3 Coastal Monitoring

The legislation under which the Council, as a coast protection authority operates, is the Coast Protection Act, 1949. This Act in effect gives the Council powers to construct defences to protect against coastal erosion should it see fit, but it does not confer a duty on it to do so.

Should the Council choose to promote a scheme it then has to make a robust case to the Department for Environment Food and Rural Affairs (DEFRA) who assess it technically, environmentally and especially economically to deem whether it is acceptable and worthwhile to receive public funding.

Available public monies are invariably exceeded by demand, so once the case for a particular project has been made a system of prioritisation is then introduced to rank eligible schemes for a particular financial years' funding. It is important therefore that when the Council submits a scheme for grant aid, every item of information that strengthens the case is included with the submission. Such information gained through monitoring is therefore paramount at this stage as it can show ongoing losses through erosion and be used to demonstrate future damage if the works do not go ahead. Priorities can then be set for each site ranking erosion rates with financial and social damages against the cost of carrying out the works.

At the turn of the last century the early days of coastal construction saw rapid development of many coastal frontages. At that time the lack of design guidance and knowledge of coastal processes led to the spread of massive masonry or concrete seawalls. Little if any thought was given to how they impacted upon the frontage as a whole or how well they would perform in the long term. Later as experience in the design of reinforced concrete structures grew, these earlier designs gave rise to poorly constructed lightweight structures that now require regular costly maintenance works. It is only quite recently with the development of monitoring techniques that feedback has enabled better informed decision-making.

Failure of private defences at Ulrome, spring 2004

In defending a coastline a structure will to some extent impact upon the natural flow or supply of sand and so affect the local coastal processes in some way. These changes tend to be greatest immediately following the construction of the defences, particularly if they contain an element of beach control, such as a groyne field. Such schemes initially raise beach levels as sand is retained opposite the defences; this then creates a corresponding reduction in supply to the south. This will be a relatively temporary interruption however lasting perhaps as little as a few months to a year, as once the groyne field is filled sand will overtop and bypass the defences restoring supply to the south. In the longer term there will be a gradual reorientation in the coastline as raised beach levels progress northwards, and a slight drop in sand supply south as the protection given to the cliffs will reduce the amount of sediment released through erosion. Monitoring the surrounding beaches and adjacent cliff lines both before and after the defences are constructed, can assist in determining the extent and nature of these changes. Ultimately the degree to which this becomes a problem will depend upon the magnitude of the impact and the sensitivity of the area particularly down drift to short-term changes in sediment supply.

For a defence scheme to succeed it is important therefore to first gain a thorough understanding of the areas ongoing coastal processes. This can be done through the use of physical or theoretical modelling techniques and desk top studies, but the best results come from sites where regular monitoring surveys have first been carried out. Site-specific data of this kind provides real first hand evidence, allowing direct interpretation or the fine-tuning of model studies. With this knowledge schemes can be tailored to work within the natural system, using it to advantage where beach control is required or by reducing unwanted impacts further afield. In this way it should then be possible to get the best financial, social and engineering benefit from the new defences.

