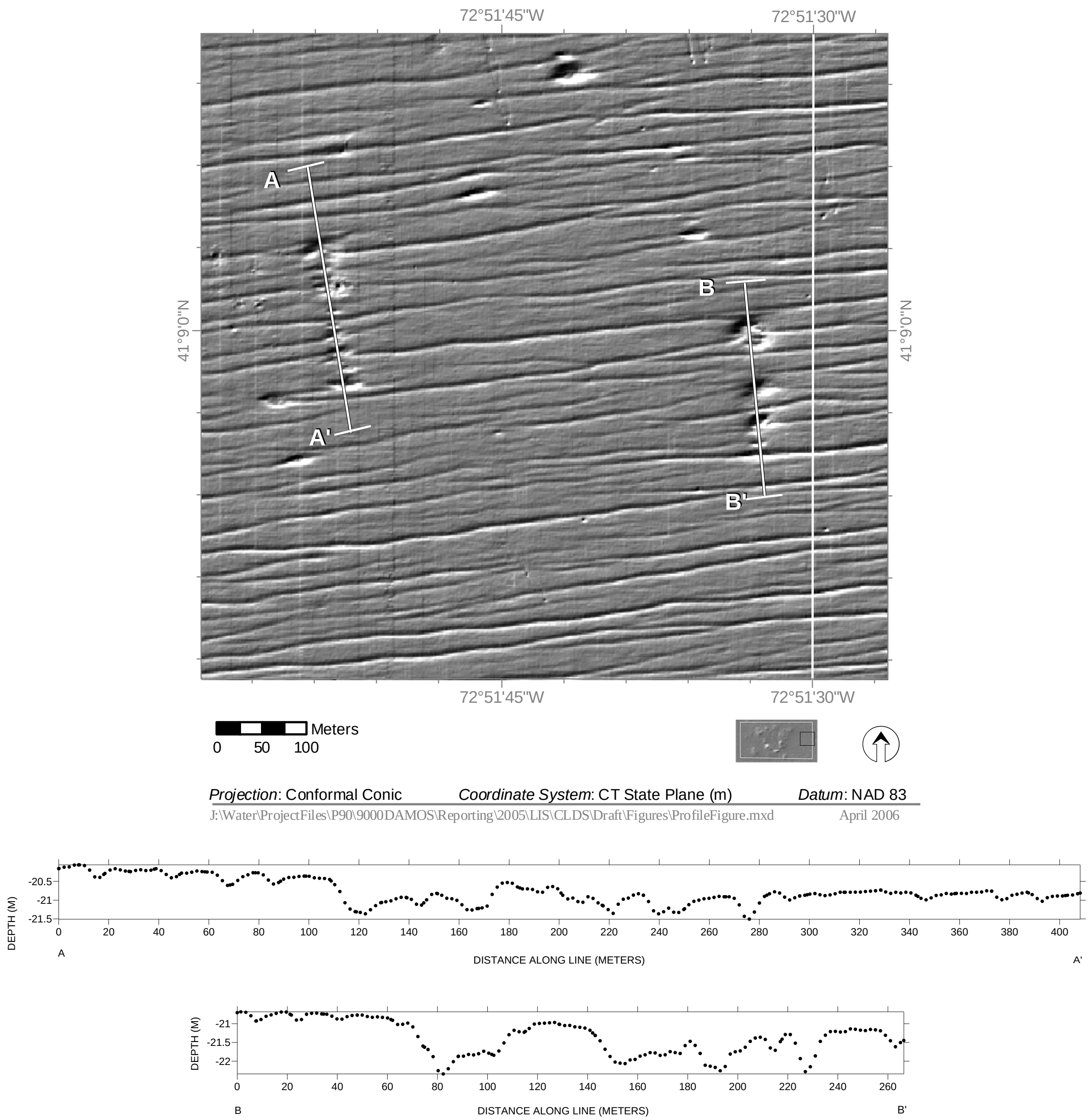


Figure 4-6. Close up and cross-sectional depth profiles of apparent impact craters in eastern CLDS (See Figure 4-5)

