ROYAL HASKONING

Halcrow

Cell 1 Regional Coastal Monitoring Programme Analytical Report 2: 'Full Measures' Survey 2009

REDCAR & CLEVELAND BOROUGH COUNCIL

Redcar & Cleveland Borough Council
Final Report

March 2010

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Abbreviations and Acronyms

Acronym / Abbreviation	Definition
AONB	Area of Outstanding Natural Beauty
DGM	Digital Ground Model
HAT	Highest Astronomical Tide
LAT	Lowest Astronomical Tide
m	metres
MHWN	Mean High Water Neap
MHWS	Mean High Water Spring
MLWN	Mean Low Water Neap
MLWS	Mean Low Water Spring
MSL	Mean Sea Level
ODN	Ordnance Datum Newlyn

Water Levels Used in Interpretation of Changes

Water Level Parameter	Water Level (mODN)			
	River Tyne to Frenchman's Bay	Frenchman's Bay to Souter Point	Souter Point to Chourdon Point	Chourdon Point to Hartlepool Headland
1 in 200 year	3.41	3.44	3.66	3.91
HAT	2.85	2.88	3.18	3.30
MHWS	2.15	2.18	2.48	2.70
MLWS	-2.15	-2.12	-1.92	-1.90
Water Level Parameter	**Water Level (mODN)**			
	Hartlepool Headland to Saltburn Scar	Skinningrove	Hummersea Scar to Sandsend Ness	Sandsend Ness to Saltwick Nab
1 in 200 year	3.87	3.86	4.1	3.88
HAT	3.25	3.18	3.15	3.10
MHWS	2.65	2.68	2.65	2.60
MLWS	-1.95	-2.13	-2.15	-2.20
Water Level Parameter	**Water Level (mODN)**			
	Saltwick Nab to Hundale Point	Hundale Point to White Nab	White Nab to Filey Brigg	Filey Brigg to Flamborough Head
1 in 200 year	3.88	3.93	3.93	4.04
HAT	3.10	3.05	3.05	3.10
MHWS	2.60	2.45	2.45	2.50
MLWS	-2.20	-2.35	-2.35	-2.30

Source: *River Tyne to Flamborough Head Shoreline Management Plan 2*. Royal Haskoning, February 2007.

Glossary of Terms

Term	Definition
Beach nourishment	Artificial process of replenishing a beach with material from another source.
Berm crest	Ridge of sand or gravel deposited by wave action on the shore just above the normal high water mark.
Breaker zone	Area in the sea where the waves break.
Coastal squeeze	The reduction in habitat area which can arise if the natural landward migration of a habitat under sea level rise is prevented by the fixing of the high water mark, e.g. a sea wall.
Downdrift	Direction of alongshore movement of beach materials.
Ebb-tide	The falling tide, part of the tidal cycle between high water and the next low water.
Fetch	Length of water over which a given wind has blown that determines the size of the waves produced.
Flood-tide	Rising tide, part of the tidal cycle between low water and the next high water.
Foreshore	Zone between the high water and low water marks, also known as the intertidal zone.
Geomorphology	The branch of physical geography/geology which deals with the form of the Earth, the general configuration of its surface, the distribution of the land, water, etc.
Groyne	Shore protection structure built perpendicular to the shore; designed to trap sediment.
Mean High Water (MHW)	The average of all high waters observed over a sufficiently long period.
Mean Low Water (MLW)	The average of all low waters observed over a sufficiently long period.
Mean Sea Level (MSL)	Average height of the sea surface over a 19-year period.
Offshore zone	Extends from the low water mark to a water depth of about 15 m and is permanently covered with water.
Storm surge	A rise in the sea surface on an open coast, resulting from a storm.
Swell	Waves that have travelled out of the area in which they were generated.
Tidal prism	The volume of water within the estuary between the level of high and low tide, typically taken for mean spring tides.
Tide	Periodic rising and falling of large bodies of water resulting from the gravitational attraction of the moon and sun acting on the rotating earth.
Topography	Configuration of a surface including its relief and the position of its natural and man-made features.
Transgression	The landward movement of the shoreline in response to a rise in relative sea level.
Updrift	Direction opposite to the predominant movement of longshore transport.
Wave direction	Direction from which a wave approaches.
Wave refraction	Process by which the direction of approach of a wave changes as it moves into shallow water.

Preamble

The Cell 1 Regional Coastal Monitoring Programme covers approximately 300km of the north east coastline, from the Scottish Border (just south of St. Abb's Head) to Flamborough Head in East Yorkshire. This coastline is often referred to as 'Coastal Sediment Cell 1' in England and Wales (Figure 1). Within this frontage the coastal landforms vary considerably, comprising low-lying tidal flats with fringing salt marshes, hard rock cliffs that are mantled with glacial till to varying thicknesses, softer rock cliffs, and extensive landslide complexes.

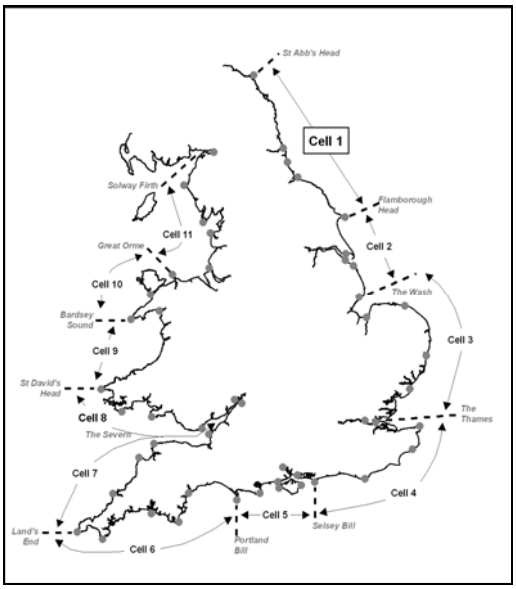


Figure 1 Sediment Cells in England and Wales

The programme commenced in its present guise in September 2008 and is managed by Scarborough Borough Council on behalf of the North East Coastal Group. It is funded by the Environment Agency, working in partnership with the following organisations.

Northumberland County Council
Northumberland Coast AONB
North Tyneside Council
South Tyneside Council
Sunderland City Council
Durham County Council
Redcar & Cleveland Borough Council
Hartlepool Borough Council
Whitby Scarborough Filey Borough of Scarborough
East Riding of Yorkshire Council
A great place to live, work & play
Environment Agency
Natural England
The National Trust

The data collection, analysis and reporting is being undertaken as a partnership between the following organisations:

The main elements of the Cell 1 Regional Coastal Monitoring Programme involve:

- beach profile surveys
- topographic surveys
- cliff top recession surveys
- real-time wave data collection
- bathymetric and sea bed characterisation surveys
- aerial photography
- walk-over surveys

The beach profile surveys, topographic surveys and cliff top recession surveys are undertaken as a 'Full Measures' survey in autumn/early winter every year. Some of these surveys are then repeated the following spring as part of a 'Partial Measures' survey.

Each year, an Analytical Report is produced for each individual authority, providing a detailed analysis and interpretation of the 'Full Measures' surveys.

This is followed by a brief Update Report for each individual authority, providing ongoing findings from the 'Partial Measures' surveys.

A Cell 1 Overview Report will also be produced periodically. This will provide a region-wide summary of the main findings relating to trends and interactions along the entire Cell 1 frontage within distinct time phases of the programme, defined by specific funding allocations. The first such report is expected to be produced in spring 2011 (covering 2008 – 2011) when the initial three year funding allocation comes towards an end.

To date the following reports have been produced:

Table 1 Analytical, Update and Overview Reports Produced to Date

Year		Full Measures		Partial Measures		Cell 1 Overview Report
		Survey	Analytical Report	Survey	Update Report	
1	2008/09	Sep-Dec 08	May 09	Mar-May 09	June 09	-
2	2009/10	Sep-Dec 09	Mar 10 (*)			-

(*) The present report is **Analytical Report 2** and provides an analysis of the 2009 Full Measures survey for Redcar & Cleveland Borough Council's frontage.

In addition, separate reports are produced for other elements of the programme as and when specific components are undertaken, such as wave data collection, bathymetric and sea bed sediment data collection, aerial photography, and walk-over visual inspections.

For purposes of analysis, the Cell 1 frontage has been split into the sub-sections listed in the Table 2.

Table 2 Sub-divisions of the Cell 1 Coastline

Authority	Zone
Northumberland County Council	Spittal A
	Spittal B
	Goswick Sands
	Holy Island
	Bamburgh
	Beadnell Village
	Beadnell Bay
	Embelton Bay
	Boulmer
	Alnmouth Bay
	High Hauxley and Druridge Bay
	Lynemouth Bay
	Newbiggin Bay
	Cambois Bay
	Blyth South Beach
North Tyneside Council	Whitley Sands
	Cullercoats Bay
	Tynemouth Long Sands
	King Edward's Bay
South Tyneside Council	Littehaven Beach
	Herd Sands
	Trow Quarry (incl. Frenchman's Bay)
	Marsden Bay
Sunderland Council	Whitburn Bay
	Harbour and Docks
	Hendon to Ryhope (incl. Halliwell Banks)
Durham County Council	Featherbed Rocks
	Seaham
	Blast Beach
	Hawthorn Hive
	Blackhall Colliery
Hartlepool Borough Council	North Sands
	Headland
	Middleton
	Hartlepool Bay
Redcar & Cleveland Borough Council	Coatham Sands
	Redcar Sands
	Marske Sands
	Saltburn Sands
	Cattersty Sands (Skinningrove)
Scarborough Borough Council	Staithes
	Runswick Bay
	Sandsend Beach, Upgang Beach and Whitby Sands
	Robin Hood's Bay
	Scarborough North Bay
	Scarborough South Bay
	Cayton Bay
	Filey Bay

1. Introduction

1.1 Study Area

Redcar & Cleveland Borough Council's frontage extends from the South Gare Breakwater at the mouth of the River Tees estuary to Cowbar Nab at Staithes. For the purposes of this report, it has been sub-divided into six areas, namely:

- Coatham Sands
- Redcar Sands
- Marske Sands
- Saltburn Sands
- Cattersty Sands (Skinningrove)
- Staithes

The Staithes frontage straddles the boundary of jurisdiction of both Redcar & Cleveland Council and Scarborough Borough Council and therefore reporting has been duplicated in both reports.

1.2 Methodology

Along Redcar & Cleveland Borough Council's frontage, the following surveying is undertaken:

- Full Measures survey annually each autumn/early winter comprising:
    - Beach profile surveys along 9 no. transect lines
    - Topographic survey along Coatham Sands
    - Topographic survey along Redcar Sands
    - Topographic survey along Marske Sands
    - Topographic survey along Saltburn Sands
    - Topographic survey along Cattersty Sands

- Partial Measures survey annually each spring comprising:
    - Beach profile surveys along 9 no. transect lines
    - Topographic survey along Redcar Sands
    - Topographic survey along Saltburn Sands
    - Topographic survey along Cattersty Sands

- Cliff top survey annually at:
    - Staithes

The location of these surveys is shown in Figure 2. They have also previously been provided on a digital file which can be opened in Google Earth showing the locations of the surveys.

The Full Measures survey was undertaken along this frontage between September and October 2009. During the surveys at Coatham Sands, Redcar Sands, Marske Sands and Saltburn Sands (September 2009) the weather conditions were fine and breezy, with a calm sea state. During the Cattersty Sands survey (October 2009), the weather was fine but foggy, with a calm sea state. Conditions were dry but breezy with a calm sea state during the Staithes survey (September 2009).

