Monitoring Cruise at the Saco Bay
Disposal Site, May 1990

Disposal Area Monitoring System DAMOS

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April 1991

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The Saco Bay Disposal Site (SBDS) was approved for one-time use by two projects at the nearby Biddeford Pool. From 9 January to 11 May 1989, approximately 34,800 cubic meters of dredged sediment were disposed at the site. The objectives of this monitoring cruise at SBDS were to measure the areal extent of dredged material and to assess the status of benthic recolonization on and adjacent to the disposal site.

The acoustic survey did not show a distinct mound at the buoy position, although several small topographic features (less than 1 m high) were noted in the vicinity. Due to the lack of a pre-disposal baseline survey and the lateral distribution of dredged material, bathymetry proved inadequate for detecting the areal extent of most dredged sediment at SBDS. REMOTS® sampling found dredged material at most stations in the central and southwestern portions of the survey grid. However, the full extent of dredged sediments was not measured at SBDS, extending beyond the southern and western stations of the survey grid. Calculations of dredged sediment volume based on REMOTS® photographs indicated that at least 38% of the reported scow deposition at SBDS was encompassed by the REMOTS® survey. The actual amount was probably much larger, because almost all REMOTS® photographs at stations with dredged material present showed deposited sediment equal to or greater than the penetration depth of the camera. Although the entire extent of dredged material at SBDS was not measured, it is likely that most sediment is confined to a relatively small region extending south and west of the disposal site center.

Benthic recolonization at SBDS was largely as expected, with the exception that Stage II taxa were not observed on the disposal site stations. The presence of Stage I on III taxa at many stations on dredged material indicated that indigenous infauna were recolonizing the affected area. Given more time for the further establishment of Stage III taxa, it is expected that the infaunal community will return to an assemblage similar to the reference areas.

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EXECUTIVE SUMMARY

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Benthic recolonization at SBDS was largely as expected, with the exception that Stage II taxa were not observed on the disposal site stations. The presence of Stage I on III taxa at many stations on dredged material indicated that indigenous infauna were recolonizing the affected area. Given more time for the further establishment of Stage III taxa, it is expected that the infaunal community will return to an assemblage similar to the reference areas.

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MONITORING CRUISE AT THE
SACO BAY DISPOSAL SITE
MAY 1990

1.0 INTRODUCTION

The objectives of the present survey were to characterize dredged materials deposited at the Saco Bay Disposal Site. This material came from dredging activities for two projects at the nearby Biddeford Pool. The Saco Bay Disposal Site was approved for use by only these projects and was located 1.3 nm east of Ferry Beach, Maine, and 1.7 nm northeast of the Saco River inlet (Figure 1-1). This site was centered at 70°19.300'W, 43°28.500'N, and consisted of a circular area 500 yards in diameter. From 9 January to 11 May 1989, approximately 34,800 cubic meters of dredged sediment were disposed at the site. A previously deployed disposal buoy was removed on 7 October 1989, 8 months prior to the present survey.

The areal extent and thickness of dredged material were measured using both acoustic techniques and REMOTS® sediment photographs. A precision bathymetric survey was conducted at the site on 18 May 1990, and a REMOTS® survey completed the following day, on 19 May 1990. In addition, REMOTS® pictures were used to map benthic disturbance gradients and monitor the process of benthic recolonization on and adjacent to the disposal area. Prior to this work, no previous bathymetric or REMOTS® surveys had been conducted at this site, and therefore no pre-disposal baseline data existed for the area. A capping model currently under development had predicted the formation of a small mound of dredged material, approximately 2 m high and 500 m in diameter. Because a year had passed since the last disposal event, the benthic community successional stage on this mound was predicted to be primarily Stage II going to Stage III recolonization.

2.0 METHODS

2.1 Bathymetry and Navigation

Precision bathymetry and navigation methods were used to delineate the areal extent and thickness of dredged materials at the Saco Bay Disposal Site. The SAIC Integrated Navigation and Data Acquisition System (INDAS) supplied the precision navigation required for the bathymetric survey. This system used a Hewlett-Packard 9920 series computer to provide real-time navigation and to collect position, depth, and time data for subsequent analysis. The ship's position was determined to an accuracy of ±3 m from ranges provided by a Del Norte Trisponder® system. Shore stations were established at sites in Maine located along Old Orchard Beach

(43°30.131'N, 70°22.978'W) and at the Stage Island Monument (43°27.403'N, 70°21.101'W). These stations were selected based on the availability of accurate horizontal control points.

Individual depth measurements were determined to a resolution of 10 cm using an Odom Echotrac® model DF3200 survey fathometer equipped with a 208 kHz transducer, as described in DAMOS Contribution #48 (SAIC, 1985). An averaged speed of sound in seawater was calculated from two profiles of temperature and salinity. These were obtained with an Applied Microsystems STD-12 at the start and finish of the survey.

The bathymetric survey covered an 800 X 800 m area centered at 43°28.500'N and 70°19.300'W, on the former coordinates of the disposal buoy (Figure 2-1). A total of 33 lanes spaced 25 m apart were surveyed in the east-west direction. During analysis the raw depth data were standardized to Mean Low Water by correcting for the ship's draft, speed of sound in seawater, and changes in tidal height during the survey. A more detailed description of the bathymetric analysis procedure is provided in SAIC (1989), and QA/QC procedures are reviewed in SAIC (in prep.).

2.2 REMOTS® Sediment-Profile Photography

REMOTS® photography was used to detect and map the distribution of thin (1-20 cm) dredged material layers. This capability complemented the precision bathymetric survey, which was able to resolve changes greater than 10 cm in depths found at this site. A detailed description of REMOTS® image acquisition, analysis and interpretative rationale is given in SAIC (1989).

The REMOTS® survey grid was centered on the same coordinates as the bathymetric survey (43°28.500'N, 070°19.300'W). The sampling grid consisted of 25 stations spaced at 100 m intervals over a 400 X 400 m area. Twelve additional stations were established at 33 m and 66 m north, south, east and west of center, and at 66 m northwest, northeast, southwest, and southeast of center. REMOTS® stations were named based on distance and direction from the center (station CTR) of the survey grid (Figure 2-3). At each of the 37 stations an attempt was made to acquire 3 replicate sediment-profile photographs.

In addition to the main sampling grid, 3 reference areas (REF-1, REF-2, and REF-3) were sampled. Each reference area consisted of a cross-shaped pattern of 9 stations at 100 m, 200 m, and 300 m north, south, east and west of a central station (Figure 2-3). Reference stations were positioned approximately 1000 m from the disposal site center at the following coordinates: 43°28.198'N, 070°18.685'W for REF-1; 43°28.720'N, 070°19.978'W for REF-2; and 43°29.032'N, 070°19.429'W for REF-3. These stations were selected based on similarity in water depth (20 to 30 m), proximity to the

main sampling grid, and general background information. Positioning of the reference areas was constrained by the need to find areas of comparable water depth and bottom type, while still maintaining a sufficient distance from the disposal site boundaries. Adequate locations for reference stations were difficult to establish, because most of the region surrounding the disposal site was either too shallow or too hard-bottomed.

Three replicates were analyzed for the majority of REMOTS® stations within the disposal site and at REF-3 (Figure 2-2). Some stations, such as those at REF-1, yielded few pictures for analysis. This was due principally to hard substratum and subsequent lack of camera penetration. The rocky nature of the bottom at REF-1 illustrates the difficulty of selecting adequate reference stations in the immediate vicinity of the Saco Bay Disposal Site (Figure 2-4). Reference areas REF-2 and REF-3 provided the majority of photographs used for analysis and interpretation.

3.0 RESULTS

3.1 Bathymetry

Acoustic detection of dredged materials at the Saco Bay Disposal Site was hampered by the relatively low volume of material disposed, its apparently wide distribution over the site, and the lack of a pre-disposal survey. Although the bathymetric survey did not detect a single, distinct mound, there were several features that probably represented the results of dredged material disposal. A potential disposal feature was present in the region between the 32.0 m and 32.5 m contours, just west of the survey center and tending toward the southwest (Figure 3-1). An enlargement of this region revealed three small peaks (A, B, C) elevated approximately 0.5 m above the surrounding topography, and between 25 to 60 m in diameter (Figure 3-2). The area encompassing peaks A, B, and C was approximately 11,940 m^2 and roughly 150 m in diameter. Water depths across the site deepened progressively towards the east and away from shore (Figure 3-1). The shallow feature at the extreme northeast corner of the survey was part of the natural bottom topography and unrelated to disposal activities.

3.2 REMOTS® Sediment-Profile Photographs

The REMOTS® survey identified dredged material in the central and southern portions of the survey (Figure 3-3). Almost all of this material extended beyond the penetration depth of the camera and consisted of fine sands (3-2 phi) over the top of very fine sands (4-3 phi) (Figure 3-4). In contrast, ambient sediments were unlayered and composed of very fine sands (4-3 phi) to silt (>4 phi) (Figure 3-5). Undisturbed sediments were present north of

the survey center and along the upper portions of the east and west borders (Figure 3-3). Dredged material was observed at 62% of the disposal site stations and was located principally in the central and southern areas. This material extended as far as some stations along the eastern, southern, and western borders of the REMOTS® grid (Figure 3-3).

Fine sands (3-2 phi) and very fine sands (4-3 phi) were the most prevalent grain sizes on the disposal site, whereas very fine sands (4-3 phi) were the major grain size mode at the reference stations (Figure 3-6). Stations north of the disposal site center and along the eastern and western borders had finer grain sizes than central and southern stations. The coarsest sediments (medium sands, 2-1 phi) were found at the center of the survey grid.

The grain size major modes of the disposal site and reference stations were significantly different ($p < 0.05$, Mann-Whitney U-test). The northern reference station (REF-1) yielded few photographs with sufficient penetration, indicating a hard bottom. The second reference station (REF-2) was positioned northwest of the main REMOTS® grid and generally consisted of very fine sand (4-3 phi). Bed formations were visible at the sediment surface in most photographs taken at REF-2. These features were similar to bed forms at the central and southern portions of the disposal site (Figure 3-7). Reference station 3 (REF-3) was positioned south-east of the main survey grid and consisted of mostly very fine sand (4-3 phi) and some fine sand (3-2 phi), with no bed forms present.

Mean apparent Redox Potential Discontinuity (RPD) depths ranged from 1.3 to 5.5 cm over the entire disposal site (Figure 3-8). In comparison with the reference stations, RPD depths were significantly shallower for disposal site stations with measurable dredged material present ($p < 0.05$, Mann-Whitney U-test) (Figure 3-9). Mean RPD depths of the reference stations ranged from 2.4 to 6.3 cm.

Infaunal successional seres in the central and southern regions of the disposal site were generally either Stage I or Stage I on III (Figure 3-10). To the north and along the eastern and western borders, Stage II and Stage II on III were the dominant seres. The reference stations consisted principally of either Stage I on III at REF-2, or Stage II and Stage II on III at REF-3. Large infaunal burrows (some as long as 9 cm) were present in REMOTS® photographs taken at both the disposal site and the reference stations (Figure 3-11).

