Monitoring Cruise at the
Portland Disposal Site
July 1992

Disposal Area Monitoring System DAMOS

D A M O S

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13. ABSTRACT

Between October 1991 and June 1992, a capping project was conducted at the Portland Disposal Site (PDS) as part of the Disposal Area Monitoring System (DAMOS) Program. Fine-grained dredged material from the US Coast Guard project in South Portland (13,270 m^3) was capped with cleaner fine-grained sediment from the same project (19,451 m^3), as well as with sandy material from the Northeast Petroleum project (18,310 m^3)

Science Applications International Corporation (SAIC) conducted a monitoring cruise at PDS in July 1992. The survey was designed to map the areal extent of dredged material at the site, to determine the effectiveness of the capping operation, and to obtain sediment chemistry data on the cap and at the reference areas. The field work included a REMOTS® sediment-profile survey, a bathymetric survey, an acoustic sediment density study, and sediment sampling for chemistry and grain size.

Based on the REMOTS® survey, the areal extent of dredged material at PDS ranged from 200 m west of the disposal buoy to 700 m southwest of the buoy location. The bathymetric survey, when compared to the previous bathymetric survey in January 1989, showed accumulations up to 0.75 m thick within 200 m of the buoy. The comparison of the 1989 and 1992 bathymetric surveys also indicated an area of accumulation 500 m south of the buoy. This corresponded to the southernmost detection of dredged material from the REMOTS® survey in an area that received dredged material after 1989.

The acoustic sediment density survey showed that, in general, the coarser grained sediment was concentrated in water depths shallower than 54 m, and the finer grained sediment was concentrated in the deeper areas. The acoustic data were patchy and, after smoothing, precluded identification of the project cap material. The patchiness was attributed to both the heterogeneity of dredged material and the rapidly changing slopes in the survey area.

Sediment chemistry data from the surface of the cap showed that contaminant concentrations were within the ranges measured at PDS reference areas, indicating that the cap was effectively isolating contaminants. Two stations, F7 and H5 near the location of a historical (1984) disposal buoy, showed elevated levels of several metals, though these levels *were similar to the cap material and much less than the contaminated material that was disposed. delete the following* [potentially attributed to the disposal of contaminated material at.] A comparison of the metal and polycyclic aromatic hydrocarbon (PAH) baseline chemistry data from PDS reference areas and data collected by the National Oceanographic and Atmospheric Administration (NOAA) National Status and Trends (NS&T) Program for the Gulf of Maine showed that the PDS reference areas were well within the ambient values for metals and PAHs in the area (NOAA 1991).

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EXECUTIVE SUMMARY

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Sediment chemistry data from the surface of the cap showed that contaminant concentrations were within the ranges measured at PDS reference areas, indicating that the cap was effectively isolating contaminants. Two stations, F7 and H5, showed elevated levels of several metals, although metal levels were overall within the range measured in samples collected in the cap material prior to dredging. A comparison of the metal and polycyclic aromatic hydrocarbon (PAH) baseline chemistry data from PDS reference areas and data collected by the National Oceanographic and Atmospheric Administration (NOAA) National Status and Trends (NS&T) Program for the Gulf of Maine showed that the PDS reference areas were well within the ambient values for metals and PAHs in the area (NOAA 1991).

1.0 INTRODUCTION

The Portland Disposal Site (PDS) is located in Bigelow Bight, 7.1 nmi east of Dyer Point on Cape Elizabeth, Maine (Figure 1-1). It is one of ten regional dredged material disposal sites in New England managed by the US Army Corps of Engineers, New England Division (NED), as part of the Disposal Area Monitoring System (DAMOS) Program. The Portland Disposal Site was first used for the disposal of dredged material in 1979. Since then, it has been periodically monitored as part of the DAMOS Program. The site is a 1 nmi square with sides running true north-south and east-west, centered at 43°34.100′ N, 70°02.000′ W, North American Datum 1927 (NAD 27). It is characterized by a flat, sandy valley, surrounded by rocky outcrops. Water depths range from 42 m on the hard rock ridges to 64 m in the valleys.

In January 1989, a bathymetric survey and a REMOTS® survey were conducted at the site. From January 23, 1989 to November 15, 1990, 14,810 m^3 of dredged material was released near the PDS buoy location (43°34.270′ N, 70°01.968′ W). Most of this material came from the Portland International Terminal and the Royal River Boatyard. On January 31, 1989, one barge load of material (412 m^3) was recorded as being released at 43°34.100′ N, 70°01.900′ W. The next series of disposal events, from March 18 to April 30, 1991, (6,193 m^3) was also released near 43°34.100′ N, 70°01.900′ W. Navigational charts and the USCG light list do suggest that a buoy may have been at that location during these disposal events.

In October 1991 a capping project was begun at PDS. This project at PDS set a precedent among DAMOS capping projects since the water depths at the site are much greater than 20 m (20 m is the average water depth for Long Island Sound sites). From October 1991 through January 1992, 13,270 m^3 of material that was determined to be unsuitable for unconfined open ocean disposal was released at or near the buoy (43°34.270′ N, 70°01.968′ W). One barge load of this material (625 m^3) was reported released at 43°34.100′ N, 70°01.900′ W on November 8, 1991. All material unsuitable for unconfined open water disposal came from the US Coast Guard (USCG) project in South Portland and consisted of 75-86% silt/clay contaminated with moderate to high levels of metals.

In January 1992, Science Applications International Corporation (SAIC) conducted postdisposal, precapping bathymetric, and REMOTS® surveys at PDS for C&B Marine. The results of these surveys were used to map the location of the dredged material and to determine disposal points for subsequent cap placement.

Capping began in January 1992 and was completed in June 1992. The cap material (37,761 m^3) consisted of fine-grained material from other portions of the USCG project (19,451 m^3) and sandy material (70-86% sand) from the Northeast Petroleum project

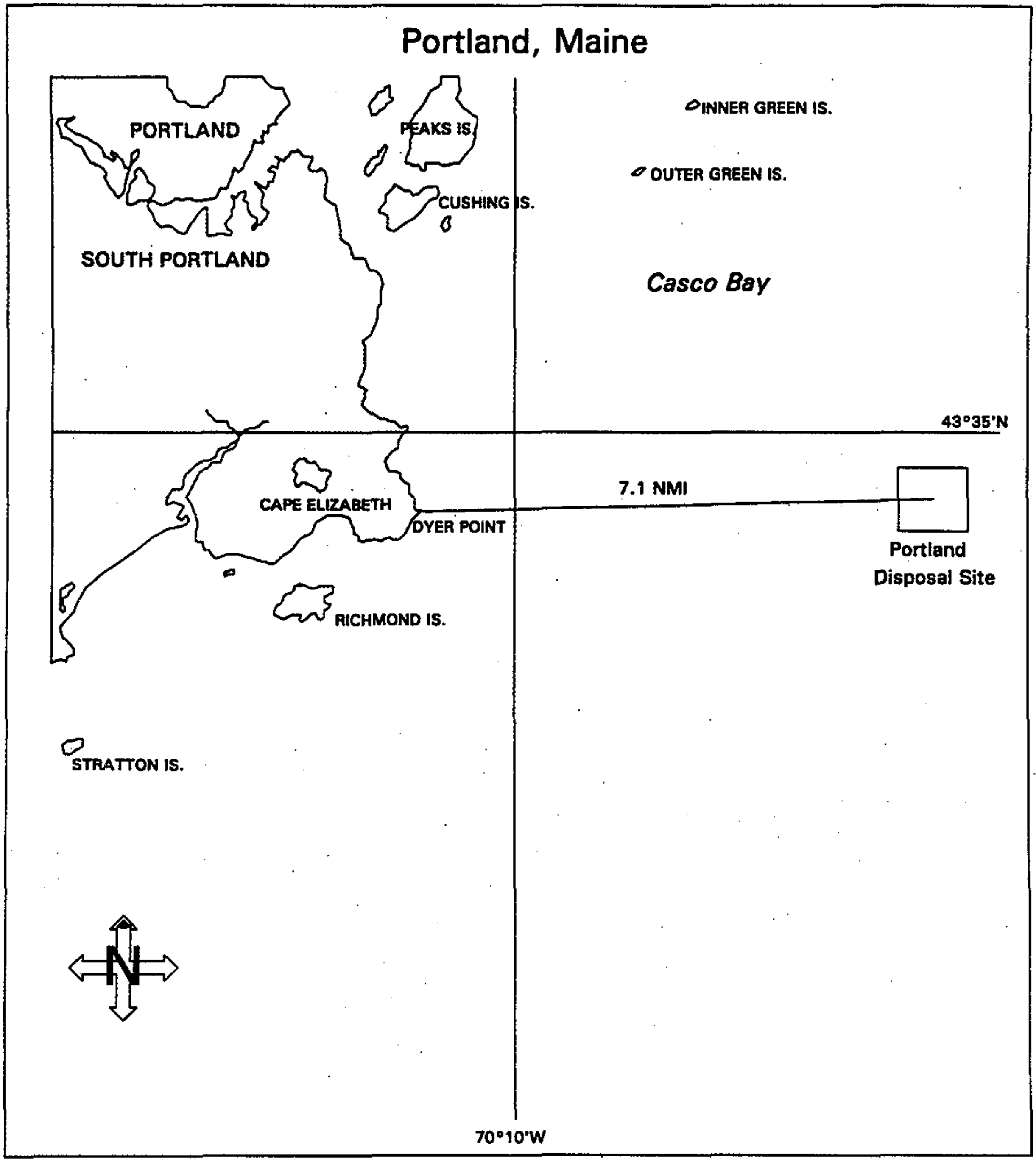

Figure 1-1. Location of the Portland Disposal Site in relation to Cape Elizabeth, ME

(18,310 m^3). The cap materials from both projects, coarse- and fine-grained, were released concurrently, confounding physical differentiation between the silt/clay contaminated material and the silt/clay and sand cap. Additional material (about 2,700 m^3) from a project at the Merrills Marine Terminal was released at the same location during late June and early July 1992.

Once finished, the capping project was expected to cover the material that was unsuitable for unconfined open ocean disposal with at least 30 cm of cap. Because the cap material was released at the site within a few months of the survey, the benthic community around the buoy was expected to be in a relatively early stage of colonization, with the frequency of Stage I organisms at the buoy being greater than at the reference areas.

2.0 METHODS

The July 1992 survey at PDS was designed to map the extent of dredged material at the site, to evaluate the status of benthic recolonization, and to determine the effectiveness of the capping operation by obtaining sediment chemistry data on site and at the reference areas. To accomplish this, SAIC conducted a bathymetric survey, a REMOTS® sediment-profile survey, an acoustic sediment density study, and sediment sampling for chemistry and grain size.

2.1 Bathymetry and Navigation

The precision navigation required for all field operations was provided by the SAIC Integrated Navigation and Data Acquisition System (INDAS). This system uses a Hewlett-Packard 9920 series computer to collect position, depth, and time data for real-time navigation. Contribution No. 60 (Parker and Revelas 1989) contains a detailed description of INDAS and its operation. Positions were determined to an accuracy of ±3 meters from ranges provided by a Del Norte Trisponder® System. All positions are in datum NAD 27. For the present survey, shore stations were established at known benchmarks: Cape Elizabeth Light (43°33.959′ N, 70°12.034′ W) and Portland Head Light (43°37.381′ N, 70°12.502′ W).

The July 1992 PDS bathymetric survey was set up over the same area used in January 1989. The 900 × 1100 m area consisted of 45 lanes oriented east and west with 25 m lane spacing. An ODOM DF3200 Echotrac® Survey Recorder with a narrow-beam 208 kHz transducer recorded depth to a resolution of 3.0 cm (0.1 ft) as described in DAMOS Contribution No. 48 (SAIC 1985). At the beginning of the survey, a surface-to-bottom cast of a Sea-Bird Electronics, Inc., Model SBE 19-01 conductivity-temperature-depth profiler (CTD) was done to obtain accurate speed of sound data for the analysis. Analysis of the bathymetric data was conducted using the Hydrographic Data Analysis System (HDAS). All depth values were converted to Mean Low Water (MLW) after compensating for vessel draft and tidal fluctuations that occurred while surveying. During analysis, position and depth data were checked to identify and eliminate any outlying values before producing an accurate contour plot.

2.2 REMOTS® Sediment-Profile Photography

A REMOTS® survey was conducted at PDS and reference stations on July 22 and 23, 1992. The orthogonal REMOTS® sampling grid at the disposal site was designed to map the areal extent of the dredged material deposit and to confirm predictions about benthic recolonization. Forty-two stations were surveyed at the disposal site. The three reference areas, SEREF, SREF, and EREF (Table 2-1), were each surveyed in a 13-station cross-shaped grid. Triplicate photographs were taken at all stations.

Table 2-1

Portland Disposal Site Reference Areas

Reference Areas	Location		Water Depth
SEREF	43°32.802′ N	70°00.193′ W	90 m
SREF	43°33.346′ N	70°01.753′ W	60 m
EREF	43°34.429′ N	69°59.732′ W	70 m

In January 1992, as part of the USCG capping project, a 64-station orthogonal REMOTS® survey around the disposal buoy mapped the distribution of dredged material at PDS (Figure 2-1). Ambient sediment formed the western boundary of the dredged material deposit in January, and hard rock was found in the northeast, leaving the location of the dredged material boundary unclear on the east, and north and south (Figure 2-2).

The REMOTS® stations surveyed in July were chosen to further define the boundaries of the dredged material and to determine the status of benthic recolonization at the site. Fourteen REMOTS® stations were surveyed on July 22 (Figure 2-3). Seven of these stations (E1, G2, F3, E4, H5, G7, E8) were also surveyed in January. The seven stations outside of the boundary of the January survey (I4, J5, I7, D9, I9, M9, E10) were surveyed to further delineate the dredged material boundary. After reviewing the REMOTS® photographs from these 14 stations for the presence of dredged material, an additional 28 REMOTS® stations were sampled to demarcate further the dredged material boundary and to gain more information on benthic recolonization on the cap.

2.3 Sediment Density

A 24 kHz acoustic survey was conducted concurrent with the July 21 bathymetric survey. The survey interfaced the 24 kHz sound source with the Acoustic Core System® (model CE-IB-100; Caulfield Engineering Group, Oyama, BC, Canada). The Acoustic Core System® is a combination hardware/software package designed to provide quality control during shallow seismic data acquisition. It provided acoustic impedance and density predictions based on signal amplitude in the shallow seismic field. The system calculated impedance values relative to seawater, and generated density estimates based on the work of Hamilton (1970, 1971). Surface sediment grab samples were collected to ground truth sediment density estimates.