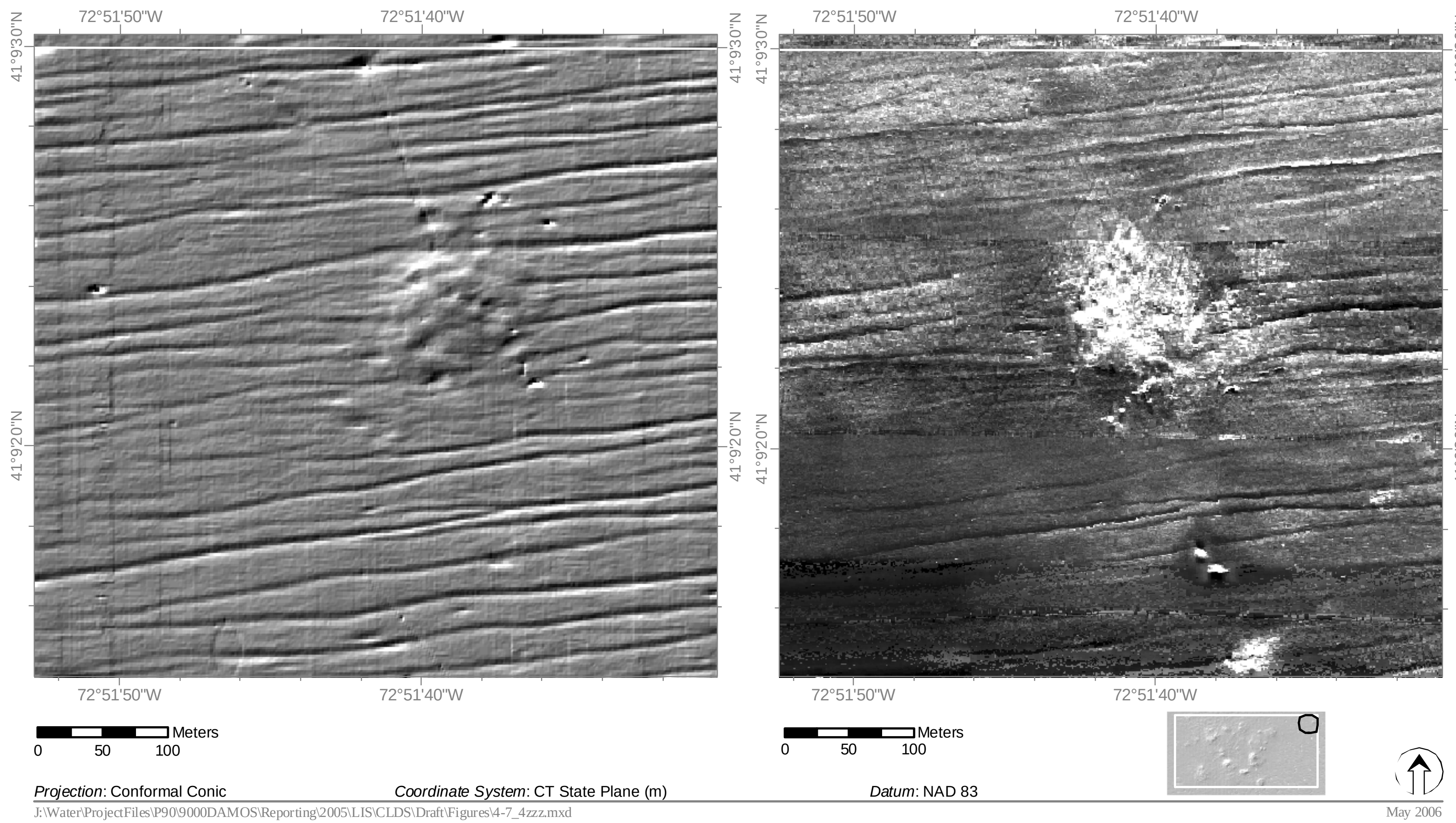


Figure 4-7. FVP Mound in northeastern corner of CLDS. The image on the left shows hillshaded 2005 multi-beam data. The image on the right shows the USGS 1997 side-scan data draped over 2005 bathymetry.