The distribution of median Organism-Sediment Index (OSI) values was patchy but generally lower (4-8) in the central and southwest region of the disposal site, and higher (9-11) in the north and along the northeast and northwest borders (Figure 3-12).

The exception to this was a group of stations in the center of the survey, all with higher OSI values (+9 to +10). OSI values were indeterminate at REF-2 and ranged from +6 to +11 at the other reference stations. The OSI frequency distribution for the disposal site was similar to the reference stations, with +9 the major class interval for each (Figure 3-13).

4.0 DISCUSSION

The objectives of this survey were to assess the areal extent of dredged material and determine the level of benthic recolonization at the disposal site. These goals were met almost completely, although delineation of the southwestern boundary of the deposit was not accomplished (Figure 3-3). The mapped distribution of dredged material was based principally on REMOTS® photographs, since bathymetric techniques proved inadequate due to the lack of a pre-disposal baseline survey and the absence of a well-defined disposal mound at the buoy position.

Several factors contributed to the presence of dredged sediment beyond the REMOTS® survey boundaries. The greatest influence was most likely due to positioning error of the disposal barges relative to the center of the REMOTS® survey. Scow logs indicated that a large portion of disposal took place up to 50 m south and west of the buoy. This was in agreement with the distribution of dredged sediments seen in REMOTS® photographs, which showed that most of the material lay southwest of the survey center (Figure 3-3).

It is also possible that some dredged material was partially dispersed beyond the limits of the REMOTS® survey. Evidence of elevated current speeds was seen in REMOTS® photographs. Bed formations were observed at both REF-2 and in the central and southern regions of the disposal site (Figures 3-4 and 3-7). The two layer stratigraphy of coarse-over-fine dredged material (Figure 3-4) also indicated that winnowing of the upper sediment surface had occurred. Currents in this area were probably tidal in nature, because the bottom was too deep (>30 m) to be influenced strongly by local storm events. However, it is unlikely that these currents would be sufficiently high to either erode or prevent the formation of a disposal mound. Other disposal areas, such as the New London Disposal Site, have been shown to exhibit stable mounds over long time periods despite the presence of strong tidal currents (SAIC, 1990).

The amount of dredged material outside the boundaries of the REMOTS® survey was difficult to estimate. A conservative estimate for the volume of dredged sediment present in the REMOTS® survey was calculated by multiplying the areal extent of observed dredged material (76,700 m^2) by its maximum observed depth (14.6 cm), producing a volume estimate of 11,200 m^3. This represented a

minimum estimate of dredged sediment present within the boundaries of the REMOTS® survey, because dredged material at nearly all stations was deeper than the penetration depth of the camera (Figure 3-3). When the total reported scow volume (34,800 m^3) was reduced by 15.4% to compensate for compaction and interstitial water loss (Tavolaro, 1980), the REMOTS® estimate of dredged material represented 38% of the corrected scow volume. This would indicate that less than half of the dredged material at the Saco Bay Disposal Site was present within the boundaries of the REMOTS® survey. However, this value represented a minimum volume of dredged sediment. Even small increases in the depth of dredged material would significantly change the percentage of sediments accounted for within the bounds of the REMOTS® survey (Table 4-1). For instance, a dredged sediment depth of only 35 cm with the same observed distribution (Figure 3-3) would account for 91% of the reported scow deposition. Depths of this magnitude are quite reasonable. The small half-meter peaks observed in the bathymetric survey may provide some indication of dredged sediment depths at Saco Bay, although without baseline bathymetry data this cannot be confirmed. While it is clear that some dredged material lies outside the boundaries of the present survey, most of the sediment is probably confined to a relatively small area in the vicinity of the southern and western boundaries of the present REMOTS® grid.

Although the bathymetric survey did not show clear evidence of a distinct mound, the central region of the site contained three small features that were probably the result of disposal activities (Figure 3-2). These areas projected only about half a meter above the surrounding topography and fell within the bounds of dredged material mapped by REMOTS®. The region encompassing all 3 rises was about 150 m in diameter, covering an area of approximately 11,940 m^2. Dredged material in REMOTS® photographs extended across an area at least 76,700 m^2 in the central and southern parts of the survey (Figure 3-3). The mound height was most likely overestimated by the capping model (2 m) because disposal of dredged material was apparently spread across the site (Figure 3-2), rather than in a tightly controlled area close to the buoy. Furthermore, without pre-disposal bathymetric data, accurate verification of the model height and radius predictions was not possible.

Most REMOTS® parameters (OSI, RPD depth, and grain size major mode) indicated the presence of two distinct regions within the boundaries of the sediment camera survey. Dredged material was absent from the northern region of the REMOTS® grid, and this area was generally colonized by Stage II and Stage II on III infauna, similar to the reference areas. In contrast, the central and southwestern areas of the disposal site survey had dredged material present and Stage I and Stage I on III infauna. This would indicate that, although indigenous fauna were present, they had not yet fully recolonized the dredged material. The predicted community of Stage II going to Stage III was present in the

northern region of the disposal site but was not yet fully established in the south, within the area of observed dredged material. However, there was no evidence to indicate that the infaunal community will not return to an assemblage similar to the reference areas after more time is allowed for further establishment of Stage III taxa.

5.0 CONCLUSIONS

The small volume of sediment deposited at Saco Bay appeared to be confined to an area near the center and south and west of the former buoy position. The southern and western limits of the dredged sediment were not fully surveyed, but volume calculations based on REMOTS® images indicate that this extension was not large. Errors in scow positioning was the most likely explanation for the lateral distribution of dredged material, although there is also some evidence for sediment dispersal by bottom currents.

Benthic recolonization at the site was largely as expected (Stage II going to Stage III), although Stage I and Stage I over III seres were also present in the region of dredged sediment disposal. Stage III taxa were observed recolonizing the area affected by dredged sediment disposal, and with further time it is expected that this region will return to an assemblage similar to the reference areas.

6.0 REFERENCES

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Tavolaro, J.F. 1980. Sediment budget study for clamshell dredging and disposal activities. US Army Corps of Engineers. New York District, 26 Federal Plaza, New York, NY. 54 pp.

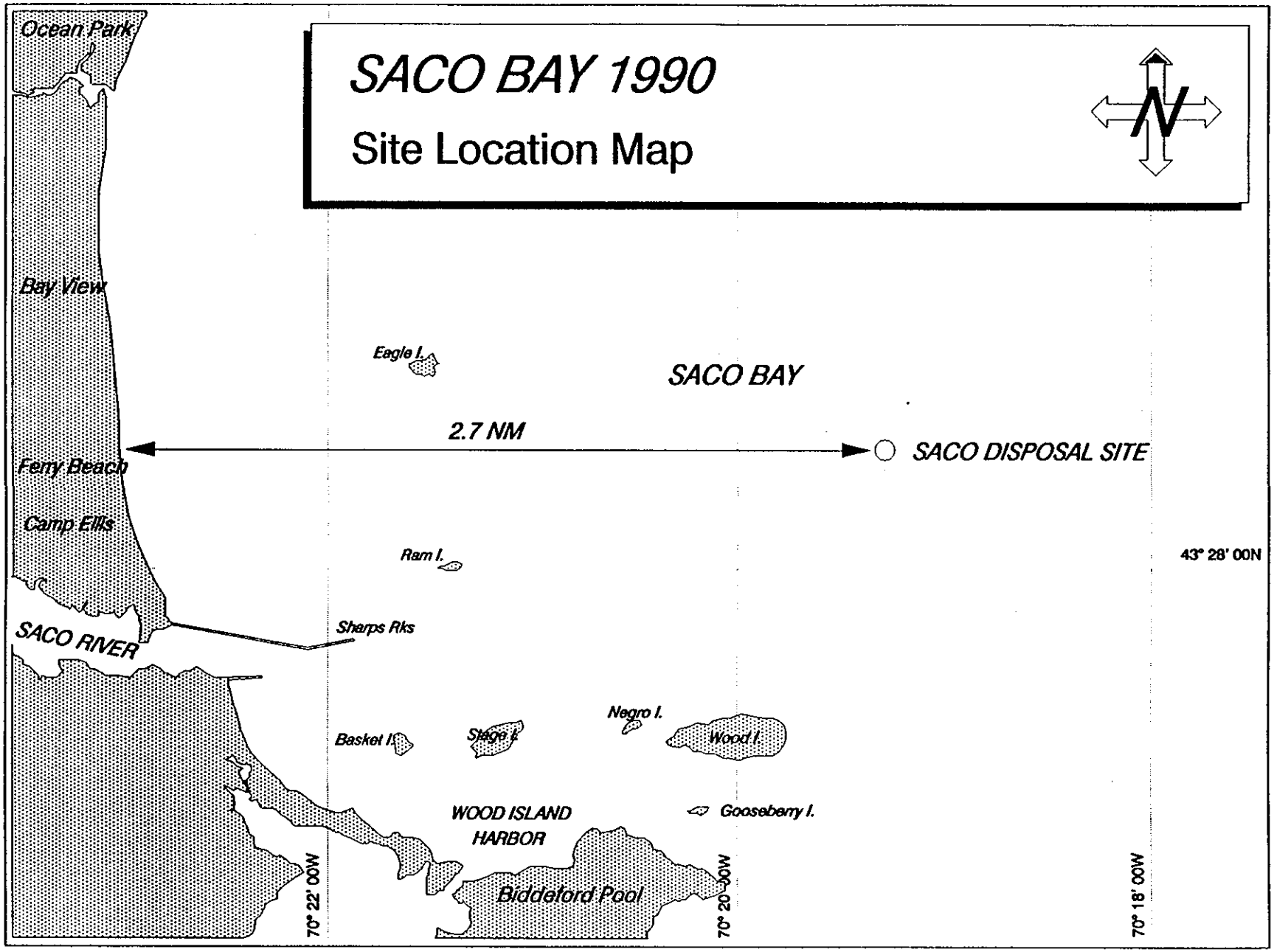


Figure 1-1. General location of the Saco Bay Disposal Site.