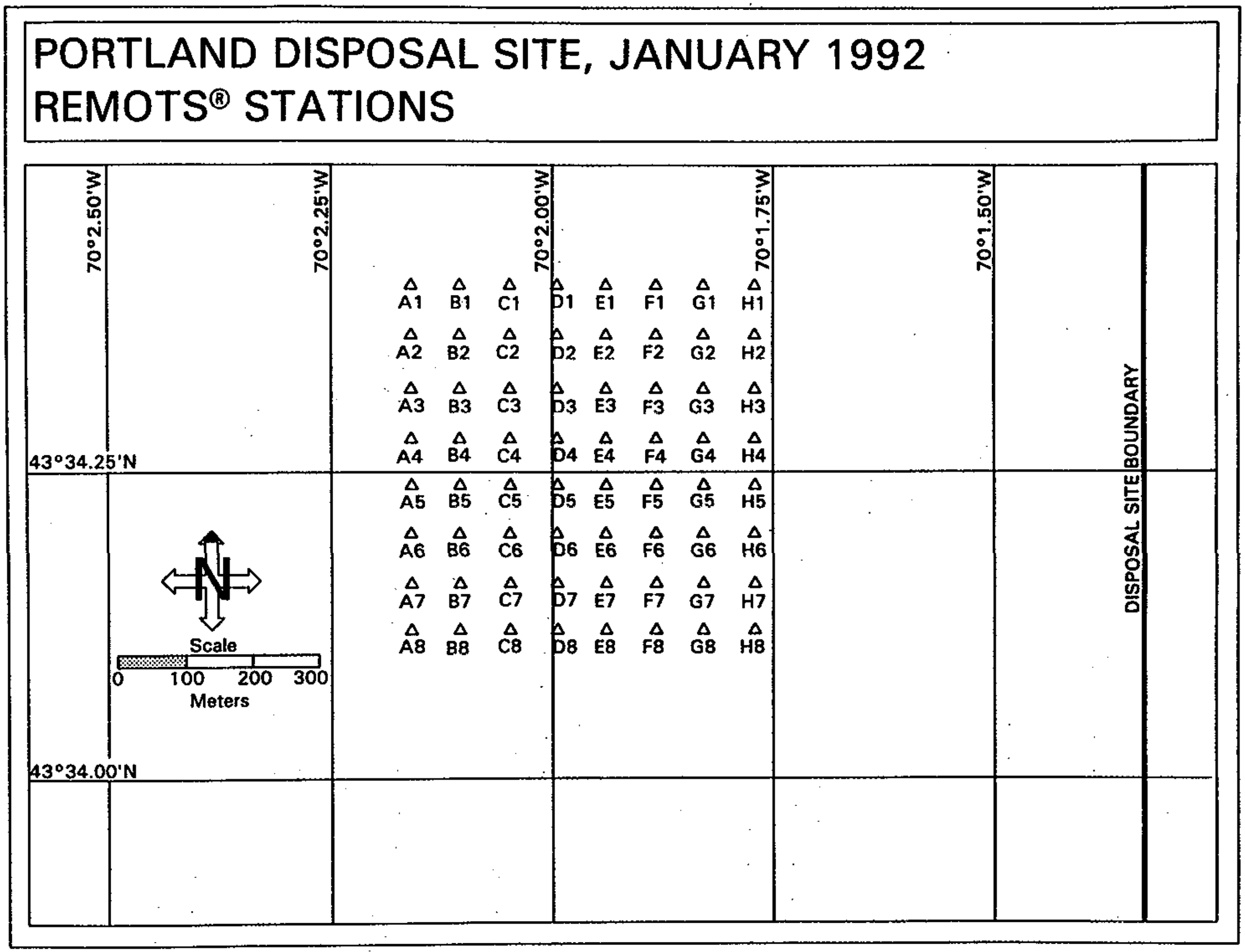

Figure 2-1. REMOTS® station locations at the Portland Disposal Site, January 1992

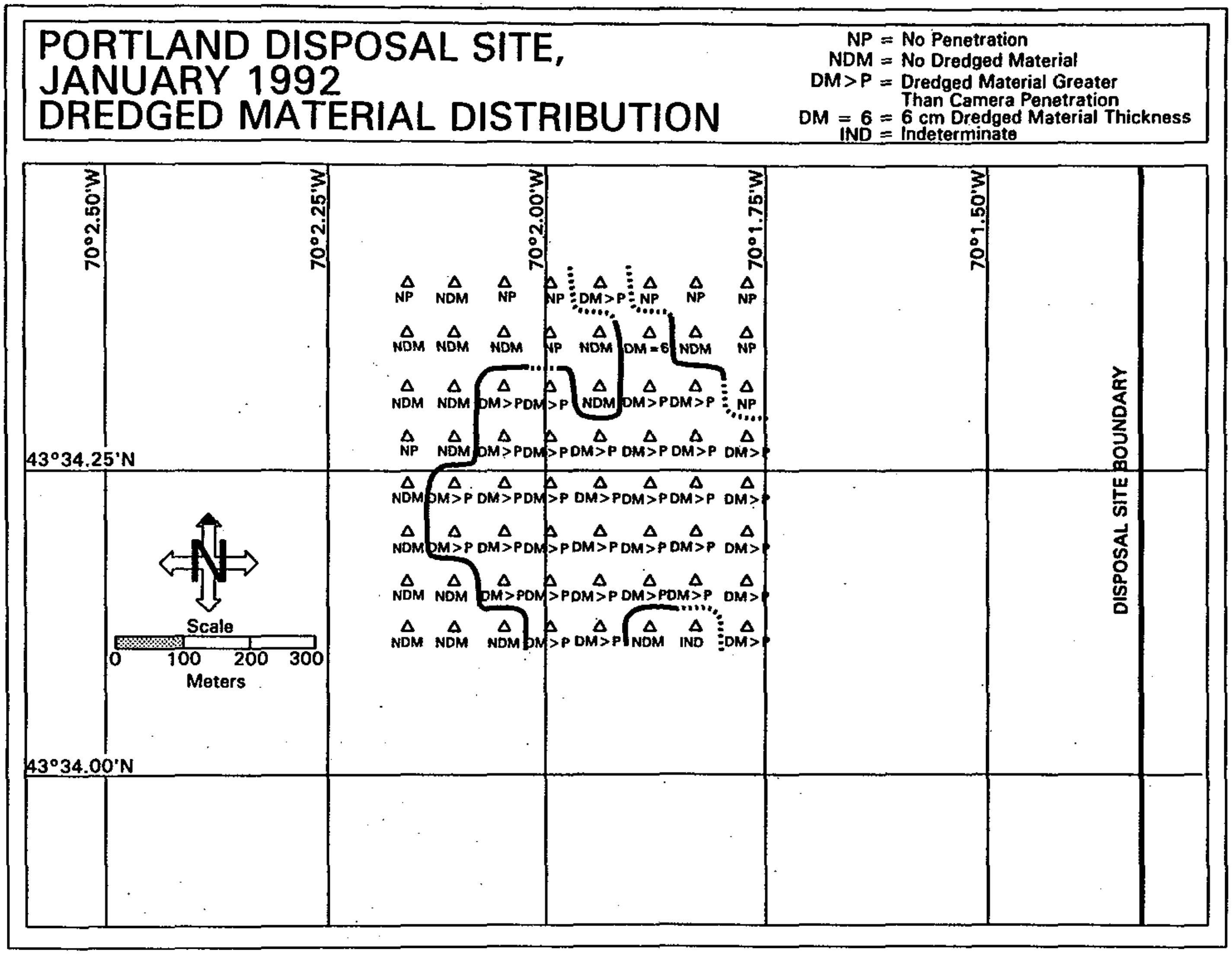

Figure 2-2. Dredged material location at the Portland Disposal Site, January 1992

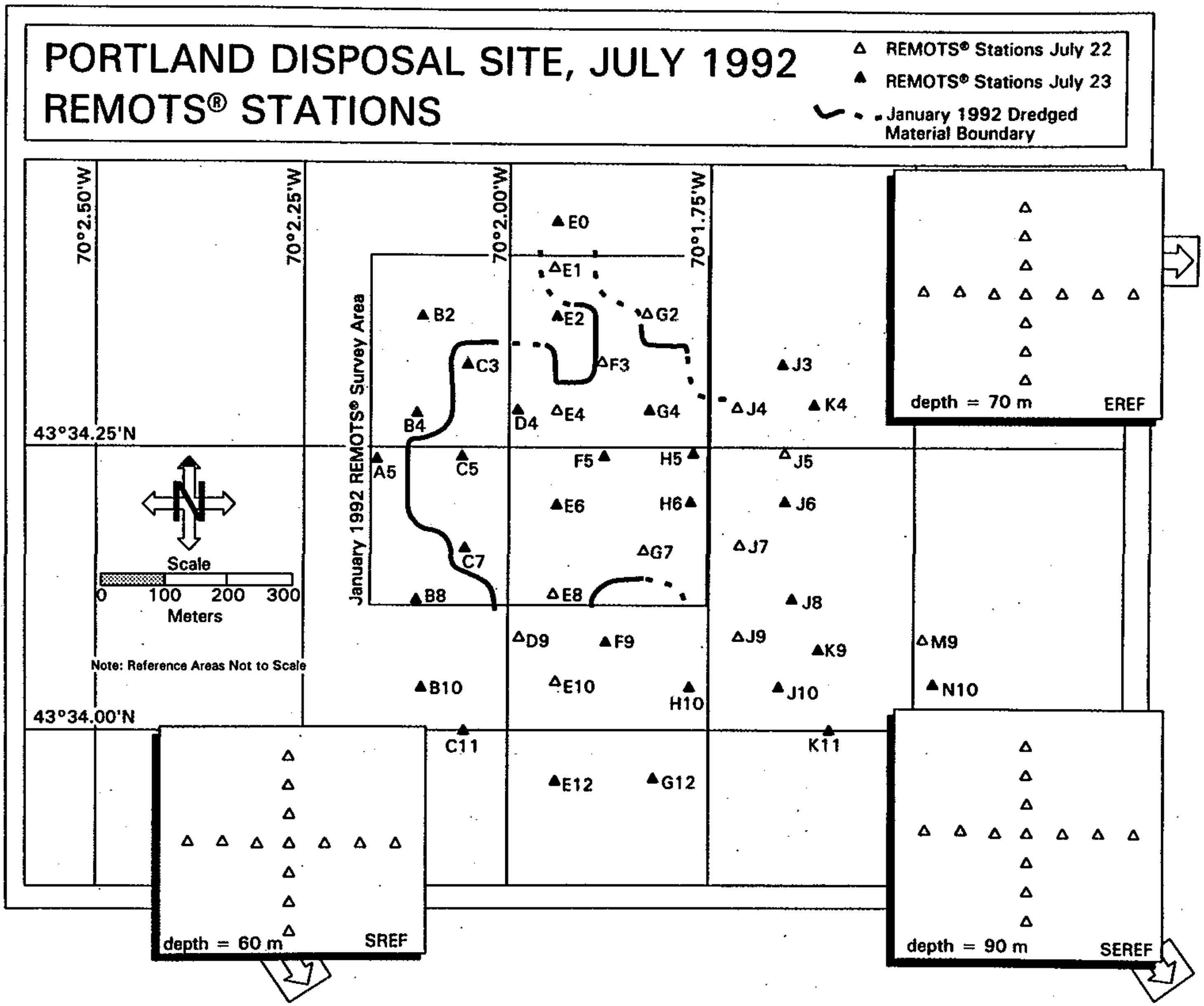

Figure 2-3. July 1992 REMOTS® stations at the Portland Disposal Site

Data output from the Acoustic Core System® included amplitude and acoustic impedance values. Acoustic impedances have been reliably assigned to different sediment types and, therefore, can be used to detect changes between sediments with dissimilar impedance characteristics (Hamilton 1970, 1971). Impedance values were converted to density values and mapped to quantify changes in sediment type. For a more detailed discussion of the analysis procedure, see Caulfield and Yim (1983) and Caulfield (1984). The density values converted from the impedance values were compared to the density values calculated for the surface sediment samples at the cap site to ground truth the data.

2.4 Sediment Sampling and Analysis

Sediment samples were collected from the center of the three PDS reference areas (SREF, SEREF, and EREF) and from 13 stations located within the lateral limits of the cap at PDS (H5, F5, D5, B5, H7, F7, E1, F3, G3, E3, C3, D7, B7). The stations on the cap correspond to the REMOTS® stations. The sediment samples were collected with a 0.1 m^2 teflon-lined Van Veen grab sampler. Three samples were collected for analysis at SEREF, and two were collected from EREF and SREF due to difficulty in collecting sediments. One grab sample was collected from each of the 13 stations on the cap (Figure 2-4). Each grab at the reference stations was subsampled for metals, polycyclic aromatic hydrocarbons (PAHs), and grain size and % total organic carbon. The grabs from the surface of the cap sediment were subsampled for metals and grain size. Sediment to be analyzed for metals and PAHs was placed in precleaned (acid-washed) glass jars. Sediment to be analyzed for grain size and % total organic carbon (TOC) was placed in plastic bags. Samples were kept cold (approximately 4° C) and delivered to the NED laboratory.

2.4.1 Grain Size Analysis

Physical analysis of sediments by the NED laboratory included visual classification, and grain size analysis (sieve and hydrometer) using ASTM Method D-422 (ASTM 1990; Table 2-2). Grain sizes were classified using the Wentworth (phi) scale: -2 to -1 phi for gravel, between -1 and +4 phi inclusive for sand, between +4 and +8 phi inclusive for silt, and greater than or equal to 9 phi for clay. Prior to initiating the grain size analysis, a subsample (approximately 5-20 g) was taken for total solids analysis for determination of moisture content. A sieve analysis was then performed in which the sample was separated into size fractions greater than 62.5 μm (<4 phi - sand and gravel), and less than or equal to 62.5 μm ($\geq$4 phi - silt and clay). The gravel/sand fraction was subdivided further by mechanically dry sieving it through a graded series of screens. The wet sieved and dry sieved fractions less than 62.5 μm were combined for each sample. The silt/clay fraction was then subdivided using a pipet technique which utilizes the differential settling rates of particles of different sizes.

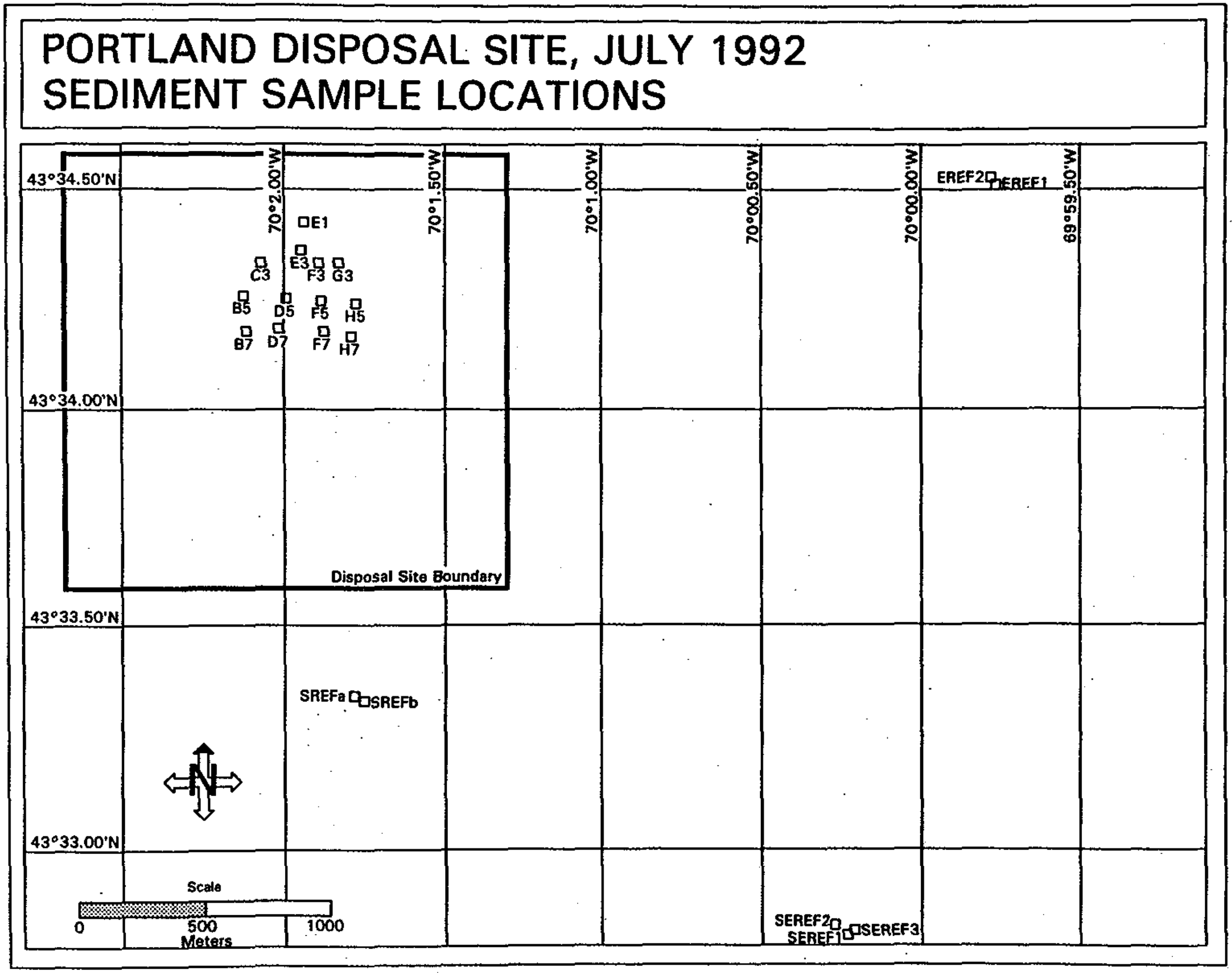

Figure 2-4. Sediment sample locations at the Portland Disposal Site, July 1992

Table 2-2

Summary of Laboratory Analytical Work, 1992

Type of Test	**Test Method**		**Instrumentation**
Metals	EPA Test Method No.		
	Sample Prep	Analytical	
Arsenic (As)	3051	7060	GFAA
Lead (Pb)	3051	7421	GFAA
Mercury (Hg)	7471	7471	CVAA
Aluminum (Al)	3051	6010	ICP
Cadmium (Cd)	3051	6010	ICP
Chromium (Cr)	3051	6010	ICP
Copper (Cu)	3051	6010	ICP
Iron (Fe)	3051	6010	ICP
Nickel (Ni)	3051	6010	ICP
Zinc (Zn)	3051	6010	ICP
Polynuclear Aromatic Hydrocarbons (PAHs)	3540	8270	GC/MS
Total Organic Carbon		9060	Carbonaceous Analyzer
Grain Size	ASTM D422-63		

GC/MS = Gas Chromatograph/Mass Spectrometer
ICP = Inductively Coupled Argon Plasma Emission Spectrometry
GFAA = Graphite Furnace Atomic Absorption
CVAA = Cold Vapor Atomic Absorption

2.4.2 Total Organic Carbon

Total organic carbon, a measurement of organic matter (both labile and refractory) in sediments, was measured using protocols described in the Environmental Protection Agency's (EPA's) *Test Methods for Evaluating Solid Waste* (SW-846) Method 9060 (USEPA 1986). Organic carbon in the samples was converted by the analyzer to carbon dioxide (CO_2), which was subsequently measured by an infrared detector. The amount of CO_2 is directly proportional to the concentration of carbonaceous material in the sample. Inorganic forms of carbon (carbonate and bicarbonate) are not included as part of the reported total organic carbon value..

