Scarborough Borough Council

Strategic Coastal Monitoring Programme
2001 – 2006

Condition Analysis of Coast Protection Assets, Cliffs and Beaches from Staithes to Speeton

July 2005

Halcrow Group Limited

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Executive Summary

This document forms reports on the annual strategic monitoring survey of cliff activity, coastal defence asset condition and beach levels undertaken for the North Yorkshire coastline (from Staithes to Speeton) in May to June 2005.

Scarborough Borough Council (Scarborough BC) commissioned Halcrow to complete the following activities:

Task	Objective
A visual inspection of coastal assets along the Borough's coastline.	To complete the 2005 survey of assets, and to assess and report on their condition and to compare with previous surveys.
Complete a visual inspection of 270 cliff frontages across the Borough.	Re-classify cliff type / activity and record and compare with previous assessments.
Analyse collected beach survey data for a number of locations throughout the Borough.	Identify changes in beach volume when compared with previous analyses.

The cliff units have been classified as being dormant, inactive, locally active, partly active or totally active. The distribution of cliff activity classifications for both the 2005 and 2002 surveys shows that cliffs were and remain predominantly classified as locally active. This suggests that shallow, small scale cliff failures are common along the whole coastline. Between 2002 and 2005, the number of partly active cliffs has increased slightly, while the number of totally active cliffs has decreased. This pattern suggests on-going episodic failure of cliffs through landsliding in a small number of cliffs. Part of the 2002 survey was undertaken using a different classification scheme, and consequently some of the minor changes may not be significant.

The condition of coastal defence assets has been classified using standard Environment Agency / Defra guidelines. The data from the analysis of coastal defence assets shows that the majority of structures are in a moderate to good condition, with many examples of newly built structures, such as those protecting

the Castle Headland, e.g. the Harbour at Scarborough. Important exceptions to this general observation (i.e. where the general condition is noted as poor), are at the coastal defences located in:

- Staithes Harbour, where some harbour walls are in poor condition;

- Runswick Bay;

- Sandsend;

- Whitby, West Cliff where coastal defences need attention;

- The beach access at Cayton Bay;

- Filey Sailing Club frontage;

- Martin's Gill, Filey

Some elements have been assessed as poor, but omitted from this summary as their condition does not affect the overall Coast Protection offered by the particular asset, i.e. lower level steps in poor condition.

The data from the beach surveys shows that the beach levels have fluctuated with periods of **erosion** and **accretion** throughout the study period. However, the defended North and South Bays have experienced a net gain of material, whilst the beaches at Cayton and Whitby (the former being predominately undefended) have experienced a net loss of sediment. As such, the nature of change along the North Yorkshire coastline is not uniform. Whilst this could be attributed to the presence of defences and beach profiling, analysis of further data will be required to confirm this. Other factors contributing towards change may include the nature of wave attack, stability of backing cliffs and geographical characteristics of the locality.

Following this study it is recommended that annual inspections of the cliffs, coastal assets and beach levels, should be continued. Regular surveys are important when identifying continued 'hotspots' of activity along the coastline and in managing the projected impacts of climate change, including sea-level rise and seasonal increases in rainfall.

With respect to the cliff condition survey, it is also recommended that the council consider collecting vertical aerial imagery and LiDAR on a regular basis. This data would be used to make very accurate measurements of coastal change and to precisely monitor the impacts of climate change. This data could also be used to monitor beach levels along the whole North Yorkshire coastline, and would be particularly useful at areas where access is difficult.

1 Introduction

1.1 *Scope of Work*

The following extract is taken from the study brief which describes the scope and need for asset surveys.

"Scarborough Borough Council's strategic coastal monitoring programme (2001 – 2006) extends along the length of its North Yorkshire coast from Staithes in the north to Speeton in the south, a distance of approximately 68 km. Coastal settlements include Staithes, Runswick Bay, Sandsend, Whitby, Robin Hoods Bay, Scarborough, and Filey: all of which have defended frontages.

The Council's strategic coastal monitoring programme aims to rationalize and provide synergy with the recommended coastal monitoring as set out in The Huntcliffe to Flamborough Head Shoreline Management Plan (Sub cell 1d) 1997, and the subsequent strategy studies.

The present coastal defence policies within the Shoreline Management Plan are developed on the basis of information available at that time. During the development of the Shoreline Management Plan it became evident that an extensive monitoring programme was needed before there can be confidence in the ability to predict the long-term evolution of the North Yorkshire Coastline.

The current five yearly strategic coastal monitoring programme recommendations include studies for monitoring of both the built and natural coastal defences and assessing the changes. The findings of the study will also be used to inform the Shoreline Management Plan review process (SMP2) for sub-cells 1b, 1c and 1d which is due to commence in 2004."

Halcrow was commissioned in late 2004 to undertake:

- Beach analysis;
- Coastal Asset Condition Survey; and
- Cliff Inspection.

The work was deliberately and prudently delayed at Halcrow's request, to allow the surveys to be completed in months with more hours of daylight. The beach analysis work was completed ahead of this timeframe to allow Scarborough Borough Council to use the results for beach management purposes, and also to comply with its commitments to DEFRA regarding its monitoring.

The results of the surveys have been entered into the Terra Firma *KeyShore* database, which was specifically purchased by Halcrow for use on this project. The database will be transferred to Scarborough Borough Council when all information has been up-loaded to Terra Firma's central database.

Following the Introduction, the report is separated into the following sections: Section 2 reports upon the Cliff Condition Assessment carried out in Summer 2005; section 3 details the Coast Protection Asset Survey, and the Analysis of Beach Surveys is presented in section 4.

2 Cliff Condition Assessment

2.1 *Introduction*

This section of the report documents the condition of coastal cliffs from Staithes to Speeton in North Yorkshire. Cliffs have previously been mapped and classified according to their behaviour by both Halcrow and High Point Rendel. Detailed descriptions of the cliff units in Filey and Cayton Bays, (from Speeton to Cornelian Bay) are presented in Halcrow 2001a & b, and these reports provide a baseline description of cliff activity which uses a five category classification of activity. The cliffs from South Bay, Scarborough northwards to Staithes are described by High Point Rendel (2002). This report uses a different system of defining cliff type to that employed by Halcrow's earlier study, where cliff activity is described using a ten category classification. In 2002, Halcrow conducted a further cliff condition assessment for Filey and Cayton Bays, which compared cliff activity to the baseline of 2001. This report included the first description of cliff type and activity between Cornelian Bay and South Bay, Scarborough. The details of these reports are summarised in Table 2.1.

Table 2.1 Details of past and present cliff assessment reports

Title	Date	Consultant	Extent
Filey Bay Strategy Study	2001	Halcrow	Speeton to Filey Brigg
Cayton Bay Strategy Study	2001	Halcrow	Filey Brigg to Cornelian Bay
Strategic coastal monitoring, Staithes to Scarborough	2002	High-Point Rendel	South Bay, Scarborough to Staithes
Filey and Cayton Bay cliff inspection and condition assessment	2002	Halcrow	Speeton to South Bay, Scarborough
Strategic coastal monitoring, Staithes to Speeton	2005	Halcrow	Speeton to Staithes

The aim of the current work can be summarised as follows:

- conduct a walk-over survey and provide a cliff condition assessment for the whole coastline of North Yorkshire for May 2005;
- enter the results of the inspection into the Council's *KeyShore* database;

- harmonise the different methods of defining cliff activity used in various past cliff assessment studies. Following discussion with Scarborough Council the five category system employed by Halcrow (2002) has been adopted;
- compare data to identify hotspots, or areas of dynamic change; and
- provide an update on the various assets at risk from coastal recession.

Information on the geology of the cliffs is provided in the Council's *KeyShore* database. Further information is provided in previous reports by Halcrow and High Point Rendel and also in geological field guides by Rawson and Wright (2000) and Eccleston and Eccleston (1998). The geological maps covering the study area are the Whitby and Scalby map (sheets 35 and 44, British Geological Survey 1881) and the Scarborough Map (Sheet 54, British Geological Survey 1998). The important industrial archaeology of this coastline is described in Goldring (2001) and Eccleston and Eccleston (1998). Many of these artefacts are at risk, to varying degrees, from coastal **erosion** and are only recently being fully described and documented.

2.2 Methodology

2.2.1 *Walk-over survey*

A cliff condition assessment was undertaken by a systemic walk-over survey of the whole coastline from Staithes to Speeton. Inspection was primarily conducted from the cliff-top, which is followed for much of the coastline by the Cleveland Way permitting ready access. Where the Cleveland Way moved inland the inspection kept to the cliff edge to ensure the whole coastline was observed. The beach and foreshore were inspected where there was safe access from the cliff top. However, in most cases the cliff face and beach could be satisfactorily inspected from the cliff edge. In the future, inspection from a boat could be considered where the cliff face or beach cannot be observed from the cliff top.

During the walk-over survey, cliff units previously classified were re-assessed, photographed and their activity noted. Base-mapping was also checked for accuracy and any significant changes in the cliff form, due to land sliding, were noted. Cliff activity was classified into five classes described in Table 2.2.

2.2.2 *Data harmonisation*

As highlighted above, the cliff activity classes used in previous inspection reports have been different. It is therefore necessary to harmonise the past and present data so that trends or hotspots can be identified. A reinterpretation of the cliff

activity status assigned in the High Point Rendel report on the coastline between Staithes and Scarborough (2002) has been undertaken by a process of grouping, so that the ten original activity classes have been reduced to five. Caution is required when comparing activity of the cliffs between 2002 and 2005 in areas initially mapped by High Point Rendel, due to this grouping exercise. Details of the past and present classes of cliff activity are presented in Table 2.3.

Table 2.2 Cliff activity classes used in the May 2005 assessment

Activity class	Description
Totally active	Retreating cliffline almost entirely affected by large-scale landsliding or intense **erosion**
Partly active	Retreating cliffline with very common smaller-scale landslides or areas of intense **erosion**
Locally active	Retreating cliffline with localised small landslides or areas of **erosion**
Inactive	Relict cliffs or landslides with vegetated slopes and localised **erosion** of the toe or failure of the headscarp
Dormant	Protected cliffline or landslide complex with no visible evidence of landslide activity.

To avoid confusion, the unique cliff coding systems employed by High Point Rendel (2002) and Halcrow (2002) have been preserved. Therefore, in the region from Staithes to Scarborough South Bay, cliffs are coded as follows:

4/1 – i.e. Coastal Management Unit 4, Cliff Unit 1

While those in the region from Scarborough South Bay to Speeton are coded:

24A/AB – i.e. Coastal Management Unit 24A, Cliff Unit AB

All the cliff units, coastal defence structures and beaches documented in this report lie in coastal sediment cell 1, covered in the Huntcliffe to Flamborough Head Shoreline Management Plan (Mouchel, 1997).

2.3 *Cliff activity and assessment of change*

The cliff activity observed during the walkover survey of May to June 2005 is shown in Figures 2.1 to 2.18. These diagrams show the cliff activity colour coded

using the same methodology as presented previously in Halcrow (2002). Key observations made at each management unit are summarised below and full data on each cliff unit is provided in the *KeyShore* database. Reference is also made to the changes in cliff activity observed between 2002 and 2005. In these figures, dashed coloured lines show cliff units with no change in activity and solid colours indicate units with a change in activity. Colours indicate the nature of the changes in activity. Particular attention is drawn to cliff units where the activity status recorded in 2002, is different to those in 2005. Caution is required when interpreting change in cliff condition for areas first mapped by High Point Rendel, due to the different methods of activity classification.

Table 2.3 Cliff activity classes used in past cliff activity assessments

Activity class	Halcrow (2001)	High Point Rendel (2002)
5. Totally active	Very active	10. Retreating cliffline affected by widespread active landslide features 9. Retreating cliffline with numerous active relatively small-scale or common large-scale landslide features affecting the cliff top
4. Partly active	Active	8. Retreating cliffline with common active relatively small-scale or occasional large-scale landslide features affecting the cliff-top 7. Retreating cliffline with occasional active relative small-scale landslide features affecting the cliff top
3. Locally active	Marginally stable	6. Retreating cliffline with rare active relative small-scale landslide features affecting the cliff top 5. Historical and relict landslide complexes and undercliffs affected by active sea cliff retreat and occasional small-scale landslide activity on the rear cliff
2. Inactive	Inactive	4. Historical and relict landslide complexes and undercliffs affected by active sea cliff retreat and rare small-scale landslide activity on the rear cliff 3. Protected cliffline affected by occasional small-scale rock fall or landslide activity, with potential for rare large-scale slope movements
1. Dormant	Dormant (defended)	2. Protected cliffline affected by occasional small-scale rock fall or landslide activity 1. Protected cliffline with no visible evidence of rock fall or landslide activity

2.3.1 *Management Unit 4 – Staithes*

This unit comprises a series of rock cliffs that are retreating through undercutting and rock-falls from the face (Figure 2.1). Most of this frontage is currently partly active, with common cliff failures and an absence of vegetation on the cliff faces and little or no development of talus slopes.

Activity rates appear to have increased at the cliff top in the area of the harbour from dormant to locally or partly active. The cliff toe is defended at this location, halting cliff toe **erosion**. Therefore, the suggested increase in activity probably reflects localised cliff-top failures as the cliff stabilises.

2.3.2 *Management Unit 5 – Jet Wyke*

This management unit comprises a single vertical rock cliff unit which is partly active (Figure 2.1). Failures are typically through rock falls and debris slides of till from the cliff top.

No change in activity is identified between the two mapping surveys.

2.3.3 *Management Unit 6 – Port Mulgrave*

This management unit includes the bay of Port Mulgrave and the cliffs to the south as far as Runswick Bay (Figure 2.1 and Figure 2.2). The cliffs are locally or partly active with active cliff faces failing through rock falls and common debris slides from the till-capped cliff tops. Management Unit 6/3 is protected from inshore waves by the derelict harbour piers of Port Mulgrave, but has locally active slopes.

The cliff condition in this Management Unit remained locally or partly active between 2002 and 2005.

2.3.4 *Management Unit 7 – Runswick Bay*

The management unit is restricted to Runswick Bay and is characterised by till cliffs punctuated by a series of streams (Figure 2.2). MU7/1 includes the village of Runswick Bay, old sea walls and a series of relict landslides. The village has been protected by a Coastal Defence Scheme, which has stabilised the slopes. Other units in the bay are locally active due to small-scale failures in the till cliffs.

There has been no increase in cliff activity in this management unit.

2.3.5 *Management Unit 8 – Kettleness*

This extensive unit includes the promontory of Kettleness and surrounding cliffs as far south as Sandsend (Figure 2.2, Figure 2.3 and Figure 2.4). Kettleness itself is heavily modified by alum quarrying and the remaining cliffs (MU 8/3 and 8/4) are bare of vegetation and include numerous, locally significant debris slides. The cliffs north of Sandsend (MU 8/13, 8/14, 8/15) are also dominated by the effects of the alum industry and exhibit a range of failures in natural slopes of till and artificial slopes in quarry spoil. All of the cliffs affected by alum works are classified as being partly active. Other cliffs in this unit are not affected by the alum works and are almost vertical rock slopes with localised failures; these cliffs are classified as being locally active.

There has been a variable change in activity along this Management Unit, with continued partly active cliff units at Kettleness headland and slight increases in activity to the east of the headland. Cliff units 8/3, 8/14 and 8/15 have become less active, from totally to partly active.

2.3.6 *Management Unit 9 – Sandsend*

Management Unit 9 comprises two cliff units which make up the defended frontage of the village of Sandsend (9/1 and 9/2) and a further undefended cliff which is comprised of till (9/3), shown on Figure 2.4. The coastline is punctuated by two streams that flow through valleys cut into glacial sediments. The defended cliffs (9/1 and 9/2) are classified as being dormant, while the undefended cliff is partly active with numerous mudslides (9/3).

The key change in this management unit is the activation of unit 9/3 from inactive to partly active. Activity is related to landslides in the coastal slopes inland of the road. These cliffs are currently being investigated by North Yorkshire County Council as part of the Whitby Coastal Defence Strategy.

2.3.7 *Management Unit 10 – Upgang Beach*

This management unit comprises a series of partly active mudslide embayments cut into till cliffs (Figure 2.4). The cliff top was once traversed by a railway line abandoned in 1965, the route of which has now been lost to landsliding.

Cliffs in this management unit have reduced in activity between 2002 and 2005.

2.3.8 *Management Unit 11 – Whitby*

This management unit includes the cliffs west of Whitby harbour which comprise regraded till slopes and a single rock cliff, which is also locally defended (Figure 2.4 and Figure 2.5). Despite the defences, the cliffs are classed as being locally active, with each unit having evidence of shallow movements. There is also evidence of settlement in the promenade and sea-wall in MU11/2, which may date from the time of initial construction. Installation of monitoring pins should be considered at this location.

The cliffs were classed as dormant in 2002 suggesting there has been an increase in activity since this time. This apparent change may be a factor of two classification schemes being used, or due to different assessments made by different observers. These changes require review and confirmation at the next inspection survey.

2.3.9 *Management Unit 12 – Whitby Abbey*

This management unit comprises locally active rock cliffs to the east of Whitby harbour (Figure 2.5). Unit 12/1 is protected from the sea by the harbour and coast defence, but degradation has still occurred, with localised failures from the headscarp. Unit 12/2 is not defended by the Whitby coastal protection works, and is actively retreating through toe **erosion** and undercutting. Recent failures of the cliff top have led to the loss of a section of the cliff top path. There is also concern over the future of the coast guard look-out and TV transmitter aerial.

The cliffs were previously classed as dormant or inactive but now show signs of local failures, suggesting some increase in cliff activity.

2.3.10 *Management Unit 13 – Saltwick*

The management unit comprises the cliff line from Whitby Abbey to the lighthouse at Whitestone Point and includes Saltwick and Black Nabs which are former alum quarries (Figure 2.5 and Figure 2.6). Much of the management unit is partly active with extensive undercutting of the cliffs and on-going degradation of the former quarries. The quarry at Black Nab is the exception, being locally active.

Cliffs in this management unit have maintained or reduced activity levels.

2.3.11 *Management Unit 14 – Widdy Head*

This management unit comprises a single rock cliff unit which is locally active, with failures through headscarp recession and toe undercutting (Figure 2.6). The

cliff was previously classified as being partly active, suggesting a reduction in activity.

2.3.12 *Management Unit 15 – Rain Dale*

The management unit includes cliffs from Hawkser to the northern side of Robin Hood's Bay, which are formed of rock with a variable thickness till cap (Figure 2.6 and Figure 2.7). Cliff Unit 15/1 is locally active, 15/2 is totally active due to a very extensive series of mudslides and rock falls, and units 15/3 and 15/4 are partly active.

This management unit has predominantly maintained partial or low activity levels or reduced in activity. Cliff unit 15/2 is of concern having become totally active.

2.3.13 *Management Unit 16 – Robin Hood's Bay north*

The management unit includes the cliffs of Robin Hood's Bay village, which include rock cliffs with a till cap and an inactive landslide system (Figure 2.7 and Figure 2.8). Unit 16/1 is a partly active rock cliff with numerous rock falls and mudslides. Unit 16/2 is a protected, dormant landslide complex and unit 16/2 is a protected, dormant rock cliff. These cliffs have not changed their activity levels since 2002. Coast protection and cliff stabilisation systems were installed approximately ten years ago to cliff units 16/2 and 16/3.

2.3.14 *Management Unit 17 – Robin Hood's Bay south*

This unit includes the cliffs from the village of Robin Hood's Bay to the headland of Peak Steel at Ravenscar (Figure 2.8 and Figure 2.9). Cliffs are formed of rock with a capping of till and are locally to partly active. Cliff failure is through basal undercutting and failures of till from the cliff top.

The majority of these cliffs have not changed their activity levels, although unit 17/1 has become partly active from dormant, and unit 17/6 has become more stable, moving from partly to locally active.

2.3.15 *Management Unit 18 – Ravenscar*

This management unit includes the coast line from Peak Steel to Petard Point and includes a series of cliffs with undercliff complexes (Figure 2.9 and Figure 2.10). From the cliff top the undercliffs have the appearance of large, deep-seated landslides, but inspection of the cliff faces at the shoreline and of the benches in the undercliff, shows that the configuration of the cliffs is not the result of landsliding. Instead, it is likely that the undercliffs are the result of extensive rock

fall activity, from a series of susceptible strata. The cliffs are all locally active, with on-going failures of the back scarp, the scarps fronting benches and of the sea cliffs.

The complex cliffs maintained a low level of activity. Cliff classifications have occasionally changed from inactive to locally active, but this is probably related to differences in approaches used in the 2002 and 2005 studies.

2.3.16 *Management Unit 19 – Hayburn Wyke to Scalby Ness*

This management unit includes a variety of different cliff types including undercliffs, and till-capped rock cliffs (Figure 2.10, Figure 2.11 and Figure 2.12). Activity is predominantly localised, but an active mudslide complex was observed at Hayburn Wyke (unit 19/2), at Cloughton Wyke (19/5) and north of Scalby (19/9 and 19/10), where there are numerous active mudslides. The instability at Cloughton Wyke has destroyed the cliff-top footpath, leading to a temporary path diversion. Activity in this management unit has generally maintained low to moderate levels, or in places activity has reduced. Unit 19/3 is suggested to have increased to a state of local activity. The on-going Scalby Ness Strategy Study covers the section of Management Unit 19/11 crossed by the Scalby Beck and not the coastal frontage of this unit.

2.3.17 *Management Unit 20 – Scarborough North Bay*

Scarborough's North Bay is defended by a continuous sea wall that protects till cliffs in the north and a high rock cliff at the south (Figure 2.12 and Figure 2.13). The protected till cliffs in the north (20/1 20/2 and 20/3) are dormant and no sign of activity was observed. Defences at the toe of the rock and till cliffs to the south (Unit 20/4) prohibit undercutting, but the cliff faces and till slopes are locally active, with much evidence of movement in the till slopes and rock falls from the vertical cliffs. These failures have led to closure and redirection of footpaths which cross the slope in this region. These cliff units have maintained a low level of localised activity since 2002. The management of these cliff units is covered by the Scarborough Coastal Protection Strategy.

2.3.18 *Management Unit 21 – Scarborough Castle*

The castle headland is protected by the Marine Drive coastal defence works which have stopped toe **erosion**. The recently constructed defences protect and secure the lower part of the cliff (Figure 2.13). Failure of the cliff face and cliff top is on-going due to rock fall activity.

The increased activity of cliffs at Scarborough Castle is not thought to be significant and, probably relates to the different survey methods used in previous assessments (see section 2.2.2). The management of these cliff units is covered by the Scarborough Coastal Protection Strategy.

2.3.19 *Management Unit 22 – Scarborough South Bay*

The cliffs of Scarborough's south bay are formed from till which has been prone to landsliding (Figure 2.13 and Figure 2.14). All of the cliffs in this unit have toe protection, but localised activity on the slopes and headscarps is common. The graded slope of the Holbeck Hall landslide (22/8) is particularly hummocky, with evidence of compression and extension within the slope. Current activity on these cliffs is shallow and does not appear to be related to deep-seated landslide movements.

Many of these cliffs have an increased level of activity. However, this is not thought to be significant and is possibly a function of the different survey methods used in previous assessments (see section 2.2.2).

2.3.20 *Management Unit 23 - White Nab*

Management Unit 23 marks the beginning of the section of coastline previously monitored by Halcrow in 2002. Cliff unit classifications from this Management Unit, south to Reighton, use the cliff codes previously assigned by Halcrow, as discussed in section 2.2.2.

Management Unit 23 is characterised by degraded composite and ancient complex landslide systems, generally with localised activity, but with significant areas of partial and total activity around White Nab (Units 23/D1, 23/D2, 23/D3, 23/E and 23/F) and at the toe of large mudslides on Frank Cliff (23/H1, 23/H2 and 23/H3). Cliff Units are shown on Figure 2.14.

There is a high degree of increased activity in this management unit, particularly around White Nab and Frank Cliff where a number of recent landslides were seen, especially at Units 23/H1, 23/H2 and 23/H3. These failures are generally at the cliff toe and do not immediately threaten the cliff top assets at Knipe Point.

2.3.21 *Management Unit 24 - Cayton Bay*

This unit contains large-scale, ancient landslide systems at Cayton Cliff (Unit 24a/A) and Tenants Cliff (24a/B), with smaller simple cliffs and simple landslides further south (Figure 2.14). Units are dominantly classified as inactive or locally

active, although there is an area of partially active cliffs at Killerby Cliffs (Figure 2.15).

The majority of cliff units have not changed their activity levels since 2002. Exceptions are at the toe of the Cayton landslide where one unit at the landslide toe has become partially active (24a/A1). This increased activity does not currently threaten the properties at Knipe Point. Landslides at Killerby Cliffs also have increased activity (24b/L, 24b/M, 24b/N and 24b/O), although no cliff top properties are affected.

The National Trust has landholding interests in this area, specifically the area from Knipe Point to the boundary of Tenants Cliff fields with the A165. No change was seen at the top of the Cayton Bay landslide complex adjacent to the A165.

2.3.22 *Management Unit 25 - Gristhorpe Cliff*

This unit is dominated by high Upper Jurassic cliffs capped by a thin veneer of till (Figure 2.15). The majority of units are locally active where the till has slumped. Areas of greater activity are found at unit's 25/Y, 25/X, 25/AA and 25/AB. Of these, only unit X was partially active in 2002, suggesting an increased amount of activity. Other units have maintained low or partial levels of activity.

2.3.23 *Management Unit 26 - North Cliff*

This unit is characterised by high Upper Jurassic cliffs with a thin veneer of till (Figure 2.16). The majority of units have localised activity associated with slumping of the till and rock falls from the cliffs. Landslides in unit 26/AJ and 26/AK is partly active, which has caused the collapse of the cliff-top footpath, and a large topple of rock from the cliffs was observed on cliff unit 26/AQ.

With the exception of unit 26/AK, which has become partly active, other units have maintained low or partial levels of activity.

2.3.24 *Management Unit 27 - Filey Brigg*

Management Unit 27 is one of the most active in the study area, with widespread mudsliding and gully formation associated with failure of the thick till capping of Filey Brigg (Figure 2.16). Gully processes associated with the thick till cap mean much of the south side of the Brigg is partially or totally active. Cliff units on the north side of the Brigg are generally less active, being predominantly locally or partially active.

Levels of activity on the Brigg have not changed substantially since 2002, with the persistence of partial or total levels of activity in most units. A number of units on the south side of the Brigg have reduced in activity a little, moving from total to partial activity, while a single unit on the north side (27/BA) has changed from locally to totally active. This increase in activity threatens the coastal path and it is recommended that cliff activity on Filey Brigg is regularly monitored.

2.3.25 *Management Unit 28 - Filey*

This unit covers Filey town and the frontage is protected by a sea wall (Figure 2.16 and 2.17). In contrast, many of the unprotected cliffs north of the town's defences are more active, with areas of totally, partly and locally active cliffs. Key active cliffs are 28/M and 28/N. Activity is generally highest to the north, nearer the Brigg. The coastal slopes behind Filey Town are dormant with no indication of current activity.

Generally, cliffs in this management unit have diminished in activity since 2002, with only Cliff Unit 28/N increasing in activity. This increase in activity does not threaten any assets. Cliffs adjacent to Coble landing have generally diminished in activity or maintained localised activity.

2.3.26 *Management Unit 29 - Flat Cliffs*

The unit comprises a series of low till cliffs and landslides (Figure 2.17). Those in the north are all locally active, with **erosion** of sea cliffs and small mudslides. Units to the south, around Hunmanby Gap, are partially or totally active, 29C/BB to 29C/BH). No recent activity was observed at the Hamlet of Flat Cliffs, although a number of localised defences have been built by residents to protect the cliff toe. The effectiveness of these structures in terms of coast protection and or cliff stability appears to be very limited.

There is little change in cliff activity in this management unit. Some cliffs have become more stable around Primrose Valley and there is very little change around Flat Cliffs. The area to the south of Hunmanby Gap is an area of increasing activity. No early warning system has been introduced as of yet, however, one is recommended.

2.3.27 *Management Unit 30 – Reighton*

There is a series of landslides within the northwest section, with more stable cliffs to the southeast (Figure 2.18). Cliffs were predominantly rated partly or totally active, with mudslides and retreating headscarps especially active in Unit 30/CC.

The cliffs are partly or locally active, with common mudslides from the Speeton Clay and overlying tills.

The pattern of change in this management unit indicates a general increase in the amount of cliff activity, especially around the Reighton Sands holiday park.

2.4 *Assets at risk*

The assets in each cliff behaviour unit that are at risk are highlighted in Table 2.4. Assets identified include transport infrastructure, properties and other buildings or engineered structures. Public footpaths, National Trust land and Sites of Special Scientific Interest (SSSI) are also identified. Areas designated as SSSI typically include the foreshore, cliff face and cliff top. Instances where only the foreshore is designated are noted.