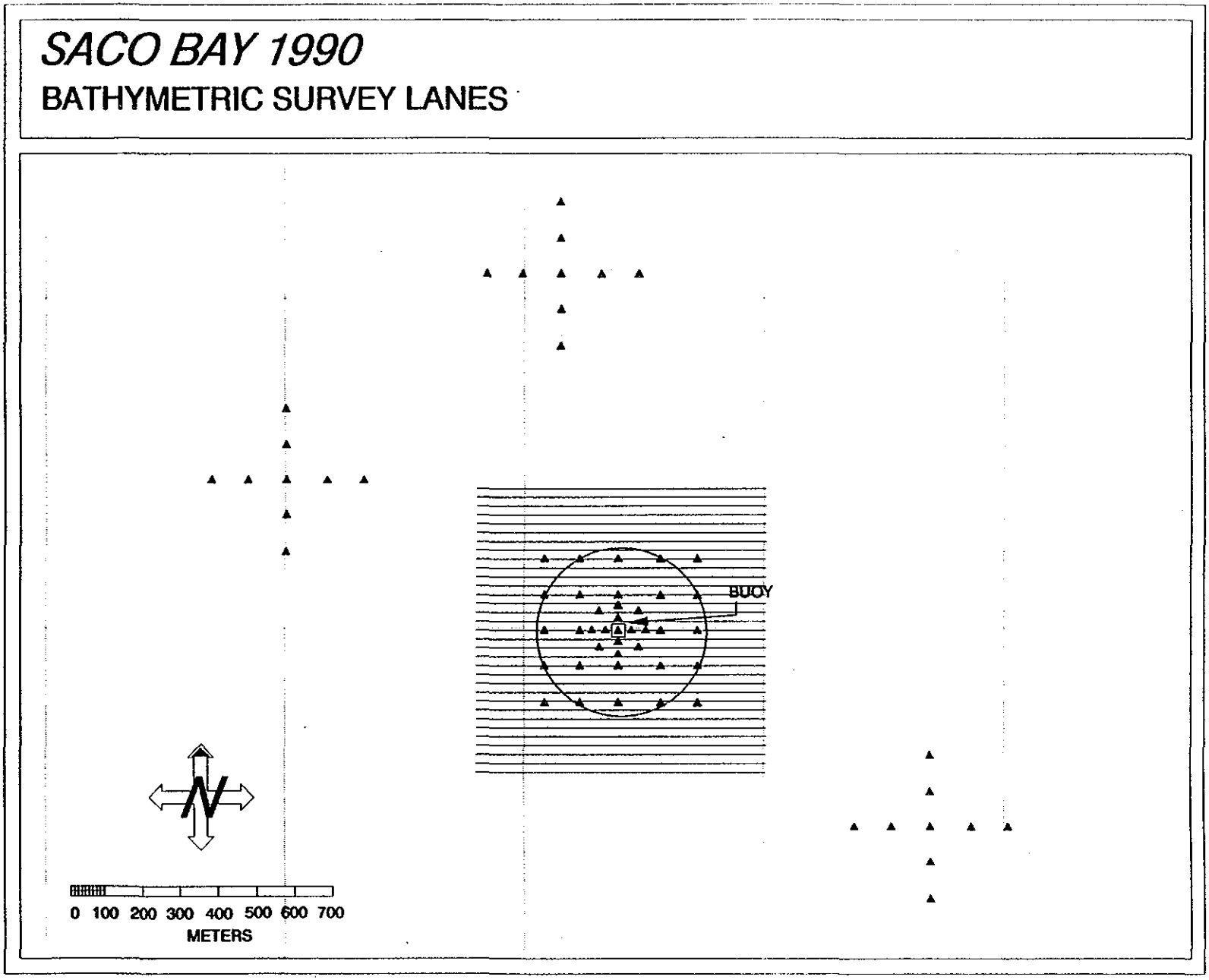


Figure 2-1. Bathymetric survey lanes, buoy position, and relative position of REMOTS® grid and reference stations. Circle indicates disposal site boundary.

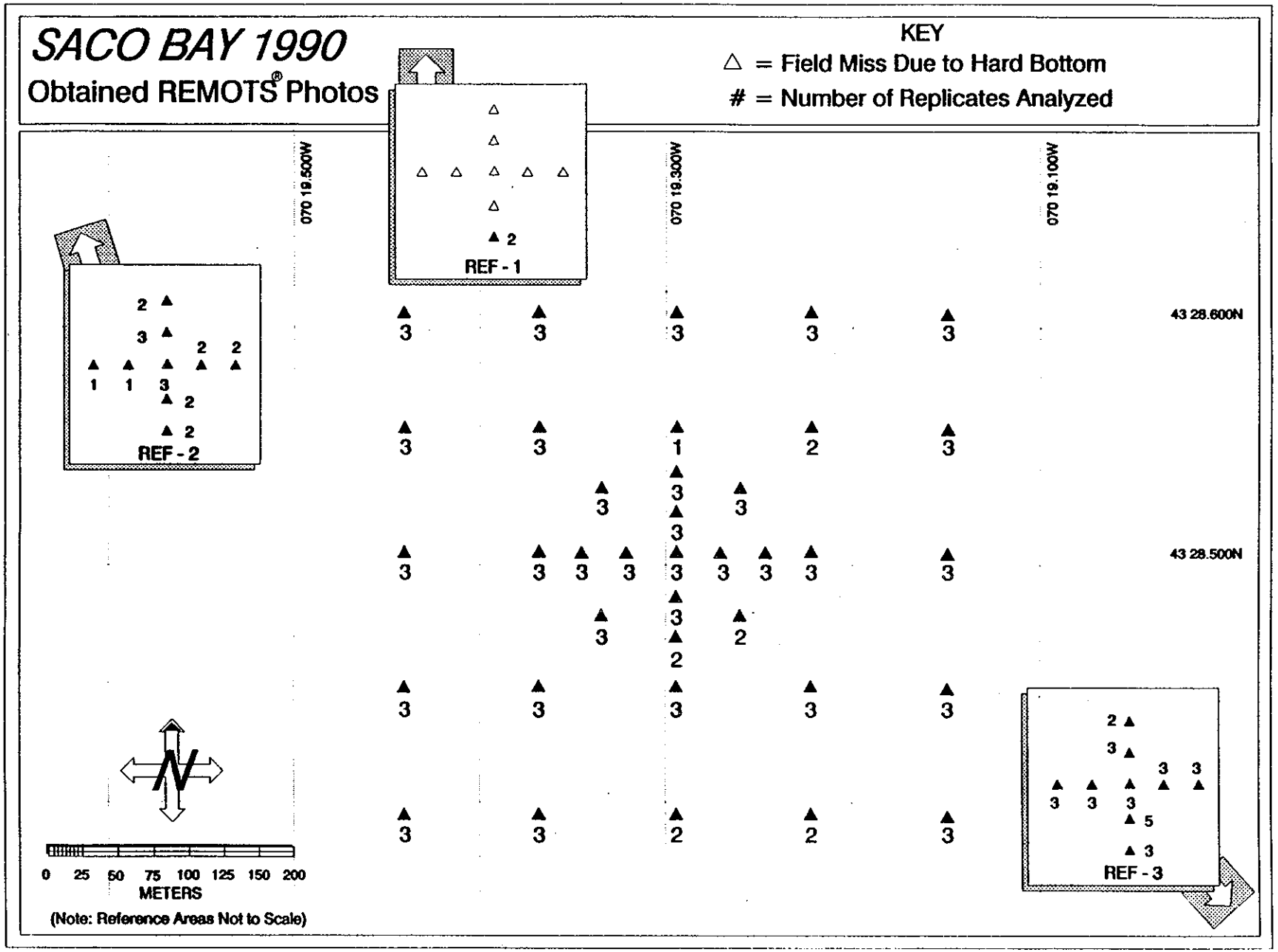


Figure 2-2. Location and number of usable REMOTS® photographs taken at Saco Bay Disposal Site and reference stations.

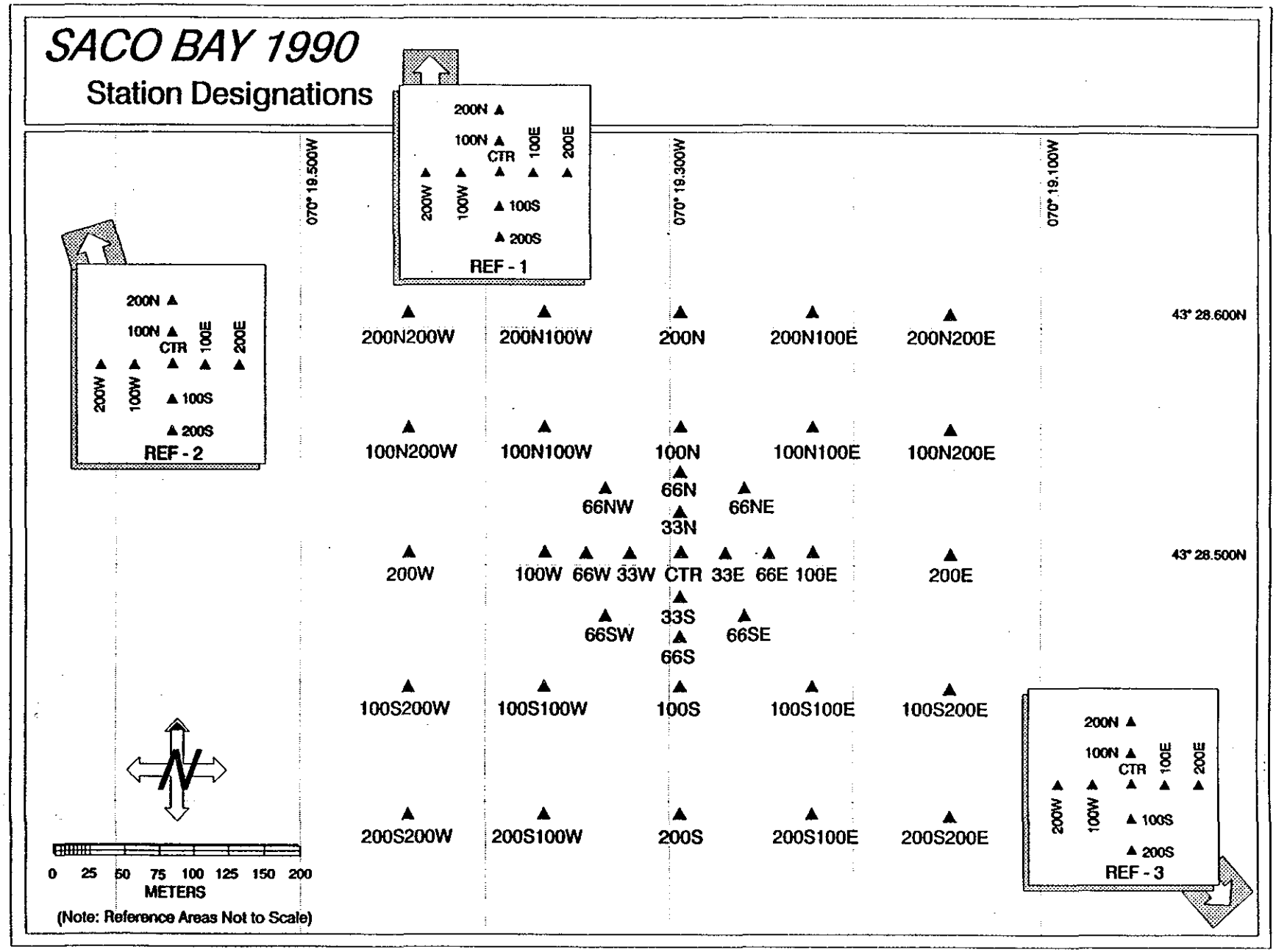


Figure 2-3. Station position and naming convention at Saco Bay Disposal Site and reference stations.

