Monitoring Cruise at the
Massachusetts Bay Disposal Site
March 31 - April 4, 1992

Disposal Area Monitoring System DAMOS

D A M O S
DISPOSAL AREA MONITORING SYSTEM

Contribution 100
October 1995

US Army Corps
of Engineers
New England Division

REPORT DOCUMENTATION PAGE

Form approved
OMB No. 0704-0188

1. AGENCY USE ONLY (LEAVE BLANK)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	October 1995	Final report

4. TITLE AND SUBTITLE
Monitoring Cruise at the Massachusetts Bay Disposal Site March 31-April 4, 1992

5. FUNDING NUMBERS

6. AUTHOR(S)
Mary Baker Wiley and
Judith B. Charles

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Science Applications International Corporation
221 Thrid Street
Newport, RI 02840

8. PERFORMING ORGANIZATION REPORT NUMBER
SAIC-C103

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
US Army Corps of Engineers-New England Division
424 Trapelo Road
Waltham, MA 02254-9149

10. SPONSORING/ MONITORING AGENCY REPORT NUMBER
DAMOS Contribution
Number 100

11. SUPPLEMENTARY NOTES
Available from DAMOS Program Manager, Regulatory Division
USACE-NED, 424 Trapelo Road, Waltham, MA 02254-9149

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT ***(MAXIMUM 200 WORDS)***

A monitoring survey was conducted at the Massachusetts Bay Disposal Site (MBDS) from March 30 to April 4, 1992 as part of the Disposal Area Monitoring System (DAMOS). The previous bathymetric/REMOTS monitoring surveys at MBDS occurred in August 1990. Since that time, MBDS has been subject to two major storms, Hurricane Bob and the Halloween Storm. In addition, initiation of a major construction project in the Boston area , the Central Artery/Thrid Harbor Tunnel (CA\THT) project, resulted in increased disposal activity at the site. The objectives of the 1992 field work were to map the distribution and thickness of dredged materials that MBDS received following the 1990 survey, and to assess the status of the benthic communities around the reference site.

Surveying and monitoring were conducted with precision bathymetry and REMOTS sediment profile photography. It was predicted that

1) the dredged materials disposed since 1990 would have increased the size of the mound detected by bathymetry in 1990;
2) the benthic communities at the reference areas would be similar to those found in the 1990 survey;
3) benthic infauna (Stage III taxa) would be absent around the disposal buoy due to the presence of fresh Boston Blue Clay.

The precision bathymetric survey detected the maximum thickness of the disposal mound approximately 100 m west of the buoy. Dredged material detected by the 1992 REMOTS survey extended 600 m east, 400 m south, 800 m west, and 400 m north of the buoy location. The results of the survey showed there to be no substantial resuspension or transport of dredged material occurred as a result of Hurricane Bob and the Halloween Storm.

The benthic communities at the reference areas and at the stations away from the center of the disposal mound contained Stage III taxa, indicative of a well-colonized, healthy benthic community. Evidence benthic recolonization at the mound and the abundance of Stage III infauna at the disposal site and reference area stations indicate no severe disturbance from disposal activities or from the two storms in 1991.

14. SUBJECT TERMS
MBDS DAMOS bathymetric benthic REMOTS sediment dredging

15. NUMBER OF PAGES
23

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified			

MONITORING CRUISE
AT THE MASSACHUSETTS BAY DISPOSAL SITE
MARCH 31 - APRIL 4, 1992

CONTRIBUTION #100

October 1995

Report No.
SAIC-C103

Submitted to:

Regulatory Branch
New England Division
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, MA 02254-9149

Prepared by:
Mary Baker Wiley
Judith B. Charles

Submitted by:
Science Applications International Corporation
Admiral's Gate
221 Third Street
Newport, RI 02840
(401) 847-4210

US Army Corps
of Engineers
New England Division

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

A monitoring survey was conducted at the Massachusetts Bay Disposal Site (MBDS) from March 30 to April 4, 1992 as part of the Disposal Area Monitoring System (DAMOS). The previous bathymetric/REMOTS® monitoring surveys at MBDS occurred in August 1990. Since that time, MBDS has been subject to two major storms, Hurricane Bob and the Halloween Storm. In addition, initiation of a major construction project in the Boston area, the Central Artery/Third Harbor Tunnel (CA/THT) project, resulted in increased disposal activity at the site. Of the 289,588 m^3 of dredged sediments MBDS received since the August 1990 surveys, 81% of the total volume originated from the CA/THT project. Dredged material from this project consisted of Boston Blue Clay, very distinct in its greenish-gray color and homogeneous, fine-grained appearance. The objectives of the 1992 field work were to map the distribution and thickness of dredged materials that MBDS received following the 1990 survey, and to assess the status of the benthic communities around the reference areas.

Surveying and monitoring were conducted with precision bathymetry and REMOTS® sediment-profile photography. It was predicted that

1) the dredged materials disposed since 1990 would have increased the size of the mound detected by bathymetry in 1990;
2) the benthic communities at the reference areas would be similar to those found in the 1990 survey; and that
3) benthic infauna (Stage III taxa) would be absent around the disposal buoy due to the presence of fresh Boston Blue Clay.

The precision bathymetric survey detected the maximum thickness of the disposal mound approximately 100 m west of the buoy. Depth difference isopachs for 1990-1992 indicated a maximum change in depth of 2 m. The acoustically detected mound was elliptical in shape with an average diameter of 400 m. A comparison made of the depth matrices from 1988 to 1992 showed similar results with an average mound diameter of 500-700 m. Dredged material detected by the 1992 REMOTS® survey extended 600 m east, 400 m south, 800 m west, and 400 m north of the buoy location. These results indicate no substantial resuspension or transport of dredged material occurred as a result of Hurricane Bob and the Halloween Storm.

The benthic communities at the reference areas and at stations away from the center of the disposal mound contained Stage III taxa, indicative of a well-colonized, healthy benthic community. Stations located near the center of the disposal mound and on the Boston Blue Clay were characterized by Stage I pioneering polychaetes. Evidence of benthic recolonization at the mound and the abundance of Stage III infauna at the disposal site and reference area stations indicate no severe disturbance from disposal activities or from the two storms in 1991.

Results of the 1992 bathymetric/REMOTS® monitoring surveys at MBDS were as predicted. Dredged material released at MBDS since 1990 did increase the size of the disposal mound. The Stage III benthic communities at the reference areas were unchanged since 1990; no benthic infauna (Stage III organisms) were found in the Boston Blue Clay at the center of the mound.

1.0 INTRODUCTION

The Massachusetts Bay Disposal Site (MBDS) is located in the northeast portion of Massachusetts Bay, approximately 18 nmi east-northeast of the entrance to Boston Harbor and 10 nmi south-southeast of Gloucester, Massachusetts (Figure 1-1). The disposal site consists of a 2 nmi diameter circle centered at 42° 25.700′ N and 70° 34.000′ W. Ambient water depth at the buoy location is approximately 90 m. As part of the Disposal Area Monitoring System (DAMOS), Science Applications International Corporation (SAIC) has conducted six monitoring surveys at MBDS, from 1985 to 1992. These studies mapped the distribution of dredged materials, monitored the formation of the disposal mound, evaluated the benthic environment, provided information on the physical parameters of the site, and determined the extent of chemical contamination. Assessment techniques for the surveys have included precision bathymetry, side-scan sonar, REMOTS® sediment-profile photography, current meter and transmissometer deployments, conductivity, temperature, depth, and dissolved oxygen (CTD/DO) monitoring, and sediment and benthic sampling for physical and chemical analyses. The 1985 survey also included observational cruises using manned submersibles, fish collections, and the implementation of the Benthic Resources Assessment Technique (BRAT).

A major construction project underway in the Boston area, the Central Artery/Third Harbor Tunnel (CA/THT) project, has increased disposal activity at MBDS. MBDS has received 289,588 m^3 of dredged sediments since the last bathymetric/REMOTS® surveys in August 1990; 81% of this volume originated with the CA/THT project and consisted primarily of Boston Blue Clay. Disposal of sediments from the CA/THT project began with one barge load of material in August 1991 (2,280 m^3) and did not begin again until January 1992. Disposal of Boston Blue Clay at MBDS had been occurring for three months at the time of the survey. Boston Blue Clay is a relatively homogeneous, light greenish-gray to medium gray clay which was deposited in a nearshore marine environment that existed in the Boston area during an interglacial period about 18,000 years ago. Results of the grain size analyses indicate some variability in the Boston Blue Clay which is a natural feature resulting from the environmental changes during deposition: the gravel content ranged from 0.3 to 16.9%, sand ranged from 0.8-14.7%, silt ranged from 3.1-73.2%, and the clay content varied from 25.7-65.3% (Camp, Dresser, and McKee, Inc. 1993). In general, the clay can be characterized as having a large proportion of fines, generally greater than 40%. The remaining 19% of the dredged sediments deposited at MBDS were a mix of sands, silts, and clays determined suitable for open water dredged material disposal from the Hingham, Nut Island, JFK, Manchester Harbor, and Gloucester State Pier projects. These sediments, with the exception of 1,064 m^3 from the State Pier Project, were deposited before mid-July 1991. Based on the barge logs, dredged material was released within 350 m of the "MDA" buoy, centered at 42° 25.086′ N and 70° 34.457′ W.

