Monitoring Surveys at the
Foul Area Disposal Site
February 1987

Disposal Area Monitoring System DAMOS

Contribution 64
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US Army Corps
of Engineers
New England Division

MONITORING SURVEYS AT THE FOUL AREA DISPOSAL SITE FEBRUARY 1987

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FEBRUARY 1987

1.0 INTRODUCTION

The Foul Area Disposal Site (FADS) is located in Massachusetts Bay approximately 18 nautical miles (nm) east-northeast of the entrance to Boston Harbor and 10 nm south-southeast of Gloucester, Massachusetts. The site consists of a circle with a 2 nm diameter centered about 42°25.7'N by 70°34.0'W. Located just west of Stellwagen Bank, the depths in this site range from a minimum of approximately 58 meters in the northeast quadrant on the edges of Stellwagen Bank, to a maximum of 92 meters in a small depression in the southwest central portion of the area.

Prior to the establishment of the present disposal site, the regional disposal area was known as the Boston Foul Ground; this 2 nm diameter circle was centered approximately 0.75 nm west of the present site. This region of Massachusetts Bay was been used as a disposal site for many years; the old site was the recipient of many types of matter not limited to dredged material, including building debris, canisters of industrial wastes and encapsulated low-level nuclear waste. These items were deposited on an almost continual basis over the past 4 - 5 decades; in 1977, the present location for FADS was established, and disposal has been limited to dredged material only. Until recently, control of disposal was accomplished using LORAN-C and other less precise systems which resulted in many types of disposed material being scattered over the entire western half of the present site. During the past decade, use of this site has increased, especially with the closing of the Boston Lightship Disposal Site in 1976. Recent records indicate that the annual average dredged material disposal volumes at this site exceed 300,000 cubic meters (400,000 cubic yards) of material, making it the second most active site in New England surpassed only by the Central Long Island Sound site.

FADS is presently being considered for final designation by the US Environmental Protection Agency and, to assist in this effort, intensive studies have been conducted by NED over the past three years. One important question is whether a disposal mound can be formed in this depth of water using point dumping at a taut-wire moored buoy. In order to address this issue, a precision bathymetric survey was performed in the area of the "DGD" disposal buoy to document the existing topography. REMOTS® sediment profiling was also used to measure the thickness of the flanks of the dredged material deposit. These data will be used for comparison with later surveys.

During the period of July to November 1986, approximately 30,000 m^3 of maintenance material from two permit projects (Blue Circle Atlantic, 25,800 m^3; and General Electric, 4,000 m^3) were disposed at FADS which had elevated levels of PCBs and heavy metals (Table 1-1). An additional objective of this survey was to determine if these disposed materials had a unique chemical signature for specific identification so that the effectiveness of any future capping exercise could be evaluated.

2.0 METHODS

2.1 Bathymetry

The precise navigation required for all field operations was provided by the Science Applications International Corporation (SAIC) Integrated Navigation and Data Acquisition System (INDAS). This system uses a Hewlett-Packard 9920 Series computer to collect position, depth, and time data as well as to provide real-time navigation. During a bathymetric survey, a display is provided to the helmsman of the research vessel with the survey lanes and the real-time position of the vessel indicated. The positional information is recorded on magnetic disk every second along with depth and time. The computer system calculates accurate positions from the range data provided by the positioning system and is capable of converting from state plane coordinates in the Transverse Mercator system to Lambert or Mercator coordinates.

Positions were determined to an accuracy of ±3 meters from ranges provided by a Del Norte Trisponder System. Shore stations are established over known benchmarks used in previous surveys to allow accurate comparisons of seasonal surveys. For the present survey, shore stations were established at Marblehead Light and Eastern Point Light.

The individual depth measurements were determined using a Raytheon DE-719 Precision Survey Fathometer with a 208 kHz transducer. The fathometer was calibrated with a bar check at fixed depths below the transducer before the survey began. Survey lanes were run east and west at a 25 meter lane spacing over a 1200 X 1200 m area centered at the disposal buoy (42°25.1' N, 70°34.4' W; Figure 2-1). This lane spacing provides good resolution for subsequent data analysis and the production of detailed depth contour charts.

Analysis of the bathymetric data corrects the raw depth values to Mean Low Water by adjusting for ship draft and for tidal changes for the duration of the survey. All data points in terms of depth and position are checked for unreasonable values so that the final contour plots will not contain errors.

2.2 REMOTS® Sediment Profiling

The REMOTS® survey was conducted at FADS on 2 February, 1987 to map the distribution of dredged material, evaluate benthic habitat conditions, and document the process of recolonization in the disposal area. Thirty-nine stations were occupied on a cross-shaped grid centered on the "DGD" disposal buoy (Figure 2-2). Stations were located 100 meters apart and extended 600 meters north of center, 800 meters south of center, 900 meters east of center, and 700 meters west of center. Stations were also located in each of the quadrants at 250 and 500 meters NE, NW, SE, SW. Three replicate images were collected at each station; stations were located so as to extend far enough beyond the dispersion limits of dredged material in order to accurately detect the amount of seafloor covered by the recently deposited material. In addition, 34 REMOTS® images were collected at the FADS soft-bottom reference station (42°24.69' N, 70°32.81' W).

REMOTS® images were taken with a Benthos Model 3731 Sediment-Profile Camera (Benthos, Inc. North Falmouth, MA). A detailed description of the REMOTS® camera, its operation, and the analysis of the photographs taken can be found in DAMOS Contribution #60 (SAIC, 1986a).

2.3 Sediment Characterization

Sediments were collected on 22 and 29 January 1987. In order to choose the locations for collecting sediment samples of the recently deposited dredged material from the Blue Circle Atlantic and General Electric (GE) projects, scow logs were studied to determine the volume of material and approximate position of each scow load in relation to the disposal buoy. An examination of the scow logs revealed that the majority of the loads were deposited 50-100 m north of the disposal buoy. Therefore, the sediment samples were collected within an area with a radius of 100 m centered about 50 m north of the disposal buoy (see Figure 2-2). With the small volume of material involved in these two projects and the great depth of water, it was unlikely that all the sediment samples would in fact contain material from the Blue Circle and/or GE projects.

Single samples were collected from each of fifteen stations randomly located within the pre-determined radius using a 0.1 m^2 Smith-McIntyre grab sampler. Six polycarbonate plastic core liners (6.5 cm ID) were pushed into each sediment grab sample and extracted. One complete core per grab was placed into a bag for subsequent chemical and physical analysis by the NED laboratory. The top 2 cm of the remaining five cores per grab were composited and bagged separately for possible comparison with the results from the complete core. The samples were kept cold and returned to the NED laboratory, where they were stored at 4°C until analyzed. The parameters measured included grain size, metals (Hg, As, Cd, Cr, Cu, Ni, Pb, Zn), and several organic constituents (petroleum hydrocarbons, total organic carbon, PCBs, DDTs). Only the whole cores from ten of the fifteen stations were analyzed for this study.

Sediment analyses were conducted by the NED chemistry lab using methods described by the U.S. Environmental Protection Agency (Plumb, 1981). Mercury analysis was performed using acid digestion and cold vapor atomic absorption spectrophotometry; arsenic analysis was accomplished using acid digestion and gaseous anhydride atomic absorption spectrophotometry. The other inorganic compounds (arsenic, lead, zinc, chromium, copper, cadmium and nickel) were analyzed using acid digestion and flame atomic absorption spectrophotometry.

Total organic carbon analyses were conducted with an autoanalyzer using a combustion technique. Oil and grease measurements were made by extracting the sediment with freon and then analyzing the freon by infrared spectrophotometry. PCBs and DDTs were extracted with hexane and also analyzed by electron capture gas chromatography.

3.0 RESULTS

3.1 Bathymetry

Examination of the contoured bathymetric chart (Figure 3-1) indicates that the disposal point is located in a slight trough running NW-SE. Depths reach more than 90 meters in the center of the survey area and rise to approximately 89.5 to the northeast and 87.5 meters to the southwest. Bathymetry was unable to detect a distinct bell-shape disposal mound (such as those usually formed at shallower sites) as a result of the recent disposal operations. Because no previous bathymetric survey was conducted over the area using the same lane spacing, volume difference calculations were not possible.

3.2 REMOTS® Sediment Profiling

The distribution and thickness of dredged material as determined from REMOTS® images reflects the presence of the material deposited at the "DGD" buoy since November, 1985 (Figure 3-2). The overall spatial distribution of dredged material extends to the following limits: between 400 and 500 meters south of center, 400 to 500 meters west of center, 500 to 600 meters east of center, and as far north of center as surveyed (700 meters). This dispersion pattern is essentially the same as that mapped in the January 1986 REMOTS® survey of this area. Several REMOTS® stations extended beyond the eastern, western, and southern limits of the area where disposed material was detected. All dredged material detected is confined within the FADS designated boundary.

The distribution of modal grain-size over the area surveyed at FADS is relatively uniform. Most stations consist of silt-clay ($\geq$ 4 phi) or very fine-sand (4-3 phi). The coarsest sediment (2-1 phi; medium sand) is found at Station 100E. Many stations located on dredged material have subordinate modes within the sand fraction. All 34 replicate images taken at the FADS Reference station have a major mode of silt-clay ($\geq$ 4 phi).

Based on sediment grain-size, sediment mass properties (as inferred from profile images), and other REMOTS® parameters that will be discussed below, new or freshly deposited materials were recognized at Stations 200N, Center, 100E, 200S, and 300S. Disposed material occurs in a layer that is thicker than the camera prism penetration depth at these 5 stations (> 20 cm). It appears that most of the deposited material is dispersed along the north-south transect; this is also illustrated when the measured depositional layers from the 1986 and 1987 REMOTS® survey are compared (Figure 3-3). The North-South transect shows an increase in the spatial extent of dredged material in this 1987 survey.

