



**Cell 1 Regional Coastal Monitoring Programme
Analytical Report 3: 'Full Measures' Survey 2010**



**Redcar & Cleveland
Borough Council
Final Report**

February 2011

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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.

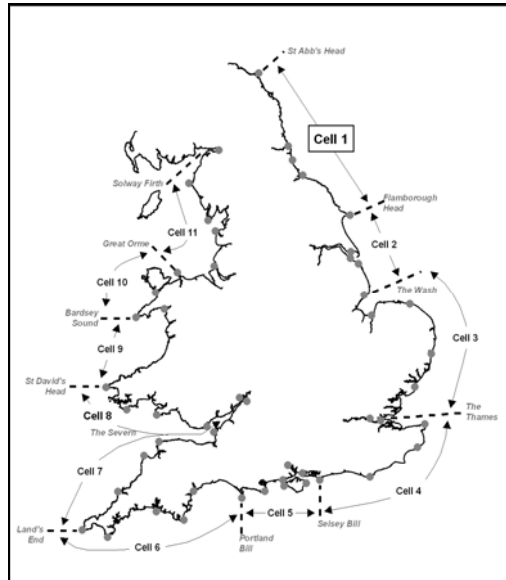


Figure 1 Sediment Cells in England and Wales

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.



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	Mar-May 10	July 10	-
3	2010/11	Sep-Dec 10	Feb 11 ^(*)			

^(*) The present report is **Analytical Report 3** and provides an analysis of the 2010 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, Uppgang 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 November 2010. During the Coatham, Redcar, Marske and Saltburn surveys (November 2010) weather conditions were wet and breezy and the sea state was moderate but with a long swell. During the Skinningrove survey (November 2010) weather conditions were wet and windy and the sea state was rough with a light swell. During the Staithes survey (September 2010) weather conditions were breezy and wet and the sea state was moderate.

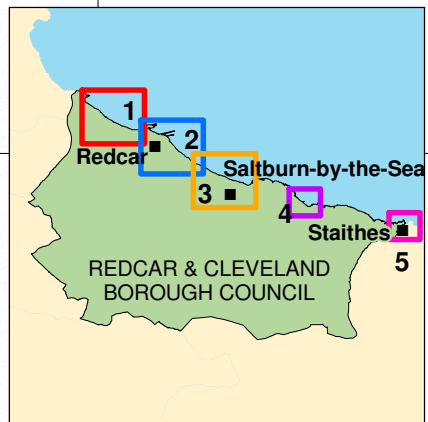
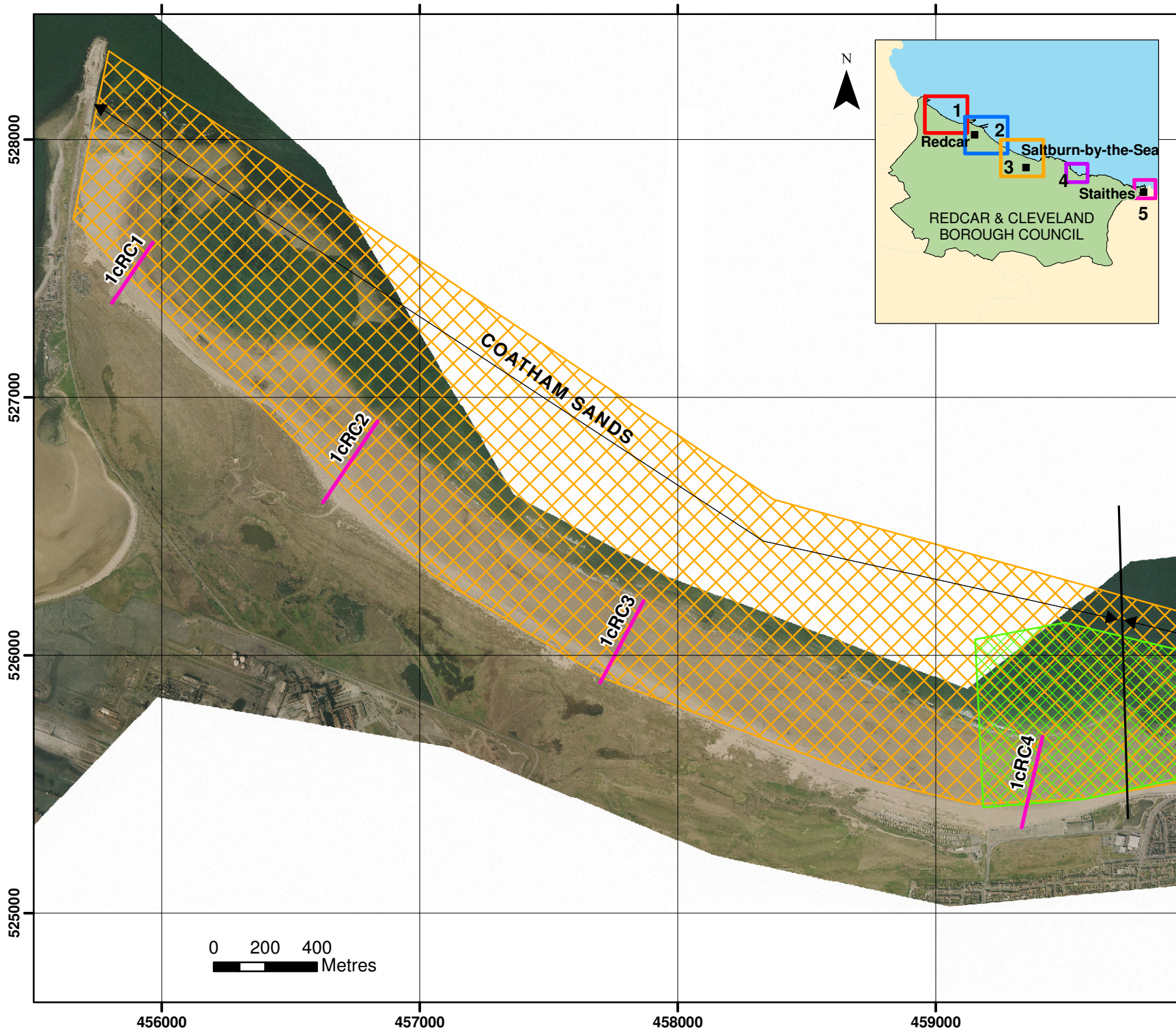
All data have been captured in a manner commensurate with the principles of the Environment Agency's *National Standard Contract and Specification for Surveying Services* and stored in a file format compatible with the software systems being used for the data analysis, namely SANDS and Arc-GIS. This 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 (Blue line)
- Bi-Annual (Pink line)

Topographic Surveys

- 6 monthly (Green grid)
- yearly (Orange grid)
- 5 yearly (Brown grid)

Cliff Top Monitoring Pegs

- @ 50 centres (Purple bar)
- @ 100 centres (Green bar)
- @ 300 centres (Red bar)

(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 3
 'Full Measures' Survey 2010

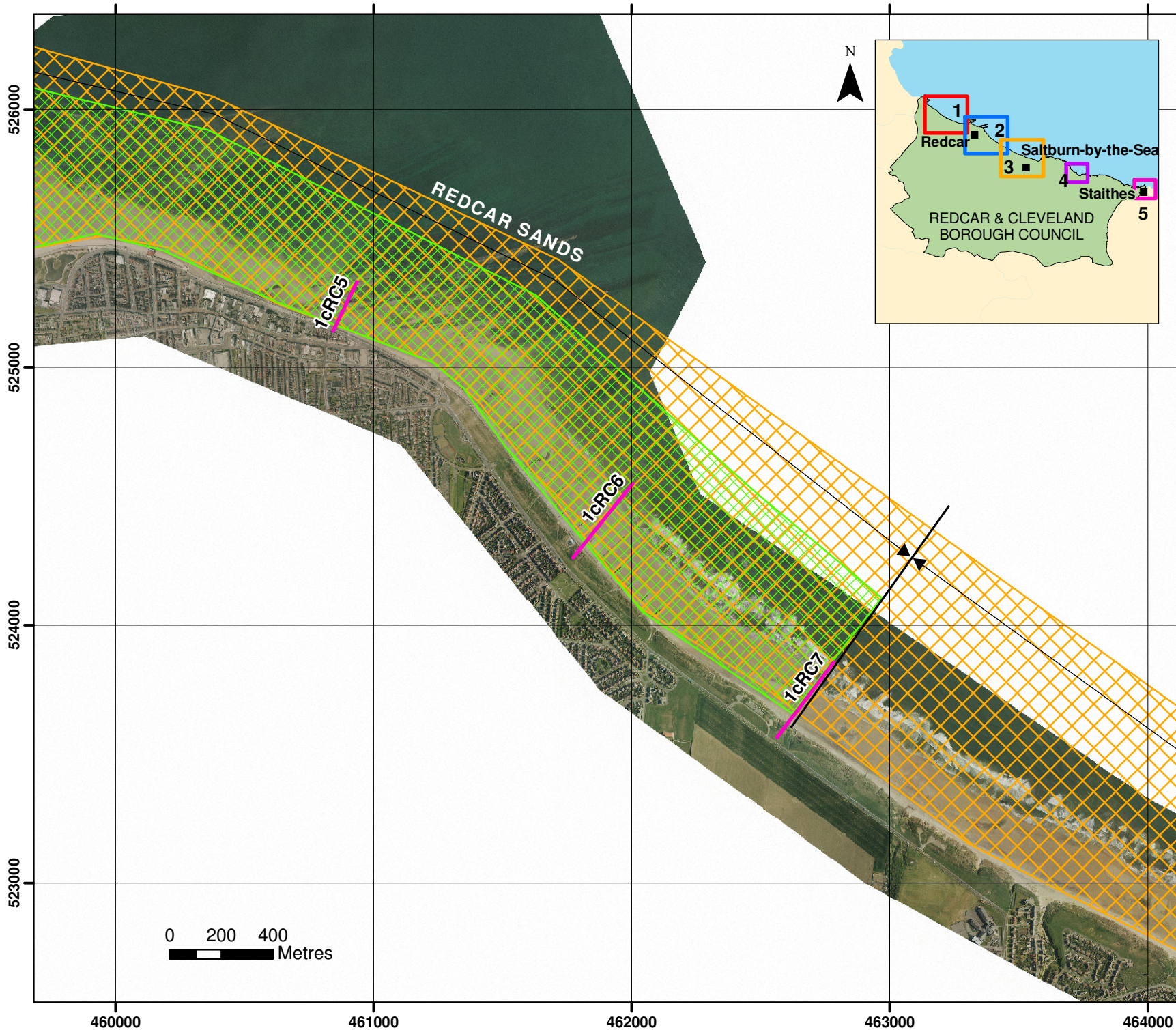
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Checked by: NC	Date: 29/11/2010
Approved by: NC	Date: 06/12/2010

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www.northeastcoastalobservatory.org.uk

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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 3
'Full Measures' Survey 2010

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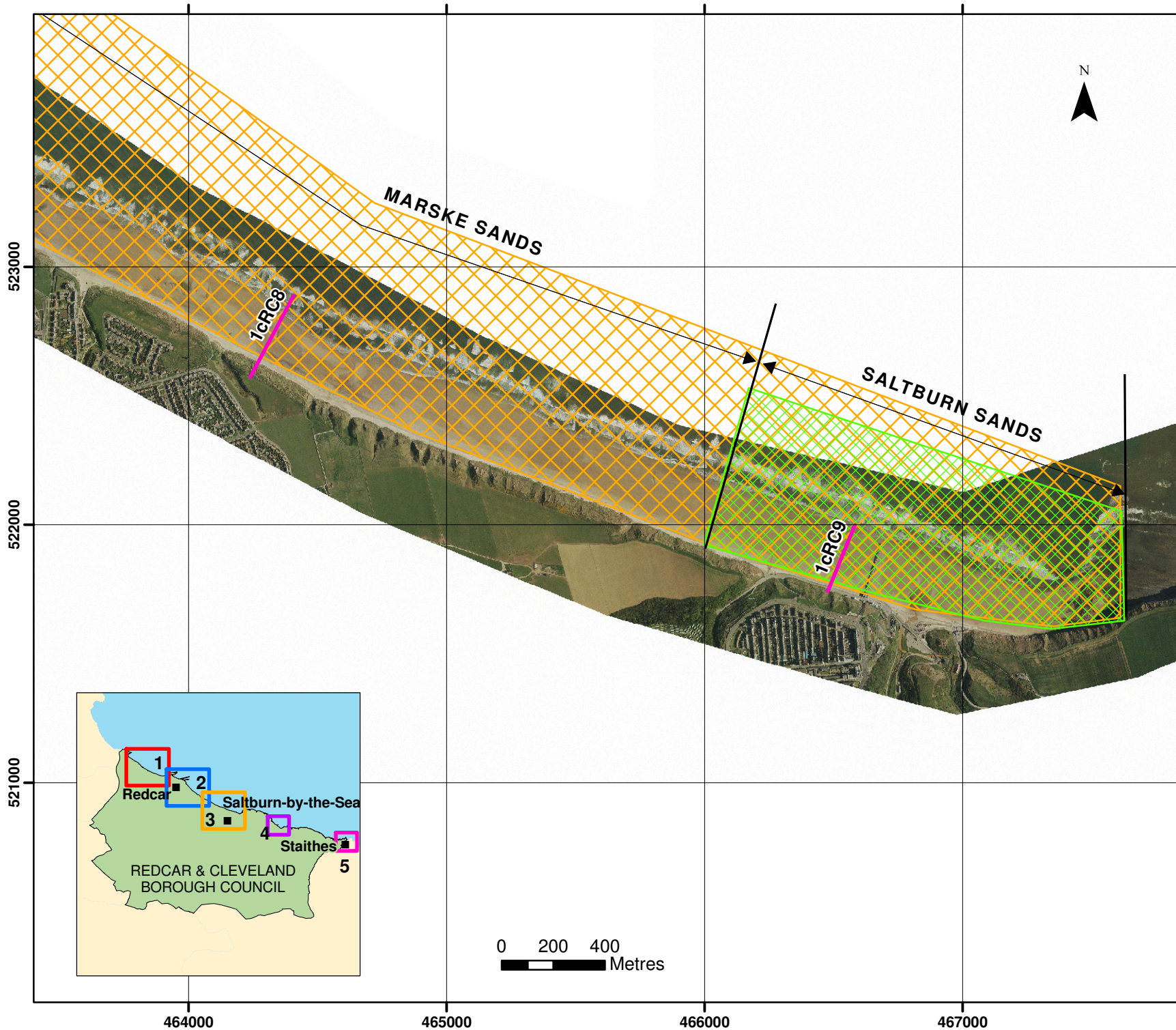
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SURVEY LOCATIONS

- 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 3
 'Full Measures' Survey 2010

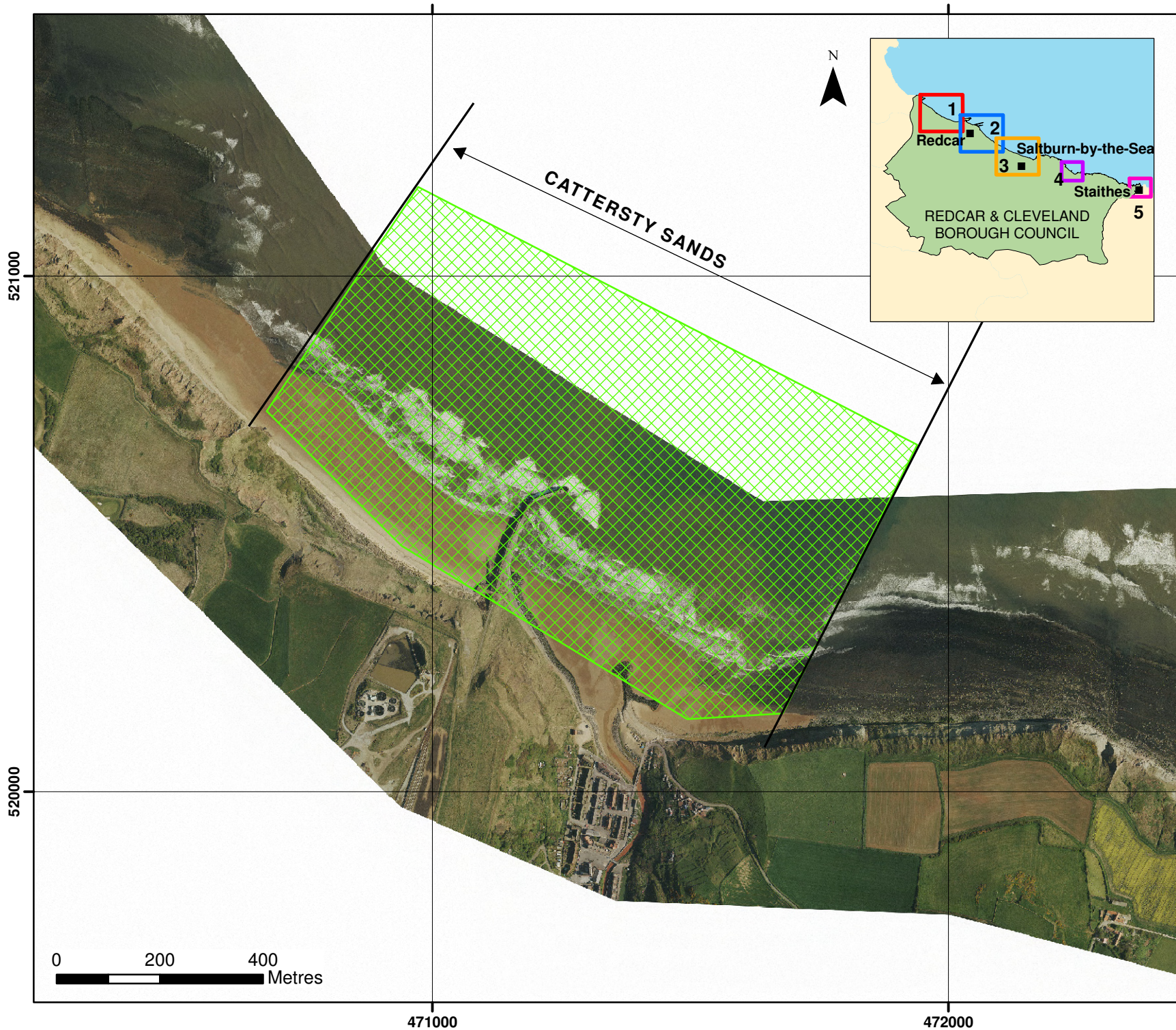
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Drawn by: TC	Date: 29/11/2010
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Photography courtesy of North East Coastal Observatory
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SURVEY LOCATIONS

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 3
'Full Measures' Survey 2010