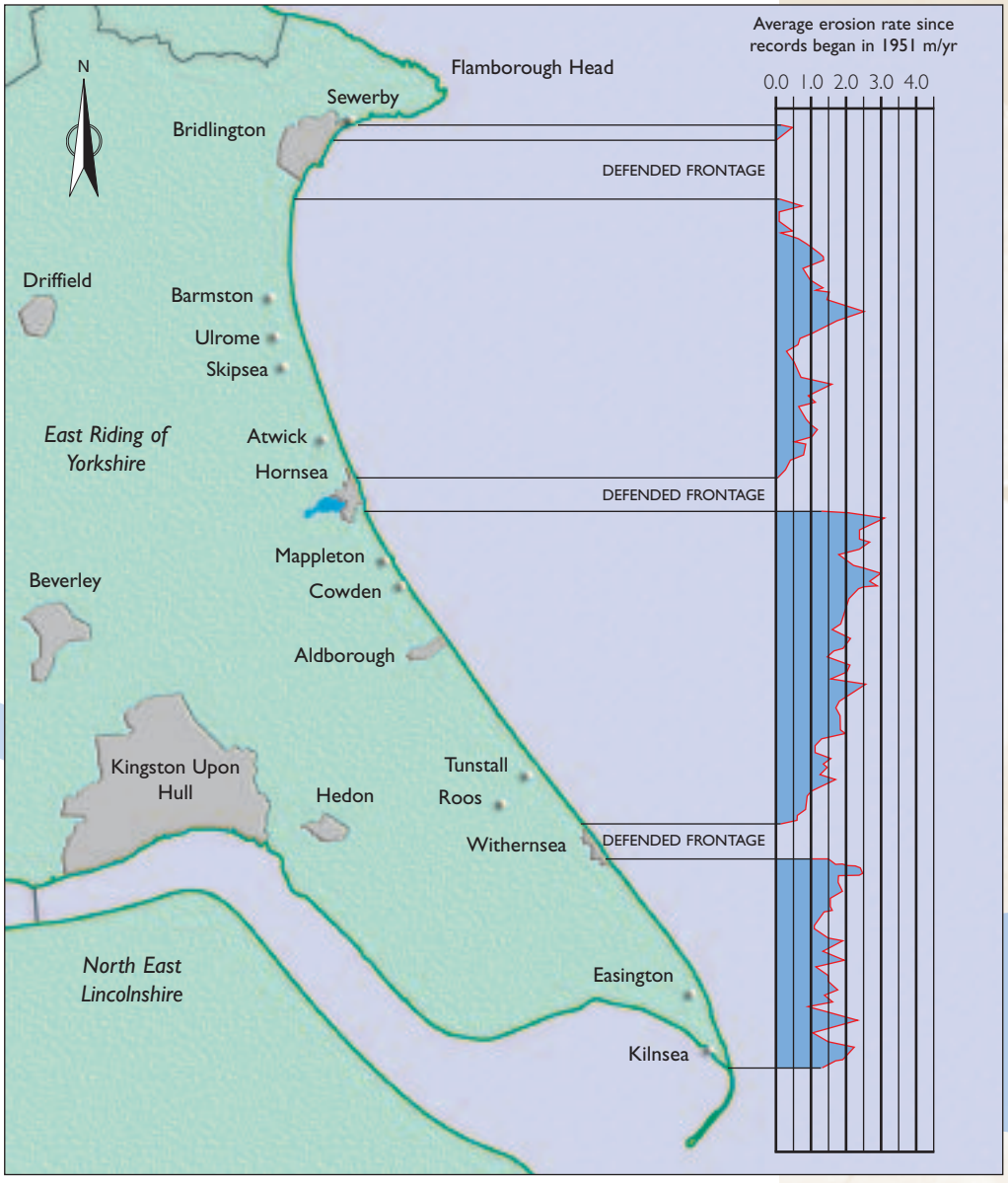
South Beach, Hornsea

Development of Monitoring Programme

With the growing awareness of the sensitivity of the coastline to outside interference, the value of coastal monitoring is now well recognised with many coastal authorities and independent bodies employing a variety of techniques to survey their frontages.

Monitoring of the East Riding coastline began in 1951 with the establishment of over one hundred cliff erosion monitoring posts. These posts are used to measure distances to the cliff edge on a regular basis, thus building up a record of erosion. Up until then there were no accurate figures for erosion rates, estimates could only be made using old maps or rather dubious anecdotal evidence. With the establishment of these posts, annual measurements could be taken at key locations down the coast. Over the years as this data set increases annual variances that can give inaccurate short-term erosion rates are averaged and eventually converge towards a more reliable annual value. Summaries of these figures are contained within Section 6.