The quality of disposed material can also help to identify sediment derived from specific projects, especially if they have a unique lithology. The Blue Circle Atlantic dredged materials may have consisted, in part, of highly-cohesive clays; cohesive, high-reflectance mud clasts were found at Station 100 N (Figure 3-4A and 4B). These clasts are devoid of macrofauna and are apparently overconsolidated; numerous fractures can be seen in these clast cross-sections. This material appears to have the properties of modelling clay.

Station Center (Figure 3-5) shows evidence of the deposition of fine-grained and reduced sediment at the sediment surface. The inference that this is fresh material is based on the fact that the oxidization of surface sediments by colonizing organisms has not yet occurred to a notable depth. Sand mixed with cohesive mud was seen in images taken at Station 100E (Figure 3-6). The presence of reduced fine-grained sediment was detected at stations 200S and 300S (Figures 3-7 and 3-8, respectively). These stations are either not colonized or are in an early stage of colonization. This ecological information further indicates that these stations are located on "new" dredged materials.

The surface boundary roughness values measured in this survey (Figure 3-9) are not significantly different from those measured in January 1986. The relative "smoothness" of the disposal area surveyed most likely is related to the depth of water. Sediments which descend through over 90 meters of water to the bottom spread out evenly and are quickly reworked into older deposits. Much of the microtopography over both the disposal area and ambient bottom is related to biogenic activity. The highest boundary roughness is located at Station 100N, related to the presence of the cohesive clay clasts (Figure 3-4) at the surface. However, because of the deep penetration of the camera into this material, the maximum extent of this boundary roughness could not be determined at this particular location.

The mean apparent RPD depth at the FADS Reference Station is 4.77 cm; this is not significantly different from the value measured in January 1986 (4.81 cm). At the disposal location, RPD depths have not changed significantly since January 1986 (Figure 3-10). In the present survey, the RPD values measured at the disposal location are significantly less than those at the reference station (Figure 3-11; $p < 0.001$, Kruskal-Wallis test). The shallowest RPD values are found at stations which are located within the dredged material area (Figure 3-10). Mean RPD depths are particularly shallow (< 2 cm) at Station CTR, 200S, 300S, 100W, 300E, 400E, 300N, 400N, 600N and 250NE. The shallowest RPD depths are located at Station 300S, which exhibits highly reducing sediment at the sediment-water interface (Figure 3-8). The lack of an apparent RPD at 300S indicates that significant infaunal colonization of the dredged material at this station has not occurred.

The distribution of infaunal successional stages shows that most stations located on disposed dredged material have been successfully colonized by subsurface deposit-feeders (Stage III seres; Figure 3-12). However, two stations were apparently devoid of macroinfauna: Station 100N, consisting of overconsolidated cohesive clay-like material and Station 300S, which exhibited reducing sediments up to the sediment-water interface. Most of the other stations surveyed which are located on dredged material are dominated by Stage III seres and are similar in their successional status to the FADS Reference Station.

The Organism-Sediment Index (OSI) values from stations in the "DGD" disposal area (Figure 3-13) are significantly lower than those measured at the FADS Reference Station (Figure 3-14; $p < 0.001$, Kruskall-Wallis test). Within the disposal area, OSI values have not significantly changed since the January 1986 survey.

3.3 Sediment Characterization

Results from the chemical analysis of the sediment samples are presented in Table 3-1. These data are for the ten sediment cores collected from ten of the fifteen grabs. The results for several of the parameters indicate that the distribution of contaminated material is quite heterogenous. The concentrations of lead ranged from 146 to < 12 ppm and the range of concentrations measured for petroleum hydrocarbons was 1300 to <50 ppm. Total organic carbon values were between 0.94 and 0.01 %. The concentrations of several of the contaminants were below the analytical detection limits; these included cadmium, nickel and DDTs.

The levels of contaminants in the dredged material deposited at this site are shown in Table 1-1; these levels are generally similar to those measured at the disposal site except for mercury and PCBs, which had much higher levels in the original dredged material.

4.0 DISCUSSION

4.1 Bathymetry

Approximately 197,000 m^3 of dredged material has been deposited at the "DGD" buoy since this disposal location was established in November 1985. It is not certain whether the lack of a distinct, bell-shaped disposal mound, typical of shallower sites, is due to the depth of water and the behavior of the dredged material during convective descent in these depths or to the distribution of the actual locations of individual scow loads during disposal (Figure 4-1). Previous studies have indicated FADS to be a containment site with no significant bottom currents capable of sediment resuspension and transport. Because of the depth of the site, the acoustic bathymetric records can reliably detect large-scale changes in depth over the entire area surveyed on the order of 50 cm or more. This value reflects the accumulation of errors introduced by the positioning system, tidal corrections, and the calibration of the fathometer (speed of sound through the water column) as well as the vertical motion of the research vessel during the survey. During disposal, the falling sediment is expected to spread because the greater depth offers more time for entrainment of water into the sediment (Figure 4-2). As more water is mixed into the sediment during convective descent, a larger percentage of the original dredged material volume forms sediment/water mixtures with densities approaching that of the surrounding seawater. The falling velocity of these mixtures is greatly reduced so that the increased descent time to the bottom results in a greater spreading of the material as compared with a shallower location.

Results of the REMOTS® survey in this area revealed the presence of dredged material within a circle with a radius of approximately 500-600 meters. Spreading 197,000 m^3 of dredged material over that area in an even layer would result in an estimated thickness between 17 - 25 cm. This thin layer of dredged material would not be detectable acoustically.

4.2 REMOTS® Sediment Profiling

The previous REMOTS® survey at this area was performed in January 1986; it is interesting to note that the dispersion pattern of dredged material from the February 1987 survey is essentially unchanged from the areal limits detected in January 1986, despite the additional volume of material disposed. Table 4-1 presents the disposal volumes of operations conducted since that survey.

The areal extent of the dredged material detected by REMOTS® images (Figure 3-2) is the result of disposal operations at this disposal point from November 1985, when the disposal point was established, to February 1987, when this survey was conducted. Newly deposited material can be distinguished from "old" dredged material in REMOTS® images by comparing imaged sediment with known characteristics of sediment barged to the disposal site. For example, cohesive mud clasts are readily distinguished in REMOTS® images (see Figure 3-4). In addition, gradients in boundary roughness, successional stage, depth of the mean apparent RPD, and Organism-Sediment Indices (OSI) can be used to identify freshly deposited materials. Once deposited, dredged materials experience changes in mass properties, chemistry, and biology; these can collectively be termed "weathering" or diagenetic changes. Our experience with REMOTS® mapping of recently disposed materials in Long Island Sound indicates that the "weathering" process makes recently disposed materials on the flanks of the disposal mounds indistinguishable from "old" disposed materials within a few months when depositional layers are less than 5 cm thick. The material deposited at the "DGD" buoy since the last REMOTS® survey can be recognized in images from the present survey; a comparison of these two surveys shows the difference in dredged material thickness detected (Figure 3-3).

Measurements of the area of seafloor covered with dredged material show approximately 792,400 m^2 of bottom are covered by this deposit. The REMOTS® images from approximately 89% of this area show dredged material in excess of the REMOTS® prism penetration (maximum penetration = 20 cm), while the remaining 11% of the area shows an average dredged material thickness of approximately 8 cm. By estimating a **minimum** thickness of 20 cm of dredged material in those areas where depositional layers exceed prism penetration, a conservative calculation shows the estimated volume of dredged material covering this area would equal approximately 147,825 m^3. The REMOTS® estimates give minimum thicknesses of approximately 20 cm; the "true" thickness of newly deposited material would therefore fall somewhere between 20 cm (the REMOTS® detection limit) and 50 cm (bathymetric detection limit for this area and depth). According to the disposal scow logs, a total volume of

196,874 m^3 have been deposited at the "DGD" buoy since November, 1985; given the area of the seafloor covered with dredged material as detected by REMOTS® technology, the entire volume deposited can be accounted for if one assumes an average thickness of 27 cm for those areas around the disposal point where the dredged material exceeded the prism penetration limits.

The fact that mean apparent RPD depths have not changed at the disposal area between surveys is not surprising, because disposal operations have been occurring steadily up to the time of each REMOTS® survey. The difference in RPD depths between the disposal area and Reference Station is due to the frequency of disturbance from disposal operations, the shallower depth of bioturbation on the dredged material, and possibly because of higher BOD and COD in the dredged materials.

The major change in OSI values detected between last year's survey and the present survey at the disposal area is the appearance of negative values in the 1987 data set. This is attributed to the appearance of reducing sediments and poorly colonized dredged material at Station 200S and 300S (Figures 3-7 and 3-8). Even though the OSI for Station 100N cannot be calculated because it is not possible to evaluate the RPD depth for this station, this location appears to be devoid of colonizing benthos and apparently has a relatively low index value as well.

4.3 Sediment Characterization

The sediment chemistry data collected were analyzed with the intent of finding unique compound ratios that could be used for specifically detecting the GE/Blue Circle sediment in future sampling efforts. If characteristic ratios were identified, results of sediment chemical analyses from sampling after capping could be used to study the effectiveness of the capping operation. For example, chemical analyses conducted on the Saugus River/General Electric material before dredging indicated relatively high PCB (ranging from below detection to 3.0 ppm) but low copper (60-93 ppm) concentrations. Therefore, if this relation was also found at the disposal site, the PCB/copper ratio would have been potentially useful in identifying this material.

