Northey Island set-back scheme
Report 2
August 1991 to January 1992

Institute of Estuarine and Coastal Studies
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1 Introduction

In 1991 a small experimental scheme was implemented on Northey Island, Essex, to re-open an area of enclosed land to tidal inundation with the aim of re-creating an area of saltmarsh habitat. The rationale behind this scheme, and the original methods and results of monitoring prior to the implementation, were reported by IECS in October 1991. This present report aims to assess the early results of the scheme after the work was implemented in July 1991. This report should be read in conjunction with the original report as full details of the early work are not included here.

2 Topographic survey

2.1 Sampling methods

The second baseline topographic survey, carried out in August 1991, established three permanent benchmarks which were relocated and used in the renewed survey in January 1992 as height reference. A topographic survey was then carried out using the same method as the original surveys i.e. by sampling random points across the marsh and mudflat surface. By comparing the new data with the original surveys, using the Land Survey System as described in the original report it is possible to produce quantitative measurements of volume changes.

2.2 Results

A contour map of the surface of the set-back marsh as recorded in January 1992 is included as figure 1. When comparing the new map with those of the original survey it is important to note that the configuration of the contours may have altered without registering an actual change in the marsh surface. This is purely due to the random nature of the sampling points, a technique which was developed to minimise the disturbance effect of repeatedly sampling the same permanent points.

The contours provide a visual indication of the gross topography of the surface, but the differences between surface elevations on successive surveys may be evaluated using a statistical comparison between the two elevation data sets. Using a t-test the difference between the two elevation means for the marsh surface, as recorded in August 1991 and January 1992, of -3mm is shown to be non-significant at the 95% level.

Thus, as expected, no significant shange in elevation can be reported using this technique although, as indicated below, accretion veneers have been observed in some areas of the marsh.

The open area of marsh immediately to the west of the set-back site is approximately 20cm higher than the set-back marsh. This may have implications for the development of marsh communities in this area, with the potential for upper marsh communities which are rare in the Essex context.

The highest part of the set-back marsh, at a height of 3.3m OD, is at the western end of the site towards the rear sea wall as shown by the contours on figure 1. On most of the tides this area is not covered, only a total of about 18 tides per year reaching this area, compared with approximately 100 tides per year over most of the set-back area. The maximum tide level covers the entire marsh, reaching the lower part of the rear wall where the drift line was recorded at a height of 3.39m.

3 Accretion measurements

3.1 Sampling methods

It was originally recommended that the line of accretion plates which were positioned in August 1991 should be left undisturbed for at least six months to allow for settling of the plates and sediment plugs. However, to meet the requirements of the current project it was decided to take some accretion measurements at this stage, which may then act as a calibration for future measurements.

The general locations of the accretion plates are marked by bamboo canes which lie 1m to the north of each plate. The plates themselves are re-located by means of a metal detector, five readings of depth to the plate taken by inserting a graduated rod and an average depth recorded for each plate. The results of these measurements are shown in table 1 and figure 2.

3.2 Results

Although the results seem to show an increase in sediment depth above most of the accretion plates care should be taken in interpreting these results. It is more likely that these initial results are simply due to the settling of the plates into their final positions rather than an amount of sediment accretion. Future measurements will provide a better indication of the actual situation.

There has, however, been a significant amount of accretion of sediment over the surface of the vegetation on the setback site, as shown in plate 2. This is somewhat irregular in distribution but the measurement of sediment accumulated on one vegetation sample recorded 0.078g of sediment per square cm. Assuming a density of 1.6g cm^{-1}, and a void ratio of 0.6 this weight of sediment would result in a vertical accretion of 0.0748cm over the 6 month period.