Sea conditions and the sediment available control the natural erosion rate down the coastline and without further interference this erosion would tend towards a constant average value for all locations. This steady state is however further controlled by natural and man made obstructions and changes in the orientation of the coastline. Prior to man's intervention, the shelter given by Flamborough Head reduced erosion in its lee to near zero, southwards erosion steadily increased reaching approximately 1.5m/yr at Hornsea and a maximum of about 1.8m/yr at Easington. This simple system has however been complicated by the construction of the numerous defended frontages, which in holding on to sand tend to protect cliffs to the north creating the saw tooth pattern in erosion as shown on the diagram opposite. From the post data it can be seen that wide variations in erosion rates now exist with this being particularly evident across defended frontages.



Recent cliff erosion rates from East Riding of Yorkshire Council erosion post data

Beach Monitoring

Mappleton

Historically the East Riding of Yorkshire coastal defences relied upon massive seawalls fronted by groynes, with each working almost independently. Seawalls were made strong enough to withstand sea conditions but little thought was given to how they would work together with the groynes in controlling beach levels. Beach level information was used to establish groyne profiles and foundation details, but once in place no further beach profile data was taken.

This situation changed with the construction of the Mappleton defences in 1991. This scheme was designed to work in conjunction with the beach, using it to dissipate wave energy naturally on the foreshore, thus removing the need to build a massive onshore structure. Beach levels were therefore vital in its design and to its long-term success, so a programme of beach monitoring was begun. Initially beach level data was used to determine construction details and then later to access the effectiveness of the defences in controlling beach levels. Beach profiles were taken down to low water at eight key locations, one either side of the groynes and then at centres to the north and south. When drawn together these profiles demonstrated the steady build up and ongoing retention of sand opposite the defences.

Easington

The next big step in the collection of beach data came with the proposed Easington defences. This project aimed to defend a kilometre of coastline opposite the Easington Gas Terminals, a site bounded on both sides by sites of special scientific interest (SSSI). Disturbance to these sites had to be minimised so the defences were designed to offer as little interference to the flow of sand as possible. With no form of beach control such as groynes, the defences hug the base of the cliff preventing further erosion without attempting to build beach levels. In this way sand should continue to move past, and cliffs erode on either side as before. To confirm this and to aid in the design of any mitigation works if beach levels were seen to change, an extensive 25-year programme of monitoring works was initiated. This work was based upon the collection of beach profile data from cliff top to mean low water at 75 locations between Withernsea and Spurn Point every six months.

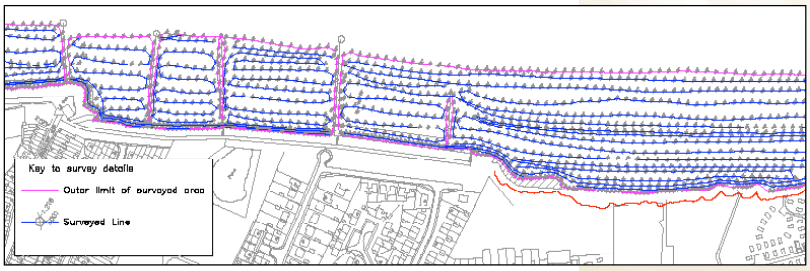
Without recent advances in surveying techniques it would have been impractical to carry out such a large survey, the man-hours involved would span several weeks making it too costly to justify. However with the advent of electronic distance measuring devises and more recently with the development of global positioning satellite systems (GPS) it has become possible to rapidly survey large areas with remarkable accuracy.

Once again the results from the survey work have been able to confirm that the defences are performing as they should, a judgement it would have been almost impossible to make with any certainty without the evidence provided by the monitoring programme.