Table 2.4 – Summary of Assets at Risk

CBU	Location	Activity status	Assets at risk
4/1	Staithes, Cowbar Nab	Partly active	Properties, access road, cliff top path, National Trust land, west harbour pier
4/2	Staithes	Locally active	Cleveland Way, agricultural land, east harbour pier, Site of Special Scientific Interest (SSSI)
4/3	Staithes	Partly active	Cleveland Way, agricultural land, SSSI
5/1	Staithes	Partly active	Cleveland Way, agricultural land, SSSI
6/1	Brackenberry Wyke	Locally active	Cleveland Way, agricultural land, SSSI
6/2	Twixt Hills	Partly active	Cleveland Way, agricultural and National Trust (NT) land, SSSI
6/3	Port Mulgrave	Locally active	Cleveland Way, properties, harbour and mining archaeology, cliff top path, agricultural and NT land, SSSI
6/4	Rosedale Cliffs	Locally active	Cleveland Way, properties, agricultural and NT land
6/5	Rosedale Cliffs	Locally active	Cleveland Way, agricultural land
6/6	High Lingrow	Partly active	Cleveland Way, agricultural land, SSSI
6/7	Wrack Hills	Locally active	Cleveland Way, agricultural and NT land, SSSI
6/8	Caldron Cliff	Locally active	Cleveland Way, agricultural land
7/1	Runswick Bay	Inactive	Cleveland Way, village infrastructure and properties
7/2	Nettle Dale	Locally active	Cleveland Way, forested land
7/3	Dother Pits	Locally active	Cleveland Way, forested land

CBU	Location	Activity status	Assets at risk
7/4	Hob Holes	Locally active	Cleveland Way, sailing club, forested land
8/1	Whitestones Cliff	Locally active	Cleveland Way, agricultural land
8/2	Catbeck Hill	Locally active	Cleveland Way, agricultural land
8/3	Kettleness	Partly active	Cleveland Way, properties, industrial archaeology
8/4	Kettleness	Partly active	Cleveland Way, agricultural land, industrial archaeology
8/5	Kettleness	Partly active	Cleveland Way, agricultural land, industrial archaeology
8/6	Maiden Wyke	Locally active	Cleveland Way, agricultural land
8/7	Seaveybog Hill	Locally active	Cleveland Way, agricultural land
8/8	Ovalgate Cliff	Locally active	Cleveland Way, agricultural land
8/9	Loop Wkye	Partly active	Cleveland Way, agricultural land
8/10	Tellgreen Hill	Locally active	Cleveland Way, agricultural land
8/11	Keldhowe Steel	Locally active	Cleveland Way, agricultural land, industrial archaeology
8/12	Oversadle Wyke	Locally active	Cleveland Way, agricultural land
8/13	Stonecliff End	Partly active	Cleveland Way, agricultural land
8/14	Sandsend Alum Quarry	Partly active	Cleveland Way, agricultural land, industrial archaeology
8/15	Sandsend Alum Quarry	Partly active	Cleveland Way, agricultural land, industrial archaeology
9/1	Sandsend	Dormant	Village infrastructure and A174, properties, coastal defences
9/2	Sandsend	Dormant	Village infrastructure and A174, properties, coastal defences
9/3	Raven Hill	Partly active	A174 , Cleveland Way
9/4	Raven Hill	Partly active	A174, Cleveland Way
10/1	Upgang Beach	Partly active	A174, Cleveland Way, golf course
10/2	Upgang Beach	Partly active	Golf course
11/1	Whitby West Cliff	Locally active	Town infrastructure, properties
11/2	Whitby West Cliff	Locally active	Town infrastructure, properties
11/3	Whitby West Cliff	Locally active	Town infrastructure, properties, Spa Pavilion
11/4	Whitby West Cliff	Locally active	Town infrastructure, properties
12/1	Whitby Abbey Plain	Locally active	Town infrastructure, properties (Henrietta St), St Mary's Church
12/2	Whitby Abbey Plain	Locally active	Infrastructure (Abbey Road), CG lookout, mast, SSSI

CBU	Location	Activity status	Assets at risk
13/1	Whitby East Cliff	Partly active	Cleveland Way, agricultural land, SSSI
13/2	Saltwick Nab	Partly active	Cleveland Way, agricultural and NT land, industrial archaeology, SSSI
13/3	Saltwick Bay	Partly active	Cleveland Way, agricultural land, SSSI
13/4	Saltwick Bay	Partly active	Cleveland Way, agricultural land
13/5	Black Nab	Locally active	Cleveland Way, agricultural land
13/6	South Batts	Partly active	Properties, Cleveland Way, agricultural land
14/1	Widdy Head	Locally active	Cleveland Way, agricultural land, SSSI
15/1	Hawkser	Locally active	Cleveland Way, agricultural land, SSSI
15/2	Raindale	Totally active	Cleveland Way, agricultural and NT land, SSSI
15/3	Bay Ness	Partly active	Cleveland Way, agricultural and NT land, SSSI
15/4	Green Hills	Partly active	Cleveland Way, agricultural and NT land, SSSI
16/1	Robin Hood's Bay	Partly active	Village infrastructure, properties, Cleveland Way, SSSI
16/2	Robin Hood's Bay	Dormant	Village infrastructure, properties, Cleveland Way, SSSI
16/3	Robin Hood's Bay	Dormant	Village infrastructure, properties, coastal defences, Cleveland Way, SSSI
17/1	Robin Hood's Bay	Partly active	Village infrastructure, properties, Cleveland Way, agricultural land, SSSI
17/2	Robin Hood's Bay	Partly active	Cleveland Way, agricultural land, SSSI (on foreshore)
17/3	Robin Hood's Bay	Partly active	Cleveland Way, agricultural and NT land, SSSI (on foreshore)
17/4	Strickland Dump	Partly active	Cleveland Way, agricultural and NT land, SSSI
17/5	Stoupe Beck Sands	Partly active	Property, Cleveland Way, agricultural land, SSSI
17/6	High Scar	Locally active	Cleveland Way, agricultural land, industrial archaeology, SSSI
17/7	Peak Alum works	Partly active	Cleveland Way, agricultural land, industrial archaeology, SSSI
17/8	Wine Haven	Partly active	Agricultural land, SSSI
17/9	Wine Haven	Partly active	Agricultural and National Trust land, SSSI
18/1	Ravenscar	Locally active	Village infrastructure and properties, Cleveland Way, agricultural and NT land, SSSI
18/2	Ravenscar, Fox Cliff	Locally active	Village infrastructure and properties, Cleveland Way, agricultural and NT land, SSSI

CBU	Location	Activity status	Assets at risk
18/3	Ravenscar, Common Cliff	Locally active	CG lookout, Cleveland Way, agricultural land, SSSI
18/4	Petard Point	Locally active	Cleveland Way, agricultural land, SSSI
19/1	Herbert Hole	Locally active	Cleveland Way, agricultural land
19/2	Hayburn Wyke	Partly active	Cleveland Way and beach access path, agricultural land, SSSI
19/3	Little Cliff	Locally active	Cleveland Way, agricultural land, SSSI
19/4	Sycarham Wood	Locally active	Cleveland Way, agricultural land, SSSI
19/5	Cloughton Wyke	Partly active	Cleveland Way, agricultural land, SSSI
19/6	Hundale Point	Locally active	Cleveland Way, agricultural land, SSSI
19/7	Creek Point	Locally active	Cleveland Way, agricultural land, SSSI
19/8	Crook Ness	Locally active	Cleveland Way, agricultural land, SSSI
19/9	Scalby Ness sands	Partly active	Cleveland Way, agricultural land, SSSI
19/10	Scalby Ness	Partly active	Cleveland Way, agricultural land, SSSI
19/11	Scalby Ness, Long Nab	Locally active	Cleveland Way, agricultural land, SSSI
20/1	Scalby, Sea Life Centre	Dormant	Town infrastructure, Sea Life Centre
20/2	Scarborough North Bay	Dormant	Town infrastructure and properties
20/3	Scarborough North Bay	Dormant	Town infrastructure and properties
20/4	Scarborough, N. Sands	Locally active	Town infrastructure and properties, SSSI
21/1	Scarborough, N. Sands	Locally active	Town infrastructure, castle and coastal defences, SSSI
21/2	Castle Hill	Locally active	Town infrastructure, castle and coastal defences, SSSI
22/1	St Nicholas Cliff	Inactive	Town infrastructure and properties
22/2	South Cliff	Locally active	Town infrastructure, properties, Spa Complex
22/3	South Cliff	Locally active	Town infrastructure and properties, SSSI (on foreshore)
22/4	South Cliff	Locally active	Town infrastructure and properties, SSSI (on foreshore)
22/5	South Cliff Gardens	Locally active	Town infrastructure and properties, SSSI (on foreshore)
22/6	South Cliff Gardens	Locally active	Town infrastructure, properties, Cleveland Way, SSSI (on foreshore)
22/7	Holbeck Gardens	Locally active	Town infrastructure, properties, Cleveland Way, SSSI (on foreshore)
22/8	Holbeck Ravine	Locally active	Town infrastructure, properties, Cleveland Way, SSSI (on foreshore)

CBU	Location	Activity status	Assets at risk
23-A	Black Rocks	Locally active	Cleveland Way, carpark, SSSI
23-B	Black Rocks	Partly active	Cleveland Way, SSSI
23-C	Black Rocks	Locally active	Cleveland Way, SSSI
23-D1	Wheatcroft Cliff	Partly active	Cleveland Way, golf course, SSSI
23-D2	Wheatcroft Cliff	Partly active	Cleveland Way, golf course, SSSI
23-D3	Wheatcroft Cliff	Partly active	SSSI
23-E	Raven Scar	Partly active	Cleveland Way, golf course, SSSI
23-F	Frank Cliff	Partly active	Cleveland Way, beach access path, defences for drainage pipe, SSSI
23-G1	Frank Cliff	Totally active	Waste water pumping station, Cleveland Way, beach access path, SSSI
23-G2	Frank Cliff	Locally active	Cleveland Way, SSSI
23-H	Frank Cliff	Locally active	Cleveland Way, SSSI
23-H1	Frank Cliff	Totally active	SSSI
23-H2	Frank Cliff	Totally active	SSSI
23-H3	Frank Cliff	Totally active	SSSI
23-I	Cornelian Bay	Locally active	Properties at Knipe Point, Cleveland Way, NT land, SSSI
23-I1	Cornelian Bay	Partly active	NT land, SSSI
23-I2	Cornelian Bay	Partly active	NT land, SSSI
23-I3	Cornelian Bay	Partly active	NT land, SSSI
23-I4	Cornelian Bay	Partly active	NT land, SSSI
23-J	Cornelian Bay	Locally active	NT land, pill box, SSSI
24A-A	Cayton Cliff	Locally active	Cleveland Way and beach access path, property at Knipe Point, National Trust land, SSSI
24A-A1	Cayton Cliff	Partly active	Cleveland Way, beach access path, NT land, SSSI
24A-A2	Cayton Cliff	Locally active	Cleveland Way, beach access path, NT land, SSSI
24A-A3	Cayton Cliff	Locally active	Cleveland Way, beach access path, NT land, SSSI
24A-A4	Cayton Cliff	Locally active	Beach access path, NT land, SSSI
24A-A5	Cayton Cliff	Locally active	Beach access path, NT land, SSSI
24A-A6	Cayton Cliff	Locally active	Beach access path, NT land, SSSI
24A-A7	Osgodby Point	Locally active	NT land, SSSI
24A-A8	Osgodby Point	Locally active	NT land, SSSI
24A-B	Tenants' Cliff	Inactive	A165 and footpath, Pumping station and access road, coastal cliff protection, NT land, SSSI
24A-B1	Tenants' Cliff	Locally active	NT land, SSSI
24A-B2	Tenants' Cliff	Locally active	NT land, SSSI

CBU	Location	Activity status	Assets at risk
24A-B3	Tenants' Cliff	Locally active	NT land, SSSI
24A-B4	Tenants' Cliff	Locally active	NT land, SSSI
24A-B5	Tenants' Cliff	Locally active	NT land, SSSI
24A-B6	Tenants' Cliff	Locally active	NT land, SSSI
24A-B7	Tenants' Cliff	Locally active	NT land, SSSI
24A-B8	Tenants' Cliff	Locally active	NT land, SSSI
24A-B9	Tenants' Cliff	Locally active	Outflanking of coastal protection at the disused pumping station (currently private property) , SSSI
24A-B10	Tenants' Cliff	Inactive	Cliff protection measures, property, access road, SSSI
24B-C	Cayton Sands	Locally active	Cleveland Way, access road to property, SSSI
24B-D	Cayton Sands	Locally active	Cleveland Way, access road, SSSI
24B-E	Cayton Sands	Locally active	Cliff-top property, agricultural land, Cleveland Way, SSSI
24B-F	Cayton Sands	Locally active	Cliff-top property, agricultural land, Cleveland Way, SSSI
24B-G	Cayton Sands	Locally active	Cleveland Way, agricultural land, SSSI
24B-H	Cayton Sands	Locally active	Cleveland Way and beach access path, cliff-top property and access road, drainage pipes, agricultural land, underground services, SSSI
24B-I	Killerby Cliff	Locally active	Cleveland Way footpath, SSSI
24B-J	Killerby Cliff	Locally active	Cliff-top property, Cleveland Way, SSSI
24B-K	Killerby Cliff	Locally active	Cliff-top property, Cleveland Way, agricultural land, SSSI
24B-L	Killerby Cliff	Partly active	Cleveland Way, agricultural land, SSSI
24B-M	Killerby Cliff	Partly active	Cleveland Way, agricultural land, SSSI
24B-N	Killerby Cliff	Partly active	Cleveland Way, agricultural land, SSSI
24B-O	Killerby Cliff	Partly active	Cleveland Way, agricultural land, SSSI
24B-P	Killerby Cliff	Locally active	Cleveland Way, agricultural land, SSSI
24B-Q	Killerby Cliff	Locally active	Cleveland Way, agricultural land, SSSI
24B-R	Killerby Cliff	Locally active	Cleveland Way, agricultural land, SSSI
24B-S	Killerby Cliff	Locally active	Cleveland Way, agricultural land, SSSI
25-T	High Red Cliff	Locally active	Cleveland Way, agricultural land, SSSI
25-U	High Red Cliff	Locally active	Cleveland Way, agricultural land, SSSI
25-V	High Red Cliff	Partly active	Cleveland Way, agricultural land, SSSI
25-W	Lebberston Cliff	Locally active	Cleveland Way, agricultural land, SSSI
25-X	Lebberston Cliff	Partly active	Cleveland Way, agricultural land, SSSI

CBU	Location	Activity status	Assets at risk
25-Y	Yons Hill	Locally active	Cleveland Way, agricultural land, SSSI
25-Z	Three Nabs	Locally active	Cleveland Way, agricultural land, SSSI (on foreshore)
25-AA	Gristhorpe Sands	Partly active	Cleveland Way, agricultural land, caravan park, SSSI (on foreshore)
25-AB	Gristhorpe Sands	Partly active	Cleveland Way, caravan park, SSSI (on foreshore)
25-AC	Gristhorpe Cliff	Locally active	Cleveland Way, caravan park, SSSI (on foreshore)
25-AD	Gristhorpe Cliff	Locally active	Cleveland Way, caravan park
25-AE	Cunstone Nab	Locally active	Cleveland Way, caravan park
25-AF	Cunstone Nab	Locally active	Cleveland Way, caravan park
26-AG	Cunstone Nab	Locally active	Cleveland Way, agricultural land, caravan park
26-AH	The Wyke	Locally active	Cleveland Way, agricultural land
26-AI	The Wyke	Locally active	Cleveland Way, agricultural land
26-AJ	The Wyke	Partly active	Cleveland Way, agricultural land
26-AK	Newbiggin Cliff	Partly active	Cleveland Way, agricultural land
26-AL	Newbiggin Cliff	Locally active	Cleveland Way, agricultural land
26-AM	Newbiggin Cliff	Locally active	Cleveland Way, agricultural land
26-AN	Newbiggin Cliff	Locally active	Cleveland Way, agricultural land
26-AO	Newbiggin Cliff	Locally active	Cleveland Way, agricultural land
26-AP	Newbiggin Cliff	Locally active	Cleveland Way, agricultural land
26-AQ	Brewster Hole	Partly active	Cleveland Way, agricultural land
26-AR	North Cliff	Locally active	Cleveland Way, agricultural land
26-AS	North Cliff	Locally active	Cleveland Way, agricultural land
26-AT	North Cliff	Locally active	Cleveland Way, agricultural land
26-AU	North Cliff	Locally active	Cleveland Way, agricultural land
26-AV	North Cliff	Locally active	Cleveland Way, agricultural land
26-AW	North Cliff	Locally active	Cleveland Way, agricultural land
26-AX	North Cliff	Locally active	Cleveland Way, agricultural land
27-AY	North Cliff	Locally active	Cleveland Way, agricultural land, SSSI
27-AZ	North Cliff	Locally active	Cleveland Way, agricultural land, SSSI
27-BA	Black Hole	Totally active	Cleveland Way, SSSI
27-BB	Spa Nab	Partly active	Cliff-top footpath, SSSI
27-BC	Spa Nab	Partly active	Cliff-top footpath, SSSI
27-BD	Long Doodle	Partly active	Cliff-top footpath, Roman signal station remains, SSSI
27-BE	Second Doodle	Locally active	Cliff-top footpath, SSSI
27-BF	First Doodle	Locally active	Cliff-top footpath, SSSI

CBU	Location	Activity status	Assets at risk
27-A	Carr Naze	Partly active	Cliff-top footpath, SSSI
27-B	Carr Naze	Partly active	Footpath from cliff-top to Brigg, hut at cliff foot, SSSI
27-C	Carr Naze	Partly active	Footpath from cliff-top to Brigg, hut at cliff foot, SSSI
27-D	Filey Brigg	Totally active	Footpath from cliff-top to the beach, SSSI
27-E	Filey Brigg	Partly active	Footpath from cliff-top to the beach, SSSI
27-F	Filey Brigg	Partly active	Footpath from cliff-top to the beach, SSSI
27-G	Filey Brigg	Locally active	Footpath from cliff-top to the beach, SSSI
27-H	Filey Brigg	Partly active	Footpath from cliff-top to the beach, SSSI
27-I	Filey Brigg	Partly active	Cliff-top footpath, SSSI
27-J	Filey Brigg	Partly active	Cliff-top footpath, SSSI
27-K	Filey Brigg	Partly active	Wolds Way, SSSI
28A-L	Filey Brigg	Totally active	Wolds Way, SSSI
28A-M	Filey Brigg	Totally active	Wolds Way, SSSI
28A-N	Filey Brigg	Totally active	Wolds Way, SSSI
28A-O	Filey Brigg	Partly active	Wolds Way, SSSI
28A-P	Filey Brigg	Partly active	Wolds Way, SSSI
28A-Q	Filey Spa	Partly active	Wolds Way, Filey country park, SSSI
28A-R	Filey Spa	Partly active	Wolds Way, Filey country park
28A-S	Wool Dale	Locally active	Wolds Way, Filey country park
28A-T	Wool Dale	Locally active	Wolds Way, Filey country park sailing club, protection measures
28A-U	Hom Dale	Locally active	Wolds Way, sailing club access road, protection measures
28A-V	Pampletine Cliffs	Partly active	Wolds Way, sailing club access road, protection measures
28A-W	Pampletine Cliffs	Locally active	Wolds Way, beach access from Coble Landing
28A-X	Pampletine Cliffs	Locally active	Wolds Way, town infrastructure and properties, coastal defences, Coble Landing
28B-Y	Filey Town	Dormant	Wolds Way, town infrastructure and properties, coastal defences, Coble Landing
28B-Z	Filey Town	Dormant	Wolds Way, town infrastructure and properties, coastal defences, Coble Landing
29A-AA	Martins Gill	Locally active	Wolds Way, golf course, cliff-toe rock armouring
29A-AB	Muston Sands	Locally active	Cliff-top footpath and golf course
29A-AC	Muston Sands	Locally active	Cliff-top footpath and golf course

CBU	Location	Activity status	Assets at risk
29A-AD	Muston Sands	Locally active	Cliff-top footpath and golf course
29A-AE	Muston Sands	Locally active	Cliff-top footpath and golf course
29A-AF	Muston Sands	Locally active	Cliff-top footpath and golf course
29A-AG	Muston Sands	Locally active	Cliff-top footpath and golf course
29A-AH	Muston Sands	Locally active	Cliff-top footpath and golf course
29A-AI	Muston Sands	Locally active	Beach access road
29B-AJ	Hunmanby Sands	Partly active	Cliff-top properties, beach access road
29B-AK	Hunmanby Sands	Locally active	Cliff-top properties, Primrose Valley holiday park, access road
29B-AL	Hunmanby Sands	Locally active	Primrose Valley holiday park
29B-AM	Hunmanby Sands	Locally active	Primrose Valley holiday park
29B-AN	Hunmanby Sands	Locally active	Primrose Valley holiday park
29B-AO	Hunmanby Sands	Locally active	Primrose Valley holiday park
29B-AP	Hunmanby Sands	Locally active	Primrose Valley holiday park, access road and footpath, abandoned sea defences
29B-AQ	Hunmanby Sands	Locally active	Primrose Valley holiday park footpath, access to Yorkshire Water (YW) pumping station
29B-AR	Flat Cliffs	Locally active	Hamlet infrastructure and properties. Access to YW pumping station, Primrose Valley holiday park
29B-AS	Flat Cliffs	Locally active	Hamlet infrastructure and properties. YW pumping station, Primrose Valley holiday park
29B-AT	Butcher Haven	Locally active	Cliff-top footpath, beach access road
29B-BA	Butcher Haven	Locally active	Cliff-top footpath
29B-BB	Hunmanby Gap	Partly active	Cliff-top footpath, agricultural land
29B-BC	Hunmanby Gap	Partly active	Cliff-top footpath, agricultural land
29B-BD	Hunmanby Gap	Partly active	Cliff-top footpath, agricultural land.
29B-BE	Hunmanby Gap	Locally active	Cliff-top footpath, property, access road, refreshment hut and lavatories, agricultural land
29C-BF	Hunmanby Gap	Totally active	Cliff-top footpath, drainage engineering
29C-BG	Hunmanby Gap	Totally active	Cliff-top footpath
29C-BH	Hunmanby Gap	Totally active	Cliff-top footpath
29C-BI	Hunmanby Gap	Partly active	Cliff-top footpath
29C-BJ	Hunmanby Gap	Partly active	Cliff-top footpath
29C-BK	Hunmanby Gap	Partly active	Cliff-top footpath
29C-BL	Reighton Sands	Locally active	Cliff-top footpath, agricultural land
29C-BM	Reighton Sands	Locally active	Cliff-top footpath, agricultural land

CBU	Location	Activity status	Assets at risk
29C-BN	Reighton Sands	Locally active	Cliff-top footpath, agricultural land
29C-BO	Reighton Sands	Locally active	Cliff-top footpath, agricultural land
29C-BP	Reighton Sands	Locally active	Cliff-top footpath, agricultural land
29C-BQ	Reighton Sands	Locally active	Cliff-top footpath, agricultural land
30A-BR	Boat Cliff	Partly active	Cliff-top properties and footpath, beach access road, pill boxes and abandoned sea defences, agricultural land
30A-BS	Speeton Sands	Partly active	Cliff-top properties and footpath, Reighton holiday park
30A-CA	Speeton Sands, New Closes Cliff	Partly active	Cliff-top properties and footpath, Reighton holiday park
30A-CB	Speeton Sands	Partly active	Cliff-top properties and footpath, Reighton holiday park
30B-CC	Speeton Sands, Middle Cliff	Totally active	Cliff-top footpath, Reighton holiday park, agricultural land
30B-CD	Black Cliff	Locally active	Cliff-top footpath, agricultural land
30B-CE	Black Cliff	Locally active	Cliff-top footpath, agricultural land
30B-CF	Speeton Cliffs	Partly active	Cliff-top footpath, agricultural land
30B-CG	Speeton Cliffs	Partly active	Cliff-top footpath, agricultural land
31A-CH	Speeton Cliffs	Partly active	Cliff-top footpath, agricultural land
31A-CI	Speeton Cliffs	Locally active	Cliff-top footpath, agricultural land
31A-CJ	Speeton Cliffs	Locally active	Cliff-top footpath, agricultural land

3 Coastal Protection Assessment

3.1 Introduction

3.1.1 *Client requirements*

This section of the report describes the asset survey carried by Halcrow for Scarborough BC. An assessment of the coast protection assets was undertaken at the following locations:

- Staithes;
- Runswick Bay;
- Sandsend:
- Whitby;
- Robin Hoods Bay;
- Scarborough;
- Filey;
- and in addition the original commission at Port Mulgrave,
- Gouldsborough;
- and Cayton Bay

A location plan of the sites is in Figure 5.1.

The main requirements are summarised below and were developed from the Scarborough brief and following meetings held with key staff and included for each asset:

(a) Identify for each asset:
- Condition of the foreshore/beach
- Condition of the coastal slopes
- Condition of the coast protection asset
- Residual life of coast protection asset
- Risk to assets protected
- Amendments/variations to the coast protection inventory
- Any defects and description thereof

(b) Photograph any defects and cross reference to inspection details

(c) Cross reference photographs taken of each asset

(d) Categorise each defect according to repair urgency (Low/Medium/High)

(e) Submit the data on an Inspection Report pro-forma

(f) Enter the data into the *KeyShore* database

(g) Assign an inspection number,

3.2 *Evaluation Criteria*

The evaluation criteria have been developed in conjunction with Scarborough Council to ensure a consistent approach with the existing database of coastal defences in the *KeyShore* system. Furthermore, a representative of Scarborough BC accompanied the first asset survey, ensuring that the evaluation criteria were consistently applied in respect to the previous inspections. Table 3.1 below lists the categories used for the asset survey.

Table 3.1. Asset Survey Classifications

Category	Comments	Classification Required
Foreshore Types	The foreshore has been classified into the following preferred categories of Scarborough BC	**Sand** **Clay** **Shingle** **Rock**
Foreshore Condition	The foreshore condition has been divided into four preferred categories given by Scarborough BC	**Good** – even covering of base material **Light scour** – majority of base material present **Heavy scour** – greater then 50 % of base material lost **Poor** – near 100% depletion of base material
Residual Life	The residual life of assets has been assessed using the preferred approach of Scarborough BC, which classifies the remaining residual life into one of 4 bands	**< 1 yr** **1-5 yrs** **6-10 yrs** **10 yrs+**
Asset Condition		**Class 1** – Very Good, Condition as built **Class 2** – Good, Some signs of wear **Class 3** – Fair, Moderate works required **Class 4** – Poor, Significant works needed in 1 – 5 years **Class 5** - Very Poor, Failed
Priority of repair	To assist Scarborough Borough Council	**Low** – Monitor, not significant,

Category	Comments	Classification Required
(Urgency)	in prioritising its ongoing maintenance programme, defects have been divided into three bands as implemented in the *KeyShoreKeyShore* system	inspect annually **Medium** – Urgent, repair should start within 4 to 12 months. **High** – Critical, repair should start within 4 weeks.

3.3 *Assessment Method*

The coastal assets were assessed using walkover surveys and by subsequent desktop analysis with any available data. The first survey was conducted with a representative of Scarborough BC, to ensure that the survey method and applied criteria would yield results that are consistent with previous survey campaigns.

The assessment was carried out between the 11th to 15th of April and on the 26th of April 2005. During the site visit the inspection pro-forma was completed and digital photographs were taken for future referencing. The number of the photographs was immediately noted on the inspection pro-forma.

3.4 *Access Issues*

The surveys were carried out at low water in order to maximise access to the coastal assets. Nevertheless, some assets could not be surveyed fully due to natural environmental or man-made restrictions. Details of these restrictions and where they occurred are noted on the inspection pro-forma and the *KeyShore* database.

3.5 *Condition Assessment*

3.5.1 *CU4 – Staithes*

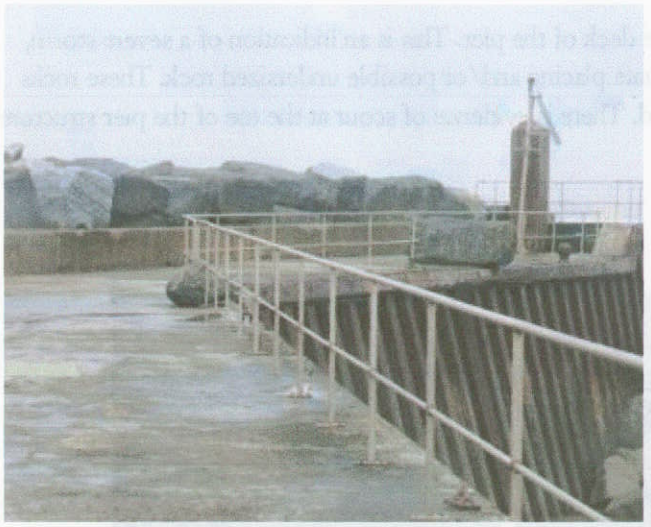
Eight separate frontages have been identified at Staithes. These are described from west to east, starting with the Northern Breakwater. These frontages may have been surveyed before, but these records do not form part of the *KeyShore* database records.

The Northern Breakwater (confusingly located at the West of Staithes) comprises a mass concrete pier structure with rock armour, protecting its seaward face. The seaward part of the pier structure is faced with steel sheet piles. A large proportion of the horizontal and vertical concrete surfaces of the pier are abraded and/or cracked. This situation requires ongoing monitoring. The hand railing is heavily corroded but presently functional. Of concern are the two displaced rocks

currently resting on the deck of the pier. This is an indication of a severe storm, and/or less than adequate placing and/or possible undersized rock. These rocks should be re-positioned. There is evidence of scour at the toe of the pier structure.

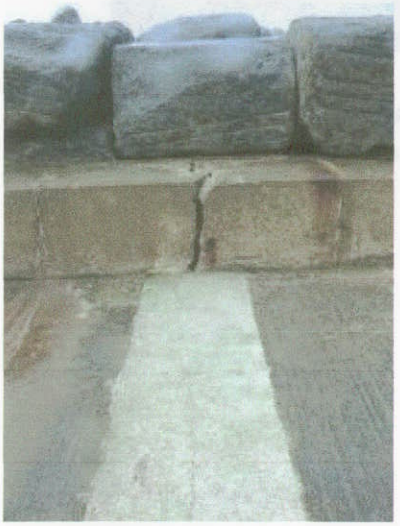
Photograph 3.1 Staithes Northern Breakwater. View at root of seaward revetment

Photograph 3.2 Staithes Northern Breakwater. Slipway to Seaward side



Photograph 3.3 Staithes Northern Breakwater. Displaced rock armour.

Photograph 3.4 Staithes Northern Breakwater. Corroded steel sheet piles



Photograph 3.5 Staithes Northern Breakwater. Abraded and damaged concrete coping

Photograph 3.6 Staithes Northern Breakwater. Abraded vertical surfaces and toe scour

Photograph 3.7 Staithes Northern Breakwater. Steps at root of Northern Breakwater

Moving eastwards, there are the remnants of a concrete promenade or apron. The coping and hand rails remain and are severely undermined. The function of these assets is not known for sure, but they are possibly there to keep people away from the cliff. However, their condition is such that they themselves could potentially present a Health and Safety Hazard. These will continue to deteriorate and should be removed.

Photograph 3.8 Staithes between Northern Breakwater.

Photograph 3.9 Staithes between Northern Breakwater.

There is a RNLI slipway on the right bank of the river as it enters Staithes Harbour. The gabion baskets are in fair condition and should be monitored. Their

function appears to prevent further undermining of the slipway from scour. The concrete of the slipway is abraded.

Photograph 3.10 Staithes RNLI Slipway. Gabion Baskets beneath slipway

Photograph 3.11 Staithes RNLI Slipway. Gabion Baskets beneath slipway

The harbour walls within Staithes Harbour, for which there are assigned frontage numbers, comprise of seawalls, slipways and redundant groynes. The condition of these structures ranges from fair to poor. There are signs of toe scour, walls leaning forward, and bulging failure of the masonry structures.

Frontage 02-04-01 is showing signs of ageing and wear, and is assessed as being in poor condition. There are voids in the masonry wall, and mesh is exposed in various concrete elements. The wall is leaning seaward and there are recently repaired bulges. These require monitoring. The coping is also assessed as being in poor conditions with surface cracks and voids evident.

Photograph 3.12 Staithes 02-04-01.
Poor condition wall, missing blocks etc

Photograph 3.13 Staithes 02-04-01.
Leaning wall with toe scour.

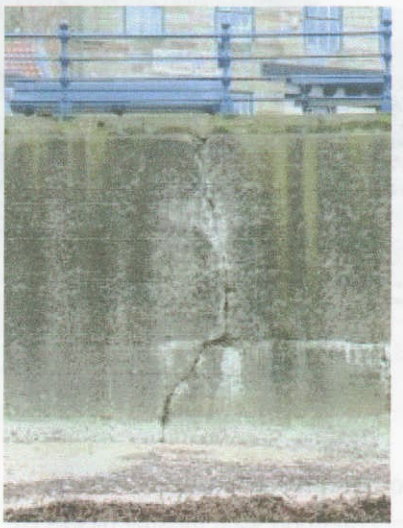
The central section of Staithes includes a slipway. Generally the condition is assessed as poor, with the surface of the slipway being abraded. There are damaged flap valves within the seawall itself. The wall and the coping are cracked and have been repaired. The repairs appear to be failing.

Photograph 3.14 Staithes 03-04-01.
Cod & Lobster Slipway

Photograph 3.15 03-04-01 Staithes.
Damaged flap valves and cracked seawall.

The remainder of the Staithes harbour walls located to the south appear to be in fair to good condition, with only minor signs of defects, such as cracking.

Photograph 3.16 Staithes 04-04-01.
Steps and hand railing



Photograph 3.17 Staithes 04-04-01
Cracked harbour walls.

Continuing eastwards, there is a slipway, a concrete pier structure and the eastern breakwater. The slipway and the concrete pier appear to be in fair condition.

Photograph 3.18 Staithes.
Concrete Pier / groyne at south-eastern corner of harbour.

Photograph 3.19 Staithes
Slipway at SE corner of harbour.

The eastern side of Staithes Harbour is protected by a breakwater. This comprises a concrete pier structure with a rock armour revetment at its seaward (eastern)

side. Generally, this structure is in a good condition. However, there is a set of steps that terminates with a drop of 2 m into ponded water (at low water.) Signage should be considered to warn users. Some of the rocks have been placed in a stacked fashion, but it is unlikely that this will affect the performance of the breakwater. Units 02-04-01, 03-04-01 and 04-04-01 are not currently on the database. However, these have been inspected and the survey sheets appended to this report.

Photograph 3.20 Staithes Eastern Breakwater
Root of rock armour breakwater

Photograph 3.21 Staithes Eastern Breakwater.
Steps on eastern side.

Photograph 3.22 Staithes Eastern Breakwater
Rock armour revetment

Photograph 3.23 Staithes Eastern Breakwater
View on harbour side of concrete pier structure

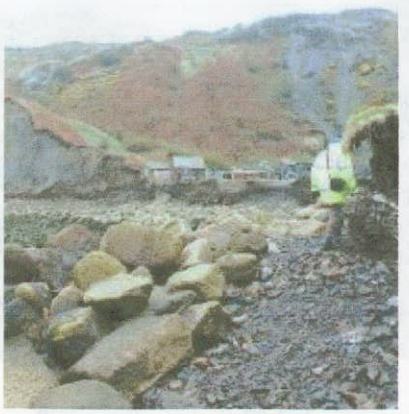
Table 3.2 Summary of Survey Results for CU04 - Staithes Harbour

Defence ID	Residual Life		Condition		Foreshore		Repair required?	Priority	Full Access
	Current	Last Insp.	Current	Last Insp.	Type	Condition			
Northern Breakwater	+ 10 yrs	?	2		Rock	Fair	Yes	Low	No
??	0 yrs	?	5		Shingle	Very Poor	No	Low	Yes
RNLI Slipway	6-10 yrs	?	3		Sand/Shingle	Fair	No	Low	Yes
02-04-01	1-5 yrs	?	3		Sand	Good/Slight Sour	Yes	High	Yes
03-04-01	6-10 yrs	?	3		Sand	Good	Yes	Medium	Yes
04-04-01	+ 10 yrs	?	2		Sand	Good	No	Low	Yes
East Pier	+ 10 yrs	?	2		Rock	Good	Yes	Low	No
East Breakwater	+ 10 yrs	?	2		Rock	Good	No	Low	No

3.5.2 *CU6 – Port Mulgrave*

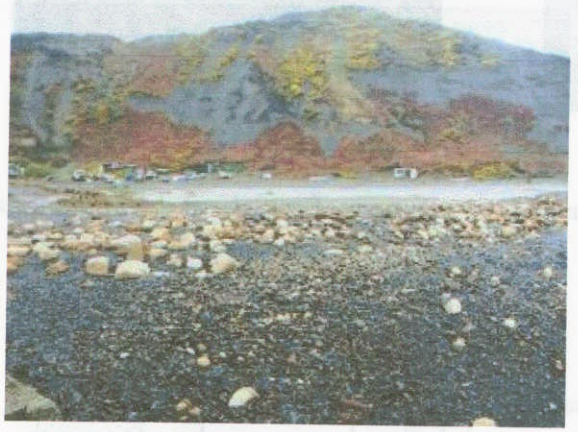
The only man made defences in the coastal unit 6 are the walls of the former Port Mulgrave. The harbour walls are derelict, having been partially destroyed during WW2 and the harbour basin has silted-up. There is no vehicular access to the Port, which can only be reached by a steep footpath from a small road from Rosedale Lane in Hinderwell village.