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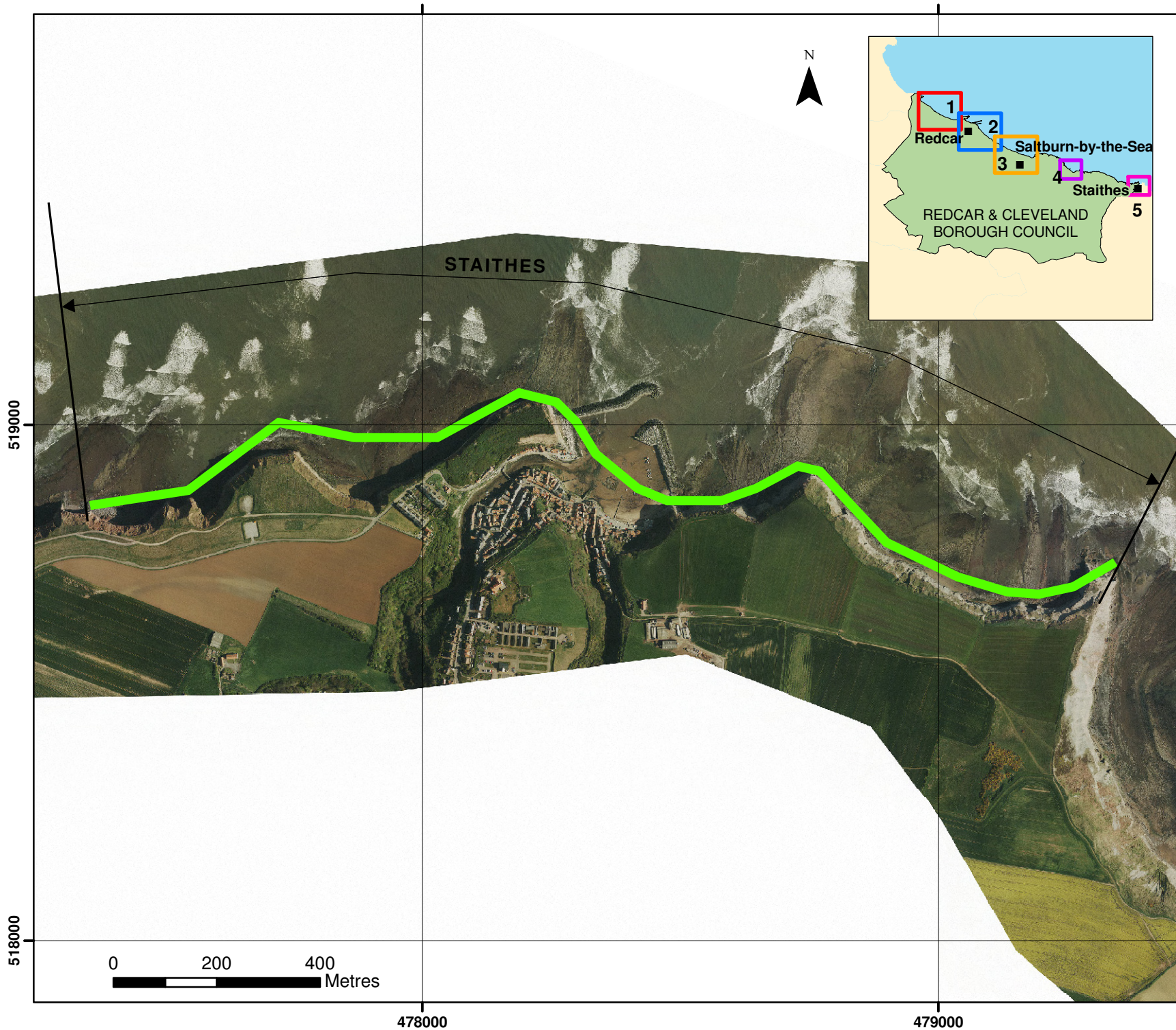


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- SURVEY LOCATIONS**
- Topographic Profiles**
- Annual
 - Bi-Annual
- Topographic Surveys**
- 6 monthly
 - yearly
 - 5 yearly
- Cliff Top Monitoring Pegs**
- @ 50 centres
 - @ 100 centres
 - @ 300 centres
- (Indicative Survey Extents shown)*

Client: North East Coastal Group
 Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 5
Redcar & Cleveland
Borough Council Frontage

Analytical Report 3
 'Full Measures' Survey 2010

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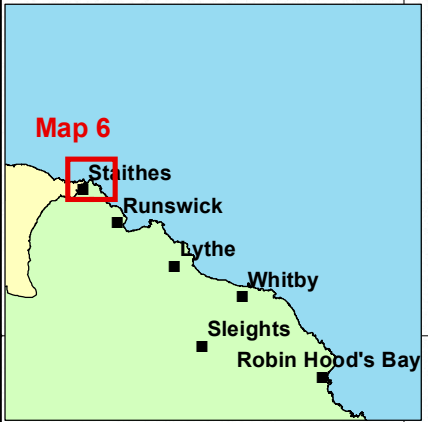
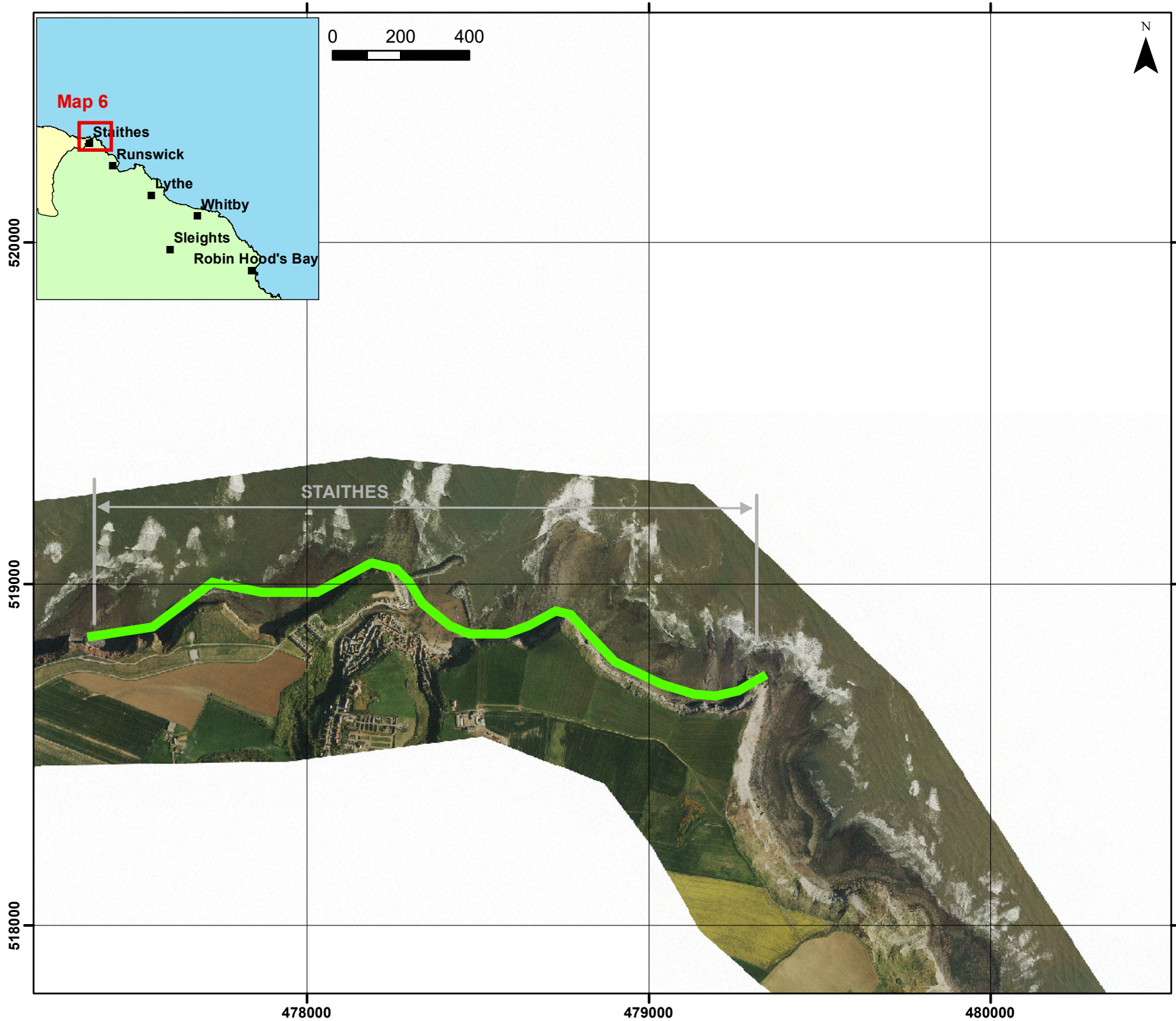
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SURVEY LOCATIONS

Topographic Profiles

- Blue line
- Magenta line

Topographic Surveys

- Green cross-hatch pattern: 6
- Orange cross-hatch pattern
- Brown cross-hatch pattern: 5

Cliff Top Monitoring Pegs

- Purple square: 50
- Green square: 100
- Red square: 300

(Indicative Survey Extents shown)

1

Figure 2 - Map 6
Redcar & Cleveland
Borough Council Frontage

3
 2010

1 15,000 4

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 01/12/2010

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2. Analysis of Survey Data

2.1 Coatham Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
11-2010	<p>Beach Profiles: Coatham Sands is covered by four beach profile lines during the Full Measures survey (RC1 to RC4; Appendix A).</p> <p>RC1 is located approximately 300m south of the South Gare breakwater, immediately in the lee of the German Charlies. The profile shows some minor accretion to upper foreshore levels, above MHWS, and also to the face and crest of the seaward dune ridge. The berm previously recorded around MHWN in April 2010 had been flattened by the November 2010 survey, but the lower foreshore received some of this sediment and increased in level by up to around 0.5m.</p> <p>RC2 showed clear growth on the seaward face of the fronting dune ridge and accretion by up to 0.15m on the upper beach profile, down to a chainage of around 175m. Seaward of this point, the lower foreshore lowered by around 0.15m.</p> <p>Along RC3 upper beach levels remained similar to those recorded in April 2010, despite some dune accretion on the seaward face. Modest lowering of <0.1m occurred along the profile seaward of around MHWN, increasing to a peak of around 0.2m towards the seaward end of the transect.</p> <p>Considerable accretion was recorded along RC4 between September 2009 and April 2010, but this trend was reversed to November 2010 with material eroded from the mid and lower profile to record new low levels, but for the first time since surveys began in November 2008 two berms were formed on the upper beach, one around MHWS and one just above HAT.</p>	<p>Whilst the dunes and beach along RC1 are relatively well protected by the German Charlies slag banks offshore, the profile has experienced some variations over time, particularly in relation to the presence (November 2008, April 2009, September 2009) or absence (April 2010, November 2010) of a berm at around the level of HAT. The most recent survey shows relatively healthy conditions in terms of lower foreshore levels, with an absence of a berm around HAT.</p> <p>Changes along RC2 indicate presently healthy upper beach and dune levels, and whilst the lower foreshore experienced some lowering it remains at a healthy level compared to some earlier surveys.</p> <p>Although beach levels remained low along RC3, the profile form was characteristic of the previous survey records along this transect and do not present a significant net change from the previous surveys.</p> <p>A new behaviour was observed along RC4, with berm formation on the upper beach from sediment eroded from the mid and lower profiles.</p>

Survey Date	Description of Changes Since Last Survey	Interpretation
11-2010	<p>Topographic Survey:</p> <p>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 that the beach contours recorded in November 2010 were relatively consistent across the frontage, with a slight accumulation of material directly in the lee of the German Charlies slag banks, and that the foreshore was relatively featureless across its inter-tidal width.</p> <p>The GIS has also been used to calculate the differences between the current topographic survey and the earlier (September 2009) topographic survey, as shown in Appendix B – Map 1b, to identify areas of erosion and accretion. Since the previous topographic survey in September 2009 the changes along Coatham Sands can be characterised along two distinct sections. In the north of the frontage, there has been a notable redistribution of sediment, with lowering (generally) along the upper beach and accretion (generally) along the lower beach, representing a flatter profile gradient overall. In the centre and south of the frontage, the net change since September 2009 has been one of foreshore lowering across the entire width of the inter-tidal zone.</p>	<p>Whilst the 6-monthly beach profile transects are designed show typical seasonal behaviour of Coatham Sands, the annual topographic survey is intended to identify longer terms trends of net erosion or accretion. At present the surveys are too short to determine any significant longer term trends, but the changes between September 2009 and November 2010 are characteristic of redistribution of sediment in the northern part of Coatham Sands, but in the southern section there may have been a net loss of sediment from the frontage, rather than purely redistribution, but future datasets will aid in this understanding.</p>

2.2 Redcar Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
11-2010	<p>Beach Profiles: Redcar Sands is covered by three beach profile lines during the Full Measures survey (RC5 to RC7; Appendix A), with RC7 being approximately on the boundary with the Marske Sands area.</p> <p>Along RC5 there was a lowering of beach levels within a zone of about 10m wide at the toe of the sea defences, but alternate accretion then lowering then accretion further down the profile, with the rock outcrops identified in the April 2010 survey now being covered with a veneer of sand.</p> <p>Between September 2009 and April 2010 a section of profile RC6 became 'scalloped' with liberated material being deposited at the toe of the dunes to form a new foredune. To November 2010 this foresdune remained, but had been eroded landward slightly, with material released partly infilling the scalloped trough in the beach. Further seaward of these changes there was very modest accretion of sand on the mid and lower foreshore.</p> <p>Profile RC7 generally experienced lowering along its entire length following the accretion that previously occurred between September 2009 and April 2010.</p>	<p>Redcar Sands appears to exhibit redistribution of sediment across the profiles, although towards the southern end, at RC7, there are generally alternate trends of lowering or accretion along the whole profile length rather than redistribution from the upper to lower foreshore (or <i>vice versa</i>).</p>
	<p>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. This shows that the general beach contours move inland, and in particular the higher beach contours become intercepted by the sea wall, in the vicinity of the main section of Redcar town. This is the area where a major capital coastal defence scheme is due to commence imminently. Beyond this 600m length, the contours are relatively consistent across the frontage and exhibit a relatively featureless beach form.</p> <p>The GIS has also been used to calculate the differences between the current topographic survey and the earlier Full Measures (September 2009) topographic survey, as shown in Appendix B – Map 2b, to identify areas of erosion and accretion. Between the previous Full Measures topographic survey in</p>	<p>Where 6-monthly survey data is available, it has shown that whilst there appears to be a notable difference between the September 2009 and November 2010 surveys, the processes of most upper beach drawdown occurred between September 2009 and April 2010 (a characteristic winter profile response to the increased wave climate) with subsequent redistribution of material from the lower profile to the upper between April 2010 and November 2010 (a classic summer profile response to the more 'constructive' wave action leading to upper beach build up).</p>

Survey Date	Description of Changes Since Last Survey	Interpretation
	<p>September 2009 and the current November 2010 survey, there has been a general lowering of upper foreshore levels along the main town frontage, with some of the liberated sediment being deposited on the lower foreshore to present a flatter overall gradient. Along The Stray the changes were more modest but also generally involved redistribution from upper to lower foreshore areas.</p> <p>The GIS has also been used to calculate the differences between the current topographic survey and the most recent (April 2009) topographic survey, as shown in Appendix B – Map 2c, to identify areas of erosion and accretion. Between the last survey in April 2010 and the current November 2010 survey the pattern of change along the main town frontage was one of erosion of the lower foreshore and accretion along parts of the upper foreshore. Changes along The Stray were relatively modest, although increased towards the southern end at its boundary with Marske Sands (discussed in Section 2.3).</p>	

2.3 Marske Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
11-2010	<p>Beach Profiles:</p> <p>Marske Sands is covered by two beach profile lines during the Full Measures survey (RC7 to RC8; Appendix A), with RC7 being approximately on the boundary with the Redcar Sands area.</p> <p>RC7 is located along The Stray and has been discussed in Section 2.2.</p> <p>RC8 showed modest redistribution of sediment along the foreshore and general stability in the high backing dunes.</p>	<p>Marske Sands represents a continuation of Redcar Sands and appears to be relatively stable, with changes confined to minor redistribution of sediments across and along the foreshore, rather than any significant net trends of erosion or accretion.</p>
	<p>Topographic Survey:</p> <p>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 that the beach contours are relatively consistent across the frontage and exhibit a relatively featureless beach form.</p> <p>The GIS has also been used to calculate the differences between the current topographic survey and the earlier (September 2009) topographic survey, as shown in Appendix B – Map 3b, to identify areas of erosion and accretion. Since the previous topographic survey in September 2009, there has been a general redistribution of sediment from the upper foreshore to the lower, although the process is not as continuous as may be expected. Towards the southern end, at the junction with Saltburn Sands, the lowering becomes greater in magnitude and width across the foreshore, with few areas of corresponding accretion.</p>	<p>There may be a slight tendency for net loss of material towards the southern end of Marske Sands, but in general the frontage shows a redistribution of sediment depending on the prevailing wave and tidal conditions.</p>

2.4 Saltburn Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
11-2010	<p>Beach Profiles: Saltburn Sands is covered by one beach profile lines during the Full Measures survey (RC9; Appendix A).</p> <p>The survey reveals no significant change since the April 2010 survey and therefore foreshore levels remain relatively low. There was no further lowering at the toe of the sea defence.</p>	<p>The profile along Saltburn Sands shows that beach levels remain at relatively low levels, but generally the variations between maximum and minimum levels along this transect are relatively modest at around only 0.2 – 0.3m.</p>
	<p>Topographic Survey:</p> <p>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. This shows that the beach contours are relatively consistent across the frontage, although the highest beach contours do taper out towards the southern end, and that the foreshore exhibits a relatively featureless form.</p> <p>The GIS has also been used to calculate the differences between the current topographic survey and the earlier Full Measures (September 2009) topographic survey, as shown in Appendix B – Map 4b, to identify areas of erosion and accretion. Over this time, foreshore lowering has occurred along almost the entire foreshore (length and width) west of Skelton Beck.</p> <p>However, comparison with the most recent Partial Measures survey in April 2010 (see <i>Update Report</i> (May 2010) Appendix B – Maps 2b and 2c) shows that most of this change occurred over the winter of 2009/10 and since April 2010 the foreshore has exhibited little net change.</p>	<p>West of Skelton Beck the foreshore exhibited lowering over the winter of 2009/10 but relatively stability since then to November 2010.</p>

2.5 Cattersty Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
11-2010	<p>Topographic Survey:</p> <p>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.</p> <p>The GIS has also been used to calculate the differences between the current topographic survey DGM (November 2010) and the earlier (February 2010) topographic survey DGM, with better than 5 m 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 shows a sequence of shore-parallel change. At the head of the beach a narrow band of accretion dominates, as is typical of summer behaviour at this location. However, seawards there are marked bands of erosion and less extensive accretion, perhaps indicating the onset of beach drawdown typical of the winter season. To the east of the Jetty the upper beach has generally trended towards sediment loss over the period of comparison, whilst the inter-tidal zone has experienced accretion. As the river flows across the beach it produces a complex signal of change, with a trend towards erosion.</p>	<p>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. To the west subtle seasonal shore parallel variability is identifiable. In contrast, in the east, fluvial impacts do not run parallel to the shoreline, resulting in different patterns of beach/ river mouth change.</p>

2.6 Staithes

Survey Date	Description of Changes Since Last Survey	Interpretation
09-2010	<p>Cliff Top Survey:</p> <p>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 100m (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.</p> <p>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.</p>	<p>When survey accuracy is taken into consideration, ten of the twenty points have shown no change since the November 2008 survey, indicating local stability of the cliff face. Three locations (points 1, 4, 13) have shown cliff line recession ranging 0.2- 2.1 m (± 0.1 m due to survey accuracy). Points 4 and 13 have consistently registered cliff erosion in each full and partial measures report to date. Less consistent, but repeated, recession measurements are also determined for points 1, 2, & 5. These survey locations are principally located in the west adjacent to Cow Bar Lane. The specific processes responsible for this recessional change would need to be determined by a dedicated field inspection. Seven locations (points 3, 9, 10, 12, 16, 17, 19) have shown an increase in distance to the cliff edge (0.2- 1.5 m). It is noted that points 3, 10, 12 (all in the west) have consistently registered an advancing cliff line. Less consistent, but repeated, cliff advance measurements are also determined for points 9, 16, 17, & 19. Whilst possibly representing a toppling failure the far more likely scenario is different interpretation of the cliff edge between comparative surveys.</p>

3. Problems Encountered and Uncertainty in Analysis

There were no major problems encountered during the surveys.

