Cell 1 Regional Coastal Monitoring Programme
Analytical Report 7: 'Full Measures' Survey 2014

Redcar and Cleveland Borough Council
Final Report

February 2015

Contents

Appendices

List of Figures

List of Tables

Authors	
Alex Bellis	CH2M HILL
Dr Paul Fish – Review of Draft	CH2M HILL
Dr Andy Parsons – Approval of Final	CH2M HILL

Disclaimer

Halcrow Group Limited ('Halcrow') is a CH2M HILL company. Halcrow has prepared this report in accordance with the instructions of our client Scarborough Borough Council (SBC) for the client's sole and specific use. Any other persons who use any information contained herein do so at their own risk. This report is a review of coastal survey information made available by SBC. The objective of this report is to provide an assessment and review of the relevant background documentation and to analyse and interpret the coastal monitoring data. Halcrow has used reasonable skill, care and diligence in the interpretation of data provided to them and accepts no responsibility for the content, quality or accuracy of any Third party reports, monitoring data or further information provided either to them by SBC or, via SBC from a Third party source, for analysis under this term contract.

Raw data analysed in this report is available to download via the project's webpage: www.northeastcoastalobservatory.org.uk. The North East Coastal Observatory does not "license" the use of images or data or sign license agreements. The North East Coastal Observatory generally has no objection to the reproduction and use of these materials (aerial photography, wave data, beach surveys, bathymetric surveys), subject to the following conditions:

1. North East Coastal Observatory material may not be used to state or imply the endorsement by North East Coastal Observatory or by any North East Coastal Observatory employee of a commercial product, service, or activity, or used in any manner that might mislead.
2. North East Coastal Observatory should be acknowledged as the source of the material in any use of images and data accessed through this website, please state "Image/Data courtesy of North East Coastal Observatory". We recommend that the caption for any image and data published includes our website, so that others can locate or obtain copies when needed. We always appreciate notification of beneficial uses of images and data within your applications. This will help us continue to maintain these freely available services. Send e-mail to Robin.Siddle@scarborough.gov.uk
3. It is unlawful to falsely claim copyright or other rights in North East Coastal Observatory material.
4. North East Coastal Observatory shall in no way be liable for any costs, expenses, claims, or demands arising out of the use of North East Coastal Observatory material by a recipient or a recipient's distributees.
5. North East Coastal Observatory does not indemnify nor hold harmless users of North East Coastal Observatory material, nor release such users from copyright infringement, nor grant exclusive use rights with respect to North East Coastal Observatory material.
6. North East Coastal Observatory material is not protected by copyright unless noted (in associated metadata). If copyrighted, permission should be obtained from the copyright owner prior to use. If not copyrighted, North East Coastal Observatory material may be reproduced and distributed without further permission from North East Coastal Observatory.

Abbreviations and Acronyms

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

Water Levels Used in Interpretation of Changes

Water Level Parameter	Water Level (m AOD) Hartlepool Headland to Saltburn Scar	Skinningrove	Hummersea Scar to Sandsend Ness	Sandsend Ness to Saltwick Nab
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 (m AOD) Saltwick Nab to Hundale Point**	**Hundale Point to White Nab**	**White Nab to Filey Brigg**	**Filey Brigg to Flamborough Head**
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 sediment to varying thicknesses, softer rock cliffs and extensive landslide complexes.

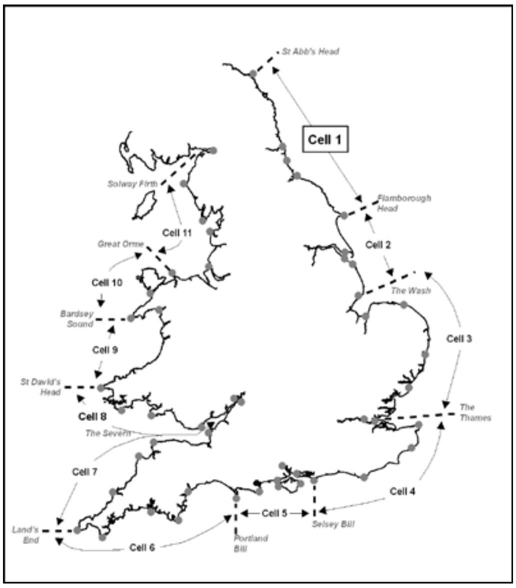


Figure 1 Sediment Cells in England and Wales

The work commenced with a three-year monitoring programme in September 2008 that was managed by Scarborough Borough Council on behalf of the North East Coastal Group. This initial phase has been followed by a five-year programme of work, which started in October 2011. The work is funded by the Environment Agency, working in partnership with the following organisations:

The original three year programme of work was undertaken as a partnership between Royal Haskoning, Halcrow and Academy Geomatics. For the current five year programme of work the data collection associated with beach profiles, topographic surveys and cliff top surveys is being undertaken by Academy Geomatics. The analysis and reporting for the programme is being undertaken by Halcrow (rebranded as CH2M HILL since 2013).

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.

Annually, a Cell 1 Overview Report is also produced. This provides a region-wide summary of the main findings relating to trends and interactions along the entire Cell 1 frontage. 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		-
2	2009/10	Sep-Dec 09	Mar 10	Feb-Mar 10	Jul 10	-
3	2010/11	Aug-Nov 10	Feb 11	Feb-Apr 11	Aug 11	Sep 11
4	2011/12	Sep-Oct 11	Oct 12	Mar-May 12	Feb 13	
5	2012/13	Sep 12	Mar 13	Feb- Mar 13	May 13	
6	2013/14	Oct-Nov 13	Feb 14	Mar-Apr 14	Jul 14 (*)	
7	2014/15	Sep-Oct 14	Feb 15 (*)			

* The present report is **Analytical Report 7** and provides an analysis of the 2014 Full Measures survey for Redcar and 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 to Cowbar Nab, Staithes. For the purposes of this report, report and for consistency with previous reporting, 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 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 (since 2008) each autumn/early winter comprising:
    - Beach profile surveys along nine 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 (since 2009) comprising:
    - Beach profile surveys along nine transect lines
    - Topographic survey along Redcar Sands
    - Topographic survey along Saltburn Sands
    - Topographic survey along Cattersty Sands
- Cliff top survey annually at:
    - Staithes

The Full Measures survey was undertaken along this frontage in September and October 2014. The weather during the survey was mostly dry with light to moderate breezes and a rough to moderate sea state. For further details please refer to the Survey Report from Academy Geomatics.

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 ArcGIS. 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.

1.3 Uncertainties in data and analysis

While uncertainty due to survey accuracy or systematic error is likely to be present in all datasets, the work is carefully managed to ensure data are as accurate as possible and results are not misleading. Error may arise from the limits of precision of survey techniques used, from low accuracy measurements being taken or from systematic failings of equipment.

For beach profiles and topographic surveys, all incoming data are checked allowing systematic errors to be identified, and removed from plots and subsequent analysis. The accuracy of these surveys is not known, but it is likely that all measurements are correct to ±0.1m. Therefore, changes are less than ±0.1m are ignored and greyed out in the topographic change plots. For cliff top erosion surveys, there are commonly problems in precisely recognising the cliff edge due to vegetation growth and the convex shape of the feature. Errors manifest themselves as results that suggest the cliff edge has advanced, which is very unlikely unless a toppling failure has been initiated, but the block has not yet fully detached. The accuracy of cliff top surveys are also unknown, but it is assumed that each measurement is accurate to ±0.1m.

These limits of accuracy mean that comparison of annual or biannual data can be of limited value if the measured change is less than or equal to the assumed error. However, all results become more significant over longer time periods when the errors in measurement in years 1 and *x* are averaged over the monitoring period:

$$\text{Error rate of change per year} = \frac{\text{Error in first measurement} + \text{Error in last measurement}}{\text{Years between measurements}}$$

The effect of averaging error over different monitoring periods is summarised in Table 3, which assumes that each annual survey is accurate to 0.1m.

Table 3 Error bands for long-term calculations of change.

Years between surveys	Error in inter-survey comparison (±m/yr)
1	0.200
2	0.100
3	0.067
4	0.050
5	0.040
5	0.033
7	0.029
8	0.025
9	0.022
10	0.020

While considering the uncertainty in comparing and analysing change between monitoring data sets it is also relevant to raise caution about drawing conclusions about short or longer term trends. Clearly the longer the data set the more confidence that can be given to likely ranges of beach changes and trends in change. Potential for seasonal, annual and longer term cycles need to be considered. Studies of long term monitoring data sets for other coastal and estuarial data have established that there are long period cyclical trends related to the 18.6 years lunar nodal cycle which need to be accounted for. Simply put this means that although the Cell 1 monitoring programme now has data in some locations up to 11 years, another 8 to 10 years of consistent data is needed before confidence can be given in trends from the analysis. In the context of this report “Longer Term Trends” are mentioned in each section and it should be noted that this is based on simple visual interpretation of the available data since the current programme began, and is generally based on only 5 years of data.

2 Wave Data and Interpretation

2.1 Introduction

Wave monitoring data relevant to the Cell 1 Regional Coastal Monitoring Programme is available from one offshore regional wave buoy located at Tyne and Tees and three regional wave buoys, which are further inshore at Newbiggin, Whitby and Scarborough. The Tyne Tees buoy is managed by Cefas as part of the WaveNet system, while the three inshore buoys is managed by Scarborough BC as part of the Cell 1 monitoring programme.

An assessment of baseline wave data is presented in the 2011 Wave Data Analysis Report, which reviewed all readily available data in the region. In 2014 a wave data update report updated the baseline with analysis of the wave data collected under the programme for 2013, including the 5th and 6th December storm. That report was further updated in 2015 to include the records from 2014. In order to help put the beach and cliff changes discussed in this report into context analysed storm data for the wave buoys is presented in this section.

The longest consistent relevant wave data record in the Cell 1 region is from the WaveNet Tyne Tees buoy deployed under the national coastal monitoring programme by Cefas. Data has been downloaded from WaveNet and loaded into SANDS for analysis alongside the beach and cliff monitoring data. Results from analysis of the data to extract details of significant storms are presented in Table 4 below.

To aid interpretation of the results in Table 4 alternate years have been shaded and the storm with the largest peak wave height each year has been highlighted in bold. The annual storm with the highest wave energy at peak has also been highlighted in bold red text as this depends on wave period as well as wave height and so is not always the same as the largest wave height, e.g. in 2009 and 2010.

Table 4: SANDS Storm Analysis at Tyne/Tees WaveNet Buoy (updated to include data to 7th Dec 2014)

General Storm Information							At Peak					
StartTime	***EndTime***	***Dur (hr)***	***Peak of Storm***	***Mean Dir***	***No of Events***	***Mean Direction Vector***	***Hs (m)***	***Tp (s)***	***Tz (s)***	***Dir***	***Energy @ Peak (KJ/m/s)***	***Total Energy (KJ/m)***
19/03/2007 10:30	21/03/2007 05:30	43	20/03/2007 14:30	23	64	78.2	6.2	12.4	8.5	23	1.7E+04	1.4E+07
25/06/2007 20:30	26/06/2007 13:30	17	26/06/2007 10:00	54	18	77.3	4.4	8.6	7.2	23	4.0E+03	1.7E+06
26/09/2007 03:00	27/09/2007 05:00	26	26/09/2007 19:00	11	33	79.7	4.6	11.6	7.6	6	**7.8E+03**	3.6E+06
08/11/2007 20:00	12/11/2007 15:00	91	09/11/2007 08:30	16	58	77.7	**6.2**	**13.3**	**9.0**	**6**	1.9E+04	1.6E+07
19/11/2007 03:30	25/11/2007 21:30	162	23/11/2007 05:00	88	52	76.8	4.9	10.7	7.6	17	7.6E+03	6.8E+06
08/12/2007 03:00	10/12/2007 14:30	59.5	08/12/2007 03:30	106	8	82.9	4.1	10.7	7.6	17	5.4E+03	7.5E+05
03/01/2008 10:30	04/01/2008 01:30	15	03/01/2008 23:30	77	24	14.6	4.2	9.1	7.6	62	4.2E+03	2.5E+06
01/02/2008 15:00	02/02/2008 09:30	18.5	02/02/2008	41	30	80.1	6.0	13.8	9.0	17	1.9E+04	8.7E+06
10/03/2008 08:30	10/03/2008 12:30	4	10/03/2008 11:00	146	9	307.5	4.6	8.1	6.5	141	3.8E+03	7.3E+05
17/03/2008 15:00	25/03/2008 03:00	180	22/03/2008 05:00	81	58	82.1	**7.9**	**12.4**	**9.0**	**6**	2.7E+04	1.7E+07
05/04/2008 22:00	07/04/2008 05:00	31	06/04/2008 19:00	49	20	83.1	4.6	11.7	7.6	6	7.9E+03	3.0E+06
20/07/2008 16:00	21/07/2008 09:30	17.5	20/07/2008 23:30	15	8	76.0	4.2	9.9	7.6	11	4.9E+03	9.1E+05
03/10/2008 03:00	03/10/2008 20:30	17.5	03/10/2008 16:30	55	17	76.7	4.7	11.4	7.6	23	**8.1E+03**	2.8E+06
21/11/2008 04:00	25/11/2008 12:30	104.5	22/11/2008 11:30	15	112	75.8	6.0	13.1	8.5	11	1.7E+04	2.2E+07

General Storm Information							At Peak					
StartTime	***EndTime***	***Dur (hr)***	***Peak of Storm***	***Mean Dir***	***No of Events***	***Mean Direction Vector***	***Hs (m)***	***Tp (s)***	***Tz (s)***	***Dir***	***Energy @ Peak (KJ/m/s)***	***Total Energy (KJ/m)***
10/12/2008 12:00	13/12/2008 18:00	78	13/12/2008 08:00	109	37	332.1	4.9	8.4	7.2	129	4.7E+03	4.0E+06
31/01/2009 16:30	03/02/2009 09:00	64.5	02/02/2009 22:00	84	57	7.2	5.8	9.6	8.5	84	8.7E+03	8.1E+06
23/03/2009 22:30	28/03/2009 20:30	118	28/03/2009 16:30	217	14	89.4	5.3	8.4	7.6	6	5.4E+03	1.3E+06
10/07/2009 01:30	10/07/2009 02:30	1	10/07/2009 01:30	13	2	78.7	4.2	10.0	7.2	11	5.0E+03	2.3E+05
29/11/2009 20:30	30/11/2009 15:00	18.5	30/11/2009 00:30	18	36	72.7	**6.0**	**9.4**	**8.0**	**11**	9.0E+03	5.9E+06
17/12/2009 10:30	18/12/2009 05:00	18.5	17/12/2009 19:30	64	36	26.3	5.4	10.7	8.0	68	**9.4E+03**	5.7E+06
30/12/2009 09:00	30/12/2009 23:00	14	30/12/2009 12:30	84	24	7.7	5.1	7.6	7.2	90	4.1E+03	2.3E+06
06/01/2010 05:30	06/01/2010 11:00	5.5	06/01/2010 06:30	30	10	63.6	4.2	10.7	7.2	11	5.7E+03	1.1E+06
29/01/2010 10:30	30/01/2010 00:30	14	29/01/2010 22:30	9	21	81.9	5.4	8.6	8.0	6	6.0E+03	2.1E+06
26/02/2010 22:30	27/02/2010 02:30	4	27/02/2010 01:00	18	7	72.4	4.6	8.5	7.6	17	4.2E+03	7.0E+05
19/06/2010 07:00	20/06/2010 08:30	25.5	19/06/2010 20:00	21	49	69.2	5.4	10.7	7.6	23	**9.4E+03**	8.5E+06
29/08/2010 14:00	30/08/2010 06:30	16.5	30/08/2010 01:00	243	17	92.8	4.7	8.6	7.6	6	4.7E+03	1.6E+06
06/09/2010 22:30	07/09/2010 16:00	17.5	07/09/2010 15:30	101	22	353.2	4.6	8.8	8.0	90	4.5E+03	2.3E+06
17/09/2010 07:00	17/09/2010 18:30	11.5	17/09/2010 08:30	10	17	80.7	4.7	11.0	8.0	11	7.5E+03	2.9E+06
24/09/2010 03:00	26/09/2010	45	24/09/2010 10:00	21	80	71.6	5.3	10.2	8.0	11	8.0E+03	1.2E+07
20/10/2010 02:00	24/10/2010 16:30	110.5	20/10/2010 10:00	13	16	78.2	4.2	11.2	7.2	17	6.4E+03	1.8E+06
08/11/2010 14:00	09/11/2010 20:30	30.5	09/11/2010 10:00	88	58	3.0	**5.6**	**8.8**	**8.0**	**73**	6.9E+03	7.8E+06
17/11/2010 11:00	17/11/2010 18:30	7.5	17/11/2010 12:00	136	9	322.4	4.7	7.7	6.9	129	3.7E+03	8.1E+05
29/11/2010 19:30	02/12/2010 08:30	61	29/11/2010 21:00	80	45	11.8	5.1	9.4	7.6	56	6.3E+03	5.4E+06
16/12/2010 15:00	17/12/2010 06:30	15.5	17/12/2010 03:30	12	22	79.1	4.6	10.5	7.6	17	6.4E+03	2.8E+06
23/07/2011 14:00	24/07/2011 11:00	21	24/07/2011 03:00	23	39	67.1	**4.7**	**10.7**	**7.6**	**17**	**7.2E+03**	5.8E+06
24/10/2011 18:30	25/10/2011 09:30	15	25/10/2011 09:30	103	26	348.5	4.1	9.5	6.9	79	4.2E+03	2.6E+06
09/12/2011 08:30	09/12/2011 10:00	1.5	09/12/2011 08:30	7	3	84.0	4.1	11.9	8.0	6	6.7E+03	4.8E+05
05/01/2012 16:00	06/01/2012 05:00	13	06/01/2012 03:00	12	19	79.0	4.6	10.5	7.6	17	6.4E+03	2.6E+06
03/04/2012 13:30	04/04/2012 10:30	21	03/04/2012 17:30	66	38	25.1	5.6	8.1	7.6	56	5.9E+03	5.5E+06
24/09/2012 08:30	25/09/2012 10:30	26	25/09/2012 01:30	74	50	16.7	4.7	10.3	8.0	62	6.6E+03	7.4E+06
26/10/2012 16:30	27/10/2012 14:30	22	26/10/2012 23:00	12	34	79.4	4.9	12.8	7.6	11	1.1E+04	4.9E+06
05/12/2012 16:00	15/12/2012 01:30	225.5	14/12/2012 19:30	78	31	18.4	5.4	8.8	7.6	96	6.4E+03	4.5E+06
20/12/2012 06:00	21/12/2012 14:30	32.5	20/12/2012 23:00	101	56	348.4	5.6	9.5	8.0	96	8.0E+03	8.8E+06
18/01/2013 18:30	22/01/2013 06:00	83.5	21/01/2013 10:00	81	54	9.2	6.7	9.4	8.5	84	1.1E+04	1.1E+07
06/02/2013 08:00	07/02/2013 06:00	22	06/02/2013 12:30	47	38	81.6	5.4	10.0	7.6	11	8.2E+03	6.1E+06
07/03/2013 21:00	10/03/2013 21:30	72.5	08/03/2013 04:00	67	37	24.6	4.9	9.0	7.6	73	5.4E+03	4.3E+06
18/03/2013 09:00	25/03/2013 00:30	159.5	23/03/2013 14:30	85	153	5.1	6.0	10.2	8.0	90	1.0E+04	2.8E+07
23/05/2013 18:00	24/05/2013 12:00	18	23/05/2013 22:30	13	32	77.5	6.7	10.5	8.5	17	1.4E+04	7.1E+06

General Storm Information							At Peak					
StartTime	*EndTime*	*Dur (hr)*	*Peak of Storm*	*Mean Dir*	*No of Events*	*Mean Direction Vector*	*Hs (m)*	*Tp (s)*	*Tz (s)*	*Dir*	*Energy @ Peak (KJ/m/s)*	*Total Energy (KJ/m)*
10/09/2013 13:00	10/09/2013 19:30	6.5	10/09/2013 14:00	11	14	79.3	4.4	9.2	7.2	11	4.6E+03	1.5E+06
09/10/2013 22:30	11/10/2013 09:00	34.5	10/10/2013 17:00	68	62	79.8	5.4	10.7	7.6	22	9.4E+03	1.2E+07
29/11/2013 22:30	30/11/2013 06:30	8	30/11/2013 00:30	42	17	84.5	5.6	10.7	8.0	11	1.0E+04	3.3E+06
05/12/2013 14:00	07/12/2013 04:30	38.5	06/12/2013 20:00	24	59	80.8	4.7	14.3	9.0	6	1.3E+04	1.2E+07
27/12/2013 09:30	27/12/2013 12:30	3	27/12/2013 10:00	218	3	249.3	4.1	6.1	6.5	202	1.8E+03	1.3E+05
05/02/2014 04:00	05/02/2014 18:00	14	05/02/2014 05:30	139	9	318.4	4.4	7.8	6.9	129	3.3E+03	7.2E+05
12/02/2014 20:00	14/02/2014 19:00	47	12/02/2014 21:00	183	8	275.6	4.6	7.5	6.5	141	3.2E+03	7.8E+05
21/10/2014 22:00	22/10/2014 01:30	3.5	21/10/2014 23:00	6	5	84.4	4.4	9.6	7.6	6	5.0E+03	6.0E+05

The storms mostly arrive from the north to northeast direction, 0 to 40 degrees, which has the longest fetch, but there are also a significant number of storms from other directions, particularly 80 to 140 degrees.

Comparing the annual storm records it can be seen that 2010 had the most storms (13). In 2010 the largest storm had an incident direction of 73 degrees which is unusual. We might therefore expect that the alongshore drift on the Cell 1 beaches in 2010 may have been atypical with unusual changes from the storm conditions. This was noted in several of the 2010 Full Measures reports.

The year with the fewest storms was 2011. This was reflected by accretion recorded in a number of the annual Full Measures reports.

The winter of 2012 to 2013 appears to have suffered with larger storms than usual, with the second largest peak wave height (7.3m) recorded on 23rd March 2013. The longest duration storm in the record was from 5th to 15th December 2012 (226.5 hours).

The storm on the 5th to 7th December 2013, was particularly notable. Although this event did not have such large waves as the 23rd March 2013 storm, it had a high peak energy and exceptionally long wave period at 14.3 seconds. The 6th December 2013 storm was also accompanied by a significant storm surge with recorded water levels around 1.75m higher that predicted tides. The combined high water levels and large waves causing significant damage to many coastal defences and beaches.

2.2 Wave data for the Scarborough Frontage.

There are two local buoys on the Scarborough Borough Council frontage, at Whitby and Scarborough that were deployed in January 2013. Analysed storm data for these two buoys is presented in Tables 5 and 6.