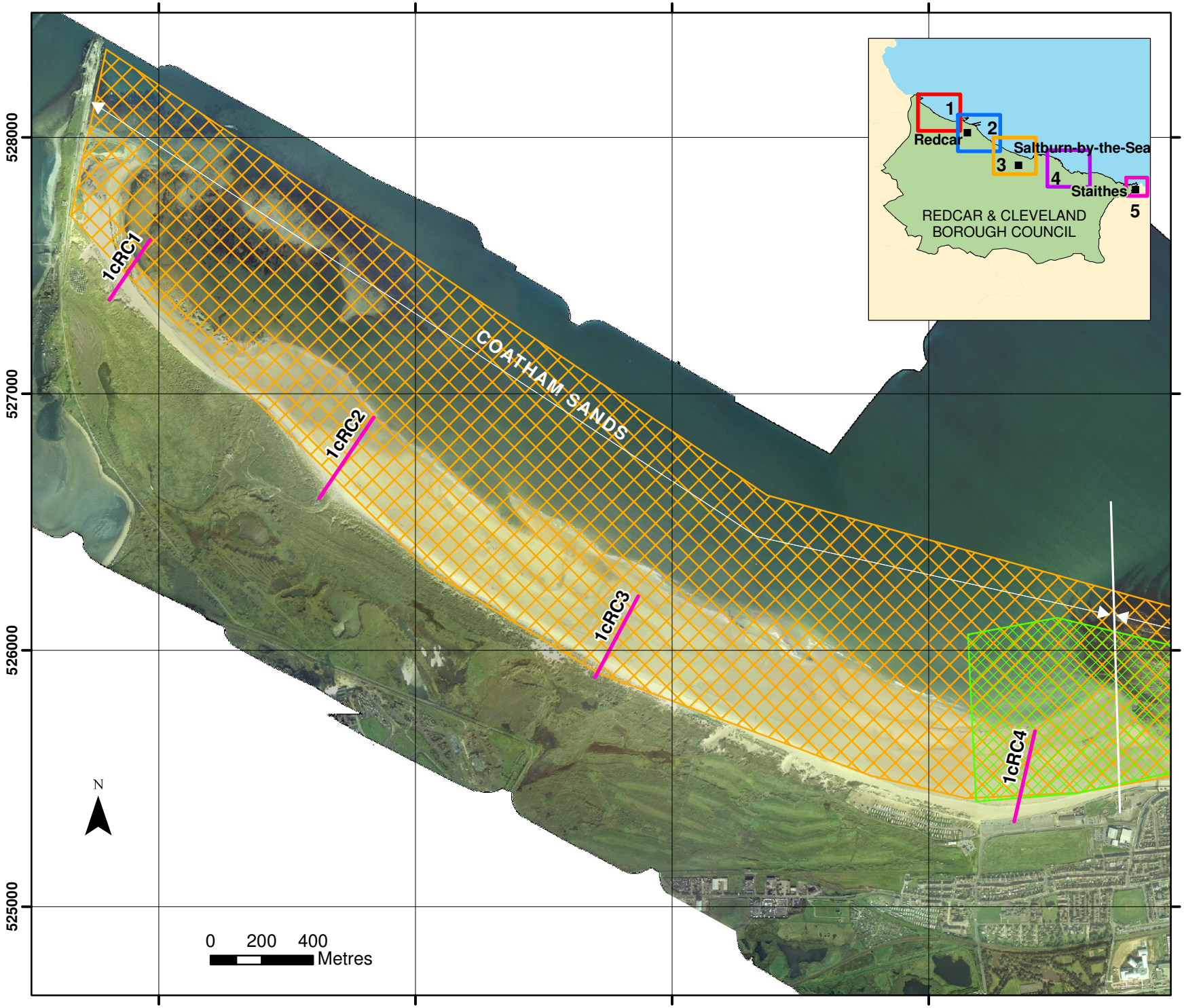
All data have been captured in a manner commensurate with the principles of the Environment Agency's *National Standard Contract and Specification for Surveying Services* and stored in a file format compatible with the software systems being used for the data analysis, namely SANDS and Arc-GIS. This data collection approach and file format is comparable to that being used on other regional coastal monitoring programmes, such as in the South East and South West of England.

Upon receipt of the data from the survey team, they are quality assured and then uploaded onto the programme's website for storage and availability to others and also input to SANDS and GIS for subsequent analysis.

The Analytical Report is then produced following a standard structure for each authority. This involves:

- description of the changes observed since the previous survey and an interpretation of the drivers of these changes (Section 2);
- documentation of any problems encountered during surveying or uncertainties inherent in the analysis (Section 3);
- recommendations for 'fine-tuning' the programme to enhance its outputs (Section 4); and
- providing key conclusions and highlighting any areas of concern (Section 5).

Data from the present survey are presented in a processed form in the Appendices.



SURVEY LOCATIONS

Topographic Profiles
- Annual
- Bi-Annual

Topographic Surveys
- 6 monthly
- yearly
- 5 yearly

Cliff Top Monitoring Pegs
- @ 50 centres
- @ 100 centres
- @ 300 centres

(Indicative Survey Extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 1
Redcar & Cleveland Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:20,000 at A4

Drawn by:	TC	Date:	22/10/2009
Checked by:	NC	Date:	19/11/2009
Approved by:	NC	Date:	19/11/2009

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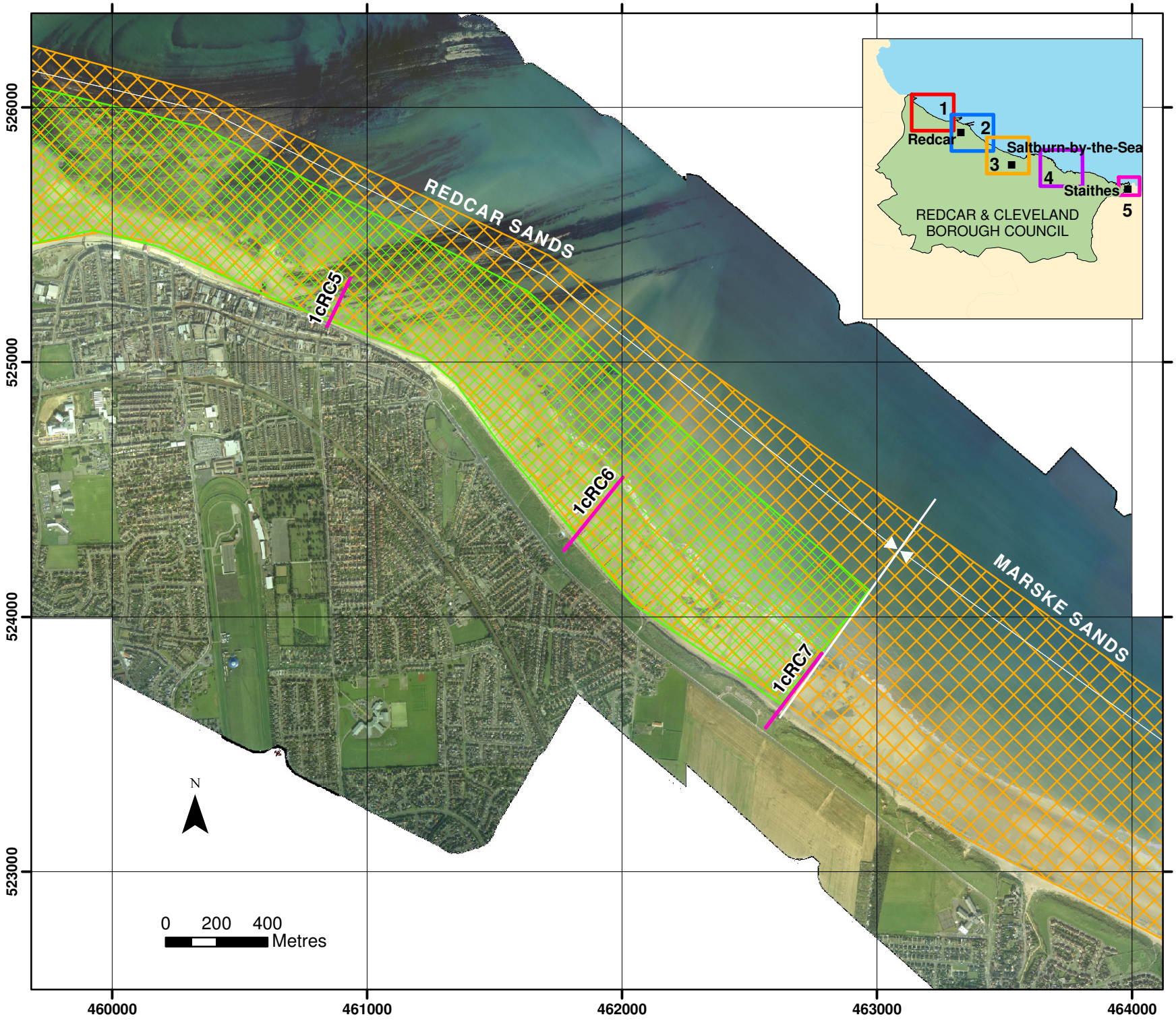

SURVEY LOCATIONS

Topographic Profiles
- Annual
- Bi-Annual

Topographic Surveys
- 6 monthly
- yearly
- 5 yearly

Cliff Top Monitoring Pegs
- @ 50 centres
- @ 100 centres
- @ 300 centres

(Indicative Survey Extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 2
Redcar & Cleveland Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

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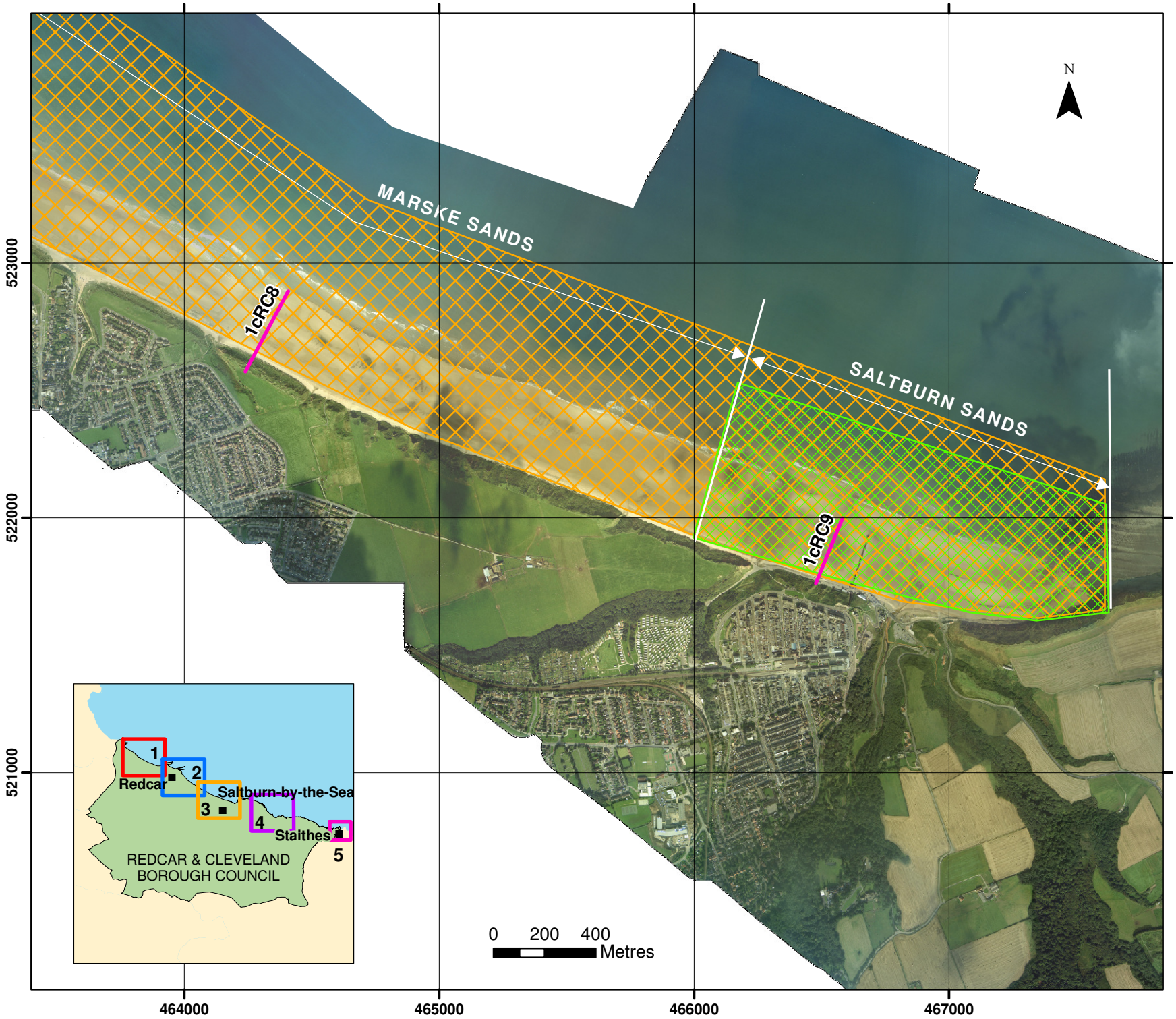

SURVEY LOCATIONS

Topographic Profiles

- Annual
- Bi-Annual

Topographic Surveys

- 6 monthly
- yearly
- 5 yearly

Cliff Top Monitoring Pegs

- @ 50 centres
- @ 100 centres
- @ 300 centres

(Indicative Survey Extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 3
Redcar & Cleveland Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

