CH2MHILL
Halcrow

Cell 1 Regional Coastal Monitoring Programme
Analytical Report 6: 'Full Measures' Survey 2013

HARTLEPOOL
BOROUGH COUNCIL

Hartlepool Borough Council
Final Report

February 2014

Contents

Appendices

List of Figures

List of Tables

Authors	
Lily Booth	CH2M HILL
Dr Paul Fish	CH2M HILL
Dr Andy Parsons	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 (m AOD)			
Water Level Parameter	**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 (m AOD)			
Water Level Parameter	**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

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.

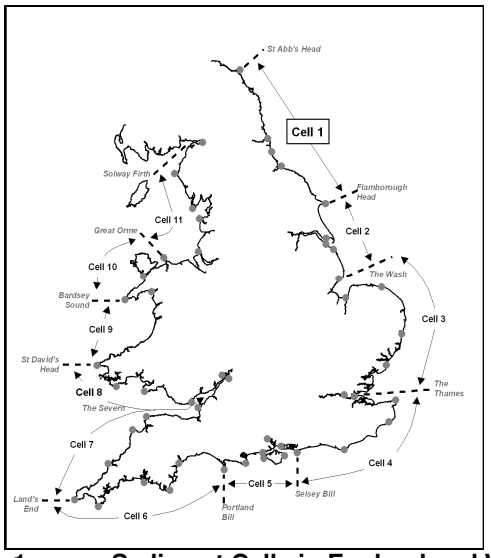


Figure 1 Sediment Cells in England and Wales

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:

Northumberland County Council

Northumberland Coast AONB

North Tyneside Council

South Tyneside Council

Sunderland City Council

Durham County Council

Redcar & Cleveland Borough Council

Hartlepool Borough Council

Whitby Scarborough Filey Borough of Scarborough

A great place to live, work & play

East Riding of Yorkshire Council

Environment Agency

Natural England

The National Trust

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	July 10	-
3	2010/11	Aug-Nov 10	Feb 11	Feb-April 11	August 11	Sept 11
4	2011/12	Sep-Oct 11	Oct 12	Mar-May 12	Feb 13	-
5	2012/13	Sep 2012	Feb 13	April 13	May 13	-
6	2013/14	Sep-Oct 13	Feb 14 (*)			

(*) The present report is **Analytical Report 6** and provides an analysis of the 2013 Full Measures survey for Hartlepool 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

Hartlepool Borough Council's frontage extends from Crimdon Beck in the north, to the North Gare Breakwater in the south. For the purposes of this report, it has been sub-divided into four areas, namely:

- North Sands
- Hartlepool Headland
- Middleton
- Hartlepool Bay

1.2 Methodology

Along Hartlepool Borough Council's frontage, the following surveying is undertaken:

- Full Measures survey annually each autumn/early winter comprising:
    - Beach profile surveys along nine transect lines
    - Topographic survey along part of North Sands (referred to as Hartlepool North or 'HN')
    - Topographic survey along Middleton (referred to as Hartlepool Central or 'HC')
    - Topographic survey along Hartlepool Bay (referred to as Hartlepool South or 'HS')
- Partial Measures survey annually each spring comprising:
    - Beach profile surveys along 9 no. transect lines
- Additionally, every five years (starting with 2008 as the baseline year), the Full Measures topographic survey at Hartlepool North is extended to fully cover the whole of North Sands and Hartlepool Headland with a topographic survey. This extends across the boundary of jurisdiction between Hartlepool Borough Council and County Durham Council.

The location of these surveys is shown in Figure 2. The 2013 Full Measures survey was undertaken along this frontage on various dates between 17th September and 23rd October. During this time weather conditions varied considerably. The survey reports from Academy Geomatics document details of the weather conditions over this survey period.

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, whilst 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 Halcrow's 2011 Wave Data Analysis Report, which reviewed all readily available data in the region. In 2014 a wave data update report will update the baseline with analysis of the wave data collected under the programme for 2013, including the 5th and 6th December storm. 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. To aid interpretation of the results 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 3 SANDS Storm Analysis at Tyne/Tees WaveNet Buoy

General Storm Information					At Peak			
Start Time	**End Time**	**Duration (Hours)**	**Peak of Storm**	**Mean Direction Vector (Degrees)**	**Hs (m)**	**Tp (s)**	**Direction (Degrees)**	**Energy @ Peak (KJ/m/s)**
19/03/2007 10:30	21/03/2007 05:30	43	20/03/2007 14:30	79.0	6.2	12.4	22	11759.3
25/06/2007 20:00	26/06/2007 13:30	17.5	26/06/2007 10:00	81.6	4.4	8.6	22	2832.6
26/09/2007 03:00	27/09/2007 05:00	26	26/09/2007 19:00	80.4	4.6	11.6	6	5488.7
08/11/2007 20:00	**12/11/2007 15:00**	**91**	**09/11/2007 08:30**	**78.7**	**6.2**	**13.4**	**6**	**13698.9**
19/11/2007 03:30	25/11/2007 21:30	162	23/11/2007 05:00	78.8	4.9	10.7	17	5353.7
08/12/2007 03:00	10/12/2007 14:30	59.5	08/12/2007 03:30	85.1	4.1	10.8	17	3816.4
03/01/2008 10:30	04/01/2008 01:30	15	03/01/2008 23:30	14.8	4.2	9.1	62	2964.9
01/02/2008 15:00	02/02/2008 09:30	18.5	02/02/2008	80.9	6.0	13.8	17	13641.7
10/03/2008 08:30	10/03/2008 12:30	4	10/03/2008 11:00	307.6	4.6	8.0	141	2631.9
17/03/2008 15:00	**25/03/2008 03:00**	**180**	**22/03/2008 05:00**	**83.8**	**7.9**	**12.4**	**6**	**19123.9**
05/04/2008 22:00	07/04/2008 05:00	31	06/04/2008 19:00	83.8	4.6	11.6	6	5520.5
20/07/2008 16:00	21/07/2008 09:30	17.5	20/07/2008 23:30	75.9	4.2	9.9	11	3492.5
03/10/2008 03:00	03/10/2008 20:30	17.5	03/10/2008 16:30	82.4	4.7	11.4	22	5728.4
21/11/2008 04:00	25/11/2008 12:30	104.5	22/11/2008 11:30	75.8	6.0	13.1	11	12267.5
10/12/2008 12:00	13/12/2008 18:00	78	13/12/2008 08:00	331.9	4.9	8.3	129	3286.2

General Storm Information					At Peak			
Start Time	End Time	Duration (Hours)	Peak of Storm	Mean Direction Vector (Degrees)	Hs (m)	Tp (s)	Direction (Degrees)	Energy @ Peak (KJ/m/s)
31/01/2009 16:30	03/02/2009 09:00	64.5	02/02/2009 22:00	7.1	5.8	9.5	84	6078.5
23/03/2009 20:30	28/03/2009 20:30	120	28/03/2009 18:30	89.7	4.9	9.3	0	4053.0
10/07/2009 01:30	10/07/2009 02:30	1	10/07/2009 01:30	78.8	4.2	9.9	11	3504.3
29/11/2009 20:00	**30/11/2009 15:00**	**19**	**30/11/2009 00:30**	**73.4**	**6.0**	**9.4**	**11**	**6331.4**
17/12/2009 10:30	18/12/2009 05:00	18.5	17/12/2009 19:30	26.4	5.4	10.6	68	**6549.5**
30/12/2009 09:00	30/12/2009 23:00	14	30/12/2009 12:30	7.7	5.1	7.5	90	2866.0
06/01/2010 05:30	06/01/2010 11:00	5.5	06/01/2010 06:30	63.7	4.2	10.7	11	4044.1
29/01/2010 10:30	30/01/2010 00:30	14	29/01/2010 22:30	83.9	5.4	8.6	6	4258.2
26/02/2010 22:30	27/02/2010 02:30	4	27/02/2010 01:00	72.6	4.6	8.5	17	2925.7
19/06/2010 07:00	20/06/2010 08:30	25.5	19/06/2010 20:00	69.4	5.4	10.7	22	**6611.8**
29/08/2010 14:00	30/08/2010 06:30	16.5	29/08/2010 22:30	91.8	4.9	8.9	0	3715.5
06/09/2010 22:30	07/09/2010 16:00	17.5	07/09/2010 15:30	353.3	4.6	8.8	90	3192.5
17/09/2010 07:00	17/09/2010 18:30	11.5	17/09/2010 08:30	80.8	4.7	11.0	11	5323.3
24/09/2010 03:00	26/09/2010	45	24/09/2010 10:00	73.1	5.3	10.1	11	5564.7
20/10/2010 02:00	24/10/2010 16:30	110.5	20/10/2010 10:00	78.3	4.2	11.3	17	4514.5
08/11/2010 14:00	**09/11/2010 20:30**	**30.5**	**09/11/2010 10:00**	**3.1**	**5.6**	**8.8**	**73**	**4870.6**
17/11/2010 11:00	17/11/2010 18:30	7.5	17/11/2010 12:00	322.2	4.7	7.8	129	2646.0
29/11/2010 19:30	02/12/2010 08:30	61	29/11/2010 21:00	11.8	5.1	9.4	56	4474.2
16/12/2010 15:00	17/12/2010 06:30	15.5	17/12/2010 03:30	80.2	4.6	10.5	17	4504.6
23/07/2011 14:00	**24/07/2011 11:00**	**21**	**24/07/2011 03:00**	**67.5**	**4.7**	**10.8**	**17**	**5082.6**
24/10/2011 18:30	25/10/2011 09:30	15	25/10/2011 09:30	348.5	4.1	9.5	79	2986.1
09/12/2011 08:30	09/12/2011 10:00	1.5	09/12/2011 08:30	84.4	4.1	11.9	6	4669.0
05/01/2012 15:30	06/01/2012 05:00	13.5	06/01/2012 00:30	81.4	4.5	9.9	14	3896.6
03/04/2012 13:30	04/04/2012 10:30	21	04/04/2012 03:00	26.5	5.7	8.4	90	4510.0
24/09/2012 07:30	25/09/2012 11:00	27.5	24/09/2012 17:30	17.2	5.3	9.3	77	4786.2
26/10/2012 12:00	27/10/2012 15:00	27	26/10/2012 23:00	78.9	4.9	12.9	11	**7839.9**
05/12/2012 15:00	**15/12/2012 01:30**	**226.5**	**14/12/2012 18:30**	**39.6**	**6.1**	**8.4**	**107**	**5080.9**
20/12/2012 06:00	21/12/2012 14:30	32.5	20/12/2012 23:30	347.3	6.0	8.8	103	5436.3
18/01/2013 17:30	22/01/2013 07:30	86	21/01/2013 09:30	7.6	6.8	9.3	83	7978.4
06/02/2013 08:00	07/02/2013 08:30	24.5	06/02/2013 12:30	82.6	5.6	9.9	11	6039.7
07/03/2013 21:00	11/03/2013 04:00	79	08/03/2013 04:00	24.3	5.1	8.4	82	3667.4
18/03/2013 07:00	**25/03/2013 02:00**	**163**	**23/03/2013 10:30**	**4.5**	**7.3**	**9.3**	**89**	**9164.3**
23/05/2013 18:00	24/05/2013 12:00	18	23/05/2013 22:30	77.5	6.7	10.5	17	**9678.4**

General Storm Information					At Peak			
Start Time	**End Time**	**Duration (Hours)**	**Peak of Storm**	**Mean Direction Vector (Degrees)**	**Hs (m)**	**Tp (s)**	**Direction (Degrees)**	**Energy @ Peak (KJ/m/s)**
10/09/2013 13:00	10/09/2013 19:30	6.5	10/09/2013 14:00	79.3	4.4	9.2	11	3237.0
29/11/2013 22:30	30/11/2013 05:30	7	30/11/2013 00:30	82.8	5.6	10.7	11	7071.5
05/12/2013 14:00	07/12/2013 04:30	38.5	06/12/2013 20:00	80.4	4.7	14.3	6	8937.4
27/12/2013 09:30	27/12/2013 12:30	3	27/12/2013 10:00	249.3	4.1	6.1	202	1237.4

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.

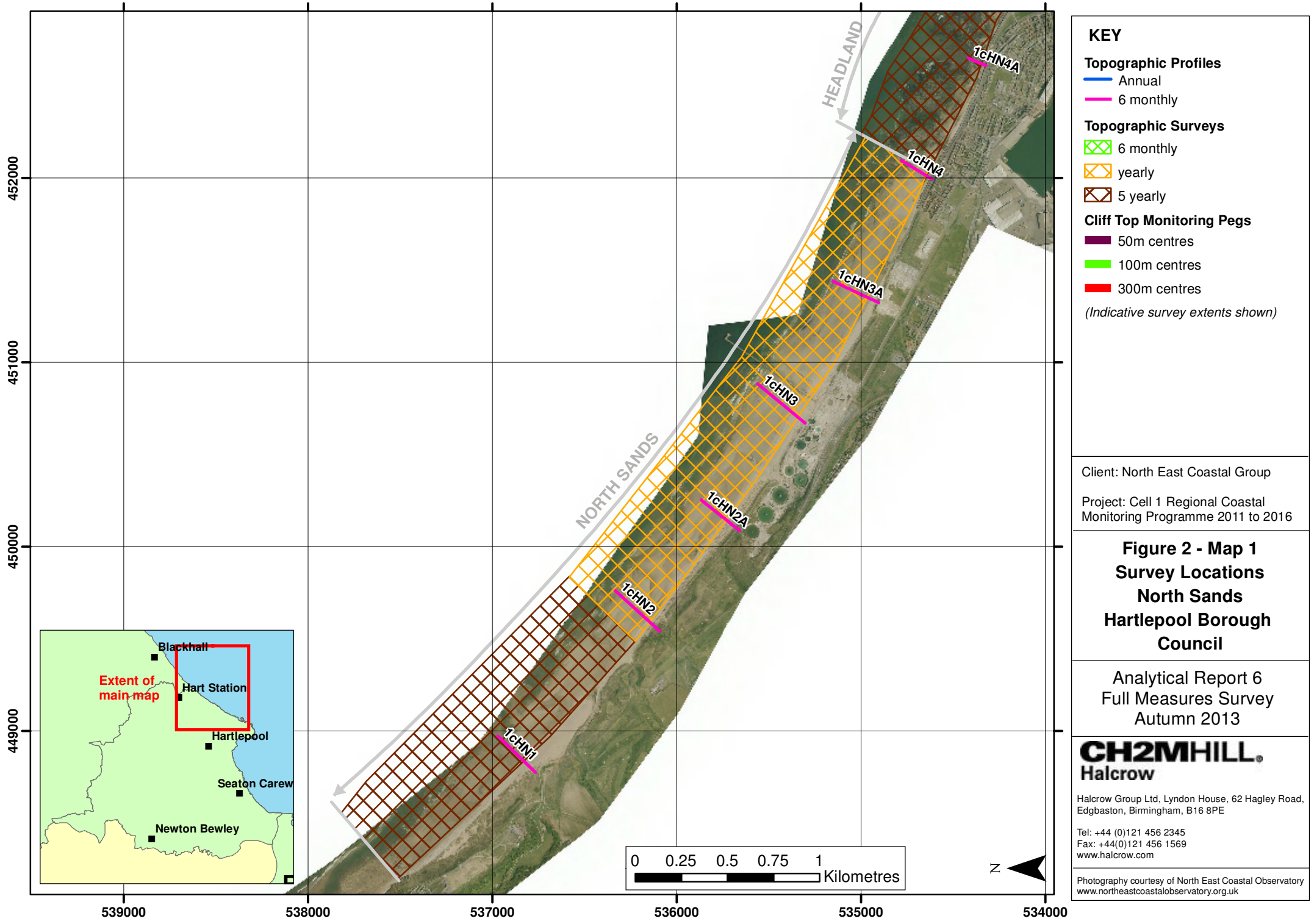
Comparing the annual storm records it can be seen that 2010 had the most storms, with 13 recorded. In 2010 the largest storm had an incident direction of 73 degrees which is unusual. We might therefore expect that the alongshore drift on the Cell 1 beaches in 2010 may have been atypical with unusual changes from the storm conditions. This was indeed noted in several of the 2010 Full Measures reports, for example the Hartlepool report noted unusual beach lowering along North Sands, and there was significant beach lowering at a number of locations at Sunderland.

The year with the fewest storms was 2011. This was reflected by accretion recorded in a number of the annual Full Measures reports, for example recovery of the beaches at North Sands and Middleton beaches in Hartlepool, and recovery of beaches was noted at Sunderland.

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, 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 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. However, the autumn 2013 full-measures survey data set which is assessed in this report was collected during September and October and so as no post storm surveys were available the impacts will not be seen until the Spring 2014 Partial Measures surveys

At Hartlepool and North Gare the surveys were carried out not long after the last storm in the record on the 10th September 2013. The North Sands frontage showed steepening and erosion of the seaward extent of the beach. At Middleton, where the reversal in the previous years trends may have been due to the easterlies which would have swept waves onto the shore and redistributed material in the bay.