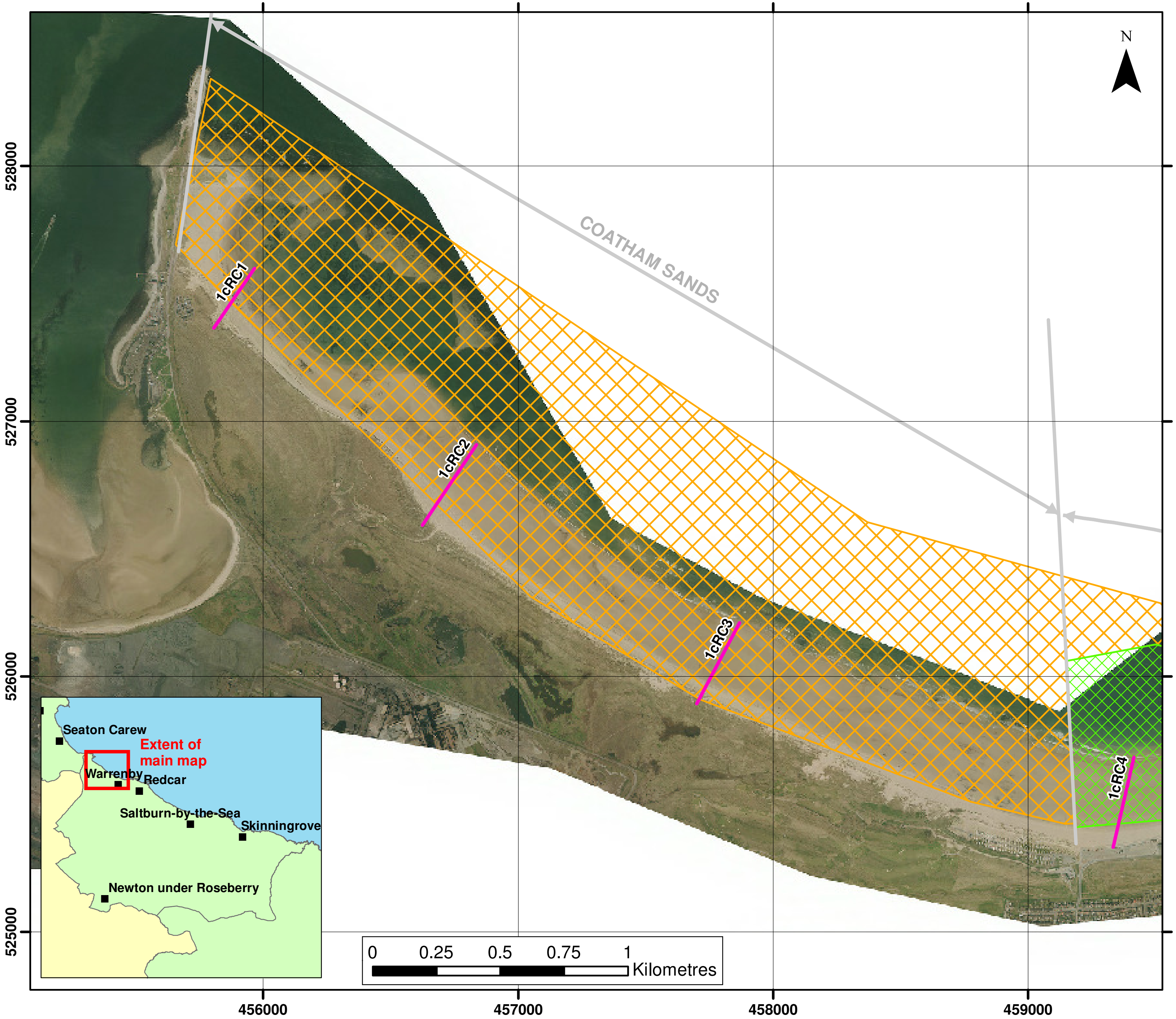
Overall the data for the storms recorded at Scarborough and Whitby are comparable in terms of wave height, period and energy. The highest energy storm recorded at Whitby was the 5th and 6th of December 2013 storm. The second most severe storm at Whitby in terms of wave height and energy was on the 10th October 2013, this is the most severe storm recorded in the Scarborough dataset.

Table 5: Storm analysis for Scarborough WB (data 17/01/2013 to 31/10/2014)

General Storm Information							At Peak					
Start Time	End Time	Dur (hr)	Peak of Storm	Mean Dir	No of Events	Mean Direction Vector	Hs (m)	Tp (s)	Tz (s)	Dir	Energy @ Peak (KJ/m/s)	Total Energy (KJ/m)
21/01/2013 02:00	21/01/2013 20:00	18	21/01/2013 13:00	68	35	22	5.1	9.3	7.8	65	6.4E+03	4.5E+06
06/02/2013 13:30	07/02/2013 02:00	12.5	06/02/2013 17:00	14	15	77	4.3	9.3	7.4	17	4.5E+03	1.7E+06
22/03/2013 20:00	24/03/2013 23:00	51	23/03/2013 15:30	74	99	16	5.1	9.9	7.7	65	7.1E+03	1.4E+07
23/05/2013 21:30	24/05/2013 10:30	13	24/05/2013 00:30	19	27	71	**5.7**	**9.9**	**8.5**	**18**	**9.0E+03**	4.9E+06
10/09/2013 13:00	10/09/2013 22:30	9.5	10/09/2013 19:30	13	19	77	5.0	8.4	7.3	13	4.9E+03	2.3E+06
10/10/2013 02:00	11/10/2013 06:30	28.5	10/10/2013 23:00	28	56	72	5.8	10.5	8.0	21	1.1E+04	1.1E+07
Data missing for 5th / 6th December 2013 storm as buoy was off station												
14/10/2014 03:00	14/10/2014 06:00	3	14/10/2014 04:30	61	4	33	4.4	7.6	6.7	61	3.2E+03	3.2E+05

Table 6: Storm analysis for Whitby WB (data 17/01/2013 to 31/10/2014)

General Storm Information							At Peak					
StartTime	EndTime	Duration (hr)	Peak of Storm	Mean Dir	No of Events	Mean Direction Vector	Hs (m)	Tp (s)	Tz (s)	Dir	Energy @ Peak (KJ/m/s)	Total Energy (KJ/m)
21/01/2013 02:30	22/01/2013 03:00	24.5	21/01/2013 14:30	64	38	27	5.0	9.3	8.2	61	6.0E+03	5.0E+06
06/02/2013 11:00	07/02/2013 04:00	17	06/02/2013 18:30	17	35	73	4.8	9.9	7.1	16	6.4E+03	4.3E+06
08/03/2013 03:30	11/03/2013 05:30	74	11/03/2013 04:00	58	12	36	4.3	8.4	7.1	45	3.7E+03	1.1E+06
18/03/2013 18:30	24/03/2013 17:30	143	23/03/2013 13:00	70	95	20	5.2	9.3	8.2	72	6.6E+03	1.2E+07
23/05/2013 21:00	**24/05/2013 12:30**	**15.5**	**24/05/2013**	**20**	**27**	**70**	**5.8**	**10.5**	**8.3**	**24**	**1.0E+04**	**5.0E+06**
10/09/2013 14:00	10/09/2013 22:30	8.5	10/09/2013 16:00	19	17	72	4.4	9.3	6.9	24	4.6E+03	1.8E+06
10/10/2013 01:30	11/10/2013 06:30	29	11/10/2013	30	57	69	5.7	11.2	8.3	31	1.1E+04	1.1E+07
30/11/2013	30/11/2013 06:30	6.5	30/11/2013 03:30	16	13	75	4.8	10.5	7.4	20	7.1E+03	2.1E+06
05/12/2013 20:00	06/12/2013 22:00	26	06/12/2013 19:30	20	45	71	4.7	14.0	9.1	32	**1.2E+04**	8.2E+06
14/10/2014 04:30	14/10/2014 05:30	1	14/10/2014 05:30	52	2	40	4.1	7.0	6.5	53	2.3E+03	1.2E+05



KEY

Topographic Profiles
- Annual
- 6 monthly

Topographic Surveys
- 6 monthly
- yearly
- 5 yearly

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

(Indicative survey extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Figure 2 - Map 1
Survey Locations
Coatham Sands
Redcar & Cleveland
Borough Council

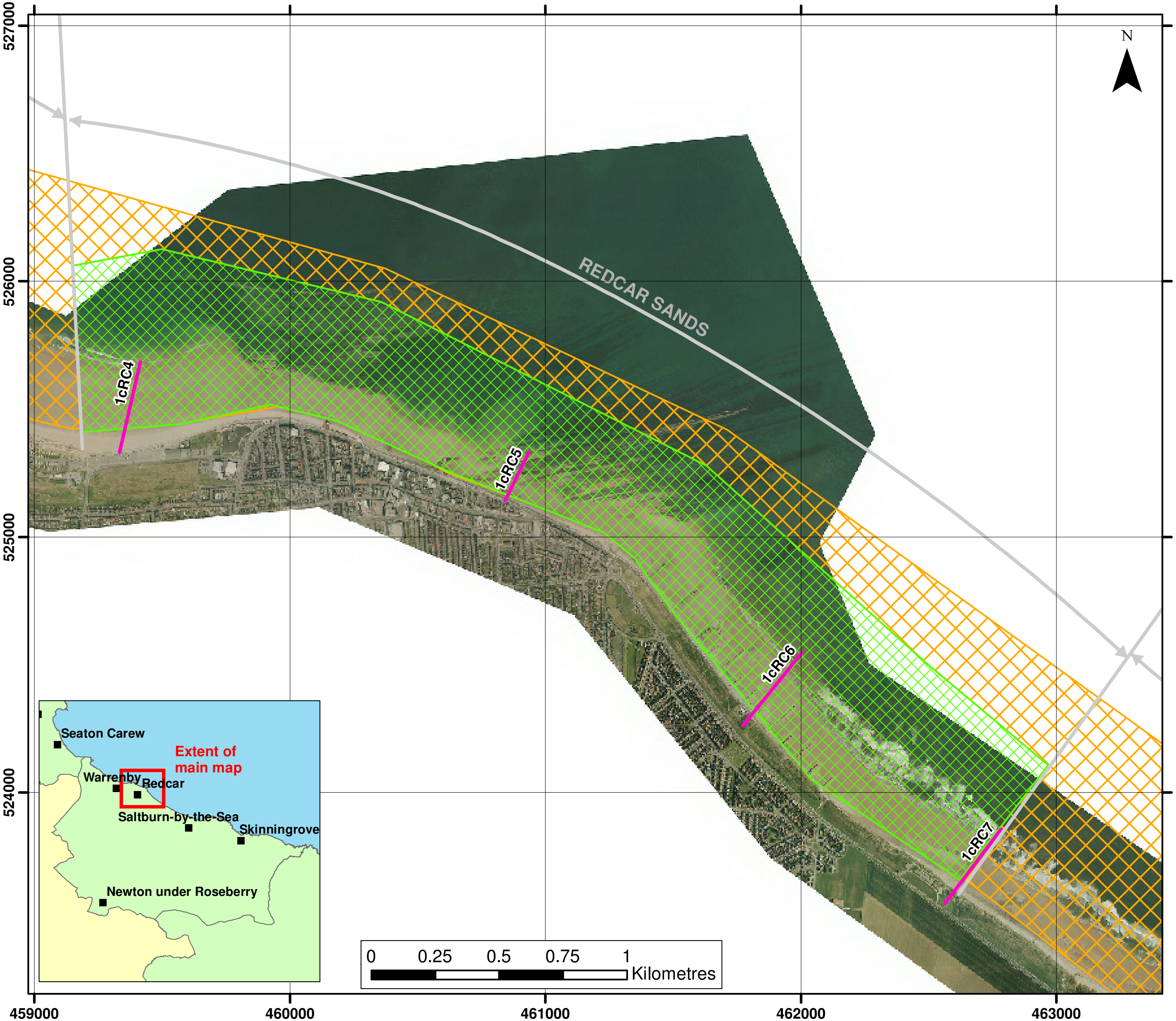
Analytical Report 7
Full Measures Survey
Autumn 2014

CH2MHILL
Halcrow

Halcrow Group Ltd, Lyndon House, 62 Hagley Road, Edgbaston, Birmingham, B16 8PE

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



KEY

Topographic Profiles
- Annual
- 6 monthly

Topographic Surveys
- 6 monthly
- yearly
- 5 yearly

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

(Indicative survey extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Figure 2 - Map 2
Survey Locations
Redcar Sands
Redcar & Cleveland
Borough Council

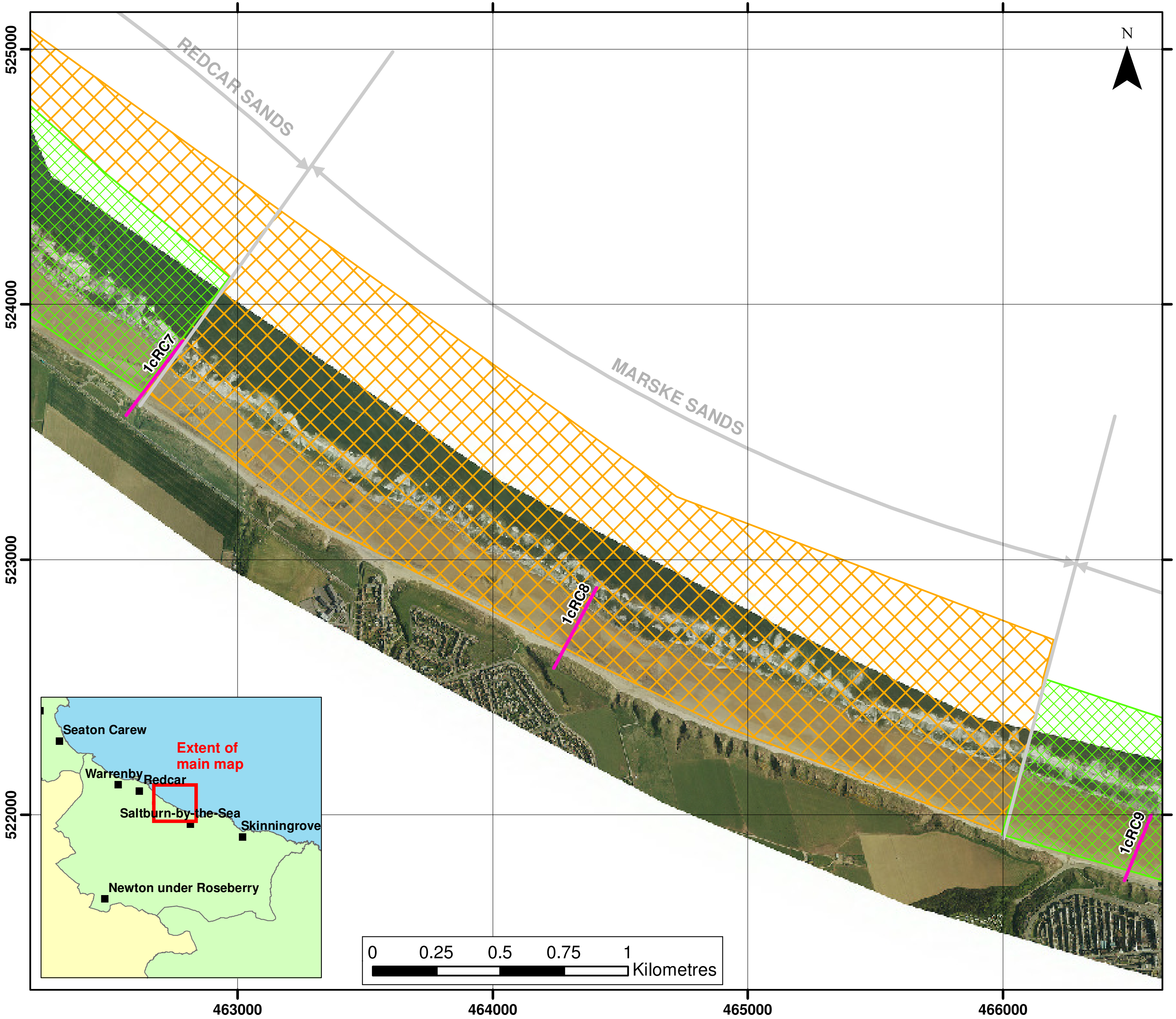
Analytical Report 7
Full Measures Survey
Autumn 2014

CH2MHILL
Halcrow

Halcrow Group Ltd, Lyndon House, 62 Hagley Road, Edgbaston, Birmingham, B16 8PE

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



KEY

Topographic Profiles

- Annual
- 6 monthly

Topographic Surveys

- 6 monthly
- yearly
- 5 yearly

Cliff Top Monitoring Pegs

- 50m centres
- 100m centres
- 300m centres

(Indicative survey extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Figure 2 - Map 3
Survey Locations
Marske Sands
Redcar & Cleveland Borough Council

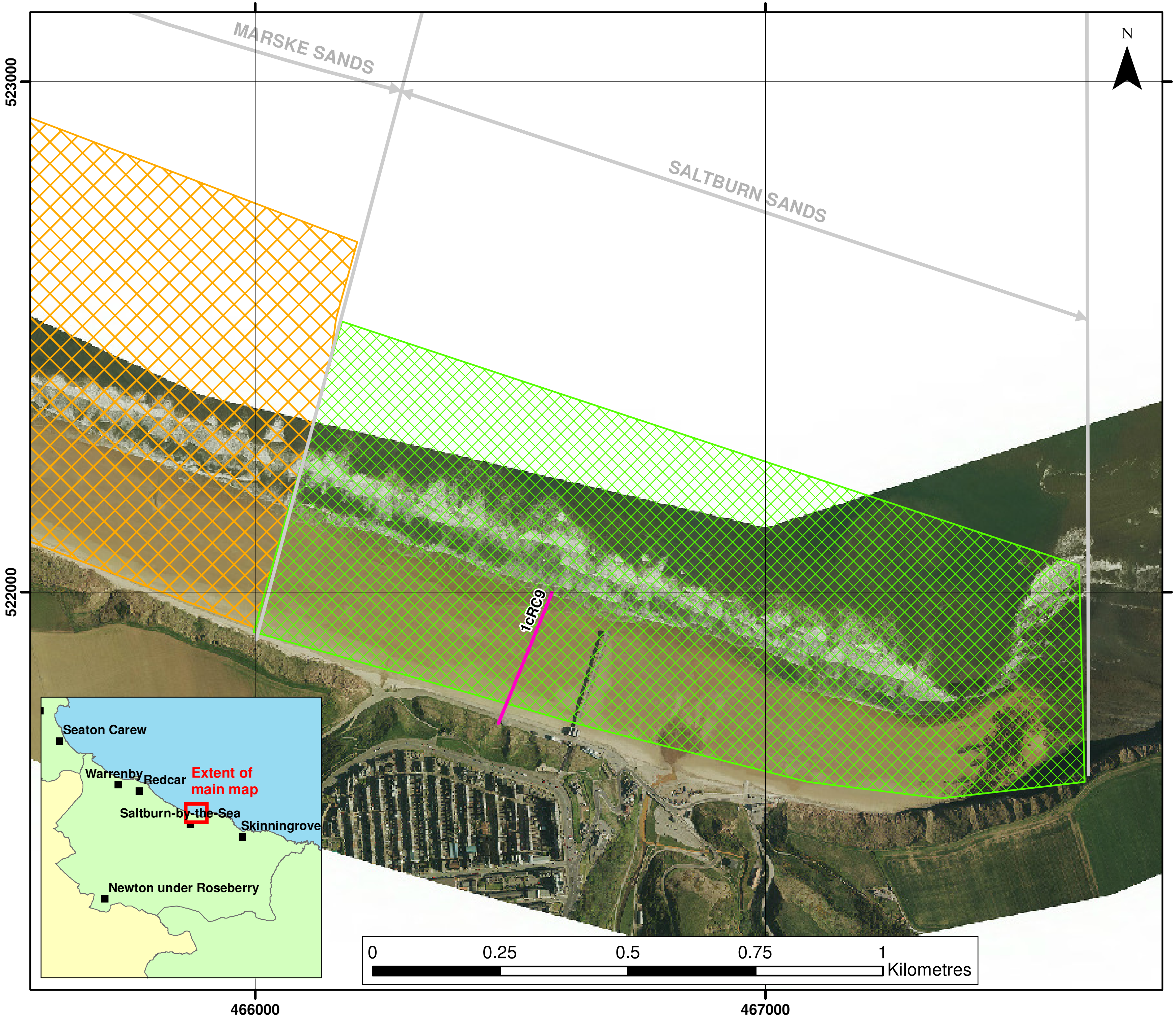
Analytical Report 7
Full Measures Survey
Autumn 2014

CH2MHILL
Halcrow

Halcrow Group Ltd, Lyndon House, 62 Hagley Road, Edgbaston, Birmingham, B16 8PE

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



KEY

Topographic Profiles

- Annual
- 6 monthly

Topographic Surveys

- 6 monthly
- yearly
- 5 yearly

Cliff Top Monitoring Pegs

- 50m centres
- 100m centres
- 300m centres

(Indicative survey extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Figure 2- Map 4
Survey Locations
Saltburn Sands
Redcar & Cleveland Borough Council

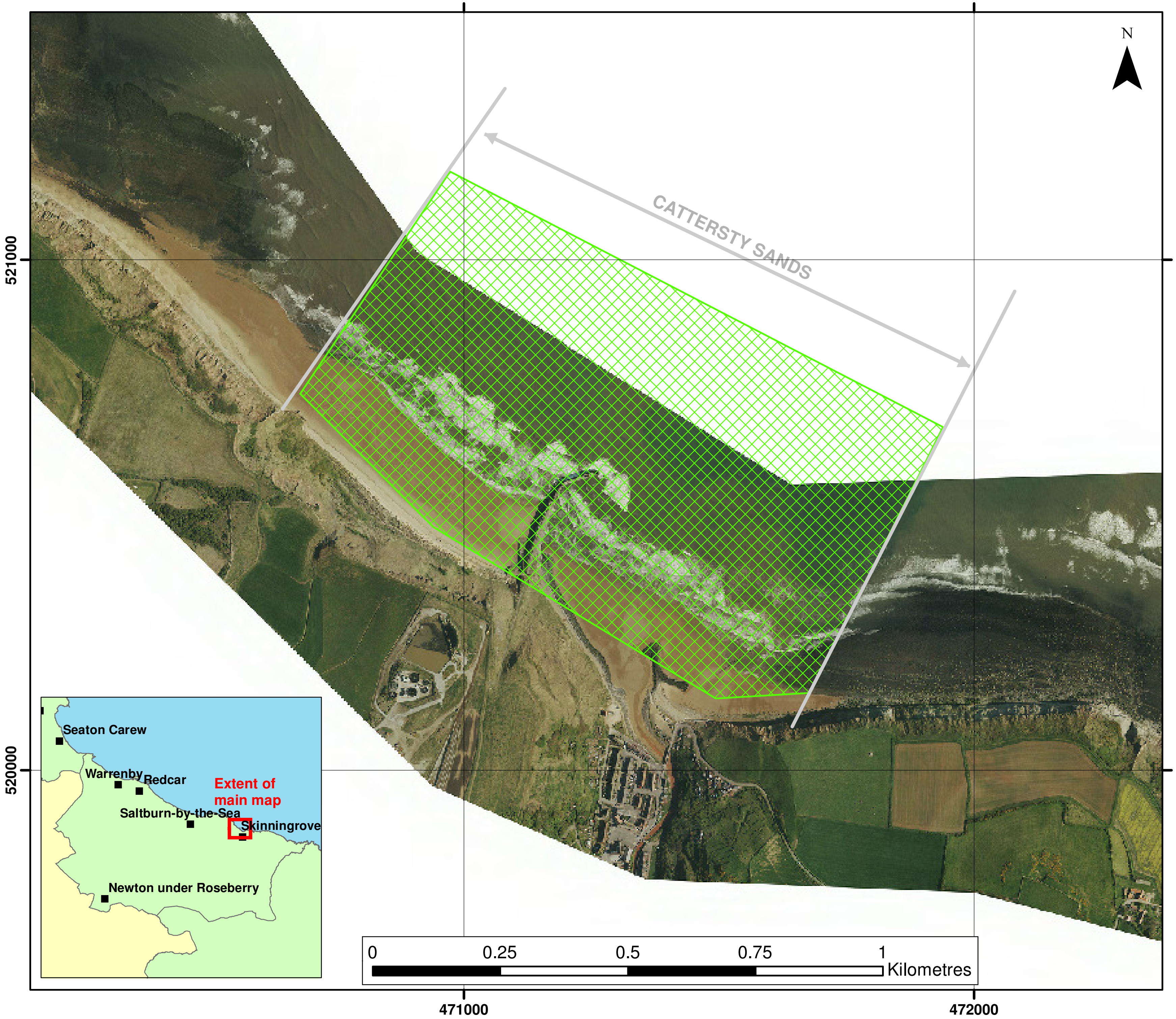
Analytical Report 7
Full Measures Survey
Autumn 2014

