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Northey Island Set-back Scheme
Report 3

Institute of Estuarine and Coastal Studies
University of Hull
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CONTENTS

1 Introduction

The Northey Island managed retreat experiment (Stage 3) called for the continued physical monitoring of this important experimental site. The original rationale behind the project and results of previous monitoring were presented in reports 1 and 2. The Institute of Estuarine and Coastal Studies has been carrying out topographic monitoring of the site since implementation of the experiment in July 1991. Further site visits were made in August 1992 and February 1993 to repeat the detailed topographic surveys and accretion measurements. Sediment samples were also taken to determine any change in sediment size and to assess spatial sedimentation patterns across the set-back site. This report contains the results of the monitoring during the period since January 1992.

2 Topographic survey

2.1 Sampling methods

In both August and February the site was surveyed using the same methodology as for previous surveys. The instrument was set-up over the permanent station established during the initial site survey following implementation of the scheme in August 1991. Readings were taken to the established permanent benchmarks to verify the accuracy of the station position and maintain the same reference objects (RO's) as in previous surveys. Once accuracy had been established the survey was carried out in the same manner outlined in previous reports, with random sampling of the set back surface and fronting mudflat. The data collected during the surveys was processed by the Institute's survey software (LSS) which generates a site map of the area surveyed and allows statistical comparison with earlier surveys.

2.2 Results

The August 1992 and February 1993 maps are included as figures 1 and 2. Due to the random sampling employed it must be borne in mind that direct visual comparison of the maps may give a misleading impression of minor changes in topography. However, several real changes in the surface topography have occurred since the last report.

The NRA have undertaken maintenance works both upon the surface of the set-back site and the enclosure walls since the January 1992 survey described in Report 2 The work involved the infilling of the old borrow pits running along the inside front edge and side walls of the set-back site. Prior to this work the old borrow pits were not draining properly and were giving rise to areas of standing water on the set-back surface. The NRA filled the old borrow pits with clay obtained through widening of the new borrow pit behind the rear enclosure wall. This material was then placed into the old borrow pits and compacted by the bulldozers leaving the site. The topographic surveys since then show the effect of this work, particularly the February 1993 survey, in creating a planar surface of approximately 7-10m width along the eastern enclosure wall. This surface is also illustrated in plates 1, 2 and 8. The effect of this procedure has been to effectively reduce the surface area of the set-back site as the imported clay has been compacted to such an extent that no vegetation colonisation seems to be occurring.

Another topographic change which can be seen from the survey data is the deepening of the two creek systems. In the August '92 survey these features, although present, were not as pronounced as in the February '93 survey. This could be due in large part to the presence of standing water in these creeks which is causing the sediments to become waterlogged.

These trends may be further examined by subjecting the surface elevation data collected on both surveys to a t-test in order to assess the statistical validity of any observed changes. Prior to this analysis, it was decided to exclude data representing the creek systems, as the overall mean elevation would have been affected by the inclusion of these extreme values. It was found that the mean levels had increased by 5mm from 2.959mOD to 2.964mOD over the 6 month period. This is not statistically significant at the 95% level of confidence, but is supported by marsh accretion plate data and visual evidence of sediment accretion on the marsh surface (plates 6 and 7). A similar test carried out on levels taken from the fronting mudflat indicated an accretion of 2.2cm, with mean elevation increasing from 0.529mOD to 0.551mOD. This was again not statistically significant, but concurs with the accretion plate measurements discussed in section 3.2.

3 Accretion measurements

3.1 Sampling methods

A line of 17 accretion plates was established in August 1991. Twelve of these plates were on the fronting mudflat, with the remaining five positioned on the set-back site. The plates were left to settle for six months, although readings were taken during the January 1992 site visit. Care should be taken in interpreting these initial readings as any change in depth could be as a result of plate settlement rather than an actual change in elevation due to accretion or erosion. The readings taken in August 1992 resulted in the first 'real' measurements of accretion, these readings were repeated again in February 1993.

The actual methodology involved in locating the accretion plates and taking readings is outlined in Report 2. The results of the accretion plate readings are shown in table 1, and figures 3 and 4.

3.2 Results

Figure 3 shows the two sets of accretion data which can be considered to show real changes in the elevation of both the mudflat and the set-back surface, i.e. it is assumed that any effects due to plate settlement are no longer significant.

It can be seen from table 1 that the mudflat surface is clearly accreting, on average by 1.953 cm over the six month period (Aug '92 - Feb '93). This effect is more pronounced at the lower reaches of the mudflat with accretion plate 2 showing an increase of 3.9 cm. This relatively large increase in surface elevation continues up the profile until accretion plate 10 where the accretion rate is only 0.6 cm. At this point on the profile the underlying estuarine clays are virtually exposed, whereas below this point the recently deposited soft sediments predominate. The remaining two accretion plates on the mudflat (11 and 12) also exhibit much smaller increases in sediment (0.22 and 0.55 cm respectively).

The accretion data for the set-back surface is also presented in table 1. It can be seen from the table that there is an apparent erosion of the set-back surface, however visual evidence (see plates 6 and 7) suggests that accretion is continuing across the site. A possible explanation for the apparent erosion may be a combination of the accretion methodology and the state of the set-back surface. The set-back surface consists of a solid clay underlayer which is covered by the remains of the original vegetation, which in turn is covered by the recently deposited sediment. When an accretion plate reading is taken the probe is inserted into the set-back surface until contact is made with the accretion plate. A measurement of depth is then taken to the surface which gives an overall depth of the accretion plate, including recently deposited sediment. However, as the original vegetation below the deposited sediment continues to decay it loses its structure and becomes more compact. When subsequent measurements are taken at the same site it appears that erosion has taken place because the depth of the accretion plate has marginally reduced, but this is as a result of the process outlined above rather than any real erosion.

Another complication which has arisen with regard to accretion plate readings is the incidence of standing water on the set-back surface. This currently only effects accretion plate 13 - the first accretion plate on the set-back site. This plate is now covered by a 15-20 cm pool of water which makes determination of the actual mud surface difficult. Readings were obtained for this accretion plate but their accuracy must be considered in relation to the other readings.