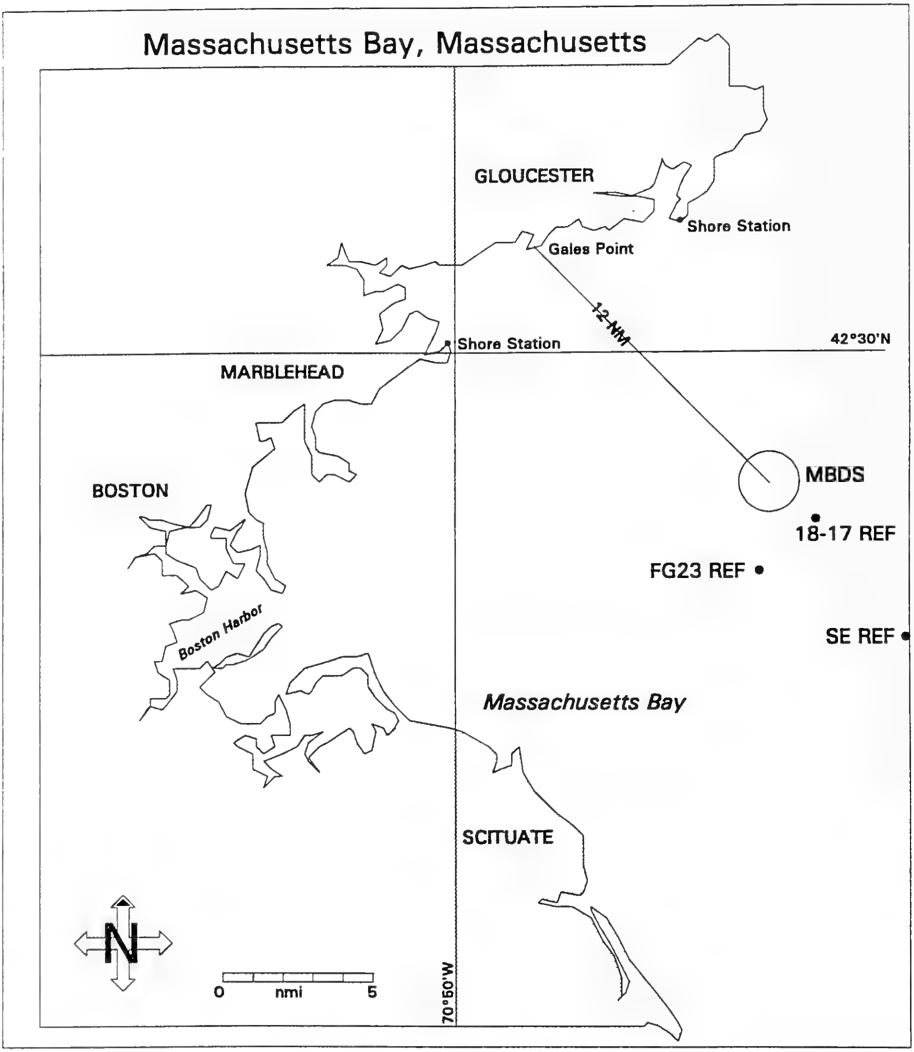

Figure 1-1. Location of MBDS and reference areas in relation to Boston and Gloucester, Massachusetts

Two major storms occurred in Massachusetts Bay between 1990 and 1992. Hurricane Bob passed quickly over Massachusetts Bay on August 19, 1991, and an extreme (among the strongest recorded to date) Atlantic coast northeast storm occurred in October 1991. With the exception of 54,792 m^3 of dredged material deposited from August 1990 to mid-July 1991, the remaining volume (234,796 m^3) of dredged sediments disposed at MBDS was received after these two storms and consisted primarily of Boston Blue Clay. Hurricane Bob produced an average maximum wind speed of 45 knots with peak gusts of 59 knots at the Boston Buoy, 42.2° N and 70.8° W (Morris 1992). The October 1991, or Halloween Storm, occurred over October 30 and 31, and has been estimated as a 100-year storm with a Class 5 magnitude (Chandler 1992). An unusual feature of this northeaster was the long duration of the 30-to-40-knot winds (Davis and Dolan 1992). On October 28 high waves were generated, and on October 29 sustained 30-knot winds were observed. The storm strengthened on October 30 as it combined with the remnants of Hurricane Grace (which had begun moving north from Bermuda on October 28) creating a 10-knot increase in wind speeds (Davis and Dolan 1992). The Halloween Storm lasted 114 hours and sustained 40-knot winds. Wave heights in Massachusetts Bay were over 30 feet (Chandler 1992).

Dredged material which settles on the bottom at MBDS can be expected to remain in place for extended periods of time (EPA 1989). The prevailing low current velocities in this area reduce the possibility of dredged material resuspension, and the deep water also isolates the bottom from all but the strongest storm events (SAIC 1988). Physical oceanographic studies conducted under the DAMOS program, as well as those by other investigators, have shown that current velocities 8 m off the bottom of the site are low, averaging less than 7 $cm \cdot s^{-1}$ (Butman 1977, Gilbert 1975, SAIC 1987). Occasional higher velocities (near 20 $cm \cdot s^{-1}$ in a westerly direction) have been observed at this depth in response to easterly storm events that occurred in fall and winter. Prior to conditions set up by the two major storms outlined above, no strong bottom currents had been observed as a result of storm events, and currents of 20 $cm \cdot s^{-1}$ 8 m off the bottom were not predicted to be strong enough to resuspend sediments at MBDS (EPA 1989, Hubbard et al. 1988, SAIC 1988). These 20 $cm \cdot s^{-1}$ currents 8 m off the bottom would be sufficient for transport if another mechanism, such as bioturbation or wave action, were available to resuspend the sediment (Hubbard et al. 1988).

As part of the site evaluation study for MBDS, wave hindcasting procedures (CERC 1984) were used to predict the parameters of waves as a function of wind speed, fetch, and duration (Hubbard et al. 1988). Wave generation from the westerly direction is severely limited due to the sheltering provided by the Massachusetts coastline. Waves from the easterly direction have essentially an unlimited fetch and with sufficient wind speed and time could be expected to affect the sediment stability (Hubbard et al. 1988). Storms generating easterly winds (northeast storms) approach MBDS from the west and south, and generally the ocean is exposed to high wind speeds for a relatively short period of time. Model predictions from the site evaluation study indicated that, for a typical northeaster to generate waves sufficient enough to cause sediment resuspension at the MBDS, winds would have to blow at 43 knots for at least 12 hours. Smaller storms with winds on the order of 30-40 mph would not be expected to cause significant erosion (Hubbard et al. 1988). Hurricane Bob and the Halloween Storm both had storm conditions that exceeded those predicted to cause bottom erosion, especially the Halloween Storm.

Normally, storms producing conditions to cause sediment resuspension at the MBDS are predicted to occur once every four years (Hubbard et al. 1988). These events are usually of short duration (1-2 days). The effect of these storms on more shallow deposits of natural sediments is certain to sharply increase the suspended sediment load of the entire region; the addition of small amounts of sediment dispersed from the MBDS disposal site would be insignificant and undetectable (Hubbard et al. 1988).

From 30 March to 4 April 1992, SAIC conducted field operations at MBDS to provide information on the effects of disposal operations since the August 1990 bathymetric and REMOTS® surveys. Field operations included precision bathymetry and REMOTS® sediment-profile photography. This study was designed to test the following predictions:

1) the dredged materials disposed since 1990 should have increased the size of the mound detected by bathymetry in 1990,

2) the benthic community at the reference area would be similar to that found in the 1990 survey, and

3) benthic infauna would be absent around the disposal buoy due to the presence of fresh Boston Blue Clay from the dredging of Boston Harbor.

2.0 METHODS

2.1 Navigation and Bathymetry

The SAIC Integrated Navigation and Data Acquisition System (INDAS) provided the precise navigation required for all field operations. DAMOS Contribution No. 48 (SAIC 1985) includes a complete description of this system. Shore stations for the 1992 field operations were Marblehead Neck Light (42° 30.320′ N and 70° 50.051′ W) in Marblehead, and Eastern Point Light (42° 34.809′ N and 70° 39.899′ W) in Gloucester, Massachusetts. Previous MBDS surveys were also conducted with these shore stations. Repeated use of these stations allows accurate comparisons of past and present surveys.

The stated objective of the 1992 bathymetric survey was to map that portion of the dredged material mound that was greater than 20 cm thick. Forty-nine lanes were run east to west at 25 m spacing on 31 March 1992 to cover a 1200 × 1200 m grid centered at the "MDA" buoy (42° 25.039′ N and 70° 34.505′ W). This same grid has been used in bathymetric surveys since January 1987.

An Odom DF3200 Echotrac® Survey Fathometer with a narrow-beam 200 kHz transducer recorded depth. The fathometer recorded depth to a resolution of 3 cm (0.1 ft.). However, the acoustic records could reliably detect changes in depth on the order of 20 cm due to the accumulation of errors introduced by the positioning system, tidal corrections, the calibration of the fathometer (speed of sound through the water column), the slope of the bottom, and the vertical motion of the vessel. Water temperature and salinity data measured by a Seabird model 19-01 CTD were used to calculate the speed of sound.

During the 1990 bathymetric survey, the survey team had used a different Odom DF3200 Echotrac® Survey Fathometer to record depth. This particular fathometer was rented to temporarily replace identical equipment normally used because of a malfunction in the in-house fathometer. The raw data for this survey were noted to contain a higher variance which was most likely due to lower maintenance standards on the rental equipment. The result is an apparent higher level of "noise" in the contoured bathymetric chart in comparison to the 1992 survey. It is important to note that this variance does not obscure the general correspondence of contours between the two surveys.