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Approved by:	NC	Date:	19/11/2009

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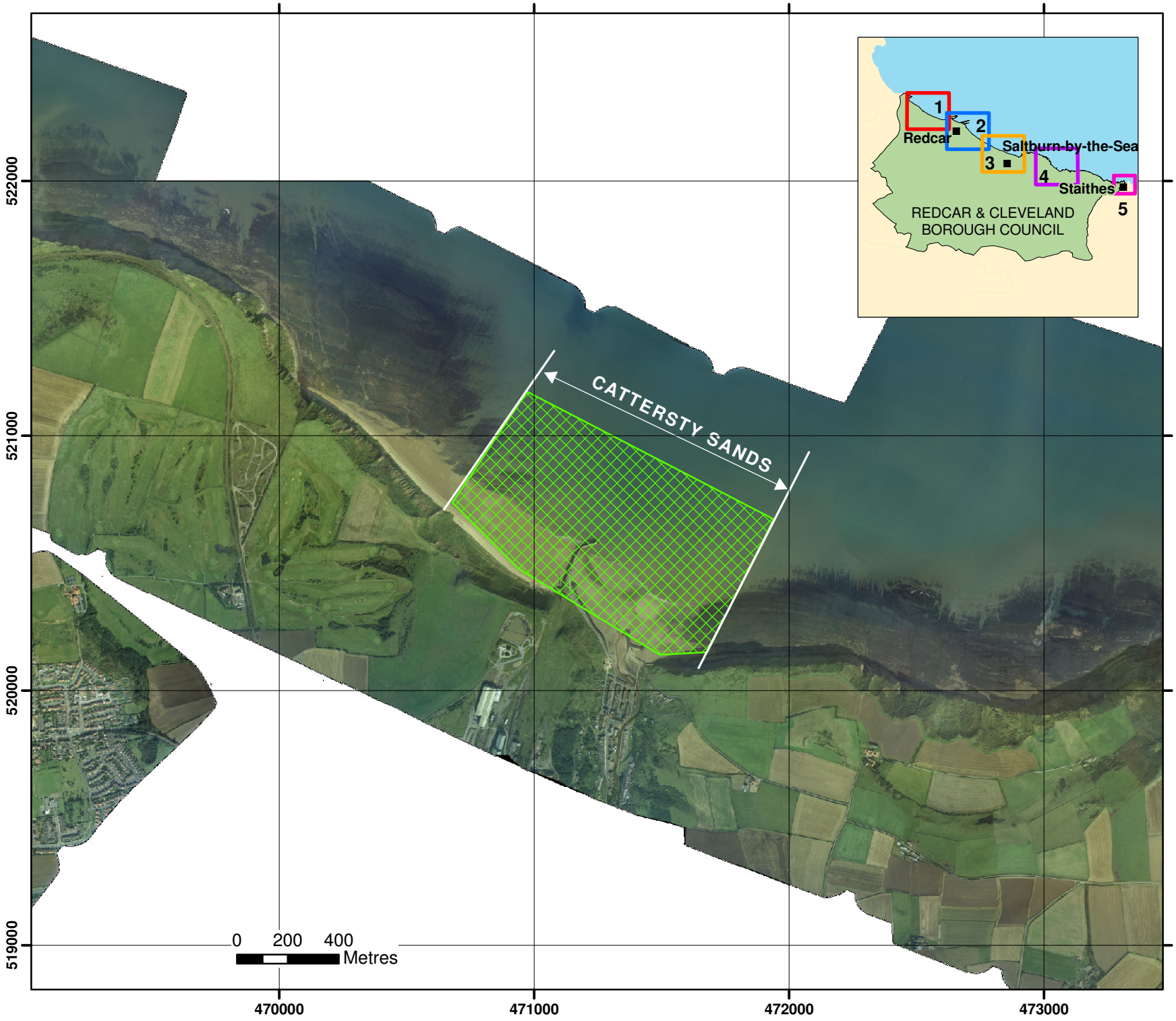

SURVEY LOCATIONS

Topographic Profiles
- Annual
- Bi-Annual

Topographic Surveys
- 6 monthly
- yearly
- 5 yearly

Cliff Top Monitoring Pegs
- @ 50 centres
- @ 100 centres
- @ 300 centres

(Indicative Survey Extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 4
Redcar & Cleveland Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:20,000 at A4

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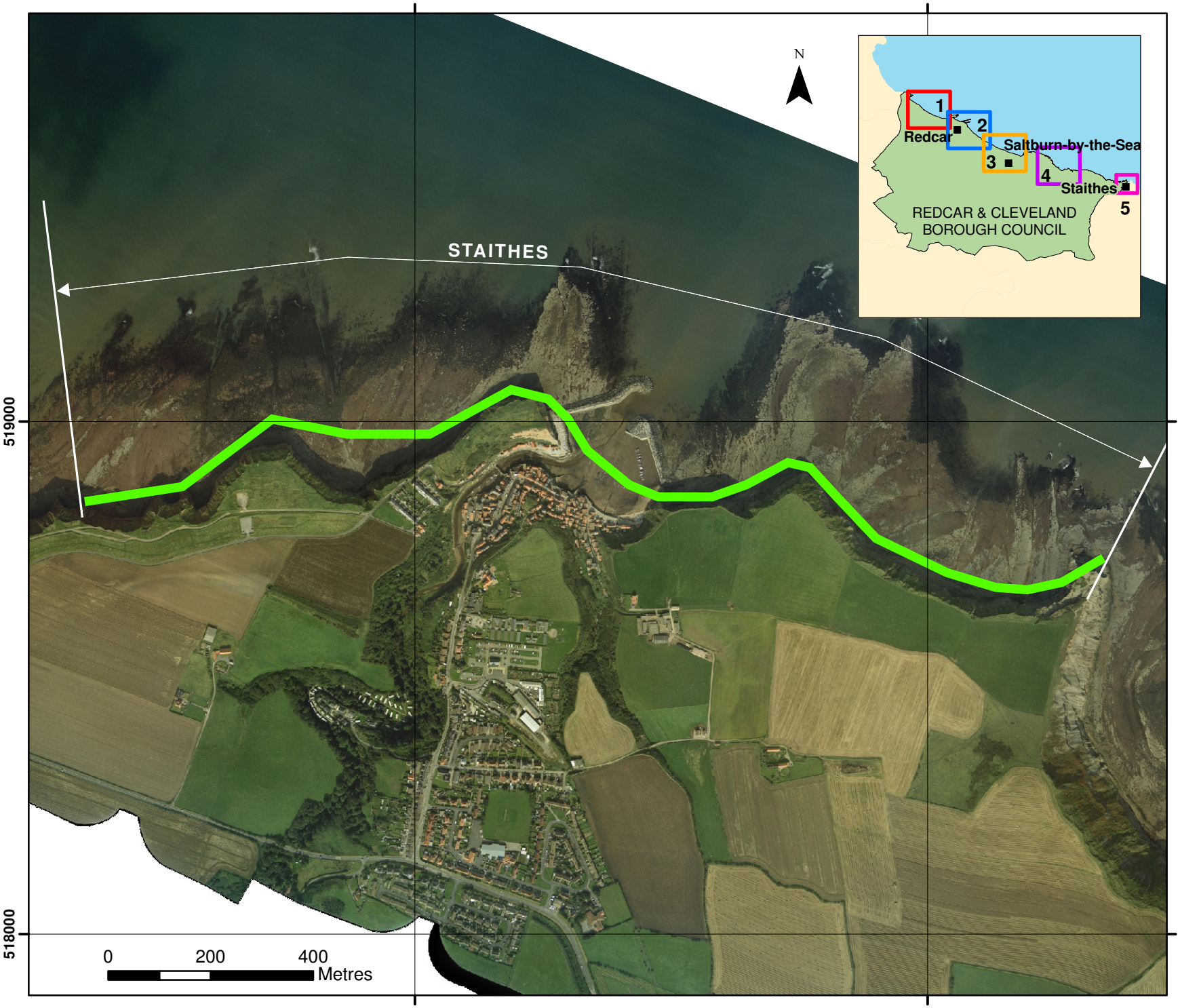

SURVEY LOCATIONS

Topographic Profiles

- Annual
- Bi-Annual

Topographic Surveys

- 6 monthly
- yearly
- 5 yearly

Cliff Top Monitoring Pegs

- @ 50 centres
- @ 100 centres
- @ 300 centres

(Indicative Survey Extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 5
Redcar & Cleveland Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

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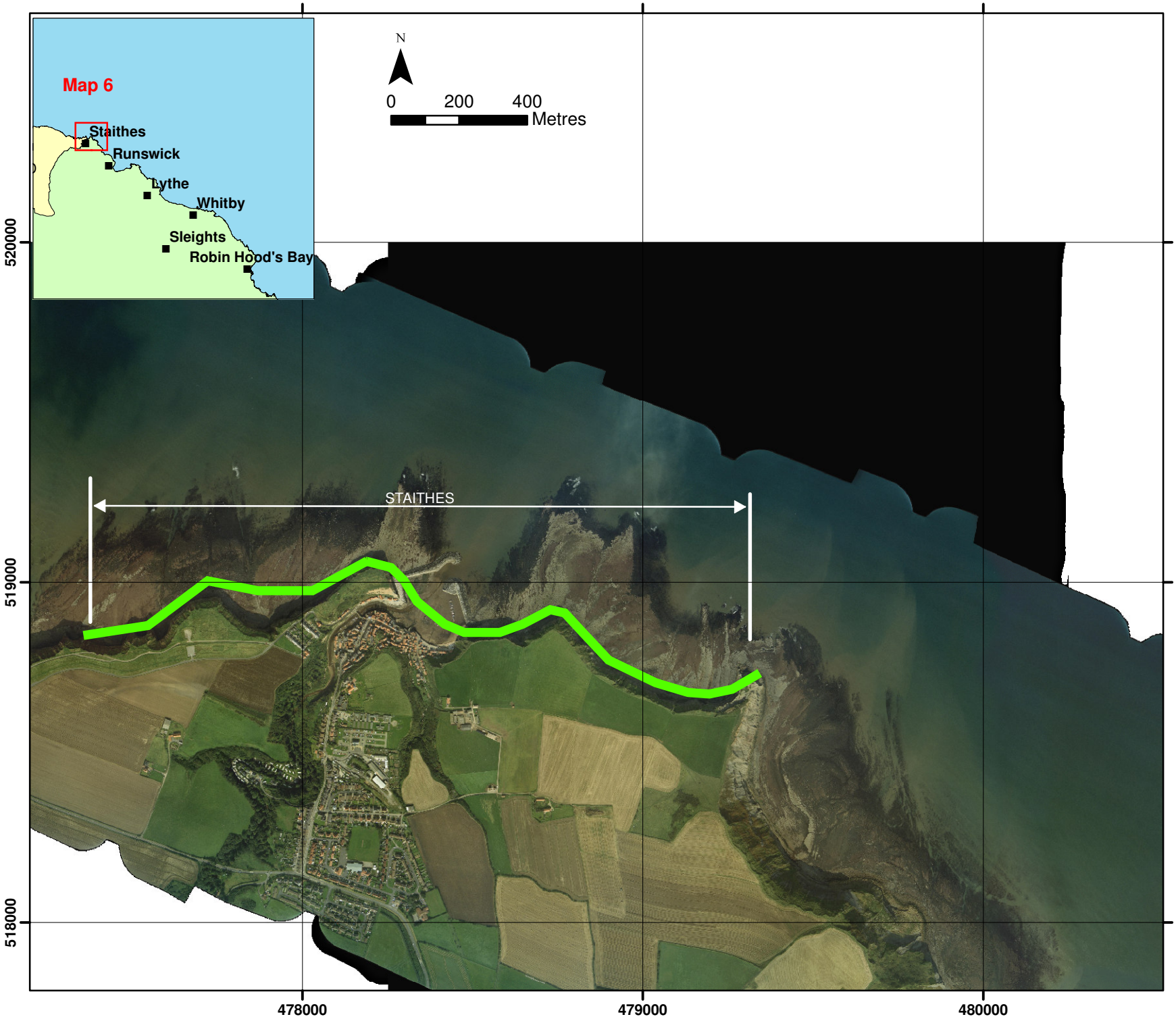

SURVEY LOCATIONS

Topographic Profiles

- Annual
- Bi-Annual

Topographic Surveys

- 6 monthly
- yearly
- 5 yearly

Cliff Top Monitoring Pegs

- @ 50 centres
- @ 100 centres
- @ 300 centres

(Indicative Survey Extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 6 Redcar & Cleveland Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

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2. Analysis of Survey Data

2.1 Coatham Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
09-2009	**Beach Profiles:** Coatham Sands is covered by four beach profiles (RC1 to RC4; Appendix A). RC1 is located approximately 300m south of the South Gare Breakwater, immediately in the lee of the German Charlies. This profile demonstrates stability across the dunes and only minor changes since March 2009 survey, with a movement if some material from between MSL and MHWN to the upper beach in the form of a notable berm. Along profiles RC2 to RC4 inclusive, there was very little measurable change between the March 2009 survey and the current survey.	The northern section of Coatham Sands, in the lee of German Charlies, remains relatively protected by the offshore slag banks and by the breakwater structure, and was subject to minor accretion. There also appears to be an accretion of sand across the rocky outcrops towards the north of the Sands, but this is likely to be the arrival of a temporary sand veneer across the rock outcrops. Elsewhere along the frontage the redistribution of sand from the lower to upper beach was notable, with a tendency for greater stability towards the south of the bay, approaching Coatham Rocks.
	Topographic Survey: Coatham Sands is covered by an annual topographic survey extending from the South Gare Breakwater, although the survey is contiguous with the Redcar Sands topographic survey (which is surveyed 6-monthly). Data have been used to create a DGM (Appendix B – Map 1a) using a Geographic Information System (GIS) computer software package. This shows how the German Charlies provide sheltering in the north of the frontage, resulting in a build up of sand adjacent to the South Gare Breakwater. The GIS has also been used to calculate the differences between the current topographic survey and the earlier (November 2008) topographic survey, as shown in Appendix B – Map 1b, to identify areas of erosion and accretion. This generally shows that there is a zone of accretion in the north of the bay, relatively little change in the south of the bay, and only minor redistribution of sand from the lower to upper profile along the central sections.	