Three PDS sediment samples from the reference areas were analyzed for TOC; results were accompanied by one method blank which was below detection (<0.1% TOC). In addition, eight EPA Standard Reference Material (SRM) sample results were submitted with the TOC samples. The recovery of TOC from these samples ranged from 91.2 to 103.5%, well within acceptable limits (80-120%).

2.4.3 Metals and PAH Analysis

Portland Disposal Site sediment samples were analyzed for a suite of eight trace metals as well as aluminum and iron. All metals were analyzed using standard SW-846 procedures for metals analysis (Table 2-2; USEPA 1986). Sediment samples were digested using nitric acid in a microwave oven (Method 3051) except for mercury analysis (Method 7471). Aluminum (Al), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), nickel (Ni), and zinc (Zn) were analyzed by inductively coupled argon plasma emission spectrophotometry (ICP, Method 6010). Digestates can be heated in several stages allowing removal of unwanted matrix components. Analysis by ICP allows simultaneous or rapid sequential determination of many different metals. Atomic adsorption determinations are completed as single element analyses which allow for low detection limit thresholds. Arsenic (As) and lead (Pb) were analyzed using graphite furnace atomic adsorption techniques (GFAA), and mercury (Hg) was analyzed using cold vapor atomic adsorption (CVAA).

The three PDS reference station samples were analyzed for polynuclear aromatic hydrocarbons (PAHs) using SW-846 Method 8270 (Table 2-1; USEPA 1986). This method determines the concentration of semivolatile organic compounds from a sample extract using a gas chromatograph with a mass spectrometer detector (GC/MS). Detection limits for PAH compounds were within limits recommended for the method.

Each PAH sample was spiked with three system-monitoring or surrogate compounds (2-fluorobiphenyl, nitrobenzene-D_5, and terphenyl-D_{14}) as a measure of accuracy. Surrogate samples are analyzed as a check on the laboratory's ability to extract known concentrations of compounds not found normally in the sample. All PAH surrogate recoveries were within acceptance limits except for high recoveries of terphenyl-D_{14} in all samples except the method blank. The high surrogate recoveries were potentially caused by matrix interference. The acceptable recoveries of 2 out of 3 surrogate compounds indicate no laboratory extraction problem (USEPA 1988a).

Specific QC samples for the PAH analyses included a method blank, a spiked sample, and a spiked duplicate sample. These results are discussed in the QA/QC section below (2.4.4).

2.4.4 QA/QC

Results submitted by the NED laboratory were found to be acceptable and supported by appropriate documentation. Sample data were evaluated using protocols developed by the EPA (USEPA 1988a, 1988b). Quality control checks from the NED laboratory consisted of method blanks, matrix spikes, duplicate samples, and laboratory control samples. Method blanks are laboratory QC samples processed with the samples but containing only reagents. Method blanks test for contamination which may have been contributed by the laboratory during sample preparation. Matrix spike sample analyses provide a measure of the efficiency and effectiveness of sample preparation and analysis procedures, in addition to an indication of how tightly a compound is bound to its matrix. Matrix spikes are also used to assess the accuracy of analytical measurements. Duplicate samples indicate variability in laboratory procedures and degrees of difference between individual samples. Duplicate blank spike and duplicate matrix spike samples were used to measure precision in laboratory procedures. Laboratory control samples used by the NED were EPA standard reference material (SRM) samples analyzed using identical procedures as with the samples.

All samples submitted for metals analysis were extracted and analyzed within EPA recommended holding times, except for Hg samples which were extracted 32 days after collection and analyzed the following day. EPA guidelines suggest a maximum holding time of 28 days for Hg (USEPA 1988b). The Hg results were not qualified because of the short time delay and the refrigeration of the samples. Samples analyzed for PAHs, PCBs, and pesticides were extracted and analyzed within EPA recommended holding times (USEPA 1988a).

Method blanks were below detection for all metals except for Zn (13 ppm). All samples contained zinc in concentrations greater than 5 times the concentration detected in the method blank, so no qualifications were necessary (USEPA 1988b). The method blank samples for PAHs, PCBs, and pesticides were below the practical quantitation limit for all compounds.

Spike and spike duplicate samples were analyzed as an evaluation of laboratory accuracy and precision. Duplicate spike samples were analyzed for all of the metals analyzed in the PDS samples, two PAH compounds (acenaphthene and pyrene), total PCBs, and six pesticide compounds (lindane, heptachlor, aldrin, dieldrin, endrin, and 4,4′-DDT) using the same methods described above. All spike recoveries were within control limits except for low recoveries of endrin in both pesticide spike samples (51% and 55%; the acceptance range is 56-121%). Since four out of five pesticide recoveries were within control limits, the endrin results indicate no laboratory extraction problem.

Precision was measured as a relative percent difference between the spike and spike duplicate results. Relative percent differences for all QC samples were within laboratory control limits, indicating acceptable sample precision.

3.0 RESULTS

3.1 Bathymetry

The Portland Disposal Site varies in depth from 42 to 64 m (Figure 3-1). The higher elevations are hard rock ridges with steep slopes that enclose more gently sloping sandy valleys. The ridges are located in the southwest corner of the site (minimum water depth of 43 m), at the northern border of the site (minimum water depth of 45 m), and to the east (minimum water depth of 49 m). These ridges enclose two main valleys. One, centered at approximately 43°34.167′ N, 70°02.167′ W, trends northwest to southeast and has a maximum depth of 60 m. The other valley trends north to south in the center of the site and slopes to a maximum water depth of 64 m.

The July 1992 bathymetric survey identified a well-defined mound just south of the buoy location. The mound is approximately 100 m in diameter and 7 m in height (minimum water depth 49 m; Figure 3-1). The location and shape of the mound appear to have remained unchanged since 1989 (Figure 3-2).

A depth difference comparison between the January 1989 and the July 1992 bathymetric surveys shows extensive areas of accumulation (Figure 3-3) and isolated areas of loss (Figure 3-4). Accumulations of 0.75 m and 1.0 m are located within a 300 m radius of the buoy location. Below 43°34.083′ N, another broad area of accumulation with similar values is seen. Large (>1 m) positive differences in depth between 1989 and 1992 occur in very localized areas and are marked by dense contour lines. Most areas of negative depth differences are localized around areas of steeply sloping ridges. Two areas of negative depth difference (southeast of 43°34.250′ N, 72°02.250′ W and northeast of 43°34.000′ N, 70°01.750′ W) are located on the southwest slopes of ridges.

3.2 REMOTS®

The REMOTS® photographs from the 42 stations were analyzed for the presence of dredged material and a variety of parameters indicative of the health of the benthic environment. Previous REMOTS® surveys at PDS have been hampered by the hard rock bottom which can inhibit data collection (SAIC 1990). Because the general location of the dredged material was known in July, more usable images were collected from the disposal site than in January. Due to the rocky bottom, there were still difficulties in collecting data from the reference areas, and no data was obtained at 16 out of 39 stations.

The January 1992 PDS REMOTS® survey outlined the dredged material boundary within 250 m of the disposal location (Figure 2-2). The REMOTS® stations in the present survey were chosen to repeat some of the dredged material stations surveyed in January and to further define the dredged material footprint by expanding the survey into ambient bottom.

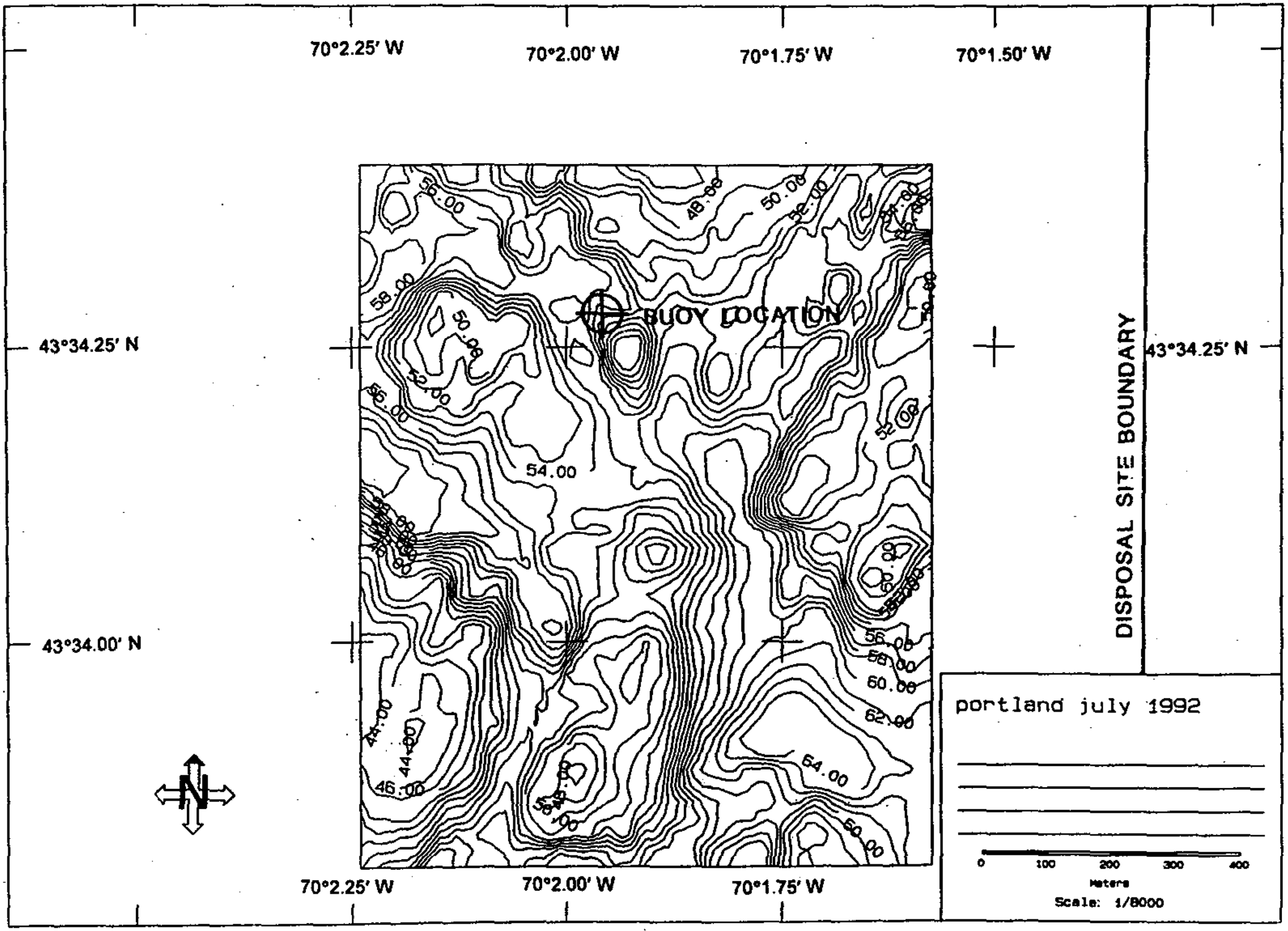

Figure 3-1. Contoured bathymetric chart of the Portland Disposal Site, July 1992 (depth in meters)

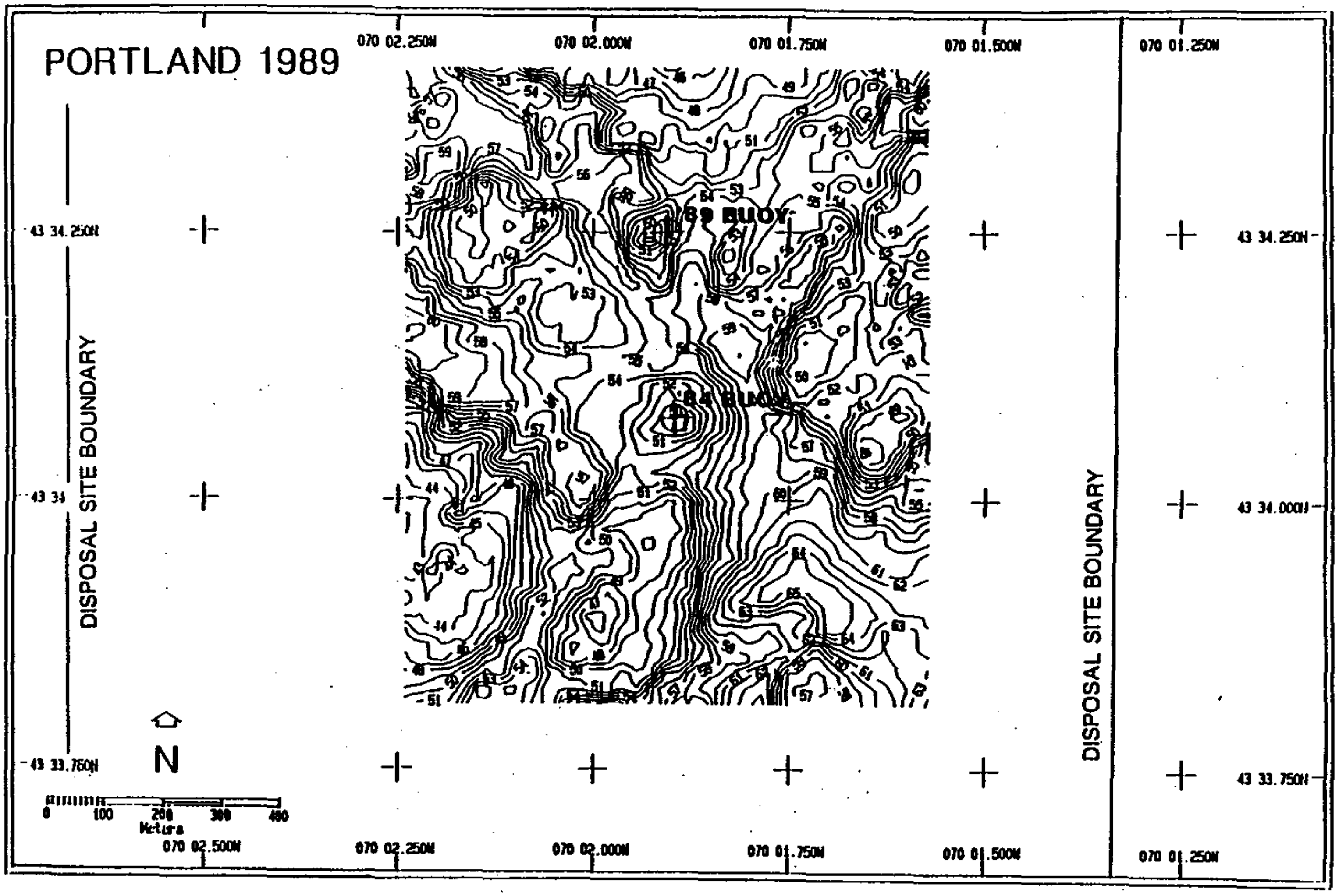

Figure 3-2. Contoured bathymetric chart of the Portland Disposal Site, January 1989 (depth in meters)

