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Cell 1 Regional Coastal Monitoring Programme
Update Report 5: 'Partial Measures' Survey 2013

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BOROUGH of SCARBOROUGH

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Scarborough Council
Final Report

June 2013

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Abbreviations and Acronyms

Acronym / Abbreviation	Definition
AONB	Area of Outstanding Natural Beauty
DGM	Digital Ground Model
HAT	Highest Astronomical Tide
LAT	Lowest Astronomical Tide
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	**Hartlepool Headland to Saltburn Scar**	**Skinningrove**	**Hummersea Scar to Sandsend Ness**	**Sandsend Ness to Saltwick Nab**
1 in 200 year	3.87	3.86	4.1	3.88
HAT	3.25	3.18	3.15	3.10
MHWS	2.65	2.68	2.65	2.60
MLWS	-1.95	-2.13	-2.15	-2.20
Water Level Parameter	**Water Level (m AOD) Saltwick Nab to Hundale Point**	**Hundale Point to White Nab**	**White Nab to Filey Brigg**	**Filey Brigg to Flamborough Head**
1 in 200 year	3.88	3.93	3.93	4.04
HAT	3.10	3.05	3.05	3.10
MHWS	2.60	2.45	2.45	2.50
MLWS	-2.20	-2.35	-2.35	-2.30

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

Glossary of Terms

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

Preamble

The Cell 1 Regional Coastal Monitoring Programme covers approximately 300km of the north east coastline, from the Scottish Border (just south of St. Abb's Head) to Flamborough Head in East Yorkshire. This coastline is often referred to as 'Coastal Sediment Cell 1' in England and Wales (Figure 1).

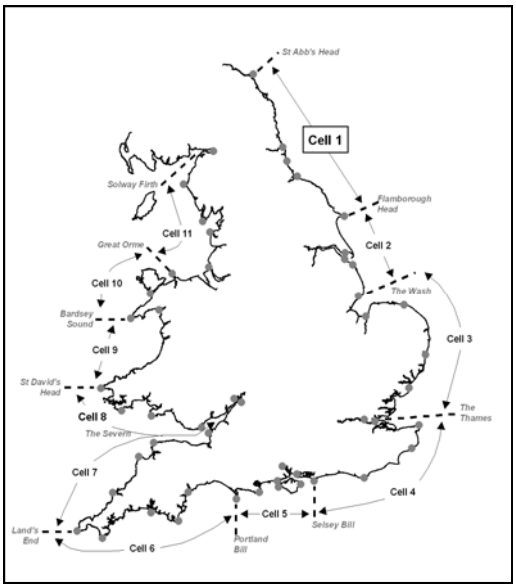


Figure 1 Sediment Cells in England and Wales

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.

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	Sept-Dec 08	May 09	Mar-May 09	June 2009	-
2	2009/10	Sept-Dec 09	Mar 10	Feb-Mar 10	Jul 10	-
3	2010/11	Aug-Nov 10	Feb 11	Feb-Apr 11	Aug 11	Sept 11
4	2011/12	Oct-Nov 11	Oct 12	Mar-May 12	Feb 13	
5	2012/13	Sept 12	Mar 13	Apr-May 13	May 13 (*)	

(*) The present report is **Update Report 5** and provides an analysis of the 2013 Partial Measures survey for Scarborough Council's frontage.

1. Introduction

1.1 Study Area

Scarborough Council's frontage extends from Staithes Harbour in the north, to Speeton in Filey Bay in the south. For the purposes of this report, it has been sub-divided into eight areas, namely:

- Staithes[1]
- Runswick Bay
- Sandsend Beach, Upgang Beach and Whitby Sands
- Robin Hood's Bay
- Scarborough North Bay
- Scarborough South Bay
- Cayton Bay
- Filey Bay

1.2 Methodology

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

- Full Measures survey annually each autumn/early winter comprising:
    - Beach profile surveys along 20 transect lines
    - Topographic survey at Runswick Bay
    - Topographic survey along the Sandsend to Whitby frontage
    - Topographic survey at Robin Hood's Bay
    - Topographic survey at Scarborough North Bay
    - Topographic survey at Scarborough South Bay
    - Topographic survey at Cayton Bay
    - Topographic survey at Filey Bay
- Partial Measures survey annually each spring comprising:
    - Beach profile surveys along 20 transect lines
    - Topographic survey at Runswick Bay
    - Topographic survey at Robin Hood's Bay
    - Topographic survey at Filey Bay (Town coverage)
- Cliff top survey bi-annually at:
    - Staithes
    - Robin Hoods Bay (new addition Spring 2010)
    - Scarborough South Bay (new addition Spring 2010)
    - Cayton Bay
    - Filey

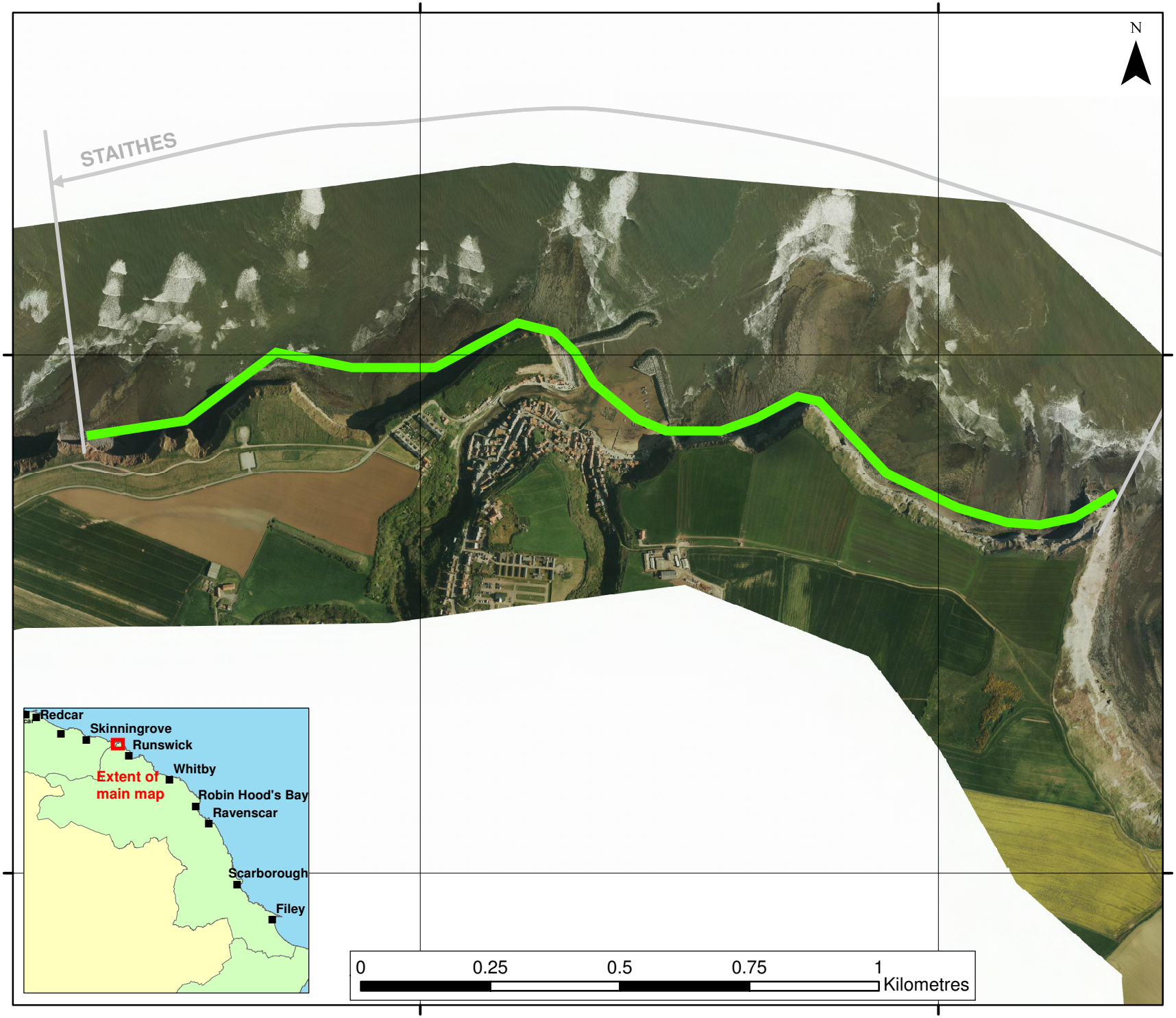
The location of these surveys is shown in Figure 2. The Partial Measures survey was undertaken along this frontage between 9th April and 1st May 2013. During this time weather conditions varied considerably; refer to the survey reports for details of the weather conditions over this survey period.

The Update Report presents the following:

- 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).

[1] The Staithes frontage straddles the boundary of jurisdiction of both Redcar & Cleveland Borough Council and Scarborough Borough Council.

