Monitoring Cruise at the
Cornfield Shoals Disposal Site
August 1992

Disposal Area Monitoring System DAMOS

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13. ABSTRACT

After fine-grained dredged material was released at the Cornfield Shoals Disposal Site (CSDS) between October 1991 and May 1992, there was evidence that ambient sand was being transported over the fine-grained dredged material deposit. The presence of ambient sand over fine-grained dredged material in REMOTS sediment-profile photographs, current meter studies, and transmissometer and backscatter data all supported active bedload transport in a study conducted at CSDS in 1991/1992. However, the areal extent of the fine-grained dredged material under the sand and the thickness of the sand over the unknown.

The present study, conducted at the Cornfield Shoals Disposal Site in August 1992, attempted to delineate the extent of the fine grained dredged material under the sand and to measure the sand thickness. Part of the May 1992 REMOTS survey was repeated in August. All but two stations that were formerly fine-grained dredged material had been covered with sand by August. The new REMOTS stations in August were concentrated south of the mapped fine-grained deposit . Dredged material was detected under sand at two stations south of this area, extending the dredged material boundary to the south.

An acoustic sediment density study was conducted at CSDS to define the surface sediment density and locate the fine-grained dredged material. It was also conducted to gather the subsurface sediment density information and map the thickness of the sand over the mud. The surface density values, calculated every 50m along the survey track, did not delineate the fine-grained material that was at REMOTS stations G8 and G9. Subsurface densities were measured at 15 cm intervals below the sediment water interface. These subsurface densities did not detect any decrease in sediment density with depth, suggesting that the depth to the base of the mud was less than 15cm or that the acoustic survey was unable to detect the density changes.

The transformation from fine-grained dredged material at the center of the mound to sand over mud or sand at all but two REMOTS stations (G8 and G9) continues to support the theory that sand is being transported over the fine-grained dredged material at the Cornfield Shoals Disposal Site. This is not unexpected in that the site is dispersive and material is normally transported across and ultimately out of the area.

The acoustic sediment density study was not successful in locating the fine-grained dredged material either at the center of the disposal mound or under the sand on the flanks of the deposit. The lack of success with the 24 kHz acoustic survey may have been due in part to the resolution of the system, but attention to and adjustment to varying system parameters in future surveys may result in more successful distinction between subbottom layers.

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The present study, conducted at the Cornfield Shoals Disposal Site in August 1992, attempted to delineate the extent of the fine-grained dredged material under the sand and to measure the sand thickness. Part of the May 1992 REMOTS® survey was repeated in August. All but two stations that were formerly fine-grained dredged material had been covered with sand by August. The new REMOTS® stations in August were concentrated south of the mapped fine-grained deposit. Dredged material was detected under sand at two stations south of this area, extending the dredged material boundary to the south.

An acoustic sediment density study was conducted at CSDS to define the surface sediment density and locate the fine-grained dredged material. It was also conducted to gather subsurface sediment density information and map the thickness of the sand over the mud. The surface density values, calculated every 50 m along the survey track, did not delineate the fine-grained material that was at REMOTS® stations G8 and G9. Subsurface densities were measured at 15 cm intervals below the sediment water interface. These subsurface densities did not detect any decrease in sediment density with depth, suggesting that the depth to the base of the mud was less than 15 cm or that the acoustic survey was unable to detect the density changes.

The transformation from fine-grained dredged material at the center of the mound to sand over mud or sand at all but two REMOTS® stations (G8 and G9) continues to support the theory that sand is being transported over the fine-grained dredged material at the Cornfield Shoals Disposal Site. This is not unexpected in that the site is a dispersive site and material is normally transported across and ultimately out of the area.

The acoustic sediment density study was not successful in locating the fine-grained dredged material either at the center of the disposal mound or under the sand on the flanks of the deposit. The lack of success with the 24 kHz acoustic survey may have been due in part to the resolution of the system, but attention to and adjustment to varying system parameters in future surveys may result in more successful distinction between subbottom layers.

1.0 INTRODUCTION

The Cornfield Shoals Disposal Site (CSDS) is located 3.3 nmi south of Cornfield Point in Old Saybrook, Connecticut (Figure 1-1). It is the only dredged material disposal site managed as a dispersive site by the US Army Corps of Engineers, New England Division (NED), as part of the Disposal Area Monitoring System (DAMOS) Program. At a dispersive disposal site, unlike a containment site, it is expected that dredged material disposed at the site will be transported out of the area.

The Cornfield Shoals Disposal Site has been under study by the NED as part of the DAMOS Program since 1978. From 1978 to 1991, the site received low volumes of mostly hydraulically dredged sands (29,000 m^3 annually) although some mechanically dredged fine-grained material (5,500 yds^3 from North Cove) was released at the site in January 1988. The material was released at LORAN-C coordinates, usually at the center of the disposal site. Bathymetric surveys conducted before 1991 did not detect any well-defined dredged material disposal mounds (SAIC 1988, Germano et al. 1994).

As part of a joint study between the University of Connecticut and the Newport, RI, office of Science Applications International Corporation (SAIC), a taut-wire moored buoy was deployed at two locations within CSDS in 1991. Between 12 September and 9 October 1991, 50,803 m^3 of sandy dredged material was released at buoy location A2 (Figure 1-2). Between November 13, 1991 and April 14, 1992, 105,479 m^3 of fine-grained dredged material from North Cove was released at buoy location B. Coincident with these disposal operations, a near-bottom current meter was deployed at BTM-A (near A2) on August 8, prior to disposal, and moved to BTM-B (near B) on October 21. A midwater current meter (MWM) was deployed southwest of BTM-A on August 1 (Figure 1-2). A series of studies at CSDS from July 1991 (predisposal) to May 1992 (postdisposal) documented the accumulation of dredged material at these buoy locations and provided circumstantial evidence for active bed transport in the area (Wiley 1994). The current meter data showed the east-west tidal component as the dominant current direction. Maximum velocities for the midwater meter were 120 $cm \cdot s^{-1}$ on the spring tide and 60 $cm \cdot s^{-1}$ on the neap. For the nearbottom meter, maximum velocities were 80 $cm \cdot s^{-1}$ on the spring and 40 $cm \cdot s^{-1}$ on the neap. All of these current velocities are sufficient to erode medium to fine sands (Bohlen et al. 1992)

The accumulation of dredged material at CSDS from 1991 to 1992 was detected both with bathymetry and with REMOTS® sediment-profile photography. The bathymetric surveys from August 1991 to May 1992 documented the formation of the disposal mounds and illustrated the shifts in sediment accumulation patterns over time. These shifts in accumulation patterns may have been due to the addition of dredged material to the site and/or to the natural sediment transport patterns within the area.