4 Sediments

4.1 Sampling methods

Samples for particle size and organic carbon analysis were collected to reflect grain size trends along a transect (samples 1-4) and to describe spatial trends across the site (random samples R1-R10) as shown in figures 1 and 2. Grain size analysis was carried out using a Malvern Particle Sizer, which uses the principle of laser diffraction to obtain accurate particle size distributions down to 0.1μm diameter. Organic carbon content was determined by wet digestion, and loss on ignition was carried out to identify the coal percentage in each sample.

4.2 Results

Both datasets display several common trends that may be explained with reference to the observed pattern of tidal inundation and the topography of the set-back area. Examining the grain size trend along a transect parallel to the accretion plates first, a fining from around 14μm to around 9μm with distance up the marsh is present in both surveys. Given the steady increase in height and lack of topographic irregularities shown in both surveys (figures 1 and 2), this simply reflects the diminishing power of the incoming tide as it ponds up towards the back of the site, causing settling out of coarser particles on the lower marsh edge. This is supported by the decrease in standard deviation towards the inner wall, which implies a better degree of sorting.

However, the random samples collected during both surveys display several distinct trends across the site. The majority of the samples display a mean grain size between 8 and 10μm in diameter and are slightly positively skewed, the latter implying that accretion is predominant over the site. One anomaly lies in sample R1, which displays a coarser, more positively skewed distribution. This sample, taken from the area immediately adjacent to the sluice cutting, will undergo prolonged inundation and be subject to relatively high velocity currents on the incoming tide. This will result in high rates of deposition of coarser sediment in this zone, causing the observed sediment distribution. Erosion of the sea wall, illustrated in plate 3, may supplement the coarse tidal deposition. Sample R5, taken in the vicinity of the central relic creek, exhibits the coarsest mean diameter of around 18μm in both surveys and a relatively poor degree of sorting, with a standard deviation of almost 1.6 phi. As reported in February 1992, this creek acts as a conduit carrying the incoming tide to the rear of the site. Hence it may be expected that this area will be characterised by coarse, poorly sorted deposits, owing once again to the relatively fast currents and long periods of inundation. These coarse deposits will be augmented by the transport of sediment from the old sea wall as waves break over the wall on the incoming tide. Field observations and topographic evidence illustrate this, as the gradient from the former wall to the marsh has noticeably decreased.

Over much of the site, a general trend of increasing mean grain size and standard deviation towards the top north-east corner may be identified in both datasets. This may be put down to two complementary processes. Tidal inundation will be less frequent and of a shorter duration as the elevation increases towards this corner, causing less deposition of imported sediment. Moreover, the surface sediments will retain more of the characteristics associated with cultivated areas as the proportion of deposited material progressively decreases. Hence a tendency towards pre-breach conditions may be expected, with mean grain sizes and standard deviation approaching the ranges reported in the baseline study. The abnormal negative skew found in the area of sample R9 on both occasions implies erosion, but no topographic evidence or tidal currents may be found to support this.

Organic carbon analysis reveals a high variation across the marsh, from almost 3% to over 23% in the western corner of the site. Organic carbon content will be influenced primarily by the degree of vegetation cover at each locality and the presence of macro-fauna. The predominantly high organic carbon levels evidently reflect this, owing to the presence of colonising marsh vegetation, particularly in the central area of the site, and the accumulation of rotting terrestrial grasses across most of the marsh. Hence little trend may be discerned as these two factors will not as yet result in a spatial distribution of organic carbon. Thus the high values around R3 and R4 may reflect the presence of a rotting vegetation layer, whilst the similar high value of R9 in the far western corner may arise from the presence of colonising marsh species. In addition, all samples contained large numbers of *Hydrobia spp.* which add to the total organic content.

Two distinct areas of low organic carbon content were identified near the old sea wall at R6 and the eastern sea wall at R1 and R2. The former may reflect the washover processes described above, causing deposition of material from the old sea wall top, which will be naturally low in organic content. Similarly, the area in the vicinity of the eastern sea wall has recently been subject to infilling using material derived from the new borrow pit which will evidently be of a different nature to sediment inside the set-back site.

5 Vane shear strength

5.1 Sampling method

Following the proposal advanced in Report 2, an attempt was made to measure the shear strength of sediments at varying depths along a transect from the low water mark to the top of the marsh adjacent to accretion plate markers. Readings were taken at 5cm, 11cm and 22cm depth using a Pilcon hand-held shear vane.

5.3 Results

The results, shown in figure 5, display a fairly consistent trend up to 60m from low water, at which point the underlying estuarine clays begin to affect the data. Up to this point, near-surface readings average about 0.2 KPa, readings at 11cm depth run at 2.0 KPa and values approaching 3KPa are found at 22cm depth. To landward of this point, the underlying estuarine clays cause a rapid increase in readings up to the 30KPa limit on the instrument at depths below 11cm. On the marsh surface, it was hoped to obtain baseline data on the strength of newly-deposited sediment, but insufficient deposition had taken place by this time to allow this measurement. It was therefore decided to obtain readings immediately below this surface veneer, with the results shown in figure 5. These high readings do not reflect the true nature of the sediment at this depth, but arise from the presence of rotting vegetation which displays high shear strengths. Readings taken at 22cm depth merely represent the underlying estuarine beds and therefore are not to be seen as relevant to the surface sediments. An appropriate method will be devised to overcome these problems and provide subsequent data to compare to this baseline survey.

6 Drainage topography

The drainage topography of the site has largely remained the same as that detailed in the last report. Since the NRA maintenance works the seaward borrow pit has been enclosed, which has prevented the incoming tidal water from using this feature as a 'flood pathway'. Site flooding is now determined largely by topography than any remaining man-made features.

Ebb drainage of the site is also determined by topography, although there are several locations where areas of standing water are generated. This occurs most noticeably at the relic creek in the middle of the site and at the remains of the borrow pit of the old sea wall (see plates 8, 9, and 10).