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



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
Staithes
Scarborough
Borough Council

Update Report 5
Partial Measures Survey
Spring 2013

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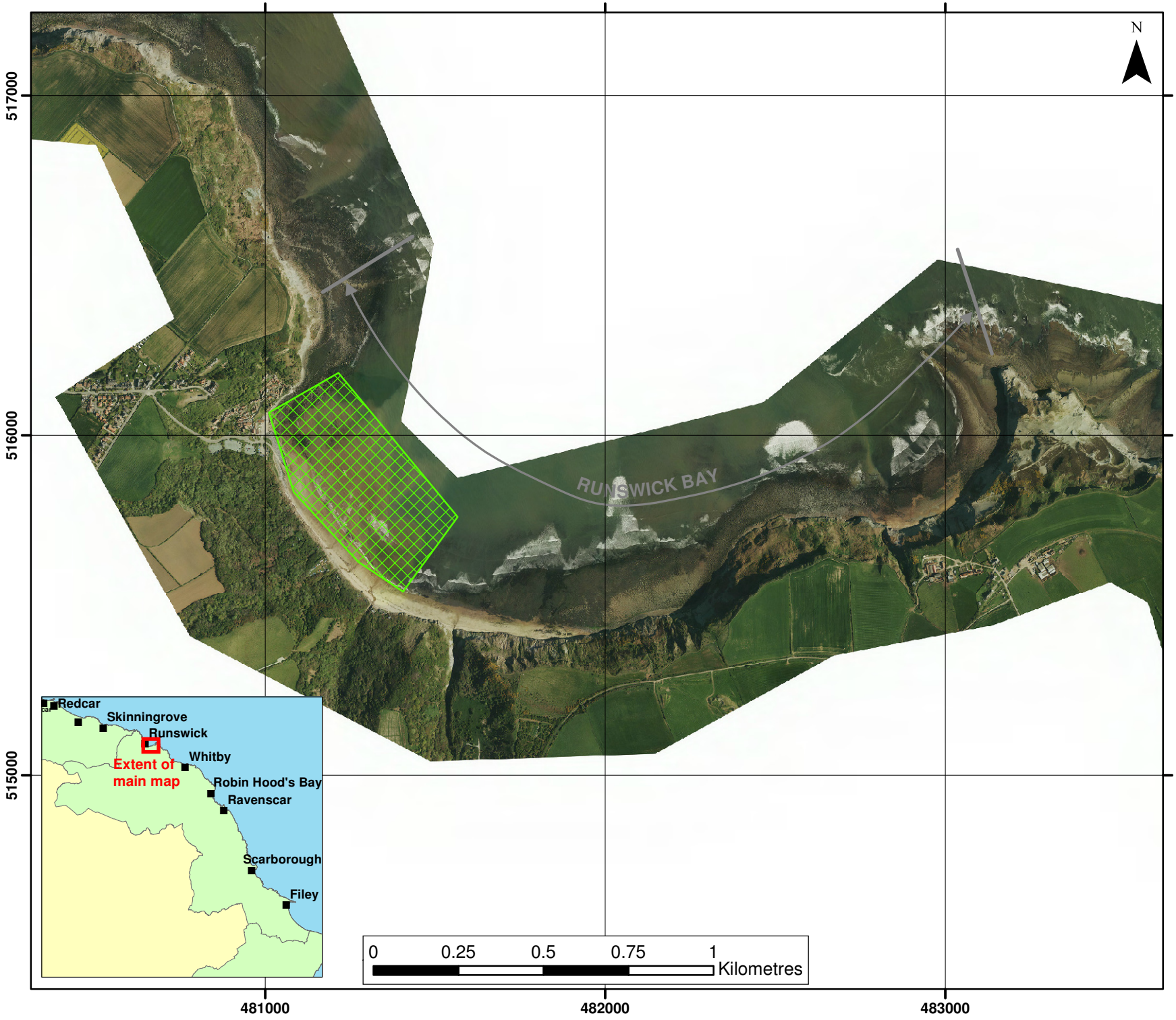

KEY

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
Runswick Bay
Scarborough
Borough Council

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Partial Measures Survey
Spring 2013

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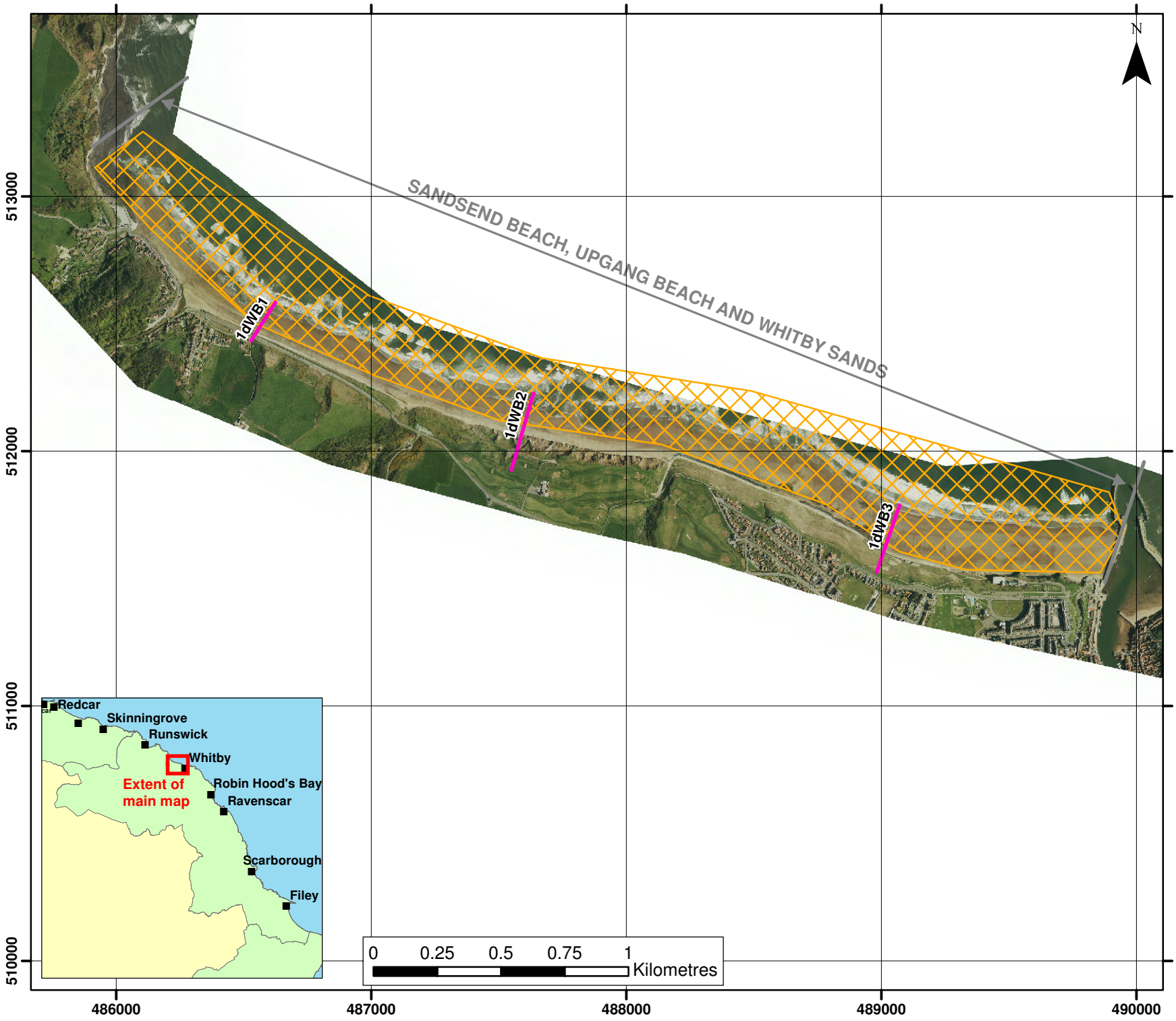

KEY

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
Sandsend to Whitby
Scarborough
Borough Council