The cliff top surveys at Staithes are assumed to have a limit of accuracy of $\pm 0.1\text{m}$ 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).

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

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 well sheltered against waves by the South Gare Breakwater and to a lesser extent German Charlies slag banks. In the southern section of Coatham Sands there may have been a net loss of sediment from the frontage, rather than purely redistribution, but future datasets will aid in this understanding.
- There appears to have been a classic summer profile response to the more 'constructive' wave action operating since the previous survey in April 2010 along Redcar Sands. This has led to upper beach build up along some parts of the frontage.
- There may have been a slight tendency for net loss of material towards the southern end of Marske Sands, but in general the frontage shows a redistribution of sediment depending on the prevailing wave and tidal conditions.
- West of Skelton Beck, the Saltburn Sands foreshore exhibited lowering over the winter of 2009/10 but relatively stability since then to November 2010.
- Cattersty Sands (Skinningrove) shows beach change typical of seasonal (summer and winter) marine processes to the west of the Jetty, and also depicts the influence of the outflowing river in the east. 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 principally to the west adjacent to Cowbar Lane, and more locally the cliff west of Penny Steel.

Appendices

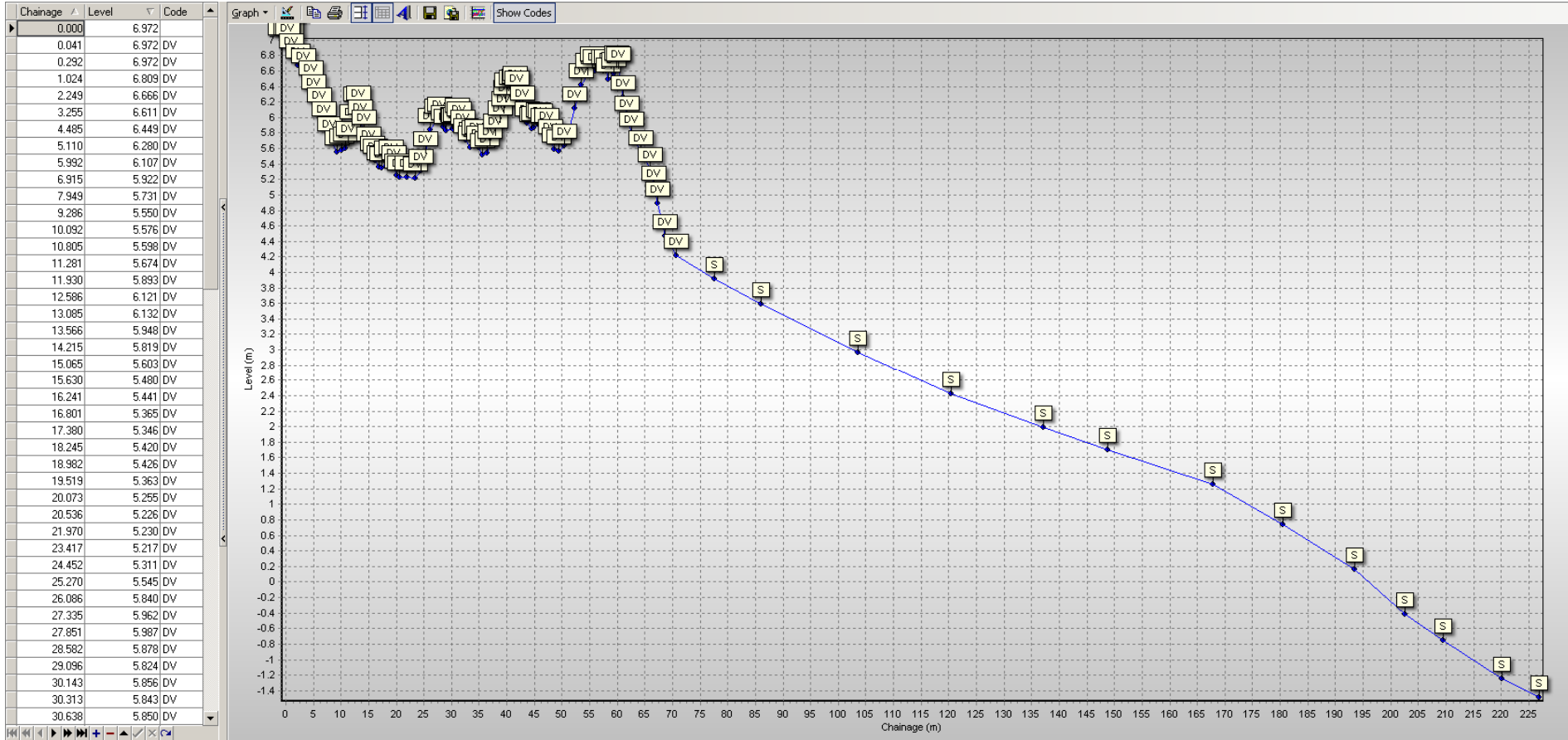
Appendix A
Beach Profiles

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

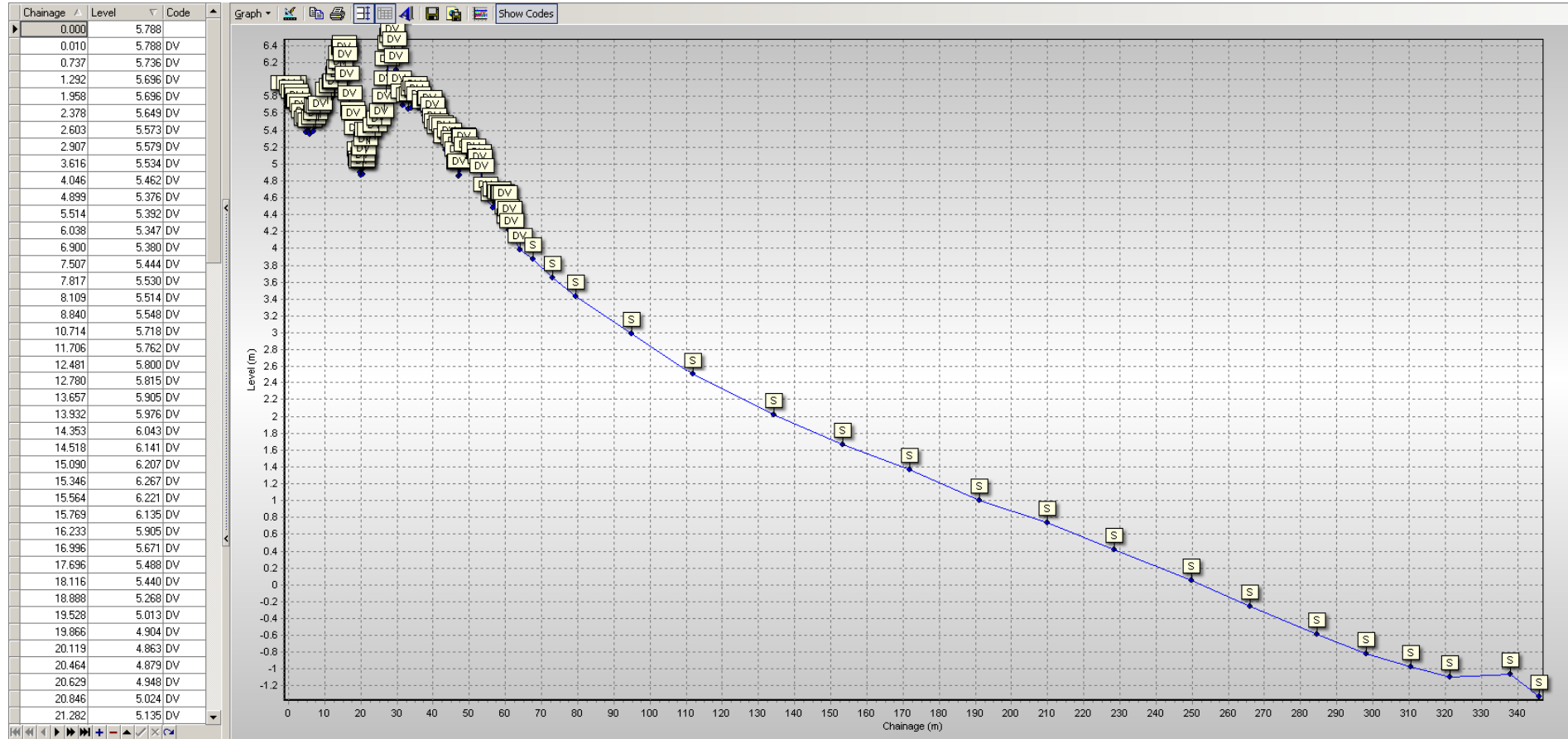
Code	Description
M	Mud
S	Sand
G	Gravel
GS	Gravel & Sand
GM	Gravel & Mud
MS	Mud & Sand
B	Boulders
R	Rock
SD	Sea Defence
SM	Salt Marsh
GR	Grass
D	Dune (non-vegetated)
DV	Dune (vegetated)
F	Forested
X	Mixture
FB	Obstruction
CT	Cliff Top
CE	Cliff Edge
CF	Cliff Face
SH	Shell
W	Water Body
ZZ	Unknown

Redcar

1cRC1 - 05/11/2010

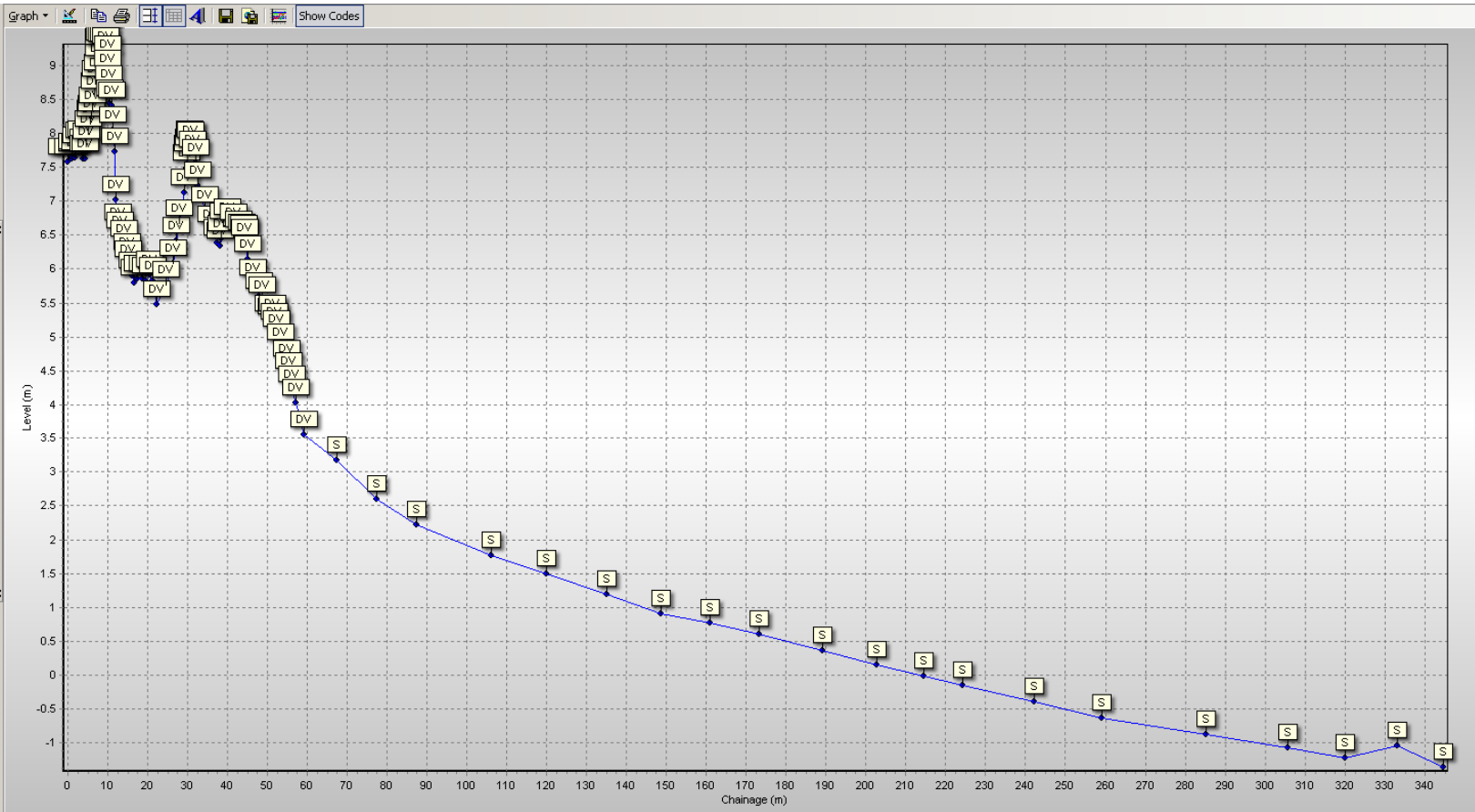


1cRC2 - 05/11/2010

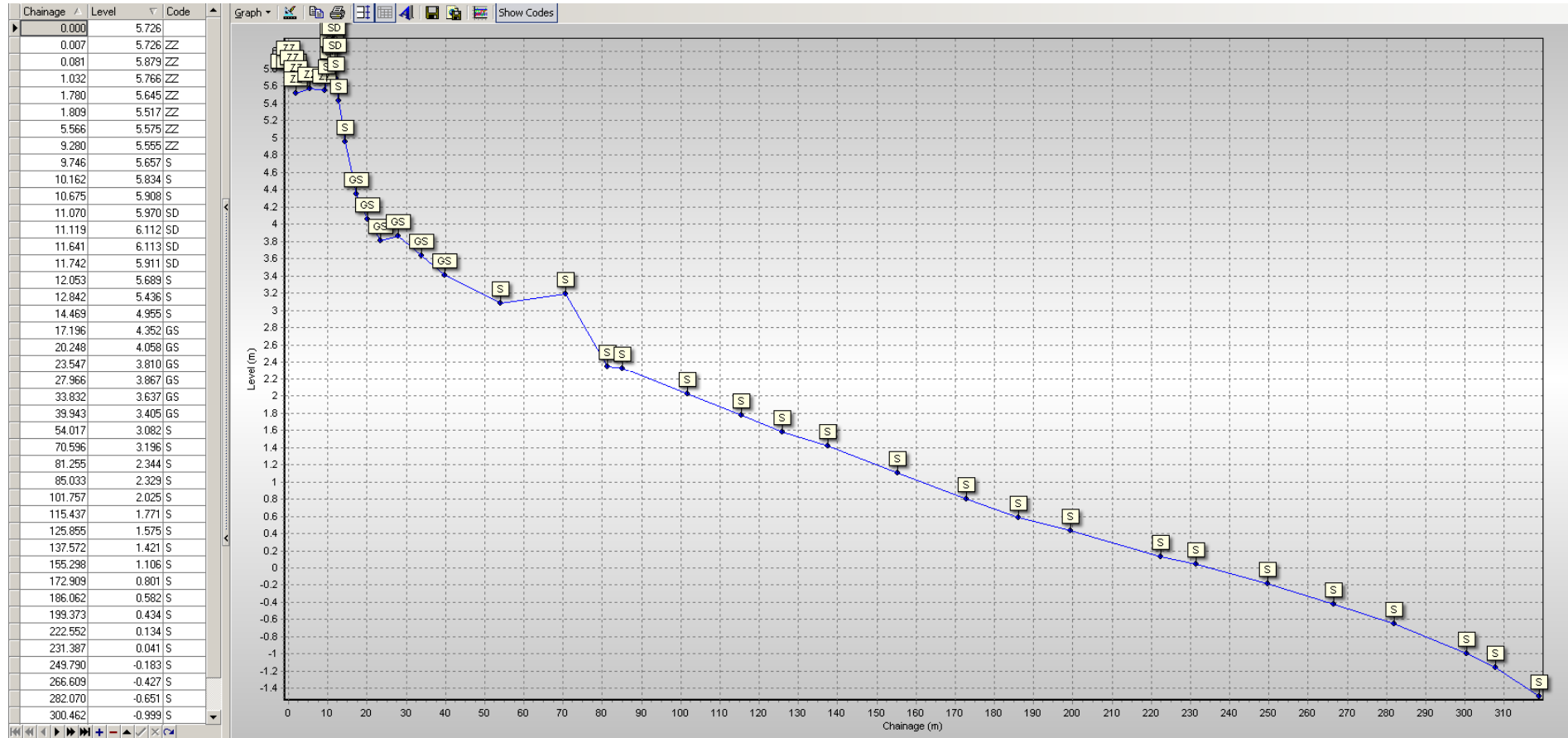


1cRC3 - 05/11/2010

Chainage	Level	Code
0.000	7.578	
0.026	7.578	DV
0.908	7.622	DV
1.047	7.656	DV
1.818	7.640	DV
2.091	7.737	DV
2.755	7.819	DV
3.368	7.826	DV
3.727	7.714	DV
3.821	7.620	DV
4.331	7.616	DV
4.508	7.798	DV
5.079	7.984	DV
5.614	8.141	DV
5.952	8.212	DV
6.267	8.337	DV
6.756	8.545	DV
6.987	8.724	DV
7.425	8.806	DV
7.571	9.031	DV
7.673	9.196	DV
8.067	9.250	DV
8.449	9.232	DV
8.891	9.240	DV
9.414	9.210	DV
9.876	9.081	DV
10.027	8.873	DV
10.346	8.653	DV
10.602	8.429	DV
10.933	8.406	DV
11.388	8.042	DV
11.711	7.726	DV
12.036	7.019	DV
12.493	6.605	DV
12.976	6.488	DV
13.999	6.367	DV
14.896	6.173	DV
15.168	6.065	DV
16.026	5.895	DV
16.567	5.802	DV
17.475	5.856	DV
18.697	5.862	DV