Initially the Easington survey work stuck rigidly to the requirements of the monitoring programme in that section lines were surveyed at discrete centres with no further data being taken between them. Obviously any feature that developed between the profiles would be missed. To improve the quality of the survey work, use was soon made of the GPS's ability to automatically record data on a grid basis. With repeated passes this process builds up an accurate picture of the beach as a whole. When entered into a computer the information can be used to create a permanent 3 dimensional digital model of the beach. Analysis of this model through the production of contoured maps means that features that may have been missed or impossible to trace between profiles can now be readily identified. An additional feature that now becomes possible is the ability to compare two separate surveys and display only the changes in level that have occurred. A contoured map of these results then identifies where sand has moved between surveys. Long term or seasonal changes as well as the rapid changes in beach profile that occur following a storm can now be displayed and quantified as never before.

Monitoring information of this kind is useful as it can be used to determine in fine detail how well each element of a defence is performing. It is now possible for example, to fine-tune a groyne field so that each groyne has its optimal spacing, alignment, length and profile. Weak points in need of upgrading are also highlighted, with the same data being used at the design stage to determine the most effective solution to the problem.

Typical beach monitoring results - South Withernsea area



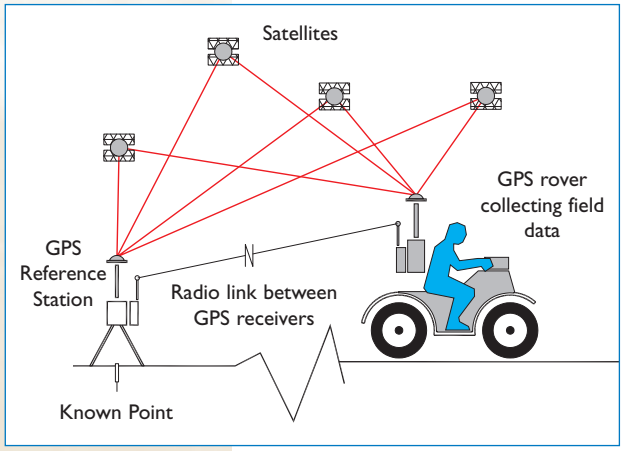
Beach survey results June 2003

Ground model created from survey data

Beach level contours June 2003

Changes in beach level: November 2002 to June 2003

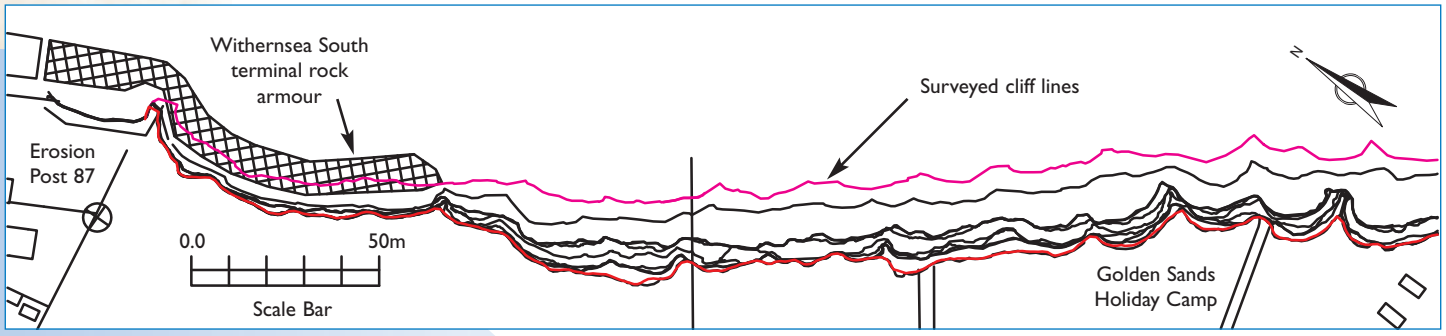
GPS Surveying



GPS survey systems work by first calculating the exact distance between the receiver and each of the visible satellites. With three or more such measurements its then possible for it to fix its position in all three dimensions. A single such receiver has an accuracy of within a few metres, however this can be improved upon with the use of a second receiver. When positioned over a known point this second receiver provides corrections, via a radio link, that enable the moving receiver to calculate its true position to within a few centimetres.