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Partial Measures Survey
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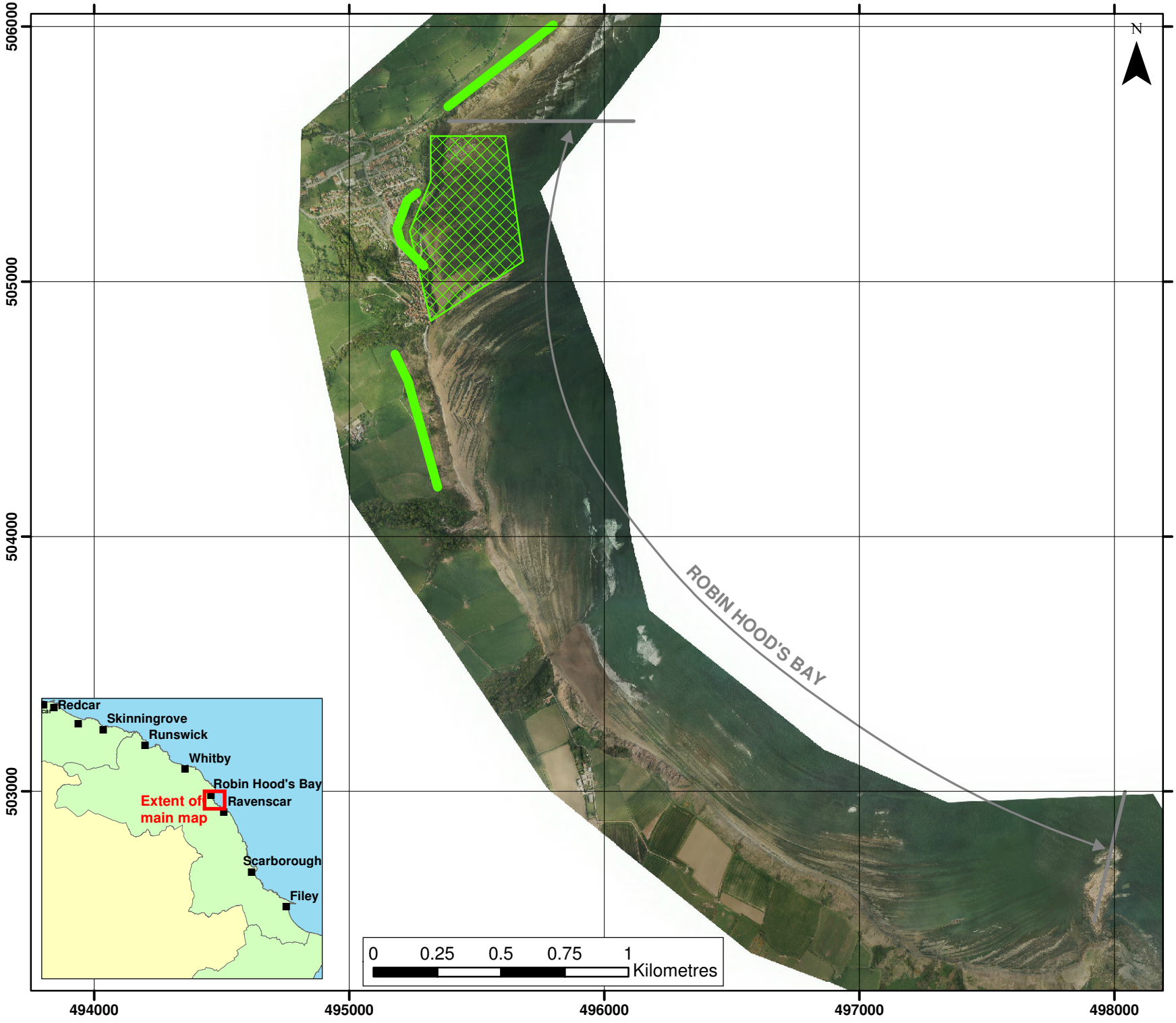

KEY

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
Robin Hood's Bay
Scarborough
Borough Council

Update Report 5
Partial Measures Survey
Spring 2013

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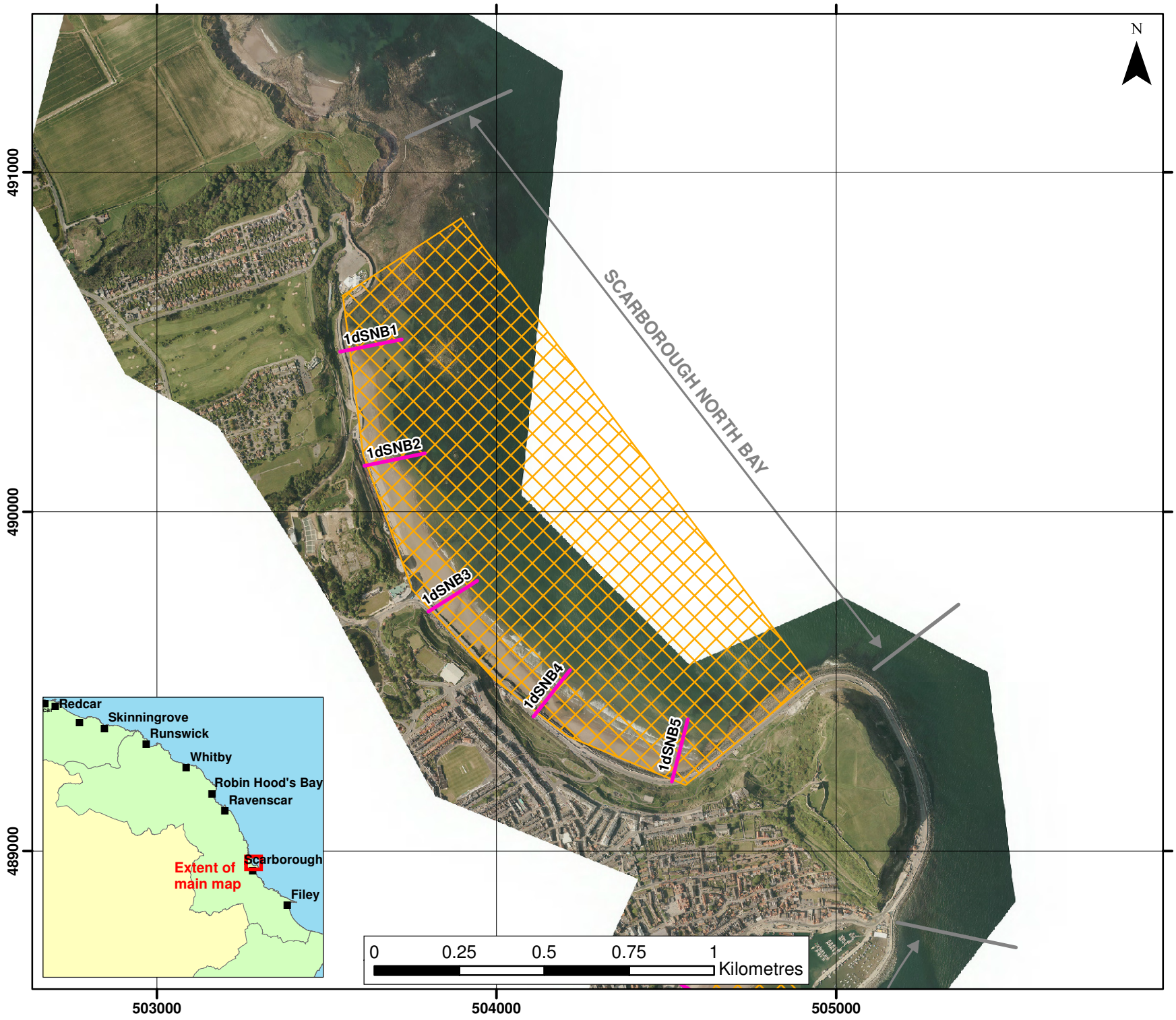

KEY

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
Scarborough North Bay
Scarborough Borough Council

Update Report 5
Partial Measures Survey
Spring 2013

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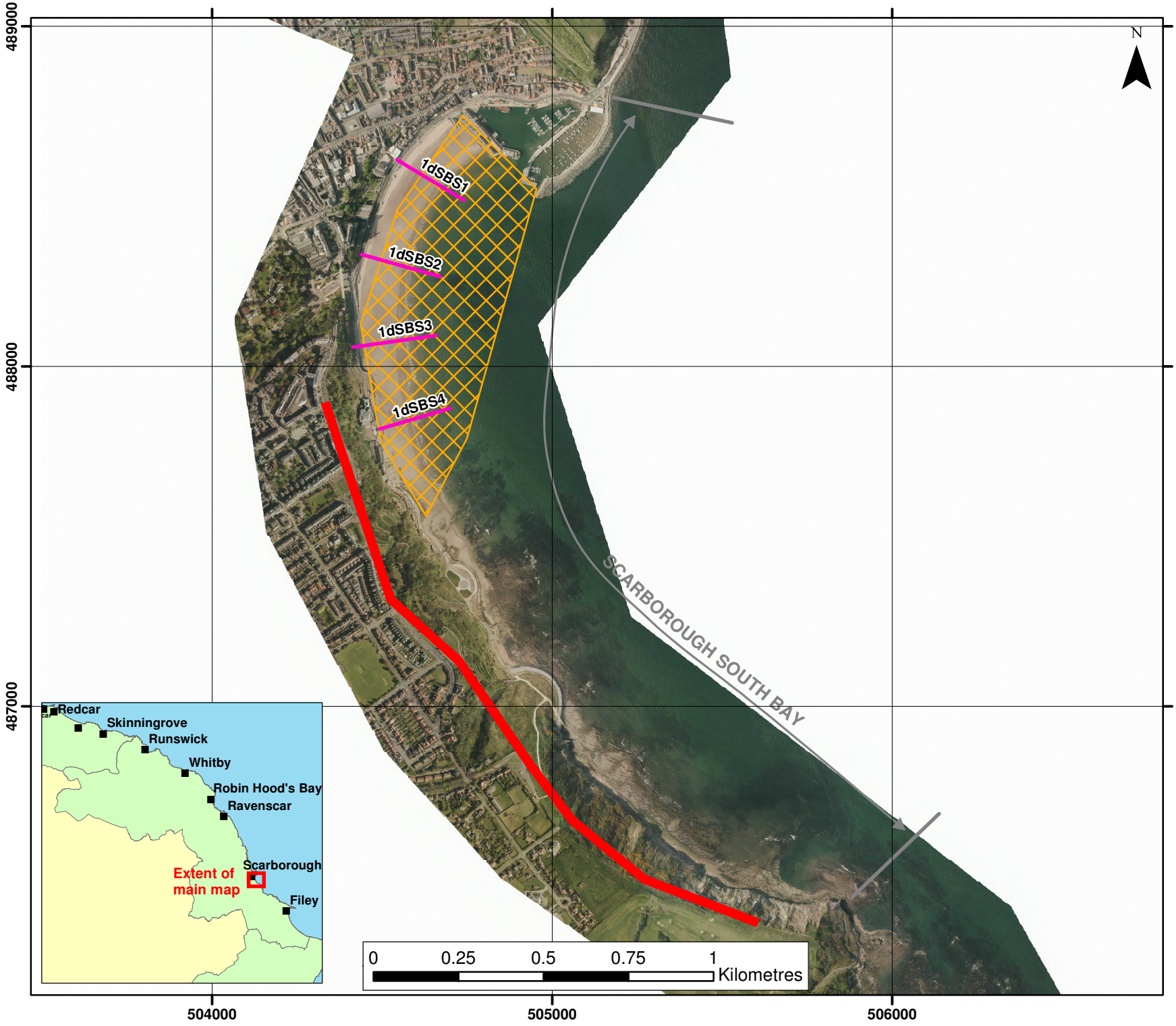