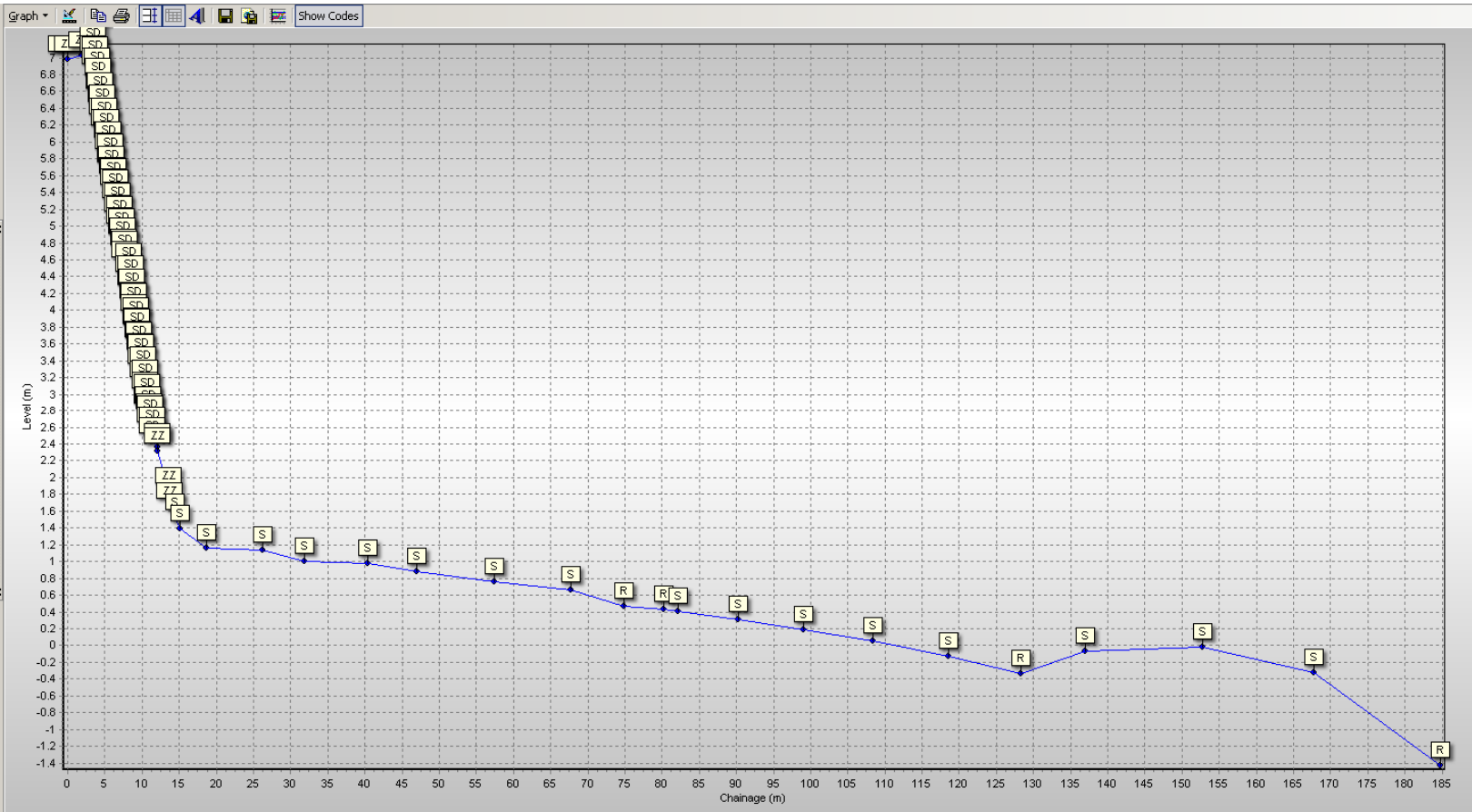


1cRC4 - 05/11/2010

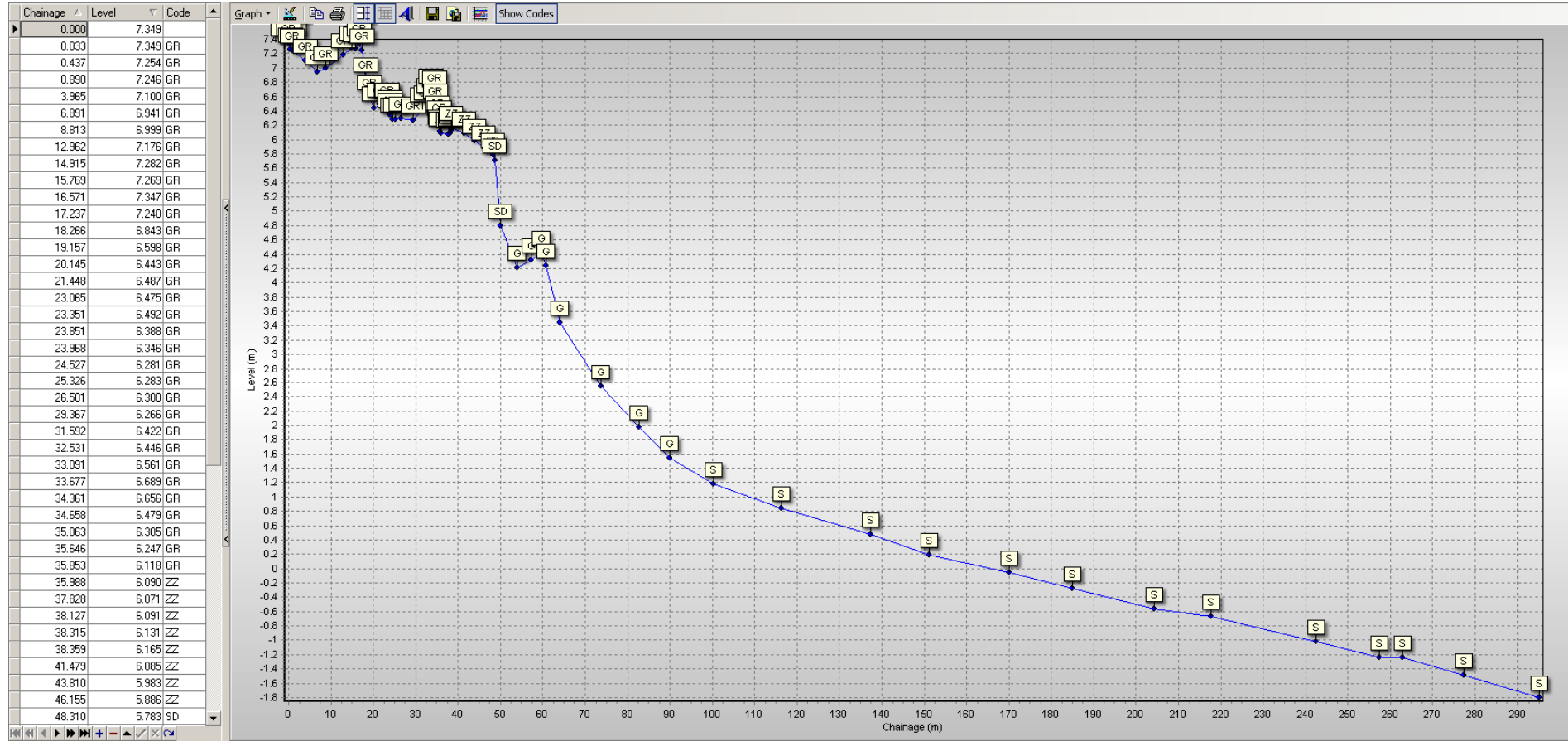


1cRC5 - 05/11/2010

Chainage	Level	Code
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0.014	6.979	ZZ
1.937	7.031	ZZ
3.425	7.116	SD
3.438	6.978	SD
3.716	6.973	SD
3.726	6.840	SD
3.943	6.840	SD
4.072	6.699	SD
4.187	6.710	SD
4.236	6.549	SD
4.457	6.549	SD
4.478	6.390	SD
4.708	6.398	SD
4.722	6.245	SD
4.966	6.242	SD
4.986	6.111	SD
5.217	6.105	SD
5.296	5.962	SD
5.464	5.961	SD
5.496	5.828	SD
5.702	5.819	SD
5.773	5.675	SD
5.963	5.670	SD
5.982	5.537	SD
6.216	5.523	SD
6.231	5.398	SD
6.444	5.388	SD
6.525	5.245	SD
6.722	5.230	SD
6.749	5.088	SD
6.980	5.072	SD
7.025	4.944	SD
7.213	4.927	SD
7.239	4.819	SD
7.465	4.816	SD
7.514	4.687	SD
7.715	4.666	SD
7.760	4.535	SD
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8.258	4.365	SD
8.475	4.364	SD

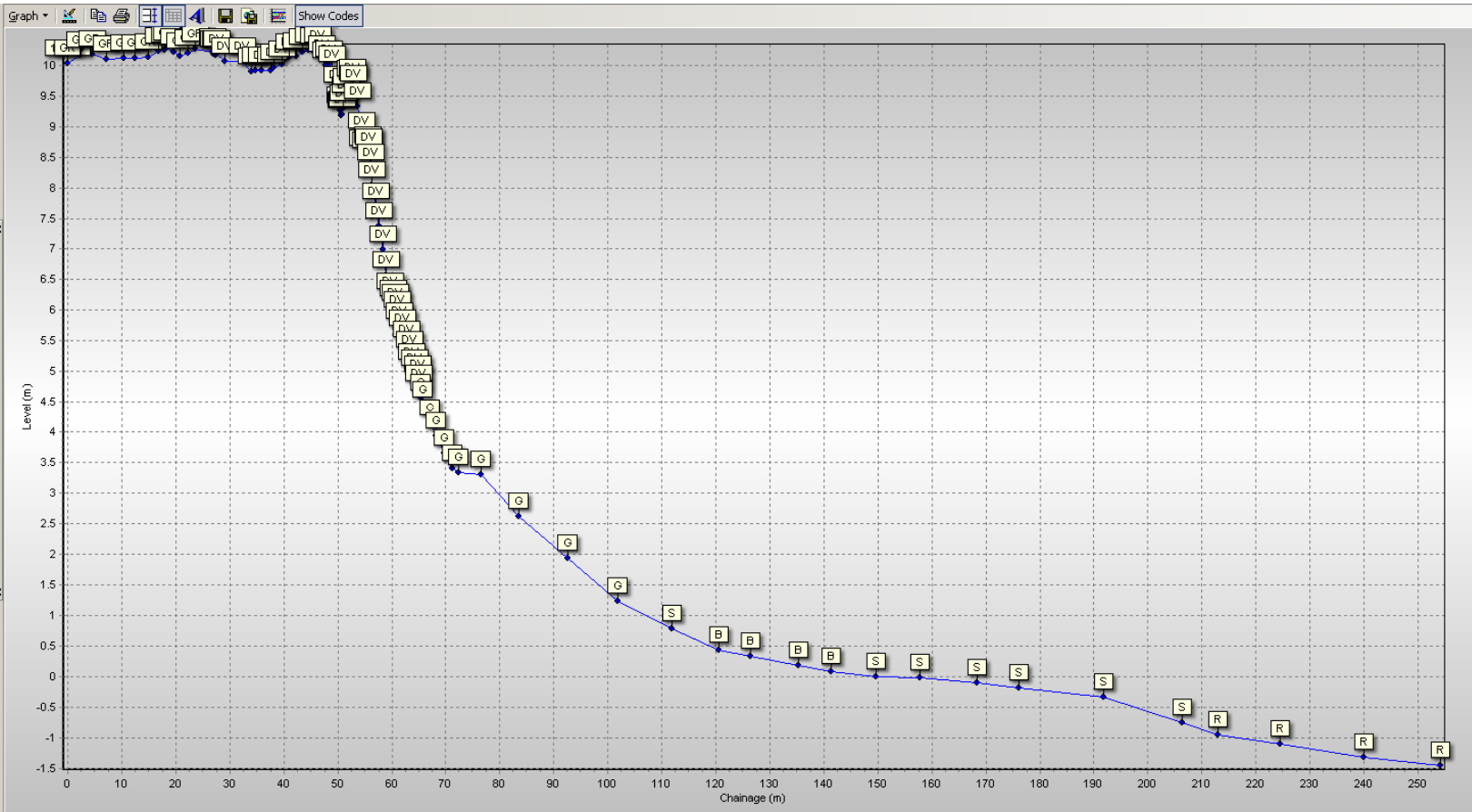


1cRC6 - 05/11/2010

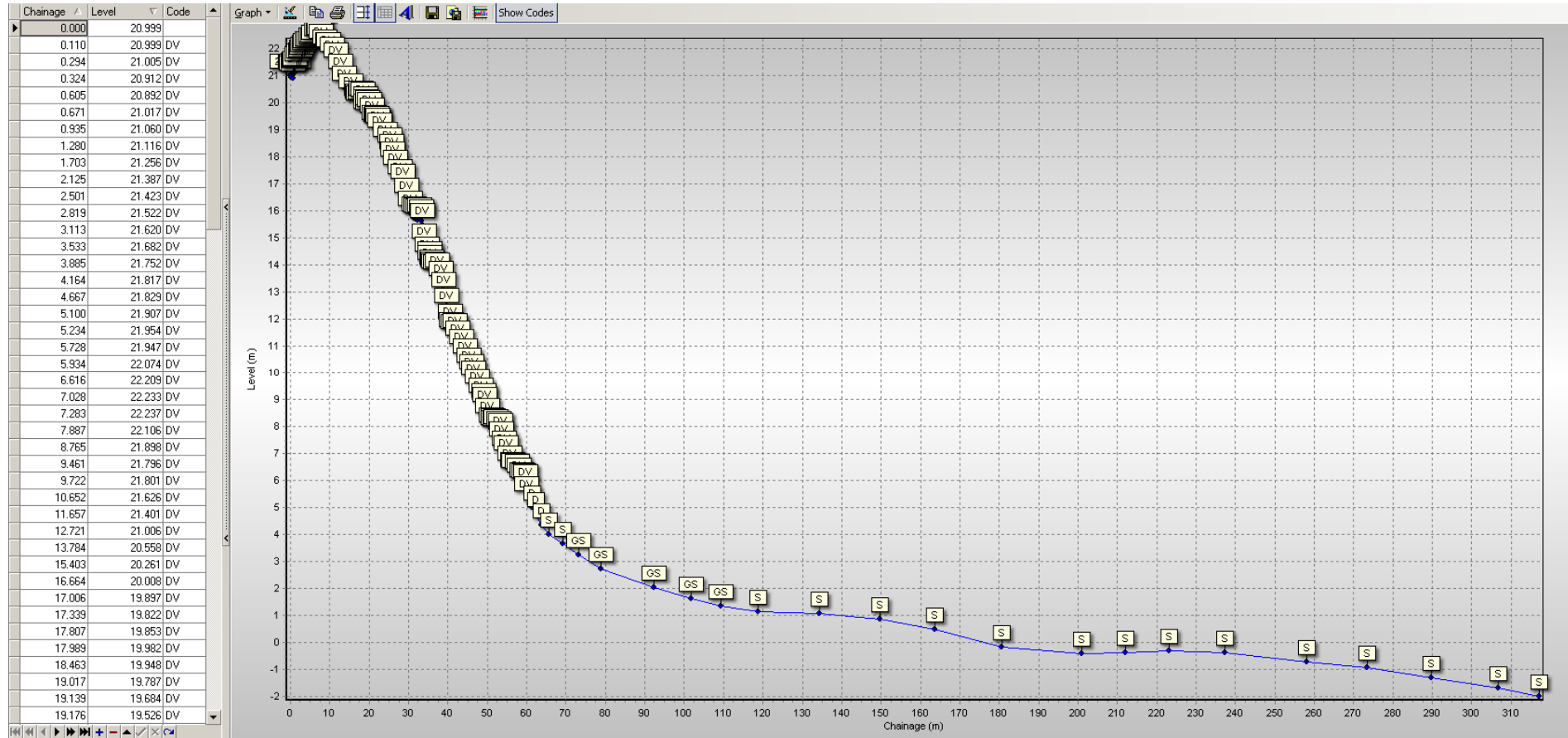


1cRC7 - 05/11/2010

Chainage	Level	Code
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0.052	10.025	GR
2.340	10.158	GR
4.484	10.180	GR
7.122	10.090	GR
10.420	10.111	GR
12.555	10.118	GR
15.021	10.129	GR
16.795	10.225	GR
17.997	10.242	GR
18.240	10.277	GR
19.745	10.205	GR
20.841	10.147	GR
22.260	10.199	GR
23.645	10.253	GR
26.754	10.205	DV
27.058	10.183	DV
27.369	10.160	DV
27.563	10.173	DV
29.179	10.066	DV
32.397	10.052	DV
33.996	9.899	DV
34.830	9.911	DV
35.862	9.909	DV
37.528	9.911	DV
38.168	9.957	DV
39.657	10.003	DV
40.926	10.119	DV
42.273	10.143	DV
43.538	10.212	DV
44.590	10.251	DV
45.527	10.226	DV
46.211	10.238	DV
47.030	10.099	DV
47.748	9.990	DV
48.295	10.006	DV
48.972	9.920	DV
49.809	9.601	DV
50.466	9.256	DV
50.650	9.182	DV
50.813	9.195	DV
50.937	9.232	DV