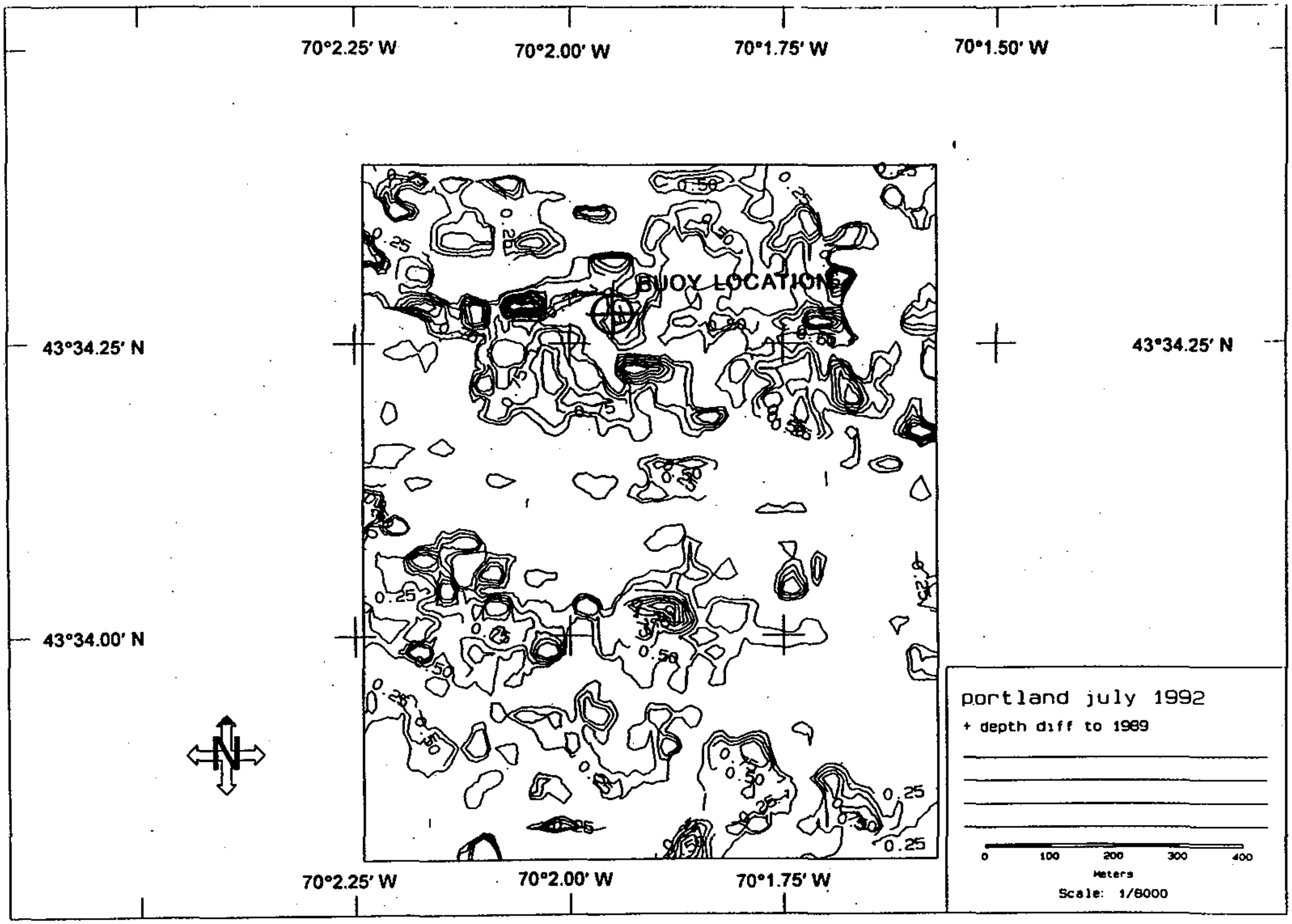

Figure 3-3. Positive depth difference contour chart (in meters) based on the comparison of 1989 and 1992 Portland Disposal Site bathymetry

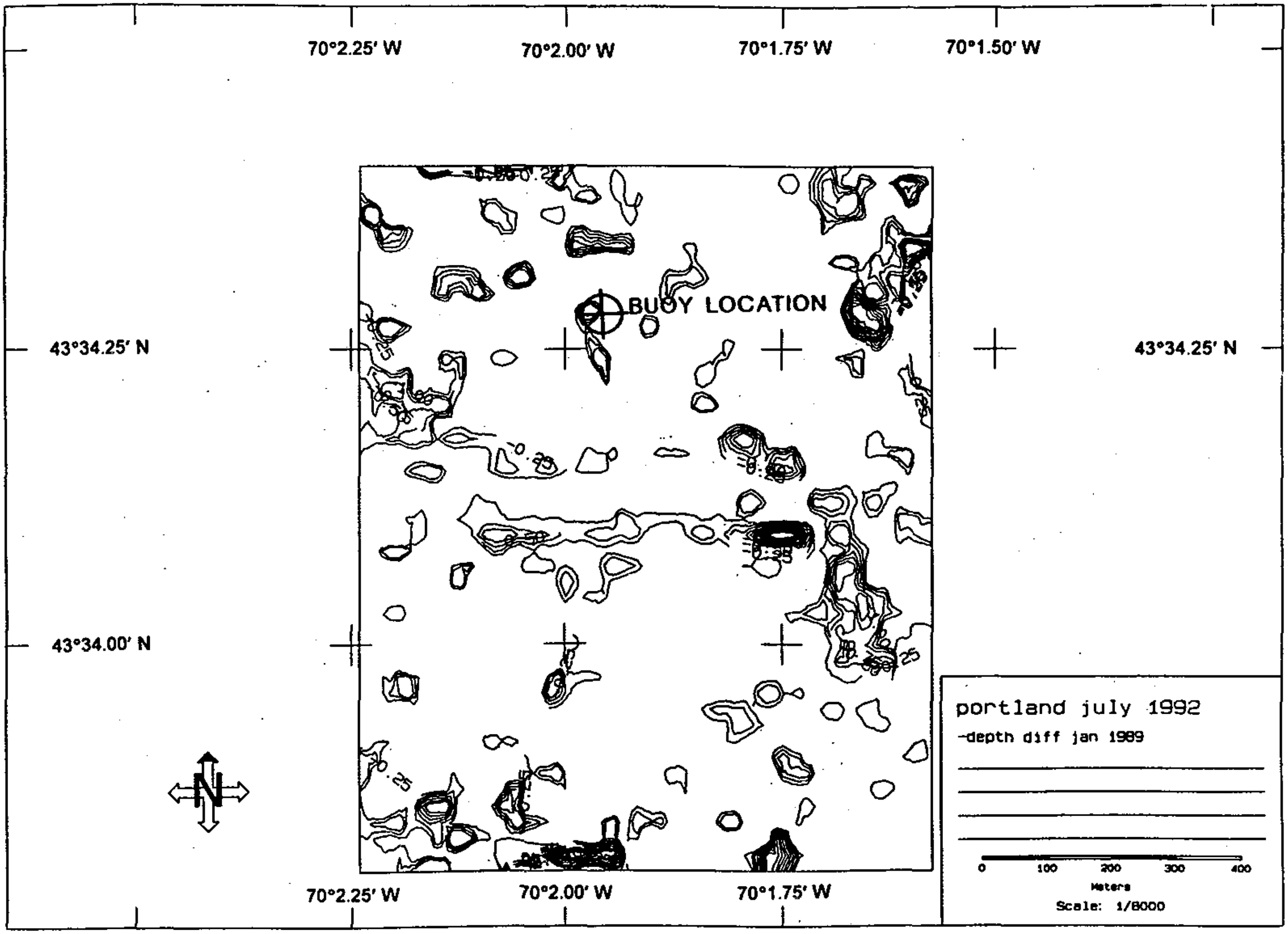

Figure 3-4. Negative depth difference contour chart (in meters) based on the comparison of 1989 and 1992 Portland Disposal Site bathymetry

Twenty REMOTS® stations were surveyed in both January and July. In July, fourteen remained dredged material, four remained ambient sediment, one (B2) was ambient and became covered with dredged material, and one (G2) was ambient in January, but the camera did not penetrate the sediment in July (Figure 3-5). In general, penetration depths were shallower for ambient sediment than dredged material.

In January, the dredged material boundary was undefined at the north central point and to the east and south. REMOTS® Station E0 was surveyed in July, and dredged material was detected, extending the undefined boundary to the north. Stations J3, J5, K4, and J6 were chosen in July to determine the extent of the dredged material boundary to the east. Ambient sediment was detected at these stations and more clearly defined the eastern boundary of the dredged material. Additional stations to the south (J8, D9, F9, I9, B10, E10, H10, J10, C11, K11, E12, and G12) all exhibited dredged material, leaving the southern boundary undefined. These stations are near the location of the disposal buoy from 1979 to 1984 (43°34.110' N, 70°01.910' W). Stations K9, M9, I7, and N10 were water or surface photos, providing no clear information.

Parameters that indicate the health of the benthic environment in the REMOTS® photographs include the Redox Potential Discontinuity (RPD) depth and the successional stage. The multiparameter REMOTS® Organism-Sediment Index (OSI) is used to characterize habitat disturbance. The parameters used to calculate the OSI values are the mean apparent RPD depth, the presence of methane or low dissolved oxygen, and the successional stage (Parker and Revelas 1989).

RPD values at PDS in July ranged from 0 to 3.28 cm (Figure 3-6). Most RPD values (21 stations) were between 1.5 and 3.4 cm. Seventeen stations on the disposal site had indeterminate values due to condensation on the camera lens. At the reference stations where data was collected (23 stations), 17 stations had RPDs between 1.5 and 3.4 cm (Figure 3-7).

At PDS, 18 out of 42 REMOTS® stations had indeterminate successional stage values due to condensation on the camera lens. Where the successional stage could be determined, 21 out of 24 stations had Stage III organisms (Figure 3-8). Stage I organisms were found at three stations: E1, F3, and F9. At the reference stations, Stage III seres were found at 17 out of 23 stations. Stage I taxa were found at SREF stations 200E and 300E. Three stations were indeterminate.

OSI values at PDS ranged from 3 to 9.5. Since the OSI value is dependent on the RPD and successional stage values, as well as other factors, 19 stations at the disposal site were indeterminate (Figure 3-9). Of the remaining 23 stations, five had OSIs less than +6, indicating areas that were stressed. At the reference areas, OSIs at two out of 23 stations were indeterminate, three were below +6, and the remainder ranged from six to 11. The

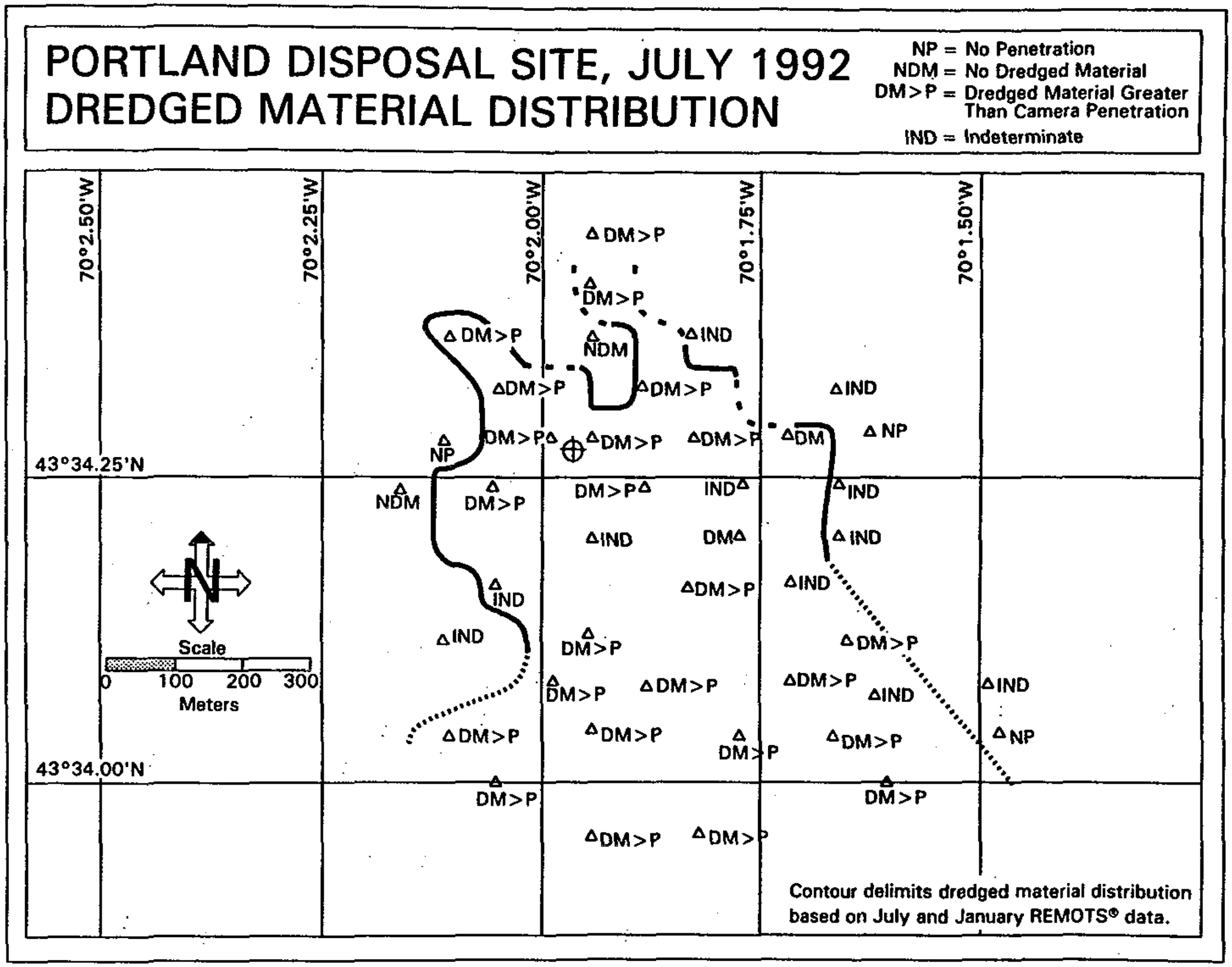

Figure 3-5. Dredged material location, based on REMOTS®, at the Portland Disposal Site, July 1992