The data presented in Table 3-1, however, shows that the PCB concentration is not very high at the disposal area (<0.02 - 0.30 ppm). The measured concentrations are about a factor of ten lower than those measured at the site of dredging. The concentrations of PCBs and copper are both similar to those that have been measured on other dredged materials at FADS (SAIC, 1986b); therefore, this ratio is both different from that found in the material at the dredge site and also not unique as far as previous measurements made at the disposal site.

The mercury concentrations measured at the disposal area (Table 3-1) are relatively high compared to those measured both on and off of dredged material at FADS (SAIC, 1986b). Mercury concentrations were particularly high in relationship to the other parameters measured. Therefore, the ratio of mercury to one of the other elements might be a better tag.

The ratios of several parameters were calculated for the samples analyzed in the present study and for other data from FADS (SAIC, 1986). The most promising of these appeared to be the arsenic/mercury ratio. This ratio was 33 ± 10 (range 21 - 48) for samples from the present survey and 111 ± 25 (range 63 - 250) for other areas both on and off of dredged material at FADS (SAIC, 1986b). The disadvantage to using mercury is that for many areas away from dredged material, the mercury concentrations have been reported to be below detection. This, of course, may greatly limit the usefulness of this method. Mercury does occur at some level in all of the sediments and could be measured with additional analytical effort. This, however, could increase the costs of the analyses.

In order to determine the number of replicates required to detect a 50% difference between any sediment samples from the mound and the ambient seafloor for the chemical contaminants measured with 80% certainty at a 5% level of significance, the following formula was used:

$$n \geq 2 \left(\frac{\sigma}{\delta}\right)^2 \{t_{\alpha[\nu]} + t_{2(1-P)[\nu]}\}^2$$

where n = number of replications

σ = true standard deviation

δ = the smallest true difference that is desired to detect. (NOTE: it is necessary to know only the ratio of σ to δ, not their actual values)

ν = degrees of freedom of the sample standard deviation ($\sqrt{MS_{within}}$) with α groups and n replications per group

α = significance level (such as 0.05)

P = desired probability that a difference will be found to be significant (if it is as small as δ)

$t_{\alpha[\nu]}$ and $t_{2(1-P)[\nu]}$ = values from a two tailed t-table with ν degrees of freedom and corresponding to probabilities of α and 2(1 - P), respectively

Results from this calculation determined that to detect this level of difference in sediment samples analyzed for chromium required 2 replicates; arsenic, copper, and zinc, 4; lead, mercury, and total organic carbon, 10; PCBs, 12; and petroleum hydrocarbons, 15. Because only 10 sediment samples from the disposal area were analyzed, additional replicates for PCB and petroleum hydrocarbon analyses would be required in order to meet the detection criteria stated above.

5.0 CONCLUSIONS

The combined data from the bathymetric and REMOTS® surveys suggest that the most recent (November 1985 to February 1987) disposal operations produced a relatively thin deposit (i.e., less than 30 cm) on the bottom that is spread over an area with a 500-600 m radius. Although the depth of water (90 m) and the behavior of dredged material during descent have a significant effect on the dispersion of the dredged material on the bottom, disposal operations occurring within a radius of over 300 meters (Figure 4-1) could be expected to produce a deposit of dredged material of this morphology. However, until controlled experiments are conducted, the actual effect of either depth or scow locations on the distribution of dredged material on the bottom can not be determined.

By using REMOTS® technology, estimates of dredged material volume detected at the site showed fair agreement with scow log disposal volumes. The persistence of Stage III infaunal successional assemblages in this area suggest that the 20 - 27 cm layer of deposited material accumulated at a slow rate over the 14 months of disposal operations and that there were no quantum inputs of sediment thick enough to eliminate the larger deposit feeders. REMOTS® criteria suggest that the material from the most recent operations (GE and Blue Circle) is located at Stations 100N, CTR, 100E, 200S, and 300S. Material from the Blue Circle dredging operation (overconsolidated mud clasts) is most likely present at 100N and possibly 100E. Medium sand from the Saugus River (GE disposal operation) project may be present at Station 100E. The balance of material at the above stations consists of fine-grained, reducing sediments.

The results of sediment chemistry analyses showed that sufficient replicates were analyzed to detect differences among sediment samples at an 80% level of precision for all contaminants measured with the exception of PCBs and total petroleum hydrocarbons. The concentrations of most parameters measured in sediment from the disposal area were generally low. In particular, PCB concentrations were considerably lower than expected and would probably not be useful as tracers of this material. Examination of the chemical data from the FADS sediment samples for a unique chemical marker of the dredged material from the Saugus and Mystic River projects indicated that the most promising signature was the ratio of arsenic to mercury. Use of this ratio, however, at the disposal site was limited by the low levels of mercury at some locations.

Overall, the existing data do not show that the Saugus River/General Electric and Mystic River/Blue Circle Atlantic sediments can be detected chemically at the FADS; there are many possible reasons for this. Likely explanations could include inadequate characterization of the material from the dredge site and/or imprecise location information on where these materials were deposited. Given the fact that the total volume of these projects was less than 15% of the entire amount disposed at the "DGD" buoy since its deployment in November 1985, it is not very surprising that a unique chemical signature for these two maintenance projects cannot be found at the disposal site.

6.0 REFERENCES

Plumb, R.H. 1981. Procedures for Handling and Chemical Analysis of Sediment and Water Samples. Technical Report EPA/Ce-81-1.

SAIC. 1986a. Seasonal Monitoring Cruise at the New London Disposal Site, July 1986. SAIC Report #86/7540&C60, US Army Corps of Engineers, New England Division, Waltham, MA. DAMOS Contribution #60.

SAIC. 1986b. Environmental Information in Support of Site Designation Documents for the Foul Area Disposal Site. Submitted to U.S Army Corps of Engineers, New England Division, Waltham, MA, SAIC Report No. SAIC-85/7528&93.

Table 1-1

Contaminant Concentrations in Dredged Material from the Saugus River/General Electric and Mystic River/Blue Circle Atlantic Projects

(Concentrations in ppm dry weight)

	Saugus River/ General Electric						Mystic River/ Blue Circle Atlantic	
SAMPLE #	1	2	3	4	5	6	1	2
Mercury	5.30	0.58	1.70	1.20	0.93	1.30	1.50	0.95
Arsenic	**	**	**	**	**	**	31	20
Lead	77	84	70	170	110	130	250	290
Zinc	**	**	**	**	**	**	240	440
Chromium	150	130	150	250	170	190	55	200
Copper	70	75	60	93	69	79	130	240
Cadmium	2.5	4.2	1.9	3.2	3.1	5.1	0.64	4.5
Nickel	**	**	**	**	**	**	15	38
Total PCBs	1.9	3.0	2.7	ND	2.9	3.0	<0.5	2.8

** Not Analyzed

ND = Not Detected

Table 3-1

Results of Chemical Analyses of Sediment Collected at FADS
January 1987

(Concentrations in ppm dry weight, except % TOC)

SAMPLE #	1	4	5	6	8	9	10	11	12	14
Mercury	0.31	0.30	0.40	<0.10	0.49	0.37	0.23	0.23	0.30	<0.10
Arsenic	12.2	6.5	15.0	12.7	10.4	11.4	9.6	9.8	14.5	9.7
Lead	94	67	144	117	116	146	81	54	40	<12
Zinc	143	127	183	150	166	134	127	95	113	80
Chromium	63	<58	60	72	87	85	68	<58	72	<58
Copper	79	59	87	77	88	67	73	54	56	35
Cadmium	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Nickel	<38	<38	<38	<38	<38	<38	<38	<38	<38	<38
TOC (%)	0.50	0.75	0.01	0.94	0.79	0.80	0.90	0.84	0.53	0.03
PHC*	1300	620	1100	830	990	510	680	340	250	<50
Total PCBs	0.12	0.11	0.14	0.23	0.07	0.20	0.10	0.15	0.30	<0.02
DDTs	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

* Petroleum Hydrocarbons

Table 4-1

Project Volumes Disposed at "DGD" Buoy
Since the January 1986 REMOTS Survey.

Volume (m^3)		Dates
64,130		2/01/86-5/15/86
25,857	(Blue Circle)	7/18/86-7/26/86
4,010	(GE)	9/4/86-10/29/86
93,997	TOTAL	