7 General observations

7.1 Wall erosion

Wall erosion is still a major problem at the eastern end of the site. The extent and seriousness of the problem can be seen in plates 3 and 4. The east wall was repaired by the NRA during its maintenance program at the site in June 1992, but the wall has since been eroded severely in several places to such an extent that the geo-fabric used to strengthen the wall is now visible. It is believed that the erosion is due to a combination of ebb current velocities and wind-generated waves across the site. It is difficult to be more precise about the mechanisms involved without further detailed study of the current velocities generated during a flood/ebb cycle.

The seepage through the east wall outlined in Report 2 is still a significant problem (plate 2). This is possibly associated with the erosional problem at this end of the site as it does not seem to occur at any other locations.

7.2 Vegetation zonation

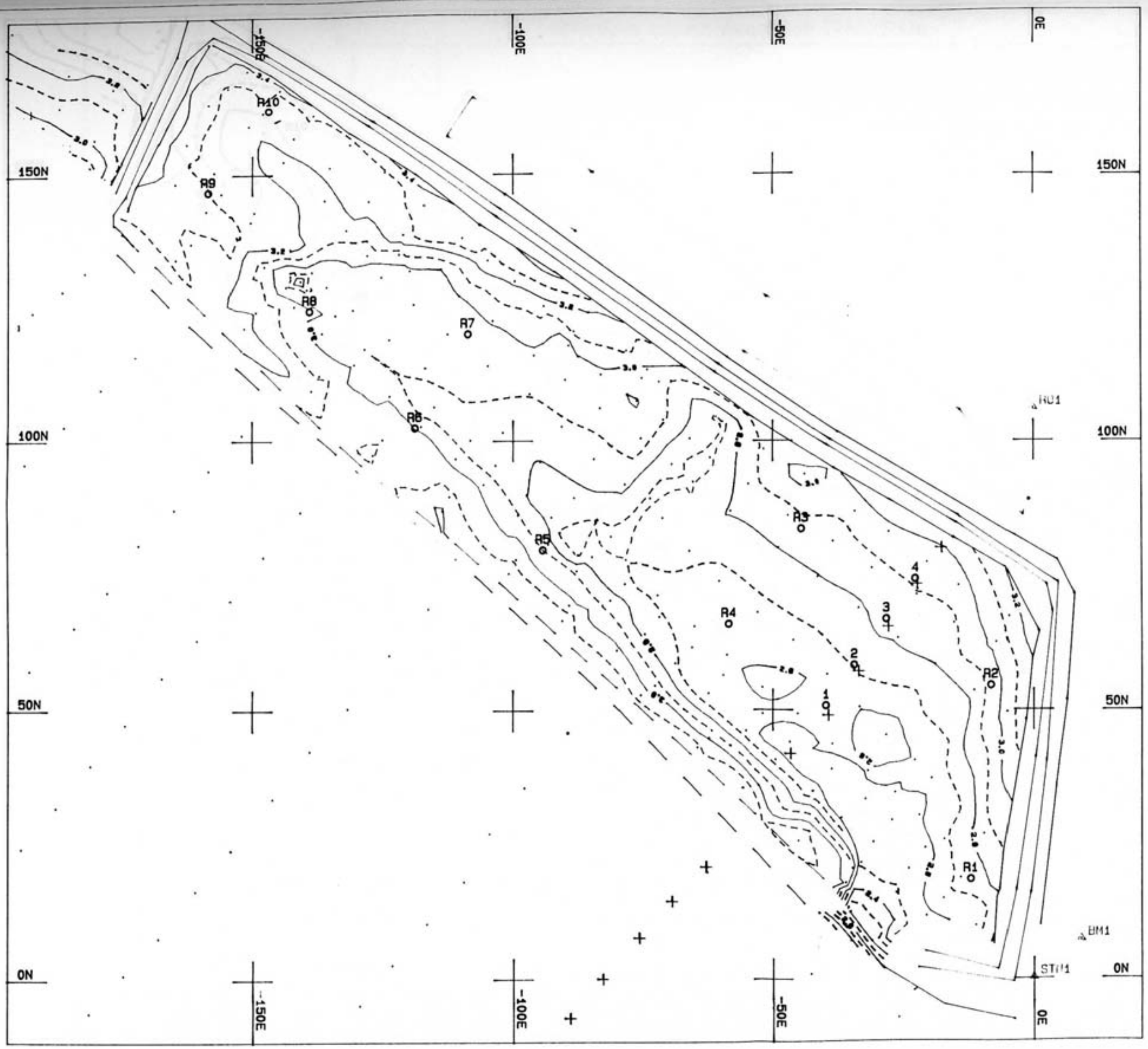
Although beyond the scope of this report some mention is made of the apparent zonation of the vegetation on the set-back surface. Three distinct zones of vegetation can be readily identified: zone 1 corresponds to the lower-lying most frequently inundated areas at the eastern end of the site; zone 2 is that area which lies between the relic creek in the middle of the site, and the remains of the flooded borrow pit towards the west end of the site; zone 3 is westwards of the old flooded borrow pit. The level of vegetation colonisation increases as one moves westwards. Zone 1 contains sparse patches of vegetation mainly towards the rear of the site, zone 2 has a higher level of vegetation cover whilst still being generally sparse; zone 3 is comparatively heavily vegetated, particularly along the edge of the old borrow pit. This zonation can be seen in plates 8, 9, and 10. Plate 11 shows the area of original saltmarsh to the west of the set-back site and is included to show the similarity between the set-back site and an area of adjacent marsh.

7 Proposals for future monitoring

7.1 Monitoring of results

It is recommended that the monitoring of geomorphological results should be continued by carrying out:

- Continued **topographic survey** twice a year until 1996 and annually thereafter. Methodology as for previous surveys, using an EDM with data logger, taking a number of random points across the marsh surface and inputting the data into **LSS** for analysis. Contour maps and volumetric analyses will be produced.
- measurements of **accretion rates** on the marsh and mudflat surfaces twice a year for the first five years and annually thereafter. Methodology as for previous surveys, re-locating the accretion plates positioned in August 1991, taking five readings of plate depth below the surface and averaging these to produce one depth reading for each plate along the transect line from inner sea wall across the marsh and mudflats to the low water mark.
- collection of **sub-surface sediments**, to be analysed for grain size, organic content and clay mineralogy. Methodology as for previous surveys, four samples along transect line to assess temporal changes and a number of random samples across the site to determine spatial changes.
- collection of **accreted sediments** using a random sampling procedure twice a year for the first five years and annually thereafter, to be analysed for grain size, organic content and clay mineralogy to compare with the sub-surface sediments.



