DAMOS
Summary Report
1985-1990

Disposal Area Monitoring System DAMOS

D A M O S

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13. ABSTRACT

Most of the material dredged from New England's waterways and harbors is deposited into nine offshore disposal sights. The offshore disposal of the dredged material must be properly managed to ensure no unacceptable adverse impacts to biota in the marine environment. The Disposal Area Monitoring System (DAMOS) Program provides this as well as additional tasks that contribute to the overall management of the DAMOS Program. Operated by the US Army Corps of Engineers, New England Division (NED), DAMOS has been in existence since 1977. The last summary of the DAMOS Program was published in 1984. This report summarizes the program efforts from 1985 to 1990.

The DAMOS Program monitors nine offshore dredged material disposal sights from the Long Island Sound to the Gulf of Maine: Central Long Island Sound Disposal Sight (CLIS), Western Long Island Sound Disposal Sight (WLIS), New London Disposal Sight (NLDS), Cornfield Shoals Disposal Sight (CSDS), Portland Disposal Site (PDS), Rockland Disposal Sight (RDS), Cape Arundel Disposal Sight (CADS), Massachusetts Bay Disposal Sight (MBDS), Buzzards Bay Disposal Sight (BBDS) and several special-use sites. In 1990 field work was conducted at CLIS, WLIS, NLDS, CSDS, MBDS, and BBDS. Additional nonfield work has included verification of the DAMOS Capping Model, management of the DAMOS database, integration of the Geographic Information System (GIS) with dredging and disposal site information, and the development of a tiered monitoring plan by the DAMOS Technical Advisory Committee.

Continuous monitoring of the nine dredged material disposal sites has shown that, in most cases, (1) disposal mounds are stable over time, (2) there is minimal transport of material away from the sight, and (3) organisms did not take up significant levels of contaminants. Stable disposal mounds with no offsite transport are found at containment sites. Eight of the nine disposal sites are containment sites where material is expected to stay in the area. The only noncontainment, or dispersive, site is CSDS. At CSDS, material is expected to leave the site, and it is managed as not to adversely effect the marine environment.

Recent nonfield DAMOS efforts (Capping Model, database, GIS, and tiered monitoring) have provided a better understanding of DAMOS requirements. The DAMOS Capping Model, designed to predict the size and shape of a dredged material mound, provides a reliable estimate of the dredged material mound if the disposal operation is tightly controlled. Once dredged material is in place, the DAMOS database, accessed through INFORMIX interface on the PC-based system, can provide information on the dredged material and disposal operations. Given the ongoing generation of information by DAMOS field work, the tiered strategies developed by TAC were designed to prevent significant adverse impacts on the environment by providing early warnings for such occurrences.

Field operations at the DAMOS dredged material disposal sites, predictive modeling, tiered monitoring, and the ability to extract and present data from a database combine to provide an effective management plan for dredged material disposal in New England waters. This summary of the DAMOS Program from 1985 to 1990 outlines each aspect of the program and presents highlights of the most recent field data.

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EXECUTIVE SUMMARY

Most of the material dredged from New England's waterways and harbors is deposited in nine offshore disposal sites. The offshore disposal of the dredged material must be properly managed to ensure no unacceptable adverse impacts to biota in the marine environment. The Disposal Area Monitoring System (DAMOS) Program provides this management control. The DAMOS Program includes field monitoring of the disposal sites as well as additional tasks that contribute to the overall management of the DAMOS Program. Operated by the US Army Corps of Engineers, New England Division (NED), DAMOS has been in existence since 1977. The last summary of the DAMOS Program was published in 1984. This report summarizes the program efforts from 1985 to 1990.

The DAMOS Program monitors nine offshore dredged material disposal sites from Long Island Sound to the Gulf of Maine: Central Long Island Sound Disposal Site (CLIS), Western Long Island Sound Disposal Site (WLIS), New London Disposal Site (NLDS), Cornfield Shoals Disposal Site (CSDS), Portland Disposal Site (PDS), Rockland Disposal Site (RDS), Cape Arundel Disposal Site (CADS), Massachusetts Bay Disposal Site (MBDS), Buzzards Bay Disposal Site (BBDS), and several special-use sites. In 1990 field work was conducted at CLIS, WLIS, NLDS, CSDS, CADS, MBDS, and BBDS. Additional nonfield work has included verification of the DAMOS Capping Model, management of the DAMOS database, integration of the Geographic Information System (GIS) with dredging and disposal site information, and the development of a tiered monitoring plan by the DAMOS Technical Advisory Committee (TAC).

Continuous monitoring of the nine dredged material disposal sites has shown that, in most cases, (1) disposal mounds are stable over time, (2) there is minimal transport of material away from the site, and (3) organisms did not take up significant levels of contaminants. Stable disposal mounds with no offsite transport are found at containment sites. Eight of the nine disposal sites are containment sites where material is expected to stay in the area. The only noncontainment, or dispersive, site is CSDS. At CSDS, material is expected to leave the site, and it is managed so as not to adversely effect the marine environment.

Site-specific adjustments in management have been needed at NLDS since 1984. At NLDS, a capping project required dredged material to be spread evenly over an existing mound. Multiple points on the mound were chosen as target release points with the plan that the randomness inherent in the disposal operation would result in an even distribution of the sediment. The cap material formed discrete mounds with less spreading over the base mound than expected. As a result of this finding, additional material was directed to this location to augment the cap.

Recent nonfield DAMOS efforts (Capping Model, database, GIS, and tiered monitoring) have provided a better understanding of DAMOS management requirements. The DAMOS Capping Model, designed to predict the size and shape of a dredged material mound, provides a reliable estimate of the dredged material mound if the disposal operation is tightly controlled. Once dredged material is in place, the DAMOS database, accessed through the INFORMIX interface on the PC-based system, can provide information on the dredged material and disposal operations. Given the ongoing generation of information by DAMOS field work, the tiered strategies developed by the TAC were designed to prevent significant adverse impacts on the environment by providing early warnings for such occurrences.

Field observations at the DAMOS dredged material disposal sites, predictive modeling, tiered monitoring, and the ability to extract and present data from a database combine to provide an effective management plan for dredged material disposal in New England waters. This summary of the DAMOS Program from 1985 to 1990 outlines each aspect of the program and presents highlights of the most recent field data.

1.0 INTRODUCTION

Since 1984, the DAMOS (Disposal Area Monitoring System) Program has continued to monitor nine offshore dredged material disposal sites from Long Island Sound to the Gulf of Maine: Central Long Island Sound Disposal Site (CLIS), Western Long Island Sound Disposal Site (WLIS), New London Disposal Site (NLDS), Cornfield Shoals Disposal Site (CSDS), Portland Disposal Site (PDS), Rockland Disposal Site (RDS), Cape Arundel Disposal Site (CADS), Massachusetts Bay Disposal Site (MBDS), Buzzards Bay Disposal Site (BBDS), and also several special-use sites. The sites have been monitored to assess the extent and stability of dredged material deposits and the effect of dredged material disposal on the quality of the benthic environment. In 1990, field work was conducted at CLIS, WLIS, NLDS, CSDS, CADS, MBDS, and BBDS. The 1990 field work at all sites consisted of bathymetric and REMOTS® surveys. While most bathymetric surveys were conducted over the most recent disposal area in the site, the bathymetric survey at WLIS was conducted over the entire disposal site. In addition to bathymetric and REMOTS® surveys, sediment and tissue chemistry was analyzed at CLIS, WLIS, MBDS and BBDS. Other tasks in 1990 consisted of the verification of the DAMOS Capping Model, the management of a DAMOS database, steps to integrate a Geographic Information System (GIS) with dredging and disposal site information, and the development of a tiered monitoring plan by the DAMOS Technical Advisory Committee (TAC). The tiered monitoring plan is an evolving monitoring program with interactive feedback that addresses specific program objectives and provides information useful for making management decisions. This report describes 1990 work that was not part of the field effort and summarizes the field program findings at each of the nine disposal sites from 1985 to 1990.

2.0 DAMOS CAPPING MODEL VERIFICATION

The DAMOS Capping Model was designed to predict the configuration of a dredged material disposal mound and help estimate the amount of material needed to cap the mound adequately. Previous analysis of the model determined that it provided an accurate basis for cap volume estimations and generally predicted the lateral extent of disposal mounds but did not predict mound height accurately.

The ability of the DAMOS Capping Model to predict lateral extent and height of dredged material was tested using data from five disposal mounds in Long Island Sound as variables: CLIS-89 and CS-90-1 at CLIS, the WLIS "D" mound at WLIS, and mounds NL-88 and NL-TR at NLDS. Systematic changes in the parameters, or data sets, from each mound were used to determine if the parameters could be refined to improve the model's accuracy in predicting mound height. The effect of changes in the parameters on predicted mound height could not be isolated from the effect of the random distribution pattern built into the model. The DAMOS Capping Model was then run numerous times with an identical data set to determine the number of model runs necessary to obtain an average mound height to specified confidence limits.

Attempts to verify the accuracy of the DAMOS Capping Model by using data from the Long Island Sound dredged material mounds showed that the model's predictive accuracy is dependent on the degree of accuracy in the composition, amount, and placement of dredged material during a disposal operation. If these parameters are correct, five runs of the model with the same set of parameters will predict a mound height to the 90% confidence level. It is important that the distribution of dredged material at the site be controlled to mimic the center-weighted distribution that is predicted in the model. With this control, the dredged material will form one peak as predicted by the model.

The behavior of the dredged material over time is not factored into the model. Consolidation can result in significant changes in mound height depending on the type and amount of dredged material, whether the mound was capped, and the composition of the capping material. If the DAMOS Capping Model is used to predict the height of a dredged material mound at any time after deposition, the effect of consolidation must be considered.

For further information see: Wiley, M. B. 1994. DAMOS capping model verification. DAMOS Contribution No. 89 (SAIC Report No. SAIC-91/7603&C95). US Army Corps of Engineers, New England Division, Waltham, MA.

3.0 DAMOS DATABASE

The DAMOS Database was designed and established to incorporate all environmental data collected during the DAMOS Program, as well as any pertinent historical data available at or near the disposal sites collected prior to the initiation of DAMOS (1977). The Database originally resided on the HARRIS computer at the New England Division (NED) of the Corps of Engineers office in Waltham, Massachusetts and used the INFO database management system. In 1988, a Banyan VINES network was acquired by NED-Regulatory, and ORACLE was chosen as the database management system.. In 1989, a SUN Server replaced the VINES network, and INFORMIX was chosen as the database management system to handle the database queries. User-interface software is being developed to allow user-friendly access to the database. Throughout the entire development period, all data generated by the DAMOS Program as well as all disposal barge logs have been entered into a PC-based INFORMIX database system. This system will be moved to the SUN Server as soon as the final hardware-software configuration is installed. In 1990, all database queries were made through the INFORMIX interface on the PC-based system.

During review of this report, further developments have been implemented in the DAMOS database. The database has been transferred to FoxPro for Windows, a PC-based database management system, which is much faster and more user friendly than Informix. The scope of the database has also been expanded to provide for the integration with the GIS.

For further information see: Inglin, D. C.; Murray, P. M. 1994. Damos database description and data quality protocols. SAIC Report No. 333. Draft report submitted to US Army Corps of Engineers, New England Division, Waltham, MA.

4.0 GEOGRAPHIC INFORMATION SYSTEMS (GIS)

With the recent increase in power of personal computers and the decrease in cost of more powerful UNIX-based workstations, Geographic Information Systems (GIS) are being widely used by a diverse group of federal and state agencies and municipalities. GIS is a powerful tool for manipulating large grids of spatial data, such as satellite images, topographic maps, and bathymetric charts, to aid the user in comparing land features, designing transit systems, determining areas and volumes of changes in topography, retrieve information based on its geographic position, etc.

The DAMOS Program is beginning to incorporate GIS as a tool for spatially characterizing dredging and disposal sites. Available environmental, bathymetric, coastline, and sediment chemistry data for these areas are being collected. As more data are stored in GIS, a comprehensive database for the New England area will develop that will greatly enhance our understanding of any potential effects of dredged material disposal on the environment. The goal is to link the existing DAMOS database to GIS to form an integrated system that would allow the results of queries of the database to be presented both graphically and in tabular form as required.

5.0 TAC MEETING/TIERED APPROACH

As a result of comments received from the 1985 DAMOS public symposium held in Mystic, Connecticut, both the environmental resource managers at NED and scientists at Science Applications International Corporation (SAIC) realized the DAMOS Program would benefit enormously from a periodic outside peer review. To accomplish this goal, NED formed a Technical Advisory Committee (TAC). Scientists who are nationally recognized experts in a variety of disciplines related to ocean disposal, but who were not associated directly with the program, were invited in the fall of 1987 to join the DAMOS TAC. The outside scientists of the committee were

Dr. Brock Bernstein (Statistics, Biological Oceanography)
Dr. Henry Bokuniewicz (Geology and Estuarine Dynamics)
Dr. Iver Duedall (Chemical Oceanography)
Dr. Robert Engler (Environmental Effects of Dredging)
Dr. Willis Pequegnat (Biological Oceanography) (deceased)

A series of three workshops was held with the TAC in January, April, and November 1988 to review the current program and to help NED develop a new DAMOS monitoring strategy. Scientists from NED and SAIC also participated in these workshops; members from NED included Dr. T. Fredette, Mr. J. Crawford, Mr. S. Congdon, Mr. V. Andreliunas, Mr. J. Waugh, and Mr. R. Zeroka. SAIC scientists included Dr. J. Germano, Dr. R. Morton, Dr. D. Rhoads, Mr. J. Parker, Mr. J. Lunz, and Dr. J. Scott.

The committee's primary goal was to develop an integrated, tiered approach to the DAMOS Program focused on addressing specific program objectives and providing information useful for making management decisions. The ideal end-product would be an evolving monitoring program with an iterative feedback linked both to decisions about disposal site management and to screening criteria for dredged material permits. The tiered monitoring plans developed during the TAC workshops were designed to address concerns about the short- and long-term environmental impacts of dredged material disposal, i.e., to assure that disposal activities being managed by NED were in compliance with environmental laws and regulations.

Open-water disposal is regulated under Section 404 of the Clean Water Act and Section 103 of the Marine Protection, Research, and Sanctuaries Act. The language of these laws regarding marine environmental impacts is very general and in essence states that disposal must not cause unreasonable adverse impacts. Therefore, compliance with environmental laws and regulations relating to the disposal of dredged material requires that disposal activities, including the actual presence of dredged material in the region, do not result in significant adverse effects on marine fisheries and other valuable marine resources. How to convert these generally stated but critically important laws and regulations into the specifications for a well-designed, regional monitoring program was the challenge that faced the DAMOS TAC.

During the course of the three TAC workshops, background assumptions underlying the philosophy of ecological monitoring were identified and debated. The next step entailed the construction of a basic framework or structure for identifying, examining, and displaying probable relationships between dredged material disposal and the physical, chemical, and biological environmental alterations that would occur as a result of disposal operations. The most intense discussions during these meetings revolved around describing the physical-chemical-biological linkages associated with dredged material disposal and developing tiered approaches to monitoring short- and long-term impacts on biological resources.

The TAC's objective was to address the disposal-related environmental impacts through a tiered monitoring approach. The steps necessary to achieve this end were (1) identifying the resources to be protected (being as specific as possible); (2) predicting the processes, specific magnitudes, and areal extent of change that would be necessary to bring about an impact; (3) incorporating monitoring tools with a rapid data return so that field results could be used to make management decisions; and (4) recognizing there are limited resources and a need to develop a parsimonious monitoring plan. The group's knowledge of the constituents of dredged material, its physical and chemical behavior, and known responses of biological communities to disturbance factors made it possible to outline the events that would need to take place before an effect of sufficient magnitude to be considered adverse would occur.

Three tiered monitoring plans were developed: 1) a management overview, outlining the structure of the decision tree for dredged material permit testing and acceptable disposal options; 2) a monitoring plan for unconfined aquatic disposal; and 3) a monitoring plan for confined aquatic (capped) disposal mounds. The principal concern addressed in the last two plans developed for open water (i.e., noncapped and capped disposal mounds) was the potential for transport of sediment-associated contaminants from the mound to the food web, where they ultimately could adversely impact the ecosystem, as well as pose human health risks through seafood consumption. Each tier of these monitoring plans was structured to focus on detecting change relative to a specific, conservative, early warning threshold. Typically, lower tiers focused on processes that need to occur first in order for the undesired biological impact to take place, while the highest tiers focused on changes in the resource itself. The intent was for this tiered strategy to prevent significant adverse impacts by providing early warnings for such an occurrence.

The tiered strategies developed by the TAC are the first serious attempt by NED to implement a long-term strategy and to base a monitoring program on hypothesis testing using sampling techniques with rapid data return. There is no doubt that these draft protocols developed over the past few years will be revised and modified as we learn that some of our initial assumptions, predictions, or conceptual models are incorrect. The TAC will continue to play an important role in the overall DAMOS management strategy by providing periodic, outside quality assurance reviews of program results and revisions to current sampling techniques and/or monitoring protocols.

6.0 SUMMARY OF DAMOS FIELD WORK

A large part of the DAMOS Program since 1984 has been the continued monitoring of nine offshore dredged material disposal sites located from Long Island Sound to the Gulf of Maine. The sites have been monitored to assess the extent and stability of dredged material deposits and the effect of dredged material disposal on the quality of the benthic environment. At sites where dredged material formed mounds detectable by bathymetry, repeated surveys showed that the mounds were stable. Hurricane Gloria moved over Long Island Sound in September 1985 but showed no significant impact on mound stability. At all sites, dredged material was found as a thin (<20 cm) layer of sediment beyond the base of the mound flanks that were detected by bathymetry. The observed areal distribution of dredged material was due to both the location of barge release points and the physical spread of the sediment immediately following the bottom impact. Barge release points at most sites ranged from 100 to 300 m from the specified disposal location. Variables controlling the distribution of barge release points include the wide watch circle where conventionally moored buoys are used, sites where buoys are not used for point control, and the influence of weather and waves on operational control.

The effect of dredged material disposal on the benthic environment was monitored through REMOTS® surveys, sediment chemistry, and body burden analysis. Based on the tiered approach to monitoring dredged material disposal sites (Germano, Rhoads, and Lunz 1994), all sites show the expected response in REMOTS® images for benthic recolonization patterns (Tier 1). Sediment chemistry results at all sites showed decreasing concentrations of contaminants going from fresh to relic dredged material and to ambient sediment. Any contamination was low to moderate according to the guidelines of the New England River Basins Commission (NERBC) and reflected the contamination levels expected of the dredged material (Table 6-1). Studies of transects heading away from the dredged material showed no far-field transport of the contaminated material. There were no trends reported in the analysis of tissue concentration for any of the sites, suggesting that the organisms did not take up significant levels of contaminants.

Site-specific adjustments in management have been needed at NLDS since 1984. At NLDS, a capping project required dredged material to be spread evenly over an existing mound. Multiple points on the mound were chosen as target release points with the plan that the randomness inherent in the disposal operation would result in an even distribution of the sediment. The cap material formed discrete mounds with less spreading over the base mound than expected. As a result of this finding, additional material was directed to this location to augment the cap.

Table 6-1

NERBC Sediment Guidelines

	Low (ppm)				Moderate (ppm)				High (ppm)			
	MA	ME	CT	NY	MA	ME	CT	NY	MA	ME	CT	NY
As	<10	<7	<10	<10	10-20	7-22	10-20	10-20	>20	>22	>20	>20
Hg	<0.5	<0.5	<0.5	<0.5	0.5-1.5	0.5-3.0	0.5-1.5	0.5-1.5	>1.5	>3.0	>1.5	>1.5
PCB	<0.5				0.5-1.0				>1.0	>2.9	>1.0	>1.0
DDT									>0.5	>0.2	>0.5	>0.5
Pb	<100	<83	<100	<100	100-200	83-285	100-200	100-200	>200	>285	>200	>200
Cd	<3	<3	<5	<3	3-7	3-15.5	5-10	3-7	>7	>15.5	>10	>7
Cr	<100	<112	<100	<100	100-300	112-513	100-300	100-300	>300	>513	>300	>300
V	<75		<75	<75	75-125	75-125	75-125	75-125	>125		>125	>125
Zn	<200	<135	<200	<200	200-400	135-436	200-400	200-400	>400	>436	>400	>400
Ni	<50	<36	<50		50-100	36-92	50-100		>100	>92	>100	
Cu	<200	<83	<200		200-400	83-342	200-400		>400	>342	>400	
% O+G	<0.5	<0.25	<0.2		0.5-1.0	0.25-1.26	0.2-0.75		>1.0	>1.26	>0.75	
% Vol Sol	<5.0	<4.5	<5.0		5-10	4.5-15.3	5-10		>10	>15.3	>10	
% Fines	<60	15-60	<60		60-90	60-90	60-90		>90	>90	>90	

Sediment Classification by State

6.1 CENTRAL LONG ISLAND SOUND DISPOSAL SITE

6.1.1 Summary of CLIS

The Central Long Island Sound Disposal Site (CLIS) is located 5.6 nmi south of South End Point in East Haven, Connecticut. The site is 2 nmi by 1 nmi and is centered at 41°08.95′ N, 72°52.85′ W (Figure 6-1). The ambient water depths at this site range from 17.5 to 22.5 m with the peaks of some of the disposal mounds as shallow as 14.0 m. Since 1984, five disposal mounds have been created at CLIS: CLIS-86, CLIS-87, CLIS-88, CLIS-89, and CS-90-1. A 1200 × 1200 m area of CLIS, surveyed in 1990, showed the four most recent mounds (Figure 6-2). This site has been utilized primarily for the disposal of dredged material from the New Haven area, but also from areas as distant as Stamford and Norwalk Harbors. The energy regime at CLIS is dominated by tidal currents running in an east-west direction. A southerly component introduced by the Quinnipiac River between West and East Haven is more pronounced during periods of spring runoff. This low energy regime is reflected in the ambient fine silt and clay sediments. The incidence of storm-driven, wave-induced currents at CLIS is reduced considerably due to the restricted fetch available at the site. Only the most severe northeast storms have any appreciable effect (SAIC 1988a).

There is little finfishing activity inside the site with the exception of lobstermen trawling for bait and an occasional trawler fishing for scup. The nearest leased oyster grounds are approximately 3 miles north of this site.

Six monitoring cruises were conducted at CLIS by scientists from SAIC since 1984 (SAIC 1989a, 1990a, 1990b, 1990c, Germano et al. 1994). These studies assessed the stability of the dredged material disposed in the area and any potential adverse environmental effects. CLIS has been studied closely over the years, using many of the proven disposal assessment techniques developed in the DAMOS Program. These included precision bathymetric and side-scan sonar surveys, remote sensing such as underwater television observations and the REMOTS® sediment-profile camera, and sediment sampling for chemical, physical, and benthic community analysis. This site was studied extensively using innovative techniques such as the DAISY *in situ* multiparametric array. The Field Verification Program (FVP) disposal mound in the northeast corner of CLIS was studied intensively until 1988 as part of the Field Verification Program for the US Army Waterways Experiment Station and the US Environmental Protection Agency (EPA). The program was designed to determine the applicability, reproducibility, and field verification of test methods for the evaluation of the effects of dredged material disposal (Gentile 1988). In addition to regularly scheduled surveys, a monitoring cruise was conducted immediately following the occurrence of Hurricane Gloria in 1985 (SAIC 1989a). During this study, it appeared that the storm produced local redistribution of sediment at some of the disposal mounds but no major transport of dredged material out of the disposal site boundaries.

CLIS received approximately 1,175,000 m^3 of dredged material from 1985 to 1990 (Figure 6-3). Distinct disposal mounds were formed during each disposal season. A common objective within the DAMOS monitoring program has been to assess the extent and stability of dredged material. The areal extent of dredged material, including deposits less than 15 cm (the limit detected by bathymetry), was mapped by REMOTS® photographs (Figure 6-4). The larger footprint of dredged material detected by REMOTS® as compared to that detectable by bathymetry was due partly to the distance of the release points from the buoy location (Figure 6-5). Continued monitoring has shown that the disposal mounds remain stable over time (Figure 6-6). During Hurricane Gloria in 1985, only disposal mound CS-1, capped with silt rather than sand, experienced a loss of surface sediment (SAIC 1989a). Reductions in mound height over time are due to consolidation of dredged material and ambient sediment. Consolidation will be more pronounced where mounds are capped with permeable sediment, as was shown at STNH-N where a sand cap was used (Poindexter-Rollings 1990).

The convenient location and protected waters at CLIS resulted in the selection of this site for several capping experiments from 1979 to 1983. Since 1984, capping projects have been conducted at CLIS-86 (SAIC 1990c) and CS-90-1. Both sand and silt have been employed as capping material. The scarcity of dredging projects with clean sand in Long Island Sound probably restricts future capping operations to employ mainly clean silt. Data show that both methods are effective in containing contaminants, but that sand caps provide greater resistance to erosion during storm events (SAIC 1989a).

Chemical and biological parameters at CLIS were investigated in 1986 and 1987. Sediment samples were collected in 1986 at 10 disposal mounds, at eight stations around the STNH-N mound, and at the reference area (Figure 6-7). Recent and relic areas of dredged material showed higher levels of Cr, Cu, Fe, Zn, and oil and grease than off-mound and reference areas (Figure 6-8). Concentrations of metals and oil and grease were either low or moderate by NERBC limits; moderate levels of Cu, Pb, and Zn were present on the recent dredged material (Table 6-1).

Test organisms for body burden analysis in 1986 were collected from four of the disposal mounds (STNH-N, FVP, MQR, and CLIS-86) and at the reference area (Figure 6-7). Results indicated higher levels of Cd, Cr, Cu, and Pb at CLIS-86 as compared with the reference area and relic areas (Figure 6-9). Comparing CLIS-86 *Nephtys* samples with samples from other mounds showed sediment in the gut of the CLIS-86 samples. This could account for the higher levels of metals as compared to other mounds (SAIC 1990a). PCBs were not detected in any of the *Nephtys* samples analyzed.

A transect study was conducted in 1987 along the axis of predominant current movements to monitor possible contaminant resuspension and transport and provide additional baseline data on contaminant body burden in the polychaete worm *Nephtys*.

Sediment chemistry results indicated levels of metals and oil and grease to be low (Table 6-1) at reference, mound, and off-mound locations. No major trends were noted. Concentrations of organochlorine pesticides and polychlorinated biphenyls (PCBs) in sediments were below the analytical detection limits at almost all of the reference and on-site stations. The concentration of PCBs was greatest in the recent dredged material, but was also below the 1.0 ppm considered to be a high level of contamination according to the NERBC guidelines (Table 6-1).

Body burden results for 1987 indicated that the concentrations of Cd, Pb, and Hg in *Nephtys* were below the analytical detection limits at both the reference and on-site stations (Figure 6-9). Reflecting the general pattern of sediment contaminants, *Nephtys* body burdens showed no distinct trend (SAIC 1990a).

Dissolved oxygen (DO) measurements were made in 1987, 1988, and 1990 (SAIC 1990b, 1990c, Germano et al. 1994). Hypoxic water (DO concentration less than 3 $mg \cdot l^{-1}$) was present throughout the water column in all of Long Island Sound in the summer of 1987. The similarity of DO measurements at the disposal mounds and reference stations led to the conclusion that hypoxic conditions were unrelated to disposal activity (SAIC 1990b). In 1988 and 1990, the thermocline was well developed at 5-10 m, and there continued to be no significant difference in DO values between the mound and reference stations.

6.1.2 CLIS: 1990 Monitoring Results

Field operations at CLIS were conducted in July 1990 to delineate the extent and topography of the recently deposited dredged material, to measure near-bottom and near-surface DO concentrations and vertical profiles of temperature and salinity at select disposal site and reference stations, and to collect additional baseline sediment grain size and chemistry samples from the reference areas. The data included precision bathymetry, REMOTS® sediment-profile photography, conductivity, temperature, depth (CTD) and DO information, and sediment grab samples.

The precision bathymetric survey detected disposal mounds CLIS-88, CLIS-89, and CS-90-1, formed since the 1988 survey. Dredged material was detected at all REMOTS® stations in the survey. In many cases, REMOTS® photographic evidence of off-mound deposits of dredged material was supported by small (0.20 to 0.40 m) decreases in water depth detected in a comparison of 1988/1990 bathymetric data.

Benthic recolonization was determined from the analysis of REMOTS® photographs obtained at CLIS-89, with Stage I taxa (initial stages of recolonization) predominating and at CS-90-1, with Stage I taxa occurring 200 m southwest of the buoy location. Most of the remaining stations and the reference stations had Stage III (mature successional stage) assemblages.

The CTD and DO data from CLIS and the reference areas were spatially homogeneous. DO values ranged from 3.4 to 6.34 $mg \cdot l^{-1}$, indicating the absence of hypoxia.

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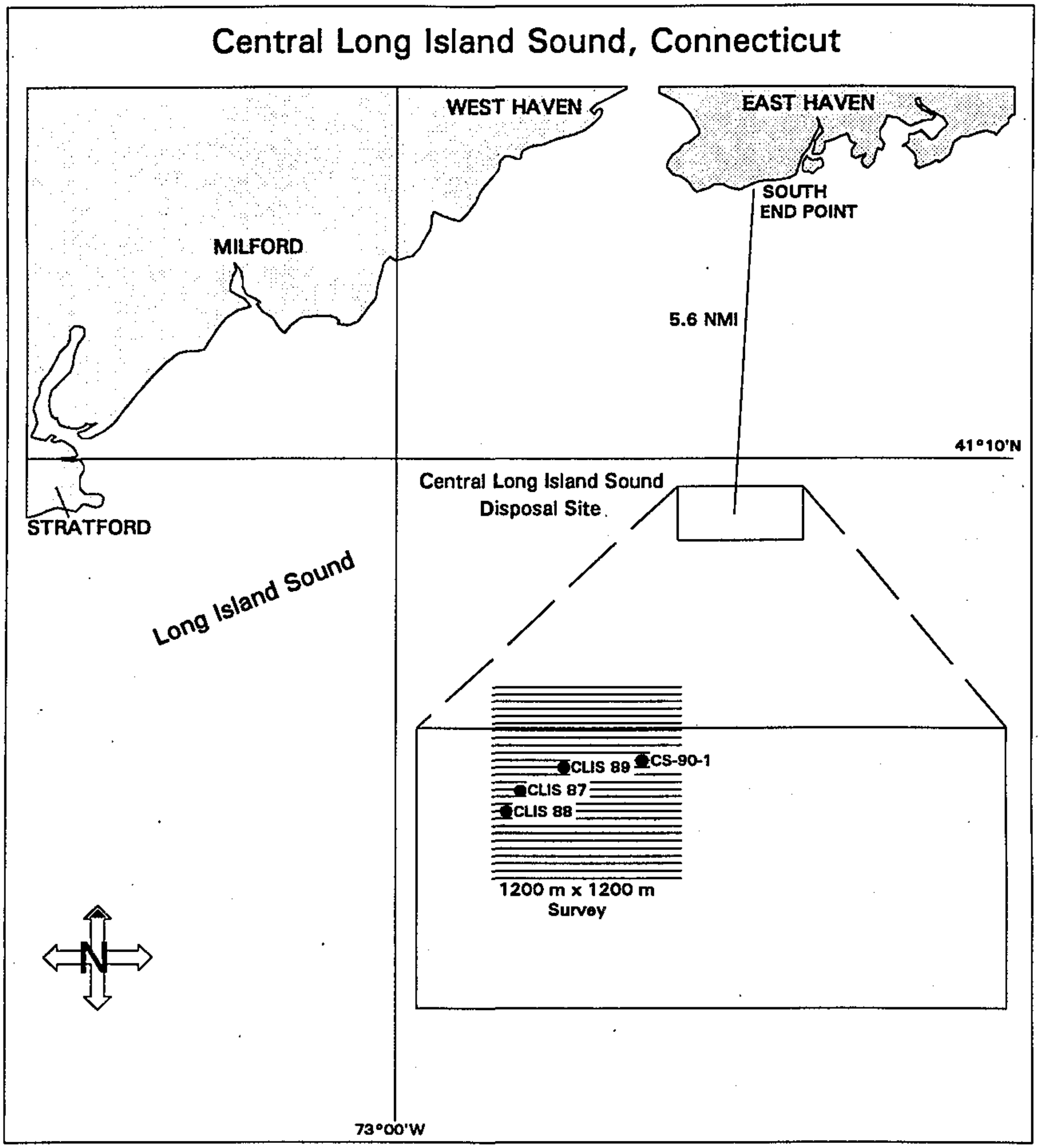

Figure 6-1. Location of CLIS in relation to South End Point, East Haven, Connecticut