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

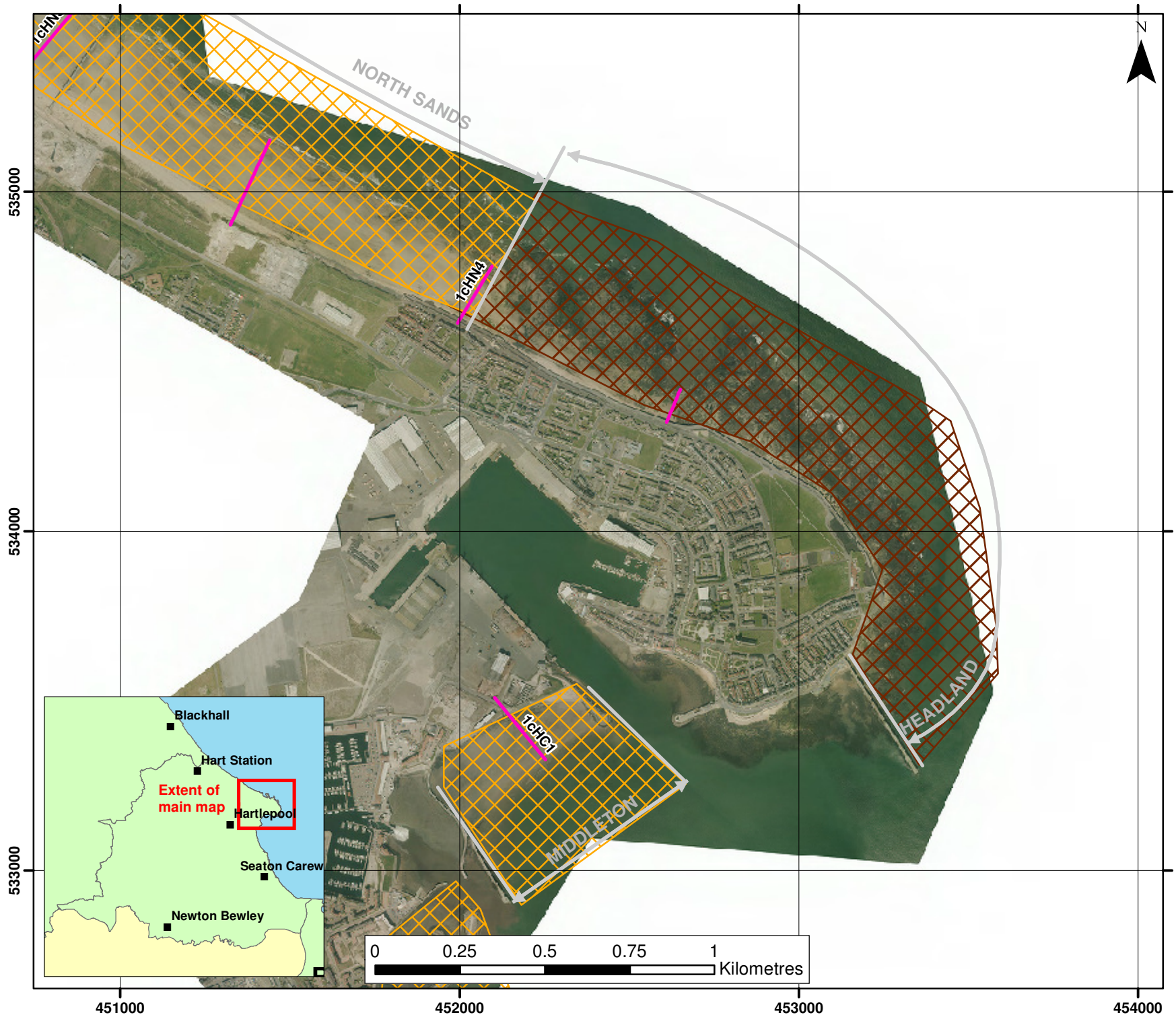
Figure 2 - Map 1 Survey Locations North Sands Hartlepool Borough Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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



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

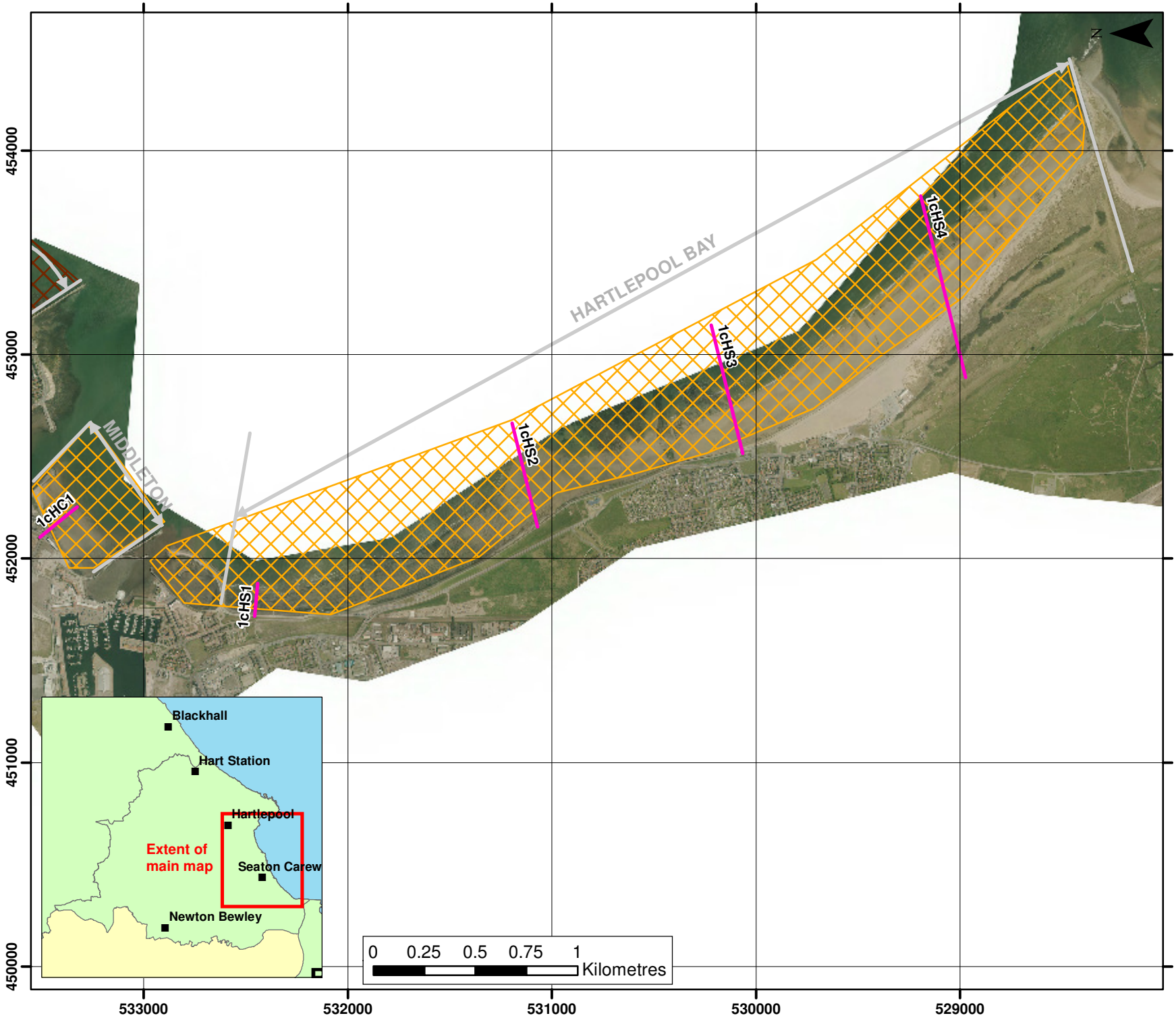
Figure 2 - Map 2
Survey Locations
Headland and Middleton
Hartlepool Borough Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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



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

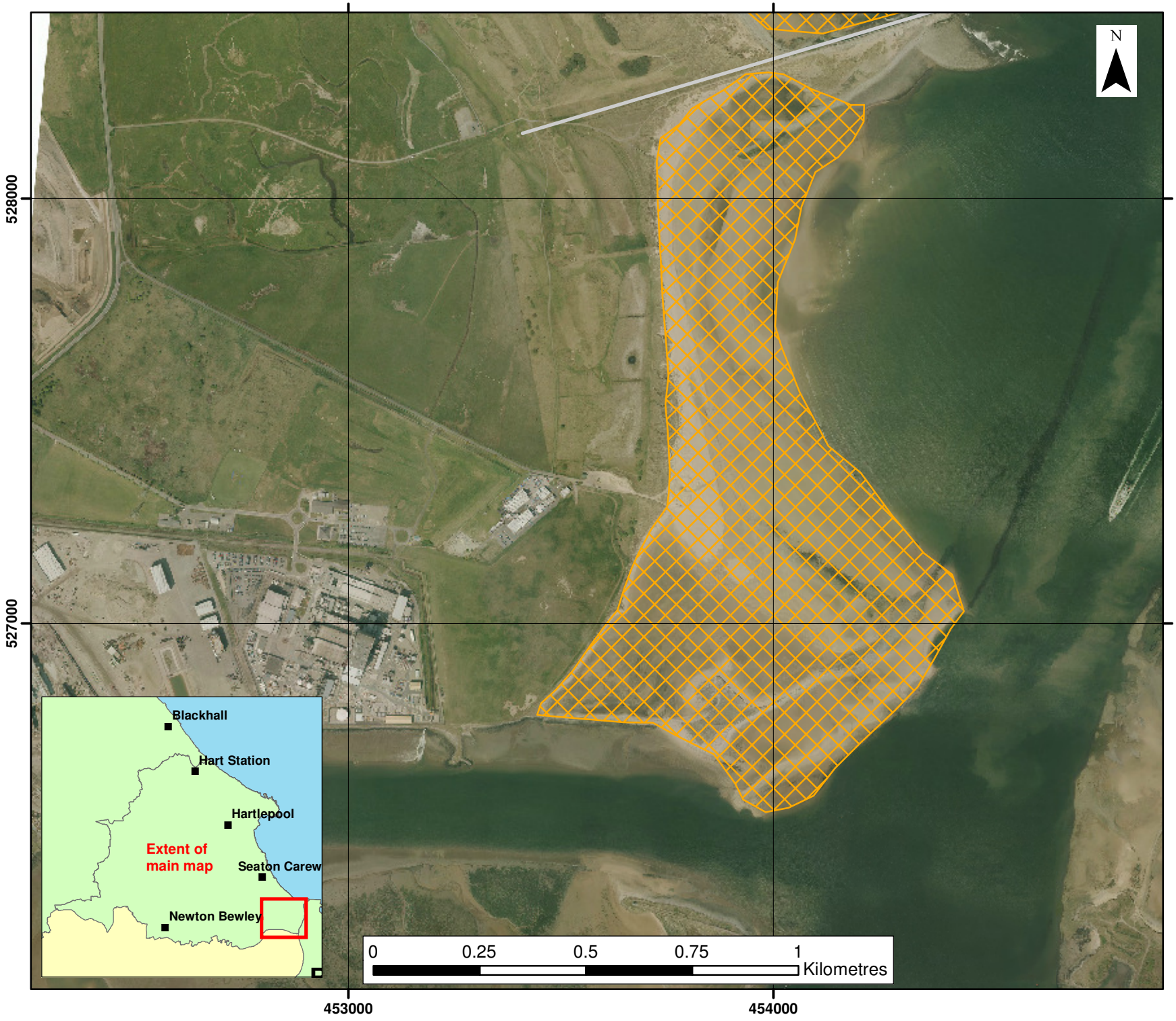
Figure 2- Map 3
Survey Locations
Hartlepool Bay
Hartlepool Borough Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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



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
Hartlepool North Gare
Hartlepool Borough Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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

3. Analysis of Survey Data

3.1 North Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
17th Oct 2013	**Beach Profiles:** North Sands is covered by four beach profile lines during the Full Measures survey (Appendix A). Profile **1cHN1** is located within Durham County Council's jurisdiction, about 400m north of the outfall of Crimdon Beck, but has been reported here so changes can be interpreted in association with those observed elsewhere along North Sands at HN2, HN3 and HN4. At **1cHN1** the beach above MHWS has changed very little. Below the level of MHWS, the upper beach has flattened, infilling a channel observed in April 2013. From 110m chainage to 170m chainage the beach has accreted by up to 0.7m. Between 170m and 195m chainage a channel has formed due to the erosion of 0.2m of material from the beach since April 2013. From 195m chainage to the end of the survey at 250m both the April and October profiles are dominated by a lower beach berm, thus there is little change in beach level. At Profile **1cHN2** the mound of material which was previously at the base of the dunes was much smaller in October 2013. Overall the beach had flattened, losing the two berms which were present in April 2013. From 60m chainage to 100m the beach has accreted by 0.5m. Between 100m and 130m chainage a berm had flattened, with the beach level dropping by 0.3m. From 130m to 170m chainage the beach had accreted by 0.4m. From 170m chainage to the end of the survey at 220m chainage the lower beach berm is present in both surveys, but the October 2013 profile is 0.3m lower than in April 2013. Profile **1cHN3** has developed a fore-dune since 2008. The fore-dune has accreted by 0.1m since April 2013. From the crest of the foredune at 35m chainage to 110m chainage the beach has accreted by 0.5m. Between 110 and 145m there has been little change, with the beach fluctuating by 0.2m. From 145m to the end of the survey at 220m chainage the lower beach berm has dropped by up to 1m. At Profile **1cHN4** the section above MHWS was stable over the summer of 2013. The beach from 15m to 95m has eroded by 0.4m since April 2013. From 95m chainage to the end of the survey at 200m chainage the beach level has dropped to a low level compared to previous surveys, A significant amount	All of the North Sands frontage has been subject to steepening at the seaward extent of the beach. Profile HN4 is the exception, where the lower beach has remained stable between April and October 2013, this is due to the exposure of the rocky shore platform In both surveys. The steepening of the lower beach may be due to net erosion or a transfer of material towards the upper beach during a single storm, such as that experienced on the 10th September. The topographic plots for Autumn 2012 to Autumn 2013 also show erosion of the beach, especially towards MLW. While some of the pattern of change is related to migration of berms, overall there has been erosion and steepening of beach through 2013. The erosion may have been due to the storms that affected the area a week before the surveys, or a longer term trend. **Longer term trends**: Past surveys in 2011 and 2012 show more obviously shore parallel changes, related to migration of berms and consequently the pattern of more widespread erosion seen in 2013 is unusual over the monitoring period. All annual change plots have shown accretion in front of the site of the former Britmag works site, although the shape of the

Survey Date	Description of Changes Since Last Survey	Interpretation
	of rock was exposed in the foreshore during the October 2013 survey. **Topographic Survey:** North Sands is covered by an annual topographic survey. Data from the 2013 Full Measures survey have been used to create a DGM (Appendix B – Map 1a) using a GIS package. The plot shows that small berms have formed during 2013. The majority of the frontage is characterised by shore-parallel contours. In the north-west half of the frontage contours highlight two streams with channels running across the beach. The GIS has also been used to calculate the differences between the Autumn 2012 and Autumn 2013 topographic survey, as shown in Appendix B – Map 1b, to identify areas of net erosion and accretion. Overall 2013 has been dominated by erosion. North of the jetty there are shore parallel strips of erosion of more than 1m. Just to the north of the jetty the whole foreshore has accreted by up to 0.5m. South of the jetty the erosion recorded is more modest at around 0.5m, at the seaward extent the beach has eroded by 1m. The difference plot from the previous Full Measures report (2012), shows that between Autumn 2011 and Autumn 2012 the difference in the level of the beach was smaller, with a mix of erosion and accretion. The widespread erosion recorded between Autumn 2012 and Autumn 2013 is therefore unusual. **Long Term Topographic Trends Autumn 2008 to Autumn 2013:** The long term difference plots (Appendix B – Map 1c) provide information on net of change in beach levels between Autumn 2008 and Autumn 2013 at North Sands. The plot shows an uneven distribution of erosion and accretion with changes of over 1m generally associated with shore-parallel linear strips near MLW. Accretion was recorded at the centre of the frontage near the water works, and in the northern and southern extremes.	accretionary area changes annually. Accretion may be due to the effects of the jetty on waves and sediment transport or the removal of former pipelines that crossed the beach or the placement of material on the beach during the demolition and site remediation works. **Autumn 2008 to Autumn 2013 trends** The long-term change plot shows a clear difference between the widespread erosion south of the jetty and shore parallel changes to the north. Over this period, the beach appears to be steepening with erosion of up to 2m recorded at the seaward extent of the survey. Erosion of up to 1m dominated the rest of the beach. The consistent accretion in front of the former works site has been shown in many of the annual plots and may be due to the number of pipes and outlets on the beach and the demolition and site remediation work that has been ongoing. There is also accretion in the north and south extent of the survey.

3.2 Middleton

Survey Date	Description of Changes Since Last Survey	Interpretation
17th Sept 2013	**Beach Profiles:** Middleton is covered by one beach profile line during the Full Measures survey (Appendix A). The beach at Profile **1cHC1** was high in the upper and lower beach, while the mid beach was at its lowest recorded level since 2008. The face of the seawall has not changed. The toe of the seawall, between 45m and 65m chainage, has accreted by 0.7m since April 2013. For the rest of the survey the difference between the April and September 2013 beach levels is minimal. **Topographic Survey:** The frontage is covered by an annual topographic survey between Middleton Jetty and North Pier. Data from the 2013 Full Measures survey have been used to create a DGM (Appendix B – Map 2a) using GIS software. The beach contours recorded in 2010 to 2012 showed the beach in the east, adjacent to the harbour breakwaters, was steeper than the western section. However, in the autumn 2013 survey these differences were less marked. The GIS has also been used to calculate the differences between the Autumn 2012 and Autumn 2013 topographic surveys, as shown in Appendix B – Map 2b, to identify areas of net erosion and accretion. The difference plot shows a clear distinction between two zones separated by a zone of zero change between MHW in the east and MLW in the west. The upper and western part of the beach is dominated by erosion of up to 0.75m while the lower and eastern parts of the beach, adjacent to the breakwaters have accreted by up to 1m. **Long Term Topographic Trends Autumn 2008 to Autumn 2013:** The long term plot of change at Middleton (Appendix B – Map 2b) shows a similar pattern and magnitude of change to plot covering the last year. However the magnitude of change is smaller, suggesting that annual changes are more significant than the net long term change. In all cases, it appears there is a net drift of sediment towards the east.	The September 2013 profile was concave while previous profiles were smooth or convex. This change in shape meant the upper and lower beaches were near the highest recorded while the mid beach was near the lowest since 2008. **Longer term trends**: the beach had an observed increase in steepness towards the east, where it abuts the breakwater. This pattern was recorded in all previous data. The difference plot for the past 12 months shows the pattern comprises erosion in the west and accretion in the east. The change in the morphology of a small beach such as this is likely to be due to the storm of 10th September. **Autumn 2008 to Autumn 2013 trends** The long term plot of change between 2008 and 2013 shows a similar pattern to the past 12 months, with erosion in the west of the bay and accretion in the east. The magnitude of change in the 2008-2013 difference plot is less than the changes observed in the 2012-2013 plot, which suggests annual variability, but longer-term stability of the bay. During defence inspections in Autumn 2012 the low beach levels at the root of the North Pier were exposing voids in the toe apron. Further beach lowering over the last year raises concern over undermining to the structure.