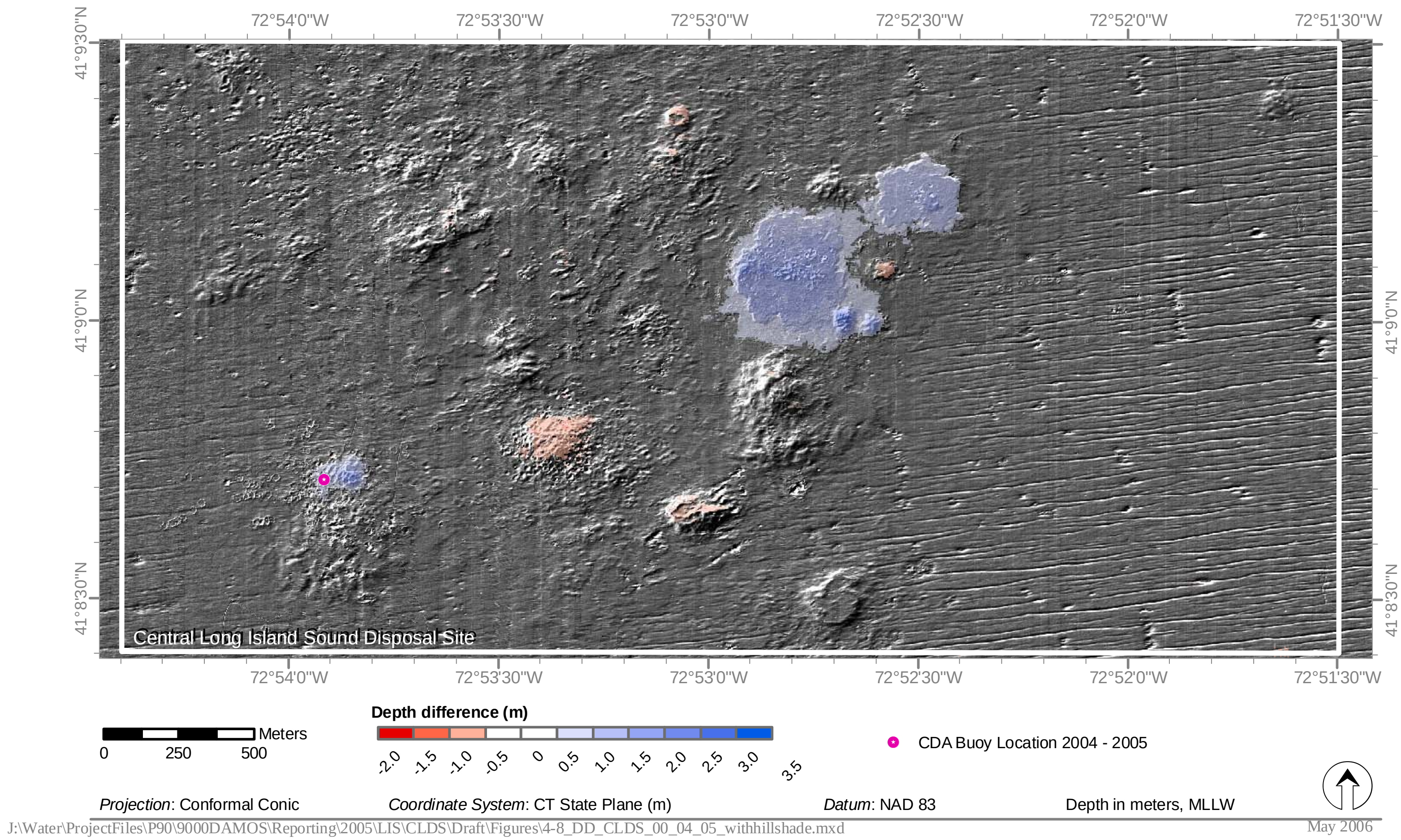


Figure 4-8. CLDS depth difference map (2000 to 2005) draped over 2005 hillshaded bathymetry.

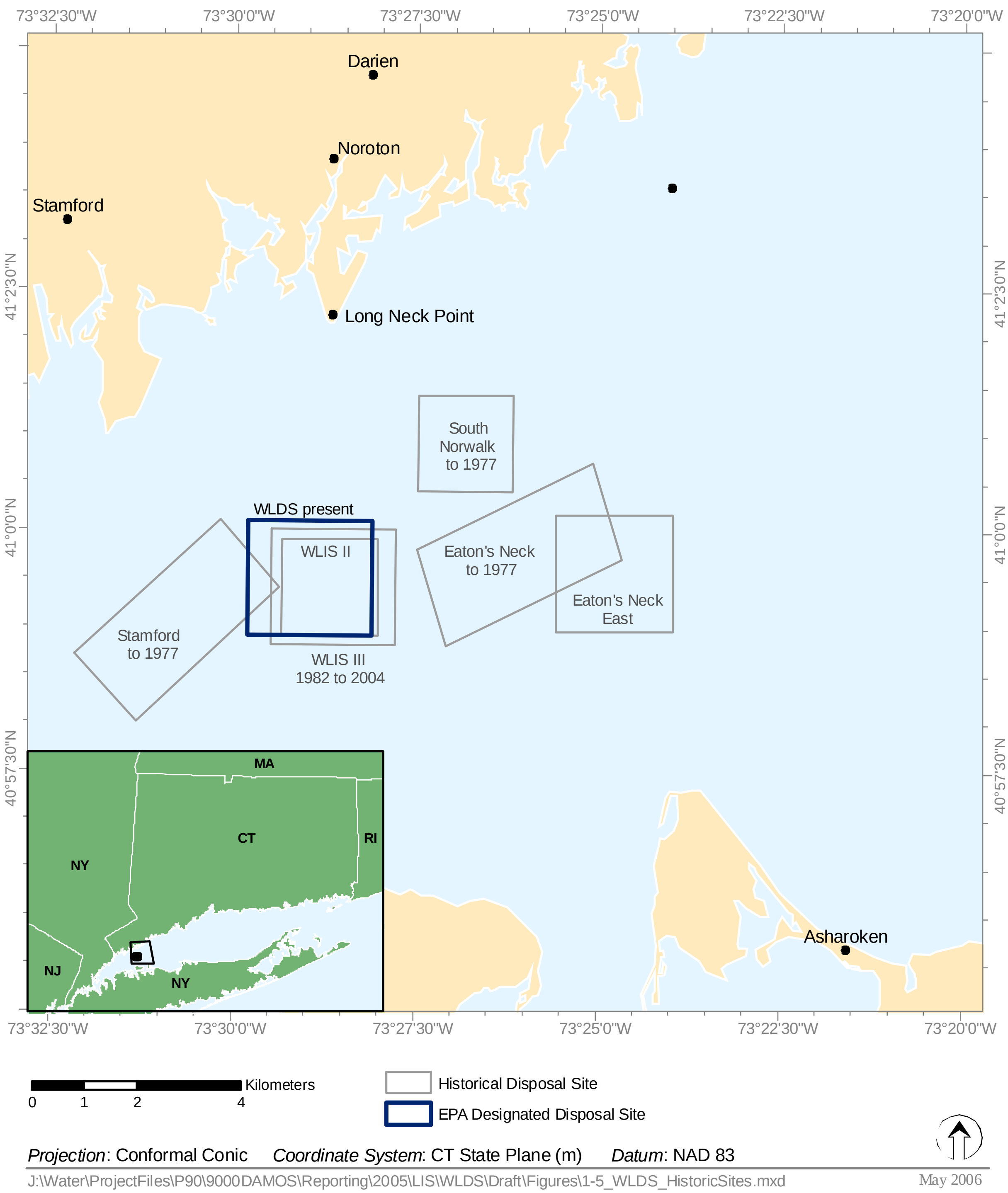


Figure 4-9. Location of historic disposal sites in western Long Island Sound.