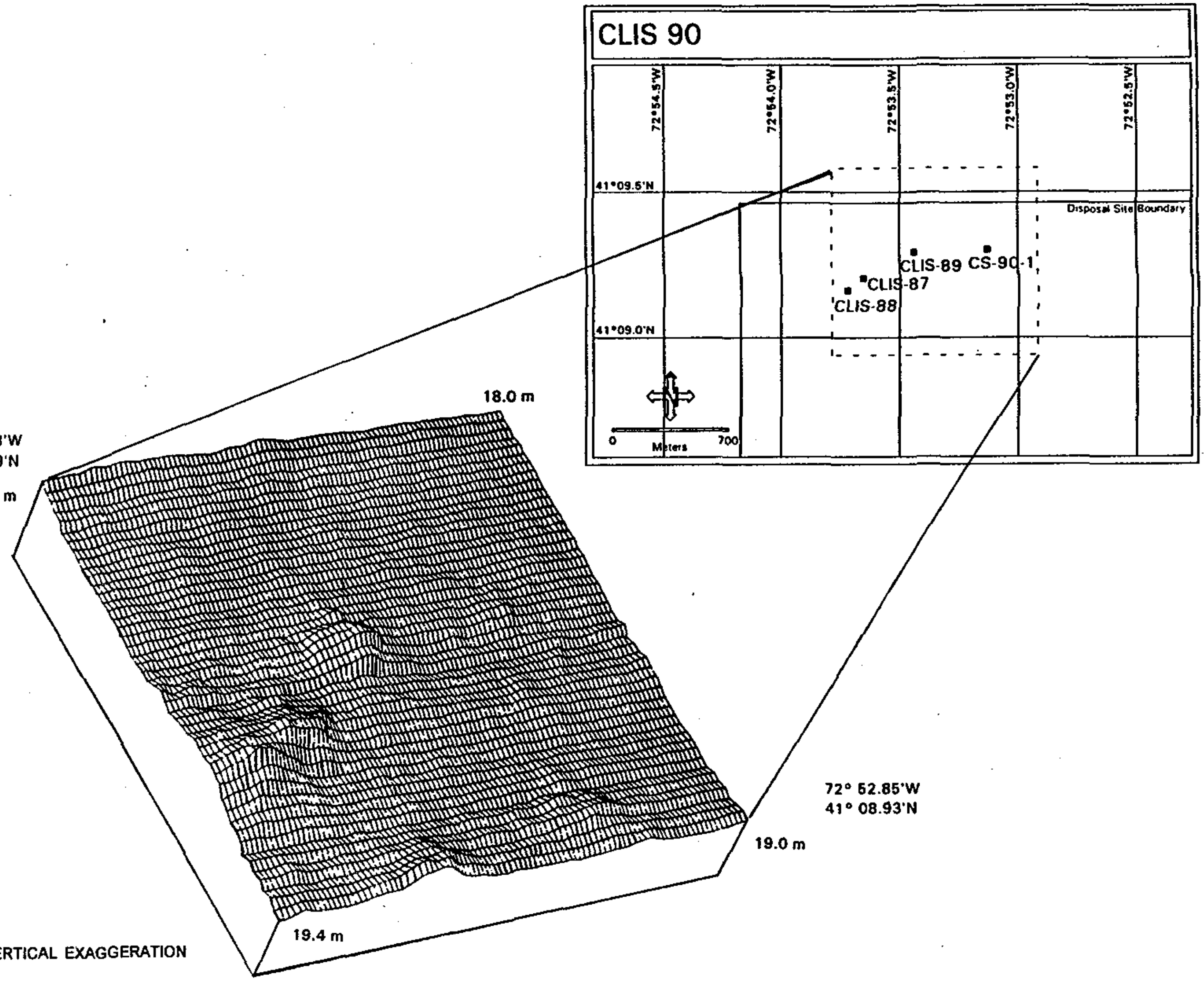

Figure 6-2. Three-dimensional bathymetric plot of the CLIS 1990 survey

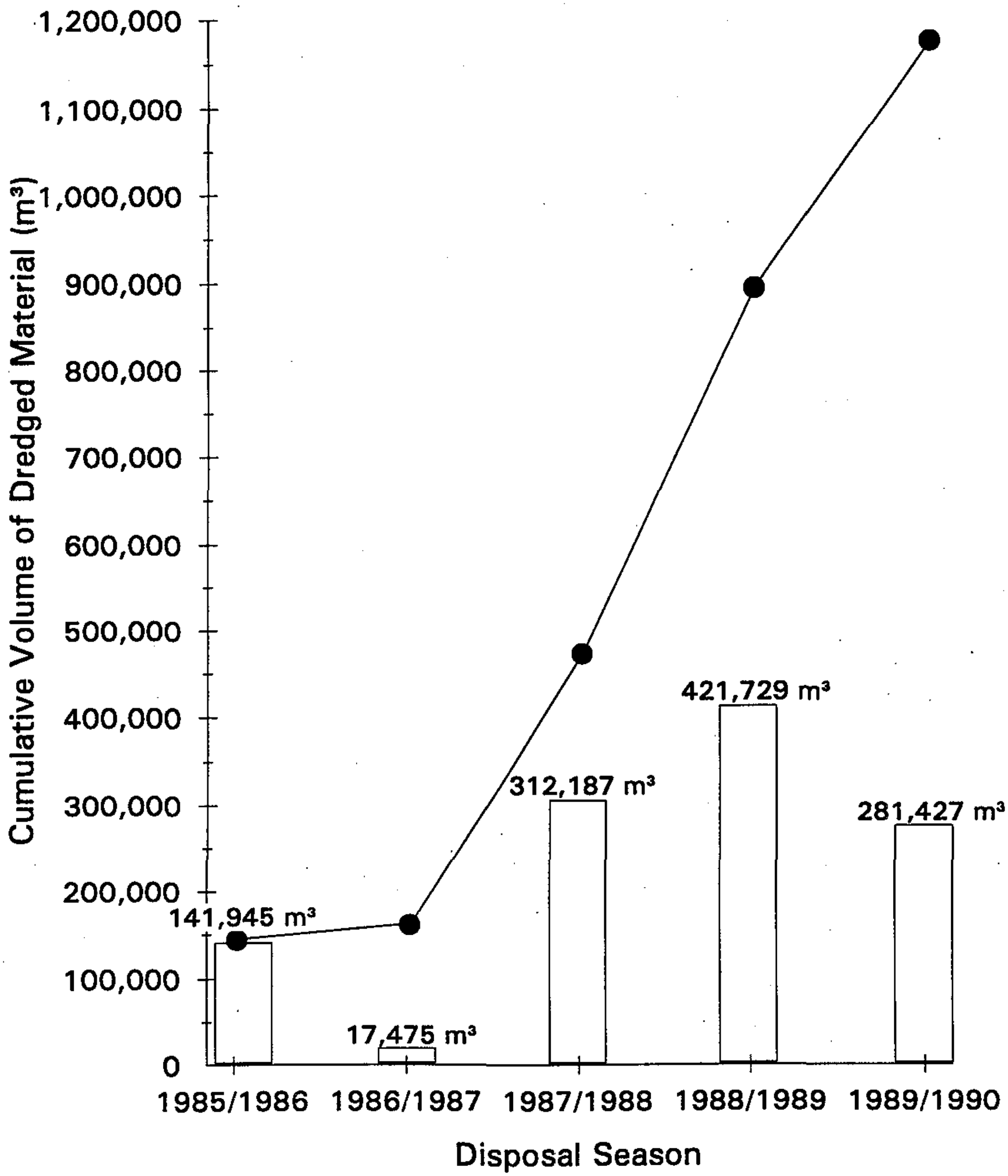

Figure 6-3. Dredged material disposal at CLIS, 1985-1990

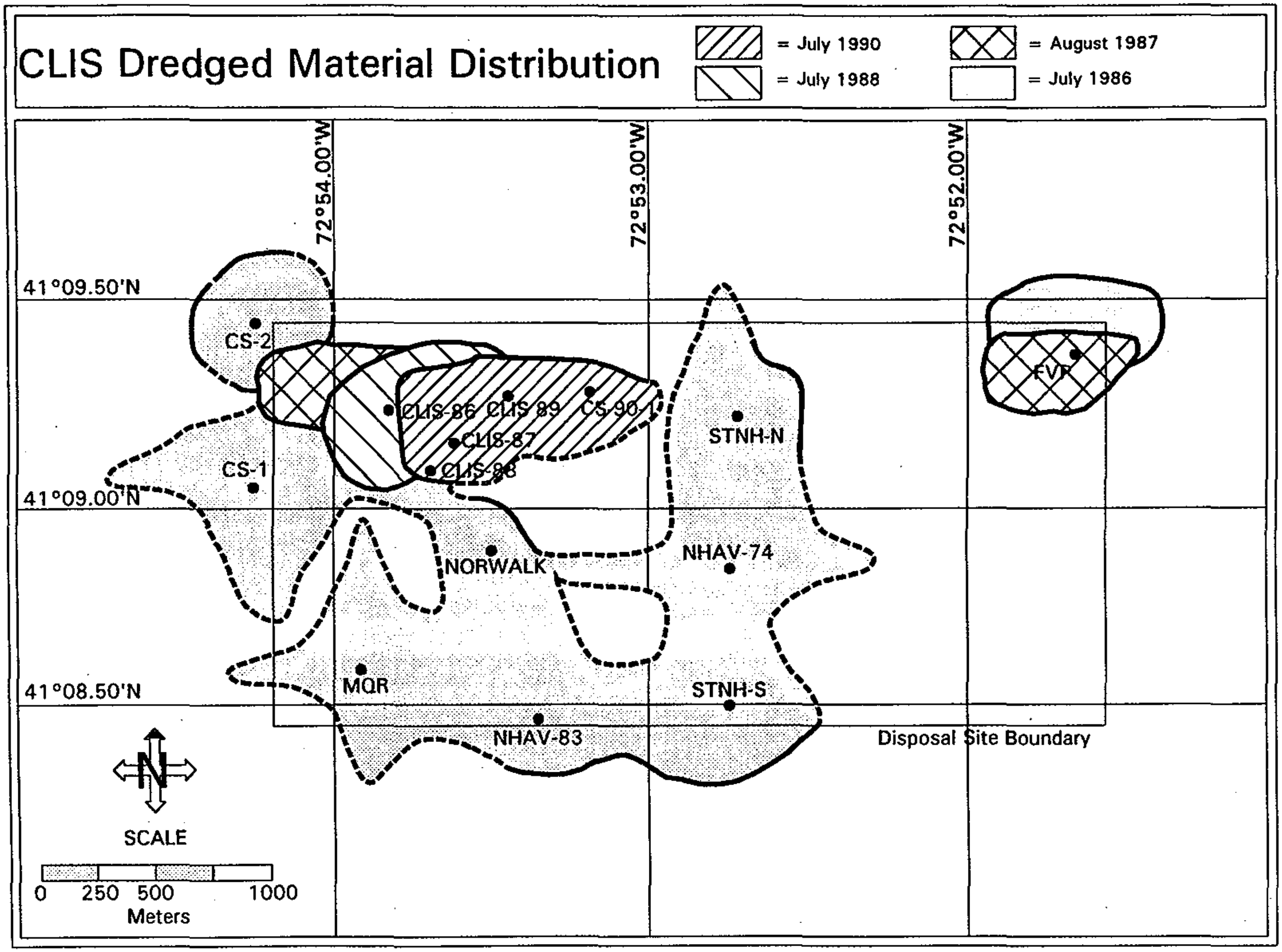

Figure 6-4. Dredged material distribution at CLIS, 1986-1990

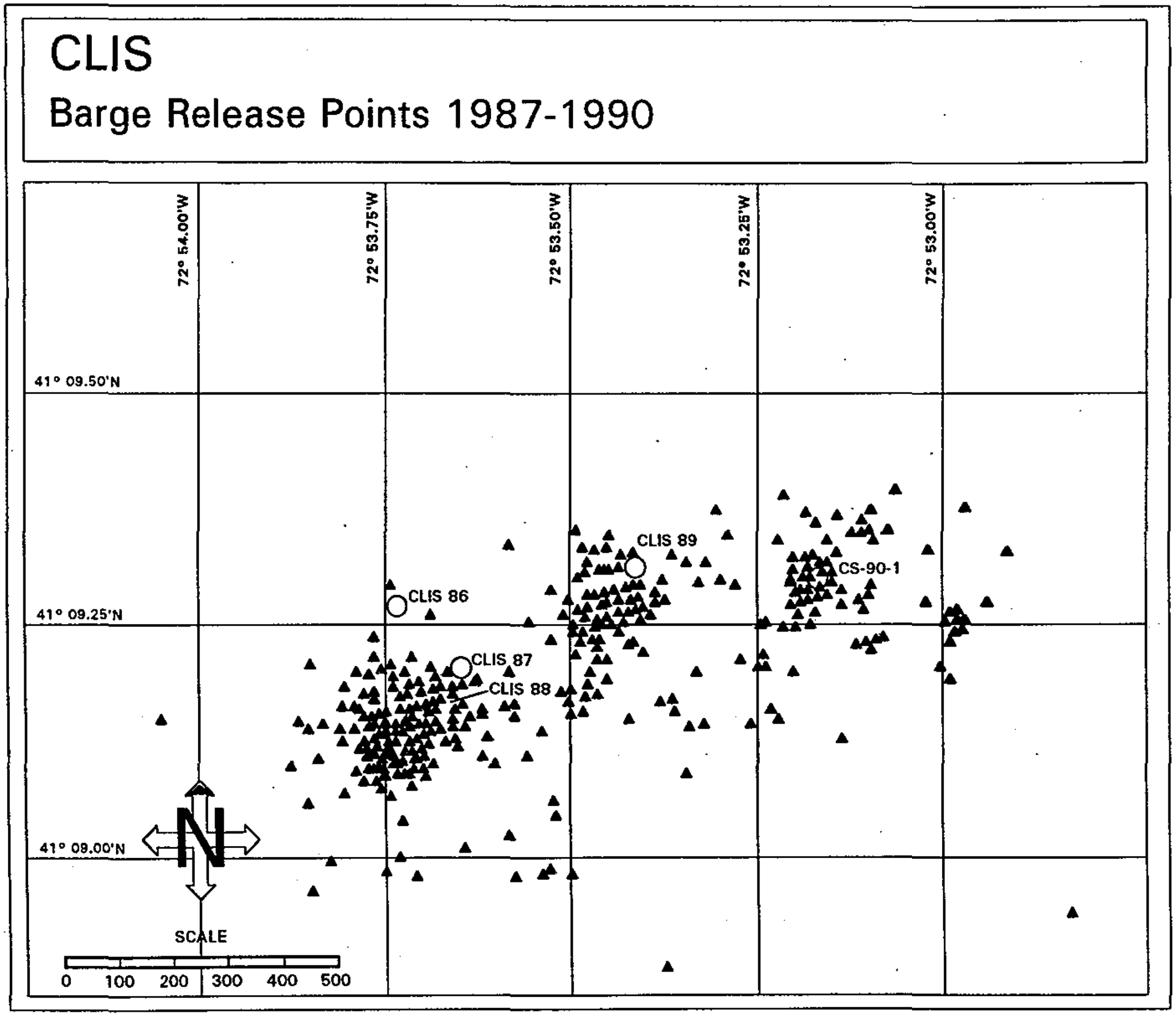

Figure 6-5. Barge release locations at CLIS, 1987-1990

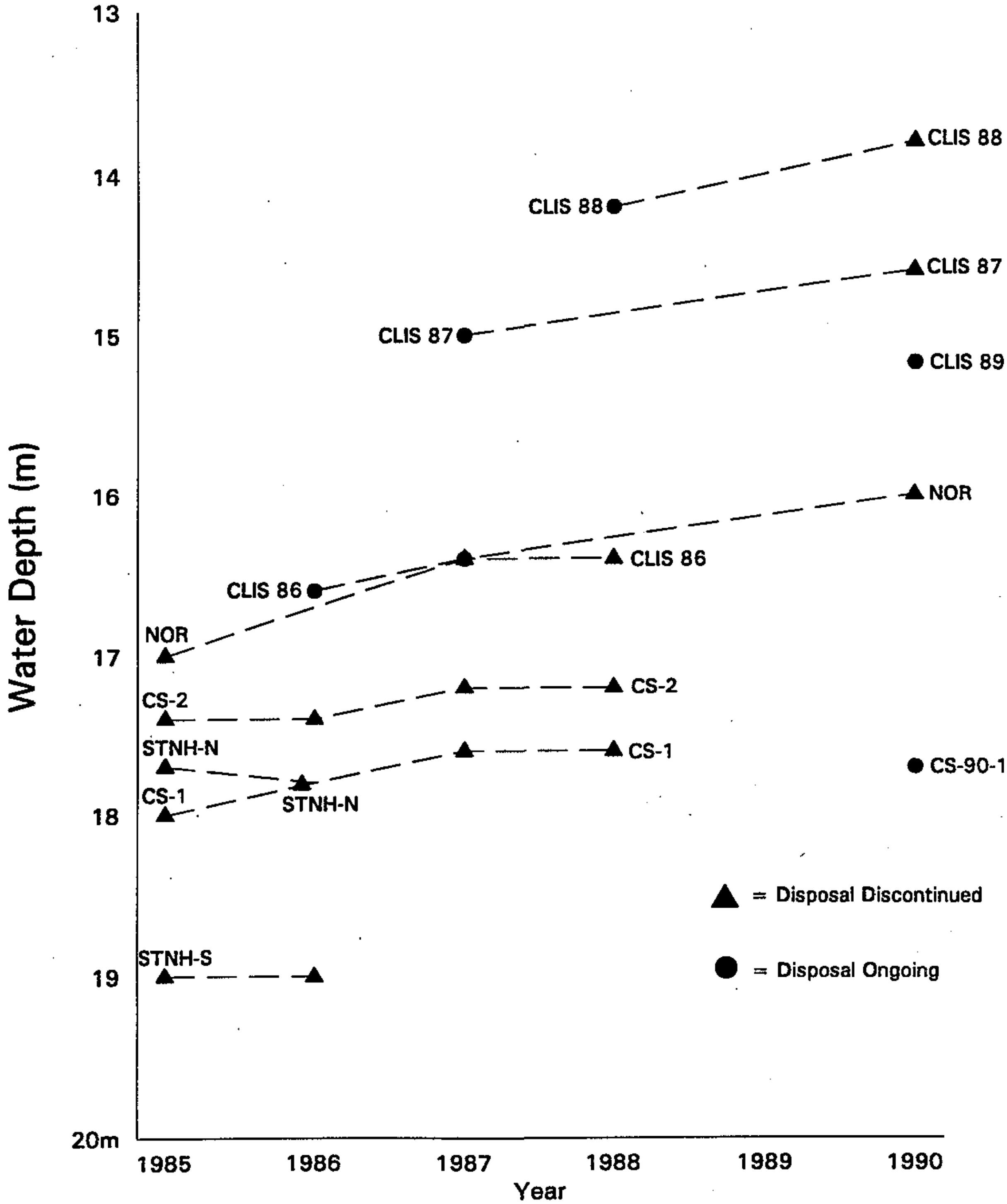

Figure 6-6. Dredged material mound heights at CLIS over time

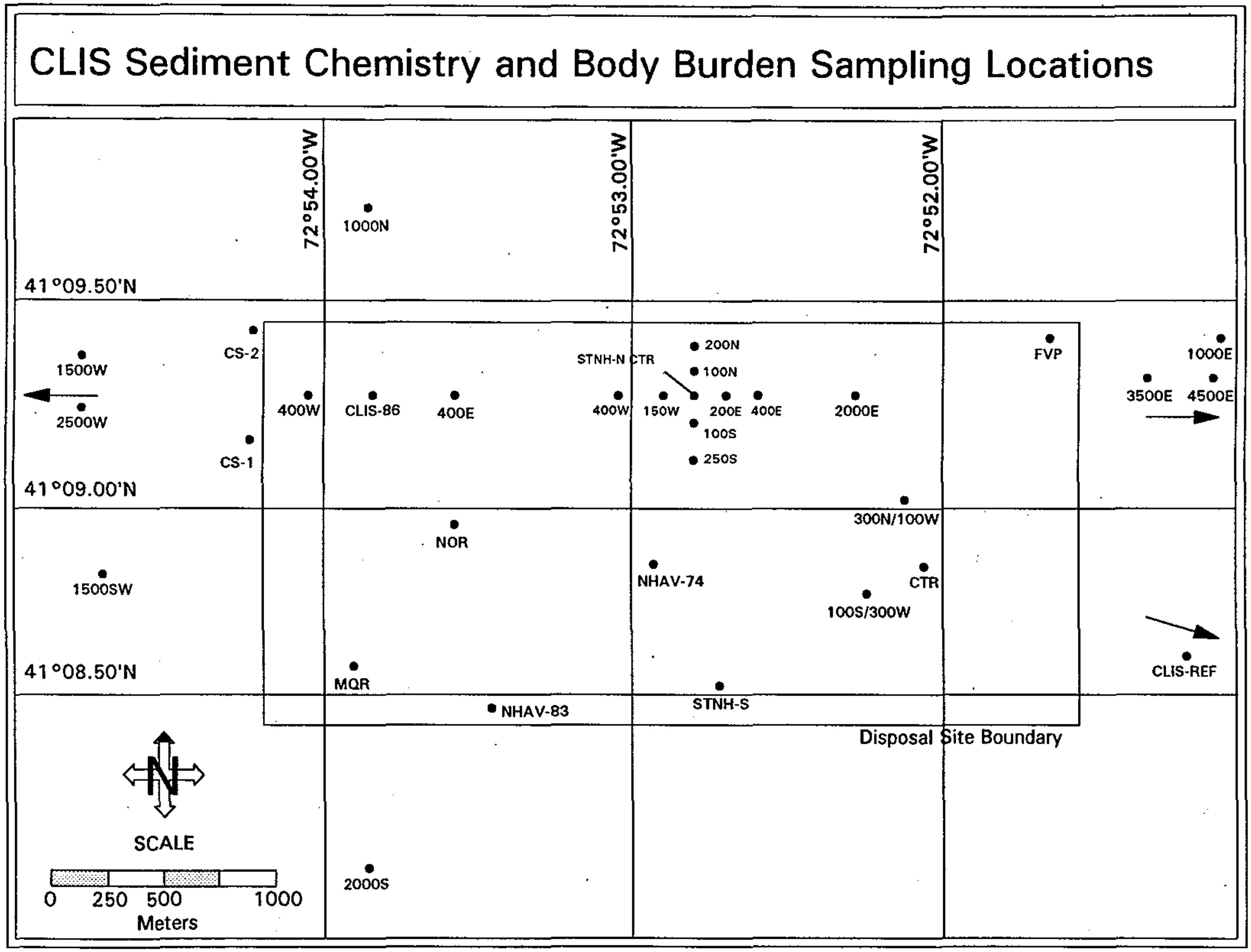

Figure 6-7. Sediment chemistry and body burden sampling locations at CLIS, 1986 and 1987

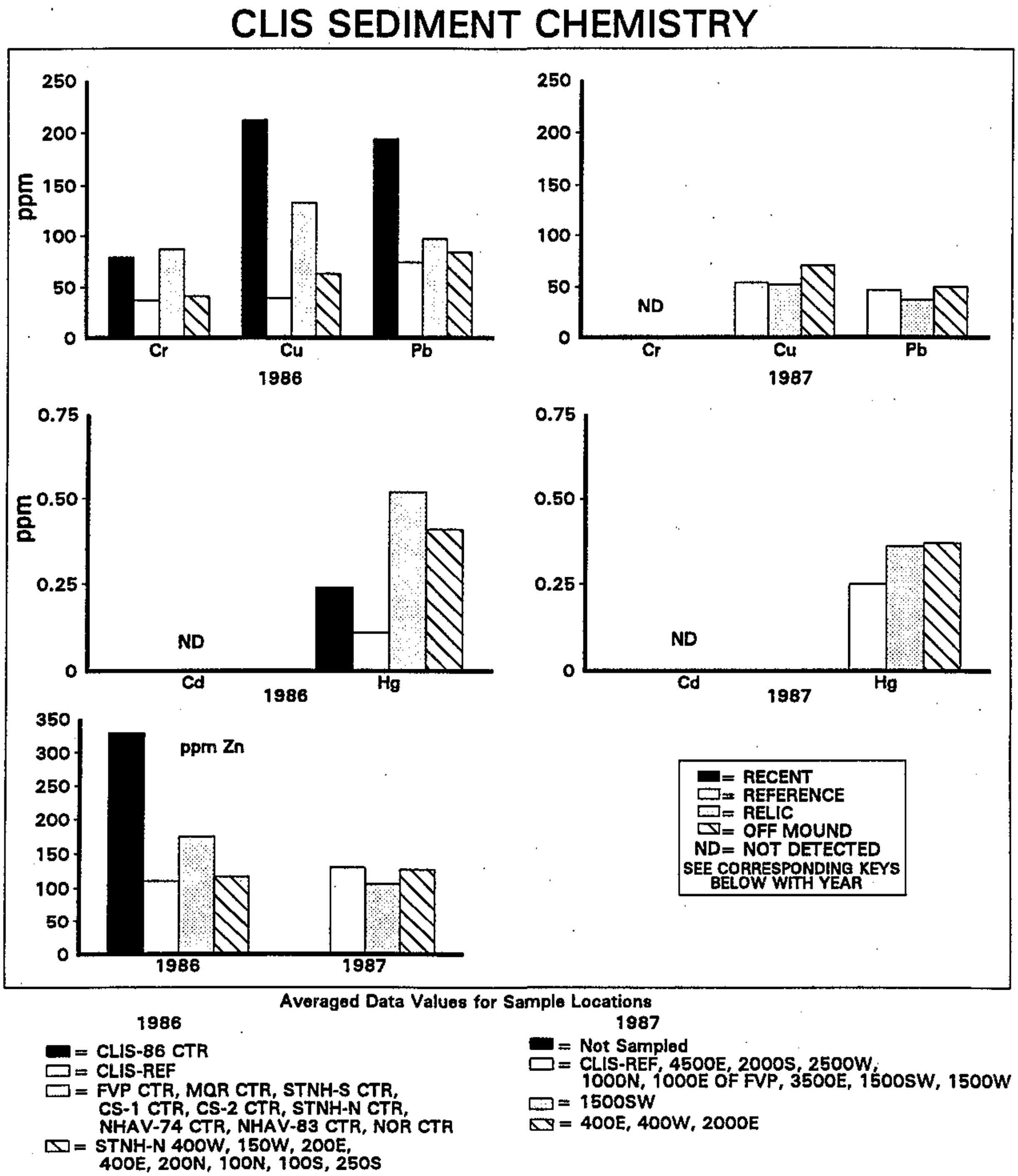

Figure 6-8. Results of CLIS sediment chemistry analyses

CLIS SEDIMENT CHEMISTRY

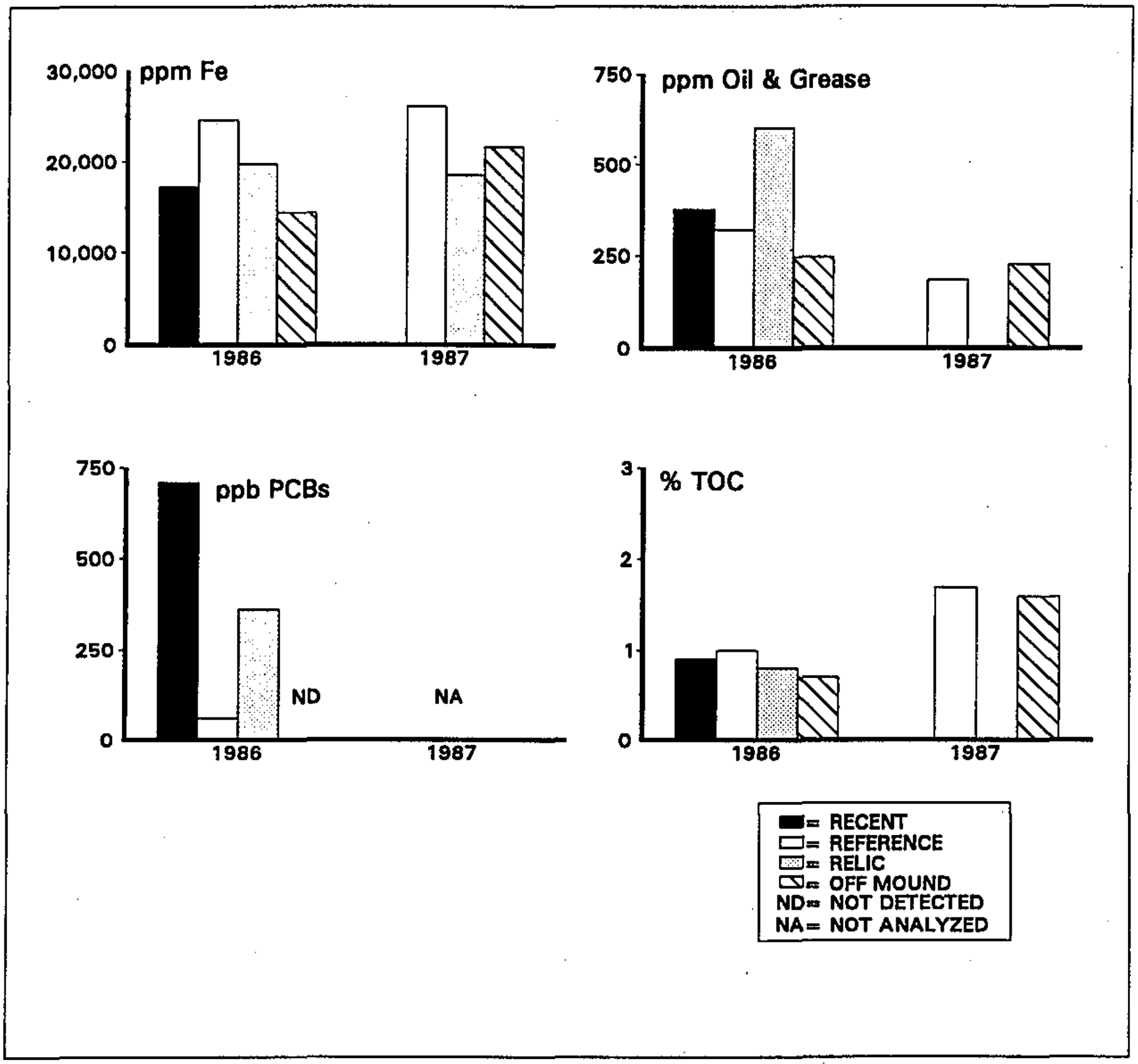

Figure 6-8. (cont.)

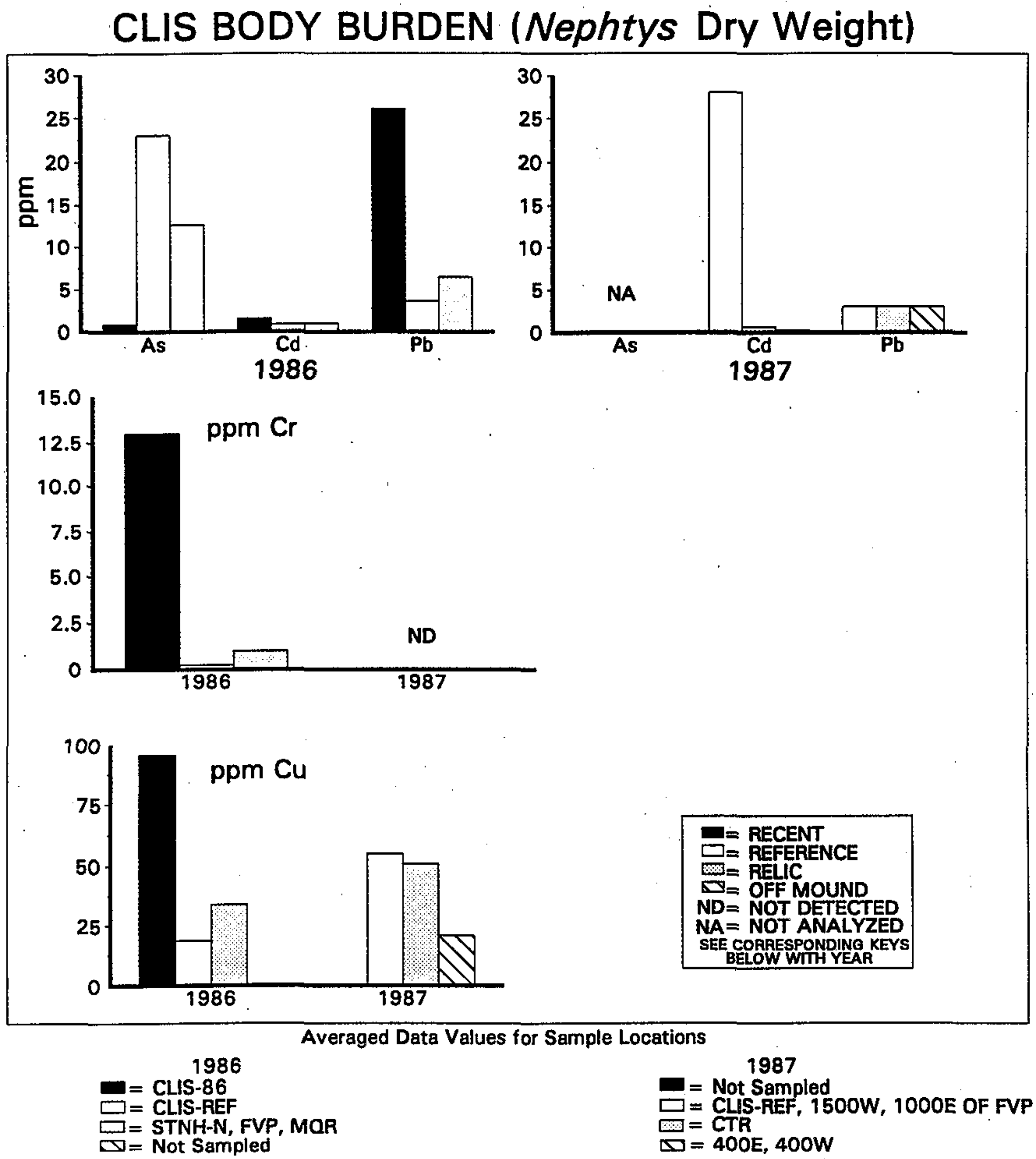

Figure 6-9. Results of CLIS body burden analyses (measurements based on dry weight of *Nephtys*)

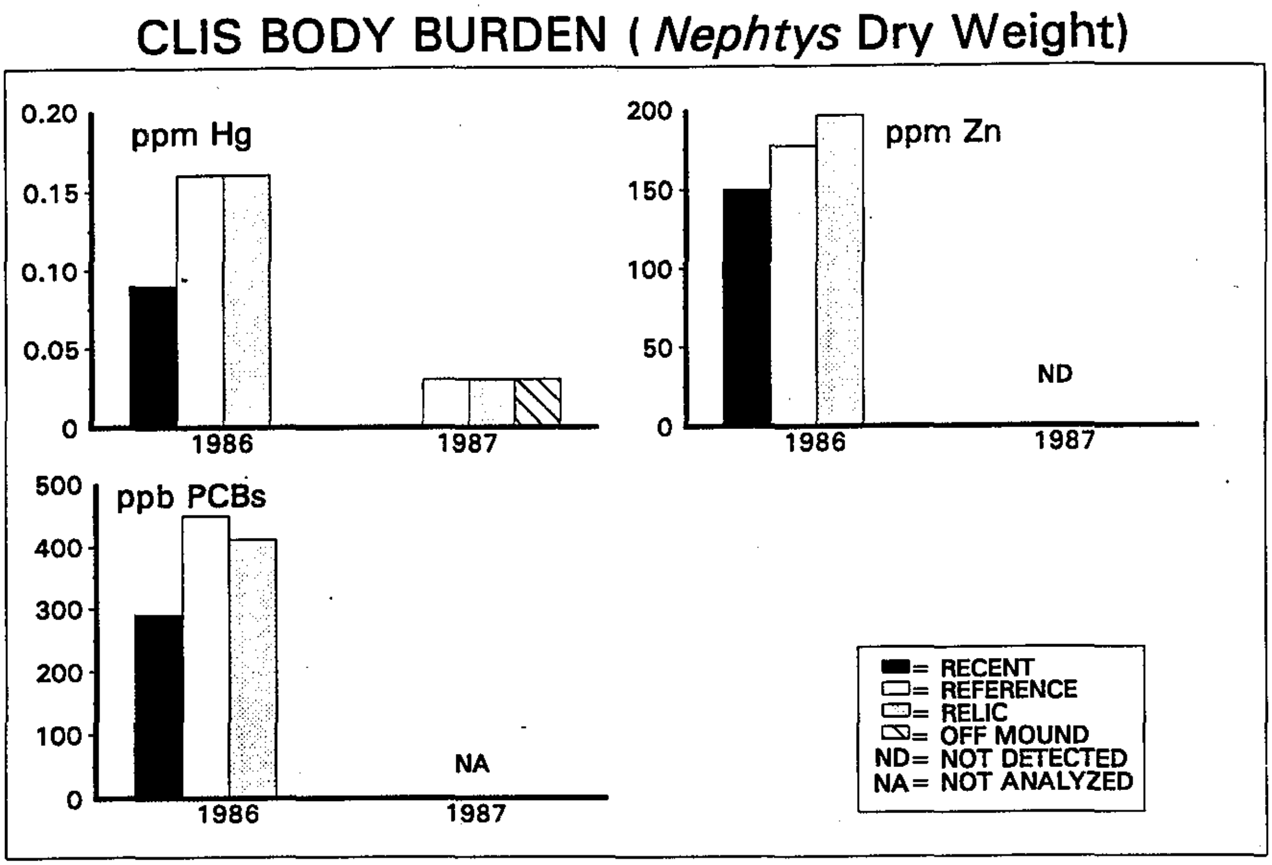

Figure 6-9. (cont.)

6.2 WESTERN LONG ISLAND SOUND DISPOSAL SITE

6.2.1 Summary of WLIS

The Western Long Island Sound Disposal Site (WLIS) is located 2.7 nmi south of Long Neck Point, southeast of Stamford, Connecticut, between the Stamford and Eaton's Neck historical disposal grounds (Figure 6-10). The site is 1 nmi^2, centered at 40°59.400′ N and 73°28.700′ W. Water depth at the center of the site is approximately 33 m, with an overall range from 24 to 34 m. The sediments consist primarily of fine silts and clays with some patches of relic dredged material from the discontinued Eaton's Neck disposal site (SAIC 1988a).

Scientists from SAIC conducted the baseline survey at WLIS in January 1982 (SAIC 1982). This survey indicated that diurnal tidal changes within Long Island Sound were the principal influence governing the current regime, reaching 20 and 18 $cm \cdot s^{-1}$ for flood and ebb tides, respectively. The limited fetch within the region reduces the incidence of storm-driven, wave-induced currents and, in conjunction with the east-west trending trough in the southwest region of the site, provides conditions ideal for the containment of dredged sediments. Since disposal first began at WLIS in March 1982, varying quantities of dredged material have been deposited annually. As a result, four distinct dredged material disposal mounds ("A", "B", "C", and "D") currently exist at the site (Figure 6-11).

Lobstering is the most important fishery at WLIS. Prime lobster fishing grounds are located east and west of the site at the previously used disposal sites, as well as in the vicinity of Cable and Anchor Reef. In addition, leased oyster beds are present north of WLIS in the shallow waters off Norwalk and Stamford, Connecticut. Disposal is curtailed from June through August when oyster spawning activity is high (SAIC 1988a).

SAIC conducted six monitoring surveys at WLIS since fall 1984. They occurred annually and/or followed the cessation of major disposal events (SAIC 1987a, 1988b, 1990d, 1990e, Germano et al. 1993). The objectives of the surveys included determining the areal extent of dredged materials and the stability of the disposal mounds, evaluating the response and subsequent recolonization of the benthic environment, and monitoring chemical and physical sediment parameters and water column DO content. Assessment techniques included precision bathymetry, side-scan sonar, sediment sampling for physical, biological and chemical analyses, SCUBA diver observations, current meter and transmissometer deployments, invertebrate bioaccumulation, CTD/DO monitoring, and REMOTS® sediment-profile photography (SAIC 1990f).

Approximately 633,000 m^3 of dredged sediments were deposited at WLIS (Figure 6-12). The dredged material either was added to pre-existing disposal mounds or formed new mounds. The steepness of the disposal mounds at WLIS supported the premise that the disposal mounds were stable and no significant sediment erosion occurred (SAIC 1990e; Figure 6-13). Increased water depth over "B" mound from 1988 to 1990 was attributed partly to compaction of sediments on the mound and partly to an artifact of the data analysis (Germano, Parker, and Williams 1993). The October 1985 survey, when mound height was determined to be unaffected by the passage of Hurricane Gloria, further confirmed mound stability (SAIC 1988b). Based on bathymetric and REMOTS® surveys, thin layers ($\leq$20 cm) of dredged material extended beyond the base of the disposal mounds detectable by bathymetry (Figure 6-14). The two factors contributing most to this distribution are the physics of the disposal process and the release of dredged material away from the center of the mound (Figure 6-15).

In August 1986, REMOTS® photography at WLIS revealed a stressed biological community in conjunction with the extremely low near-bottom DO levels which were recorded throughout Long Island Sound (SAIC 1987a, 1987b). This regionwide low DO phenomenon, unrelated to disposal activities, is believed to be due to eutrophication effects during the strong temperature gradient present in the water column during the summer months in the Sound (SAIC 1987b). DO measurements recorded since that time have been above hypoxic levels (i.e., greater than 3 $mg \cdot l^{-1}$). In addition, REMOTS® analyses have shown an overall continued improvement in the benthic habitat at WLIS with no significant difference between the on-site and reference station communities in 1987 and 1988 surveys. The disturbance resulting from dredged material disposal has been primarily physical in nature, with rapid recolonization of the seafloor by the resident benthic fauna.

Sediment chemistry samples were collected in 1985, 1986, and 1987 to monitor contaminant levels within the disposal site and check for indications of contaminant resuspension and transport. Samples were obtained from the center of each of the three disposal mounds ("A", "B", and "C") and the WLIS reference area in 1985; the "A" mound and WLIS reference area in 1986; and along an east-west transect in the direction of the dominant current regime in 1987 (Figure 6-16). Body burden samples were obtained in 1986 and 1987 at locations identical to the sediment chemistry sampling stations.

Results of sediment chemistry analyses in 1985 indicated that the sediment at the reference area had lower concentrations of Cu, Cr, and Pb, while the recent dredged material, in general, showed higher concentrations of most metals in comparison to relic dredged material and the reference area (Figure 6-17). Statistical analyses of sediments collected in 1986 indicated that the concentrations of Pb, Ni, Cu, and oil and grease were significantly higher in the relic dredged material than in the reference area (Figure 6-17). The levels of Hg, Ni, Pb, Zn, and PCBs at the "A" mound were moderate according to the NERBC limits (Table 6-1).

The objective of the 1987 sediment chemical study was to assess whether contaminants deposited at the WLIS site were subject to resuspension and transport, possibly resulting in long-term accumulation of these materials outside the site boundaries. The concentration ranges of metals found at WLIS were comparable to levels found in DAMOS surveys conducted in August 1985 and 1986 and similar to others reported for the site and for Central Long Island Sound (SAIC 1988b, 1987a). Together these facts strongly suggest that contaminants associated with dredged sediments disposed over several years (i.e., since 1982) at the WLIS site were not accumulating in detectable concentrations outside the site.

The results from the 1986 body burden study showed higher levels of Pb and lower levels of Zn and Cd in *Nephtys* collected at the "A" mound than those collected at the reference area (Figure 6-18). Concentrations of the metals were similar to those for *Nephtys* collected at the CLIS reference station (Field Verification Program site; SAIC 1987c). PCB levels were higher in *Nephtys* collected at the reference area than at the "A" mound. The measured level of PCBs in the reference organisms was not expected due to the higher PCB sediment concentration at the "A" mound. The measured wet weight concentrations for PCBs were well below the FDA Alert Level (2 ppm). Reflecting the general pattern of sediment contamination in 1987, body burden results showed no real trends and were consistent with levels found in previous studies (Figure 6-18; SAIC 1990d).

6.2.2 WLIS: 1990 Monitoring Results

In July 1990, SAIC conducted field operations at WLIS to monitor the effects and areal distribution of dredged material deposited during the 1989-1990 disposal season and to assess the status of benthic recolonization and mound stability at the inactive disposal points. Field operations included an 800 × 800 m bathymetric survey, REMOTS® sediment-profile photography, sediment chemistry and grain size sampling, and near-bottom DO determination. A second bathymetric survey (2500 × 3000 m) provided detail of the entire WLIS site.

The disposal of dredged material during the 1989-1990 season resulted in the formation of the "D" mound with a minimum water depth of 28.0 m, a maximum thickness of 5.3 m, and radius of approximately 225 m. The minimum water depth at the "A" and "C" mounds increased slightly since the July 1988 survey; however, the minimum water depth at the "B" mound increased 1.0 m, due partly to compaction of sediments on the mound and partly to an artifact from the bathymetric data analysis. According to the tabulation of disposal logs, barges disposed 185,000 m^3 of material at the site.

Several REMOTS® stations on and around the "D" mound exhibited rapid infaunal recolonization of the recently deposited dredged material. Benthic conditions within the three reference areas (2000W, 2000S, and WLIS-REF) remained similar to the 1988 results; the presence of Stage III taxa and high organism-sediment index (OSI) values (+11) indicated that a relatively healthy and stable environment existed in these areas.

Near-bottom DO concentrations measured at the reference areas and the "D" disposal point ranged from 4.1 to 4.5 $mg \cdot l^{-1}$. Although lower overall relative to near-surface values (9.2 - 11.8 $mg \cdot l^{-1}$), near-bottom DO content remained above hypoxic levels. The health and condition of the benthic environment at WLIS and its response to dredged material disposal are considered to be influenced significantly by the regionwide, near-bottom hypoxic events which can occur in Long Island Sound. Historical evidence indicates that bottom-water hypoxia is becoming more persistent in the summertime in Long Island Sound, presumably from increased nutrient input (e.g., from sewage treatment plants) and consequent eutrophication (Parker and O'Reilly 1991).

6.2.3 References for Section 6.2

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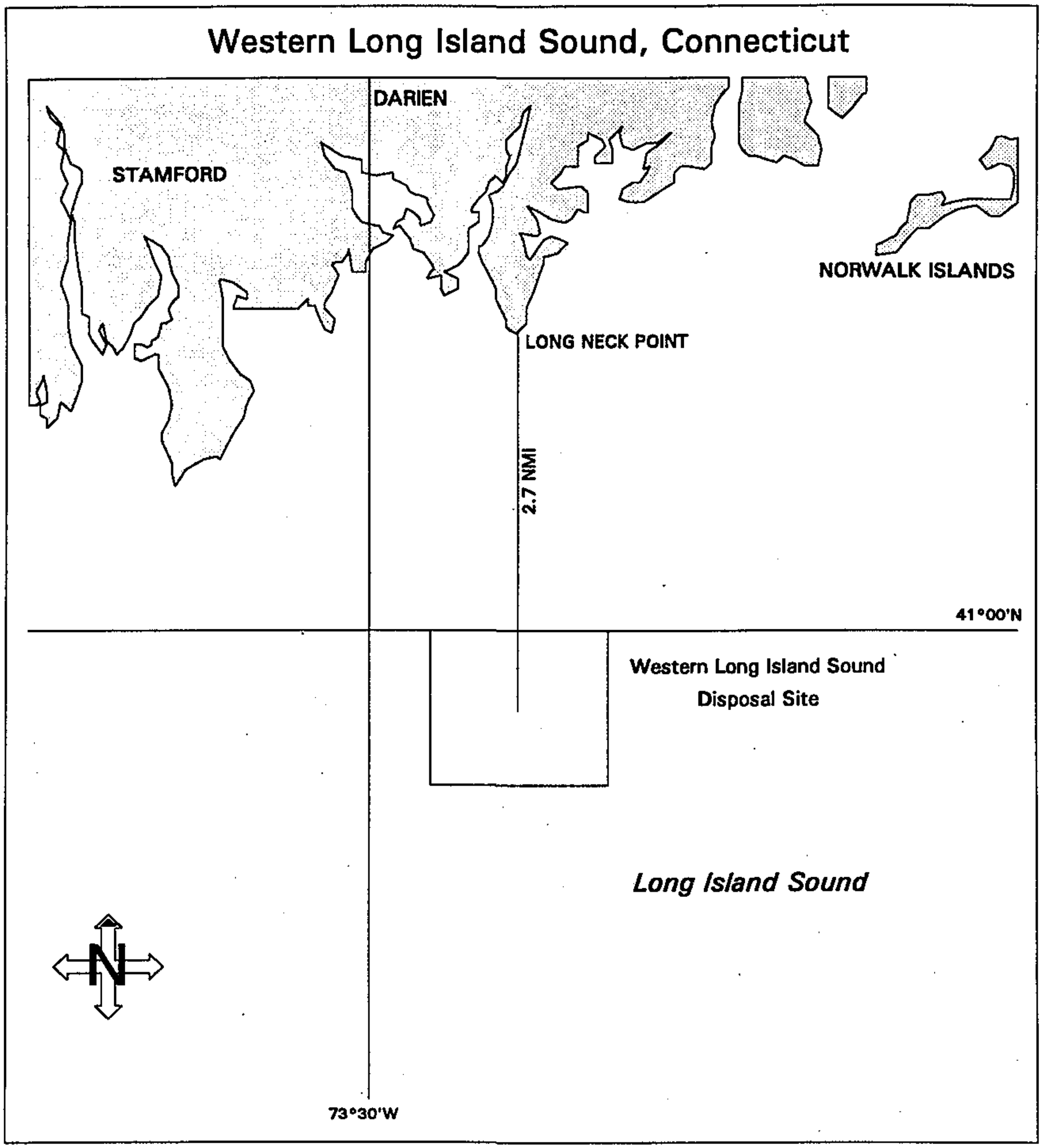


Figure 6-10. Location of WLIS in relation to Long Neck Point, near Stamford, Connecticut