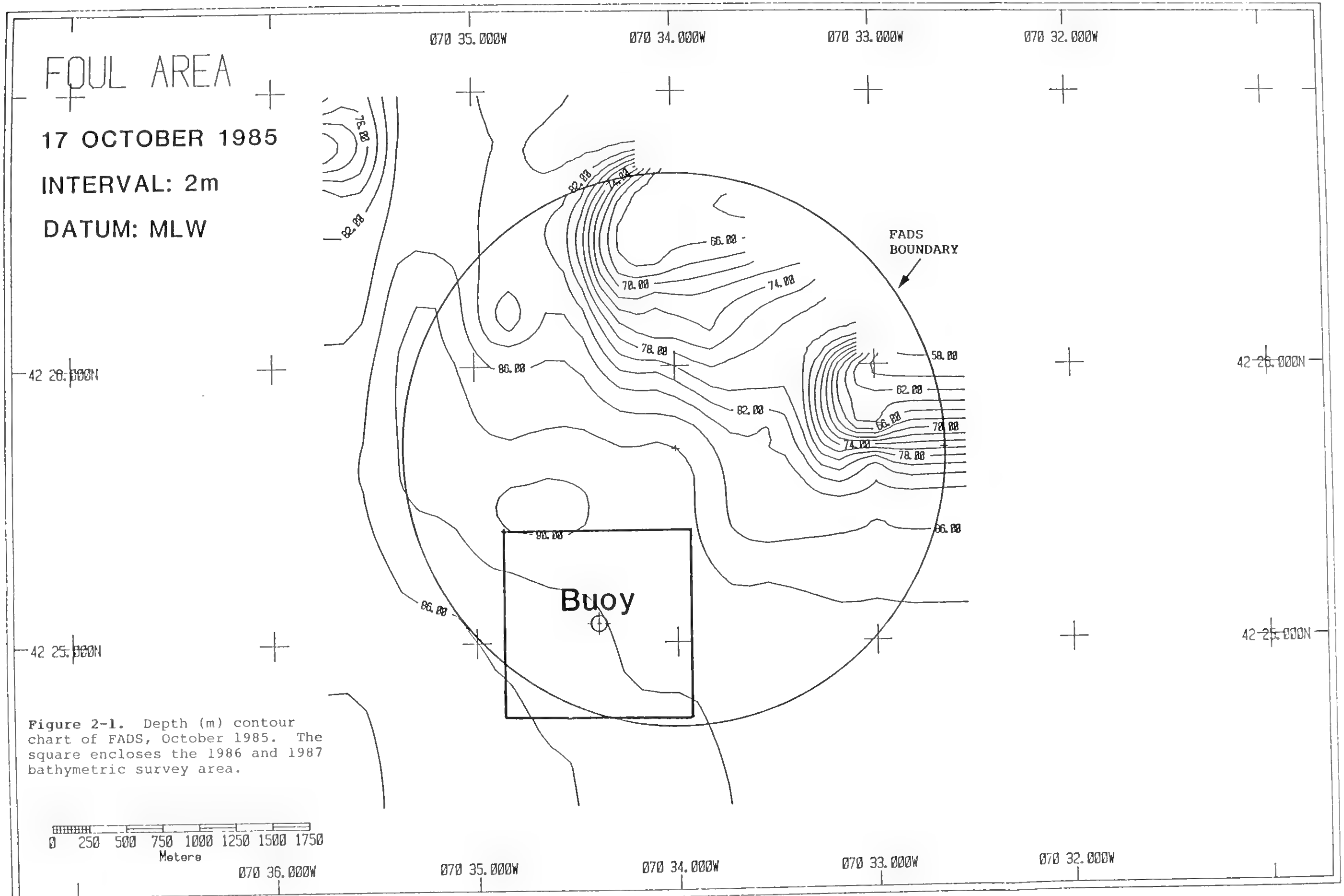


Figure 2-1. Depth (m) contour chart of FADS, October 1985. The square encloses the 1986 and 1987 bathymetric survey area.

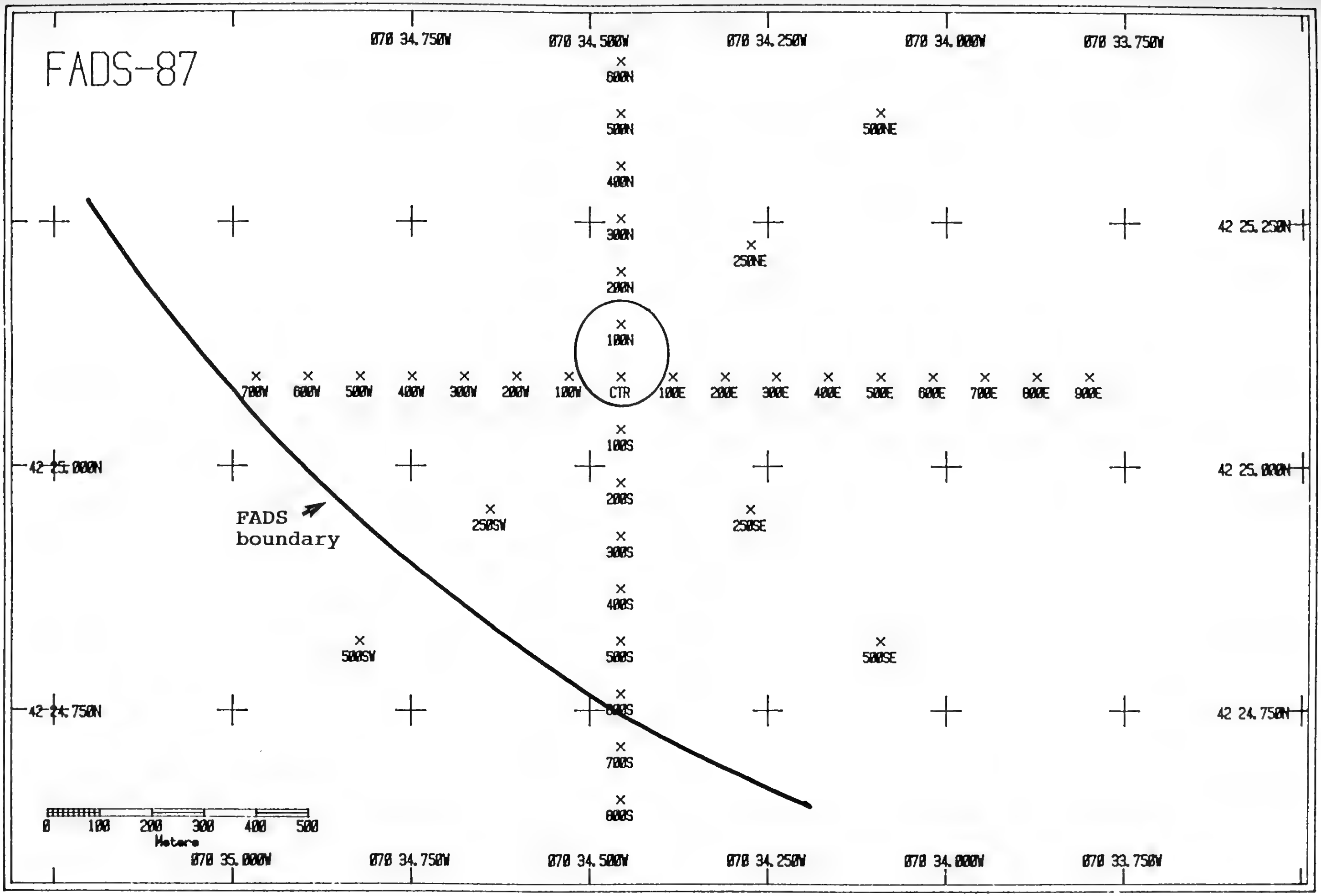


Figure 2-2. Map showing location of REMOTS® stations sampled on 2 February 1987. Circle indicates site of sediment samples.

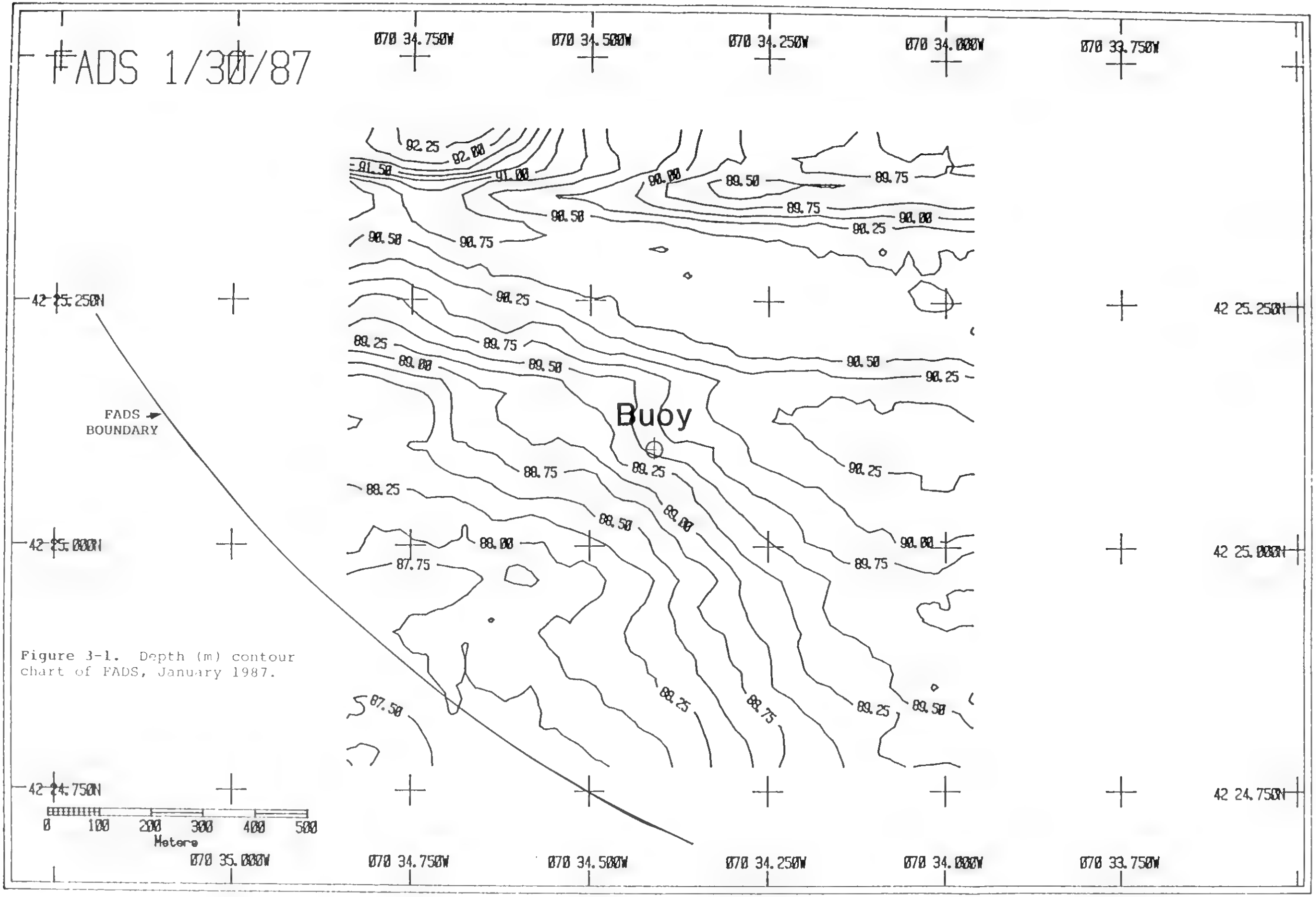


Figure 3-1. Depth (m) contour chart of FADS, January 1987.