4 Sediments

4.1 Sampling methods

Samples of the sediments were taken along the same line as previously to determine whether any changes to the sediments beneath the peat layer had occurred, although temporal changes beneath the vegetated surface would not be expected. In addition, two further sub-surface samples were taken at random points across the site (samples R1 and R2), as shown on figure 3, to assess any spatial variations in the sediment type. The vegetation with overlying deposited sediments was collected with three of these samples (samples 1,3 and 4), and the sediments analysed to determine the composition of the marine accretions. A further sample from a known area of vegetation (sample VEG) was analysed to determine the dry weight of deposited sediment in order to provide an indication of the rate of renewed sediment accretion, as described in section 3.2.

4.2 Results

The sediments were analysed to determine the grain sizes, the clay mineralogy and the organic content.

The results of the particle size analysis are included in table 2. As expected the four samples collected from under the peat layer (samples 1 to 4) varied little between the two sampling visits. The two new random samples (samples R1 and R2), also taken from under the peat layer showed grain size distributions similar to those of samples 1 to 4, although the mean size of sample R1 was somewhat coarser and both samples were skewed towards larger sediments.

Three of the four sediment samples obtained from the surface showed a lower percentage of silt/clay compared with the sub-surface samples. This may indicate that a higher energy environment is being experienced than during previous sedimentary events. Of these surface sediments, sample 1 located nearest to the spillway, has a higher proportion of silt/clay. Although it would be expected that this sample would be subject to more energy from wave action, the higher silt content may be a reflection of the amount of time this sample is submerged.

The analysis of the clay mineralogy had not been completed by the report date (and thus table 3 is missing), but will be included in later reports.

The results of the analysis of organic content are included as table 4 and show that there is a marked difference in the amount of organic carbon in sample 2 compared with the other samples. The percentage of organic carbon by weight is significantly higher in sample 2, as is the coal fraction where the difference between the two LOI figures is 4.15% compared with an average of 2.9% in the other 5 samples.

5 Drainage topography

The positions of the relic creek and the remaining borrow pits are readily visible from the results of the topographic survey, and photographs were taken to record the patterns of water movement across the site.

The single relic creek through the centre of the site remains in the same conformation, following the same course as recorded during the original survey, with a depth of 20cm as before. During the early stages of the flood tide this creek carries the flow to the back of the marsh, then spilling into the rear borrow pit which spreads the flood water along the back edge of the site. This is shown in plates 3 and 4. Similarly the borrow pit immediately behind the original sea wall carries water to the western end of the site before the main area of marsh is covered. The two borrow pits are therefore altering the pattern of flow from that which would be expected in the drainage topography of a normal saltmarsh site.

Plate 5 shows that the height of the spillway, combined with the patterns of flow through the creek and borrow pits means that most of the set-back site is covered before the water tops the front wall.

6 General observations

6.1 Tidal currents

Observations during visits to the site indicate that tide rates entering the site are faster than the predicted 15cm/sec, possibly causing ripping around the edges of the spillway. This is demonstrated in plate 6 which was taken at the east end of the site looking west across the spillway during an early stage of the rising tide. This shows waves breaking around the corner of the spillway and fast currents running into the borrow pit behind the outer wall. Later in the rising tide, as shown in plate 7, when the surface of the site is covered, the flow continues to be fast around the corner of the spillway but there is a still area immediately behind the wall over the line of the borrow pit with the current sweeping in a wider curve over the marsh surface.

Plate 8 shows the extent of a spring high tide demonstrating which areas at the back of the marsh are not normally covered. The bank-full situation is shown in plate 9. It is important to note the waves breaking on the original sea wall at the front of the site, which is therefore protecting the seaward edge of the marsh from these erosive forces.

6.2 Wall erosion

The current velocities, possibly combined with winds generated across the site may be responsible for the observed erosion of the enclosing wall at the east end of the site. Plate 10 shows the height of the tide up this wall, the worst erosion occurring at the far end of the wall on this photograph. Plate 11 shows an example of the erosion in this area which extends intermittently with varying degrees of severity for approximately 10m. Plate 12, taken at high tide, shows that there is seepage through lower parts of the wall in the same general location as the eroded sections described above.