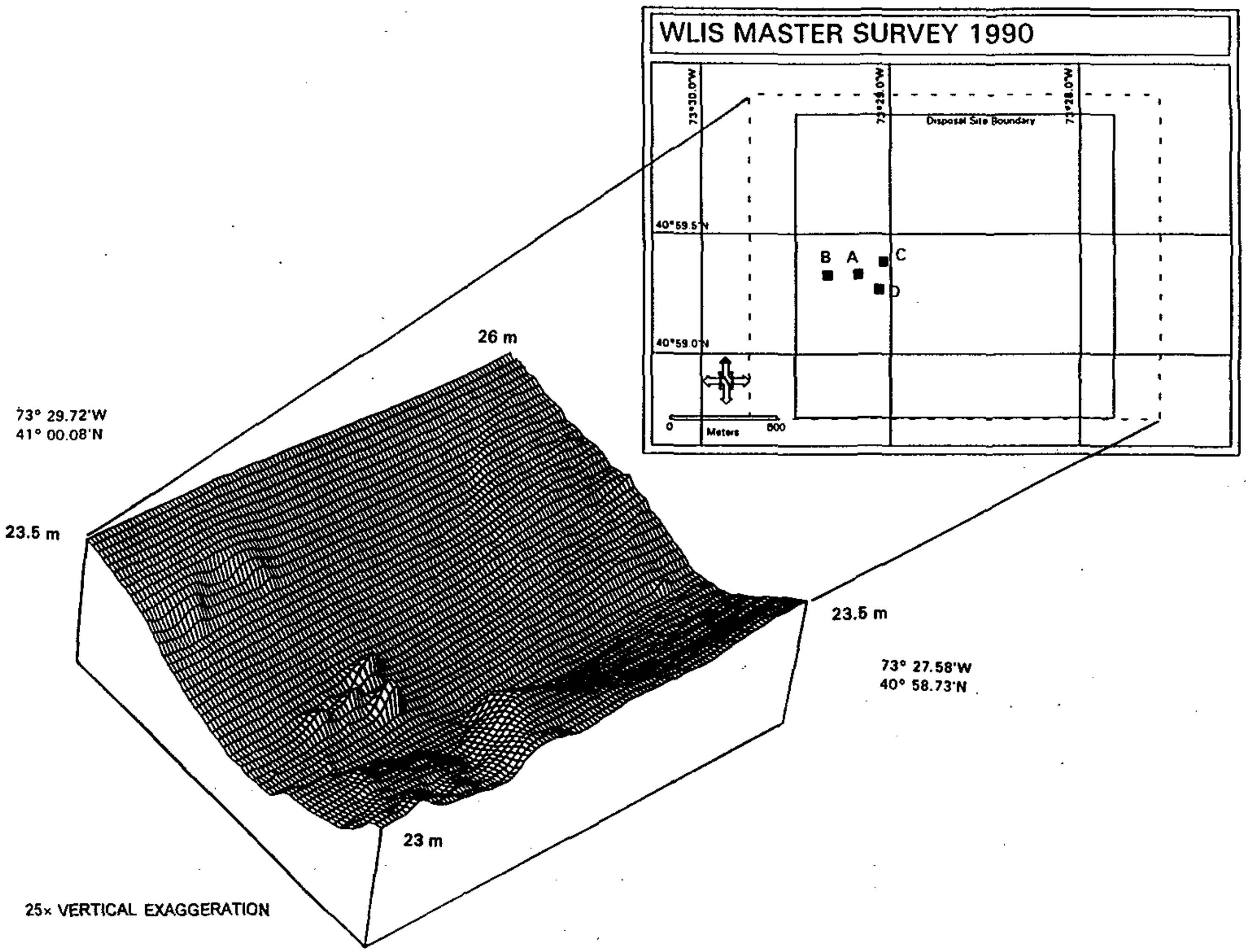


Figure 6-11. Three-dimensional bathymetric plot of Master WLIS 1990 survey

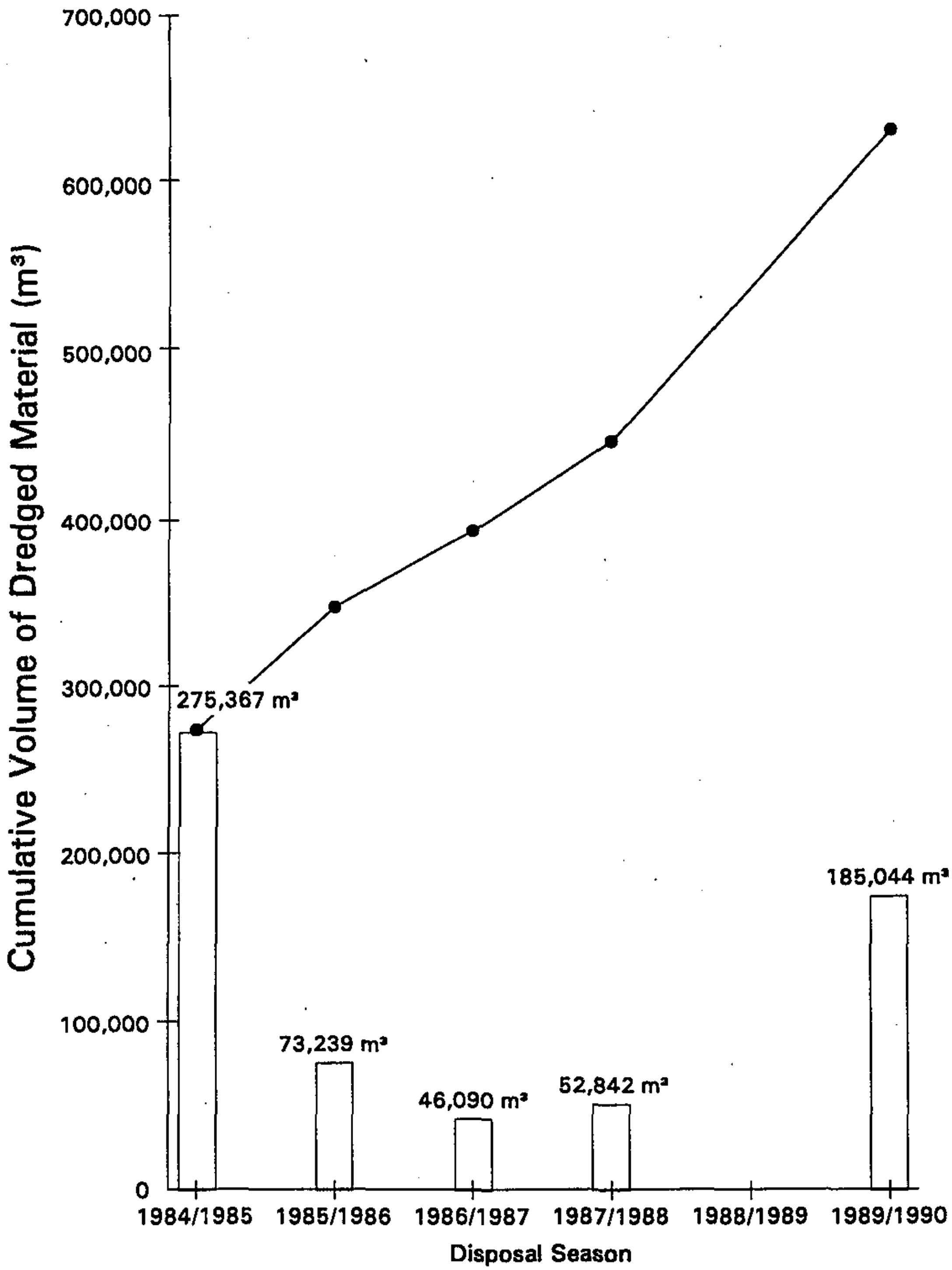


Figure 6-12. Dredged material disposal at WLIS, 1984-1990

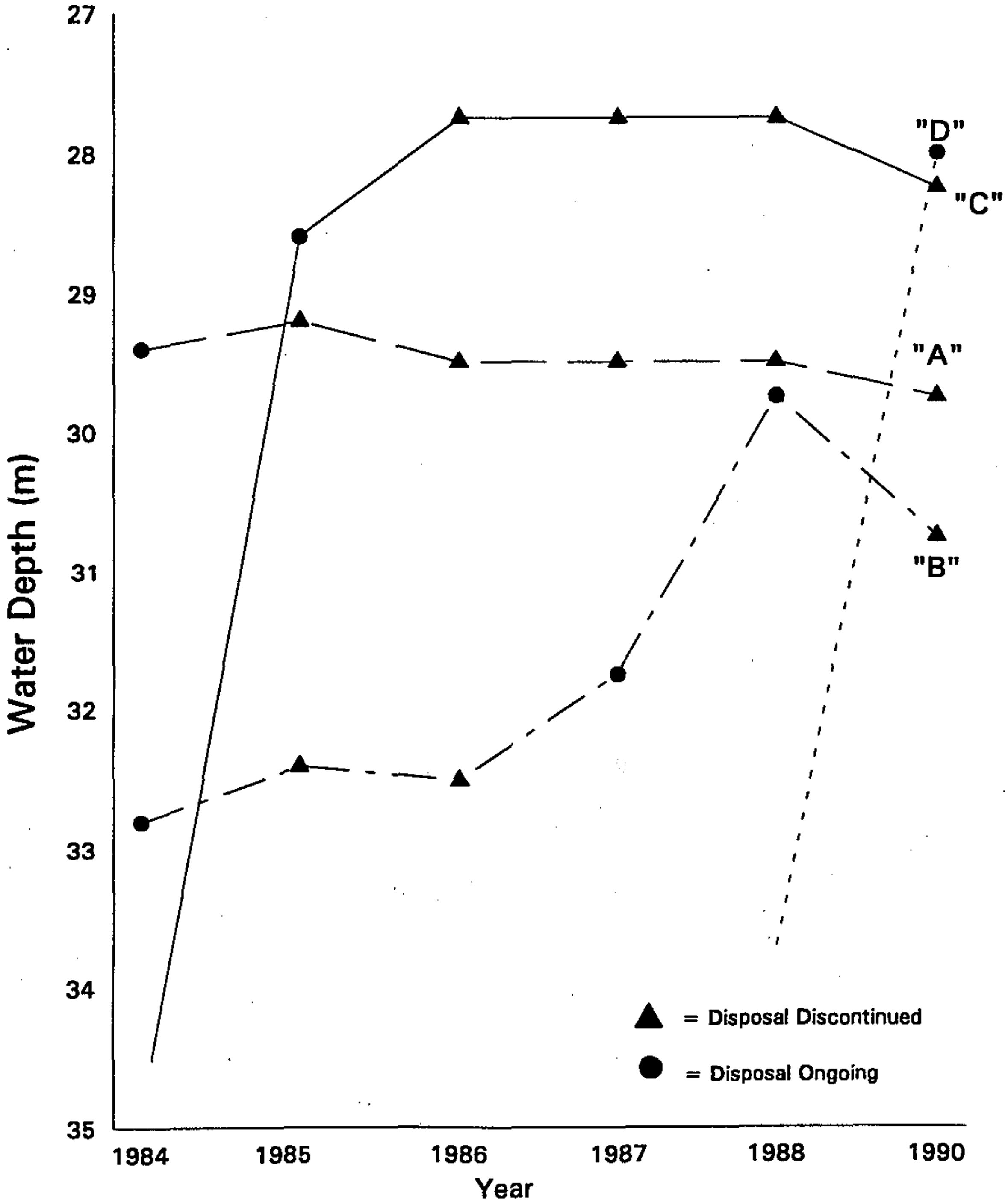


Figure 6-13. Dredged material mound heights at WLIS over time

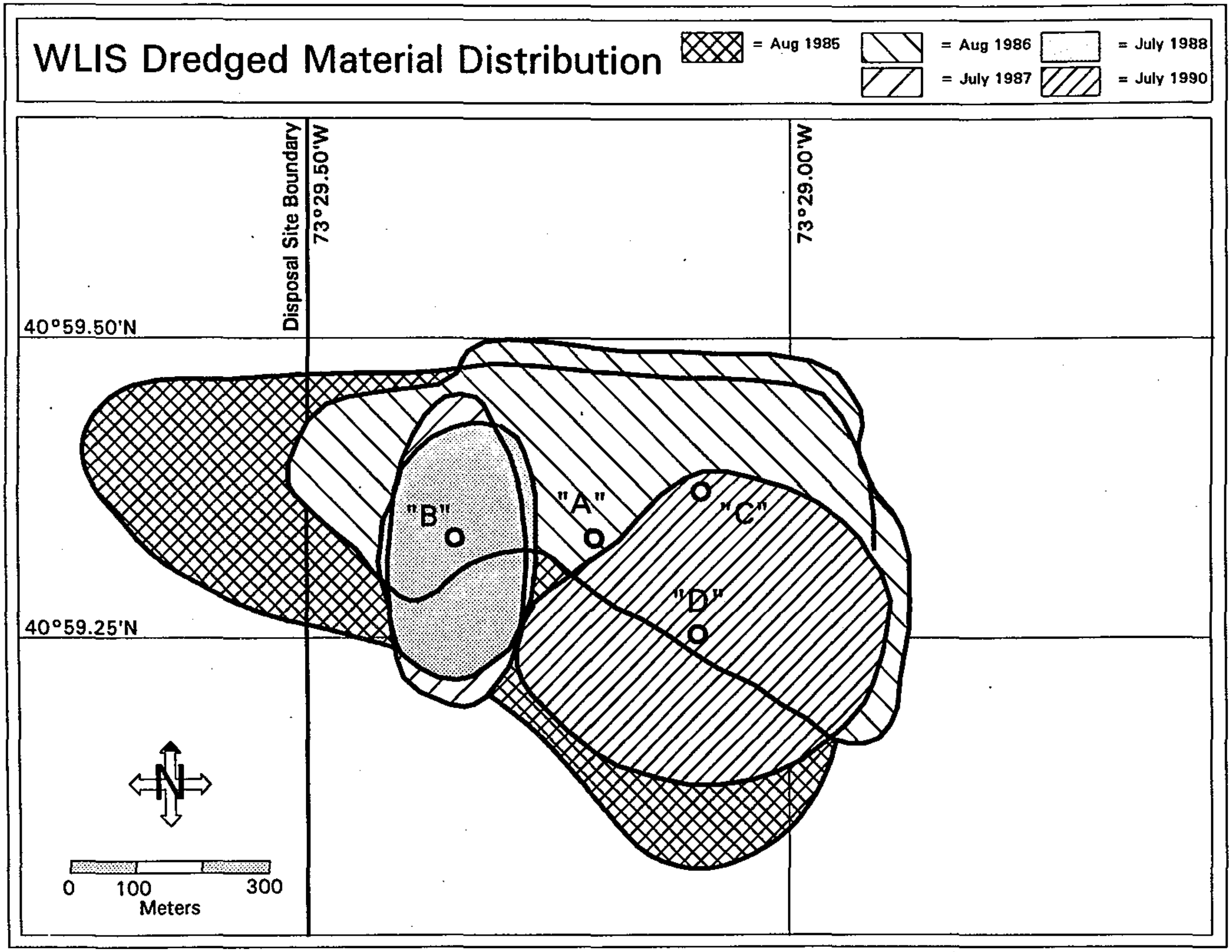


Figure 6-14. Dredged material distribution at WLIS, 1985-1990

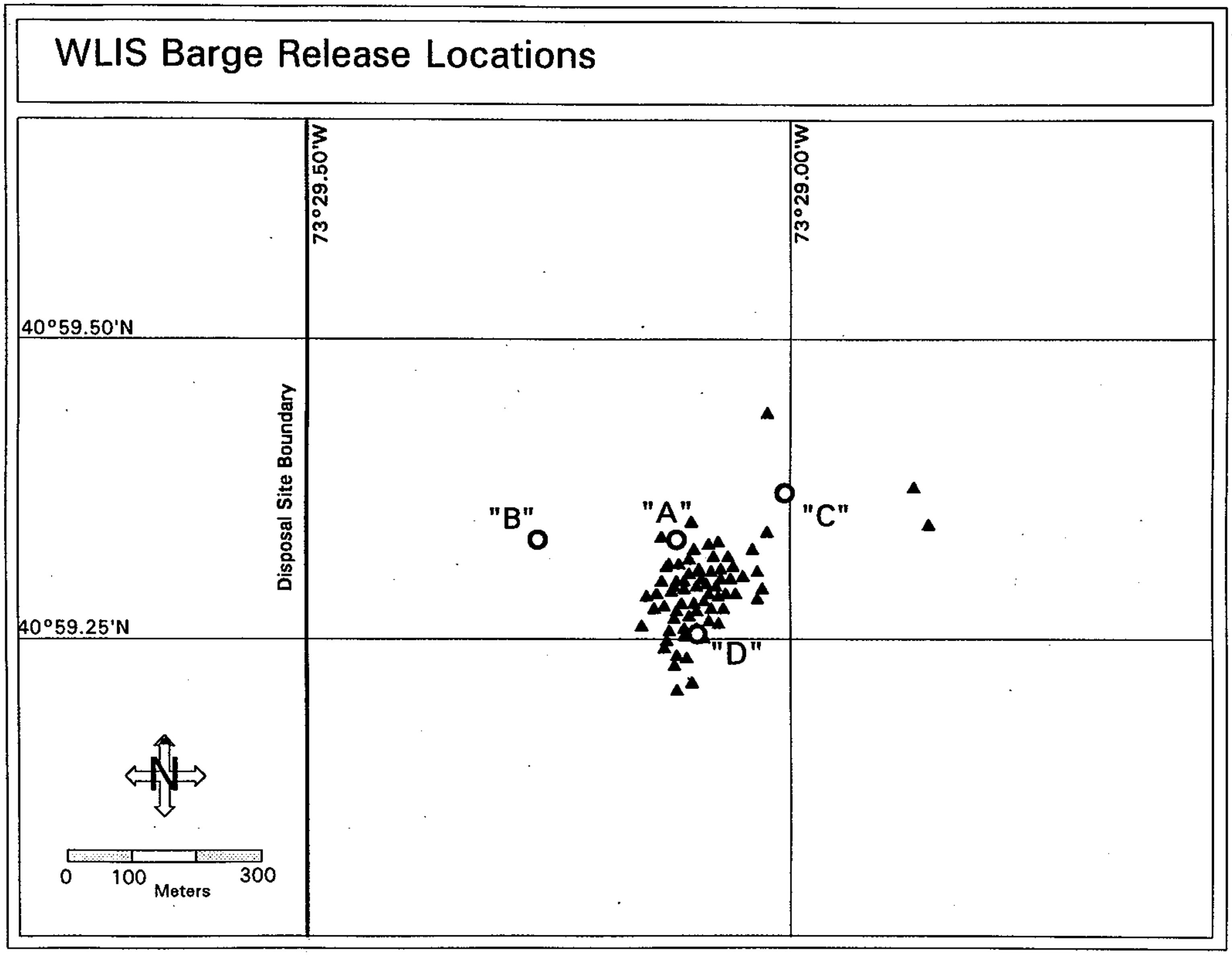


Figure 6-15. Barge release locations at WLIS, 1989-1990

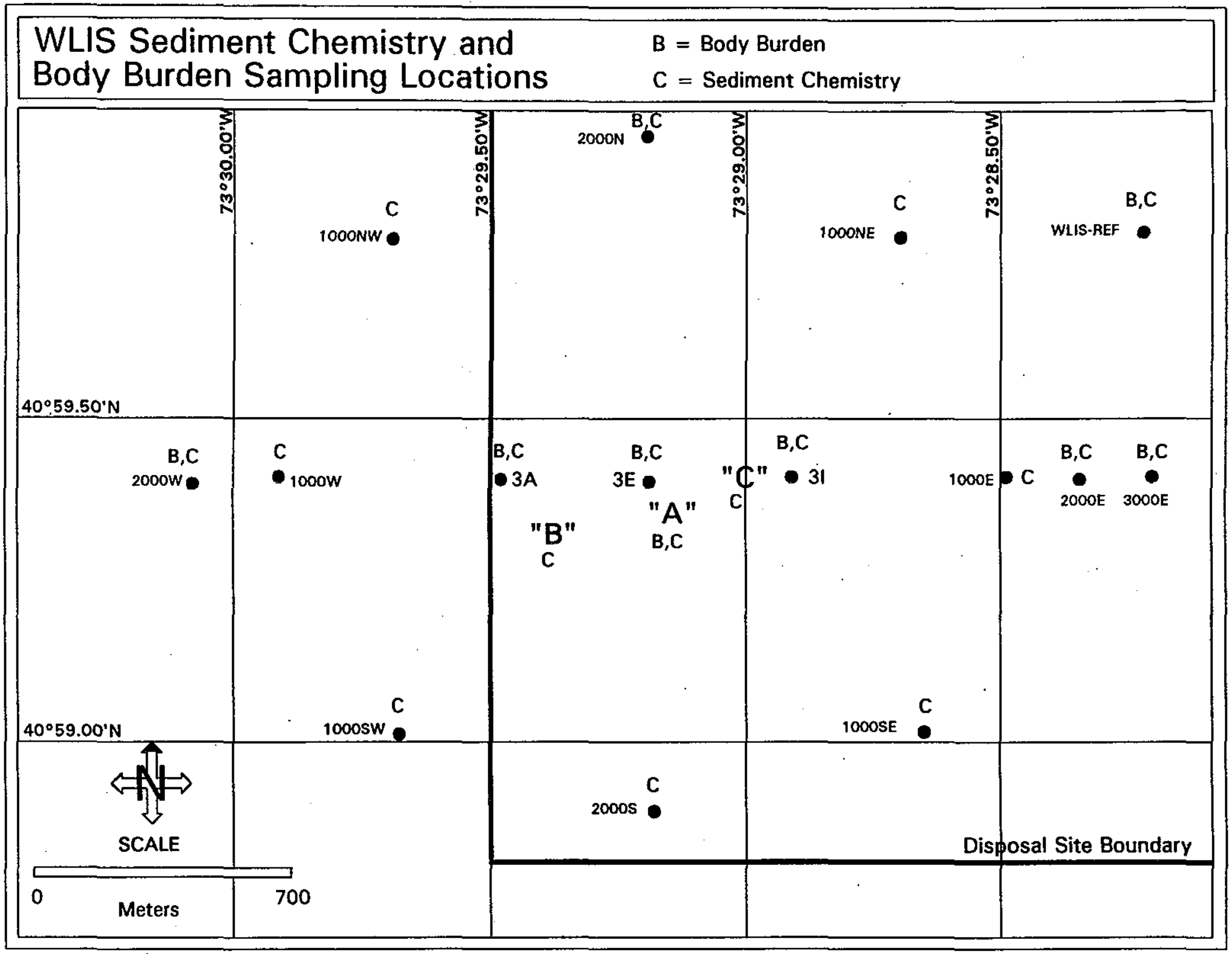
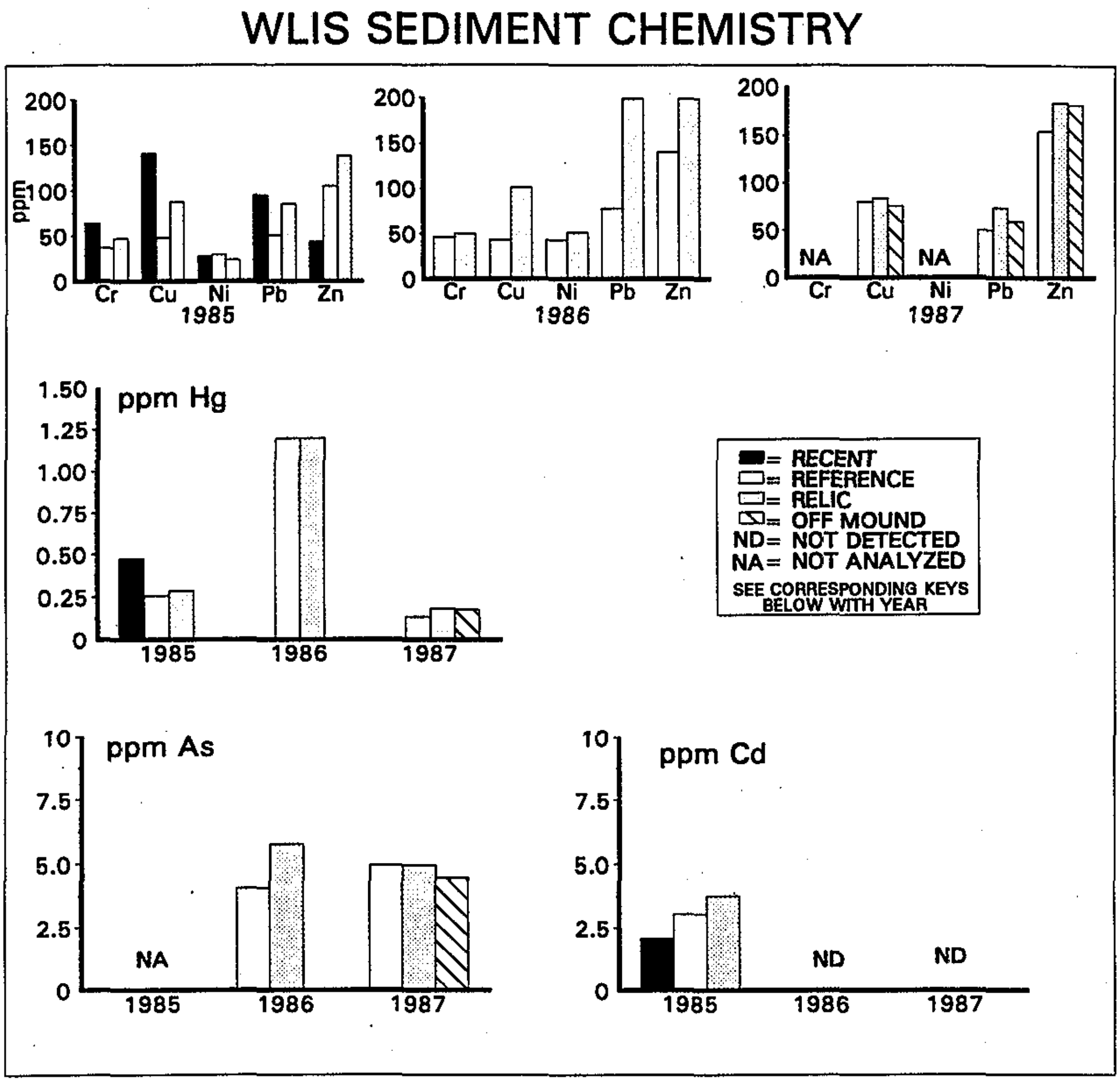


Figure 6-16. Sediment chemistry and body burden sampling locations at WLIS, 1985, 1986 and 1987



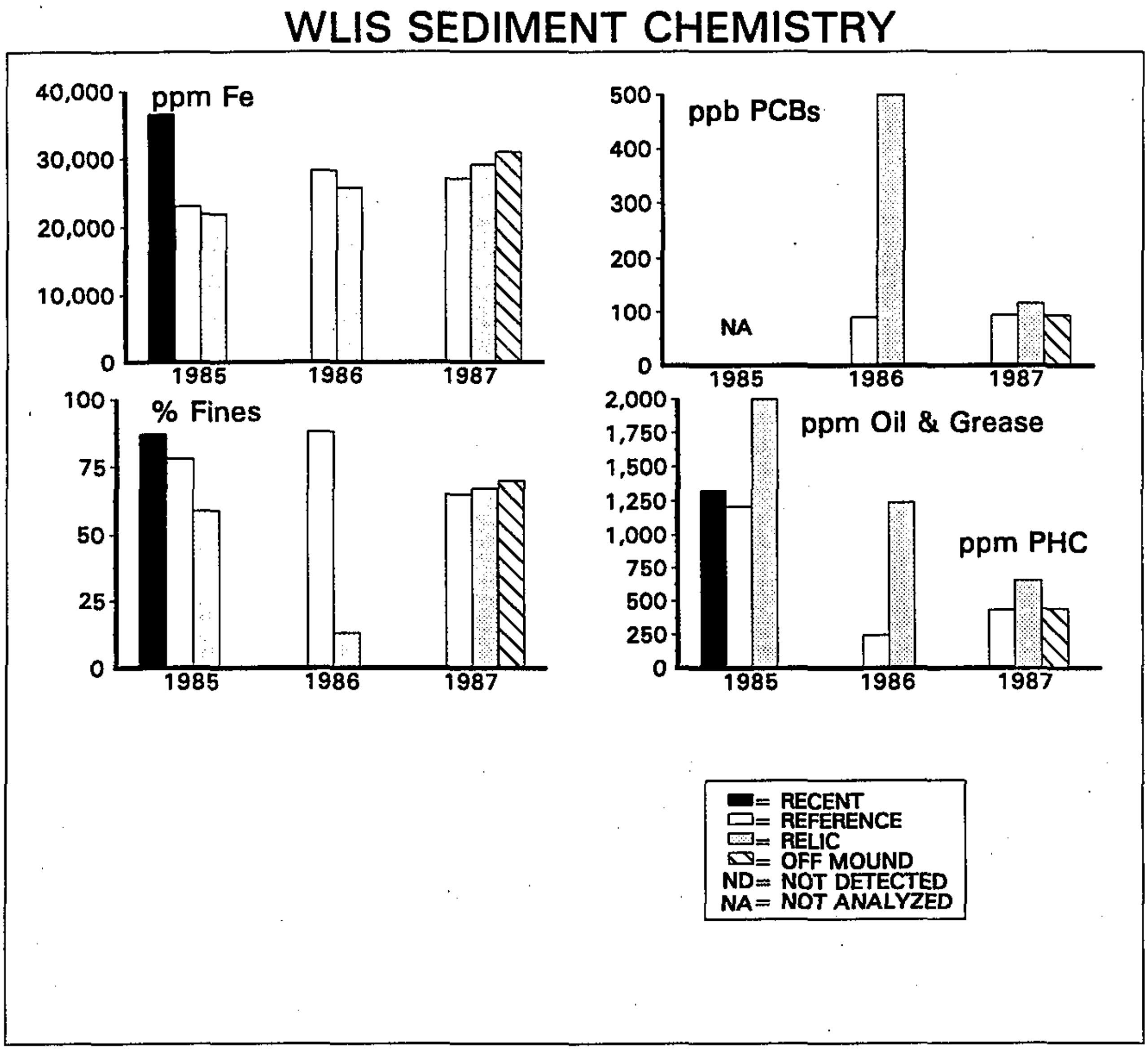
Averaged Data Values for Sample Locations

1985
- = Mound C
- = WLIS-REF
- = A, B
- = Not Sampled

1986
- = Not Sampled
- = WLIS-REF
- = A
- = Not Sampled

1987
- = Not Sampled
- = WLIS-REF, 2000W, 2000S, 3000E, 2000N
- = 3A, 3E, 3I
- = 1000SW, 1000SE, 1000W, 1000E, 2000E 1000NW, 1000NE

Figure 6-17. Results of WLIS sediment chemistry analyses



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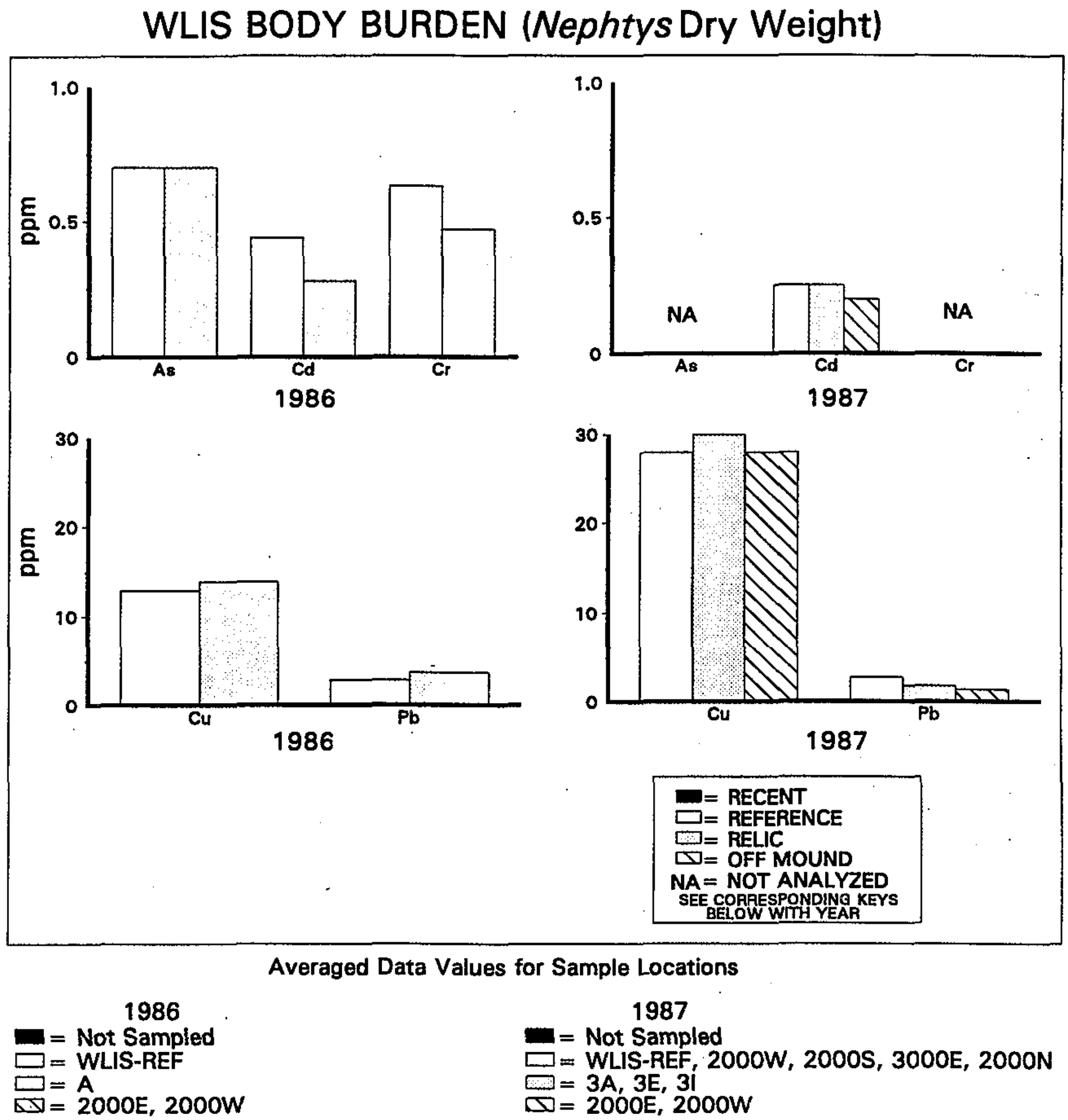

Figure 6-18. Results of WLIS body burden analyses (measurements based on dry weight of *Nephtys*)

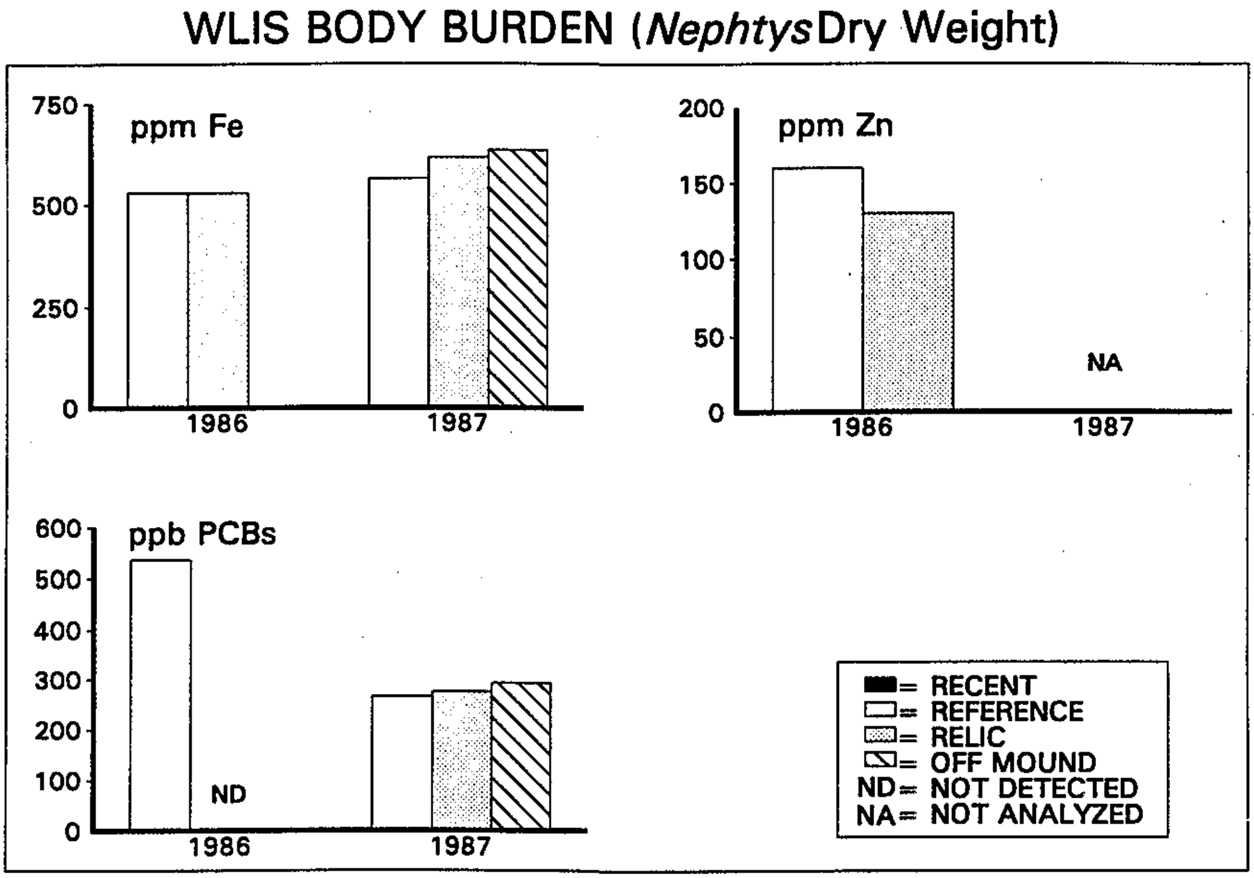

Figure 6-18. (cont.)

6.3 NEW LONDON DISPOSAL SITE

6.3.1 Summary of NLDS

The New London Disposal Site (NLDS) is located 3.1 nmi south of Eastern Point in Groton, Connecticut (Figure 6-19). The site, centered at 41°16.100′ N and 72°04.600′ W, is 1 nmi^2, with water depths ranging from 14 to 25 m. Currents in the region are primarily tidal-induced, with a maximum tidal flow in a northwest-southeast direction ranging between 30 and 40 $cm \cdot s^{-1}$. Additional current flows are introduced by the Thames River. Since disposal began at NLDS in 1977 with the dredging of the Thames River and Groton Submarine Base, several disposal mounds have been formed (Figure 6-20).

The location of NLDS, within commercial shipping lanes, is not conducive to trawling activities or setting lobster pots. However, lobstering and trawling for fluke are conducted in the general vicinity of the site. There is an active sport fishing industry at NLDS, with catches of tautog, flounder, bluefish, and weakfish (SAIC 1988a). As with other sites in Long Island Sound, disposal activity at NLDS is curtailed from June through August.

SAIC conducted 10 monitoring cruises at NLDS between 1985 and 1990 (SAIC 1988c, 1989b, 1990g, 1990h, 1990i, Germano et al. 1995). These surveys assessed the areal extent of dredged material, the stability of existing disposal mounds, and the effectiveness of capping operations. The cruises also were designed to monitor the benthic community, sediment characteristics, and water column DO concentrations. Periodic monitoring allowed evaluation of the response and subsequent recolonization of the benthic environment following disposal operations. Assessment techniques have utilized precision bathymetry, side-scan sonar, sediment sampling for chemical, physical, and biological analyses, current meter and DAISY array deployments, SCUBA diver observations, and REMOTS® sediment-profile photography (SAIC 1990f).

Approximately 783,000 m^3 of dredged sediments has been deposited at NLDS (Figure 6-21). This dredged material either was added to a pre-existing disposal mound, formed a new mound, or served as cap material to contain contaminated sediments. After disposal was completed at a mound, most mound heights remained stable over time (Figure 6-22). Side-scan sonar and REMOTS® surveys have shown thin layers ($\leq$15 cm) of dredged material extending beyond the disposal mounds and outside of the disposal site boundaries (Figure 6–23). This broad distribution of dredged material has resulted primarily from barge release points away from the disposal buoy and the proximity of designated disposal points to the site boundary (Figure 6-24). Although strong, intermittent currents occur in the region, the limited fetch at the NLDS site reduces the incidence of storm-driven currents and the possibility of redistribution of sediments. The precision bathymetric survey following the passage of Hurricane Gloria did not reveal any evidence of mound erosion (SAIC 1989b).

Due to contaminant levels measured in some project material prior to disposal, capping has been conducted at NLDS. Approximately 13,700 m^3 of contaminated sediments from the Thames River were capped at NLDS. SAIC monitored the coverage of the capping operation since October 1988 with bathymetric and REMOTS® surveys (SAIC 1988c, 1990h, Germano et al. 1995). Monitoring has indicated that the cap thickness at this capping disposal point varied considerably, primarily due to multiple point dumping of capping material. Additional cap material continued to be directed to this point through ongoing site management to augment the cap.

Sediment chemistry and body burden analyses were conducted at NLDS in 1986 and 1987. In 1986, sediment chemistry samples were collected at the center of each of the five disposal mounds (NL-85, NL-I, NL-II, NL-III, and NL-Relic) and at the reference area. Sampling stations in 1987 transected the disposal site along the axis of predominant water movement (Figure 6-25).

Results for both years indicated that the levels of As, Cd, Cr, Cu, Hg, Ni, Pb, Zn, oil and grease, and PCBs were well within the low limits for contaminant levels of dredged material relative to the NERBC classification system (Figure 6-26). No significant contamination was observed when data were normalized to Fe or percent total carbon. Concentrations of organochlorine pesticides measured in sediments in 1987 were, in general, below the analytical detection limits at all stations. In most cases, the concentrations of sediment contaminants in 1985 were higher at the five disposal mounds than at the reference area and were higher in recent dredged material than in relic (Figure 6-26). The percent fines and percent total organic carbon were also elevated for these areas in comparison with the reference area. Results of the 1987 study did not detect contaminant deposition outside of the site.

Test organisms for body burden analysis in 1986 (the bivalve *Pitar*) were collected at the reference area and the NL-II disposal mound (Figure 6-25). Results of statistical tests (Mann-Whitney U-test) indicated that there were no significant differences, at the $p<0.05$ level, in the tissue levels of any of the trace metals measured between the two stations (Figure 6-27). This information and comparisons of the trace metal data to literature values from relatively clean sites suggested that trace metals were not bioaccumulating in the bivalve (SAIC 1989b). In 1987, *Pitar* was not present in sufficient abundance for body burden collection. Contaminant levels in tissues of the suspension-feeding amphipod *Leptocheirus* were measured in 1987 and were either below detection limits, less than, or not different from levels obtained at the reference station (Figure 6-27).

REMOTS® sediment-profile surveys have revealed a typical, progressive recolonization of dredged material by the benthic infauna. Similar to that of other Long Island Sound disposal sites (i.e., WLIS, CLIS, and CSDS), the response of the NLDS benthic community to disposal operations reflects the physical, relatively time-dependent nature of this disturbance. The stressed benthic conditions observed in 1986 were attributed to the widespread hypoxia prevalent at that time throughout Long Island Sound and were unrelated to dredged material disposal (SAIC 1989b).

6.3.2 NLDS: 1990 Monitoring Results

SAIC conducted a survey of the NLDS site in July 1990. The objectives of the monitoring cruise were 1) to delineate the extent and topography of dredged material deposited since the August 1988 survey, 2) to determine mound stability, and 3) to assess near-bottom DO concentrations relative to REMOTS® benthic analyses.

Sampling at NLDS was concentrated in two regions of recent disposal activity. The first area, designated NL-TR, was a region where contaminated sediments were covered with a cap of clean material. The second disposal point, identified as NL-88, was adjacent (150 m west) to the former active mound listed as NL-85 in the July-August 1988 survey (SAIC 1990i).

The bathymetric survey revealed that 46,700 m^3 of new sediment had accumulated in the vicinity of the capped NL-TR mound since the July-August 1988 survey. The radius of dredged sediment deposited at NL-TR was approximately 550 m by 400 m, and benthic recolonization was as anticipated, indicating a healthy recovery well within expected recolonization rates. However, three of the six disposal points earmarked for the 1988 capping operation still had not received the full cap thickness. Recommendations were that future disposal operations should be directed to these three points with greater navigational control. An additional 11,560 m^3 of material had accumulated in the southern portion of NLDS at the two adjacent mounds (NL-85 and NL-88). The REMOTS® survey at NL-85 found that dredged material was distributed across the mound and that benthic recolonization was as predicted (Stage II and III).

Water column profiles of temperature, salinity, and sigma-t showed that significant stratification of the water column did not exist during the period of the survey. Near-bottom DO concentrations were highly uniform at all stations, both on and off the disposal site, and there was no indication that dredged material disposal operations were influencing oxygen concentrations adversely in the region.

6.3.3 References for Section 6.3

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SAIC. 1990h. Capping survey at the New London Disposal Site, February 3, 1989. DAMOS Contribution No. 71 (SAIC Report No. SAIC-89/7554&C76). US Army Corps of Engineers, New England Division, Waltham, MA.

SAIC. 1990i. Monitoring cruise at the New London Disposal Site, August 1988. DAMOS Contribution No. 77 (SAIC Report No. SAIC-89/7557&C77). US Army Corps of Engineers, New England Division, Waltham, MA.