3.3 Hartlepool Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
23th Oct 2013	**Beach Profiles:** Hartlepool Bay is covered by four beach profile lines during the Full Measures survey (Appendix A). Profile **1cHS1** is located approximately 150m south of the root of the South Pier. The profile starts at the wall to the rear of the promenade and extends across the promenade, over the fronting concrete splash wall and down the sloping face of the rock armour revetment before reaching the beach. It then gently slopes down to low water. Little has changed between 0 and 40 metres chainage over the summer of 2013. From 40m to 65m chainage the beach level has increased by 0.3 since April 2013. Between 65m and the end of the survey at 75m there has been very little change. Profile **1cHS2** had developed two berms in October 2013, compared to the single berm in the April profile. Between 30m and 40m chainage the beach has eroded by 0.2m. There was little change between 40m and 60m chainage. From 60m to 130m chainage the beach has eroded by 0.2m. The beach has accreted by 0.4m between 130m and 190m chainage, where a dip has infilled. From 190m to the end of the survey at 300m chainage the beach has remained stable between April and October 2013. At profile **1cHS3** the October 2013 profile has flattened and steepened compared to the April 2013 profile. From the face of the seawall at 25m chainage to 110m chainage the beach has accreted by 0.5m. Between 110m and 150m the beach has accreted by 0.2m. From 150 to 210m the beach has eroded by 0.4m. At the end of the survey a berm has formed by the accretion of 0.5m since April 2013. The profile **1cHS4** is located further south, around 1km north of the North Gare breakwater. It is in the area of undefended dunes at Seaton Sands. The profile covers approximately 350m of dunes before reaching the open coast. The dune section looks reasonably stable, a foredune appears to be accreting at around 320m chainage. Overall, on the beach the slope below HAT has become very steep and, as a result, is a short beach. From 320m to 410m chainage the beach has accreted by a maximum of 1.5m since April 2013. From 410m to the end of the survey at 470m the April 2013 berm has eroded, resulting in a drop in level of around 1m.	The October 2013 beach profiles show that HS2 and HS3 have become more concave. Profiles HS1 and HS4 are much steeper than any of the previous profiles dating back to 2009. The profiles which are steep are often have the highest recorded upper beach and the lowest recorded lower beach. The concave profiles had notably low beach levels in their centre. At HS4 the foredune continues to accrete showing that the dunes are in good condition. This pattern of accretion is reflected in the topographic survey data in this area. The topographic difference plot shows erosion of the mid beach in the centre of the frontage, which agrees with the more concave beach profiles recorded. The north has accreted, but the south has been subject to erosion in the lower beach and accretion in the upper beach, which reflects the steepening discussed in HS4. The changes recorded have been within a range of 1m for the majority of the frontage. **Longer term trends**: The beach change was complex in 2011 and 2012 with no clear patterns of accretion or erosion. However, the changes observed in 2013 were more significant, with many areas showing a reverse of their direction of change. **Autumn 2010 to Autumn 2013 trends**

Survey Date	Description of Changes Since Last Survey	Interpretation
	Topographic Survey: Hartlepool Bay is covered by an annual topographic survey between the South Pier and the North Gare Breakwater. Data from the 2013 Full Measures survey have been used to create a DGM (Appendix B – Map 3a) using a GIS software package. The plot shows the two smaller bays within the larger Hartlepool Bay frontage. These smaller bays are separated by a slight or promontory at Carr House Sands between Hartlepool and Seaton Carew, which has a steeper beach face. The rest of the bay has a more gently sloping beach slope. The GIS has also been used to calculate the differences between Autumn 2012 and Autumn 2013 topographic survey, as shown in Appendix B – Map 3b, to identify areas of erosion and accretion. The changes recorded over 2013 show a series of continuous shore parallel bands of change, with a strip of erosion of up to 1m dominating the frontage. This is separated by areas of accretion towards MLW and MHW The alignment of the bands of change is slightly different to that of the coastline, which is indented, and consequently the zone of erosion abuts the cliff edge in the northern and southern parts of Hartlepool Bay, and covers the mid-beach area in the centre of the frontage. **Long Term Topographic Trends Autumn 2010 to Autumn 2013:** The net changes observed between the first full measures survey in 2010 and the most recent in Autumn 2013 are shown in Appendix B – Map 3c. The plot shows a very similar pattern of change to that seen over the past year, but with slightly greater magnitudes of change that commonly reach ±1m.	The long term difference plots show that over the last three years the evolution of the bay is different in the two constituent smaller bays, with moderate change in the north and larger change in the south. The southern part of the bay has been steepening with widespread erosion on the lower beach and accretion on the upper beach. The northern bay has generally accreted throughout, although there is localised erosion, probably associated with migration of berms. Some of the changes seen in the difference plots at the back of the beach near the south of Seaton Carew are likely to be due to the construction works at the pumping station that were ongoing in autumn 2012.

3.4 North Gare

Survey Date	Description of Changes Since Last Survey	Interpretation
11th October 2013	**Topographic Survey:** North Gare is covered by an annual topographic survey between the North Gare Breakwater and the Seaton on Tees Channel. The area is designated as the Teesmouth National Nature Reserve. This year is the first year that the area has been described as part of the reporting for the Hartlepool Region although surveys have been carried out since Autumn 2011. Data from the 2013 Full Measures survey have been used to create a DGM (Appendix B – Map 4a) using GIS software. The beach contours recorded in 2013 show the promontory and the contours running shore parallel the beach in the north has a much shallower angle than the beach in the south, which is steep. The GIS has also been used to calculate the differences between the Autumn 2012 and Autumn 2013 topographic surveys, as shown in Appendix B – Map 4b, to identify areas of net erosion and accretion. The difference plot shows that the part of the frontage facing Teesmouth have shore parallel bands of accretion and erosion. In the bay near North Gare breakwater there has been erosion of up to 0.75m in the upper and lower beach while the central part of the beach has accreted by up to 1m. A large area around the point of land at North Gare Sands has eroded by 0.75m, while there has been accretion on the landward of the point. The flat top of the promontory and the part of the frontage adjacent to the Seaton on Tees Channel has a patchy distribution of change limited to ±0.25m with no discernible trend. **Long Term Topographic Trends Autumn 2011 to Autumn 2013:** The long term plot of change at North Gare (Appendix B – Map 4c) is very similar to the plot for Autumn 2012 to Autumn 2013. There is little change on the flat part of the promontory which comprises stable sandflats. The remainder of the frontage is characterised by shore parallel bands of accretion and erosion within ±1m.	The area of sand south of the North Gare Breakwater has been subject to three clear zones of change between Autumn 2012 and Autumn 2013. Nearest the breakwater, the beach has accreted and eroded in shore parallel bands, reflecting migration of berms. The tip of the promontory has experienced consistent erosion and the sandflats further up the estuary mouth have shown little change. **Longer term trends**: Data has only been collected at this location since 2011 and therefore the context of changes is unknown. **Autumn 2011 to Autumn 2013 trends** The longer-term change shows a similar pattern to that experienced over the past 12 months suggesting stability of this landform, however, more years' data are needed to better understand patterns and trends.

4. Problems Encountered and Uncertainty in Analysis

Beach profile HN1 is located within Durham County Council's jurisdiction but has been reported here so changes can be interpreted in association with those observed elsewhere along North Sands, along HN2, HN3 and HN4.

At Hartlepool South major excavation work was being carried out on the beach, including digging a deep hole these works have been ongoing since 2012. The excavation were assumed to be related to the replacement of buried outfall pipeline. There was also a fenced off area due to deep excavations for replacement of sea wall. Approximately half of the wall is completed at time of survey.

At North Gare the flat upper beach to the south and the area south of the breakwater was very soft sand. As a result, the surveyor was unable to complete south west corner of survey.

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

No changes are needed at the present time.

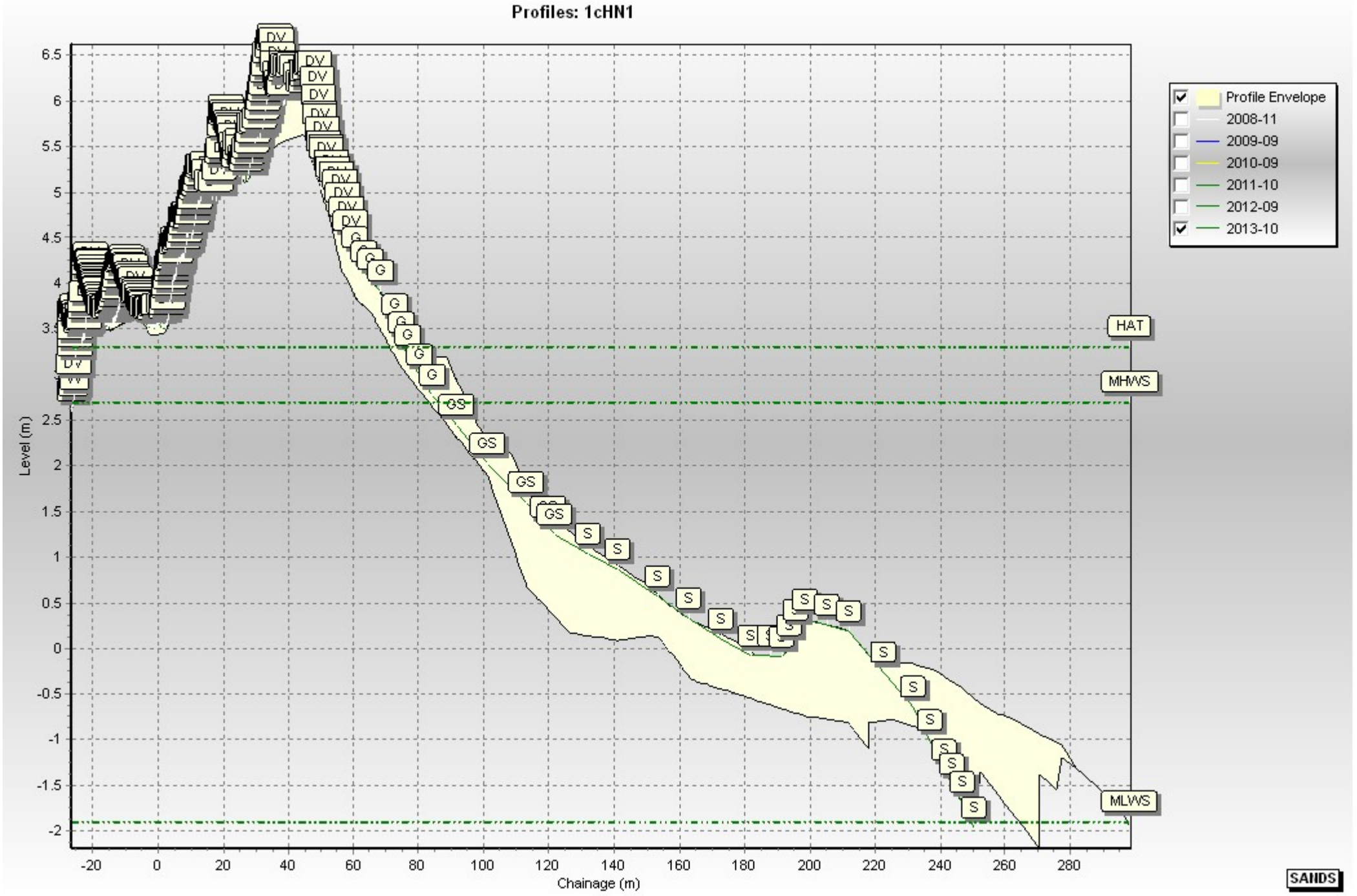
6. Conclusions and Areas of Concern

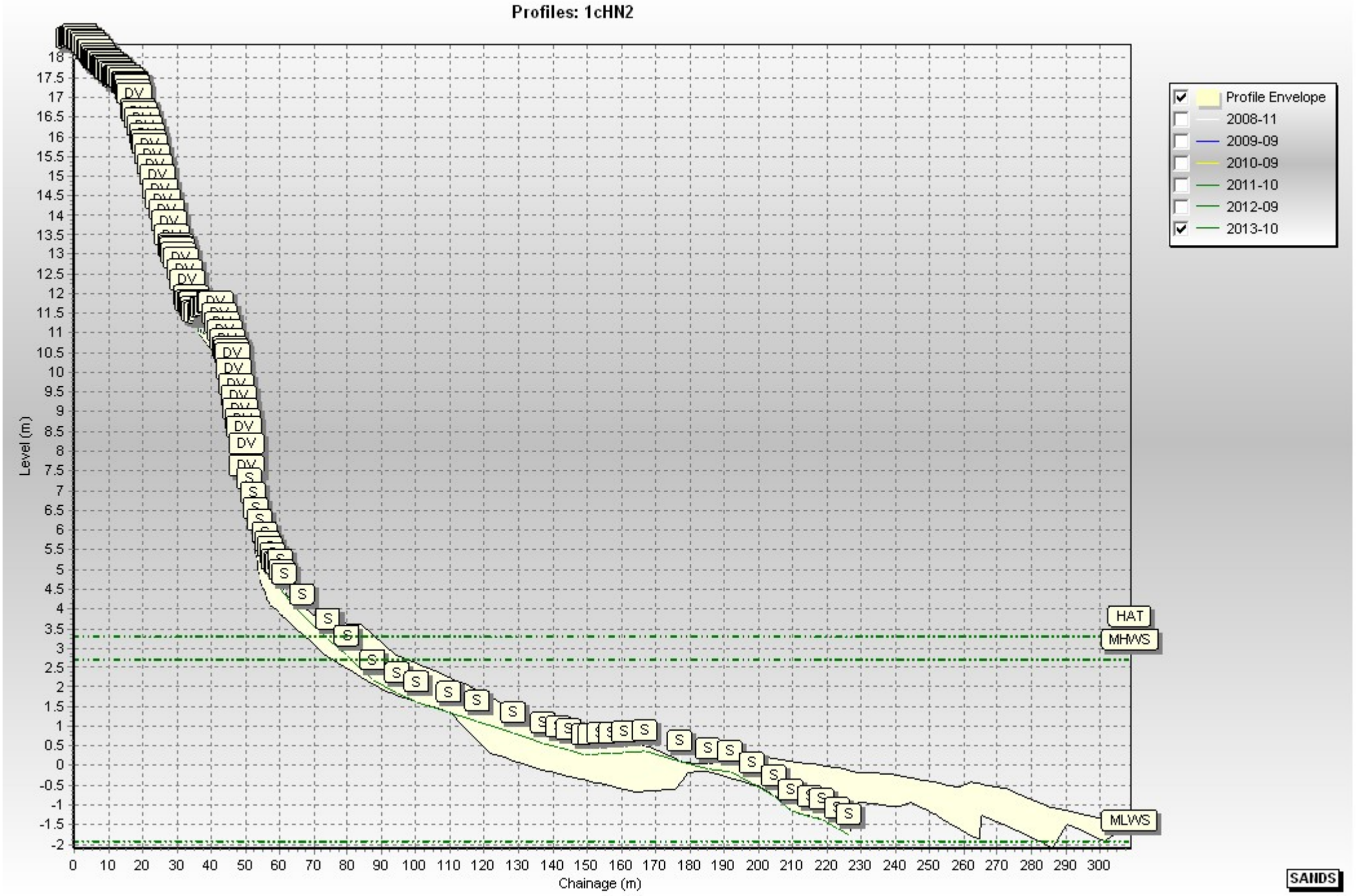
- At North Sands the topographic plots for Autumn 2012 to Autumn 2013 show erosion at the seaward extent of the beach, which supports the changes shown in the beach profiles. Over 2013 there has been erosion throughout the frontage. The difference plots show a beach which is eroding and steepening overall. The exception is the accretion in front of the works in the centre of the bay. There is no cause for concern.
- At Middleton, the beach had an observed increase in steepness as you move east. This change was also recorded in the 2010, 11 and 12 Full Measures plots. The Autumn 2013 plots show shore parallel contours with a slight increase in steepness at the eastern end. The difference plot for Autumn 2012 to Autumn 2013 reflect this change with erosion in the west and accretion in the east. This may have been due to the movement of beach material due to the 10th September storm. The low beach levels adjacent to the north breakwater may be a cause for concern
- The topographic difference plot at Hartlepool Bay shows erosion of the mid beach in the centre of the frontage, which agrees with the more concave beach profiles recorded. The north has accreted, but the south has been subject to erosion in the lower beach and accretion in the upper beach, which reflects the steepening observed at HS4. The changes recorded have been within a range of 1m for the majority of the frontage. There is no cause for concern
- This year is the first year that data from the beach south of the North Gare has been analysed. The topographic plots show: the section facing the open ocean is subject to changes associated with migration of berms; the tip of the promontory has eroded; and the sandflats are stable. There is no cause for concern.