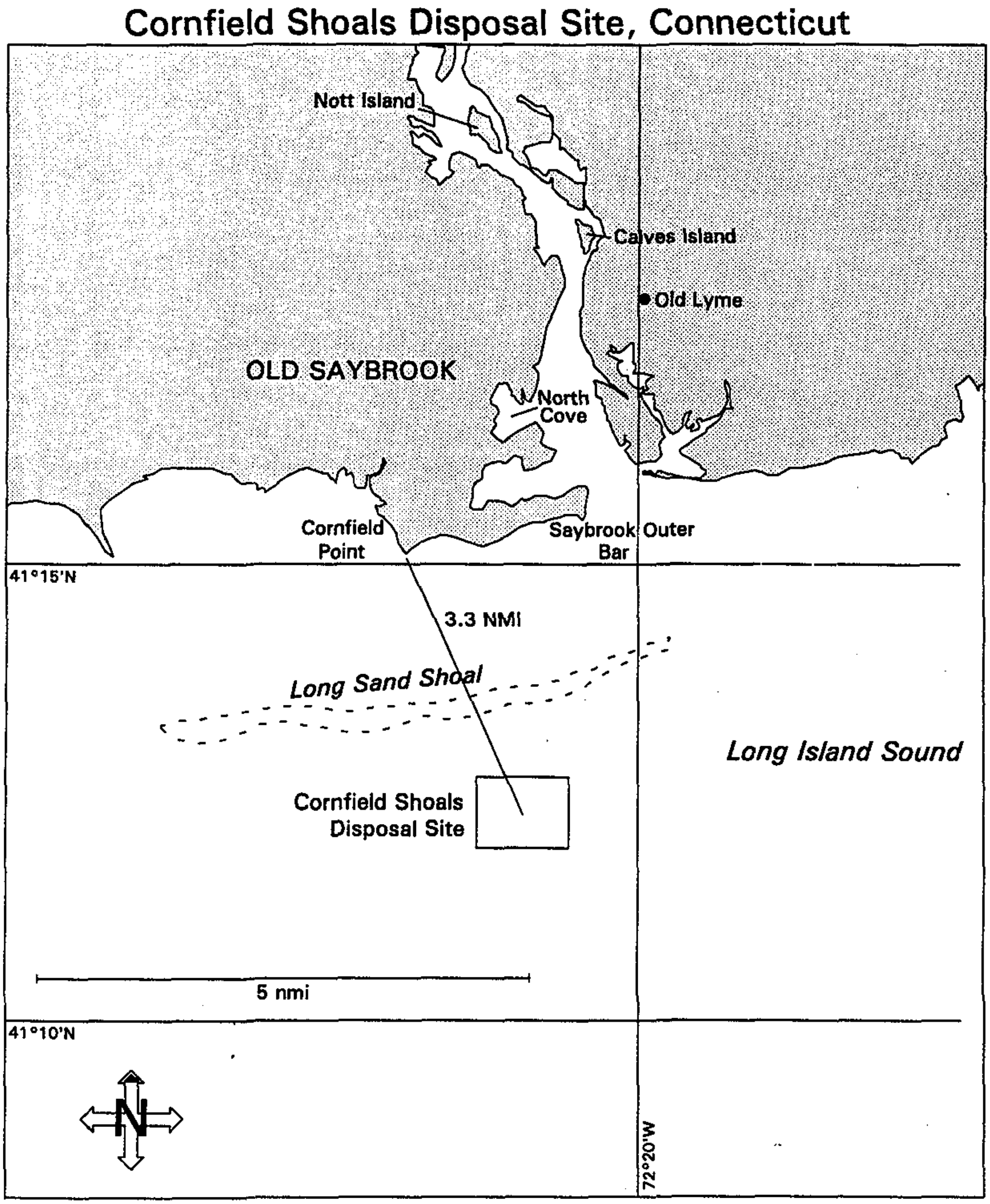


Figure 1-1. Location of Cornfield Shoals Disposal Site

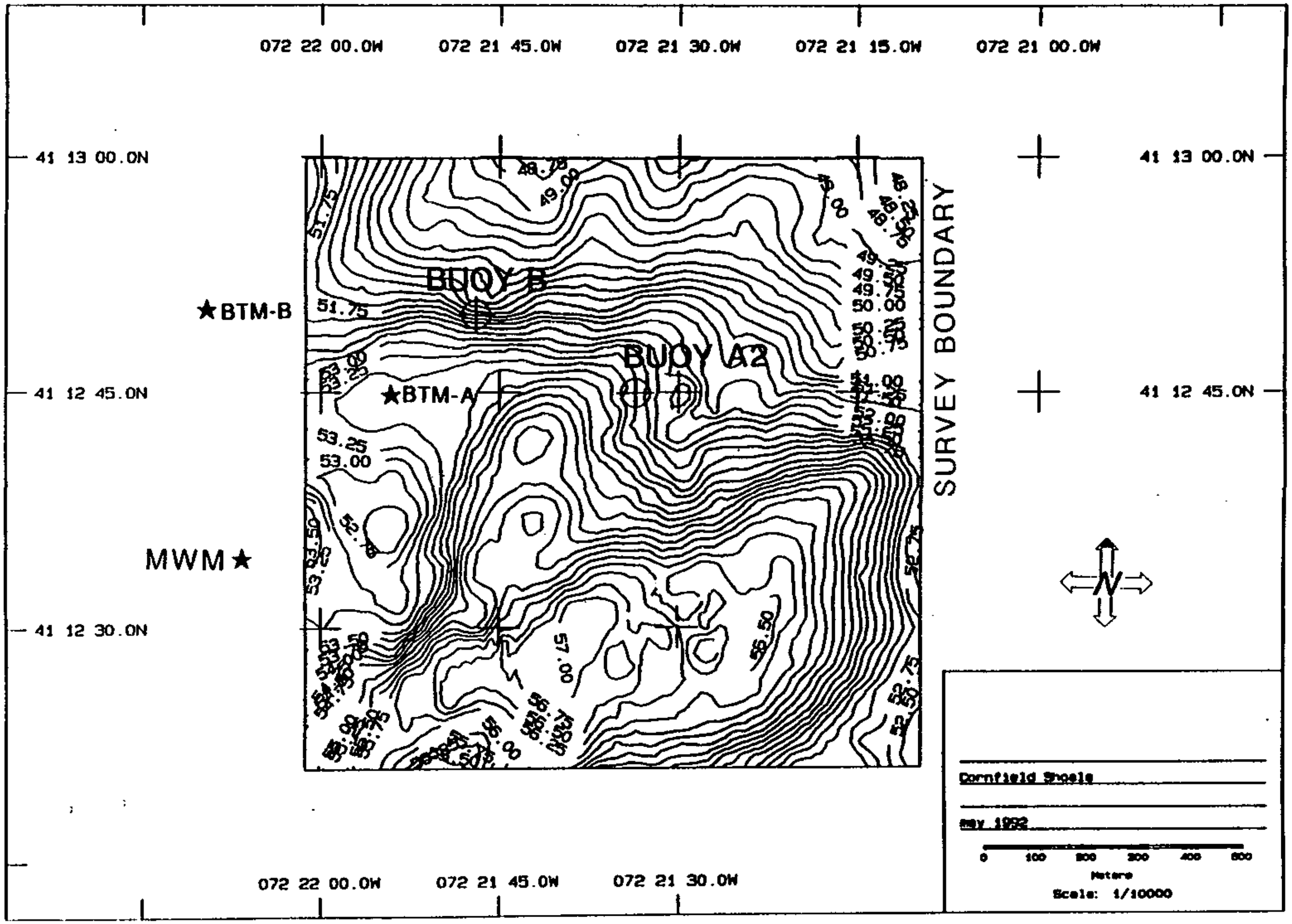


Figure 1-2. Location of disposal buoy and current meters at the Cornfield Shoals Disposal Site, 1991-1992

Because the ambient sediment at CSDS is sand, the fine-grained dredged material that formed the disposal mound at buoy location B was seen very clearly in the May 1992 REMOTS® photographs. On the flanks of the fine-grained disposal mound, the REMOTS® photographs showed a thin layer of sand (< 10 cm) covering the mud. At further distances from the center of the mound, ripples on the surface of the sand appeared in the REMOTS® photographs. The apparent movement of sand over the mud contributed to the evidence for active bed transport at CSDS. Additional evidence for active bed transport included optical backscatter and transmissometer data.

The present investigation, conducted 5-10 August 1992, was designed to assess any further sediment transport, particularly the movement of sand over mud. It was expected that the two disposal mounds detected by earlier surveys would have remained stable and that the extent and thickness of the sand veneer over the fine-grained dredged material would be detectable using subbottom profiling.

2.0 METHODS

The August 1992 CSDS survey team used bathymetry, REMOTS® sediment-profile photography, and a 24 kHz acoustic survey to determine the stability of the disposal mounds and investigate any further sediment transport at the disposal site. The bathymetric and REMOTS® sediment-profile surveys have been used in numerous studies to monitor benthic conditions (Parker and Revelas 1989, Germano et al. 1994). The 24 kHz acoustic survey has been used at other disposal sites to determine both surface (Wiley 1993) and subsurface sediment densities (SAIC 1991). Together these technologies should provide an accurate assessment of the sedimentology at the site.

2.1 Bathymetry

The SAIC Integrated Navigation and Data Acquisition System (INDAS) provided the precision navigation required for all field operations. This system uses a Hewlett-Packard 9920® series computer to collect position, depth, and time data for later analysis, and to provide real-time navigation. A Del Norte Trisponder® System provided positioning to an accuracy of ±3 m. Shore stations were established in Connecticut at known benchmarks at Cornfield Point (41°15.79′ N, 72°23.04′ W) and Lynde Point Light (41°16.29′ N, 72°20.59′ W) in Old Saybrook, Connecticut. DAMOS Contribution No. 60 (Parker and Revelas 1989) contains a detailed description of INDAS and its operation.

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). Depth values transmitted to the computer were adjusted for speed of sound and transducer depth. Before starting the bathymetry survey, a SeaBird Instruments, Inc. SEACAT SBE 19-01 conductivity-temperature-depth profiler (CTD) was used to calculate a sound velocity profile. During analysis, all depth values were converted to Mean Low Water (MLW) after compensating for vessel draft and tidal fluctuations that occurred while surveying. Position and depth data were also checked to identify and eliminate any outlying values before producing an accurate contour plot. Analysis of the bathymetric data was conducted using the Hydrographic Data Analysis System (HDAS).

The August 5, 1992 bathymetric survey at CSDS was set up over the same grid used in the 1991 and May 1992 surveys (Wiley 1994). The 1200 × 1200 m survey consisted of 49 lanes oriented east and west with 25 m lane spacing.

2.2 REMOTS®

A REMOTS® survey was conducted at CSDS on August 6, 1992 to define the limits of dredged material distribution. In May 1992, a 45-station orthogonal REMOTS® grid had been surveyed to define the dredged material boundary (Figure 2-1). In August 1992,

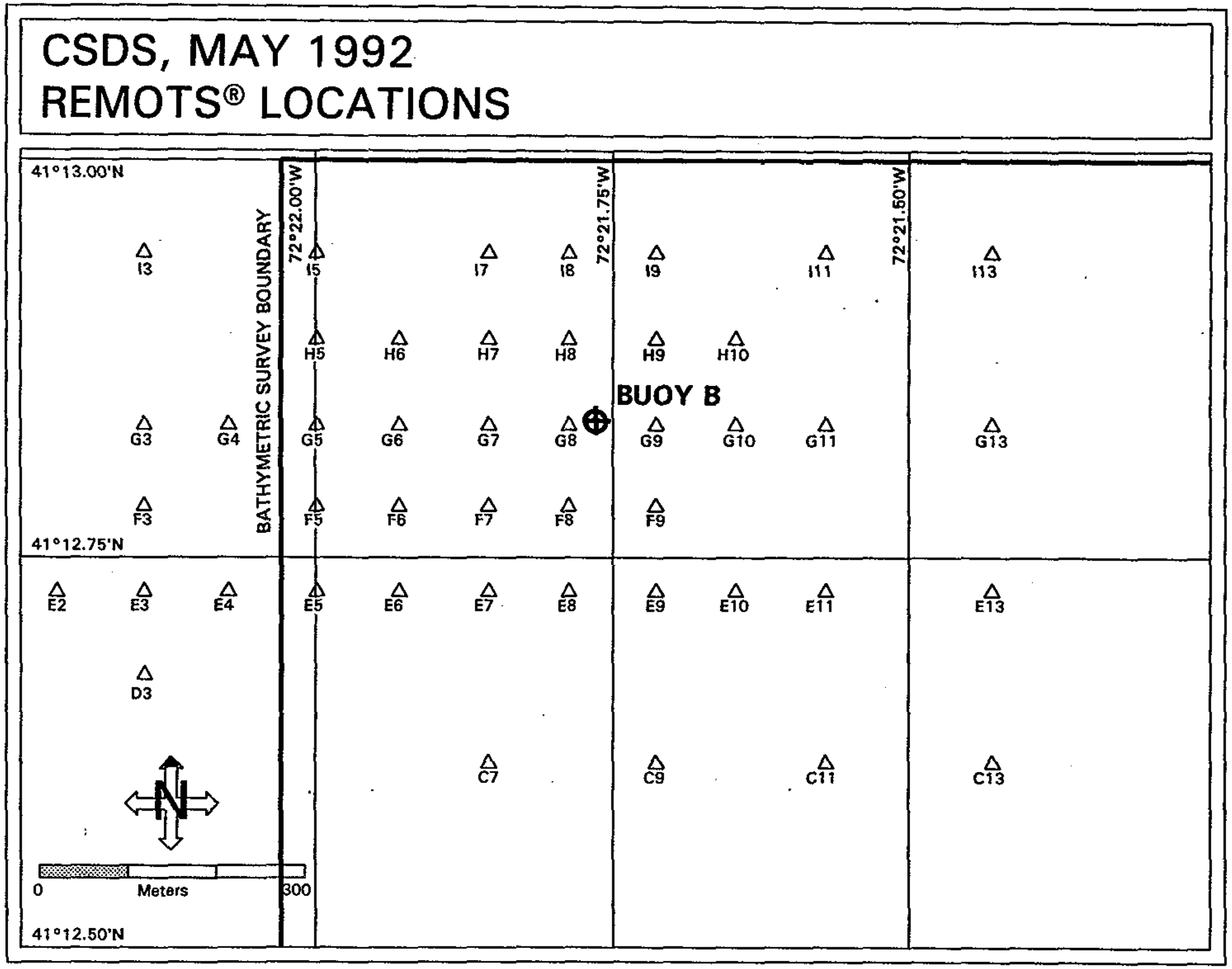


Figure 2-1. REMOTS® station locations at the Cornfield Shoals Disposal Site, May 1992

15 stations were resurveyed. Ten additional stations along the southern boundary of the dredged material deposit were surveyed at this time to map further the extent of the fine-grained dredged material documented in the May survey (Figure 2-2). Three replicates were taken at all stations. Analysis of the REMOTS® sediment-profile photographs was limited to grain size measurement, average penetration, and documentation of the presence of dredged material.