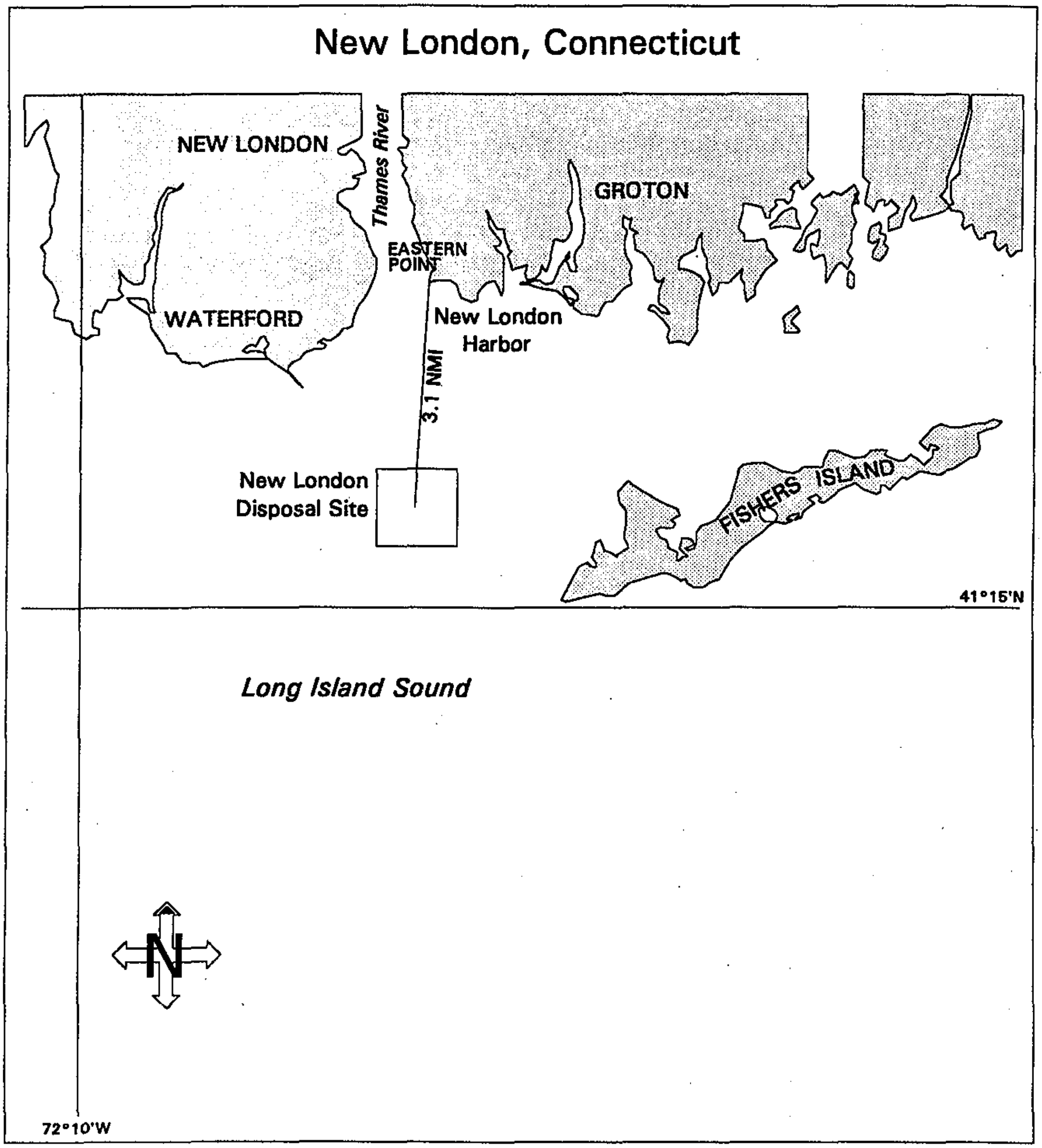

Figure 6-19. Location of NLDS in relation to Eastern Point, Groton, Connecticut

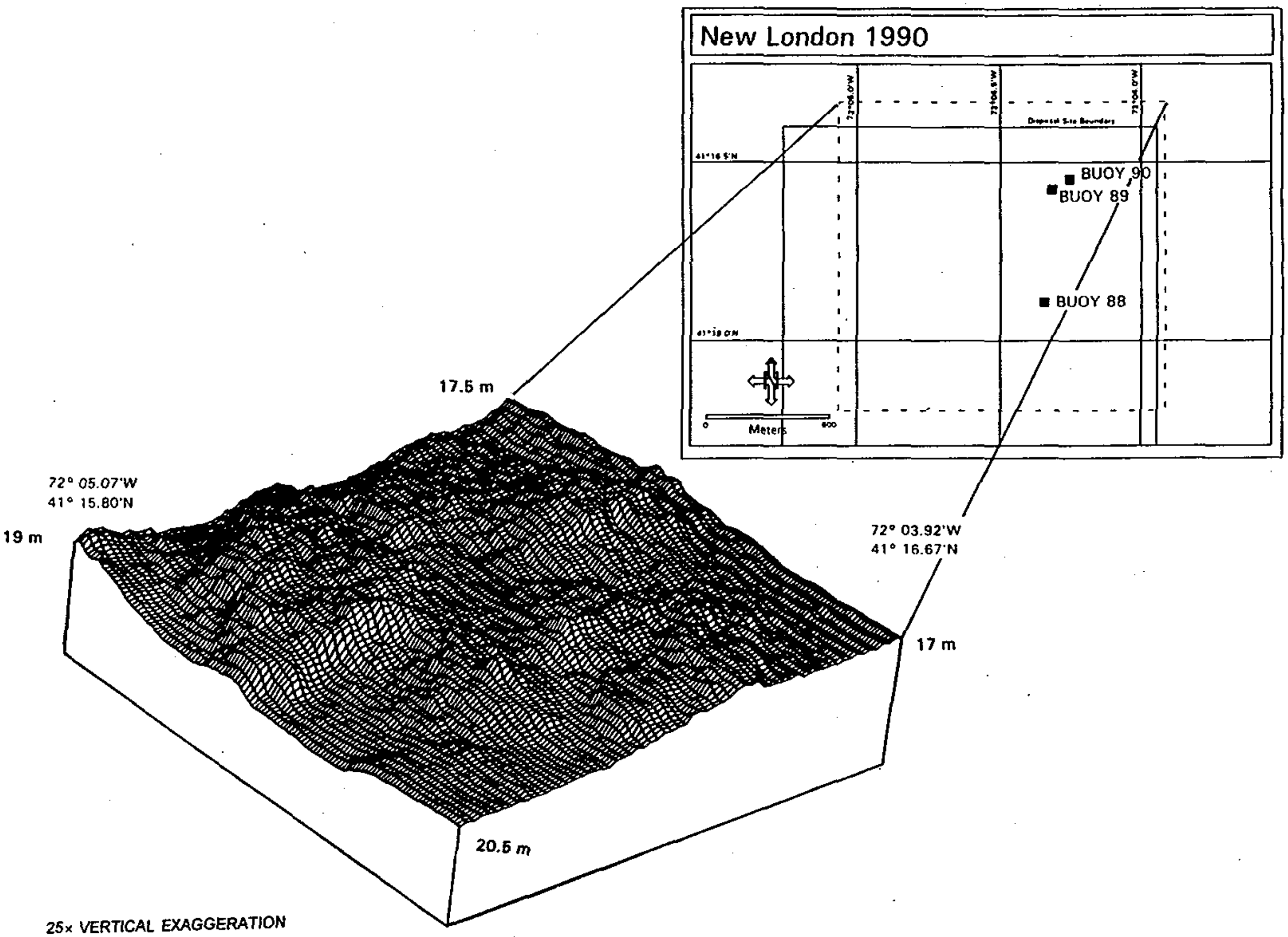

Figure 6-20. Three-dimensional bathymetric plot of NLDS 1990 survey

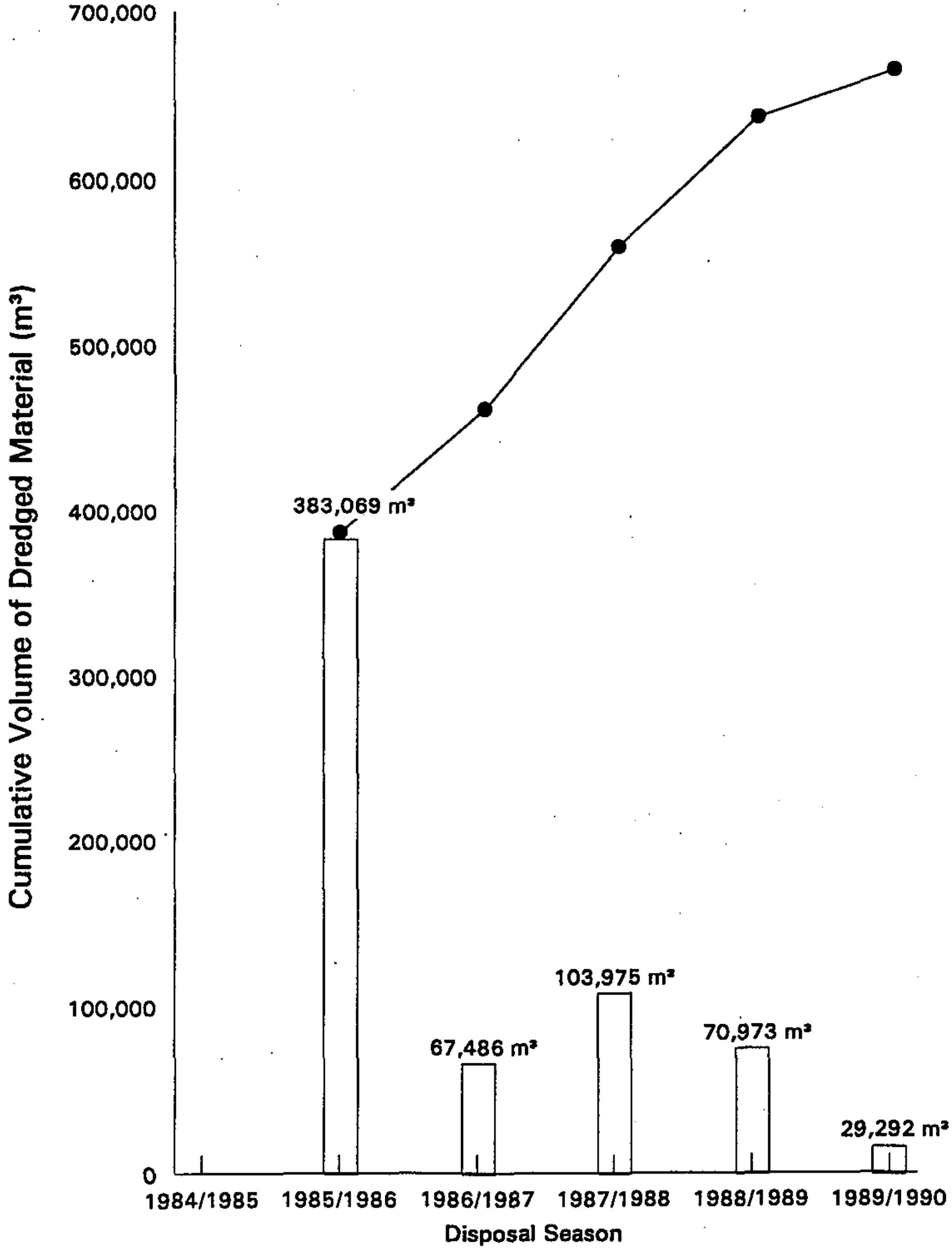

Figure 6-21. Dredged material disposal at NLDS, 1986-1990

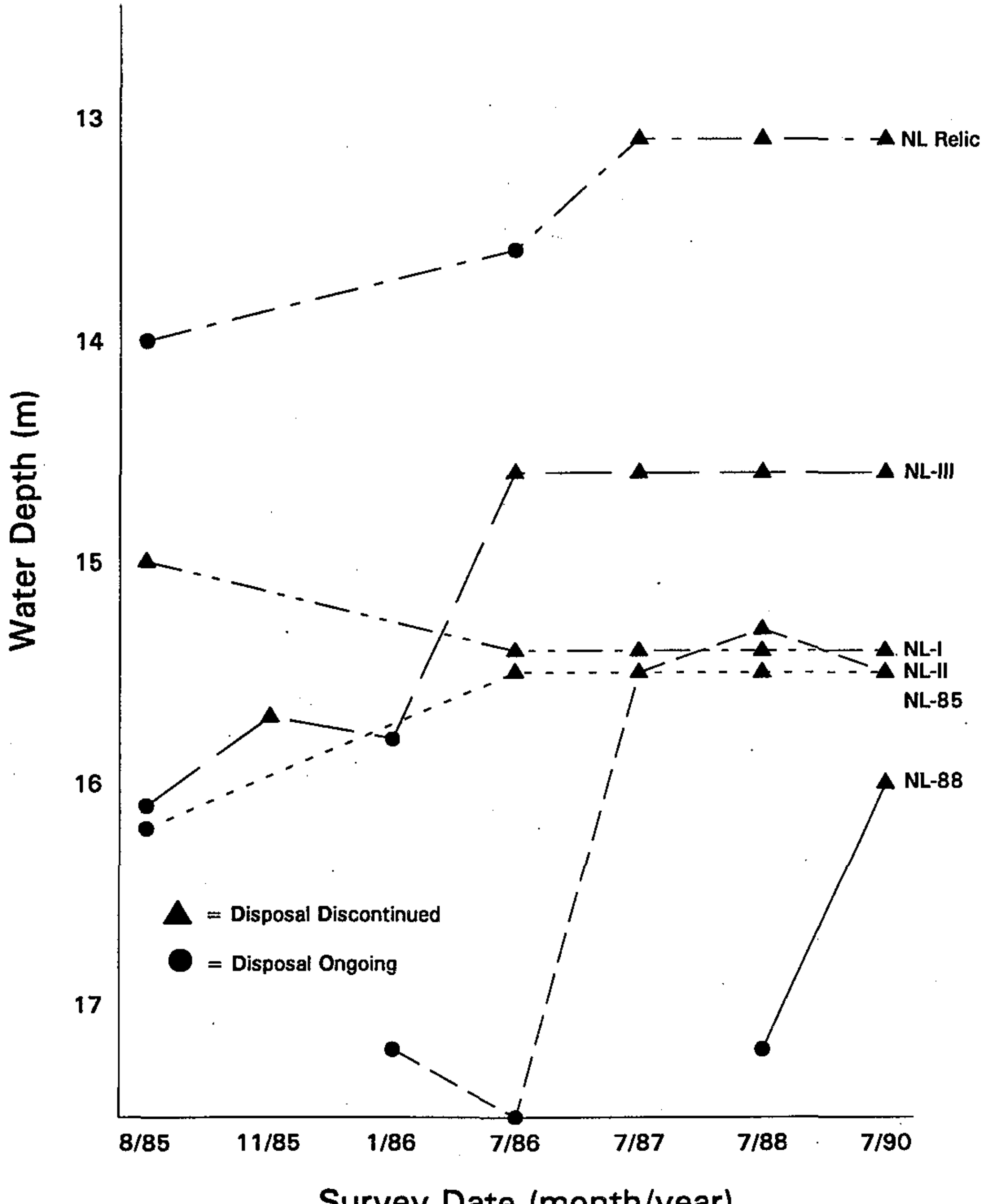

Figure 6-22. Dredged material mound height at NLDS over time

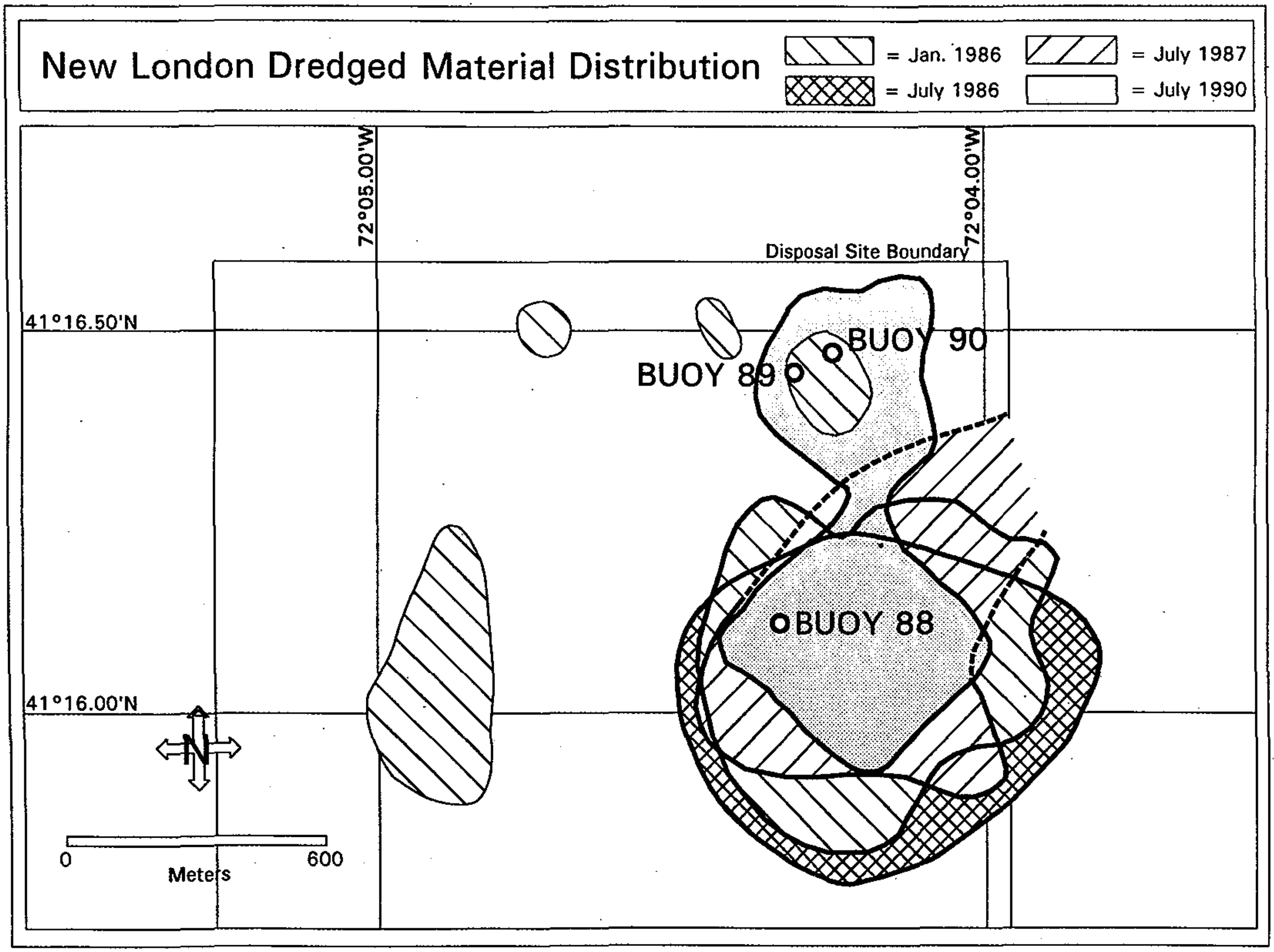

Figure 6-23. Dredged material distribution at NLDS, 1986-1990

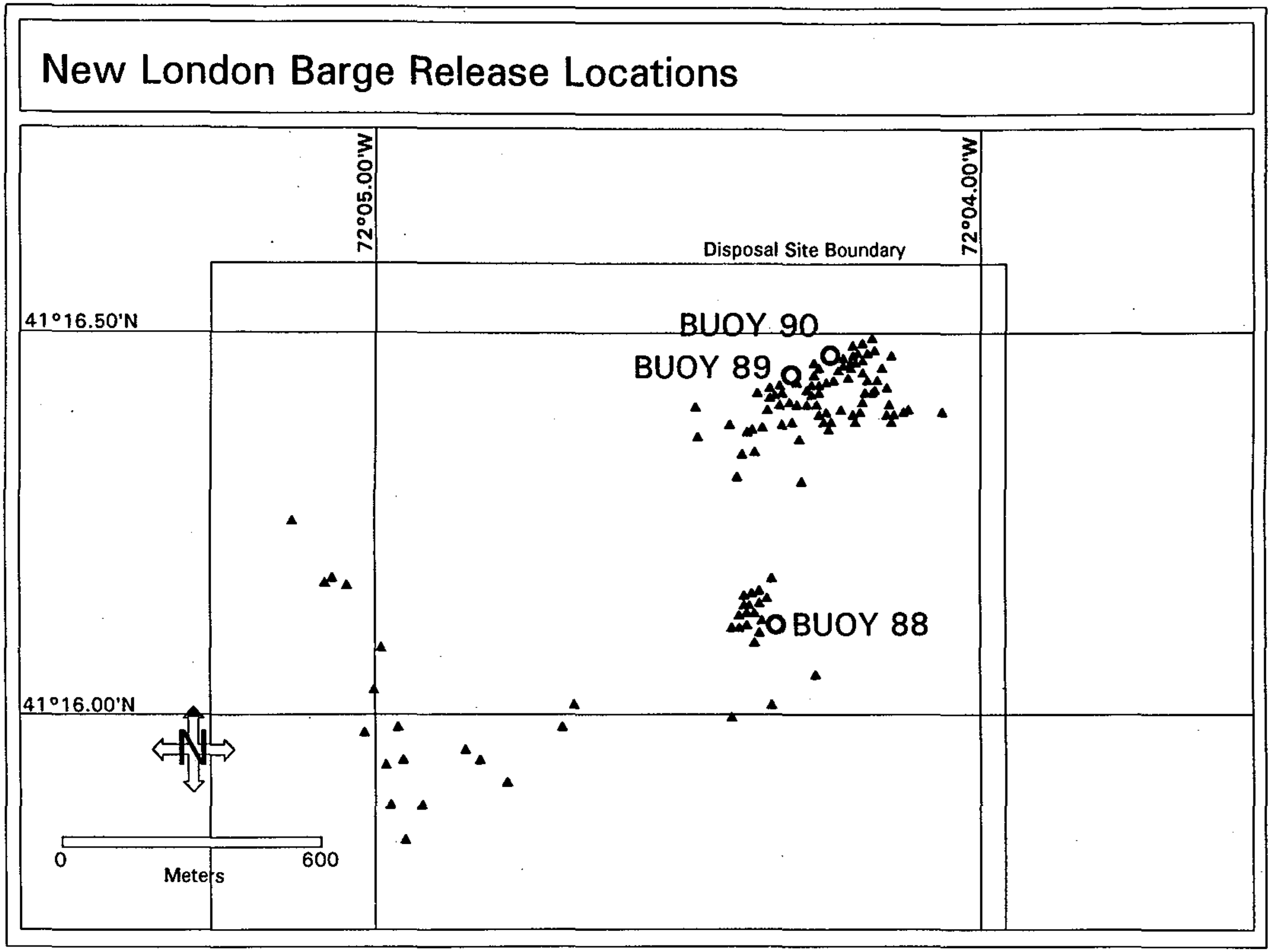

Figure 6-24. Barge release locations at NLDS, 1988-1990

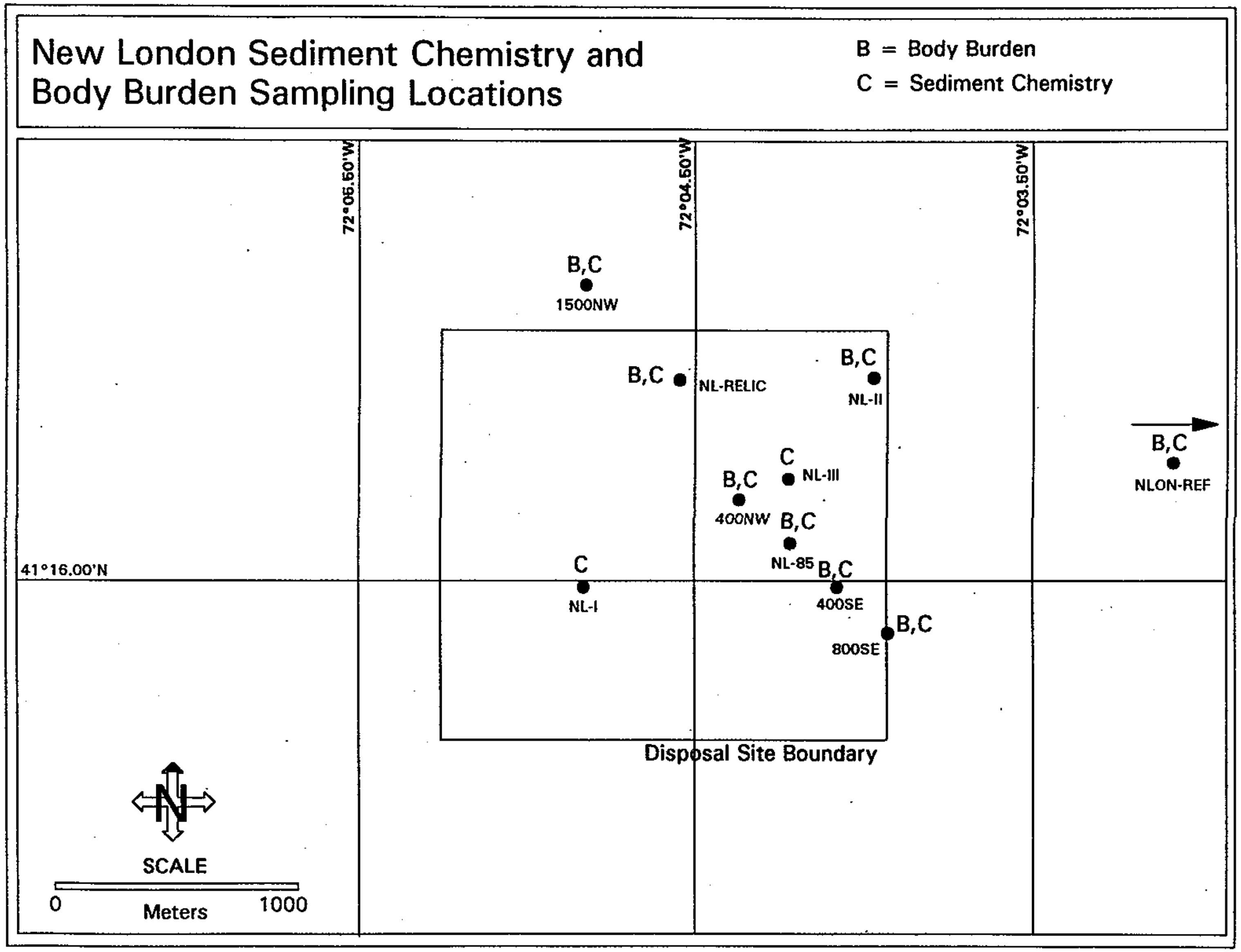

Figure 6-25. Sediment chemistry and body burden sampling locations at NLDS, 1986 and 1987

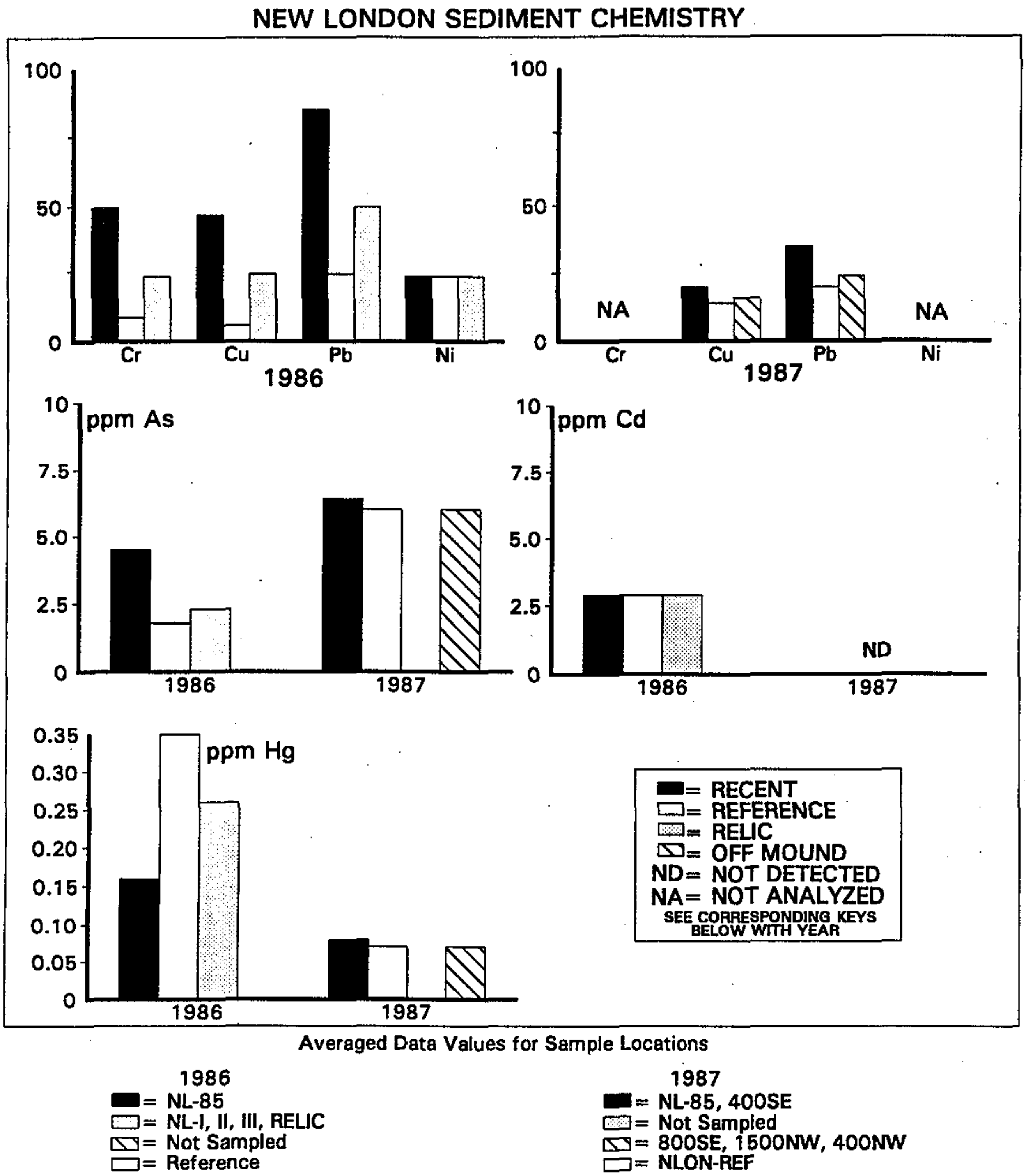

Figure 6-26. Results of NLDS sediment chemistry analyses

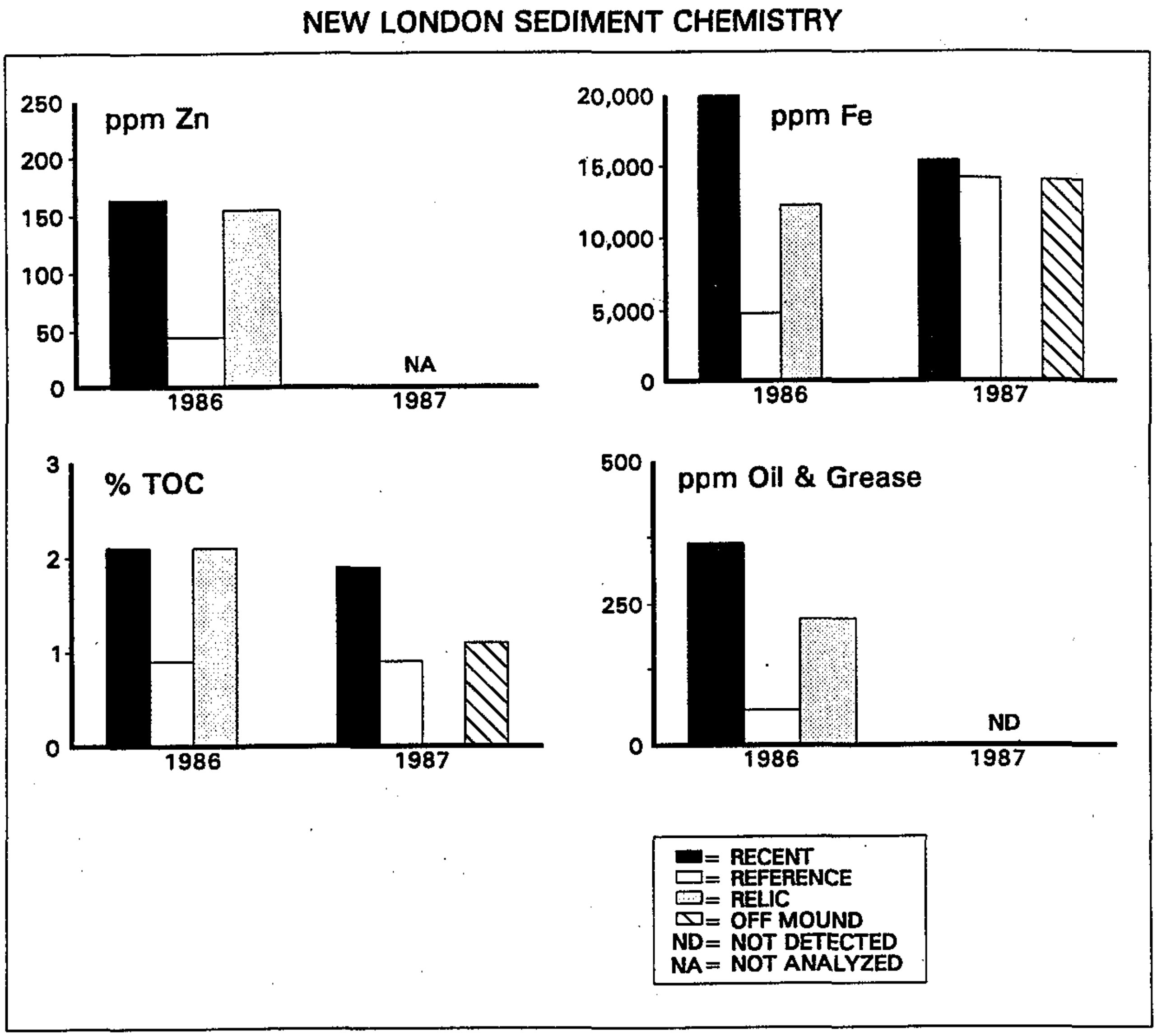

Figure 6-26. (cont.)

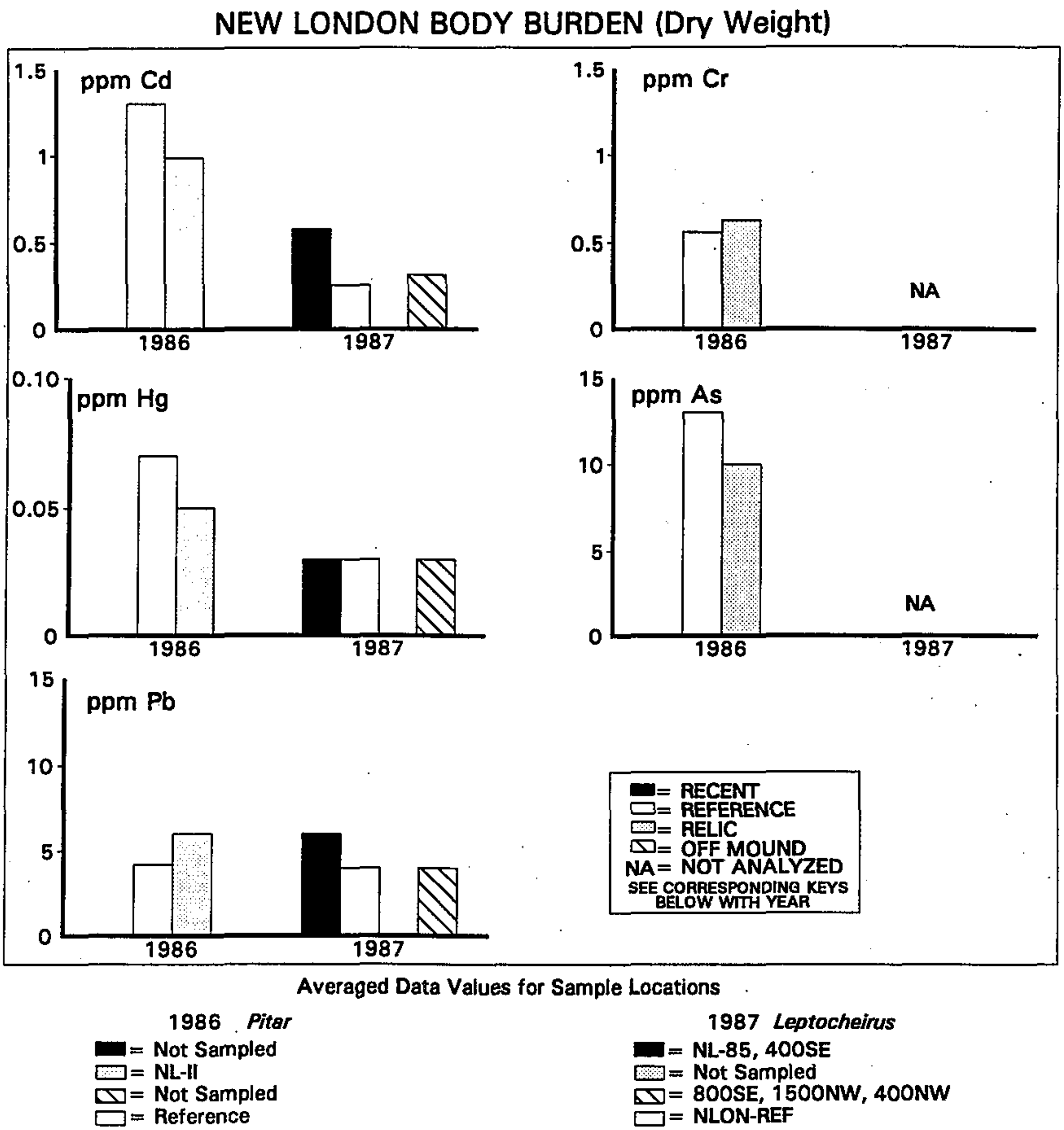

Figure 6-27. Results of NLDS body burden analyses (measurements based on dry weight of *Pitar* or *Leptocheirus*)

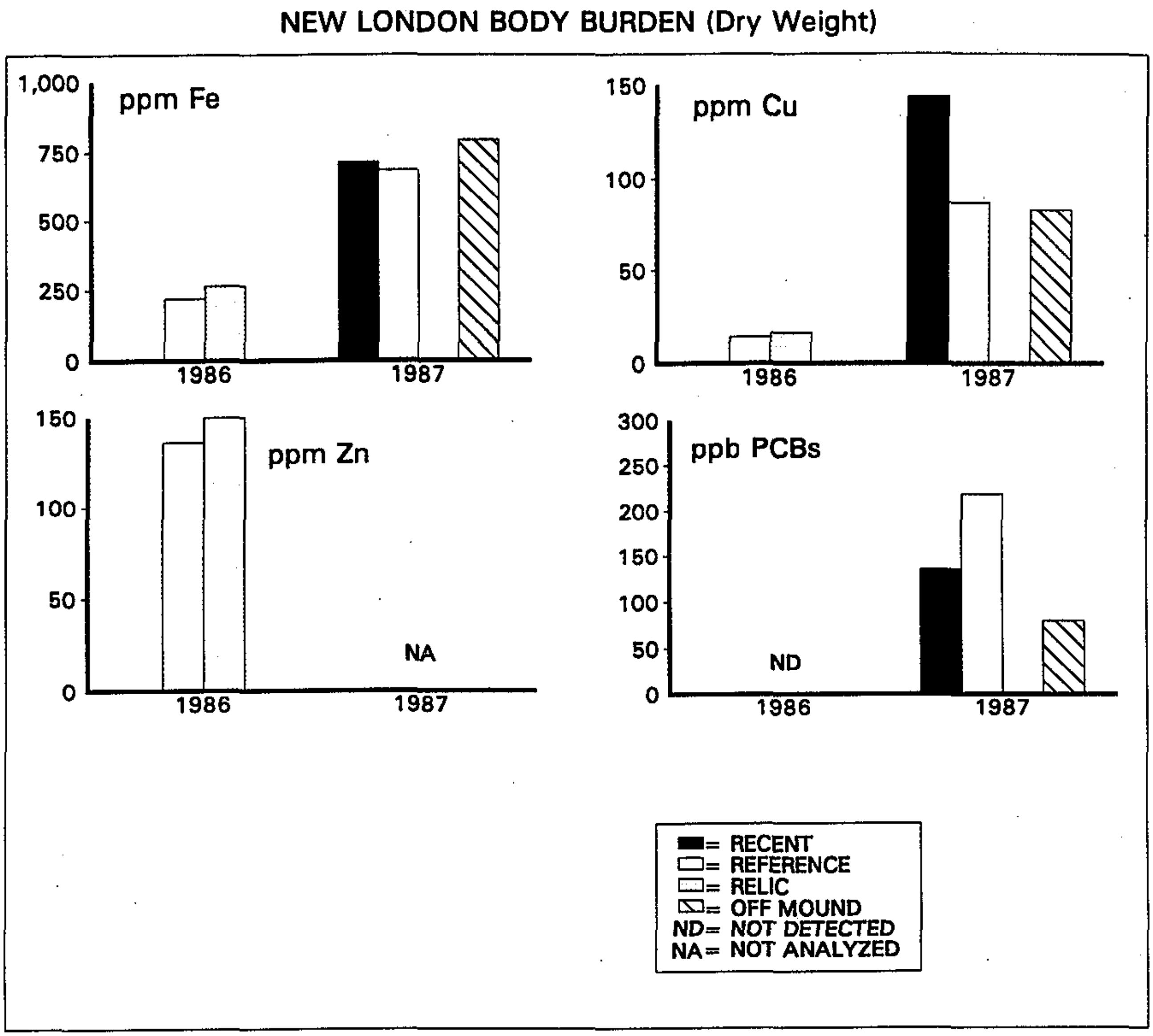

Figure 6-27. (cont.)

6.4 CORNFIELD SHOALS DISPOSAL SITE

6.4.1 Summary of CSDS

The Cornfield Shoals Disposal Site (CSDS) is located 3.3 nmi southeast of Cornfield Point, Old Saybrook, Connecticut and has been under study by NED since 1978. CSDS occupies an area of 1 nmi^2 centered at 41°12.680′ N, 72°21.520′ W (Figure 6-28). Water depths at this site range from 49 m in the northeast corner to 58 m in the south central portion. The predominant topographic features are a smooth, sandy bottom and bedforms oriented in an east-west direction (Figure 6-29). The energy regime at CSDS is the highest of all the DAMOS disposal sites. The major currents in this area are the result of an east-west tidal flow and runoff from the Connecticut River; seasonal river effects can be quite pronounced due to spring runoff and snow melt. Tidal flow is in a northwest-southeast direction with an average maximum of 32 $cm \cdot s^{-1}$. During spring runoff, peak tidal flow can reach 44 $cm \cdot s^{-1}$. Nontidal current flows to the southwest with a mean peak of 10 $cm \cdot s^{-1}$ (SAIC 1988a).

Relatively little is known about the potential value of this area as a resource for sport and commercial fisheries. At present there are small "day boats" which trawl in the shallower waters adjacent to this site. Lobster and whelk are commercially fished shoreward of Long Sand Shoal on a seasonal basis as the "run" occurs. Some lobsters are caught in the central depressions and in the sand-wave area to the south of the disposal site. Because there is no shelter and little food on the sand, it can be assumed that the lobsters are moving through this area and are not resident (SAIC 1988a).

In 1978 and 1979, studies were conducted at CSDS to assess near-bottom currents and turbidity conditions, sediment chemistry, and bathymetry (NUSC 1979). There have been two monitoring cruises at CSDS since 1984. A bathymetric survey was conducted in July 1987 to determine if there had been any significant changes in bottom topography since 1979 (SAIC 1988d). A combined bathymetric and REMOTS® sediment-profile survey in July 1990 identified the location and areal extent of dredged material at CSDS (Germano et al. 1994).

There was no disposal buoy at CSDS from 1987 to 1990. This management action was implemented because the dispersive nature of CSDS indicated that a discrete disposal mound would be unstable. When dredged material is deposited at CSDS, tidal action disperses it throughout the site to form a thin layer of material undetectable by bathymetry. As a result, the amount of accumulated dredged material at CSDS has been limited.