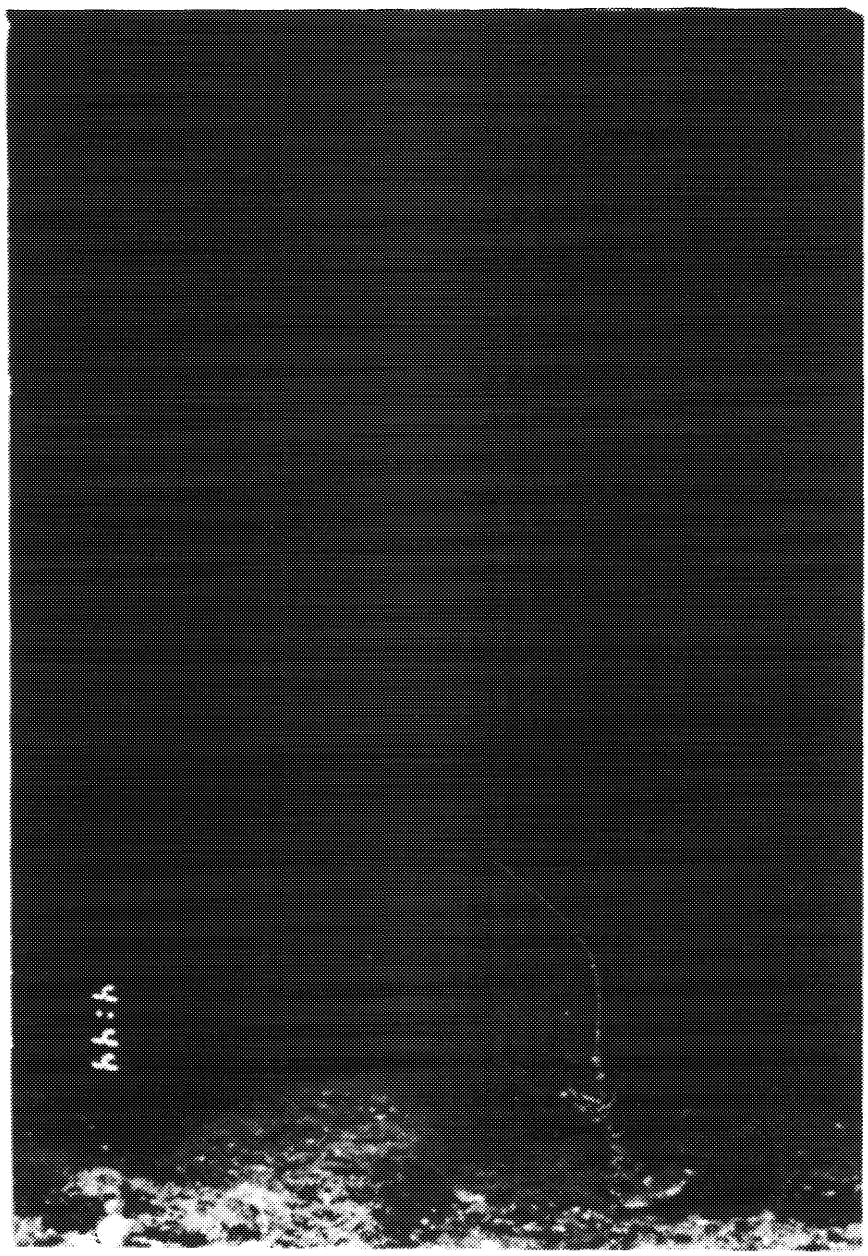


Figure 2-4. REMOTS® photograph from REF-1, showing the lack of camera penetration due to rocky substratum. Station 100W.

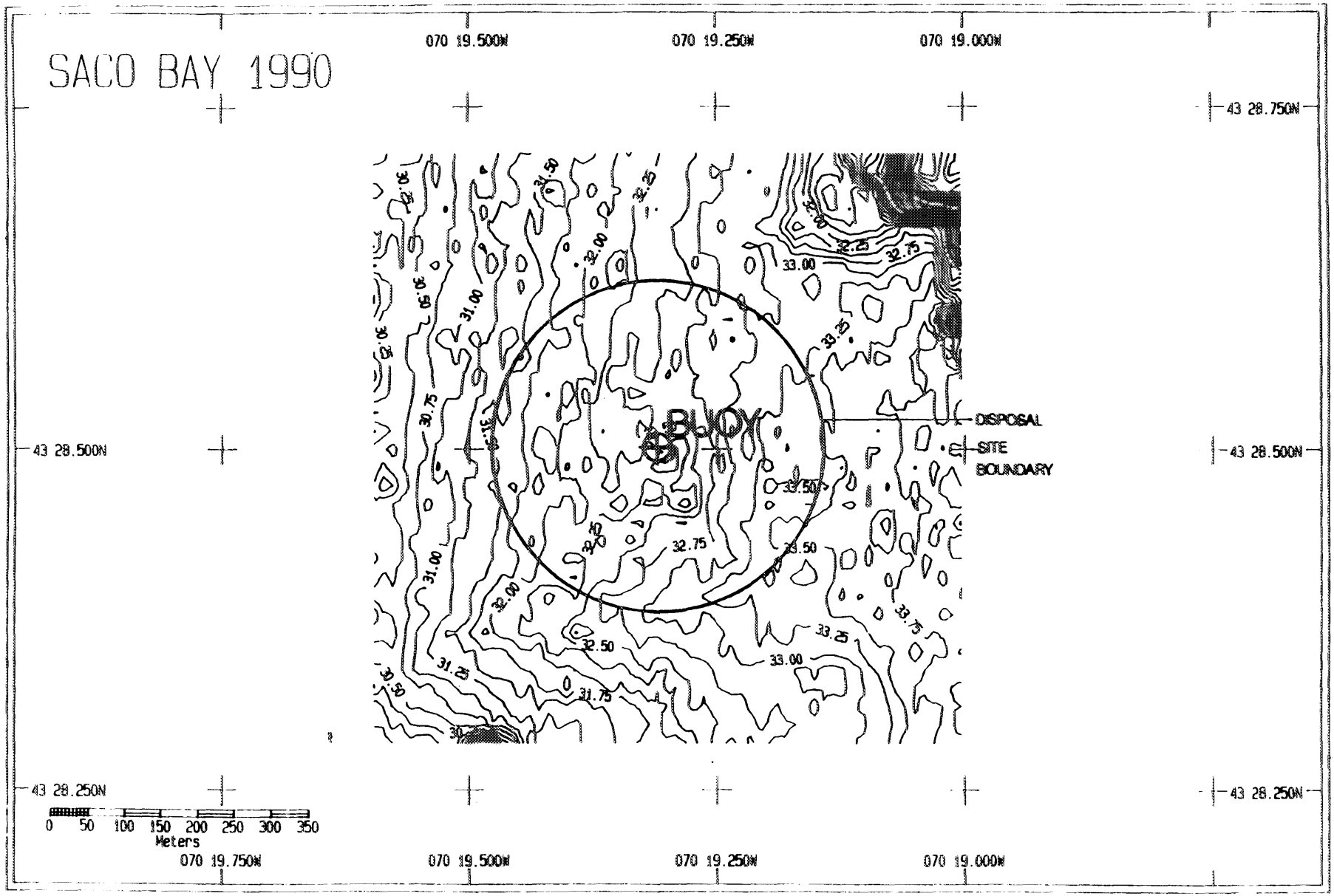


Figure 3-1. Bathymetric contour chart (800 X 800 m) of Saco Bay Disposal Site, May 1990.

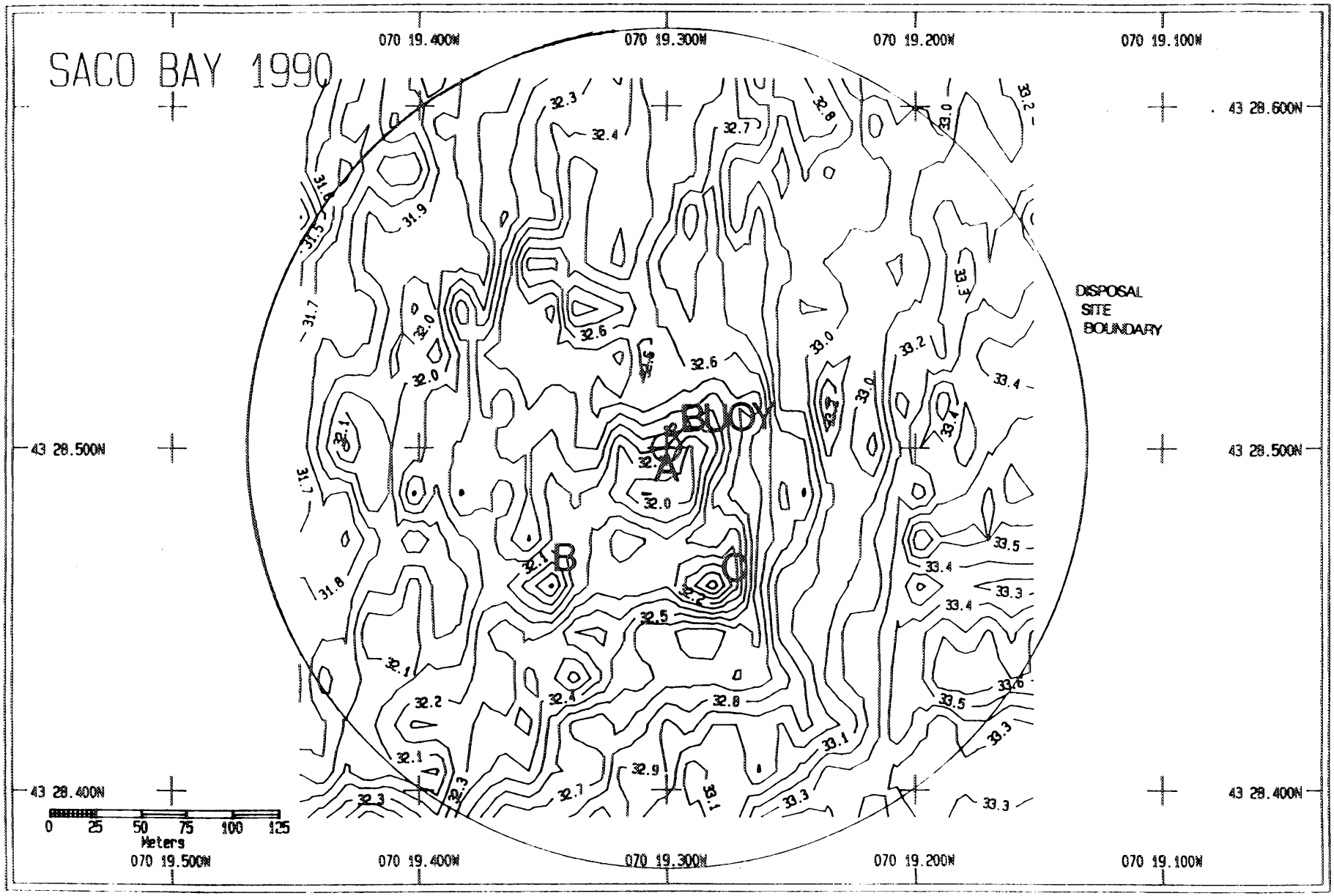


Figure 3-2. Detail of bathymetric contour chart (400 X 400 m) of Saco Bay Disposal Site, May 1990. A, B, C mark three small mounds.