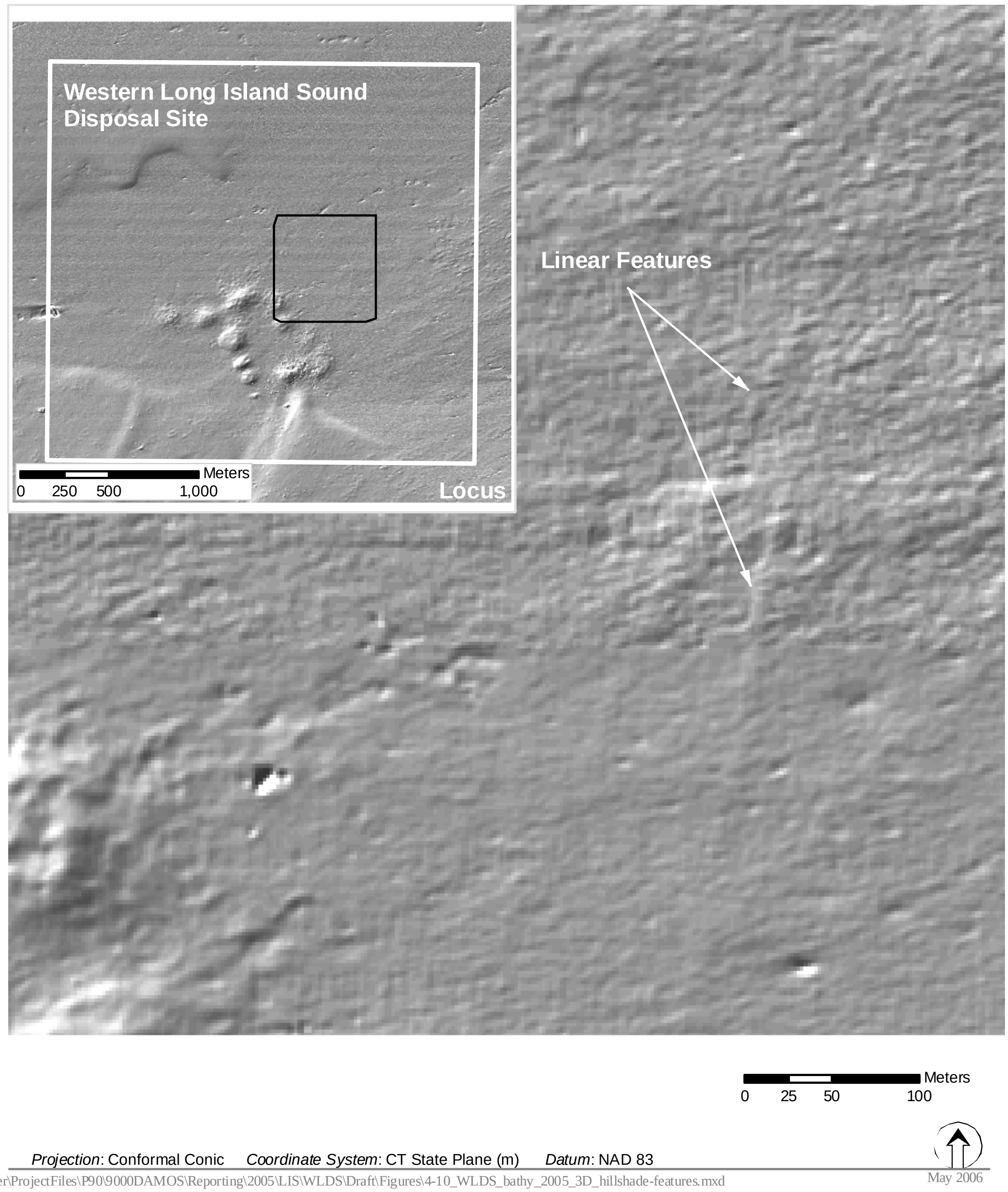


Figure 4-10. Faint linear features on the seafloor of WLDS

5.0 CONCLUSIONS

The July 2005 bathymetric surveys at CLDS and WLDS provided detailed baseline bathymetry following the designation and slight modifications of the boundaries of the disposal sites in June 2005 (USEPA 2004a). The multi-beam surveys provided a detailed dataset in which small-scale (on the order of a few meters in area and 10 cm in depth) sedimentary features could be observed. The formation of these features can be inferred by matching observations with previously described behavior of sediment transport and dredged material disposal.

The detailed acoustic data resulting from either multi-beam or side-scan surveys allow for observation of small-scale sedimentary features and identification of historic disposal events, including precise location and extent of deposits. This can be useful to understand historic activities and in the identification of reference areas (e.g., SAIC 1999). A time-series of detailed bathymetric datasets (either multi-beam or side-scan) provides a means to evaluate small-scale variation in sedimentary features and to assess their stability. An identification and analysis of sedimentary features can aid in site management by monitoring long-term stability of these features, providing insight into the physical processes of dredged material disposal and causal mechanisms of the various features, and identifying areas for remediation.

In addition to the comprehensive baseline bathymetric maps developed from the 2005 multi-beam survey, comparison with previous surveys allowed for identification of new disposal mounds within the sites. Following the disposal of 58,500 m^3 of dredged material at CLDS during the 2004-05 disposal season, a new mound, CLIS 04, was formed as expected north of historic mound MQR. Following the disposal of 78,500 m^3 of dredged material at WLDS during the 2004/05 disposal season, a new mound, Mound M was formed as expected between WLIS F and WLIS J Mounds.