Disposal volumes at CSDS have varied greatly over the past few years, with an average annual amount of approximately 29,000 m^3 (Figure 6-30). Bathymetric surveys have indicated there has been no significant change in topography since the baseline survey. In

1990, REMOTS® sediment-profile results identified a patch of fresh dredged material within a relatively large area of relic dredged material (Figure 6-31). The wide and thin distribution of dredged material at CSDS may be due to both tidal action and barge release point distribution (Figure 6-32).

6.4.2 CSDS: 1990 Monitoring Results

In July 1990, SAIC conducted field operations at CSDS to assess areal distribution of dredged material deposited since the previous July 1987 monitoring survey and to verify the usefulness of REMOTS® sediment-profile photography as a survey tool at this site. Field operations included a 1000 × 1000 m bathymetric survey and a 13-station REMOTS® survey.

According to the barge logs, 104,000 m^3 of material were deposited at CSDS between 1987 and 1990. Volume calculations based on the 1990 and 1987 bathymetric surveys showed that an estimated 16,600 m^3 of dredged material had accumulated at the site. The remaining material was presumably too thin to be accounted for using bathymetric volume estimation methods.

As a result of the high energy regime at CSDS, no significant changes in topography (e.g., the development of distinct disposal mounds) were detected in consecutive bathymetric maps. REMOTS® photography, however, did detect fresh and/or relic dredged material at several stations, supporting the utility of REMOTS® technology to track dredged material distribution at CSDS. Enlargement of the REMOTS® grid to incorporate stations outside of the dredged material dispersion area (where ambient bottom conditions persist) would assist future monitoring efforts at the site.

6.4.3 References for Section 6.4

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NUSC. 1979. DAMOS disposal area monitoring system annual data report: proceedings of symposium, 14-15 May 1979. Naval Underwater Systems Center, Newport, RI.

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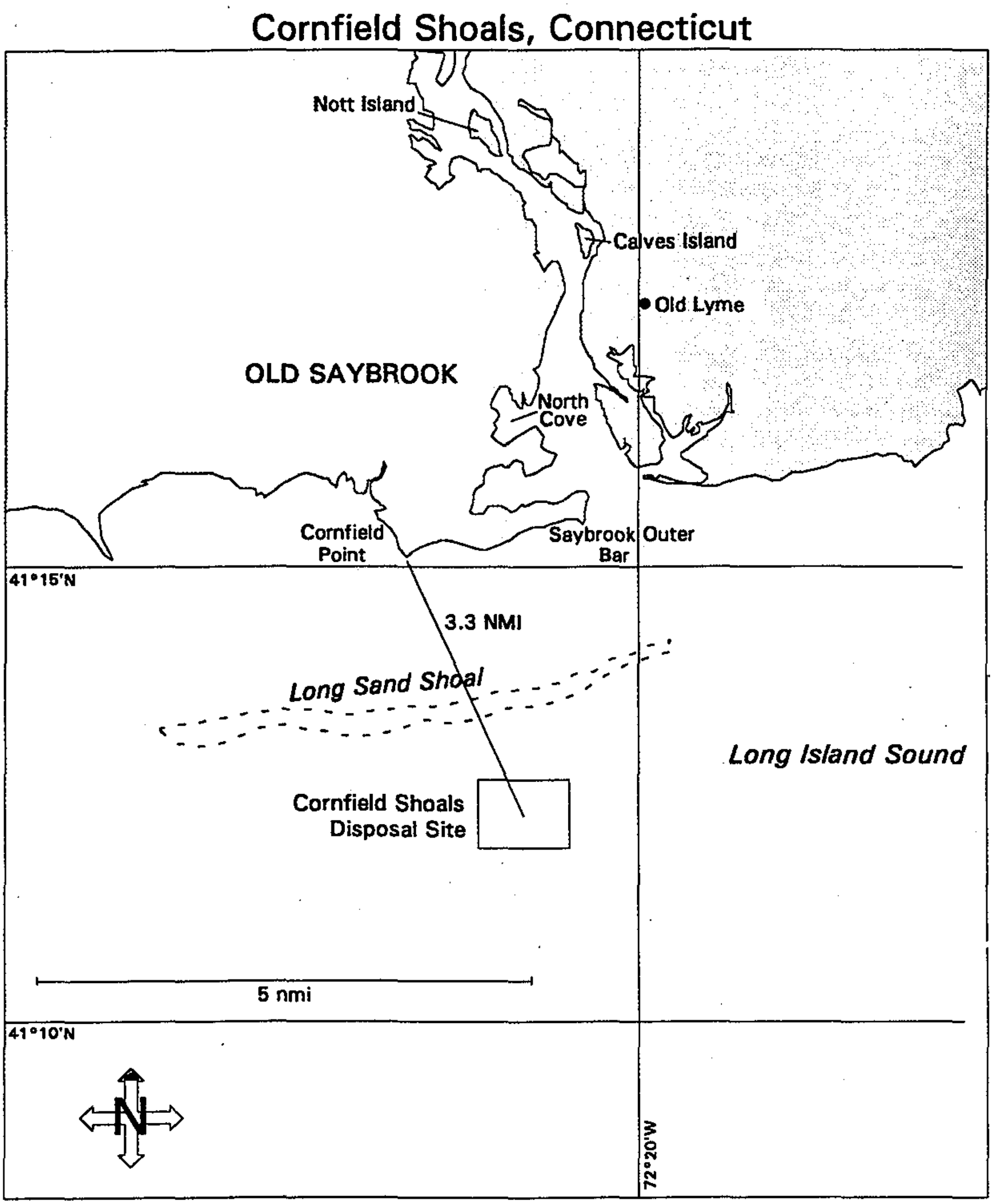

Figure 6-28. Location of CSDS in relation to Cornfield Point, Old Saybrook, Connecticut

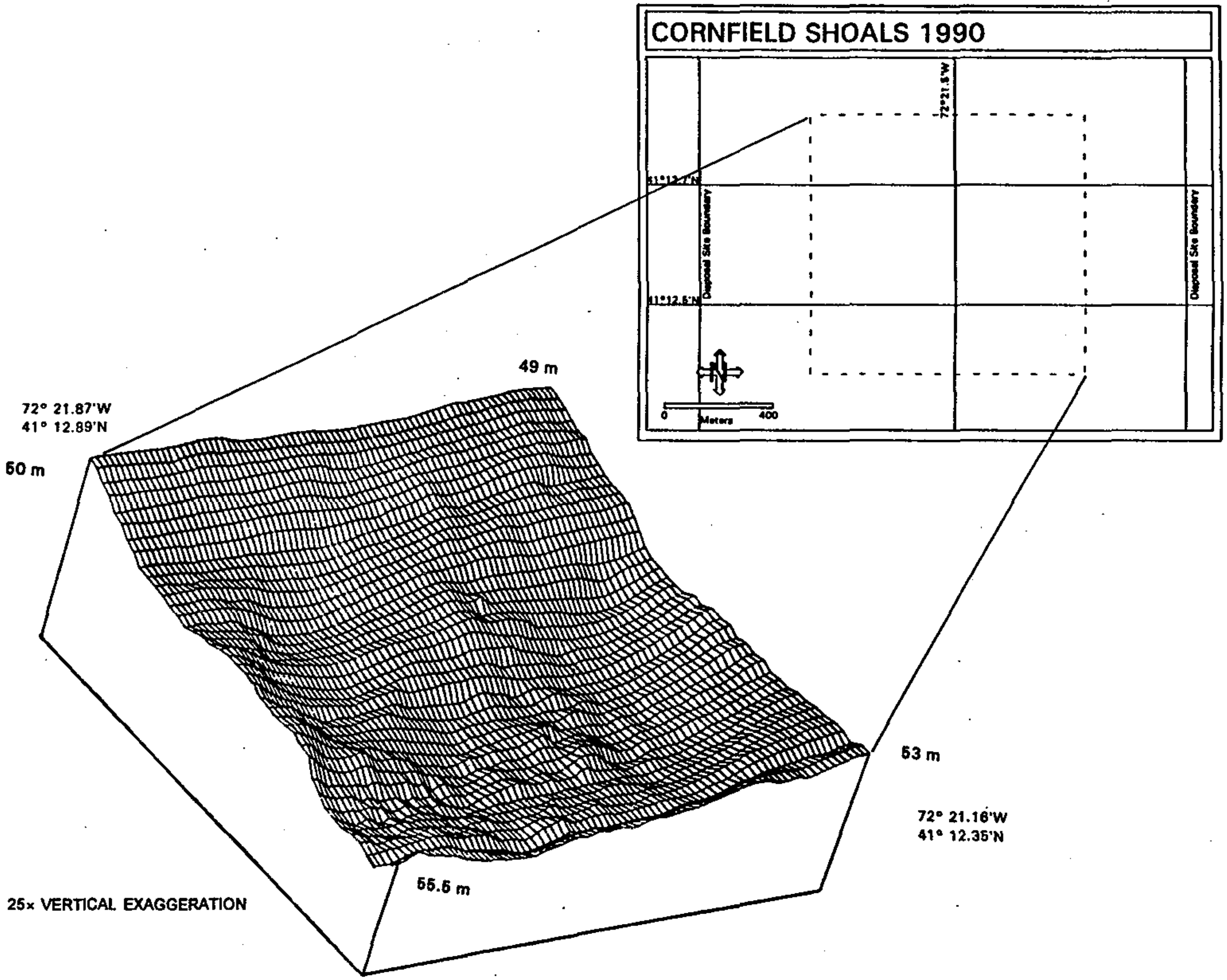

Figure 6-29. Three-dimensional bathymetric plot of CSDS 1990 survey

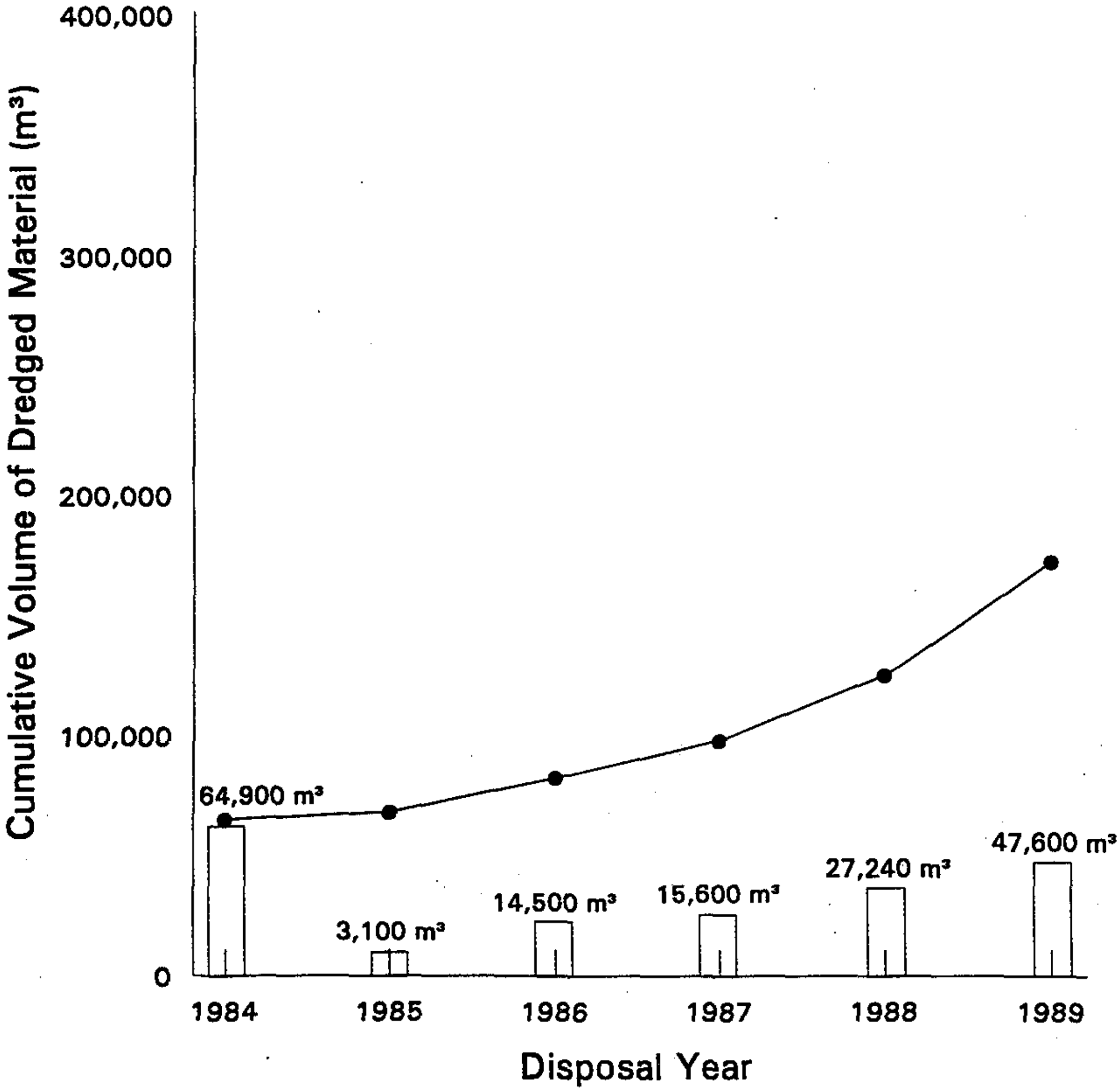

Figure 6-30. Dredged material disposal at CSDS, 1984-1989

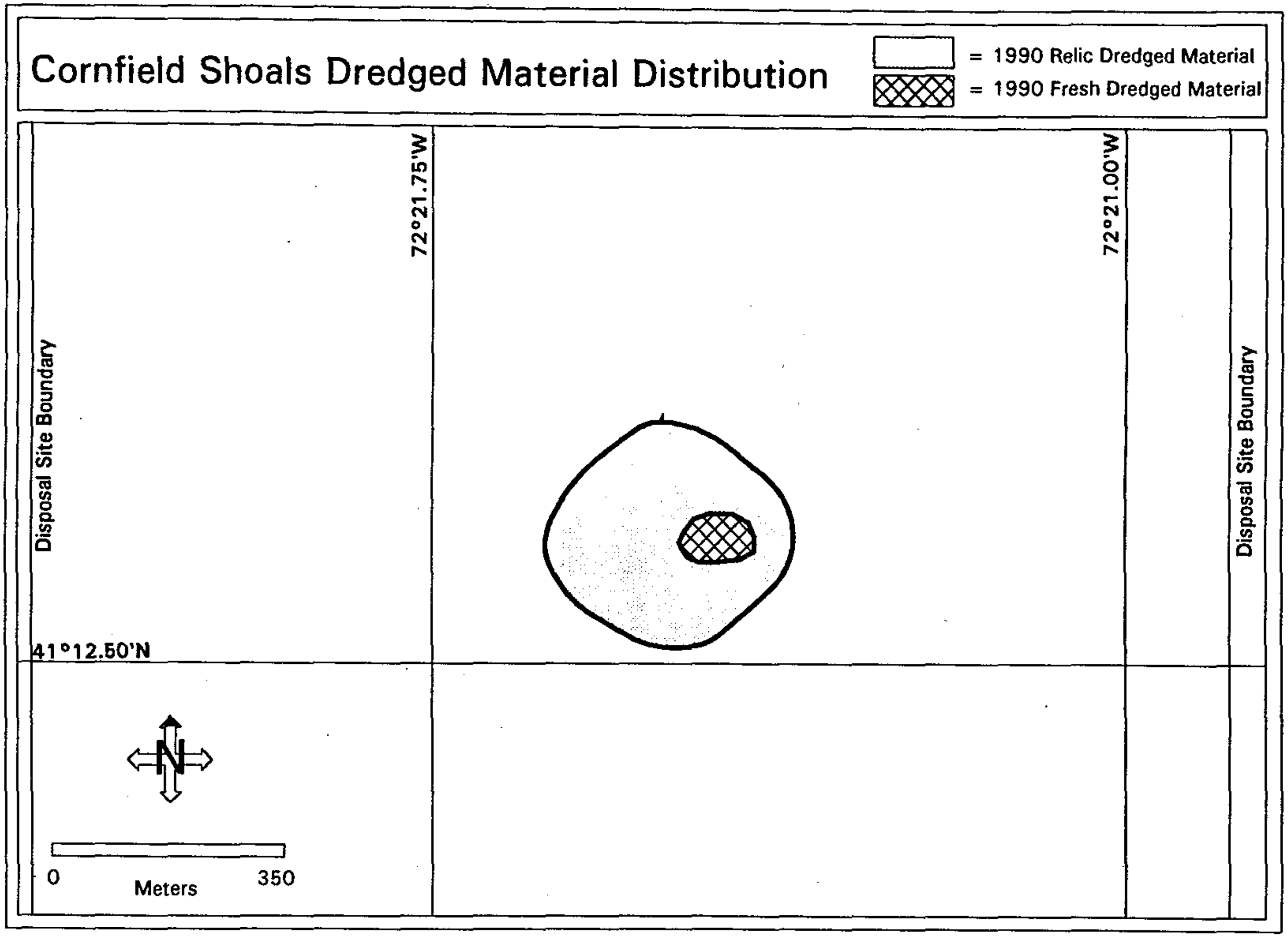

Figure 6-31. Dredged material distribution at CSDS, July 1990

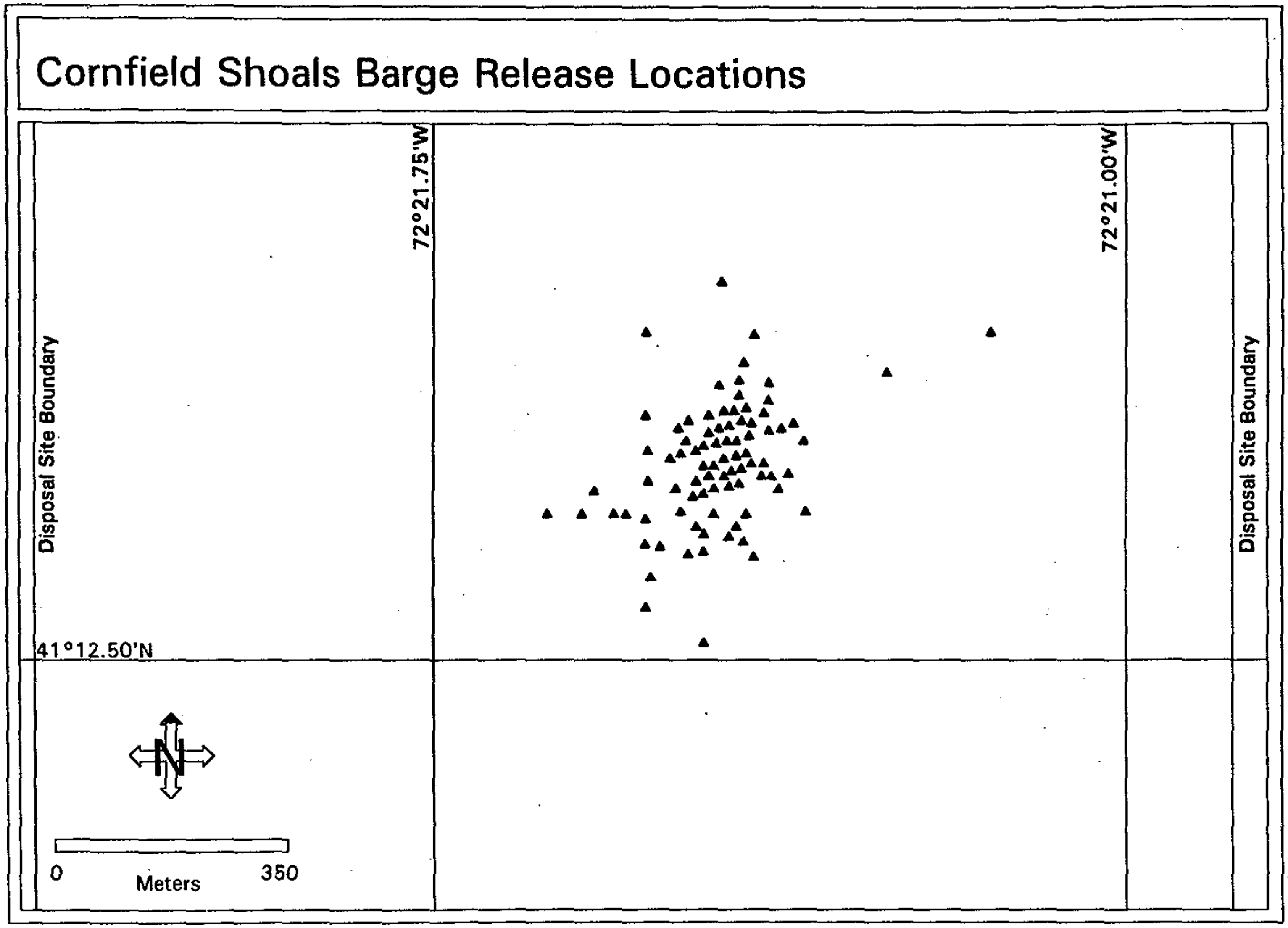

Figure 6-32. Barge release locations at CSDS, 1987-1990

6.5 PORTLAND DISPOSAL SITE

6.5.1 Summary of PDS

The Portland Disposal Site (PDS) is located in Bigelow Bight approximately 7.1 nmi east of Dyer Point, Cape Elizabeth, Maine. The site is a 1 nmi^2 area centered at 43°34.100′ N, 70°2.000′ W (Figure 6-33). The site is characterized by a flat, sandy valley, surrounded by rocky outcrops, with water depths ranging from 41 to 62 m (Figure 6-34). Current velocities at PDS are the least energetic of all disposal sites monitored under the DAMOS program and are influenced primarily by a nontidal, southerly flow averaging 5-6 $cm \cdot s^{-1}$. The average peak flow of tidal-induced currents is approximately 8 $cm \cdot s^{-1}$ in a northwest-southeast direction. Unlimited fetch to the south and southeast, combined with strong gale force winds in the winter, may produce wave-induced currents. However, the deeper portions of the site would experience a minimum of storm-induced energy as compared to the shallower outcrops (SAIC 1988a).

Commercial finfishing within the disposal site is limited due to the rough and rocky bottom topography and the resulting increased possibility of "hanging up" trawling gear; however, bottom gill nets are set along the edge of the site in winter and spring. The site is about 1 nmi shoreward of an important trawling area which yields a variety of finfish including dab, gray sole, and flounder in the summer and cod, haddock, and other groundfish in the winter. With the exception of the Atlantic herring, all commercially important fish in the area have buoyant eggs or spawn in the estuaries. Most of the lobster fishing takes place in the waters shoreward of West Cod Ledge during the summer months; however, some lobsters are caught at the disposal site following migration out of the cooler shallow waters between November and April (SAIC 1988a).

6.5.2 PDS: 1989 Monitoring Results

Since 1984, one monitoring survey has been conducted at PDS (SAIC 1990j). The objectives of this January 1989 survey were to map the distribution of dredged material deposited since the May 1984 survey and to assess the status of benthic recolonization. The distribution of dredged material was determined acoustically where the disposal mound was greater than 30 cm. REMOTS® sediment-profile photography was used to delineate the extent and thickness of dredged material <20 cm. In addition, REMOTS® photography was used to observe the status of benthic recolonization in the disposal area (SAIC 1990f).

PDS received an estimated 47,000 m^3 of dredged material between 1985 and 1989 (Figure 6-35). In 1984, the bathymetric survey around the disposal buoy location detected a distinct dredged material mound. The 1989 bathymetric survey covered the area surveyed in 1984 as well as the area around the 1989 buoy location to the north. The 1984 disposal mound remained stable at 49 m water depth from 1984 to 1989. The 1989 bathymetric survey did not detect changes in topography over the area since 1984. The mound detected at the 1989 buoy location was detected previously on the northern boundary of the 1984 survey. The thin distribution of dredged material detected in the 1989 REMOTS® survey was attributed to a combination of the small volume of material disposed, the water depth, and the wide watch circle of the conventionally moored disposal buoy (Figure 6-36). The barge logs also recorded release points up to 150 m away from the buoy location (Figure 6-37).

The irregular, rocky, and steep-sided topography of PDS contributes to the containment of dredged material within the site. However, given the depth of PDS, and the use of a conventionally moored buoy, the accumulation of dredged material would not be expected to be as concentrated as in shallower, more protected disposal sites.

6.5.3 References for Section 6.5

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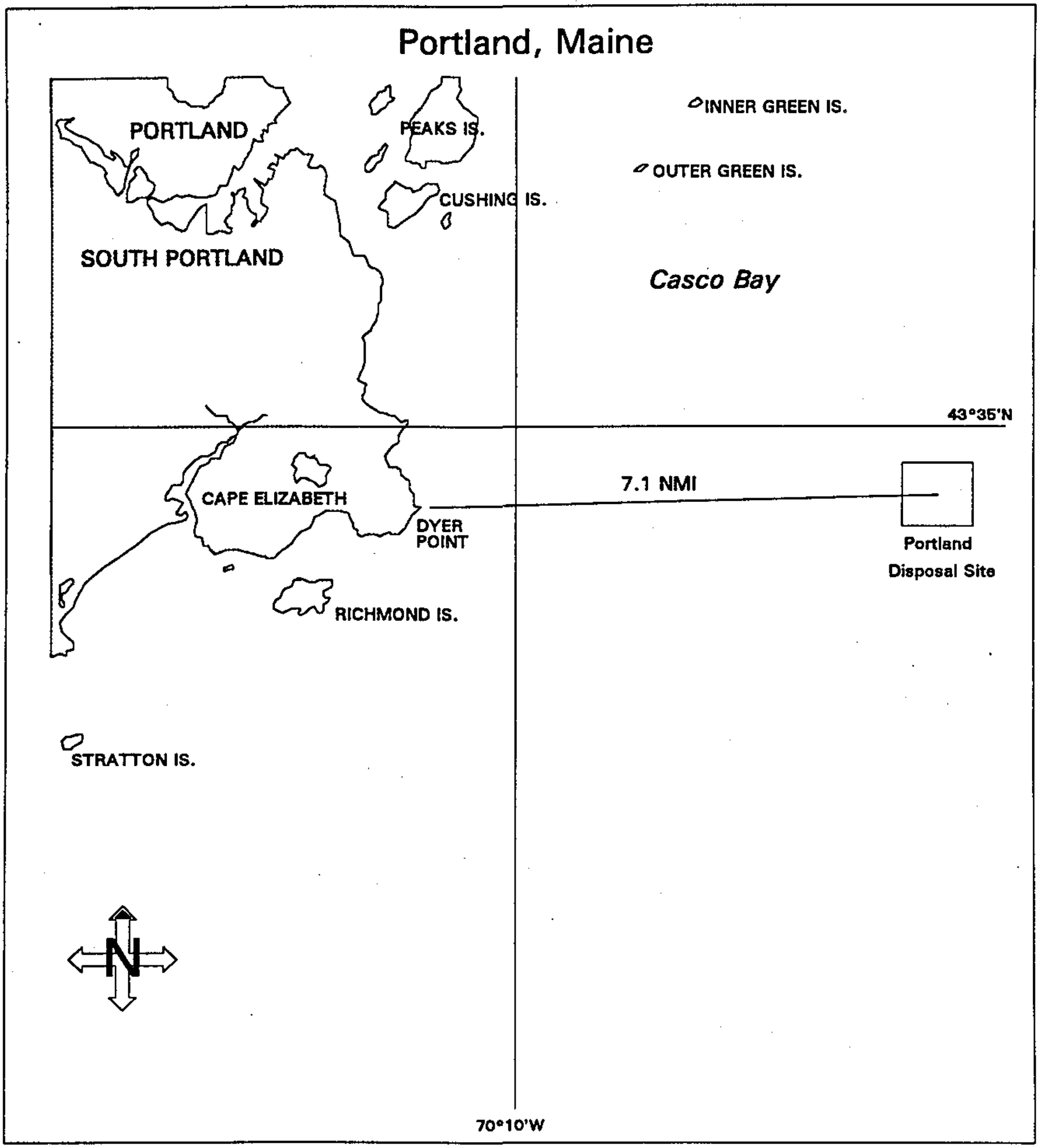

Figure 6-33. Location of PDS in relation to Dyer Point, Cape Elizabeth, Maine

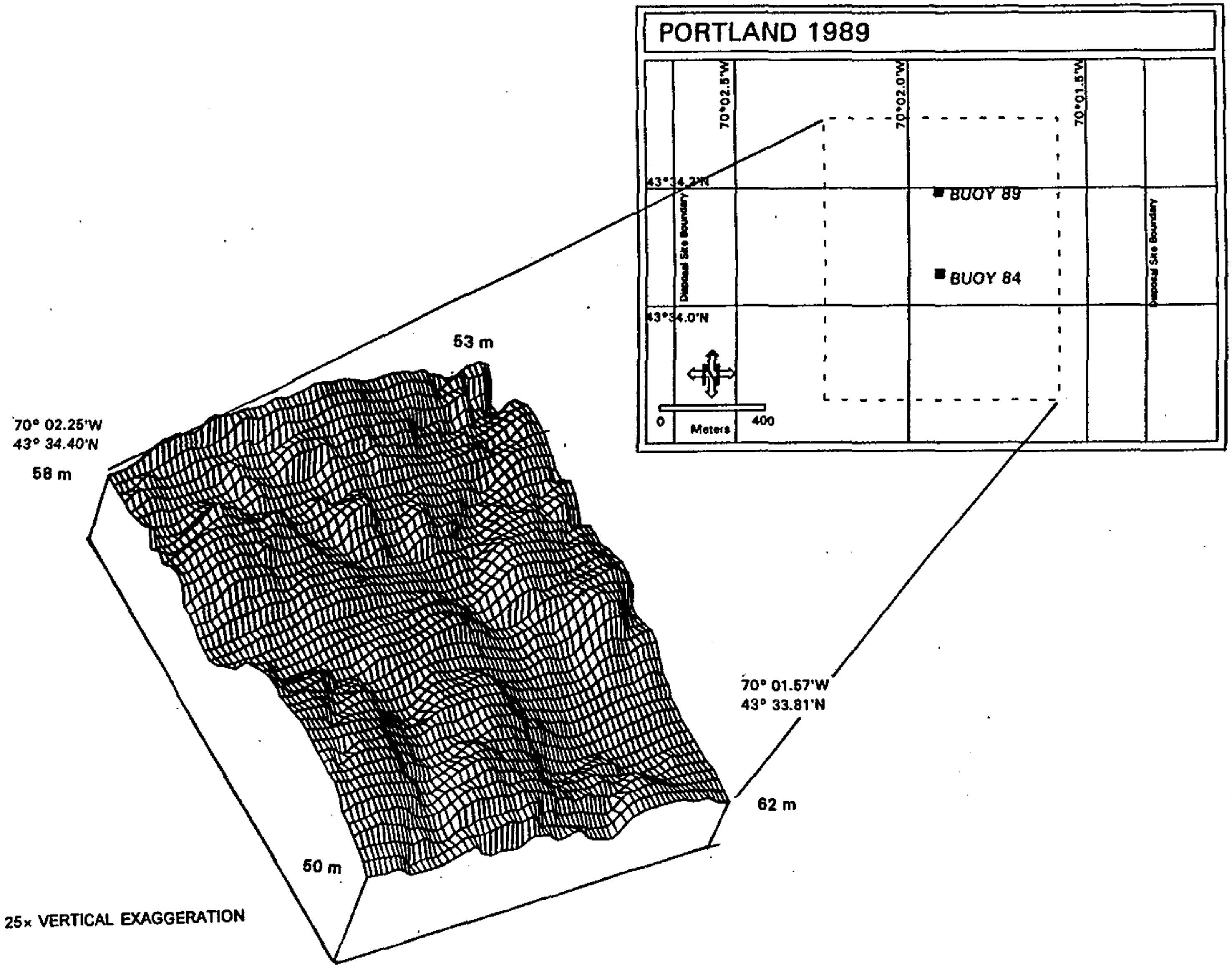

Figure 6-34. Three-dimensional bathymetric plot of PDS 1989 survey .

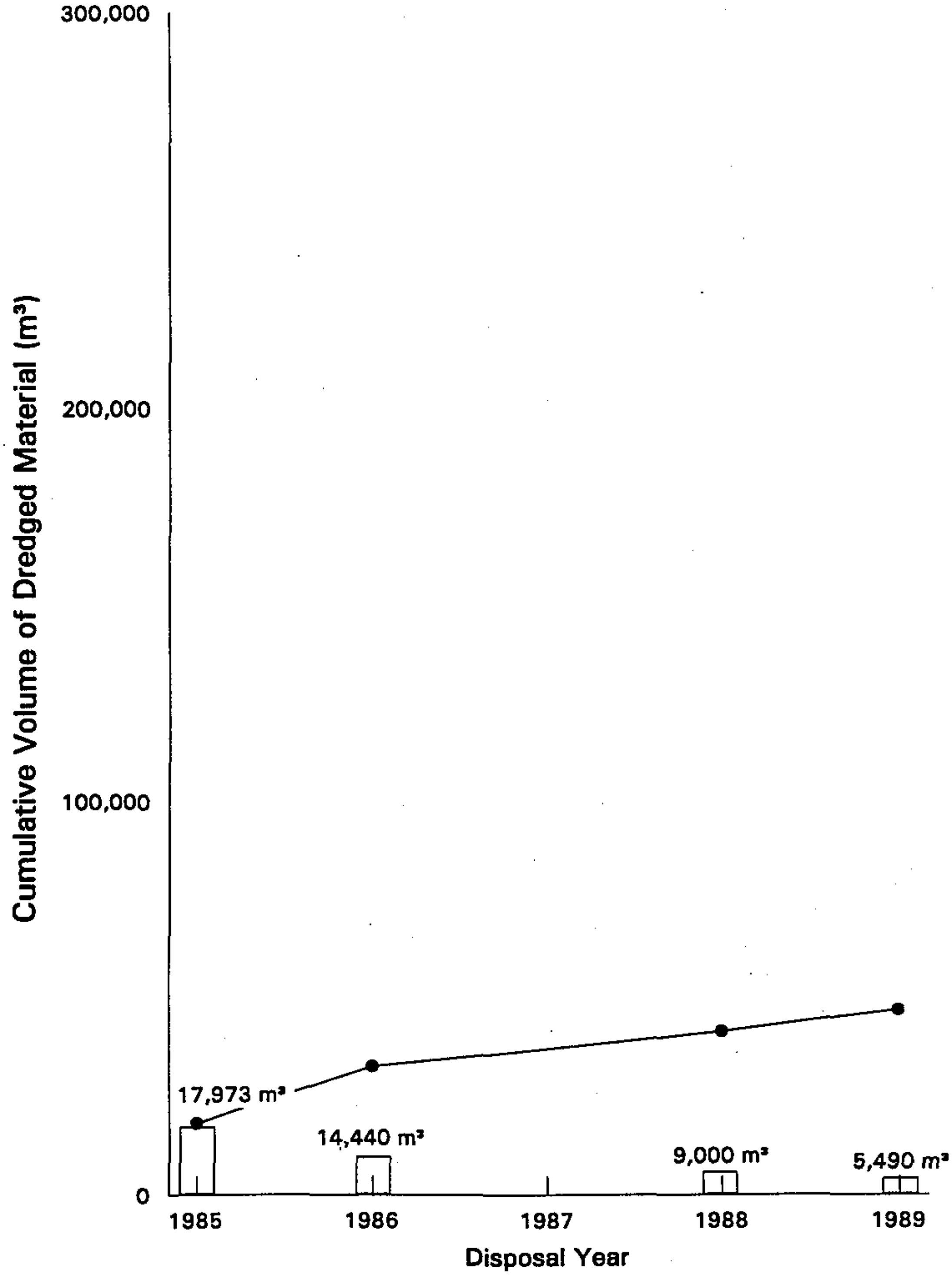

Figure 6-35. Dredged material disposal at PDS, 1985-1989

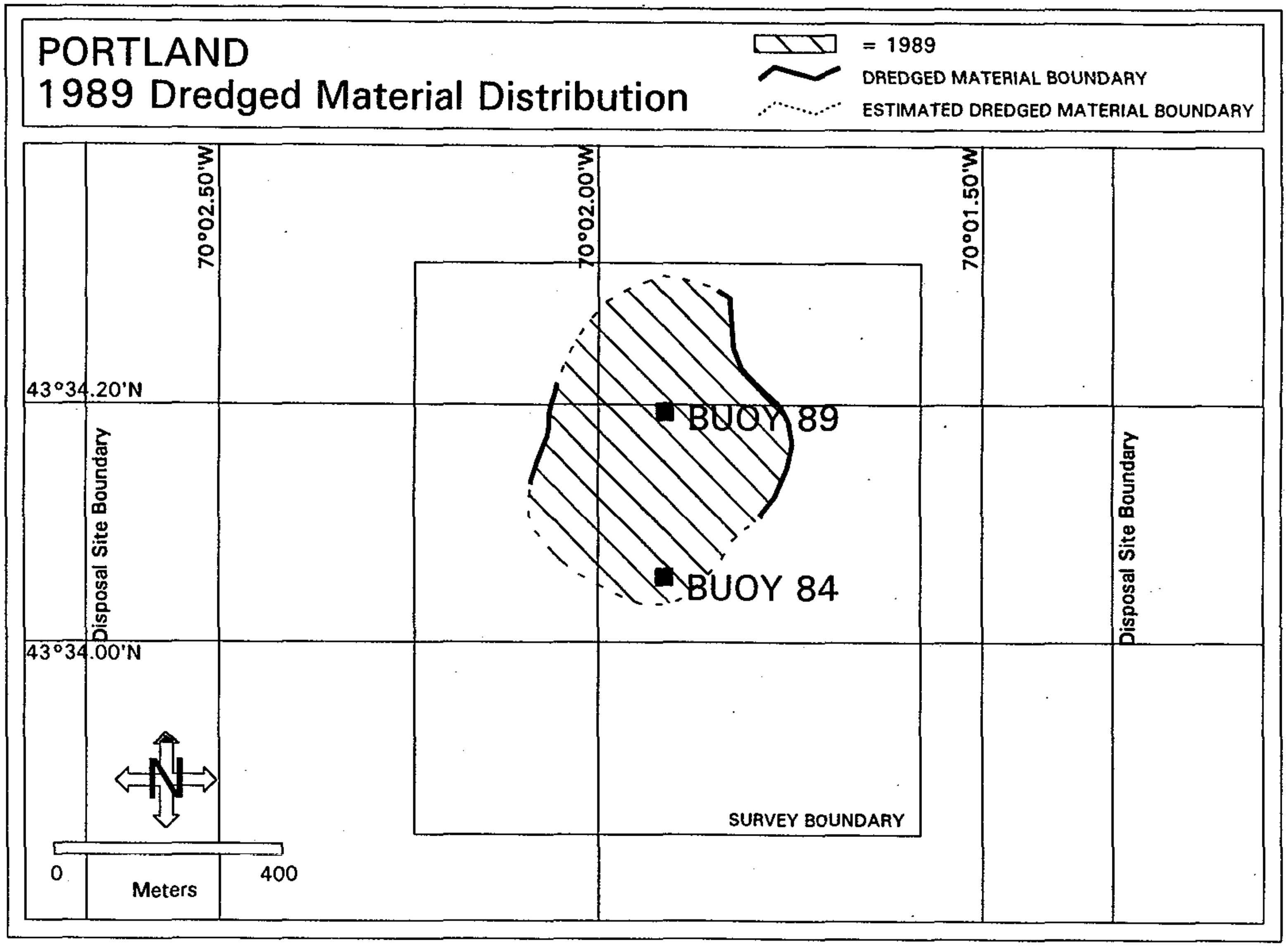

Figure 6-36. Dredged material distribution at PDS, 1989

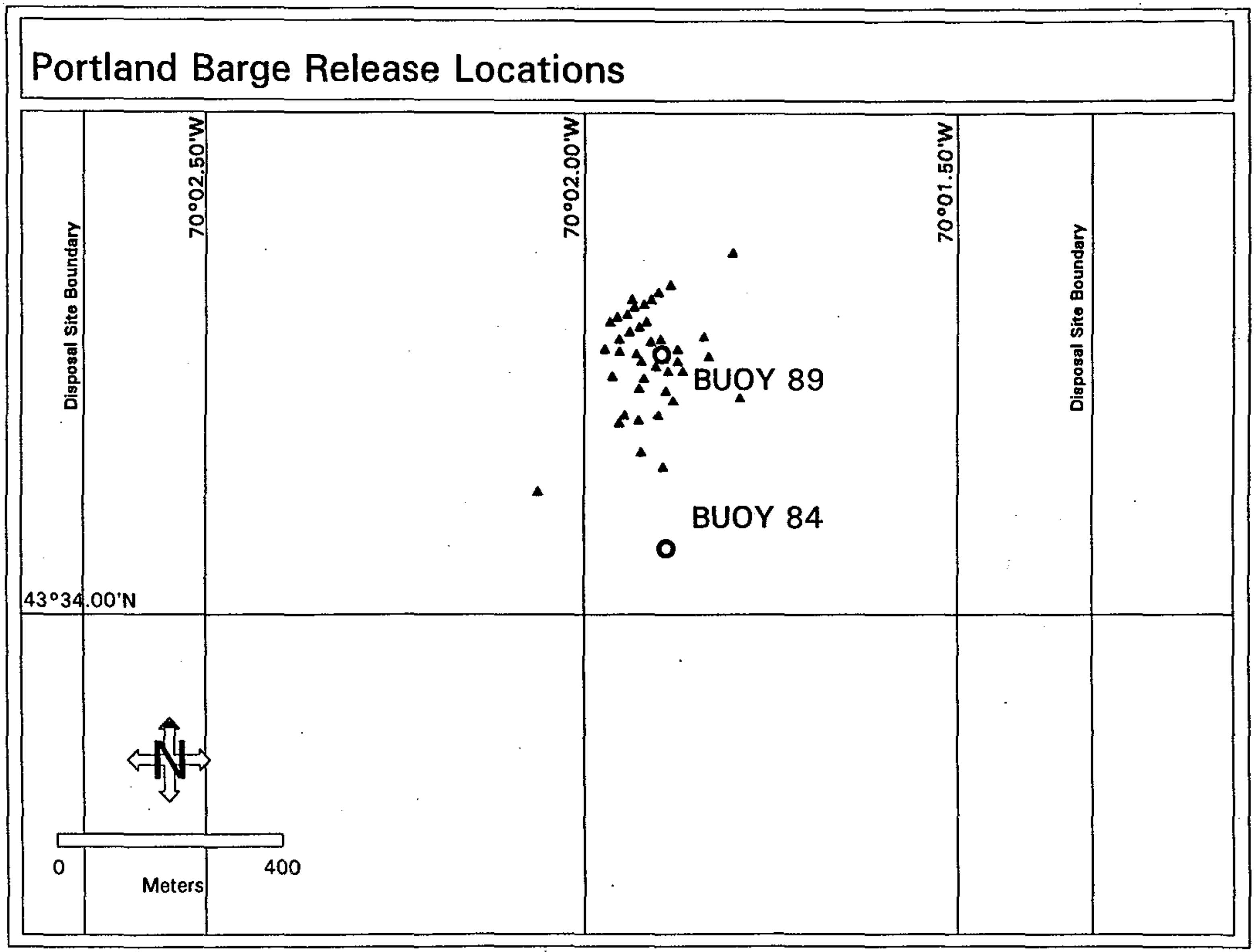

Figure 6-37. Barge release locations at PDS, 1985-1989

6.6 ROCKLAND DISPOSAL SITE

6.6.1 Summary of RDS

The Rockland Disposal Site (RDS) is located in the center of West Penobscot Bay approximately 3.3 nmi northeast of the Rockland Harbor breakwater (Figure 6-38). The site is a 0.5 nmi^2 with sides running true north-south and east-west, centered at 44°07.100′ N and 69°00.300′ W. Water depths at RDS range from 65 to 80 m. The site is characterized by a depression which is well-defined in the northern portion of the site, but widens and shoals toward the south, completely losing its identity over the southern half of the site (Figure 6-39). The ambient sediment consists of silty clays overlying a rocky glacial substratum that outcrops in the southwest corner of the site. The current regime in this area is influenced primarily by the strong, north-south tidal flow (SAIC 1988e). Current velocities averaged 4 - 16 $cm \cdot s^{-1}$, with peak velocities of approximately 40 $cm \cdot s^{-1}$ occurring during the flood tide. The relatively short fetch and deep water at RDS restrict any possible wave-induced erosion associated with major storm events (SAIC 1988a).