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:

- a **topographic survey** twice a year for the first five years 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.
- additional measurements of **vane shear strength** of the marsh and mudflat sediments to determine whether the illite swelling component is having a significant effect on the stability of the sediment.

7.2 Monitoring of processes

It is recommended that the monitoring is extended to include the geomorphological processes which are occurring on the site. This will allow predictions to be made about the expected rates of change which will be observed through the monitoring of results (see section 7.1), and will also allow identification of any potential problems on this site before they occur. More important, perhaps, is the identification of the basic processes governing set-back marsh regeneration so that the Northey island experiment may be used as a guide for future marsh regeneration programmes.

7.2.1 Methods

The proposal is for a one-day intensive deployment of experimental techniques during a single over-marsh tide occurrence, i.e. during spring tides in March and September, and all the following measurements will be obtained simultaneously.

a) Current velocities

- Two current meters arranged vertically will be deployed in the main channel to record over one tidal cycle, to provide data on bed shear stress and tidal current asymmetry.
- Two current meters, also arranged vertically, will be deployed at the spillway, recording bed shears and flow velocities over the sill.
- To obtain measurements of flow velocities over the marsh surface 9 drogues will be released at 15 minute intervals throughout the duration of the over-marsh tide, the release and recovery positions marked and surveyed using EDM techniques, and vectors of speed and direction plotted.

b) Suspended sediments

- Simultaneously with the current velocity measurements a transect of suspended sediment measurements will be taken every 30 minutes from the channel through to the head of the marsh using a turbidity meter. A concentration profile will be recorded at each station along the transect. This will provide a record of patterns of sediment concentrations in the flooding water throughout the tide.
- The spatial variability of suspended sediments over the flooding marsh wil be monitored by taking water samples at 15 minute intervals. These samples will subsequently be analysed to determine sediment concentration, grain size and organic content.
- A reference suspended sediment concentration at the bed of the spillway will be monitored throughout the tidal cycle using a turbidity meter. This reference will be used to calculate the suspended sediment concentration profile using the methodology of Dyer (1986). Water samples will be taken at regular intervals during the tidal cycle and these will be subsequently analysed for grain size and organic content.

The above data will be incorporated in the analysis of instantaneous sediment flux throughout the tidal cycle using the methodology of McCave (1986). The results wil be used to calculate the tidal sediment budget for the set-back area.

c) Accretion processes

- Total accretion on the marsh surface over one tidal cycle will be measured using deposition on pre-weighed filter papers. These will provide information on total weight of sediment deposited, grain size of deposited material and organic content.

The relationship between the observed accretion and the spatial variation in current flows and suspended sediment concentration will form a major part of the analysis of these data.

d) Tidal data

- Tidal stage will be recorded at the water line at 10 minute intervals throughout th tidal cycle. This procedure avoids the problem of tidal wave amplification in shallow intertidal conditions which would result from the use of conventional tidal gauge methods.

e) Shear strength

- The shear strength of the mudflat sediments will be measured along a transect anc related to the tidal current shear stresses as measured above, to assess whether these are super- or sub-critical. This may be compared with the calculated bed shear of any waves which are present on the sampling day (see below) to allow calculation of sediment input to the marsh from this source.

f) Waves

- The probability of obtaining a wave on an over-marsh tide is low. If waves are present, however, then two wave recorders wil be deployed, one in the central channel and one in the marsh. These will allow the bed shear stress at each stage of the tide to be calculated, and will be used in a numerical model, being developed by IECS for the NRA Anglian region, to predict mudflat erosion/accretion during the tidal cycle in the channel and the marsh.
- If waves are not present during the survey day the site-specific wave characteristics will be predicted using numerical techniques, and these will be used to calculate bed shear stress as above

7.2.2 Timescale for process monitoring

An indication of the seasonality of these processes is important, and it is therefore recommended that this intensive monitoring exercise be carried out over one day during both the March and September spring tidal cycles, with more frequent repetitions if possible.

It is also important to repeat the same monitoring methods after vegetation colonisation, or, if possible, at intervals as different vegetation types become established.