LEGEND

- Present Sea Wall Base
- Present Sea Wall Top
- New Borrow Ditch
- Former Sea Wall Top
- Former Sea Wall Base
- Marsh Edge
- Accretion Plate
- Sediment Sample
- Random Sediment Sample
- Survey Point

All measurements to OD

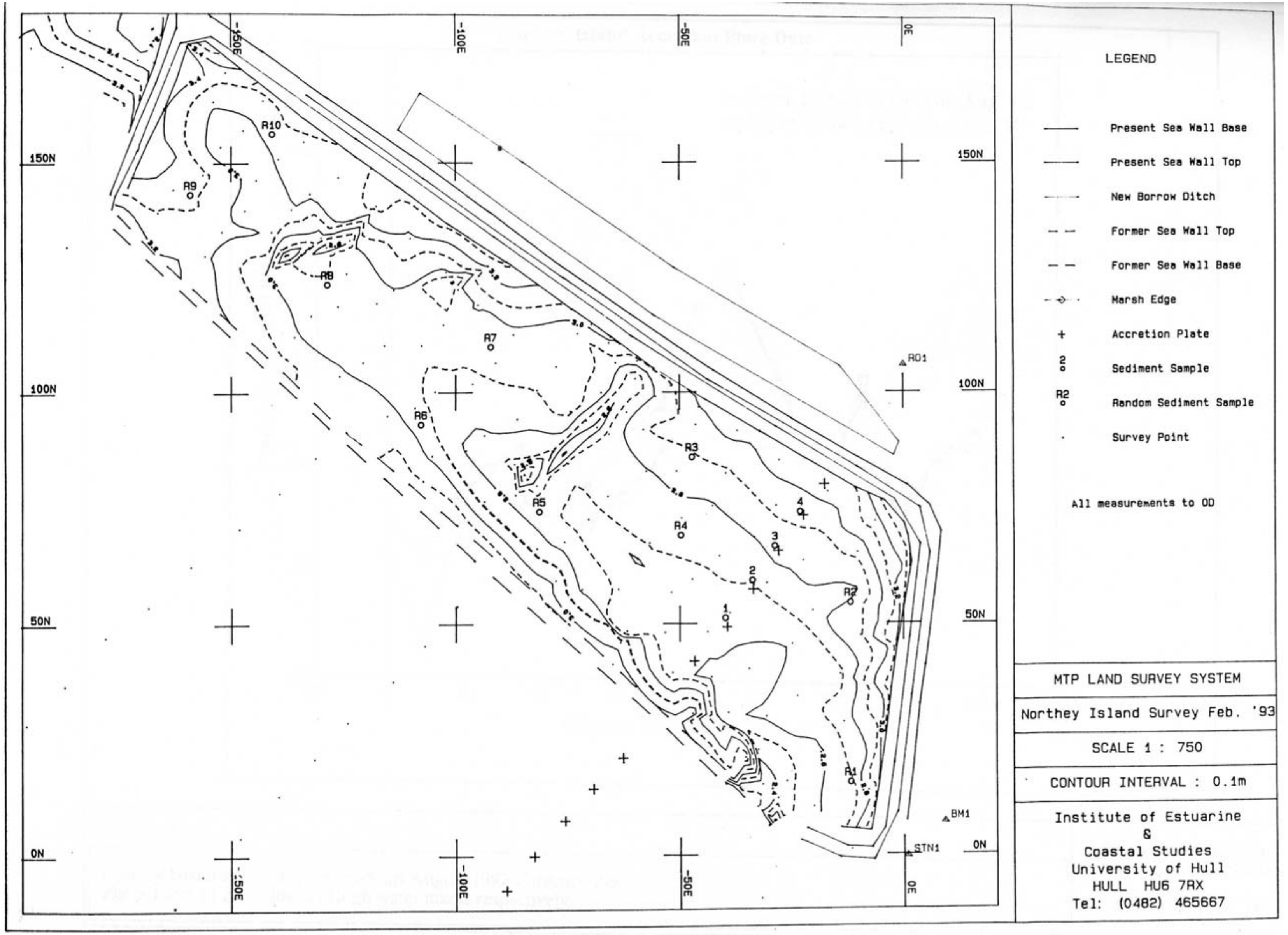
MTP LAND SURVEY SYSTEM

Northey Island Survey Aug. '92

SCALE 1 : 750

CONTOUR INTERVAL : 0.1m

Institute of Estuarine
&
Coastal Studies
University of Hull
HULL HU6 7RX
Tel: (0482) 465667