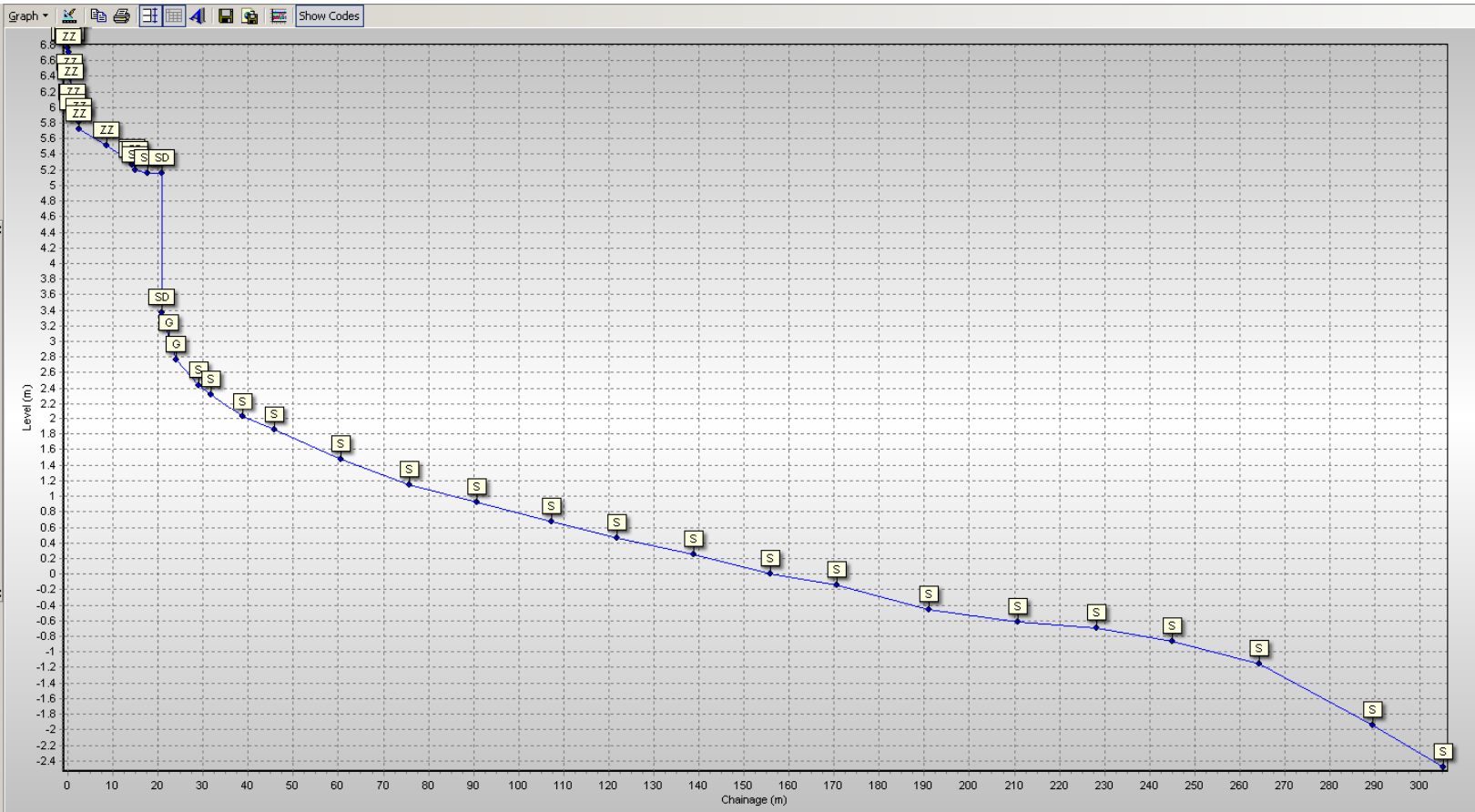


1cRC8 - 05/11/2010

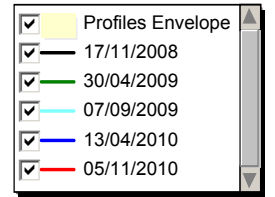
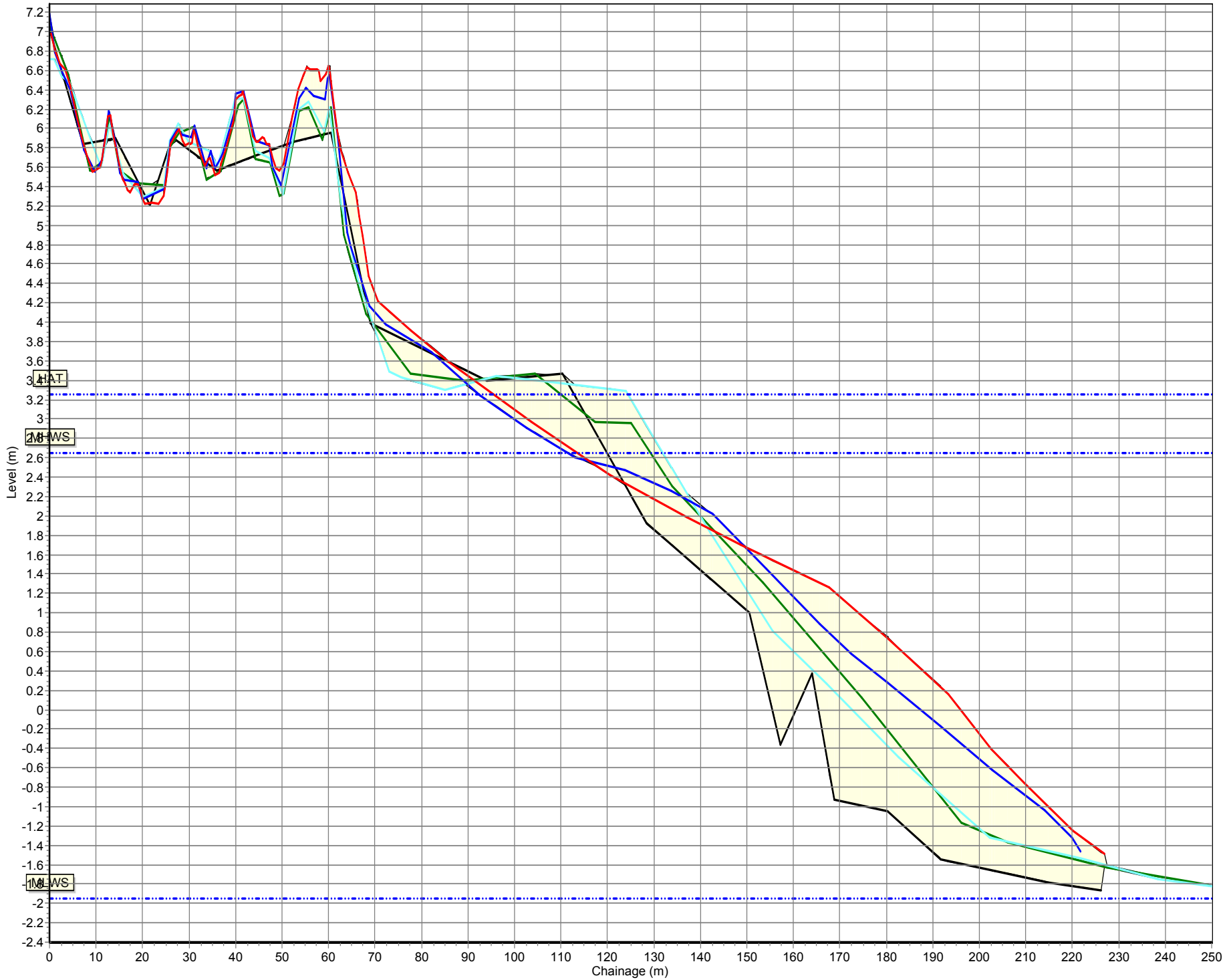


1cRC9 - 05/11/2010

Chainage	Level	Code
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0.014	6.760	ZZ
0.126	6.704	ZZ
0.538	6.374	ZZ
0.778	6.264	ZZ
0.833	6.003	ZZ
1.171	6.004	ZZ
1.171	5.869	ZZ
2.444	5.812	ZZ
2.453	5.720	ZZ
8.718	5.509	ZZ
14.375	5.287	ZZ
14.393	5.255	ZZ
14.891	5.259	SD
14.901	5.196	SD
17.725	5.151	SD
20.784	5.155	SD
20.979	3.364	SD
22.477	3.041	G
23.977	2.768	G
28.946	2.432	S
31.676	2.320	S
38.861	2.033	S
45.755	1.857	S
60.542	1.471	S
75.881	1.153	S
90.809	0.924	S
107.413	0.668	S
121.743	0.463	S
138.957	0.252	S
155.873	0.003	S
170.614	-0.145	S
191.138	-0.454	S
210.822	-0.611	S
228.323	-0.691	S
244.977	-0.871	S
264.361	-1.155	S
289.479	-1.938	S
305.168	-2.482	S



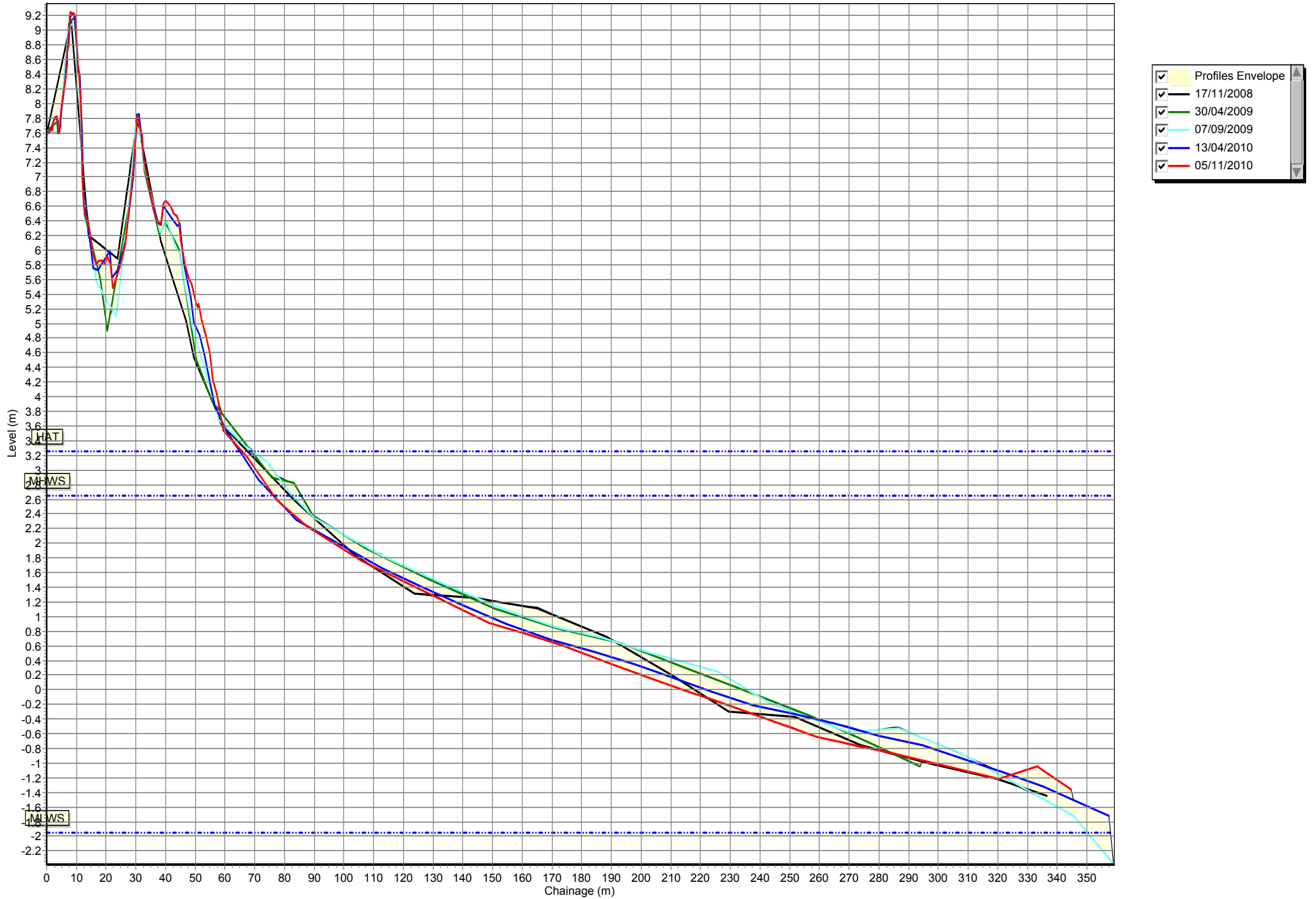
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Beach Profiles: 1cRC2



Beach Profiles: 1cRC3



Beach Profiles: 1cRC4



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- 30/04/2009
- 07/09/2009
- 13/04/2010
- 05/11/2010

Beach Profiles: 1cRC5



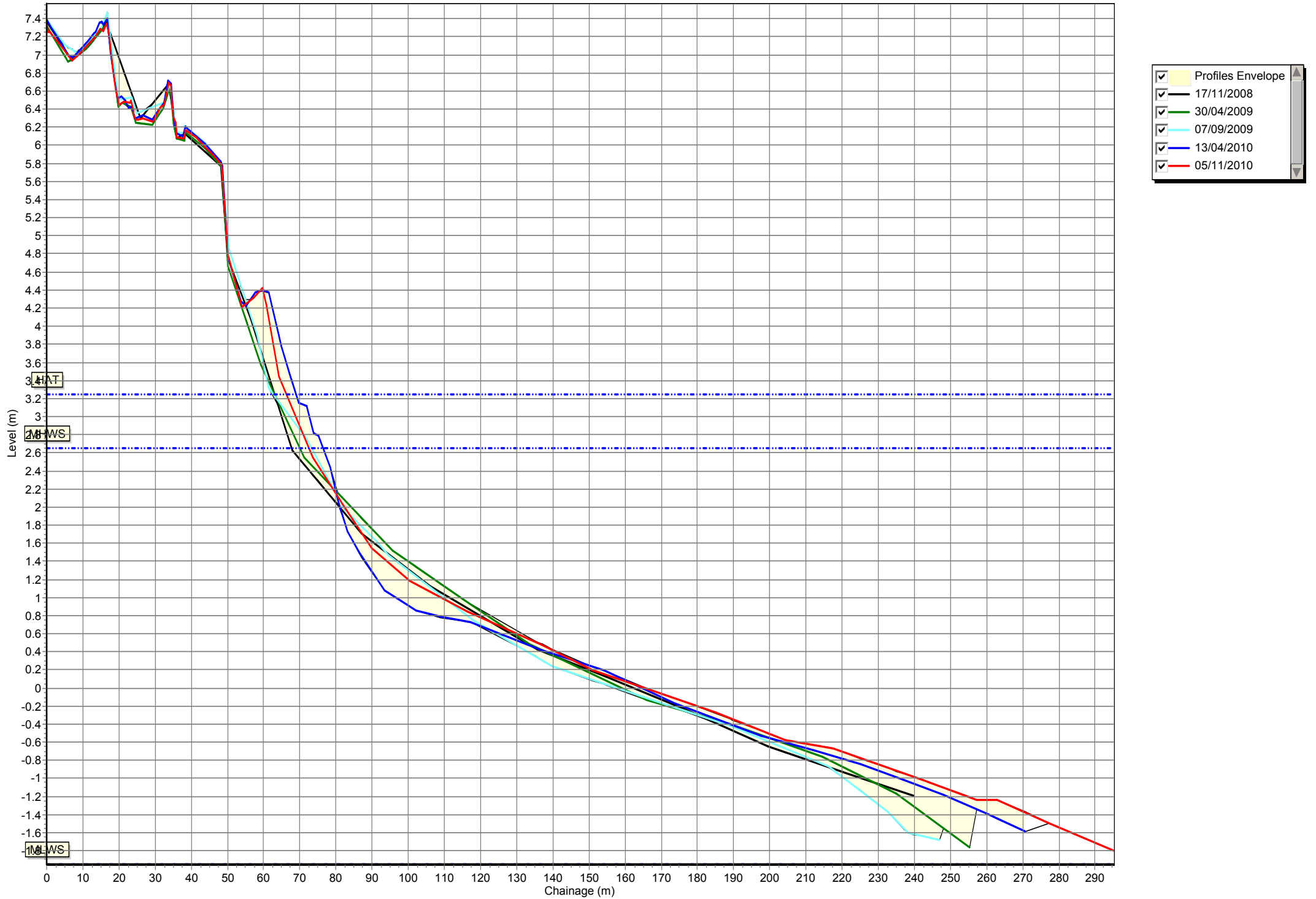
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HAT

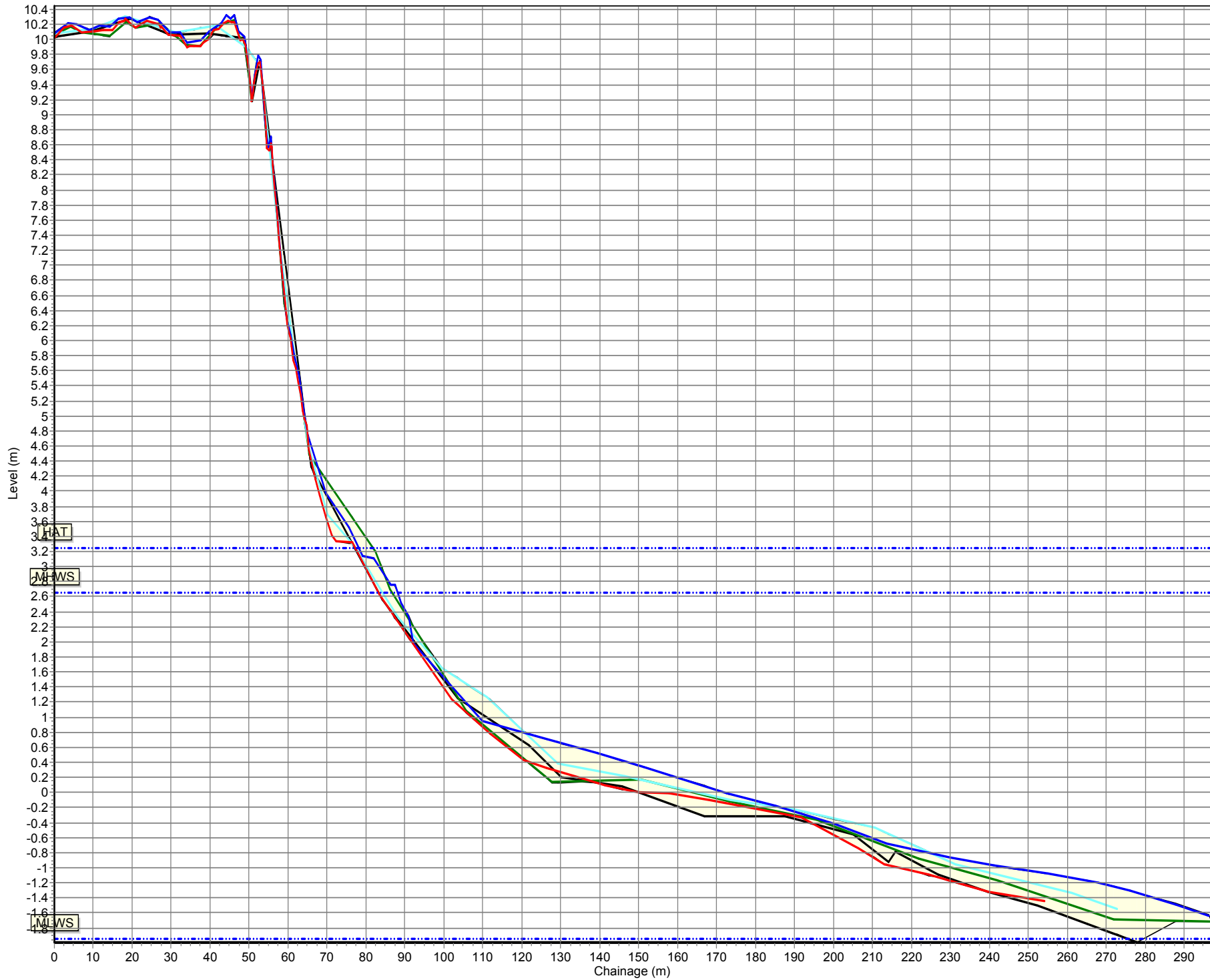
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MWS