Photograph 3.24 Port Mulgrave.
Beginning of access path



Photograph 3.25 Port Mulgrave.
Sheds, housing fishing equipment

The coastal slope is locally active in this area and several small surface failures were noted during the site visit. Several small, well maintained fishing boats were landed on top of the filled basin and a few sheds housing fishing equipment, indicating some small-scale fishing activity is still taking place. Some sections of the south breakwater are still standing, but they are potentially unstable. The surface of the south breakwater has collapsed in places. The seaward facing wall of the breakwater articulates and is presently leaning against the remains of the adjacent structure. The end of the south breakwater has collapsed entirely.



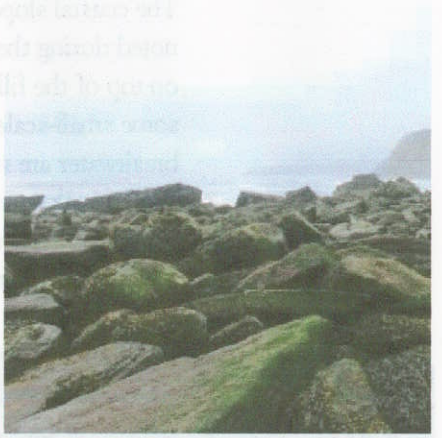
Photograph 3.26 Port Mulgrave.
Harbour basin with boats

Photograph 3.27 Port Mulgrave.
Seaward facing wall of south breakwater

Only remnants indicate the former existences of a north breakwater and rock armour. Broken sections of this structure remain along the frontage.

Photograph 3.28 Port Mulgrave. Collapsed surface of south breakwater

Photograph 3.29 Port Mulgrave.
End of south breakwater and view onto remains of north breakwater



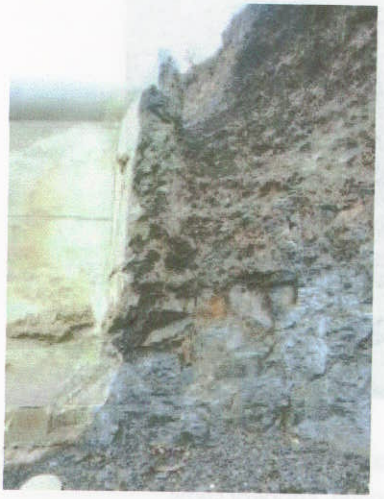
Photograph 3.30 Port Mulgrave.
Remains of north breakwater and rock armour

3.5.3

CU7 – Runswick Bay

The coastal unit 7 encompasses the coastal settlement of Runswick Bay. The defences in the south have been recently built and are in a good condition, with very few minor defects. The defence assets in the north of the coastal unit are in a fair to poor condition, with two assets needing urgent action.

At the northern end of the unit, the asset no 07-07A-01 has failed. Part of the seawall is missing and the frontage is subject to direct wave attack, increasing the risk of outflanking of the defences. The adjacent asset no 07-07A-02 is also in a poor condition, with several patch repairs and an *ad hoc* extension with concrete bag-work forming a protective wall to a private property. The structural integrity and effectiveness of this extension is questionable. The access to the beach is very steep and slippery at this point and may present a hazard to pedestrians. Furthermore, the foundations of the steps leading past the private property onto a path to the main road, are being undermined by a small stream.



Photograph 3.31 Runswick Bay 07-07A-01
Failed seawall section

Photograph 3.32 Runswick Bay 07-07A-02
Patch repairs with ad-hoc extension of wall and access to beach

The apron of the asset no 08-07A-01 has been heavily abraded in places and has also suffered some undermining. This should be repaired now to sustain the life of the structure. The steps to the beach, asset no 08-07A-02, no longer provide safe access, due to them being steep with rounded edges, and the surfaces being covered in algae.

Photograph 3.33 Runswick Bay 08-07A-01.
Damaged apron in front of seawall

Photograph 3.34 Runswick Bay 08-07A-02.
Very rounded, slippery steps

The remaining assets along this unit are in a fair to good condition. The recently built defences are in a good condition. It should be noted, however, that the slope behind these is locally active and should be monitored annually.

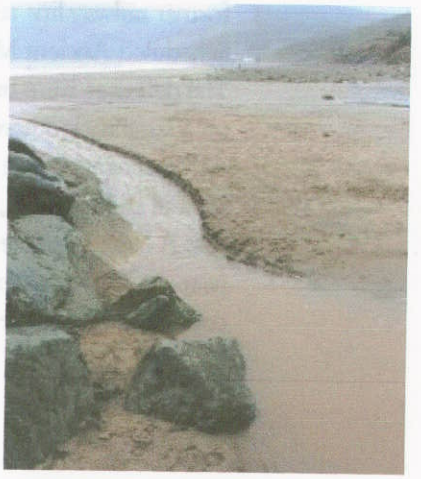
Photograph 3.35 Runswick Bay 08-07A-03.
Small slip onto the upper wall at promenade level.

Photograph 3.36 Runswick Bay 10-07B-02.
Shallow localised slope failure above the rock revetment.

A drain on the landward side of the coastal asset no 10-07B-01 is routed through the rock armour and over the slipway onto the beach. The amount of water

coming from this drain occasionally causes a build-up at the end of the slipway, forming a large stream, reducing the public's ability to access the beach.

Photograph 3.37 Runswick Bay 10-07B-01
Water running through rock armour onto beach



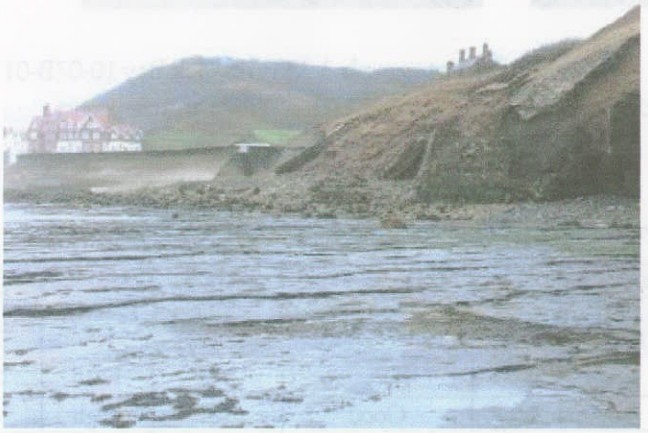
Photograph 3.38 Runswick Bay 10-07B-01
Access to beach – public at times must negotiate the ponded water

Table 3.3 Summary of survey results for CU07 Runswick Bay

Defence ID	Residual Life		Condition		Foreshore		Repair required	Priority	Full Access
	Current	Last Insp.	Current	Last Insp.	Type	Condition			
07-07A-01	<1yr		4		Rock	Light scour	Yes	High	Yes
07-07A-02	<1yr		4		Rock	Good	Yes	High	Yes
07-07A-03	+10yrs		2		Rock	Light scour	Yes	Low	Yes
08-07A-01	6-10yrs		3		Rock	Heavy scour	Yes	Medium	Yes
08-07A-02	1-5yrs		3		Rock	Heavy scour	Yes	Medium	Yes
08-07A-03	+10yrs		2		Rock	Light scour	No	Low	Yes
08-07A-04	+10yrs		2		Rock	Good	No	Low	Yes
08-07A-05	+10yrs		2		Sand	Good	No	Low	Yes
08-07A-06	+10yrs		2		Sand	Good	No	Low	Yes
09-07A-01	+10yrs		2		Sand	Good	Yes	Low	Yes
09-07A-02	+10yrs		2		Sand	Good	No	Low	Yes
10-07A-01	+10yrs		2		Sand	Good	No	Low	Yes
10-07B-01	+10yrs		2		Sand	Good	No	Low	Yes
10-07B-02	+10yrs		2		Sand	Good	No	Low	Yes

3.5.4 *CU8 – Gouldsborough*

The coastal unit 8 continues north from the car park in Sandsend. There are no settlements in the direct vicinity of the defences, although a coastal path and former railway line run along the top of the cliffs. The unit does contain two Scheduled Ancient Monuments, however the policy for this area is "Do Nothing". The defences were built directly in front of the cliffs and the coastal slope founded on a large rock outcrop, which covers the whole area. The defence has failed and only remnants of the original structures remain. There are five sections of the seawall still standing, however even these have been undermined and are hollowed out. A large concrete apron can be found leaning against the slope at beach level near the car park, next to the foundation of a seawall. Only steel and some concrete remains are left indicating the former existence of the second section of seawall.



Photograph 3.39 Gouldsborough 12-08B-01. Concrete base and masonry wall foundations.

Photograph 3.40 Gouldsborough 12-08B-01. Steel and concrete remnants of a wall

The third and fourth sections are still clearly identifiable as a masonry wall, however they have been significantly hollowed out and are undermined. The adjacent cliffs have also been subject to wave attack and several large caves and fissures have formed.

Photograph 3.41 Gouldsborough 12-08B-01
Third remaining section of seawall

Photograph 3.42 Gouldsborough 12-08B-01.
Wash-out behind remnant seawall

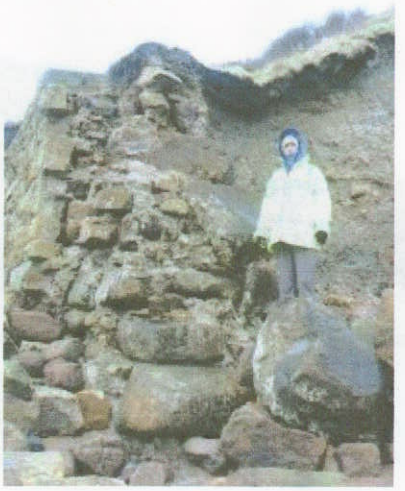
The final section of the remaining sea defences is a wall with rock armour in front. This wall looks newer than the other sections. Nevertheless, the partly active slopes have caused the failure of the defence on both sides of the remaining wall. The rock armour in front of the defence appears to be too small for the impacting waves, as several rocks have been displaced and/or cracked.

The effectiveness of this wall at preventing further coastal **erosion** is uncertain. Furthermore, the presence of such a structure may represent a health and safety hazard when it is exposed at low water. Work will be needed if coast protection is required in the future, and if the H&S hazard is to be removed. The assets have been assessed as being in poor condition and therefore are in need of repair. However, the SMP has shown that there is no strategic need to carry out these repairs as the policy for this frontage is to retreat the line.

Table 3.4 Summary of survey of CU08 Gouldsborough

Defence ID	Residual Life		Condition		Foreshore		Repair required	Priority	Full Access
	Current	Last Insp.	Current	Last Insp.	Type	Condition			
12-08B-01	0yrs		4		Rock	Good	Yes	High	No

Photograph 3.43 Gouldsborough 12-08B-01. Failed seawall with rock armour



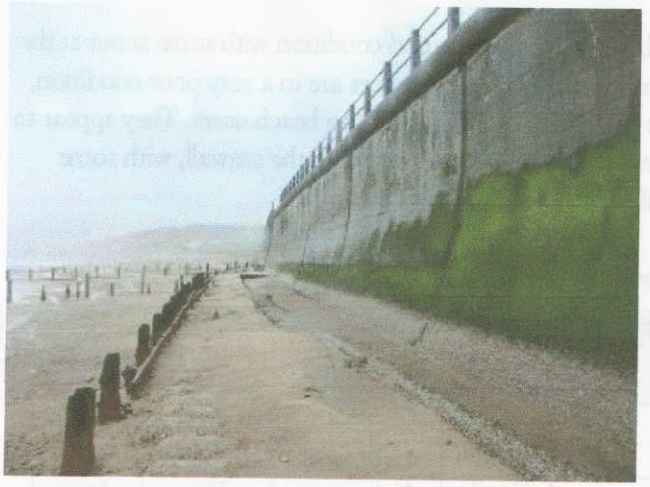
Photograph 3.44 Gouldsborough 12-08B-01. Failed defence

3.5.5 *CU9 – Sandsend*

The coastal unit 9 encompasses the small coastal settlement of Sandsend. The sea defences to the south of the town, fronting dunes, are sloping embankment walls with a rock core, covered by a concrete apron. These defences are in a poor condition, the concrete surface has been broken off exposing the base material, which has also been removed in sections. Furthermore, the slope behind the defences is partly active and several small slips have taken place over the defences and coastal road. The staircases have been recently installed and are in good condition.

Photograph 3.45 Sandsend 17-09C-01.
Surface removed showing base material, small landslips

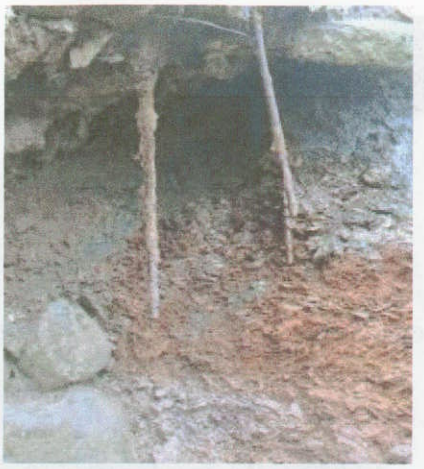
Photograph 3.46 Sandsend 16-09C-05
Staircase



Photograph 3.47 Sandsend 14-09B-05.
Light scour at toe and dilapidated groynes

Photograph 3.48 Sandsend 14-09B-01.
Minor damage to wave return feature of wall

Photograph 3.49 Sandsend 13-09A-01
Undermining and **erosion** of defences



Photograph 3.50 Sandsend 13-09A-01
Weak, washed-out foundation

The defences in the village are in a fair to good condition with some scour at the toe. However, the groynes in front of the defences are in a very poor condition, with exposed metal ties presenting a safety hazard to beach users. They appear to be ineffective as groynes. Minor defects are present in the seawall, with some abrasion damage and fill missing in places.

Table 3.2. Summary of survey results for CU09 Sandsend

Defence ID	Residual Life		Condition		Foreshore		Repair required ?	Priority	Full Access
	Current	Last Insp.	Current	Last Insp.	Type	Condition			
13-09A-01	0yrs		4		Rock	Good	Yes	High	Yes
13-09A-02	+10yrs		3		Rock	Light scour	No	Low	Yes
13-09A-03	+10yrs		2		Shingle	Light scour	Yes	Low	No
14-09B-01	+10yrs		2		Shingle	Good	No	Low	Yes
14-09B-02	+10yrs		2		Shingle	Light scour	No	Low	Yes
14-09B-03	+10yrs		2		Sand	Light scour	Yes	Low	Yes
14-09B-04	+10yrs		2		Sand	Good	Yes	Low	Yes
14-09B-05	+10yrs		2		Sand	Good	No	Low	Yes
14-09B-06	+10yrs		2		Sand	Good	Yes	Low	Yes
14-09B-07	+10yrs		2		Sand	Good	No	Low	Yes
15-09B-01	+10yrs		2		Sand	Good	Yes	Low	Yes
15-09B-02	+10yrs		2		Sand	Good	No	Low	Yes
15-09B-03	+10yrs		2		Sand	Good	No	Low	Yes
15-09B-04	+10yrs		2		Sand	Good	No	Low	No

Defence ID	Residual Life		Condition		Foreshore		Repair required ?	Priority	Full Access
	Current	Last Insp.	Current	Last Insp.	Type	Condition			
15-09B-05	+10yrs		2		Sand	Good	No	Low	Yes
15-09B-06	+10yrs		2		Sand	Good	No	Low	Yes
15-09B-07	+10yrs		2		Sand	Good	No	Low	Yes
16-09C-01	+10yrs		2		Sand	Good	No	Low	Yes
16-09C-02	+10yrs		2		Sand	Good	No	Low	Yes
16-09C-03	+10yrs		3		Sand	Good	Yes	Medium	Yes
16-09C-04	1-5yrs		3		Sand	Good	Yes	Medium	Yes
16-09C-05	+10yrs		2		Sand	Good	No	Low	Yes
17-09C-01	5-10yrs		3		Sand	Good	Yes	Medium	Yes
17-09C-02	+10yrs		2		Sand	Good	No	Low	Yes

At the northern end of Sandsend, the defences are generally in a fair to good condition. However, one defence asset, asset no 13-09A-01, is in very poor condition. The coastal slope in this area is partly active and an on-going failure has undermined the seawall structure. The corroded sheet pile foundation is partially removed, exposing weak, weathered glacial sediment. Remedial measures should be undertaken immediately to prevent outflanking and failure of the defence.

3.5.6 *CU10 – Sandsend Wyke*

This coastal unit stretches between Whitby and Sandsend and includes Upgang Beach. Only two defences are in this unit, but both assets are in a very poor condition. The concrete apron in front of the dunes has suffered severe abrasion at the toe, with the base material being exposed and partially removed in sections. The timber and steel defences are rotten and pitted.

Photograph 3.51 Sandsend Wyke 17-10-01
Undermined and partially failed Defence

Photograph 3.52 Sandsend Wyke 17-10-01
Abrasion and scour at toe of defence

Table 3.3. Summary of survey result for CU10 Sandsend Wyke

Defence ID	Residual Life		Condition		Foreshore		Repair required	Priority	Full Access
	Current	Last Insp.	Current	Last Insp.	Type	Condition			
17-10-01	1-5yrs		4		Sand	Good	Yes	Medium	Y
17-10-02	0yrs		5		Sand	Good	Yes	Medium	Y

3.5.7 *CU11 – Whitby (Westdiff)*

This coastal unit covers the west of Whitby town. Most of the coastal defences consist of seawalls which are in a fair to good condition, with only minor defects present, and two defences that have failed.

The drainage of the seawalls on the western end of the coastal unit (defence unit no 18-11A-01 to 19-11A-01) is not working properly. Water is standing behind the defences after moderate rain, with nó water seeping through the drainage pipes. This may have an impact on the landward coastal slope which is locally active.

Photograph 3.53 Whitby West Cliff 18-11A-02. Water standing behind the defence after a mild rain

Photograph 3.54 Whitby West Cliff 18-11A-02 Drainage pipe

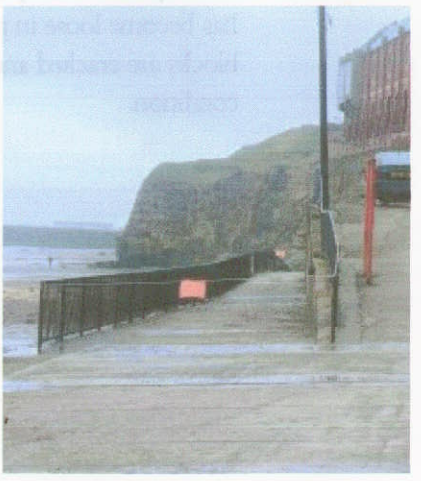
There is minor damage and some scour present at the remaining seawalls along this frontage at the western extent of the coastal unit. The minor damage encompasses mainly defects to the hand rails and coping blocks. The hand railing has become loose in places and has not been painted and is corroding. The coping blocks are cracked and damaged in places, but are overall in a good to fair condition.

Photograph 3.55 Whitby West Cliff 20-11A-01. Loose hand railing and scour

Photograph 3.56 Whitby West Cliff 19-11A-01. Damaged coping

The coastal defence asset no 20-11A-02 has failed and should be repaired urgently to ensure the overall integrity of the structure. Several masonry blocks are missing below the promenade: the access to this part of the promenade has been informally blocked off.

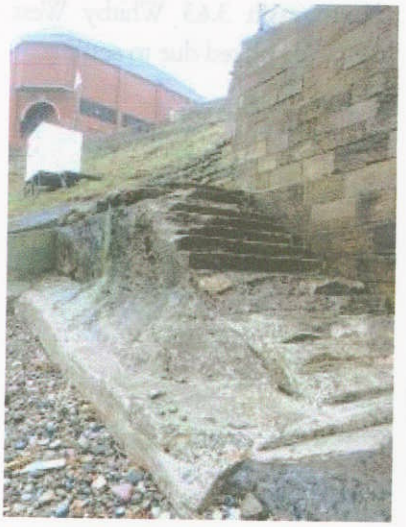
Photograph 3.57 Whitby West Cliff 20-11A-02. Masonry blocks are missing just below the promenade



Photograph 3.58 Whitby West Cliff 20-11A-02. Informally blocked promenade

The nearby coastal defence unit 22-11A-02 has also failed in its function to provide safe access to the beach. The concrete of this asset is strongly abraded; the steps are worn off and cannot be used safely.

Unit 26-11B-01 has lost a masonry block just below the promenade and settlement has occurred. There is minor settlement and abrasion of the road surface.



Photograph 3.59 Whitby West Pier 22-11A-02 Abraded steps

Photograph 3.60 Whitby West Pier 26-11B-01. Masonry blocks missing and surface settlement has occurred.

Photograph 3.61 Whitby West Pier 26-11B-02. Scour at the base of harbour wall

Photograph 3.62 Whitby West Pier 26-11B-02. Uneven surface at access to walkway

Scouring at the toe of Unit 26-11B-02 is evident. The hand railing on the promenade has corroded and should be monitored and considered for repair.

Photograph 3.63 Whitby West Pier 27-11B-01. Blocks displaced due to settling.

There are vertical cracks evident in the north face of the west pier (unit 27-11B-01). In addition, displacement of masonry blocks has occurred. Cracks and voids can be seen in several locations along the harbour wall. (See photograph 3.63). It is not possible to comment on the development of these cracks as these frontages do not appear in the *KeyShore* database.

Access to the piers is limited by tide levels and the inspection was limited to part of the West pier only. Units 26-11B-01, 26-11B-02 and 27-11B-01 are not currently on the database. The original survey sheets for these units have been provided in Appendix 1. The remaining coastal assets in this unit are in a fair to good condition and have only minor defects.

Table 3.4 Summary of survey results for CU11 Whitby (Westcliff)

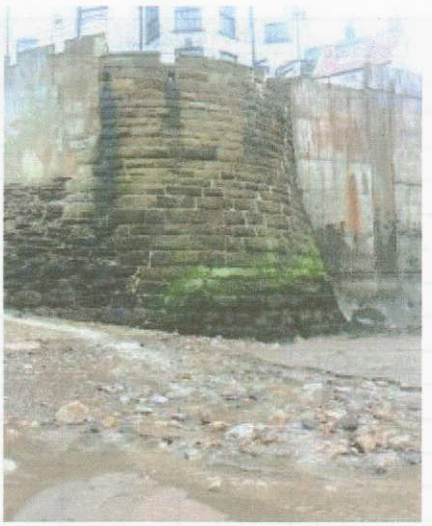
Defence ID	Residual Life		Condition		Foreshore		Repair required	Priority	Full Access
	Current	Last Insp.	Current	Last Insp.	Type	Condition			
18-11A-01	+10yrs		2		Sand	Good	No	Low	Yes
18-11A-02	+10yrs		2		Sand	Good	Yes	Medium	Yes
18-11A-03	+10yrs		2		Shingle	Good	Yes	Medium	Yes
18-11A-04	+10yrs		2		Sand	Good	Yes	Medium	Yes
19-11A-01	+10yrs		2		Sand	Heavy scour	Yes	Low	Yes
20-11A-01	+10yrs		3		Sand	Light scour	Yes	Medium	Yes

Defence ID	Residual Life		Condition		Foreshore		Repair required	Priority	Full Access
	Current	Last Insp.	Current	Last Insp.	Type	Condition			
20-11A-02	0Yrs		4		Sand	Good	Yes	High	Yes
21-11A-01	+10yrs		2		Sand	Good	No	Low	Yes
21-11A-02	+10yrs		2		Sand	Good	Yes	Low	Yes
22-11A-01	5-10yrs		2		Shingle	Good	No	Low	Yes
22-11A-02	0yrs		4		Shingle	Good	Yes	High	Yes
22-11A-03	+10yrs		3		Shingle	Light scour	Yes	Low	Yes
24-11B-01	+10yrs		2		Shingle	Good	No	Low	Yes
25-11B-01	+10yrs		2		Sand	Good	No	Low	Yes
25-11B-02	5-10yrs		2		Sand	Good	Yes	Low	Yes
25-11B-03	+10yrs		2		Sand	Good	Yes	Medium	Yes
26-11B-01	+10yrs		3		Sand	Light Scour	Yes	Low	Yes
26-11B-02	+10yrs		3		Sand	Good	Yes	Medium	Yes
27-11B-01	+10yrs		3		Sand + Rock	Good	Yes	Medium	No
70-11A-01	+10yrs		2		Sand	Good	No	Low	Yes
70-11A-02	+10yrs		2		Shingle	Good	Yes	Low	Yes
70-11A-03	+10yrs		2		Sand	Good	Yes	Medium	Yes
70-11A-04	+10yrs		2		Shingle	Heavy scour	Yes	Low	Yes
71-11A-01	+10yrs		3		Rock + Shingle	Poor	Yes	Medium	Yes
71-11A-02	+10yrs		2		Sand	Light scour	Yes	Low	Yes
71-11A-03	+10yrs		2		Sand	Good	Yes	Low	Yes
71-11A-04	+10yrs		2		Sand	Good	Yes	Low	Yes
71-11A-05	+10yrs		2		Sand	Heavy scour	Yes	Low	Yes

3.5.8 *CU16 – Robin Hood's Bay*

The coastal unit 16 covers the coastal settlement Robin Hood's Bay. The defences consist mainly of high sea walls and rock revetments which are in a good to fair condition overall. The defences at the northern end of the coastal unit at the slipway, asset 32-16A-01 and asset 32-16A-02, are in a good condition. However, the coastal slope is very steep and the drainage pipe on the slope leads directly to the cliff with water seeping onto the cliff frontage.

Photograph 3.64 Robin Hood's Bay (RHB) 32-16A-02. Slipway with rocks partially covering access

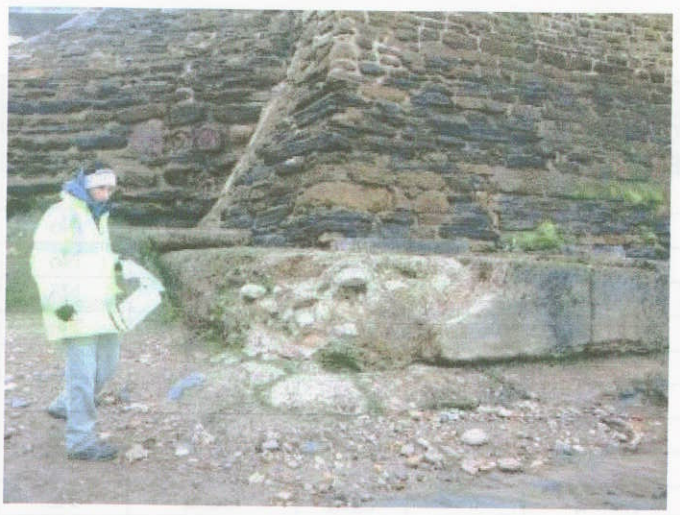


Photograph 3.65 RHB 34-16A-01. Diagonal full height cracks

A protective steel mesh has been placed over the cliff front at the slipway. Despite these measures, the cliffs are locally active with some material from the cliffs falling onto the rock revetment. This area should be monitored on an annual basis

The defence asset 34-16A-01, next to the slipway in the village centre, is worn and has several cracks running diagonally along the full height of the structure. Some of these cracks have been repaired previously, but have since re-opened. Installation of 'tell tales' to monitor these cracks should be considered here.

The concrete apron of asset 36-16A-01, on the other side of the slipway, is heavily abraded and should be repaired to sustain the life of the structure. It should be noted that the sea wall serves also as a foundation for a residential property.



Photograph 3.66 RHB 36-16A-01. Heavily abraded concrete apron

The coastal slope from defence asset 37-16C-01 up to 37-16C-03, is partly active and several shallow failures are visible. The soil is very wet above the defences with standing water, indicating drainage is a problem. A recent landslip has partially buried the defence asset 37-16C-03. Geotextile is visible, both damaged and exposed at the top of the landslip. The defences are at risk of being outflanked with further slope failures likely in future periods of intense rainfall.

Photograph 3.67 RHB 37-16C-03. Landslip partially covering defence asset

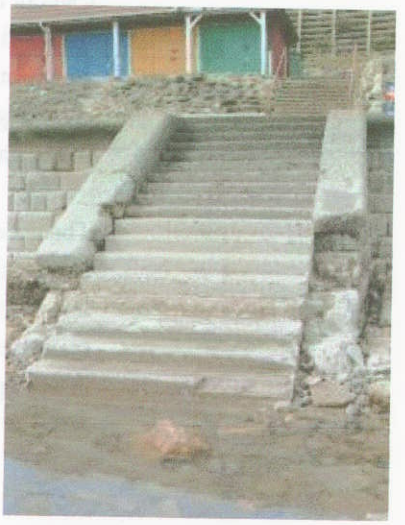
Table 3.5 Summary of survey results for CU16 Robin Hood's Bay

Defence ID	Residual Life		Condition		Foreshore		Repair required	Priority	Full Access
	Current	Last Insp.	Current	Last Insp.	Type	Condition			
32-16A-01	+10yrs		2		Sand	Good	No	Low	Yes
32-16A-02	+10yrs		2		Sand	Good	No	Low	Yes
33-16A-01	+10yrs		2		Sand	Good	No	Low	Yes
33-16A-02	+10yrs		2		Sand	Good	No	Low	Yes
34-16A-01	6-10yrs		3		Sand	Good	Yes	Medium	Yes
35-16B-01	+10yrs		3		Rock	Good	Yes	Low	Yes
36-16B-01	+10yrs		3		Rock	Light scour	Yes	Medium	Yes
36-16B-02	+10yrs		2		Sand	Good	No	Low	Yes
36-16B-03	+10yrs		2		Sand	Good	No	Low	Yes
37-16C-01	+10yrs		2		Sand	Good	Yes	Medium	Yes
37-16C-02	+10yrs		2		Shingle	Good	Yes	Medium	Yes
37-16C-03	+1-5yrs		3		Sand	Good	Yes	High	Yes

3.5.9 *CU20 – Scarborough (North Bay)*

The coastal unit 20 covers Scarborough North Bay. The sea defences in this area comprise mainly of a seawall promenade with several access staircases to the beach. Normally the beach levels are relatively high and cover most of the staircases along the North Bay promenade, however a heavy storm on the 8th of April 2005 has lowered the beach levels significantly and has damaged several of the access staircases and defences along the frontage.

Photograph 3.68 – Scarborough North Bay (SNB) 42-20A-09. High beach levels with sand covering most of the staircase, 22 February 2002. Note elevation of sand relative to red staircase handrails in this image.



Photograph 3.69 SNB 42-20A-09. Damaged staircase with low beach levels and scouring 12 April 2005

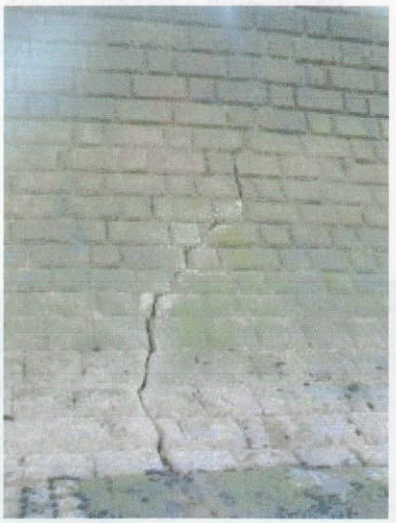
Photograph 3.70 SNB 42-20A-09. Damaged wave return wall

Photograph 3.71 SNB 43-20B-02. Works in progress

Some works to the defence structures were already taking place during the survey in May 2005, which on occasion obstructed the assets, making a full visual inspection not possible. However, a reasonable estimate of the structures condition could be made for all the coastal assets in this coastal unit.

Overall the defences are in a fair to good condition along the frontage; some localised scour and minor damage is present. The seawall shows some vertical cracks at several locations, which might be due to differential settlement or changing pore pressure behind the seawall. Nevertheless, these cracks should be investigated and monitored.

The access staircase near the Oasis Café, assets 44-20B-04 and 44-20B-03, are in a fair condition but need some remedial works. The assets are structurally sound, however the access to the beach is hazardous to beach users due to significant quantities of rock and debris being scattered or exposed near the landing area. Several people were seen during the survey to struggle with the access especially families with young children.