KEY

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
Scarborough South Bay
Scarborough
Borough Council

Update Report 5
Partial Measures Survey
Spring 2013

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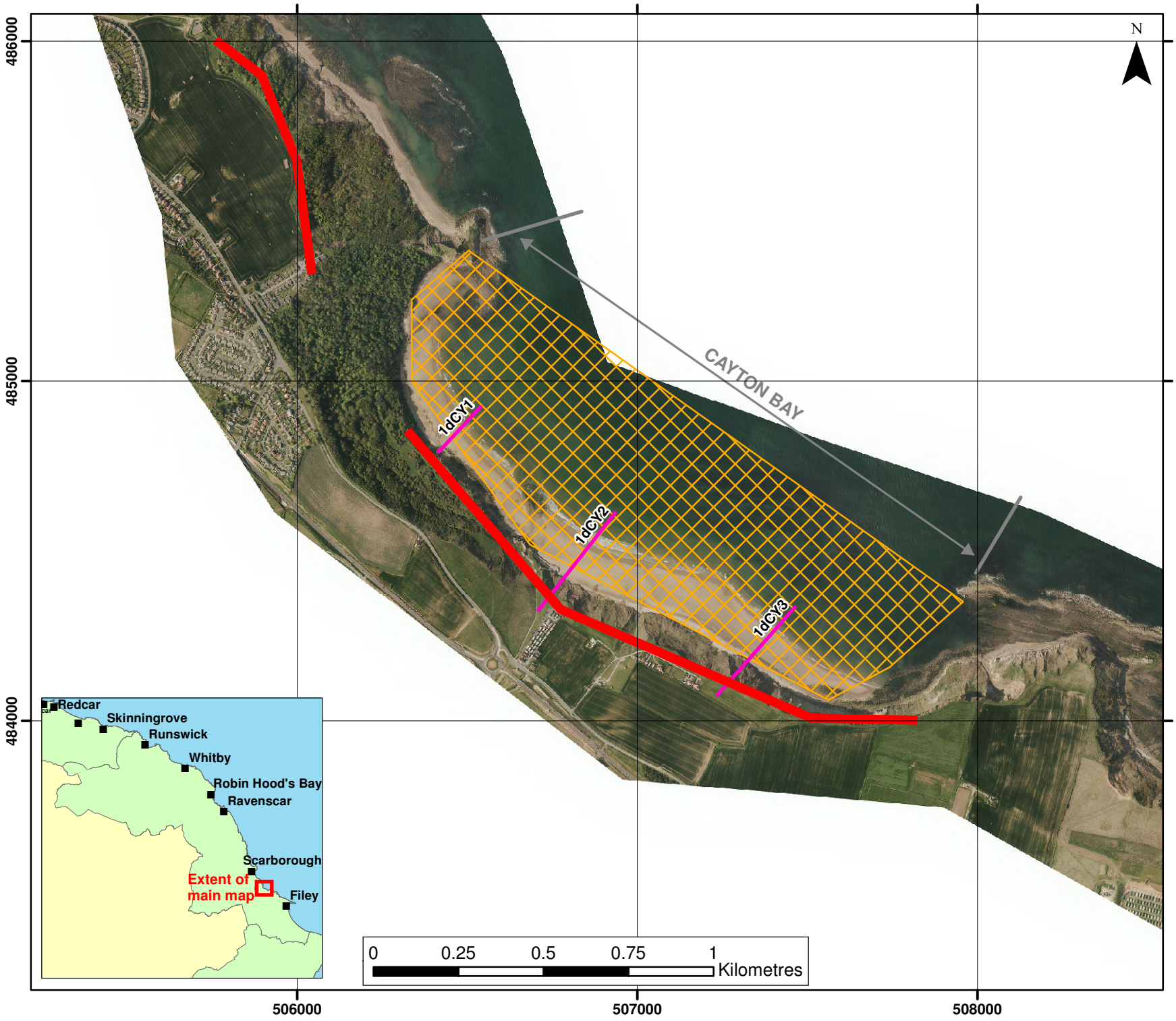

KEY

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 7
Survey Locations
Cayton Bay
Scarborough Borough Council

Update Report 5
Partial Measures Survey
Spring 2013

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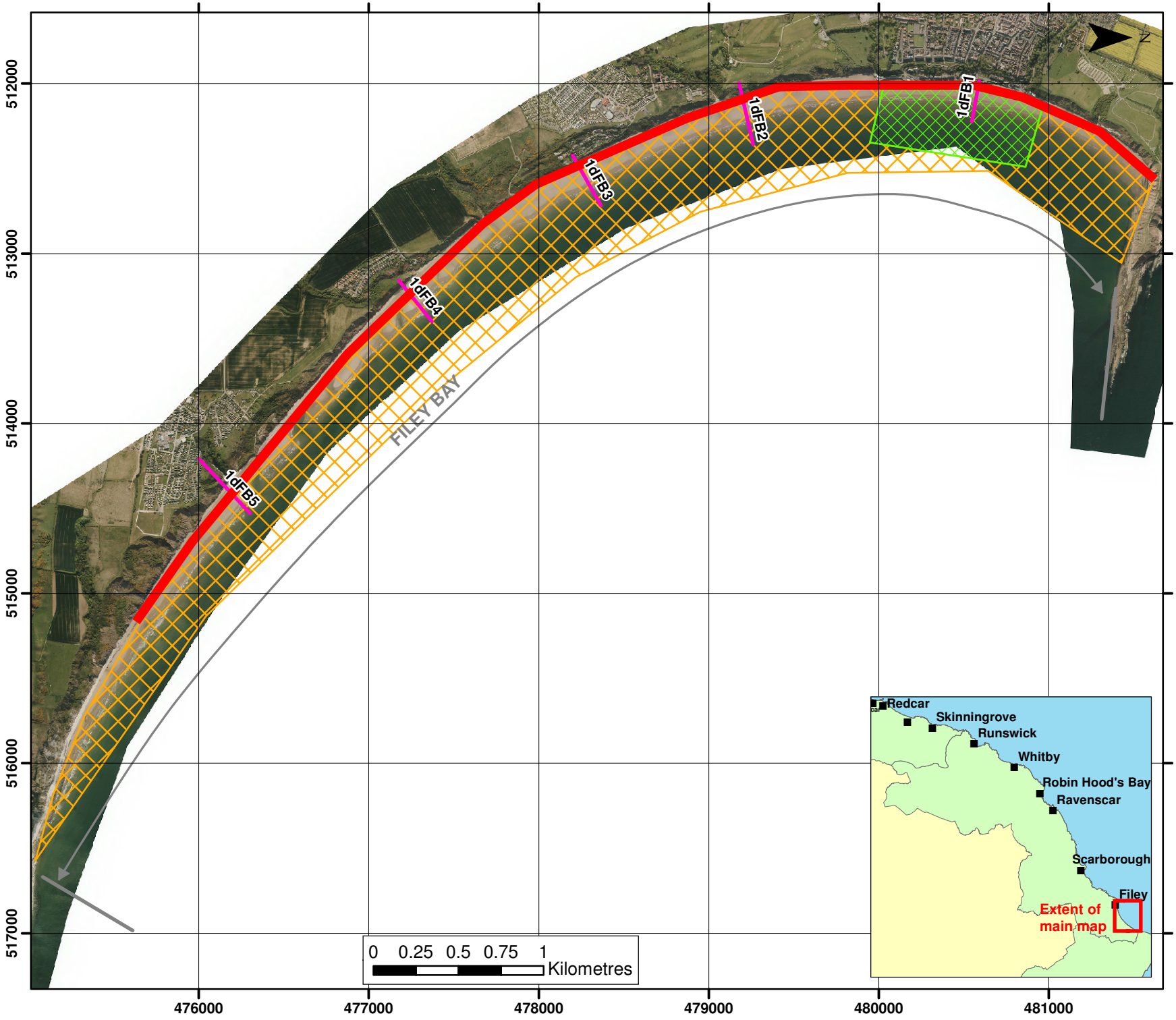

KEY

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 8
Survey Locations
Filey
Scarborough
Borough Council

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Partial Measures Survey
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2. Analysis of Survey Data