2.3 Sediment Density

REMOTS ® photographs from the May 1992 survey at CSDS showed the presence of two sediment types with sharply different densities: sand and fine-grained mud (Wiley 1994). The 24 kHz acoustic survey conducted at CSDS on August 10, 1992 was designed to determine if the system could identify the different sediment densities that were observed in the REMOTS® photographs. The sediment density 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). The survey covered the same area as the first 25 lanes of the bathymetric survey and collected data every 50 m along the survey track. Subsurface density information was collected every 15 cm below the seafloor.

Data output from the Acoustic Core System® included amplitude and acoustic impedance values. Acoustic impedances have been reliably assigned to different sediment types; therefore, they 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. The densities of surface sediment samples taken from the site were used to verify the densities calculated from the impedance values. For a more detailed discussion of the analysis procedure, see Caulfield and Yim (1983) and Caulfield (1984).

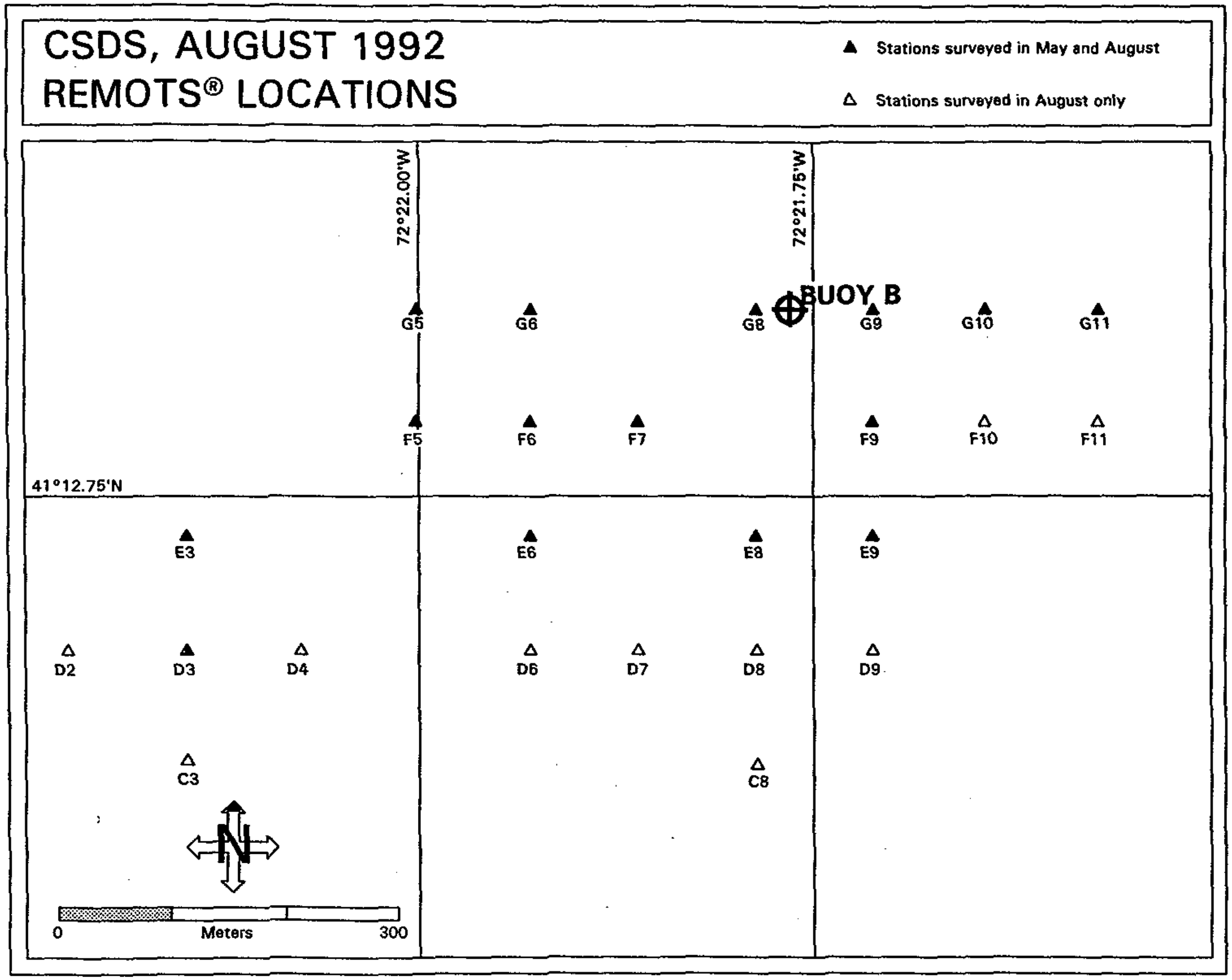


Figure 2-2. REMOTS® station locations at the Cornfield Shoals Disposal Site, August 1992

3.0 RESULTS

3.1 Bathymetry

The bathymetry at CSDS changed very little between May 1992 (Figure 3-1) and August 1992 (Figure 3-2). At approximately 72°21.75′ W and 41°12.85′ N, the mound formed by the disposal of fine-grained sediment from North Cove caused the contour lines to bend to the south in both surveys. South of 41°12.50′ N, the contours in the August survey were slightly deeper and more convoluted than in May. This is the area where sand waves were recorded in the fathometer trace in May (Wiley 1994). Comparing depths in the two bathymetric surveys showed very little loss from May to August (Figure 3-3). Five areas of -20 cm depth difference exist, each a maximum of 75 m in diameter. Up to 40 cm of material had accumulated at 16 locations in the southern portion of the survey area from May to August (Figure 3-4). Each of these areas was less than 100 m in diameter.

3.2 REMOTS®

Of the 25 REMOTS® stations surveyed at CSDS in August 1992, two were fine-grained dredged material, and four were sand over mud. The remaining stations were sand (Figure 3-5). The two stations with fine-grained dredged material (G8 and G9) were located closest to the specified disposal point. Of the REMOTS® stations that were surveyed both in May and August 1992, E3, F6, F7, G5, G10, D3, F8, and E9 were sand over mud in May, but only sand was visible in August (Figure 3-6). Station F9 was ambient sandy sediment in May, but in August it was sand over dredged material (Figures 3-7 and 3-8). Stations G6, G8, and G9 remained unchanged. Sand is very difficult for the REMOTS® camera to penetrate; as a result, REMOTS® photographs taken at a sandy station usually have very low penetration and often do not show the subbottom structure. Ten new stations were surveyed in August to determine if there was any other fine-grained material at the site that had not been detected in May. Eight of these stations detected only sand, but D6 and D7 showed sand over fine-grained dredged material.

In addition to documenting the presence of ambient sand or fine-grained dredged material, the REMOTS® sediment-profile photographs showed variations in the sand grain size between stations and mapped the locations of sand waves or lag deposits. In both May and August, coarser grained sand with lag deposits of pebbles or shells was found north of 41°12.75′ N, and finer grained sand with bed forms was found to the south (Figure 3-8).