LEGEND
Present Sea Wall Base
Present Sea Wall Top
New Borrow Ditch
Former Sea Wall Top
Former Sea Wall Base
Marsh Edge
Accretion Plate
Sediment Sample
Random Sediment Sample
Survey Point
All measurements to OD
MTP LAND SURVEY SYSTEM
Northey Island Survey Feb. '93
SCALE 1 : 750
CONTOUR INTERVAL : 0.1m
Institute of Estuarine & Coastal Studies
University of Hull
HULL HU6 7RX
Tel: (0482) 465667
150N
100N
50N
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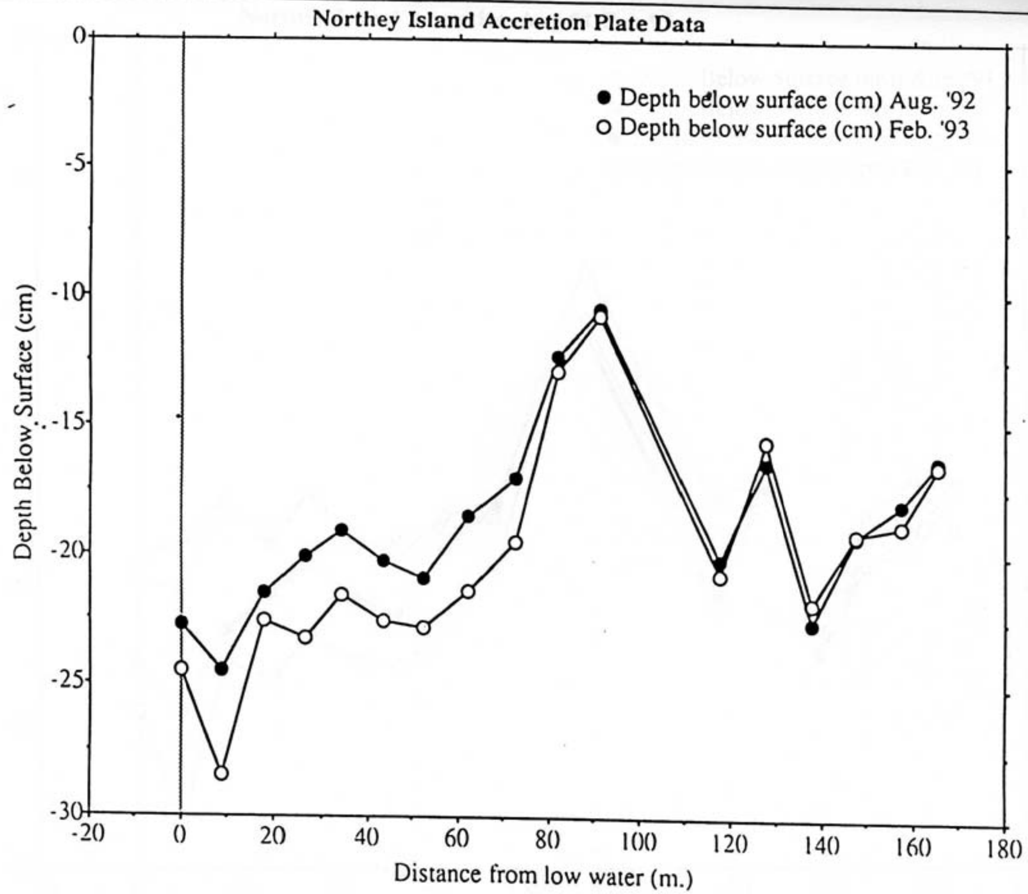

Figure 3

Northey Island accretion plate readings August 1992-February 1993.
Plates 1 and 11 are at low and high water marks respectively.

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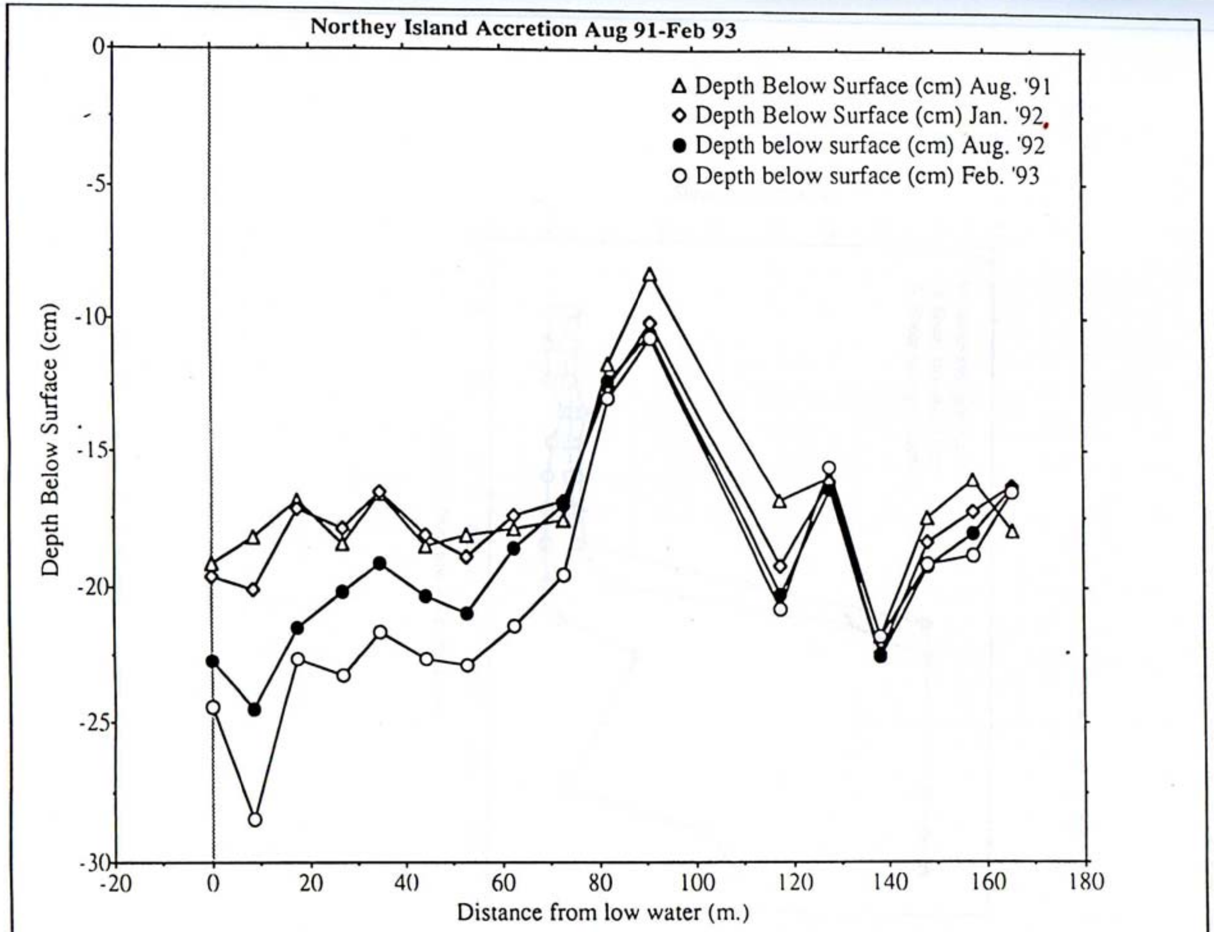

Figure 4	Institute of Estuarine and Coastal Studies University of Hull
Northey Island accretion plate readings August 1991-February 1993. Plates 1 and 11 are at low and high water marks respectively.	