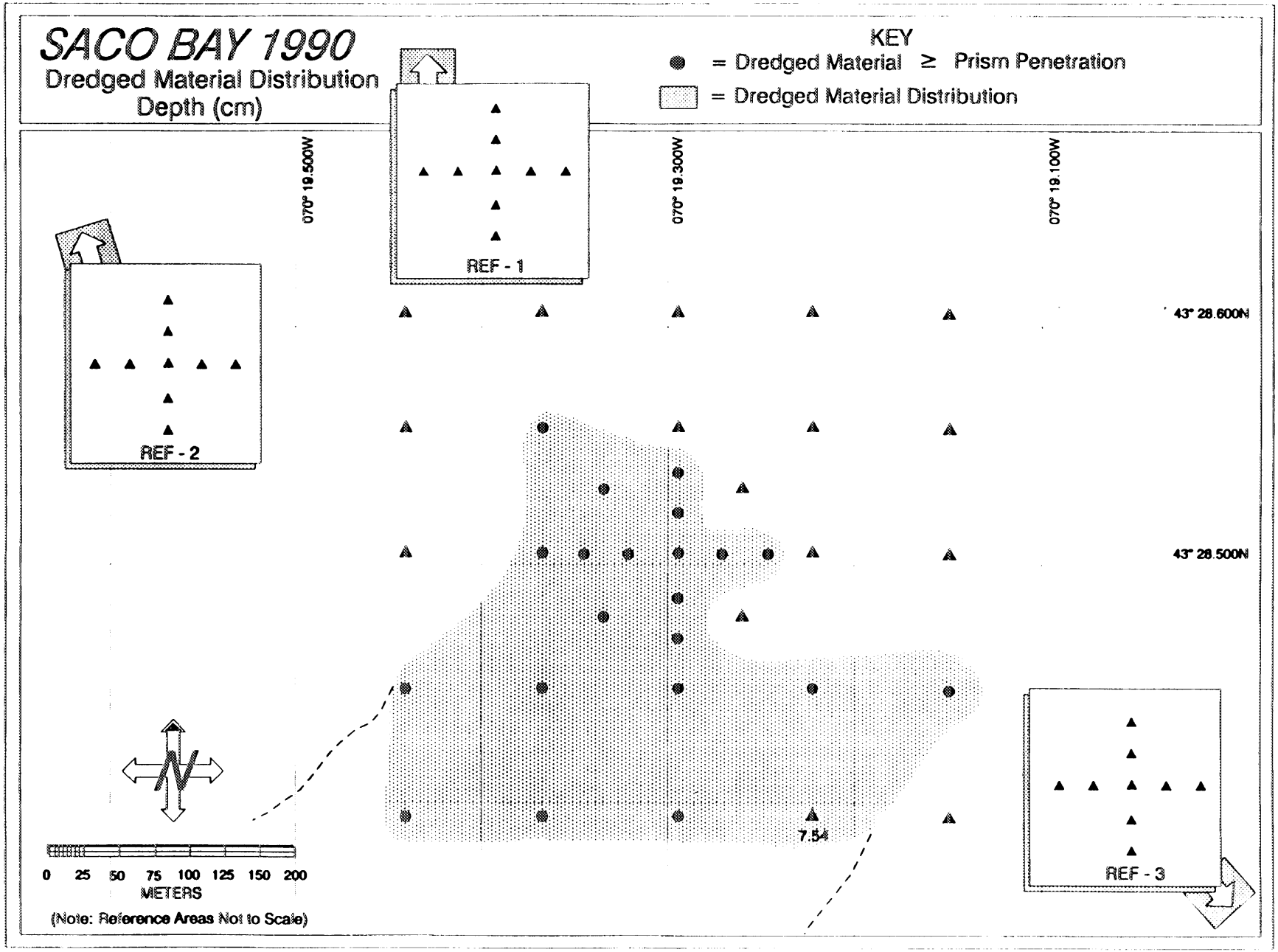


Figure 3-3. Distribution of dredged material based on REMOTS® photographs taken at Saco Bay Disposal Site, May 1990. Dotted line indicates possible extension of dredged material outside REMOTS® survey.

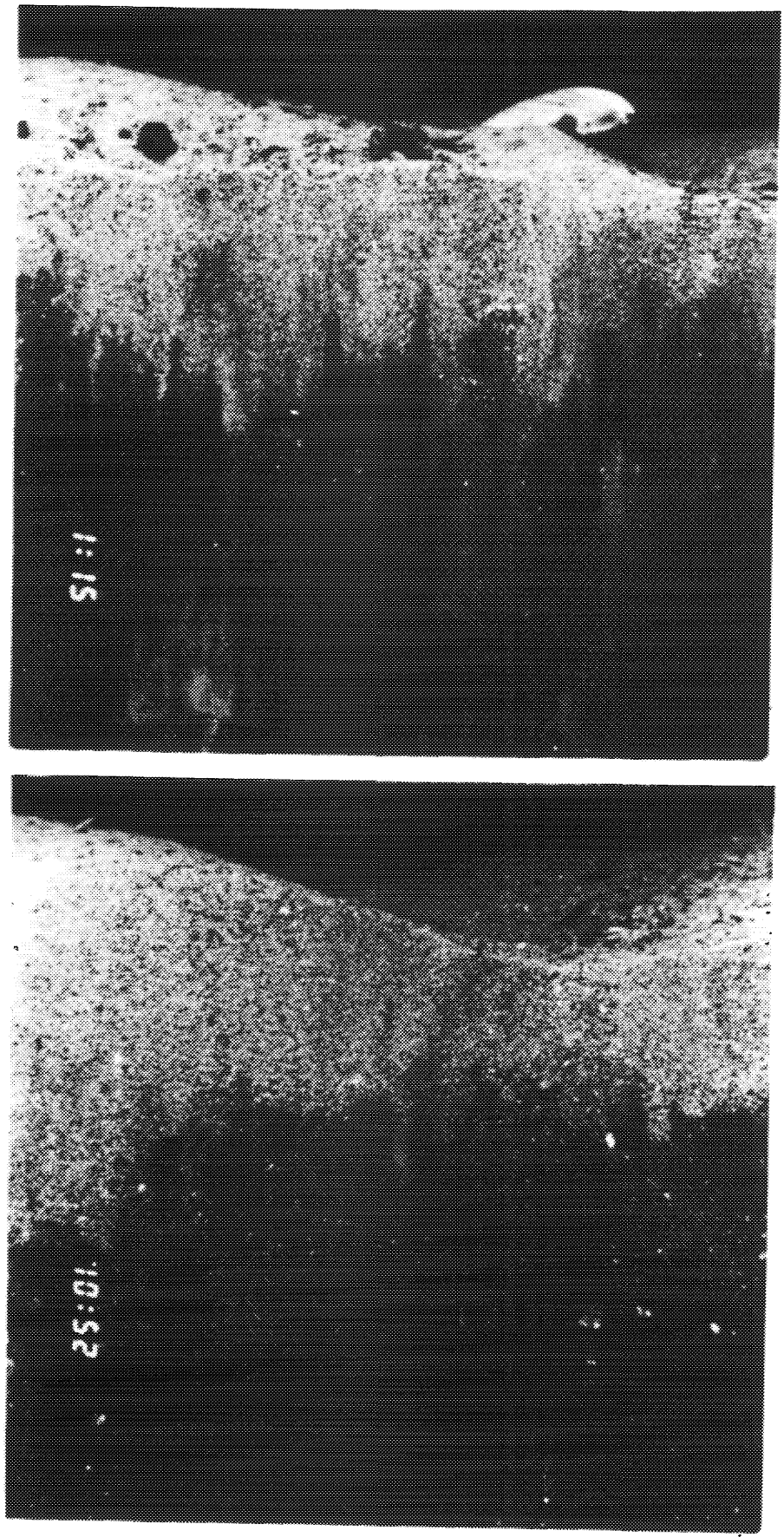


Figure 3-4. Two REMOTS® photographs showing dredged material at Saco Bay Disposal Site. A) Station 16. B) Station 37 (center). Note bed formations in both photographs.

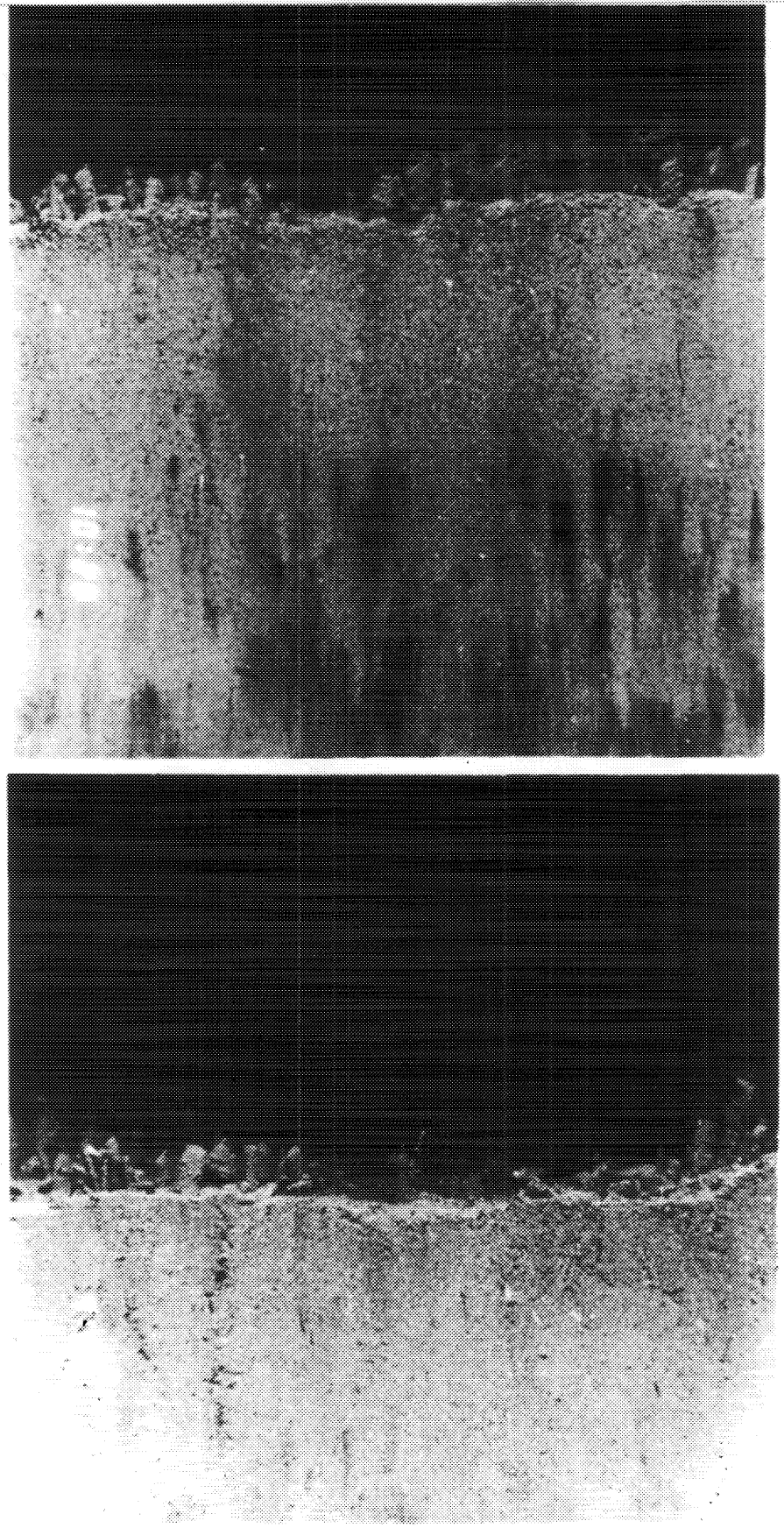


Figure 3-5. Two REMOTS® photographs showing ambient sediment at Saco Bay Disposal Site and reference stations. A) Station 6. B) REF-3, station 200N. Both photographs show undisturbed communities characterized by Stage II or Stage II on III assemblages.