CH2MHILL.
Halcrow

Halcrow Group Ltd, Lyndon House, 62 Hagley Road, Edgbaston, Birmingham, B16 8PE

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



KEY

Topographic Profiles
- Annual
- 6 monthly

Topographic Surveys
- 6 monthly
- yearly
- 5 yearly

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

(Indicative survey extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Figure 2 - Map 5
Survey Locations
Cattersty Sands
Redcar & Cleveland
Borough Council

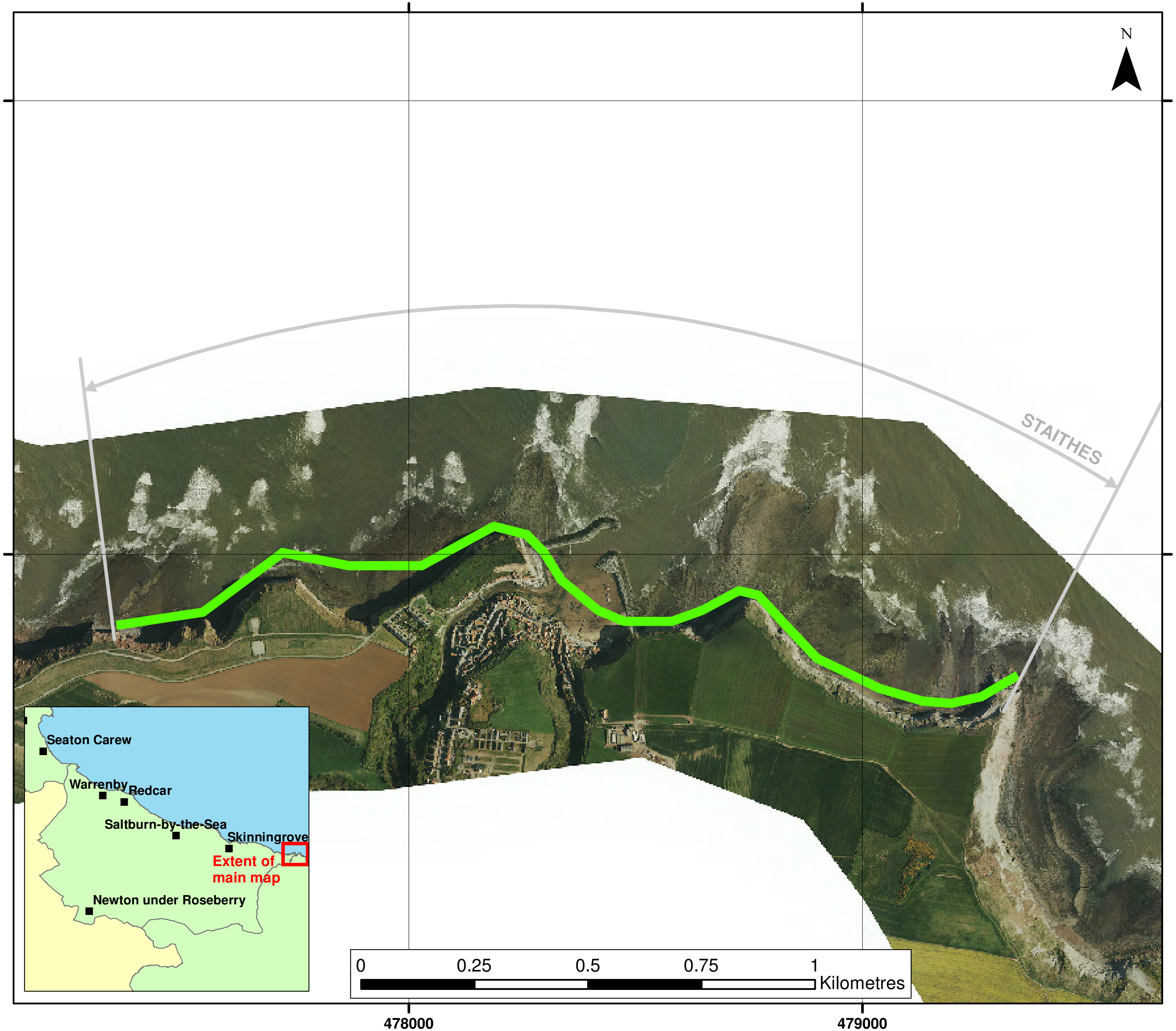
Analytical Report 7
Full Measures Survey
Autumn 2014

CH2MHILL.
Halcrow

Halcrow Group Ltd, Lyndon House, 62 Hagley Road, Edgbaston, Birmingham, B16 8PE

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



KEY

Topographic Profiles
- Annual
- 6 monthly

Topographic Surveys
- 6 monthly
- yearly
- 5 yearly

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

(Indicative survey extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Figure 2 - Map 6
Survey Locations
Staithes
Redcar & Cleveland
Borough Council

Analytical Report 7
Full Measures Survey
Autumn 2014

CH2MHILL
Halcrow

Halcrow Group Ltd, Lyndon House, 62 Hagley Road, Edgbaston, Birmingham, B16 8PE

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

3. Analysis of Survey Data

3.1 Coatham Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
7^{th} – 10^{th} Oct 2014	**Beach Profiles:** Coatham Sands is covered by four beach profile lines during the Full Measures survey (RC1 to RC4; Appendix A). Profile **1cRC1** is located approximately 300m south of the South Gare breakwater, in the lee of the German Charlies slag banks. The upper profile is dominated by dune ridges, which have remained stable since the 2009 surveys. No change has occurred in the profile as far as MHWS since April 2014. Between MHWS and 190m chainage the beach has accreted by up to 0.6m. Between 190m chainage and the end of the survey at c.350m chainage, there has been erosion of up to 0.9m as a berm previously present in the lower intertidal zone has been eroded. Overall, the beach is in the upper part of the range of beach levels seen over time. At Profile **1cRC2** the beach and dunes continue to be high compared to the profiles recorded since 2008. The dune profile has changed little since April 2014 and limited accretion has occurred in the upper beach as far as 260m chainage. A significant depression between 260m and 380m chainage has been infilled with up to 0.9m of sand to give the beach a smoother profile. The beach is at its highest level since monitoring began. Profile **1cRC3** shows a reasonably stable dune area as far as 50m chainage. However, between October 2013 and April 2014, the dune front retreated by around 8m The dune front position has not changed between April 2014 and October 2014. Limited accretion (up to 0.5m) has taken place throughout most of the profile between HAT and MLWS since April 2013, but the beach remains at nearly its lowest level since 2008. Profile **1cRC4** is the beginning of the defended section at Redcar. The principal change since April 2014 has been smoothing of the profile with loss of the previously seen bars and troughs. This profile is near	Profile 1cRC1 and 1RC2 have experienced accretion in the upper beach with some erosion in the lower intertidal zone, indicating a seasonal pattern of sediment being driven onshore over the summer. These profiles remain close to the highest levels seen. In contrast, Profile 1cRC3 is near its lowest level suggesting there is some northwards transfer of sediment within the bay. There has been no recovery of the dune front in the southern part of the bay since erosion in the December 2013 storm surge. This seasonal pattern is reflected in the topographic change plot, which shows transfer of sediment to the back of the beach in the north, and transfer of sediment towards MLW in the south of the frontage. **Longer term trends**: The severity of erosion and accretion in 2014 is more modest than that seen in the past. The upper beach in the southern part of the frontage has shown consistent erosion. **Autumn 2008 to Autumn 2014 trends** The long term plots shows that in the north of the bay the foreshore has accreted by up to 2m and a small bay has formed.

<table>
<tr><th>Survey Date</th><th>Description of Changes Since Last Survey</th><th>Interpretation</th></tr>
<tr><td rowspan="2"></td><td>its highest position since records began in 2008 range of beach levels recorded.</td><td rowspan="2">The centre of the bay has a uniform pattern of accretion by 0.5m. The southern third of the bay has a uniform pattern of erosion of around 0.5m. This pattern suggests a net movement of sediment in the bay towards the north.</td></tr>
<tr><td>Topographic Survey:

Coatham Sands is covered by an annual topographic survey extending from the South Gare Breakwater, although the survey is contiguous with the 6-monthly Redcar Sands survey. Data have been used to create a DGM (Appendix B – Map 1a) using GIS. This shows that the beach contours recorded in Autumn 2014 were relatively shore parallel along the frontage, with a gently shelving beach slope. The beach is narrower and steeper to the north west of the subtle promontory around 1km SE of the breakwater and of shallower gradient further south-east.

The GIS has also been used to calculate the differences between the current topographic (Autumn 2014) survey and the earlier topographic survey (Autumn 2012), as shown in Appendix B – Map 1b, to identify areas of erosion and accretion.

The topographic difference plot shows widespread accretion, with limited erosion. The most extensive areas of erosion are a series of shore-parallel strips in the north of the study area and an elongate area which extends from the back of the beach towards the foreshore in the south of the survey area. Change is ±1m.

Long Term Topographic Trends Autumn 2008 to Autumn 2014:

The long term difference plot (Appendix B – Map 1c) shows three distinct areas of behaviour. The most pronounced change has occurred in the northwest, where the small embayment close to the South Gare Breakwater has experienced erosion of up to 1m on the upper beach and shoreline and up to 2m of accretion further seaward. The central part of the bay shows accretion by up to 1m. The southern third has eroded by up to 0.5m in most areas, but up to 1m loss was recorded locally near MLW.</td></tr>
</table>

3.2 Redcar Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
7th - 10th Oct 2014	**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. At profile **1cRC5** the beach has accreted by up to 0.4m between the base of the sea defences and 115m chainage since April 2014. Between 115m chainage and 170m chainage, the foreshore rock platform is exposed. A further 10m of shore platform has been exposed as far as 180m chainage by erosion of sand which has also reduced the level of the sandy foreshore between this point and the end of the survey at 230m chainage by 0.5m. The upper beach is relatively high but the lower beach is near its lowest level compared to earlier surveys. At profile **1cRC6** there has been minor erosion of the accumulated gravel above HAT. Between 70m chainage and the end of the survey the beach has accreted (up to 1.2m in the lower intertidal zone where previously there was a trough), bringing the beach to its highest recorded level. The beach profile is slightly concave. Profile **1cRC7** has experienced no change above HAT since April 2014, when substantial recession of the low cliff was indicated by that survey. Further erosion of 0.3m has taken place between HAT and 110m chainage. However, throughout the rest of the profile the beach has accreted and is now at a similar level to that seen in October 2013. Beach levels above HAT are at their lowest levels since monitoring began but the lower beach is near its highest. **Topographic Survey:** Redcar Sands is covered by a six-monthly topographic survey. Data have been used to create a DGM (Appendix B – Map 2a) using GIS. The plot shows shore-parallel contours for most of the frontage with the exception of the beach in front of Redcar, where a bay is shown between the Redcar Rocks and West Scar. The most landward part of this embayment is close to Redcar Esplanade, which is fronted by a steep beach. The coastal defence scheme here was constructed between the October 2012 and	The more northern profiles show relatively high upper beaches over the last 6 months, likely to relate to surging waves pushing sediment up the beach throughout the summer. A contrasting pattern is seen in the southern profile, which is an undefended frontage, and which is still showing evidence of the erosion caused by the December 2013 storm surge, particularly above HAT. The topographic change plot reflects this pattern and shows a movement of sediment from the seaward edge of the survey area and the uppermost part of the beach which has subsequently been concentrated in the middle part of the beach. **Longer term trends**: The construction of a new defence was completed in 2012. The overall observed pattern since then has been a variable and uneven distribution of erosion and accretion, which is likely to be due to the redistribution of sediment across the beach. **Autumn 2008 to Autumn 2014 trends** The plot of long term net change between Autumn 2008 and Autumn 2014 shows a near-consistent pattern of accretion, with erosion associated with the thin sediment cover over the rocky foreshore of Redcar Rocks and West Scar. The most substantial accretion south-east of the new defences may relate

Survey Date	Description of Changes Since Last Survey	Interpretation
	March 2013 surveys. The GIS has also been used to calculate the differences between the current topographic survey (Autumn 2014) and the most recent (Spring 2014) topographic survey, as shown in Appendix B – Map 2b, to identify areas of erosion and accretion. Over the summer of 2014 erosion of up to c.1m occurred near MLW, while the central part of the beach and near MHW accreted by up to 0.75m. There are also intermittent shore-parallel strips of erosion at the back of the beach throughout much of the survey area. **Long Term Topographic Trends Autumn 2008 to Autumn 2014:** The plot of changes between Autumn 2008 and Autumn 2014 (Appendix B Map 2c) shows three distinct zones of change. In the west, the NNW-facing section of beach has experienced near-uniform accretion of up to 0.5m. The central section, which faces NNE, is characterised by a thin beach covering a rocky foreshore that shows a complex pattern of accretion and erosion. The eastern section that faces NE is dominated by accretion of c. 0.5m, with a thin but continuous strip of erosion at the back of the beach / toe of cliffs.	to the defence improvements introducing a less reflective seawall and improvements and repairs to the groynes in this area, which limit north-westwards drift.

3.3 Marske Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
7th – 10th Oct 2014	**Beach Profiles:** 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. Profile **1cRC7** is located along The Stray and has been discussed in Section 3.2. Profile **1cRC8** experienced significant erosion at the cliff toe between October 2013 and April 2014, but there has been very little further change above HAT since April 2014. A berm which had developed between HAT and MHWS has been eroded to smoothen the overall profile of the upper beach. Between 100m and 260m chainage there has been accretion of up to 1m that has smoothed the middle to upper foreshore profile. Seaward of 260m chainage there has been erosion of up to 0.5m. With the exception of the cliff toe, the beach is at relatively high compared to previous surveys. **Topographic Survey:** Marske Sands is covered by an annual topographic survey. This survey is contiguous with the Redcar Sands and Saltburn Sands topographic surveys that are both surveyed six-monthly. Data have been used to create a DGM (Appendix B – Map 3a) using GIS. The GIS has also been used to calculate the differences between the Autumn 2013 and Autumn 2014 topographic survey, as shown in Appendix B – Map 3b. The topographic contours are generally shore parallel except where the outfalls of small, culverted streams issue in front of the Marske itself. Since the previous topographic survey in Autumn 2014, erosion and accretion of up to c.1m has taken place in discontinuous elongate strips along the frontage with change of up to 1m. **Long Term Topographic Trends Autumn 2008 to Autumn 2014:** The changes observed over the five years shown in Appendix B – Map 3c shows a very different pattern to that seen over the past 12 months. The back of the beach has been eroded across the frontage by less than 0.5m, but the main part of the beach shows net accretion of 0.5 to 1m in the west, a complex pattern of erosion and accretion in the central part and uniform erosion of c. 0.5m in the east.	The erosive impact of the December 2013 storm surge is still evident at the cliff toe in the profiles above HAT, but the general pattern is of accretion. The difference plot for Autumn 2013 to Autumn 2014 shows erosion on the upper beach and primarily deposition in the mid-lower beach, although there is evidence for migration of sand bars **Longer term trends:** In 2013 the difference plot showed widespread erosion, except at the back of the beach where accretion was dominatant. This pattern was reversed in 2014. **Autumn 2008 to Autumn 2014 trends:** The long term difference plot shows a different pattern to that indicated over the last 12 months. Except in the south-easternmost part of the survey area adjoining Saltburn Sands (and to a lesser extent the foreshore in front of Marske itself) the dominant pattern is one of accretion, which suggests a continued trend of net movement of material towards the northwest The middle to high level of the beach in profile 1cRC8 (except at the cliff toe) further supports this general trend of accretion.

3.4 Saltburn Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
7th – 10th Oct 2014	**Beach Profiles:** Saltburn Sands is covered by one beach profile during the Full Measures survey (RC9; Appendix A). Profile **1cRC9** was stable where there are sea defences between 0m and 30m chainage over the summer of 2014. The rest of the profile had accreted by up to 0.2m along most of its length. This is a change from previous surveys where the trend has more been more one of erosion. However, the beach continues to remain at a low level compared to earlier surveys. **Topographic Survey:** Saltburn Sands is covered by a six-monthly topographic survey, although the survey is contiguous with the Marske Sands topographic survey that is surveyed annually. Data have been used to create a DGM (Appendix B – Map 4a) using a GIS software package. This shows that the beach contours are shore parallel and gently shelving for the majority of the frontage. The contours are slightly indented opposite Skelton Beck, where the stream has eroded the foreshore. The GIS has also been used to calculate the differences over the six month period between spring 2014 and Autumn 2014 topographic survey, as shown in Appendix B – Map 4b, to identify areas of net erosion and accretion. During the six months covered by the plot there was a small amount of erosion along the upper beach and in small areas of the east and western margins of the beach. The majority of the beach shows accretion of c. 0.5m. This is in contrast to the previous survey where there was widespread erosion. **Long Term Topographic Trends Autumn 2008 to Autumn 2014:** The plot of the change over the last six years (Appendix B – Map 4c) shows a different pattern to that shown in the last six months, with erosion of 0.5 to 1m across the majority of the beach west of Skelton Beck and accretion c. 0.5m in the smaller area east of the beck. Despite the widespread erosion in the west, the back of the beach generally shows accretion	The beach has accreted at profile 1cRC9 between April and October 2014. However the October 2014 beach level was still one of the lowest recorded profile since 2008. The difference plot for 2014 shows net erosion on the upper beach and for the most part accretion elsewhere, which differs from previous trends. **Longer term trends**: Previous comparisons of six month periods have also shown an alternating pattern of erosion and accretion. **Autumn 2008 to Autumn 2014 trends** The frontage has eroded west of Skelton Beck and accreted to the east, at the margins of the bay. The behaviour to the west of the beck is similar to the rest of the Marske/Redcar beach system that has experienced net loss of sediment. This pattern may indicate net movement of sediment to the north, in the area west of the beck, and accumulation of material at the margin of the bay due to the effects of wave refraction. The long-term data also indicate most cliff erosion in the eastern area, which may have contributed to accumulation of sediment on the adjacent beach. Surveyors also noted evidence of ‘large rock falls’ here during the Autumn 2014 survey.

3.5 Cattersty Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
8th Sep 2014	**Topographic Survey:** Cattersty Sands is covered by a six-monthly topographic survey. Data have been used to create a DGM (Appendix B – Map 5a) using a GIS package. The beach is steeper to the west of the breakwater than the east, but in both areas the gradient is relatively smooth. East of the breakwater the beach is punctuated by Kilton Beck and the harbour so the gradient is shallower. Immediately east of the three-armed revetment, the stream has cut a channel, which is most deeply incised at its landward extent. The GIS has also been used to calculate the differences between Spring 2014 and Autumn 2014 topographic surveys and is presented as DGM (as shown in Appendix B – Map 5b), to identify areas of net erosion and accretion. The difference plot shows that west of the breakwater there are shore-parallel strips of erosion and accretion. East of the breakwater the distribution of change is more complex, with erosion of up to c.0.75m dominating the area, accretion of up to 1.25m dominating the central area and a mixture of erosion and deposition in the furthest east parts of the survey area. The clear pattern of different changes on either side of the breakwater has also been seen in past surveys. **Long Term Topographic Trends Autumn 2008 to Autumn 2014:** The Autumn 2008 to Autumn 2014 plot (Appendix B – Map 5c) of elevation difference shows a different pattern of change to that seen over the past year. West of the breakwater, erosion is prevalent at the back of the beach where lowering >1m has occurred in places, but the lower beach and foreshore have accreted. East of the breakwater accretion is proportionally more widespread, although a narrow strip of erosion surrounds the boat storage area (defended by rock armour) adjacent to Kilton Beck.	The difference model shows Cattersty Sands to be a dynamic area, influenced by both coastal and fluvial processes and the breakwater. In the plot of 6 monthly change there is a marked difference in beach behaviour on either side of the breakwater. The east side showed erosion immediately east of the breakwater and more mixed erosion and accretion further east, indicating a redistribution of sediment within this area. West of the breakwater there were shore parallel strips of erosion and accretion indicating bar migration. **Longer term trends**: The change plots from the 2013 Full Measures Survey and the 2014 Partial Measures survey show accretion immediately east of the breakwater and erosion further east in the survey area. This pattern appears to have been reversed over the summer of 2014 as sediment is redistributed in this area. **Autumn 2008 to Autumn 2014 trends** The difference plot for previous six years clearly highlights the differences on either side of the breakwater, with the west side showing erosion at the back of the beach and the base of the cliff (where over 1m of sediment has been eroded in some areas), and the east side showing much more widespread accretion.

3.6 Staithes

Survey Date	Description of Changes Since Last Survey	Interpretation
17th October 2014	**Cliff-top Survey:** Twenty ground control points have been established at Cowbar and Staithes for biannual cliff top monitoring. Locations 12 to 20 are in the Scarborough Borough Council area. The separation between any two points is around 100 m. Data collection involves a distance offset measurement from the ground control point to the cliff edge along a fixed bearing. Between April 2014 and October 2014 14 of the 20 posts showed change within a range of ±0.1m, which is not considered significant given the error of the technique. Posts 5 and 15, 16 and 20 showed the largest erosion with 0.3 to 0.4m cliff recession recorded. Calculation of longer-term erosion rates based on the recorded change between 2008 and 2014 indicates that seventeen posts on the frontage recorded a change rate within a range of ±0.1m/yr, which is considered to be within the error of the measurement. Post 13 (near the eastern breakwater) shows consistent erosion through the surveys at 0.4m/yr. This pattern was very similar to that observed in the 2013 Full Measures Report. Appendix C provides results from the October 2014 survey, showing the distance 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.	Up to 0.4m of cliff recession was recorded at four of the 20 monitoring points in the 6 months to October 2014. **Longer term trends**: Table C1 shows that survey location 13 has shown the greatest total erosion with a loss of 2.2m (±0.1m) between the November 2008 baseline and October 2014, resulting in a long term average recession rate of 0.4m/yr. This area is above the eastern breakwater and is known to have experienced rock falls previously. All other points are within the margin of error over the longer term.