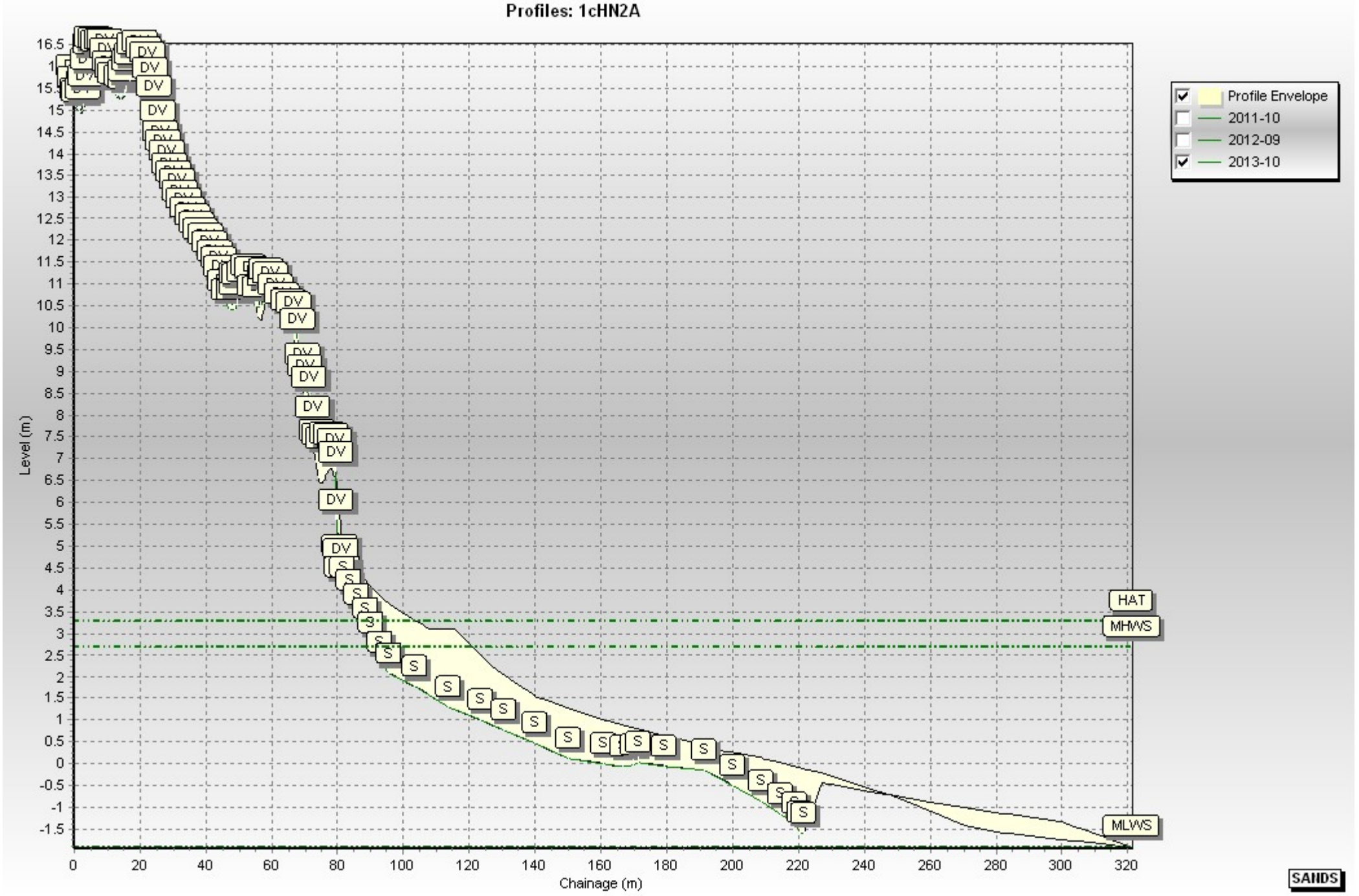
Appendices

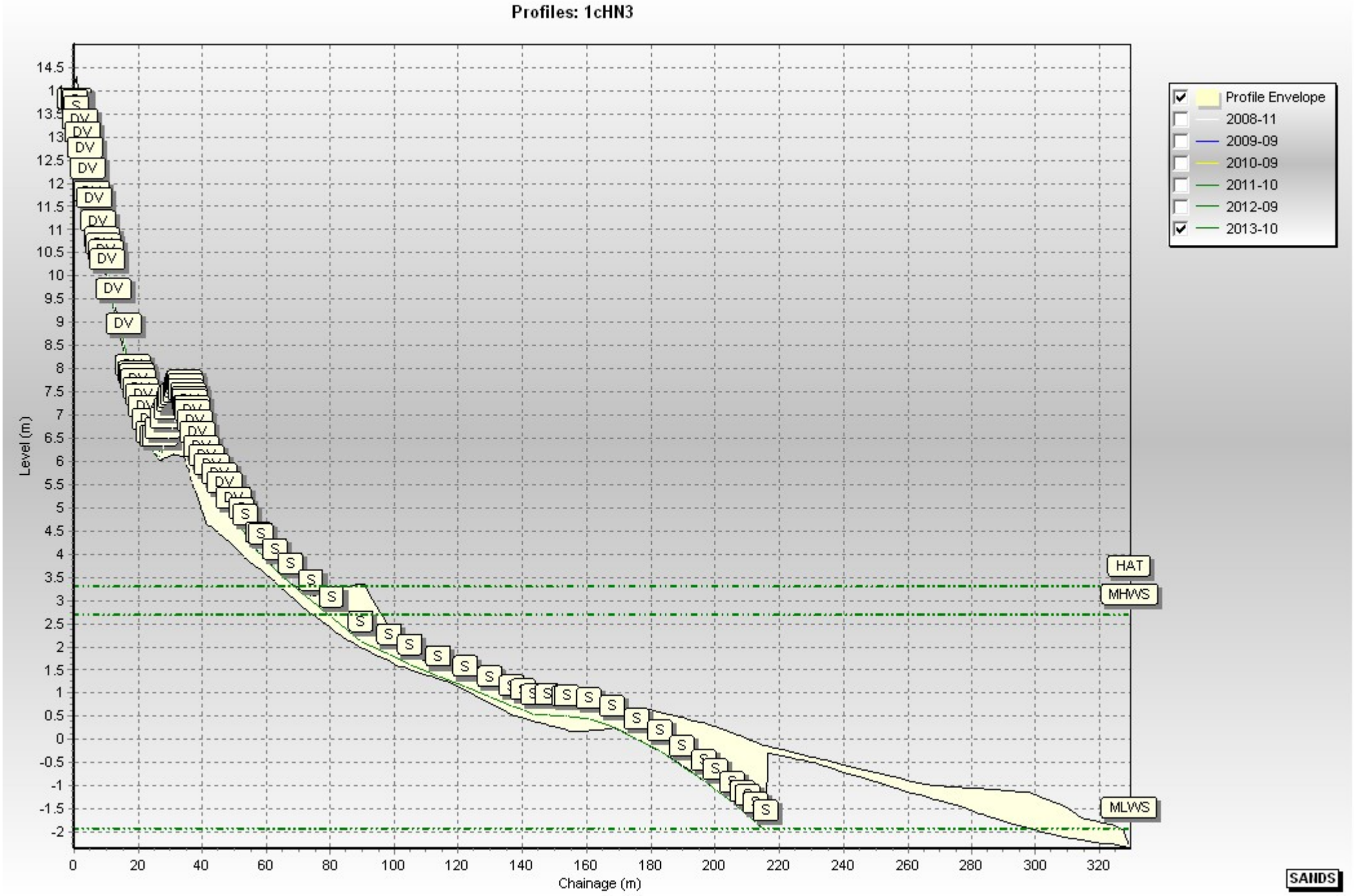
Appendix A

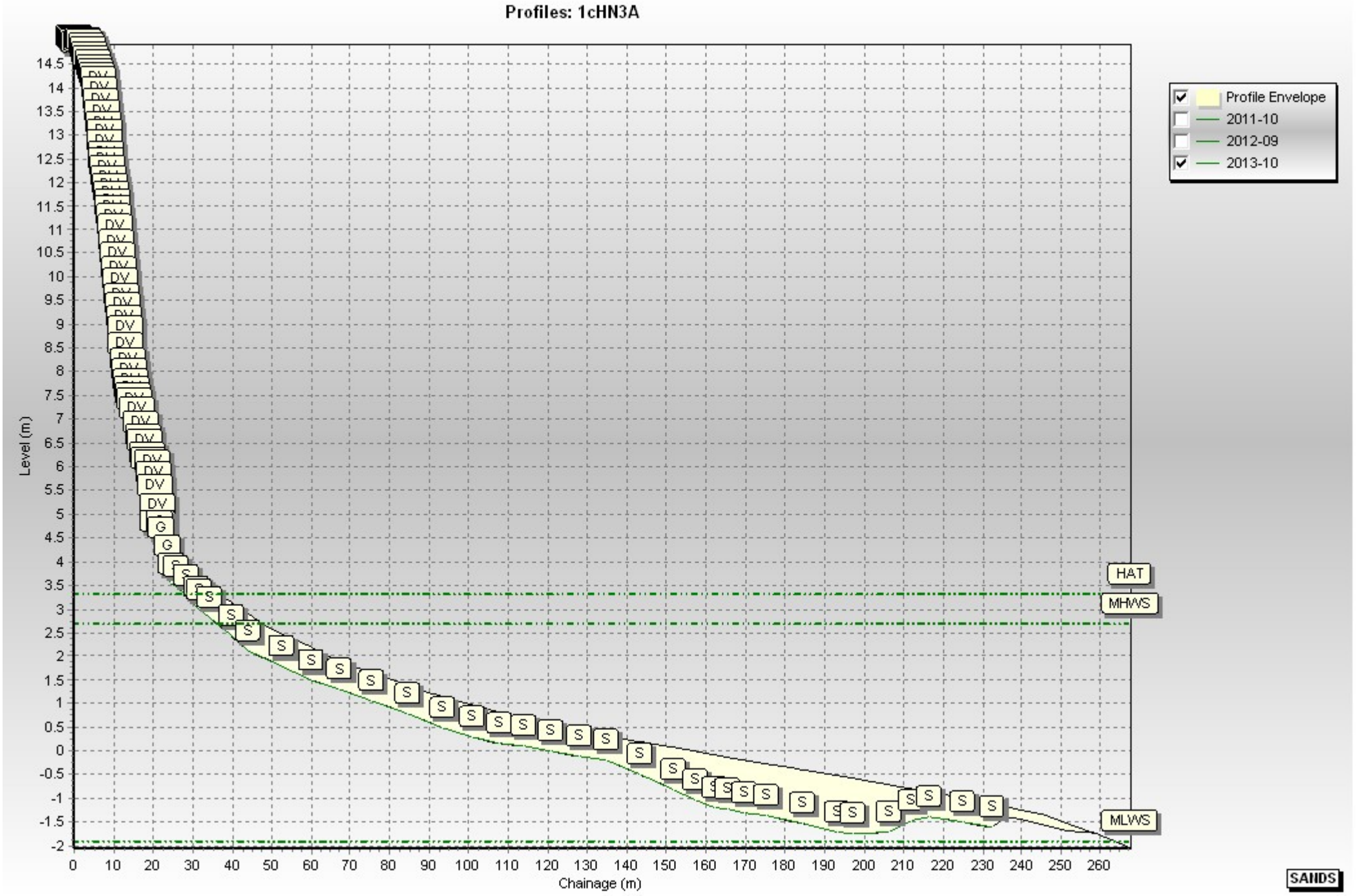
Beach Profiles

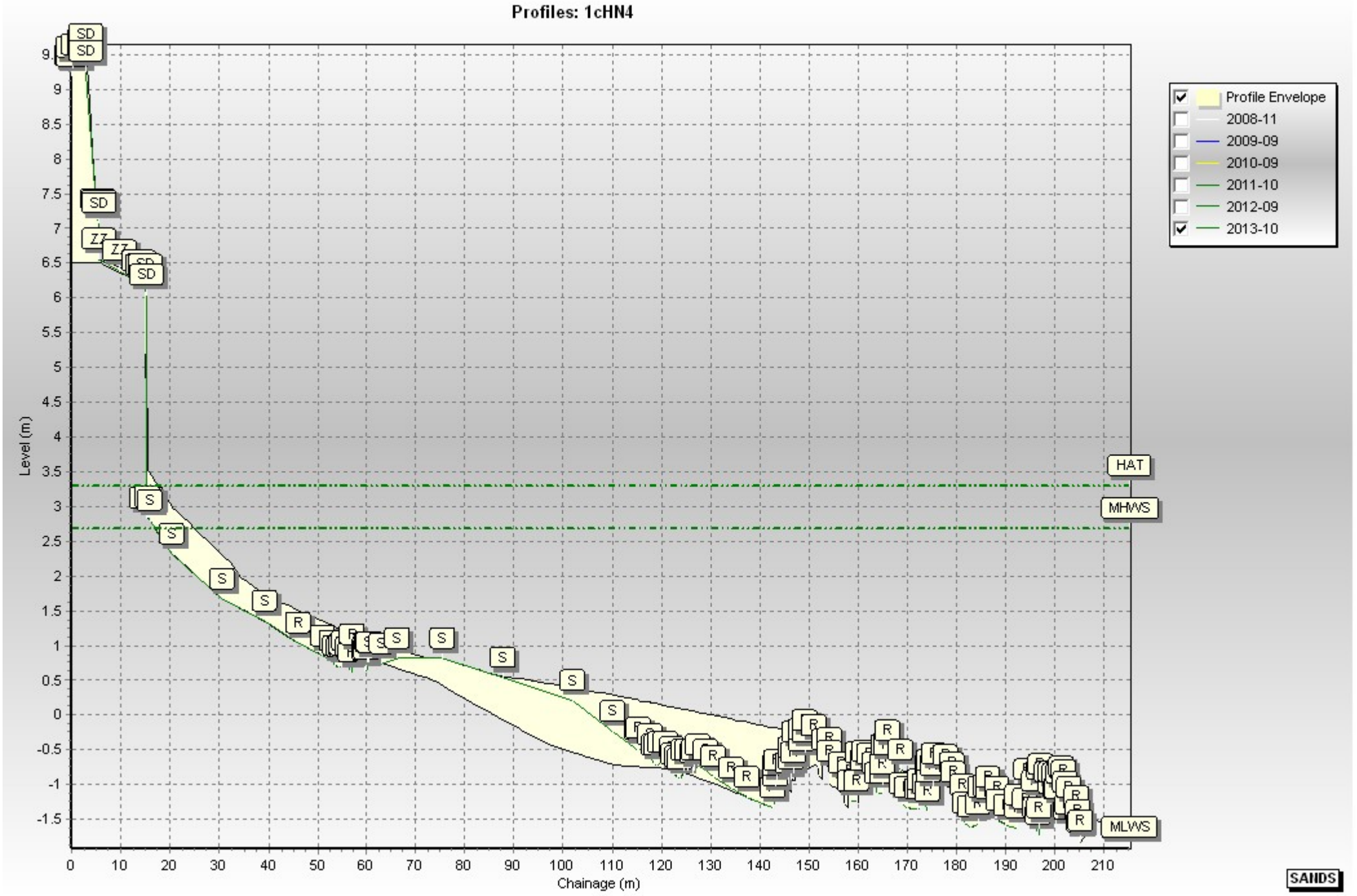

Profiles: 1cHN1
Profile Envelope
2008-11
2009-09
2010-09
2011-10
2012-09
2013-10
HAT
MHWS
MLWS
Level (m)
Chainage (m)
SANDS

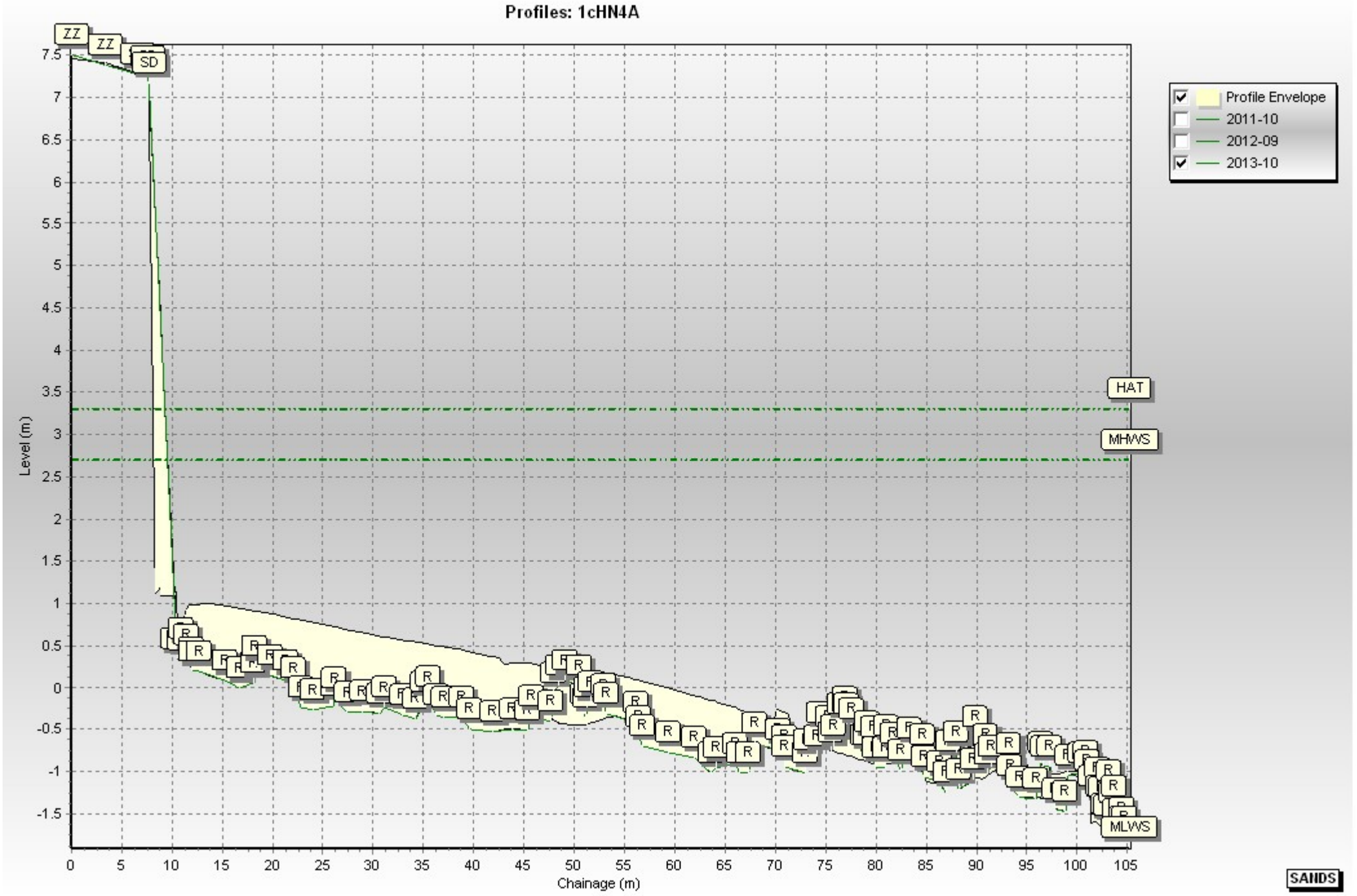

Profiles: 1cHN2
Profile Envelope
2008-11
2009-09
2010-09
2011-10
2012-09
2013-10
HAT
MHWS
MLWS
Level (m)
Chainage (m)
SANDS