Known as differential GPS this method of surveying has revolutionised the techniques used in beach monitoring, and opened up a whole new range of possibilities.

Even the simple cliff post measurements have now been made obsolete through the use of GPS equipment. Rather than relying upon single point measurements, the surveyor, whilst carrying the GPS receiver, now walks the entire cliff line automatically recording its position as he travels. A full uninterrupted record of the cliff line is then made, with successive surveys this slowly builds up a comprehensive picture of cliff erosion. Currently the entire glacial cliff top from Sewerby to Spurn is being surveyed every 6 months.

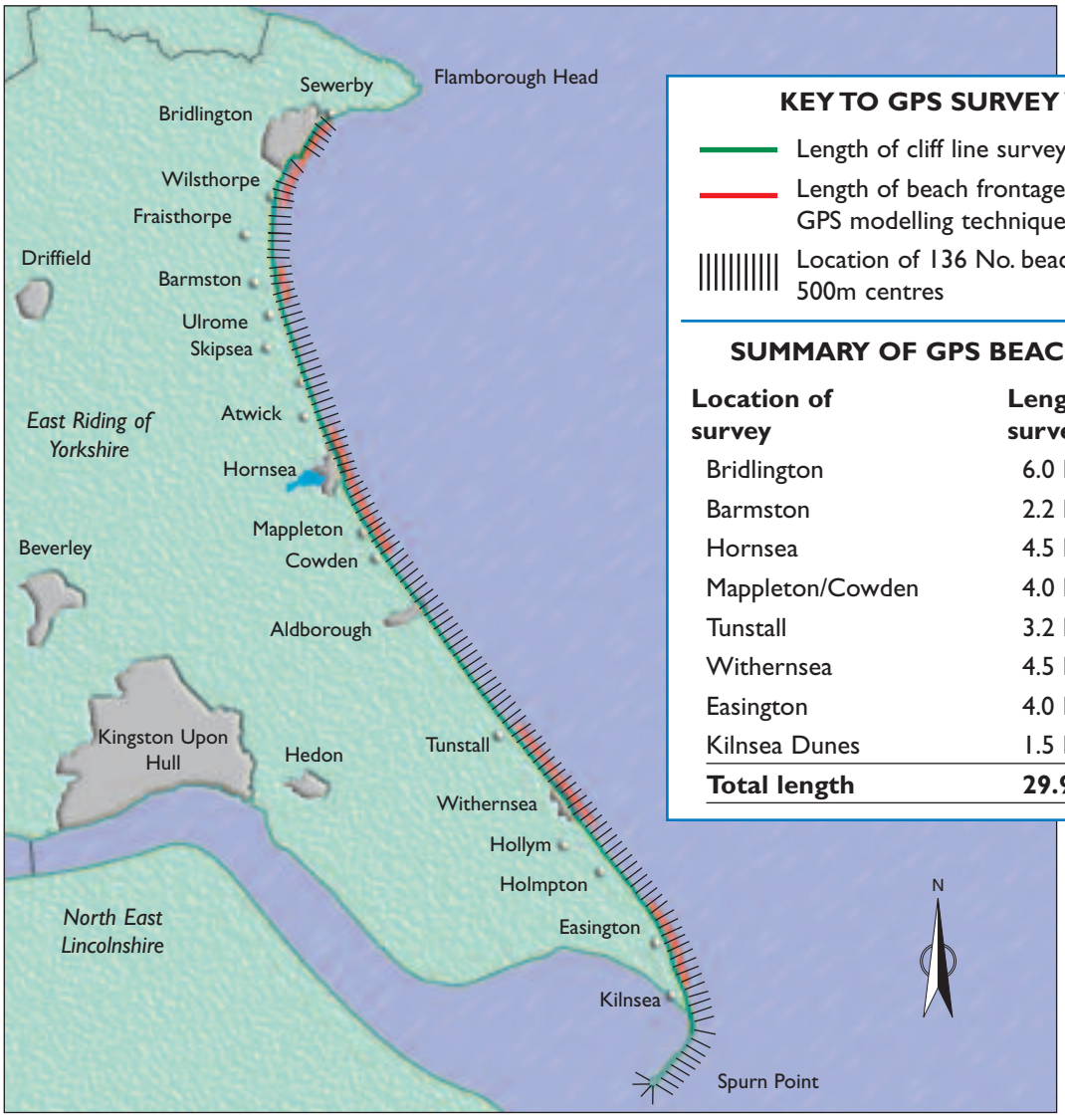


GPS Cliff monitoring south of Withernsea

GPS Monitoring

With the experience gained from carrying out the Easington beach monitoring surveys and the proven usefulness of the results produced, beach monitoring has since gradually spread to other frontages. All of the East Riding of Yorkshire's defended frontages are now surveyed using GPS modelling techniques on a six monthly basis.