Photograph 3.60 SNB 44-20B-04 and 44-20B-03. Rocks and debris near staircase landing area

Photograph 3.73 SNB 43-20B-02. Works in progress

Photograph 3.74 SNB defences south of asset 44-20B-05 show some sign of wear and have suffered some damage. They require some remedial repairs

Photograph 3.75 SNB 46-20B-05. New defences have been constructed

The defences below Chain Hill, asset location 46-20B, are currently being replaced by new defences. Since this construction is still ongoing a detailed assessment should be made after the completion of construction.

Table 3.6 Summary of survey results for CU20 Scarborough (North Bay)

Defence ID	Residual Life		Condition		Foreshore		Repair required	Priority	Full Access
	Current	Last Insp.	Current	Last Insp.	Type	Condition			
38-20A-01A	+10yrs	+10yrs	2	2	Shingle	Good	No	Low	No
38-20A-01	+10yrs	+10yrs	2	2	Shingle	Good	No	Low	Yes
39-20A-01	+10yrs	+10yrs	2	2	Shingle	Heavy scour	Yes	Low	No
39-20A-02	+10yrs	+10yrs	2	2	Rock	Good	No	Low	No
39-20A-03	+10yrs	+10yrs	2	2	Rock	Good	No	Low	Yes
39-20A-04	+10yrs	+10yrs	2	2	Rock	Good	No	Low	Yes
40-20A-01	+10yrs	+10yrs	2	2	Rock	Good	Yes	Low	Yes
40-20A-02	+10yrs	+10yrs	2	2	Sand	Good	No	Low	Yes
40-20A-03	+10yrs	+10yrs	3	2	Sand	Light scour	No	Low	No
40-20A-04	+10yrs	+10yrs	2	2	Sand	Good	No	Low	No
40-20A-05	6-10yrs	+10yrs	3	2	Sand	Heavy scour	Yes	Low	No
40-20A-06	+10yrs	+10yrs	2	2	Sand	Good	Yes	Low	Yes
41-20A-01	+10yrs	+10yrs	2	2	Sand	Good	No	Low	No

Defence ID	Residual Life		Condition		Foreshore		Repair required	Priority	Full Access
	Current	Last Insp.	Current	Last Insp.	Type	Condition			
41-20A-02	+10yrs	+10yrs	3	2	Sand	Good	Yes	Medium	Yes
41-20A-03	+10yrs	+10yrs	2	2	Sand	Good	Yes	Low	Yes
41-20A-04	+10yrs	+10yrs	3	2	Sand	Good	Yes	Low	Yes
42-20A-03	+10yrs	+10yrs	2	2	Sand	Good	No	Low	Yes
42-20A-04	+10yrs	+10yrs	2	2	Sand	Good	No	Low	Yes
42-20A-05	1-5yrs	+10yrs	3	2	Sand	Light scour	Yes	Medium	No
42-20A-06	+10yrs	+10yrs	2	2	Sand	Good	No	Low	Yes
42-20A-07	1-5yrs	+10yrs	3	2	Sand	Heavy scour	Yes	Medium	No
42-20A-08	+10yrs	+10yrs	2	2	Sand	Good	No	Low	Yes
42-20A-09	1-5yrs	+10yrs	4	2	Sand	Light scour	Yes	Medium	Yes
42-20A-10	+10yrs	+10yrs	2	2	Sand	Good	Yes	Low	Yes
42-20A-11	6-10yrs	+10yrs	3	2	Sand	Good	Yes	Medium	Yes
42-20A-12	+10yrs	+10yrs	2	2	Sand	Good	No	Low	Yes
42-20A-13	+10yrs	+10yrs	2	2	Sand	Good	Yes	Low	Yes
42-20A-14	+10yrs	+10yrs	2	2	Sand	Good	Yes	Low	Yes
42-20A-15	+10yrs	+10yrs	2	2	Sand	Good	Yes	Low	Yes
42-20A-16	+10yrs	+10yrs	2	2	Sand	Good	Yes	Medium	Yes
42-20A-17	+10yrs	+10yrs	2	2	Sand	Good	Yes	Medium	Yes
42-20A-18	+10yrs	+10yrs	2	2	Sand	Good	No	Low	Yes
42-20A-19	+10yrs	+10yrs	2	2	Sand	Good	Yes	Low	Yes
42-20A-20	+10yrs	+10yrs	2	2	Sand	Good	Yes	Low	No
42-20A-21	+10yrs	+10yrs	2	2	Sand	Good	No	Low	Yes
43-20B-01	+10yrs	+10yrs	2	2	Sand	Good	No	Low	No
43-20B-02	+10yrs	+10yrs	2	2	Sand	Good	No	Low	No
43-20B-03	+10yrs	+10yrs	2	2	Sand	Good	Yes	Low	Yes
43-20B-04	+10yrs	+10yrs	2	2	Sand	Good	Yes	Low	Yes
44-20B-01	+10yrs	+10yrs	2	2	Sand	Good	No	Low	Yes
44-20B-02	+10yrs	+10yrs	2	2	Sand	Good	No	Low	Yes
44-20B-03	+10yrs	+10yrs	2	2	Sand	Good	Yes	Low	Yes
44-20B-04	+10yrs	+10yrs	2	2	Sand	Good	Yes	Low	Yes
44-20B-05	+10yrs	+10yrs	2	2	Sand	Good	Yes	Low	Yes
45-20B-01	+10yrs	+10yrs	3	2	Sand	Good	Yes	Medium	Yes
45-20B-02	6-10yrs	+10yrs	3	2	Sand	Light scour	Yes	Medium	Yes
45-20B-03	+10yrs	+10yrs	2	2	Sand	Good	Yes	Low	No
46-20B-01	N/A	N/A	N/A	N/A	Sand	Good	N/A	N/A	N/A
46-20B-02	N/A	N/A	N/A	N/A	Sand	Good	N/A	N/A	N/A
46-20B-03	N/A	N/A	N/A	N/A	Sand	Good	N/A	N/A	N/A
46-20B-04	N/A	N/A	N/A	N/A	Sand	Good	N/A	N/A	N/A
46-20B-05	N/A	N/A	N/A	N/A	Sand	Good	N/A	N/A	N/A
46-20B-06	N/A	N/A	N/A	N/A	Sand	Good	N/A	N/A	N/A
46-20B-07	N/A	N/A	N/A	N/A	Sand	Good	N/A	N/A	N/A

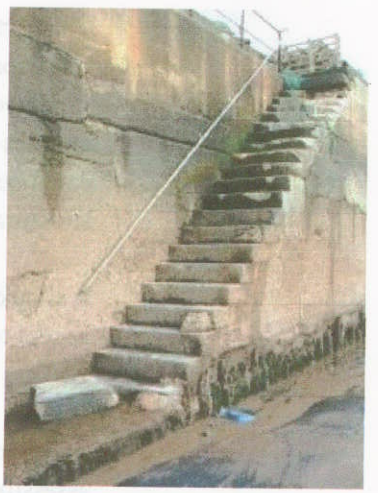
3.5.10 *CU21 – Scarborough (West Pier)*

This coastal unit contains the frontage between the south bay and the north bay of Scarborough, which are parallel to the Royal Albert Drive, Marine Drive and Sandside. Significant features in this unit are the castle cliffs and the old and east harbour.

Due to the ongoing construction work it was decided in a meeting with Scarborough Council representatives on the 11th April 2005 that only the west pier of Scarborough should be assessed in the 2005 campaign.

The west pier is generally in a fair to good condition, with some minor abrasions and cracking visible on the wall and the coping. However, asset 49-21B-03 (a staircase) is in a poor condition. It is recommended either to re-instate the staircase or block the access to it formally. Furthermore, the timber toe piles are in a poor condition and some localised undermining is taking place just above the piles. A summary of the result is listed in Table 3.7.

Photograph 3.76 Scarborough West Pier (SWP)
Timber toe piles and localised undermining



Photograph 3.77 SWP 49-21B-03
Damaged staircase

Full access was not possible to asset 49-21B-05, another staircase, due to the water level at that time. However, most of the structure could be assessed and only limited areas were not visible. It is believed that this does not significantly affect the assessment of this asset.

Table 3.7 Summary of survey results for CU21 Scarborough (West Pier)

Defence ID	Residual Life		Condition		Foreshore		Repair required	Priority	Full Access
	Current	Last Insp.	Current	Last Insp.	Type	Condition			
49-21B-01	+10yrs	+10yrs	2	2	Sand	Light scour	No	Low	Yes
49-21B-02	+10yrs	+10yrs	2	2	Sand	Light scour	No	Low	Yes
49-21B-03	+10yrs	+10yrs	2	2	Sand	Good	Yes *	High	Yes
49-21B-04	+10yrs	+10yrs	2	2	Sand	Light scour	Yes	Low	Yes
49-21B-05	+10yrs	+10yrs	2	2	Sand	Light scour	No	Low	No

* - Repair required to the stairs

3.5.11 *CU22 – Scarborough (South Bay)*

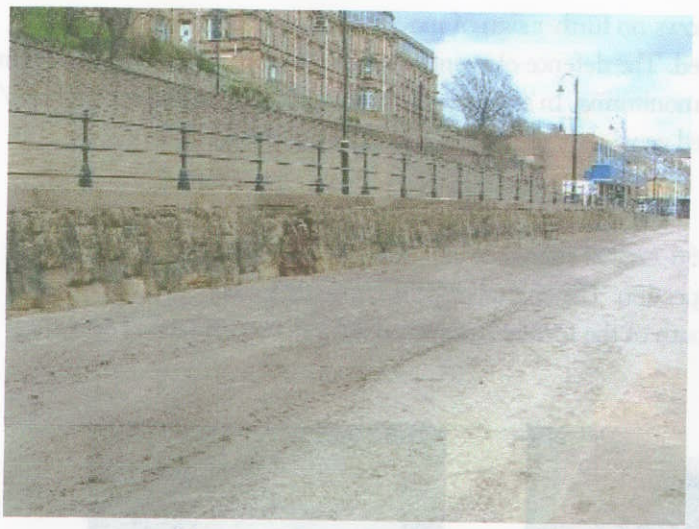
Coastal Unit 22 encompasses the Scarborough South Bay. There is a busy road behind the defences and a number of properties line the street on the landward side.

The coast protection assets comprise mainly of sea walls with a promenade, and in some areas there are localised toe protection measures.

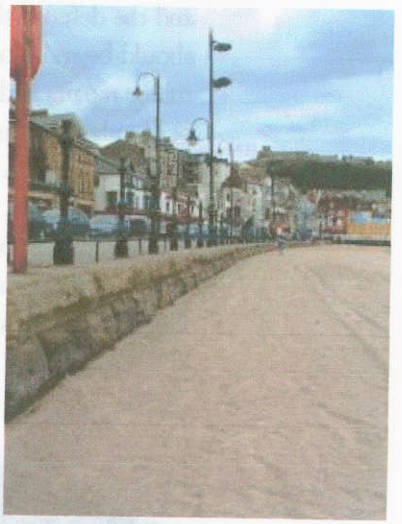
The northern end of the coastal unit 22, (Scarborough South Bay), is in a good condition with only minor defects which are mainly of aesthetic nature. Most of the defects are not structurally significant, however if the minor abrasion and **erosion** defects are not dealt with appropriately there is a possibility that they could become more severely damaged in future storms and potentially lead to structural problems.

It should be noted that the defence crest level for asset 51-22A-01 to 51-22A-12 appear to be lower then the other defences along the frontage. The crest height changes over the frontage.

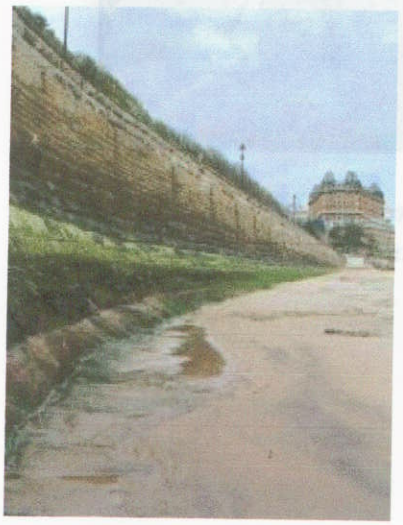
The standard of defence is possibly maintained by higher beach levels. An assessment of the beach levels and wave overtopping should be carried out separately from the asset condition to ensure the required standard of protection is maintained by the coast protection asset.



Photograph 3.78 Scarborough South Bay (SSB) 51-22A-12. Seawall with promenade.



Photograph 3.79 SSB 51-22A-12 Seawall with promenade



Photograph 3.80 SSB 51-22A-06 Seawall with promenade

Photograph 3.81 SSB 53-22B-05. Historical cracks and anchors

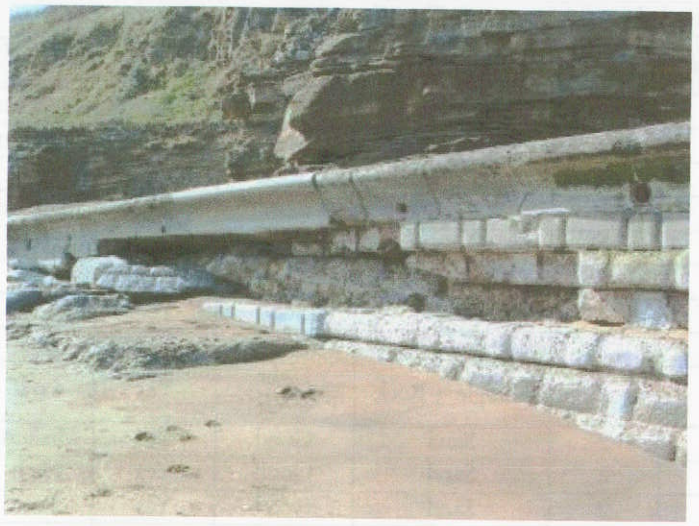
The southern half of the coastal unit 22 is generally in a good to fair condition; however localised structural defects are present. The seawall (asset 53-22B-05) has some cracks which have been filled and anchored. These cracks appear to be stable

and the defence shows no further sign of movement, nevertheless, the cracks should be monitored. The defence elements at asset locations 53, 55 and 56 require minor repairs and monitoring. In some locations, blocks have been displaced and/or abraded, localised **erosion** is taking place and the promenade kerb shows localised damage.

The defence asset 56-22B-02 should be repaired immediately, since it had failed at the time of the inspection. The coastal slope is currently locally active with small failures forming south of the former bathing pool (near 56-22B-06 and 56-22B-07).

Photograph 3.82 SSB 55-22B-01.
Abraded masonry blocks

Photograph 3.83 SSB 53-22B-05.
Damaged promenade kerb



Photograph 3.84 SSB56-22B-02. Damaged and failed defences.

Some coastal assets could not be assessed fully due to shingle or sand partially covering the asset. However, an overall assessment of the assets was made. Further details are provided in the *KeyShore* database.

Table 3.8 - Summary of survey results for CU22 Scarborough (South Bay)

Defence ID	Residual Life		Condition		Foreshore		Repair required	Priority	Full Access
	Current	Last Insp.	Current	Last Insp.	Type	Condition			
51-22A-01	+10yrs	+10yrs	2	2	Sand	Light scour	No	Low	Yes
51-22A-02	+10yrs	+10yrs	2	2	Sand	Good	Yes	Low	Yes
51-22A-03	+10yrs	+10yrs	2	2	Sand	Good	Yes	Low	Yes
51-22A-04	+10yrs	+10yrs	2	2	Sand	Good	No	Low	No
51-22A-05	+10yrs	+10yrs	2	2	Sand	Good	No	Low	Yes
51-22A-06	+10yrs	+10yrs	2	2	Sand	Good	Yes	Low	Yes
51-22A-07	+10yrs	+10yrs	2	2	Sand	Good	No	Low	Yes
51-22A-08	+10yrs	+10yrs	2	2	Sand	Good	Yes	Low	Yes
51-22A-09	+10yrs	+10yrs	2	2	Sand	Good	No	Low	Yes
51-22A-10	+10yrs	+10yrs	2	2	Sand	Good	Yes	Low	Yes
51-22A-11	+10yrs	+10yrs	2	2	Sand	Good	No	Low	Yes
51-22A-12	+10yrs	<1yr	2	2	Sand	Good	Yes	Low	Yes
52-22A-01	+10yrs	+10yrs	2	2	Sand	Good	Yes	Low	Yes
52-22A-02	+10yrs	+10yrs	2	2	Sand	Good	Yes	Low	Yes
52-22A-03	+10yrs	+10yrs	2	2	Sand	Good	Yes	Low	Yes
52-22A-04	+10yrs	+10yrs	2	2	Sand	Good	No	Low	Yes
53-22B-01	+10yrs	+10yrs	2	2	Sand	Good	No	Low	No
53-22B-02	+10yrs	+10yrs	2	2	Sand	Good	Yes	Low	Yes

Defence ID	Residual Life		Condition		Foreshore		Repair required	Priority	Full Access
	Current	Last Insp.	Current	Last Insp.	Type	Condition			
53-22B-04	+10yrs	+10yrs	2	2	Sand + Rock	Good	Yes	Medium	Yes
53-22B-05	+10yrs	+10yrs	3	2	Sand	Good	Yes	Medium	Yes
53-22B-06	+10yrs	+10yrs	2	2	Sand + Rock	Good	Yes	Low	Yes
53-22B-07	+10yrs	+10yrs	3	2	Rock	Poor	Yes	Medium	Yes
53-22B-08	+10yrs	+10yrs	2	2	Shingle + Rock	Good	No	Low	Yes
54-22B-01	+10yrs	+10yrs	2	2	Shingle + Sand	Good	Yes	Low	Yes
54-22B-02	+10yrs	+10yrs	2	2	Shingle	Good	Yes	Low	Yes
54-22B-03	+10yrs	+10yrs	2	2	Shingle + Rock	Good	Yes	Low	Yes
54-22B-04	+10yrs	+10yrs	3	2	Shingle + Rock	Light scour	Yes	Low	Yes
55-22B-01	+10yrs	+10yrs	3	2	Sand	Good	Yes	Medium	Yes
56-22B-02	0 yrs	+10yrs	4	2	Sand	Good	Yes	High	Yes
56-22B-03	6-10yrs	+10yrs	3	2	Sand	Good	Yes	Low	No
56-22B-04	+10yrs	+10yrs	2	2	Sand	Good	Yes	Low	Yes
56-22B-05	+10yrs	+10yrs	3	2	Sand + Rock	Light scour	Yes	Medium	Yes
56-22B-06	6-10yrs	+10yrs	3	2	Rock	Heavy scour	Yes	Low	Yes
56-22B-07	6-10yrs	+10yrs	3	2	Sand + Rock	Light scour	Yes	Medium	No
56-22B-08	+10yrs	+10yrs	2	2	Sand + Rock	Good	Yes	Low	Yes

3.5.12

CU24 – Cayton Bay

Most of Cayton Bay is in a natural state with no man-made defences, the only hard defences are at the foot of Tenants' Cliff which comprise a masonry and concrete seawall and apron.

A residential property and a disused pumping station are protected by these defences. Furthermore, a path and access staircase leads from the caravan park at the top of Tenants' Cliff to the beach. The ownership of the defences is divided between Scarborough BC and residents. The defences have deteriorated since the last inspection was made and in some locations the defence has failed.

The defences protecting the individual residential property are in better condition than the defences near the access to the beach. The defence asset 58-24B-01 which protects the northern side of the residential property is in an overall fair to good condition. However, the adjacent steep and locally active coastal slope is progressively outflanking the defence and may eventually cause its failure.

Photograph 3.85 Cayton Bay 58-24B-01. Steep coastal slope outflanking defence.

Photograph 3.86 Cayton Bay 59-24B-01. Patch repairs and interface between different wall elements

The defence asset 59-24B-01 protecting the remainder of the residential property has significant defects with several patch repairs evident. Strong scouring with undermining is visible at the toe of the structure. Several masonry blocks are heavily weathered and are displaced with voids between blocks. Large cracks are present throughout the structure, with its overall integrity being reduced. The brick wall on top of the seawall has experienced a significant loss of mortar and several bricks are missing at the base of a brick tower. This presents a safety hazard to beach users.

The former promenade and steps to the beach, asset 60-24B-01, have failed in their function to provide safe access to the beach. The asset provides resistance to further **erosion**, however the promenade surface is very uneven with sections broken off and cannot be used safely. The ground behind the apron of the promenade is partially eroded and some sections of the apron have broken off. A recent slip in these locally active cliffs has undermined the staircase access.

Photograph 3.87 Cayton Bay 60-24B-01. Concrete bag-work and failed defence section.

Photograph 3.88 Cayton Bay 60-24B-01. Landslip and **erosion** below steps

Table 3.9 - Summary of survey results for CU24 Cayton Bay

Defence ID	Residual Life		Condition		Foreshore		Repair required	Priority	Full Access
	Current	Last Insp.	Current	Last Insp.	Type	Condition			
58-24B-01	6-10yrs	6-10yrs	3	3	Sand	Light scour	No *	High	Yes
59-24B-01	1-5 yrs	6-10yrs	4	3	Sand	Heavy scour	No *	High	Yes
60-24B-01	0yrs	1-5yrs	4	3	Sand	Good	No *	High	Yes

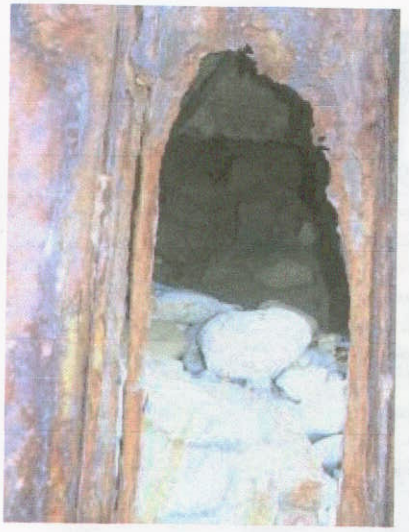
* The SMP policy for this frontage is "Retreat".

3.5.13 *CU28 – Filey Bay*

Most of Filey Bay frontages are natural with no man-made defences other than the hard defences at the Filey Sailing Club and at Filey Town. The coastal defence assets at the Sailing Club, asset no 64-28A-01 and 64-28A-02, are in a poor condition and have failed. The sheet-piles are corroded, and are partially removed in sections. Large scouring holes approximately 1m deep are forming below the concrete slab. These holes make the structure potentially unstable, as the concrete slab is at a greater risk of failure by overturning. Additionally, this presents a safety hazard to its users. The condition is aggravated further by instability behind the structure in locally and partly active cliffs. During the inspections several recent

landslides were seen on either side of the defence. The run-out debris lobe of one of these failures partially blocks the slipway of the sailing club.

Photograph 3.89 Filey Bay 64-28A-01.
Landslide run-out lobe partially blocking the slipway



Photograph 3.90 Filey Bay 64-28A-02
Corroded sheet pile and scouring

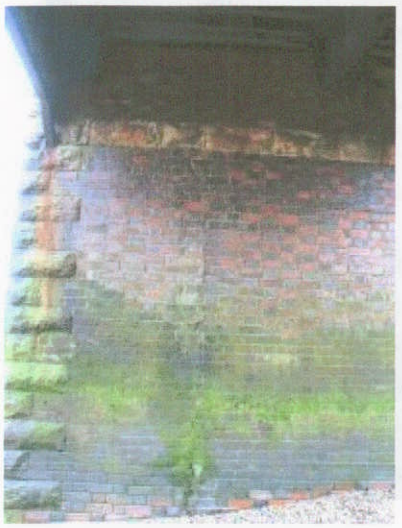
The defences in Filey town are in a fair condition; however several vertical full height cracks are present in the masonry sea walls. These cracks indicate movement which may be due to pore pressure changes behind the seawall. A full structural survey should be undertaken to clarify the origin of the cracks and continuous detailed monitoring should take place.

Vertical cracks are below the replaced footbridge at the Cargate Hill Slipway (asset 67-28B-04). These have not been detected during the last survey in 2003. It is therefore recommended to undertake monthly monitoring using tell-tale markers and a vernier scale to determine whether the cracks are widening and in which direction movement is occurring.

Several wave return copings are suffering from calcitic crystalline expansion. This process causes the coping to crack and parts of the overhang to break off. These structures should be periodically inspected and replaced.

Furthermore, scouring and beach lowering appears to have occurred at the southern end of Filey Town (asset number 67-28B-05 southwards), indicated by

several deep water puddles in front of the defences. At asset number 67-28B-07 the concrete apron is partially exposed and undermined. It is not known to what extent the walls rely on beach levels for stability.



Photograph 3.91 Filey Bay 67-28B-04.
Full height vertical crack

Photograph 3.92 Filey Bay 67-28B-04.
Vertical crack approx. 2m high

Photograph 3.93 Filey Bay 67-28B-05 Vertical full height crack

Photograph 3.94 Filey Bay 67-28B-07. Scouring at toe

The southern end of the defences protecting Filey Town is at risk of outflanking at Martin's Ravine (asset no 67-28B-13). Rock gabions and small granite boulders (less than 1 tonne) have been placed near the slipway in front of the steep, locally active coastal slope. There is an active landslip immediately behind the gabion and rockwall, which is currently partly resisted by the rockwall. Future possible slope movements could lead to failure of the gabion structure. The southern end shows evidence of outflanking, with loss of material and **erosion** at the rockwall. It is doubtful that this structure would be effective during a significant storm event and measures should be taken to protect this location from failing as a result of being outflanked.

Photograph 3.95 Filey Bay 67-28B-13. On-going coastal **erosion** and outflanking of defences

Table 3.10 Summary of survey results for CU28 Filey Bay

Defence ID	Residual Life		Condition		Foreshore		Repair required	Priority	Full Access
	Current	Last Insp.	Current	Last Insp.	Type	Condition			
64-28A-01	1-5yrs	+10yrs	3	2	Shingle	Good	Yes	Medium	Yes
64-28A-02	0 yrs	1-5yrs	4		Shingle	Good	Yes	High	Yes
67-28B-01	+10yrs	+10yrs	2	2	Sand	Light scour	Yes	Low	Yes
67-28B-02	+10yrs	+10yrs	2	2	Sand	Good	Yes	Low	Yes
67-28B-03	6-10yrs	+10yrs	3	2	Sand	Light scour	Yes	Medium	Yes
67-28B-04	+10yrs	+10yrs	2	2	Sand	Good	Yes*	High*	Yes
67-28B-05	+10yrs	+10yrs	2	2	Sand	Heavy scour	Yes	Low	No
67-28B-06	+10yrs	+10yrs	2	2	Sand	Good	Yes	Low	No
67-28B-07	+10yrs	+10yrs	2	2	Sand	Heavy scour	Yes	Medium	No
67-28B-08	+10yrs	+10yrs	3	2	Sand	Good	Yes	Low	Yes
67-28B-09	+10yrs	+10yrs	3	2	Sand	Light scour	No	Low	No
67-28B-10	6-10yrs	+10yrs	3	2	Sand	Poor	Yes	Medium	No
67-28B-11	+10yrs	+10yrs	3	2	Sand	Heavy scour	Yes	Medium	No
67-28B-12	6-10yrs		3	3	Sand	Heavy scour	Yes	Low	No
67-28B-13	1-5yrs	1-5yrs	4	4	Sand	Good	Yes	High	Yes

This asset is regarded as High Priority as monitoring is required to investigate the vertical cracks.

4 Beach Survey Assessment

4.1 *Introduction*

This chapter reviews beach survey data from coastal frontages within the boundaries of Scarborough Borough Council. The data is used to assess and analyse the nature of change in beach levels and quantities. The locations where data has been collected and analysed were:

- Staithes Bay;
- Runswick Bay
- Sandsend to Whitby Bay;
- Scarborough North Bay;
- Scarborough South Bay;
- Cayton Bay and
- Filey Bay.

4.1.1 *Survey Data*

The data was collected during surveys of the area using topographic and bathymetric surveying methods. It was collected at six-monthly intervals throughout 2002, 2003 and 2004, with additional 2001 surveys in Scarborough North and South Bays.

The data sets only represent a 'snap shot' of the beach form at the time of survey and therefore are not necessarily representative of the beach over an entire season or through a year. Information relating to beach management activities has been reviewed to establish whether this may have affected the beach form at the time of survey. Wave and water-level data relating to the survey periods has not been reviewed, and antecedent conditions are not known. Furthermore, no data relating to the survey methods was available. As such, it has not been possible to state definitively whether observed changes are due to fluctuations in beach form (e.g. **erosion/accretion**), short term process responses (e.g. storm activity) or variations in the surveying methods. Notwithstanding this, the analysis does provide a clear review of the observed variations in beach form along these seven important frontages.

It is also known that the Scarborough Borough region and its coastline were subjected to a storm in the period between the topographic and asset surveys.

It is noted that Runswick Bay (March 2002) and Staithes (March and October 2002) surveys were carried out using Total Stations as apposed to GPS. The exact survey locations therefore were not discernable as the profile co-ordinates were not definitively correct with the data in this form. At these locations, profile analysis between surveys could be inaccurate and therefore comparisons made must be treated with due caution.

4.1.2 *Analysis Methodology*

The data from each survey was used to generate a topographical beach surface for each locality within KeyTERRA-FIRMA (a component of the *KeyShore* database). In doing so, volumetric differences between the surveys were also calculated. Overlaying these six-monthly topographical beach surveys for each location enabled areas of **erosion** and **accretion** throughout the study period to be determined. Shore normal profiles at 500m intervals, starting from a common origin, were produced from these to highlight areas of change at each location. The findings were then interpreted. Oblique aerial photography of the coastline from Futurecoast (Halcrow, 2002) was used to assist in this process.

The following seven sections examine each location, discussing individual profiles (stating and analysing changes), followed by a general summary (incorporating volumetric data) and oblique aerial photographs showing the location(s). The relevant beach profiles and topographic surveys are also included in the figures section. An overall conclusion combining the findings of the seven localities is then presented. Limitations of the study and recommendations for future monitoring are also documented.

4.2 *Staithes Bay*

4.2.1 *Profile Analysis*

For Staithes Bay, beach survey data is available for:

- March 2002;
- October 2002.

It is not possible to overlay the surveys exactly, meaning profile analysis between the surveys must rely on the accuracy of the surveyors when re-establishing transects. The results can therefore only be an estimate and should be treated with due caution.

The following section examines each profile in turn, stating and analysing observed changes. A summary of Staithes Bay is presented in section 4.2.2. This is then followed by a photograph of a characteristic area of the Bay. The beach profiles and volumetric analysis are shown in figure 4.1 and figure 4.2, respectively.

(a) Profile 1

- Between March 02 and October 02 the profile gradient has remained fairly constant. A build-up of sediment is seen along the upper foreshore in both surveys.
- Slight upper foreshore **accretion** is observed between the two surveys; however as survey overlay is not exact at this location and the profile gradients appear to be very similar, this may be misleading. Extensive **erosion** is apparent along the lower foreshore between March and October 02.
- The limit of the profile on the lower foreshore, i.e. the concrete and rock groyne, is represented on the profile as a vertical line in the October 02 survey. In March 02 the vertical line is not evident and therefore the seaward limit of the profile appears to be between the two groynes (Photograph 4.1).
- Volumetric analysis is subjective at this location, due to the inability to overlay profiles exactly. The analysis reveals upper foreshore **accretion** and lower foreshore **erosion** along this profile over the study period available.

(b) Profile 2

- It was difficult to analyse this profile as the two surveys were in different locations when overlaid. This is seen where the vertical line positions on the lower foreshore of both surveys, representing the rock groyne extending offshore (Photograph 4.1), are in completely different locations.
- An accumulation of sediment on the upper foreshore is observed to varying degrees on both surveys where sediment has built-up in front of the seawall. Analysis however reveals that between March 02 and October

02 a considerable degree of upper foreshore **erosion** has occurred, while the middle foreshore has been relatively inactive.

- Volumetric analysis highlights upper and lower foreshore **erosion** over the study period, noting the unreliable nature of the surveys.

4.2.2 *Summary*

- A variety of coastal defence structures are located at Staithes, including seawalls and rock groynes. Two breakwaters in the north and east provide shelter to the harbour (Photograph 4.1). A river also flows into the northwest of the harbour. As such, it is likely that beach change will be the result of a combination of natural fluvial processes and as a result of the defence structures.
- Profile 1 is located where the river flows into the harbour and extends towards the gap between the two breakwaters. Upper beach **accretion** at this location may be due to the deposition of river sediment, while lower foreshore **erosion** may be attributed to increased scour caused by currents and eddies occurring between the ends of the two breakwaters.
- Profile 2 extends along the main beach in the bay and is backed by a seawall. Volumetric analysis appears to show overall **erosion** along the profile over the study period. This may be due to scour in front of the defences, caused by relatively exposed positions. The location of this profile is however very sheltered and therefore does not fit in with the findings.
- Overall vertical **erosion** of 7,432m³ has occurred in the harbour between March 02 and October 02. However **accretion** appears to be more dominant where the river flows into the harbour.
- As the co-ordinates for the two surveys at this location are different, the overall analysis is likely to be inaccurate and therefore results may be misleading.