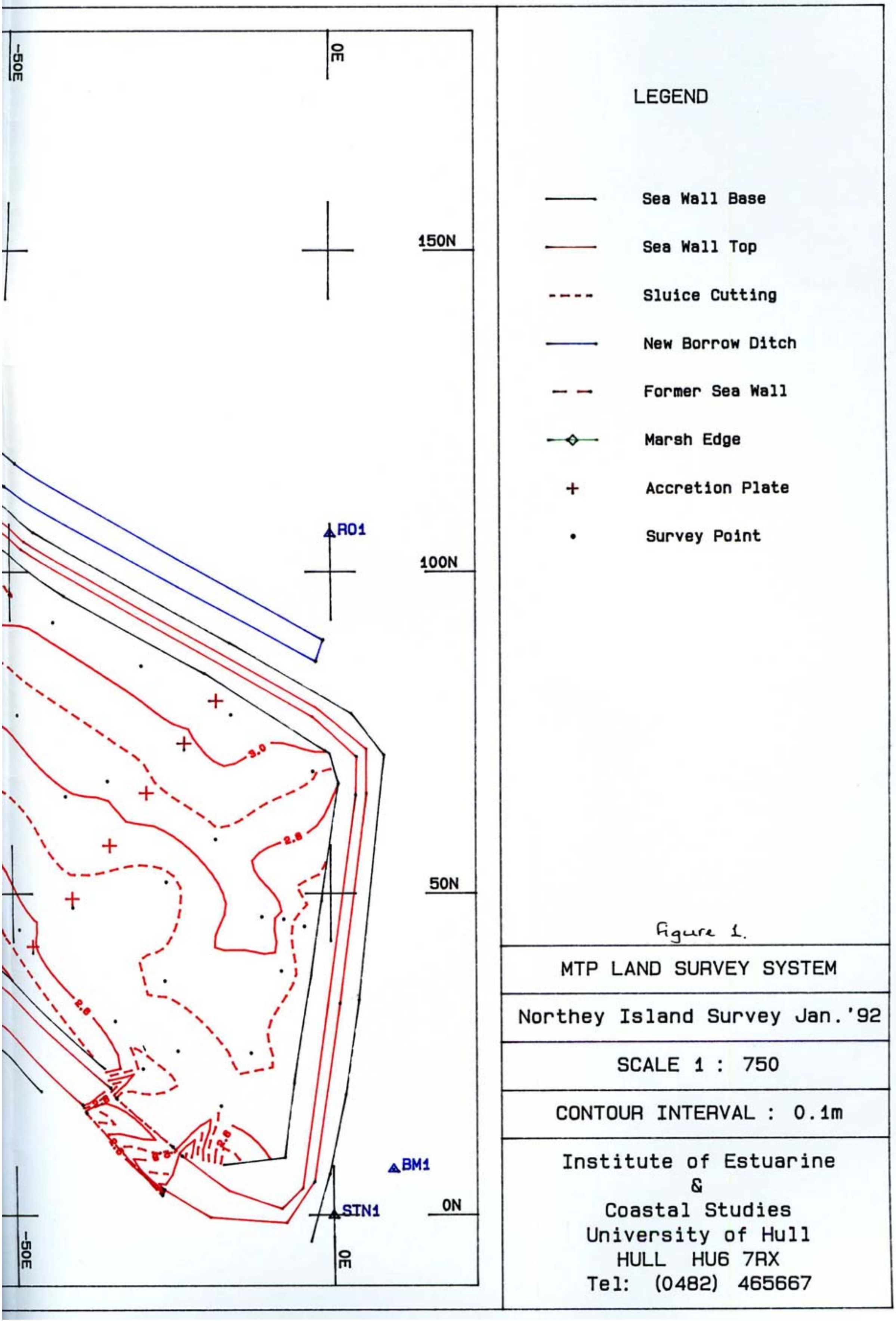
7.2.3 Data processing

a) The data base will allow calculation of:

- a sediment budget for the marsh,
- an organic matter budget for the marsh,
- identification of sources and sinks for the sediment.

b) The data will provide basic information on the physical processes of sediment transport and deposition in set-back marsh areas. Of particular importance will be:

- edge-effects experienced in this small experimental area,
- the relationship to the adjoining intertidal zone,
- the effects of the single spillway input,
- sediment dynamics on pre- and post- vegetated marsh surfaces.