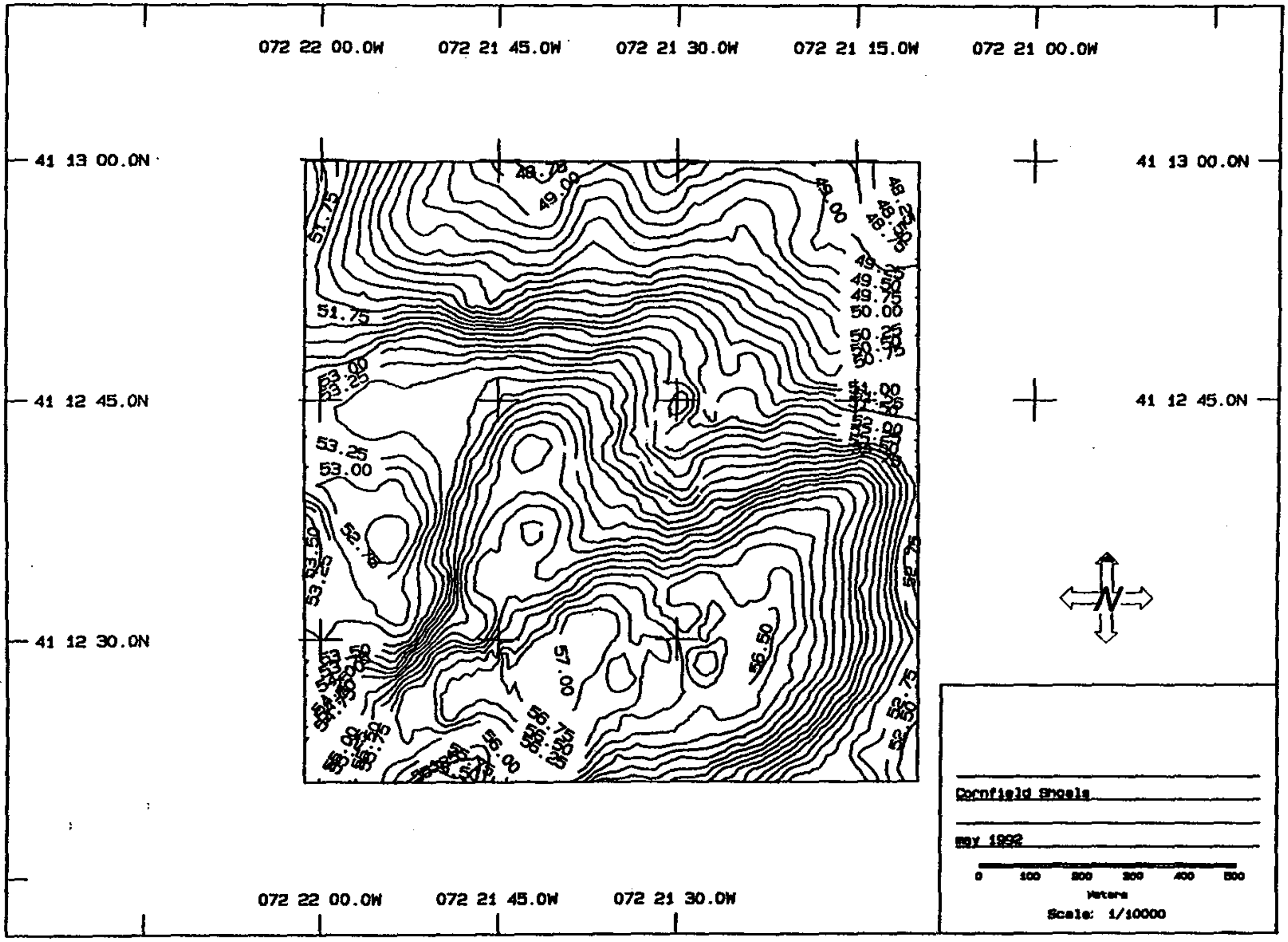


Figure 3-1. Bathymetric contour plot at the Cornfield Shoals Disposal Site, May 1992 (depth in meters)

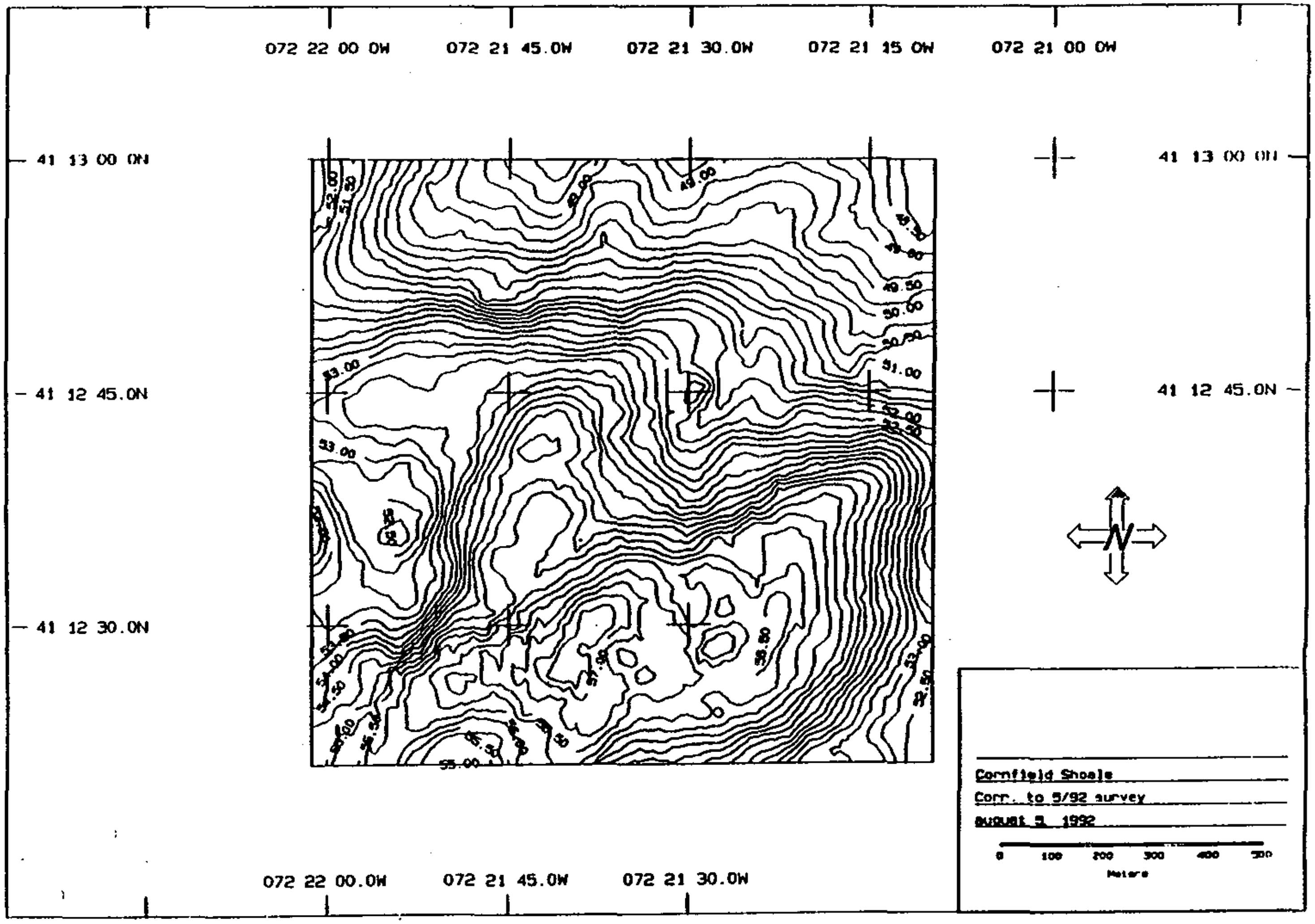


Figure 3-2. Bathymetric contour plot at the Cornfield Shoals Disposal Site, August 1992 (depth in meters)

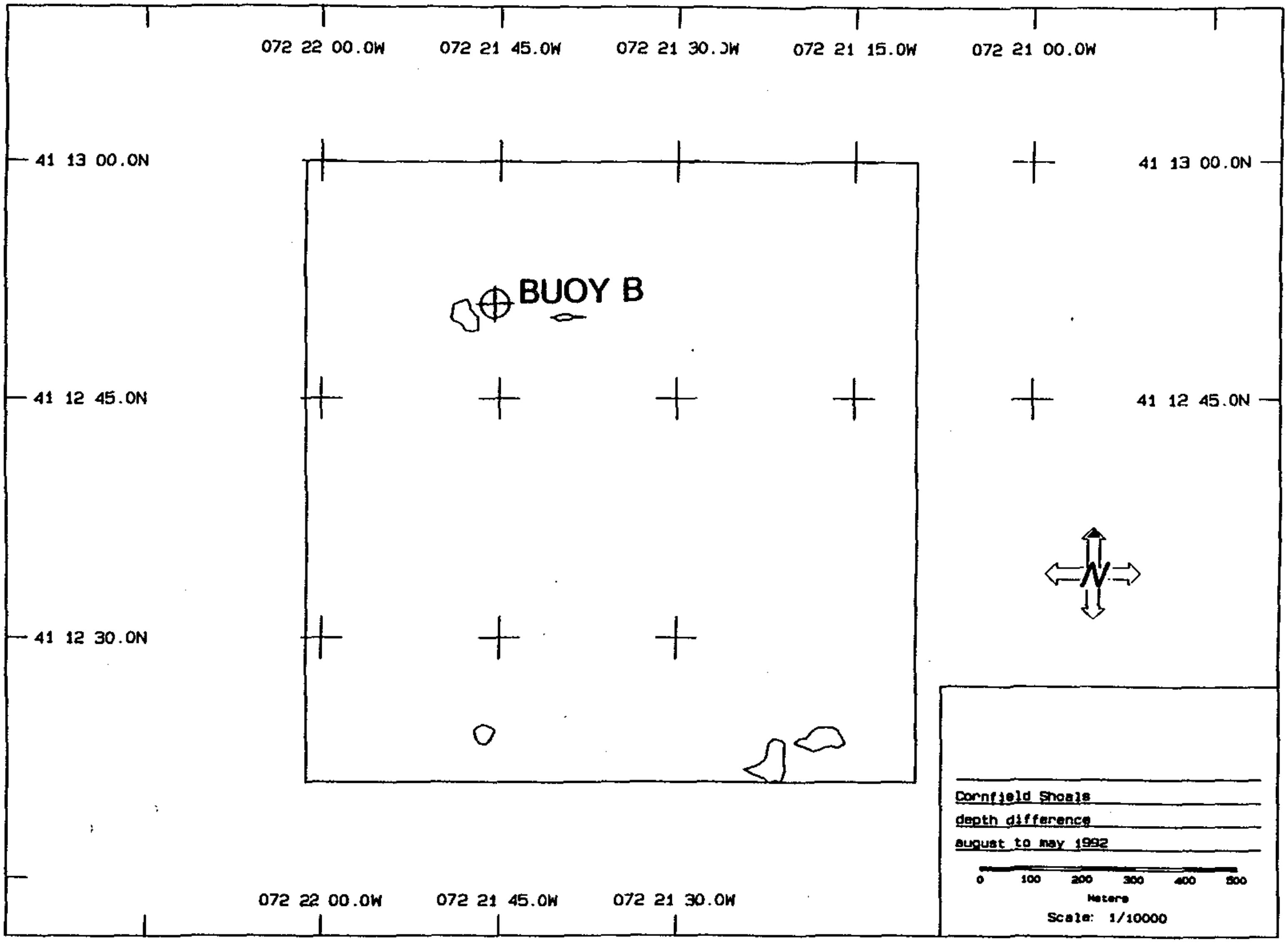


Figure 3-3. Negative depth difference contour plot between May 1992 and August 1992 (contours at 0.2 m)