4. Problems Encountered and Uncertainty in Analysis

Individual Surveys

A small area near an outfall at grid reference 462901, 523422 (Marske Sands) could not be accessed due to ongoing construction works.

Cliff Top Surveys

The cliff top surveys at Staithes are assumed to have a limit of accuracy of ± 0.1m due to the techniques used. At all survey locations the cliff edge was noted as ‘overgrown’, in such circumstances, precisely locating the cliff edge is more problematic. However, the presence of vegetation and lack of defined cliff edge indicates there has not been substantial recent recession.

5. Recommendations for ‘Fine-tuning’ the Monitoring Programme

The aim of cliff monitoring data is to gain a reliable record of the frequency and magnitude of cliff top failures. Data are collected every six months, but previous surveys have had a low accuracy, meaning that survey error is typically greater than any measured short term change. It is likely that a more reliable pattern of change will be determined over the longer term. In addition, cliff recession data are available from the analysis of aerial survey data collected in 2010 and 2012-13 that was undertaken in 2013.

6. Conclusions and Areas of Concern

- At Coatham Sands, the October 2014 profiles in the north of the survey area are near the top of the range of profiles seen over the monitoring period. However, the beach seaward of Warrenby (approximately between the Steelworks and Redcar Beach Caravan Park) is near its lowest and the dune front has not yet recovered from the erosion that occurred in December 2013.
- For Redcar Sands the beach levels near the rocky foreshore outcrops of West Scar and Redcar Rocks are relatively low, whereas the beaches either side are relatively high. The most accretion has occurred in the eastern part of the survey area and is likely due to the combined effects of an increased sediment supply from dune front erosion at Marske Sands, a north-westwards drift and the trapping effects of the groynes at Redcar.
- At Marske Sands the 2014 beach profiles still show the evidence of cliff toe erosion above HAT caused by the December 2013 storm surge. Both accretion and erosion show at Marske Sands relative to 2008 but accretion is slightly more dominant and potentially driven by the addition of sediment derived from the eroding cliff toe. The exception to this is the south eastern part of the survey area adjoining Saltburn Sands where the beach is lower than in 2008.
- The beach at Saltburn Sands has accreted between April and October 2014. However, with the exception of most easterly part of the survey area fronting the glacial till cliffs, the beach is still low compared to the overall record of beach levels since 2008.
- The Cattersty Sands difference model shows a reversal to previous surveys with accretion taking place where previously there had been erosion and vice versa. In the long term difference plot, the area west of the breakwater shows erosion at the back of the beach with accretion further seaward. East of the breakwater the trend is mostly one of accretion, although limited areas of erosion are visible, particularly at the back of the beach and along Kilton Beck where some scour has occurred since 2008.
- The measurements of the Cowbar and Staithes cliff top shows stability over the summer of 2014 and any minor recession is likely due to small rockfalls or is only *apparen*t recession due to difficulties in precisely locating the cliff edge. Considering the longer term, one point (to the east of the eastern breakwater) has eroded by 2.2m since November 2008, which is the maximum erosion observed for this frontage.

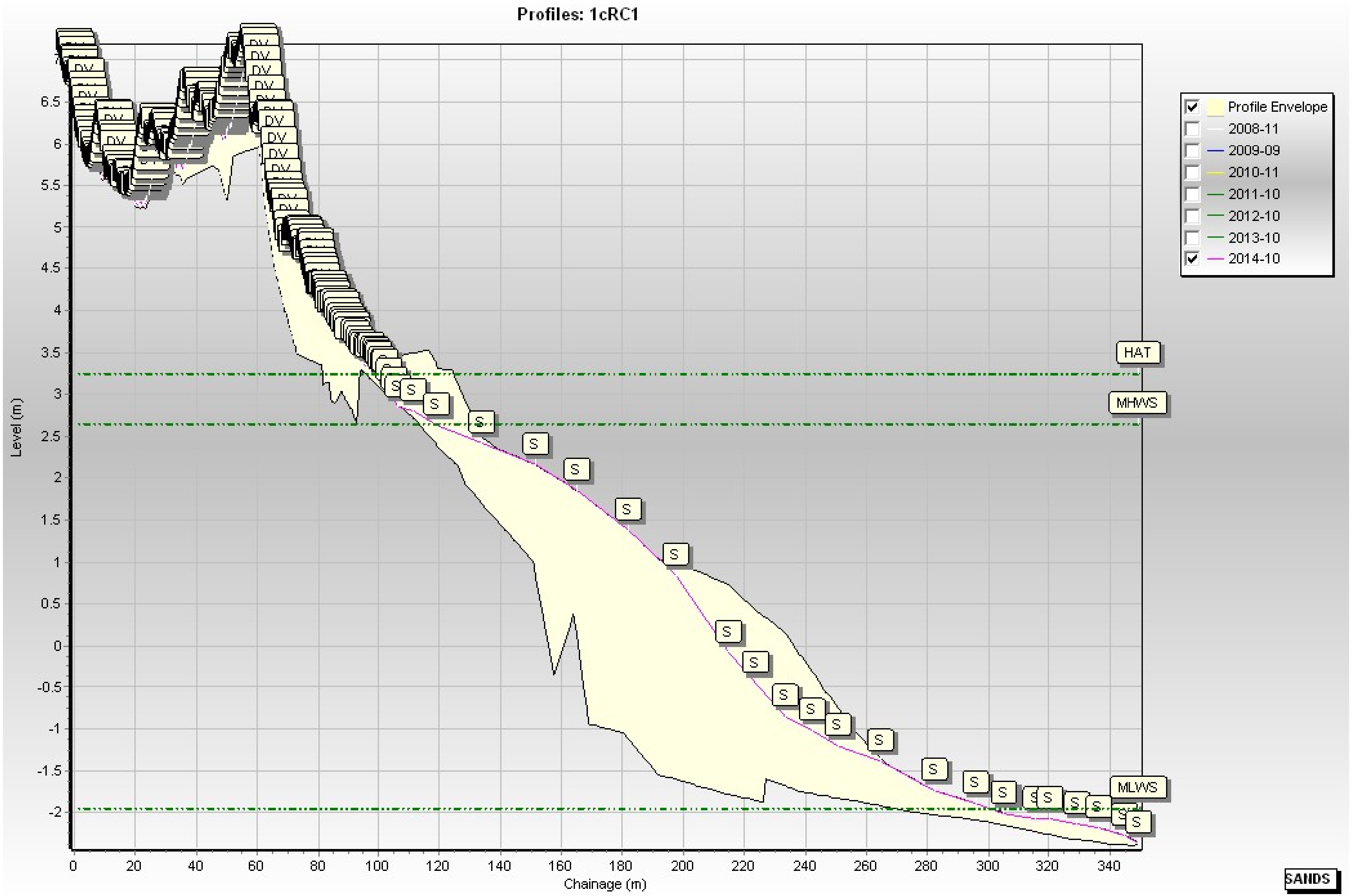
Appendices

Appendix A

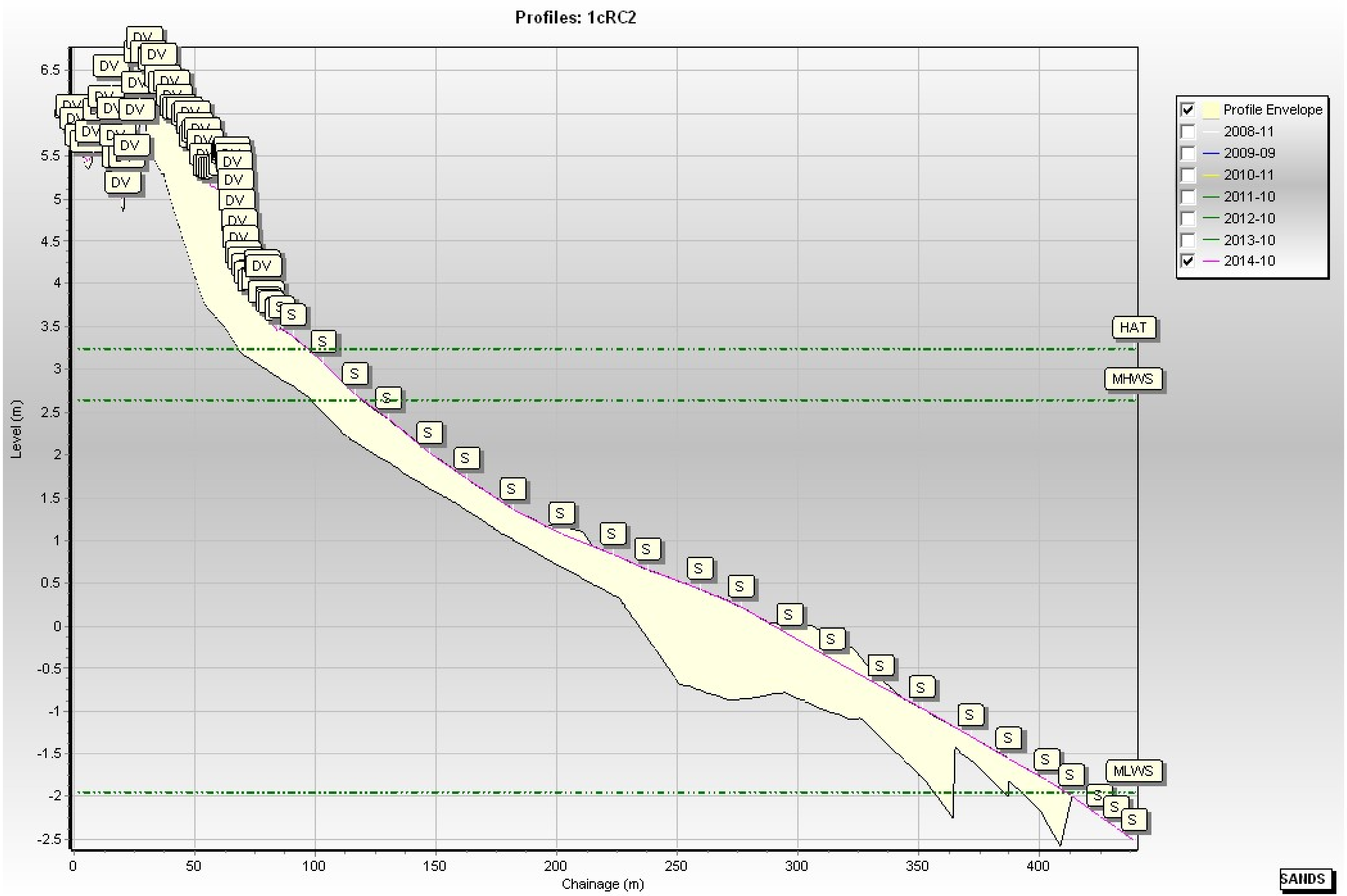
Beach Profiles

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

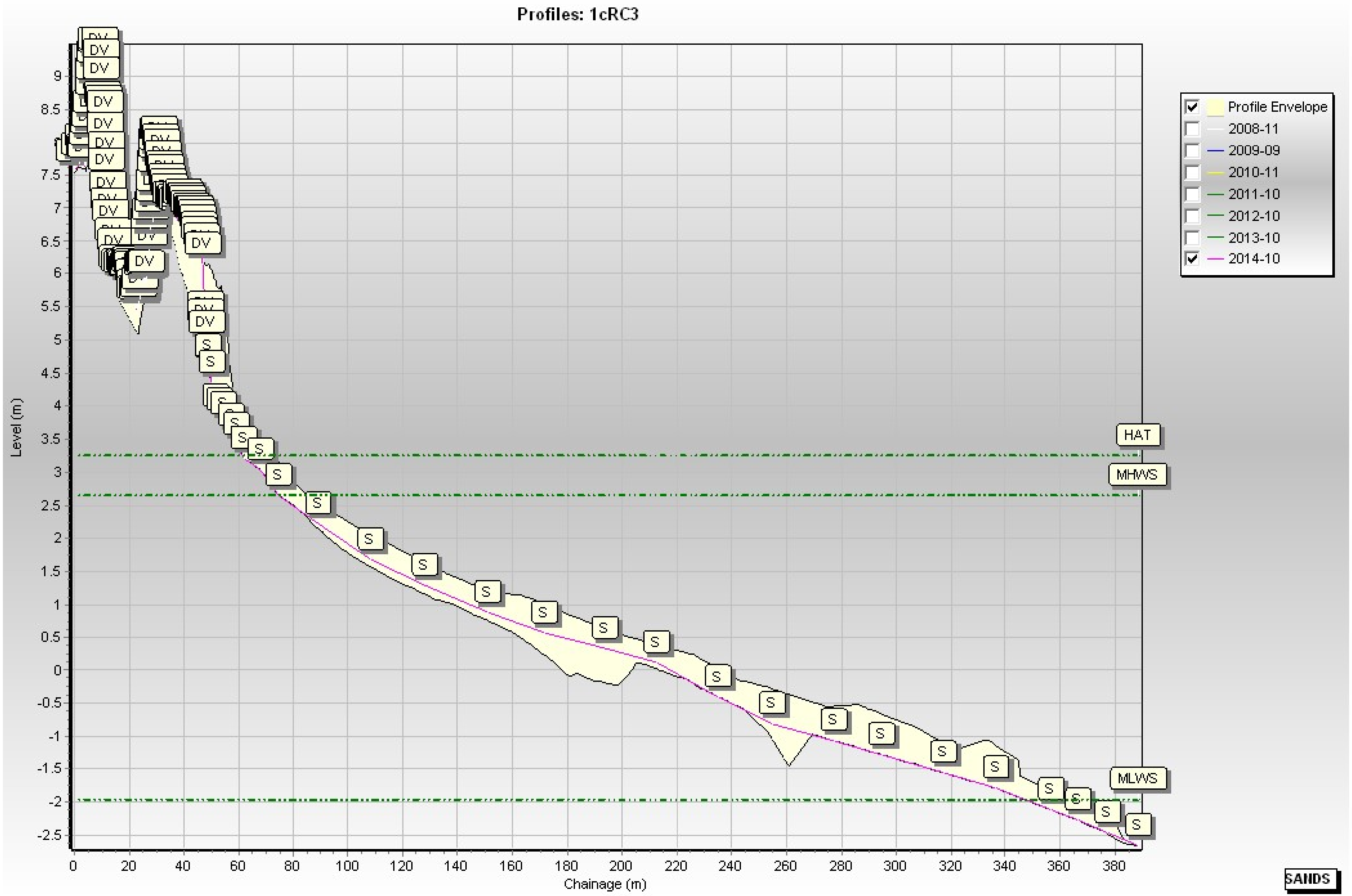
Code	Description
S	Sand
M	Mud
G	Gravel
GS	Gravel & Sand
MS	Mud & Sand
B	Boulders
R	Rock
SD	Sea Defence
SM	Saltmarsh
W	Water Body
GM	Gravel & Mud
GR	Grass
D	Dune (non-vegetated)
DV	Dune (vegetated)
F	Forested
X	Mixture
FB	Obstruction
CT	Cliff Top
CE	Cliff Edge
CF	Cliff Face
SH	Shell
ZZ	Unknown

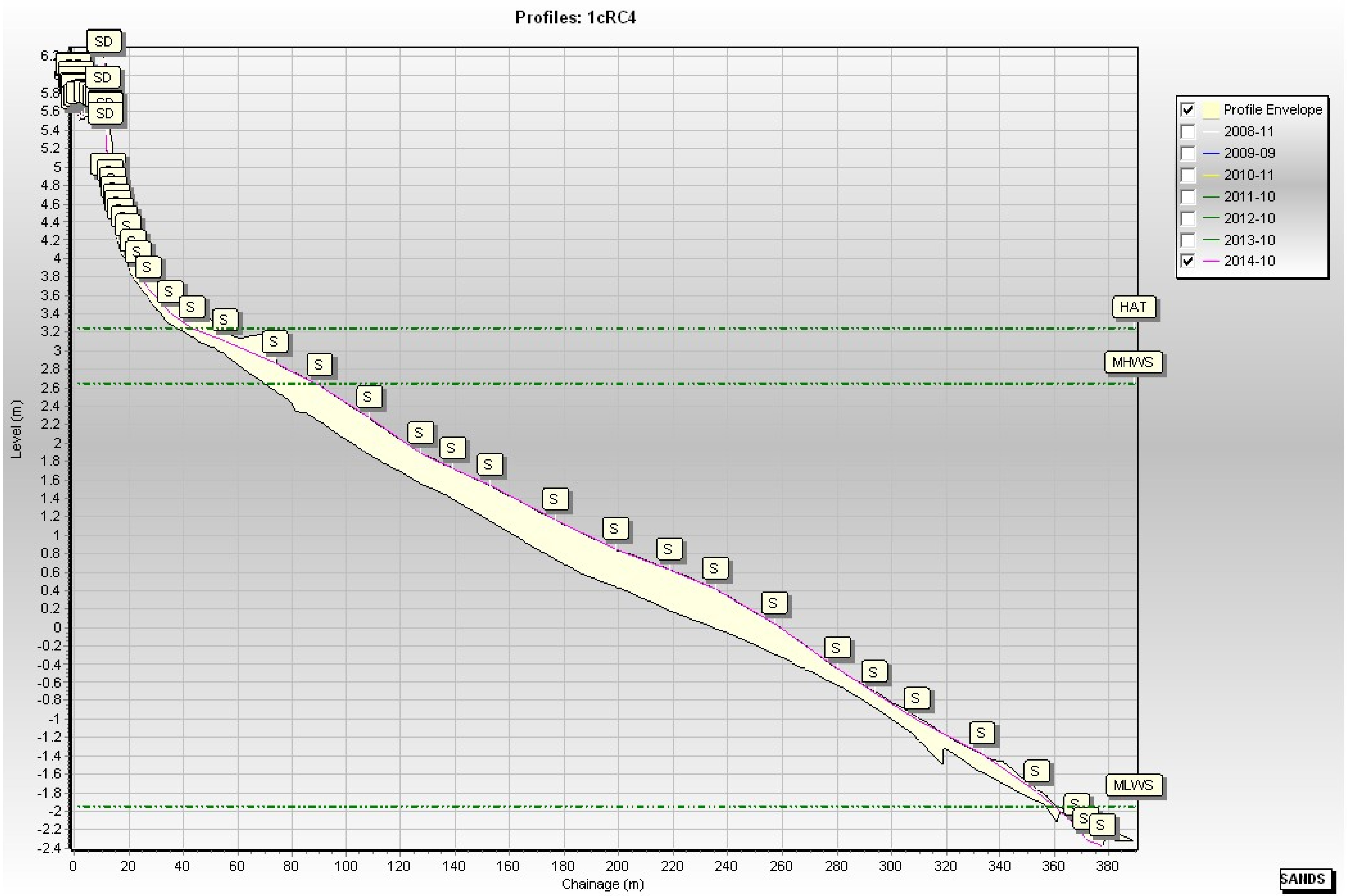


Profiles: 1cRC1
Profile Envelope
2008-11
2009-09
2010-11
2011-10
2012-10
2013-10
2014-10
HAT
MHWS
MLWS
Level (m)
Chainage (m)
SANDS

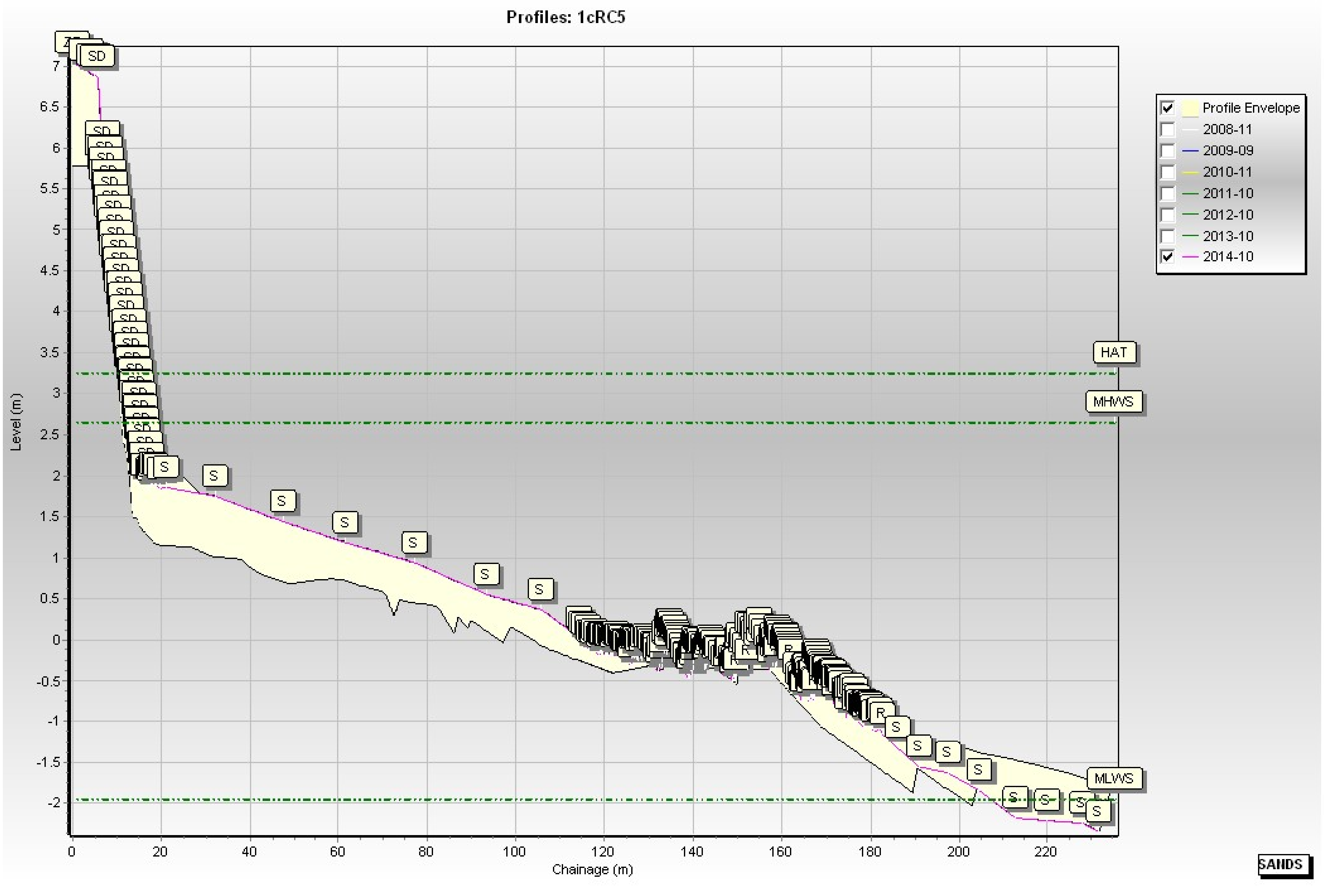


Profiles: 1cRC2
Profile Envelope
2008-11
2009-09
2010-11
2011-10
2012-10
2013-10
2014-10
HAT
MHWS
MLWS
Level (m)
Chainage (m)
SANDS