2.2 REMOTS® Sediment-Profile Photography

A REMOTS® survey was used to map the distribution of thin (1 to 20 cm) layers of recently disposed dredged material not detectable with bathymetry. The REMOTS® survey, performed on 1, 2, and 4 April 1992, generated triplicate photographs for each of the 43 disposal site stations surrounding the "MDA" buoy and the 13 stations at each of the three reference areas (Figure 2-1). Analysis of the benthic community in the REMOTS®

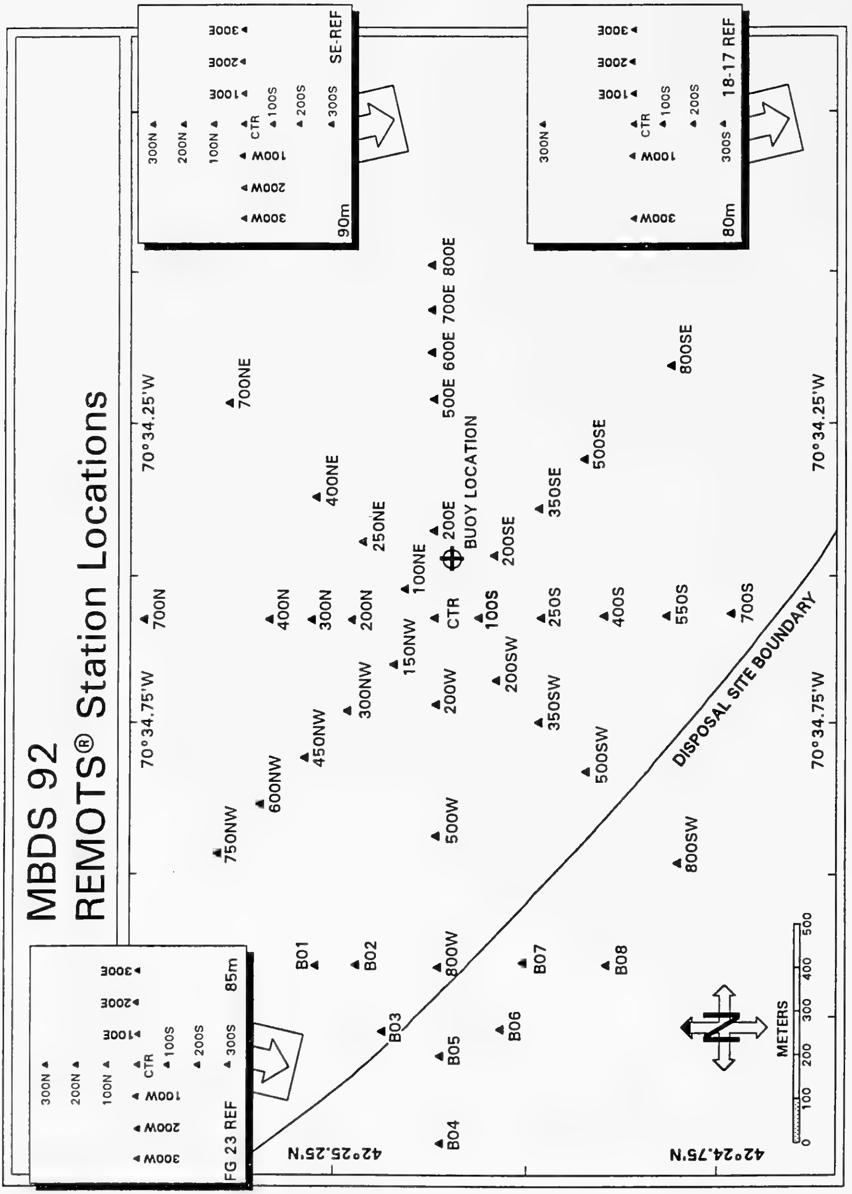

Figure 2-1. Locations and designations of REMOTS® stations at MBDS, April 1992

photographs was performed to determine the pattern of colonization within the site and at the reference areas. DAMOS Contribution #60 (SAIC 1989) presented a detailed description of REMOTS® photograph acquisition, analysis, and interpretative rationale.

In the 1990 REMOTS® survey, dredged material was detected up to 800 m west, 500 m south, 400 m east, and 500 m north of the disposal buoy (Germano, Parker, and Charles 1994). In the 1992 survey, REMOTS® stations extended beyond the previous survey and were chosen based on rapid analysis of the bathymetric data. This method of REMOTS® station selection allows efficient positioning of stations around the acoustically detected mound and on the mound flanks to clearly define the distribution of dredged material. REMOTS® stations were spaced 100 m to 300 m apart to adequately delineate the transition of dredged material on the mound flanks to ambient sediments (Figure 2-1). REMOTS® stations BO1 through BO8 (Figure 2-1) were selected to define more clearly the western boundary of the dredged material. The 13 REMOTS® stations established at each of the three reference areas (FG-23 REF, SE-REF, and 18-17 REF) allowed comparisons between ambient and on-site conditions. The reference area stations are in a cross-shaped pattern and spaced 100 m apart. Table 2-1 summarizes reference area locations, depths, and distances from the "MDA" buoy.

Table 2-1

MBDS Reference Areas

	Location	Distance from "MDA" Buoy	Depth
FG-23	42° 22.700′ N latitude 70° 34.600′ W longitude	1348 m southwest	85 m
SE-REF	42° 20.000′ N latitude 70° 28.000′ W longitude	3942 m southeast	90 m
18-17	42° 24.686′ N latitude 70° 32.814′ W longitude	723 m southeast	80 m

3.0 RESULTS

3.1 Bathymetry

Within the MBDS survey area, depths sloped northeastward from 87 m in the southwest corner to more than 90 m in the northern portion of the survey grid (Figure 3-1). The April 1992 bathymetric survey detected two mounds located west of the buoy location. The minimum water depth at the highest mound located within 100 m west of the buoy was 85.75 m. The formation of the mound was more distinct than in the August 1990 survey which showed the maximum height of the mound to be located 100 m east of the buoy and a minimum water depth of 88.50 m (Figure 3-2).

A comparison of the depth matrices from 1990 and 1992 indicated that the dredged material deposited during that time had a maximum thickness of 2 m (Figure 3-3). The shape of the deposit was elliptical, with most of the material accumulated within a 200-400 m area. A depth difference between the 1990 and 1992 bathymetric surveys gave a volume calculation of 151,764 m^3 (95% confidence limits; 121,801 m^3 to 181,727 m^3) for material deposited since the August 1990 survey.

3.2 REMOTS® Sediment-Profile Photography

REMOTS® sediment-profile photography detected dredged material out to 600 m east, 400 m south, 800 m west, and 400 m north of the center of the mound (Figure 3-5). The most recent material released at MBDS was Boston Blue Clay from the Central Artery/ Third Harbor Tunnel Project. The distinctive signature of the Blue Clay, its light greenish-gray color and homogeneous, fine-grained appearance, was seen in those stations closest to the disposal site center (Plates 1 & 2) (Figure 3-5). Relic dredged material, i.e., dredged material deposited prior to the Boston Blue Clay (Plates 3 & 4) was found further from the center of the site, particularly to the west. The REMOTS® survey indicated that all of the dredged material was contained well within the disposal site boundaries with the exception of dredged material found at station BO7 (Plates 5 & 6). All reference stations contained ambient silt-clay sediments.

Both Stage I and Stage III taxa were present at MBDS. Stage III taxa, indicative of a mature, healthy benthic community, were evident at all reference site stations and at 35 out of 43 stations at the disposal site (Figure 3-6). Stations immediately north and west of the mound center had evidence of Stage I organisms (small, pioneering polychaetes). At the center of the mound, penetration by the camera prism was low due to the high shear strength of Boston Blue Clay, and only one out of the three replicate photographs was analyzed. The successional stage was indeterminate because of the low penetration. Successional stage data were not obtained at three stations located at 18-17 REF (100N, 200N, and 200W) because of overpenetration by the camera prism in the soft sediments.