Based on the analysis enabled by the detailed multi-beam bathymetry of CLDS and WLDS, and particularly of the time-series analysis performed at CLDS with three sequential high-resolution bathymetric datasets, it is recommended that subsequent bathymetric surveys performed at these sites continue to be high-resolution, multi-beam surveys. Many years of DAMOS surveys have indicated that the mounds formed at these sites are stable, and benthic recovery generally follows the expected ecological response patterns. Therefore, the current frequency of surveys (approximately every one to three years) may not be necessary, and it is recommended that less frequent, but high-resolution surveys be performed at CLDS and WLDS to develop a strong time-series of detailed bathymetric data to evaluate mound formation and stability as well as small-scale variation in sedimentary features.

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Appendix A-1

Disposal Barge Log Summary for CLDS
October 2004 to May 2005

Project Name: BLOCKS Q, M & N
Permittee: BAYHEAD GROUP
Permit Number: 200001299

Disposal Date	Volume (yd^3)	Volume (m^3)	Disposal Latitude	Disposal Longitude	Distance from Buoy (ft)	Direction from Buoy
1/12/2005	1,581	1,209	41.144433	-72.898550	50 ft	
1/15/2005	1,600	1,223	41.145233	-72.898733	NotOnSite	
1/24/2005	1,600	1,223	41.145217	-72.898533	50 ft	
Total Dredged Material Volume	4,781	3,655				

Project Name: EAST RIVER/GUILFORD HARBOR
Permittee: TOWN OF GUILFORD
Permit Number: 200002454

Disposal Date	Volume (yd^3)	Volume (m^3)	Disposal Latitude	Disposal Longitude	Distance from Buoy (ft)	Direction from Buoy
11/7/2004	400	306	41.145667	-72.897333	50 ft	N
11/8/2004	450	344	41.145167	-72.897333	40 ft	ENE
11/9/2004	300	229	41.145000	-72.897500	60 ft	E
11/10/2004	400	306	41.145167	-72.897333	40 ft	E
11/12/2004	350	268	41.145000	-72.898333	40 ft	
11/13/2004	350	268	41.145167	-72.897333	30 ft	NE
11/14/2004	400	306	41.144500	-72.897667	59 ft	E
11/15/2004	350	268	41.145000	-72.897333	40 ft	NE
11/15/2004	350	268	41.145167	-72.897333	30 ft	E
11/16/2004	400	306	41.145167	-72.897333	30 ft	ENE
11/17/2004	400	306	41.145333	-72.897333	30 ft	NE
11/18/2004	350	268	41.145333	-72.897167	50 ft	ENE
11/19/2004	350	268	41.145167	-72.897333	30 ft	E
11/19/2004	350	268	41.145167	-72.897333	30 ft	E
11/22/2004	400	306	41.145500	-72.897667	30 ft	NE
11/22/2004	400	306	41.145333	-72.897167	40 ft	NNE
11/23/2004	450	344	41.145500	-72.897333	30 ft	NE
11/28/2004	400	306	41.145333	-72.897333	30 ft	NNE
11/28/2004	450	344	41.145000	-72.899000	20 ft	SW
11/29/2004	400	306	41.145167	-72.897333	40 ft	ENE
11/30/2004	400	306	41.145167	-72.897333	30 ft	ENE
11/30/2004	450	344	41.145167	-72.897333	30 ft	NE
12/2/2004	400	306	41.145000	-72.897167	30 ft	E
1/15/2005	600	459	41.145000	-72.898167	N/A	
Total Dredged Material Volume	9,550	7,301				

Project Name: HARBOR POINT MARINA
Permittee: HARBOR POINT MARINA
Permit Number: 200102331

Disposal Date	Volume (yd^3)	Volume (m^3)	Disposal Latitude	Disposal Longitude	Distance from Buoy (ft)	Direction from Buoy
4/28/2005	400	306	41.145667	-72.898667	30 ft	WNW
4/29/2005	500	382	41.145667	-72.898167	30 ft	N
5/3/2005	200	153	41.145667	-72.897833	30 ft	NNE
Total Dredged Material Volume	1,100	841				

Project Name: SYBIL'S CREEK/BRANFORD RIVER
Permittee: BREWER'S BRUCE & JOHNSON'S MARINA
Permit Number: 200201979

Disposal Date	Volume (yd^3)	Volume (m^3)	Disposal Latitude	Disposal Longitude	Distance from Buoy (ft)	Direction from Buoy
12/9/2004	450	344	41.145500	-72.897500	20 ft	ENE
12/9/2004	500	382	41.145667	-72.897833	30 ft	NNE
12/12/2004	600	459	41.145333	-72.896833	30 ft	
12/12/2004	600	459	41.145167	-72.897333	30 ft	ENE
12/13/2004	650	497	41.145500	-72.897500	30 ft	NE
12/14/2004	700	535	41.144833	-72.897667	40 ft	SE
12/16/2004	650	497	41.145167	-72.897167	50 ft	ENE
12/16/2004	700	535	41.144667	-72.897333	50 ft	E
12/16/2004	700	535	41.145500	-72.897667	20 ft	N
12/18/2004	600	459	41.145667	-72.897500	40 ft	NNE
12/19/2004	650	497	41.145500	-72.897333	30 ft	NNE
12/21/2004	700	535	41.145333	-72.897000	50 ft	NE
12/22/2004	500	382	41.145333	-72.897167	50 ft	NE
12/23/2004	650	497	41.145667	-72.897500	30 ft	NNE
12/28/2004	400	306	41.145500	-72.897333	30 ft	NE
12/29/2004	600	459	41.145667	-72.897000	40 ft	NE
12/30/2004	700	535	41.145667	-72.897333	30 ft	NNE
12/31/2004	600	459	41.145667	-72.897333	30 ft	NNE
1/2/2005	600	459	41.145500	-72.897500	35 ft	
1/3/2005	600	459	41.145667	-72.897500	50	
1/4/2005	600	459	41.145667	-72.897500	45	
1/5/2005	500	382	41.145833	-72.897167	50	
Total Dredged Material Volume	13,250	10,130				