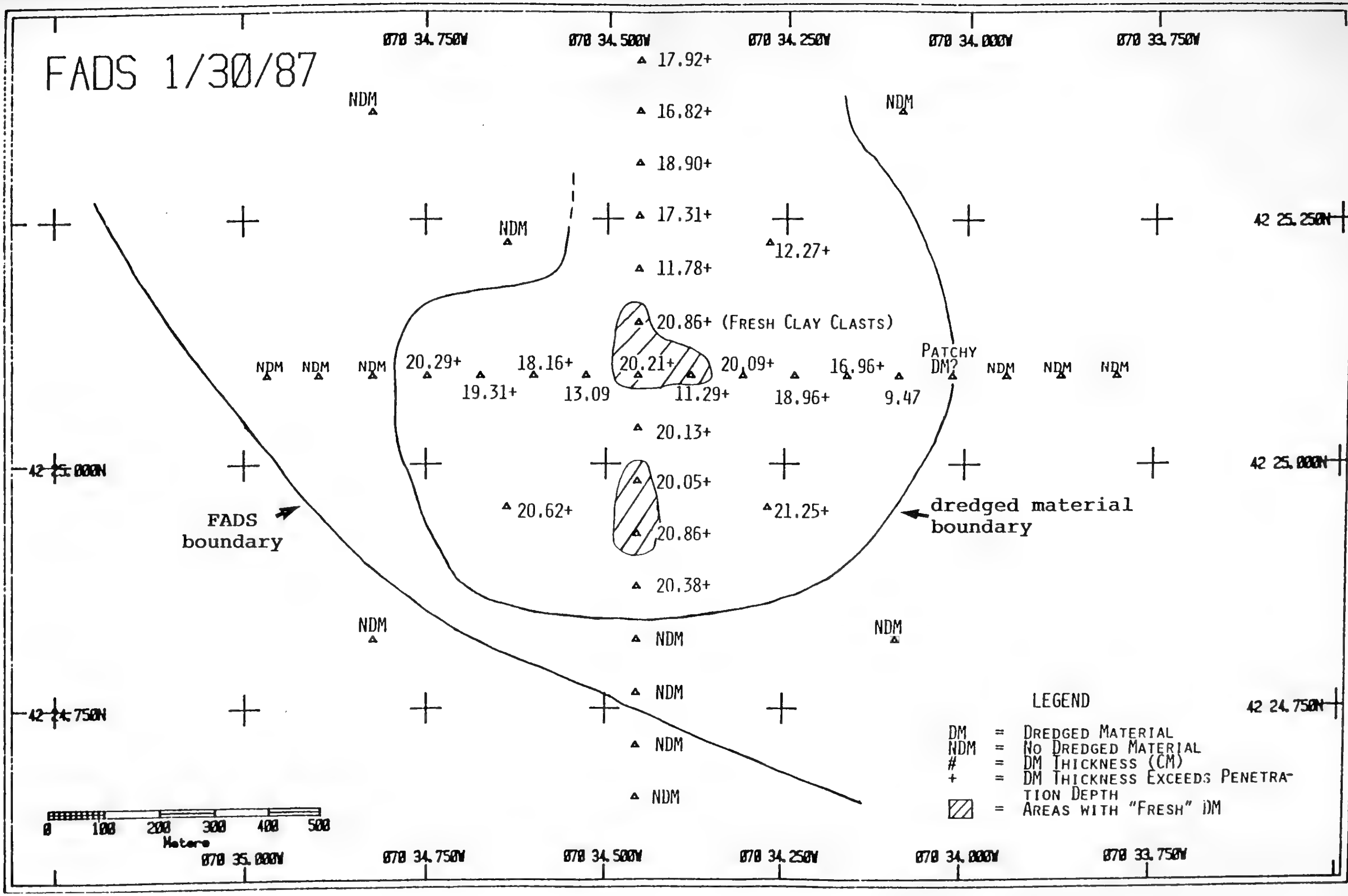


Figure 3-2. Map showing distribution of dredged material as determined from REMOTS® images.

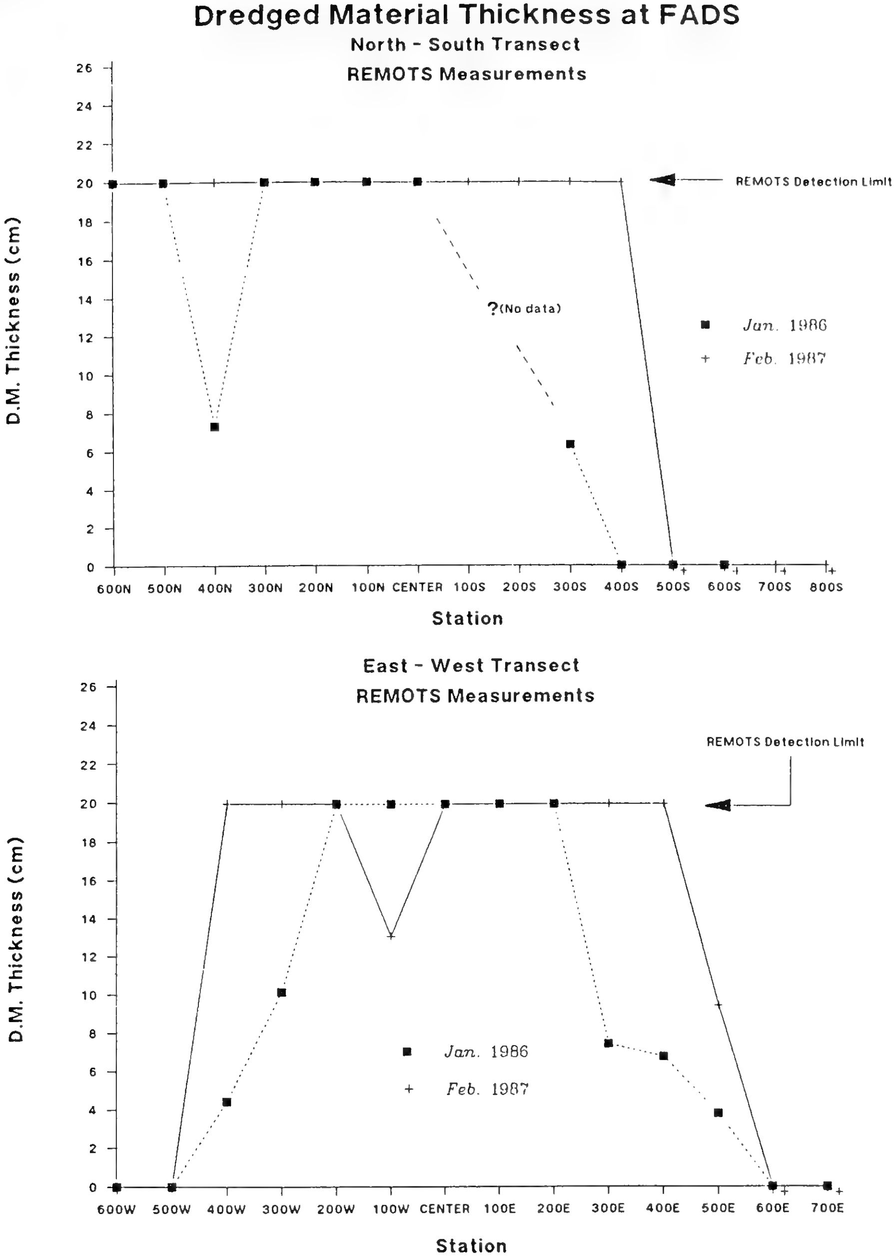


Figure 3-3. Comparison of north-south and east-west transects of dredged material thickness as determined from REMOTS® images from January, 1986 and February, 1987. Stations where dredged material exceeded REMOTS® prism penetration were assigned the maximum value of 20 cm.