RDS has virtually no commercial finfishing, and the nearest productive fishing grounds are found outside of Penobscot Bay. Lobstering, which increases during the summer months, is confined to water depths shallower (less than 20 m) than those located within the disposal site. Due to the relatively clean nature of the sediments disposed at RDS, finfish or benthic (seafloor) habitat contamination would not be expected from dredged material disposal activities (SAIC 1988a).

6.6.2 RDS: 1989 Monitoring Results

Since 1984, SAIC has conducted two monitoring surveys at RDS (SAIC 1988e, 1992). These surveys, in May 1985 and June 1989, were designed to map the areal extent of dredged material, assess the possible transport of dredged material during disposal operations, and evaluate the response and subsequent recolonization of the benthic environment. Assessment techniques included precision bathymetry, side-scan sonar, sediment sampling, acoustic plume tracking, and REMOTS® sediment-profile photography (SAIC 1990f).

Although 374,099 m^3 of dredged material was deposited at RDS from February 1985 to June 1989 (Figure 6-40), no distinct, well-defined disposal mounds were detected by bathymetric surveys in 1985 or 1989 (Figure 6-39). A depth difference calculation from the 1985 and 1989 bathymetric data revealed an elliptical mound southeast of the disposal buoy, peaking at 1.3 m, and several small mounds less than 1.0 m in height (Figure 6-41). Due to the minimal topographical changes resulting from disposal, side-scan sonar and REMOTS® sediment-profile photography were used to determine the distribution of dredged material. In each survey, dredged material was found up to 500 m from the disposal buoy (Figure 6–42).

Factors contributing to the wide distribution of dredged material include the depth at the disposal point (70 m) and the wide area of coverage by the conventionally moored buoy (SAIC 1992).

To assess the extent of dredged material dispersion when the barges released material, SAIC conducted a plume tracking study. Previous estimates of material remaining in the water column range from 1 to 5% of the volume of material disposed (Truitt 1986 and references therein). Results from the plume tracking study showed that if disposal occurred only on maximum flood tide (a worst case), an estimated 6% of the material would be transported outside of the disposal site. However, when disposal occurred evenly at all stages of the tide, the estimate would be reduced to 0.8%. When there is a need to minimize the distribution of dredged material in the water column, disposal operations should be scheduled to avoid peak flood tide (SAIC 1988a).

REMOTS® analyses conducted in 1989 at RDS revealed that much of the area affected by disposal operations since 1984 had undergone rapid recolonization by benthic organisms. Due to the relatively uncontaminated character of the dredged sediments and the intermittent nature of disposal at RDS, monitoring efforts have not been as intensive as at other sites in New England.

6.6.3 References for Section 6.6

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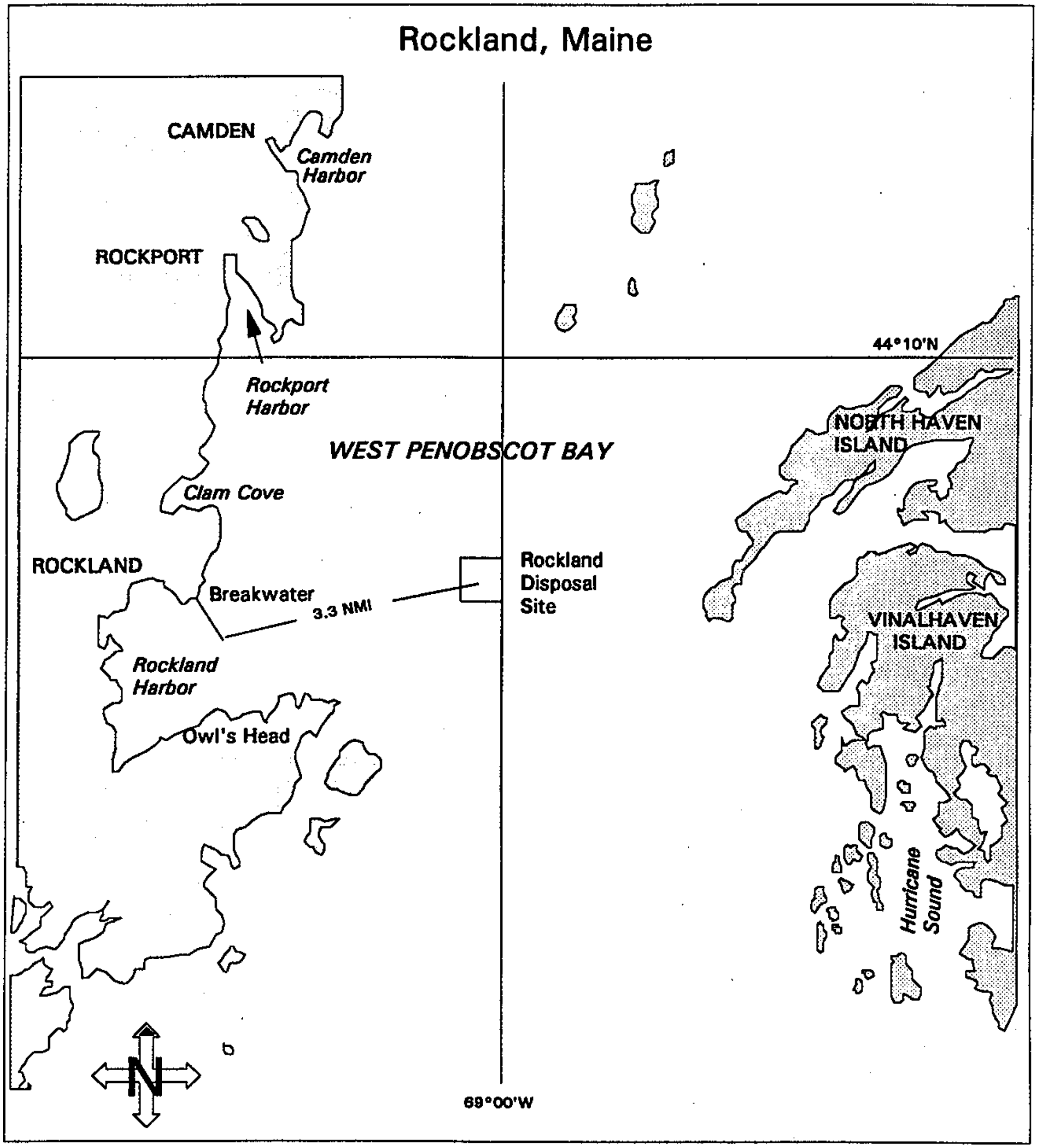

Figure 6-38. Location of RDS in relation to Rockland Harbor breakwater

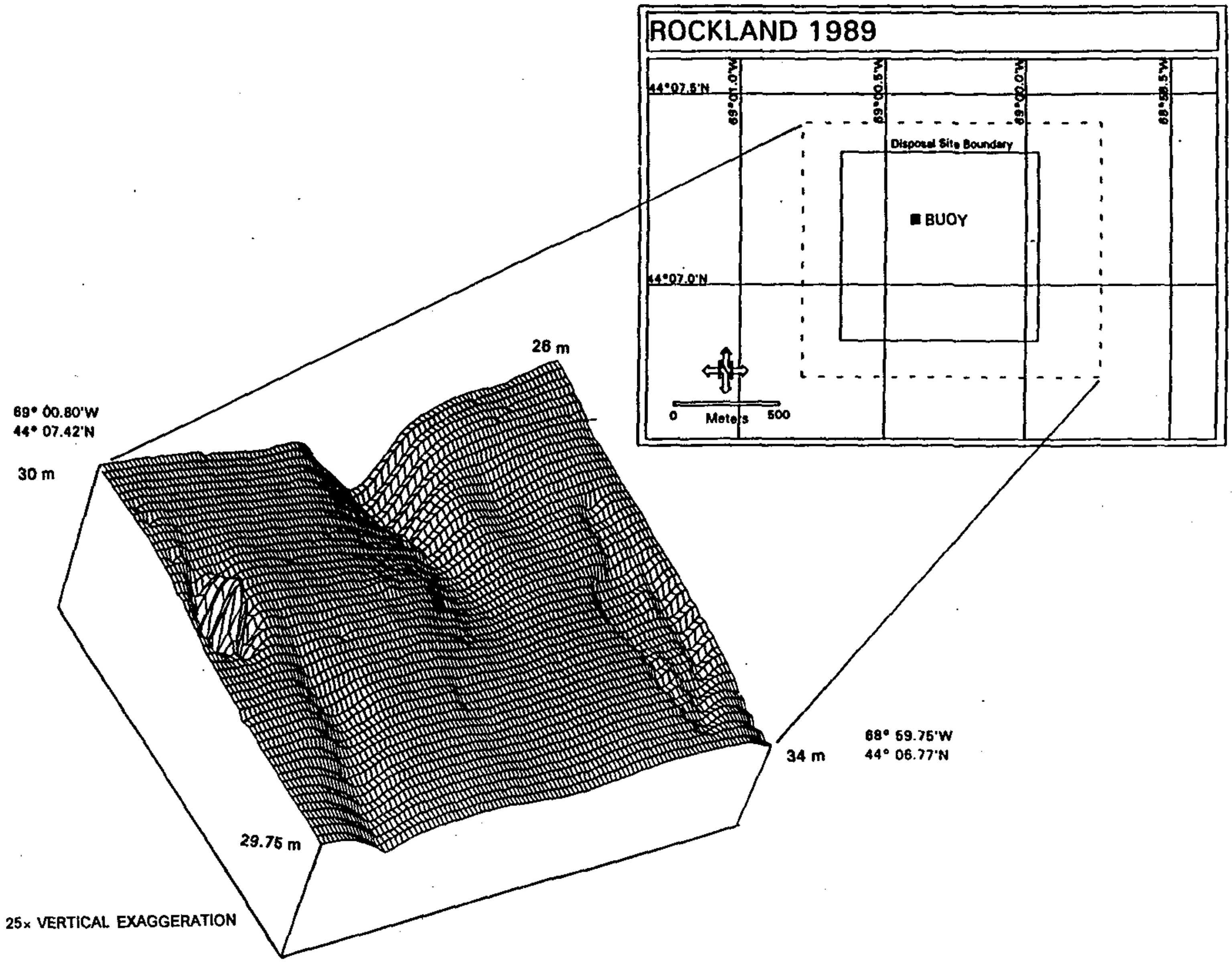

Figure 6-39. Three-dimensional bathymetric plot of RDS 1989 survey

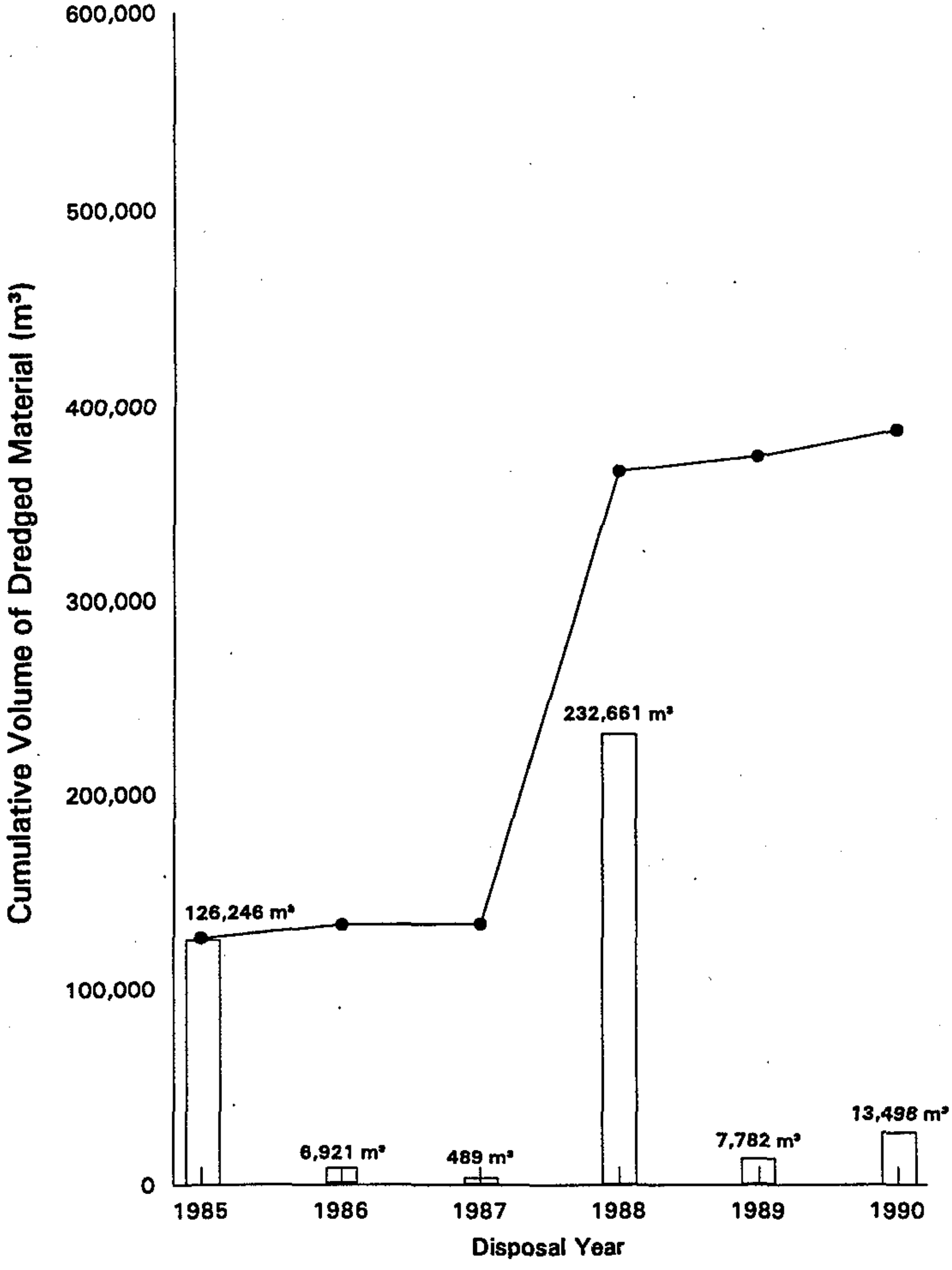

Figure 6-40. Dredged material disposal at RDS, 1985-1990

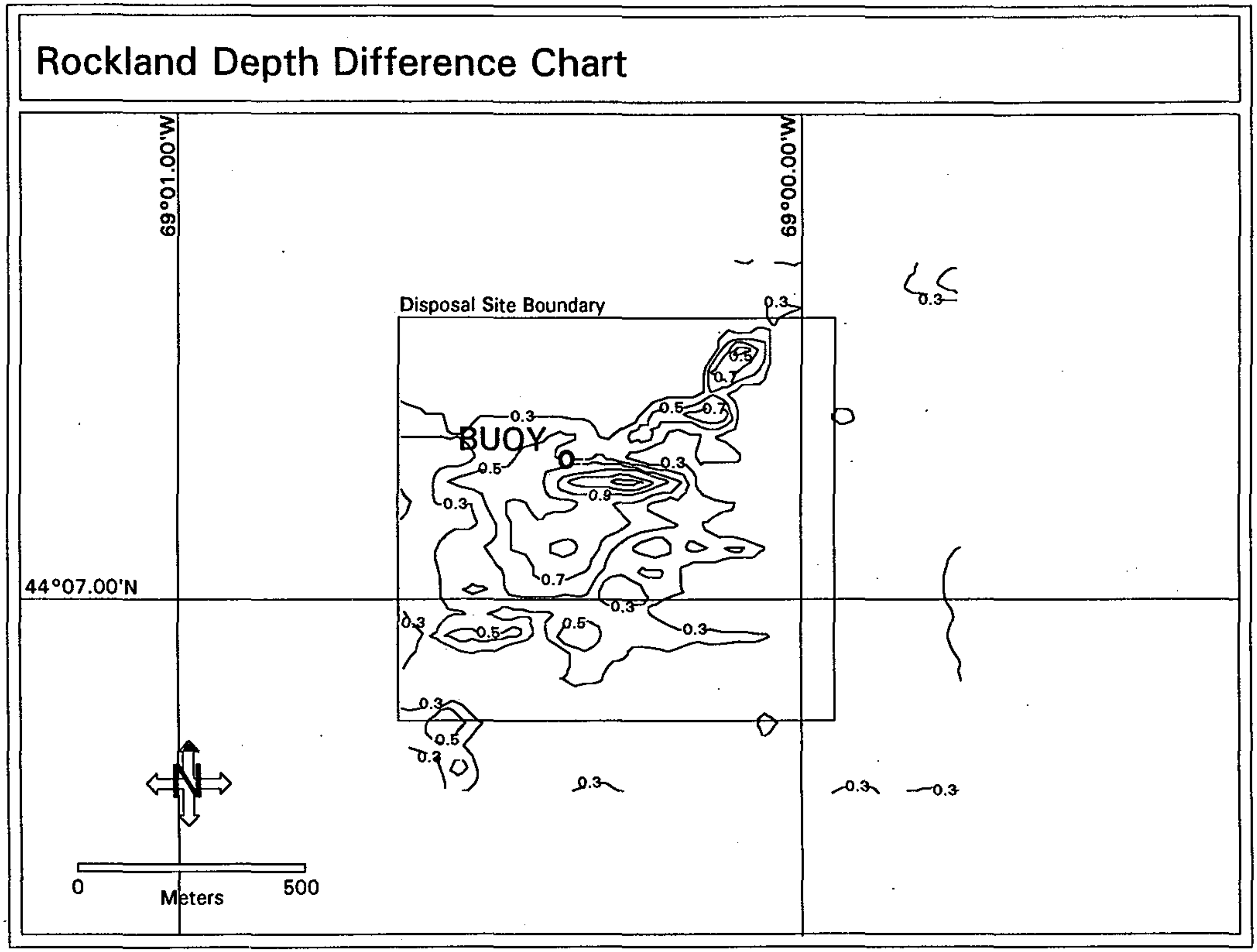

Figure 6-41. Depth difference contour chart based on comparison of the May 1985 and June 1989 bathymetric surveys at RDS

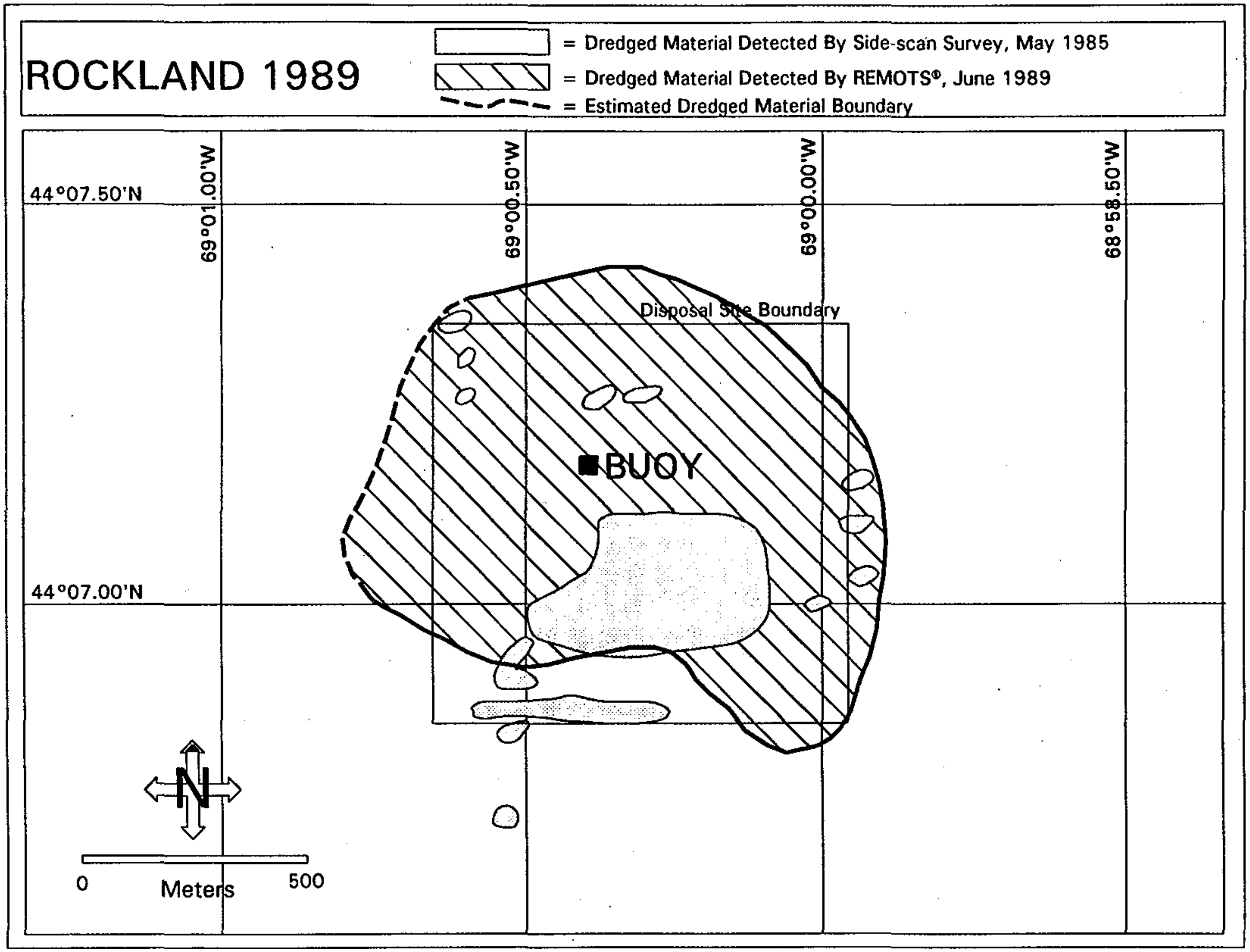

Figure 6-42. Dredged material distribution at RDS, 1985-1990

6.7 CAPE ARUNDEL DISPOSAL SITE

6.7.1 Summary of CADS

The Cape Arundel Disposal Site (CADS), a 500 yard (457.25 m) diameter area centered at 43°17.800′ N, 70°27.200′ W, is located in Bigelow Bight approximately 2.7 nmi south of Cape Arundel, Maine (Figure 6-43). The site is in an area of north-south trending ridges and valleys created as a result of glaciation and is typical of the western Gulf of Maine. Because each of these valleys is separated by bedrock ridges, the details of the local bathymetry are unique to each area and must be defined through specific bathymetric and side-scan sonar surveys. The site lies in a trough that has a maximum depth of 44 m and is oriented in a true north-south direction (Figure 6-44).

Water circulation at CADS is influenced by the counterclockwise flow around the Gulf of Maine. Current studies in recent years have revealed that the bottom currents at the disposal site are on the order of 10-15 $cm \cdot s^{-1}$ in a northerly direction (SAIC 1987c). During one 59-day current meter deployment in the fall of 1984, maximum bottom velocities of 22 $cm \cdot s^{-1}$ were recorded on several occasions coinciding with local storm events. From these data, it is apparent that the bottom currents in the vicinity of CADS are not affected significantly by wind and storm events which may drive surface currents, and it appears that bottom currents are controlled by the bottom topography. Because of the trough running through the disposal site, the currents at CADS primarily flow in a north-south direction at very low velocities and cause minimal sediment resuspension (SAIC 1988a).

In the Cape Arundel area, the near-shore rocky bottom probably is used exclusively by lobster fishermen. Rough bottom offshore may be used for lobster pots or gill nets. All disposal operations at this site are confined to the trough area to minimize the impact to potential lobster habitat. Extensive finfish dragging takes place on level bottoms offshore of the disposal area; commercial dragging is impractical at CADS due to the confined nature of the disposal trough. However, small draggers may work inshore areas seasonally for winter flounder or northern shrimp. Ocean quahogs have been found at depths less than 30 m off Maine, but have not been harvested commercially. Some finfish spawning takes place near the disposal site. Silver hake, pollock, and Atlantic cod spawn along the entire western Gulf of Maine, but these fish all have pelagic (floating) eggs which would be little affected by sediment disposal. Atlantic herring spawn along the Western Gulf of Maine and have demersal eggs which adhere to the bottom. The eggs usually are laid at depths less than 90 m in areas with high currents (average 32 $cm \cdot s^{-1}$) and hard bottoms chosen to provide maximum oxygenation and minimum siltation (SAIC 1988a).

Numerous field investigations were conducted at CADS from May 1984 to May 1990 (SAIC 1987c, 1990k, 1991a). The earlier surveys were conducted as part of the final disposal site designation study. The techniques used during these studies included bathymetric and side-scan sonar surveys, physical and chemical analyses of sediment and water samples, REMOTS® sediment-profiling surveys, fisheries studies, benthic community studies, and manned and unmanned submersible observations. The October 1987 and May 1990 surveys were conducted to determine the extent of the dredged material deposited at the site and the remaining site capacity.

Disposal of dredged material was minimal at CADS during the site designation study; 17,320 m^3 of dredged material was deposited from February to May 1985. Dredged material disposal has increased significantly since then (Figure 6-45). Site capacity was calculated for the trough within the disposal site boundaries after the October 1987 survey. Due to the dispersion of barge release points (Figure 6-46) and the rough topography, the dredged material did not form the distinct mounds that it would on a flat bottom. A sand layer on the order of 1 m or less was found over a broad area in 1987. The bathymetric survey detected the sandy dredged material layer near the buoy to be approximately 1 m thick, and the REMOTS® survey located a thinner (<20 cm) layer up to 550 m north of the buoy (outside of the disposal site boundary) (SAIC 1990k; Figure 6-47). In 1990, a detailed bathymetric survey of the disposal site revealed accumulations of dredged material in the trough of the disposal site and on the flanks of the ridges (Figure 6-48).

Between 1985 and 1986, sediment chemistry and body burden studies were conducted at CADS as part of the final site designation study. Sediment chemistry samples were collected at the southern end of the trough where dredged material disposal had already occurred and also at a reference area located in a trough to the east (Figure 6-49). In addition to these two sampling areas, body burden samples were also collected from the northern end of the trough (Figure 6-49).

Sediment chemistry results indicated that levels of As, Cr, Cu, Hg, Pb, Zn, oil and grease, and PCBs were low at CADS, according to NERBC sediment guidelines (Table 6-1), and that concentrations of Cd and Ni were below analytical detection limits. Concentrations of total organic carbon, oil and grease, and petroleum hydrocarbons (PHC) were higher at CADS than at the reference area (Figure 6-50). PCBs were below detection at CADS, but were measured in small quantities (~40 ppb) at the reference area. The lower concentrations of PCBs at the disposal site relative to reference may have been due to material deposited at CADS incorporating deep sediment that was deposited at the dredging site before the introduction of PCBs (SAIC 1987c). The average PCB concentrations at several deep-water sites in the Gulf of Maine have been reported to range from 10 to 80 ppb (Larsen et al. 1985). Reported average concentrations of Pb, Zn, Cr, Cu, and Cd in sediments from Penobscot Bay, Maine, are very similar to those reported at CADS (Larsen et al. 1983). However, levels of petroleum hydrocarbons are considerably lower at CADS than in Narragansett Bay and Long Island Sound where levels as high as 9,000 ppm have been found (SAIC 1987c and references therein).

Some differences were apparent for *Nephtys* trace metal data between stations (Figure 6-50). Copper concentrations were significantly higher at the reference station at either the south or north CADS stations. Conversely, the concentrations of iron in the reference *Nephtys* samples were significantly lower than the south or north *Nephtys* samples. DDT and PCBs were not detected in any body burden samples. The metal concentrations measured in *Nephtys* from all of the CADS locations are equal to or lower than concentrations reported for the MBDS and CLIS reference locations (SAIC 1987c and 1988f). Although Central Long Island Sound and Massachusetts Bay are not pristine, the reference locations in these areas are not considered to be seriously affected by anthropogenic activity.

6.7.2 CADS: 1990 Monitoring Results

The precision bathymetric survey conducted at CADS in May 1990 was used to position a permanent buoy and to determine the remaining site capacity. It was predicted that the central portion of the trough would have a maximum decrease in depth of 2 m with only 10 to 30% of the disposed material detected by comparing the sequential bathymetric plots. This relatively low detection was expected because of the extremely rough topography at the site.

A temporary buoy had been deployed at CADS in April 1990 at 43°17.775′ N, 70°27.194′ W. The results of the bathymetric survey in May indicated that the buoy did not need to be repositioned. The new buoy was deployed in the same location.

The initial site capacity at CADS, based on a 36 m minimum depth, was approximately 600,000 m³ within the disposal site boundaries (SAIC 1990m). The area of the disposal site >36 m depth was confined mostly to a 300 × 300 m area around the disposal buoy location. The volume of dredged material measured for the 300 × 300 m area disposed between 1987 and 1990 was 129,260 m³. Considering the percentage of material accumulating in the disposal site and compaction after disposal, the amount of dredged material necessary to fill the site would be 462,580 m³.

6.7.3 References for Section 6.7

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Larsen, P. F.; Gadbois, D. F.; Johnson, A. C. 1985. Observations on the distribution of PCBs in the deep water sediments of the Gulf of Maine. Mar. Poll. Bull. 16:439-442.

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SAIC. 1988a. A summary of DAMOS physical monitoring of dredged material disposal activities. SAIC Report No. SAIC-88/7527&C71. Final report submitted to US Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

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SAIC. 1990k. Monitoring cruise at the Cape Arundel Disposal Site, October 1987. DAMOS Contribution No. 67 (SAIC Report No. SAIC-87/7513&C67). US Army Corps of Engineers, New England Division, Waltham, MA.

SAIC. 1991a. Monitoring cruise at the Cape Arundel Disposal Site, May 1990. DAMOS Contribution No. 82 (SAIC Report No. SAIC-90/7583&C87). US Army Corps of Engineers, New England Division, Waltham, MA.

SAIC. 1990m. Analysis of sediment chemistry and body burden data obtained at the Massachusetts Bay Disposal Site, October 1987. DAMOS Contribution No. 75 (SAIC Report No. SAIC-88/7535&C73). US Army Corps of Engineers, New England Division, Waltham, MA.

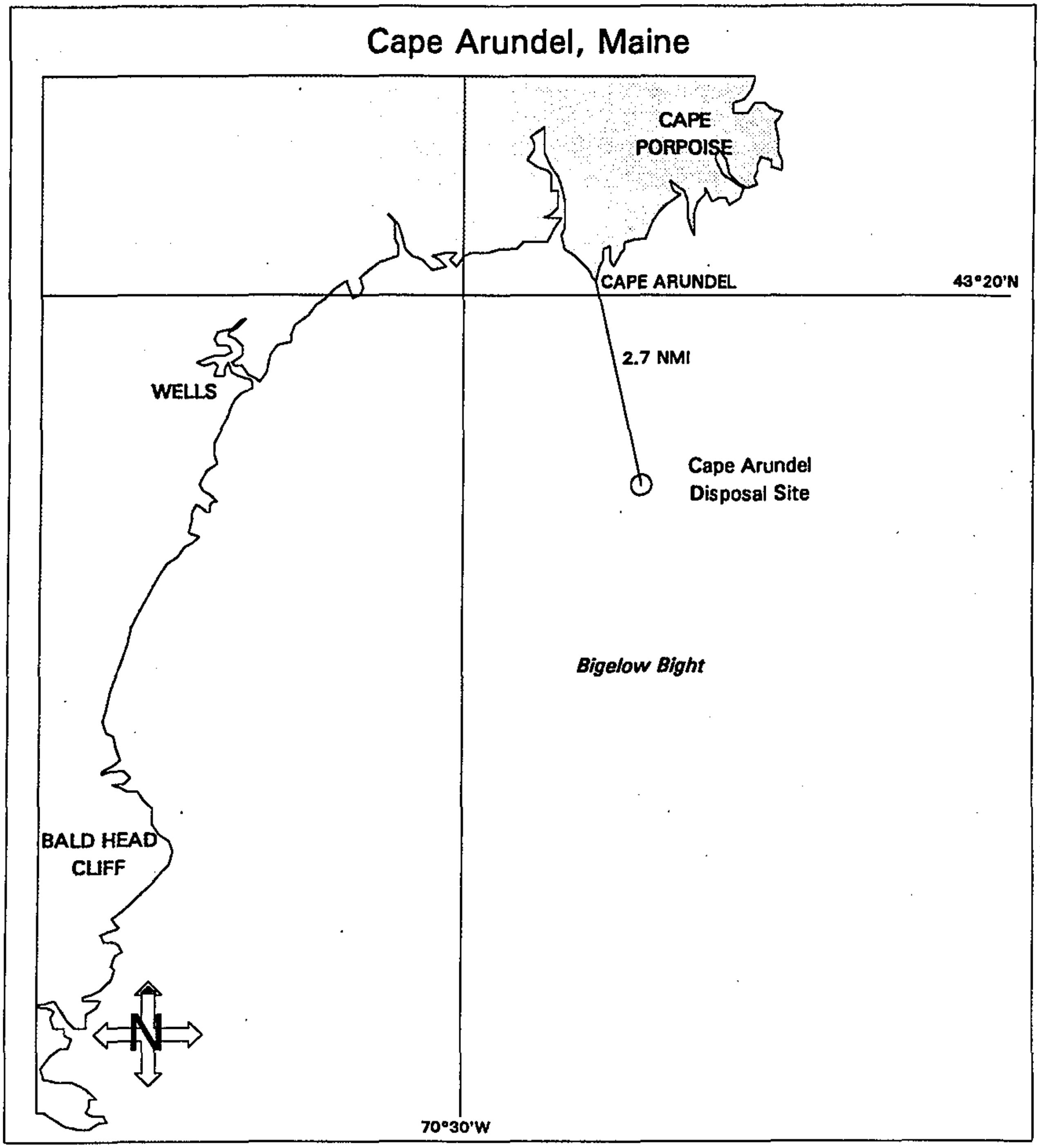

Figure 6-43. Location of CADS in relation to Cape Arundel, Maine

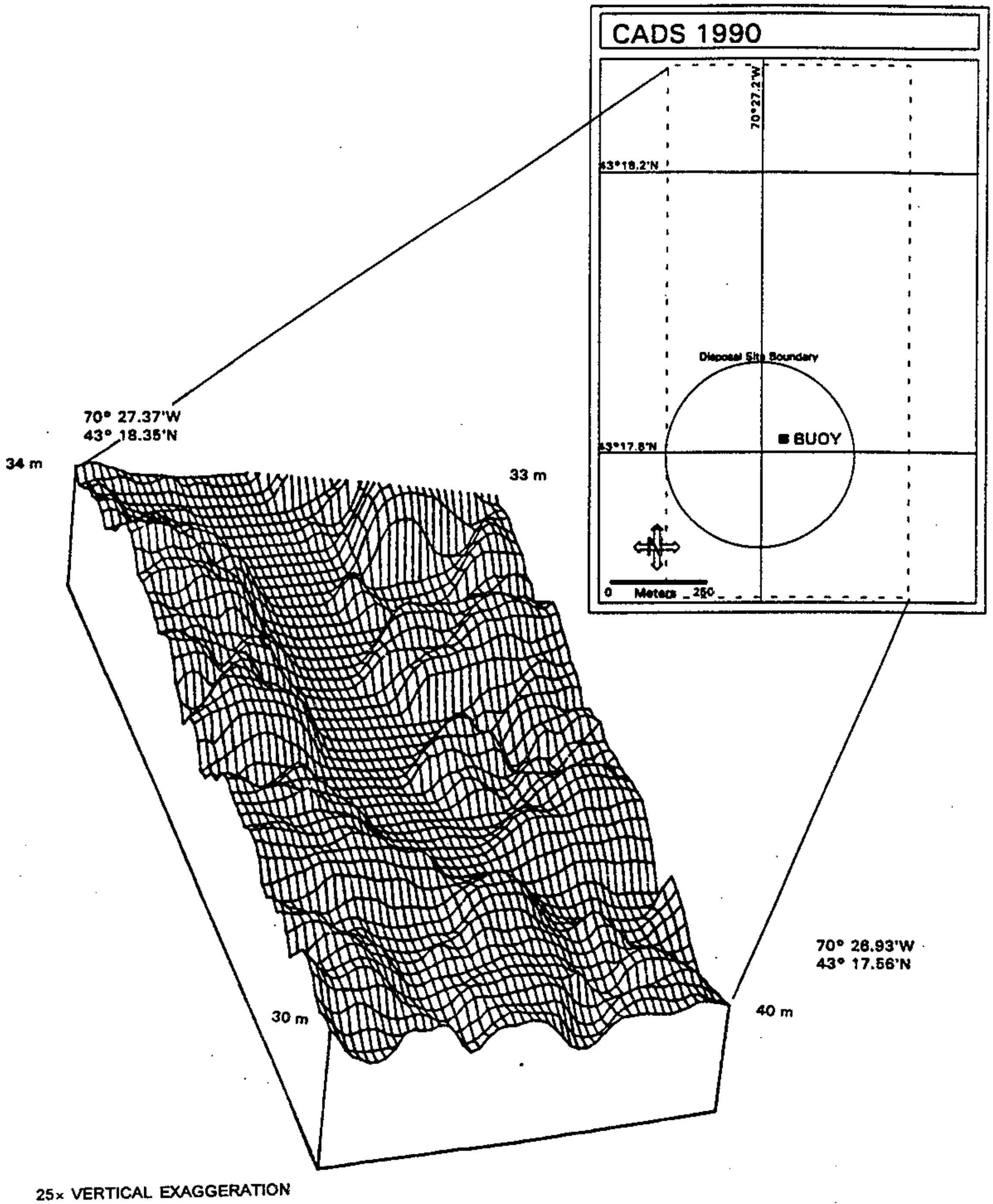

Figure 6-44. Three-dimensional bathymetric plot of CADS 1990 survey. The location of the plot in relation to disposal site boundaries and buoy locations is shown in the insert.