2.2 Redcar Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
09-2009	**Beach Profiles:** Redcar Sands is covered by three beach profiles (RC5 to RC7; Appendix A), with RC7 being approximately on the boundary with the Marske Sands area. All profiles exhibited an increase in beach levels along the mid to upper beach, but only over a short cross-shore distance. Lower foreshore levels were relatively similar to previous surveys, although along RC6 the lowest levels to date were recorded along a chainage of around 30m.	There appear to be no consistent net trends in behaviour (i.e. no evidence of persistent long term erosion or accretion), but instead a general redistribution of sediment across the foreshore. The main pattern is one of lower beach lowering and movement of sediment to the upper beach along most of the frontage between Coatham Rocks and Redcar Rocks, but there remain exceptions to this locally. South-west of Redcar Rocks, the trend was reversed with upper beach lowering and redistribution of sediment down the profile. A major capital scheme is due to be constructed over a 24 month programme, commencing around November 2010.
	Topographic Survey: Redcar Sands is covered by a 6-monthly topographic survey, although the survey is contiguous with the Coatham Sands and Marske Sands topographic surveys (which are surveyed annually). Data have been used to create a DGM (Appendix B – Map 2a) using a Geographic Information System (GIS) computer software package. The low levels and narrow beach width in front of Redcar town remain obvious. The GIS has also been used to calculate the differences between the current topographic survey and the earlier (April 2009) topographic survey, as shown in Appendix B – Map 2b, to identify areas of erosion and accretion. There generally appears to be a redistribution of sediment within normal bounds of behaviour, with movement from the lower beach to upper beach between Coatham Rocks and Redcar Rocks. South-west of Redcar Rocks, the patterns is less consistent but there does appear to be more upper beach lowering along the Stray, with (minor) accumulation along the lower profile.	

2.3 Marske Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
09-2009	**Beach Profiles:** Marske Sands is covered by two beach profiles (RC7 to RC8; Appendix A), with RC7 being approximately on the boundary with the Redcar Sands area. RC7 exhibited an increase in beach levels along the mid to upper beach, but only over a short cross-shore distance. Lower foreshore levels were relatively similar to previous surveys. A slight lowering was observed at the toe of the dunes. RC8 also exhibited an increase in beach levels along the mid to upper beach, with no change in the backing dunes.	There appear to be no consistent net trends in behaviour (i.e. no evidence of persistent long term erosion or accretion), but instead a general redistribution of sediment across the foreshore. There is no single pattern of redistribution identifiable.
	Topographic Survey: Marske Sands is covered by an annual topographic survey, although the survey is contiguous with the Redcar Sands and Saltburn Sands topographic surveys (both of which are surveyed 6-monthly). Data have been used to create a DGM (Appendix B – Map 3a) using a Geographic Information System (GIS) computer software package. This shows a fairly uniform beach form along the length of the frontage. The GIS has also been used to calculate the differences between the current topographic survey and the earlier (November 2008) topographic survey, as shown in Appendix B – Map 3b, to identify areas of erosion and accretion. Similar to Redcar Sands, there generally appears to be a redistribution of sediment within normal bounds of behaviour, with zones of both lowering and accretion along the entire length, with no clear consistent pattern of change.	

2.4 Saltburn Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
09-2009	**Beach Profiles:** Saltburn Sands is covered by one beach profile (RC9; Appendix A). RC9 is located approximately 150m north of Saltburn Pier. There has been notable accretion immediately at the toe of the sea wall with beach levels now some 0.6m higher than those recorded in April 2009. Further seaward along the profile, levels were very similar to previous surveys, although a slight bar and trough feature had developed towards the seaward limit.	There is notable variation in beach levels at the toe of the sea wall as identified by successive profile surveys along RC9. The outfall channel of Skelton Beck continues to influence foreshore level changes locally.
	Topographic Survey: Saltburn Sands is covered by a 6-monthly topographic survey, although the survey is contiguous with the Marske Sands topographic survey which is surveyed annually. Data have been used to create a DGM (Appendix B – Map 4a) using a Geographic Information System (GIS) computer software package. The GIS has also been used to calculate the differences between the current topographic survey and the earlier (April 2009) topographic survey, as shown in Appendix B – Map 4b, to identify areas of erosion and accretion. This DGM shows continue lowering in the vicinity of Skelton Beck as the outfall channel migrates across the foreshore, but general accretion or stability elsewhere, with lowering confined to only a very narrow width adjacent to the toe of the defences.	

2.5 Cattersty Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
10-2009	**Topographic Survey:** Cattersty Sands is covered by a 6-monthly topographic survey. Data have been used to create a DGM (Appendix B – Map 5a) using a Geographic Information System (GIS) computer software package. The GIS has also been used to calculate the differences between the current topographic survey DGM (October 2009) and the earlier (April 2009) topographic survey DGM, with 5m raster grids (as shown in Appendix B – Map 5b), to identify areas of erosion and accretion. This figure reveals different patterns of beach change either side of the Jetty. Cattersty Sands to the west generally show a sequence of shore-parallel change and a limited occurrence of overall beach loss. At the head of the beach accretion occurs (contrasting the erosion reported previously for this location between November 2008 and April 2009). Following this, there are marked bands of erosion and accretion within the inter-tidal zone which represent a net landward transfer of beach materials over the summer period. To the east of the Jetty the upper beach has generally trended towards sediment loss over the period of comparison. The inter-tidal zone has experienced accretion, whilst erosion is evident in the low-tide area. As the river flows across the beach it produces a complex signal of change, with a trend towards erosion.	The difference model shows this to be a dynamic area, influenced by both marine and fluvial processes; there is a marked difference in beach levels and beach behaviour on either side of the Jetty. The difference in behaviour may be partly attributed, to the presence of the river to the east of the Jetty. Long term trends in accretion / erosion are currently difficult to discern; although subtle seasonal shore parallel variability is identifiable (e.g. summer swell dominated beach profile). In contrast, fluvial impacts do not run parallel to the shoreline, resulting in different patterns of beach/ river mouth change.

2.6 Staithes

Survey Date	Description of Changes Since Last Survey	Interpretation
09-2009	**Cliff Top Survey:** Twenty ground control points have been established at Staithes for the purposes of cliff top monitoring (Appendix C – Map 1). The separation between any two points is typically around 100 m (although occasionally less). The cliff top surveys at Staithes are undertaken bi-annually. Data collection involves a distance offset measurement from the ground control point to the cliff edge along a fixed bearing. Appendix C provides results from the September 2009 survey showing the position from the ground control point to the edge of the cliff top along the defined bearing and changes in position since the November 2008 baseline survey.	When survey accuracy is taken into consideration, eight of the twenty points have shown no change since the November 2008 survey, indicating local stability of the cliff face. Seven locations (points 1, 2, 4, 11, 13, 17, 19) have shown cliff line recession ranging 0.2m to 2.1m (±0.1 m due to survey accuracy). Five locations (points 3, 8, 9, 10, 12) have shown an increase in distance to the cliff edge (0.3m to 4.3m), which possibly represent a toppling failure. However, different interpretation of the cliff edge between successive surveys could also account for this change. Future repeat surveys will reveal longer-term trends in the dynamics of this cliff line.

3. Problems Encountered and Uncertainty in Analysis

There were no major problems encountered during the surveys, although the topographic surveys along Coatham Sands, Redcar Sands, Marske Sands and Saltburn Sands covered extensive areas and were therefore highly time-consuming to conduct.

A major capital scheme is due to be constructed at Redcar seafront over a 24-month programme, commencing around October 2010. This will affect the ability of the surveyors to undertake future surveys along sections where construction activity is ongoing and a 'reasonable endeavours' approach will be adopted, around the Health & Safety constraints imposed by the scheme. The Partial Measures surveys scheduled for spring 2010 will be unaffected.

It is important to be aware that the interpolation method employed to convert the topographic point data to a DGM will introduce some minor errors, and is less reliable at the edges of the data coverage. These are normal and accepted issues of interpolating data, and therefore do not present any problems for this assessment. It is, however, beneficial to take into account edge effects when interpreting the difference between topographic surveys.

The cliff top surveys at Staithes are assumed to have a limit of accuracy of ± 0.1m due to the techniques used. At a number of locations apparent cliff advance has been calculated, which is highly unlikely excepting a toppling mechanism of failure. It is more likely that this is due to a different point being identified as the edge of the cliff, especially with different seasonal vegetation covers. This problem remains marked at Staithes, which may reflect a particular site condition, which requires further investigation (ideally by a cliff geomorphologist). This will be investigated further during the 2010 walk-over inspections.

4. Recommendations for 'Fine-tuning' the Monitoring Programme

Measures to improve the accuracy of cliff top survey data capture are being considered on a wider basis, as pre-existing concerns remain. Photography at the time of each survey (like is undertaken for the beach profiles) and a site visit by a cliff geomorphologist would increase understanding and value of these data at all sites.

Specifically at Cowbar Lane, Redcar & Cleveland Borough Council is hoping to obtain Environment Agency funding to enable more detailed and more precise laser scanning of the cliffs at this location. This information would provide a more robust assessment of change in the cliff top position and behaviour of the cliff face.

5. Conclusions and Areas of Concern

- The northern section of Coatham Sands remains sheltered against waves from all but north-easterly and easterly directions due to the presence of the South Gare Breakwater and German Charlies slag banks.

- The main frontages of Coatham Sands, Redcar Sands, Marske Sands and Saltburn Sands are relatively featureless and possess a comparatively uniform cross-shore gradient along the frontage.

- The main exception to this description is at Redcar town, where beach contours cut landward markedly, exposing the defences to direct wave attack. A major capital scheme is scheduled to be constructed here between November 2010 and November 2012.

- Foreshore changes between Coatham Sands and Saltburn Sands do not appear to demonstrate any persistent trends along the frontage, but rather represent redistributions of sediment both across the foreshore and along the frontage.

- Cattersty Sands (Skinningrove) shows beach change typical of seasonal (summer) marine processes, and also depicts the influence of the outflowing river. The patterns of beach change are therefore more complicated than would be anticipated by coastal processes alone.

- The Staithes frontage has shown areas of localised cliff top stasis, advance (either toppling failure or erroneous survey), and recession. Hotspots for cliff top retreat at this time are to the west adjacent to Cowbar Lane and Cowbar Nab, the cliff backing Penny Steel, and the Old Nab.