2.1 Staithes

Survey Date	Description of Changes Since Last Survey	Interpretation
March 2013	**Cliff-top Survey:** Twenty ground control points have been established at Staithes for the purposes of cliff top monitoring. The separation between any two points is a nominal 100 m. The cliff top surveys at Staithes are undertaken bi-annually. Appendix C provides results from the March 2013 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 and the previous September 2012 survey. The survey error is expected to be ±0.1m and consequently measured changes smaller than this are expected to be error. Reported advances in the cliff line reflect difficulties in precisely locating the cliff edge, especially if vegetation is present, and are also error. The results provided in Appendix C show that eight locations show low erosion of between 0.1m and 0.3m in the last 6 months. No change is detected at the other twelve locations.	The recorded changes to the cliff top between September 2012 and March 2013 are small. There have been no large failures which have affected the cliff top. There may have been steepening of the cliff face, which could lead to a larger failure next year. **Longer term trends:** Table C1 in Appendix C presents the erosion rate calculated from the data collected from 2008. The results show that only one profile shows a long-term average recession rate of more than 0.1m/yr since November 2008, with Point 13 eroding at a rate of 0.5m/yr.
April to June 2013	**Durham University Laser Scanning:** The Cowbar Nab cliff is subject to monthly high-resolution laser scanning surveys by Durham University that are used to precisely monitor the locations and rates of erosion. The baseline document was included in the previous full measures report. An update on erosion during April to June 2013 is provided here. Three surveys have been undertaken, allowing difference models to be calculated for two periods of Intervening time: 25 April 2013 to 23 May 2013, and 23 May 2013 to 13 June 2013. The results of the analysis are presented in Appendix D.	The data indicate limited erosion of the glacial sediments that cap the cliff and localised, small losses from a single bedrock layer of the cliff face. In all areas, total losses do not exceed c. 0.1m. Review of oblique photography from 2010 indicates the presence of vegetation on the glacial sediments where erosion is shown to have taken place and therefore the recoded change needs to be treated with caution. Two accumulations of material are visible at the toe of the cliff. The right feature is rock armour placed to protect the cliff from further erosion and the left feature is a deposit from a rockfall that predates the laser scanning monitoring. Limited erosion is indicated to be

Survey Date	Description of Changes Since Last Survey	Interpretation
		taking place on either of these cliff toe accumulations. **Longer Term Trends:** Although the cliff has remained between April 2013 and May 2013 there is a chance that the cliff could collapse over the coming winter.

2.2 Runswick Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
1st May 2013	**Topographic Survey:** Data from the most recent topographic survey (Partial Measures, Spring 2013) have been used to create a digital ground model (DGM) (Appendix B – Map 1a) using a Geographical Information System (GIS). A difference plot has also been produced using the DGM (Appendix B – Map 1b) produced from the last produced topographic survey (Full Measures, autumn 2012) and the present survey, to identify areas of net erosion and accretion. Appendix B - Map 1b shows three shore parallel strips of change. The beach has eroded on the upper and lower extent of the survey while the central section of beach has accreted. The erosion of the landward part of the beach was up to 1m, although there is a small strip of 0.25m of accretion in the centre of the bay. Seaward of the area of erosion in the mid-beach accretion of up to 1m of material has occurred since autumn 2012. Erosion has also been recorded at the seaward extent of the survey, but it was less severe than the upper beach at 0.5 to 0.75m. The surveyor report notes a “large patch of rock visible off southern cliff foot”, which corresponds to the area of erosion and beach lowering at the cliff toe.	There has been a typical pattern of winter drawdown, with a net movement of sediment from the back of the beach to the mid and lower beach. This has resulted in a flattening of the beach profile. It is likely that there has been no net loss of sediment from the bay. **Longer term trends:** The data collected since 2008 indicate a general pattern of winter drawdown and spring recovery. The erosion at the top of the beach was more severe than during the winter of 2011/12. However, there is an underlying trend of erosion in the middle part of the beach in the centre of the bay, with accretion at the margins. If this pattern of beach erosion in the bay head continues, it is likely that cliff erosion in the middle of the bay will eventually also accelerate. This will be investigated by proposed analyses of aerial photography.

2.3 Sandsend Beach, Upgang Beach and Whitby Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
12th April 2013	**Beach Profiles:** The Sandsend, Upgang and Whitby frontage is covered by three beach profile lines for the Partial Measures survey (Appendix A). The profiles were last surveyed in September 2012 (Full Measures). **Profile 1dWB1** is located around 400m south of Sandsend village. The profile above HAT (around 35m chainage) has changed very little. From 35m to 70m chainage the beach level is 0.6m higher than September 2012 and a berm has formed on the beach. Between 70m and 130m chainage a large drop in beach level is apparent, resulting in the beach surface being 0.8m lower than in September 2012. From 130m to the end of the survey at 195m the beach level is the highest since 2008. This is 0.1m higher than the September 2012 level. **Profile 1dWB2** is located in the centre of Upgang beach. The part of the profile above HAT has changed very little and is comparable with previous profiles dating back to 2008. Below HAT the beach is the lowest on record. The beach below HAT drops steeply and is up to 2m lower than the profile recorded in September 2012. **Profile 1dWB3** is located on Whitby Sands and showed no significant changes above MHWS. From 90m to 110m chainage, at the toe of the sea wall, the beach level has dropped by 0.5m since September 2012. Between 110 and 150m chainage the beach level has recovered and there is a berm 0.2m higher than the September 2012 beach level. From 150m chainage to the end of the profile at 270m chainage the beach is between 0.2m and 0.5m lower than the September 2012 profile.	All three of the beach profiles were low in April 2013 compared to September 2012 and all demonstrate a net transfer of material from the beach towards MLW associated with winter draw-down. WB1 and WB3 have developed depressions on the beach surface, which are probably low areas between sand bars/berms. Profile WB2 is very steep and low. The profiles are markedly more undulating than in September 2012, when the profiles were fairly flat. This is likely to be due to the erosion of the foreshore, which, when coupled with strong long-period swell waves that act to create complex beach morphology. **Longer term trends:** The profiles tend to be much more variable in shape than previous profiles that date back to 2008. The extremes of the current profiles are higher or lower and the previous envelope of beach profile results. WB2 is very steep and low the beach has been more severely eroded during the summer months than in previous years, which suggests the winter of 2012/13 was exceptional.

2.4 Robin Hoods Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
12th April 2013	**Topographic Survey:** Data from the most recent topographic survey (Partial Measures, spring 2012) have been used to create a digital ground model (DGM) (Appendix B – Map 2a) using a Geographical Information System (GIS). A difference plot has also been produced using the DGM (Appendix B – Map 2b) from the last topographic survey (Full Measures, autumn 2012) and the present survey. The difference plot shows changes in level between autumn 2012 and spring 2013. The pattern shows large areas which show little or no change (within ±0.25m since autumn 2012) and smaller areas of larger erosion and deposition that are randomly distributed across the beach. The largest changes are at the landward extent of the survey and over the rocks in the north of the bay. In these areas around 0.75m of erosion has occurred. There are also patches of accretion of up to 0.5m in the northern and southern extent of the survey. Overall, the beach has shown little change with only subtle evidence for winter draw-down.	Limited change was recorded over the winter of 2012/13 with only subtle evidence for winter draw down. The extensive rock shore platform at this location is likely to be the reason for the small recorded changes. **Longer term trends:** The difference plots show a continuation of the trend of patchy distribution of erosion and accretion. Overall, the observed changes are of greater magnitude than in the previous winter of 2011/12, however erosion at the top of the beach, which was particularly severe in 2012/13, was less in the current survey.
April 2013	**Cliff-top Survey:** Thirteen ground control points have been established at Robin Hood's Bay (since 3rd March 2010) to monitor cliff top recession. The separation between any two points is a nominal 200m. The cliff top surveys at Robin Hood's Bay are undertaken bi-annually. Appendix C provides results from the April 2013 survey, showing the distance from the ground control point to the edge of the cliff top along the defined bearing (Appendix C- Map 2) and changes in position since the last survey in September 2012 and the baseline survey in March 2010. The accuracy of the survey technique means change of less than 0.1m is assumed to be error. Calculated advances in the cliff are also error that relate to problems in precise identification of the cliff edge, particularly where there is thick vegetation. Taking into account the survey accuracy, only one monitoring point shows cliff recession, with Marker 9 showing erosion of 0.3m. The surveyor notes 'many rock falls and slips on the cliff face'.	Overall the cliff top has been stable since the previous survey in September 2012 with only one of the survey points showing recession of 0.3m. **Longer term trends:** The erosion rates calculated from the observed changes since March 2010 show a low erosion rate for most of the cliff points. Two of the markers have more significant recession rates; markers 1 and 10 have rates of 1.1m/yr and 0.2m/yr respectively. The data has not been collected over a long time span and as a result there is not a high confidence in the recession rates. More data collected over future years will help to clarify cliff behaviour at Robin Hoods Bay.