Photograph 4.1. Defended Staithes Harbour coastline (taken at Profiles 1 and 2 on 21/04/01 at low water +3 hours).

4.3 Runswick Bay

4.3.1 Profile Analysis

For Runswick Bay, beach survey data is available for:

- March 2002;
- March 2003.

The March 2003 survey was completed using GPS, while March 2002 was carried out using a Total Station and therefore exact profile co-ordinates for March 2002 profiles were not discernable. It has been difficult to overlay the surveys exactly, meaning profile analysis between the surveys will only be an estimate and should be treated with due caution. It is also noted that although 5 profiles were surveyed in March 2003, only 3 (Profiles 2, 3 and 4) were located in the March 2002 data provided by Scarborough BC.

The following section examines each profile in turn, stating and analysing observed changes. A summary of Runswick Bay is presented in section 4.3.2. This is then

followed by photographs of characteristic sections and the beach profiles (figures 4.3 and 4.4).

(a) Profile 1

- Profile 1 was only available for March 2003. The profile gradient is steep and the profile distance (extending between 6m and 48m distance) is relatively short compared to profiles 2, 3 and 4.

(b) Profile 2

- Between March 2002 and March 2003 the profile gradient remained constant, with only slight **erosion** occurring on the lower foreshore.

(c) Profile 3

- The location of profile 3 appears to be different in the March 2002 survey, compared to the March 2003 survey. Comparison between surveys is therefore very difficult. If the two surveys are compared for the locations given, vertical **erosion** of approximately 0.5m appears to have occurred uniformly along the whole profile.

(d) Profile 4

- Again comparison between March 02 and March 03 is subjective at this location. However, **erosion** is evident along the lower foreshore.

(e) Profile 5

- Profile 5 was only available for March 2003. The profile gradient is the steepest and the profile the shortest (being approximately 30m) of all 5 profiles.

4.3.2 *Summary*

- This length of coastline is predominantly undefended, with the only form of protection being a small length of rock revetment, located landwards of profile 1 (Photograph 4.2). As such, it is likely that beach change will be the result of natural process and not the result of defence structures.
- Beach volume analysis was not carried out at this location as the co-ordinates for the March 2002 survey were incorrect and could not be overlaid with the March 2003 survey. It was only possible to analyse beach change generally using profile analysis for profiles 2, 3 and 4. Results

appear to show overall **erosion** for Runswick Bay over the study period, however this is very subjective and no actual values were calculated.

Photograph 4.2.: Defended Runswick Bay coastline (taken at Profile 1 on 21/04/01 at low water +3 hours).

Photograph 4.3. Undefended Runswick Bay coastline (taken at Profile 3 on 21/04/01 at low water +3 hours)

4.4 *Sandsend to Whitby Bay*

4.4.1 *Profile Analysis*

For Whitby Bay, beach survey data is available for:

- March 2002;
- October 2002;
- March 2003;
- January 2004;
- April 2004.

The following section examines each profile in turn, stating and analysing changes. A summary of Whitby Bay is presented in section 4.4.2. This is then followed by photographs of characteristic sections, the beach profiles (Figure 4.5 and 4.6) and the volumetric analysis (Figure 4.7).

(a) Profile 1

- Oct 02: steep upper foreshore profile (at a distance of 10-50m) and shallower lower profile (from 50m+);
- Oct 02 – March 03: steep profile step/**accretion**;

- Jan 04: upper and lower foreshore **erosion**, with the middle section experiencing little change. Similar gradient in April 04 but a slightly lower profile.

(b) Profile 2

- March 02: upper foreshore has a steep gradient at a distance of 2-22m, this being reduced by Oct 02. The lower foreshore shows a shallower profile. Whilst this gradient is maintained, it is lowered by Oct 02;
- March 03: **accretion** occurring on the upper and lower foreshore between 12-65m and 85-105m respectively;
- Jan 04: upper foreshore **erosion** (at a distance of 12-70m), lower foreshore **accretion** (from 70m+). Apr 04 has a similar profile but shows slight **erosion** in the lower foreshore area.

(c) Profile 3

- March 02 – Oct 02: upper foreshore **accretion** and lower foreshore **erosion;**
- Oct 02 – March 03: upper foreshore **erosion** with a significant reduction in the height of the storm berm at the rear of the beach. Lower foreshore shows evidence of **accretion;**
- March 03 – Apr 04: little change with a similar gradient being maintained;
- These fluctuations may result from the natural process of relative steepening/shallowing. Volumetric analysis reveals the upper and lower foreshore to be **eroding**, and the mid section to be **accreting**.

(d) Profile 4

- From March 02 – Apr 04, the beach profiles show little variation in gradient on the upper foreshore. The lower foreshore, however, undergoes a gradual reduction in beach slope. In March and Oct 02 the lower foreshore is dominated with a low graded beach platform. This profile is reworked by March 03;
- The lack of seawall/revetment in this locality may account for the greater volume of material occupying the upper foreshore (compared to defended profiles 1 and 2). This could originate from the unprotected backing cliffs, thus suggesting they are unstable. Volumetric analysis supports this, as it highlights upper/mid foreshore **accretion** throughout the study period (which extends sporadically to profile 5). This will, however, require confirmation in the cliff survey.

(e) Profile 5

- Vertical **erosion** of upper foreshore beach sediment between March 02 and Oct 02. **Accretion** of the upper foreshore from Oct 02 – March 03, with significant **erosion** taking place on the lower foreshore (resulting in a steepening of the lower beach profile). **Erosion** from March 03 – April 04;
- Significant **erosion** in the mid-foreshore section, at a distance of 38-104m, from March 03 and Jan 04. This profile is maintained thereafter;
- Oct 02 – March 03: **erosion** of lower foreshore from 62m+;
- The lack of seawall/revetment in this locality may account for the greater volume of material occupying the upper foreshore (compared to defended profiles 1 and 2). This could originate from the unprotected backing cliffs, thus suggesting they are unstable. Volumetric analysis supports this as it highlights upper/mid foreshore **accretion** throughout the study period. This will, however, require confirmation in the cliff survey.

(f) Profile 6

- Vertical **erosion** of sediment from March 02 – Oct 02. This is concentrated across the profile as a whole but reaches a maximum of approximately 2m at the beach crest;
- Oct 02 – March 03: minimal change except for the deposition of sediment towards the upper foreshore;
- March 03 – Apr 04: **erosion** of the lower foreshore with **accretion** in the middle/upper beach profile;
- The lack of seawall/revetment in this locality may account for the greater volume of material occupying the upper foreshore (compared to defended profiles 1 and 2). This could originate from the unprotected backing cliffs, thus suggesting they are unstable. This will, however, require confirmation in the cliff survey.

(g) Profile 7

- March 02 – Oct 02: significant **erosion** across the whole profile (~2m). Gradient remains stable;
- Oct 02 – Jan 04: progressive **accretion** year on year to a distance of approximately 74m. From 74m+ there is progressive **erosion** year on year. This profile is maintained in April 2004 with slight **erosion** in the lower foreshore;

- The significant reduction in beach level from March 02 – Oct 02 may be the result of a particular storm event. After this period the beach is progressively **accreting** sediment implying a plentiful supply;
- Lower volumes of sediment in the upper foreshore, compared to profiles 4, 5 and 6, may result from the presence of a seawall/revetment. As such, material would not be supplied from the backing cliffs. The volumetric analysis reveals general vertical **erosion** throughout the whole profile.

(h) Profile 8

- The beach profile demonstrates constant **erosion** from March 02 to Jan 04. From Jan 04 – April 04 the beach **accretes** sediment with the slope gradient remaining stable;
- March 02 survey may have followed a cliff input of sediment with the subsequent profiles reflecting the working of this;
- Lower volumes of sediment in the upper foreshore, compared to profiles 4, 5 and 6, may result from the presence of a seawall/revetment. As such, material would not be supplied from the backing cliffs. The volumetric analysis reveals general **erosion** throughout the whole profile.

(i) Profile 9

- March 02 – Oct 02: a combination of **erosion** and **accretion** on the upper and lower foreshore respectively;
- Oct 02 – Apr 04: **accretion** of sediment on the upper and lower foreshore, as well as an isolated area of **erosion** towards the middle of the beach profile;
- The greater volume of sediment in the upper foreshore could be attributed to by the presence of groynes. The volumetric analysis supports this, as it shows **accretion** in the upper foreshore throughout the study period.

(j) Profile 10

- Beach slope gradient remains constant between March 02 and Oct 02. However, the lower foreshore undergoes some **erosion** resulting in the removal of a bar like formation;
- Oct 02 - March 03: lower foreshore is **eroded** by ~0.5m with the gradient of slope remaining relatively constant;
- March 03 - Apr 04: Continued **erosion** of the lower to mid beach profile resulting in a pronounced bar like formation on the lower beach and a steeper upper foreshore;

- Volumetric analysis reveals overall **erosion** of the profile throughout the study period. This could possibly result from the presence of defences updrift which act to limit sediment supply to the area.

4.4.2 *Summary*

- Seawalls and revetments extend for much of the Whitby coastline, with only the central section (between profiles 4 and 6) remaining undefended (see Photographs 4.4 and 4.5 respectively). Groynes are also present at Sandsend and Whitby;
- Profiles with defences (1, 2, 3, 7, 8, 9, 10) generally have lower volumes of sediment, possibly due to the lack of supply from cliff sources;
- Profiles without defences (4, 5, 6) generally have greater volumes of sediment, possibly supplied from the unprotected backing cliffs or as a result of increased longshore drift supply;
- Overall vertical **erosion** of -244,833 m^3 from March 02 – April 04. Whilst this is experienced along the entire length, there are isolated areas that have been consistently accreting throughout the study period (their size fluctuating over time).

Photograph 4.4.. Defended cliffs, Whitby West Cliff (profile 8 on 21/04/01 at low water +3 hrs)

Photograph 4.5.. Undefended cliffs, Upgang Beach (profile 5 on 21/04/01 at low water +3 hrs)

4.5 Scarborough North Bay

4.5.1 Profile Analysis

For North Bay, beach survey data is available for:

- September 2001;
- March 2002;
- October 2002;
- March 2003;
- January 2004;
- April 2004.

The following section examines each profile in turn, stating and analysing changes. A summary of North Bay is then presented in section 4.5.2. This is followed by photographs of characteristic sections, the beach profiles (Figure 4.8) and the volumetric analysis (Figure 4.9).

(a) Profile 1

- Sept 01 – March 03: general **accretion**, similar gradient followed (steep upper/shallower lower foreshore);
- March 03 – Jan 04: upper foreshore **erosion**, lower foreshore **accretion** (steep upper/shallower lower profile maintained);
- Jan 04 – Apr 04: upper foreshore **accretion**, lower foreshore **erosion** (steep upper/shallower lower profile maintained);
- Beach profile fluctuations are minimal. This is possibly due to protection from wave action being provided by offshore rocks (see Photograph 4.6). The profile variations therefore suggest the beach is **relatively stable** (being in, or near to, equilibrium). Given the increased natural sheltering at this location, larger changes in beach volume or profile gradient are likely to result from significant storm activity.

(b) Profile 2

- Significant vertical **accretion** on upper foreshore from Oct 02 - March 03 (of approximately 1m), compared to all other profiles (which maintain similar gradients). **Accretion** throughout this period is also highlighted in profile 1, thus suggesting the waves were more constructive in nature;
- Overall vertical **accretion** on lower foreshore from Sept 01 – Apr 04 (approximately 1m);
- Beach profile fluctuations are minimal. This is possibly due to protection from wave action being provided by offshore rocks. This therefore implies the changing nature of the profile is linked to the natural process of relative steepening/shallowing.

(c) Profile 3

- Upper foreshore remains **relatively inactive** with little variation in beach gradient from Sept 01 – April 04. Exceptions to this, however, include the **erosion** of beach sediment in Oct 02 and the **accretion** of upper foreshore sections from Sept 01 – March 02;
- 70-130m (mid foreshore): steeper gradient with **accretion** from Oct 02 – March 03 (maintained thereafter);
- Sept 2001: material has been removed from the upper beach and deposited at a distance of 130m+ (lower foreshore).

(d) Profile 4

- Significant upper foreshore **accretion** of approximately 2m from Sept 01 – March 02 (at a distance of 14-56m). A maximum of approximately 1m

of vertical **erosion** from March 02 – March 03, particularly on the upper foreshore. From March 03 – Apr 04 sediment has **accreted** along the whole profile;

- As less protection is provided by offshore rocks, the amount of wave action acting upon the beach would increase. This may therefore account for the greater **accretion/erosion** fluctuations (particularly of the upper foreshore) in comparison to profiles 1, 2 and 3. This implies an increased vulnerability of this section of coastline;
- Volumetric analysis reveals the lower foreshore to be progressively **eroding** year on year, thereby highlighting the trend for vertical **erosion** in this location.

(e) Profile 5

- Sept 01: profile fluctuates vertically between -0.6 and -1.1m. It appears as though destructive wave action has removed material from the upper foreshore and deposited it on the lower foreshore (at a distance of 75m+);
- Sept 01 – March 02: significant **accretion** at a distance of 20-90m;
- March 02 – Oct 02: slight upper foreshore **erosion** at a distance of 20-76m. Lower foreshore **accretion** at 76m+;
- Oct 02 - Apr 04: upper foreshore **accretion** at a distance of 20-60m, lower foreshore **erosion** at 60m+;
- The relatively exposed nature of this locality, in relation to those updrift (profiles 1, 2, 3 and 4), has resulted in a **highly dynamic** beach profile, which changes significantly in form and gradient year on year;
- Despite these fluctuations, volumetric analysis reveals the upper foreshore to be **accreting** and lower foreshore to be **eroding** year on year. These areas are can therefore be considered **accretion** and **erosion** hotspots. This trend continues through to profile 6.

(f) Profile 6

- March 02 – Oct 02: upper foreshore **accretion** at a distance of 26-50m, lower foreshore **erosion** at 50m+;
- **Erosion** on the upper and lower foreshore of approximately 0.25m from Oct 02 – March 03;
- March 03 - Apr 04: **accretion** at a distance of 26-32m resulting in steep profile, **erosion** from 32-39m and **accretion** from 39m+. This profile is characteristic of destructive storm waves;
- The exposed nature of this locality has resulted in a profile that, in the main, fluctuates year after year. Despite these fluctuations, volumetric

analysis reveals the upper foreshore to be **accreting** and lower foreshore to be **eroding** year after year.

4.5.2 *Summary*

- A seawall extends along the entire length of North Bay from Scalby Mills to Castle Headland (see Photograph 4.6 and 4.7);
- Overall vertical **accretion** of 19,333m³ from Sept 01 – April 04. Beach profiles 1-4 generally remain consistent between survey periods, whilst profiles 5 and 6 demonstrate significant variations (characteristic of destructive storm waves). As such, beach profiles in the north of North Bay can be considered to fluctuate but **remain generally stable**, while profiles further south have the potential for **significant variations** of volume and gradient.

Photograph 4.6.. Rocky offshore area at profile 1, North Bay (taken 21/04/01 at low water +3 hrs)

Photograph 4.7.: A typical view of North Bay (taken at profile 4 on 21/04/01 at low water +3 hrs)

4.6 *Scarborough South Bay*

4.6.1 *Profile Analysis*

For South Bay, beach survey data is available for:

- October 2001;
- April 2002;
- October 2002;
- March 2003;
- January 2004;
- April 2004.

The following section examines each profile in turn, stating and analysing changes. A summary of South Bay is then presented in section 4.6.2. This is followed by photographs of characteristic sections, the beach profiles (Figure 4.10) and the volumetric analysis (Figure 4.11).

(a) Profile 1

- Steep profile step from Oct 01 – Apr 02. Thereafter the profile remains **relatively inactive** with only minor fluctuations occurring. These fluctuations specifically relate to the upper beach, from 12-40m, where there has been vertical **accretion** from Oct 01 - Oct 02, **erosion** from Oct 02 - March 03 and **accretion** thereafter;
- The beach was reprofiled in Apr 2001, giving rise to the Oct 2001 profile. Between Apr 02 – Apr 04, upper and lower beach profiles are **inactive,** suggesting a form of equilibrium has been reached. This may have been the result of further beach reprofiling in March 02, 03 and 04. The minor fluctuations during this time are, therefore, likely to be linked to the natural process of sediment transport producing relative steepening/shallowing;
- Despite these minor fluctuations, volumetric analysis reveals the whole profile to be vertically **accreting** throughout the study period.

(b) Profile 2

- Between Oct 01 – Apr 02 there is vertical **accretion** on both the upper and lower beach, thus maintaining the profile;
- Apr 02 – March 03: slight lowering and **erosion** of upper foreshore;
- March 03 – Apr 04: **accretion/erosion** fluctuation;
- The beach profiles are generally maintained to a similar gradient, this possibly being the result of beach reprofiling in April 01 and March 02, 03 and 04. The minor fluctuations during the study period are, therefore, likely to be linked to the natural process of sediment transport producing relative steepening/shallowing. Volumetric analysis reveals the whole profile to be vertically **accreting** throughout the study period.

(c) Profile 3

- Upper foreshore (12-66m): **accretion** from Oct 01 – Apr 02, **erosion** from Apr 02 – Jan 04, **accretion** from Jan 04 – Apr 04;
- Lower foreshore (66m+): **accretion** from Oct 01 – Apr 02, **erosion** from Apr 02 – March 03, **accretion** from March 03 – Apr 04;
- Fluctuations in **erosion/accretion** are likely to be linked to the natural process of relative steepening/shallowing;
- Volumetric analysis reveals the whole profile to be **accreting**. However, between profiles 3 and 4, sporadic areas of **erosion** in the upper foreshore are shown (the size of the area fluctuating over time). This is possibly due

to a reduction in longshore drift sediment supply, caused by defences updrift of the site.

(d) Profile 4

- Upper foreshore (0-14m): **accretion** and profile steepening from Oct 01 – Apr 02, **erosion** from Apr 02 – Oct 02, **accretion** thereafter;
- In Apr 02 there is a significant area of **erosion** at a distance of approximately 5-25m, this possibly being the result of a destructive high tide. Volumetric analysis also reveals increased **erosion** during this period;
- Lower foreshore (14m+): general **accretion** from Oct 01 – Jan 04, **erosion** from Jan 04 – Apr 04 (with beach profile remaining relatively stable throughout this period);
- Volumetric analysis reveals the upper foreshore between profiles 4 and 5 to be **eroding** over time (the size of area fluctuating). This **erosion** extends to the lower foreshore mid-way between the two profiles (thereby highlighting a definite **erosion** trend). This is possibly due to a reduction in longshore drift sediment supply, caused by defences up drift of the site.

(e) Profile 5

- Upper foreshore (12-46m): **erosion** from Apr 02 – Oct 02, **accretion** from Oct 02 – March 03, **erosion** from March 03 – Jan 04, **accretion** from Jan 04 – Apr 04;
- Lower foreshore undergoes general **accretion** from April 02 – Jan 04, and **erosion** from Jan 04 – Apr 04;
- Volumetric analysis reveals the entire profile length to be **eroding**. This is possibly due to a reduction in longshore drift sediment supply, caused by defences updrift of the site.

4.6.2 *Summary*

- A seawall is present along the entire length of South Bay (see Photographs 4.8 and 4.9). Beach reprofiling has also been carried out in the north (April 01 and March 02, 03 and 04),,the location of which is evident in Photograph 4.8;
- Overall vertical **accretion** of 33,364m^3 from Oct 01 – April 04. This encompasses almost the entire length of the beach. However, **erosion** is experienced in the southern half, predominantly at the southern tip.

Photograph 4.8.: The site of the beach re-profiling (at profiles 1 and 2 on 21/04/01 at low water +3 hrs)

Photograph 4.9.: Profile 4, South Bay (taken at 21/04/01 at low water +3 hrs)

4.7 *Cayton Bay*

4.7.1 *Profile Analysis*

For Cayton Bay, beach survey data is available for:

- March 2002;
- October 2002;
- March 2003;
- January 2004;
- April 2004.

The following section examines each profile in turn, stating and analysing changes. A summary of Cayton Bay is then presented in section 4.7.2. This is followed by photographs of characteristic sections, the beach profiles (Figure 4.12) and the volumetric analysis (Figure 4.13).

(a) Profile 1

- Beach profile gradients remain **relatively constant** from March 02 – Apr 04. This is possibly due to the sheltering effect produced by the natural geography of the coastline. This will result in little reworking of sediment by wave action (see Photographs 4.10 and 4.11);
- Volumetric analysis reveals the profile throughout the study period to be **eroding**. It can be concluded from this, that little material is being supplied from the undefended backing cliffs. This suggests that the cliffs at this locality are relatively stable. However, this will require confirmation in the cliff survey;
- The volumetric analysis does, however, highlight a small **accretion** hotspot updrift from profile 1, the size fluctuating throughout the study period. This may suggest an isolated unstable section of undefended cliff is supplying material. This will also require confirmation in the cliff survey;
- Between profiles 1 and 2, the volumetric analysis highlights upper foreshore **accretion** and lower foreshore **erosion** in all profiles (the extent of each fluctuating throughout the study period).

(b) Profile 2

- Beach profile surveys for March 02, Oct 02 and March 03 seem to be incomplete compared to those made in Jan and April 04;
- March 02 – Oct 02: **accretion** in upper foreshore;
- Oct 02 – March 03: upper foreshore **accretion** and steepening of profile (to a distance of 42m), lower foreshore **erosion** (from 42m+). This gives

rise to a steep upper and shallower lower profile, that is maintained from March 03 – Apr 04;

- Between profiles 2 and 3, volumetric analysis highlights general **accretion** in the upper foreshore (possibly supplied from undefended backing cliffs) and **erosion** in the middle/lower foreshore throughout the study period, the size of these areas fluctuating over time. The undefended coastline suggests these fluctuations are the result of natural alterations in sediment supply from the cliff at the back of the beach. However, a section of **erosion** exists in the upper foreshore, just updrift from profile 3, throughout the study period. A seawall is located here, thus suggesting this is possibly the result of wave scour.

(c) Profile 3

- March 02 – Oct 02: upper foreshore **erosion** at a distance of 6-44m, lower foreshore **accretion** at 44m+;
- Oct 02 – March 03: upper foreshore **accretion** (between 6-70m), lower foreshore **erosion** (from 70m+);
- March 03 – Apr 04: area of **erosion** that is most pronounced between 40-120m;
- Volumetric analysis highlights **erosion** in upper foreshore throughout the study period. This is possibly the result of terminal scour caused by the seawall located updrift;
- Further fluctuations in **erosion/accretion** are likely to be linked to the natural process of relative steepening/shallowing and not the result of scour or altering sediment supply caused by beach defences.

(d) Profile 4

- March 02 – March 03: little profile change with generally similar gradients maintained. Whole profile undergoes lowering between March 03 and Apr 04 as a result of gradual erosive processes;
- There are no coastal defence structures in this locality, therefore high volumes of sediment in upper foreshore are likely to originate from cliff sources, thus implying they are unstable. This will require confirmation in the cliff survey;
- Volumetric analysis reveals general **erosion** throughout the study period, with 2 **accretion** hotspots in the upper and mid profile (the size fluctuating over time with the former being more extensive).

(e) Profile 5

- March 02 – Oct 02: upper foreshore **accretion** (at a distance of 10-32m) accompanied by lower foreshore **erosion** (from 32m+);
- Oct 02 – March 03: vertical **erosion** of the upper foreshore;
- March 03 – Apr 04: previous **profile maintained** revealing 3 distinct sections (steep from 10-24m, shallower from 24-70m, steep from 70m+);
- These fluctuations are only minor, possibly due to the relatively protected nature of the location, provided by the offshore Calf Allen Rocks, reducing the level of wave action;
- Volumetric analysis reveals the whole profile to generally be **eroding**.

4.7.2 *Summary*

- This length of coastline is predominantly undefended, with a 60-70m seawall, located just updrift of profile 3, providing the only form of protection (see Photographs 4.10 and 4.11). As such, it is likely that fluctuations in **erosion/accretion** are predominately linked to natural processes and not the result of defence structures;
- Overall vertical **erosion** of 137,175m^3 from March 02 – April 04. Whilst this is experienced along the entire length, there are isolated areas that have been consistently accreting throughout the study period (their size fluctuating over time).

Photograph 4.10.: Protection offered at profile 1 at Cayton Bay (taken 21/04/01 at low water +3 hrs)

Photograph 4.11.: Central Cayton Bay and sea wall (taken at profile 4 on 21/04/01 at low water +3 hrs)

4.8 Filey Bay

4.8.1 Profile Analysis

For Filey Bay, beach survey data is available for:

- March 2002;
- October 2002;
- March 2003;
- January 2004;
- April 2004.

The following section examines each profile in turn, stating and analysing changes. A summary of Filey Bay is presented in section 4.8.2. This is then followed by photographs of characteristic sections, the beach profiles (figures 4.14 and 4.15) and the volumetric analysis (figure 4.16).

(a) Profile 1

- Beach profile gradients remain constant for all years. Although the main foreshore has been relatively inactive, slight **erosion** has occurred between March 02 and April 04.
- March 02 – Oct 02: lower foreshore **erosion** has occurred where the beach has lowered by approximately 0.25m.
- Oct 02 – March 03: **accretion** has occurred on the lower foreshore, at a distance of 220m+.
- April 04: **erosion** has taken place on the lower foreshore where gradual lowering has occurred of around 0.25m to 0.5m, between 220m and 256m distance respectively.
- Volumetric analysis confirms that the profile is progressively **eroding** year on year, thereby highlighting the trend for overall vertical **erosion** in this location. Given the natural sheltering at this location, changes in beach volume are likely to result from significant storm activity.

(b) Profile 2

- This profile is also relatively inactive, reflected in constant beach profile gradients between March 02 and April 04.
- March 02 – Oct 02: slight **erosion** on both the upper and lower foreshore, at a distance of 34-110m and 210m+ respectively.

- March 03 – April 04: lower foreshore **erosion** is evident (210m+), occurring in a gradual manner similar to Profile 1.
- Volumetric analysis reveals overall **erosion** at this location throughout the study period. Minimal beach profile fluctuations however, are again afforded to the relatively sheltered nature of the beach.

(c) Profile 3

- Beach profile gradients are again relatively constant for all years.
- March 02 – Oct 02: sediment from the lower foreshore has been redistributed to the upper foreshore, resulting in slight **erosion** after 160m and sediment **accretion** between 36-56m distances.
- Oct 02 – March 03: material has **eroded** from the upper foreshore (36-85m) and **accreted** on the lower foreshore (85m+).
- April 04: vertical **accretion** of approximately 0.25m is evident on the highest limits of the upper foreshore (36-44m). Slight **accretion** is evident along the mid/lower foreshore; however the beach shows signs of significant **erosion** after a distance of 225m, similar to Profiles 1 and 2.
- Volumetric analysis highlights general upper/lower foreshore **erosion** and middle foreshore **accretion** at this profile over the study period. The section of **erosion** along the upper foreshore may be a result of wave scour in front of the seawall defences. This trend continues through to Profile 4 (photograph 4.12).

(d) Profile 4

- Profile gradient change is negligible between March 02 and April 04.
- March 02 – Oct 02: upper foreshore **accretion** at a distance of 20-90m.
- March 02 – April 04: lower foreshore **erosion** consistent with the previous profiles at this location.
- Oct 02 – April 04: slight upper foreshore **erosion** and middle beach **accretion**.

(e) Profile 5

- Unprotected and unstable backing cliffs may account for an increase in beach height at this location, where the upper beach is approximately 0.5m higher than the preceding four profiles. Cliff instability will, however, require confirmation in the cliff survey.
- March 02 – March 03: the profile remains relatively inactive, with a constant gradient visible throughout this period.
- April 04: a localised point of **erosion** is evident on the upper/middle foreshore between distances of 50-110m. Here the profile has **steepened** and a **berm** has formed, possibly the result of a destructive high tide. Vertical **erosion** has also occurred on the lower foreshore at a distance of 255m+, lowering the beach by up to 0.5m.
- Volumetric analysis reveals upper/lower foreshore **erosion** and middle foreshore **accretion** at this location throughout the study period. This trend continues through to Profiles 6 and 7.

(f) Profile 6

- March 02 – March 03: upper foreshore has remained inactive.
- Fluctuations of **erosion/accretion** are observed on the lower foreshore between March 02 and April 04. Significant **erosion**, profile **steepening** and **berm** formation is evident in Oct 02 between the distances of 180-255m, however by April 04 the profile has regained a more uniform gradient on the lower foreshore.
- April 04: **erosion** between distances of 62-166m on the upper beach. **Berm** formation at a distance of ~85m has resulted in upper foreshore **steepening**.

(g) Profile 7

- March 02 – Oct 02: **accretion** on the middle/lower foreshore (185m+), where a considerable **berm** has formed between distances of 170-250m.
- Vertical **erosion** of ~0.5m is evident on the lower foreshore between Oct 02 and March 03 (at a distance of 185m+) and at a distance of ~280m+ in April 04, lowering the beach by up to 0.5m and creating a smoother profile.
- April 04: localised **erosion** on the upper foreshore at around 85m distance, resulting in a **steeper** upper beach profile and the formation of a small **berm**.

(h) Profile 8

- The beach profile gradient is different from the previous profiles, with a steep upper and shallow lower foreshore.
- March 02 – April 04: Both March 02 and April 04 profiles are very similar in appearance. **Erosion/accretion** fluctuations have occurred between these dates.
- These fluctuations may result from the natural process of relative steepening / shallowing. Volumetric analysis reveals the upper foreshore to be **accreting**, and the lower section to be **eroding** over the analysis period.

(i) Profile 9

- The stepped profile is relatively active between Mar 02 and April 04 compared to the 8 previous profiles.
- March 02 – March 03: **accretion** on both the upper and lower foreshores between March 02 and October 02, followed by further **accretion** in March 03.
- March 03 – April 04: upper and lower foreshore **erosion.**
- Volumetric analysis reveals general **accretion** across the profile throughout the study period. The lack of seawall/revetment in this locality may account for the **accretion** of material along the upper foreshore. This could originate from the unprotected backing cliffs, thus suggesting they are unstable. This will, however, require confirmation in the cliff survey.

(j) Profile 10

- March 02 – Oct 02: general **accretion** on middle/lower foreshore (steep upper beach/shallow foreshore/berm formation between 220-280m distances).
- Oct 02 – March 03: general **erosion** along the profile.
- March 03 – April 04: vertical **erosion** along the length of the profile.
- Volumetric analysis reveals general **erosion** of the profile throughout the study period at this undefended location (photograph 4.13).

(k) Profile 11

- March 02 – Oct 02: upper foreshore **accretion** of ~0.5m between the distances 46-140m.
- Oct 02 – March 03: **erosion** is evident on the middle/lower beach, by up to ~0.75m in places. Upper foreshore inactive.
- March 03 – April 04: **accretion** between the distances 120-200m. Upper foreshore inactive.
- The exposed nature of this locality has resulted in a profile that, in the main, fluctuates year after year. Despite these fluctuations, volumetric analysis reveals general **erosion** of the foreshore throughout the study period.

(l) Profile 12

- The profile (steep upper /shallower lower foreshore) is very dynamic, where significant sediment **erosion/accretion** fluctuations occur between March 02 and April 04, where sediment is reworked up and down the profile.
- March 02 – Oct 02: upper foreshore **erosion** (at a distance of 66-100m), middle foreshore **accretion** (between 100-175m) and lower beach **erosion** (from 175m+).
- Oct 02 – March 03: upper foreshore **accretion** (at a distance of 66-90m) and lower foreshore **erosion** (from 150m+).
- March 03 – April 04: sediment is **eroded** from the middle beach at distances 95-155m and transported to the lower foreshore where **accretion** is observed between the 155-210m distance.
- The exposed nature of this locality has resulted in a profile that, in the main, fluctuates year after year. Volumetric analysis however, reveals general upper foreshore **accretion** and lower foreshore **erosion** at this location over the study period.

(m) Profile 13

- **Steep** upper foreshore gradient which progressively **shallows** along the lower foreshore. The profile has the highest upper foreshore height (>2.5m) of all the Filey profiles.

- March 02 – April 04: overall **erosion** along the whole profile. The upper foreshore section of the Oct 02 profile appears to be in error and is therefore excluded from the analysis.
- Volumetric analysis reveals that this undefended section of Filey Bay is experiencing overall **erosion** throughout the study period.

(n) Profile 14

- The profile exhibits a concave shape where the upper foreshore is steep, while the lower foreshore is relatively shallow. This is reflected in the volumetric analysis where the upper foreshore is **eroding** and the lower foreshore is **accreting** over the period analysed.
- March 02 – March 03: upper beach **erosion** between distances 64-145m, and significant lower foreshore **accretion** from a distance of 145m+. Vertical **accretion** of ~1m is observed at distance 236m.
- March 03 – April 04: **accretion** of sediment on the upper foreshore (at a distance of 78-135m) and **erosion** on the lower foreshore (from 135m+).