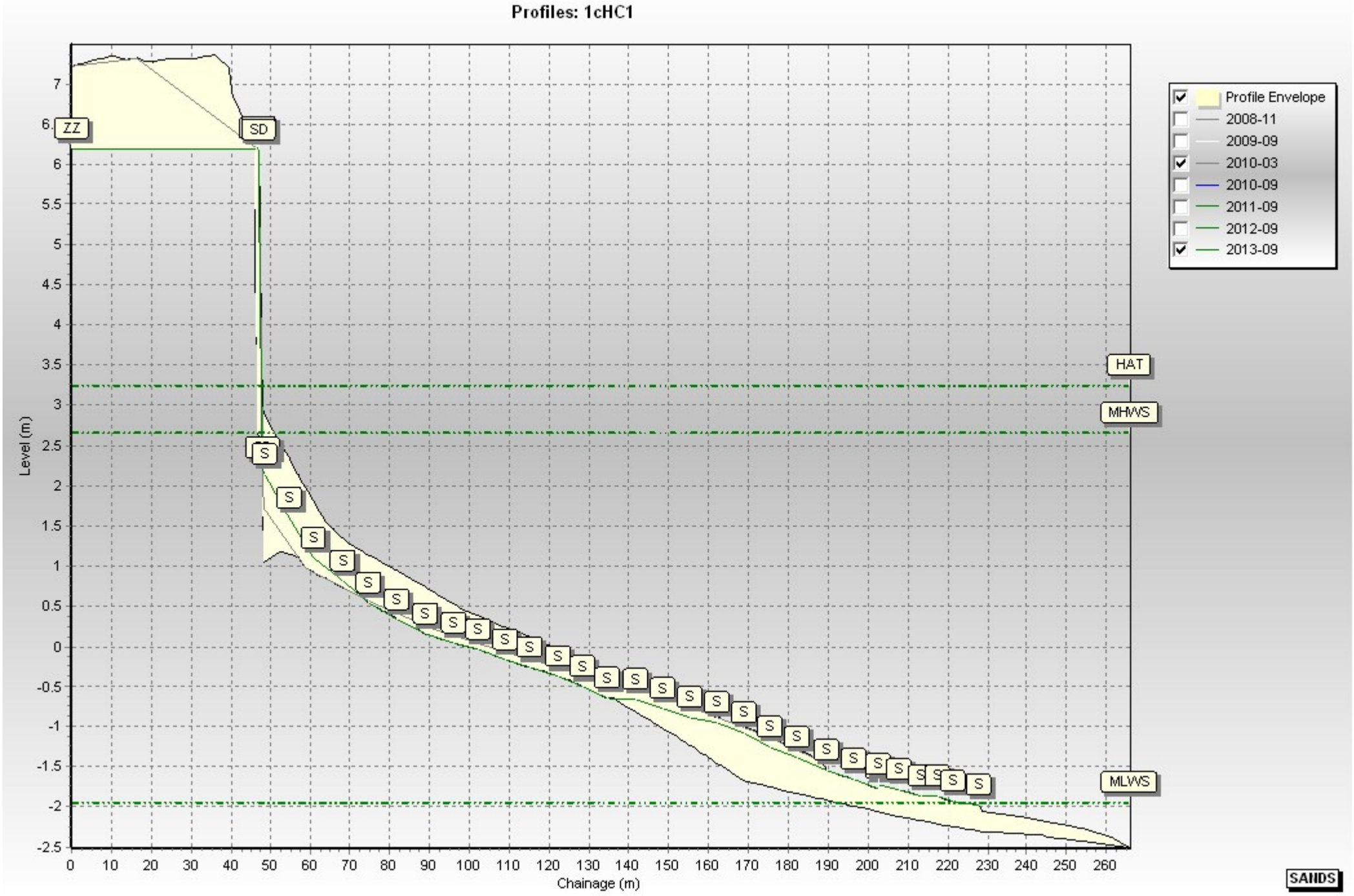

Profiles: 1cHN2A
Profile Envelope
2011-10
2012-09
2013-10
HAT
MHWS
MLWS
DV
S
Level (m)
Chainage (m)
SANDS

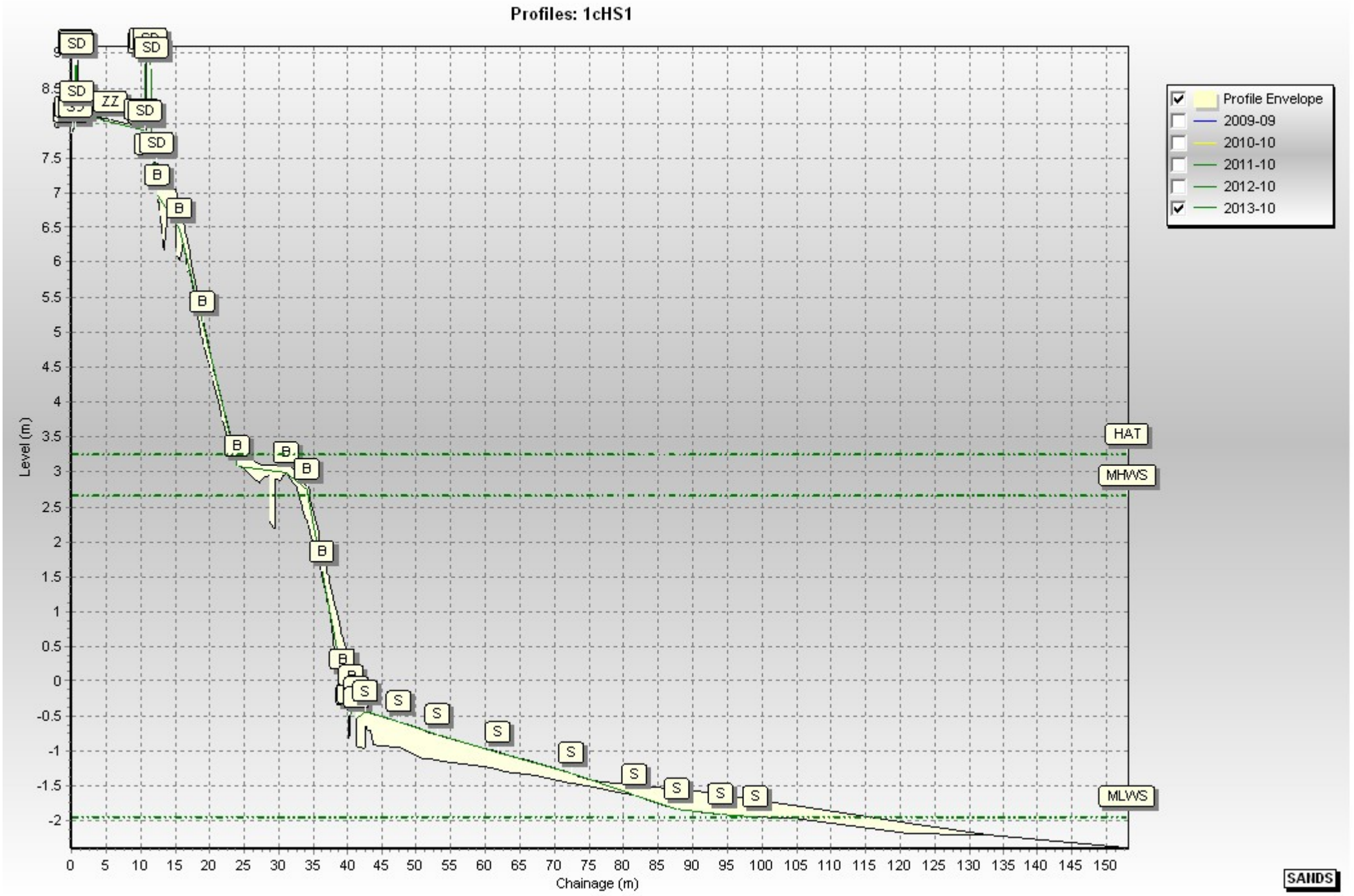

Profiles: 1cHN3
Profile Envelope
2008-11
2009-09
2010-09
2011-10
2012-09
2013-10
HAT
MHWS
MLWS
Level (m)
Chainage (m)
SANDS

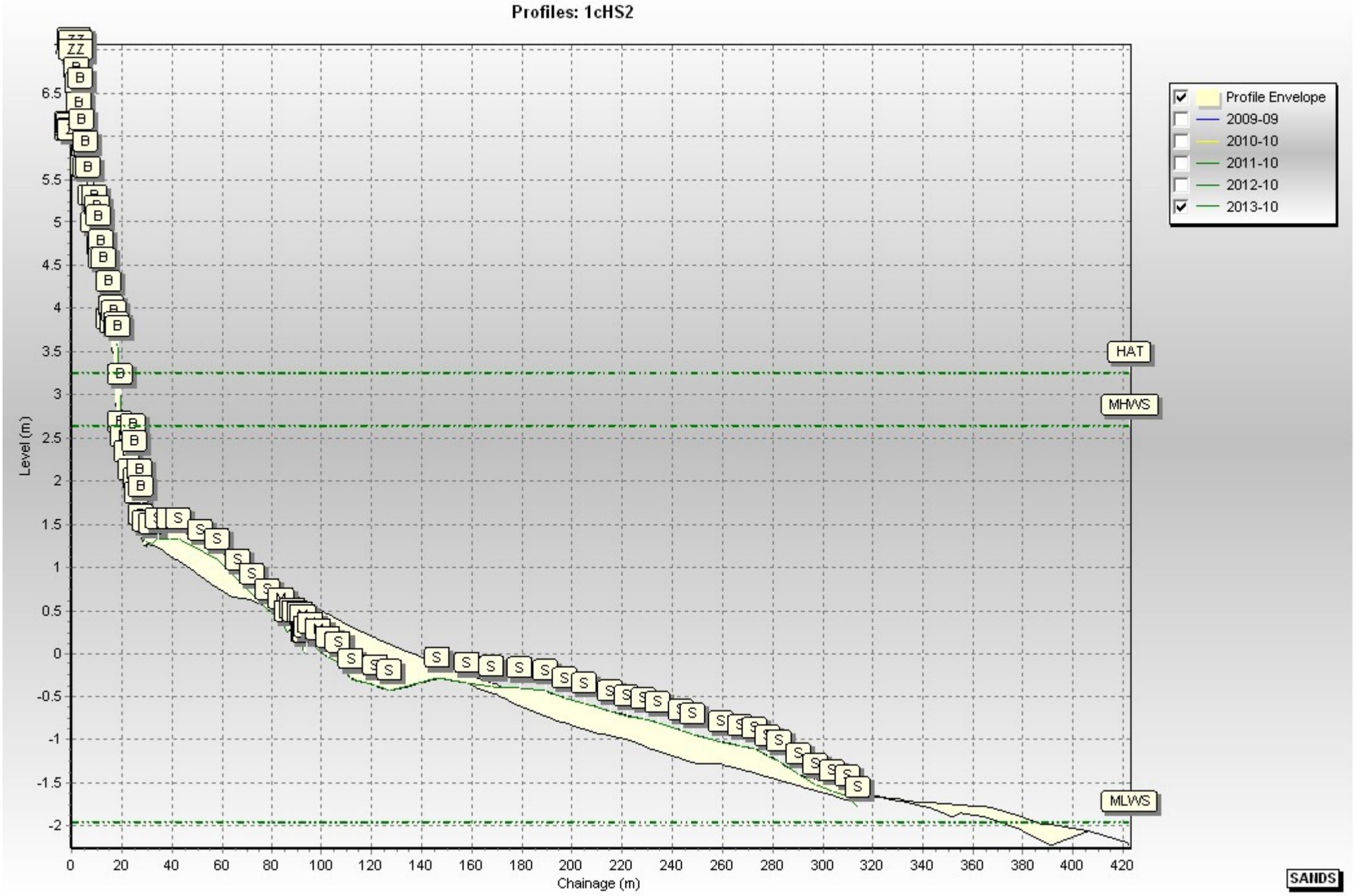

Profiles: 1cHN3A
Profile Envelope
2011-10
2012-09
2013-10
HAT
MHWS
MLWS
Level (m)
Chainage (m)
SANDS

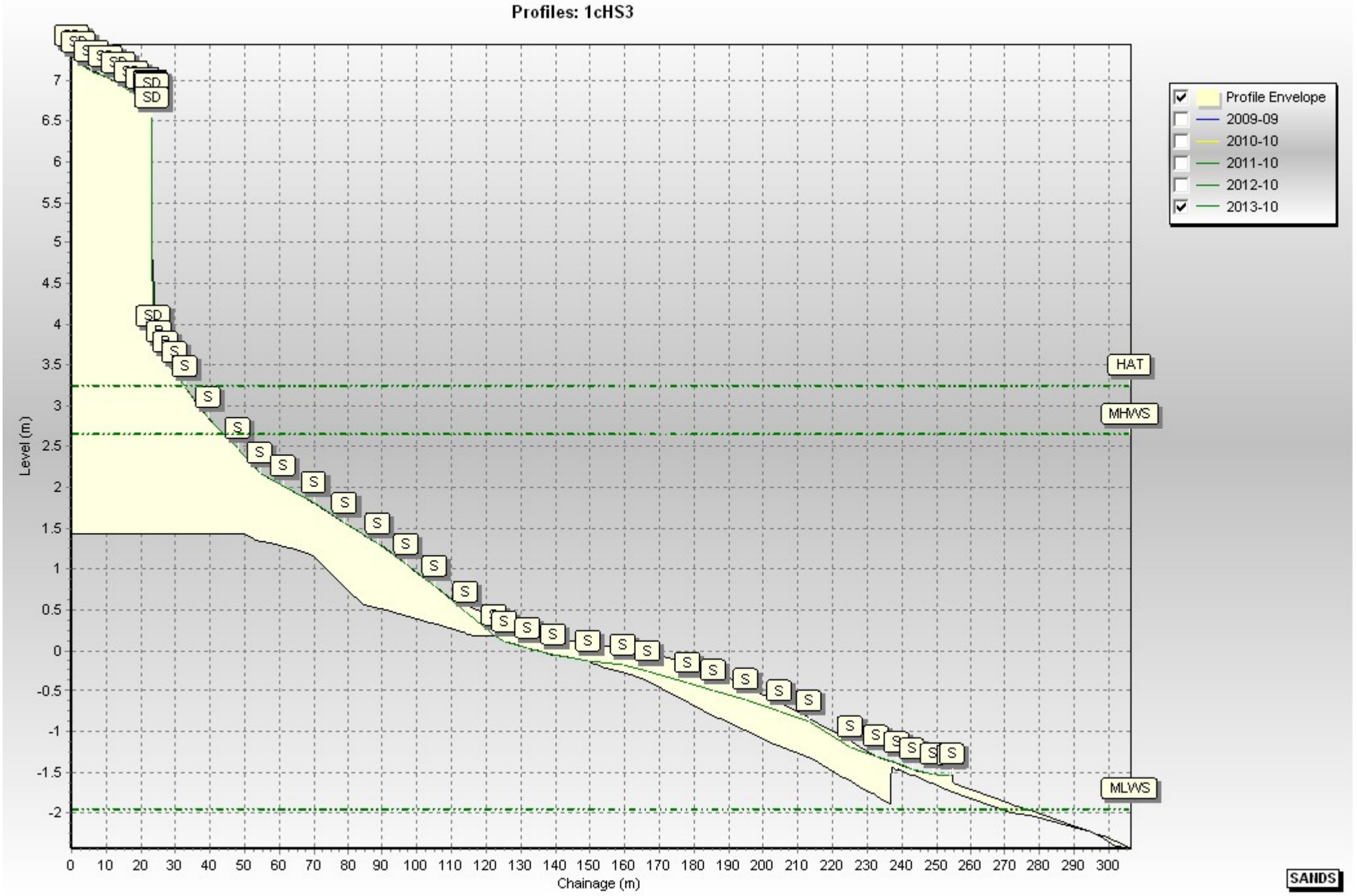

Profiles: 1cHN4
Profile Envelope
2008-11
2009-09
2010-09
2011-10
2012-09
2013-10
HAT
MHWS
MLWS
Level (m)
Chainage (m)
SD
S
R
SANDS