Project Name: BRANFORD RIVER
Permittee: GOODSELL POINT MARINA
Permit Number: 200202487

Disposal Date	Volume (yd^3)	Volume (m^3)	Disposal Latitude	Disposal Longitude	Distance from Buoy (ft)	Direction from Buoy
10/30/2004	650	497	41.145333	-72.897333	30 ft	ENE
10/30/2004	700	535	41.145500	-72.897500	40 ft	NE
11/1/2004	700	535	41.145333	-72.897500	40 ft	ENE
11/1/2004	700	535	41.145167	-72.898333	45 ft	
11/1/2004	650	497	41.145500	-72.897333	30 ft	NNE
11/4/2004	600	459	41.145833	-72.897833	50 ft	N
Total Dredged Material Volume	4,000	3,058				

Project Name: WEST RIVER/GUILFORD HARBOR
Permittee: GUILFORD YACHT CLUB
Permit Number: 200301752

Disposal Date	Volume (yd^3)	Volume (m^3)	Disposal Latitude	Disposal Longitude	Distance from Buoy (ft)	Direction from Buoy
12/11/2004	500	382	41.145333	-72.897500	25 yds	SE
12/15/2004	500	382	41.145167	-72.883667	40 yds	SW
12/16/2004	500	382	41.145050	-72.898167	5 yds	SW
12/18/2004	600	459	41.146000	-72.897500	15 yds	E
12/21/2004	450	344	41.145200	-72.897917	10 yds	SE
12/22/2004	450	344	41.145500	-72.898617	20 yds	N
12/29/2004	450	344	41.145500	-72.898617	40 yds	SE
12/31/2004	450	344	41.145250	-72.898000	20 yds	SW
1/1/2005	450	344	41.145333	-72.898333		
1/3/2005	450	344	41.145167	-72.897917	15 yds	SE
1/4/2005	450	344	41.144917	-72.898333	30 yds	SE
1/5/2005	450	344	41.145333	-72.898000	10 yds	S
1/7/2005	300	229	41.145167	-72.898417	20 yds	SE
1/11/2005	450	344	41.145000	-72.898617	20 yds	SE
1/16/2005	450	344	41.145333	-72.898583	20 yds	SE
1/19/2005	450	344	41.145000	-72.898333	100 yds	SW
1/29/2005	450	344	41.145000	-72.899333	3/4 mi +	W
3/15/2005	500	382	41.146850	-72.897817	30 yds	N
3/17/2005	450	344	41.145000	-72.898667	20 yds	SW
3/18/2005	450	344	41.144867	-72.898933	20 yds	SW
3/21/2005	450	344	41.145300	-72.898333	10 yds	N
3/22/2005	450	344	41.146667	-72.899667	40 yds	NW
3/24/2005	450	344	41.145500	-72.898833	10 yds	S
3/31/2005	450	344	41.145500	-72.898833	10 yds	SW
3/31/2005	400	306	41.145500	-72.898533	15 yds	NW
4/5/2005	400	306	41.145333	-72.898333	20 yds	WNW
4/7/2005	450	344	41.144833	-72.897033	40 yds	S
Total Dredged Material Volume	12,250	9,366				

Project Name:	FED. CHANNEL-GUILFORD HARBOR
Permittee:	TOWN OF GUILFORD
Permit Number:	NAE20041388

Disposal Date	Volume (yd^3)	Volume (m^3)	Disposal Latitude	Disposal Longitude	Distance from Buoy (ft)	Direction from Buoy
10/2/2004	500	382	41.145333	-72.898167	20 ft	N
10/3/2004	550	421	41.145500	-72.898000	25 ft	N
10/4/2004	450	344	41.145500	-72.898167	30 ft	N
10/4/2004	500	382	41.145667	-72.898333	15 ft	
10/5/2004	500	382	41.145167	-72.897833	30 ft	ENE
10/6/2004	500	382	41.145500	-72.897833	40 ft	NE
10/7/2004	400	306	41.145333	-72.897667	50 ft	NE
10/7/2004	450	344	41.145167	-72.897500	40 ft	E
10/8/2004	400	306	41.145167	-72.898833	10 ft	N
10/11/2004	450	344	41.144667	-72.898167	40 ft	E
10/13/2004	400	306	41.144500	-72.897667	50 ft	E
10/13/2004	400	306	41.145500	-72.899167	60 ft	SSW
10/13/2004	450	344	41.145333	-72.897667	40 ft	E
10/15/2004	400	306	41.145500	-72.897667	40 ft	NE
10/15/2004	450	344	41.145167	-72.897667	30 ft	NE
10/18/2004	400	306	41.145333	-72.897667	30 ft	ENE
10/19/2004	400	306	41.145833	-72.899667	50 ft	W
10/20/2004	450	344	41.145500	-72.897667	50 ft	N
10/21/2004	400	306	41.144500	-72.898167	50 ft	SE
10/21/2004	450	344	41.145500	-72.897833	40 ft	N
10/22/2004	400	306	41.145167	-72.897500	50 ft	E
10/23/2004	450	344	41.145333	-72.897833	30 ft	ENE
10/25/2004	400	306	41.145167	-72.897333	50 ft	NE
10/27/2004	400	306	41.145333	-72.897500	40 ft	ENE
10/27/2004	400	306	41.145167	-72.897333	50 ft	E
10/27/2004	450	344	41.145333	-72.897500	50 ft	NNE
10/29/2004	400	306	41.144167	-72.898167	50 ft	SSE
10/29/2004	200	153	41.145333	-72.897333	40 ft	NE
Total Dredged Material Volume	12,000	9,175				