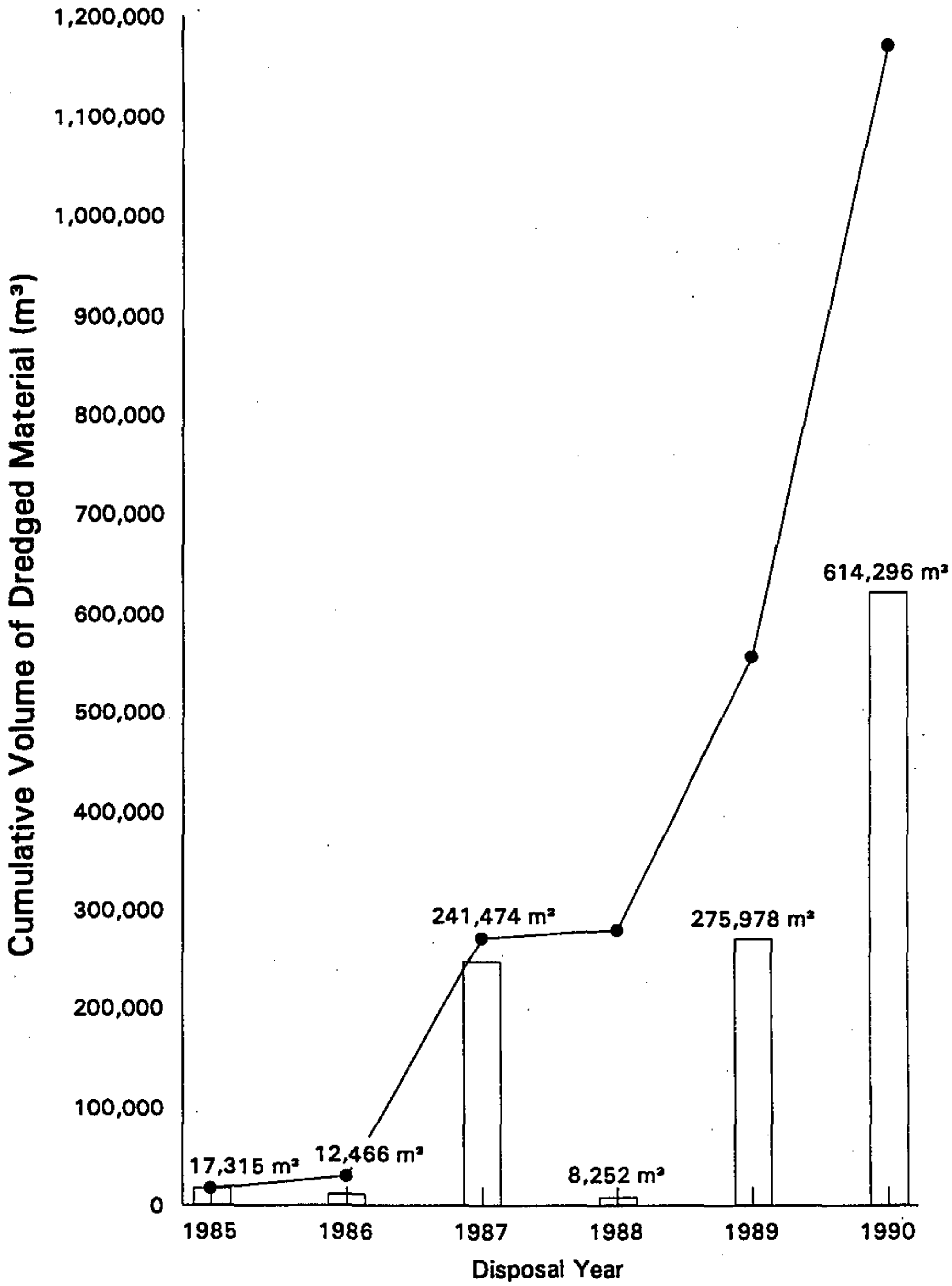

Figure 6-45. Dredged material disposal at CADS, 1985-1990

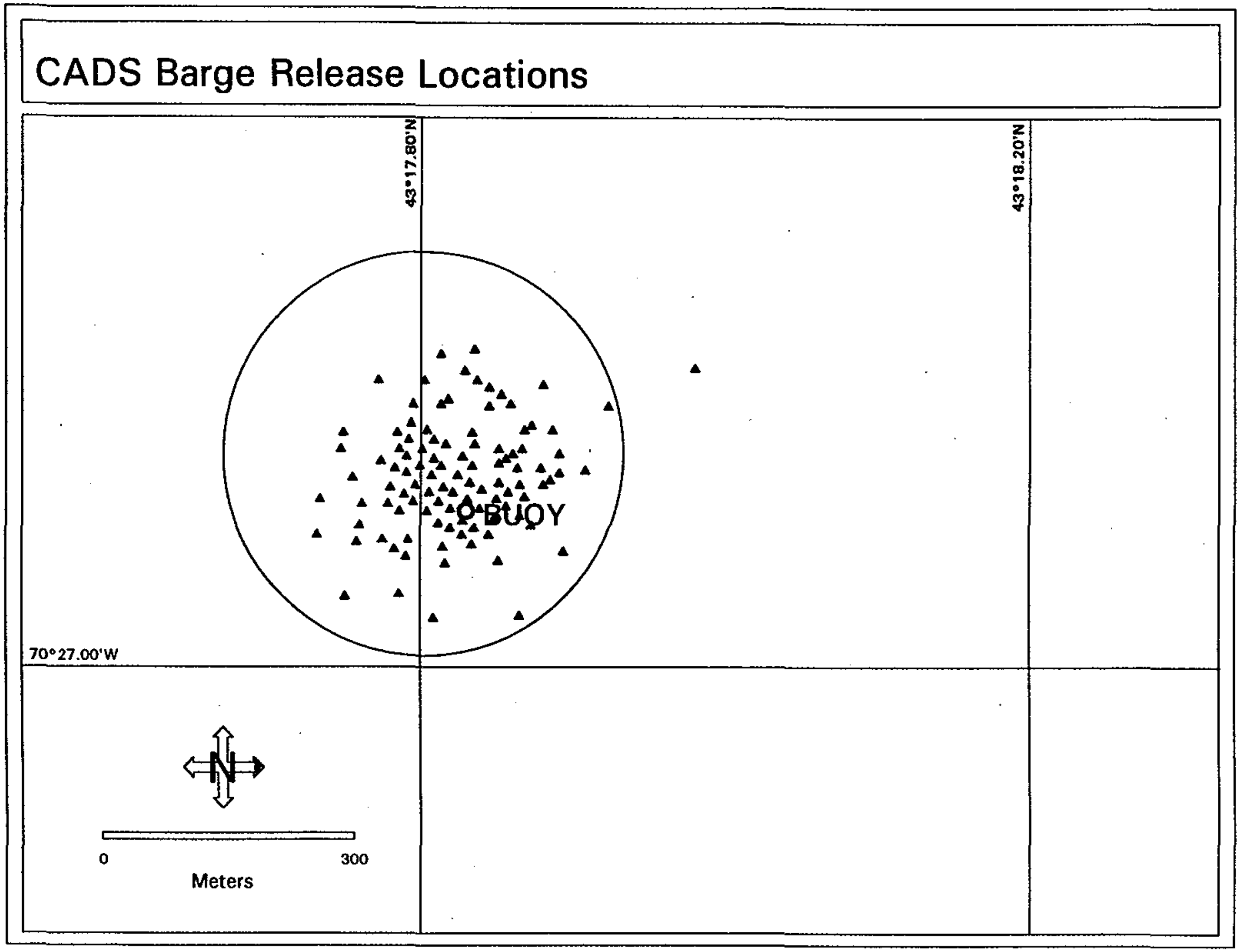

Figure 6-46. Barge release locations at CADS, 1988-1990

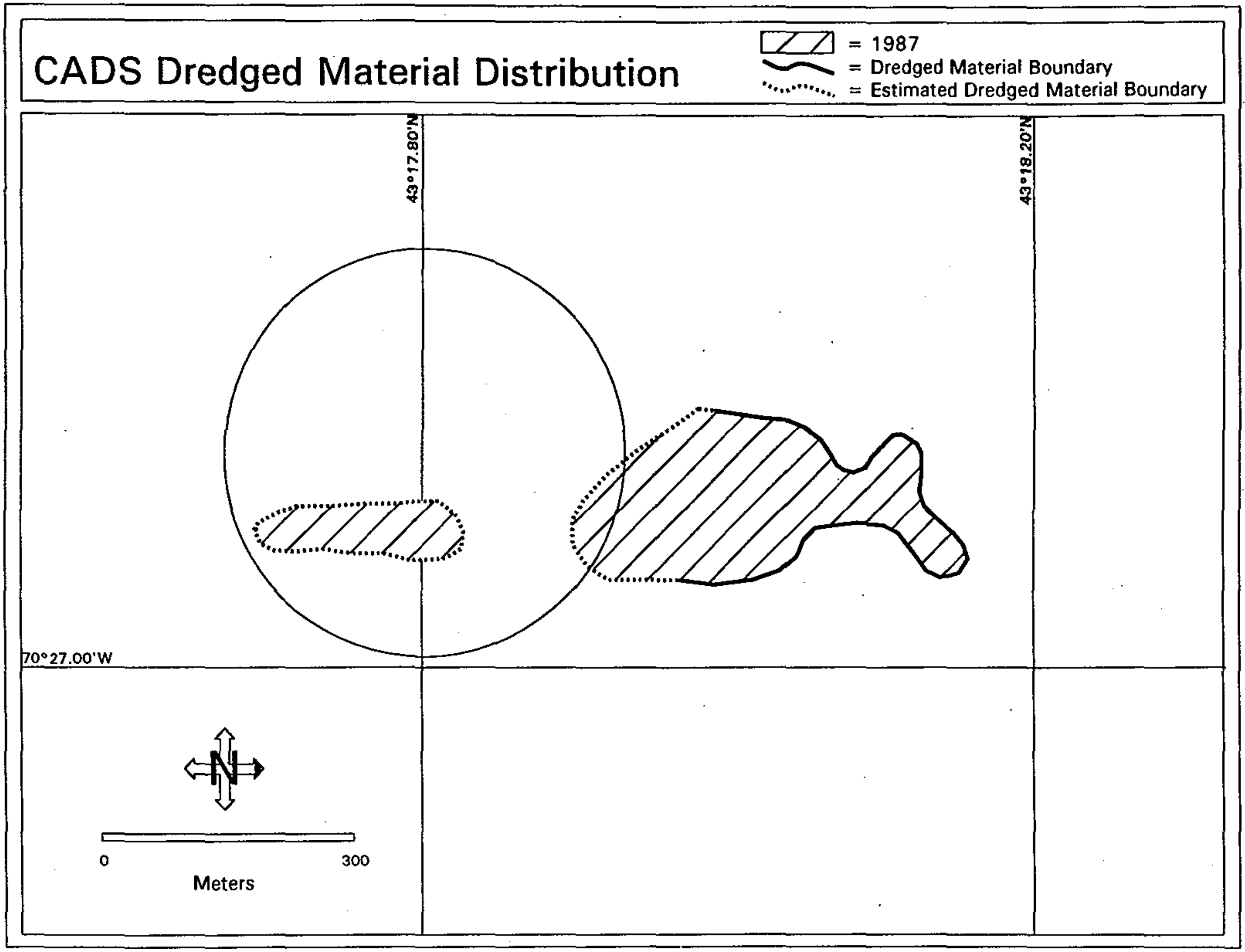

Figure 6-47. Dredged material distribution at CADS, 1985-1990

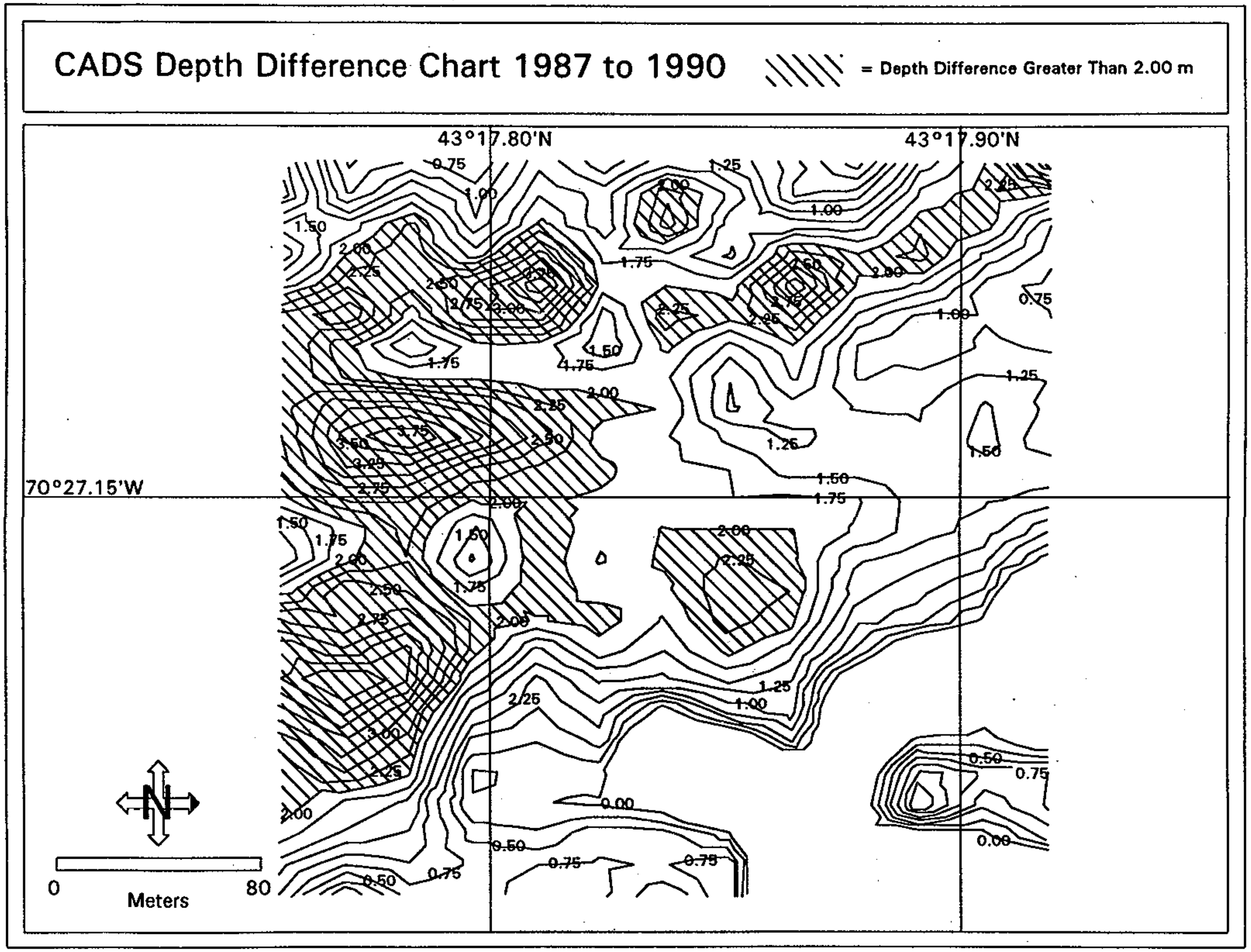

Figure 6-48. Contoured depth difference chart at CADS from 1987 to 1990

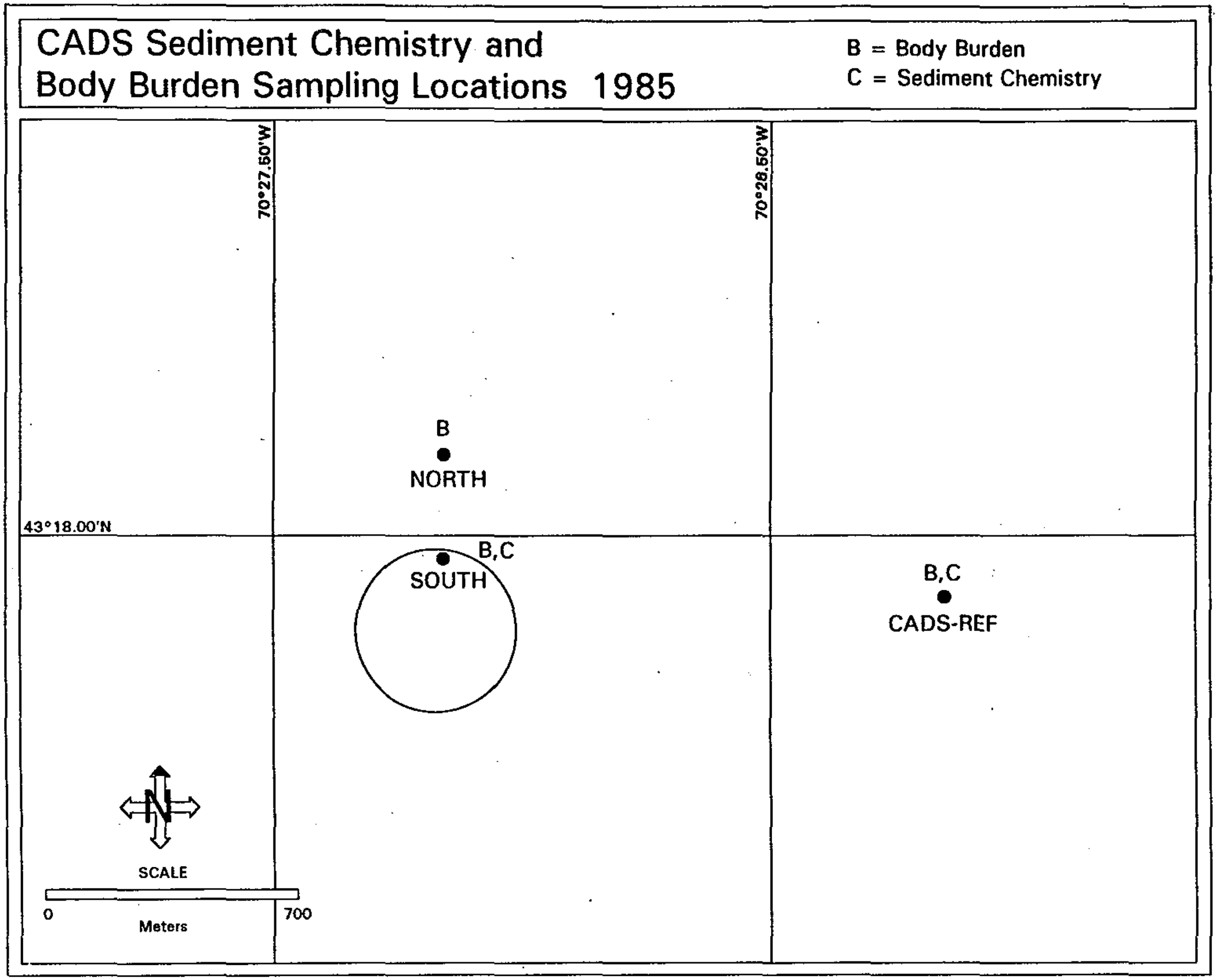

Figure 6-49. Sediment chemistry and body burden sampling locations at CADS

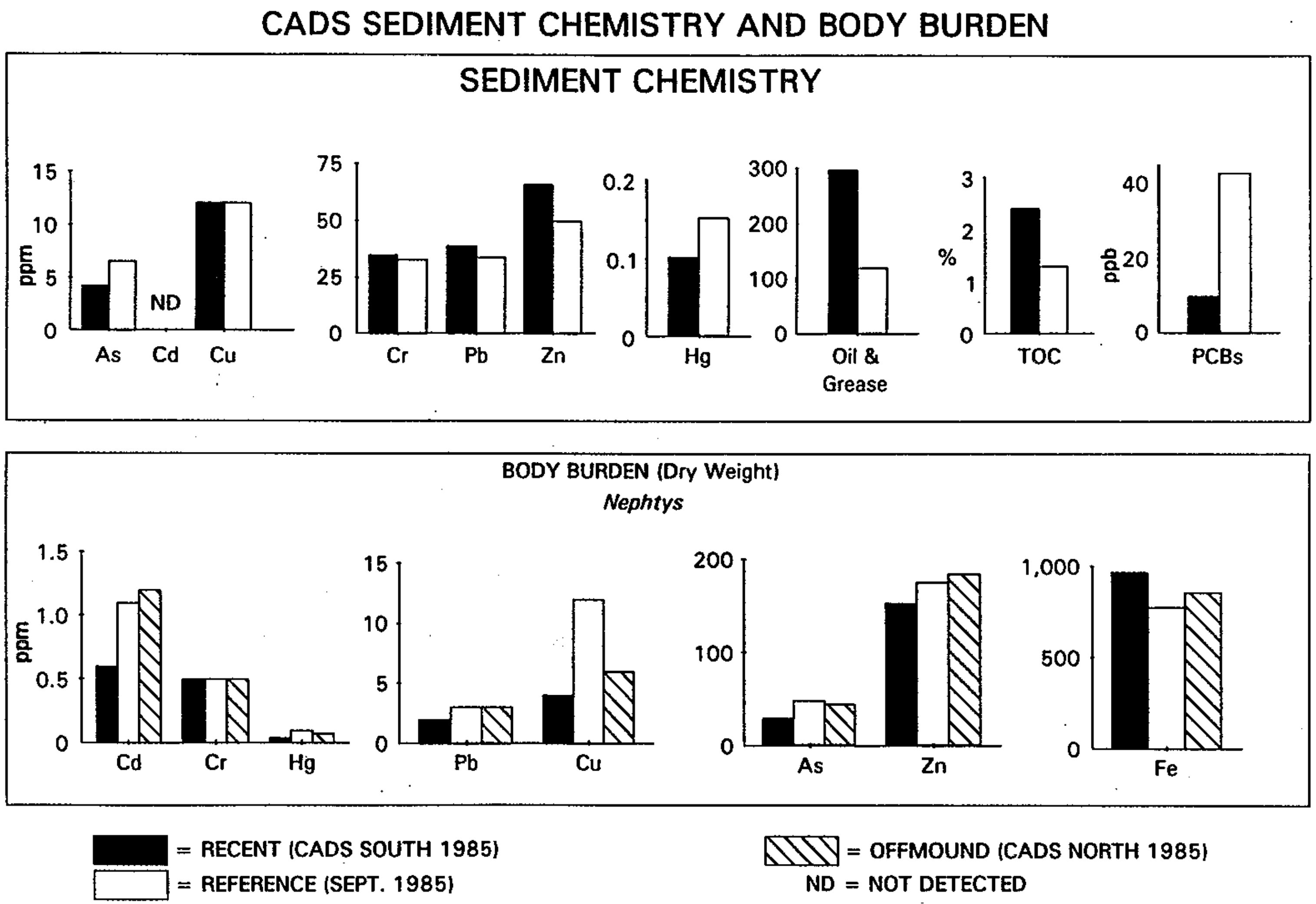

Figure 6-50. Results of CADS sediment chemistry and body burden analyses (measurements based on dry weight of *Nephtys*)

6.8 MASSACHUSETTS BAY DISPOSAL SITE

6.8.1 Summary of MBDS

The Massachusetts Bay Disposal Site (MBDS) is a circular area with a diameter of 2 nmi. It is located in the northeast portion of Massachusetts Bay (42°25.700′ N and 70°34.000′ W) approximately 12 nmi south-southeast of Gales Point, Gloucester, Massachusetts (Figure 6-51). (Note: in 1993, as part of the final designation by EPA, the site boundary was shifted about 1 nmi to the southwest. The discussion here refers to the site boundary from 1977 to 1993.) The topography of the site is divided into two areas: a shoal region in the northeast quadrant of the area and a deep, relatively flat depression with an average depth of approximately 85-90 m over the remainder of the site (Figure 6-52). Depths within a smaller surveyed area in the southwestern quadrant ranged from 87.25 m in the southwest to 92.25 m in the northwest (Figure 6-53).

The oceanography of MBDS is influenced, in part, by the circulation of the Gulf of Maine. The Gulf of Maine circulation patterns in the vicinity of MBDS are modified to a large extent by the presence of Stellwagen Bank on the eastern margin. Bottom currents in the vicinity of MBDS are less than 20 $cm \cdot s^{-1}$ under nearly all conditions, whereas mid-depth and surface currents may be higher (SAIC 1987d, 1988f). Bottom current velocities measured during site designation studies in 1987 were less than 4 $cm \cdot s^{-1}$ over 85% of the time, and historical current meter studies measured velocities less than 10 $cm \cdot s^{-1}$. These low current conditions minimize the possibility of resuspension of deposited material at this site, and the deep water tends to isolate the bottom from the effects of all but the severest of storms.

Vessels from the Massachusetts Bay area fish in the vicinity of the disposal site, including Stellwagen Bank, throughout the year. Stellwagen Bank is a popular area for fishing and whale watching and has been designated as a marine sanctuary. One major concern raised by regulatory agencies and environmental groups is the proximity of marine mammals (specifically, humpback and finback whales) on Stellwagen Bank to MBDS. These mammals feed on the small plankton in the water column. While feeding they also may ingest suspended particulates. There has been concern that there may be contaminants associated with fine-grained particles released during disposal. However, the sediments deposited at MBDS have been sands, silts, and clays which have met regulatory requirements for open water dredged material disposal. All physical oceanographic information to date has indicated that harmful effects are unlikely to occur (SAIC 1988f).

SAIC has conducted five monitoring surveys at MBDS, from 1985 to 1990 (SAIC 1988f, 1990l, 1991b, Germano et al. 1994, Murray 1994). These studies were conducted to assess MBDS for continued use as a disposal site, provide baseline information for comparison with future monitoring surveys, determine the areal extent of dredged materials, monitor formation of the disposal mound, evaluate the ecological status of the benthic environment, provide information on the physical parameters of the site, and determine the extent of chemical contamination. Assessment techniques used have been extensive, including precision bathymetry, side-scan sonar, REMOTS® sediment-profile photography, current meter and transmissometer deployments, CTD/DO monitoring, sediment and benthic sampling for physical and chemical analysis, four observational cruises utilizing manned submersibles, fish collections, and the implementation of the Benthic Resources Assessment Technique (BRAT).

Approximately 597,000 m^3 of dredged sediments were disposed at MBDS from 1985 to 1990 (Figure 6-54). The maximum thickness of the mound in 1989 was 0.3 m with a radius of 50 - 100 m as detected by bathymetry. REMOTS® results from this survey extended the detected radius to 300-350 m. Results of bathymetric analyses in 1990 indicated development of an elliptical mound centered slightly east of the MBDS buoy with gradually sloping sides and a maximum thickness of 0.6 m at the apex. The diameter of the mound was estimated to be approximately 420 m. Results from REMOTS® photographs showed the total area of the seafloor affected by dredged material to be 83% greater than that detected by bathymetry (Figure 6–55). MBDS is a deep-water disposal site (approximately 90 m), and the presence of dredged material beyond the mound may result from the spreading of sediments during descent and the occasional release of dredged material up to 400 m from the buoy (Figure 6-56).

REMOTS® analyses have indicated a steady recovery in the benthic ecosystem despite ongoing disposal activity. Stage III organisms were dominant in the 1990 survey and represent high-order successional stages typically found in low disturbance habitats.

Sediment chemistry and body burden studies were conducted at MBDS in 1985 and 1986 to determine if the existing site should receive final EPA designation. Samples were collected at the reference area, off-mound, and on recent dredged material (Figure 6-57). The concentrations of Cd, Ni, and Hg were below or just at the analytical detection limits of the methods (SAIC 1987f). Results indicated that there were no significant differences between stations in concentrations of As, but the concentrations of Pb, Zn, Cr, and Cu were all significantly elevated at the disposal site (Figure 6-58). The sediment levels of Cr, Pb, and Zn at the disposal site were moderate in terms of NERBC limits, but the levels of PCBs were high (Table 6–1). Concentrations of PHCs were significantly higher in dredged material than in sediments from the reference area and the off-mound station. The levels of PHCs at all stations were comparable to those found in Narragansett Bay, Rhode Island (SAIC 1987d). Levels of contaminants at the disposal mound were very similar for 1985 and 1986 with a decrease in PCBs in 1986, reflective of disposal of sediments with lower PCB levels.

Samples were collected in 1987 to characterize the broad-scale concentration of sediment contaminants at the site. Contaminant concentrations were very similar to those measured in 1985 and 1986 (Figure 6-58). The levels of Cr, Cu, Pb, and PHCs were higher in the recent dredged material than in samples from the reference areas and the sites containing relic dredged material (Figure 6-58).

Results of the 1985 - 1986 *Nephtys* body burden analyses indicated similar metal concentrations in organisms collected in the three sampling areas. Cadmium concentrations were higher in polychaetes from the reference area (Figure 6-59), and PCBs were detected in organisms at the disposal site. Body burden levels in 1987 showed no major trends between sampling stations (Figure 6-59).

6.8.2 MBDS: 1990 Monitoring Results

In August 1990, SAIC conducted routine field operations at MBDS to provide information on the effects of disposal operations since the November 1988 bathymetric and January 1989 REMOTS® surveys. MBDS had received 260,300 m^3 of dredged sediments since November 1988. Field operations included a precision bathymetric survey, REMOTS® sediment-profile photography, and sediment sampling for chemical and physical analyses. The surveyed areas were similar to those sampled in 1988-89.

A comparison of the August 1990 and November 1988 precision bathymetric surveys revealed that an acoustically detectable layer of dredged material, with an approximate maximum thickness of 0.6 m, had been deposited at the "MDA" buoy between the time of the two surveys. The objective of the REMOTS® survey was to map that portion of the recently deposited dredged material not detectable with bathymetry. Information obtained from the REMOTS® survey indicated the presence of "fresh" dredged material within 800 m west, 500 m south, 400 m east, and 500 m north of the disposal site center. The apparently fresh dredged material was indicated by chaotic sedimentary fabrics and anomalous grain size distributions at the site.

Stage III taxa were present at 97% of the disposal site stations, compared with 75% of the stations in 1989. Most of the Stage III organisms in both surveys were associated with Stage I taxa. These results confirm that the benthic community around the "MDA" buoy was similar to that in 1989 and suggest a steady recovery in the benthic ecosystem.

Future investigations should cover topics such as detailed bioaccumulation and capping feasibility. Capping of contaminated sediments at MBDS appears to be a feasible mitigating measure if used in conjunction with a taut-wired buoy and/or navigation systems such as Global Positioning System (GPS) or microwave trisponder. Accurate navigation would also permit dilution of contaminant levels through deposition of both contaminated and relatively uncontaminated sediments at the same location.

6.8.3 References for Section 6.8

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SAIC. 1988f. Monitoring surveys at the Foul Area Disposal Site, February 1987. DAMOS Contribution No. 64 (SAIC Report No. SAIC-87/7516&C64). US Army Corps of Engineers, New England Division, Waltham, MA.

SAIC. 1990l. Monitoring cruise at the Massachusetts Bay Disposal Site, November 1988 - January 1989. DAMOS Contribution No. 73 (SAIC Report No. SAIC-89/7558&C79). US Army Corps of Engineers, New England Division, Waltham, MA.

SAIC. 1990m. Analysis of sediment chemistry and body burden data obtained at the Massachusetts Bay Disposal Site, October 1987. DAMOS Contribution No. 75 (SAIC Report No. SAIC-88/7535&C73). US Army Corps of Engineers, New England Division, Waltham, MA.

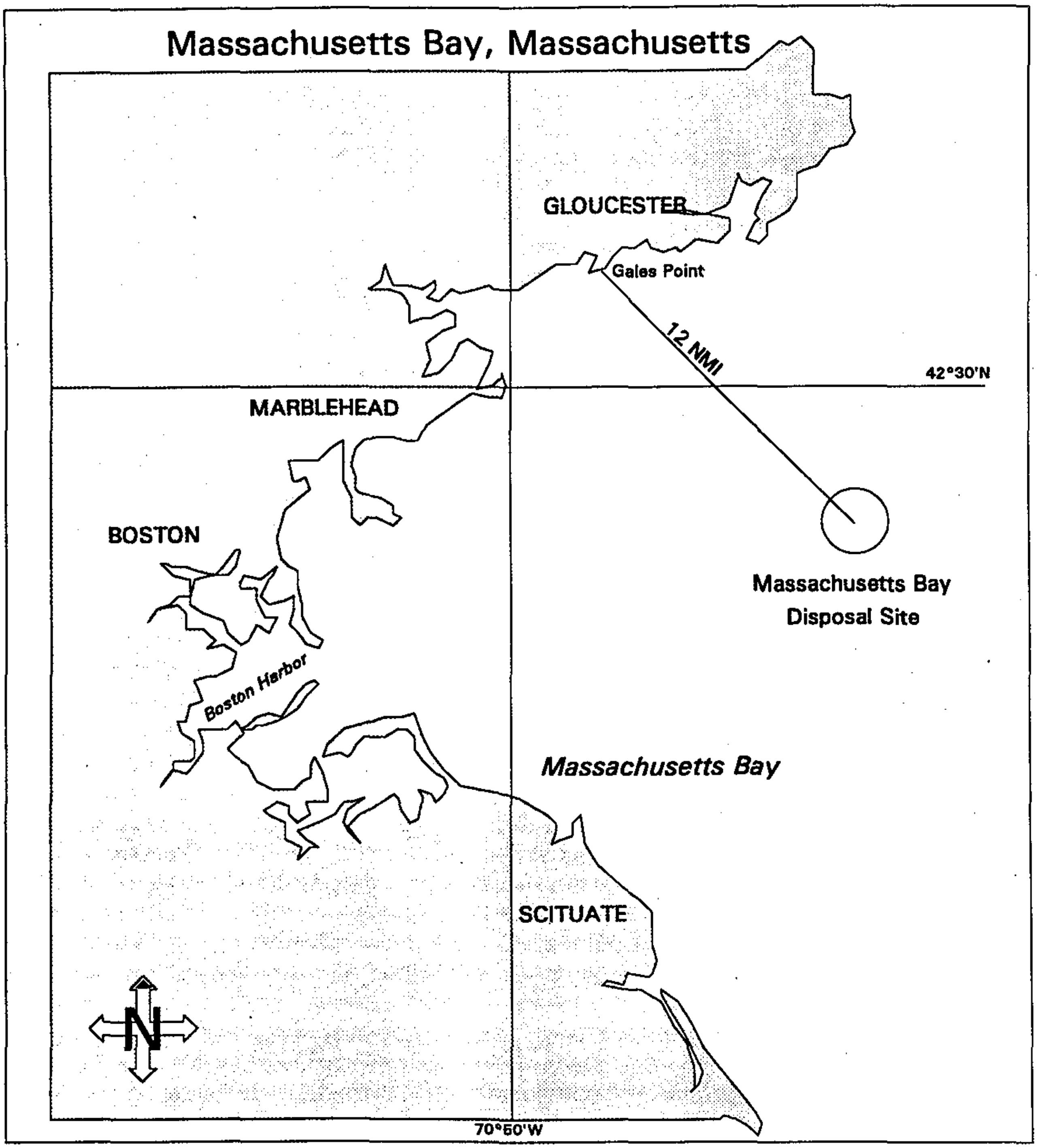

Figure 6-51. Location of MBDS in relation to Gales Point, Gloucester, Massachusetts

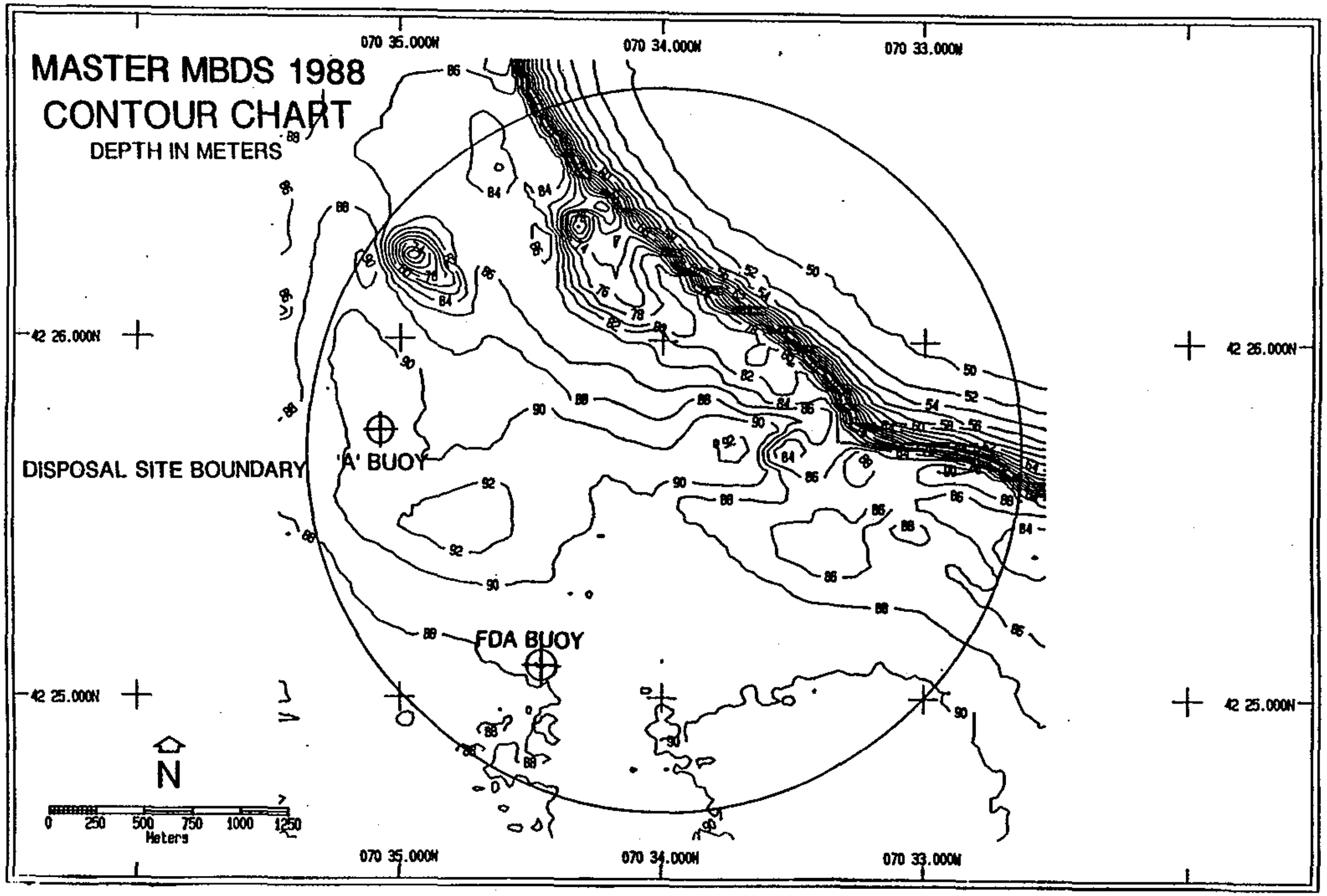

Figure 6-52. Bathymetric contour chart of the entire MBDS area, November 1988. Contour interval is 2.0 meters.