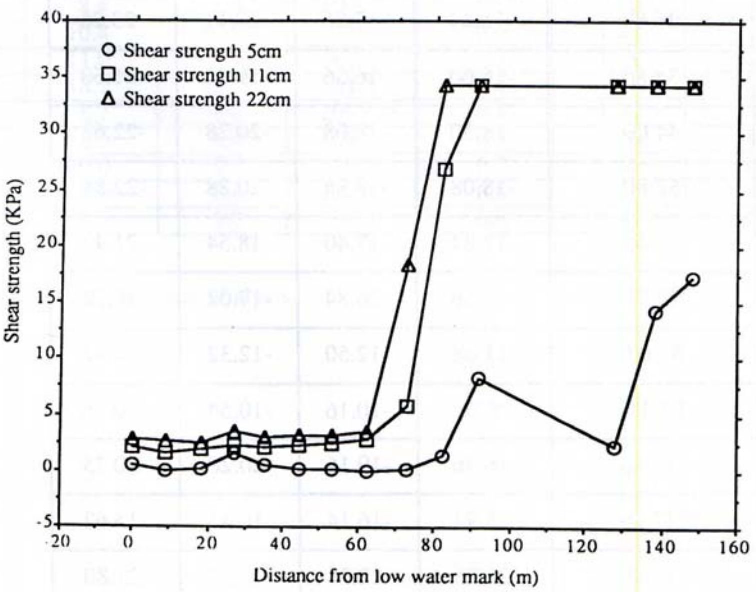

Figure 5

Shear vane results taken 1m east of accretion plates.

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Northey Island accretion plate measurements Aug 91-Feb 93

Accretion Plate	Distance from low water (m)	Aug. 91 (cm)	Jan. 92 (cm)	Aug. 92 (cm)	Feb. 93 (cm)
1	0	-19.08	-19.56	-22.71	-24.46
2	8.81	-18.14	-20.06	-24.50	-28.40
3	17.77	-16.86	-17.16	-21.50	-22.60
4	26.87	-18.44	-17.86	-20.11	-23.26
5	34.85	-16.60	-16.56	-19.11	-21.60
6	44.09	-18.50	-18.08	-20.28	-22.62
7	52.80	-18.08	-18.84	-20.88	-22.84
8	62.40	-17.84	-17.40	-18.54	-21.42
9	72.77	-17.56	-16.84	-17.02	-19.52
10	82.03	-11.68	-12.50	-12.32	-12.92
11	91.15	-8.36	-10.16	-10.54	-10.76
12	117.56	-16.86	-19.16	-20.20	-20.75
13	127.76	-15.94	-16.14	-16.45	-15.62
14	137.95	-21.78	-22.38	-22.57	-21.80
15	147.77	-17.46	-18.36	-19.21	-19.14
16	157.39	-16.04	-17.24	-17.98	-18.82
17	165.41	-17.90	-16.26	-16.34	-16.52

Table 1. Accretion plate measurements

Sample ref.	Mean µm	Median µm	% Clay & silt	Mean Ø	SD Ø	Skew
August 92 samples						
1	13.8	13.6	90.2	6.1	1.62	.15
2	14.2	15.3	92.8	6.0	1.53	.29
3	11.3	10.0	90.2	6.2	1.49	-.09
4	8.9	9.0	100	6.8	1.20	.02
R1	13.2	13.4	96.1	6.2	1.51	.32
R2	8.4	8.4	100	6.8	1.30	.20
R3	10.4	10.0	97.2	6.6	1.27	.06
R4	11.0	11.2	96.4	6.7	1.34	.07
R5	18.2	18.7	82.2	5.6	1.58	.01
R6	8.7	8.6	100	6.8	1.32	.15
R7	8.5	8.7	100	6.8	1.16	.10
R8	10.0	10.1	99.7	6.7	1.30	.19
R9	8.9	8.6	100	6.8	1.50	-.22
R10	9.7	9.7	98.2	6.8	1.41	.14

Table 2: Results of grain size analysis

Sample ref.	Mean µm	Median µm	% Clay & silt	Mean ∅	SD ∅	Skew
February 93 samples						
1	14.7	14.7	88.5	6.1	1.64	.12
2	14.6	15.7	93.2	6.1	1.50	.27
3	13.6	12.8	90.7	6.2	1.51	-.12
4	9.1	9.1	99.8	6.8	1.23	0.00
R1	12.3	12.7	97.9	6.3	1.49	.30
R2	9.7	9.7	99.7	6.7	1.32	.13
R3	9.8	9.7	99.6	6.7	1.32	.13
R4	10.7	10.4	97.6	6.6	1.37	.11
R5	17.6	17.7	84.4	5.8	1.59	.06
R6	8.9	8.9	99.6	6.8	1.38	.11
R7	8.1	8.5	100	6.9	1.14	.14
R8	9.5	9.5	99.9	6.7	1.33	.13
R9	9.4	8.8	95.4	6.7	1.46	-.15
R10	10.2	10.1	97.9	6.6	1.42	.12

Table 3: Results of grain size analysis

Sample ref.	% Organic carbon	LOI @ 400°C	LOI @ 480°C
August 92 samples			
1	12.2	9.4	4.78
2	8.5	6.4	4.24
3	16.4	11.52	6.45
4	22.1	15.21	4.52
R1	4.7	4.1	3.41
R2	5.2	12.1	8.79
R3	28.5	24.57	5.42
R4	16.2	11.52	4.52
R5	13.5	8.9	7.09
R6	1.8	2.4	2.19
R7	22.1	13.58	6.87
R8	17.8	12.64	4.87
R9	22.9	24.3	6.91
R10	13.6	6.54	5.24

Table 4. Organic carbon and LOI results August 92

Sample ref.	Mean µm	Median µm	% Clay & silt	Mean Ø	SD Ø	Skew
February 93 samples						
1	14.7	14.7	88.5	6.1	1.64	.12
2	14.6	15.7	93.2	6.1	1.50	.27
3	13.6	12.8	90.7	6.2	1.51	-.12
4	9.1	9.1	99.8	6.8	1.23	0.00
R1	12.3	12.7	97.9	6.3	1.49	.30
R2	9.7	9.7	99.7	6.7	1.32	.13
R3	9.8	9.7	99.6	6.7	1.32	.13
R4	10.7	10.4	97.6	6.6	1.37	.11
R5	17.6	17.7	84.4	5.8	1.59	.06
R6	8.9	8.9	99.6	6.8	1.38	.11
R7	8.1	8.5	100	6.9	1.14	.14
R8	9.5	9.5	99.9	6.7	1.33	.13
R9	9.4	8.8	95.4	6.7	1.46	-.15
R10	10.2	10.1	97.9	6.6	1.42	.12

Table 5. Organic carbon and LOI results February 93

Plate 1. View of the Northey Island scheme from survey station.