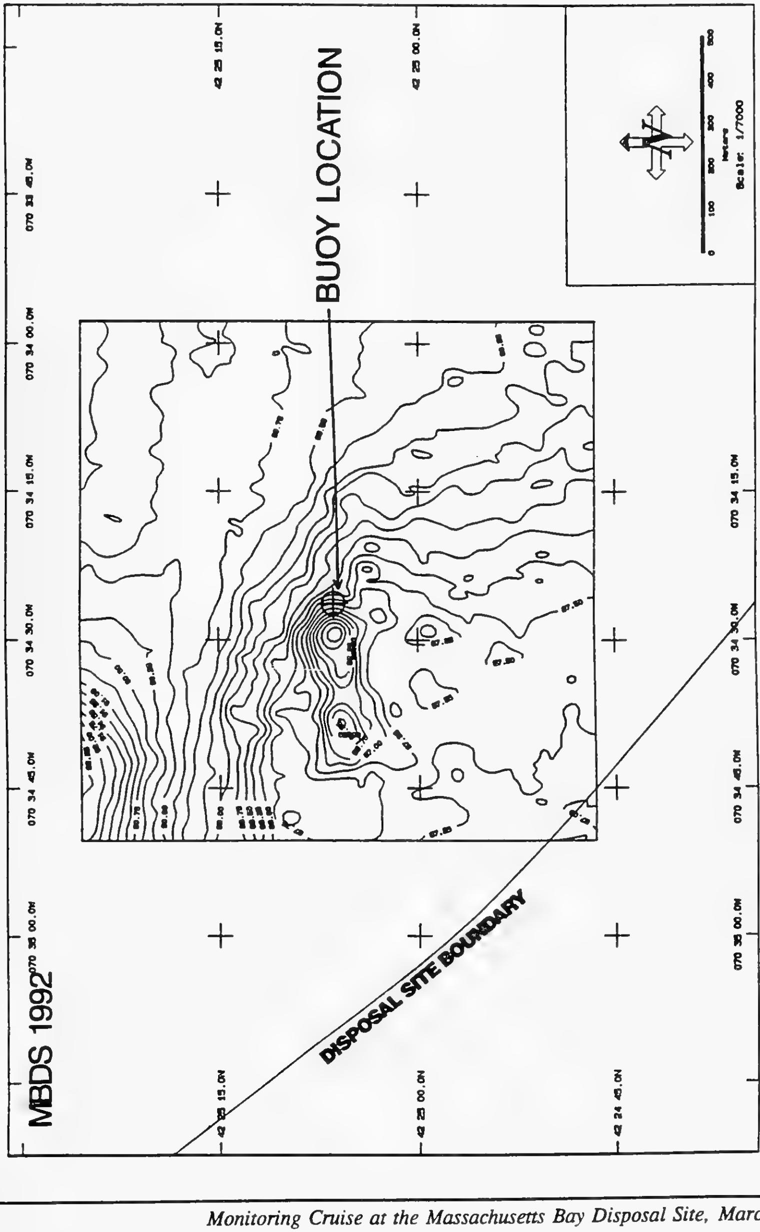

Figure 3-1. Contoured bathymetry chart (depth in meters) of MBDS, 31 March 1992. The contour interval is 0.25 m.

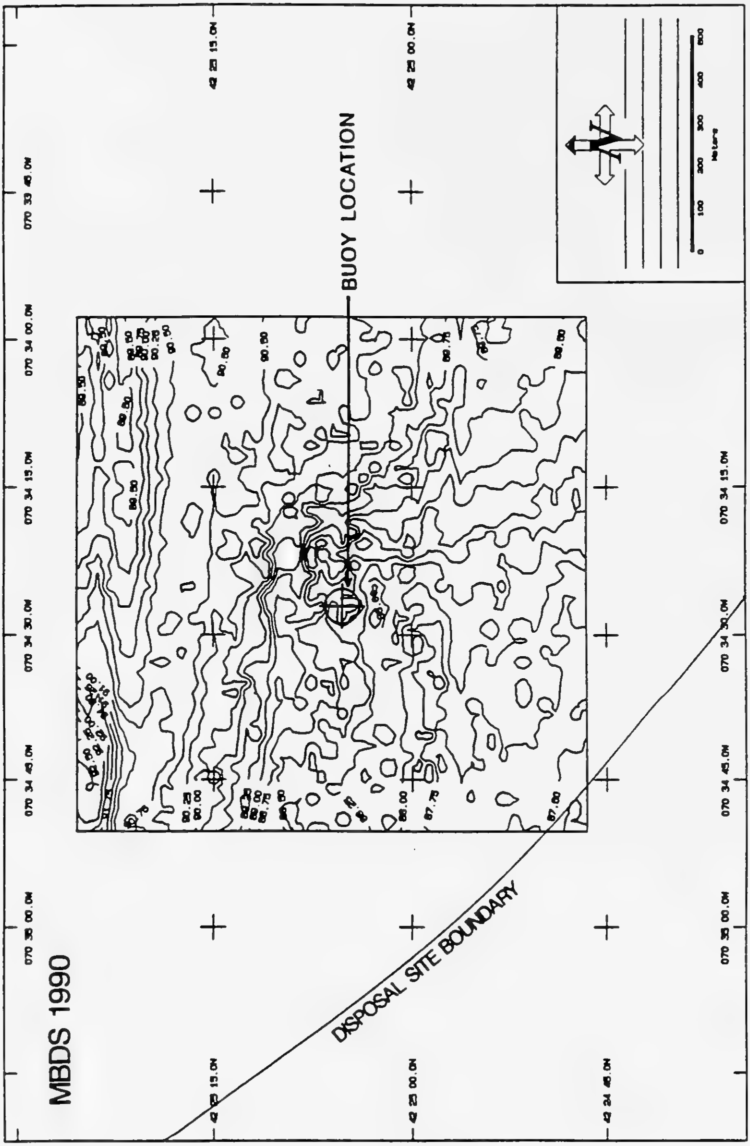

Figure 3-2. Contoured bathymetry chart (depth in meters) of MBDS, August 1990. The contour interval is 0.25 m.

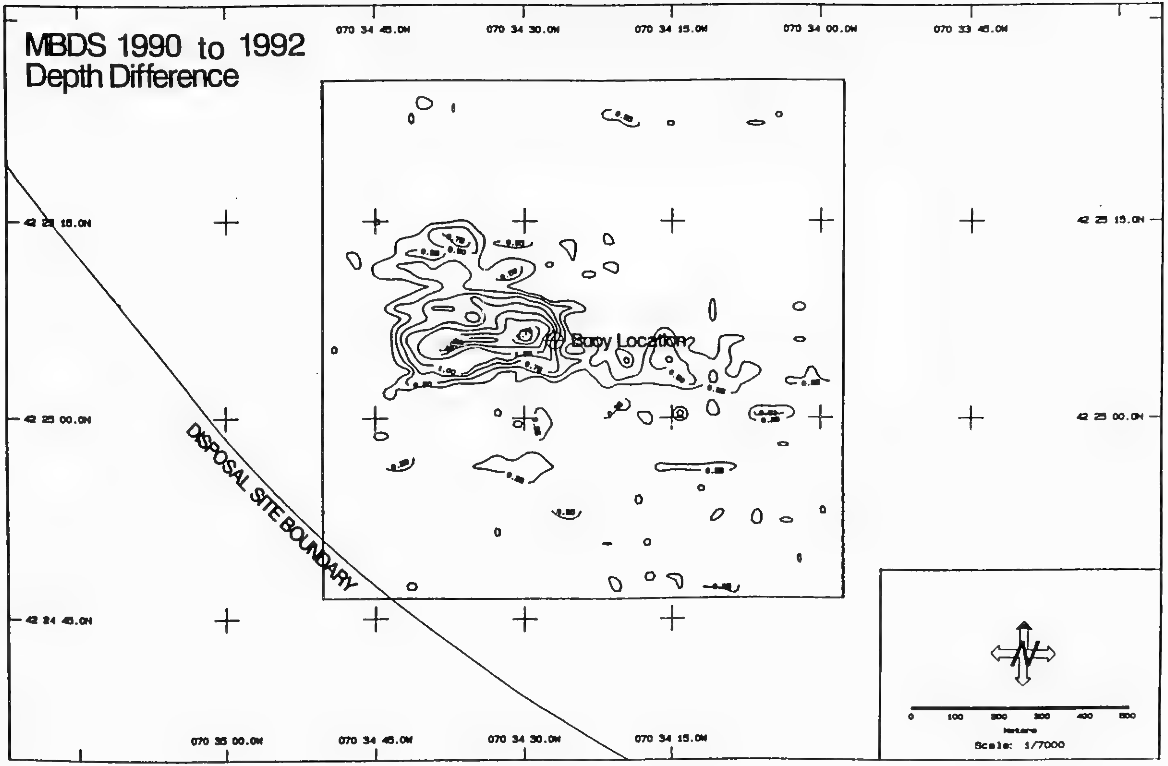

Figure 3-3. Contoured depth difference chart (in meters) at MBDS from 1990 to 1992. The contour interval is 0.25 m.