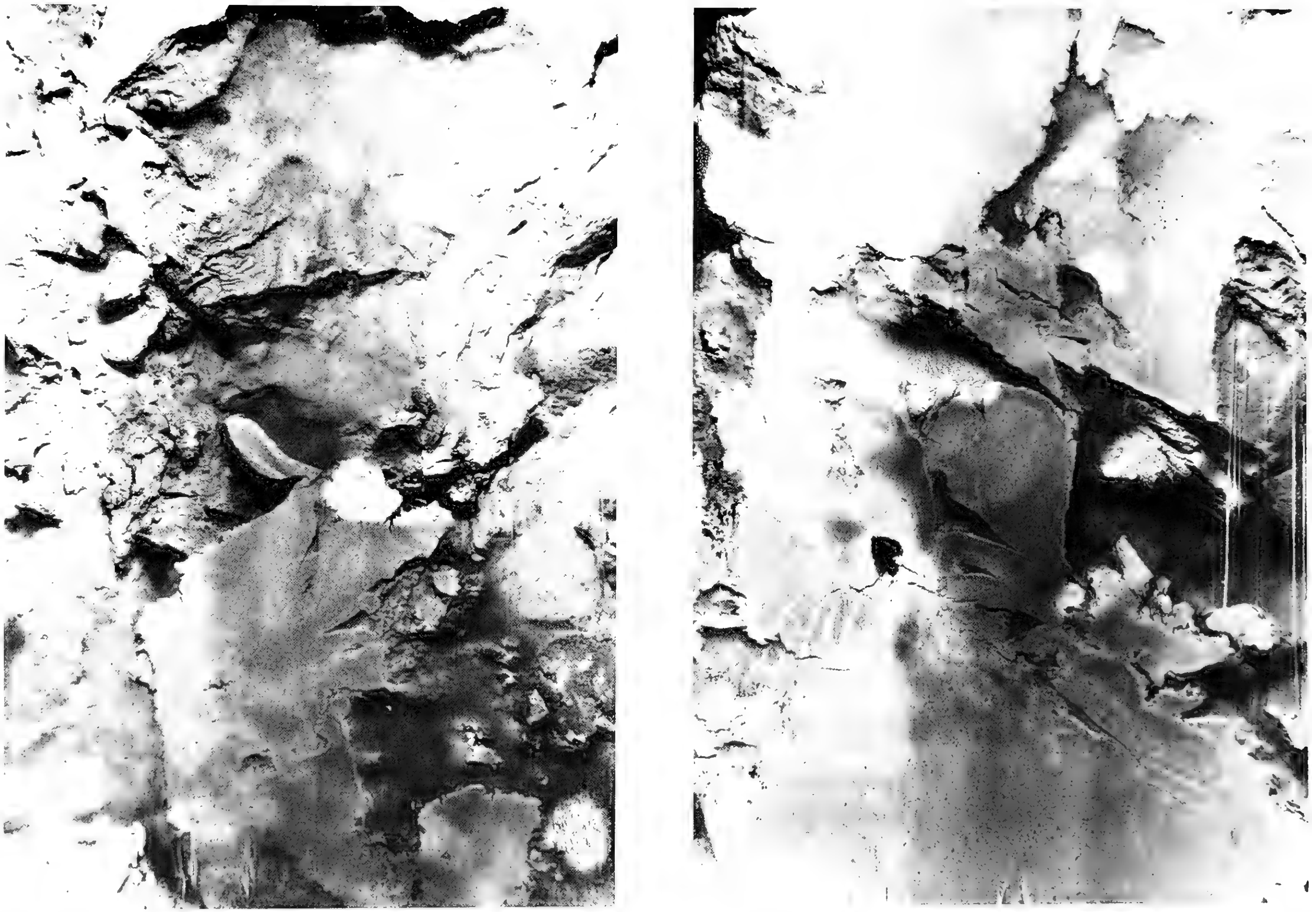


Figure 3-4. REMOTS images form Station 100N showing overconsolidated clay clumps, presumed to be remnants of Blue Circle Atlantic disposal operations. Width of photo = 15.2 cm.

Figure 3-5. REMOTS image from Station Center showing fine-grained, reduced sediment at the sediment-water interface, inferred to be recently deposited dredged material. Width of photo = 15.2 cm.

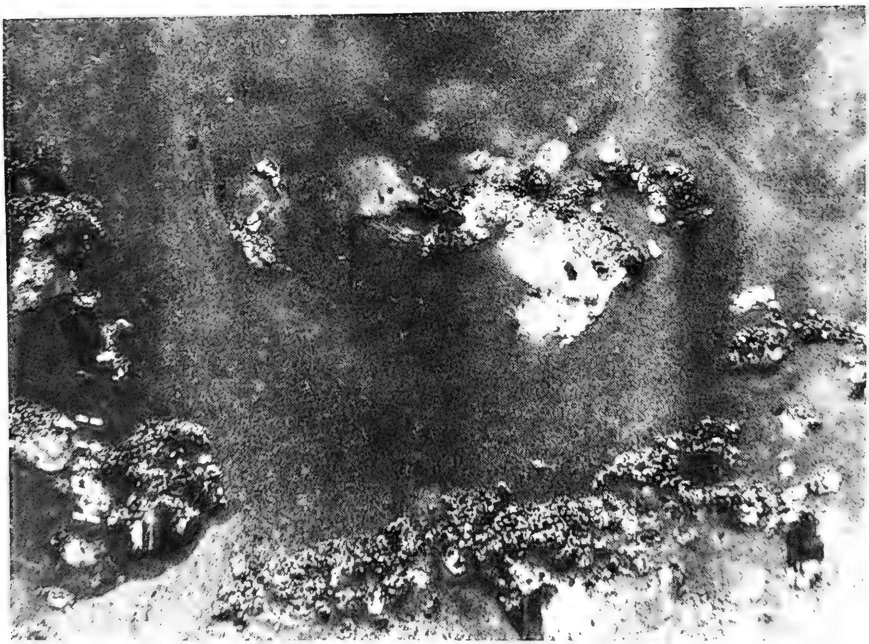
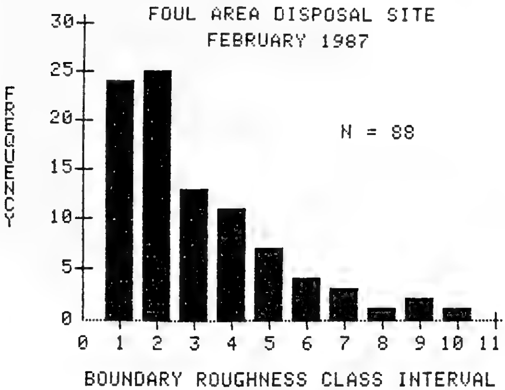


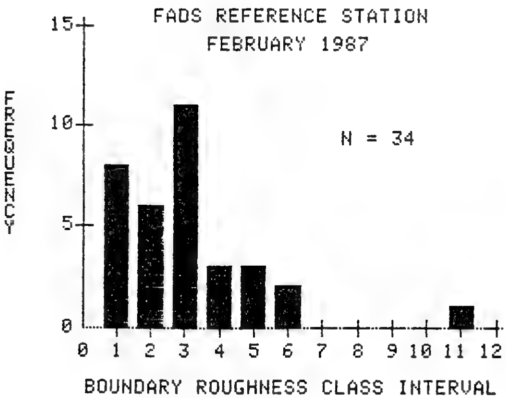
Figure 3-6. REMOTS image from Station 100E showing poorly-sorted sediment grain-size, with medium sand admixed with silt/clay; this is typical sedimentary fabric for newly deposited material. Scale = 1X.

Sediment-water interface →

Figure 3-7. REMOTS image from Station 200S showing reduced sediment at the sediment-water interface.
Scale = 1X.

Figure 3-8. REMOTS image from Station 300S showing an apparently azoic condition with reduced sediment present at the sediment-water interface. Width of photo = 15.2 cm.





KEY

Class Interval	Range of Values (cm)
1	0.0 - 0.6
2	0.6 - 1.0
3	1.0 - 1.4
4	1.4 - 1.8
5	1.8 - 2.2
6	2.2 - 2.6
7	2.6 - 3.0
8	3.0 - 3.4
9	3.4 - 3.8
10	3.8 - 4.2
11	4.2 - 4.6
12	4.6 - 5.0

Figure 3-9. The frequency distribution of small-scale boundary roughness values measured from REMOTS® images taken at the disposal area and the FADS Reference Station.

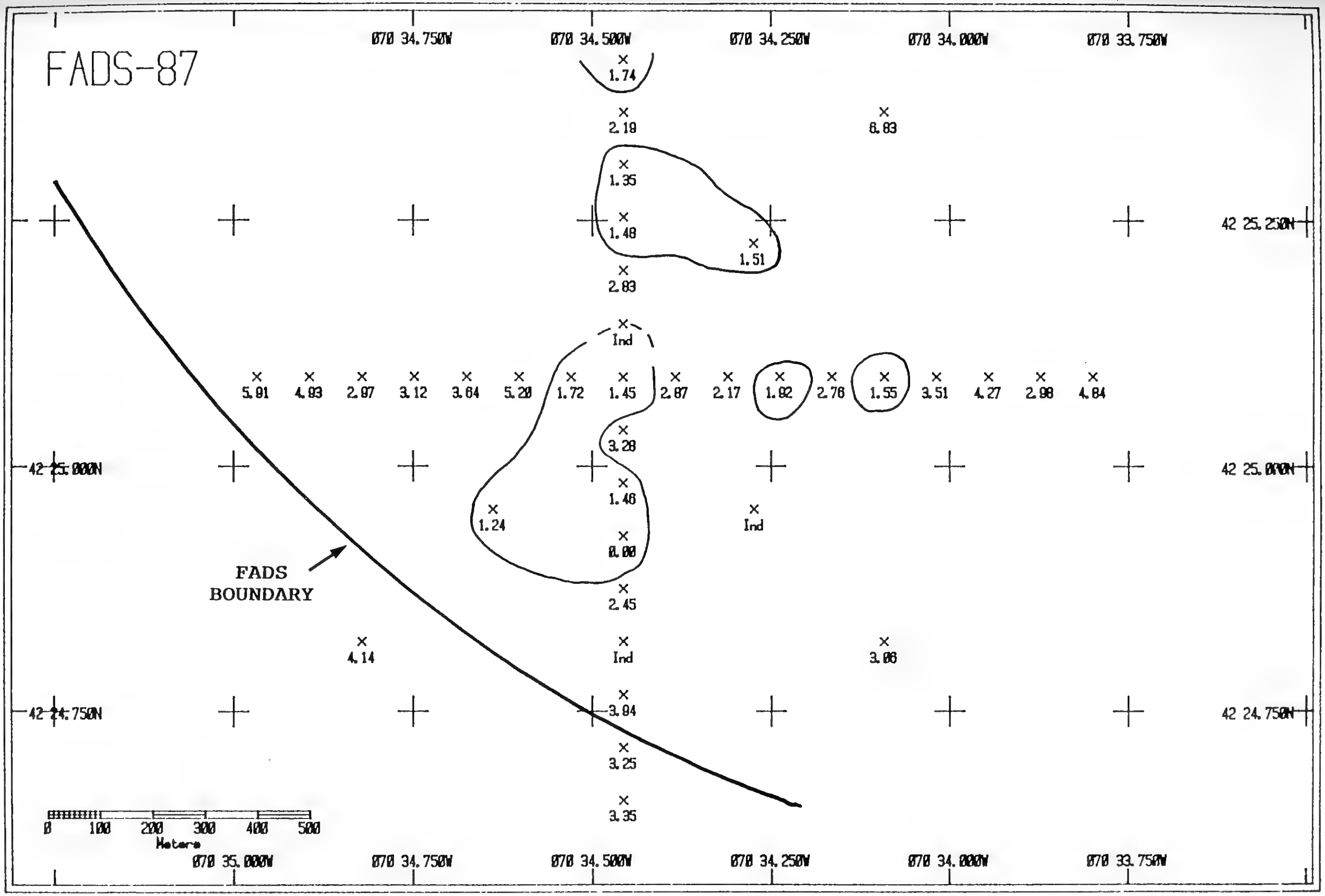


Figure 3-10. Spatial distribution of average apparent RPD depth (cm) from disposal area. The contours delimit areas where the apparent RPD depth is less than 2 cm. RPD depth was indeterminate at stations labelled Ind.