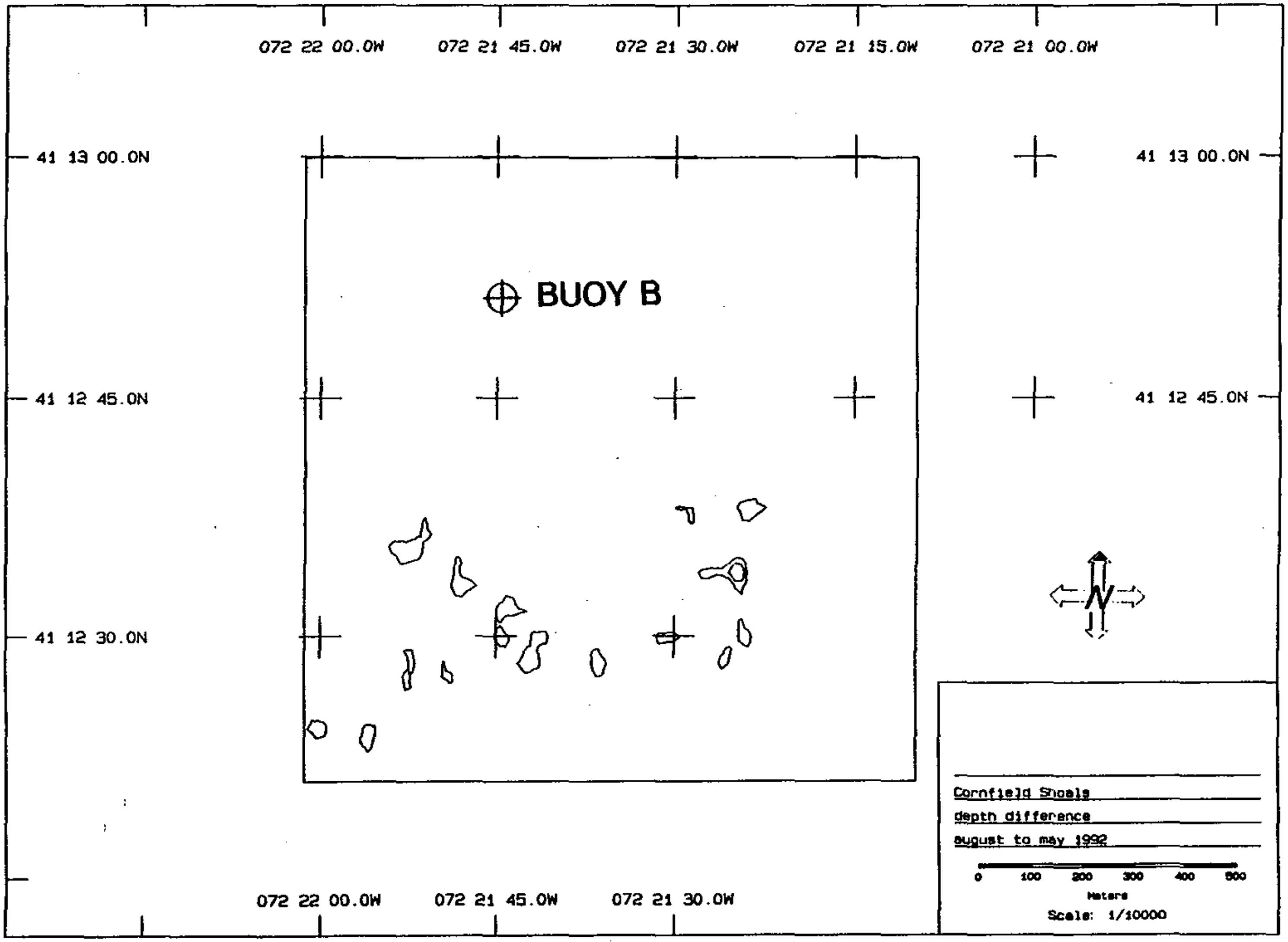


Figure 3-4. Positive depth difference contour plot between May 1992 and August 1992 (contours at 0.2 and 0.4 m)

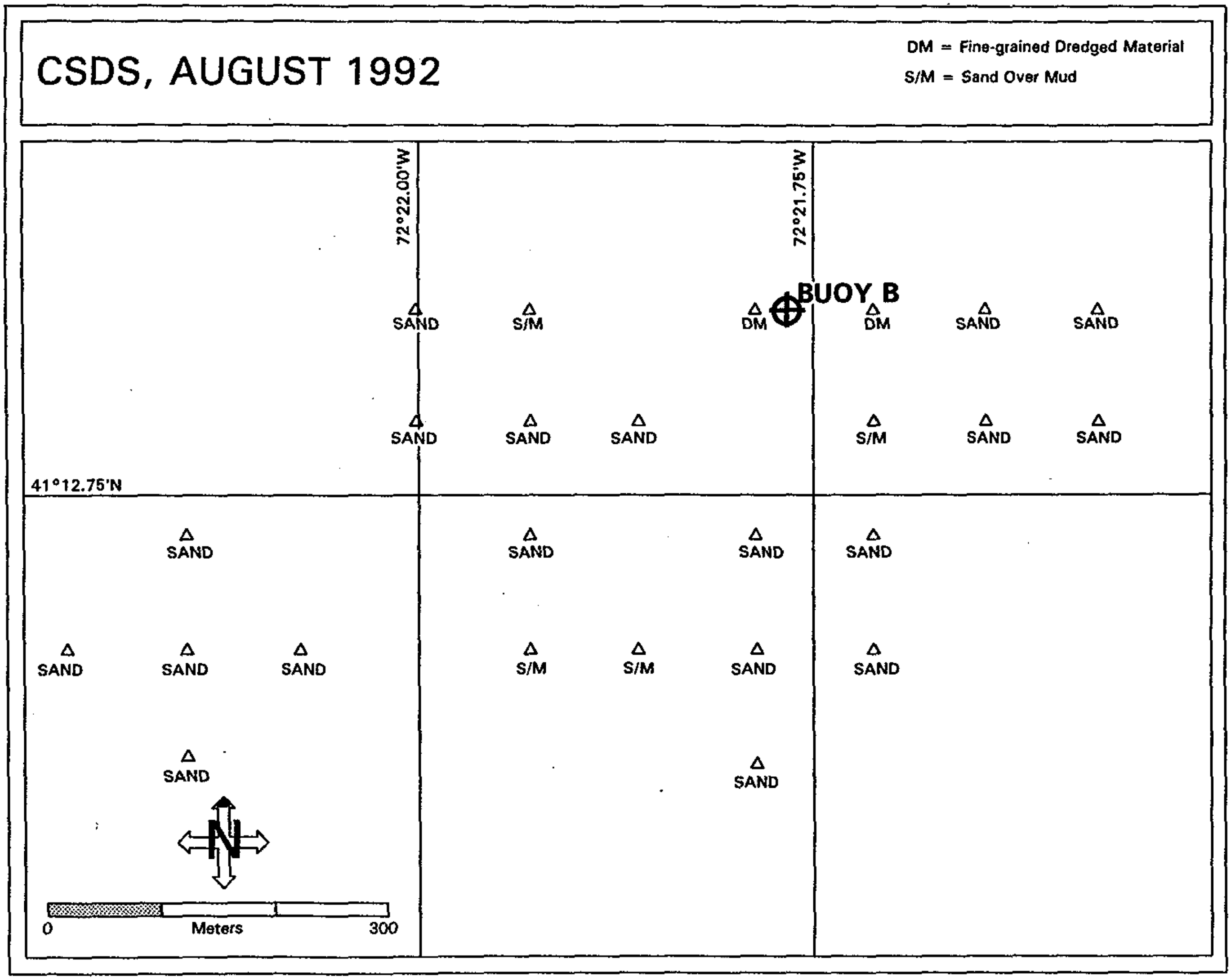
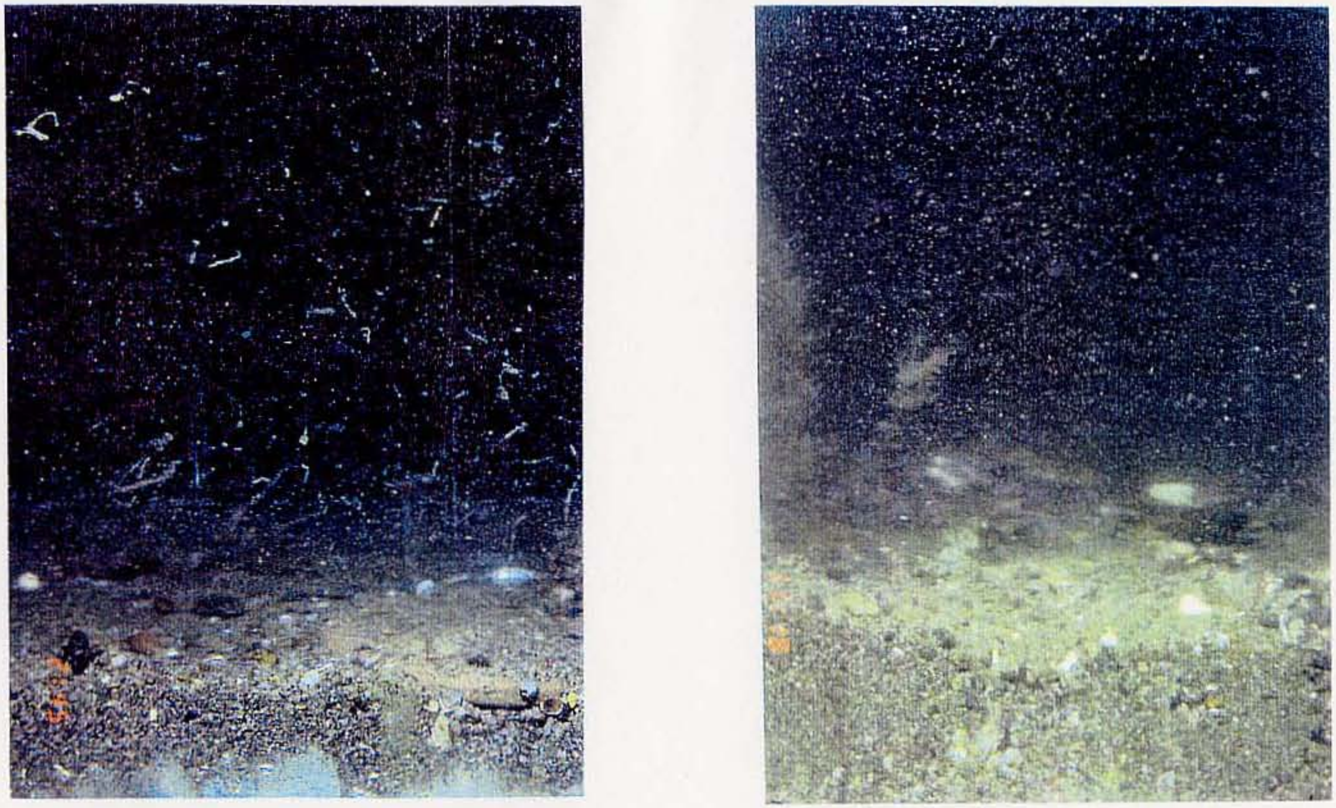