Appendices

Appendix A

Beach Profiles

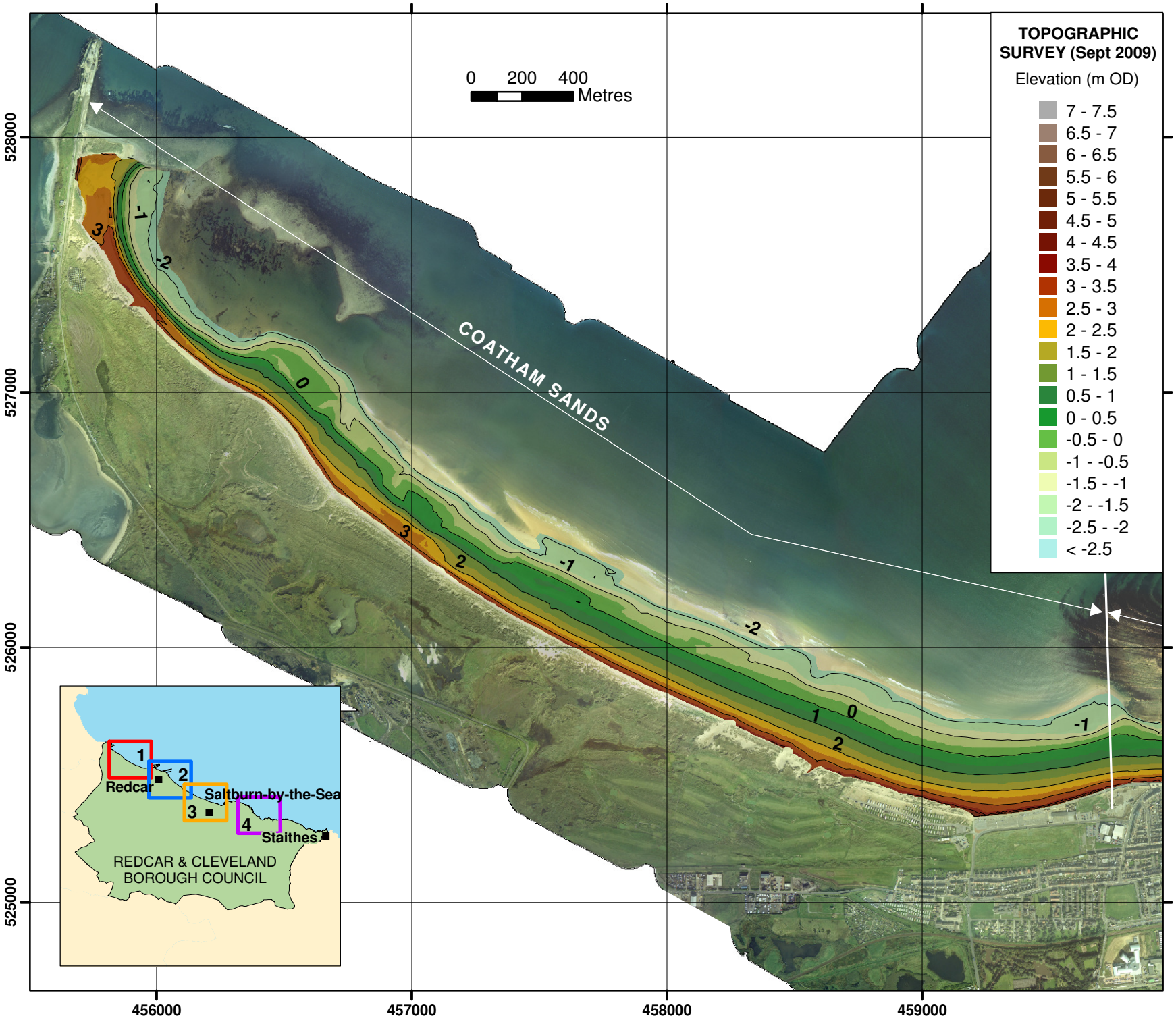
See separate file

The following sediment feature codes are used on some profile plots:

Code	Description
M	Mud
S	Sand
G	Gravel
GS	Gravel & Sand
GM	Gravel & Mud
MS	Mud & Sand
B	Boulders
R	Rock
SD	Sea Defence
SM	Salt Marsh
GR	Grass
D	Dune (non-vegetated)
DV	Dune (vegetated)
F	Forested
X	Mixture
FB	Obstruction
CT	Cliff Top
CE	Cliff Edge
CF	Cliff Face
SH	Shell
W	Water Body
ZZ	Unknown

Appendix B

Topographic Survey



TOPOGRAPHIC SURVEY (Sept 2009)

Elevation (m OD)

- 7 - 7.5
- 6.5 - 7
- 6 - 6.5
- 5.5 - 6
- 5 - 5.5
- 4.5 - 5
- 4 - 4.5
- 3.5 - 4
- 3 - 3.5
- 2.5 - 3
- 2 - 2.5
- 1.5 - 2
- 1 - 1.5
- 0.5 - 1
- 0 - 0.5
- -0.5 - 0
- -1 - -0.5
- -1.5 - -1
- -2 - -1.5
- -2.5 - -2
- < -2.5

Topographic Contours at 1 metre interval

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 1a Redcar & Cleveland Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:20,000 at A4

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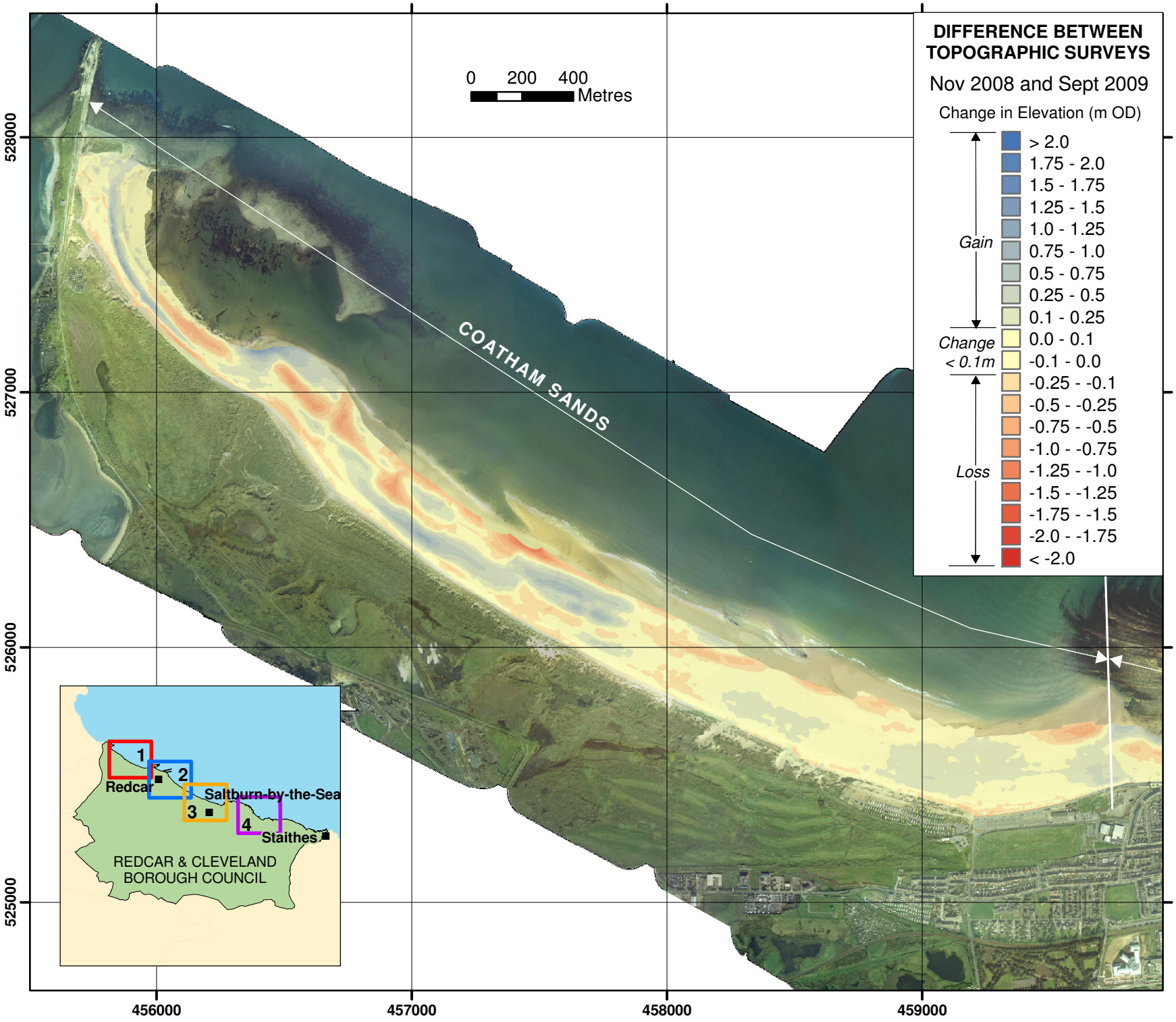

DIFFERENCE BETWEEN TOPOGRAPHIC SURVEYS

Nov 2008 and Sept 2009

Change in Elevation (m OD)

Gain	> 2.0
	1.75 - 2.0
	1.5 - 1.75
	1.25 - 1.5
	1.0 - 1.25
	0.75 - 1.0
	0.5 - 0.75
	0.25 - 0.5
	0.1 - 0.25
Change < 0.1m	0.0 - 0.1
	-0.1 - 0.0
Loss	-0.25 - -0.1
	-0.5 - -0.25
	-0.75 - -0.5
	-1.0 - -0.75
	-1.25 - -1.0
	-1.5 - -1.25
	-1.75 - -1.5
	-2.0 - -1.75
	< -2.0

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 1b Redcar & Cleveland Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:20,000 at A4

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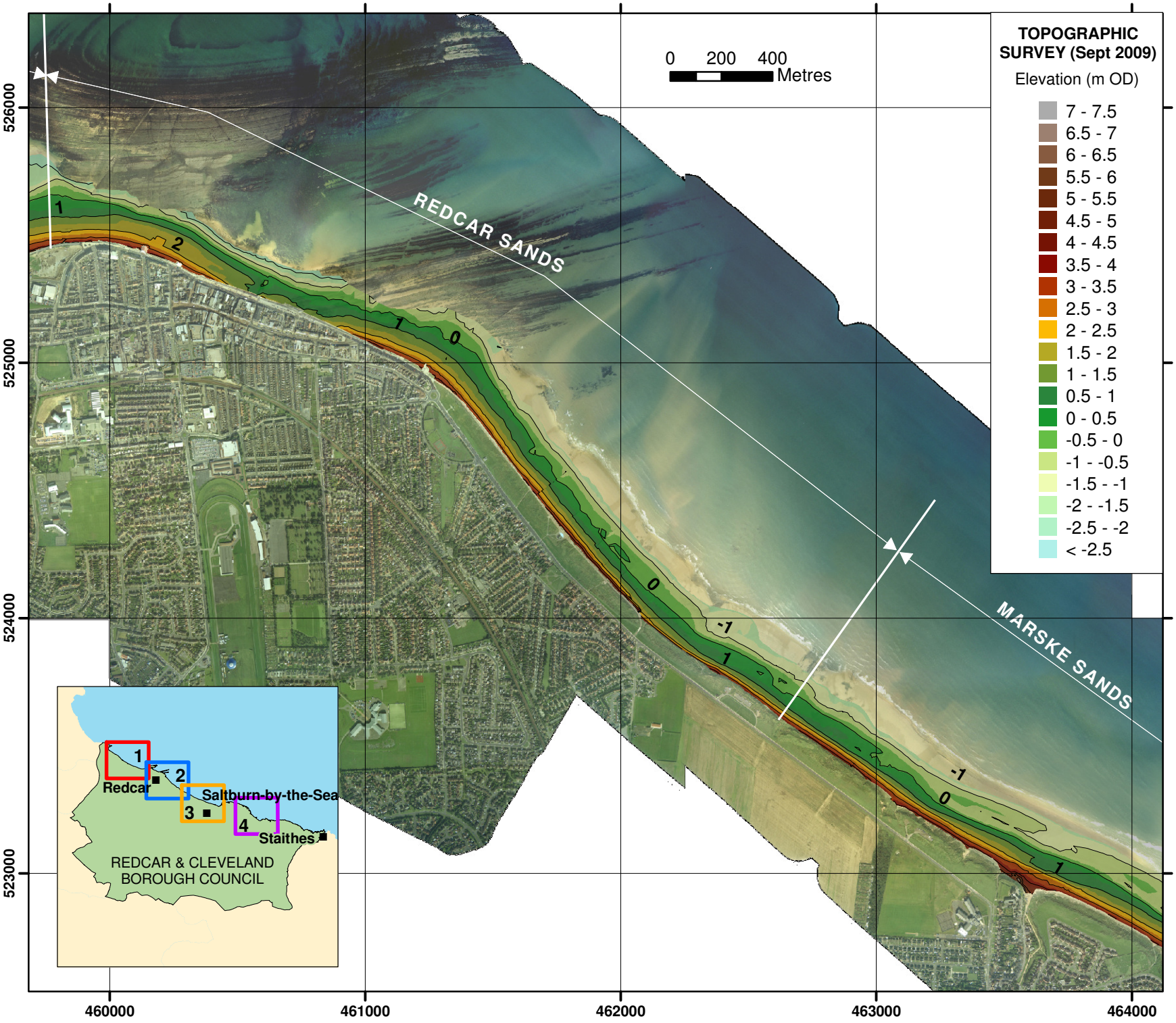