2.5 Scarborough North Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
10th April 2013	**Beach Profiles:** Scarborough North Bay is covered by four beach profile lines for the Partial Measures survey (Appendix A) that are monitoring biannually. **Profile 1dSBN1** is located around 200m south of the Sea Life Centre. The beach has changed little between 0m and 10m chainage. Between 10 and 15m the beach level has dropped and a channel appears to have formed at the toe of the sea wall. From 15m to 105m chainage there was a 0.8m high berm in the beach compared to the September 2012 profiles. The lowest part of the profile from 105 to 155m chainage is a similar level in April 2013 and September 2012. **Profile 1dSBN2** is located close to the former chair lift and the profile has shown erosion of the upper beach and accretion of the lower beach overall. The beach level between 5m and 50m chainage has dropped by up to 1.4m since September 2012. The lower part of the survey, between 50m and 145m, is around 1.4m higher than September 2012. At the bottom of the April 2013 profile the rocks are exposed on the beach, showing a low beach level. **Profile 1dSBN3** is located near Royal Albert Drive. Above the HAT level there has been little change. Below HAT the profile has been subject to erosion. The beach between 10m and 130m chainage has been subject to around 1.5m erosion throughout the length. Below 130m chainage the beach level has raised by around 0.2m between September 2012 and April 2013. **Profile 1dSBN4** is located at the northern end of Clarence Gardens. The profile above MHWS has not changed significantly. Between 25m and 40m chainage the beach level has increased and the rock outcrop visible in September 2012 is covered. From 40m chainage to the end of the survey at 170m chainage the beach level has dropped by 0.6m to 0.8m. **Profile 1dSBN5** is located on the southern side of Clarence Gardens, above MHWS the profile has changed very little. Between 30m chainage and 130m chainage the beach has dropped by between 0.2 and 0.4m. From 130m to the end of the profile at 180m chainage the level is comparable to the September 2012 level.	The beach levels in Scarborough North Bay were low in April 2013 with evidence that all profiles have experienced extreme winter draw-down of sediment. This has resulted in the upper beach being exceptionally low and the lower beach being exceptionally high when compared to data from 2008 to present. Profile SBN4 has a different pattern, with more widespread evidence for accretion of sediment. This may suggest a net drift of sediment to the south of the bay in the winter months. **Longer term trends:** The seasonal fluctuation of beach levels has been seen since monitoring began in 2008 and there is no evidence for long-term net recession or accretion. The low beach levels recorded in April 2013 are likely to relate to extreme storms in the winter of 2012/13 and are expected to recover over the summer of 2013, when conditions will be calmer.

2.6 Scarborough South Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
10th April 2013	**Beach Profiles:** Scarborough South Bay is covered by four beach profile lines for the Partial Measures survey (Appendix A). **Profile 1dSBS1** is located around 250m south of the West Pier. The profile above HAT has not changed since September 2012. Below the HAT level at 15m chainage to 125m chainage the beach has eroded by up to 0.4m. From 125 to 205m chainage the beach has accreted a mound of material up to 0.8m higher than the September 2012 profiles. Below 205m chainage to the end of the survey the beach level drops quickly. The beach profile has flattened overall as sediment has been drawn-down towards MLW. **Profile 1dSBS2** is located on the shore fronting St Nicolas cliff. From 5m to 140m chainage the beach has eroded by up to 0.6m over the winter of 2012/13. Between 140m and the end of the survey at 200m chainage the beach has accreted by up to 0.5m. The beach profile has flattened overall as sediment has been drawn-down towards MLW. **Profile 1dSBS3** is located 250m north of the Scarborough Spa complex. The profile shows the lowest beach level recorded and much of the toe of the defence is exposed. Much of the beach has dropped by 0.8m since Autumn 2012. **Profile 1dSBS4** is located on the beach in front of the Scarborough Spa Complex. The beach level in March 2013 was the lowest recorded in the upper and mid beach. Between 5m and 110m chainage the beach level has dropped between 0.2 and 0.6m. From 110m to the end of the survey at 170m chainage the beach has accreted by around 0.2m.	SBS1 and SBS2 have flattened and become shallower. This is likely to be due to the draw-down of material during winter storm events. Both SBS3 and SBS4 show the lowest recorded profiles since the monitoring began in 2008, suggesting the winter storms of 2012/13 were particularly severe. **Longer term trends:** The observed changes in South Bay are consistent with the seasonal fluctuations of sediment with a bay system. However, the severity of the erosion during the winter of 2012/13 was exceptional and much of the beach in South Bay is at its lowest level since 2008.
April 2013	**Cliff-top Survey:** 13 ground cliff top monitoring control points have been established at Scarborough South Bay and Cornelian Bay to Knipe Point. The separation between points is around 300m. The cliff top surveys at Scarborough South Bay are undertaken bi-annually. Appendix C provides results from the March 2010 baseline survey through to the most recent April 2013 survey, showing the distance from the ground control point to the edge of the cliff top along the defined bearing (Appendix C- Map 3). Error in the	The cliff monitoring data shows that two of the markers in Cornelian Bay (Numbers 11 and 12) had recession of 1.9m and 1.6m. This may suggest that part of the Cornelian Bay mudslide complex has reactivated and poses a risk to the northern part of the Knipe Point housing development. The rest of

Survey Date	Description of Changes Since Last Survey	Interpretation
	technique means change of less than 0.1m cannot be relied on. Calculated advances of the cliff line are also assumed to be error associated with difficulty precisely identify the cliff top, particularly where vegetation is present. The recorded changes between September 2012 and April 2013 show only three monitoring points show erosion, with Marker 3 showing 0.3m of erosion at the former lido and Marker 11 showing 1.9m and Marker 12 showing 1.6m of erosion in the southern part of Cornelian Bay.	Cornelian Bay and South Bay has remained stable. **Longer term trends:** The recession rates for the period of March 2010 to April 2013 are close to ±0.1m/yr for most of the frontage. The significant erosion rates are on the markers where there have been failures over the winter of 2012/13: Markers 11 and 12 in Cornelian Bay have recession rates of 0.7 and 0.6m/yr respectively.

2.7 Cayton Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
9th April 2013	**Beach Profiles:** Cayton Bay is covered by three beach profile lines for the Partial Measures survey (Appendix A). **Profile 1dCY1** is located on the beach in front of Tenants' Cliff in the north of the Bay. There is low confidence in accuracy of the upper profile at this location due to the dense vegetation encountered by the surveyor. From the MHWS level at 5m chainage to 80m chainage the beach level has eroded by 0.25m, exposing the rocks on the mid-beach. Below 80m chainage to the end of the survey the level has increased by 0.6m and a mound of material has been formed on the lower beach. **Profile 1dCY2** is close to the former pumping station in the middle of Cayton Bay. The cliff part of the profile was not surveyed due to recent landslides that had deposited mud on the foreshore. From the MHWS level at 125m chainage to 205m chainage there has been very little change (±0.2m) in beach level. Below 205m to the end of the survey the beach level has dropped by 0.5m since September 2012. **Profile 1dCY3** is located around 600m southeast of the pumping station. The middle of the cliff section could not be surveyed due to unstable ground and the surveyor noted 'mud flows on face of slope above HAT'. From the HAT level at 125m chainage to 150m chainage the beach level had dropped by 0.5m. Between 150m and 175m chainage there has been little change. From 175m to the end of the survey at 285m chainage the beach level has dropped by 0.5m.	All three of the profiles show erosion compared to the autumn 2012 profiles, with sediment moved from the upper beach towards MLW. This pattern of sediment movement is a typical response to winter storms. Recent landslides were also noted in the cliffs, which are likely to have been triggered by a combination of intense, sustained rainfall and storm waves. **Longer term trends:** The March 2013 beach levels for CY1 and CY3 are very low and comparable with the lowest survey since 2008, which occurred in March 2010. However, this is a typical response to severe winter storms and does not represent a long0term trend.
April 2013	**Cliff-top Survey:** Eight ground control points have been established within Cayton Bay for the purposes of cliff top monitoring. The separation between any two points is typically around 300m. The cliff top surveys at Cayton Bay are undertaken bi-annually. Appendix C provides results from the March 2012 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 and the previous September 2012 survey. The accuracy of the technique means results of less than 0.1m are not reliable. Furthermore, indications of an advancing cliff are error related to problems in precise identification of the cliff edge, particularly where vegetation is present. Three points show cliff recession. Marker 4 has had the largest change, with erosion of 2.7m over the	The wet winter of 2012/13 caused reactivation of coastal mudslides in the southern part of Cayton Bay, with markers 4 and 5 showing 0.2 and 2.7m erosion respectively. There has also been erosion of 0.4m at Marker 8 at the top of Red Cliff, at the south of the bay. **Longer term trends:** The long-term average recession rates show that the cliff top has changed very little since 2008. However, this masks certain areas of consistent, localised activity. Marker 2

Survey Date	Description of Changes Since Last Survey	Interpretation
	winter of 2012/13. Markers 5 and 8 have had more modest changes of 0.2 and 0.4m. This data tally with the surveyor's observation of the erosion of the cliff and recent landslides in the south of the bay.	(Tenants' Cliff) has a recession rate of 1m/yr, while in the central part of the bay, Marker 4 has a rate of 0.7m/yr while Marker 6 has a rate of 0.2m/yr.