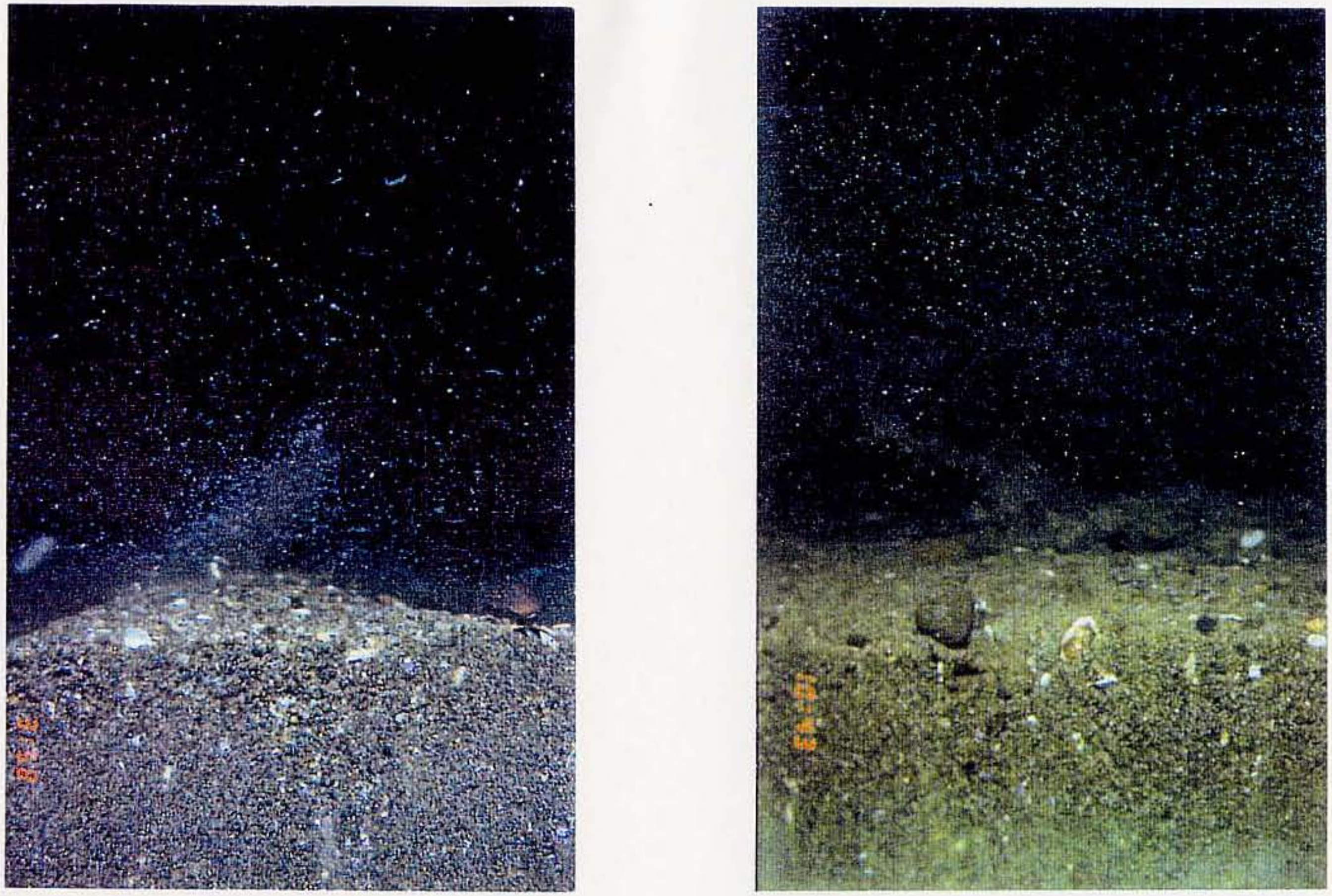
Figure 3-5. Map of sediment type at the Cornfield Shoals Disposal Site, August 1992



A

B

Figure 3-6. Station E3 showing sand/mud in May 1992 (*A*) and sand in August 1992 (*B*)



A B

Figure 3-7. Station F9 in May 1992 (*A*) and August 1992 (*B*), showing change from ambient sandy sediment to sand over mud

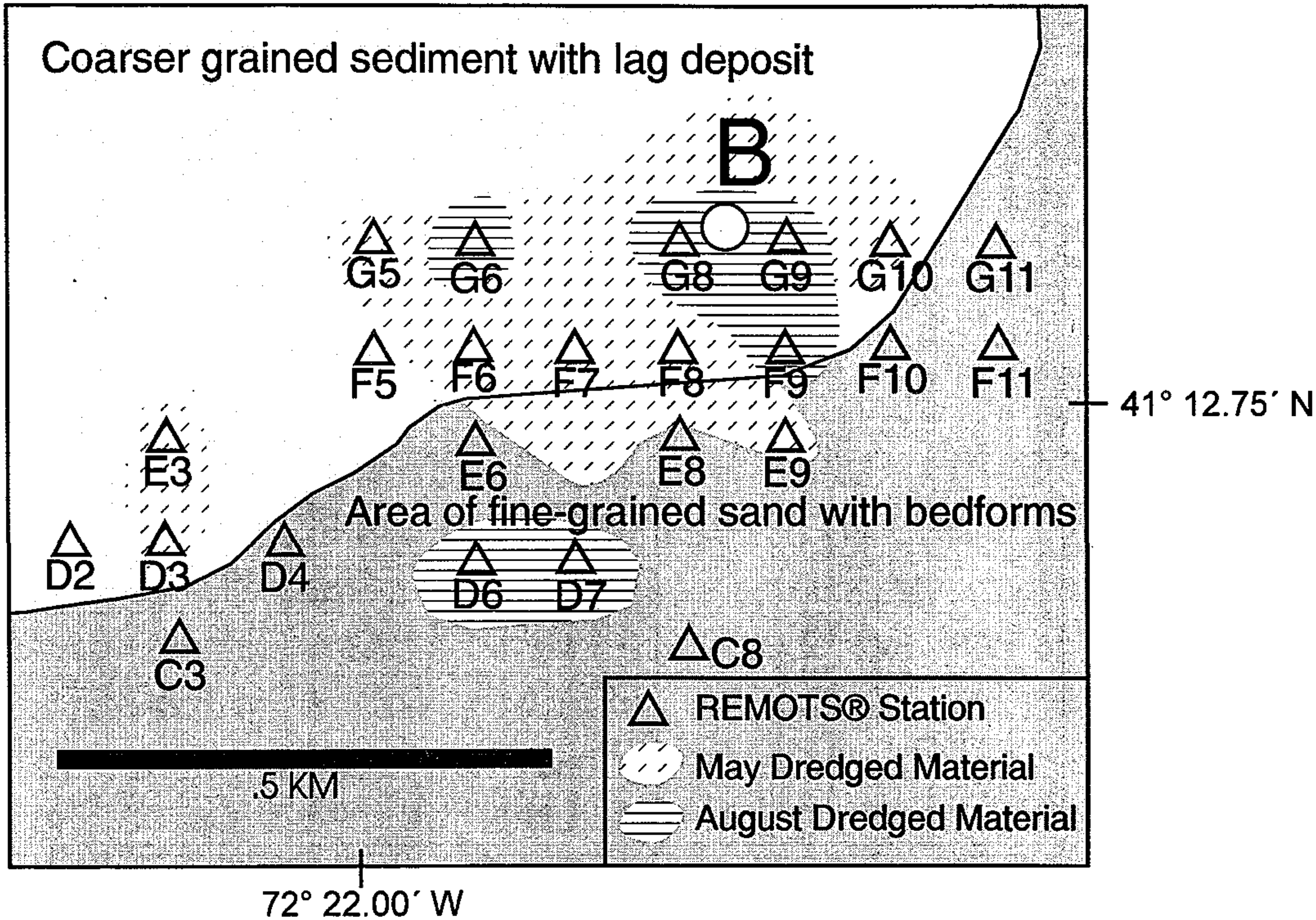


Figure 3-8. Sand and dredged material distribution at the Cornfield Shoals Disposal Site, May and August 1992

3.3 Sediment Density

Surface density data ranged from 1.3 $g \cdot cc^{-1}$ to 2.3 $g \cdot cc^{-1}$. The surface sediment density data show high variability between data points (Figure 3-9). At REMOTS® stations G8 and G9, where the median grain size mode was greater than 4 phi (silt/clay), the density values range from 1.5 to 1.8 $g \cdot cc^{-1}$. The remaining REMOTS® stations surveyed in August all had grain sizes of one to two phi (medium to fine sand) which should correspond to densities of more than 1.9 $g \cdot cc^{-1}$. The density data show values of 1.3 $g \cdot cc^{-1}$ and greater at all the REMOTS® locations. The contour plot of the density data (Figure 3-10) shows areas of relatively uniform density between 1.3 and 1.6 $g \cdot cc^{-1}$. Values greater than 1.6 $g \cdot cc^{-1}$ (Figure 3-11) are concentrated north of 41°12.75′ N.

Subsurface sediment density at CSDS was collected at 15 cm intervals below the surface. Data was collected for multiple intervals although attenuation and data degradation prevented any realistic analysis on all but the initial layer. The contour plot of the density values of the first layer (15 cm below the sediment water interface) shows an increase in density at all points of the survey (Figure 3-12).