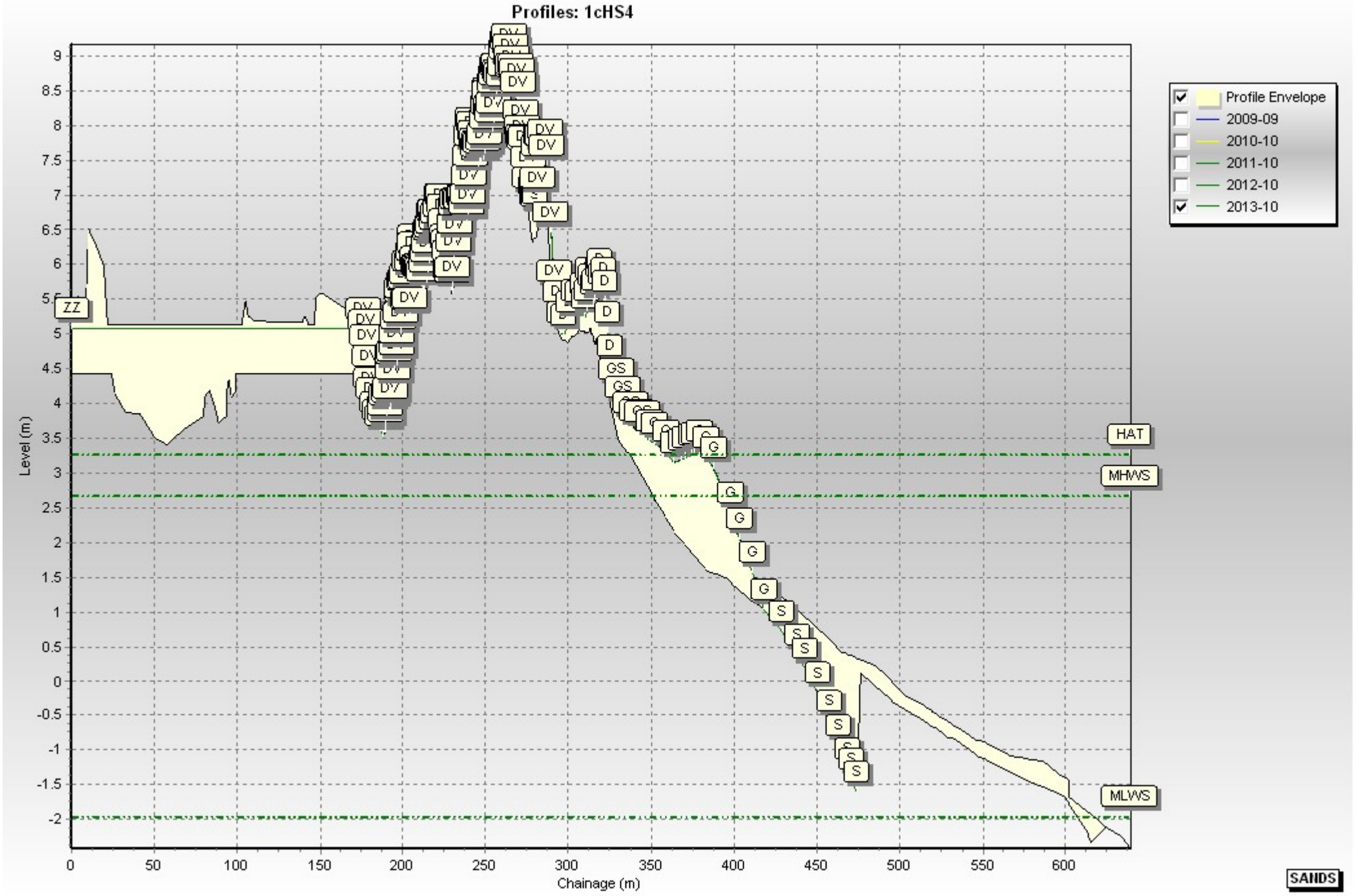

Profiles: 1cHN4A
ZZ
ZZ
SD
HAT
MHWS
MLWS
Profile Envelope
2011-10
2012-09
2013-10
Level (m)
Chainage (m)
SANDS


Profiles: 1cHC1
Profile Envelope
2008-11
2009-09
2010-03
2010-09
2011-09
2012-09
2013-09
ZZ
SD
S
HAT
MHWS
MLWS
Level (m)
Chainage (m)
SANDS


Profiles: 1cHS1
Profile Envelope
2009-09
2010-10
2011-10
2012-10
2013-10
HAT
MHWS
MLWS
SD
ZZ
B
S
Level (m)
Chainage (m)
SANDS

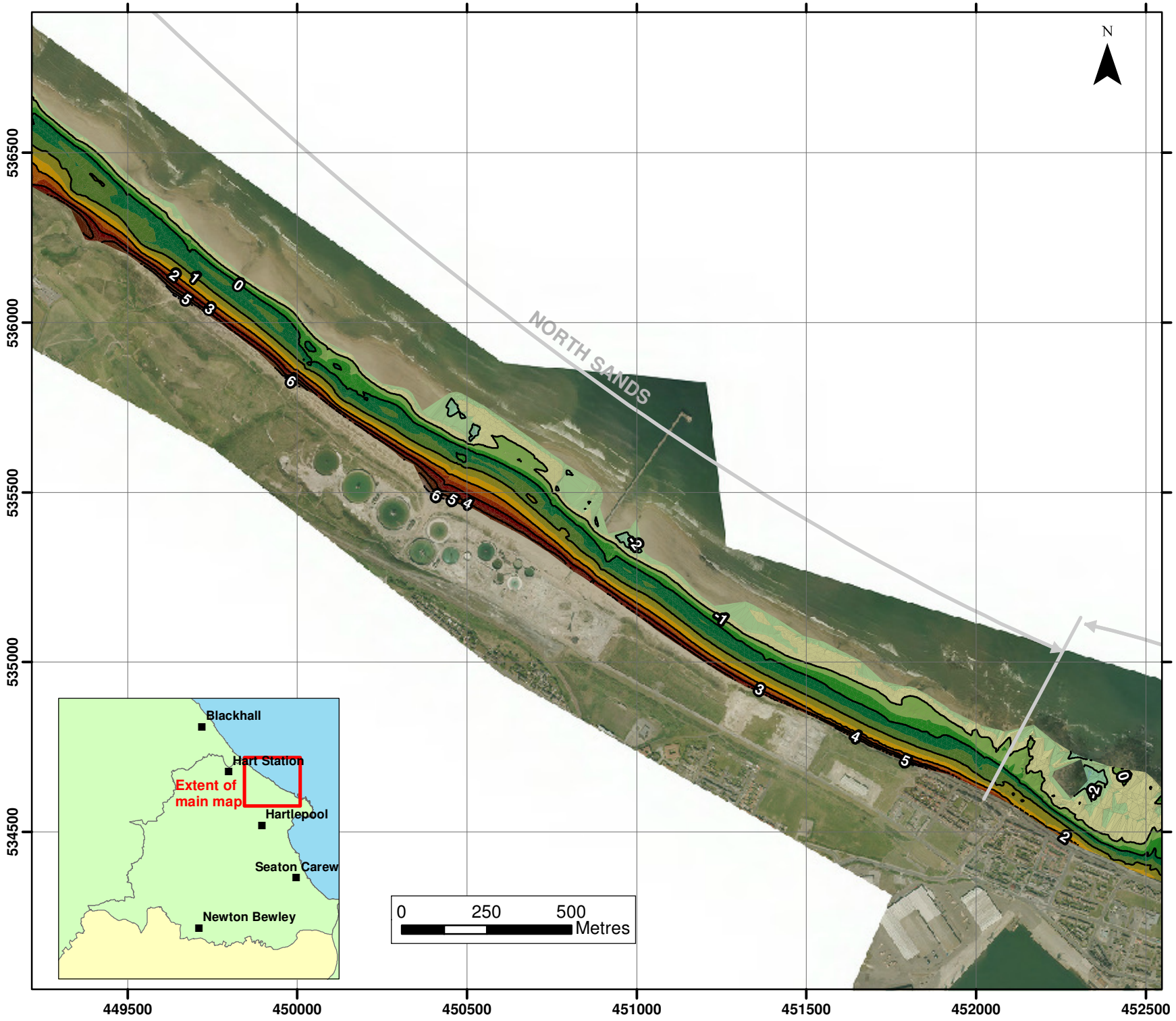

Profiles: 1cHS2
Profile Envelope
2009-09
2010-10
2011-10
2012-10
2013-10
HAT
MHWS
MLWS
Level (m)
Chainage (m)
SANDS


Profiles: 1cHS3
Profile Envelope
2009-09
2010-10
2011-10
2012-10
2013-10
HAT
MHWS
MLWS
Level (m)
Chainage (m)
SD
S
SANDS


Profiles: 1cHS4
Profile Envelope
2009-09
2010-10
2011-10
2012-10
2013-10
Level (m)
Chainage (m)
HAT
MHWS
MLWS
ZZ
DV
D
GS
G
S
SANDS

Appendix B

Topographic Survey



KEY

Elevation (m OD)

7.5 - 8	2 - 2.5
7 - 7.5	1.5 - 2
6.5 - 7	1 - 1.5
6 - 6.5	0.5 - 1
5.5 - 6	0 - 0.5
5 - 5.5	-0.5 - 0
4.5 - 5	-1 - -0.5
4 - 4.5	-1.5 - -1
3.5 - 4	-2 - -1.5
3 - 3.5	-2.5 - -2
2.5 - 3	-3 - -2.5
	Contour 1m

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

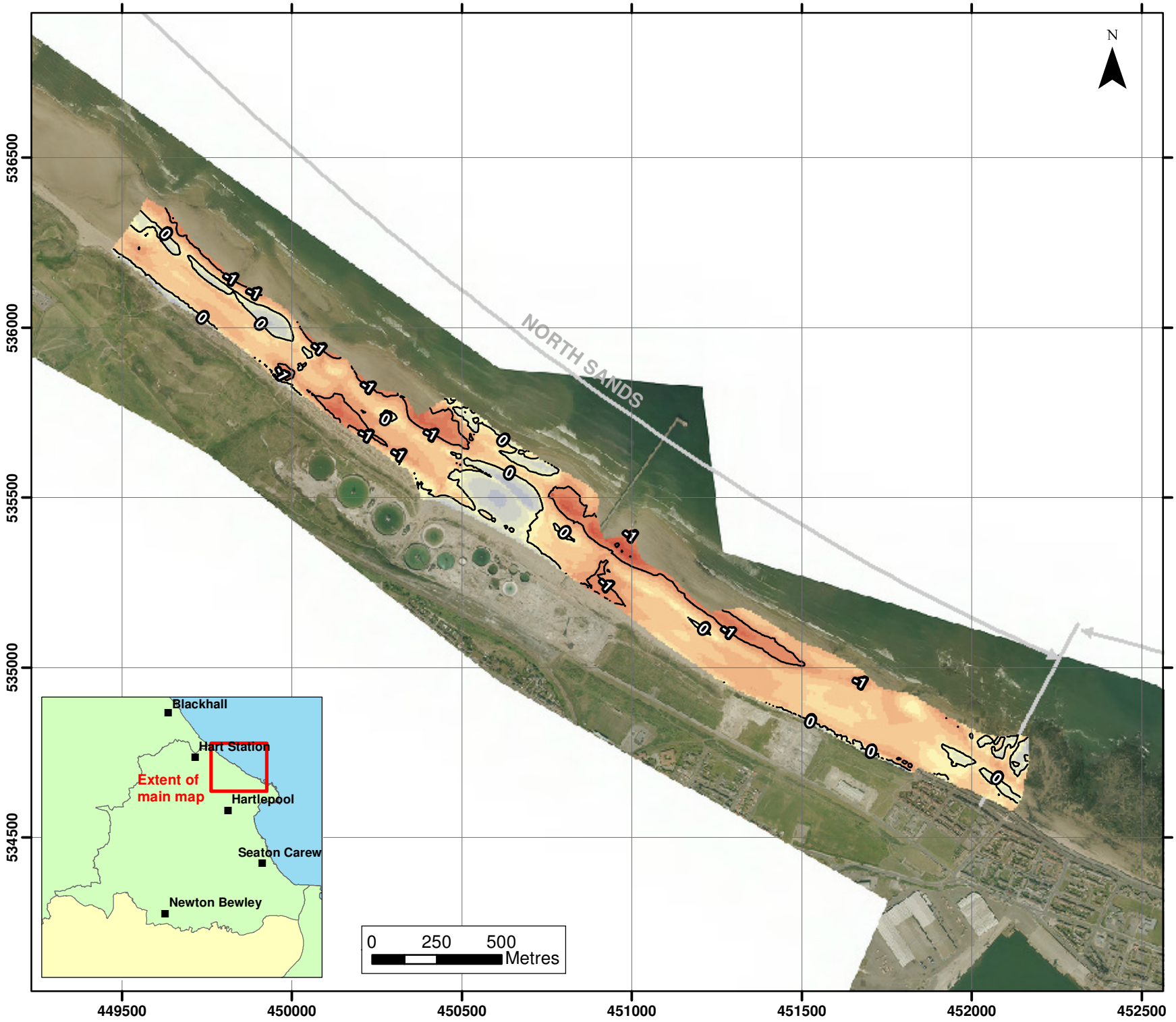
Appendix B - Map 1a
Topographic Survey
North Sands
Hartlepool Borough Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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



KEY Autumn 2012 and Autumn 2013
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

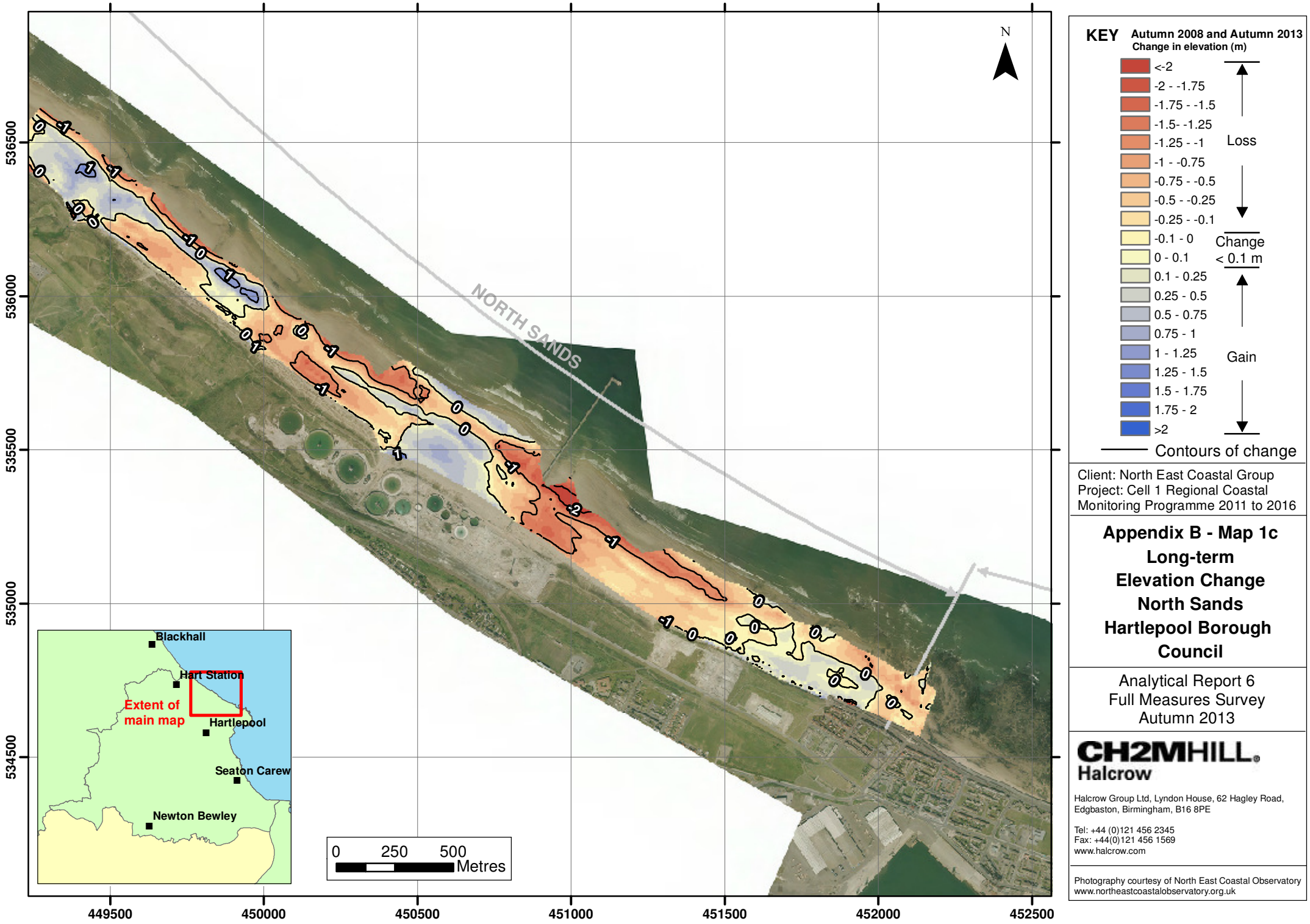
Appendix B - Map 1b
Short-term Elevation Change
North Sands
Hartlepool Borough Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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