2.8 Filey Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
11th April 2013	**Beach Profiles:** Filey Bay is covered by five beach profile lines for the Partial Measures survey (Appendix A). **Profile 1dFB1** is located in front of Filey town in the north of the bay. Overall on this profile the beach has flattened. At the toe of the seawall at 20m chainage the beach level in 2013 was comparable with the survey of September 2012. However, from 20m to 155m the beach level is up to 0.5m lower that previously. Below 155m to the extent of the survey at 230m chainage the level accreted by up to 0.4m. **Profile 1dFB2** is located north of Primrose Valley Holiday Village. The surveyor noted 'unable to measure the start of profile FB2 due to vegetation and that the face of the dune is becoming very difficult to measure due to deep fissures in soil/mud'. There is little change between the September 2012 and April 2013 profiles above 100m chainage. Between 100 and 260m chainage the beach level has dropped by around 0.5m and two mounds have appeared in beach. From 260m to the end of the survey at 320m the beach has accreted by 0.4m. Overall the beach gradient has become shallower. **Profile 1dFB3** is located in front of Flat Cliffs. There is very little change above MHWS at 45m chainage. From 45m to 175m chainage the beach has eroded by 0.5m since September 2012. From 175m to the end of the profile at 285m chainage a mound of material around 0.75m high has formed. The mound at the bottom of the profile is higher than any of the previous profiles for this part of the beach dating back to November 2008. The surveyor noted that there was a sandbar present on the beach for much of the survey **Profile 1dFB4** is located near Humanby Gap. The profile shows very little change down to the HAT level at 30m chainage. Between 30m and 125m chainage the beach level has remained within ±0.2m of the September 2012 level. From 125m to 200m chainage the beach level has dropped by up to 0.75m. From 125m chainage to the extent of the survey at 240m chainage the beach has been stable, staying within a range of ±0.1m **Profile 1dFB5** is located close to Reighton Gap. The surveyor noted that the middle of profile FB5 was unable to be measured from 65m to approx 200m chainage, due to vegetation. Below the MHSW level at 230m chainage the beach level has dropped by up to 1.2m in the most severe areas of erosion. The two mounds of material in the September 2012 profile have become more exaggerated as the	The predominant trend from Autumn 2012 to Spring 2013 has been erosion of the beach and flattening of the profile, with sediment moved from the upper beach towards MLW. This is likely to be related to beach draw-down in response to winter storms and is therefore a transient seasonal effect. **Longer term trends:** When compared to previous beach autumn profile surveys the beach levels are low. May of the profiles show erosion and in some areas the rocky shore platform was exposed for the first time. The observations of the surveyor support data, saying that 'the level of the sand is particularly low. This can be seen throughout the beach not just at the top of the beach, but there are large patches of mud / stones across the whole beach giving an idea of the underlying strata'

Survey Date	Description of Changes Since Last Survey	Interpretation
	depression between them has deepened. The April 2013 profile is one of the lowest recorded since 2008.	
April 2013	**Topographic Survey:** Data from the most recent topographic survey (Partial Measures, spring 2013) have been used to create a digital ground model (DGM) (Appendix B – Map 3a) using a Geographical Information System (GIS). The topographic plot shows the shore parallel bathymetry in front of Filey town. A difference plot has also been produced using the DGM (Appendix B – Map 3b) comparing the last topographic survey (Full Measures, Autumn 2012) to the present survey. The difference plot shows two strips of change running parallel to the shore. The landward two-thirds of the beach has experienced erosion of up to 0.75m while the seaward third of the beach has accreted by around 0.5m. There are also localised patches of accretion of up to 1m very close to the seawall on the landward extent of the survey.	The difference plot for the period between September 2012 and April 2013 shows erosion of the upper beach and accretion of the lower beach, which reflects the profile data. This suggests the process of winter draw-down has occurred throughout Filey Bay. **Longer term trends:** The erosion of the upper beach close to the promenade at Filey has been noteworthy this year. In previous years the erosion has tended to be modest and centred on the lower beach. However, the magnitude of change recorded throughout the beach over the winter of 2012/13 was much greater than over the previous winter.
April 2013	**Cliff-top Survey:** 23 ground control points were established within Filey Bay for the purposes of cliff top monitoring in November 2008. Additional points were added in September 2010 and March 2011 (as shown in Appendix C – Maps 5a and 5b) taking the total number of ground control points within Filey Bay to 28. The maximum separation between any two points is nominally 300m. The cliff top surveys at Filey Bay are undertaken bi-annually. Appendix C provides results from the April 2013 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 and the previous September 2010 survey. The accuracy of the technique means results of less than 0.1m are not reliable. Furthermore, indications of an advancing cliff are error related to problems in precise identification of the cliff edge, particularly where vegetation is present. Between the September 2012 and the current survey four markers showed recession greater than the error and between 0.2m/ and 0.4m of erosion was recorded.	Over the winter of 2012/13 the marker points show stability overall. **Longer term trends:** The majority of the bay has recession rates of less than 0.1m/yr. There are only four points which show a recession rate of more then 0.1m/yr. Marker 5, immediately south of the Filey town defences, has a recession rate of 0.4m/yr, markers 15 and 16 either side of Hunmanby Gap have 0.3m/yr, and Marker 19 near Reighton Gap is eroding at 0.4m/yr. The recession rates will become clearer as the more data is collected on the erosion rates in future years of this monitoring programme.

3. Problems Encountered and Uncertainty in Analysis

Individual Profiles

At Filey Bay the middle of section FB2 was not accessible due to soft mud and a deep fissure.

Cliff Top Surveys

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. This generally reflects the difficulty precisely identifying the cliff top, particularly where there is vegetation present. It is hoped that a more reliable pattern of change will be determined over the longer term. However, in the short term, better assessments of cliff recession will be derived from analysis of time-series remote sensing data. A high quality baseline survey, comprising LiDAR and aerial photography, was collected in 2010, a repeat survey will be completed in late 2012 and a second repeat survey is planned for 2014. These data will be analysed to give more accurate information on the behaviour of the cliffs.

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

No changes are recommended at the present time.

5. Conclusions and Areas of Concern

- All beach profiles show evidence for winter drawdown, with many showing their lowest levels since records began in 2008. This suggests the winter of 2012/2013 has been exceptional in the context of the last six years.
- At Staithes the cliff-top survey shows that there have been no large losses from the cliff line over the winter of 2012/13. The cliff is likely to continue to erode and could potentially pose a hazard, but there are no causes for concern related to the data collected.
- At Runswick Bay the topographic survey shows that the beach level in landward part of the bay has dropped while it has accreted in the mid-beach. The draw down of beach sediment is common during the winter and the beach should recover over the summer months.
- At Sandsend Beach, Upgang Beach and Whitby Sands the beach profiles show that the beach has eroded over the winter months, which is to be expected. The beach levels are among the lowest recorded on the majority of the profiles.
- At Robin Hoods Bay the topographic survey shows little change in the beach level. The cliff survey points show that there has been little change in the cliff line over the winter of 2012/12. There are no immediate causes for concern at this location.
- At Scarborough North Bay the low beach levels and shallow beach gradients are believed to be a result of beach draw-down during the winter of 2012/13.
- At Scarborough South Bay the severity of the erosion during the winter of 2012/13 was noteworthy. Much of the beach in South Bay is at its lowest recorded level. This beach is actively managed so it is likely that beach levels will recover. The erosion of the beach may have lead to the recession of the cliff. The monitoring shows that two of the markers in the south show recession off 1.9m and 1.6m where one or more large failures has caused the cliff top to recede. The rest of the frontage has remained stable.
- At Cayton Bay the beach levels are comparatively low but should recover during the summer months. The cliff monitoring recorded at least one mudslide at Markers 4 and 5 which has caused erosion of 0.2 to 2.7m. There has also been erosion of 0.4m at Marker 8.
- At Filey Bay the beach profiles show the beach has become shallower and that beach material has been drawn down the beach. The cliff monitoring shows that there have been localised areas of erosion but that the frontage has been stable overall.