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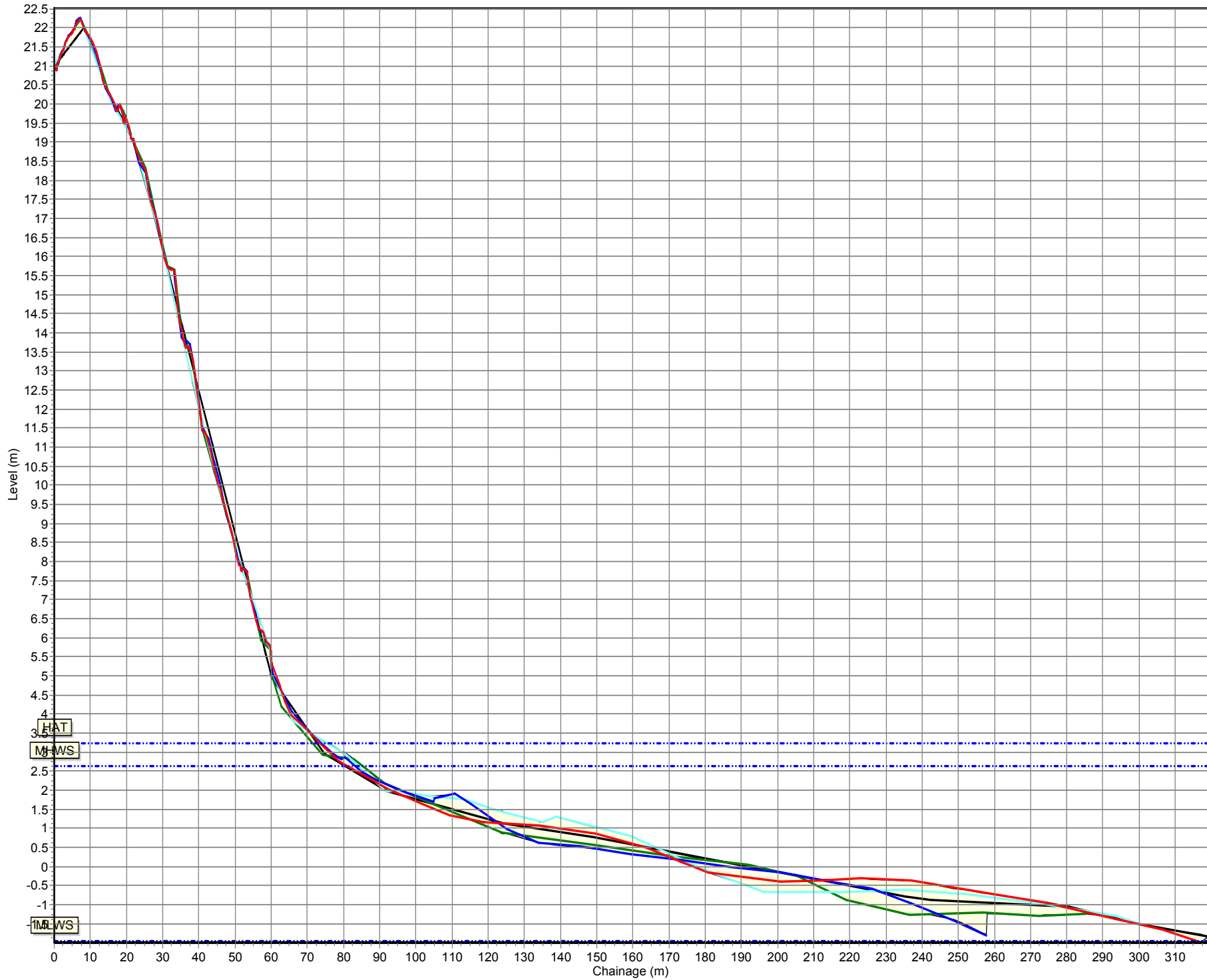


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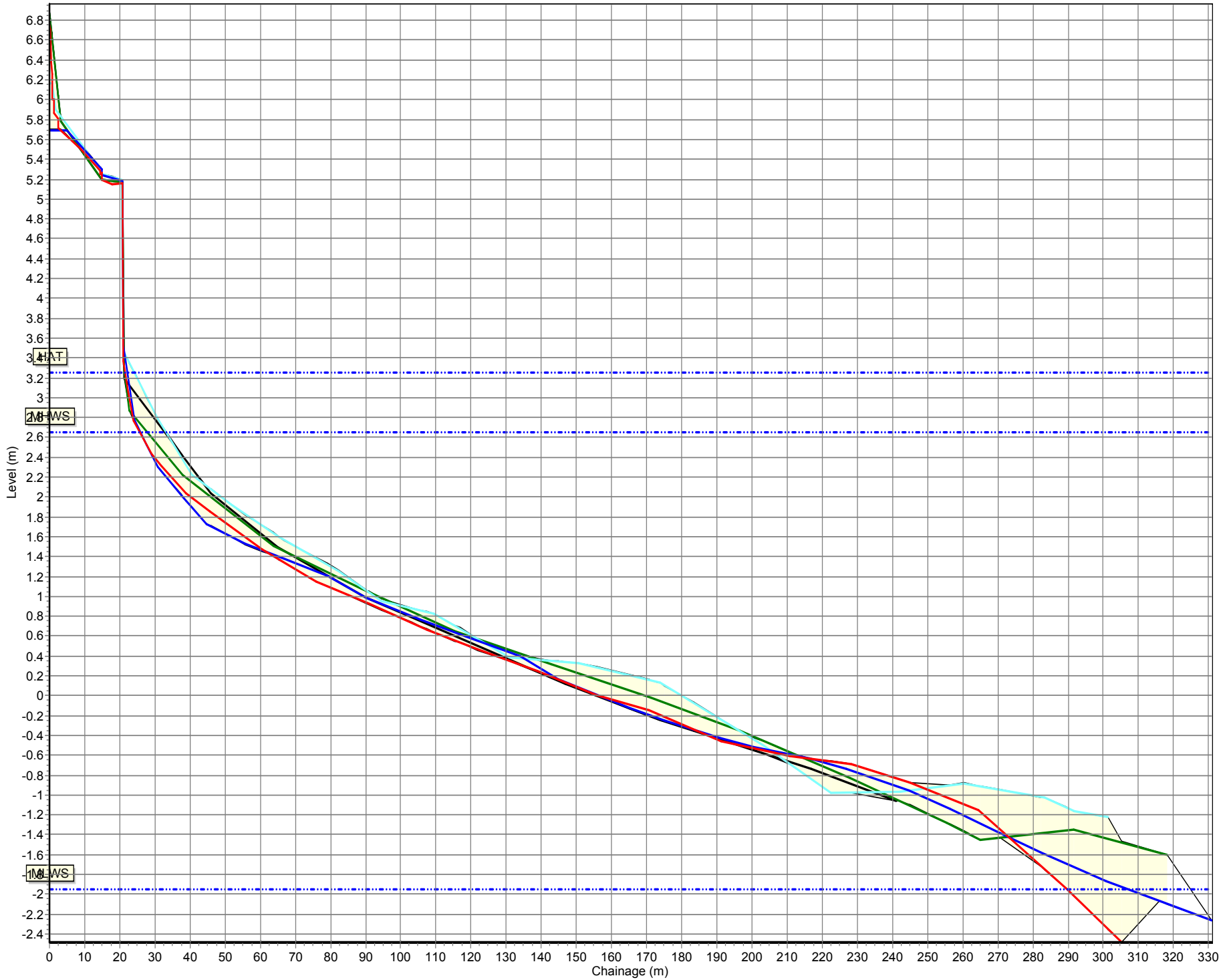
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- 30/04/2009
- 07/09/2009
- 13/04/2010
- 05/11/2010

FAT

MWS

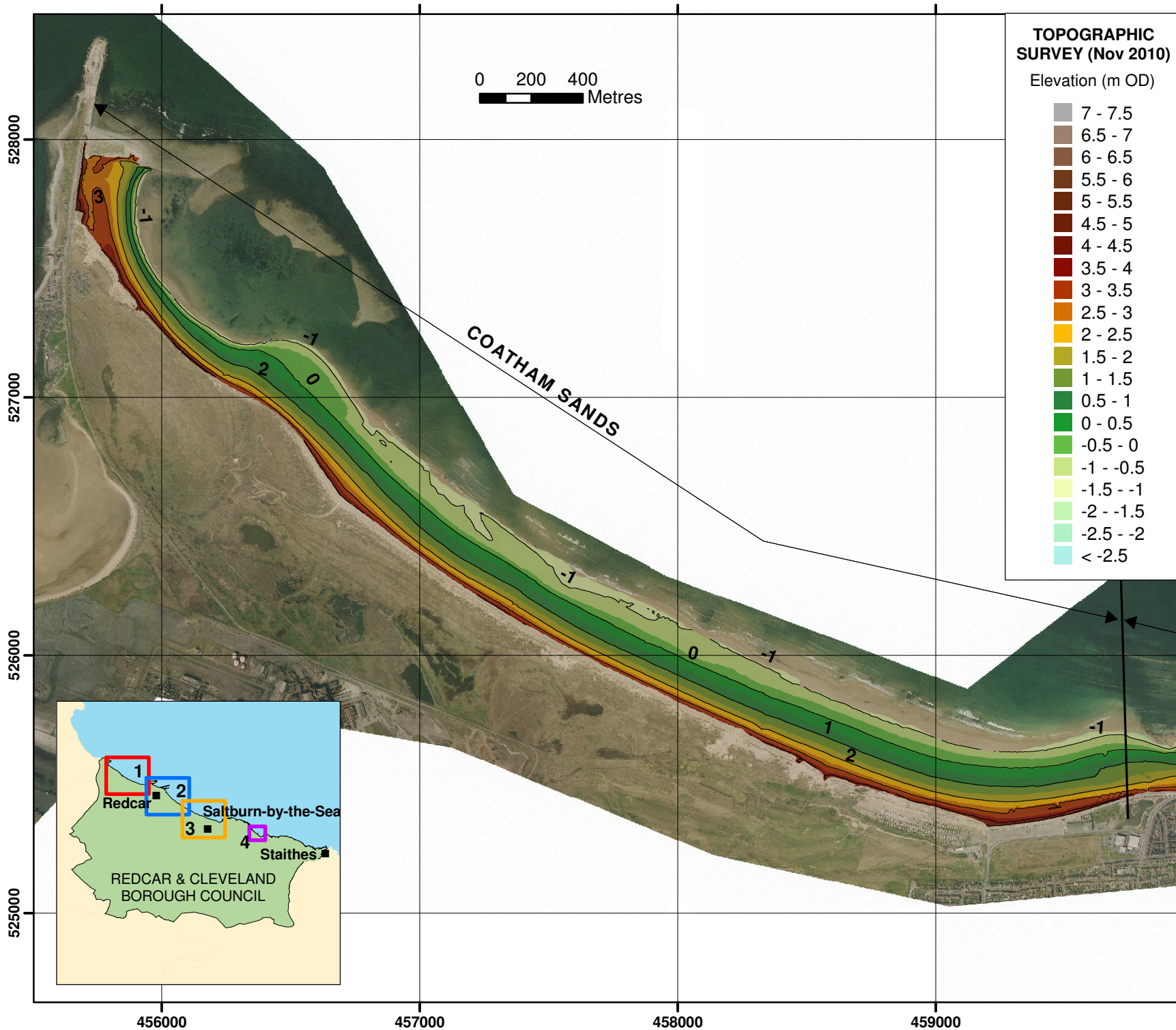
MWS

Beach Profiles: 1cRC9



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- 17/11/2008
- 30/04/2009
- 07/09/2009
- 13/04/2010
- 05/11/2010

Appendix B
Topographic Survey



TOPOGRAPHIC SURVEY (Nov 2010)
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 3
'Full Measures' Survey 2010

Drawing Scale 1:20,000 at A4

Drawn by: TC Date: 29/11/2010
Checked by: NC Date: 29/11/2010
Approved by: NC Date: 06/12/2010

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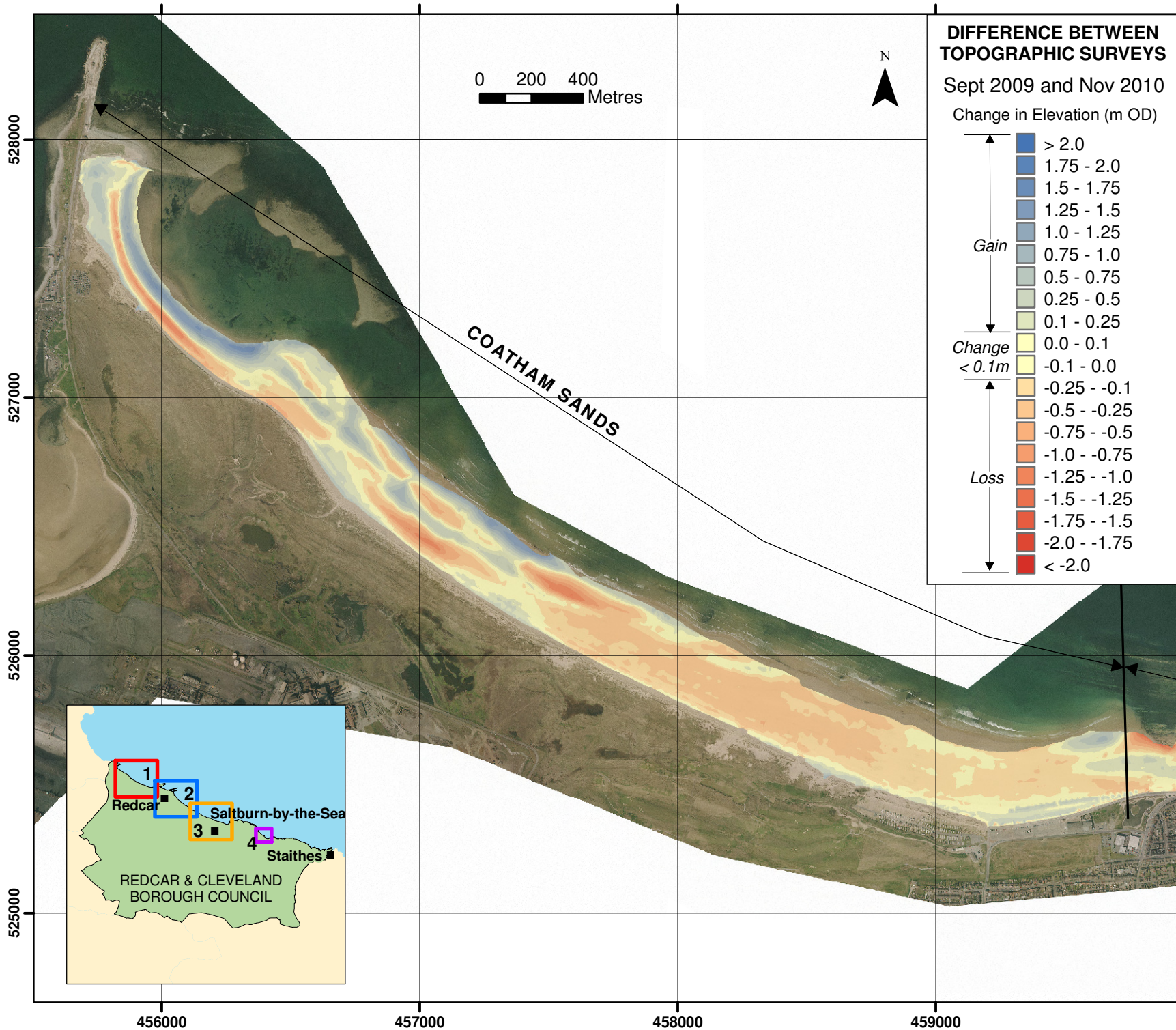
Halcrow

Halcrow Group Ltd
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B16 8PE

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Fax: +44(0)121 456 1569
www.halcrow.com

Photography courtesy of North East Coastal Observatory
www.northeastcoastalobservatory.org.uk

I:\9T6403\Technical_Data\gis\figure7_FULL_measures_report_2010\7_Redcar_Cleveland\Appendix_B_Redcar_Cleveland_Map1a.mxd



Client: North East Coastal Group
 Project: Cell 1 Regional Coastal Monitoring Programme