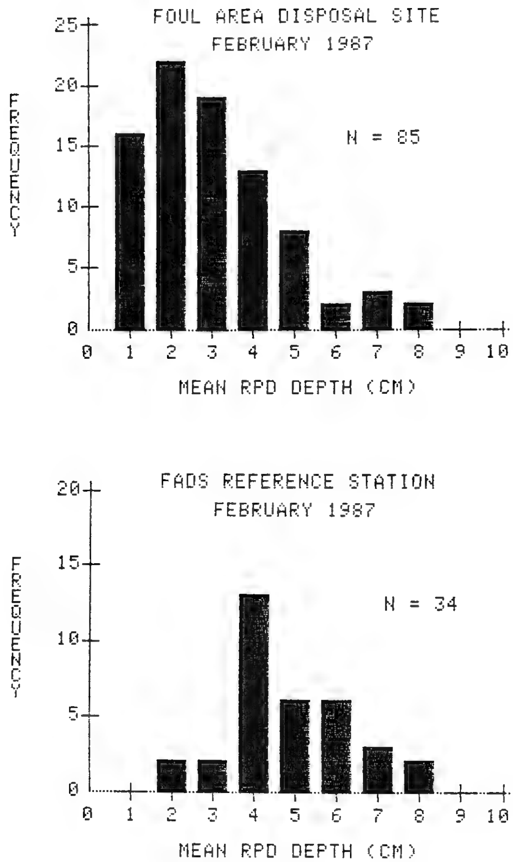


Figure 3-11. Frequency distribution of mean apparent RPD depth measured from REMOTS® images taken at the disposal area and the FADS Reference Station.

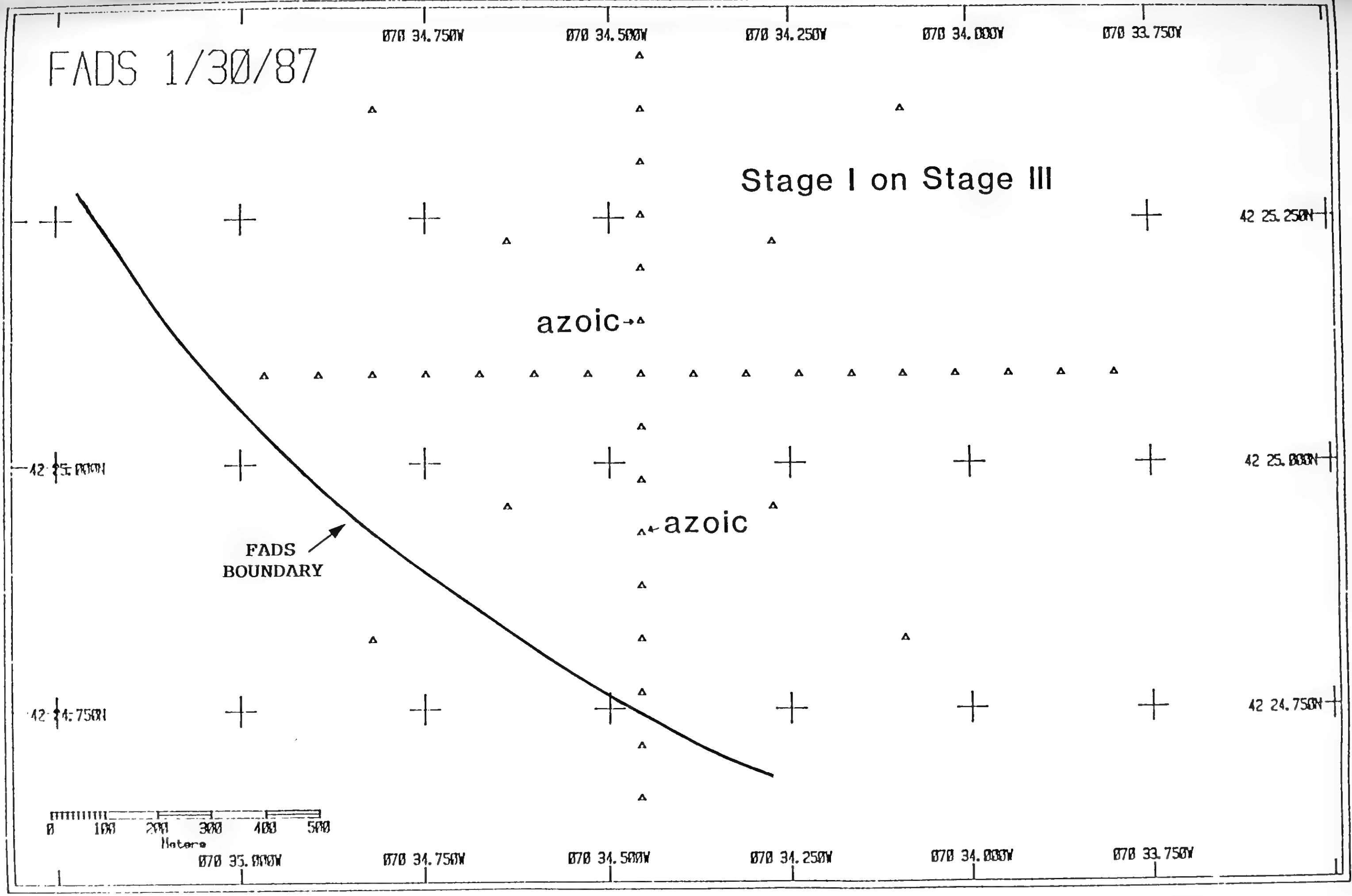


Figure 3-12. Infaunal successional stages observed at the disposal area. Two stations were apparently devoid of macrofauna. All remaining stations exhibited Stage I associated with Stage III seres.

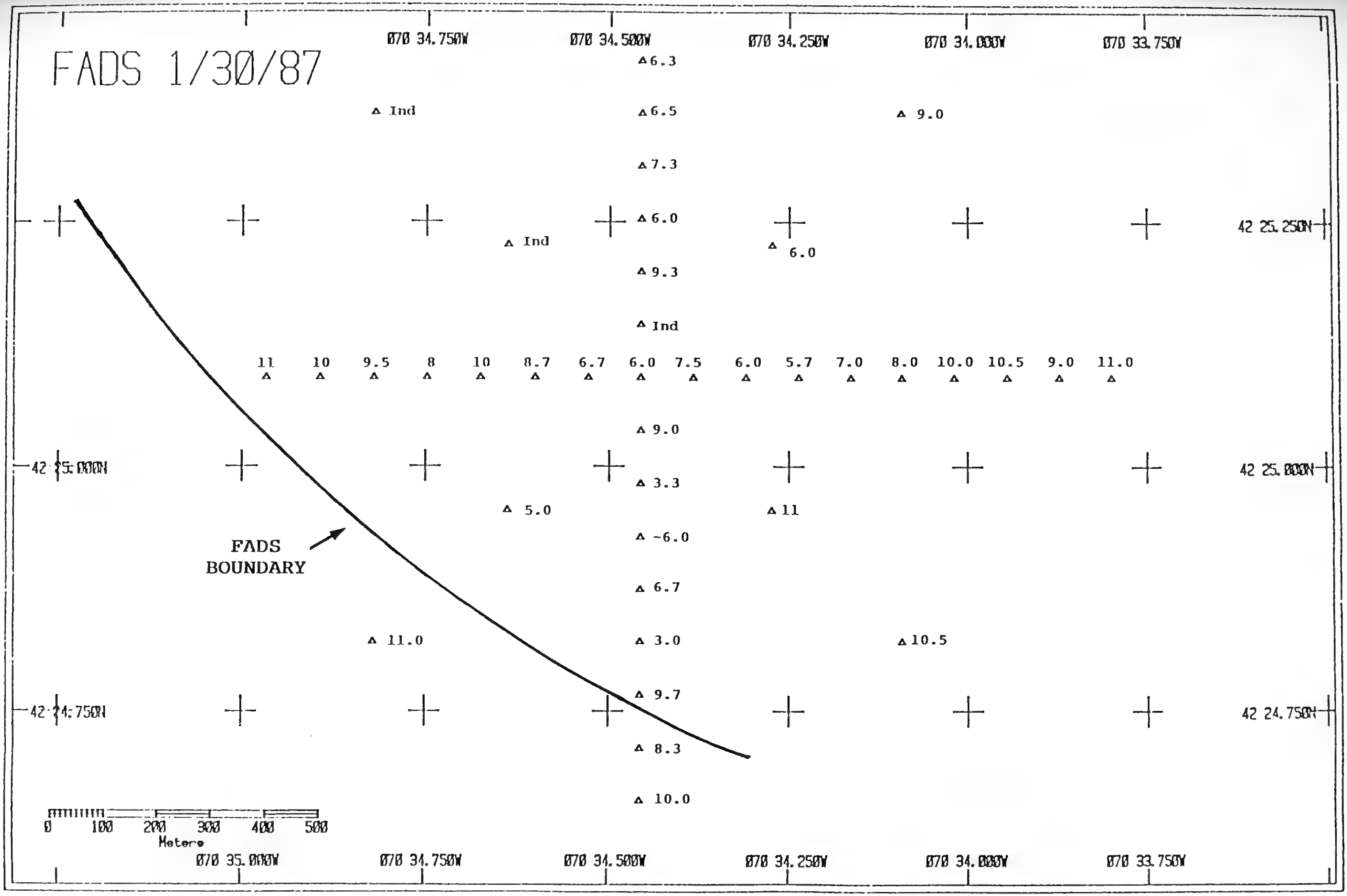


Figure 3-13. Spatial distribution of REMOTS® Organism Sediment Index values, averaged by station, at the disposal area. An Ind indicates that the Index was indeterminate.