-50E
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RO1
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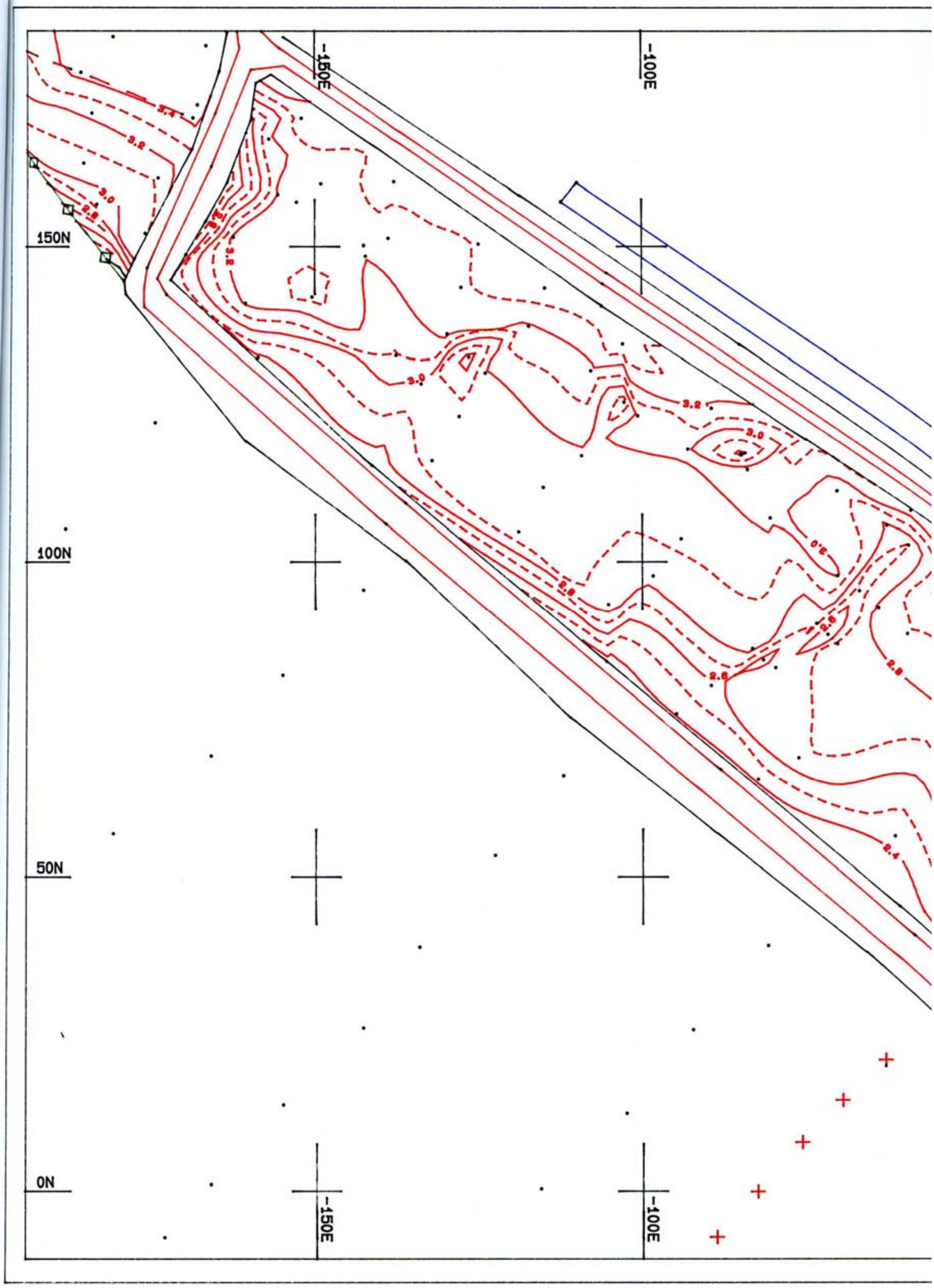
3.0
2.9
2.8
LEGEND
Sea Wall Base
Sea Wall Top
Sluice Cutting
New Borrow Ditch
Former Sea Wall
Marsh Edge
Accretion Plate
Survey Point
Figure 1.
MTP LAND SURVEY SYSTEM
Northey Island Survey Jan.'92
SCALE 1 : 750
CONTOUR INTERVAL : 0.1m
Institute of Estuarine
&
Coastal Studies
University of Hull
HULL HU6 7RX
Tel: (0482) 465667