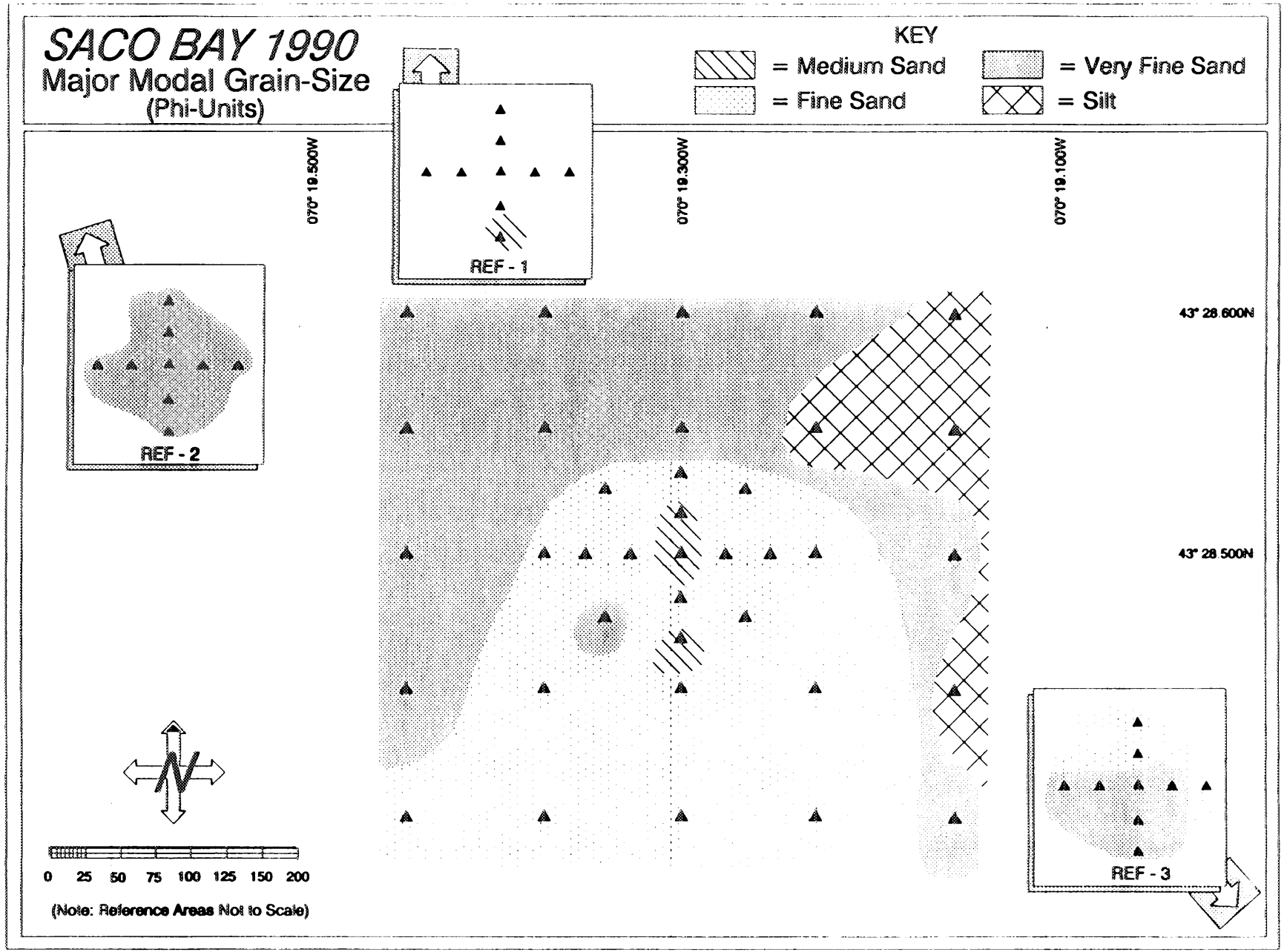


Figure 3-6. Mapped distribution of grain size major mode at Saco Bay Disposal Site and reference stations, May 1990.

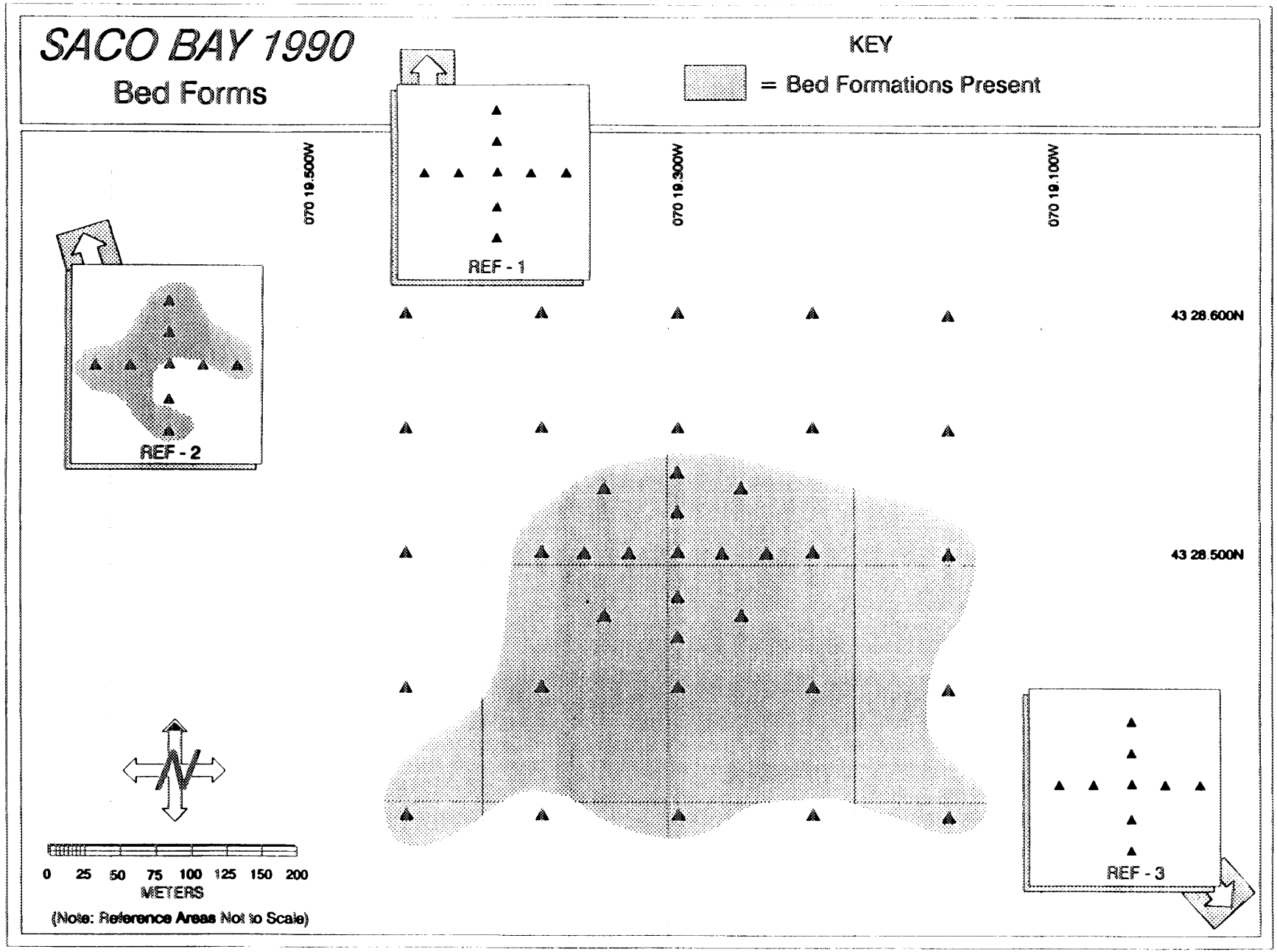


Figure 3-7. Mapped distribution of bed formations at Saco Bay Disposal Site and reference stations, May 1990.