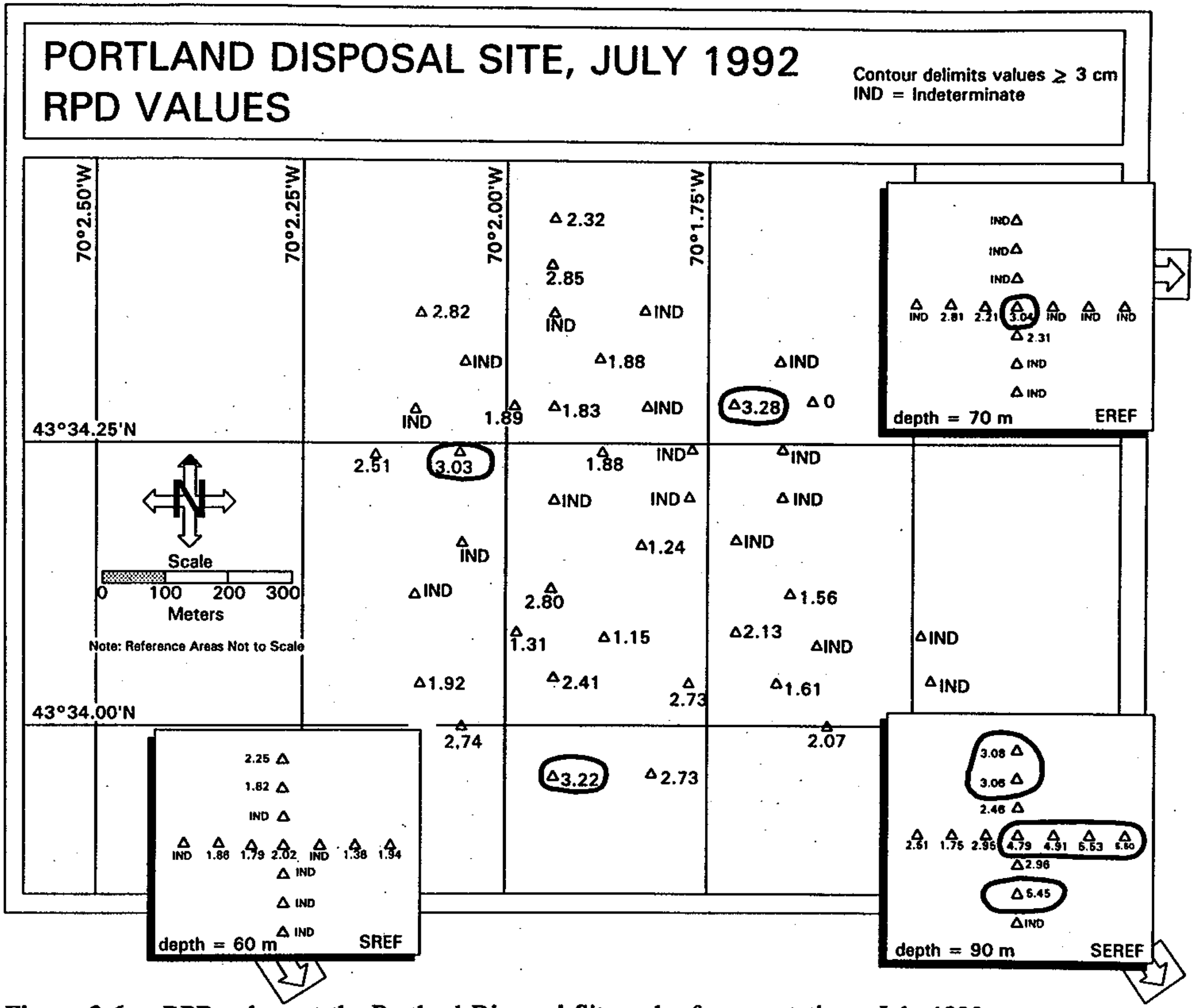

Figure 3-6. RPD values at the Portland Disposal Site and reference stations, July 1992

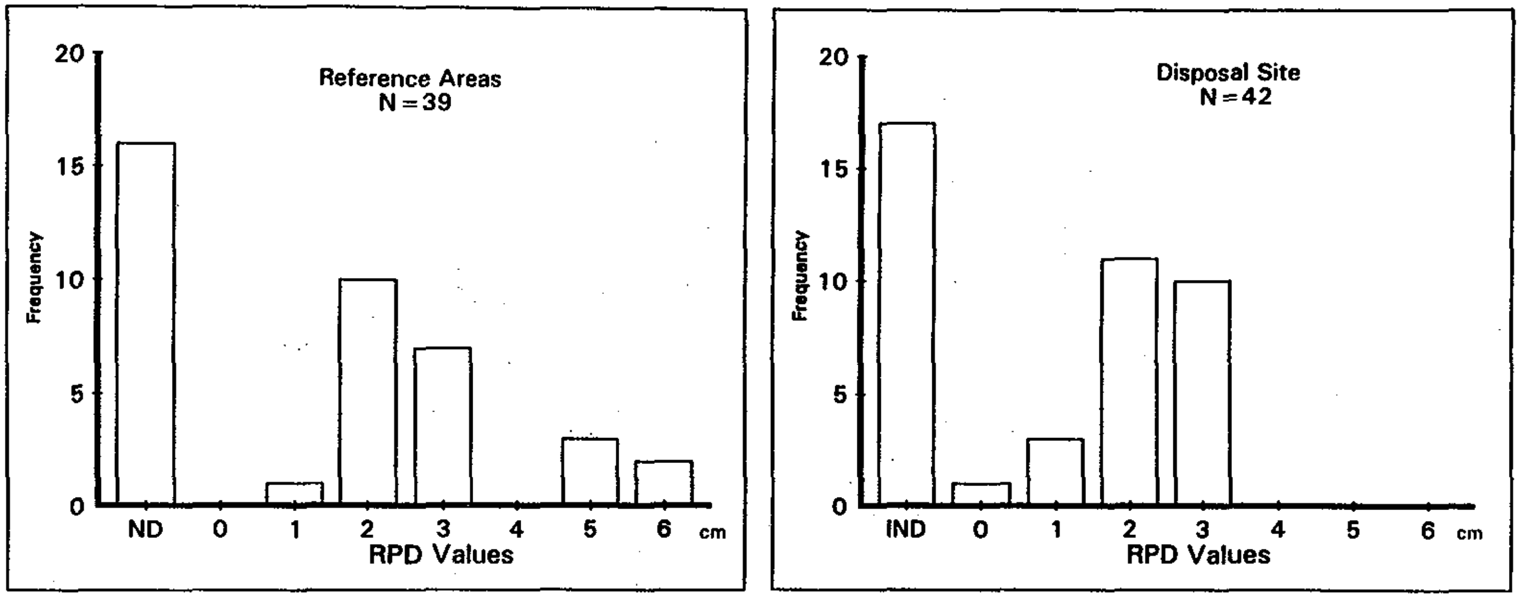

Figure 3-7. Frequency distribution of RPD values at the Portland Disposal Site and reference areas

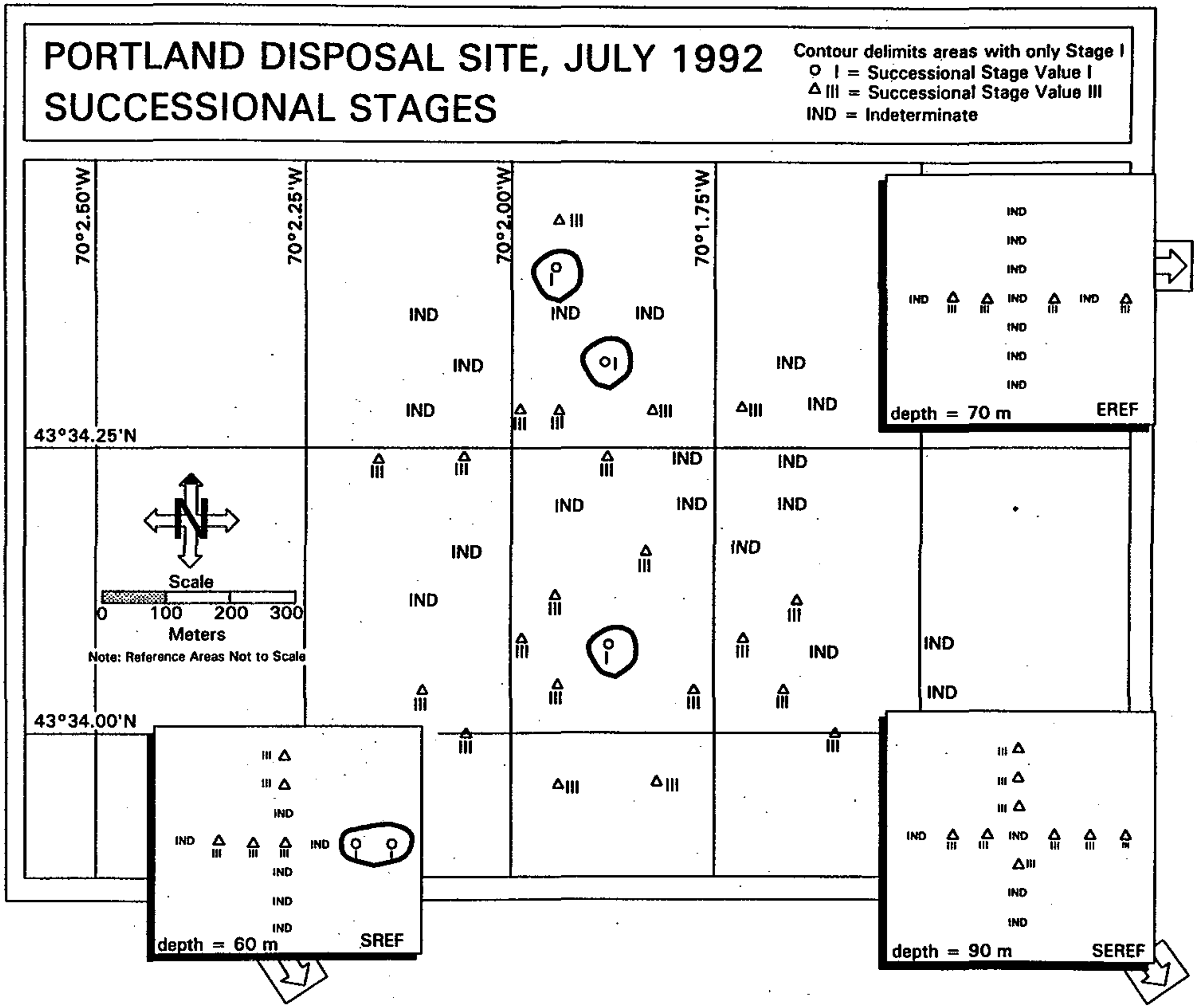

Figure 3-8. Successional stage values at the Portland Disposal Site and reference areas, July 1992

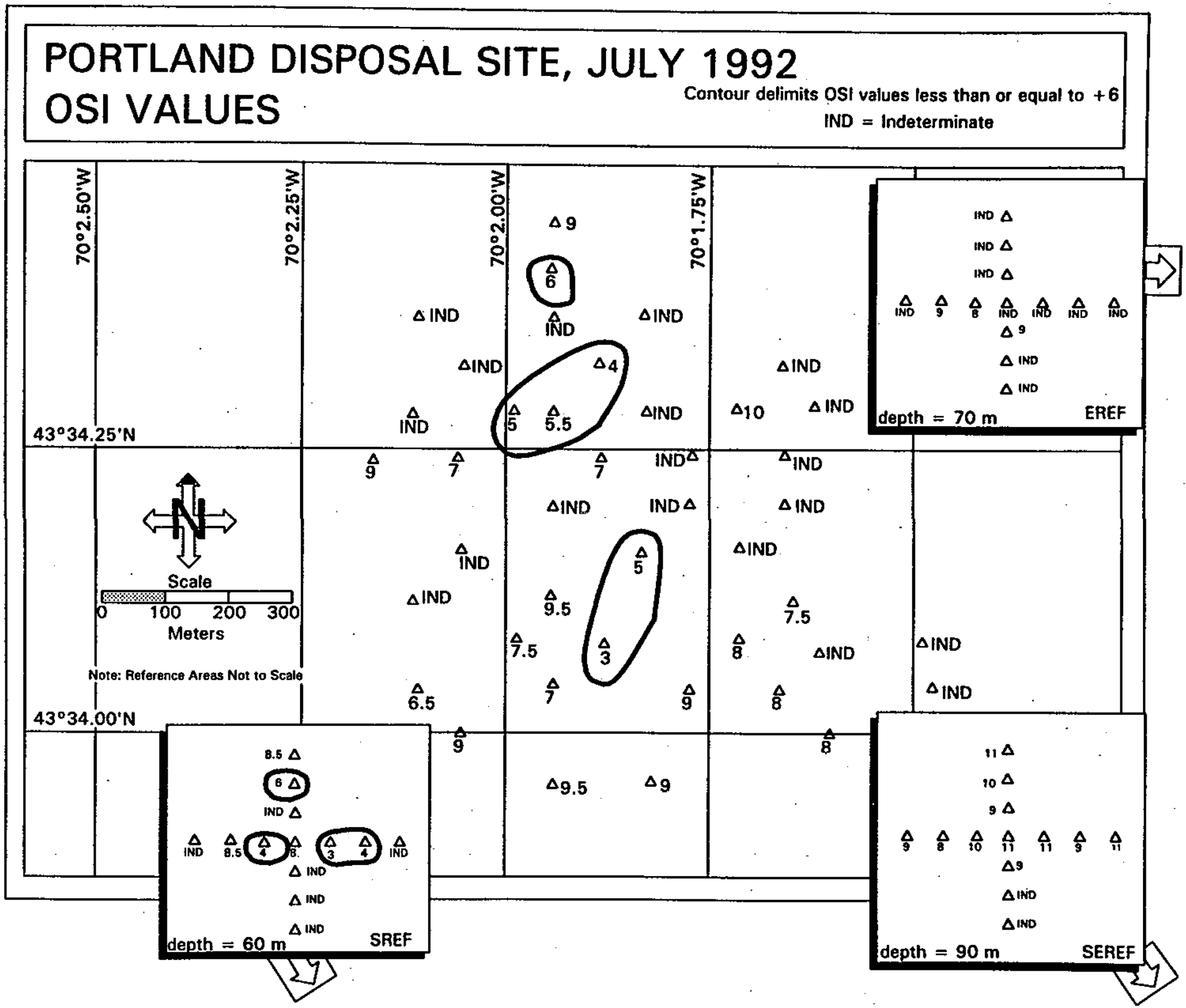

Figure 3-9. OSI values at the Portland Disposal Site and reference areas, July 1992

lower values (4, 3, and 4) were all located at SREF. Stations at SEREF had very high OSI values with four stations having a +11 OSI value.

3.3 Sediment Density

Density of the upper sediment surface was calculated from the 24 kHz survey conducted concurrent with the bathymetric survey. The software calculated density values from the acoustic return every 20 seconds along the survey track. Density values ranged from 1.2 (clay) to 1.7 $g \cdot cc^{-1}$ (sand) (Figure 3-10). The highest sediment densities, greater than 1.6 $g \cdot cc^{-1}$, were all located in water depths shallower than 54 m. The apex of the disposal mound had a density of 1.5 to 1.6$g \cdot cc^{-1}$. The less dense material ($\sim$1.4 $g \cdot cc^{-1}$) was concentrated in the deeper areas, although the results were somewhat patchy. The patchiness of the data over a large area required a high degree of smoothing during the processing of the data, which tended to decrease the ability to identify specific features. The variability in the acoustic reflection also was a function of the heterogeneity of dredged material; the acoustic reflection of the 24 kHz is affected by differences in porosity, surface "roughness", and grain size, among other factors.

3.4 Sediment Grain Size and Chemistry

3.4.1 Grain Size and Total Organic Carbon

The major mode of the grain size in samples from PDS and reference stations ranged from gravel to clay (Table 3-1). Sediments at the reference stations were medium brown silty sand with gravel at EREF and SREF, and medium to dark brown silty clay at SEREF. At EREF and SREF, the sediment was mostly gravel (18 and 22%) and fine sand (38 and 33%). At SEREF, 51% of the samples were silt, and 39% were clay. At the disposal site, the sediments ranged from light grey clay at F3 to poorly graded gravel at F7. Most of the disposal site stations contained more than 50% silt/clay (B5, B7, C3, D5, D7, E1, F3, F5, G3, H5, and H7). Stations with coarser grained sediments included E3 (65% fine sand) and F7 (60% gravel). In addition to grain size, the sediment descriptions note shell fragments at F7 and H7, and some grass at B5.

Total organic carbon was measured at the three reference areas as part of the baseline chemistry data. Average TOC values were lowest at EREF (0.60%) and highest at SEREF (1.3%) (Table 3-2).