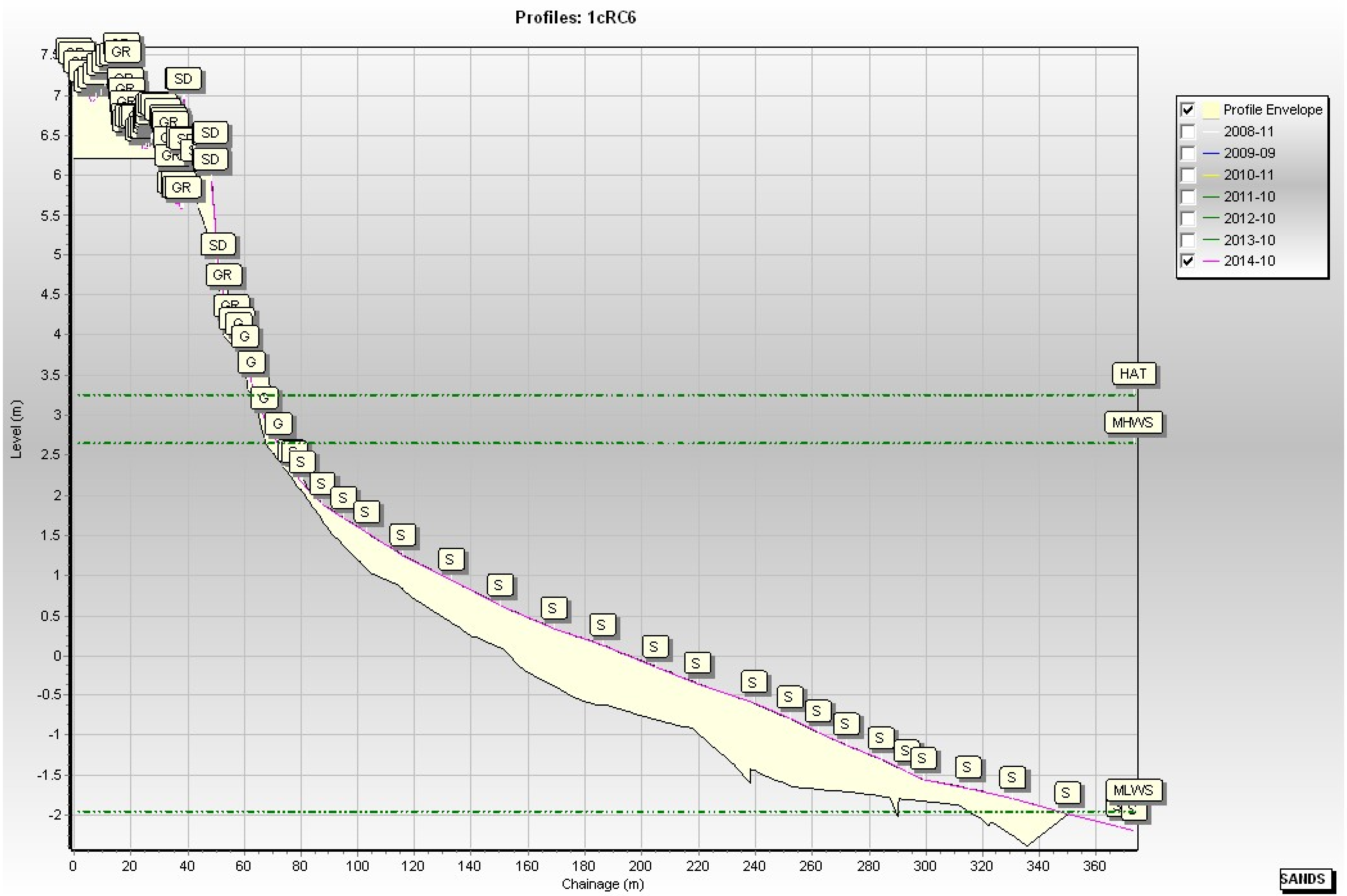

Profiles: 1cRC3
Level (m)
Chainage (m)
Profile Envelope
2008-11
2009-09
2010-11
2011-10
2012-10
2013-10
2014-10
HAT
MHWS
MLWS
DV
S
SANDS



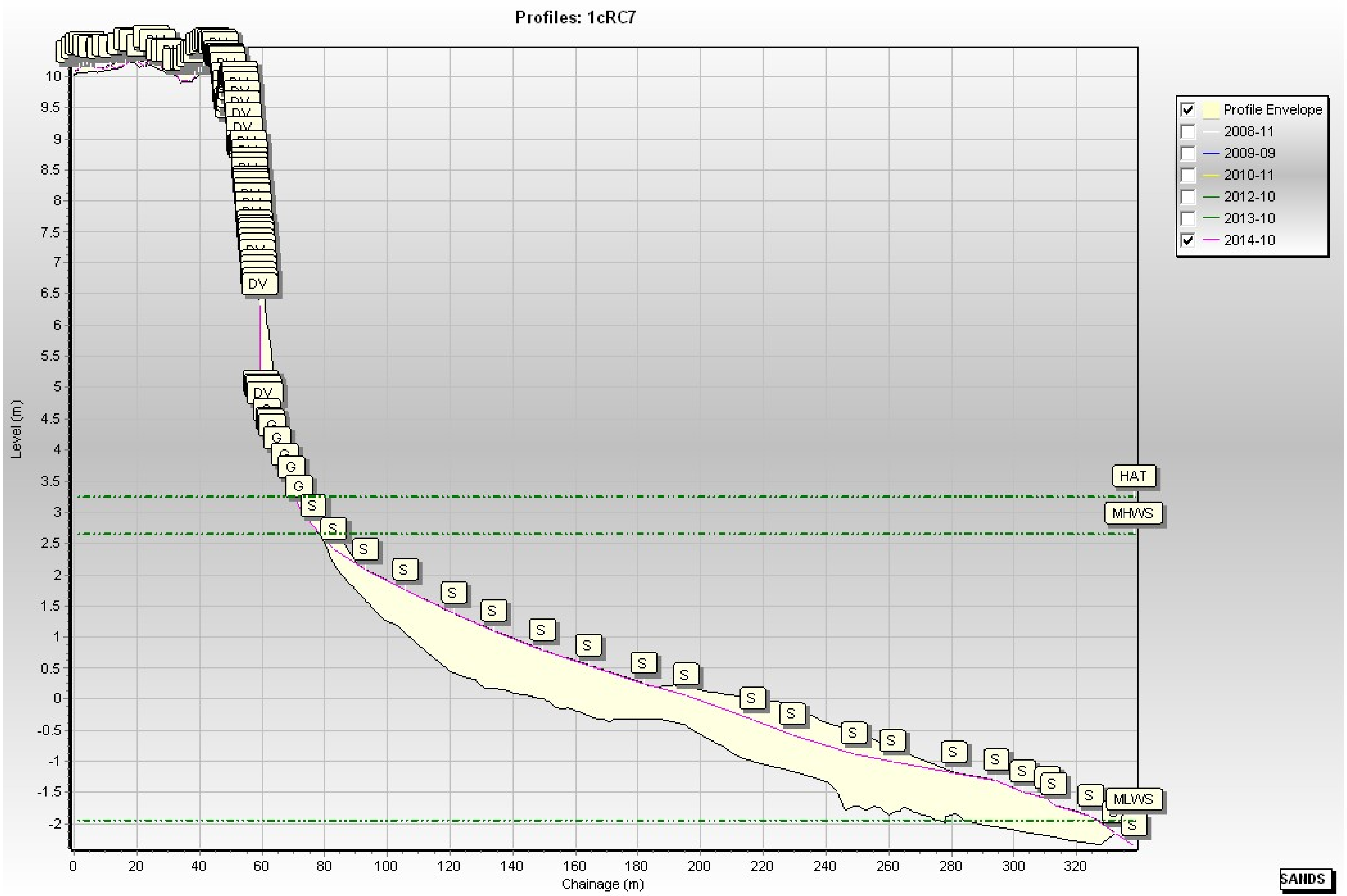
Profiles: 1cRC4
Level (m)
Chainage (m)
SD
S
HAT
MHWS
MLWS
Profile Envelope
2008-11
2009-09
2010-11
2011-10
2012-10
2013-10
2014-10
SANDS

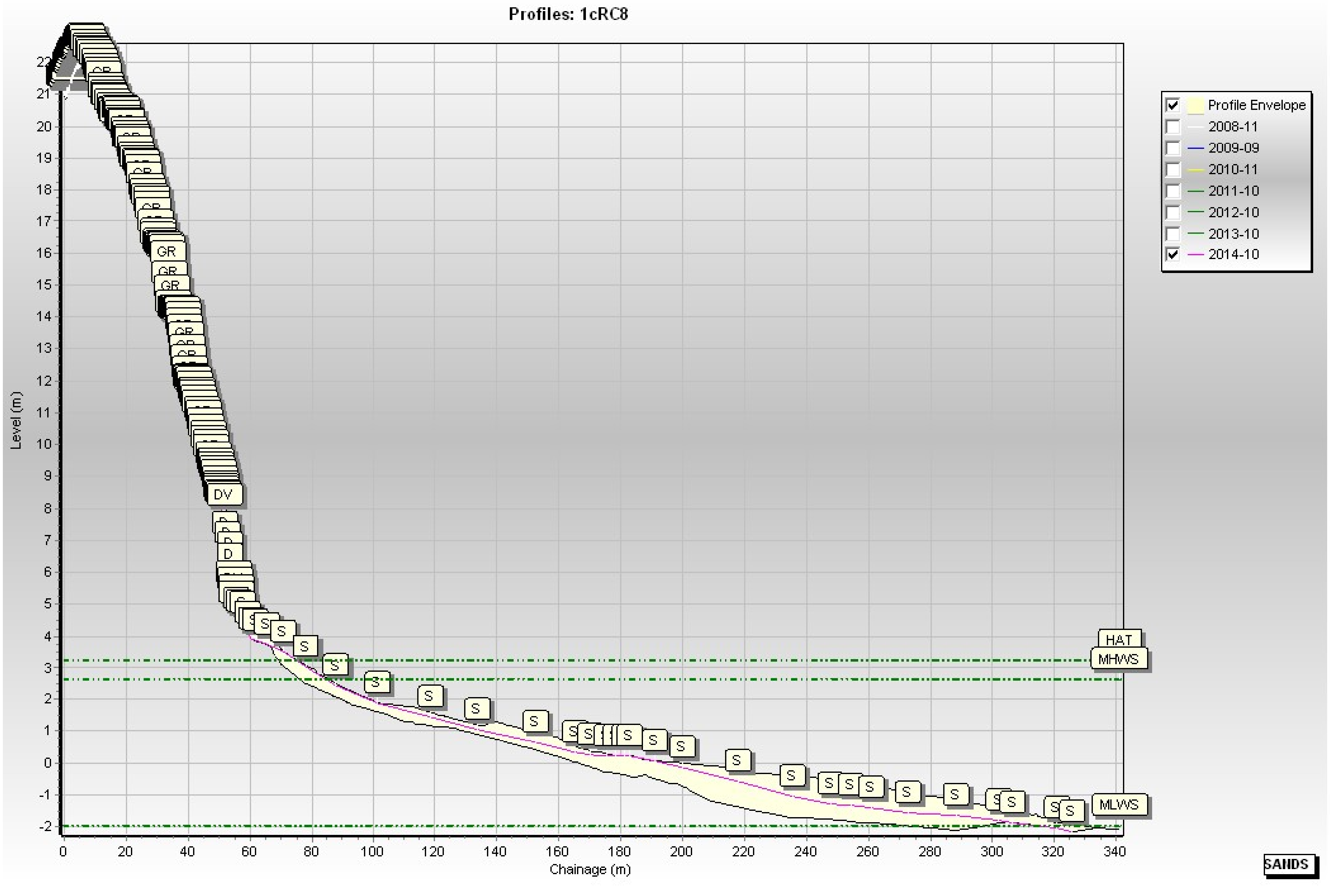


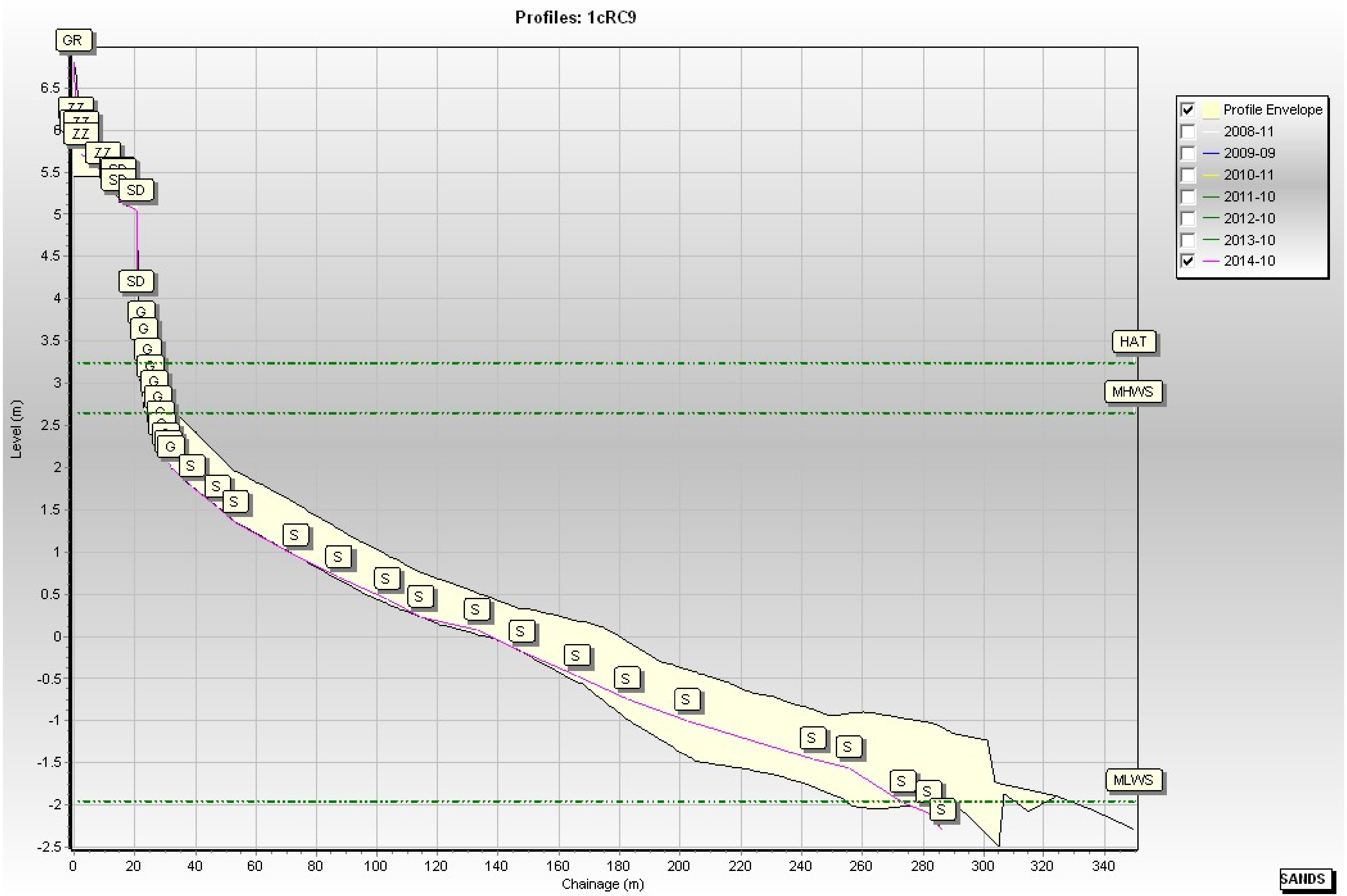
Profiles: 1cRC5
Level (m)
Chainage (m)
Profile Envelope
2008-11
2009-09
2010-11
2011-10
2012-10
2013-10
2014-10
HAT
MHWS
MLWS
SANDS



Profiles: 1cRC6
Level (m)
Chainage (m)
Profile Envelope
2008-11
2009-09
2010-11
2011-10
2012-10
2013-10
2014-10
HAT
MHWS
MLWS
SANDS


Profiles: 1cRC7
Level (m)
Chainage (m)
Profile Envelope
2008-11
2009-09
2010-11
2012-10
2013-10
2014-10
HAT
MHWS
MLWS
SANDS

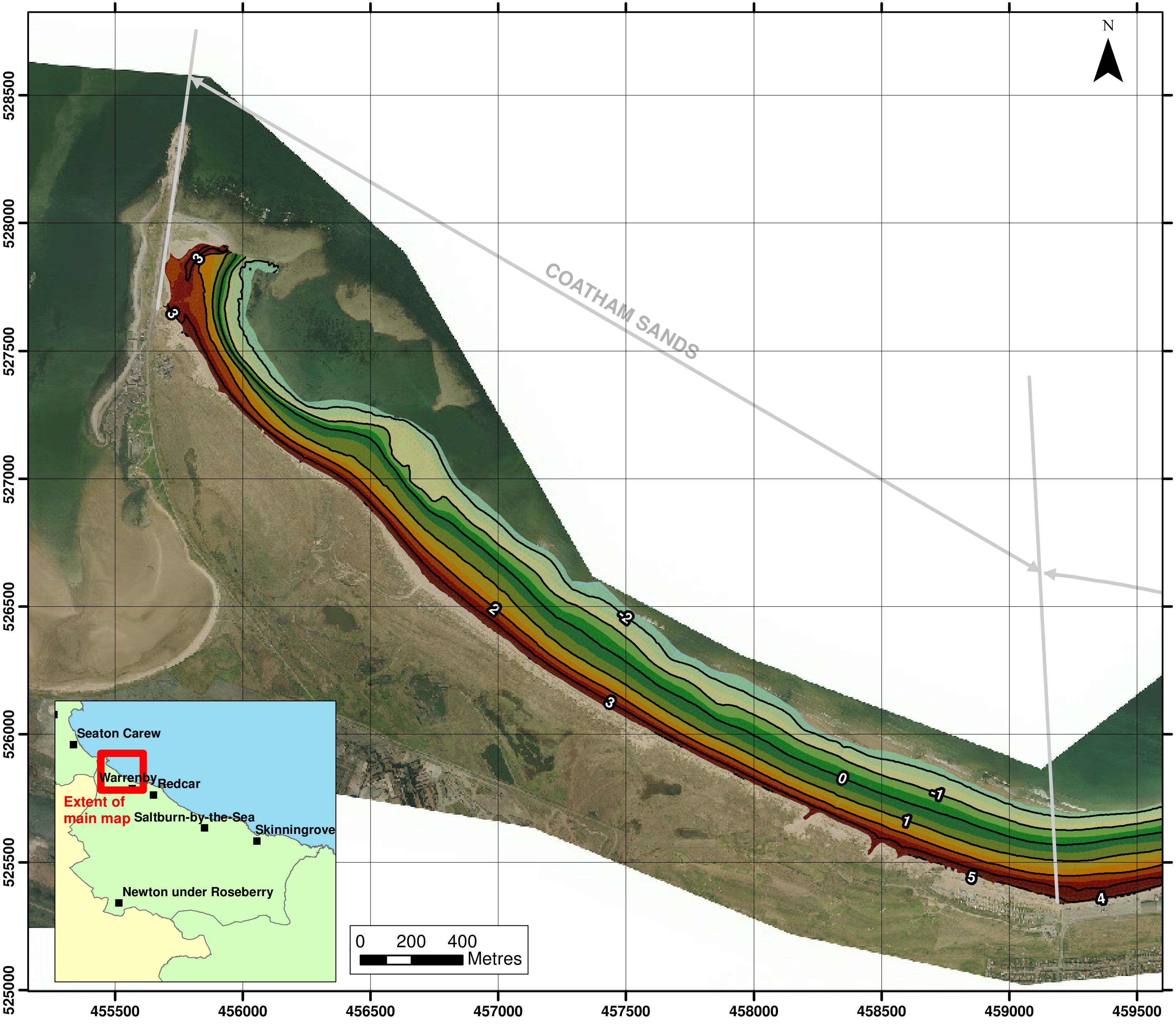

Profiles: 1cRC8
Profile Envelope
2008-11
2009-09
2010-11
2011-10
2012-10
2013-10
2014-10
Level (m)
Chainage (m)
HAT
MHWS
MLWS
DV
GR
S
D
SANDS



Profiles: 1cRC9
Level (m)
Chainage (m)
Profile Envelope
2008-11
2009-09
2010-11
2011-10
2012-10
2013-10
2014-10
HAT
MHWS
MLWS
GR
ZZ
SD
G
S
SANDS

Appendix B

Topographic Survey



KEY
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
- -3 - -2.5
- Contour 1m

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B - Map 1a
Topographic Survey
Coatham Sands
Redcar & Cleveland
Borough Council