-150E
-100E
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3.4
3.2
3.0
2.8
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2.4

Table 1. Accretion measurements (depth of accretion plates below surface)

Distance from low water (m)	Aug. 1991 (cm)	Jan. 1991 (cm)
0	-19.08	-19.56
8.81	-18.14	-20.06
17.77	-16.86	-17.16
26.87	-18.44	-17.86
34.85	-16.60	-16.56
44.09	-18.50	-18.08
52.80	-18.08	-18.84
62.40	-17.84	-17.40
72.77	-17.56	-16.84
82.03	-11.68	-12.50
91.15	-8.36	-10.16
117.56	-16.86	-19.16
127.76	-15.94	-16.14
137.95	-21.78	-22.38
147.77	-17.46	-18.36
157.39	-16.04	-17.24
165.41	-17.90	-16.26

It should be noted that both these sets of measurements were recorded during the settling period of the plates and therefore should not be interpreted as accretion.

Figure 2. Northey Island Accretion Plate Data

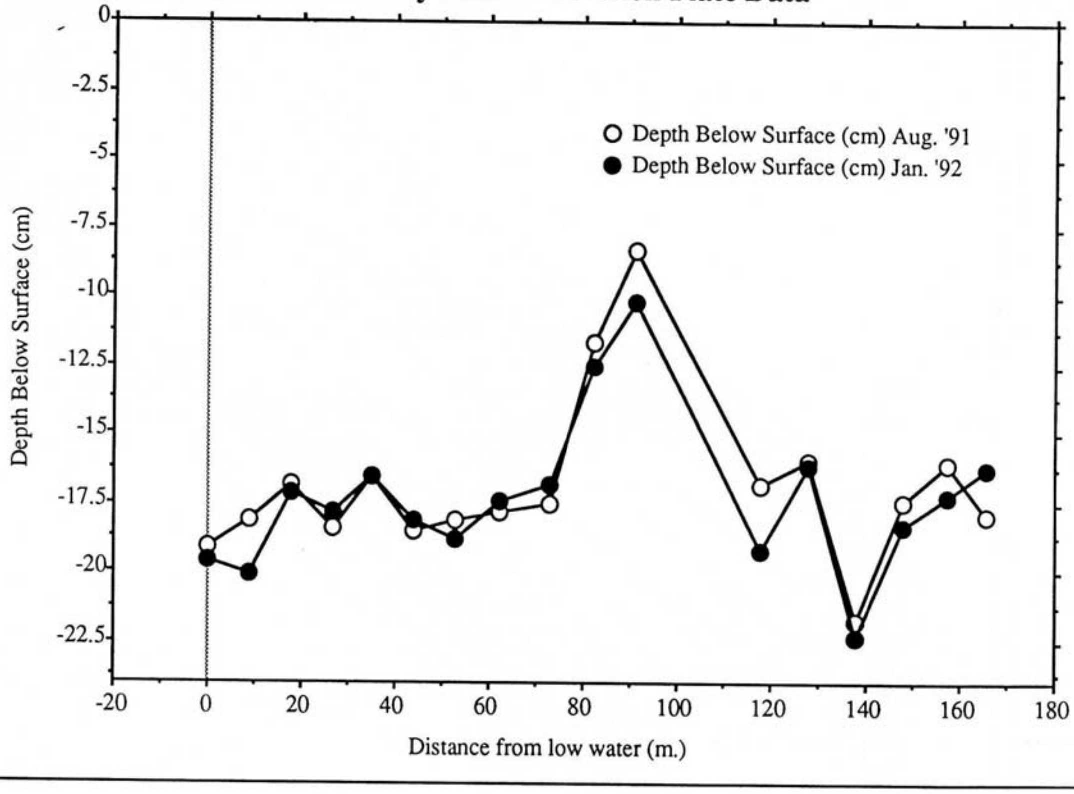

Figure [illegible]. Location of each of the sediment samples

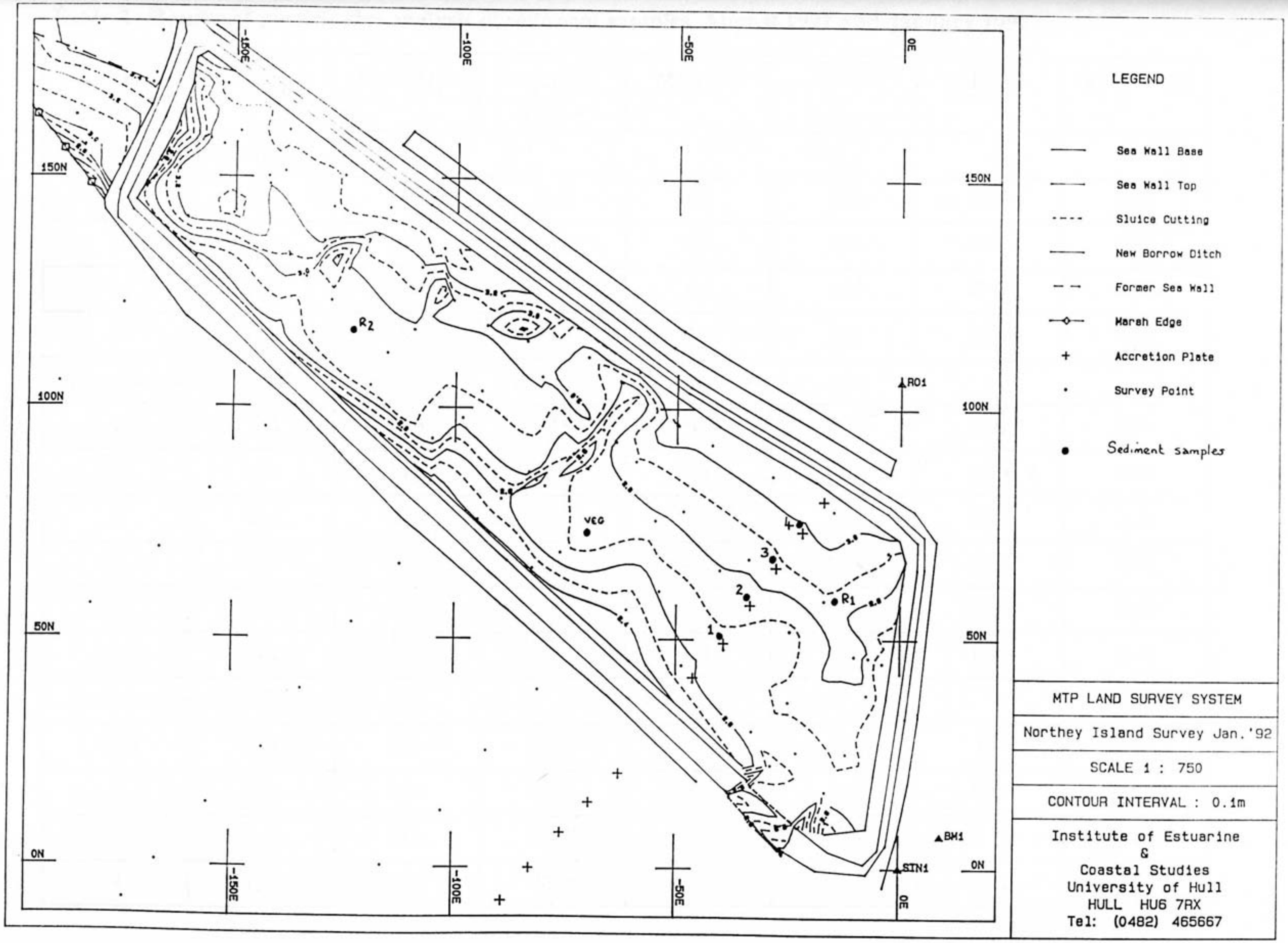

Table 2. Results of particle size analysis of sediment samples, August 1991 and January 1992

Sample	MEAN µm	MEDIAN µm	% CLAY & SILT	MEAN Ø	SD Ø	SKEW	KURTOSIS