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

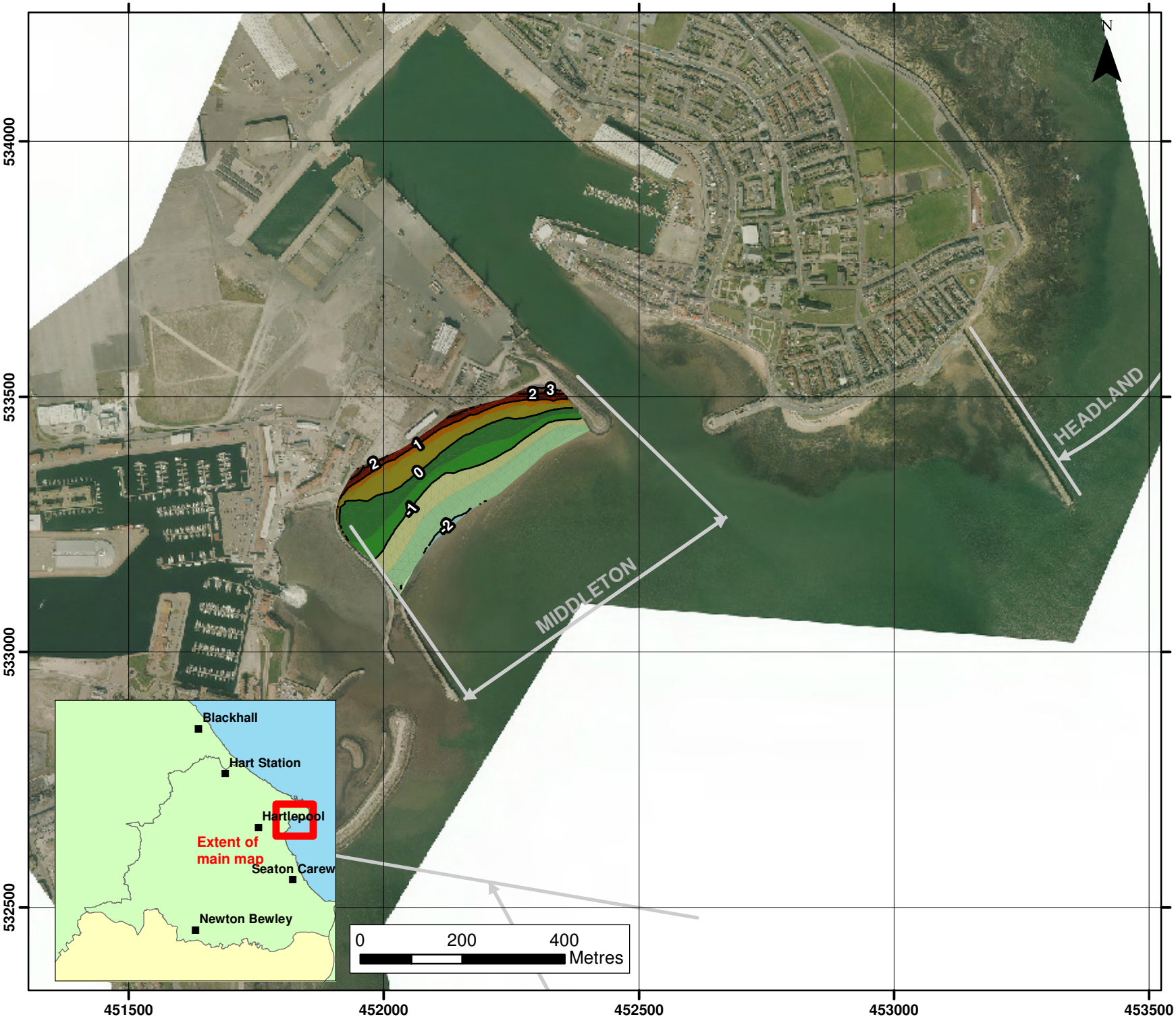
Appendix B - Map 1c
Long-term Elevation Change
North Sands
Hartlepool Borough Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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



KEY

Elevation (m OD)

- 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
- Contour 1m

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

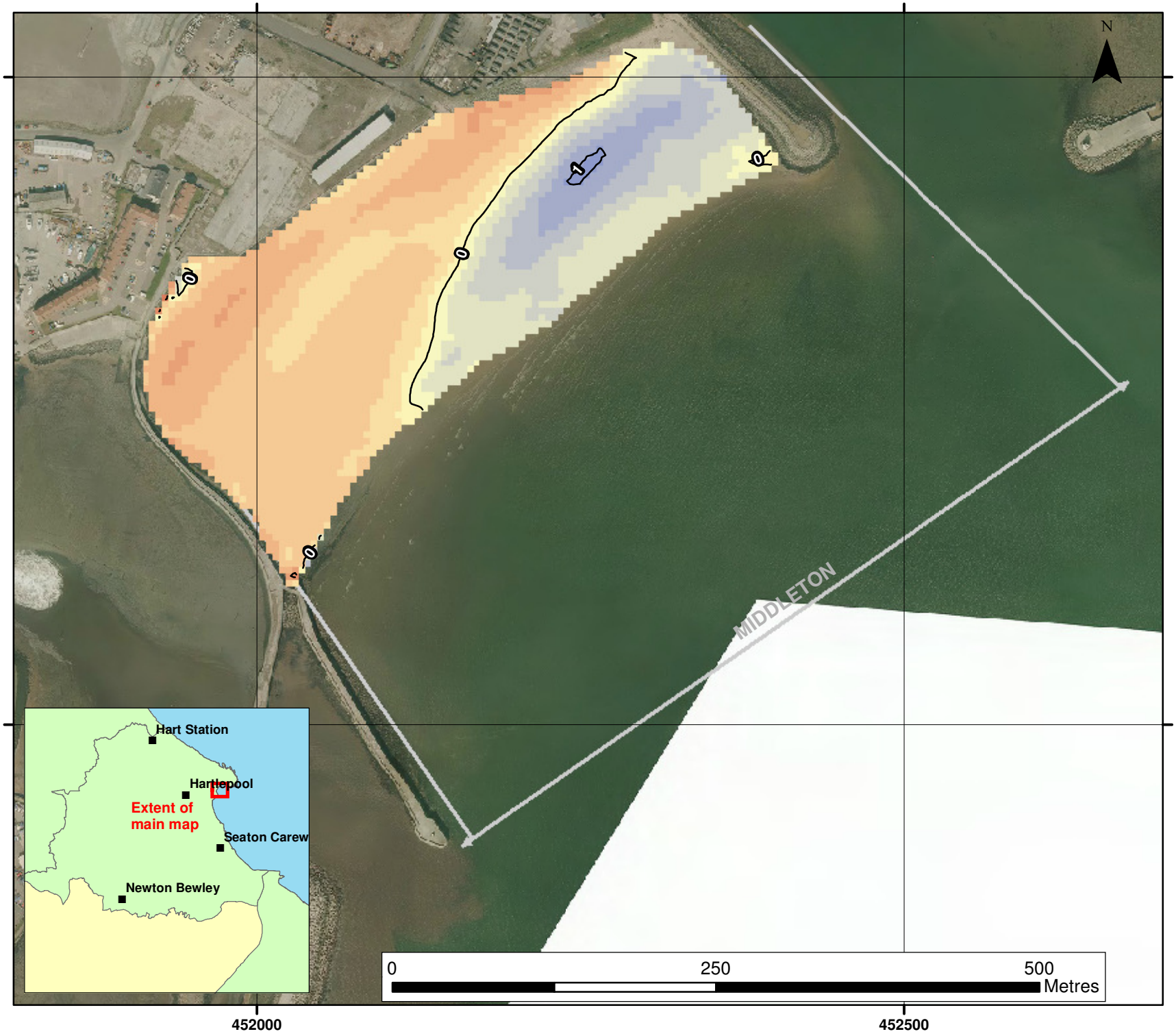
Appendix B - Map 2a Topographic Survey Headland and Middleton Hartlepool Borough Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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



KEY Autumn 2012 and Autumn 2013 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

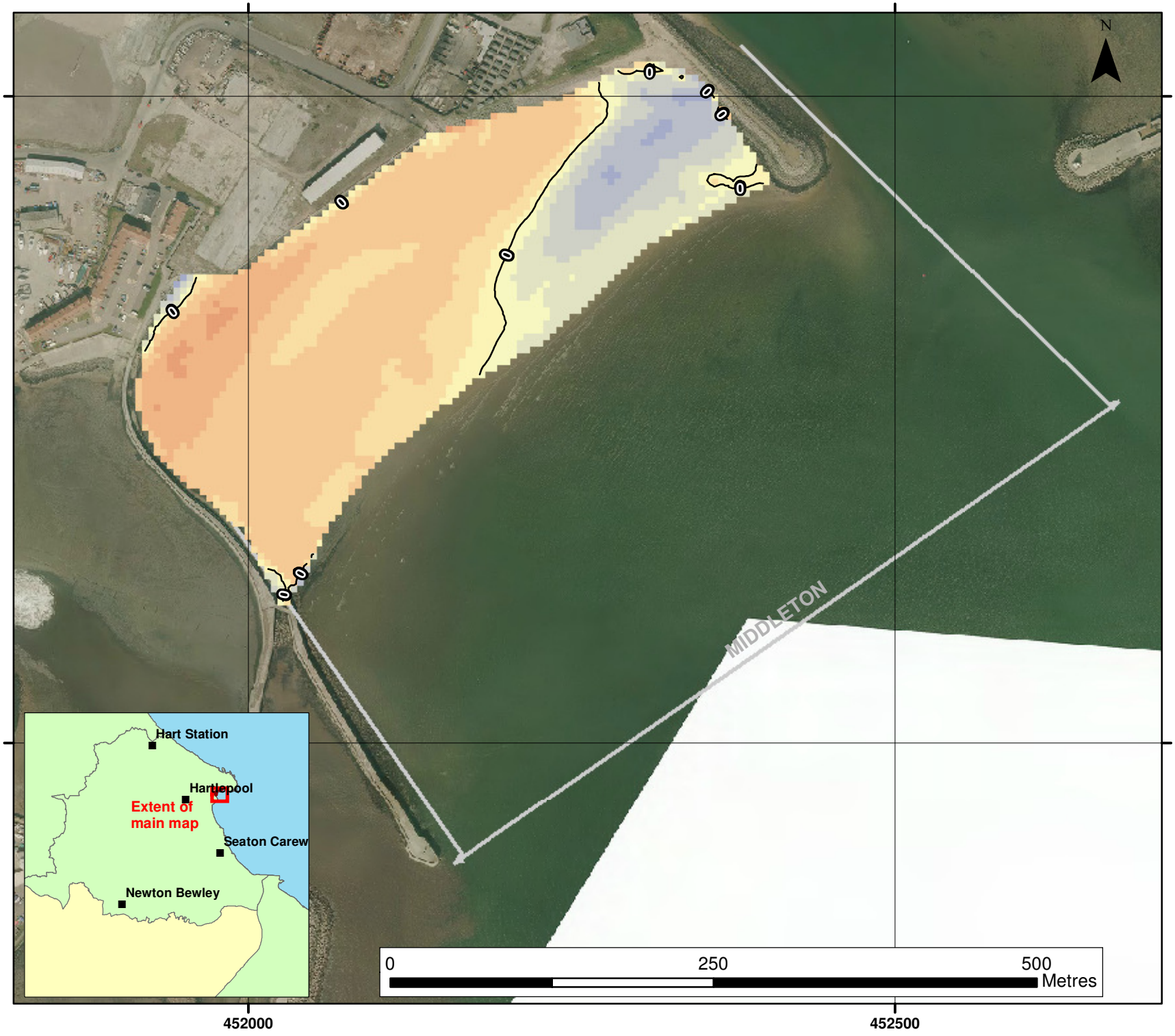
Appendix B- Map 2b Short-term Elevation Change Headland and Middleton Hartlepool Borough Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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



KEY Autumn 2008 and Autumn 2013
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

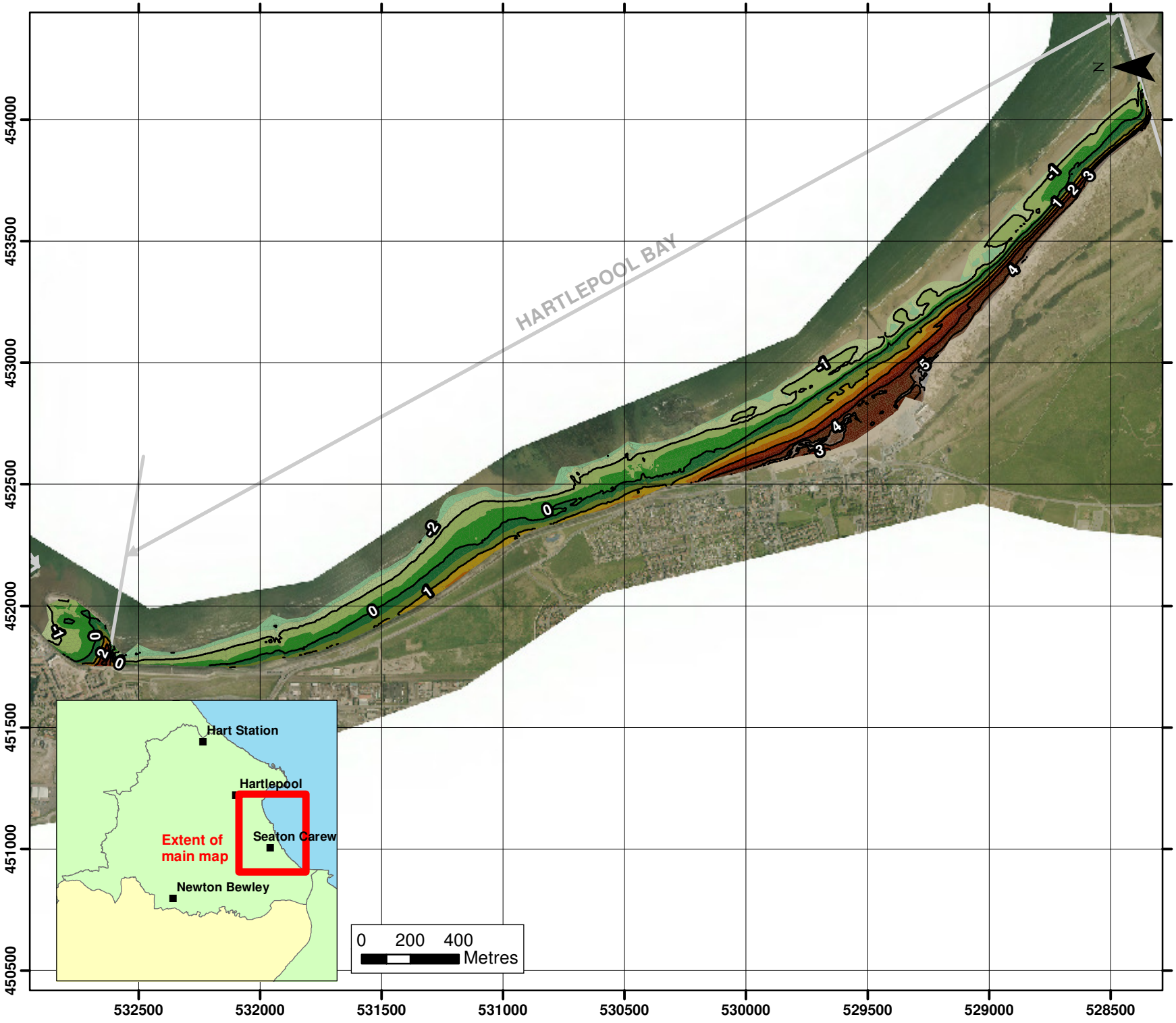
Appendix B - Map 2c
Long-term Elevation Change
Headland and Middleton
Hartlepool Borough Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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



KEY

Elevation (m OD)

- 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
- Contour 1m

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

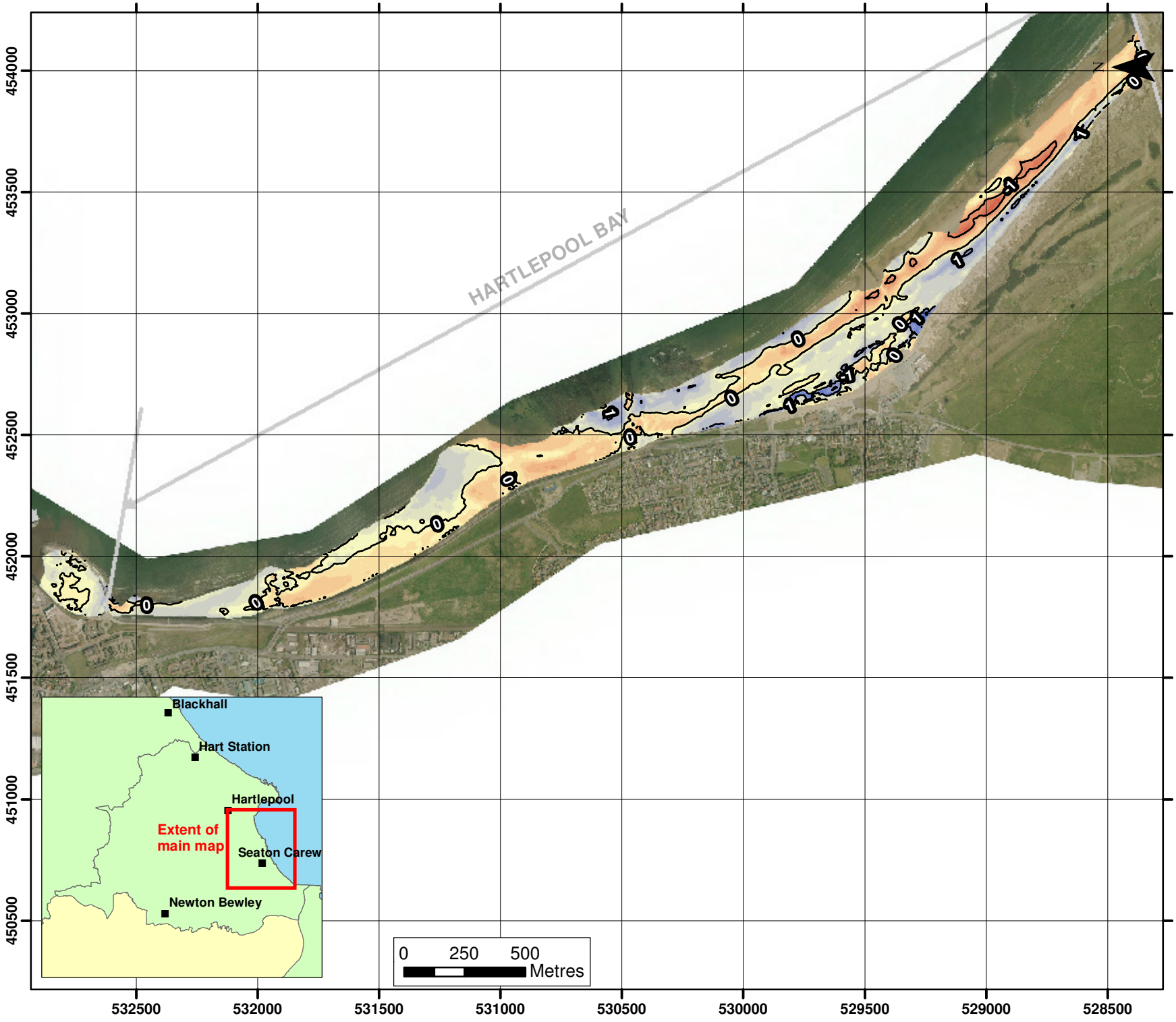
Appendix B - Map 3a
Topographic Survey
Hartlepool Bay
Hartlepool Borough Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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