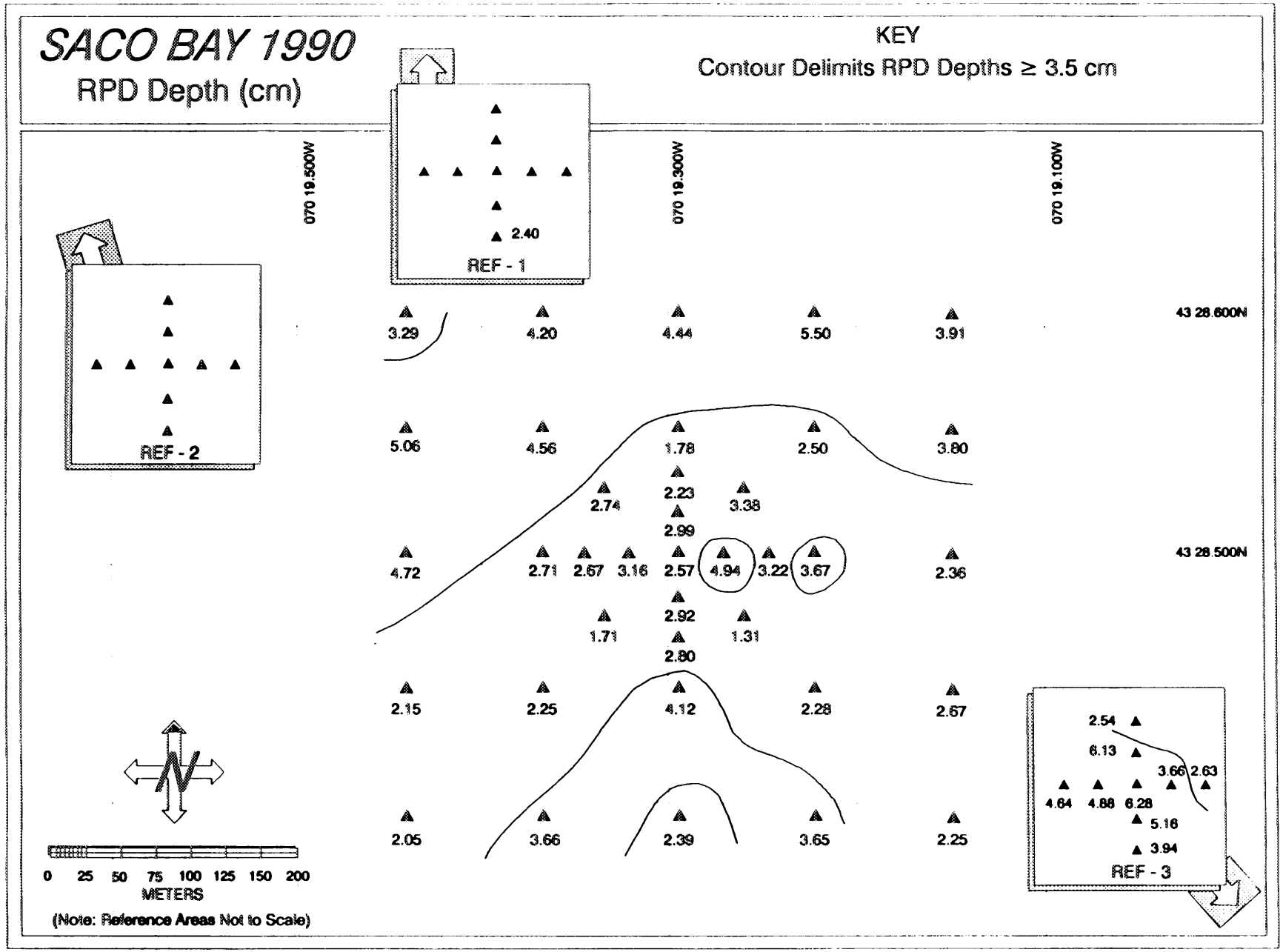
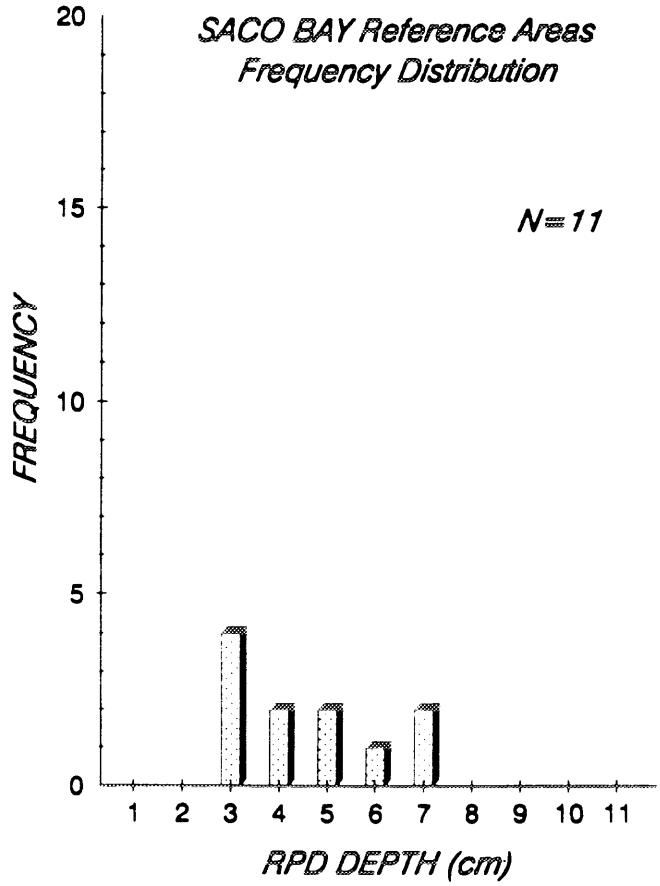


Figure 3-8. Mapped distribution of mean apparent RPD depths at Saco Bay Disposal Site and reference stations, May 1990.



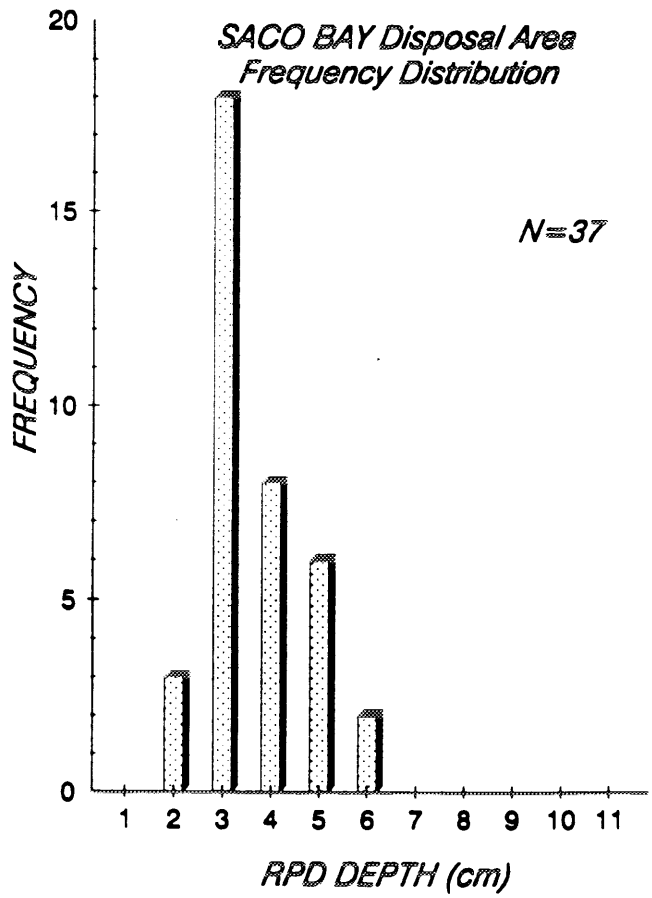


Figure 3-9. Frequency distributions for apparent RPD depths at Saco Bay Disposal Site and reference stations, May 1990.

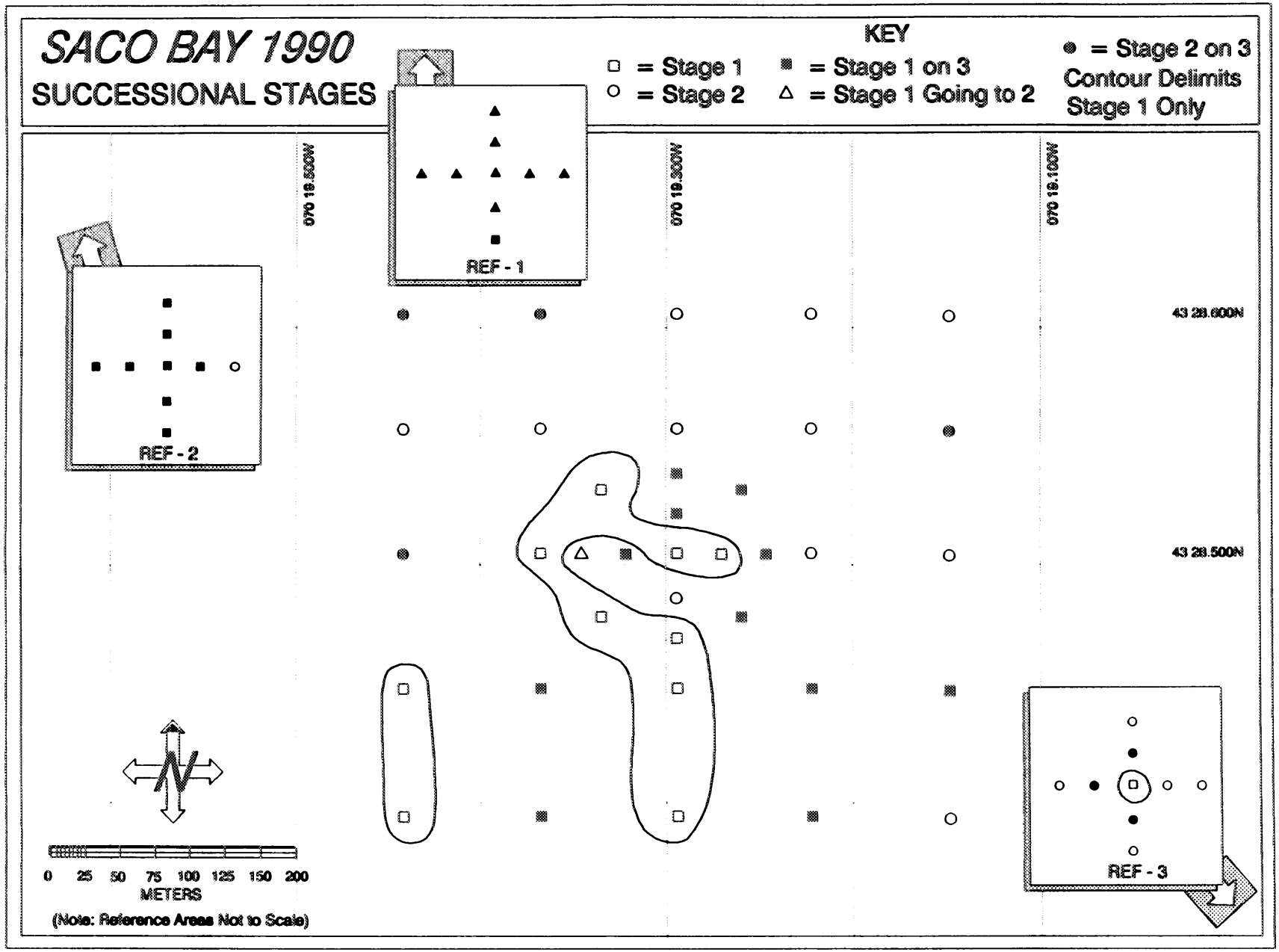


Figure 3-10. Mapped distribution of infaunal successional seres at Saco Bay Disposal Site and reference stations, May 1990.