Topographic Contours at 1 metre interval

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 2a Redcar & Cleveland Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:20,000 at A4

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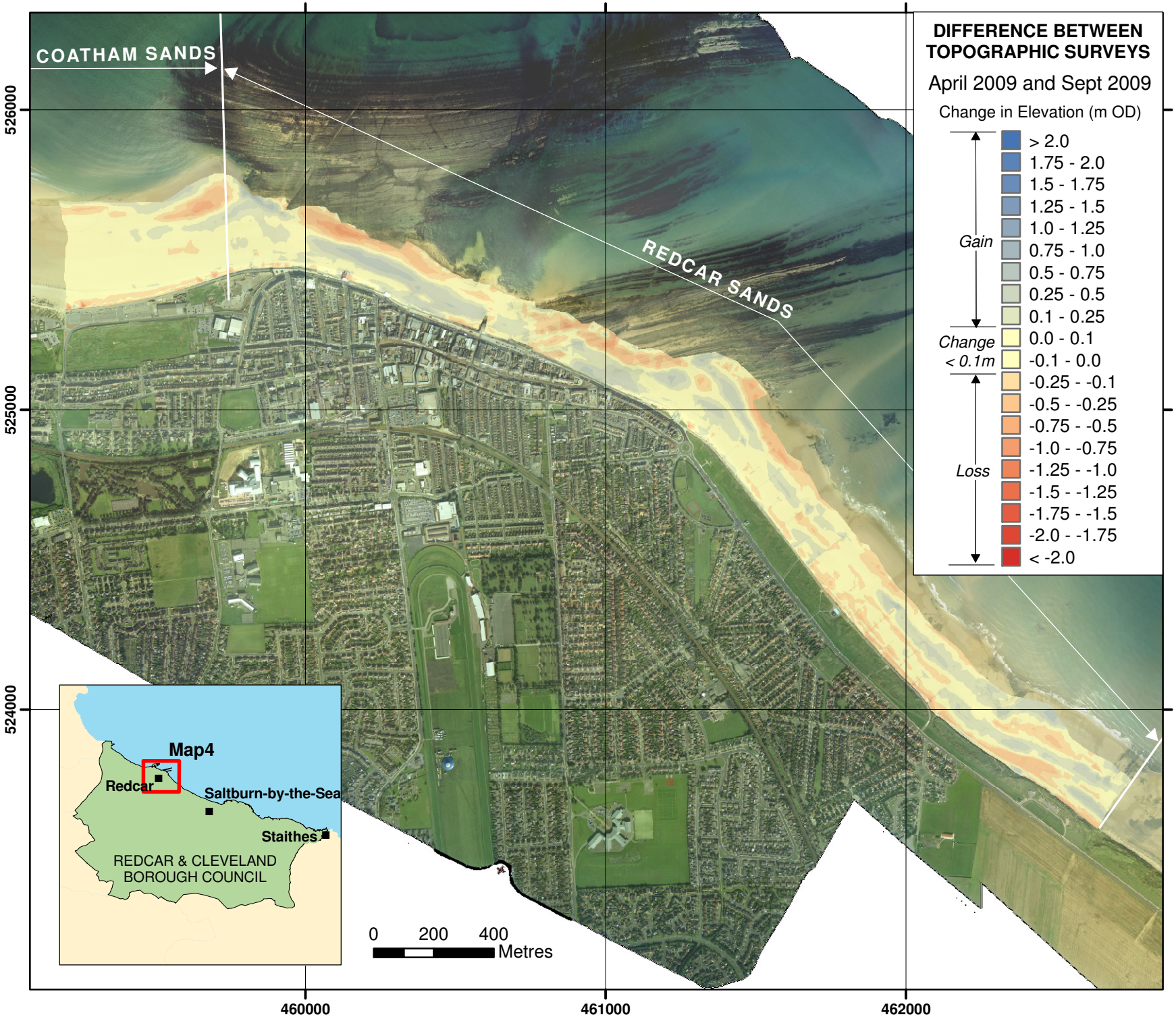

DIFFERENCE BETWEEN TOPOGRAPHIC SURVEYS

April 2009 and Sept 2009

Change in Elevation (m OD)

Gain	> 2.0
	1.75 - 2.0
	1.5 - 1.75
	1.25 - 1.5
	1.0 - 1.25
	0.75 - 1.0
	0.5 - 0.75
	0.25 - 0.5
	0.1 - 0.25
Change < 0.1m	0.0 - 0.1
	-0.1 - 0.0
Loss	-0.25 - -0.1
	-0.5 - -0.25
	-0.75 - -0.5
	-1.0 - -0.75
	-1.25 - -1.0
	-1.5 - -1.25
	-1.75 - -1.5
	-2.0 - -1.75
	< -2.0

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 2b Redcar & Cleveland Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:17,000 at A4

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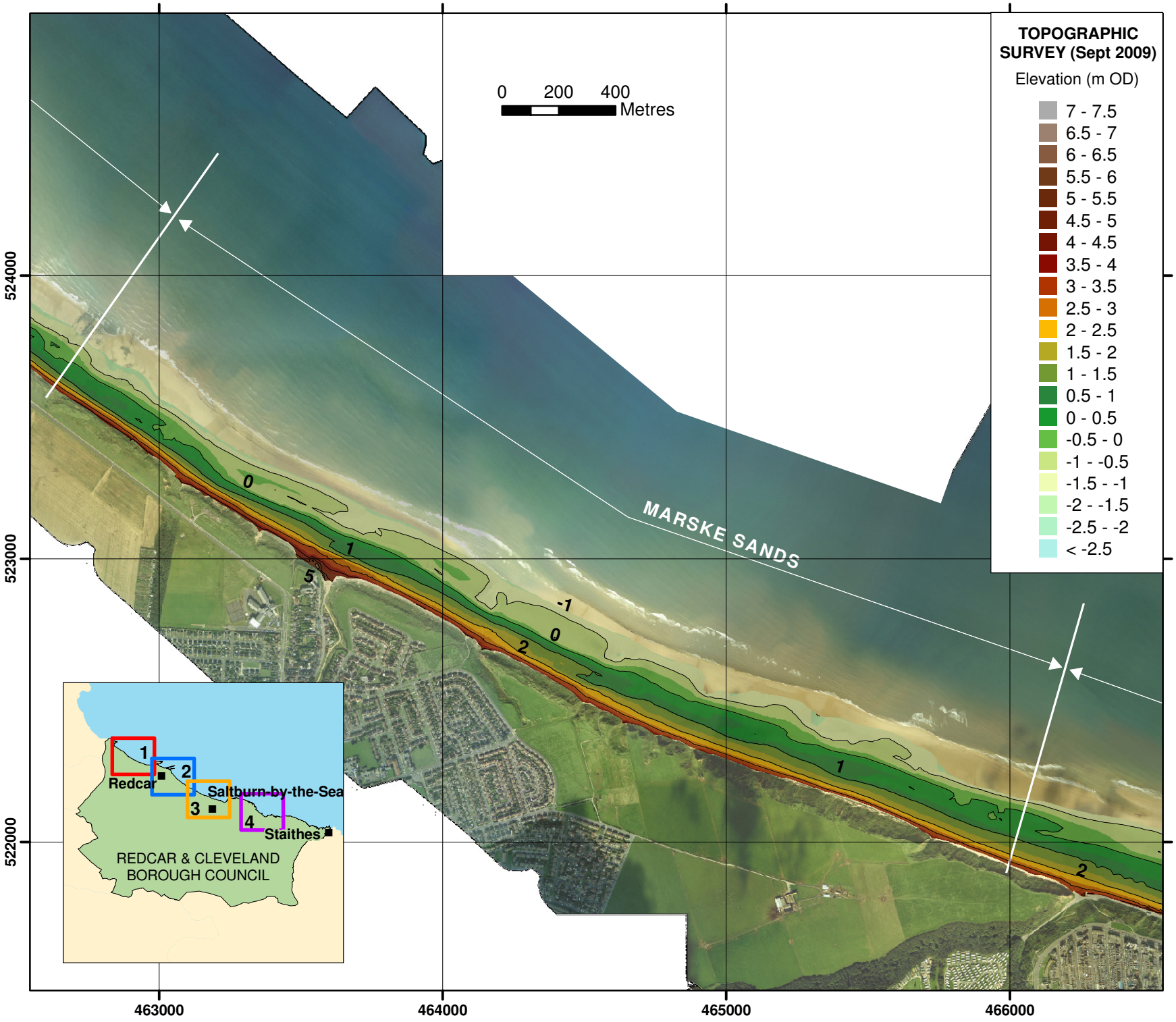

Topographic Contours at 1 metre interval

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 3a Redcar & Cleveland Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:18,000 at A4

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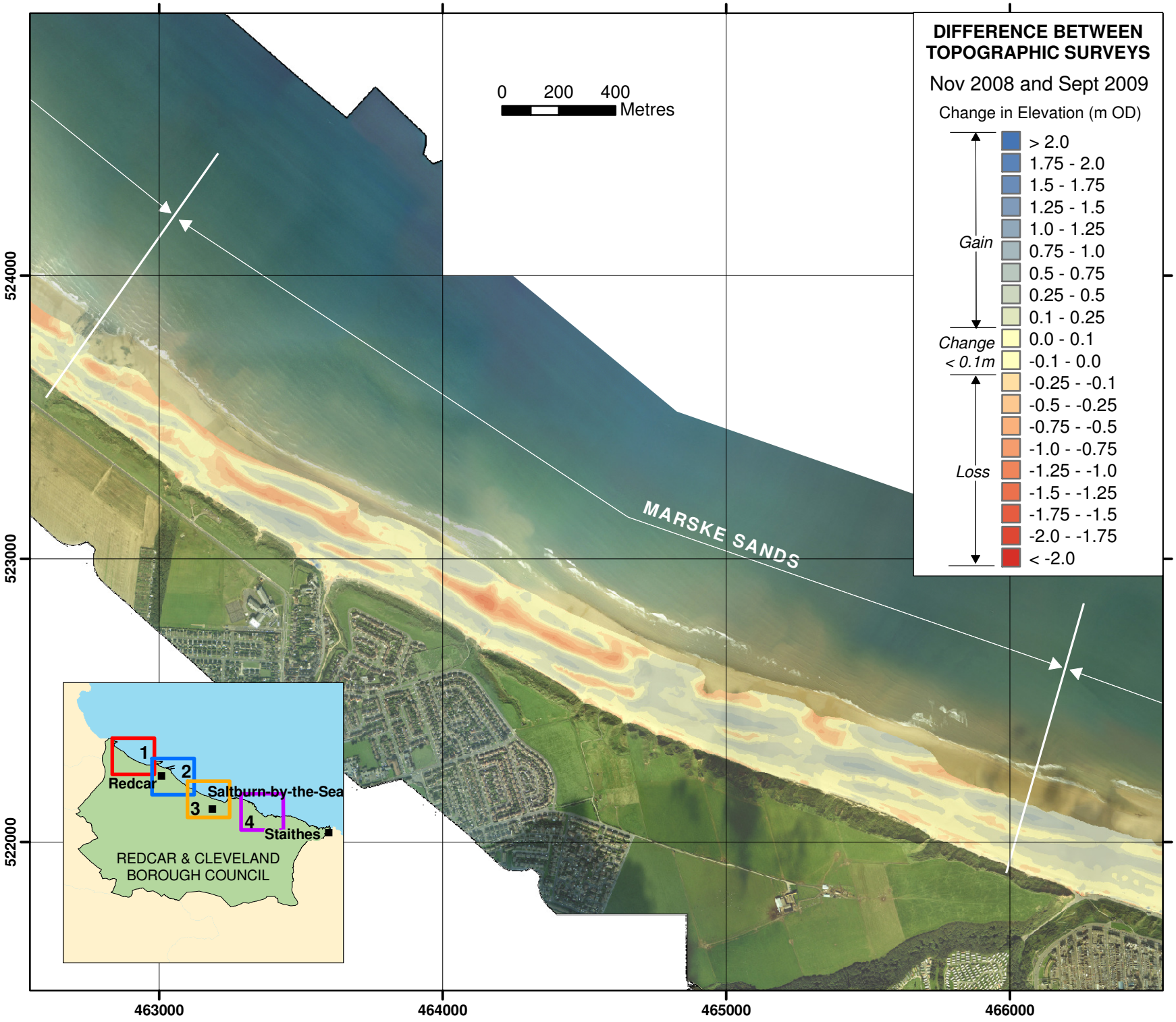