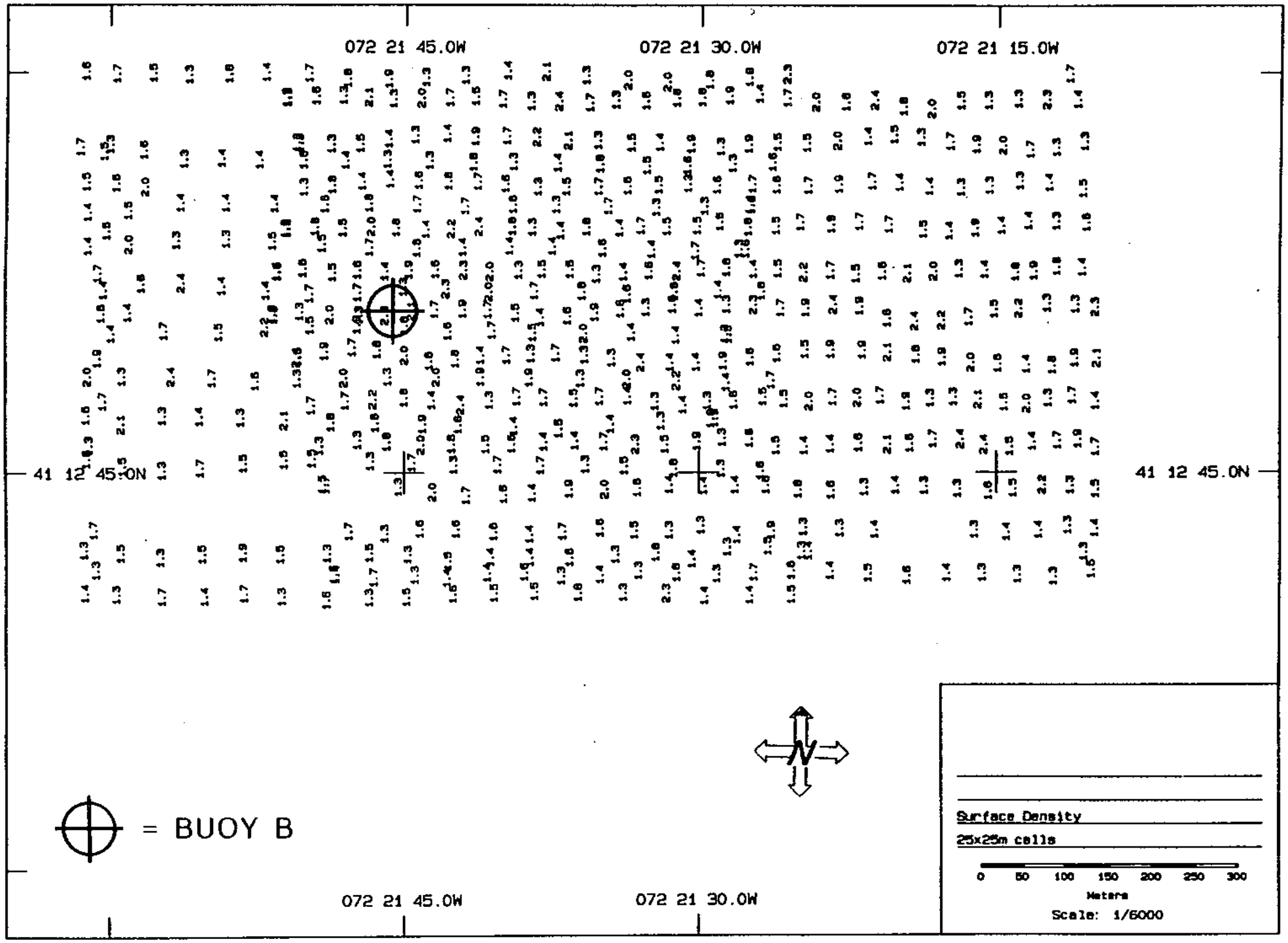


Figure 3-9. Smooth sheet of surface sediment density ($g \cdot cc^{-1}$) at the Cornfield Shoals Disposal Site, August 1992

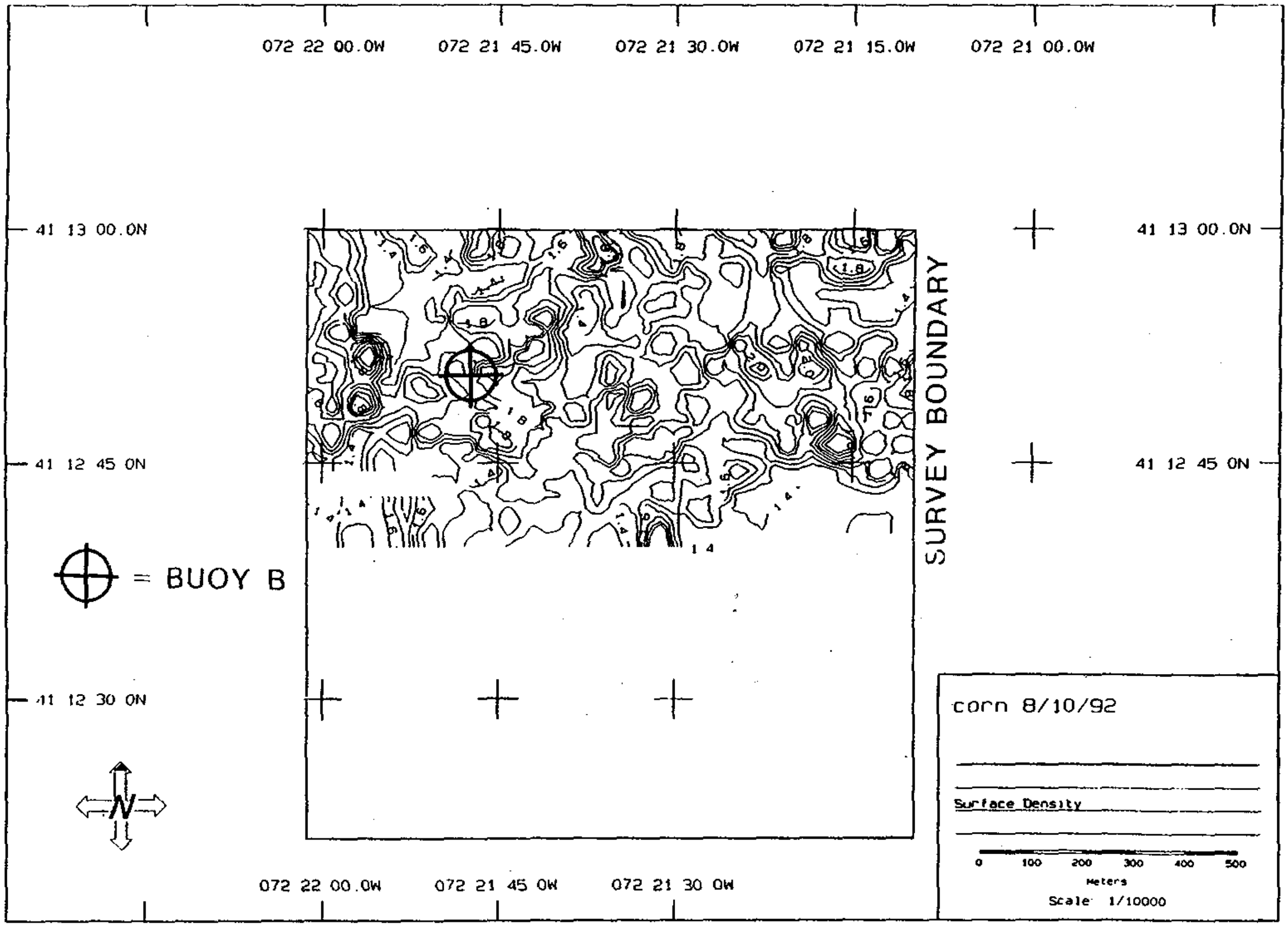


Figure 3-10. Contour plot of surface sediment density (g·cc^{-1}) at the Cornfield Shoals Disposal Site, August 1992