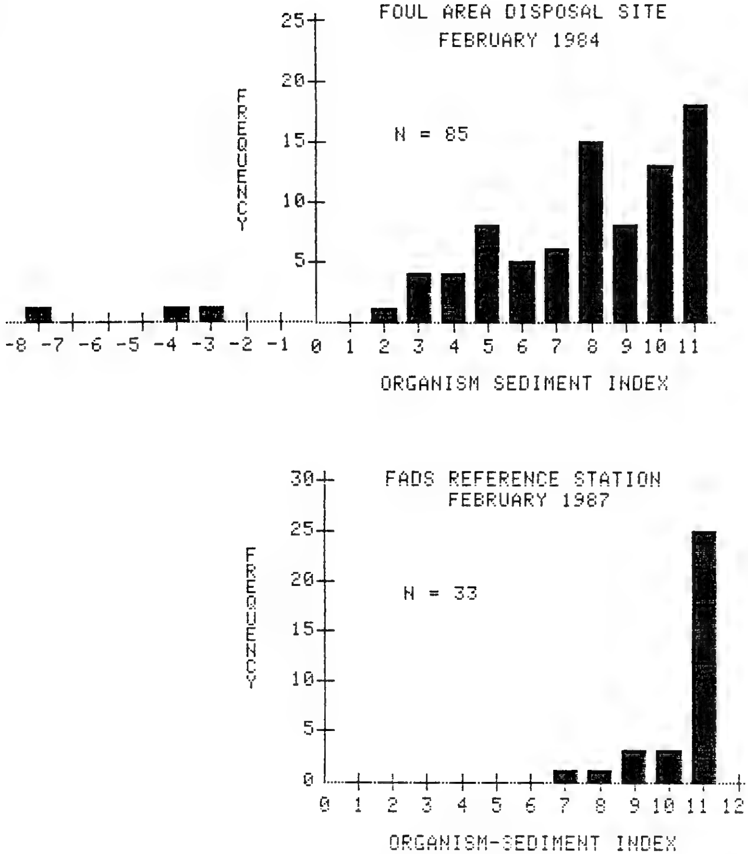


Figure 3-14. Frequency distribution of REMOTS® Organism Sediment Index values at the disposal site and FADS Reference Station.

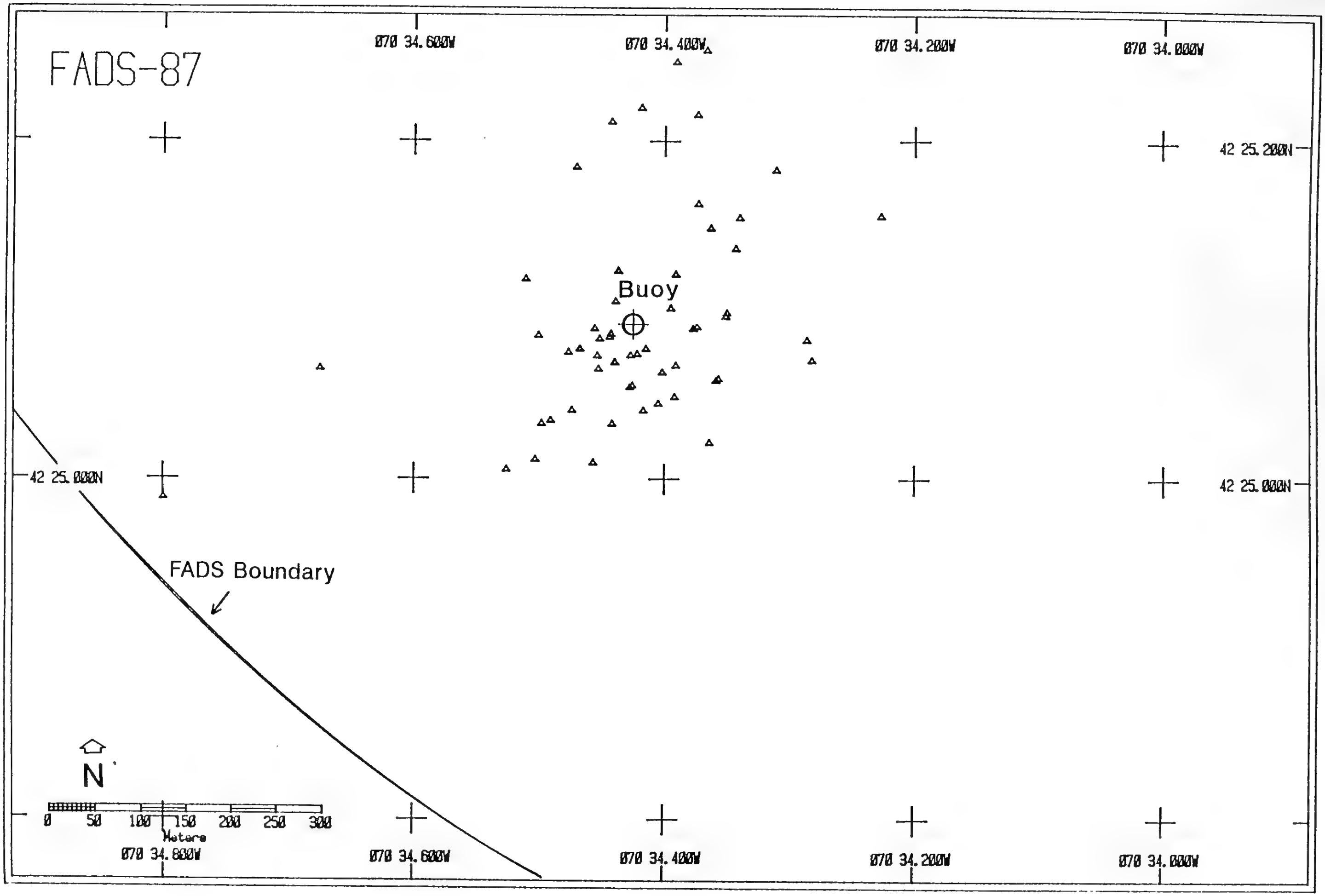


Figure 4-1. Distribution of actual locations of scows during disposal operations at FADS. Locations obtained as LORAN-C TD's from NED scow logs.

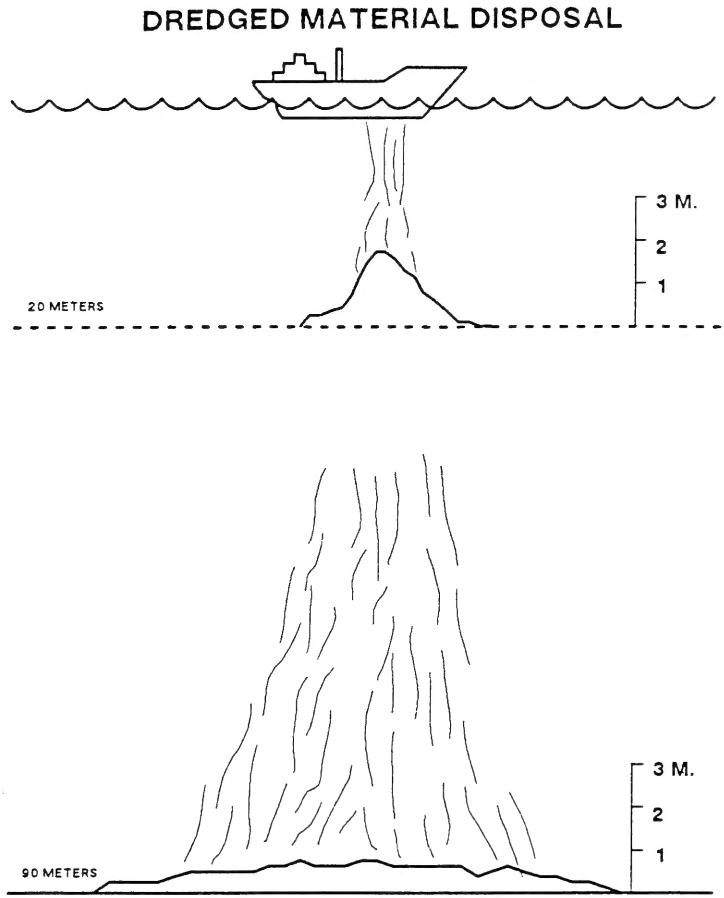


Figure 4-2. Schematic representation showing the fate of dredged material disposed in shallow (e.g., Long Island Sound) and deep water (e.g., FADS); the same volume of material would be spread out over a greater distance at greater depths.

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