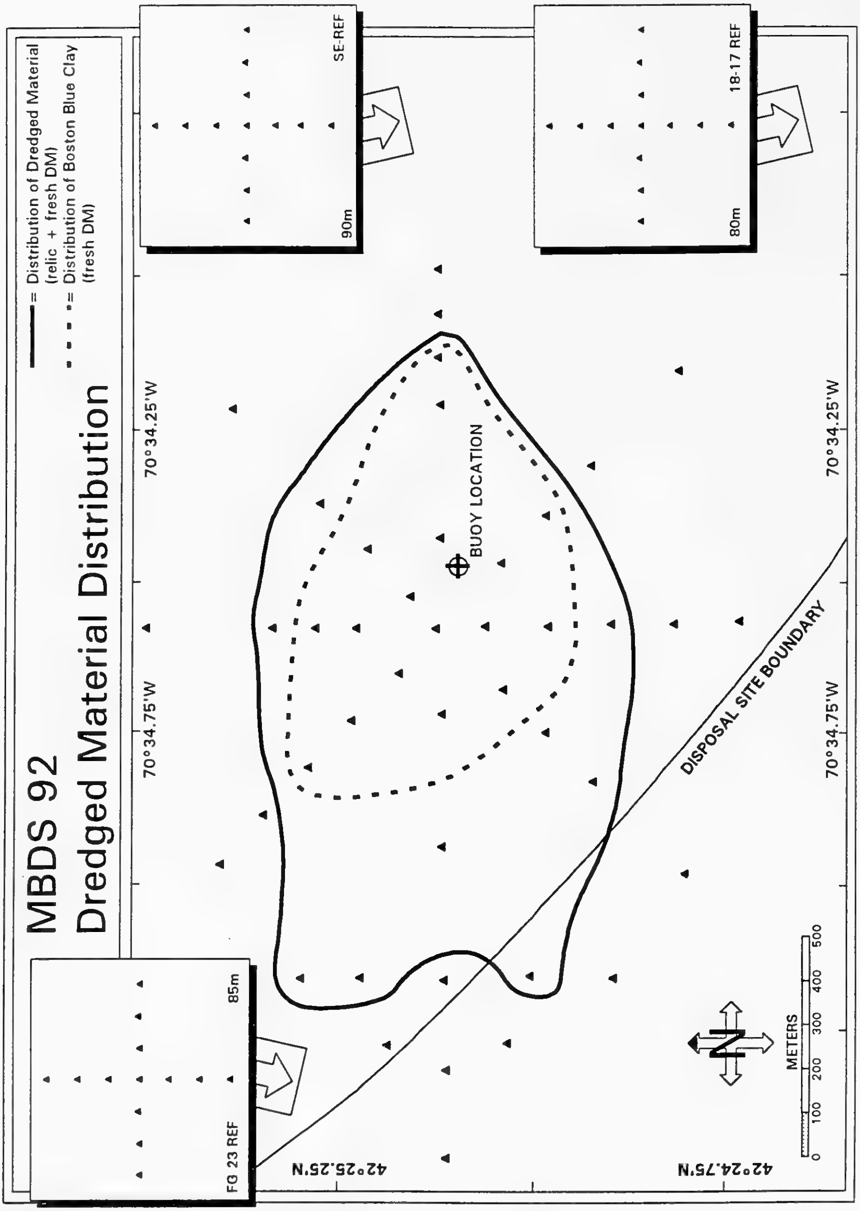

Figure 3-4. Distribution of dredged material at MBDS, April 1992

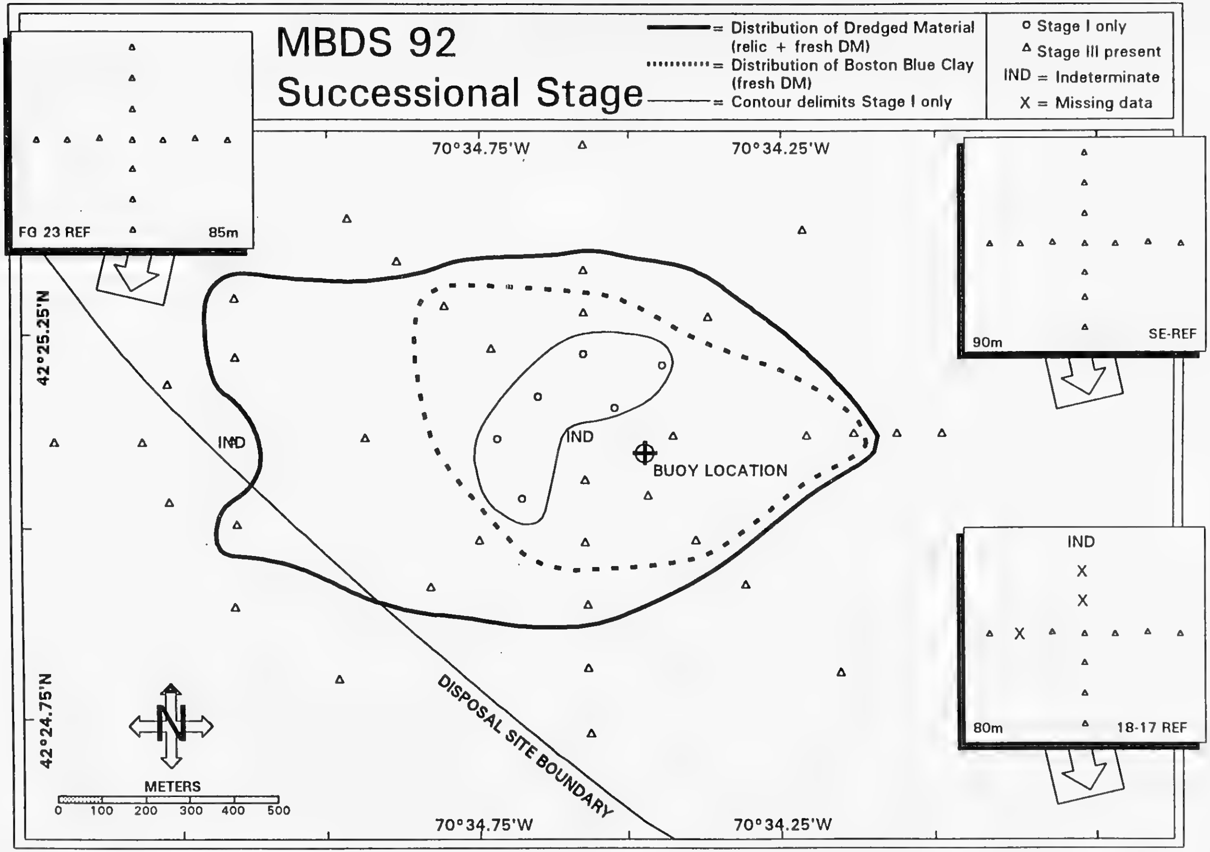

Figure 3-5. The mapped distribution of infaunal successional stages at MBDS, April 1992

4.0 DISCUSSION

The objectives of the combined REMOTS® and precision bathymetric surveys were to delineate the extent and topography of the dredged material deposit resulting from disposal at the MBDS since 1990. Also, with the passage of Hurricane Bob and the Halloween Storm, there was concern regarding the effects these storms may have had on the containment of dredged material.

4.1 Bathymetry

As predicted, bathymetric analysis showed an accumulation of up to more than 2 m of dredged material near the disposal buoy since 1990 (Figure 3-3); the majority of material was located west of the buoy. The dredged material deposit contour in the depth difference plot for the 1990 and 1992 bathymetric surveys followed the northwestward trend seen in the plot of barge release points for the 1990-1992 disposal seasons (Figure 4-1).

A shallow mound (0.8 m) was formed during the 1988-1990 disposal seasons (Figure 4-2). The average diameter of the mound was 420 m, and most of the accumulation was 100 m east of the buoy location. Depth differences on the order of 20 cm (i.e., approaching the limits of detection in this comparison of the 1990 and 1988 surveys) occurred within 400 m from the buoy, primarily to the west. A plot of the barge release points for the 1988-1990 disposal season showed that the majority of barges released dredged sediment within a 100 m radius of the buoy location (Figure 4-3).

A comparison was made of the depth matrices from 1988 to 1992 (Figure 4-4). These results were similar to the 1990 to 1992 depth difference which showed a maximum mound thickness of 2 m. Most of the material has accumulated within a 500 × 500 m area immediately west of the buoy. To the east and south of the buoy, dredged material thicknesses ranged from 0.25 m to 1.0 m (Figure 4-4). These results reflect the patterns of accumulation noted in mound formation from 1988 to 1992 (Figures 3-3 and 4-2).

The successful formation of a mound from the 1988-1992 disposal activities demonstrates that a distinct mound can be formed with dredged material at this site providing that tight control is exercised over disposal operations (Wiley 1994). Any bottom disturbance that may have occurred with the passage of Hurricane Bob and the Halloween Storm did not measurably disturb the mound.

Calculations of "depth difference" volumes based on successive bathymetric surveys have been estimated to be as much as 41% less than estimates based on barge disposal log volumes (Tavolaro 1980). This discrepancy has been attributed not only to the inaccuracies inherent in estimating dredged material volumes in the barges, but also to the compaction of the dredged material on the bottom following disposal and the significant volume of material