KEY Autumn 2012 and Autumn 2013 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	
0.25 - 0.5	
0.5 - 0.75	
0.75 - 1	
1 - 1.25	Gain
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

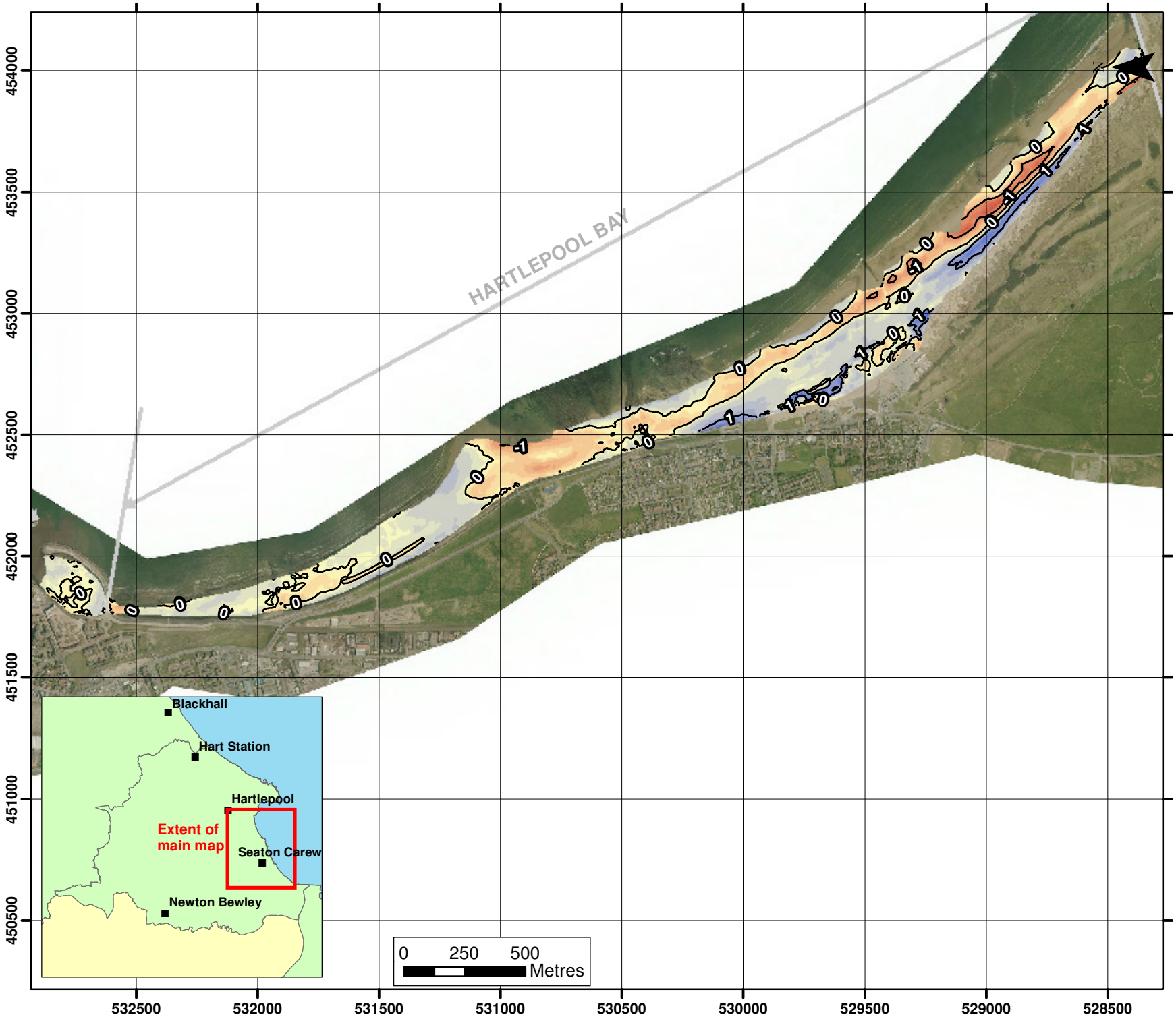
Appendix B- Map 3b Short-term Elevation Change Hartlepool Bay Hartlepool Borough Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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



KEY Autumn 2010 and Autumn 2013
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

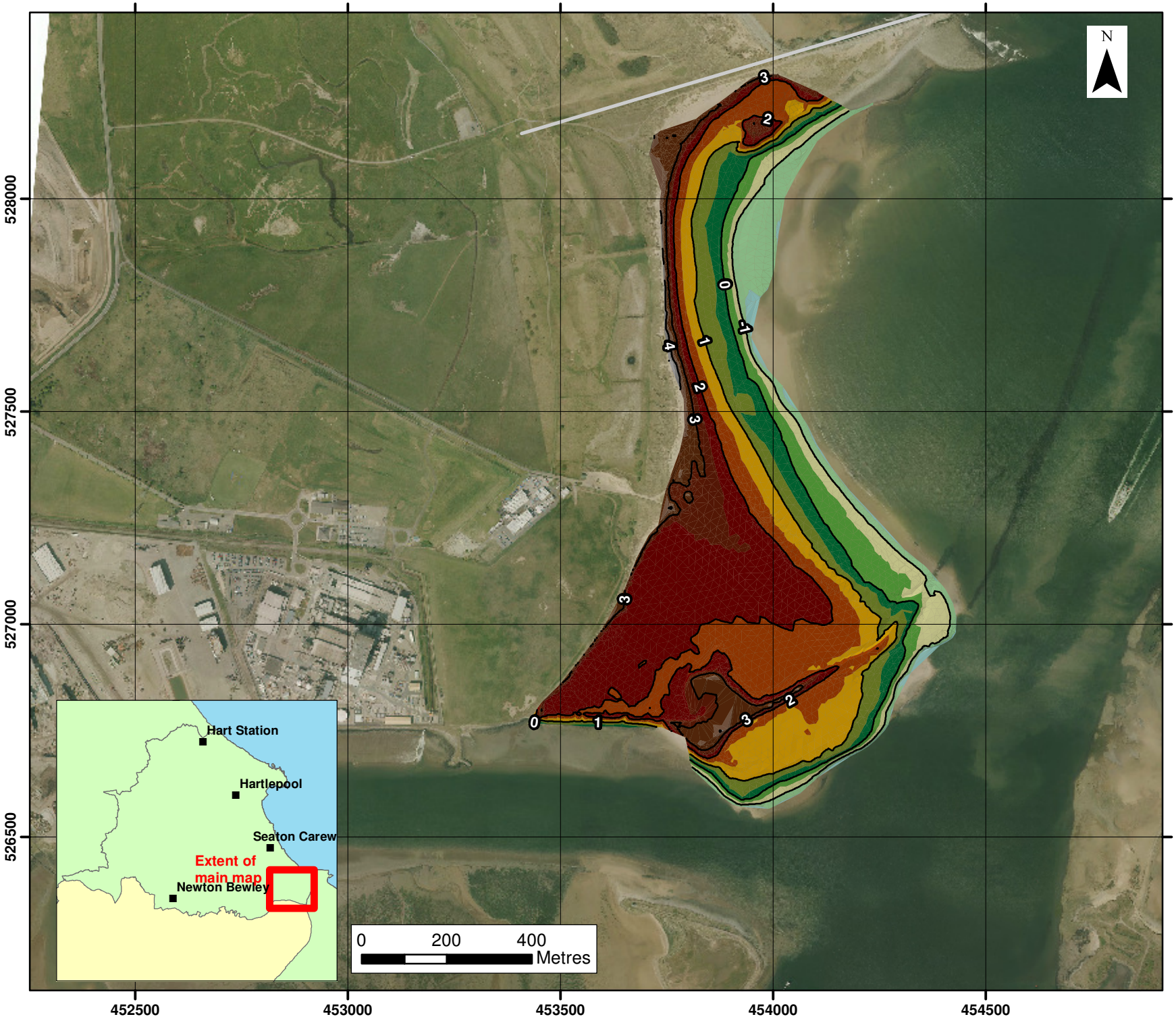
Appendix B- Map 3c Long-term Elevation Change Hartlepool Bay Hartlepool Borough Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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



KEY

Elevation (m OD)

- 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
- Contour 1m

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

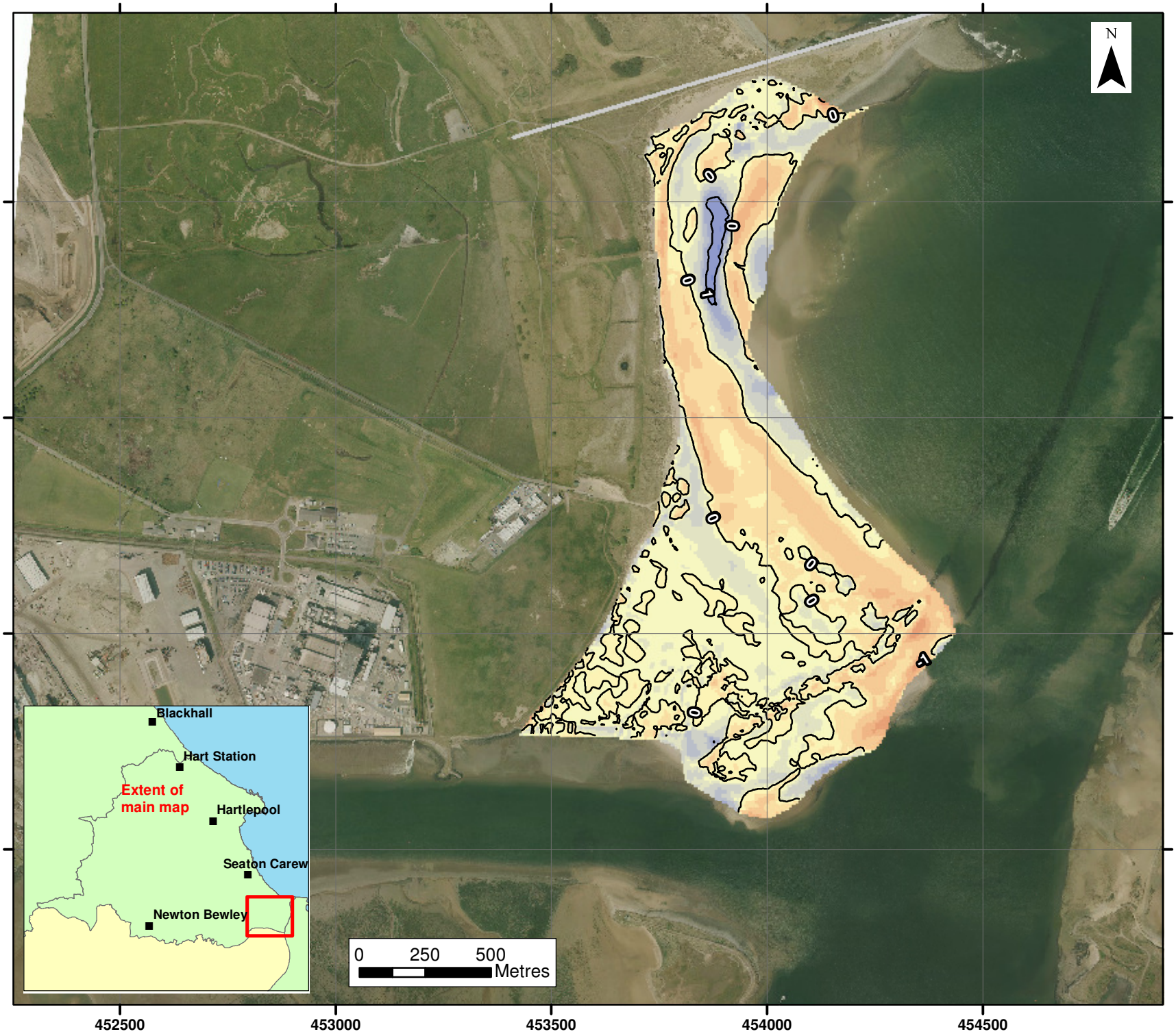
Appendix B - Map 4a
Topographic Survey
Hartlepool North Gare
Hartlepool Borough Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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



KEY Autumn 2012 and Autumn 2013 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

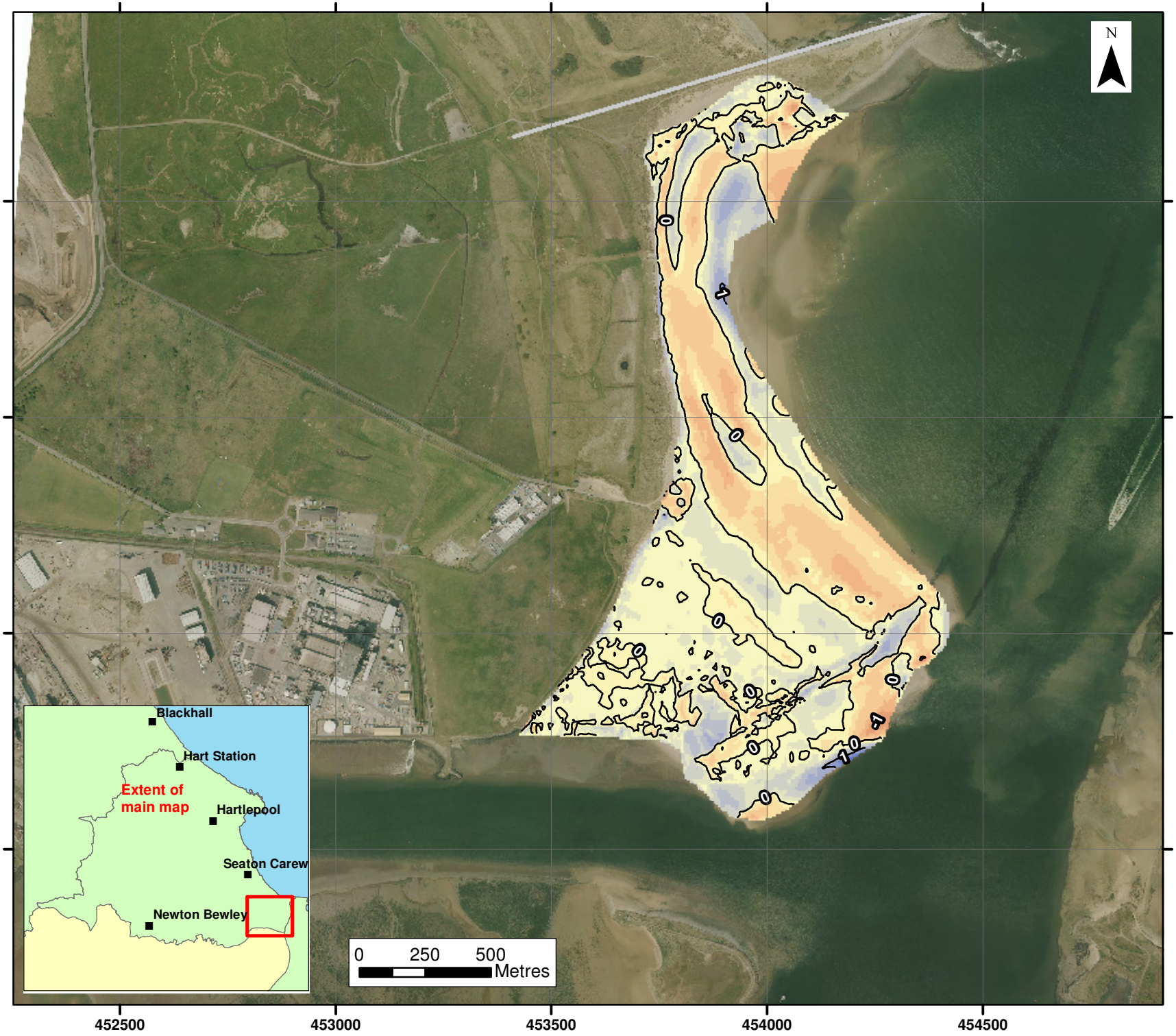
Appendix B - Map 4b
Short-term Elevation Change
Hartlepool North Gare
Hartlepool Borough Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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



KEY Autumn 2011 and Autumn 2013
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 4c
Long-term Elevation Change
Hartlepool North Gare
Hartlepool Borough Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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