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

Analytical Report 3
 'Full Measures' Survey 2010

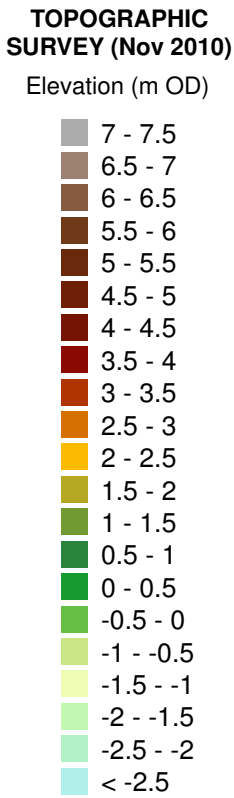
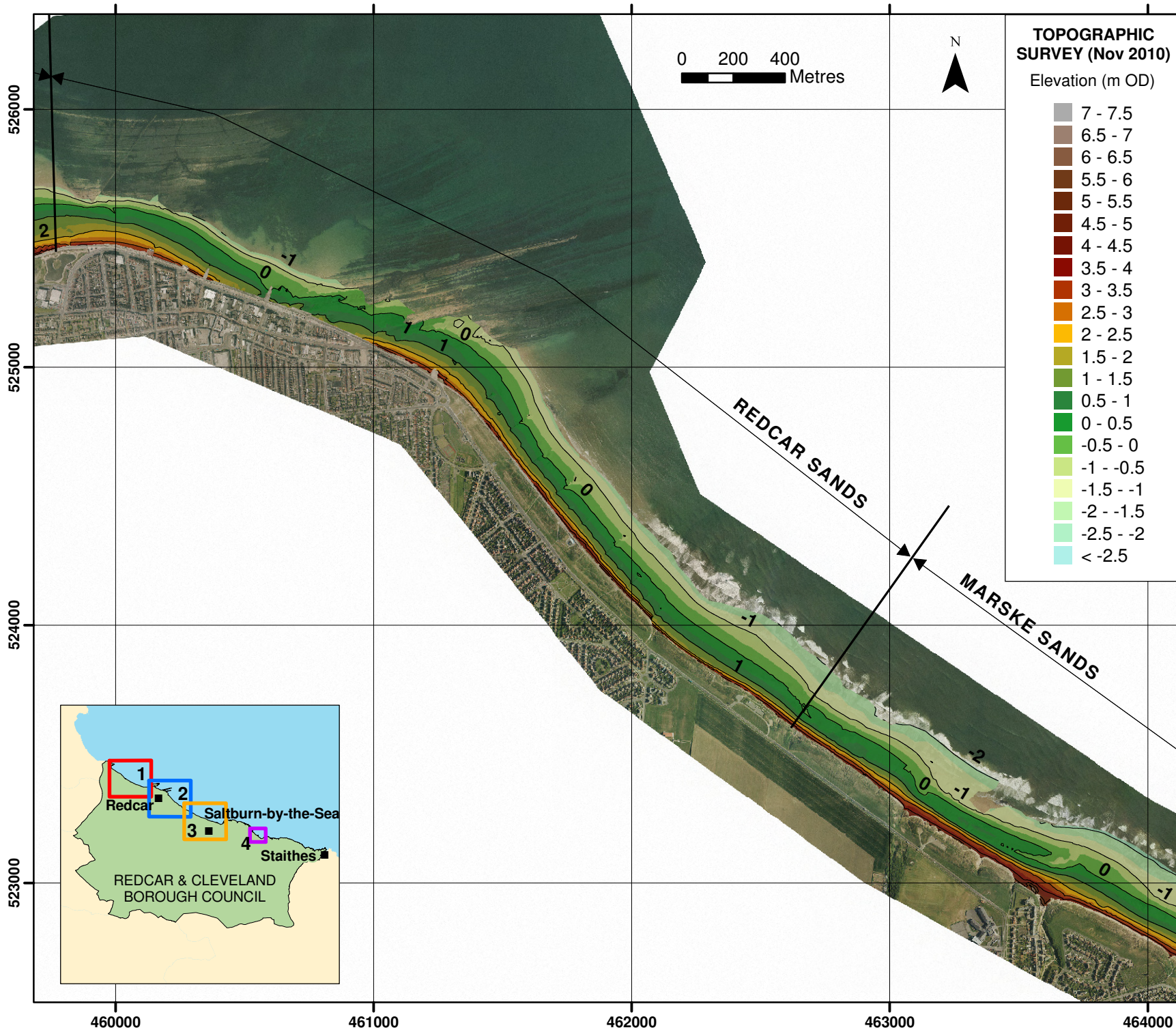
Drawing Scale 1:20,000 at A4

Drawn by: TC Date: 29/11/2010
 Checked by: NC Date: 29/11/2010
 Approved by: NC Date: 06/12/2010

 ROYAL HASKONING	 Halcrow
Royal Haskoning Marlborough House Marlborough Crescent Newcastle upon Tyne NE1 4EE	Halcrow Group Ltd Lyndon House 62 Hagley Road Edgbaston Birmingham B16 8PE
Tel: +44 (0)191 211 1300 Fax: +44 (0)191 211 1313 www.royalhaskoning.com	Tel: +44 (0)121 456 2345 Fax: +44(0)121 456 1569 www.halcrow.com

Photography courtesy of North East Coastal Observatory
 www.northeastcoastalobservatory.org.uk

I:\9T6403\Technical_Data\gis\figure7_FULL_measures_report_2010\7_Redcar_Cleveland\Appendix_B_Redcar_Cleveland_Map1b.mxd



— 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 3
'Full Measures' Survey 2010

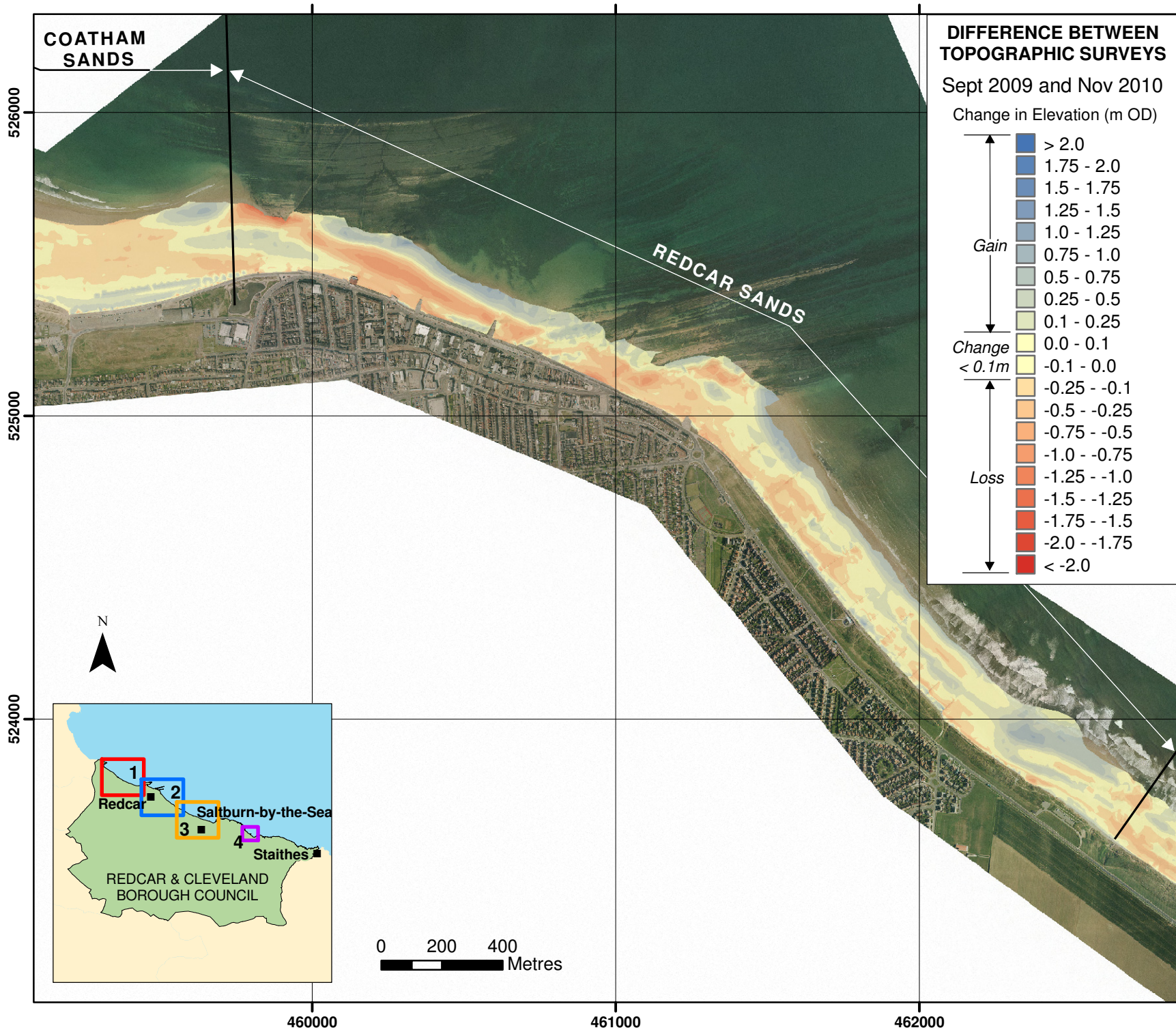
Drawing Scale 1:20,000 at A4

Drawn by: TC	Date: 29/11/2010
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Approved by: NC	Date: 06/12/2010

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Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

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

Analytical Report 3
'Full Measures' Survey 2010

Drawing Scale 1:17,000 at A4

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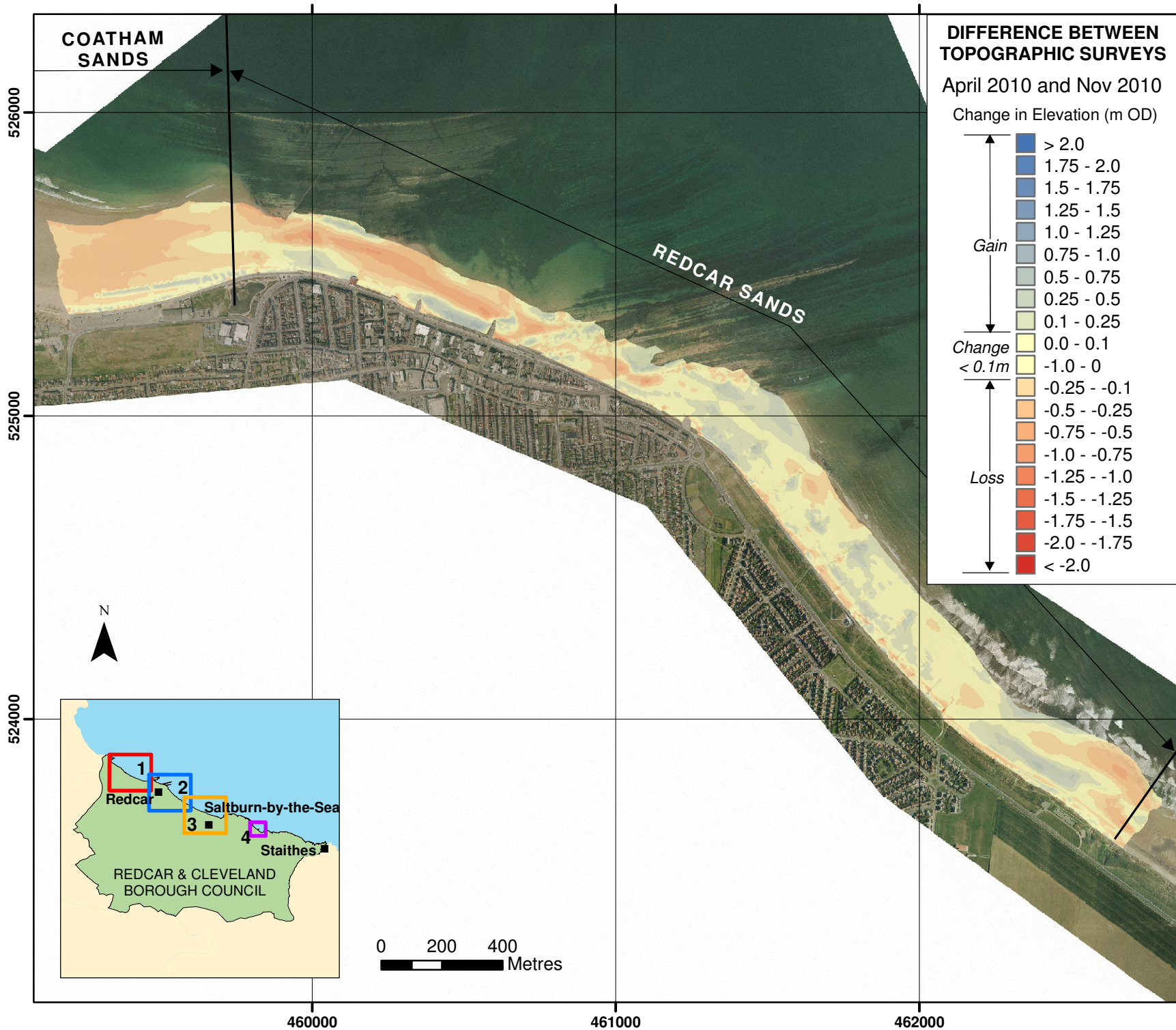
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Client: North East Coastal Group
 Project: Cell 1 Regional Coastal Monitoring Programme

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

Analytical Report 3
 'Full Measures' Survey 2010

Drawing Scale 1:17,000 at A4

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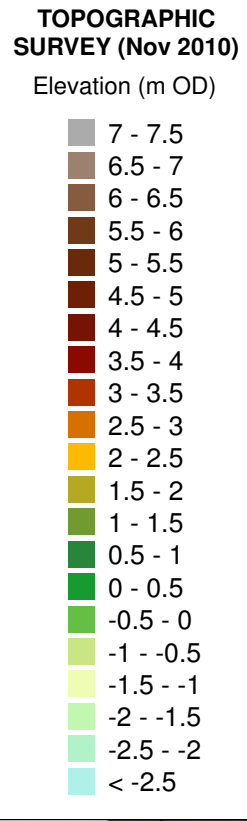
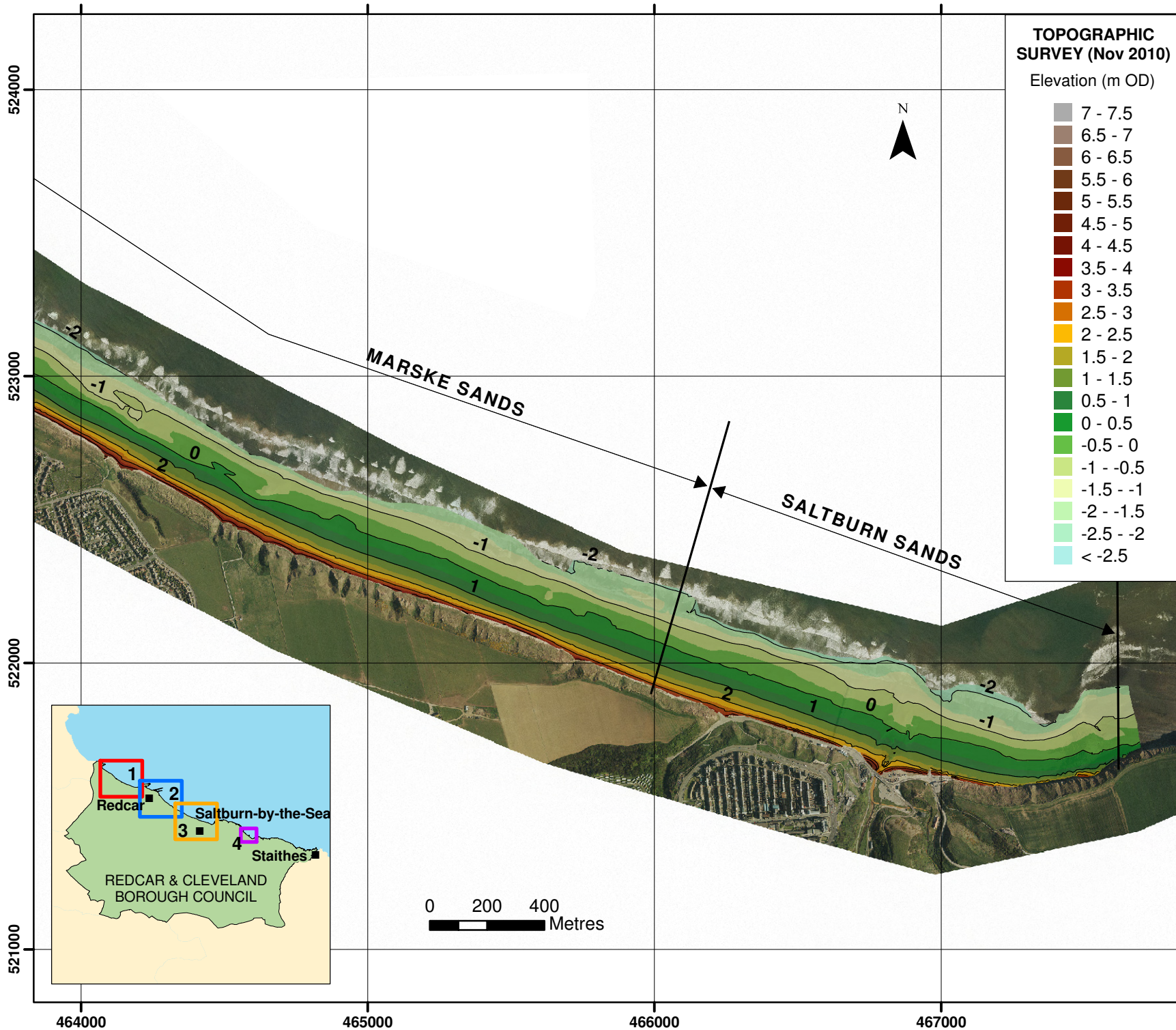
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— Topographic Contours at 1 metre interval

Client: North East Coastal Group
Project: Cell 1 Regional Coastal Monitoring Programme