DIFFERENCE BETWEEN TOPOGRAPHIC SURVEYS

Nov 2008 and Sept 2009

Change in Elevation (m OD)

Gain	> 2.0
	1.75 - 2.0
	1.5 - 1.75
	1.25 - 1.5
	1.0 - 1.25
	0.75 - 1.0
	0.5 - 0.75
	0.25 - 0.5
	0.1 - 0.25
Change < 0.1m	0.0 - 0.1
	-0.1 - 0.0
Loss	-0.25 - -0.1
	-0.5 - -0.25
	-0.75 - -0.5
	-1.0 - -0.75
	-1.25 - -1.0
	-1.5 - -1.25
	-1.75 - -1.5
	-2.0 - -1.75
	< -2.0

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 3b Redcar & Cleveland Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:18,000 at A4

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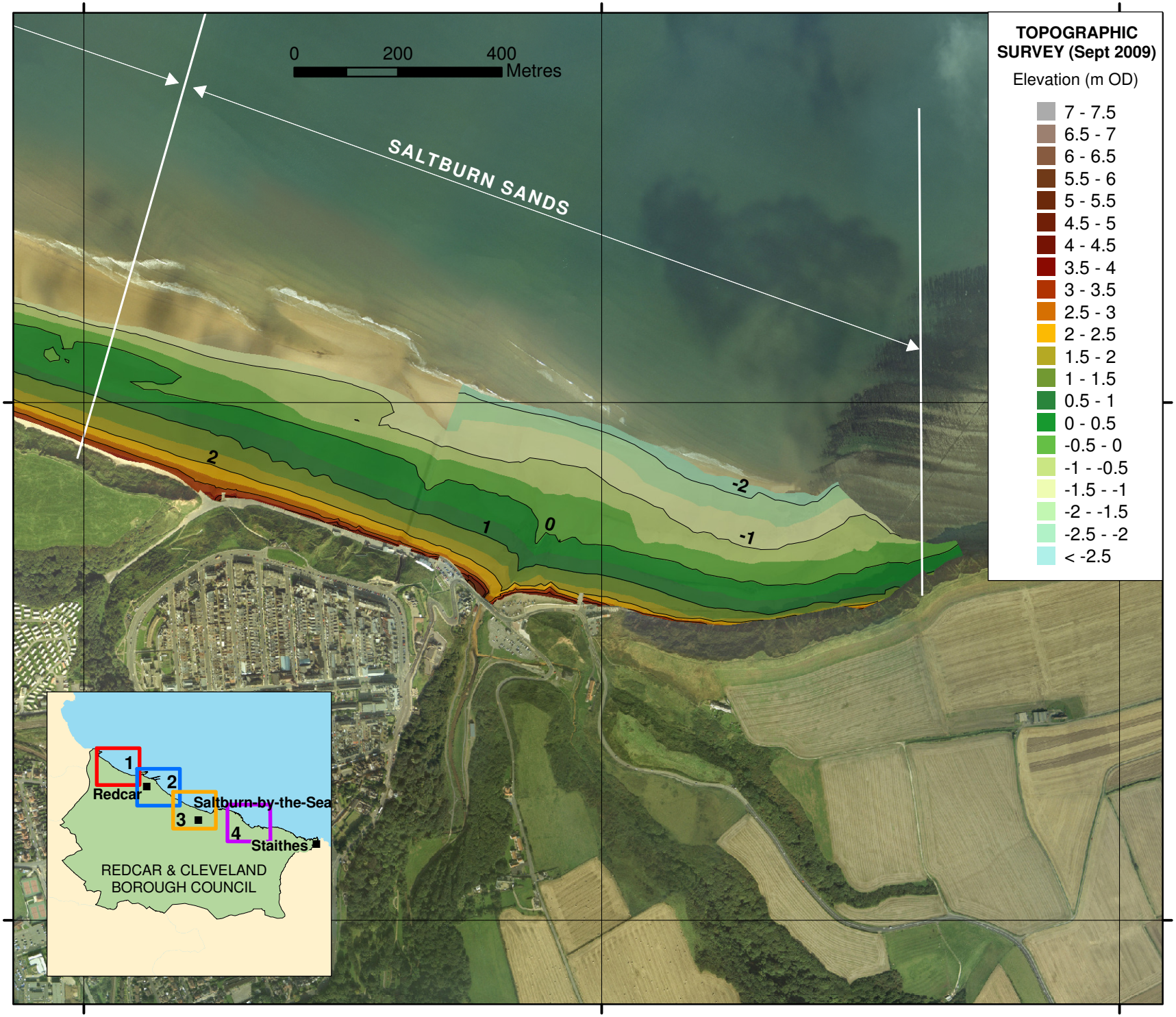

TOPOGRAPHIC SURVEY (Sept 2009)

Elevation (m OD)

- 7 - 7.5
- 6.5 - 7
- 6 - 6.5
- 5.5 - 6
- 5 - 5.5
- 4.5 - 5
- 4 - 4.5
- 3.5 - 4
- 3 - 3.5
- 2.5 - 3
- 2 - 2.5
- 1.5 - 2
- 1 - 1.5
- 0.5 - 1
- 0 - 0.5
- -0.5 - 0
- -1 - -0.5
- -1.5 - -1
- -2 - -1.5
- -2.5 - -2
- < -2.5

Topographic Contours at 1 metre interval

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 4a
Redcar & Cleveland Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:18,000 at A4

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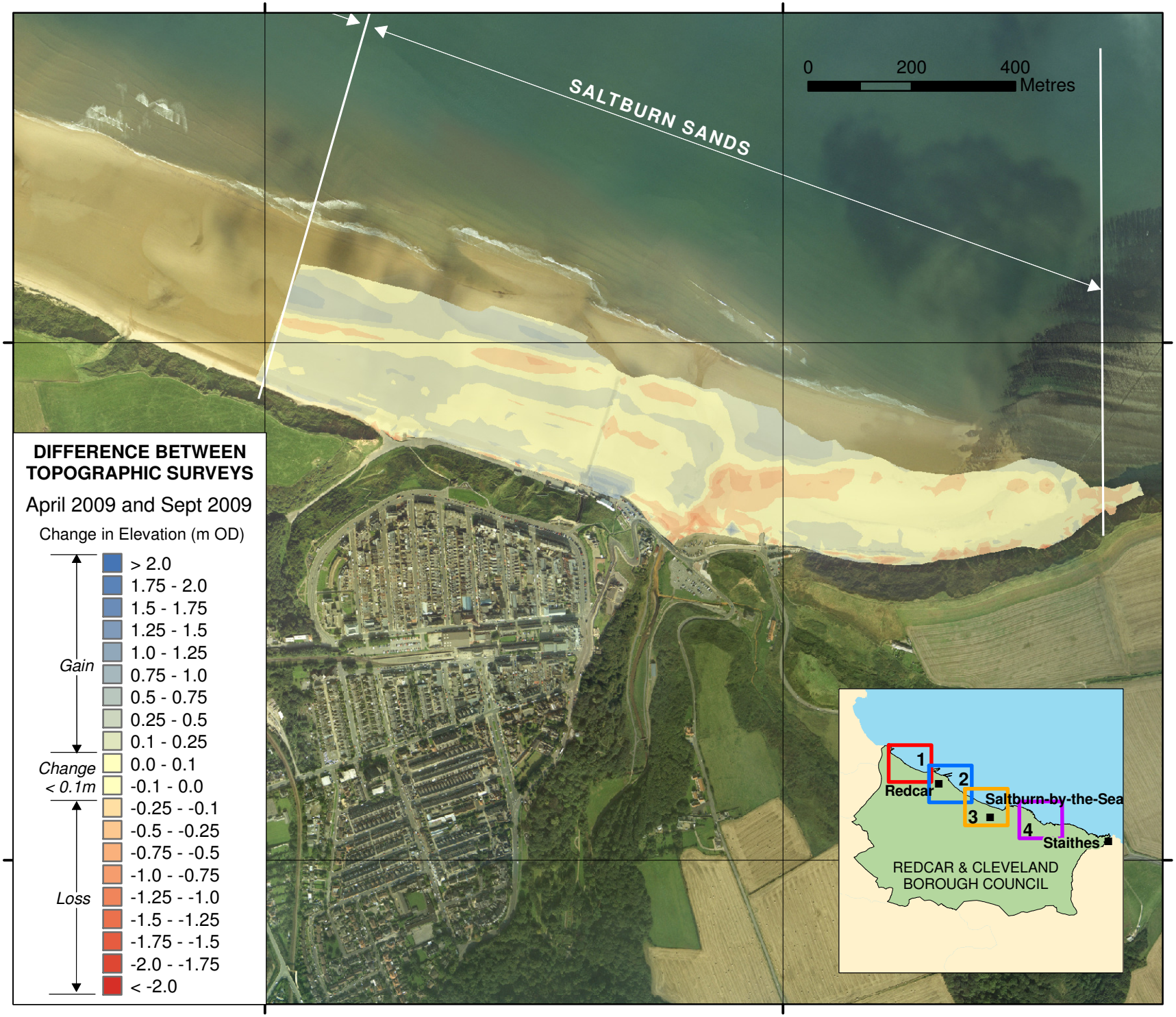

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 4b
Redcar & Cleveland Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:10,000 at A4

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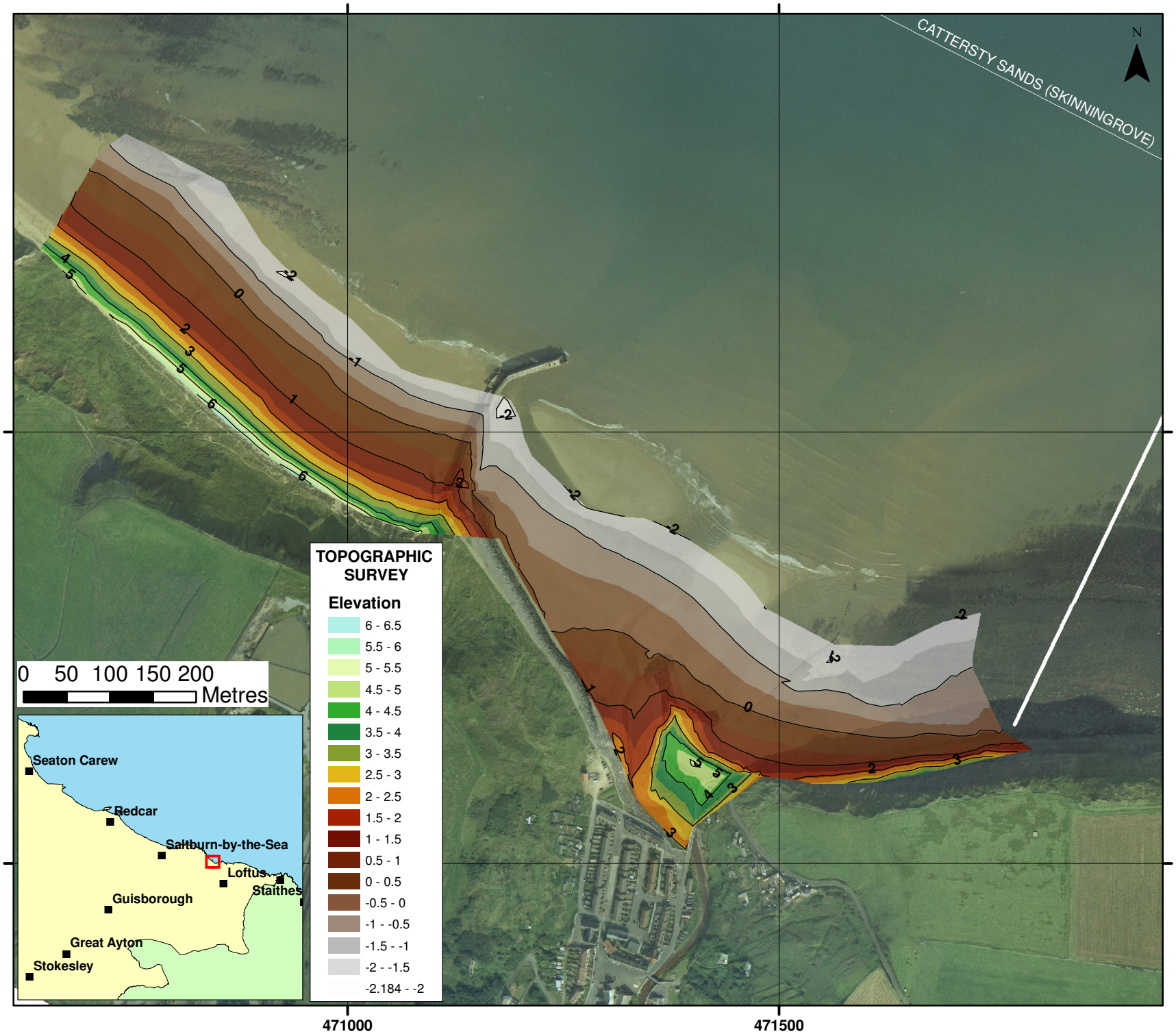