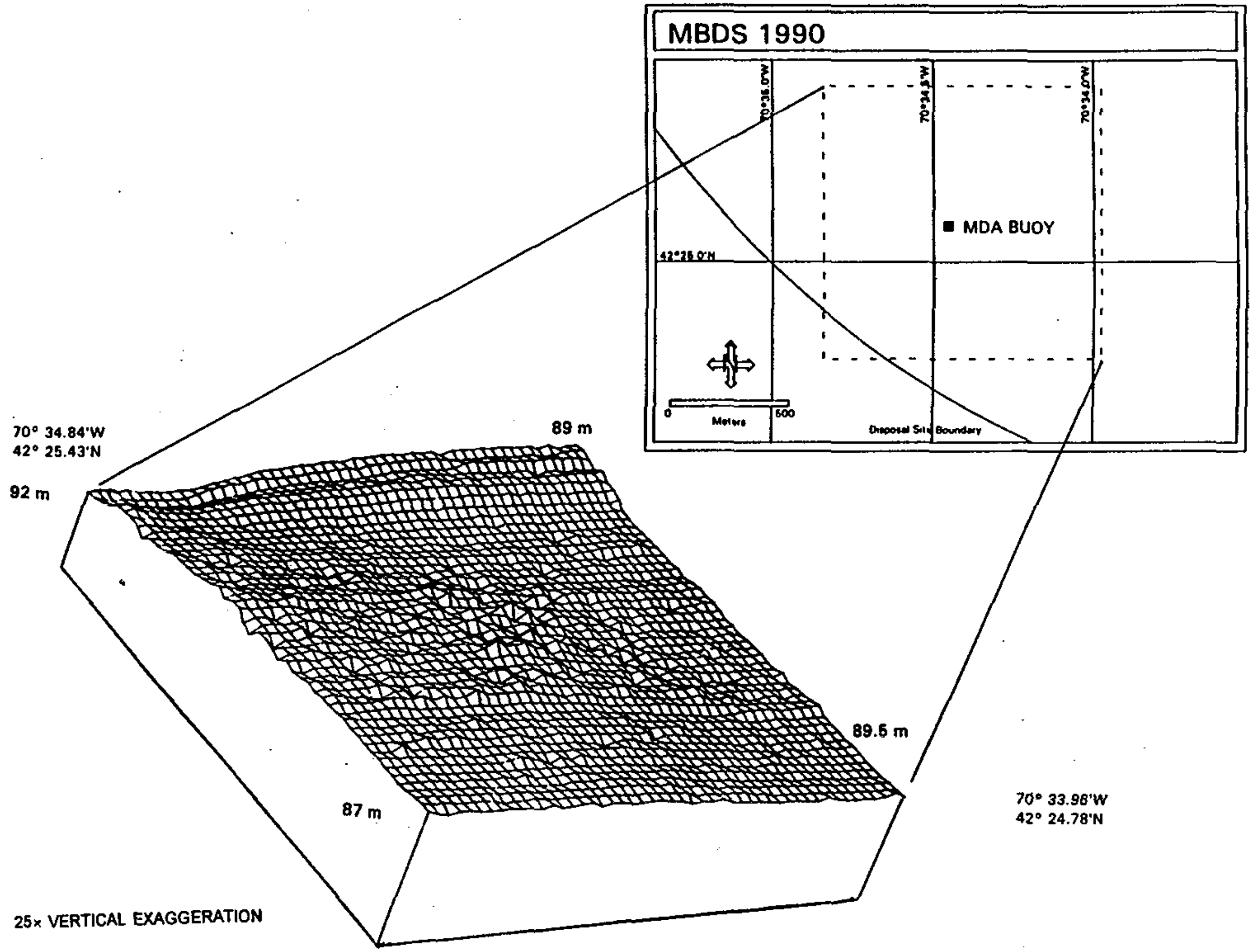

Figure 6-53. Three-dimensional bathymetric plot of MBDS 1990 survey

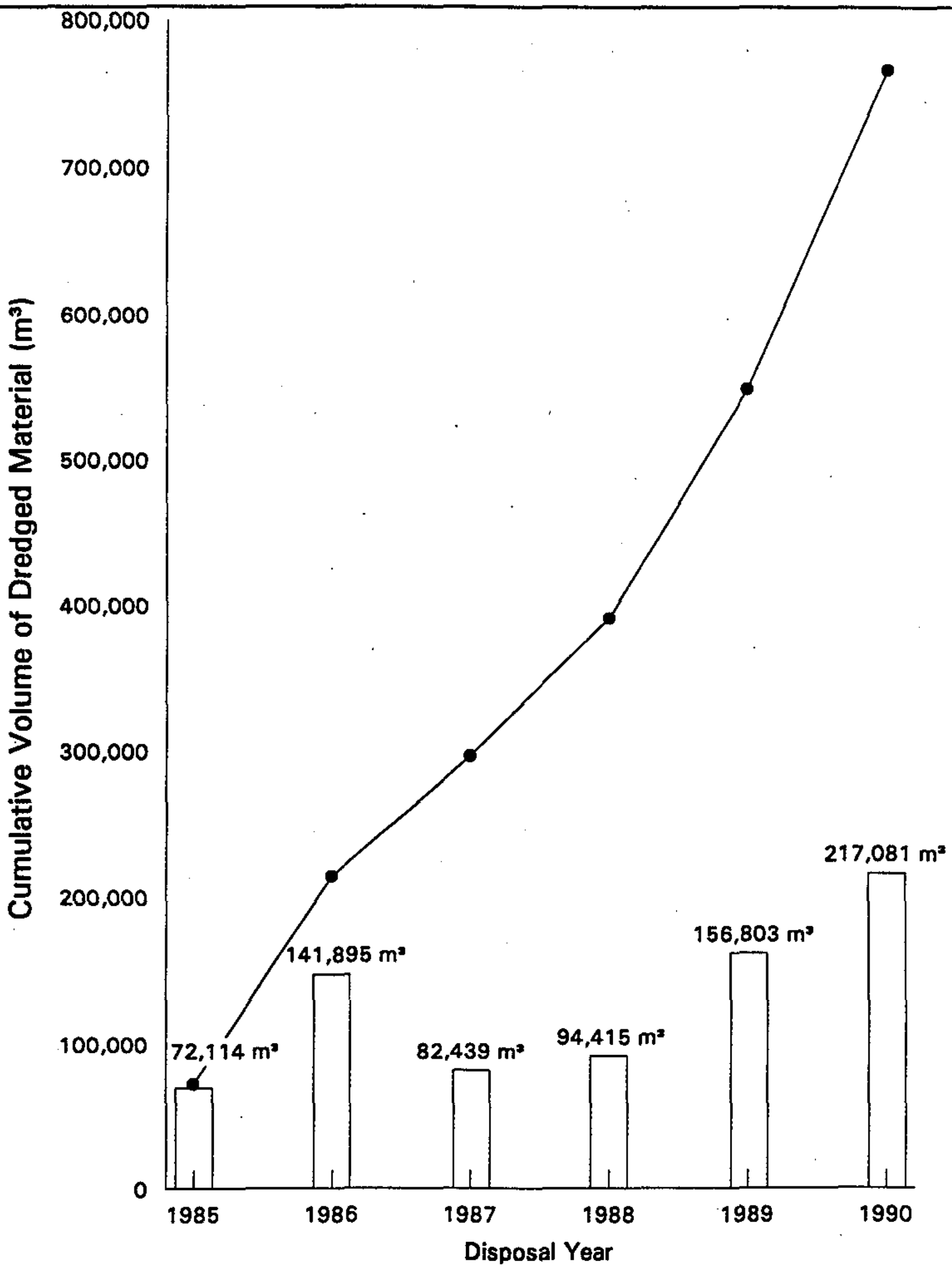

Figure 6-54. Dredged material disposal at MBDS, 1985-1990

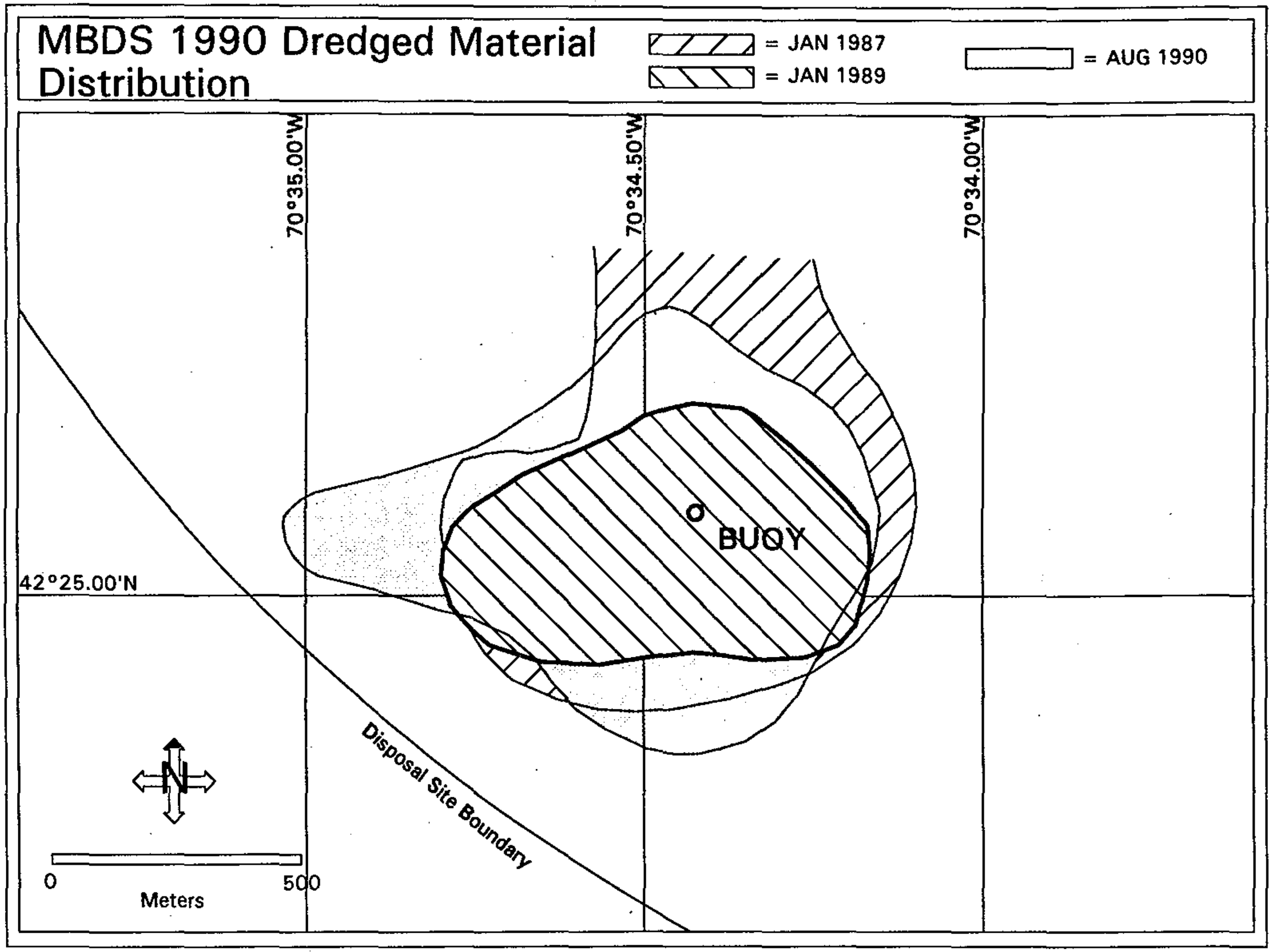

Figure 6-55. Dredged material distribution at MBDS in 1987-1990

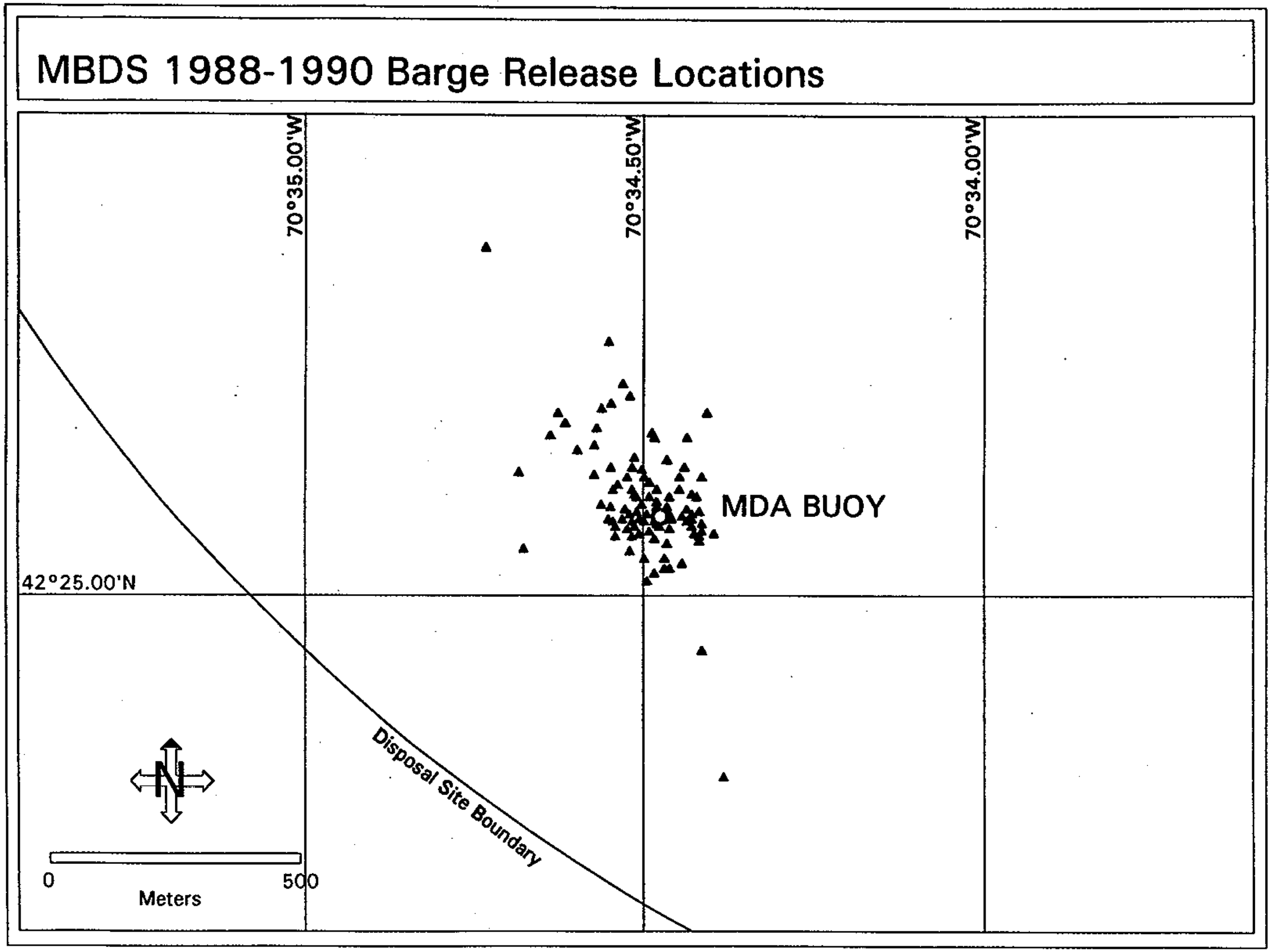

Figure 6-56. Barge release locations at MBDS, 1988-1990

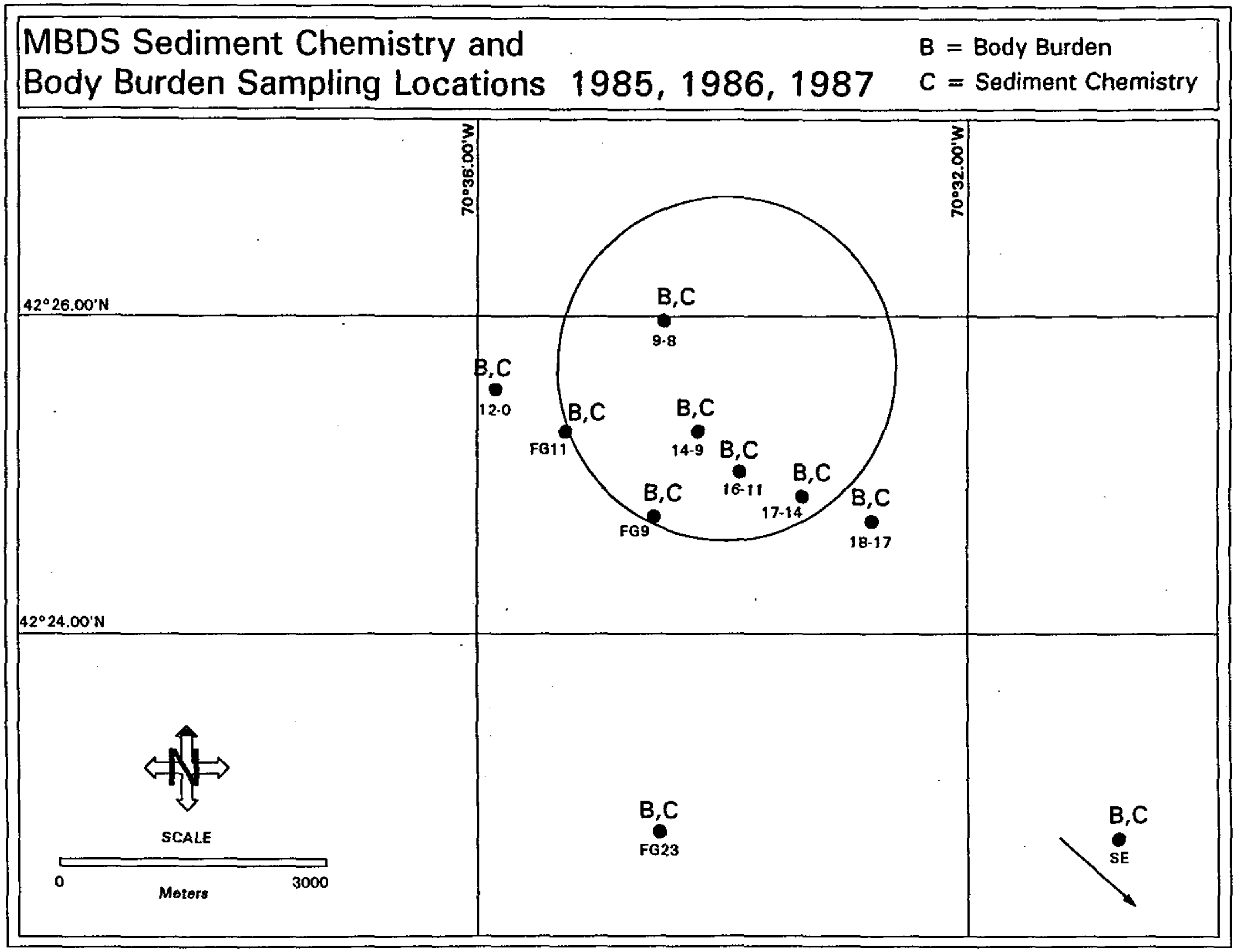

Figure 6-57. Sediment chemistry and body burden sampling locations at MBDS

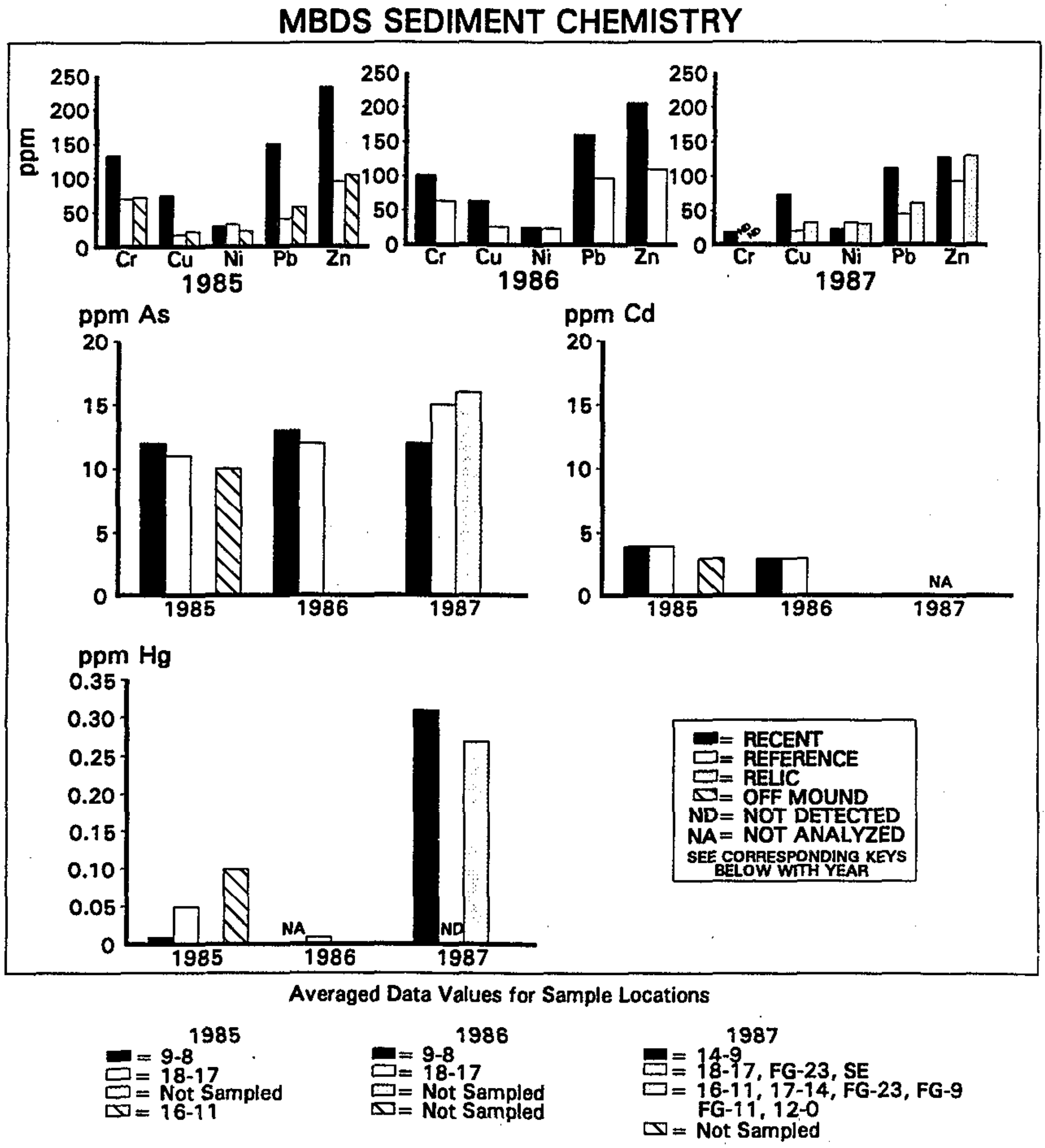

Figure 6-58. Results of MBDS sediment chemistry analyses

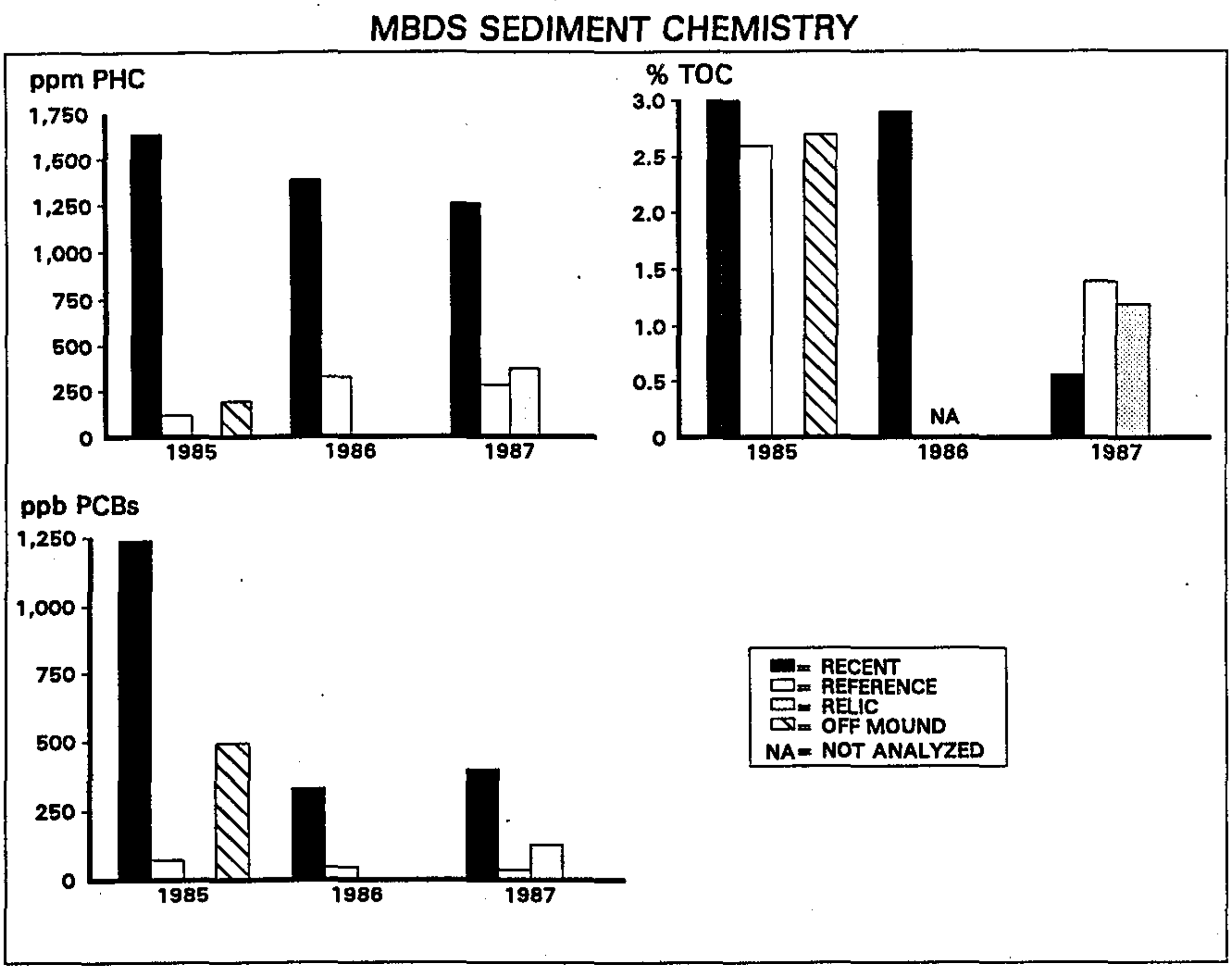

Figure 6-58. (cont.)

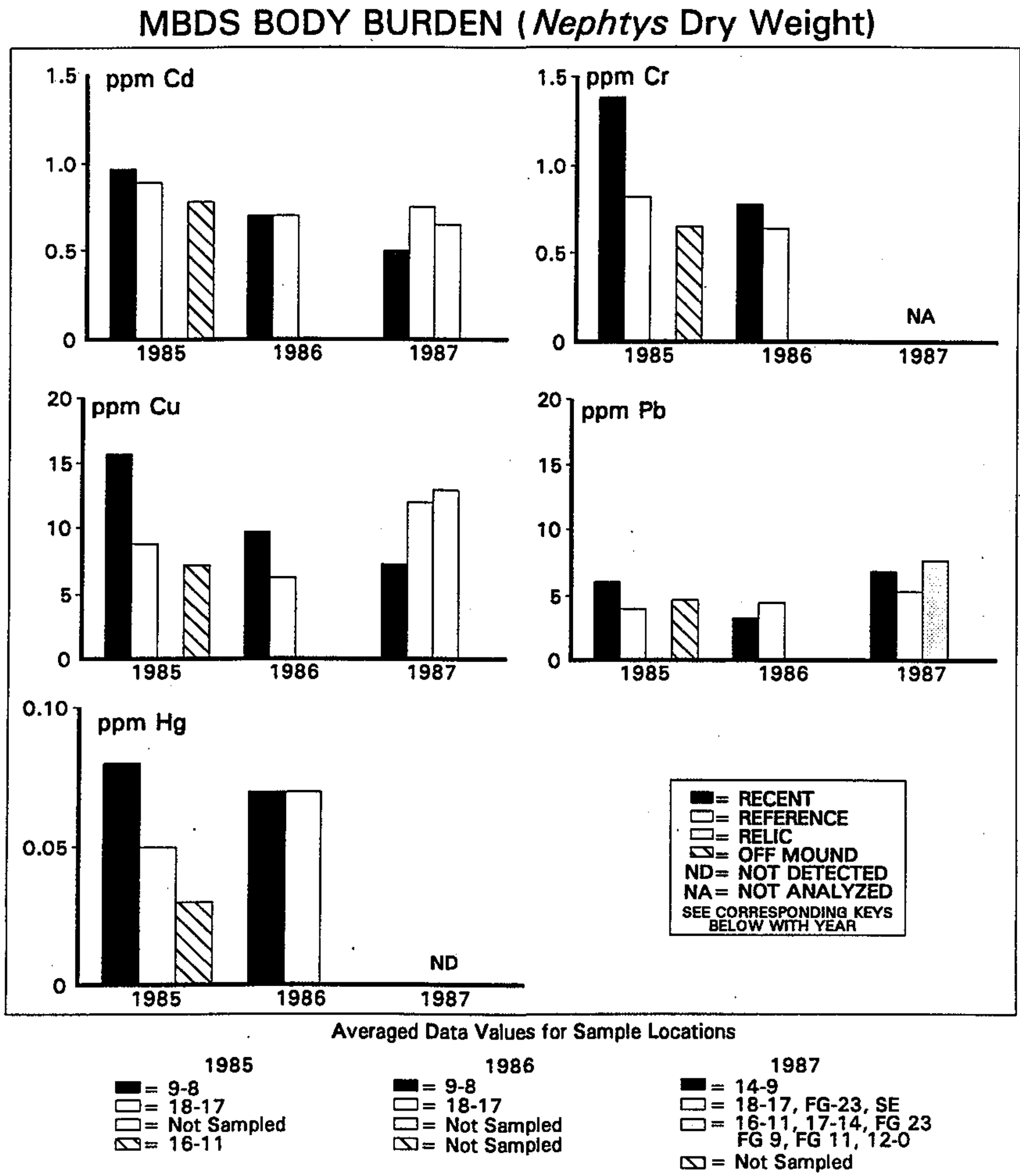

Figure 6-59. Results of MBDS body burden analyses (measurements based on dry weight of *Nephtys*)

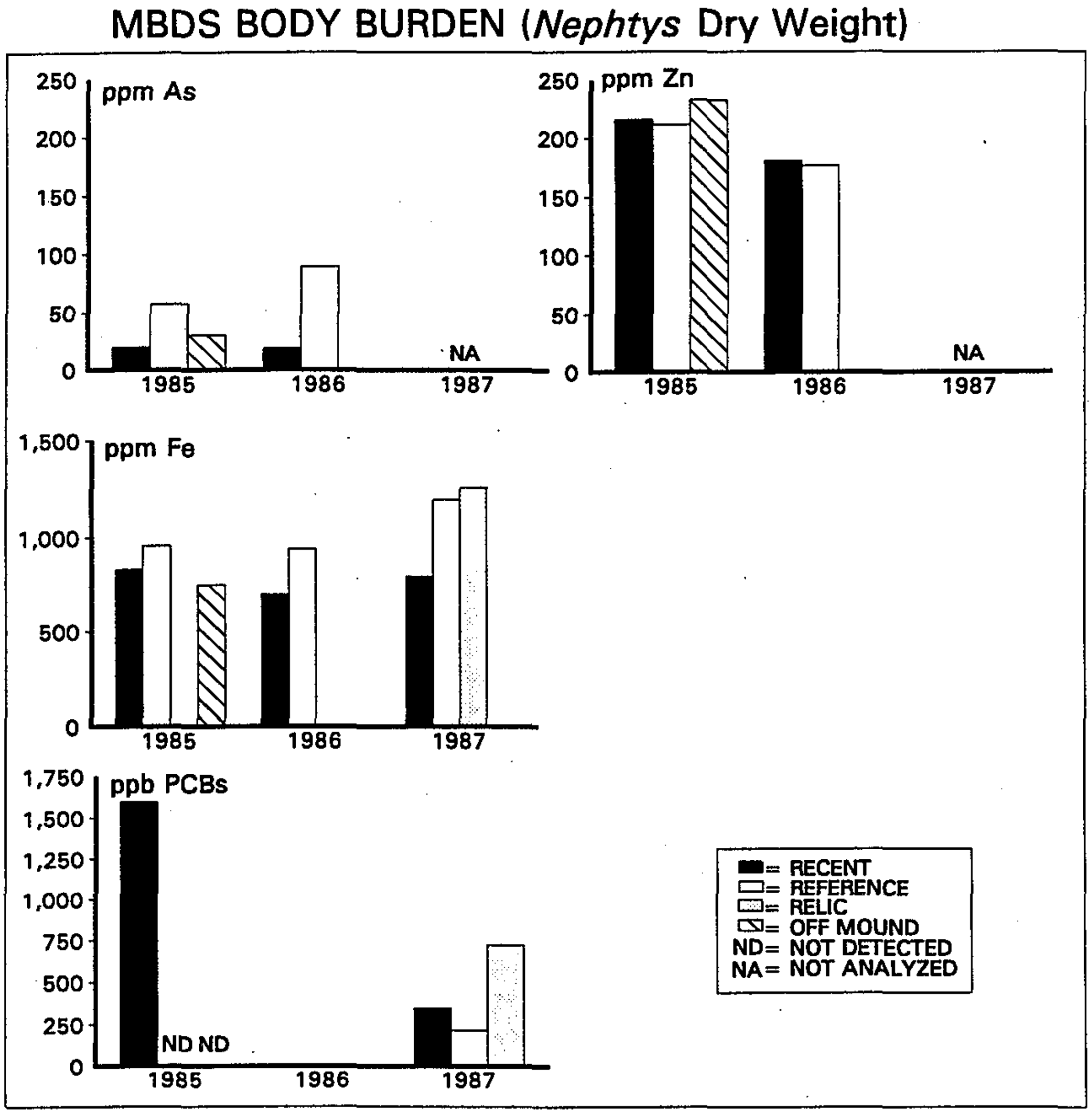

Figure 6-59. (cont.)

6.9 BUZZARDS BAY DISPOSAL SITE

6.9.1 Summary of BBDS

The Buzzards Bay Disposal Site (BBDS) is located approximately 1.4 nmi from Chappaquoit Point, West Falmouth, Massachusetts. The site consists of a 500 yard (457.25 m) diameter circle centered at 41°36.000′ N, 70°41.000′ W, lying within a slight depression between the 9 m and 12 m isobaths (Figure 6-60). Side-scan sonar and REMOTS® sediment-profile surveys, conducted in 1981 to characterize the general area, revealed six major textural regions: a deposit of coarse-grained material, a small wave-like field possibly consisting of large sand waves overlying silt-clay sediments, a cratered bottom, a rubble bottom, an eastern flat bottom, and a western flat bottom. The eastern and western flat bottoms have been interpreted to represent natural ambient bottom unaffected by disposal operations. The mound tip, a circular region approximately 500 m in diameter south of the 1990 survey area, apparently reflects the center of prior disposal operations (Germano et al. 1989). An 800 × 800 m area centered at 41°36.000′ N and 70°41.000′ W was surveyed in March 1990 (Figure 6-61).

Tidal currents are the dominant circulation forces in Buzzards Bay; the area is protected from large, long-period waves by the presence of the Elizabeth Islands to the south. Overall, BBDS lies in a portion of the bay that exhibits relatively low kinetic energy, where the tidal currents average 20 $cm \cdot s^{-1}$ (SAIC 1989c). Complete tidal mixing of bay water with ocean water is estimated to occur approximately every 10 days. Water temperatures in the bay range from a summer maximum of 22° C to 0° C in winter. Salinity levels are essentially the same as those of Block Island and Vineyard Sounds, ranging from 29.5 to 32.5 ppt, due to a minimal amount of freshwater inflow (primarily groundwater seepage) (SAIC 1989c).

In the late 1800s, the Massachusetts Division of Marine Fisheries prohibited finfishing in Buzzards Bay by seine, trap, or trawl in an effort to protect the area as a nursery for commercial fish species. This ban is still in effect, and only hook and line fishing is allowed in the bay.

Monitoring activities at BBDS have been limited in the past six years due to limited disposal activity. Since 1981, the only monitoring that took place was the field survey conducted in March 1990 to provide information on the effects of past disposal operations. That survey cruise included a bathymetric survey, REMOTS® sediment-profile photography, and sediment sampling for benthic, chemical, and physical analyses.

BBDS has received a wide range of dredged material types, although intermittently over a number of years. The most recent disposal projects began in February 1979. The sources of the material have been small harbor and river projects throughout the Buzzards

Bay region. Sediments disposed at BBDS have been relatively uncontaminated sands, and sands containing some silt and clay. The 1981 side-scan survey located a disposal mound which was part of the historic disposal site. The present disposal site is north of this area. Since 1984, the site has been used for two projects; 55,000 m^3 of dredged material was disposed at the site in 1985, and 600 m^3 was disposed in 1989 (SAIC 1991b) .

Due to the small area covered by the disposal site and the shallowness of the water, it is doubtful that this site would be a suitable candidate for future capping operations. Indeed, the shallowness of the water (9 m) over the present disposal area is a potential cause for concern as a hazard to navigation when planning future disposal operations at this site.

6.9.2 BBDS: 1990 Monitoring Results

In March 1990, field operations were conducted at BBDS to provide information on the effects of past disposal operations. Field operations included a precision bathymetric survey, REMOTS® sediment-profile photography, and sediment sampling for benthic, chemical, and physical analyses. The overall objective of the cruise was to characterize existing bathymetric, sediment grain size, sediment chemistry, and benthic conditions at and around the disposal site. Three reference areas were selected to provide comparisons between ambient and on-site conditions and were located 3107 m northwest, 3940 m west, and 2600 m southwest of the disposal site center.

The information obtained from the bathymetric survey and REMOTS® photographs permitted the detection of two disposal mounds within the surveyed area (Figure 6-62). The primary mound was central to the disposal site, 1.2 m high and 60 m wide. The other, south and west of the center mound, was 1.6 m high and approximately 90 m wide.

The major modal grain size over the surveyed area ranged from medium sand (2-1 phi) to silt-clay ($\geq$4 phi). All stations containing a major mode of medium (2–1 phi) and fine (3-2 phi) sand fractions were rippled. The distribution of the major modal grain size, as deduced from REMOTS® photographs, indicated a net bedload sediment transport of fine-grained material to the southeast along an 11.6 m isobath. Currents are most likely the dominant force contributing to the transport. The disposal site center consisted of rippled bedforms and fine sands which limited penetration by the REMOTS® camera.

The species composition found in this study was similar to that of benthic communities in Cape Cod Bay and Boston Harbor/Massachusetts Bay. Species richness was somewhat higher at the reference stations; however, both on-site and off-site stations were well within the range observed in soft-bottom, shallow-water environments. Significant differences existed between reference stations and on-site stations in REMOTS® parameters for Redox Potential Discontinuity depth, successional stages, and Organism-Sediment Index values.

Results of sediment chemistry and grain size analyses indicated acceptable levels of percent fines, metals, PAHs, PCBs, and pesticides. Currently, the surveyed area is healthy biologically and relatively uncontaminated.

6.9.3 References for Section 6.9

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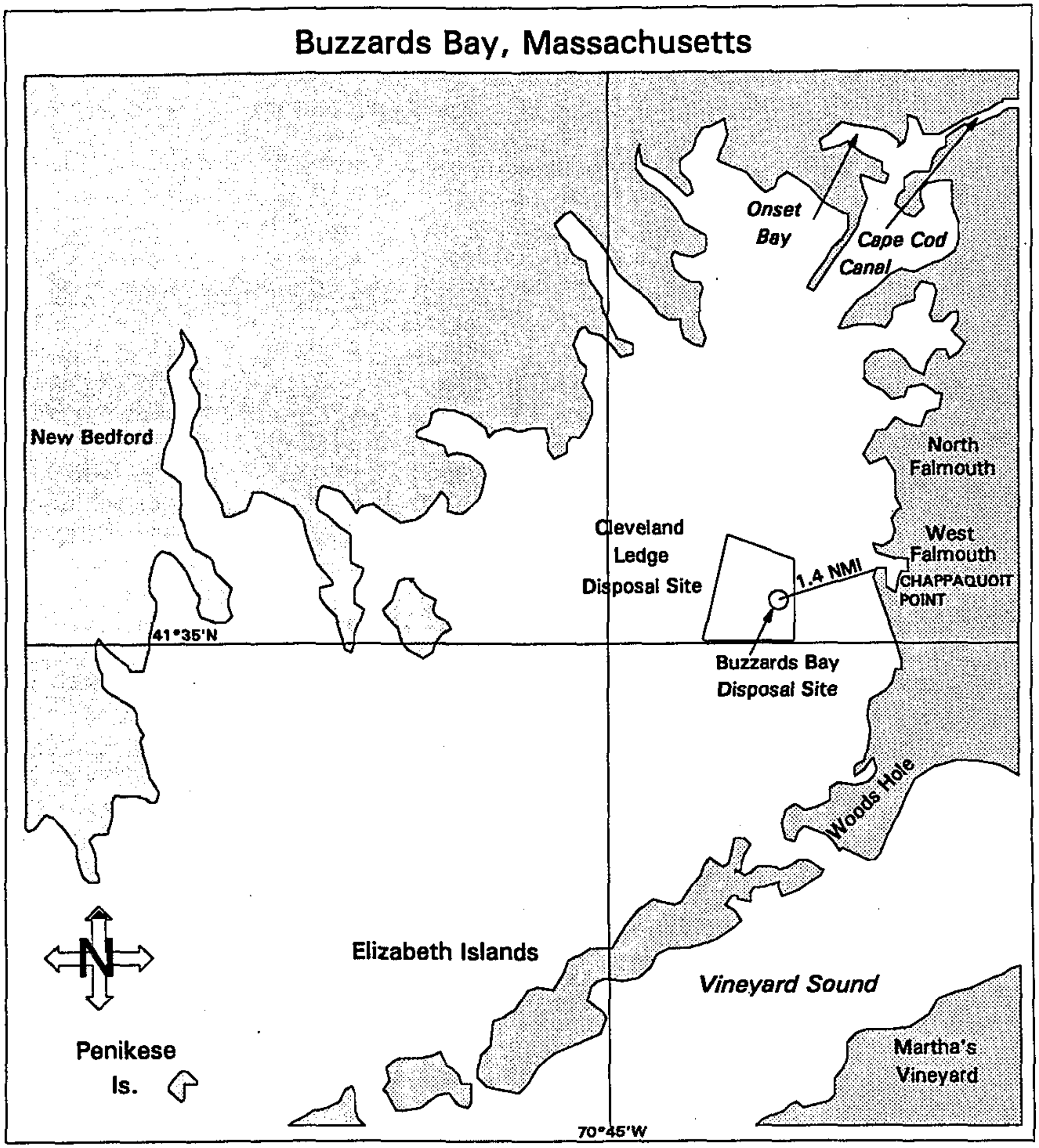

Figure 6-60. Location of BBDS in relation to Chappaquoit Point, West Falmouth, Massachusetts

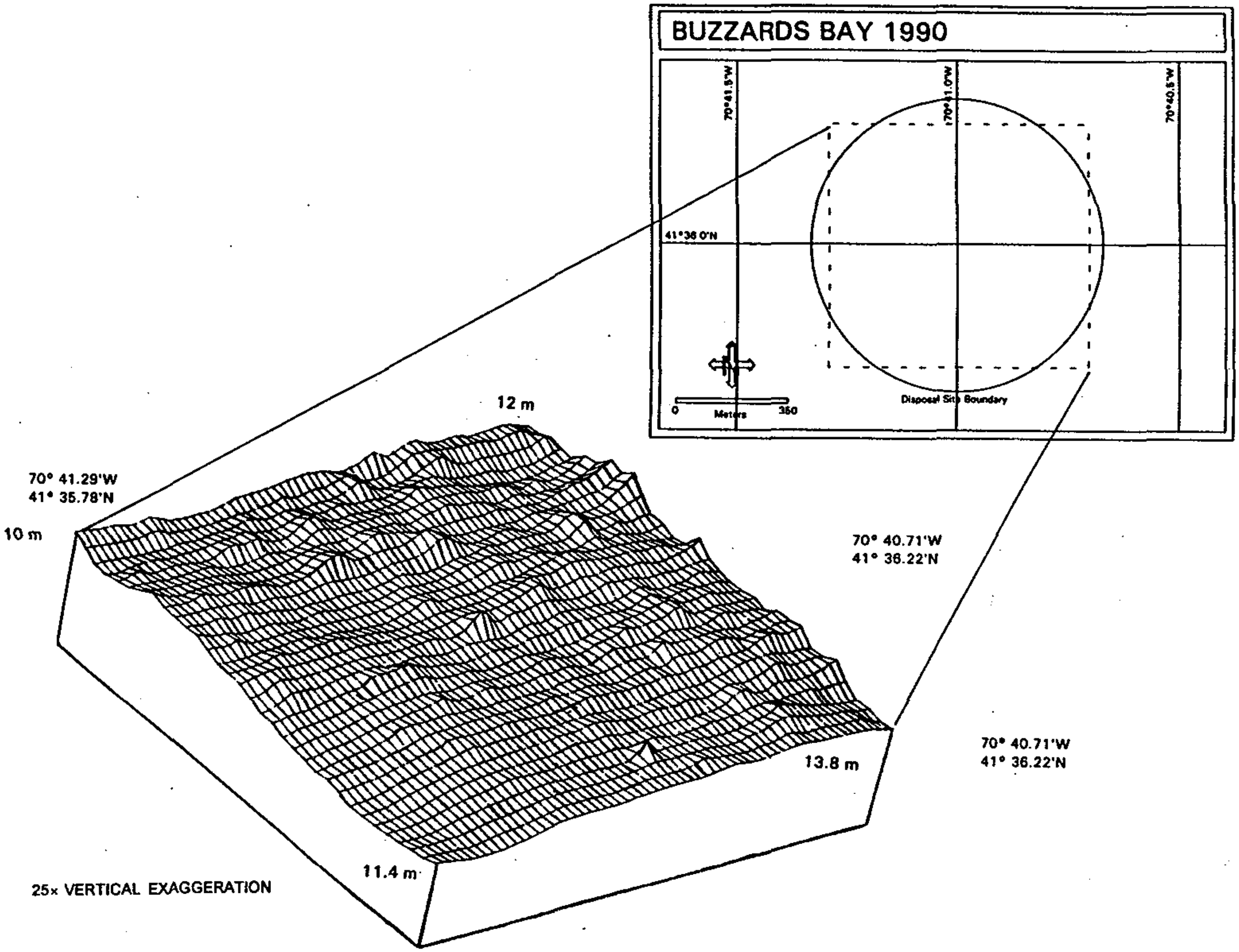

Figure 6-61. Three-dimensional bathymetric plot of BBDS 1990 survey

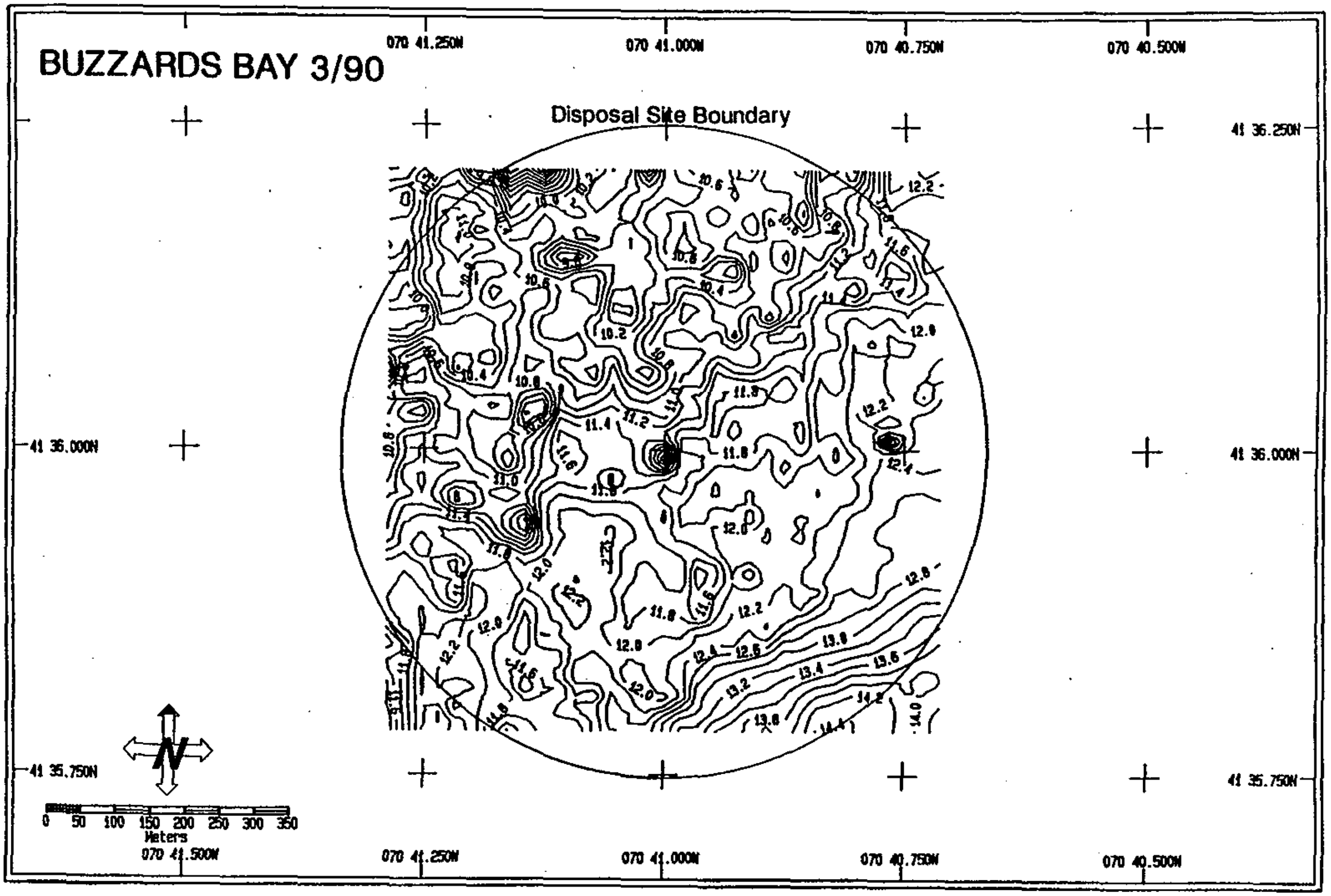

Figure 6-62. Contoured bathymetric chart of BBDS, March 1990

7.0 CONCLUSIONS

From 1985 to 1990, regular bathymetric surveying of dredged material mounds at disposal sites by the DAMOS Program has shown that the dredged material mounds are physically stable. At all sites, dredged material was detected by the REMOTS® sediment-profiling camera either extending from the base of an acoustically detected dredged material mound or, where no mound was detected, as a thin deposit of dredged material.

Any contamination detected in sampling of the dredged material disposal sites was low to moderate by NERBC classification and was related to the contamination level found in the actual project material (tested prior to dredging). Transect studies and biological sampling detected neither the transport of contaminants nor biological uptake.

In 1990, DAMOS field activities continued, concentrating on monitoring of recently formed dredged material disposal mounds. Highlights of 1990 activities not related to work in the field include review of the Capping Model, maintenance of the DAMOS database, and several meetings of the TAC. Analysis of the DAMOS Capping Model indicated that prediction of mound height was most reliable with a center-weighted distribution of dredged material, and that consolidation should be incorporated into the model for accurate long-term height prediction (Wiley 1994). The TAC workshops developed a tiered monitoring plan which can be used as a long-term management strategy for the disposal of dredged material.

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