Project Name: BRANFORD HARBOR
Permittee: TILCON CONNECTICUT INC.
Permit Number: NAE20041610

Disposal Date	Volume (yd^3)	Volume (m^3)	Disposal Latitude	Disposal Longitude	Distance from Buoy (ft)	Direction from Buoy
1/15/2005	600	459	41.145167	-72.898000	N/A	
1/16/2005	600	459	41.145333	-72.898000	N/A	
1/24/2005	600	459	41.145500	-72.898000	N/A	
1/25/2005	300	229	41.145333	-72.898000	N/A	
1/26/2005	500	382	41.145667	-72.898000	N/A	
1/26/2005	500	382	41.145333	-72.897667	N/A	
1/28/2005	500	382	41.145667	-72.898000	N/A	
1/29/2005	400	306	41.145500	-72.898000	N/A	
1/30/2005	600	459	41.145333	-72.898167	N/A	
1/30/2005	700	535	41.145500	-72.898167	N/A	
1/31/2005	700	535	41.145500	-72.898167	N/A	
2/1/2005	800	612	41.145000	-72.898500	N/A	
2/2/2005	800	612	41.145167	-72.898667	N/A	
2/3/2005	700	535	41.145167	-72.898500	N/A	
2/3/2005	700	535	41.145333	-72.898333	N/A	
2/4/2005	800	612	41.145500	-72.898333	N/A	
2/5/2005	700	535	41.145500	-72.898167	N/A	
2/7/2005	700	535	41.145333	-72.898500	0	
2/8/2005	300	229	41.145000	-72.898667	N/A	
4/1/2005	400	306	41.145667	-72.898333	20 ft	NE
4/4/2005	500	382	41.145500	-72.897833	30 ft	NE
4/5/2005	600	459	41.145333	-72.897667	40 ft	NE
4/6/2005	500	382	41.145333	-72.897667	30 ft	ENE
4/8/2005	500	382	41.145500	-72.897667	30 ft	NE
4/8/2005	600	459	41.145500	-72.898167	30 ft	NE
4/9/2005	500	382	41.145333	-72.898167	30 ft	N
4/10/2005	600	459	41.145500	-72.898333	20 ft	N
4/11/2005	500	382	41.145167	-72.897833	30 ft	N
4/12/2005	400	306	41.145667	-72.899000	20 ft	N
4/13/2005	500	382	41.145333	-72.898833	10 ft	NW
4/14/2005	500	382	41.145667	-72.899000	20 ft	NW
4/15/2005	400	306	41.145667	-72.899000	40 ft	W
4/18/2005	500	382	41.145667	-72.897500	40 ft	N
4/19/2005	600	459	41.145667	-72.898000	20 ft	N
4/26/2005	500	382	41.145333	-72.897833	20 ft	N
Total Dredged Material Volume	19,600	14,985				

Appendix A-2

Disposal Barge Log Summary for WLDS
November 2004 to May 2005

Project Name: BLOCKS R, P, O & L
Permittee: BAYHEAD GROUP
Permit Number: 200001299

Disposal Date	Volume (yd^3)	Volume (m^3)	Disposal Latitude	Disposal Longitude	Distance from Buoy (ft)	Direction from Buoy
1/8/2005	875	669	40.986417	-73.479867	AtCoords	
1/9/2005	875	669	40.986617	-73.479900	AtCoords	
1/10/2005	875	669	40.986350	-73.480050	AtCoords	
1/11/2005	875	669	40.986333	-73.479833	50 ft	
1/16/2005	800	612	40.986417	-73.479767	40 ft	E
1/17/2005	700	535	40.986150	-73.478567	40 ft	E
1/26/2005	500	382	40.986317	-73.479850	75 ft	
1/27/2005	500	382	40.985950	-73.480000	50 ft	
1/28/2005	600	459	40.986300	-73.479500	60 ft	
1/30/2005	600	459	40.986000	-73.479167	60 ft	
Total Dredged Material Volume	7,200	5,505				

Project Name: SOUTHPORT HARBOR
Permittee: COE - TOWN OF FAIFFIELD
Permit Number: 2004C0016