4.8.2 *Summary*

- This length of coastline is predominantly undefended; however a seawall extending along the short distance of upper foreshore between profiles 2 and 4 provides the only form of protection. It is likely therefore that fluctuation in **erosion/accretion** is predominantly linked to natural processes and not the result of defence structures.
- Overall vertical **erosion** of 289,434m³ is evident between March 02 and April 04. Whilst **erosion** is predominant along profiles in the undefended section of beach in the north of Filey Bay, profiles with defences display upper/lower foreshore **erosion** and middle foreshore **accretion** over the same time period.
- The majority of Filey Bay, to the south of the defences, has in general experienced upper/lower foreshore **erosion** and middle foreshore **accretion** between March 02 and April 04. Along this section of beach there are also areas which have experienced upper foreshore **accretion**, possibly linked with the accumulation of material originating from the unprotected cliffs.
- Profiles 1-8 are relatively inactive where profile gradients generally remain consistent between survey periods, due to the sheltered nature of the coast at these locations. Profiles 9-14 however, being in an exposed position are

relatively active, demonstrating significant gradient variations and fluctuations, characteristic of destructive storm waves. As such, beach profiles in the north of Filey Bay are considered to be **eroding** overall throughout the study period, but **remain generally stable**, while profiles further south have the potential for **significant variations** of volume and gradient, fluctuating between **erosion/accretion** along the upper/middle/lower foreshores.

Photograph 4.12.: Defended Filey Bay coastline (taken at Profile 4 on 21/04/01 at low water +3 hours).

Photograph 4.13.: Undefended Filey Bay coastline (taken at Profile 10 on 21/04/01 at low water +3 hours).

5 Conclusion

A summary of the results of the analysis of cliff activity, structural assets and beach profiles is shown in Figure 5.1. This figure shows the key hotspots identified in each of the surveys and also shows the key assets at risk from coastal **erosion** and the environmental designations which may be affected. With relation to the cliffs, particular hotspots are seen at Kettleness, Sandsend, Saltwick Nab, Rain Dale, Roin Hood's Bay, White Nab, Cornelian Bay, Killlerby Cliff, Filey Brigg, Hunmanby Gap and Speeton Sands. Of these areas, White Nab, Cornelian Bay and Speeton Cliffs are of particular concern, having increased significantly in landslide activity between 2002 and 2005.

The following key areas can be identified from the map, where multiple hotspots and assets coincide:

- Staithes, where active cliffs coincide with a SSSI;
- Sandsend, where there is a cluster of structural assets at risk and active cliffs;
- Whitby East Cliff, where active cliffs threaten a SSSI and a range of properties and infrastructure assets;
- Robin Hood's Bay, where many active cliffs coincide with a SSSI;
- Scarborough North Bay, where numerous properties and a SSSI are at risk;
- Cornelian Bay, where active cliffs threaten a SSSI;
- Cayton Bay, where active cliffs and beach lowering threaten structural assets and a SSSI;
- Filey Brigg, where active cliffs threaten the SSSI; and
- Speeton Sands, where active cliffs threaten a number of properties.

Visual analysis of cliff activity has been undertaken for the whole coastline of North Yorkshire from Staithes to Speeton. 270 cliff units are recognised and have been classified as being dormant, inactive, locally active, partly active or totally active. The distribution of cliff activity classifications in 2005 and in the previous survey of 2002, are shown in Figure 5.1.

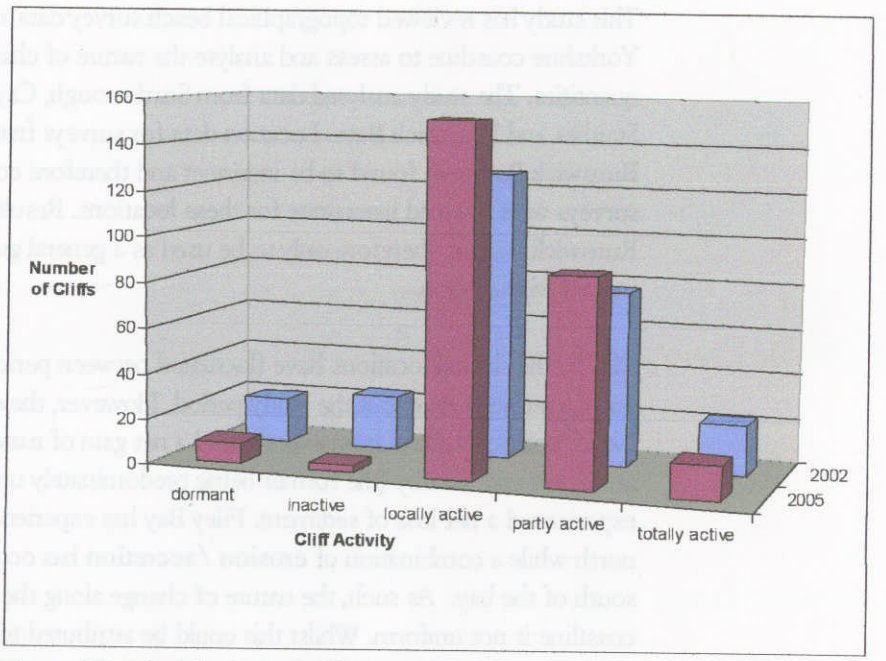


Figure 5.2. Distribution of cliff activity classification in 2002 and 2005.

The Figure shows that cliffs were predominantly classified as being locally active in both surveys. This suggests that shallow, small scale cliff failures are common along the whole coastline. Between 2002 and 2005, the number of partly active cliffs has increased slightly, while the number of totally active cliffs has decreased. This pattern suggests on-going episodic failure of cliffs through landsliding in a small number of cliffs. Because part of the 2002 survey was undertaken using a different classification scheme, subtle differences in the two annual surveys may not be significant.

The data from the analysis of coastal defence assets shows that the majority of structures in a moderate to good condition, with many examples of newly built structures, such as at Scarborough Castle Headland. Important exceptions to this general pattern are seen at Staithes, where harbour walls are in a poor state of repair and Runswick Bay, Sandsend and Whitby West Cliff where coastal defences are in need of attention. Attention was also drawn to the West Pier of Scarborough harbour, the beach access path at Cayton Bay, Filey sailing club and Filey town sea defences at Martins' Gill, where existing defences are also in a poor condition. The West and East Piers were only partially inspected due to the prevailing tidal levels.

This study has reviewed topographical beach survey data along the North Yorkshire coastline to assess and analyse the nature of change in beach levels and quantities. The study analysed data from Scarborough, Cayton, Whitby, Filey, Staithes and Runswick Bays. Location data for surveys from Staithes Bay and Runswick Bay were found to be incorrect and therefore comparisons between surveys were deemed inaccurate for these locations. Results for Staithes Bay and Runswick Bay are therefore only to be used as a general guide and should be treated with caution.

The 5 other beach locations have fluctuated between periods of vertical erosion and accretion throughout the study period. However, the defended Scarborough North and South Bays have experienced a net gain of material, whilst the beaches at Cayton and Whitby (the former being predominately undefended) have experienced a net loss of sediment. Filey Bay has experienced net **erosion** in the north while a combination of **erosion /accretion** has occurred in the middle and south of the bay. As such, the nature of change along the North Yorkshire coastline is not uniform. Whilst this could be attributed to the presence of defences and beach profiling, further analysis will be required to confirm this. Other factors contributing towards the nature of change may include the nature of wave attack, stability of backing cliffs and geographical characteristics of the locality.

5.1 Limitations of the Studies

The quality of the analysis of cliff activity is limited by the qualitative nature of the assessment, whereby there may be variation in geomorphologists' ability to discern the different classifications of activity during annual inspections. This is particularly the case in the northern section of the study area, where the 2002 and 2005 surveys were undertaken using different approaches.

In this study, a five-fold classification of cliff activity has been used because this can be applied to the cliffs with a high degree of confidence. The relatively coarse nature of this approach is recognised, especially when compared to the ten-fold scheme adopted by High Point Rendel. Confidence in the results of a ten-fold classification scheme under repeat surveys is questionable.

Only a partial inspection of the East and West Piers at Whitby was carried out. Future surveys should be timed to coincide with lowest Low Water Springs, or the survey should be carried out from a boat.

The following frontages are identified in the drawing data provided by Scarborough Borough Council, but for which no entry is made in the *KeyShore* database.

- Whitby Harbour, West Pier
  26-11B-01 and 26-11B-02
- Whitby Harbour East Pier
  27-11B-02
- Staithes Harbour
  02-04-01, and 04-04-01

It has not been possible to create the data entries due to the limitations of the licence and associated access rights. The original data sheets have been included in Appendix 1. A consequence of this is that it has not possible to make comparisons with previous surveys.

With regard to the beach profile study, it was noted that a number of the beach profile lengths vary, which may result from the collection of data at different tidal periods, thus implying a lack of continuity between surveys. Drawing definitive conclusions is challenging due to the limited number of surveys conducted (between 4 and 6 for each locality) and the limited time span covered (ranging from 18 to 31 months). In addition to this, the results are limited by the inconsistency of approach for survey methods, for some of the locations. This has entered an element of uncertainty and the results must be treated with caution.

Furthermore, the beach profile analysis is limited due to the lack of wave and tidal data. As such, no definitive conclusions can be made.

5.2 *Recommendations for future work*

It is recommended that walk-over surveys continue to be undertaken in the future, to identify changes in cliff activity and hotspots, in order to improve the precision of the cliff assessment, but also to provide a high level of accuracy. Consideration should be given to undertaking regular (2 to 5 yearly) vertical aerial surveys of the coastline. A state-of-the-art product may include simultaneous collection of digital photography and LiDAR allowing very accurate location of the cliff edge. Using GIS would permit accurate measurements of coastal change, and identification of hotspots for the whole coastline.

Using current technology it is possible to collect digital aerial imagery at a pixel resolution of around 12.5cm, and an elevation model at a ground resolution of 0.5m, with an accuracy of ±15cm.

Various actions are identified for assets along the coast and these are listed for each of the areas in turn. It is recommended that missing asset entries be included to the *KeyShore* database to ensure comparative assessments of condition can be made in future surveys.

With respect to the beach profile study, it is recommended that surveys should continue to be conducted at the same frequency (6 monthly intervals). If the regularity of surveys were increased it is felt that there would be too much data, thereby jeopardising the extraction of meaningful results. Analysis of the data should continue to take place every three years (thereby analysing a further six surveys). Monitoring should be conducted using uniform methods at each location, for ease of comparison.

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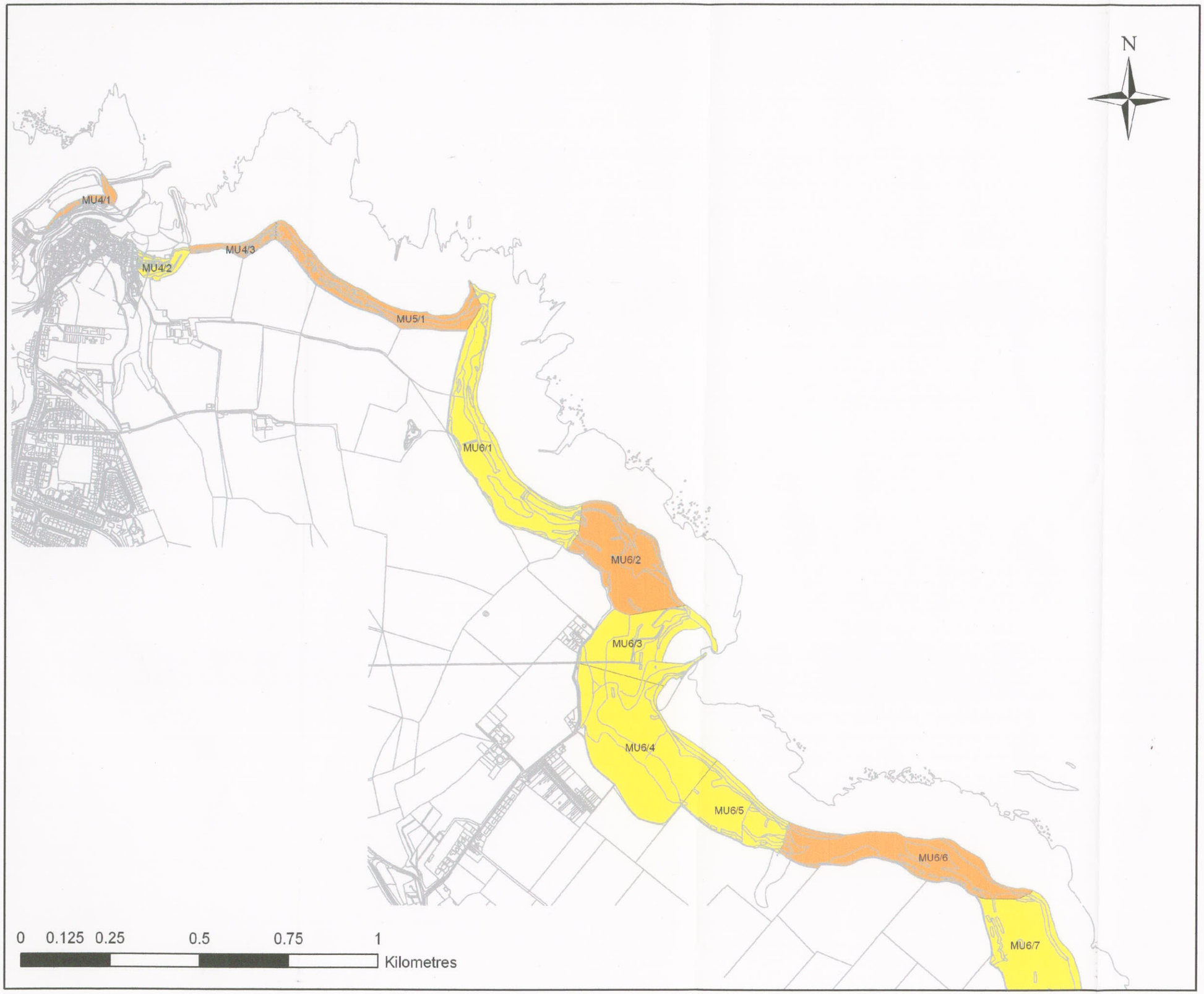
7 Figures



Scarborough Borough Council

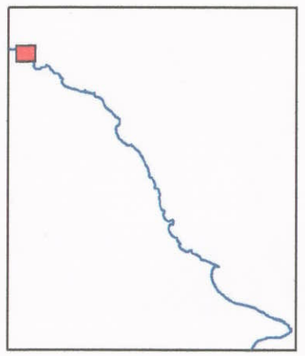
Strategic Cliff Monitoring, May to June 2005

Figure 2.1. Staithes

Cliff activity, 2005

- dormant
- inactive
- locally active
- partly active
- totally active

Drawing scale 1:10 000



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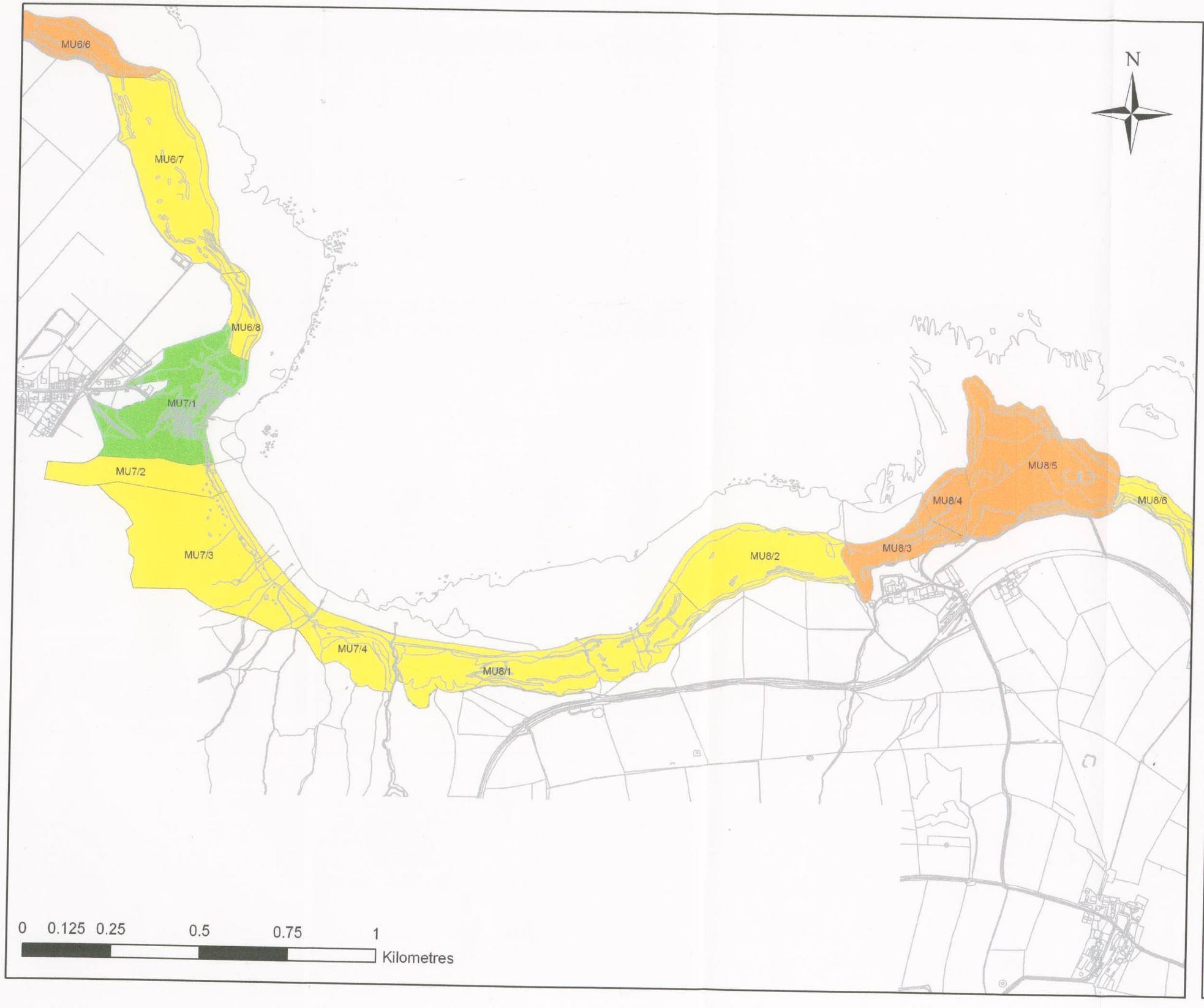
Strategic Cliff Monitoring, May to June 2005

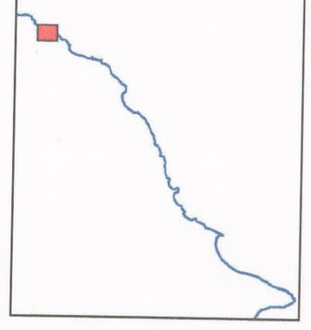
Figure 2.2. Runswick Bay



Cliff activity, 2005

- dormant
- inactive
- locally active
- partly active
- totally active

Drawing scale 1:10 000



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MU8/11
MU8/12
MU8/13
MU8/14
MU8/15

N

0 0.125 0.25 0.5 0.75 1
Kilometres

Scarborough Borough Council

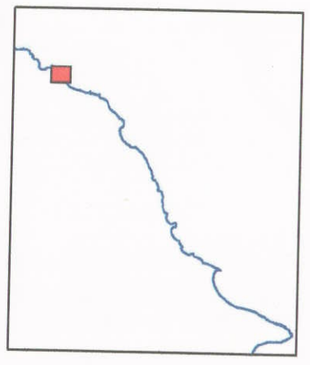
Strategic Cliff Monitoring, May to June 2005

Figure 2.3. Goldsborough

Cliff activity, 2005

- dormant
- inactive
- locally active
- partly active
- totally active

Drawing scale 1:10 000



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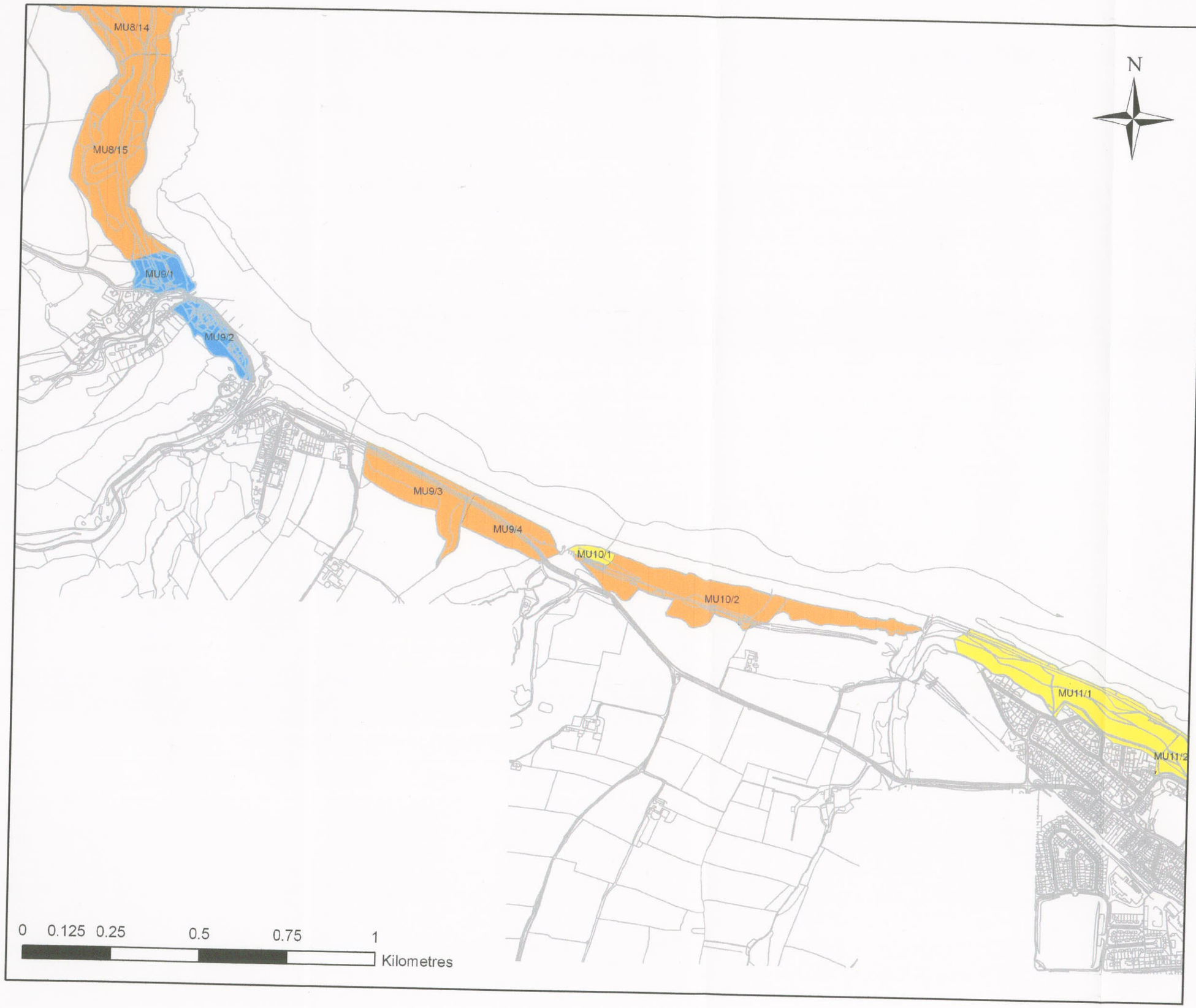


Scarborough Borough Council

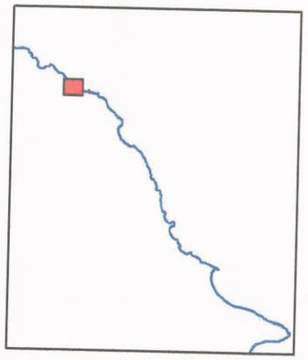
Strategic Cliff Monitoring, May to June 2005

Figure 2.4. Sandsend

Cliff activity, 2005

- dormant
- inactive
- locally active
- partly active
- totally active

Drawing scale 1:10 000



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MU11/2

MU11/3

MU11/4

MU12/1

MU12/2

MU13/1

MU13/2

MU13/3

MU13/4

MU13/5

0 0.125 0.25 0.5 0.75 1

Kilometres

Scarborough Borough Council

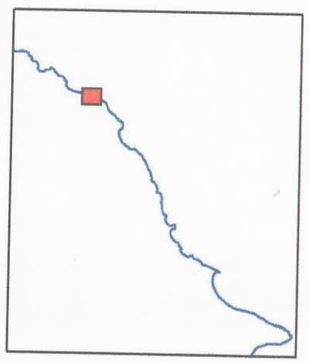
Strategic Cliff Monitoring, May to June 2005

Figure 2.5. Whitby

Cliff activity, 2005

- dormant
- inactive
- locally active
- partly active
- totally active

Drawing scale 1:10 000



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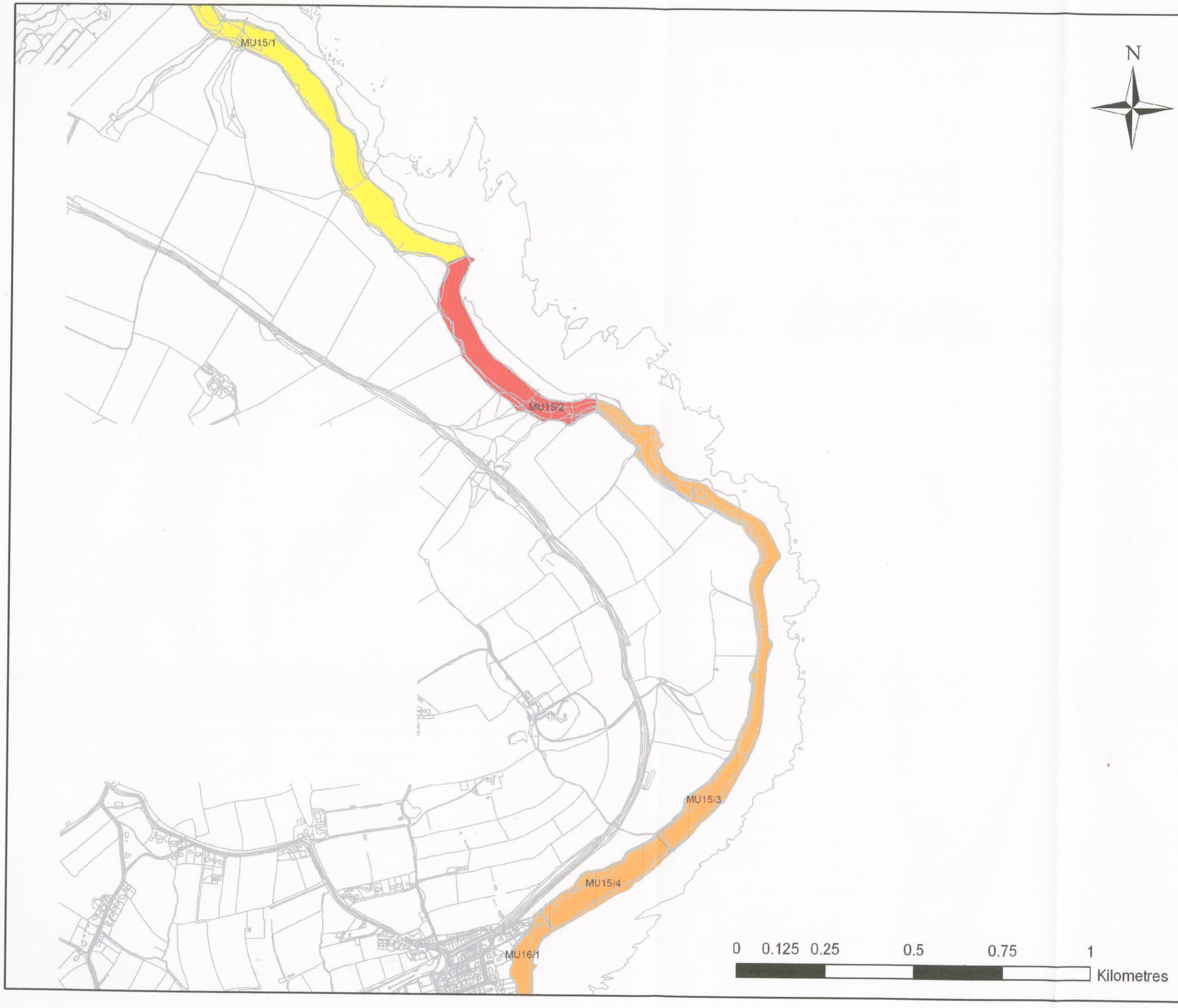


Scarborough Borough Council

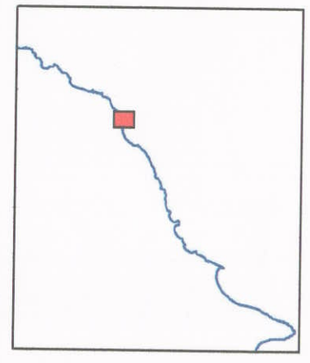
Strategic Cliff Monitoring, May to June 2005

Figure 2.7. Rain Dale

Cliff activity, 2005

- dormant
- inactive
- locally active
- partly active
- totally active

Drawing scale 1:10 000



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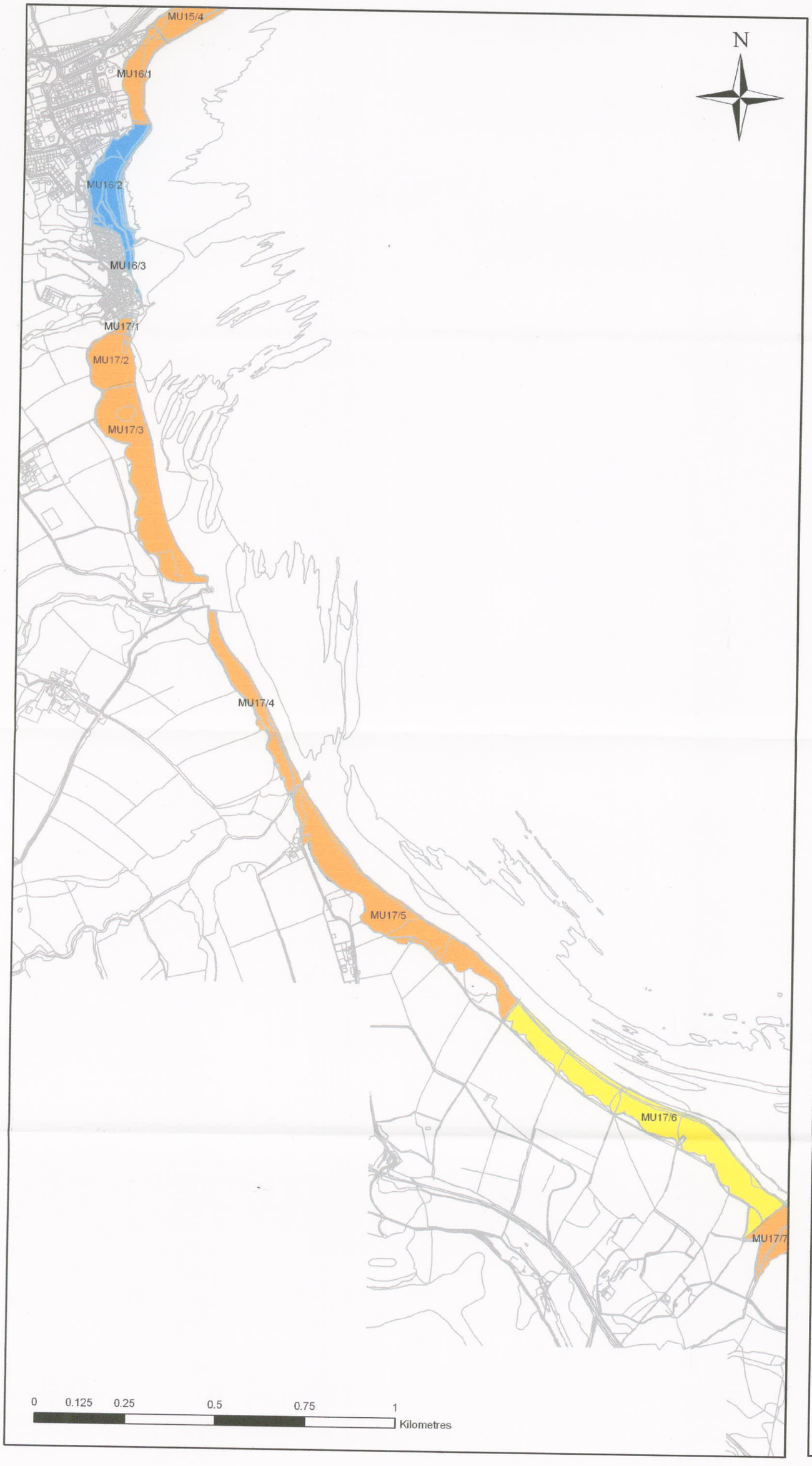