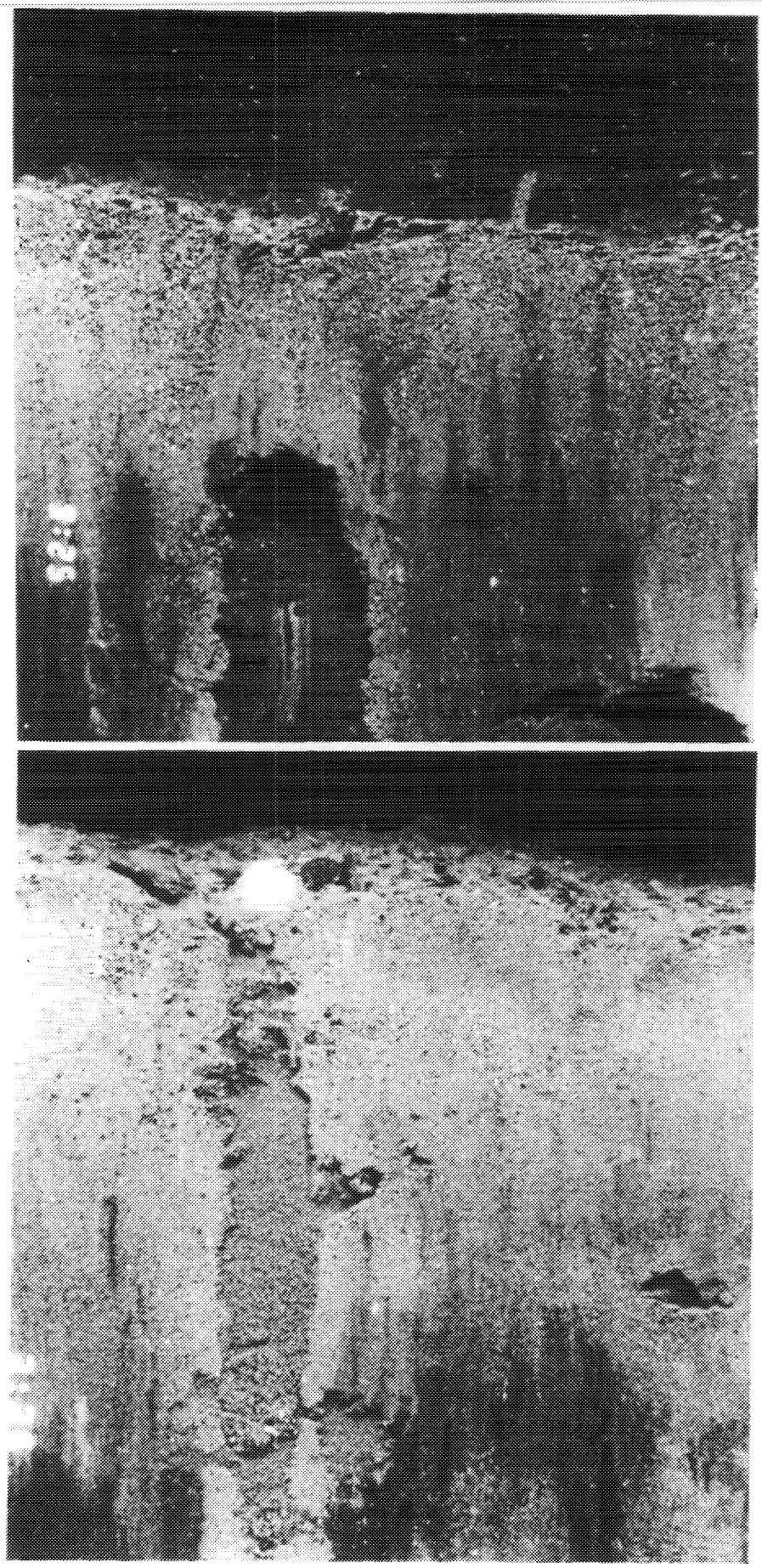


Figure 3-11. REMOTS® photographs of large burrows present at Saco Bay Disposal Site and reference stations, May 1990. A) Station 5. B) REF-3, Station CTR.

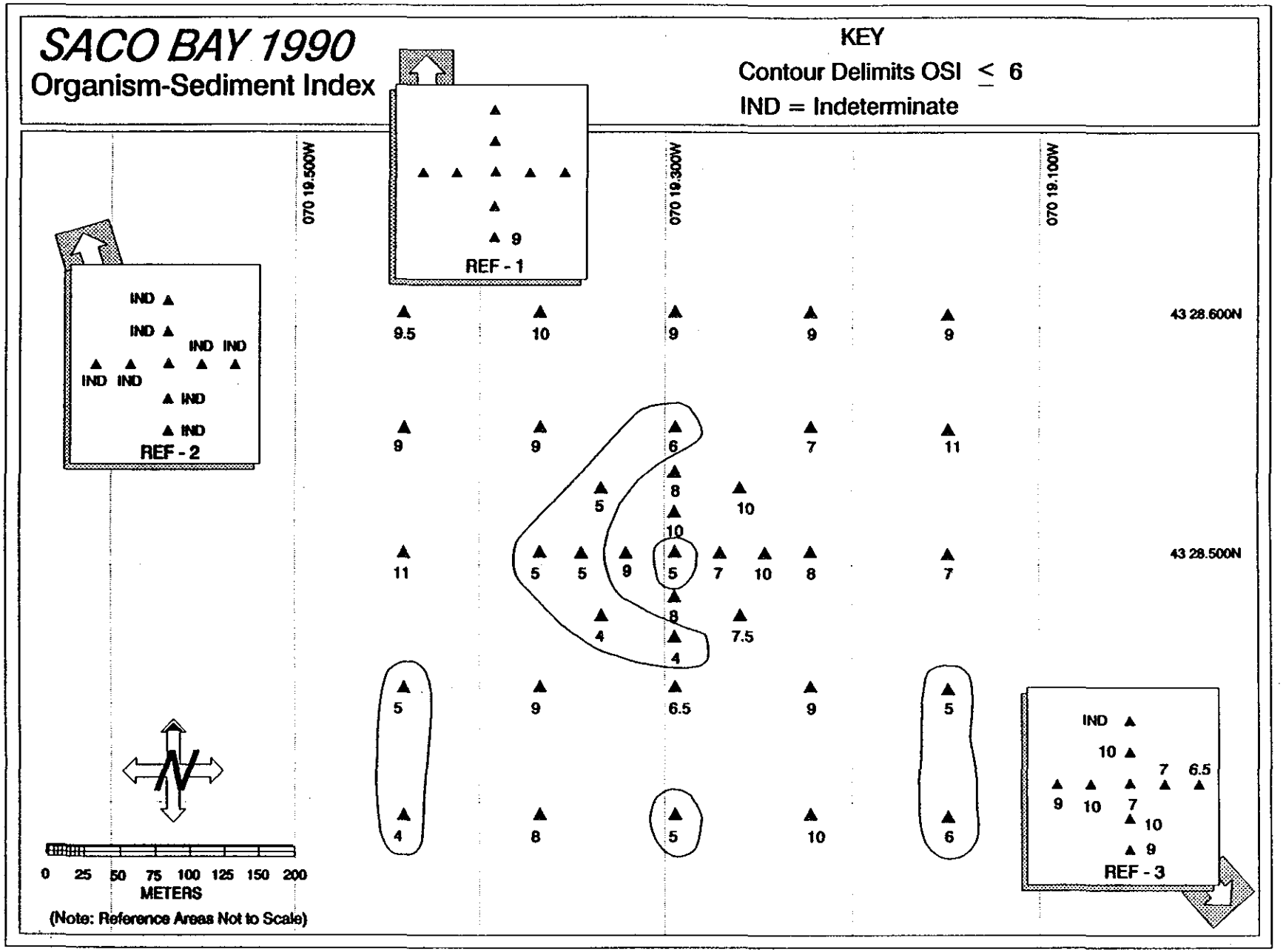
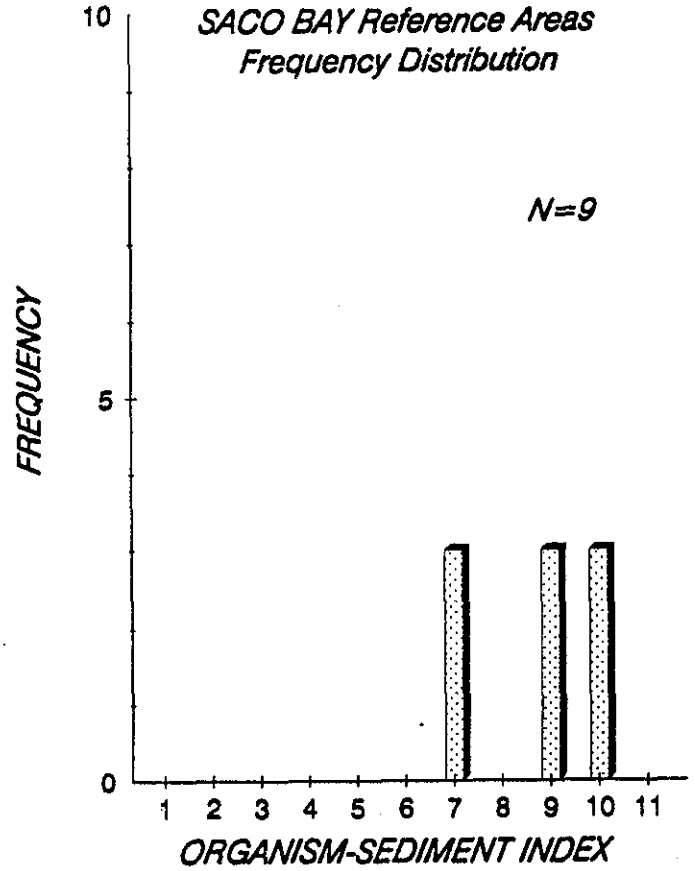


Figure 3-12. Mapped distribution of median Organism-Sediment Index (OSI) values at Saco Bay Disposal Site and reference stations, May 1990.



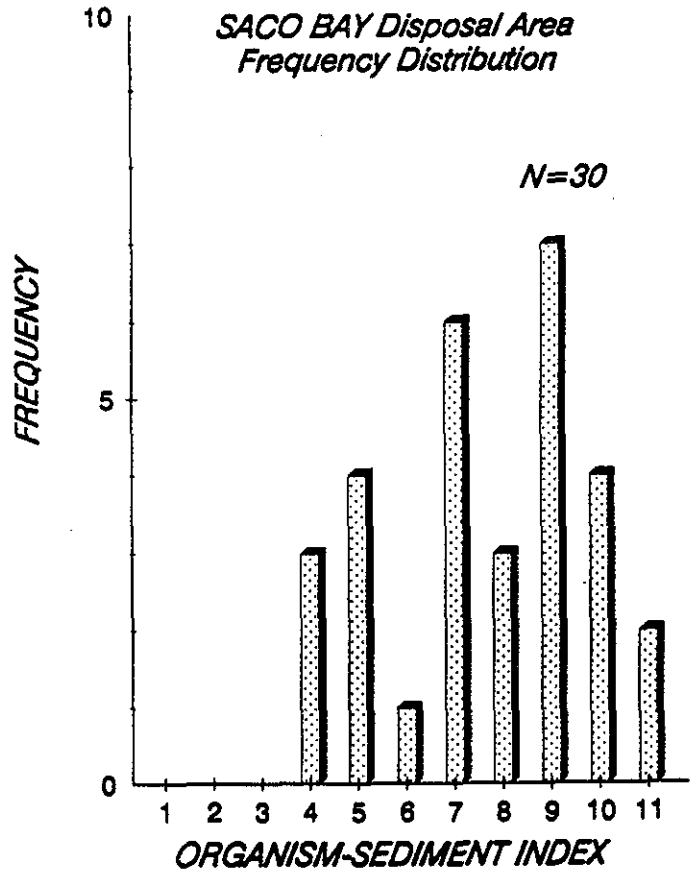


Figure 3-13. Frequency distributions of Organism-Sediment Index (OSI) values at Saco Bay Disposal Site and reference stations, May 1990.

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