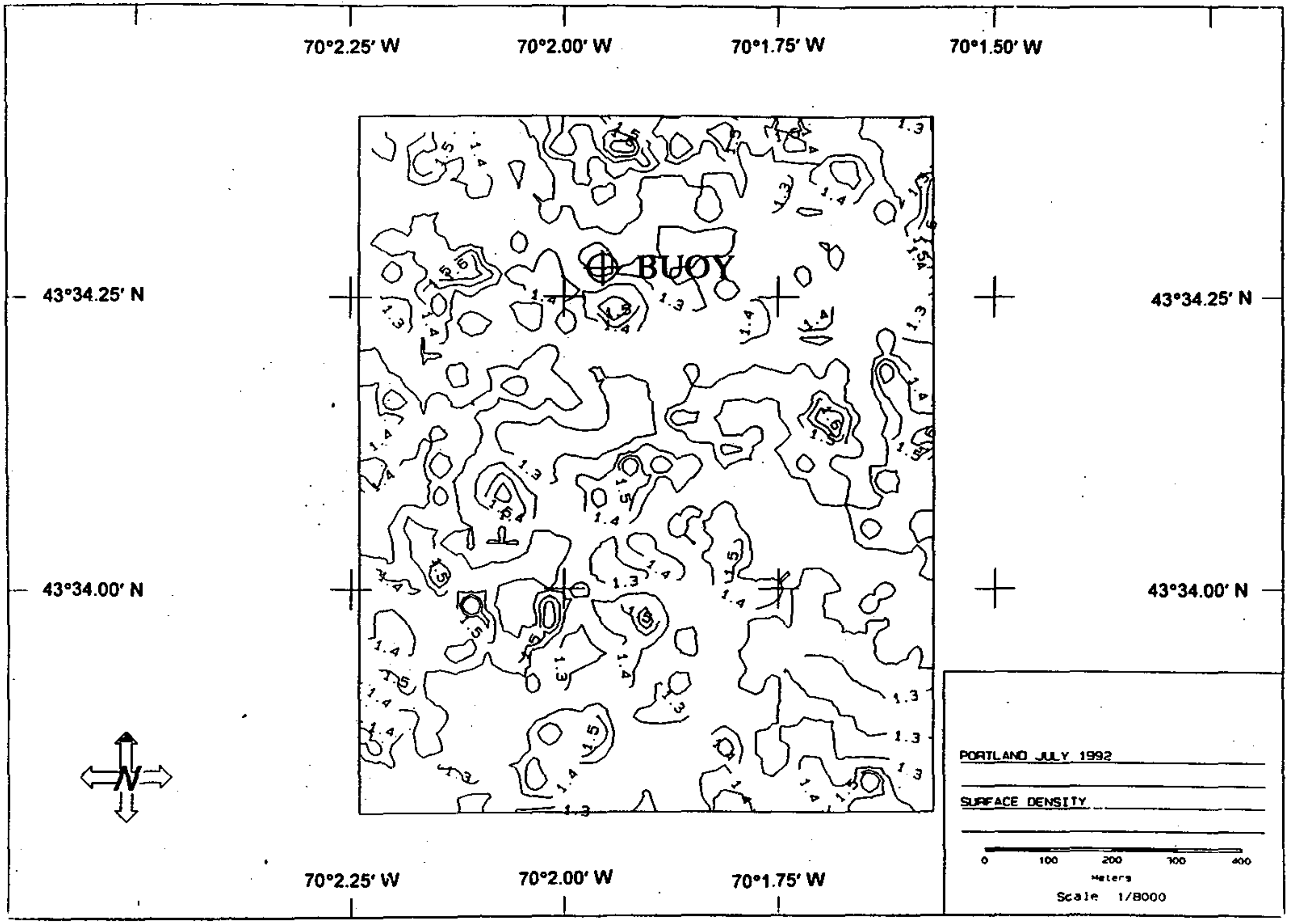

Figure 3-10. Surface sediment density (g·cc^{-1}) for the Portland Disposal Site

Table 3-1

Sediment Grain Size Analyses for Reference Stations and Cap Stations at the Portland Disposal Site, July 1992

	B5	**B7**	**C3**	**D5**
Description	Dark grey silty clay with sand and some grass	Dark grey silty clay with sand	Dark grey silty clay with sand	Dark grey lean clay
Grain Size Analysis				
% Gravel (<-1 phi)	0	0	0	0
% Coarse Sand (-1 to 1 phi)	<1	<1	<1	<1
% Medium Sand (1 to 2 phi)	3	4	7	2
% Fine Sand (2 to 4 phi)	13	21	21	4
% Silt (4 to 8 phi)	47	32	43	36
% Clay (≥8 phi)	37	43	28	56

	D7	**E1**	**E3**	**F3**
Description	Dark grey sandy silty clay	Dark grey sandy silty clay	Dark grey silty clayey sand	Light grey lean clay
Grain Size Analysis				
% Gravel (<-1 phi)	0	0	0	0
% Coarse Sand (-1 to 1 phi)	2	<1	2	<1
% Medium Sand (1 to 2 phi)	13	7	13	2
% Fine Sand (2 to 4 phi)	27	30	50	7
% Silt (4 to 8 phi)	33	32	19	34
% Clay (≥8 phi)	25	31	16	57

Table 3-1 (cont.)

	F5	F7	G3	H5
Description	Sandy grey silty clay with shell fragments	Dark grey poorly graded gravel with silt and sand	Light grey lean clay	Black sandy silty clay
Grain Size Analysis				
% Gravel (<-1 phi)	0	60	0	0
% Coarse Sand (-1 to 1 phi)	9	5	<1	3
% Medium Sand (1 to 2 phi)	13	15	3	9
% Fine Sand (2 to 4 phi)	24	14	6	19
% Silt (4 to 8 phi)	31	6	34	40
% Clay (≥8 phi)	23	<1	57	29

	H7	EREF Center	SREF Center	SEREF Center
Description	Dark grey sandy silt with some shell fragments	Medium brown silty sand with gravel	Medium brown silty sand with gravel	Medium to dark brown silty clay
Grain Size Analysis				
% Gravel (<-1 phi)	0	18	22	0
% Coarse Sand (-1 to 1 phi)	3	10	13	<1
% Medium Sand (1 to 2 phi)	7	17	15	1
% Fine Sand (2 to 4 phi)	28	38	33	9
% Silt (4 to 8 phi)	40	16	17	51
% Clay (≥8 phi)	22	<1	<1	39

Table 3-2

Total Organic Carbon Values at the Portland Disposal Site Reference Areas

Area	Rep	TOC	Average TOC
SEREF	1	1.3%	1.3%
	2	1.2%	
	3	1.4%	
SREF	1	0.80%	0.85%
	2	0.90%	
EREF	1	0.60%	0.60%
	2	0.60%	

3.4.2 Metals and PAHs

Reference station samples and samples from the surface of the cap were analyzed for metals and PAHs. Non-normalized metals values are presented in Table 3-3. In general, cap station values are within the ranges found at the reference stations. Cap stations D7, F7, and H5 do have metal values above those at the reference stations, with some exceptions. Mercury is higher than the highest measured reference value (0.087 ppm at SEREF) in all but three of the stations measured (D5, E3, and F3) at levels ranging from 0.089 to 0.72 ppm. All of these values, however, are in the "low" category defined by the New England River Basins Commission (NERBC; NERBC 1980) for Maine (<0.5 ppm) except for the value measured at H5 (0.72 ppm). Station F7 has the greater number of metals values that are above the highest reference value (As, Cr, Cu, Pb, Hg, Ni); all of the metals concentrations at this station are within the "low" NERBC category except for As (29 ppm), Cr (120 ppm), and Ni (95 ppm). Arsenic and Ni, as measured at F7, are in the "high" NERBC category for Maine (>22 ppm for As, >92 ppm for Ni), and in the "moderate" category for Cr (112-513 ppm). Four metals results at H5 are elevated above reference values (Cu, Pb, Hg, and Zn); Cu is in the "low" NERBC category, while Pb, Hg, and Zn are within the "moderate" category. Other than F7 and H5, there are several measured values that are slightly elevated relative to reference values including Cr at D5, Cu at D5 and D7, Pb at B7, D7, F5, and H7, and Ni at D5; all of these values are within the "low" NERBC categories (NERBC 1980).

All results were then normalized to the percent silt/clay. For stations with gravel (F7, EREF, and SREF), the gravel was removed before the sample was homogenized for

Table 3-3

Non-normalized Metal Analyses for the Portland Disposal Site Stations and Reference Areas

Station:	B5	B7	C3	D5	D7	E1	E3	F3	F5	F7	G3	H5	H7
Aluminum	20,000	13,000	14,000	31,000	13,000	15,000	14,000	30,000	19,000	9,400	30,000	25,000	15,000
Arsenic	7.9	5.8	6.4	8.1	6.7	6.2	5	4.8	10	29	6.1	13	5.4
Cadmium	<2.8	<2.2	<2.3	<1.9	<2.4	<3.0	<0.36	<0.32	<0.90	<0.48	<0.58	<0.72	<0.41
Chromium	35	22	27	70	24	23	28	42	37	120	43	55	28
Copper	18	17	15	28	22	14	8.1	9.818	18	20	13	74	14
Iron	26,000	17,000	20,000	13,000	18,000	20,000	16,000	33,000	24,000	21,000	34,000	29,000	19,000
Lead	22	32	16	17J	51	16	16	18	41	47	22	130	35
Mercury	0.11	0.14	0.11	0.038J	0.27	0. 089	0.073	0.049J	0.093	0.28	0.091	0.72	0.39
Nickel	16	16	17	42	17	16	20	28	25	95	25	33	15
Zinc	85	84	64	100	93	74	46	100	120	100	120	220	75

Reference Area	EREF			SEREF				SREF		
Replicate	1	2	Mean	1	2	3	Mean	1	2	Mean
Aluminum	11,000	9,400	10,200	32,000	33,000	49,000	38,000	13,000	12,000	12,500
Arsenic	5.0	6.1	5.55	9.6	9.3	14	10.97	3.7	4.8	4.25
Cadmium	<2.3	<2.1	*	<2.7	<2.3	<5.5	*	<1.3	<1.4	*
Chromium	20	21	20.5	49	46	63	52.66	20	19	19.5
Copper	<5.4	6.0J	5.7	12J	10J	18J	13.33	4.3J	4.6J	4.45
Iron	17,000	16,000	16,500	31,000	31,000	48,000	36,666	15,000	13,000	14,000
Lead	9.7	8.6	9.15	17	16	30	21	10	9.7	9.85
Mercury	0.043J	0.033J	*	0.063J	0.054J	0.087J	0.068	0.032J	0.026J	0.029
Nickel	8.5J	9.1J	0.038	25	24	33	27.33	10	7.7	8.85
Zinc	39	37	38	86	78	120	94.67	32	34	33

J = Estimated value: above the instrument detection limit but below the practical quantification limit (PQL).

* = Mean not calculated because of values below detection.

Units are all ppm dry weight non-normalized.

chemical analysis. Therefore, the results for these stations were normalized to the percent silt/clay in the fraction of the sample that was analyzed (F7=15%, EREF=20%, SREF=21%). Results from normalization of samples with <20% fine-grained material should be treated with caution as artificially inflated values can result (NOAA 1991).

The normalized results for metals analysis for both cap sediments and the reference stations are listed in Table 3-4. There are fewer normalized values that are above the maximum normalized reference values, especially for Hg. Again, the significantly elevated values are concentrated in Stations F7 (As, Cr, Cu, Pb, Ni, and Zn) and H5 (Cu, Pb, and Zn). The number of elevated normalized values at F7 is partially a function of normalization, where the data are normalized to a very small fraction of fine grained sediment. Both F7 and H5 are located along the southern edge of the sampled cap stations (Figures 3-11, 3-12, and 3-13).

PAHs were analyzed at the reference areas as part of the baseline chemistry survey. The total Low Molecular Weight (LMW) and High Molecular Weight (HMW) PAHs, not including values below detection, are listed for each reference area. SEREF had the lowest values for total LMW and HMW PAHs, and SREF had the highest values. The results for all replicates at each reference area are listed in Table 3-5.

Table 3-4

Normalized Metal Analyses for the Portland Disposal Site Stations and Reference Areas

Station:	B5	B7	C3	D5	D7	E1	E3	F3	F5	F7	G3	H5	H7
% silt/clay	84	75	72	92	58	63	35	91	54	15	91	69	62
Aluminum	238.10	173.33	197.18	336.96	22.41	238.10	400.00	329.67	351.85	627.00	329.67	362.32	241.94
Arsenic	0.09	0.08	0.09	0.09	0.12	0.10	0.14	0.05	0.19	2.00	0.07	0.19	0.09
Cadmium	<0.03	<0.03	<0.03	<0.02	<0.04	<0.04	<0.01	0.00	<0.02	<0.03	0.01	0.00	0.01
Chromium	0.42	0.29	0.38	0.76	0.41	0.37	0.80	0.46	0.69	8.00	0.47	0.80	0.45
Copper	0.21	0.23	0.21	0.30	0.38	0.22	0.23	0.11	0.33	1.30	0.14	1.07	0.23
Iron	309.52	226.67	281.69	141.30	310.34	317.46	457.14	362.64	444.44	140.00	373.63	420.29	306.45
Lead	0.26	0.43	0.23	0.18J	0.88	0.25	0.46	0.20	0.76	3.10	0.24	1.88	0.56
Mercury	0.001	0.002	0.002	0.004	0.005	0.001	0.002	0.001	0.002	0.019	0.001	0.010	0.006
Nickel	0.19	0.21	0.24	0.46	0.29	0.25	0.57	0.31	0.46	6.30	0.27	0.48	0.24
Zinc	1.01	1.12	0.90	1.09	1.60	1.17	1.31	1.10	2.22	6.70	1.32	3.19	1.21

Reference Area	EREF			SEREF				SREF		
Replicate	1	2	Mean	1	2	3	Mean	1	2	Mean
% silt/clay	20	20	20	90	90	90	90	21	21	21
Aluminum	550	470.00	510.00	355.56	544.44	366.67	422.22	590.91	545.45	568.18
Arsenic	0.25	0.31	0.28	0.11	0.16	0.10	0.12	0.17	0.22	0.19
Cadmium	<0.12	<0.11	*	<0.03	<0.06	<0.03	*	<0.06	<0.06	*
Chromium	1	1.05	1.03	0.54	0.70	0.51	0.59	0.91	0.86	0.89
Copper	<0.27	0.30J	0.29	0.13J	0.20J	0.11J	0.00	0.20J	0.21J	0.00
Iron	850	800.00	825.00	344.44	533.33	344.44	407.41	681.82	590.91	636.36
Lead	0.49	0.43	0.46	0.19	0.33	0.18	0.23	0.45	0.44	0.45
Mercury	0.002J	0.002J	0.002	0.007J	0.006J	0.004J	0.006	0.002J	0.001J	0.001
Nickel	0.43J	0.46J	0.44	0.28	0.37	0.27	0.30	0.45	0.35	0.40
Zinc	1.95	1.85	1.90	0.96	1.33	0.87	1.05	1.45	1.55	1.50

J = Estimated value: above the instrument detection limit but below the practical quantification limit (PQL).

* = Mean not calculated because of values below detection.

Units are all ppm dry weight.