Scarborough Borough Council

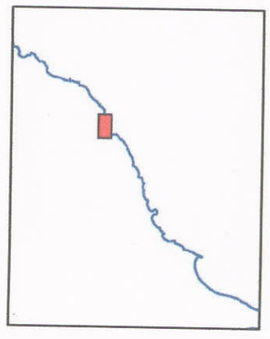
Strategic Cliff Monitoring, May to June 2005

Figure 2.8. Robin Hood's Bay

Cliff activity, 2005

- dormant
- inactive
- locally active
- partly active
- totally active

Drawing scale 1:10 000



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MU18/1
MU18/2
MU18/3

N

0 0.125 0.25 0.5 0.75 1
Kilometres

Scarborough Borough Council

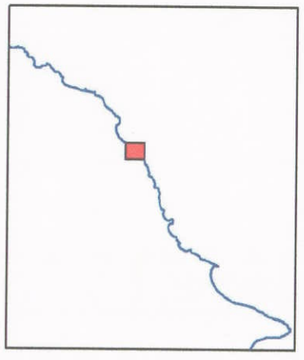
Strategic Cliff Monitoring, May to June 2005

Figure 2.9. Ravenscar

Cliff activity, 2005

- dormant
- inactive
- locally active
- partly active
- totally active

Drawing scale 1:10 000



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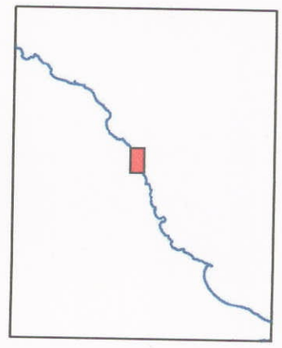
Strategic Cliff Monitoring, May to June 2005

2.10 Common Cliff

Cliff activity, 2005

- dormant
- inactive
- locally active
- partly active
- totally active

Drawing scale 1:10 000



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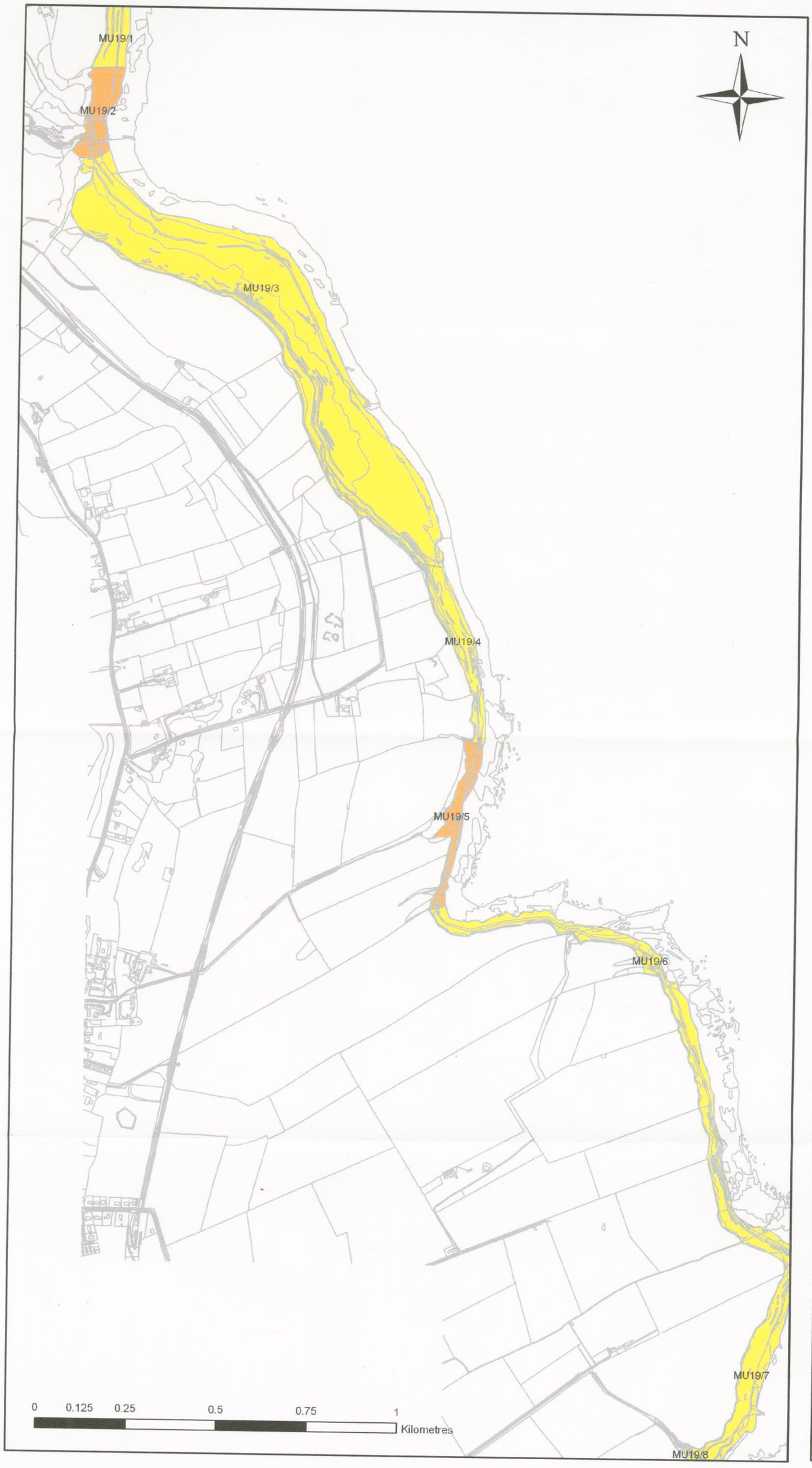


Scarborough Borough Council

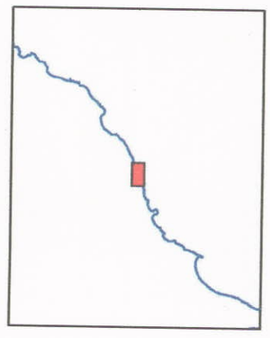
Strategic Cliff Monitoring, May to June 2005

Figure 2.11. Cloughton Wyke

Cliff activity, 2005

- dormant
- inactive
- locally active
- partly active
- totally active

Drawing scale 1:10 000



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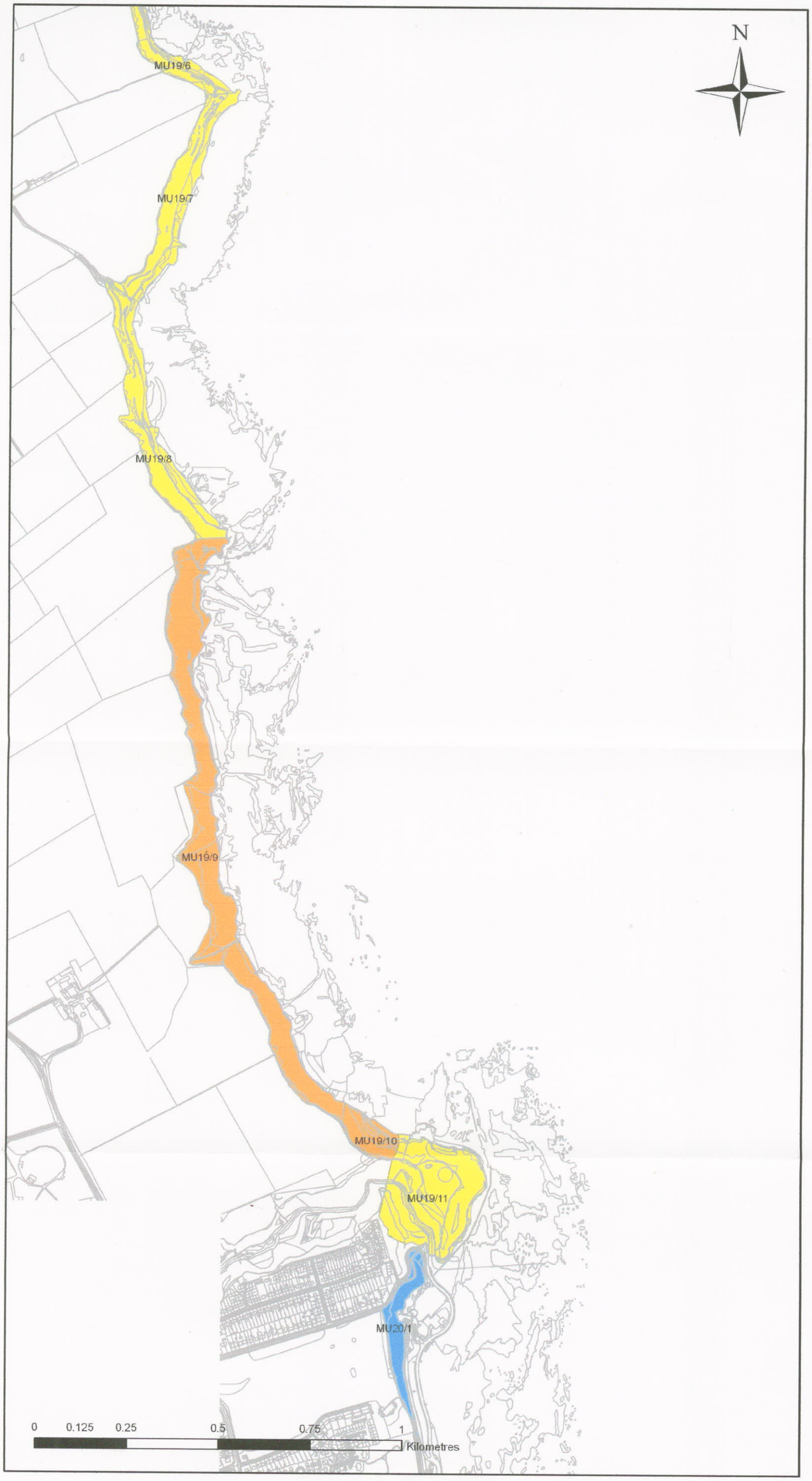


Scarborough Borough Council

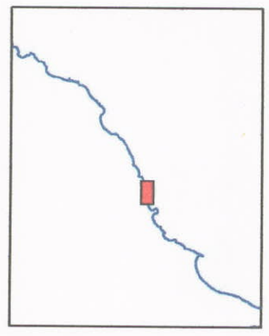
Strategic Cliff Monitoring, May to June 2005

Figure 2.12. Scalby Ness

Cliff activity, 2005

- dormant
- inactive
- locally active
- partly active
- totally active

Drawing scale 1:10 000



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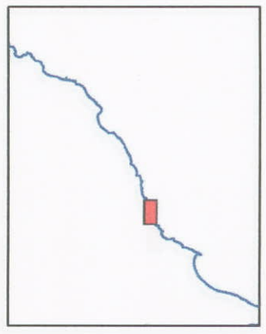
Strategic Cliff Monitoring, May to June 2005

Figure 2.13. Scarborough Castle

Cliff activity, 2005

- dormant
- inactive
- locally active
- partly active
- totally active

Drawing scale 1:10 000



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Strategic Cliff Monitoring, May to June 2005

Figure 2.16. Filey Brigg

Cliff activity, 2005

- dormant
- inactive
- locally active
- partly active
- totally active

Drawing scale 1:10 000

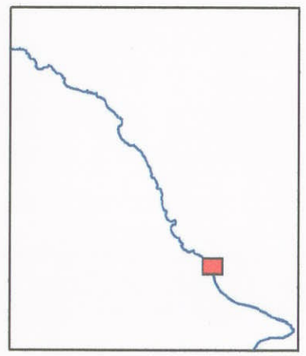

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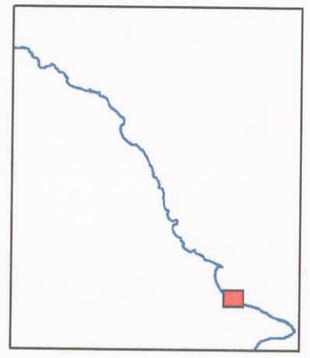
Figure. 2.18. Speeton

Cliff activity, 2005

- dormant
- inactive
- locally active
- partly active
- totally active

Drawing scale 1:10 000



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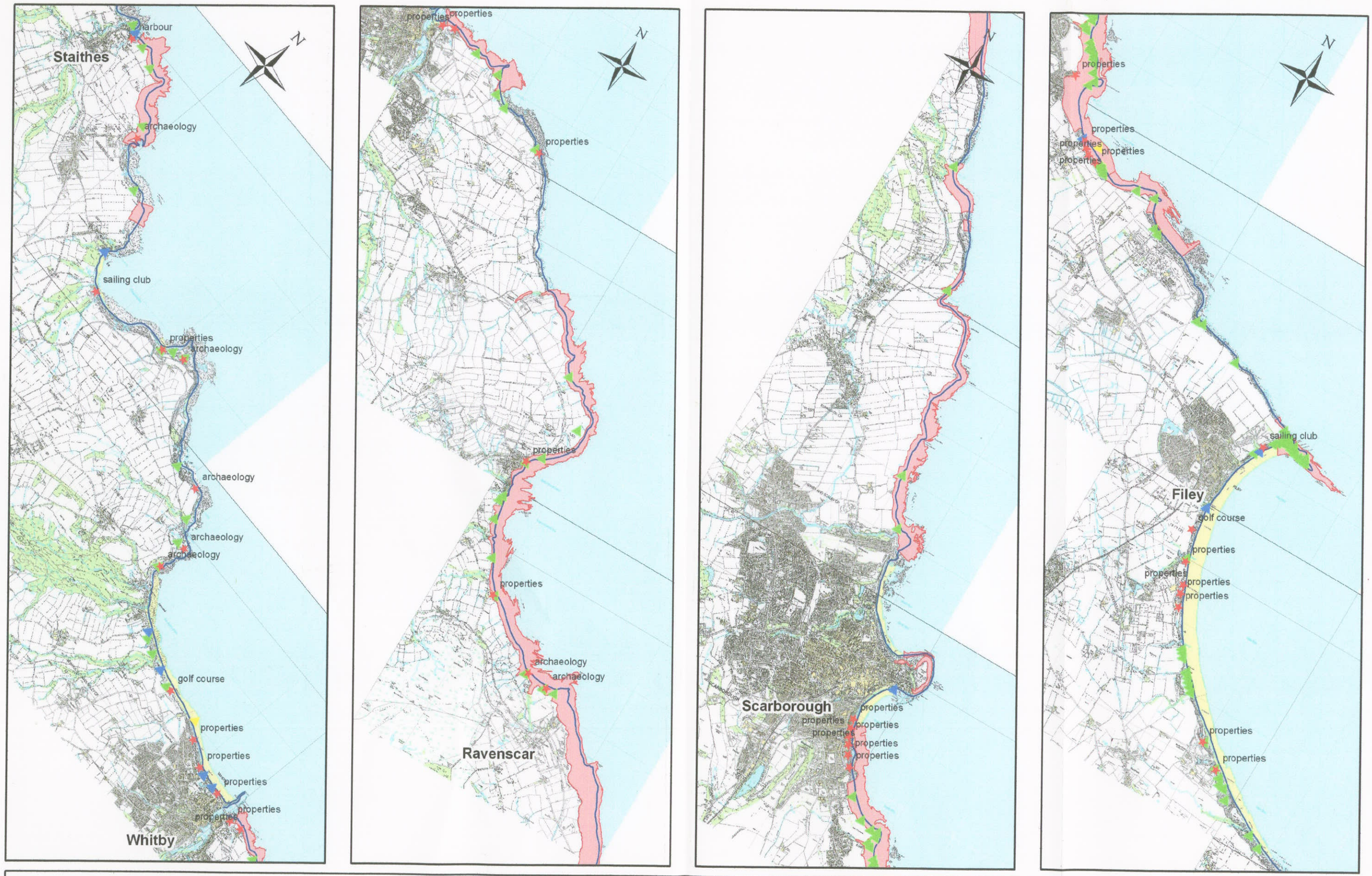

Scarborough Borough Council

Strategic Cliff Monitoring, May to June 2005

Figure 5.1. Hotspots

Hotspots and Assets

- Site of Special Scientific Interest
- Cliff hotspots (Totally active or increasing activity to Partly or Totally Active)
- Beach hotspots (areas of beach lowering)
- Structure hotspots (defnece assets at risk and in need or repair)
- Assets at risk (properties or other infrastructure)

0 0.250.5 1 1.5 2 Kilometres

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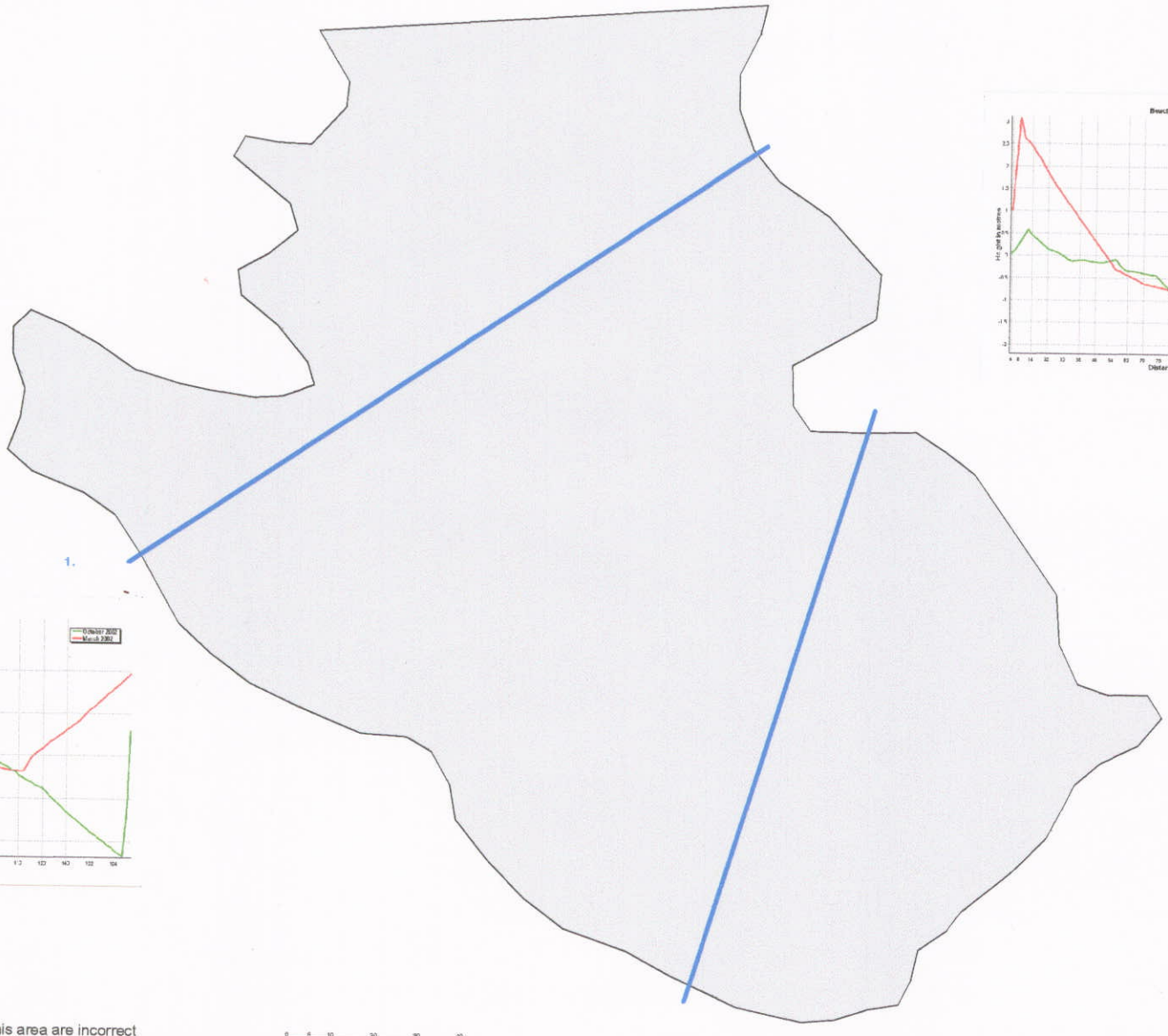
Figure 4.1 Staithes Bay Beach Profiles



NB: The coordinates of this area are incorrect and therefore cannot be used in conjunction with other data for this area.

S:\PROJECTS\Coastal\WC\SCPA\GIS\Staithes_Profile_offsite.mxd

Figure 4.2: Staithes Bay
Beach Volume Changes - 03/02 to 10/02

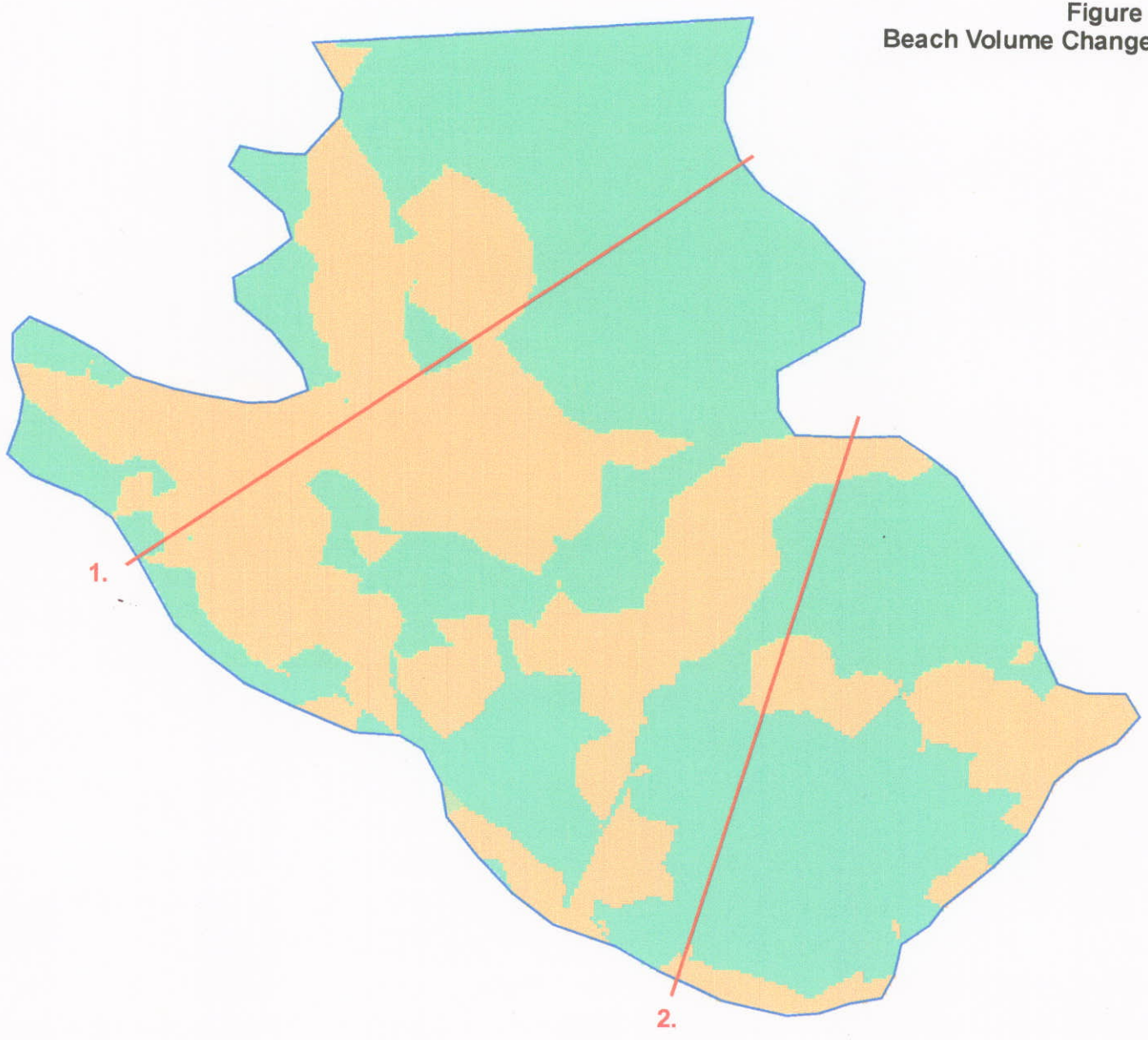
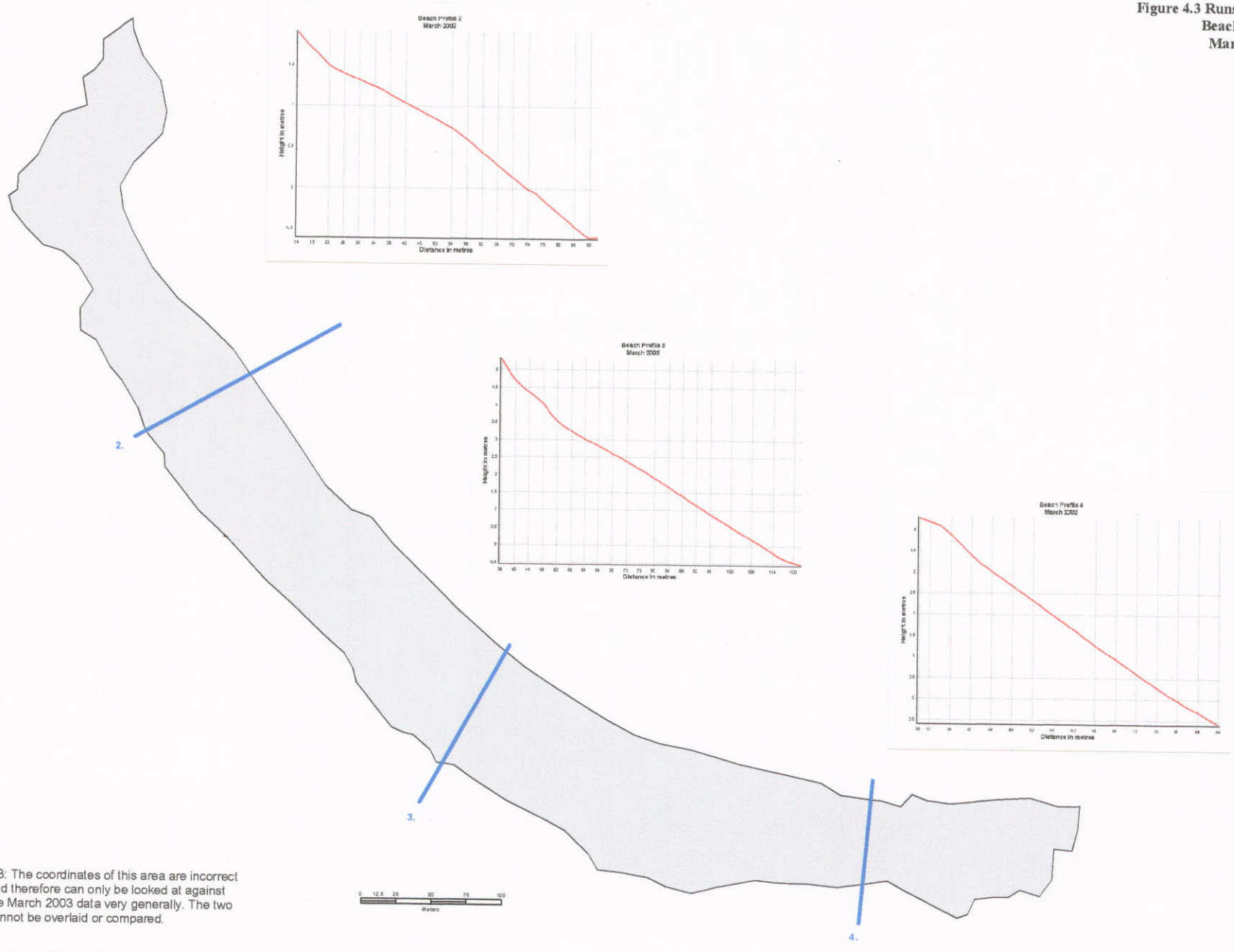


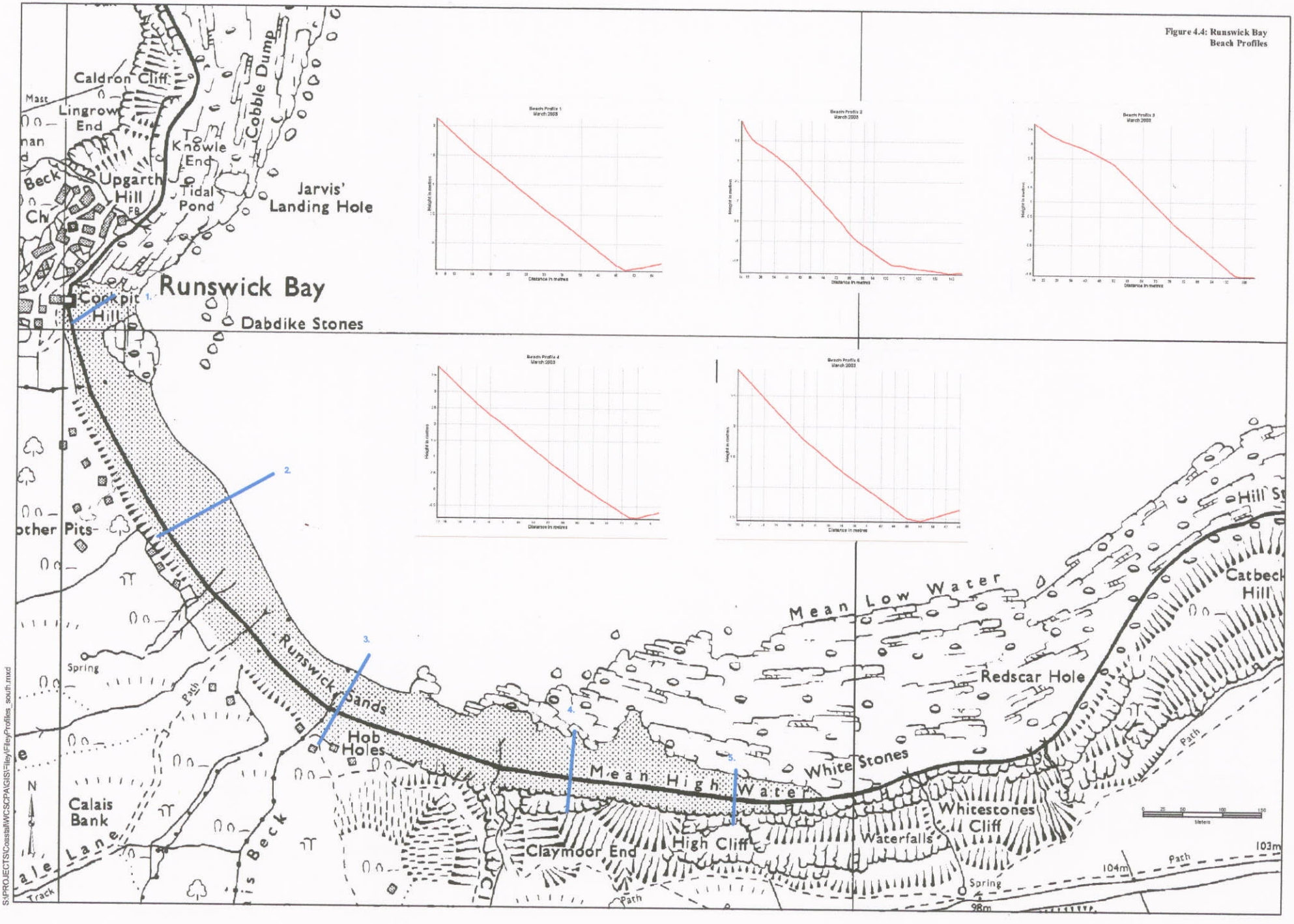
Figure 4.3 Runswick Bay
Beach Profiles
March 2002



NB: The coordinates of this area are incorrect and therefore can only be looked at against the March 2003 data very generally. The two cannot be overlaid or compared.