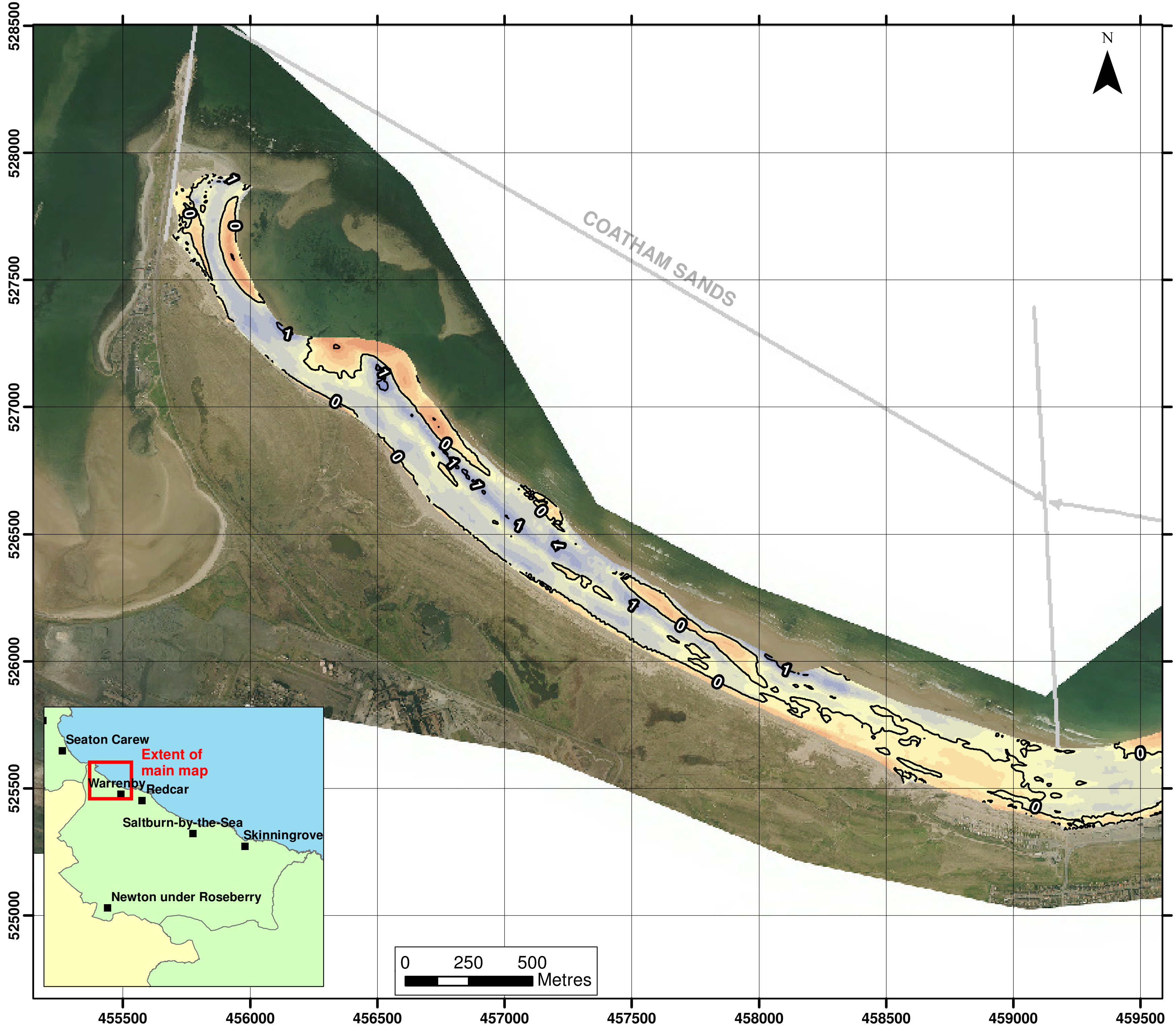
Analytical Report 7
Full Measures Survey
Autumn 2014

CH2MHILL®
Halcrow

Halcrow Group Ltd, Lyndon House, 62 Hagley Road, Edgbaston, Birmingham, B16 8PE

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



KEY Autumn 2013 and Autumn 2014
Change in elevation (m)

- <-2
- -2 - -1.75
- -1.75 - -1.5
- -1.5- -1.25
- -1.25 - -1
- -1 - -0.75
- -0.75 - -0.5
- -0.5 - -0.25
- -0.25 - -0.1
- -0.1 - 0
- 0 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- >2

Loss

Change < 0.1 m

Gain

Contours of change

Client: North East Coastal Group
Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B - Map 1b
Short-term Elevation Change
Coatham Sands
Redcar & Cleveland Borough Council

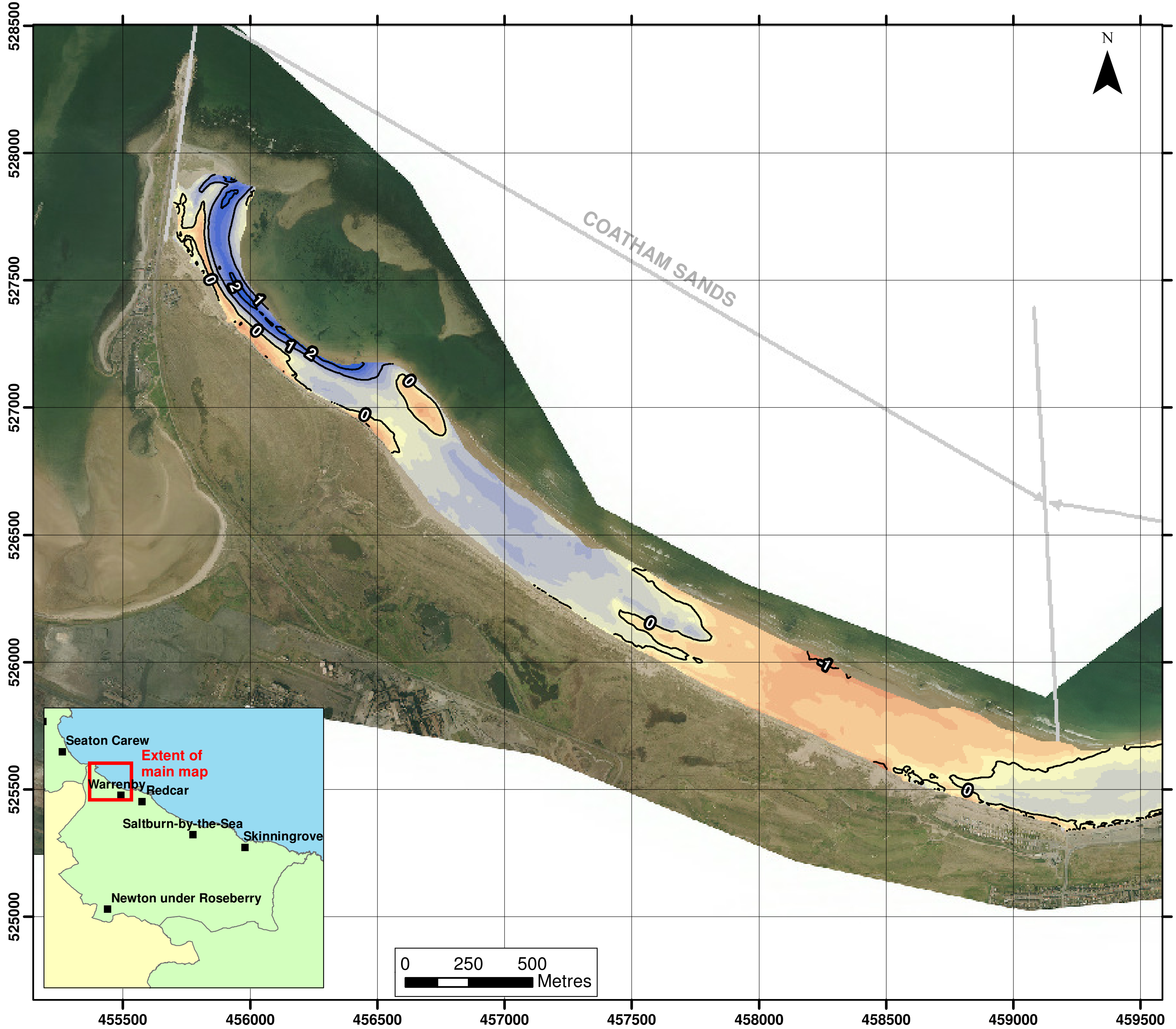
Analytical Report 7
Full Measures Survey
Autumn 2014

CH2MHILL.
Halcrow

Halcrow Group Ltd, Lyndon House, 62 Hagley Road, Edgbaston, Birmingham, B16 8PE

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



KEY Autumn 2008 and Autumn 2014
Change in elevation (m)

- <-2
- -2 - -1.75
- -1.75 - -1.5
- -1.5- -1.25
- -1.25 - -1
- -1 - -0.75
- -0.75 - -0.5
- -0.5 - -0.25
- -0.25 - -0.1
- -0.1 - 0
- 0 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- >2

Loss

Change < 0.1 m

Gain

Contours of change

Client: North East Coastal Group
Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B - Map 1c
Long-term Elevation Change Coatham Sands Redcar & Cleveland Borough Council

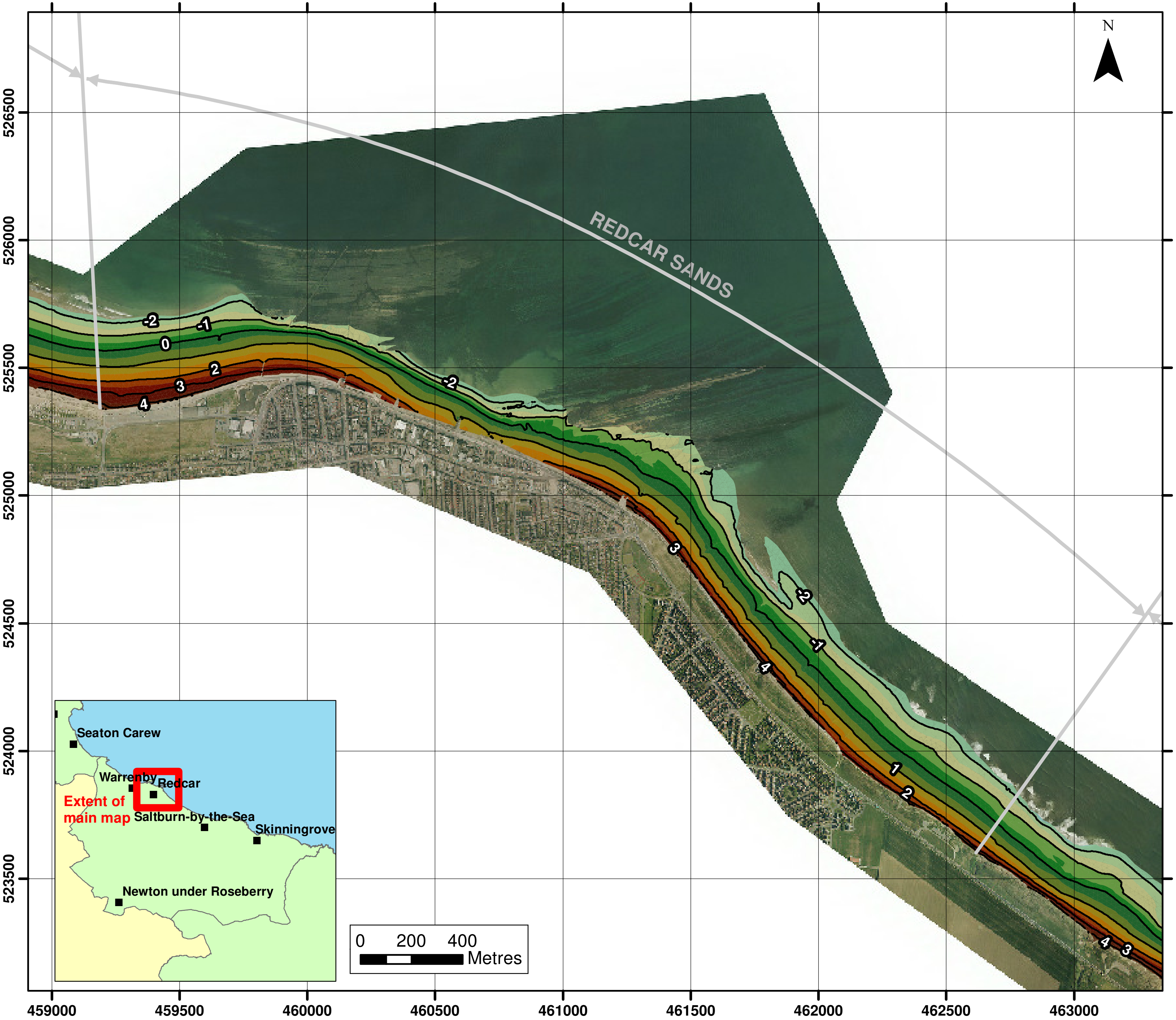
Analytical Report 7
Full Measures Survey
Autumn 2014

CH2MHILL.
Halcrow

Halcrow Group Ltd, Lyndon House, 62 Hagley Road, Edgbaston, Birmingham, B16 8PE

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



KEY

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
- -3 - -2.5
- Contour 1m

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B - Map 2a
Topographic Survey
Redcar Sands
Redcar & Cleveland Borough Council

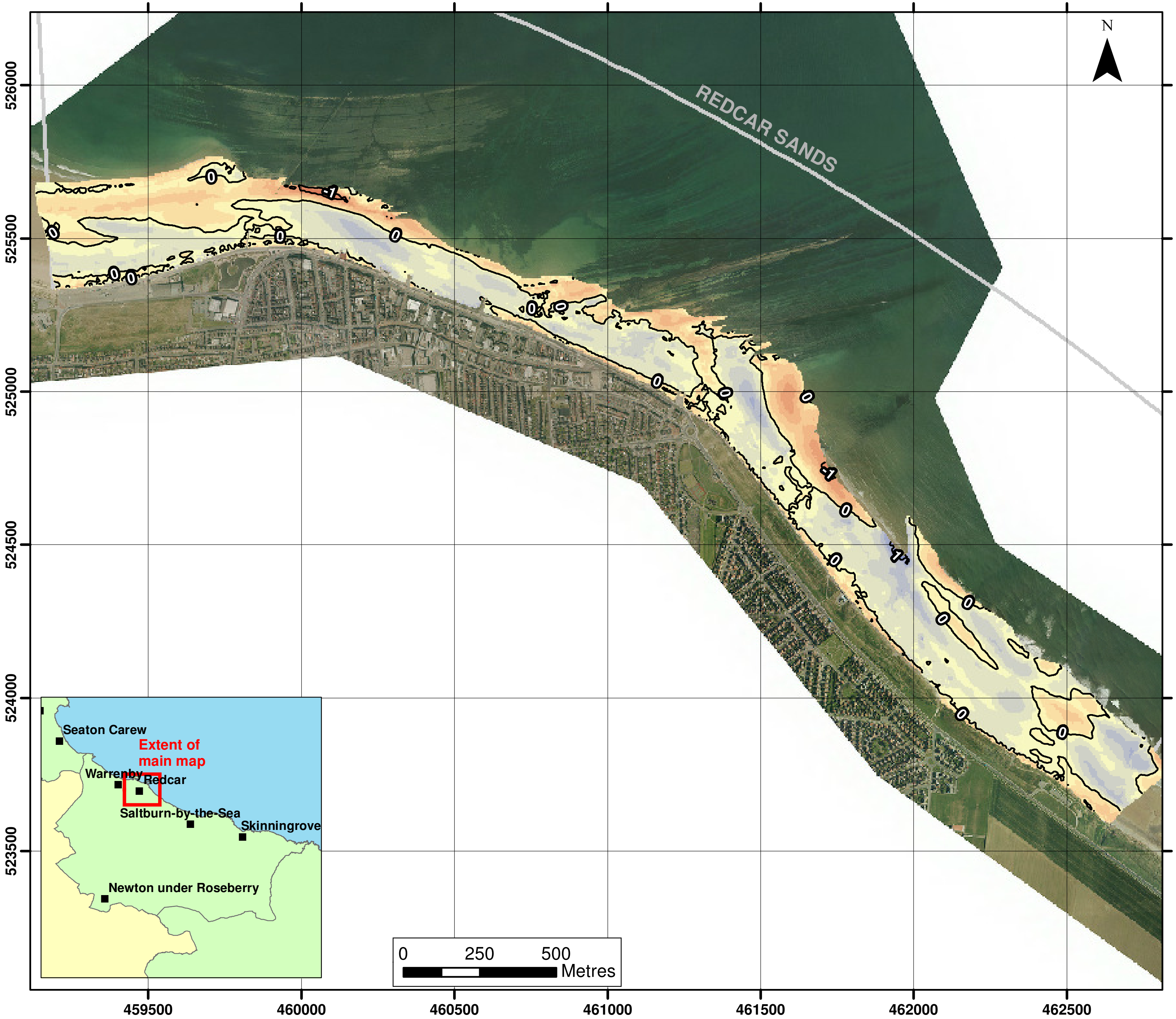
Analytical Report 7
Full Measures Survey
Autumn 2014

CH2MHILL
Halcrow

Halcrow Group Ltd, Lyndon House, 62 Hagley Road, Edgbaston, Birmingham, B16 8PE

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



KEY Spring 2014 and Autumn 2014
Change in elevation (m)

- <-2
- -2 - -1.75
- -1.75 - -1.5
- -1.5- -1.25
- -1.25 - -1
- -1 - -0.75
- -0.75 - -0.5
- -0.5 - -0.25
- -0.25 - -0.1
- -0.1 - 0
- 0 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- >2

Loss

Change < 0.1 m

Gain

Contours of change

Client: North East Coastal Group
Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B- Map 2b
Short-term Elevation Change Redcar Sands Redcar & Cleveland Borough Council

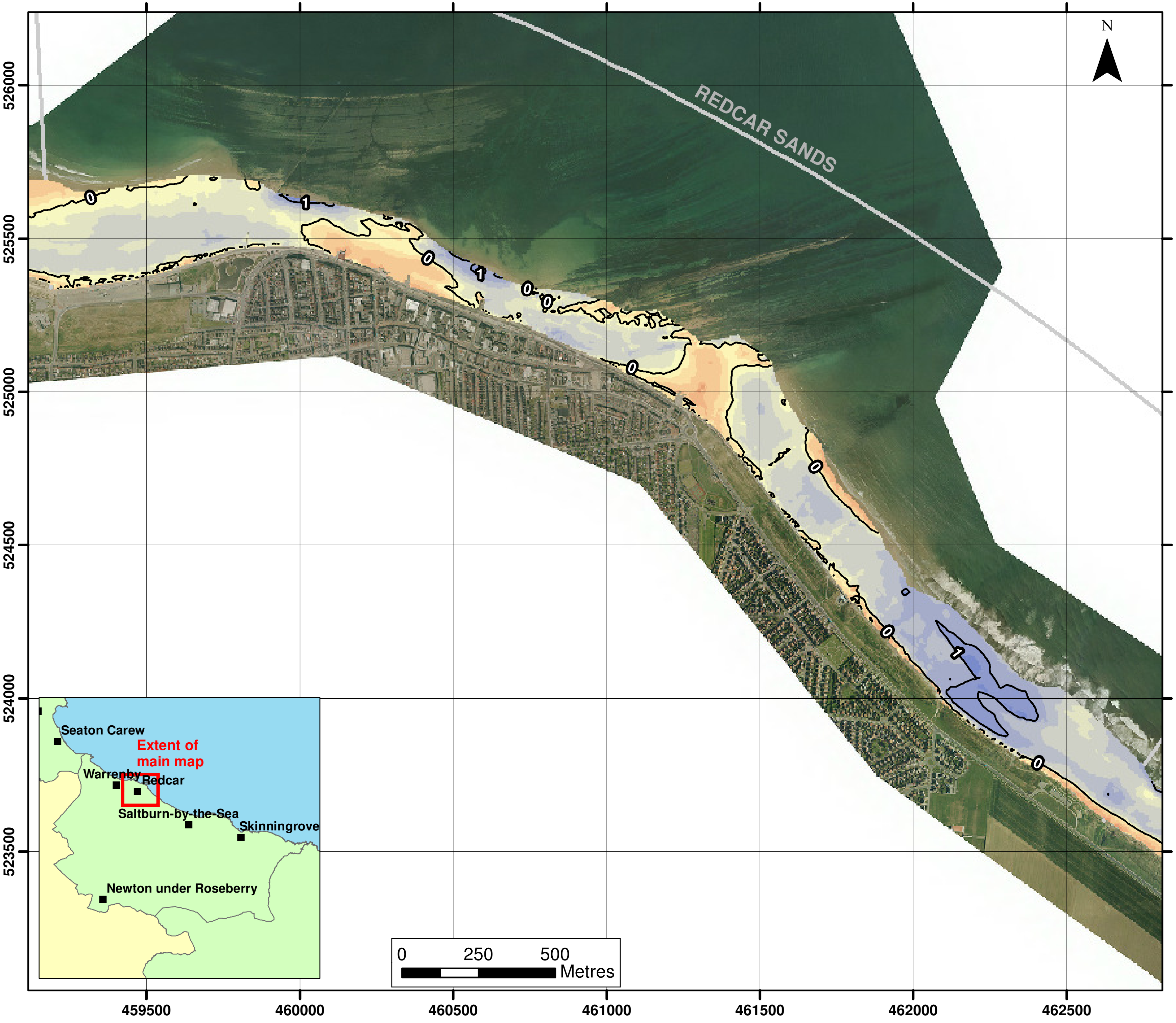
Analytical Report 7
Full Measures Survey
Autumn 2014

CH2MHILL Halcrow

Halcrow Group Ltd, Lyndon House, 62 Hagley Road, Edgbaston, Birmingham, B16 8PE

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



KEY Autumn 2008 and Autumn 2014
Change in elevation (m)

<-2	Loss
-2 - -1.75	
-1.75 - -1.5	
-1.5- -1.25	
-1.25 - -1	
-1 - -0.75	
-0.75 - -0.5	
-0.5 - -0.25	
-0.25 - -0.1	
-0.1 - 0	Change < 0.1 m
0 - 0.1	
0.1 - 0.25	Gain
0.25 - 0.5	
0.5 - 0.75	
0.75 - 1	
1 - 1.25	
1.25 - 1.5	
1.5 - 1.75	
1.75 - 2	
>2	

Contours of change

Client: North East Coastal Group
Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B- Map 2c
Long-term Elevation Change Redcar Sands Redcar & Cleveland Borough Council