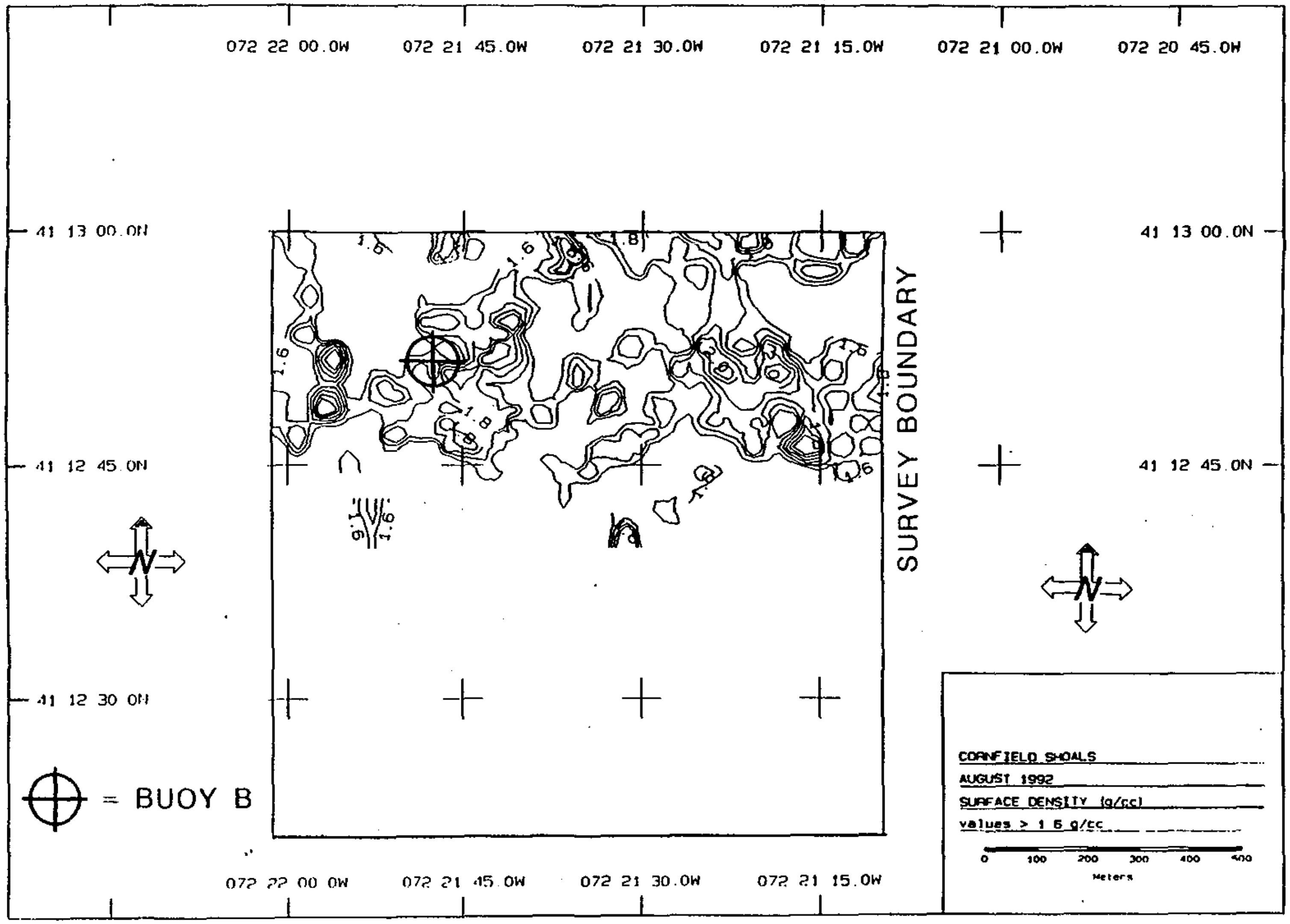


Figure 3-11. Surface sediment density values >1.6 g·cc^{-1}

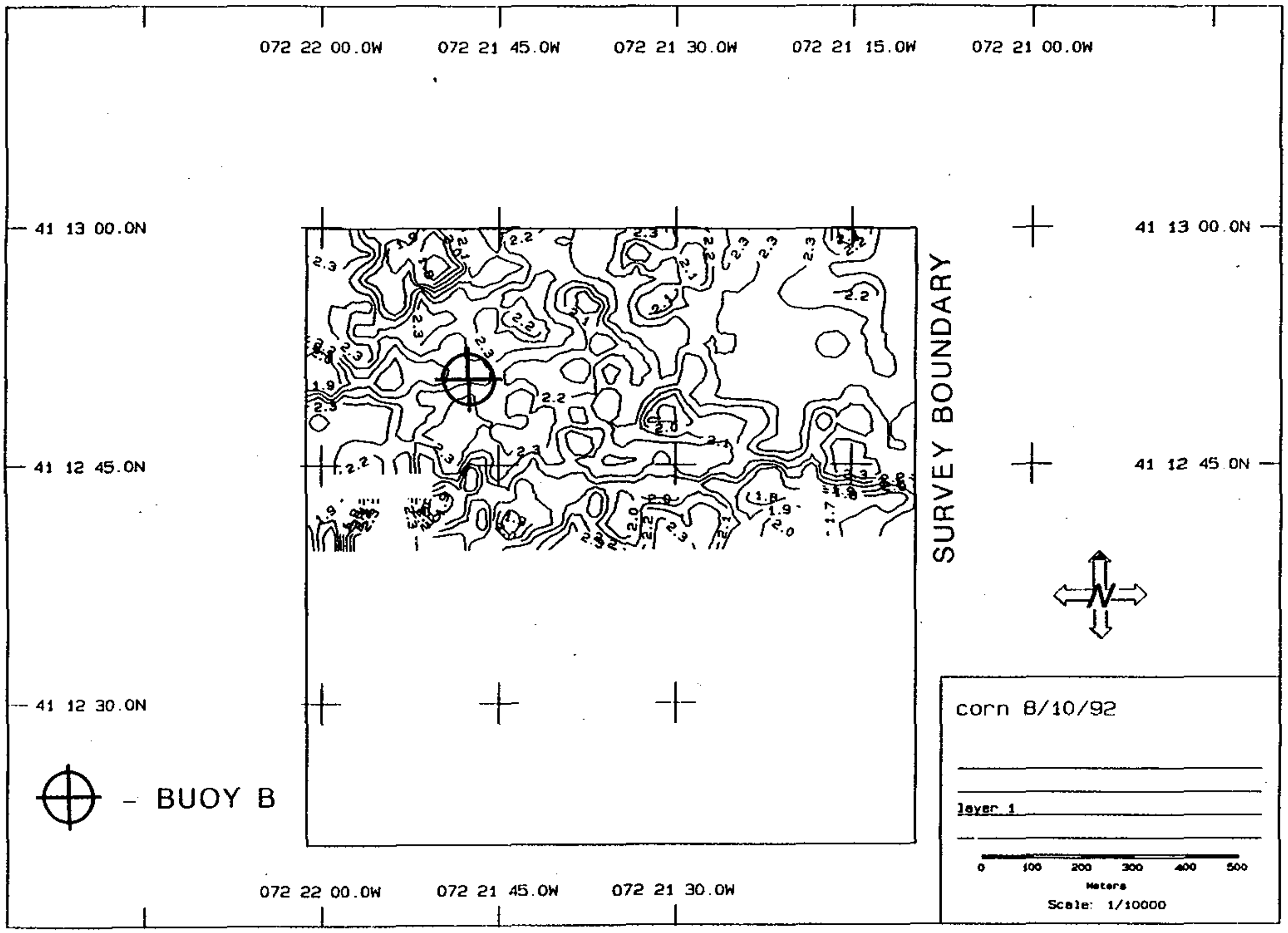


Figure 3-12. Sediment density ($g \cdot cc^{-1}$) at the Cornfield Shoals Disposal Site, approximately 15 cm below the sediment surface

4.0 DISCUSSION

The absence of any large areas of gain or loss at CSDS between May and August 1992 and the transformation from sand over mud to all sand at seven of the stations surveyed by REMOTS® support the active bed transport processes deduced from the May 1992 survey at CSDS (Wiley 1994). Although there is a predominant east-west transport direction at the site, the dispersion rate for fine-grained materials was suspected to be markedly retarded by sand armor that migrates over the more cohesive, less erosive fine-grained dredged material.

Comparing the May to August bathymetric surveys showed a clustering of positive depth differences in the southern portion of the survey area. This coincides with the known location of a sand wave field. Migration of sand waves (part of the east-west transport supported by previous studies [Wiley 1994]) could have caused the accumulations noted between May and August 1992. The north-south alignment of the areas of accumulation are also parallel to the wave crests.

At the North Cove buoy location, up to 50 cm of dredged material had accumulated between December 1991 and May 1992 (Wiley 1994). The two areas of 20 cm loss in August were to the east and west of this area of accumulation. Based on the bathymetric measurements, there was no change in the water depth at the center of the disposal mound between May and August, again supporting the relative stability of the fine-grained deposit.

In May, the REMOTS® photographs on the mound showed fine-grained material at the center surrounded by sand over mud on the flanks. By August fine-grained dredged material was visible only at the two stations closest to the center of the mound. Sand over mud was found at two stations on the flanks and at two stations almost 300 m to the southwest. Where there was dredged material or sand over mud in May but sand in August, it is likely that the fine-grained material remains buried under an accumulation of sand. When the photographs showed sand over mud in May, the sand may have been acting as a barrier to the erosion of the mud. How thick the layer of sand could be over the mud is unknown.

The absence of any detectable accumulations where the sand had moved over the mud may be a result of compaction of the mud under the sand. The change at F9 from sand in May to sand over mud in August 1992 may have been due to a loss of sand, allowing the REMOTS® camera to penetrate through to the dredged material. The new stations surveyed in August detected mud under the sand at stations D6 and D7. This extended the previous estimation of the location of the fine-grained dredged material boundary to the south.

Because sand deposits limit REMOTS® camera penetration, the absolute boundary of the fine-grained dredged material deposit remained unknown after the sediment profile survey. The size of the fine-grained deposit, its thickness and area, would help determine how much of the original material remained on site and was buried under the sand.

The 24 kHz acoustic survey at CSDS on August 10 was conducted to try to provide answers to this question. The subbottom profiler system gathered both surface and subsurface sediment density values. Changes in subsurface densities (from sand to mud) should become apparent as the acoustic signal passes from surface sand to the underlying mud. On the surface, density values should decrease as the signal passes over the center of the fine-grained deposit. The results of the surface density analysis did show a predominance of values greater than 1.6 $g \cdot cc^{-1}$ concentrated north of 41°12.75′ N. These values do correspond to the location of coarser grained material and shell lag identified in the REMOTS® photographs. An exact correlation between the REMOTS® photographs and the measured surface density values is not clear. As the survey passed over the fine-grained material at REMOTS® locations G8 and G9, the surface density values ranged from 1.5 to 1.8 $g \cdot cc^{-1}$, higher than expected for the fine-grained material that was documented in the REMOTS® photographs.

Subsurface density values were collected by the 24 kHz acoustic survey at 15 cm intervals below the seafloor. If the fine-grained material had been detected by this system (i.e., the mud was located at 15 or 30 cm below the surface), there would have been a corresponding drop in density values. The density results around the mound (at 15 cm below the seafloor) all exceed 2.0 $g \cdot cc^{-1}$. In the REMOTS® photographs, the top of the fine-grained deposit was detected within 8 cm from the seafloor. Only if the deposit exceeded 7 cm thick would it have been discernible by the subbottom system. Based on depth differences before and after the deposit of the North Cove material, the mound formed was 50 cm high at its apex. This is reason to believe that there should have been fine-grained material detected in the 24 kHz acoustic survey.

The lack of success with the 24 kHz acoustic survey may have been due in part to the resolution of the system, but attention to and adjustment to varying system parameters in future surveys may result in more successful distinction between subbottom layers.

5.0 CONCLUSIONS

The REMOTS® sediment-profile photographs at CSDS in August 1992 strongly suggest that sand at the disposal site is continuing to be transported over, and accumulating on, the fine-grained dredged material mound that was created at CSDS from sediments from North Cove. Although there is no net accumulation between bathymetric surveys in May 1992 and August 1992, the resolution of that acoustic system (>20 cm) may be too large to measure the combined sand accumulation and mud compaction. The surface sediment density study at CSDS did not reveal well-defined areas of fine-grained sediment. Instead it showed variability in the data with density values ranging from 1.3 up to 2.0 $g \cdot cc^{-1}$ over 50 m. The denser sediments were concentrated north of 41°12.75′ N, which generally corresponds to the location of sandy sediments with shell lag and pebbles. The subsurface density data did not prove to be a reliable means of locating changes in sediment density. Different sediment types observed in the REMOTS® sediment-profile photographs were, in many cases, less than 15 cm thick, the resolution of the acoustic profiling system.

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