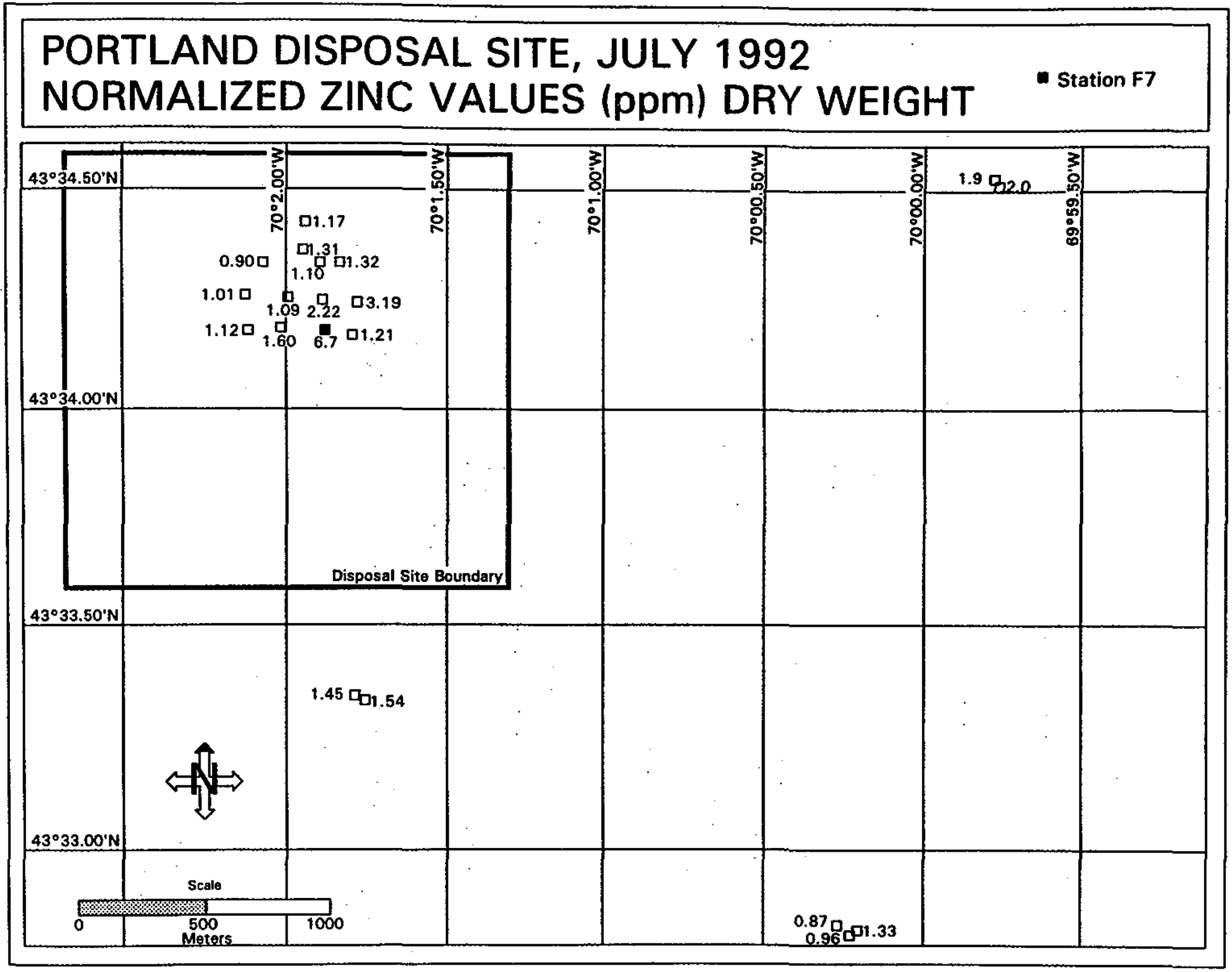

Figure 3-11. Normalized zinc values in surface sediments at the Portland Disposal Site, July 1992

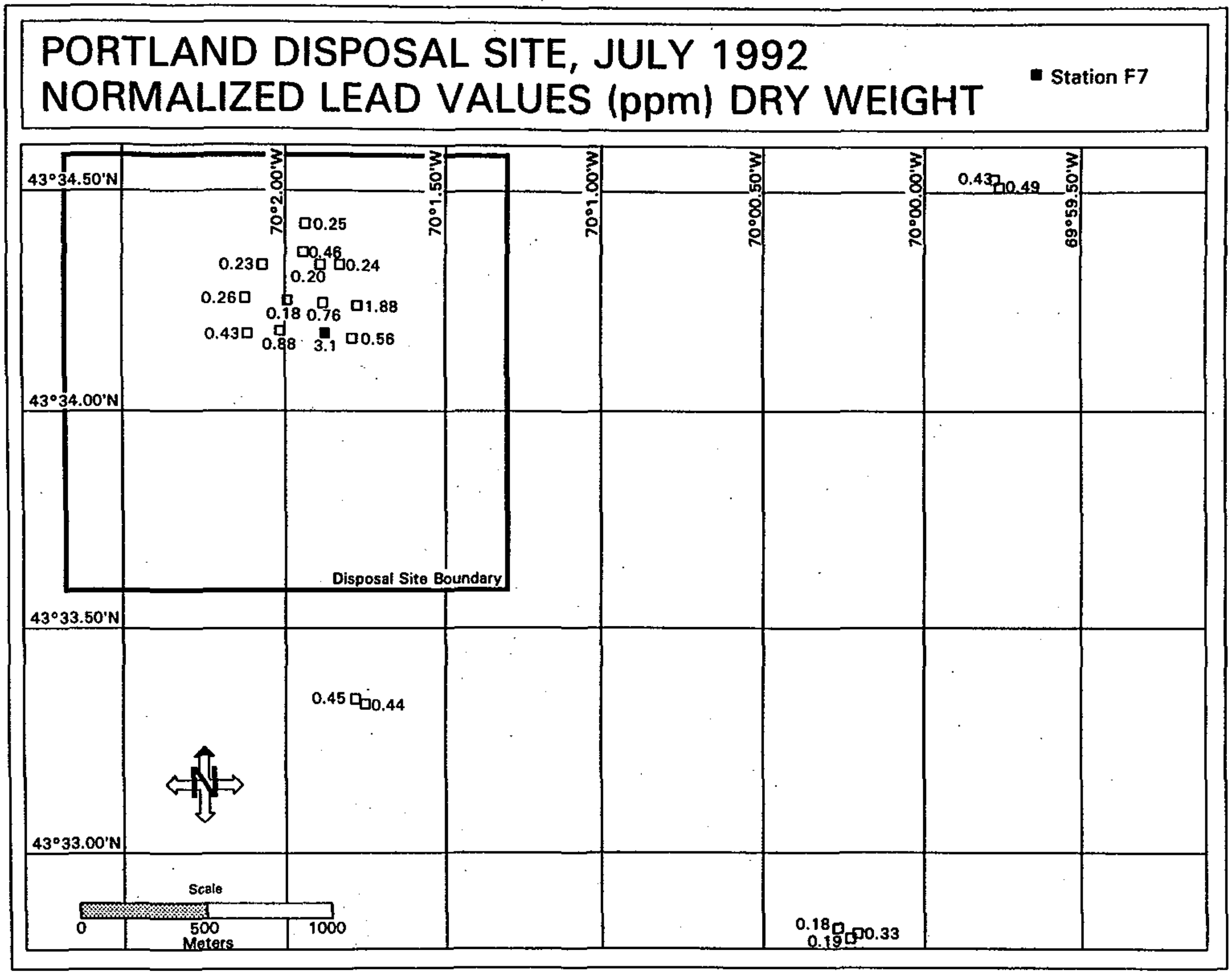

Figure 3-12. Normalized lead values in surface sediments at the Portland Disposal Site, July 1992

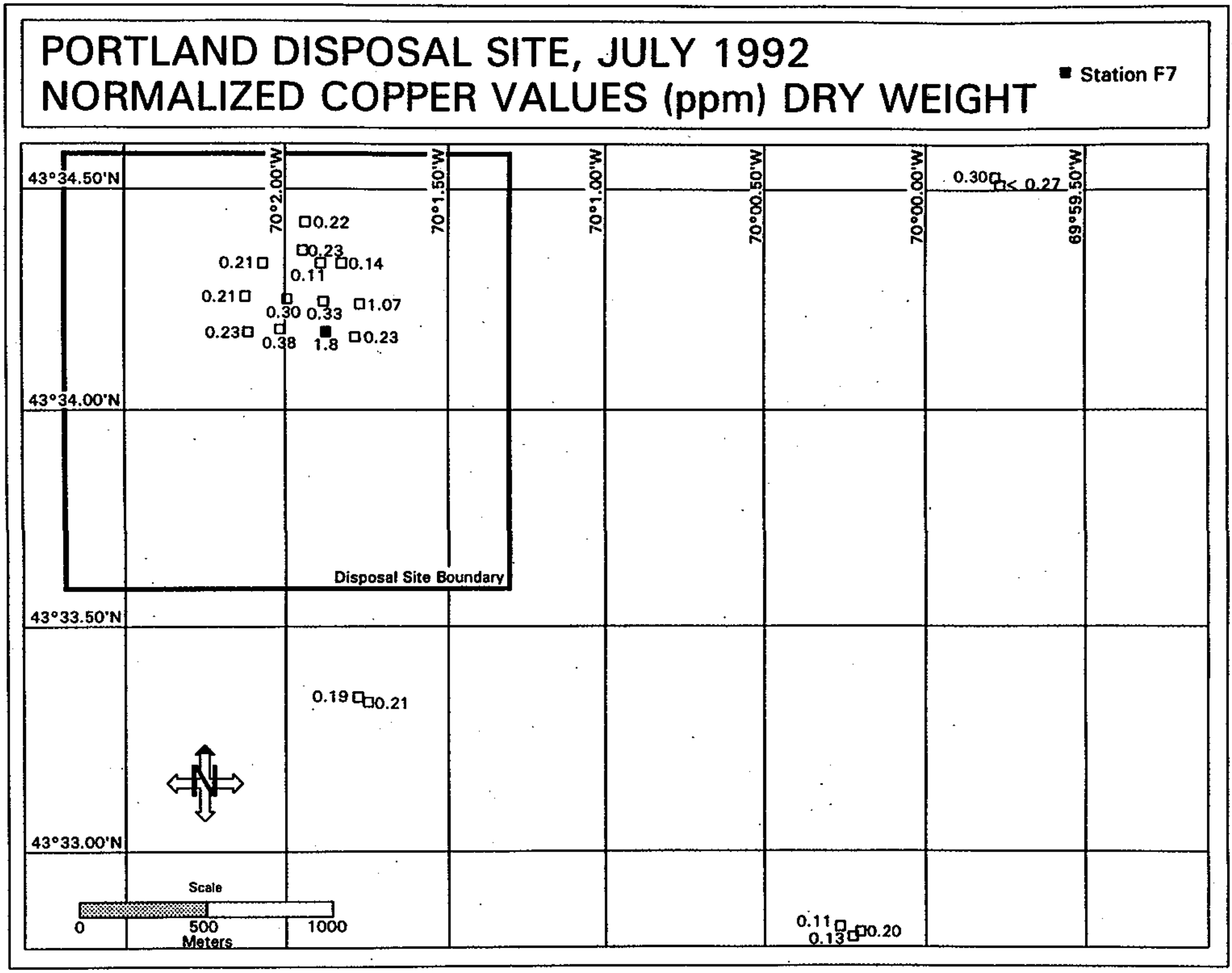

Figure 3-13. Normalized copper values in surface sediments at the Portland Disposal Site, July 1992

Table 3-5

Normalized Portland Disposal Site Reference Area Sediment Sample Results for Polycyclic Aromatic Hydrocarbons (PAHs)

	EREF (20% silt/clay)			SEREF (90% silt/clay)				SREF (21% silt/clay)		
Replicate	1	2	Mean	1	2	3	Mean	1	2	Mean
Low Molecular Weight										
napthalene	0.65 J	0.50 J	0.58	0.28 J	<0.167	0.26 J	0.18	0.77 J	0.91 J	0.84
2-methyl napthalene	<0.5	<0.5	*	<0.20	<0.167	<0.19	*	<0.50	<0.55	*
acenaphthylene	<0.5	<0.5	*	<0.20	<0.167	<0.19	*	<0.50	<0.55	*
acenaphthene	<0.5	<0.5	*	<0.20	<0.167	<0.19	*	<0.50	<0.55	*
fluorene	<0.5	<0.5	*	<0.20	<0.167	<0.19	*	<0.50	<0.55	*
phenanthrene	1.00 J	0.95 J	0.98	0.53 J	0.33 J	0.58 J	0.48	1.14 J	1.95 J	1.55
anthracene	<0.5	<0.5	*	<0.20	<0.167	<0.19	*	<0.50	<0.55	*
Total LMW PAHs			1.56				0.66			2.39
High Molecular Weight										
fluoranthene	1.60 J	1.10 J	1.35	0.86 J	0.44 J	0.99 J	0.76	1.73 J	3.05 J	3.09
pyrene	1.80 J	1.25	1.53	1.23 J	0.47 J	1.07 J	0.92	1.86 J	3.09 J	2.48
benzo(a)anthracene	2.40 J	1.80 J	2.10	0.90 J	0.54 J	1.07 J	0.84	2.41 J	3.50 J	2.96
chrysene	2.50 J	1.90 J	2.20	0.72 J	0.58 J	1.11 J	0.80	2.59 J	3.77 J	3.18
benzo(b)fluoranthene	<0.50	0.90 J	0.45	<0.20	<0.17	<0.19	*	1.18 J	1.95 J	1.57
benzo(k)fluoranthene	<0.50	0.95 J	0.48	<0.20	<0.17	<0.19	*	1.18 J	1.95 J	1.57
benzo(a)pyrene	<0.50	<0.50	*	<0.20	<0.17	<0.19	*	<0.50	<0.55	*
dibenzo(a,h)anthracene	<0.50	<0.50	*	<0.20	<0.17	<0.19	*	<0.50	<0.55	*
benzo(g,h,i)perylene	<0.50	<0.50	*	<0.20	<0.17	<0.19	*	<0.50	<0.55	*
indeno(1,2,3-cd)pyrene	<0.50	<0.50	*	<0.20	<0.17	<0.19	*	<0.50	<0.55	*
Total HMW PAHs			8.10				3.33			14.83

J = Estimated value: above the instrument detection limit but below the practical quantification limit (PQL).

* = Mean not calculated because of values below detection.

Units are all ppb normalized to % silt/clay.

4.0 DISCUSSION

The July 1992 bathymetry at PDS showed a mound at the same location as the January 1989 survey (Figure 3-1, 3-2). The depth difference comparison of these two surveys (Figure 3-3) indicated an accumulation of 1 m about 25 m east of the 1992 buoy. Below 43°34.100′ N, another broad area of accumulation is also seen. Negative depth differences between 1989 and 1992 (Figure 3-4) are clustered along steep slopes. These are most likely caused by surveying lane offsets over steeply sloping hard rock ridges (Germano et al. 1993). The extensive areas of dredged material accumulation are not on the steep slopes and are therefore not affected by lane offsets.

The pattern of sediment accumulation at PDS between January 1989 and June 1992 must be viewed in conjunction with the positions recorded in the barge logs for disposal locations. From January 1989 to November 1990, 21 barge loads of material were recorded as being released within 400′ of the buoy (43°34.270′ N, 70°01.968′ W). During this time, one barge load was recorded with a disposal position of 43°34.100′ N, 70°1.900′ W. In March and April 1991, 17 barge loads of material were again released within 200′ of that point. The release areas around these disposal points are shown in Figure 4-1. The disposal position at 43°34.100′ N was the location of the US Coast Guard deployed buoy prior to 1985. Since that time, navigational charts and the US Coast Guard light list continue to denote a buoy at that location. Reported disposal points for the contaminated project material released from October to December 1991, and the cap material released from January to June 1992, are also indicated on Figure 4-1. Most of the contaminated project material was released just north of the buoy location; one barge load on November 8, 1991 was released at 43°34.100′ N, 70°01.900′ W. Cap material was released at various points over the project mound. However, three barge loads were released to the east of the project area. These barge loads were released at a buoy location that was recorded by vessels in the area on January 30, 1992 (Figure 4-2).

The disposal locations for the material released in 1989/1990 and for the USCG capping project correspond to the areas of accumulation between the 1989 and 1992 surveys (Figure 4-1). There is no apparent accumulation at the release point recorded for the spring of 1991, but there is accumulation approximately 100 m to the south. The July REMOTS® survey detected dredged material around the designated disposal area as well as to the south. The material detected along the southern edge of the deposit may have been a thin layer deposited since 1989 (and therefore undetectable to bathymetric surveys), but it may also have been material that was released prior to 1989 that is still visible in REMOTS® sediment profile photographs.