Topographic Contours at 1 metre interval

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 5a Redcar and Cleveland Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:6,000 at A4

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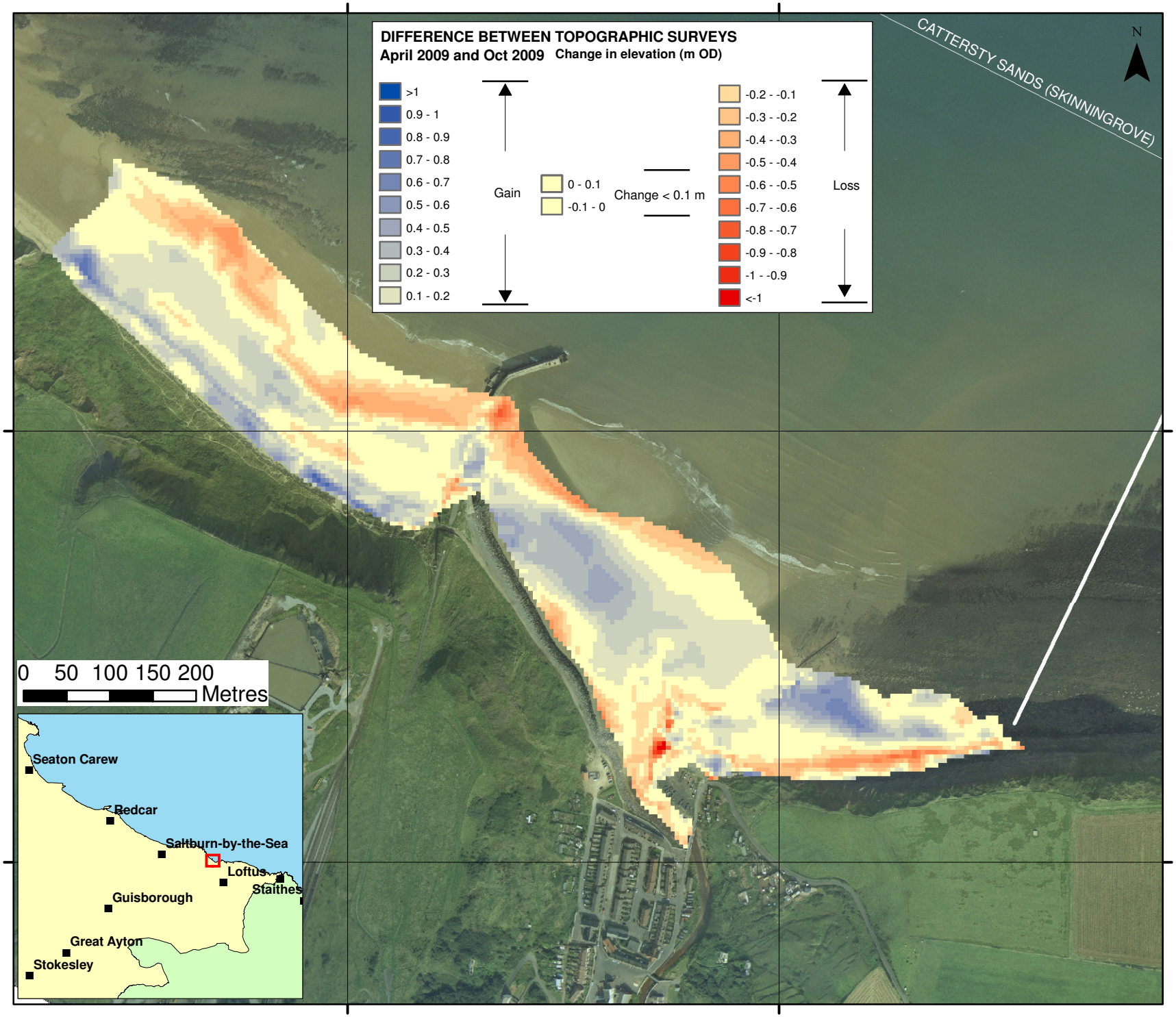

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 5b Redcar and Cleveland Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:6,000 at A4

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Appendix C

Cliff Top Survey

Cliff Top Survey

Staithes

Twenty ground control points have been established at Staithes (Appendix C - Map 1). The maximum separation between any two points is nominally 100 m.

The cliff top surveys at Staithes are undertaken bi-annually. Measurements are taken from a fixed ground control point along a fixed bearing to the edge of the cliff top.

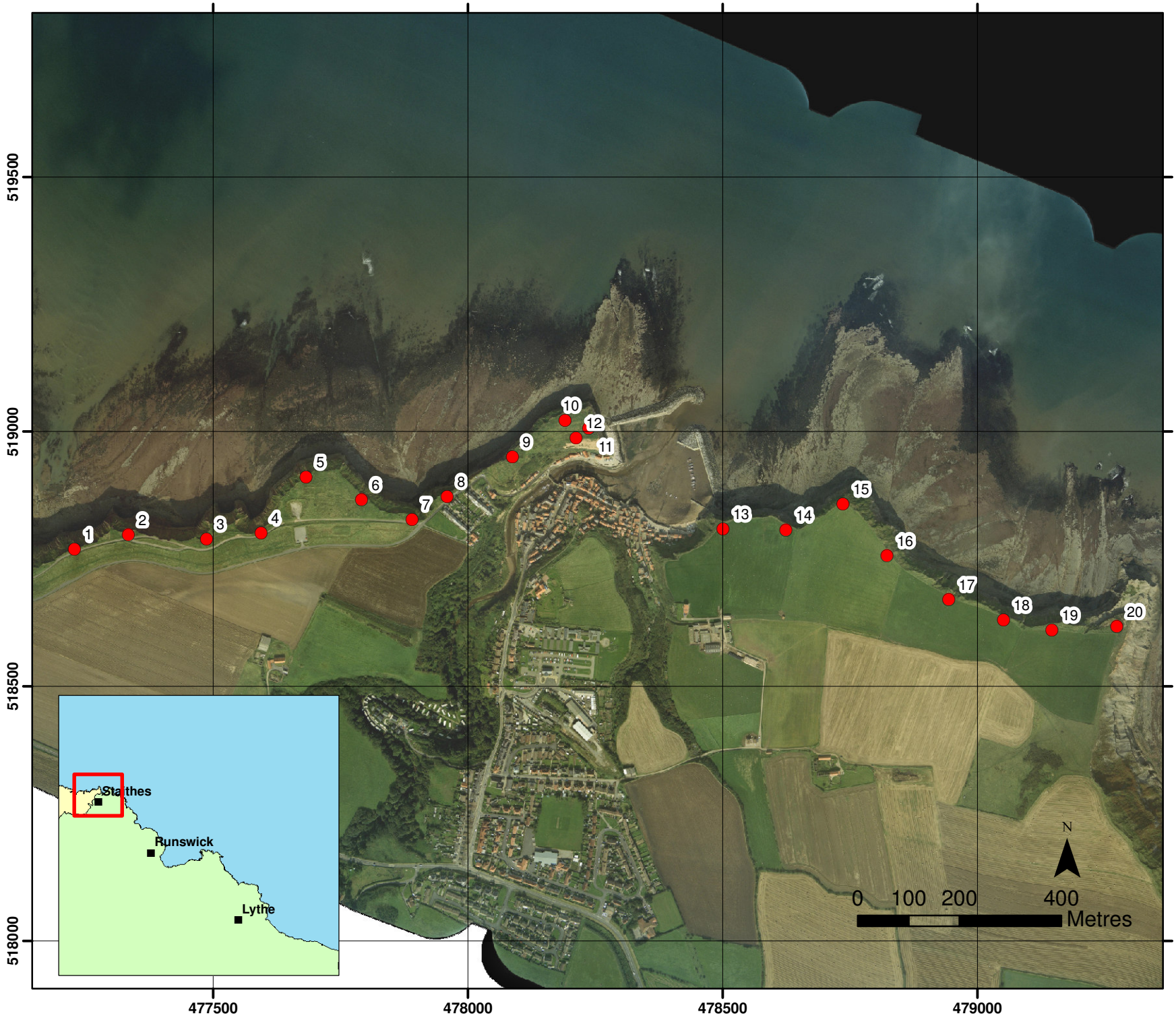
Table C1 provides baseline information about these ground control points and results from the April 2009 survey showing the position from the ground control point to the edge of the cliff top along the defined bearing and changes in position since the November 2008 baseline survey.

Table C1 – Cliff Top Surveys at Staithes

Ground Control Point Details					Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Easting	Northing	Level (mODN)	Bearing (º)	Baseline Survey (Nov 2008)	Previous Survey (April 2009)	Present Survey (Sept 2009)	Baseline (Nov 2008) to Present (Sept 2009)	Previous (April 2009) to Present (Sept 2009)	Baseline (Nov 2008) to Present (Sept 2009)
1	477228	518769	60.587	320	1.9	1.7	1.7	-0.2	0	-0.3
2	477334	518798	57.543	0	10.9	10.6	10.6	-0.3	0	-0.3
3	477487	518789	54.861	350	7.1	7.8	8.4	+1.3	+0.6	-
4	477594	518801	53.636	340	5.9	5.6	5.7	-0.2	+0.1	-0.3
5	477683	518911	48.371	350	8.4	7.8	8.5	+0.1	+0.7	-
6	477792	518867	47.422	30	8.6	8.5	8.5	-0.1	0	-0.1
7	477891	518828	44.602	60	7.7	7.6	7.7	0.0	+0.1	0.0
8	477959	518873	39.974	350	8.7	8.7	9.0	+0.3	+0.3	-
9	478088	518950	37.281	350	7.6	7.3	8.4	+0.8	+1.1	-
10	478191	519023	42.655	340	8.4	8.6	12.7	+4.3	+4.1	-
11	478237	519007	39.990	60	6.9	6.8	6.8	-0.2	0	-0.2
12	478213	518988	37.169	150	6.1	6.7	6.4	+0.3	-0.3	-

Ground Control Point Details					Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Easting	Northing	Level (mODN)	Bearing (º)	Baseline Survey (Nov 2008)	Previous Survey (April 2009)	Present Survey (Sept 2009)	Baseline (Nov 2008) to Present (Sept 2009)	Previous (April 2009) to Present (Sept 2009)	Baseline (Nov 2008) to Present (Sept 2009)
13	478501	518809	50.260	15	11.4	10.9	9.3	-2.1	-1.6	-2.5
14	478624	518807	55.345	20	7.5	7.0	7.6	+0.1	+0.6	-
15	478737	518858	56.017	60	6.1	6.8	6.1	0	-0.7	0.0
16	478823	518757	50.237	60	8.0	8.1	7.9	-0.1	-0.2	-0.1
17	478944	518671	46.764	30	9.3	9.5	9.0	-0.3	-0.5	-0.3
18	479052	518630	47.026	20	9.2	9.1	9.1	-0.1	0	-0.1
19	479147	518610	47.108	0	14.2	14.4	14.0	-0.3	-0.5	-0.3
20	479274	518618	44.243	20	11.4	11.2	11.5	+0.1	+0.3	-

Note: It is assumed that the accuracy of cliff top monitoring using this technique is ±0.1m. Therefore observed changes have been altered by this amount prior to calculation of an erosion rate. Erosion rates are not calculated where the cliff line shows advance. This is likely to be the product of differing survey interpretation, and far less likely to be a toppling cliff edge.



Ground Control Points

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix C - Map 1 Redcar & Cleveland Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:10,000 at A4

Drawn by:	ES	Date: 25/01/2010
Checked by:	RJ	Date: 25/01/2010
Approved by:	RJ	Date: 25/01/2010

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