To complete the picture the authority now also uses the GPS equipment to record beach profiles at 500m centres along the entire coastline, this fills in the gaps for frontages outside those covered by the detailed modelling work. With this data it is now possible to fully describe cliff erosion, sand movements and beach condition along the whole of the East Riding coastline.

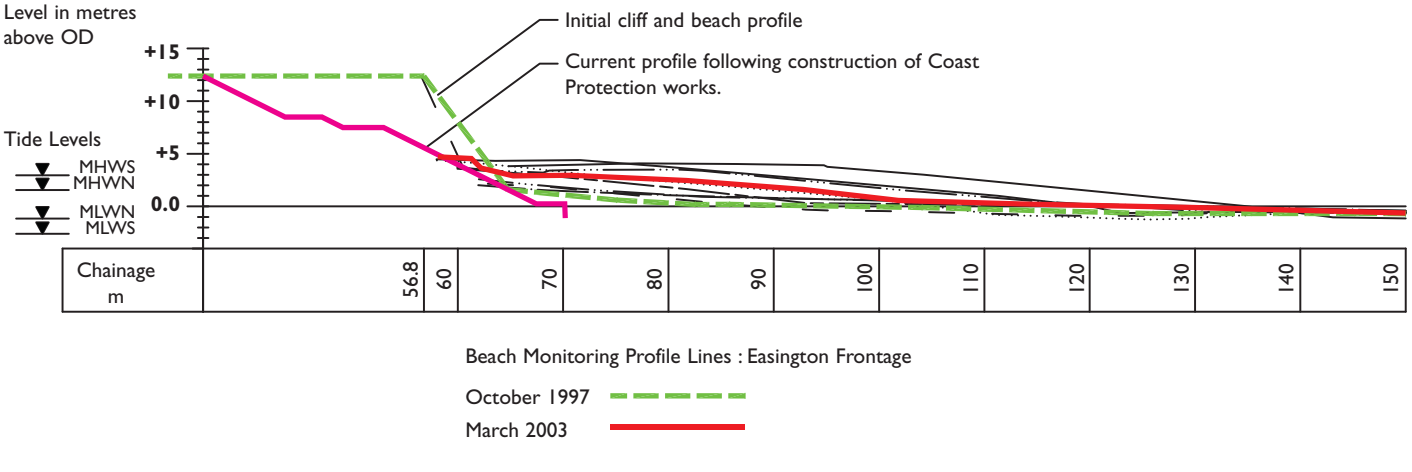


KEY TO GPS SURVEY WORK

- Length of cliff line surveyed using GPS
- Length of beach frontage surveyed using GPS modelling techniques
- Location of 136 No. beach profiles at 500m centres

SUMMARY OF GPS BEACH SURVEY

Location of survey	Length of frontage surveyed
Bridlington	6.0 Km
Barmston	2.2 Km
Hornsea	4.5 Km
Mappleton/Cowden	4.0 Km
Tunstall	3.2 Km
Withernsea	4.5 Km
Easington	4.0 Km
Kilnsea Dunes	1.5 Km
Total length	**29.9 Km**



Typical Beach Profile