Sub-surface sediments 1991							
1	11.2	11.7	96.6	6.5	1.54	0.27	2.39
2	12.9	14.7	96.0	6.3	1.55	0.43	2.40
3	11.9	13.1	97.0	6.4	1.56	0.39	2.34
4	14.9	18.4	93.3	6.1	1.60	0.50	2.50
Sub-surface sediments 1992							
1	13.1	13.5	90.8	6.3	1.77	0.01	2.69
2	14.1	14.6	88.3	6.1	1.81	0.03	2.52
3	16.9	20.4	89.4	5.9	1.72	0.42	2.70
4	15.4	18.4	89.6	6.0	1.74	0.31	2.58
R1	20.0	23.0	82.2	5.6	1.87	0.36	2.63
R2	14.2	17.1	92.6	6.1	1.65	0.48	2.46
Surface sediments 1992							
VEG	22.8	22.1	75.6	5.5	1.85	0.0	2.15
1	11.1	11.6	92.6	6.5	1.76	0.16	2.34
3	21.2	22.0	74.2	5.6	1.98	0.18	2.15
4	13.0	12.4	87.0	6.3	1.84	0.01	2.21

Table 4. Analysis of organic content of sediments

Sample number	Organic content (%) [see note A]	Loss on ignition at 400°C (%) [see note B]	Loss on ignition at 480°C (%) [see note B]
1	4.24	7.75	11.35
2	10.48	16.4	20.55
3	2.47	3.85	6.35
4	4.24	7.6	10.5
R1	3.31	5.1	7.35
R2	4.16	6.25	9.45

Notes:

A The organic content is expressed as percent organic carbon by weight

B LOI included as an independent estimate of organic carbon content to determine coal content cf. particulate organic matter. The difference between LOI at 400°C and LOI at 480°C represents the coal fraction present in the sample.

Plate 1. Set-back area prior to implementation of the works

Plate 2. Accretion of marine sediments on the vegetation

Plate 3. Relic creek with standing water through the centre of the site

Plate 4. Flow of flood water through the relic creek and into the rear borrow pit

Plate 5. The surface of the set-back area is covered before waves break over the front wall

Plate 6. Early rising tide showing current flow around the edges of the spillway and into the front borrow pit

Plate 7. Mid tide currents fast through the spillway and around the borrow pit, but now calm over the borrow pit itself

Plate 8. Extent of later stages of a spring high tide showing the high marsh areas which are covered least often

Plate 9. Bank-full situation showing waves breaking on front wall and wave refraction through the spillway

Plate 10. Low water at the east end of the site, showing the high water mark on eastern wall. Note tide marker post in the foreground

Plate 11. Erosion of the eastern wall

Plate 12. High tide at the east end of the site showing seepage through the eastern wall