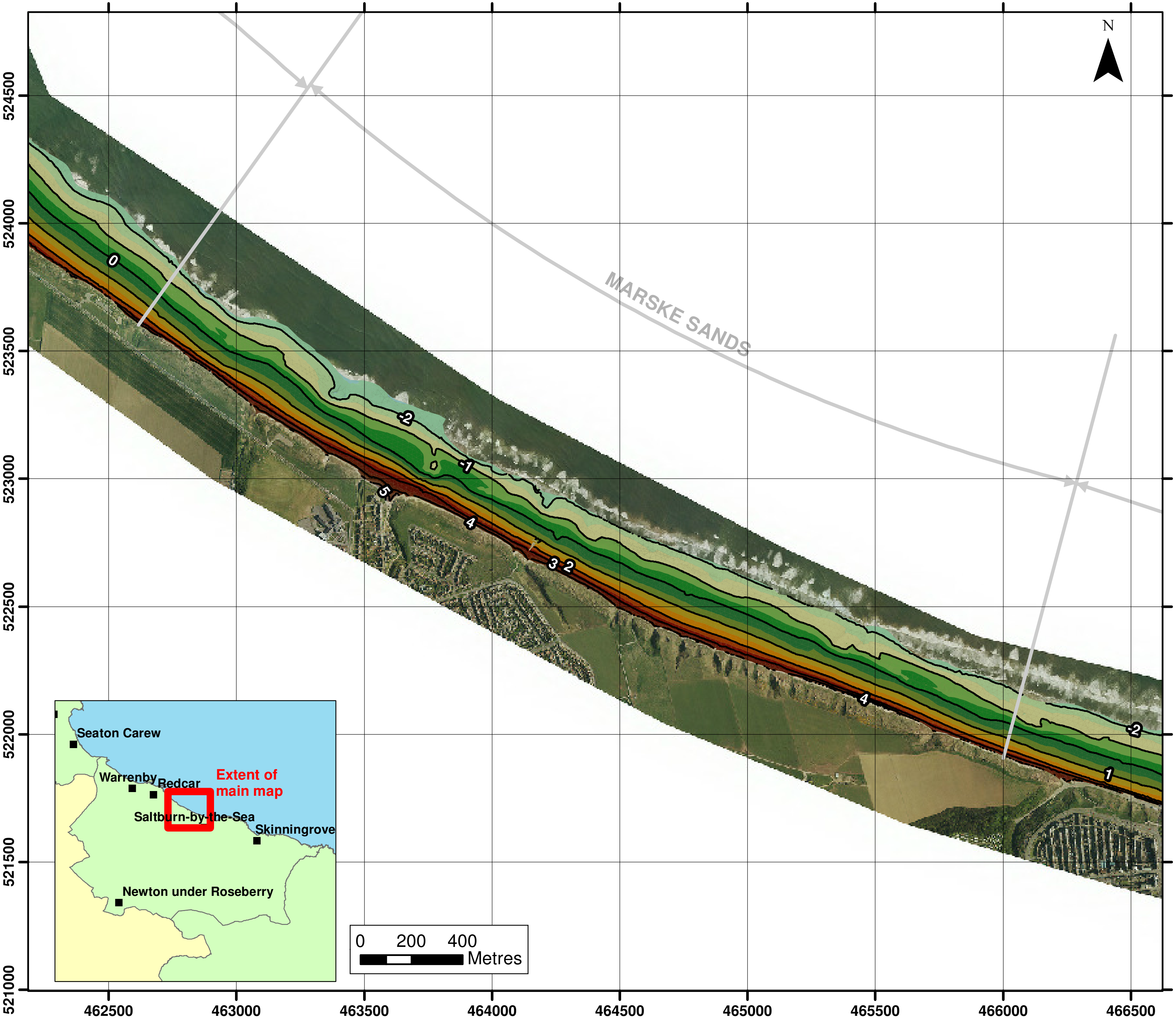
Analytical Report 7
Full Measures Survey
Autumn 2014

CH2MHILL.
Halcrow

Halcrow Group Ltd, Lyndon House, 62 Hagley Road, Edgbaston, Birmingham, B16 8PE

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



KEY

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
- -3 - -2.5
- Contour 1m

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B - Map 3a
Topographic Survey
Marske Sands
Redcar & Cleveland
Borough Council

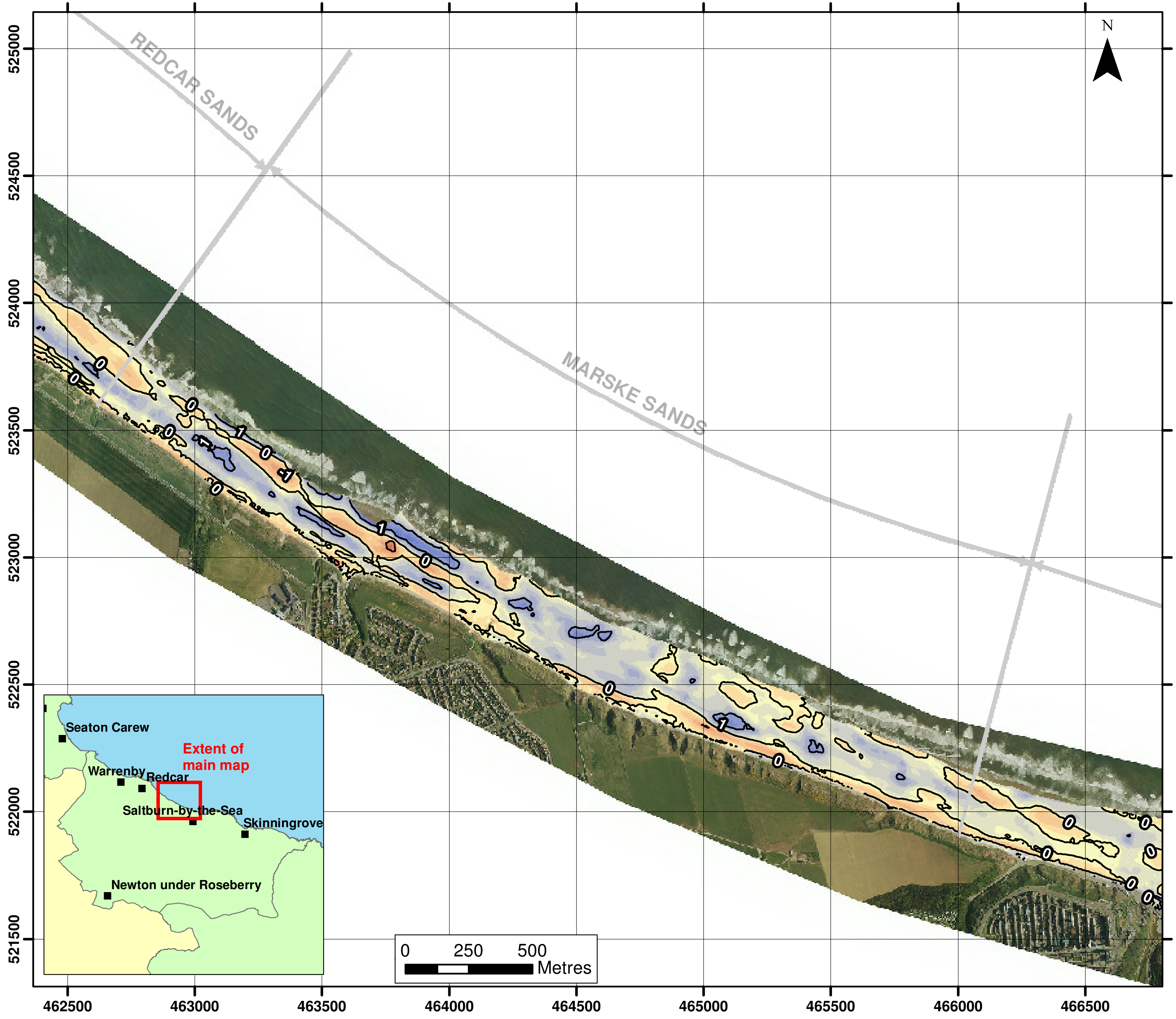
Analytical Report 7
Full Measures Survey
Autumn 2014

CH2MHILL
Halcrow

Halcrow Group Ltd, Lyndon House, 62 Hagley Road, Edgbaston, Birmingham, B16 8PE

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



KEY Autumn 2013 and Autumn 2014
Change in elevation (m)

- <-2
- -2 - -1.75
- -1.75 - -1.5
- -1.5- -1.25
- -1.25 - -1
- -1 - -0.75
- -0.75 - -0.5
- -0.5 - -0.25
- -0.25 - -0.1
- -0.1 - 0
- 0 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- >2

Loss
Change < 0.1 m
Gain

Contours of change

Client: North East Coastal Group
Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B - Map 3b
Short-term Elevation Change Marske Sands Redcar & Cleveland Borough Council

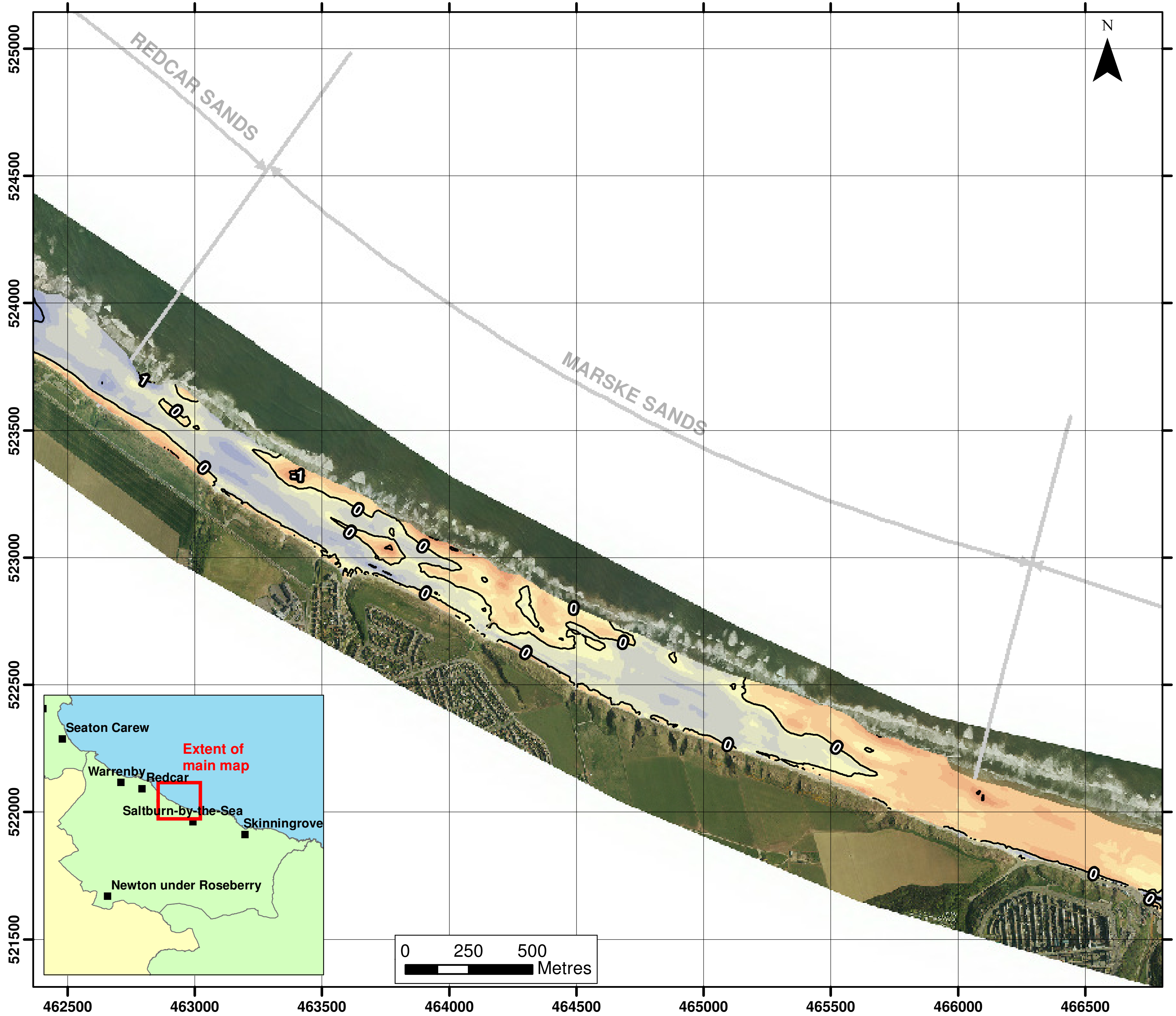
Analytical Report 7
Full Measures Survey
Autumn 2014

CH2MHILL
Halcrow

Halcrow Group Ltd, Lyndon House, 62 Hagley Road, Edgbaston, Birmingham, B16 8PE

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



KEY Autumn 2008 and Autumn 2014
Change in elevation (m)

- <-2
- -2 - -1.75
- -1.75 - -1.5
- -1.5- -1.25
- -1.25 - -1
- -1 - -0.75
- -0.75 - -0.5
- -0.5 - -0.25
- -0.25 - -0.1
- -0.1 - 0
- 0 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- >2

Loss

Change < 0.1 m

Gain

Contours of change

Client: North East Coastal Group
Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

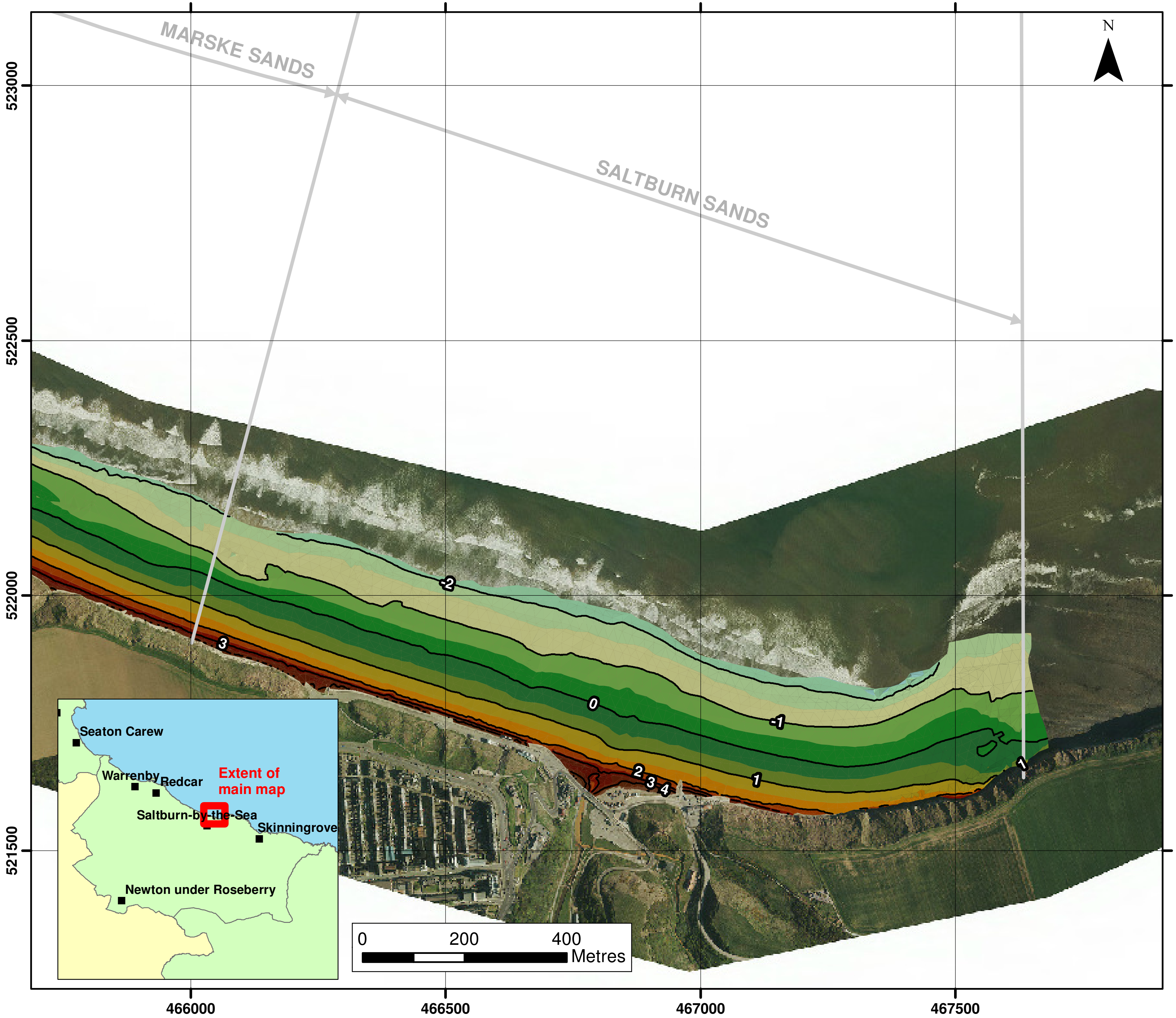
Appendix B - Map 3c
Long-term Elevation Change Marske Sands Redcar & Cleveland Borough Council

Analytical Report 7
Full Measures Survey
Autumn 2014

CH2MHILL
Halcrow
Halcrow Group Ltd, Lyndon House, 62 Hagley Road, Edgbaston, Birmingham, B16 8PE

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



KEY

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
- -3 - -2.5
- Contour 1m

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B - Map 4a
Topographic Survey
Saltburn Sands
Redcar & Cleveland
Borough Council

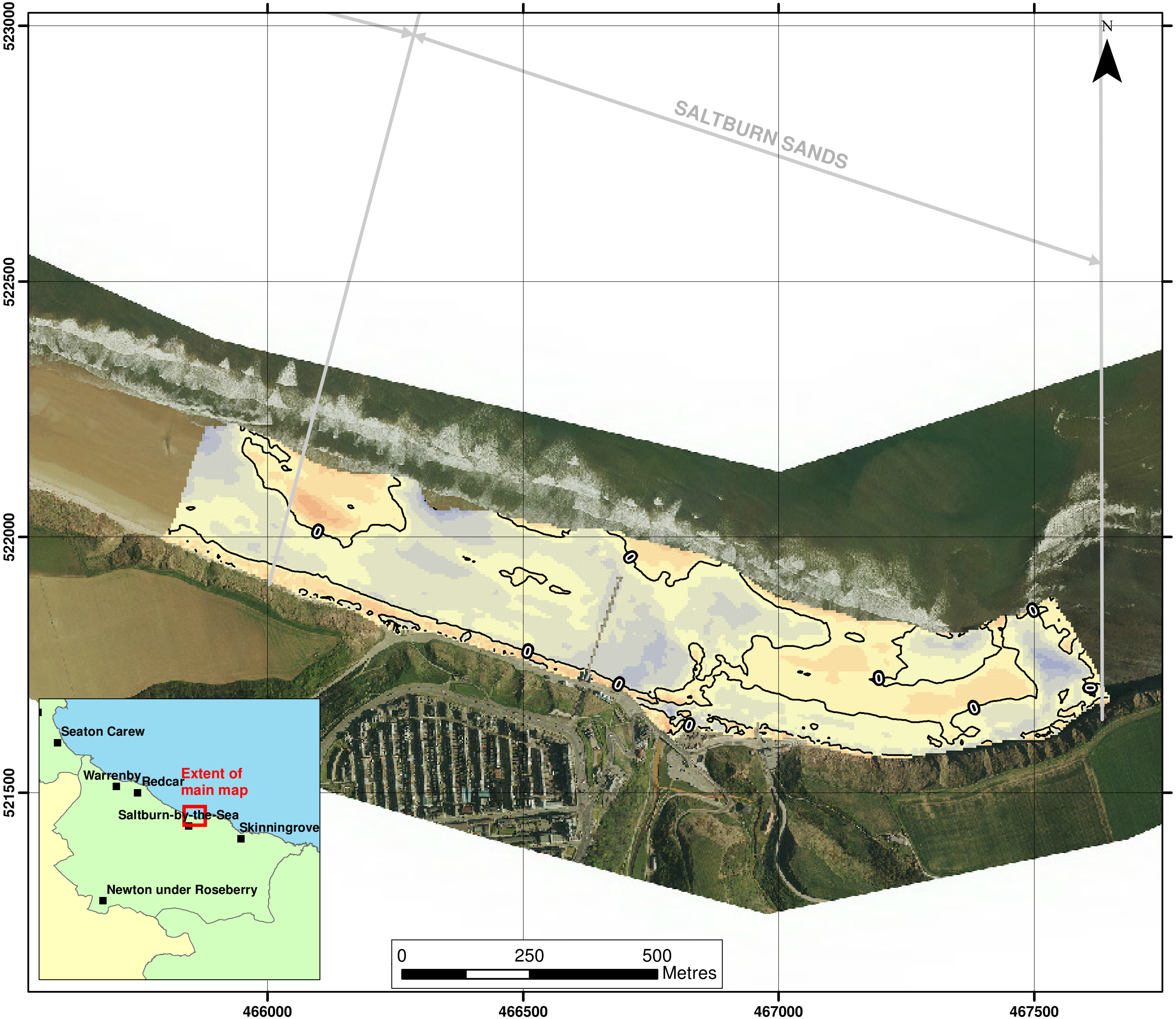
Analytical Report 7
FullMeasures Survey
Autumn 2014

CH2MHILL.
Halcrow

Halcrow Group Ltd, Lyndon House, 62 Hagley Road, Edgbaston, Birmingham, B16 8PE

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



KEY Spring 2014 and Autumn 2014
Change in elevation (m)

Loss:
- <-2
- -2 - -1.75
- -1.75 - -1.5
- -1.5- -1.25
- -1.25 - -1
- -1 - -0.75
- -0.75 - -0.5
- -0.5 - -0.25
- -0.25 - -0.1

Change < 0.1 m:
- -0.1 - 0
- 0 - 0.1

Gain:
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- >2

Contours of change

Client: North East Coastal Group
Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B- Map 4b
Short-term Elevation Change
Saltburn Sands
Redcar & Cleveland Borough Council

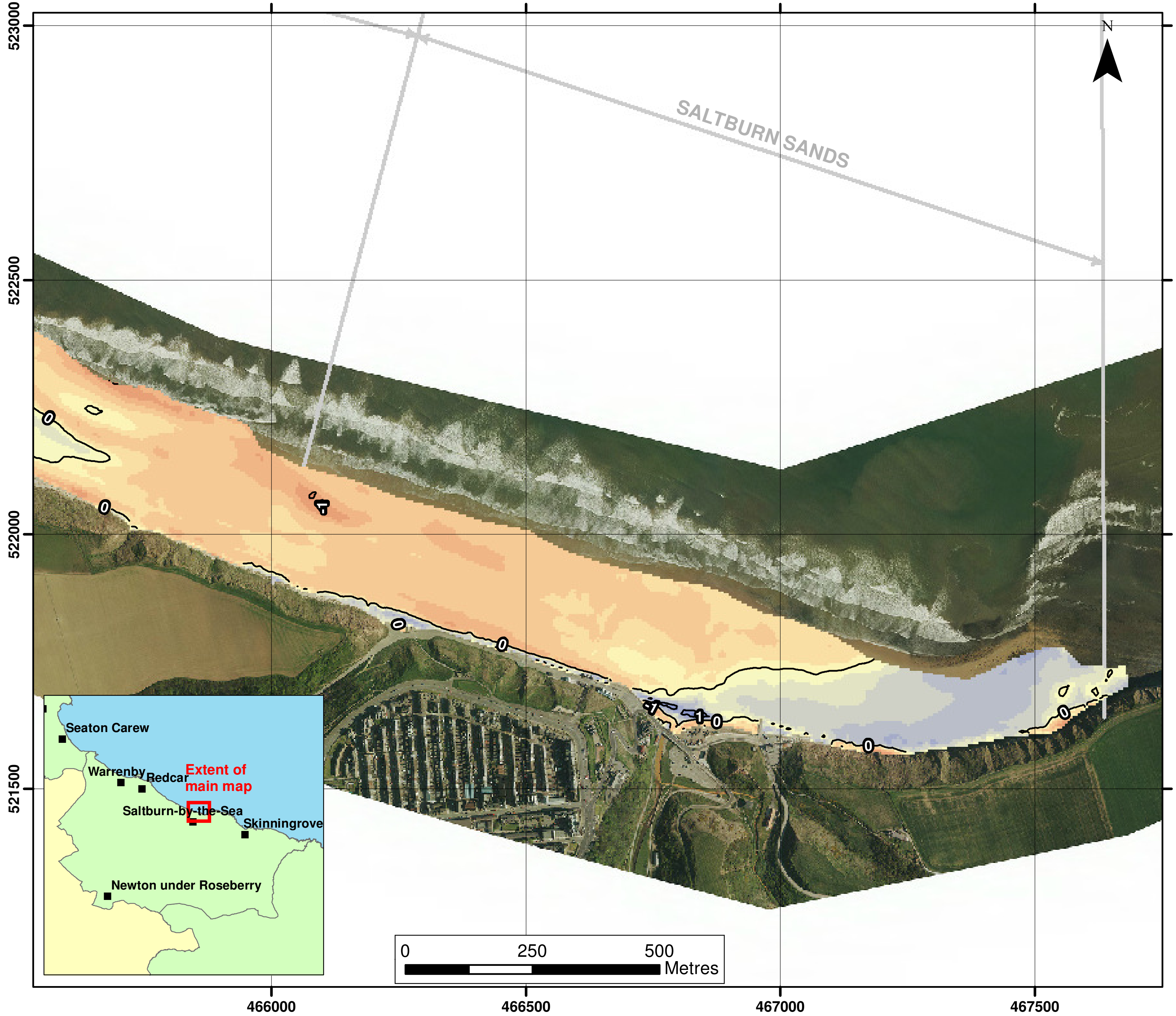
Analytical Report 7
Full Measures Survey
Autumn 2014