Plate 2. Enclosure wall at east end of site. Note severe erosion on western face and increased level of seepage at foot of wall

Plate 3. View of eastern wall erosion, geo-fabric exposed at several locations (see Plate 4).

Plate 4. Close up view of extensive erosion and exposed geo-fabric

Plate 5. View from mudflat side of spillway. Note presence of new channel.

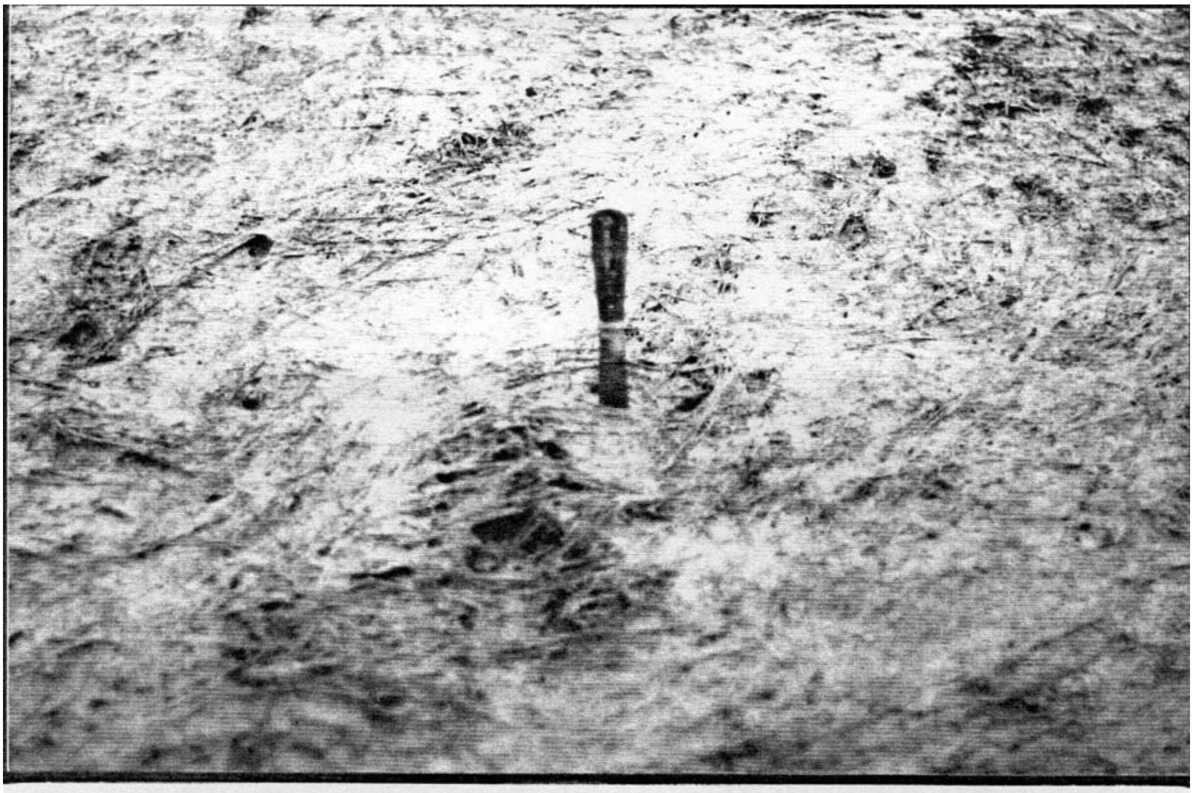

Plate 6. Surface of site showing accreted sediment over original vegetation.