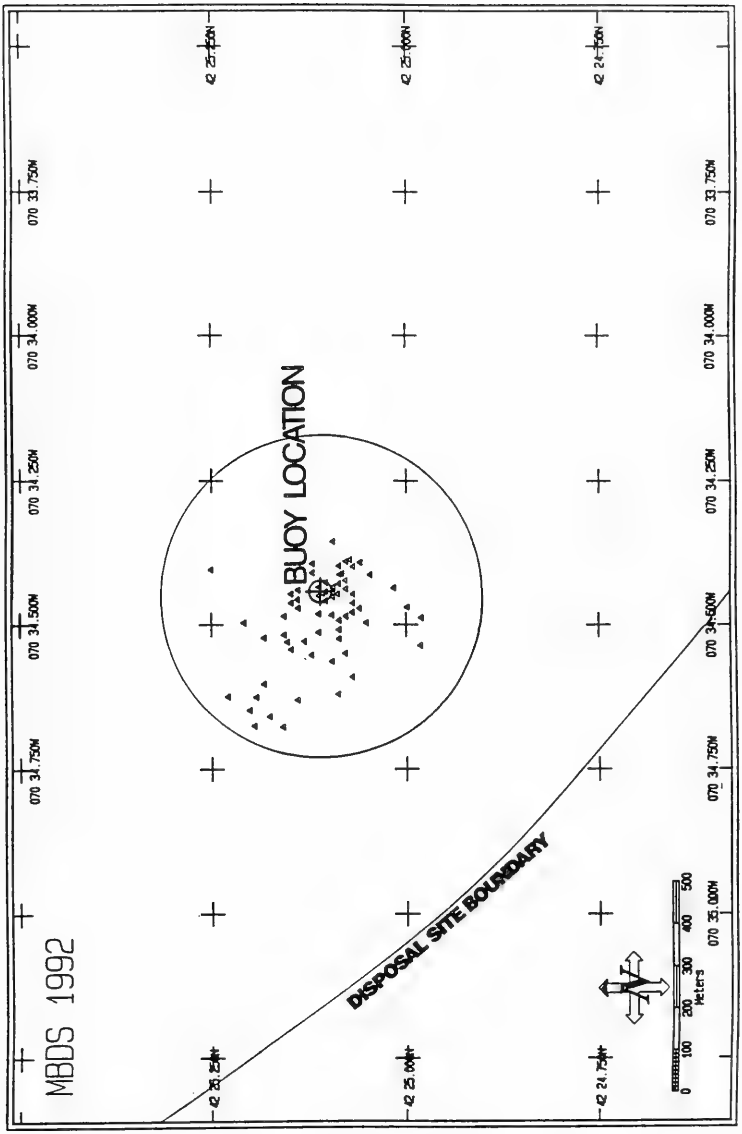

Figure 4-1. Barge release locations, September 1990 to March 1992

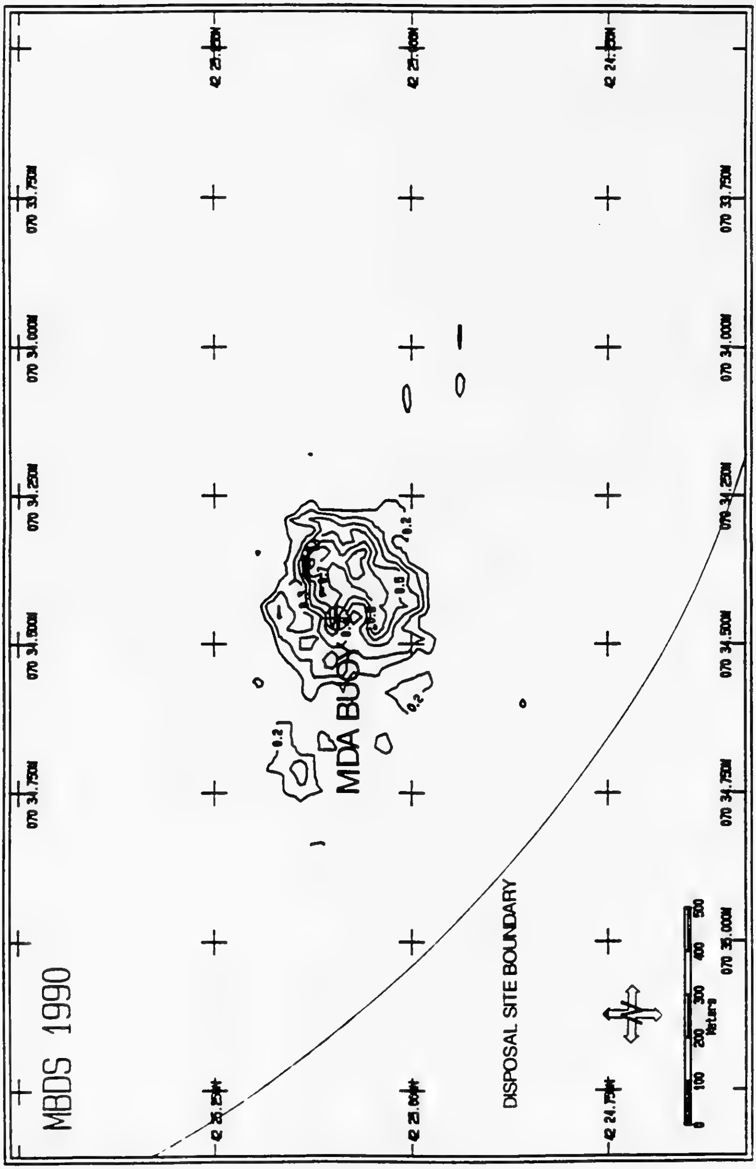

Figure 4-2. Contoured depth difference chart (in meters) at MBDS from 1988 to 1990. The contour interval is 0.25 m.

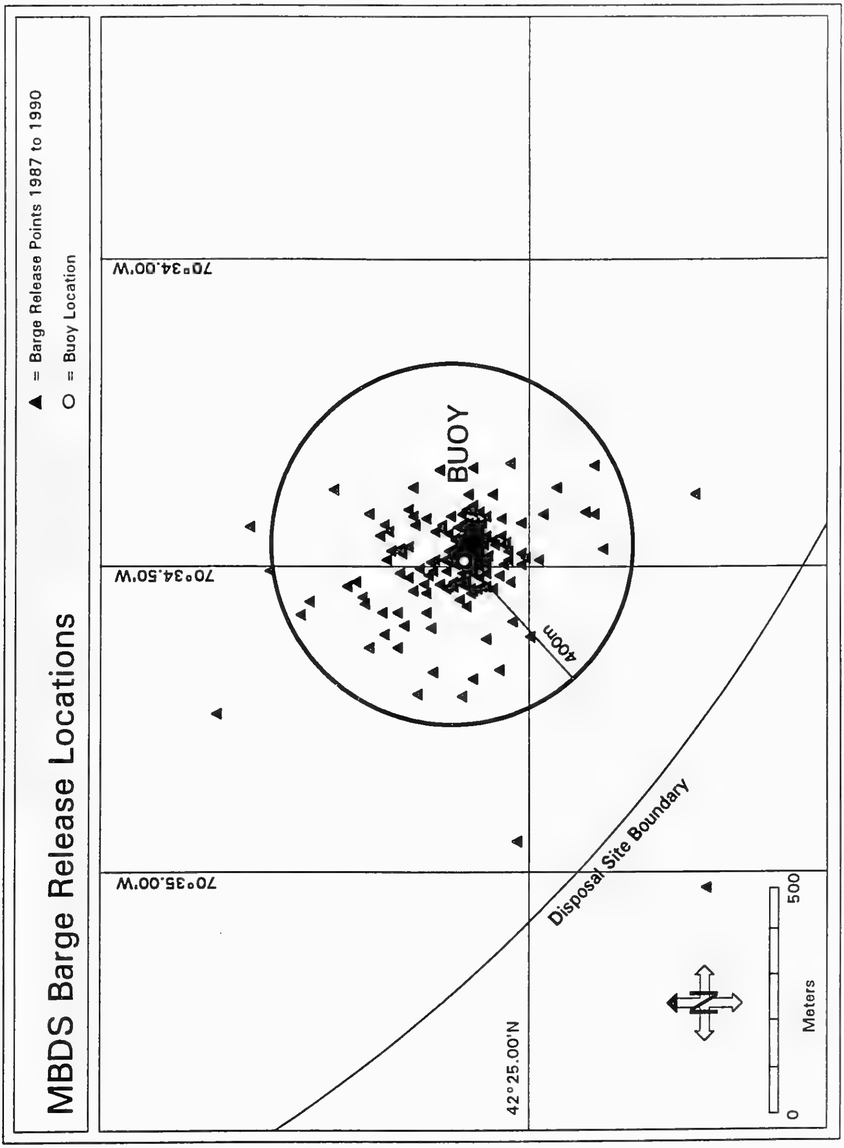

Figure 4-3. Barge release locations for the 1988-1990 disposal season

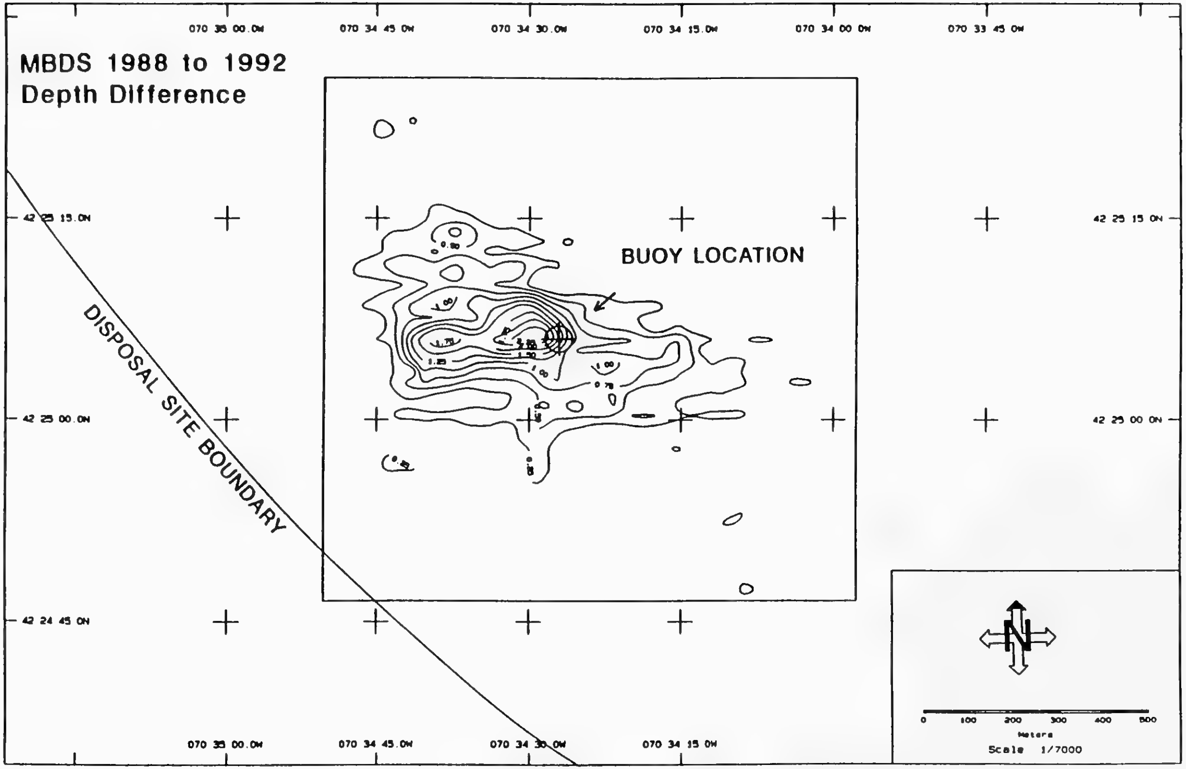

Figure 4-4. Contoured depth difference chart (in meters) at MBDS from 1988 to 1992. The contour interval is 0.25 m.

deposited at the flanks of the mounds in layers too thin to detect acoustically. Applying Tavolaro's maximum 41% correction factor to the barge log estimate of 289,588 m^3 resulted in a corrected volume of 170,857 m^3. The volume calculation from the comparison of the 1990 and 1992 bathymetric surveys was very close to this, 151,764 m^3, or 89% of the barge log volume corrected with the Tavolaro factor.