CH2MHILL
Halcrow

Halcrow Group Ltd, Lyndon House, 62 Hagley Road, Edgbaston, Birmingham, B16 8PE

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



KEY Autumn 2008 and Autumn 2014
Change in elevation (m)

<-2
-2 - -1.75
-1.75 - -1.5
-1.5- -1.25
-1.25 - -1
-1 - -0.75
-0.75 - -0.5
-0.5 - -0.25
-0.25 - -0.1
-0.1 - 0
0 - 0.1
0.1 - 0.25
0.25 - 0.5
0.5 - 0.75
0.75 - 1
1 - 1.25
1.25 - 1.5
1.5 - 1.75
1.75 - 2
>2

Loss
Change < 0.1 m
Gain

Contours of change

Client: North East Coastal Group
Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B- Map 4c
Long-term Elevation Change
Saltburn Sands
Redcar & Cleveland Borough Council

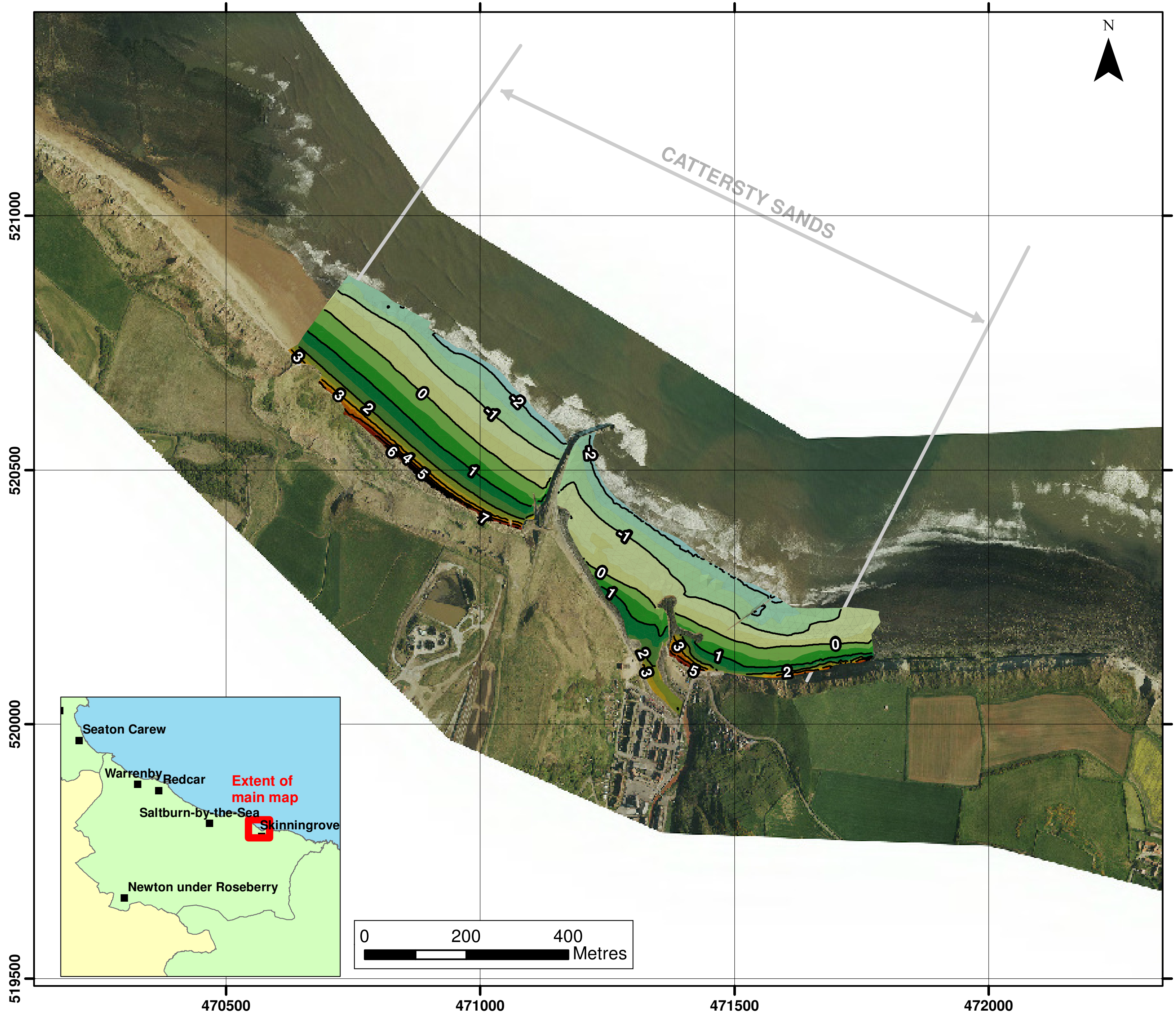
Analytical Report 7
Full Measures Survey
Autumn 2014

CH2MHILL.
Halcrow

Halcrow Group Ltd, Lyndon House, 62 Hagley Road, Edgbaston, Birmingham, B16 8PE

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



KEY

Elevation (m OD)			
	10 - 10.5		3.5 - 4
	9.5 - 10		3 - 3.5
	9 - 9.5		2.5 - 3
	8.5 - 9		2 - 2.5
	8 - 8.5		1.5 - 2
	7.5 - 8		1 - 1.5
	7 - 7.5		0.5 - 1
	6.5 - 7		0 - 0.5
	6 - 6.5		-0.5 - 0
	5.5 - 6		-1 - -0.5
	5 - 5.5		-1.5 - -1
	4.5 - 5		-2 - -1.5
	4 - 4.5		-2.5 - -2
			Contour 1m

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

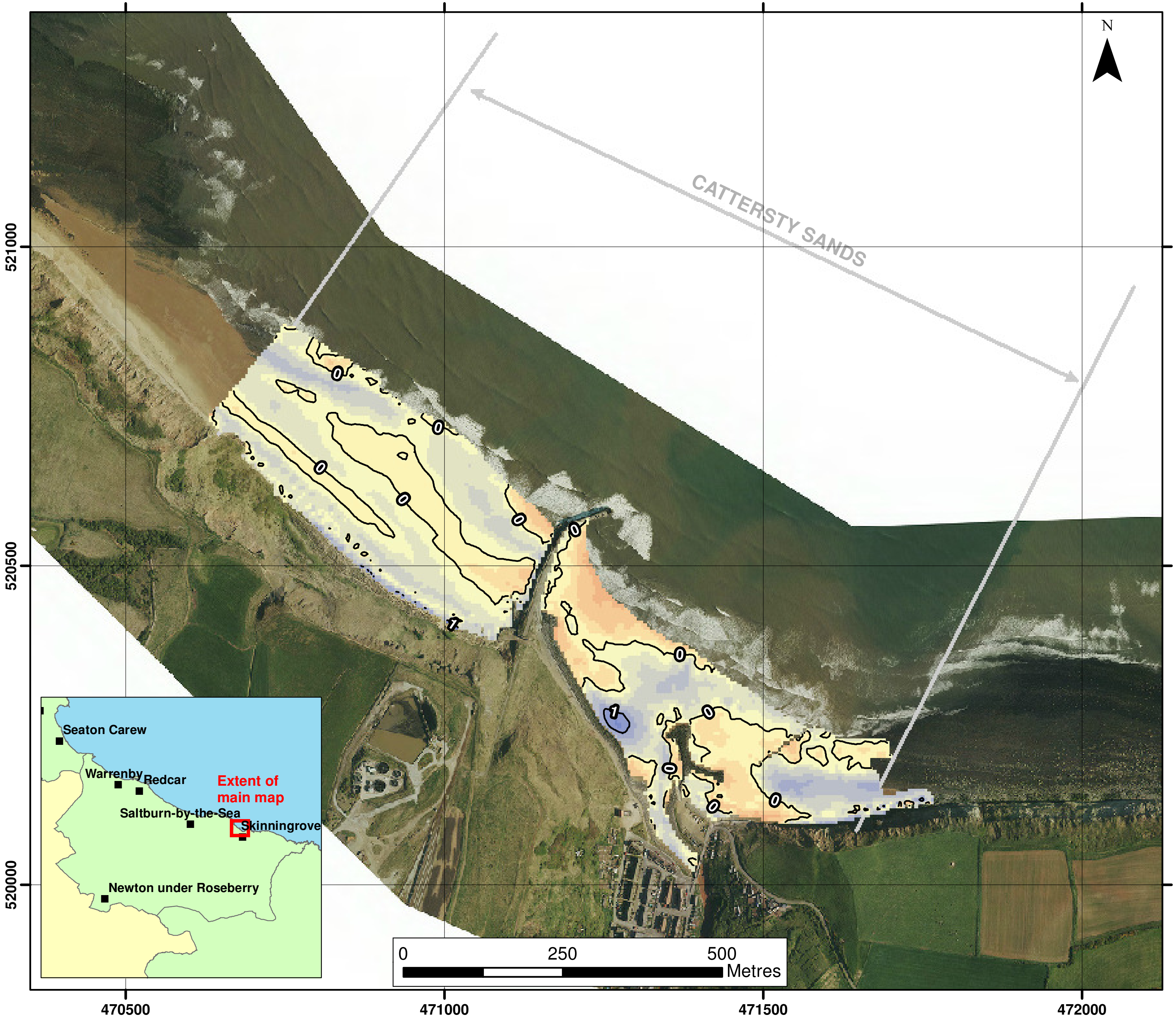
Appendix B- Map 5a
Topographic Survey
Cattersty Sands
Redcar & Cleveland Borough Council

Analytical Report 7
Fulll Measures Survey
Autumn 2014

CH2MHILL.
Halcrow
Halcrow Group Ltd, Lyndon House, 62 Hagley Road, Edgbaston, Birmingham, B16 8PE

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



KEY Spring 14 and Autumn 14
Change in elevation (m)

<-2	Loss
-2 - -1.75	
-1.75 - -1.5	
-1.5- -1.25	
-1.25 - -1	
-1 - -0.75	
-0.75 - -0.5	
-0.5 - -0.25	
-0.25 - -0.1	
-0.1 - 0	Change < 0.1 m
0 - 0.1	
0.1 - 0.25	Gain
0.25 - 0.5	
0.5 - 0.75	
0.75 - 1	
1 - 1.25	
1.25 - 1.5	
1.5 - 1.75	
1.75 - 2	
>2	

Contours of change

Client: North East Coastal Group
Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B - Map 5b
Short-term Elevation Change Cattersty Sands Redcar & Cleveland Borough Council

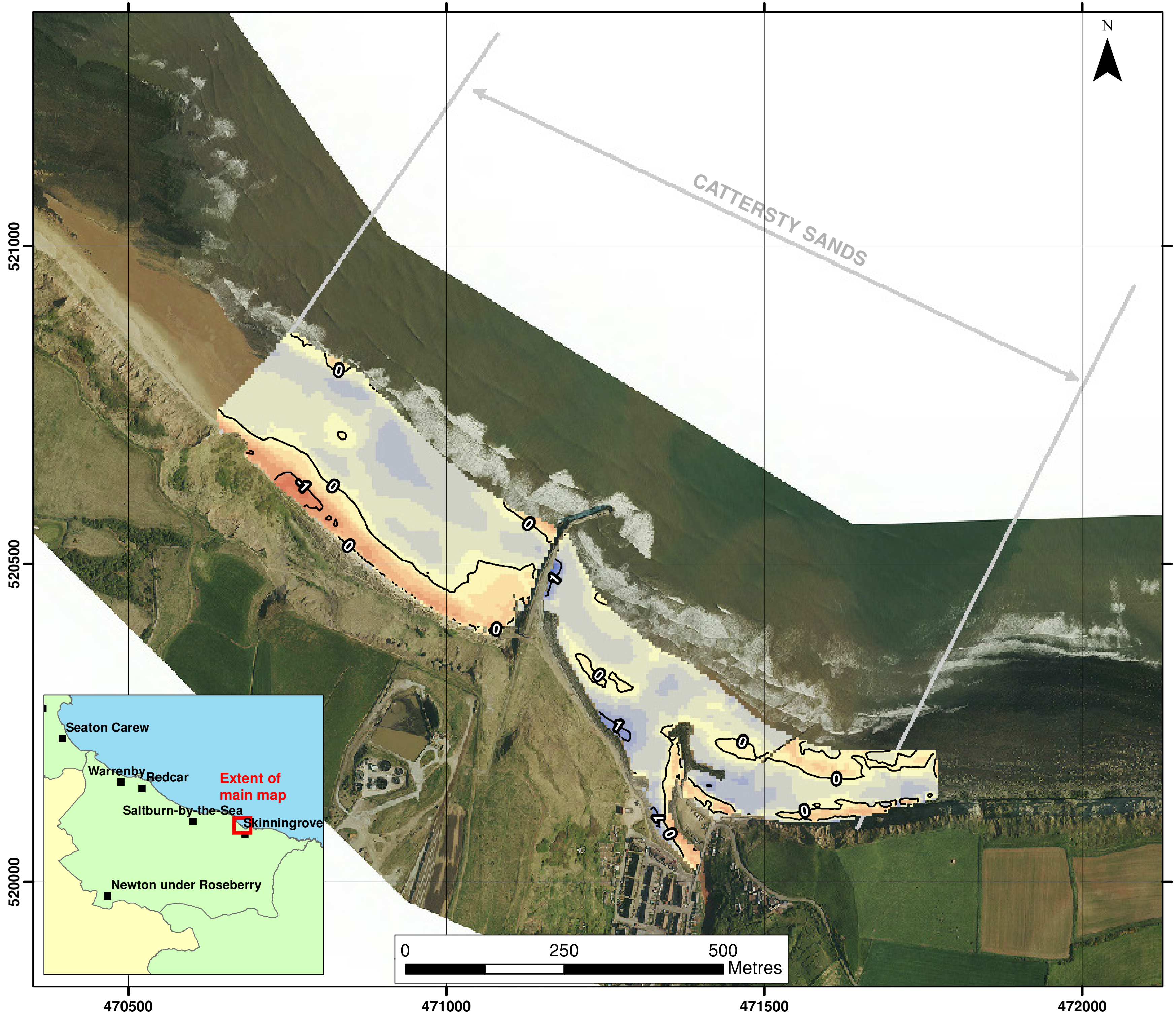
Analytical Report 7
Full Measures Survey
Autumn 2014

CH2MHILL.
Halcrow

Halcrow Group Ltd, Lyndon House, 62 Hagley Road, Edgbaston, Birmingham, B16 8PE

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



KEY Autumn 2008 and Autumn 14
Change in elevation (m)

Change in elevation (m)	
<-2	Loss
-2 - -1.75	
-1.75 - -1.5	
-1.5- -1.25	
-1.25 - -1	
-1 - -0.75	
-0.75 - -0.5	
-0.5 - -0.25	
-0.25 - -0.1	
-0.1 - 0	Change < 0.1 m
0 - 0.1	
0.1 - 0.25	Gain
0.25 - 0.5	
0.5 - 0.75	
0.75 - 1	
1 - 1.25	
1.25 - 1.5	
1.5 - 1.75	
1.75 - 2	
>2	

Contours of change

Client: North East Coastal Group
Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B - Map 5c
Long-term Elevation Change Cattersty Sands Redcar & Cleveland Borough Council

Analytical Report 7
Full Measures Survey
Autumn 2014

CH2MHILL
Halcrow

Halcrow Group Ltd, Lyndon House, 62 Hagley Road, Edgbaston, Birmingham, B16 8PE

Tel: +44 (0)121 456 2345
Fax: +44(0)121 456 1569
www.halcrow.com

Appendix C

Cliff Top Survey

Cliff Top Survey

Staithes

Twenty ground control points have been established within Staithes (Figure C1). The maximum separation between any two points is nominally 100m.

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.

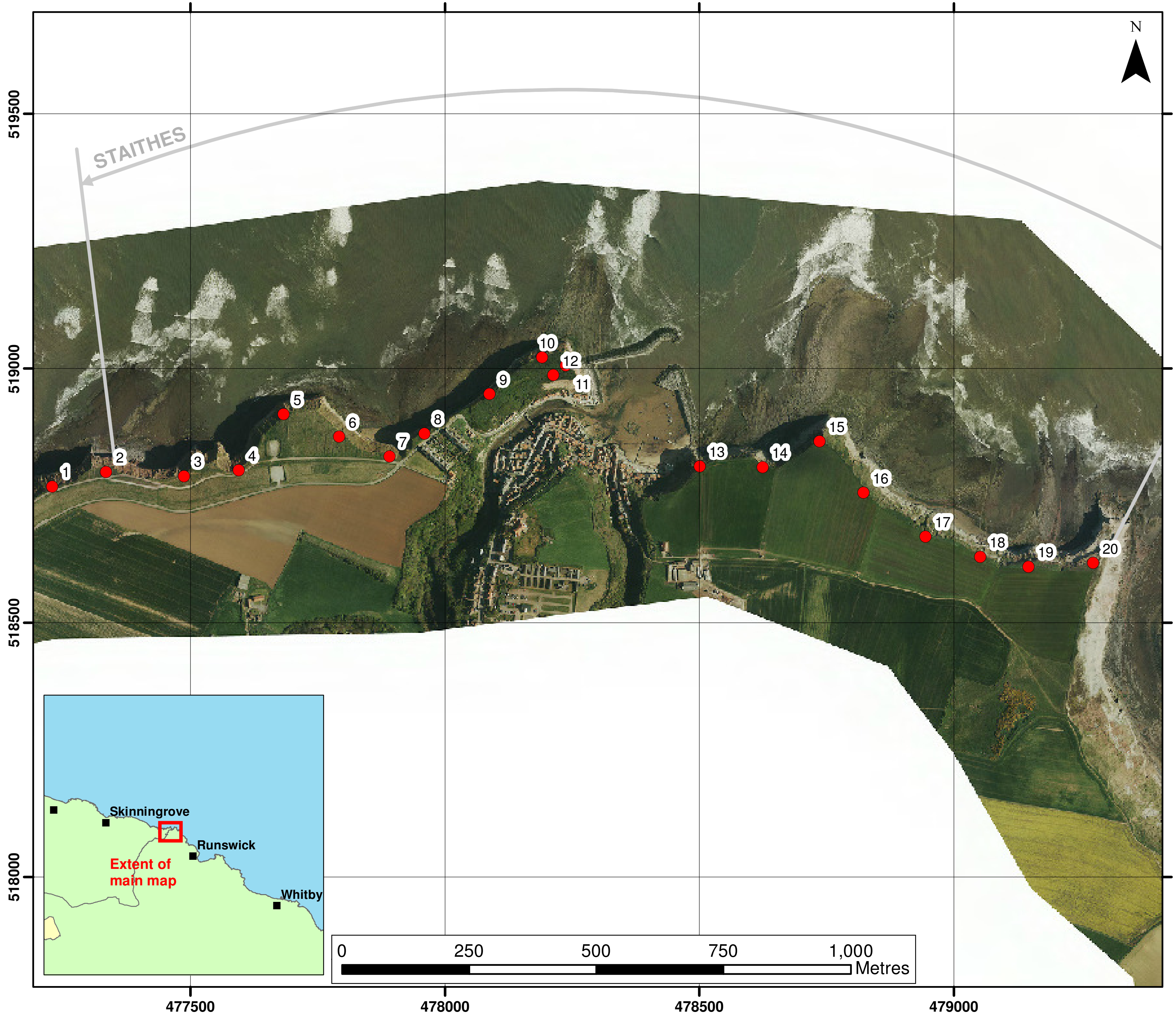
Table C1 provides baseline information about these ground control points and results from the 2008 (baseline) survey showing the position from the ground control point to the edge of the cliff top along the defined bearing. Future reports will show results from subsequent surveys and provide a means of assessing erosion since the 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	Bearing (º)	Baseline Survey (Nov 2008)	Previous Survey (April 2014)	Present Survey (Oct 2014)	Baseline (Nov 2008) to Present (Oct 2014)	Previous (April 2014) to Present (Oct 2014)	Baseline (Nov 2008) to Present (Oct 2014)
1	477228	518769	320	1.9	1.7	1.6	-0.3	-0.1	0.0
2	477334	518798	0	10.9	10.9	10.8	-0.1	-0.1	0.0
3	477487	518789	350	7.1	8.4	8.3	1.2	0.0	0.2
4	477594	518801	340	5.9	5.1	5.1	-0.8	0.0	-0.1
5	477683	518911	350	8.4	9.4	9.1	0.7	-0.3	0.1
6	477792	518867	30	8.6	8.6	8.5	-0.1	-0.1	0.0
7	477891	518828	60	7.7	7.5	7.3	-0.4	-0.2	-0.1
8	477959	518873	350	8.7	9.9	9.8	1.1	0.0	0.2
9	478088	518950	350	7.6	8.3	8.2	0.6	-0.1	0.1
10	478191	519023	340	8.4	8.8	8.8	0.4	0.0	0.1
11	478237	519007	60	6.9	6.8	6.8	-0.1	0.0	0.0

12	478213	518988	150	6.1	6.7	6.5	0.4	-0.2	0.1
13	478501	518809	15	11.4	9.2	9.2	-2.2	0.0	-0.4
14	478624	518807	20	7.5	7.5	7.5	0.0	-0.1	0.0
15	478737	518858	60	6.1	6.5	6.5	0.4	0.0	0.1
16	478823	518757	60	8	9.2	8.9	0.9	-0.4	0.1
17	478944	518671	30	9.3	9.4	9.2	-0.1	-0.3	0.0
18	479052	518630	20	9.2	9.4	9.5	0.3	0.1	0.0
19	479147	518610	0	14.2	14.4	14.4	0.2	0.0	0.0
20	479274	518618	20	11.4	11.4	11.1	-0.3	-0.3	0.0

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.



KEY

Ground Control Points

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix C - Map 1
Ground Control Points
Staithes
Redcar & Cleveland Borough Council

Analytical Report 7
Full Measures Survey
Autumn 2014

CH2MHILL
Halcrow

Halcrow Group Ltd, Lyndon House, 62 Hagley Road, Edgbaston, Birmingham, B16 8PE

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