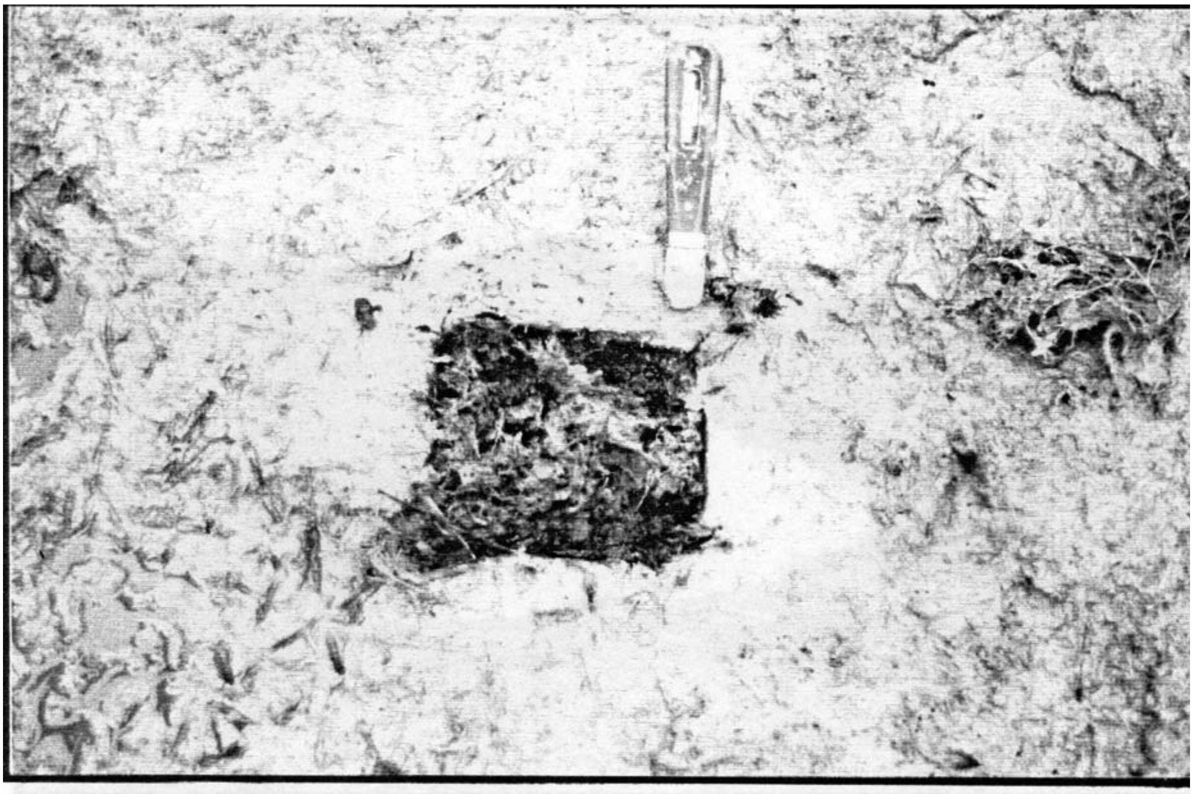

Plate 7. Accreted surface'scraped' back to expose original surface. Accretion is variable from 5mm to 15mm

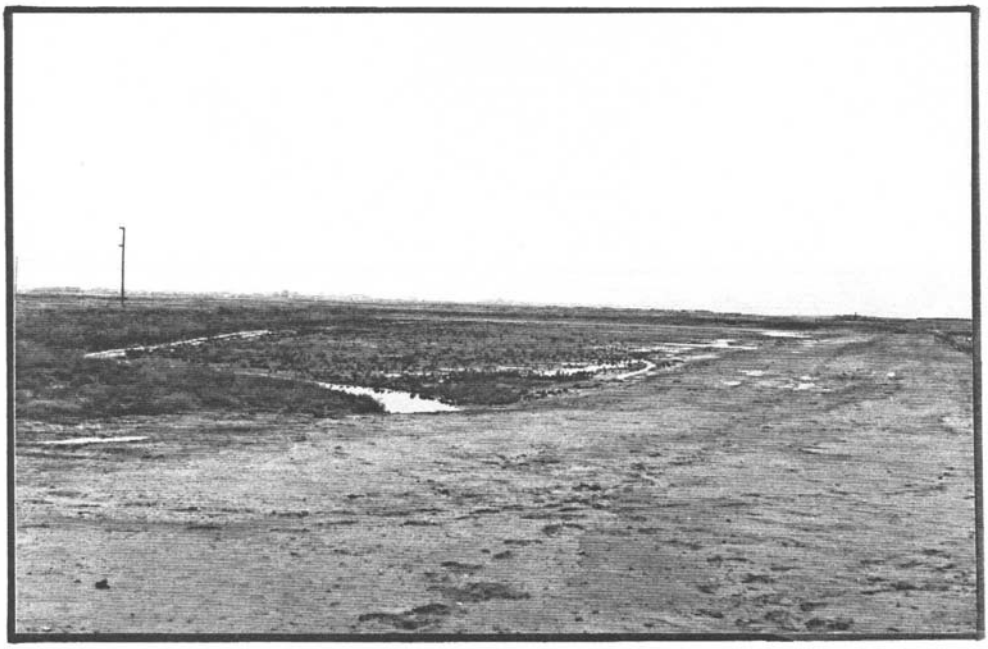

Plate 8. View from south-west corner of site. Note the three distinct zones of vetetation density.

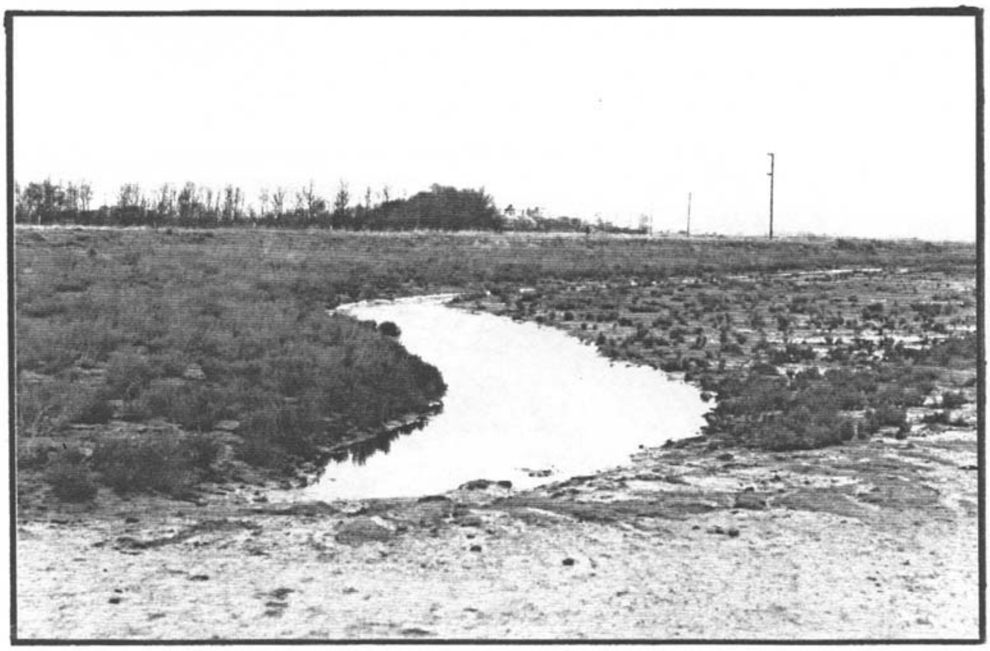

Plate 9. Vegetation zonation can clearly be seen. Zone 3 - the western most zone - is heavily vegetated in comparison to the other two zones. Note standing water in creek

Plate 10. View from the northern wall. Relic creek in foreground dividing zones 1 & 2. Note standing water.

Plate 11. Original saltmarsh immediately to the west of the study site. Although relatively heavily vegetated it has a similar appearance to the study site.