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

Analytical Report 3
'Full Measures' Survey 2010

Drawing Scale 1:18,000 at A4

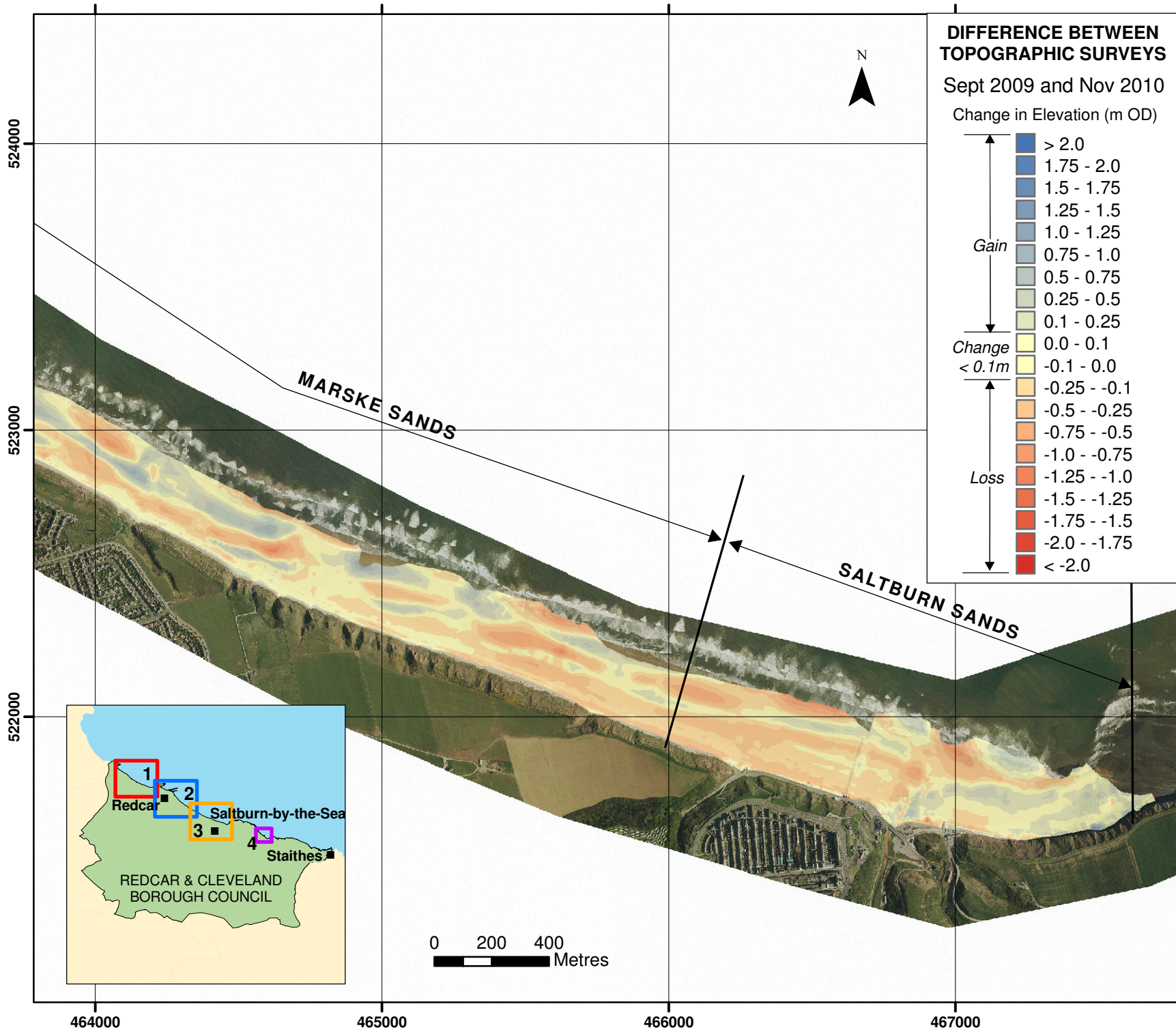
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Approved by: NC Date: 06/12/2010

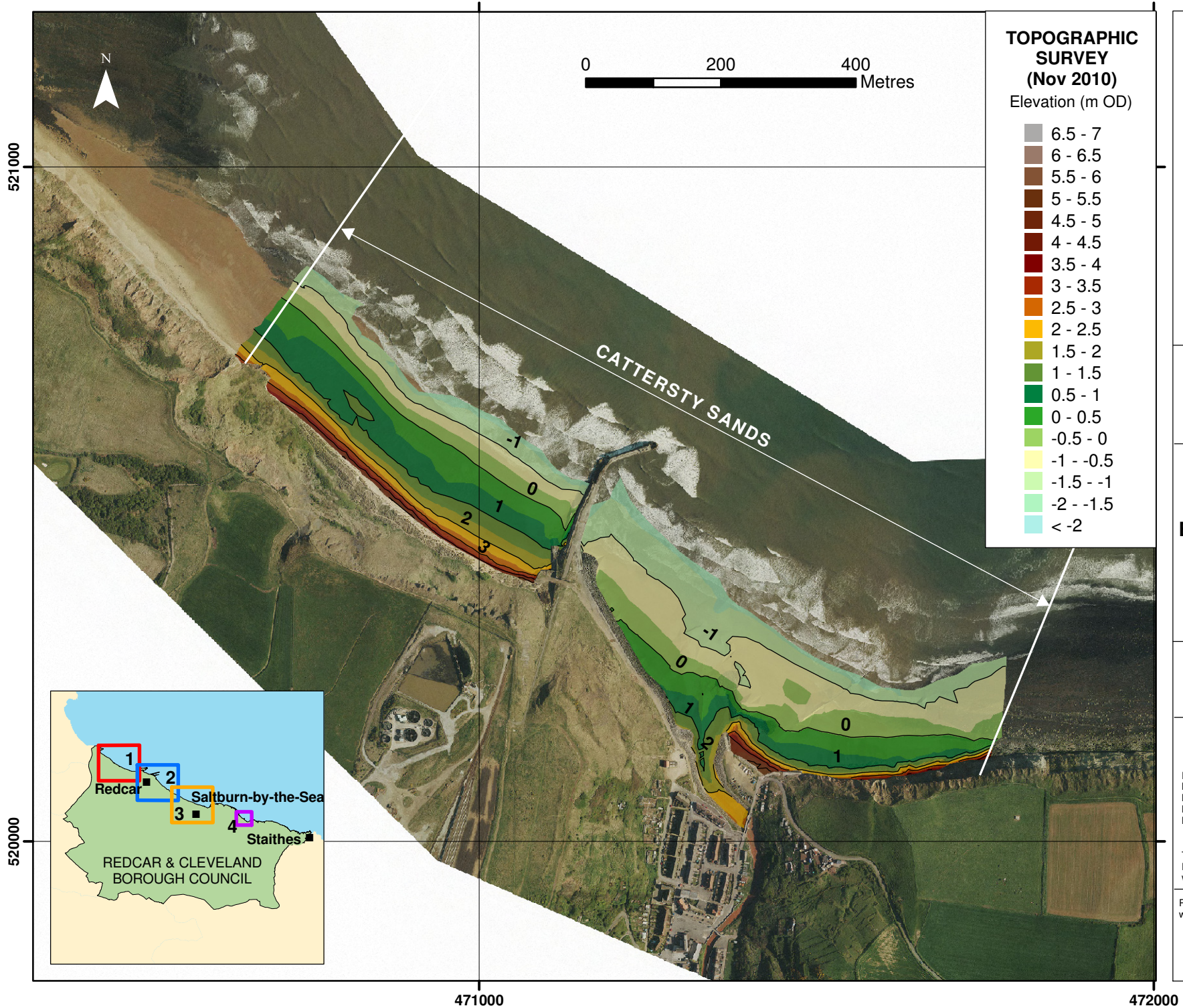
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TOPOGRAPHIC SURVEY (Nov 2010)
Elevation (m OD)

- 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

— 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 3
'Full Measures' Survey 2010

Drawing Scale 1:7,500 at A4

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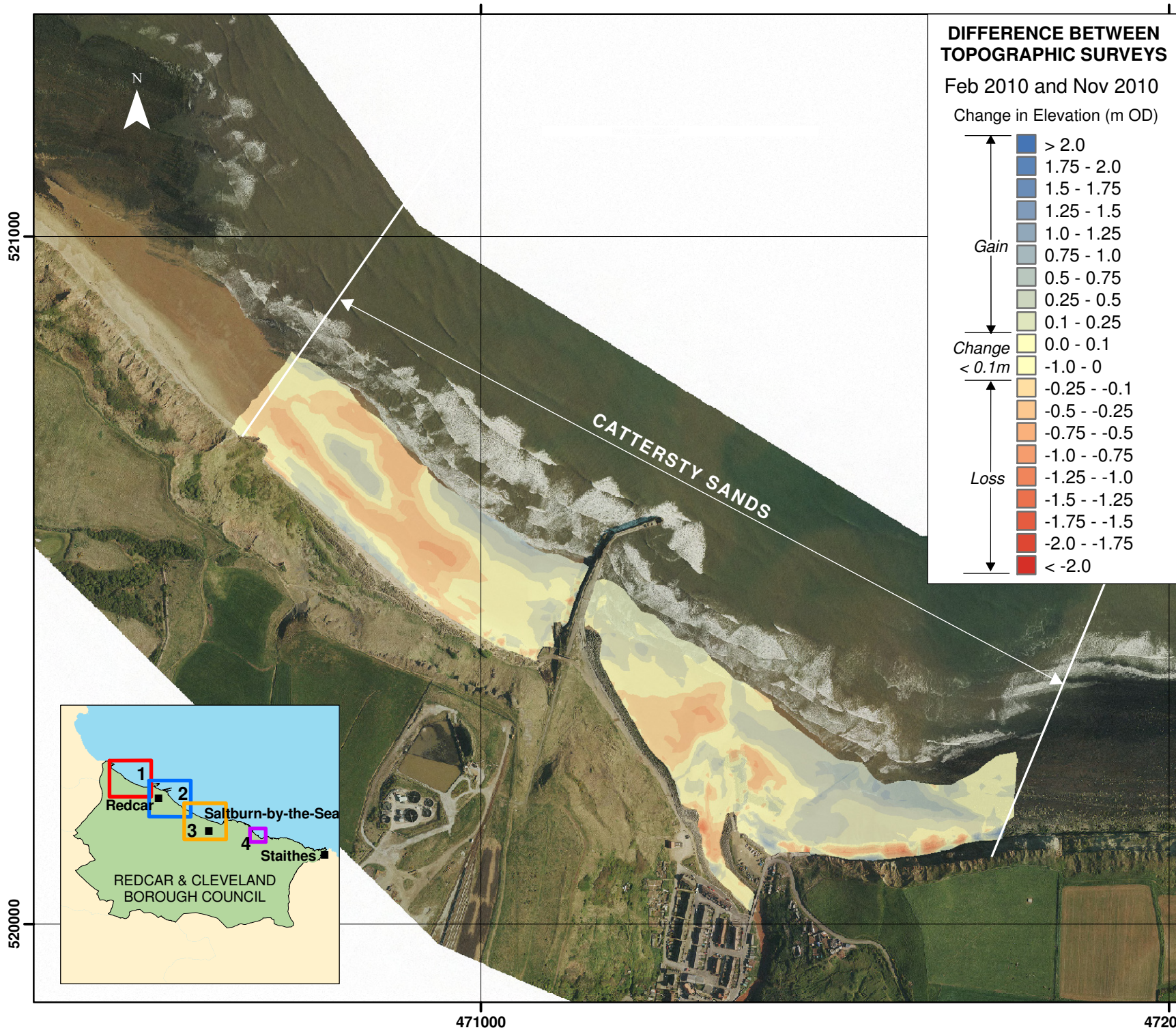


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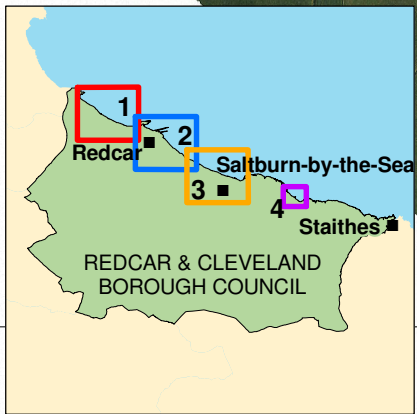
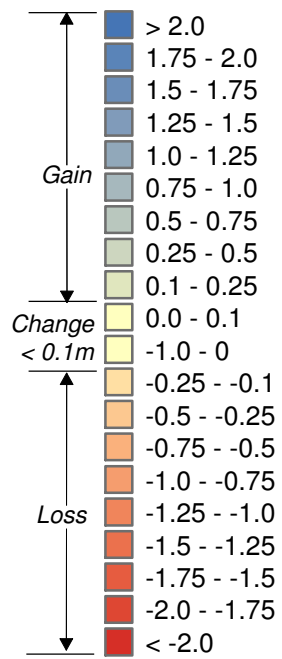
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DIFFERENCE BETWEEN TOPOGRAPHIC SURVEYS

Feb 2010 and Nov 2010

Change in Elevation (m OD)



Client: North East Coastal Group
 Project: Cell 1 Regional Coastal Monitoring Programme

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

Analytical Report 3
 'Full Measures' Survey 2010

Drawing Scale 1:7,500 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.

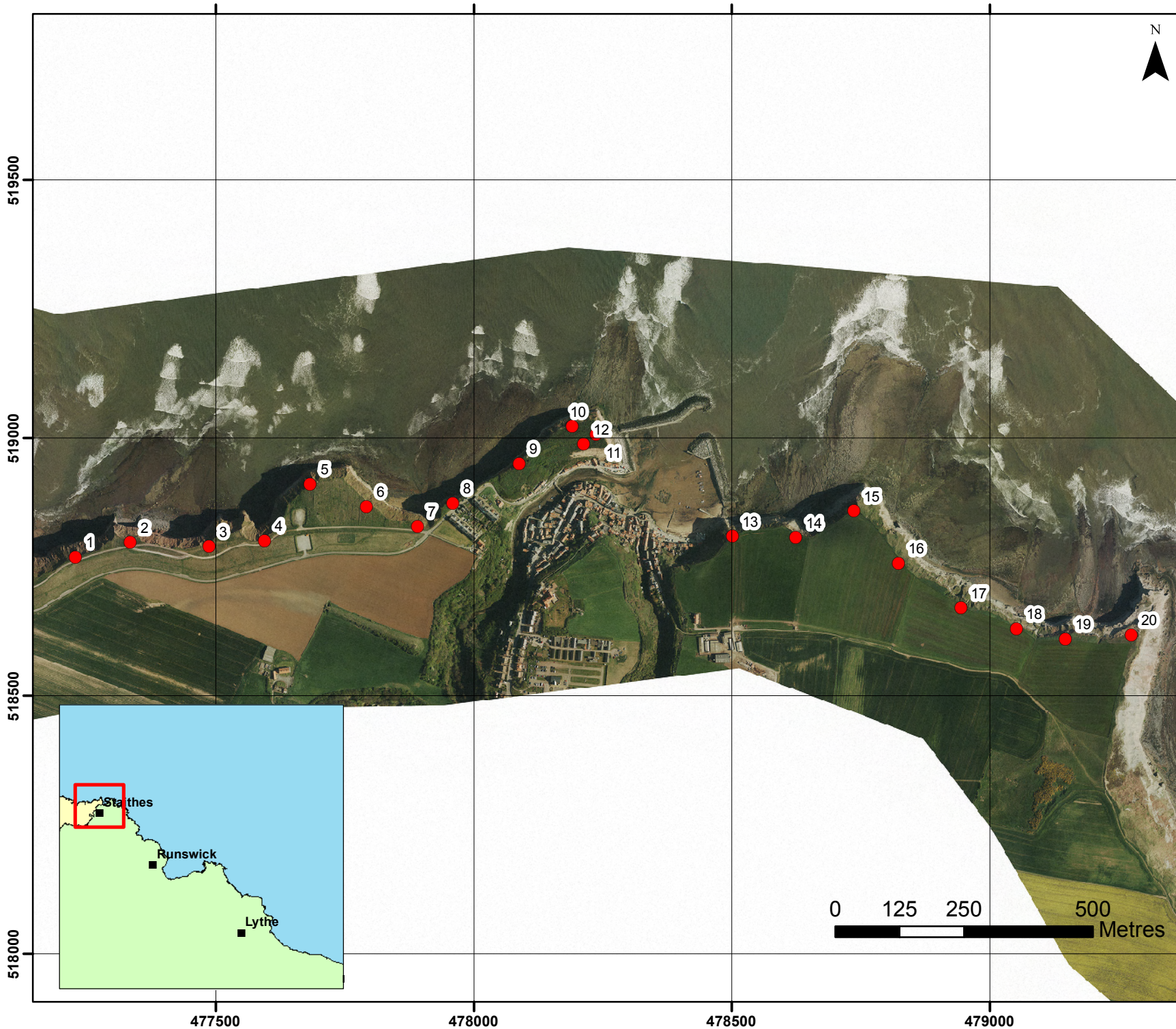
Table C1 provides baseline information about these ground control points and results from the September 2010 survey showing the position from the ground control point to the edge of the cliff top along the defined bearing and changes in position since the November 2008 baseline survey.

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 (°)	Baseline Survey (Nov 2008)	Previous Survey (Feb 2010)	Present Survey (Sept 2010)	Baseline (Nov 2008) to Present (Sept 2010)	Previous (Feb 2010) to Present (Sept 2010)	Baseline (Nov 2008) to Present (Sept 2010)
1	477228	518769	60.587	320	1.9	1.8	1.7	-0.2	-0.1	-0.1
2	477334	518798	57.543	0	10.9	10.7	10.8	-0.1	0.1	-0.1
3	477487	518789	54.861	350	7.1	8.3	8.3	1.2	0.0	-
4	477594	518801	53.636	340	5.9	5.3	5.3	-0.6	0.0	-0.3
5	477683	518911	48.371	350	8.4	8.2	8.3	-0.1	0.1	-0.1
6	477792	518867	47.422	30	8.6	8.4	8.5	-0.1	0.1	-0.1
7	477891	518828	44.602	60	7.7	7.6	7.6	-0.1	0.0	-0.1
8	477959	518873	39.974	350	8.7	8.8	8.7	0.0	-0.1	0.0
9	478088	518950	37.281	350	7.6	8.1	8.4	0.8	0.3	-
10	478191	519023	42.655	340	8.4	10.7	9.9	1.5	-0.8	-
11	478237	519007	39.990	60	6.9	6.8	6.8	-0.1	0.0	-0.1
12	478213	518988	37.169	150	6.1	6.4	6.5	0.4	0.1	-

Ground Control Point Details					Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Easting	Northing	Level (mODN)	Bearing (°)	Baseline Survey (Nov 2008)	Previous Survey (Feb 2010)	Present Survey (Sept 2010)	Baseline (Nov 2008) to Present (Sept 2010)	Previous (Feb 2010) to Present (Sept 2010)	Baseline (Nov 2008) to Present (Sept 2010)
13	478501	518809	50.260	15	11.4	9.3	9.3	-2.1	0.0	-1.1
14	478624	518807	55.345	20	7.5	7.6	7.5	0.0	-0.1	0.0
15	478737	518858	56.017	60	6.1	6.1	6.1	0.0	0.0	0.0
16	478823	518757	50.237	60	8.0	8.8	8.8	0.8	0.0	-
17	478944	518671	46.764	30	9.3	9.6	9.7	0.4	0.1	-
18	479052	518630	47.026	20	9.2	9.1	9.1	-0.1	0.0	-0.1
19	479147	518610	47.108	0	14.2	14.4	14.4	0.2	0.0	-
20	479274	518618	44.243	20	11.4	11.5	11.5	0.1	0.0	-

Note: It is assumed that the accuracy of cliff top monitoring using this technique is $\pm 0.1\text{m}$. 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 3
 'Full Measures' Survey 2010

Drawing Scale 1:10,000 at A4

Drawn by: AW	Date: 01/12/2010
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Approved by: RJ	Date: 01/12/2010

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