4.2 REMOTS® Sediment-Profile Photography

REMOTS® photographs verified the distribution of dredged material beyond the boundaries of the mound determined by bathymetry, a finding consistent with results at other disposal sites (SAIC 1989, Germano, Parker, and Wiley 1994). The presence of dredged material in a large number of REMOTS® stations away from the disposal buoy is primarily related to vessel positioning at the time of disposal. The DAMOS capping model was used to calculate the expected radius of an individual disposal event at MBDS (2,000 m^3 barge volume at a 90 m water depth). The model indicates material would spread 300 m from the point of impact (Figure 4-5). The area outlined by a 300 m radius from known barge release points (September 1990-March 1992) includes all of the disposed Boston Blue Clay and most of the relic dredged material detected by REMOTS®.

Dredged material extending to the western boundary of the disposal site was "relic" dredged material, i.e., dredged material deposited prior to the Boston Blue Clay (Figure 3-5). In general, older dredged material has been subjected to a longer period of bioturbation and smoothing of the sediment/water interface from bottom currents. REMOTS® photographs showed that these older dredged sediments had a deeper redox potential discontinuity (RPD) layer. The source of boundary roughness at the sediment/water interface is either biological or related to current activity (sand waves, ripples, etc.) versus a boundary roughness related to recent physical disturbance from dredged material disposal. The successional stages in "relic" dredged material will also tend to be more advanced, showing evidence of Stage III taxa, with correspondingly higher values for the Organism-Sediment Index (Rhoads and Germano 1982, 1986).

The most recently deposited or "fresh" dredged material consisted of Boston Blue Clay which extended radially 300-400 m from the buoy. At the center of the disposal mound, the Boston Blue Clay was devoid of any benthic infauna. However, evidence of faunal reworking on fresh Boston Blue Clay was present within 100 m from the center of the mound. The predicted lack of colonization immediately around the buoy was true only for the center of the mound. Within 100 m of the center, Stage I or Stage III taxa were present. Stage I taxa are the first fauna to recolonize a disturbed habitat and may appear within a short time after the disturbance ceases. Barge logs indicate that barges were disposing of the Boston Blue Clay during the time of the SAIC monitoring survey. In some REMOTS® photographs, there is evidence of the initial stages of faunal reworking on very fresh Boston Blue Clay.

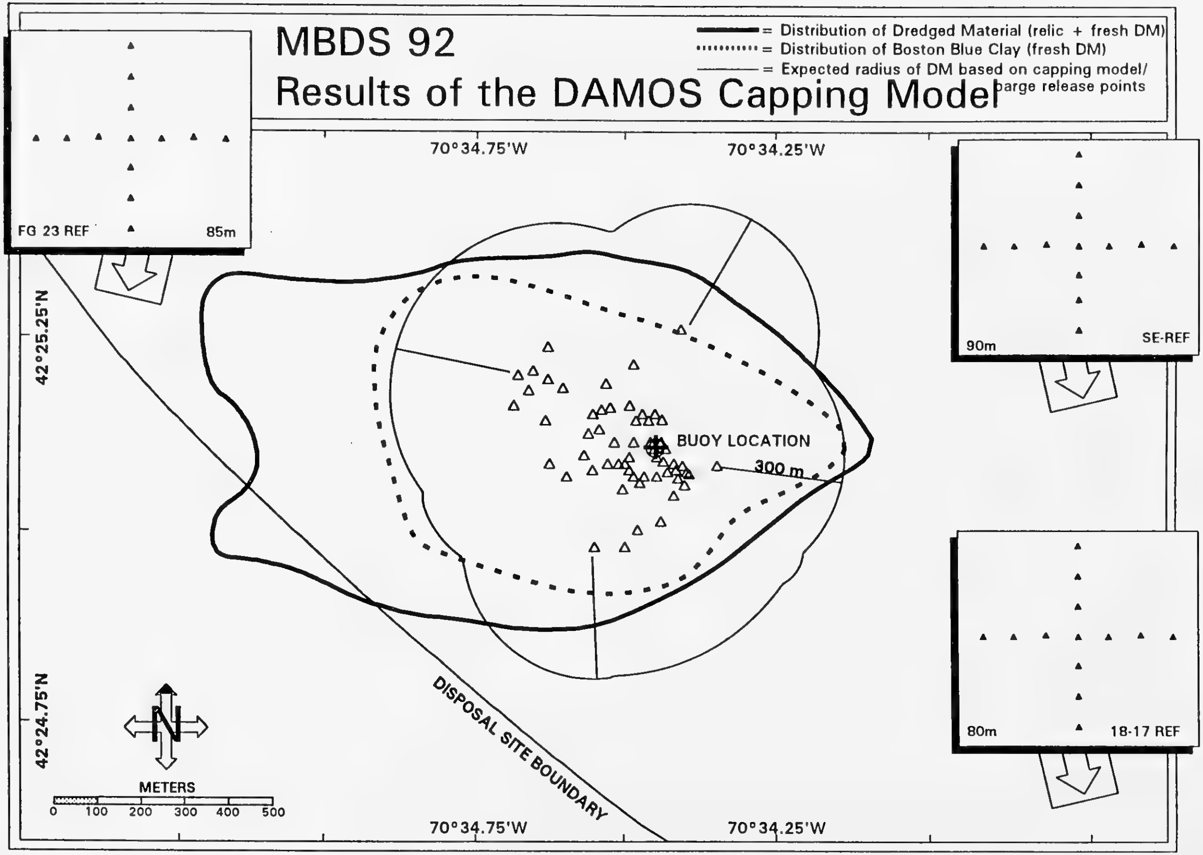

Figure 4-5. Expected radius of dredged material distribution based on barge release points (September 1990 to March 1992) and the DAMOS capping model

Stage III taxa require more time to become established than the pioneering Stage I taxa. These invertebrates are infaunal, and many feed at depth in a head-down orientation (Rhoads and Germano 1982, 1986). Disposal of Boston Blue Clay at MBDS had been occurring for three months at the time of the survey. Once the material has remained undisturbed on the seafloor for a period of time, colonization is expected to begin, as was seen with the pioneering Stage I taxa on Blue Clay around the disposal mound center. Stage III taxa are likely to have burrowed up through sequential, thin layers of dredged material at stations located further from the center (Germano and Rhoads 1984).

The colonization pattern predicted for the reference areas, Stage III taxa, was confirmed by the REMOTS® analyses, indicating that the reference areas were not subject to any disturbance or stress. For both the 1992 and the 1990 surveys, Stage III taxa were present at all reference stations (Germano, Parker, and Charles 1994). Stage III taxa generally represent high-order successional stages typically found in low disturbance regimes (Rhoads and Germano 1982, 1986).

The rapid rate of recolonization over the disposal site shows that these intense storms, particularly the 100-year Halloween Storm, did not severely affect the stability of the site or the benthic environment. There was no evidence at the reference areas or at the disposal site of any notable disruption to the benthic environment due to Hurricane Bob or the Halloween Storm. It was predicted that 43 knot winds for 12 hours could cause the resuspension of material and affect the stability of the site (Hubbard et al. 1988). The Halloween Storm generated 40 knot winds over 114 hours. This storm, which represented a potential worst-case condition, did not severely affect the site. While it is likely that there was some resuspension of bottom sediments, it is clear that the effects from a storm of this magnitude were less than mathematically predicted. Since the storm exceeded the requirement for ideal storm set up to impact the bottom, without exhibiting impact, these results reinforce the management assumptions that the Massachusetts Bay Disposal Site is a stable site for containment of disposed dredged material.

5.0 CONCLUSIONS

Dredged material deposited at the Massachusetts Bay Disposal Site since the August 1990 REMOTS® survey formed a distinct mound, centered slightly west of the disposal buoy (Germano, Parker, and Charles 1994). Results of the 1990-1992 depth difference indicated a maximum change in depth of 2 m and the formation of an elliptical mound with an average diameter of 400 m. The REMOTS® survey extended the detection of dredged material to 400 m north and south, 600 m east, and 800 m west of the mound center. The acoustically detected mound was well within the disposal site boundaries. A comparison made of the depth matrices from 1988 to 1992 also showed an elliptical mound with a maximum thickness of 2.25 m. Most of the dredged material deposited since 1988 had accumulated within a 500 m by 500 m area, immediately west of the buoy. The successful formation of a mound from disposal activities demonstrates that a distinct mound can be formed with dredged material at this site providing that tight control is exercised over disposal operations.