Disposal Date	Volume (yd^3)	Volume (m^3)	Disposal Latitude	Disposal Longitude	Distance from Buoy (ft)	Direction from Buoy
11/13/2004	1,800	1,376	40.985280	-73.479040	160	
11/14/2004	1,550	1,185	40.986930	-73.479460	200	
11/14/2004	1,900	1,453	40.986150	-73.479740	1 ft	
11/15/2004	1,600	1,223	40.986330	-73.478940	60 ft	
11/15/2004	1,900	1,453	40.986000	-73.479200	20 ft	
11/16/2004	1,500	1,147	40.985970	-73.479660	1 ft	
11/16/2004	1,580	1,208	40.986400	-73.479450	10 ft	
11/17/2004	1,400	1,070	40.986070	-73.480380	20 ft	
11/17/2004	1,700	1,300	40.986540	-73.479100	0 ft	
11/18/2004	1,400	1,070	40.986370	-73.480090	20 ft	
11/18/2004	2,000	1,529	40.986410	-73.479830	10 ft	
11/19/2004	1,700	1,300	40.986170	-73.479510	10 ft	
11/19/2004	1,400	1,070	40.986260	-73.480200	2 ft	
11/20/2004	1,200	917	40.986140	-73.479610	25 ft	
11/20/2004	1,900	1,453	40.986220	-73.480220	10	
11/21/2004	1,900	1,453	40.986440	-73.479590	10 ft	
11/21/2004	800	612	40.986430	-73.479830	0 ft	
11/21/2004	1,900	1,453	40.986020	-73.480290	0 ft	
11/22/2004	1,200	917	40.986730	-73.480280	0 ft	
11/23/2004	2,000	1,529	40.986320	-73.480460	20 ft	
11/24/2004	700	535	40.986040	-73.480190	0 ft	
11/24/2004	1,800	1,376	40.986120	-73.480580	0 ft	
11/29/2004	700	535	40.986370	-73.480350	15 ft	
11/29/2004	1,300	994	40.986640	-73.479290	0	
12/1/2004	1,200	917	40.986500	-73.479870	0 ft	
12/2/2004	1,250	956	40.986620	-73.479530	0 ft	

Disposal Date	Volume (yd³)	Volume (m³)	Disposal Latitude	Disposal Longitude	Distance from Buoy (ft)	Direction from Buoy
12/3/2004	700	535	40.986390	-73.480330	30 ft	
12/3/2004	1,800	1,376	40.987000	-73.480150	150 ft	
12/4/2004	1,850	1,414	40.986370	-73.479280	0 ft	
12/5/2004	1,500	1,147	40.986160	-73.480260	0 ft	
12/5/2004	800	612	40.986080	-73.480580	100 ft	
12/6/2004	1,500	1,147	40.985920	-73.481930	300 ft	
12/7/2004	800	612	40.986930	-73.480270	10 ft	
12/8/2004	1,600	1,223	40.988120	-73.479800	600 ft	
12/9/2004	800	612	40.986610	-73.479870	0 ft	
12/9/2004	2,000	1,529	40.986570	-73.479870	0 ft	
12/9/2004	850	650	40.986360	-73.479990	0 ft	
12/10/2004	1,275	975	40.985200	-73.481900	400 ft	
12/10/2004	900	688	40.986340	-73.479600	40 ft	
12/11/2004	1,600	1,223	40.986230	-73.479270	60 ft	
12/12/2004	1,300	994	40.986390	-73.480610	150 ft	
12/12/2004	750	573	40.986120	-73.479790	40 ft	
12/12/2004	1,200	917	40.986520	-73.479520	30	
12/13/2004	800	612	40.986640	-73.479780	0 ft	
12/13/2004	1,400	1,070	40.986260	-73.478440	60 ft	
12/14/2004	800	612	40.986670	-73.479480	40 ft	
12/14/2004	1,600	1,223	40.986290	-73.480580	100 ft	
12/15/2004	800	612	40.986540	-73.479750	0 ft	
12/16/2004	850	650	40.986210	-73.480370	30 ft	
12/16/2004	1,500	1,147	40.985950	-73.480220	0	
12/16/2004	1,700	1,300	40.986140	-73.479120	0 ft	
12/16/2004	800	612	40.986680	-73.479620	20 ft	
12/17/2004	1,300	994	40.986840	-73.479520	50 ft	
12/17/2004	800	612	40.986350	-73.479880	0 ft	
12/18/2004	1,700	1,300	40.986400	-73.479950	0 ft	
12/18/2004	900	688	40.986480	-73.480190	0 ft	
12/18/2004	1,200	917	40.986110	-73.480700	45	
12/19/2004	1,000	765	(blank)	(blank)	50 ft	
12/19/2004	800	612	40.986670	-73.479870	0	
12/19/2004	900	688	40.985670	-73.481150	seeNotes	
12/20/2004	850	650	40.986150	-73.480267	NoBuoy	
12/20/2004	750	573	40.986150	-73.479733	NoBuoy	
12/21/2004	1,600	1,223	40.986417	-73.479983	NoBuoy	
12/22/2004	800	612	40.986200	-73.480367	NoBuoy	
12/22/2004	1,600	1,223	40.988467	-73.481467	NoBuoy	
12/22/2004	800	612	40.986467	-73.479717	NoBuoy	
12/23/2004	1,800	1,376	40.986100	-73.480483	500 ft	
12/27/2004	1,500	1,147	40.986710	-73.479967	60 ft	
12/29/2004	900	688	40.986760	-73.479660	0	
12/29/2004	1,300	994	40.986110	-73.480350	0	
12/30/2004	600	459	40.986500	-73.479780	0	
12/31/2004	800	612	40.986220	-73.480580	0	
1/2/2005	800	612	40.986440	-73.479640	50	
1/3/2005	700	535	40.986150	-73.486040	70 ft	
1/7/2005	700	535	40.986340	-73.480380	60 ft	
1/7/2005	200	153	40.986200	-73.479900	0	
3/10/2005	500	382	40.985030	-73.479720	0-770 ft	
Total Dredged Material Volume	95,555	73,057				