S:\PROJECTS\Coastal\WCSCPA\GIS\Runswick\RunswickProfile_offsite.mxd

Figure 4.4: Runswick Bay
Beach Profiles



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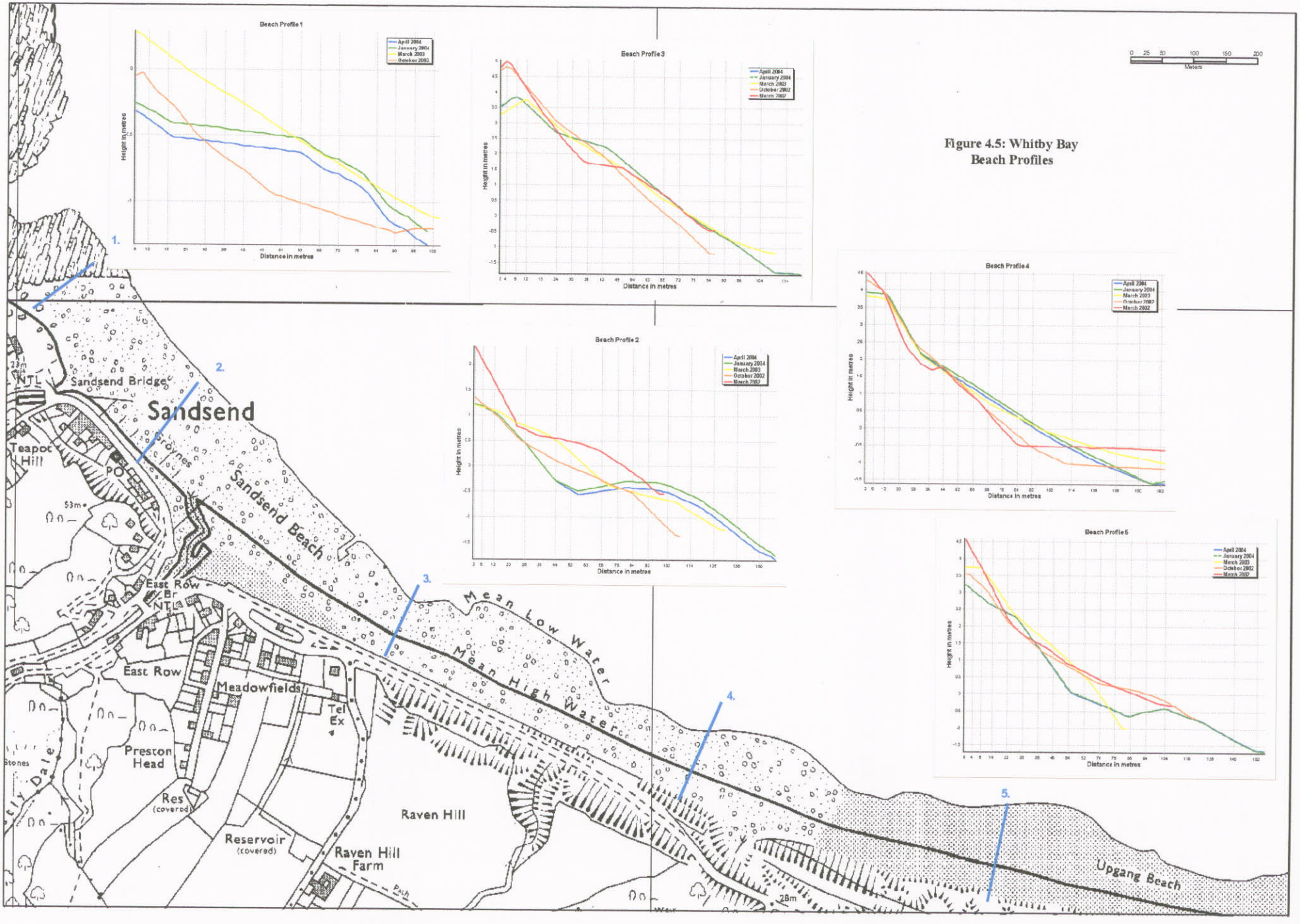
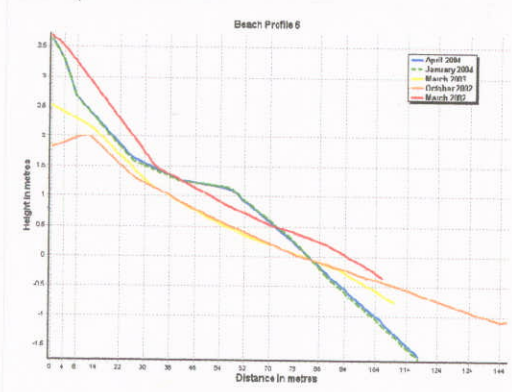
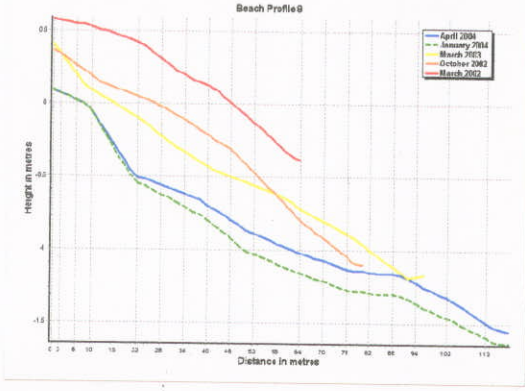
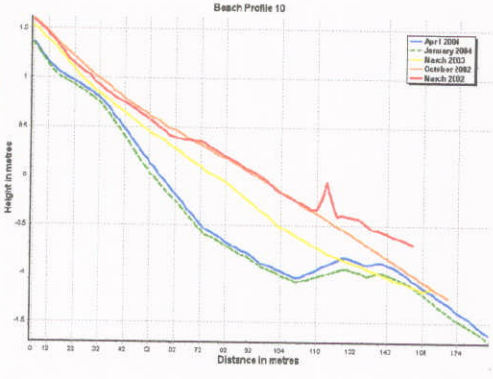


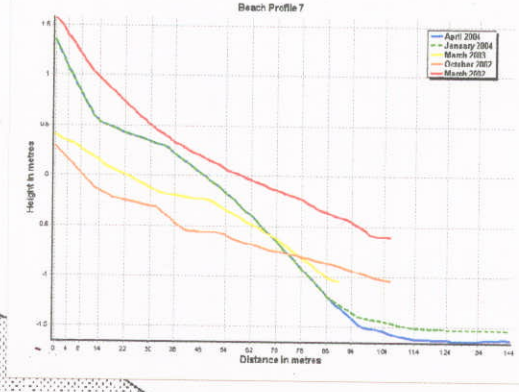
Figure 4.5: Whitby Bay Beach Profiles

Figure 4.6: Whitby Bay Beach Profiles









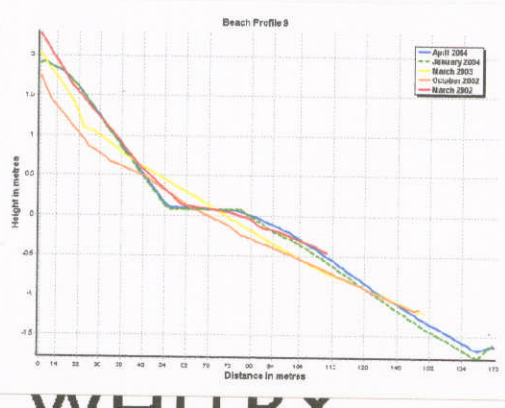
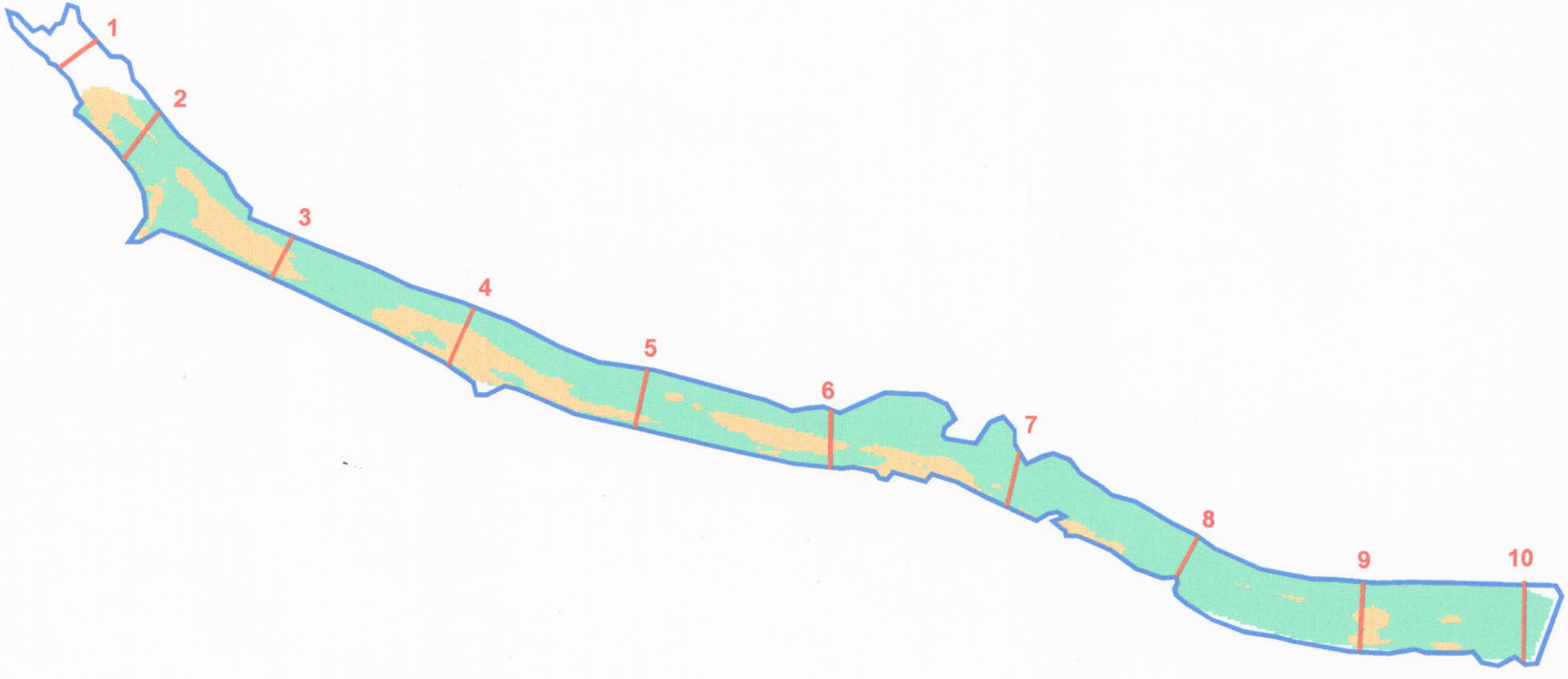


Figure 4.7: Whitby Bay
Beach Volume Changes - 03/02 to 04/04



Legend

VOLUME

- accretion
- unchanged
- erosion

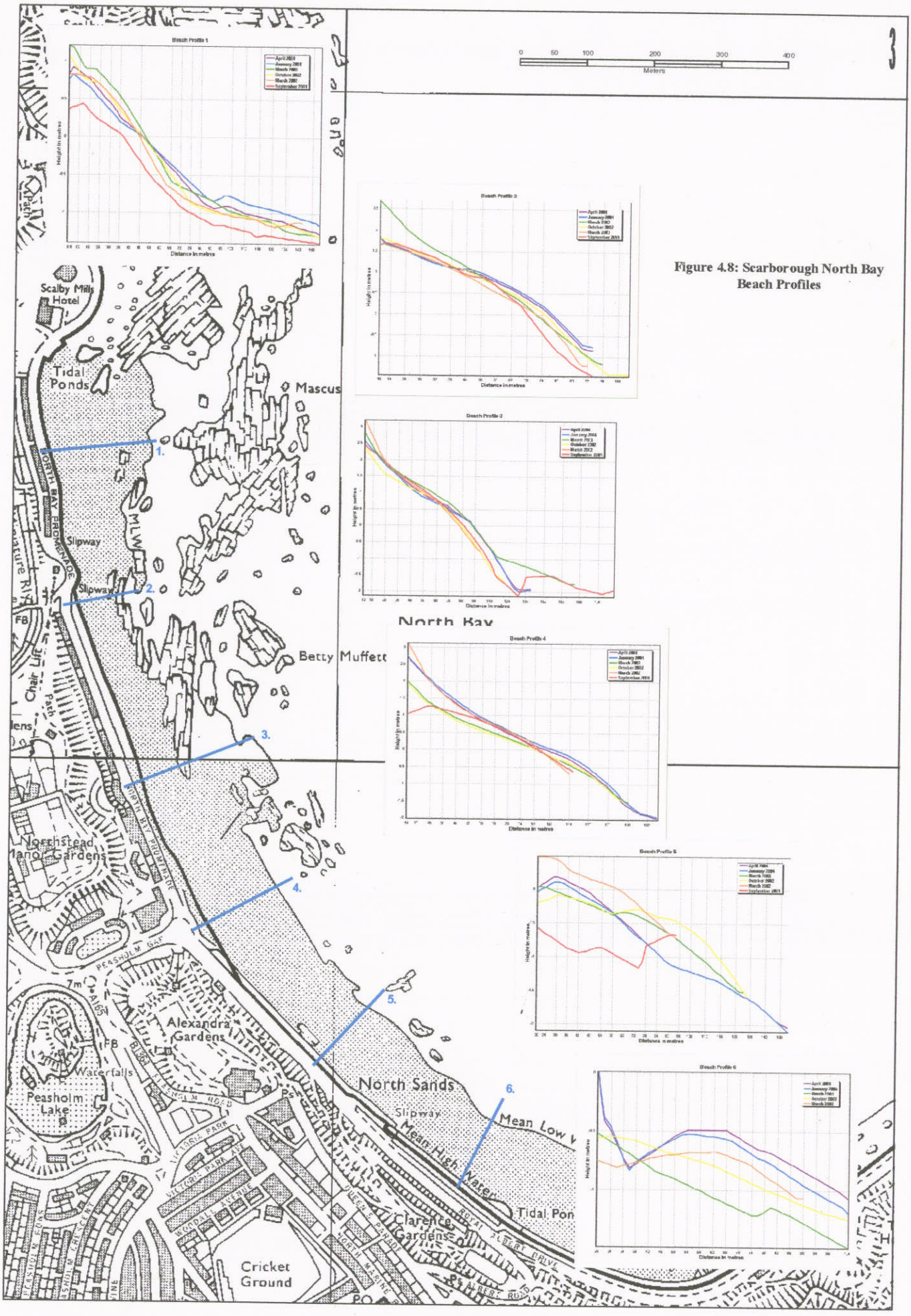


Figure 4.8: Scarborough North Bay Beach Profiles

Figure 4.9: Scarborough North Bay
Beach Volume Changes - 09/01 to 04/04

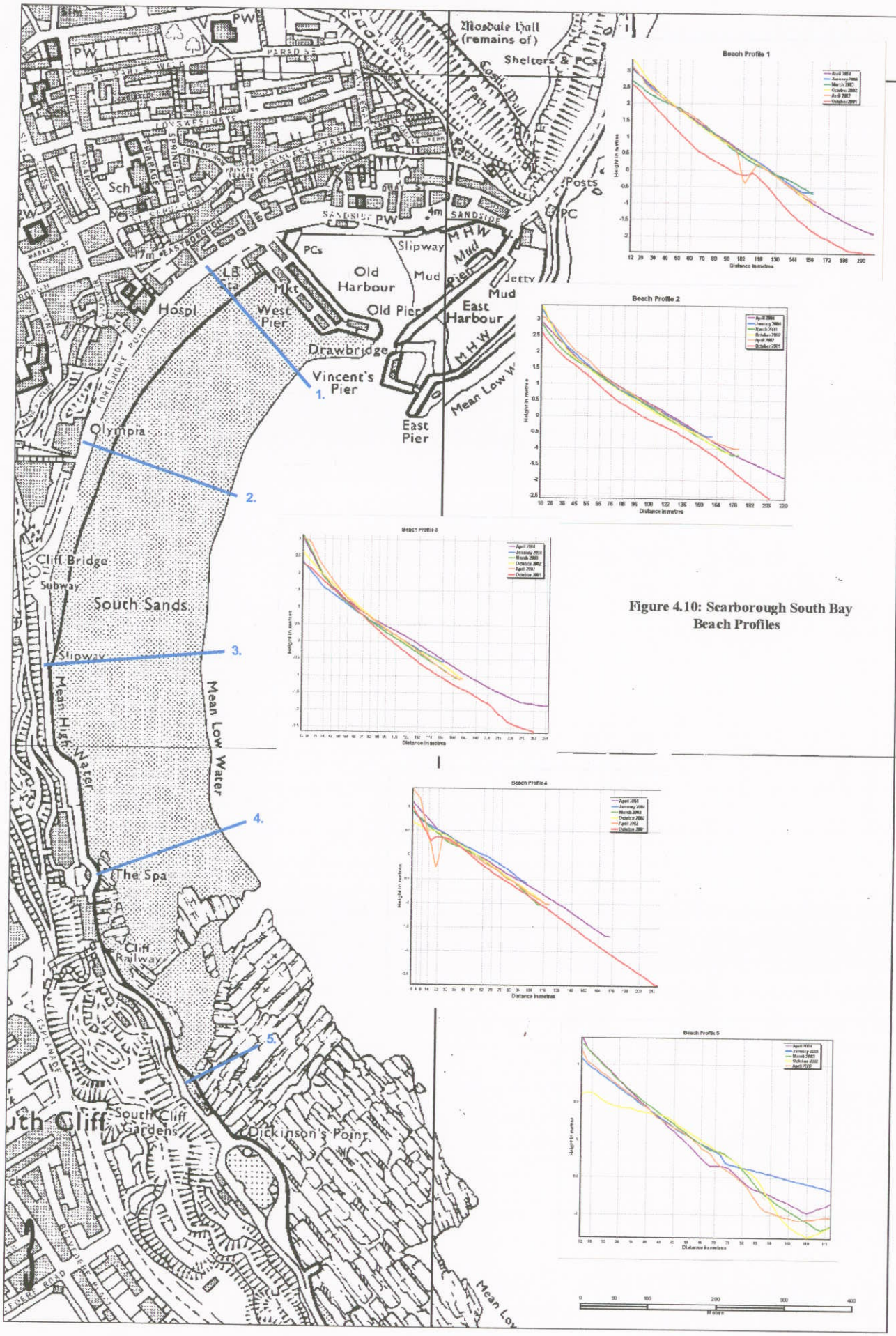
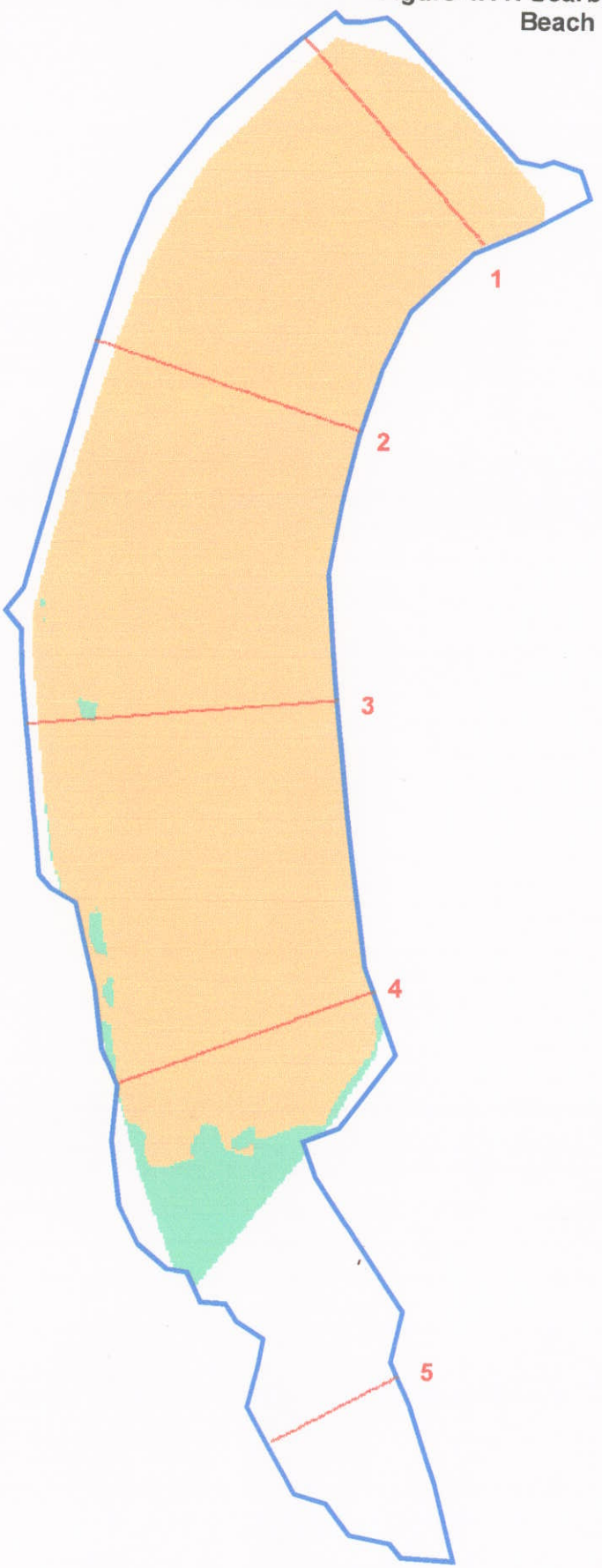


Figure 4.10: Scarborough South Bay Beach Profiles

Figure 4.11: Scarborough South Bay Beach Volume Changes - 10/01 to 04/04



Legend

VOLUME

- accretion
- unchanged
- erosion

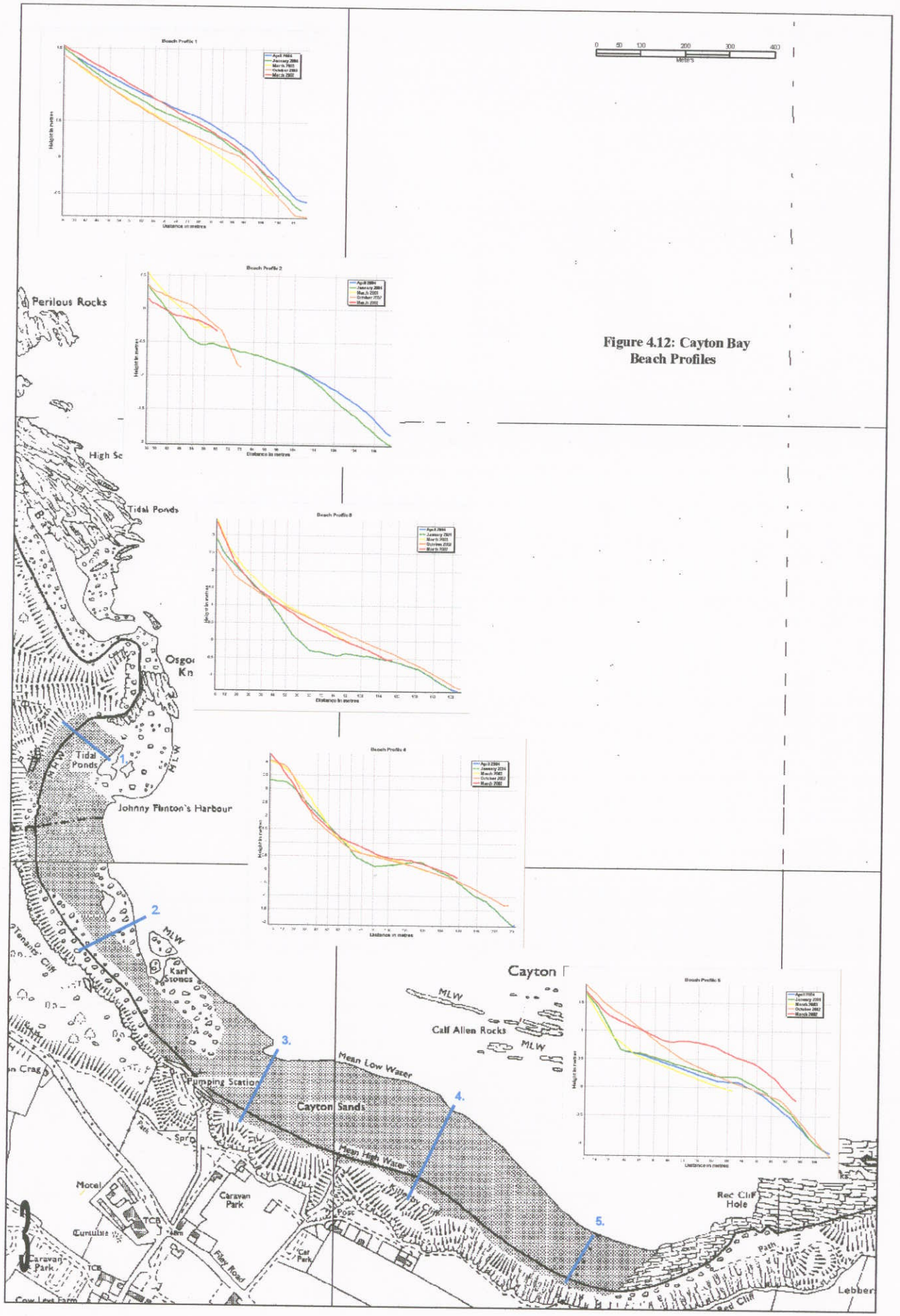


Figure 4.12: Cayton Bay Beach Profiles

Figure 4.13:Cayton Bay
Beach Volume Changes - 03/02 to 04/04

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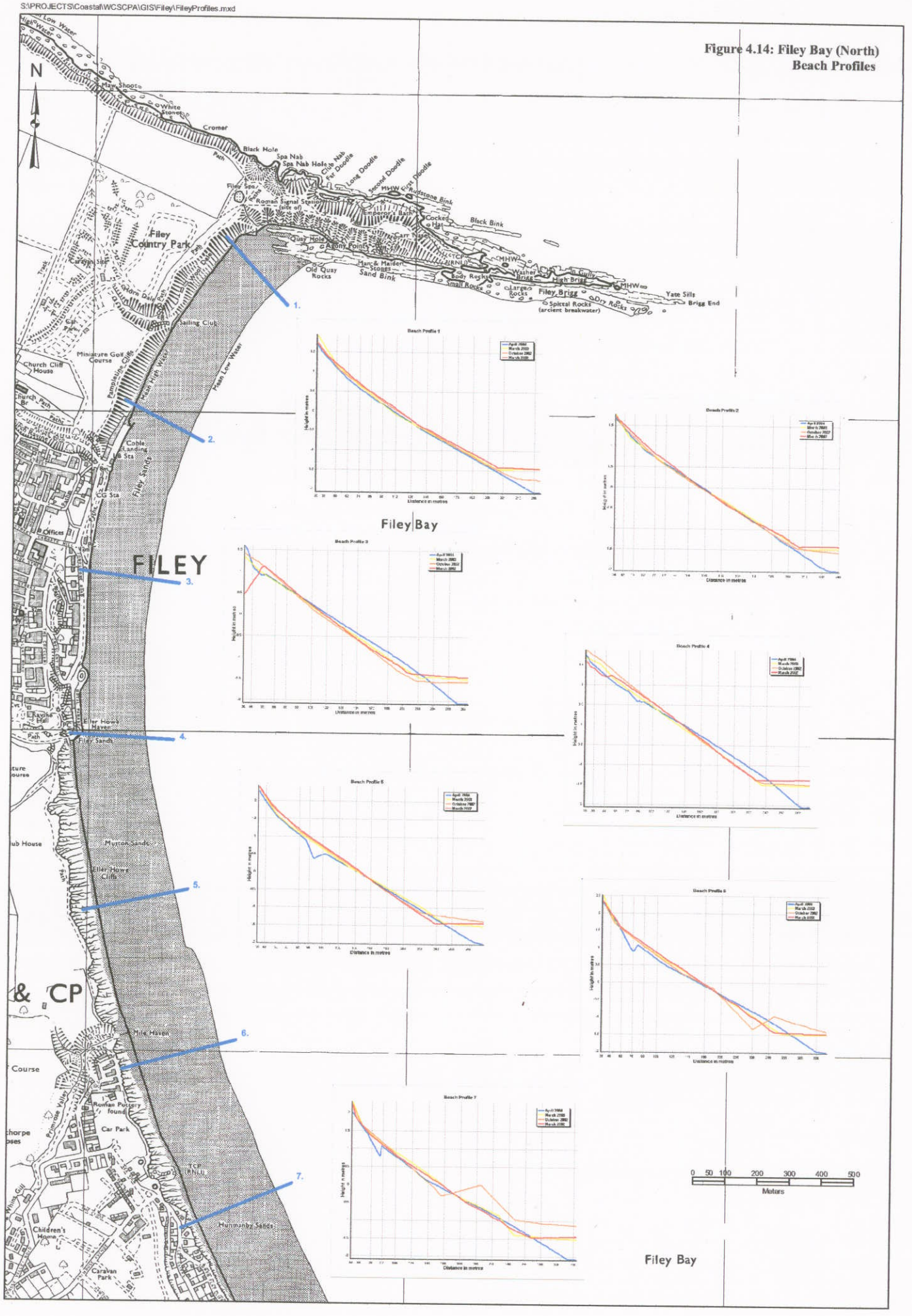
Figure 4.14: Filey Bay (North) Beach Profiles



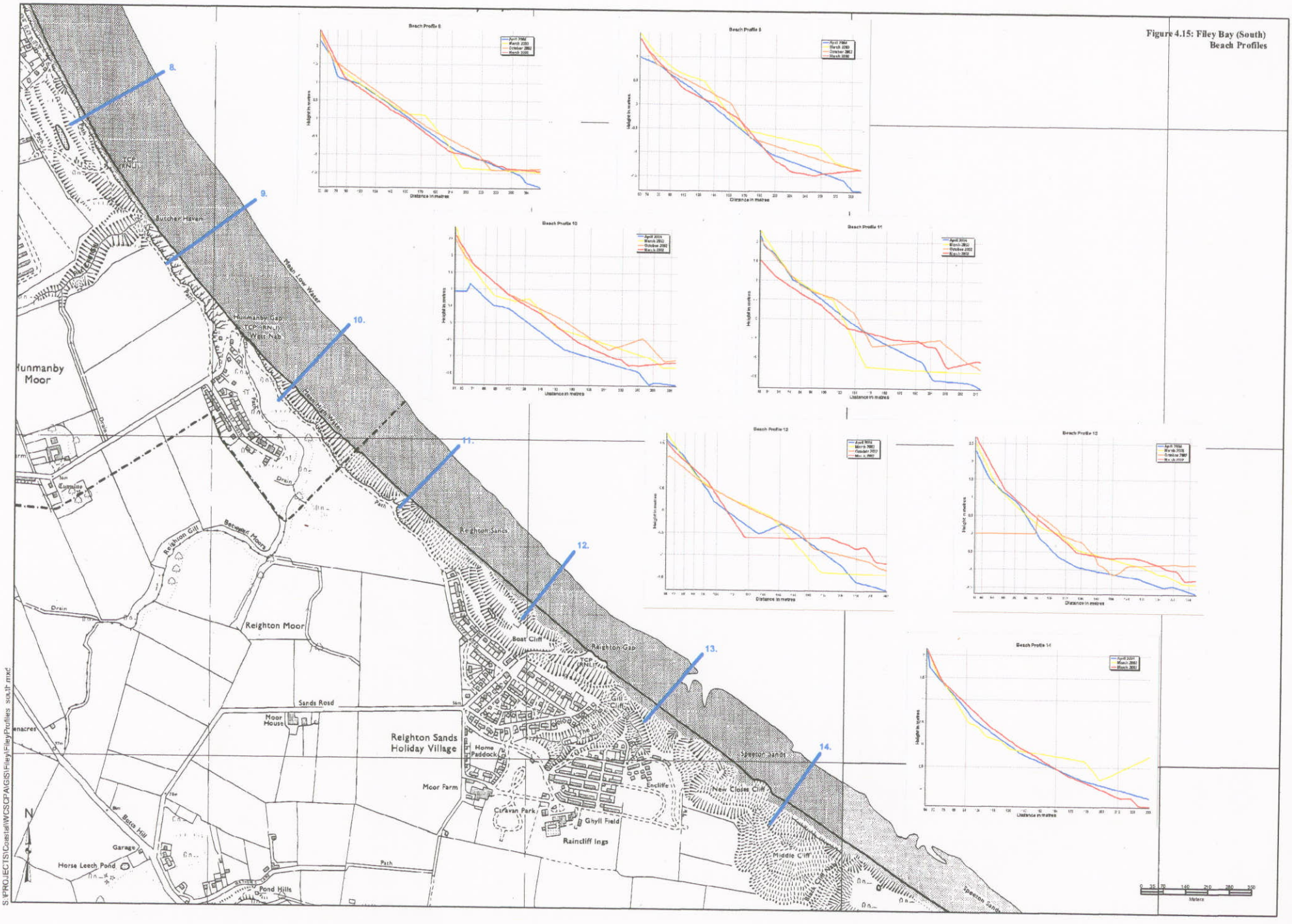


Figure 4.15: Filey Bay (South) Beach Profiles

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Figure 4.16: Filey Bay
Beach Volume Changes - 03/02 to 04/04