The fairly rapid rate of benthic recolonization at the disposal site, with the ongoing disposal of Boston Blue Clay, indicated that the benthic disturbance from disposal operations on the benthic fauna and infauna was minimal. The majority of disposal site stations as well as all of the analyzed reference area stations showed evidence of Stage III taxa, indicative of a well-colonized, healthy benthic community. At the disposal mound center, the labile organic matter associated with the fresh Boston Blue Clay stimulated the colonization of Stage I organisms. Only at the very center of the mound, where deposition was most recent, was the successional stage indeterminate.

With the passage of Hurricane Bob and the Halloween Storm in 1991, there was concern regarding disruption to the benthic environment at MBDS as a result of the storms. Although model predictions indicated that some resuspension of sediments should occur, results of bathymetric/REMOTS® surveys at the disposal site and the REMOTS® surveys at the reference areas showed no dramatic evidence of benthic disturbance or indications of substantial resuspension of dredged material. Recolonization of the mound has occurred at an acceptable rate, especially considering the ongoing disposal operations. Bathymetric results showed the acoustically detected mound was well within the disposal site boundaries.

6.0 REFERENCES

Butman, B. 1977. On the dynamics of shallow water currents in Massachusetts Bay and on the New England Continental Shelf. Unpublished manuscript. Rpt. No. WHOI-77-15. Woods Hole Oceanographic Institution, Woods Hole, MA. 174 pp.

Camp, Dresser, and McKee, Inc. 1991. Environmental consequences of utilizing Boston Blue Clay in landfill closures (Subtask 8.2). (Index and Section 3). Central Artery/Tunnel Project, Rowars Task Assignment #1 Materials Disposal, Massachusetts Department of Public Works.

Coastal Engineering Research Center. 1984. Shore protection manual. Fourth Edition. US Army Corps of Engineers. Coastal Engineering Research Center. Waterways Experiment Station. Vicksburg, MI. 2 vols.

Chandler, D. L. "Halloween '91 storm is rated worst ever." Boston Globe. April 27, 1992.

Davis, R. E.; Dolan, R. 1992. The "All Hallows' Eve" coastal storm -- October, 1991. J. Coastal Research. Vol. 8 (4), pp. 978-983.

EPA. 1989. Evaluation of the continued use of the Massachusetts Bay Dredged Material Disposal Site. Draft Environmental Impact Statement, September 1989.

Gilbert, T. R. 1975. Studies of the Massachusetts Bay Foul Area. Prepared for Commonwealth of Massachusetts, Division of Water Pollution Control. New England Aquarium, Boston, MA. 197 pp.

Germano, J. D.; Rhoads D. C. 1984. REMOTS® sediment profiling at the Field Verification Program (FVP) disposal site, pp. 536-544. In: Montgomery, R. L.; Leach, J. W., eds. Dredging and Dredged Material Disposal. Volume 1. Am. Soc. Civil Engineers. New York.

Germano, J. D.; Parker, J.; Wiley, M. B. 1994. Monitoring cruise at the Central Long Island Sound Disposal Site, July 1990. SAIC Report No. SAIC-90/7594&C89. Final report submitted to the US Army Corps of Engineers, New England Division, Waltham, MA.

Germano, J. D.; Parker, J.; Charles, J. 1994. Monitoring cruise at the Massachusetts Bay Disposal Site, August 1990. SAIC Report No. SAIC-90/7599&C90. Final report submitted to the US Army Corps of Engineers, New England Division, Waltham, MA.

Hubbard, W. A.; Penko, M. J.; Fleming, T. S. 1988. Site evaluation studies of the Massachusetts Bay Disposal Site for ocean disposal of dredged material. US Army Corps of Engineers, New England Division, Waltham, MA. pp. 1-384.

Morris, V. 1992. What about (Hurricane) Bob? Mariners Weather Log. Winter 1992.

Rhoads, D. C.; Germano, J. D. 1982. Characterization of organism-sediment relations using sediment profile imaging: An efficient method of Remote Ecological Monitoring of the Seafloor (REMOTS® System). Mar. Ecol. Prog. Ser. 8:115-128.

Rhoads, D. C.; Germano, J. D. 1986. Interpreting long-term changes in benthic community structure: a new protocol. Hydrobiologia 142: 291-308.

SAIC. 1985. Standard operating procedure manual for DAMOS monitoring activities, Volume I. DAMOS Contribution No. 48. SAIC Report No. SAIC-85/7516&C48.

SAIC. 1987. Environmental information in support of site designation documents for the Foul Area Disposal Site: physical oceanography. SAIC Report No.SAIC-85/7528&93. US Army Corps of Engineers, New England Division, Waltham, MA.

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

SAIC. 1989. Monitoring surveys at the New London Disposal Site, August 1985-July 1986. DAMOS Contribution No. 60. SAIC Report No. SAIC-86/7540&C60. US Army Corps of Engineers, New England Division, Waltham, MA.

Tavolaro, J. F. 1980. Sediment budget study for clamshell dredging and disposal activities. US Army Corps of Engineers, New York District, New York, NY. pp. 1-27.

Wiley, M. B. 1994. Deep water capping. SAIC Report No. SAIC-91/7609&C96. Final report submitted to the US Army Corps of Engineers, New England Division, Waltham, MA.

APPENDIX

Plate 1. *MBDS 100S/A*

Plate 2. *MBDS 200N/B*

Plate 3. *MBDS 400N/C*

Plate 4. *MBDS B02/B*

Plate 5. *MBDS B04/C*

Plate 6. *MBDS 800E/A*

Plate 1. MBDS 100S/A

Plate 2. MBDS 200N/B

Plate 4. MBDS B02/B

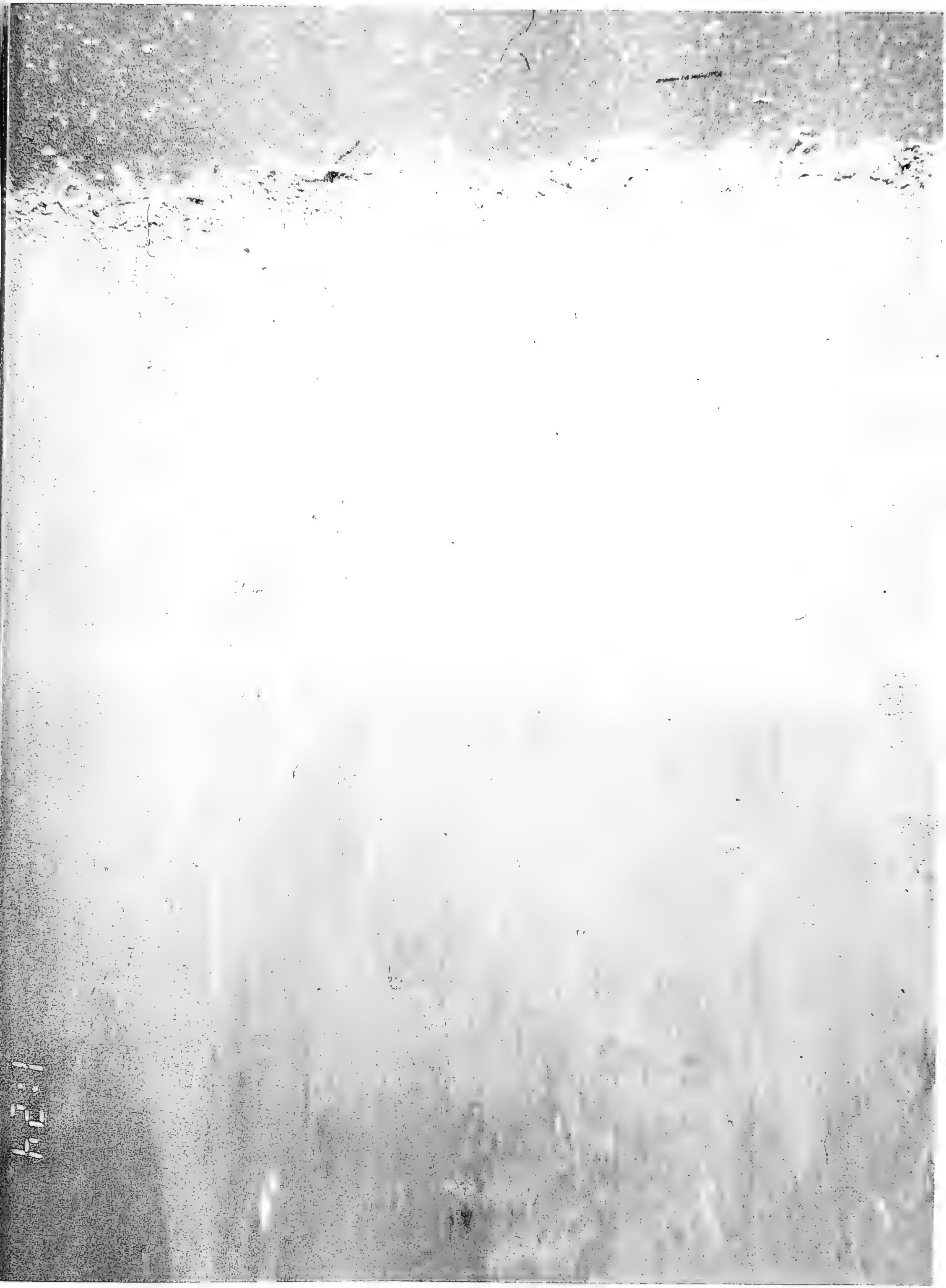

Plate 5. MBDS B04/C

Plate 6. MBDS 800E/A