The silt/clay material from the USCG project that was unsuitable for unconfined open water disposal was capped with cleaner silt/clay material as well as with sand from the Northeast Petroleum project. The concurrent release of these two types of cap material made

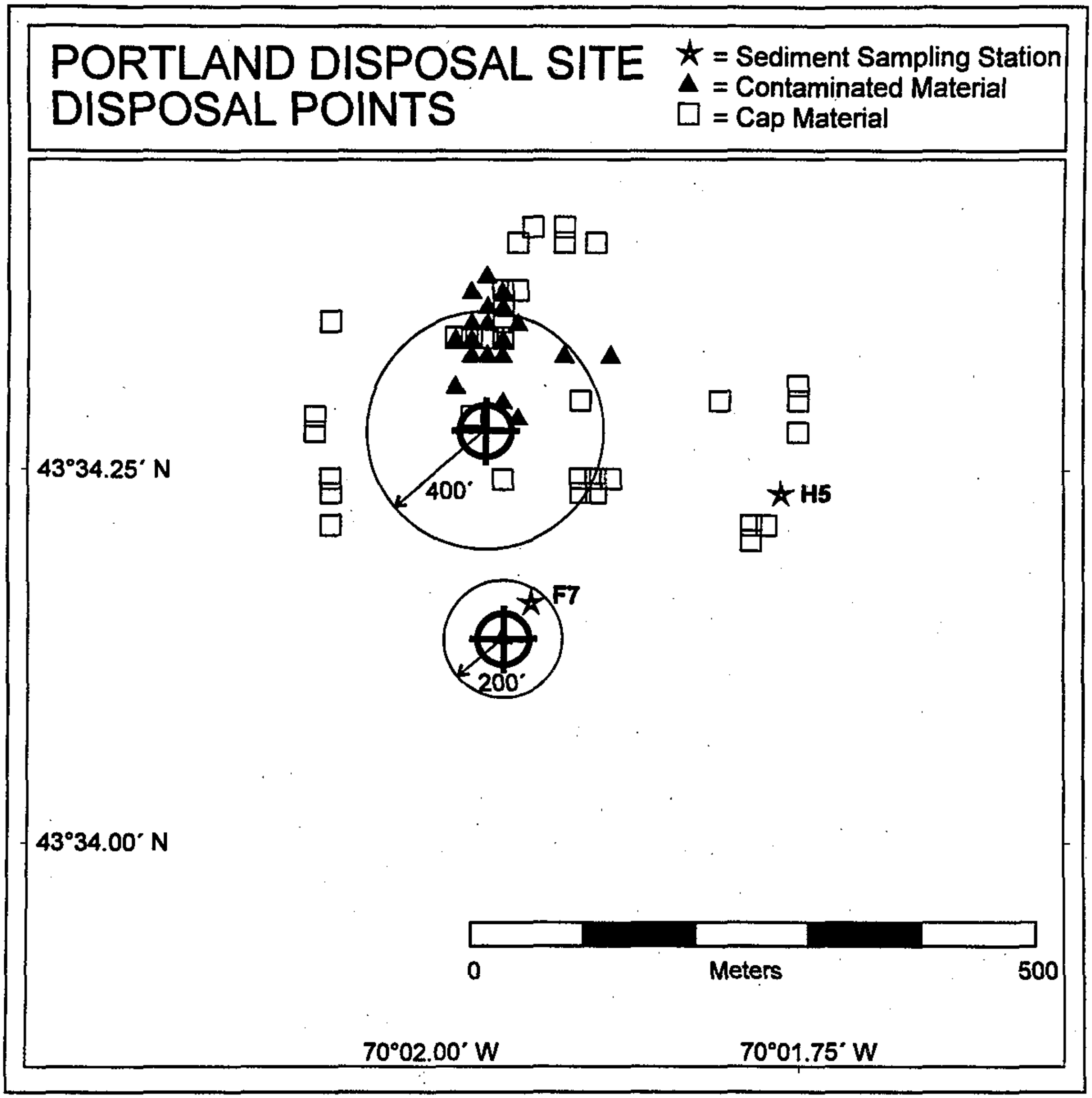

Figure 4-1. Barge disposal release points at the Portland Disposal Site, October 1991 to June 1992

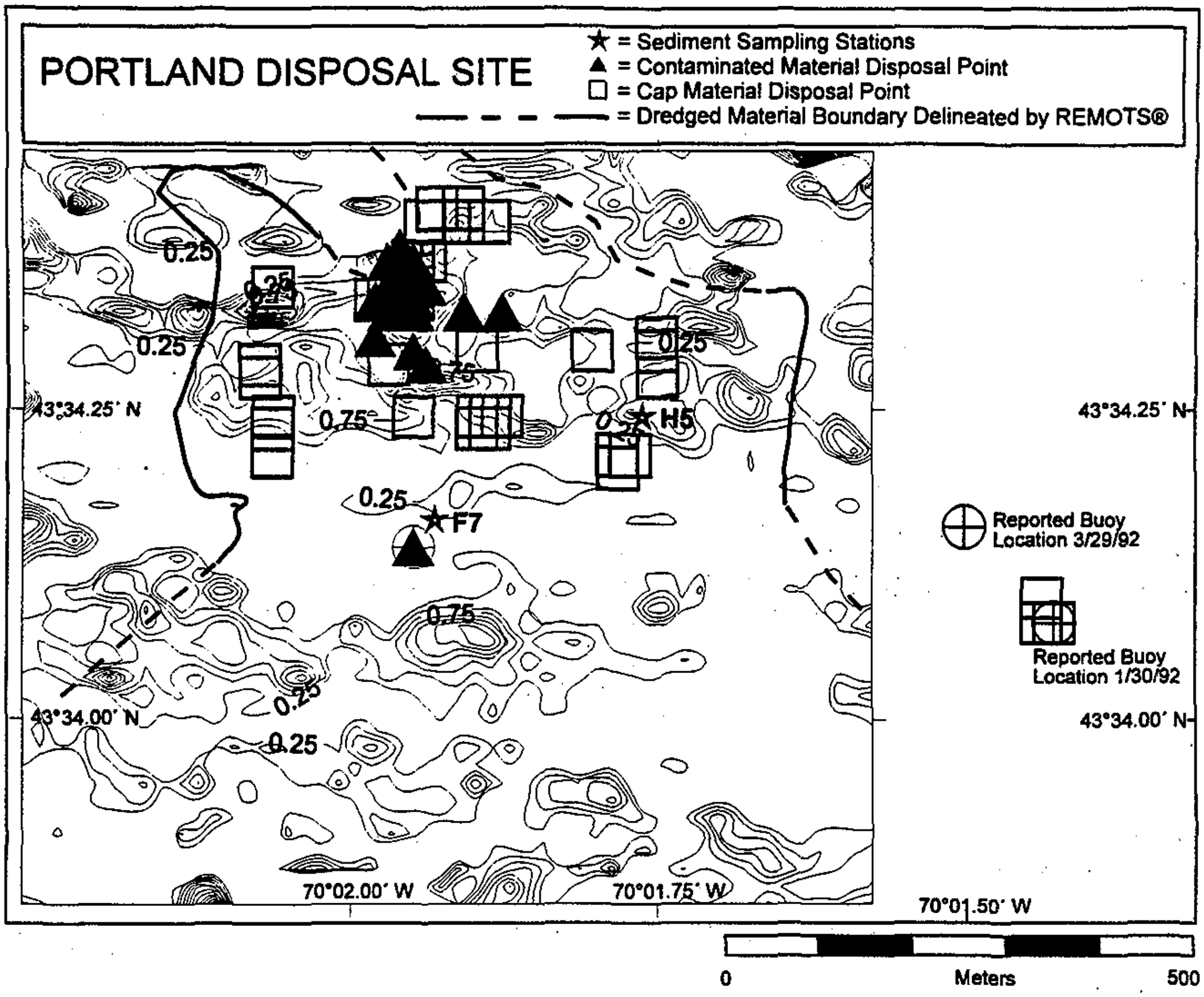

Figure 4-2. Accumulation of sediment, distribution of dredged material, and barge release locations at the Portland Disposal Site between January 1989 and June 1992

it impossible to differentiate between the cap and the disposal mound based on grain size or density. The 24 kHz survey of sediment density did not differentiate between the cap material and other dredged material.

The acoustic sediment density survey showed that, in general, the higher density sediment (coarser grain size) was concentrated in water depths shallower than 54 m, and the lower density sediment (silt and clay) was concentrated in the deepest areas. This overall pattern indicates that potentially the finer-grained materials are settling in the deepest areas of the site. The patchy data, however, prevented a conclusive identification of the project dredged material, and the smoothing of the data tended to inhibit the identification of smaller features related to dredged material disposal. The patchiness was due, in part, to the variability due to rapidly changing slopes in the survey area (as in bathymetry), and the heterogeneity of dredged material and, in particular, of the cap material that was being mapped. Finally, the acoustic method of characterizing bottom sediment is still being refined; the strength of the bottom reflection is a function of the acoustic impedance contrast between the water column and the bottom sediments and is, in theory, directly related to sediment density. More recent work has shown, however, that the strength of the return is also affected by such sediment properties as porosity, surface "roughness" (particularly a problem with heterogeneous dredged material), and grain size, among other factors (LeBlanc et al. 1992).

A capping project is designed to isolate contaminants in the dredged material by covering the dredged material with cleaner sediment which may have contaminant concentrations comparable to, or somewhat greater than, reference. Reference data collected at the PDS were compared to ambient sediment chemistry values (metals and PAHs) as measured by the NOAA National Status and Trends Program in two areas near PDS: Casco Bay (CSC) and Stover Point (MSSP). Metals and PAH data normalized to silt/clay were collected from 1984 to 1986 for CSC and in 1988 for MSSP (Table 4-1).

Mean metals values for the three PDS reference areas (Table 3-4) are within the ranges for the NS&T stations. Based on the average concentrations of metals in the NS&T stations and at the reference areas, it appears that the reference areas chosen for PDS are representative of the ambient sediment in the Gulf of Maine. The total LMW and HMW PAHs at reference areas EREF and SEREF (Table 3-5) are below the average total PAH values found at the NS&T stations. At reference area SREF, the total HMW PAHs were 11.00 ppb compared to 9.90 ppb at MSSP. The total LMW PAHs at SREF, 2.39, was within the ranges found at the NS&T stations.

Given that the reference areas appear to be representative of the area, metals concentrations from samples taken on the cap (Table 3-4) can be compared to the reference areas. In general, all stations on the cap except for F7 and H5 had normalized metals values within the ranges found at the reference areas, indicating that the cap has effectively isolated

Table 4-1

Metals and PAH Data Normalized to % Silt/Clay for NS&T Stations Casco Bay (CSC) and Stover Point (MSSP)

NS&T Station	CSC: 84	84	84	85	85	85	85	85	86	86	86	Average CSC	MSSP: 88	88	88	Average MSSP
%silt/clay	79.17	38.07	64.64	93.84	88.15	-0.10	76.30	-0.10	98.31	92.41	94.34	65.91	37.42	52.42	22.64	37.49
Aluminum	*851.33*	*1607.57*	*991.65*	*819.48*	*872.38*	*0.00*	*1220.18*	*0.00*	*0.00*	*0.00*	*0.00*	*578.42*	*125.60*	*124.00*	*256.18*	*168.59*
Arsenic	0.12	0.24	0.12	0.18	0.16	0.01	0.11	0.01	0.16	0.14	0.13	0.13	0.22	0.27	0.19	0.23
Cadmium	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.01	0.00	*	0.00	0.00	0.00	*
Chromium	1.03	2.30	1.66	1.09	1.10	0.00	1.05	0.00	0.99	0.92	0.98	1.01	1.98	1.58	1.55	1.70
Copper	0.24	0.40	0.26	0.24	0.25	0.00	0.38	0.00	0.28	0.35	0.20	0.24	0.37	0.38	0.36	0.37
Iron	334.72	848.44	447.09	417.73	450.37	0.00	391.87	0.00	426.20	397.14	435.66	377.20	69.48	62.95	83.92	72.12
Lead	0.37	0.66	0.51	0.40	0.29	0.00	0.51	0.00	0.56	0.61	0.36	0.39	0.80	0.61	1.24	0.88
Mercury	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	*	0.00	0.00	0.00	*
Nickel	0.29	0.62	0.35	0.39	0.34	0.00	0.35	0.00	0.38	0.40	0.35	0.32	0.64	0.59	0.75	0.66
Zinc	1.00	1.92	1.18	1.25	1.19	0.00	1.42	0.00	1.30	1.39	1.14	1.07	1.79	1.72	2.16	1.89
LMW PAHs																
acenaphthylene	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.20	0.00	0.10	0.03	0.40	0.31	0.33	0.34
acenaphthene	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	*
fluorene	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.07	0.00	0.00	0.03	0.17	0.14	0.15	0.15
phenanthrene	3.31	0.00	0.00	1.38	0.69	0.00	3.13	0.00	1.02	0.00	0.47	0.91	1.71	1.37	1.68	1.59
anthracene	10.02	0.00	0.00	0.18	0.00	0.00	0.69	0.00	0.99	0.00	1.08	1.18	0.40	0.31	0.43	0.38
Total LMW PAHs	13.80	0.00	0.00	1.56	0.69	0.01	4.07	0.01	2.28	0.00	1.65	2.19	2.68	2.12	2.59	2.46
HMW PAHs																
fluoranthene	6.37	0.00	0.00	2.30	1.15	0.00	5.52	0.00	1.82	0.00	0.79	1.63	3.47	2.86	3.53	3.29
pyrene	8.55	0.00	0.00	1.89	0.68	0.00	5.39	0.00	1.81	0.00	1.19	1.77	3.47	2.67	3.27	3.14
benzo(a)anthracene	7.53	0.00	0.00	0.82	0.45	0.00	2.14	0.00	0.70	0.00	0.49	1.10	1.47	1.18	1.50	1.38
chrysene	4.91	0.00	0.00	1.25	0.68	0.00	2.90	0.00	0.99	0.00	0.40	1.01	1.39	1.45	1.72	1.52
benzo(b)fluoranthene	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.68	0.00	0.45	0.10	0.69	0.67	1.02	0.79
benzo(k)fluoranthene	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.88	0.67	0.80	0.78
benzo(a)pyrene	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.91	0.00	0.37	0.39	1.79	1.45	1.72	1.65
dibenzo(a,h)anthracene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*	0.10	0.10	0.00	0.07
benzo(g,h,i)perylene	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.60	0.00	0.34	0.09	1.58	1.26	1.46	1.43
indeno(1,2,3-cd)pyrene	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.66	0.00	0.35	0.09	0.00	0.00	0.00	*
Total HMW PAHs	30.36	0.00	0.00	6.25	2.96	0.04	15.95	0.04	8.16	0.00	4.38	6.19	14.85	12.31	15.02	14.06

Metals in ppm dry weight.

PAHs in ppb dry weight.

* = Mean not calculated because of values below detection.

the contaminants from the underlying material. A few measured non-normalized values fell within the "moderate" or "high" values for Maine as defined by the NERBC (NERBC 1980) at Stations F7 and H5. Plotting normalized values of three metals (Figures 3-11 through 3-13) showed that the highest values are concentrated in the southeastern portion of the surveyed area. Although the effect of normalization using a small value for the fine-grained fraction at Station F7 contributes to the elevation of normalized metal concentrations there, the elevation at that station and Station H5 warrants closer inspection. The variability of the metals data could be a function of variability within the cap material itself, or of variability within historical dredged material placed prior to the capping project at the 1984 buoy location. Either of these hypotheses are possible; metal levels at F7 and H5 are within the range of samples collected in the cap material except for As, Cr, and Ni. Because F7 and H5 are not located near the center of disposal, however, it is possible that no project material was placed at these stations and that the metals concentrations are a result of historical disposal. It is unlikely that the samples were collected in uncapped Coast Guard material, because in samples collected from Coast Guard material prior to dredging, the entire suite of metals had much higher concentrations than measured in F7 and H5. As a reasonable management precaution, however, additional sediment from future projects should be directed to the 1984 buoy location where a small quantity (625 m^3) of contaminated material may have been disposed.

5.0 CONCLUSIONS

The July 1992 monitoring survey at PDS succeeded in further delineating the dredged material within the site boundaries. Two apparent disposal mounds were found by comparing the 1989 and the 1992 bathymetric surveys, one representing the capped mound around the 1989/1992 buoy location and one to the south nearer the 1984 buoy location, an area that received material after 1989. Dredged material distribution, as detected by the REMOTS® sediment-profile survey, includes these two areas of accumulation and extends over a broad area to the south as well. The distribution of dredged material in the REMOTS® photographs may reflect historical (pre-1989) dredged material as well as material released between 1989 and 1992 that was not thick enough to be detected acoustically.

The 24 kHz survey was not effective in distinguishing the cap material. The heterogeneity of the cap, a mix of coarse and fine-grained sediment, resulted in patchy data over a large area. The high degree of smoothing necessary during data processing decreased the ability to identify specific features in this data set. The "density" as measured by the system is only related to the strength of the acoustic signal. Recent evidence that other factors may influence signal strength (i.e, surface roughness, porosity) make the attempt to distinguish the cap material by this method alone even more difficult.

The effectiveness of the cap in isolating contaminants was determined by examining the sediment chemistry values and the benthic biology. Normalized sediment chemistry results from samples on the cap, with the exception of stations F7 and H5, show metals and PAH values within the ranges found in the ambient sediment at the reference areas. Further, these values were generally similar to or lower than values measured in cap material prior to dredging. The location of F7, near the site of the 1984 buoy where a small volume (625 m^3) of contaminated material was disposed, suggests that additional cap material should be placed there as a precautionary measure. Stage III organisms were prevalent on the cap, indicating that the benthic environment on the cap is healthy and that the cap material has most likely isolated contaminated material from the sediment/water interface.

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