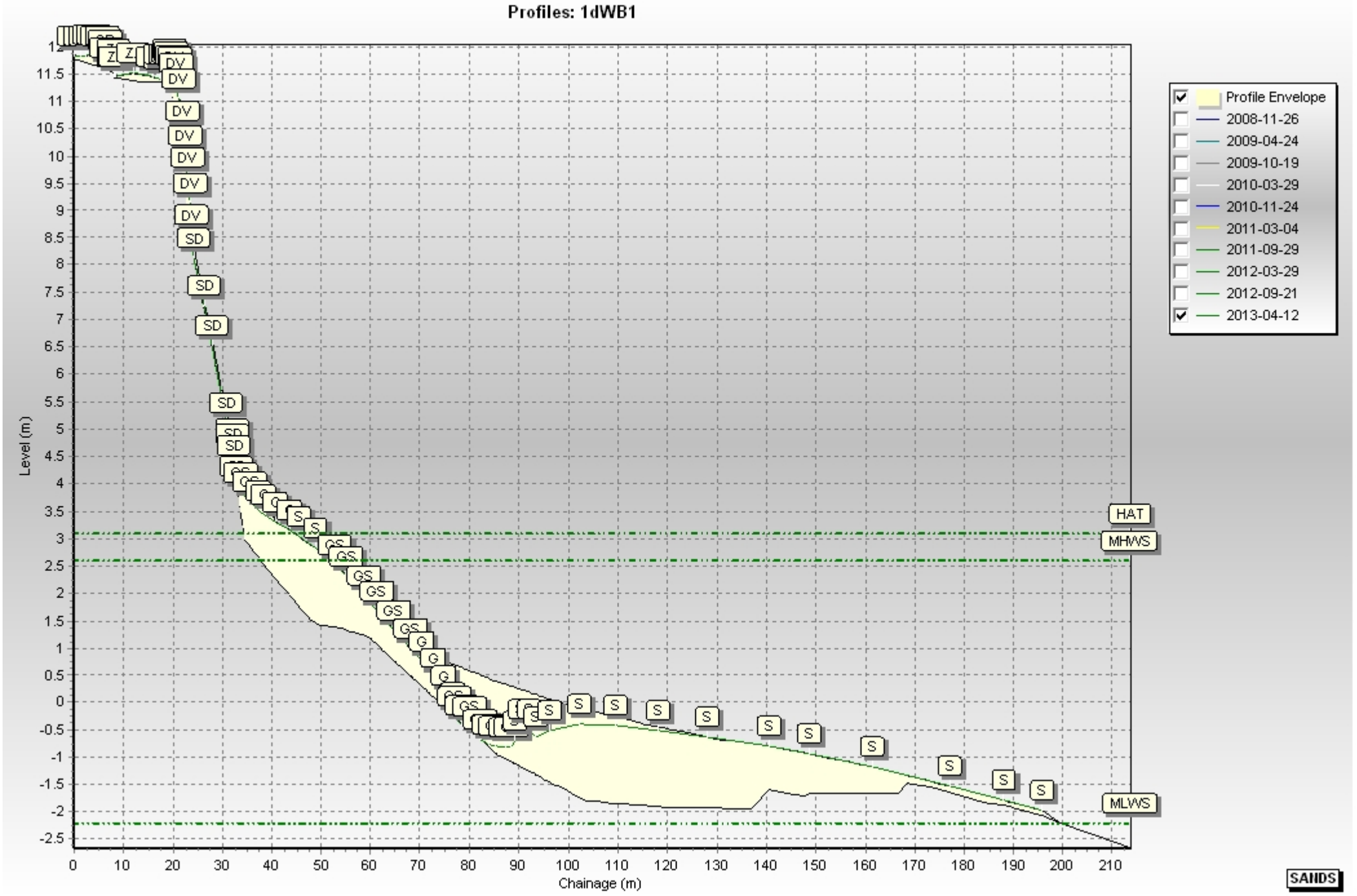
Appendices

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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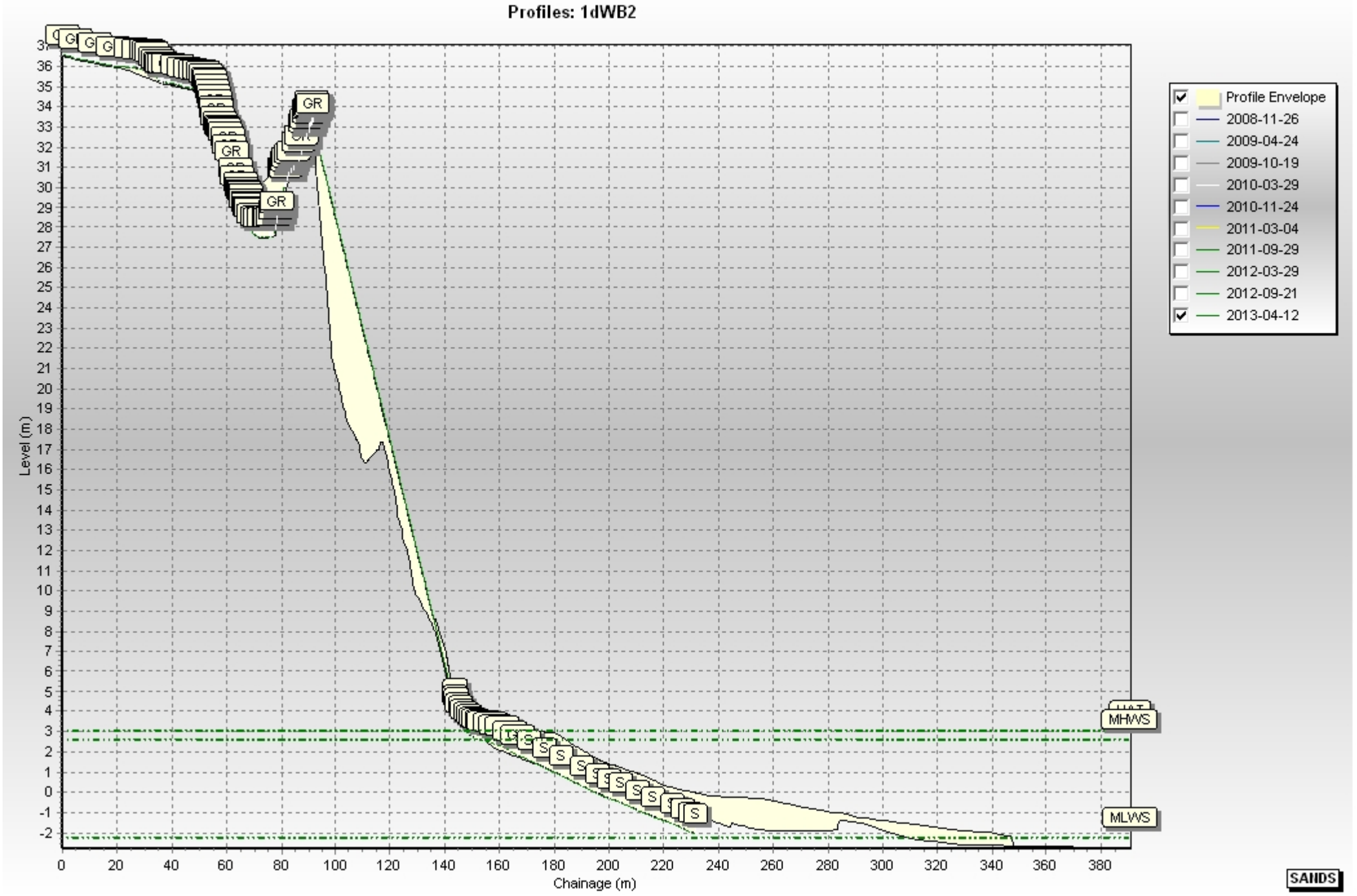
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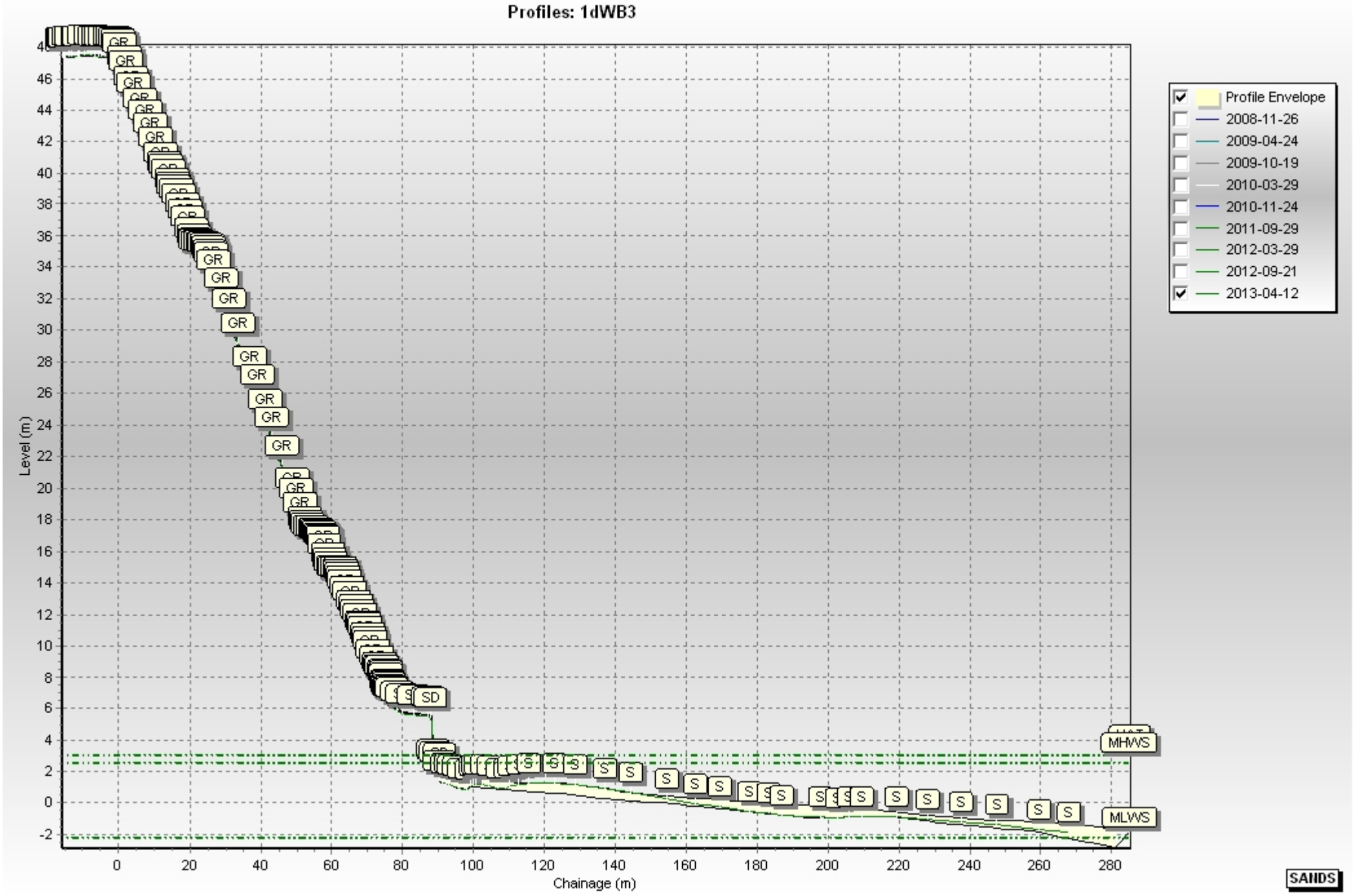
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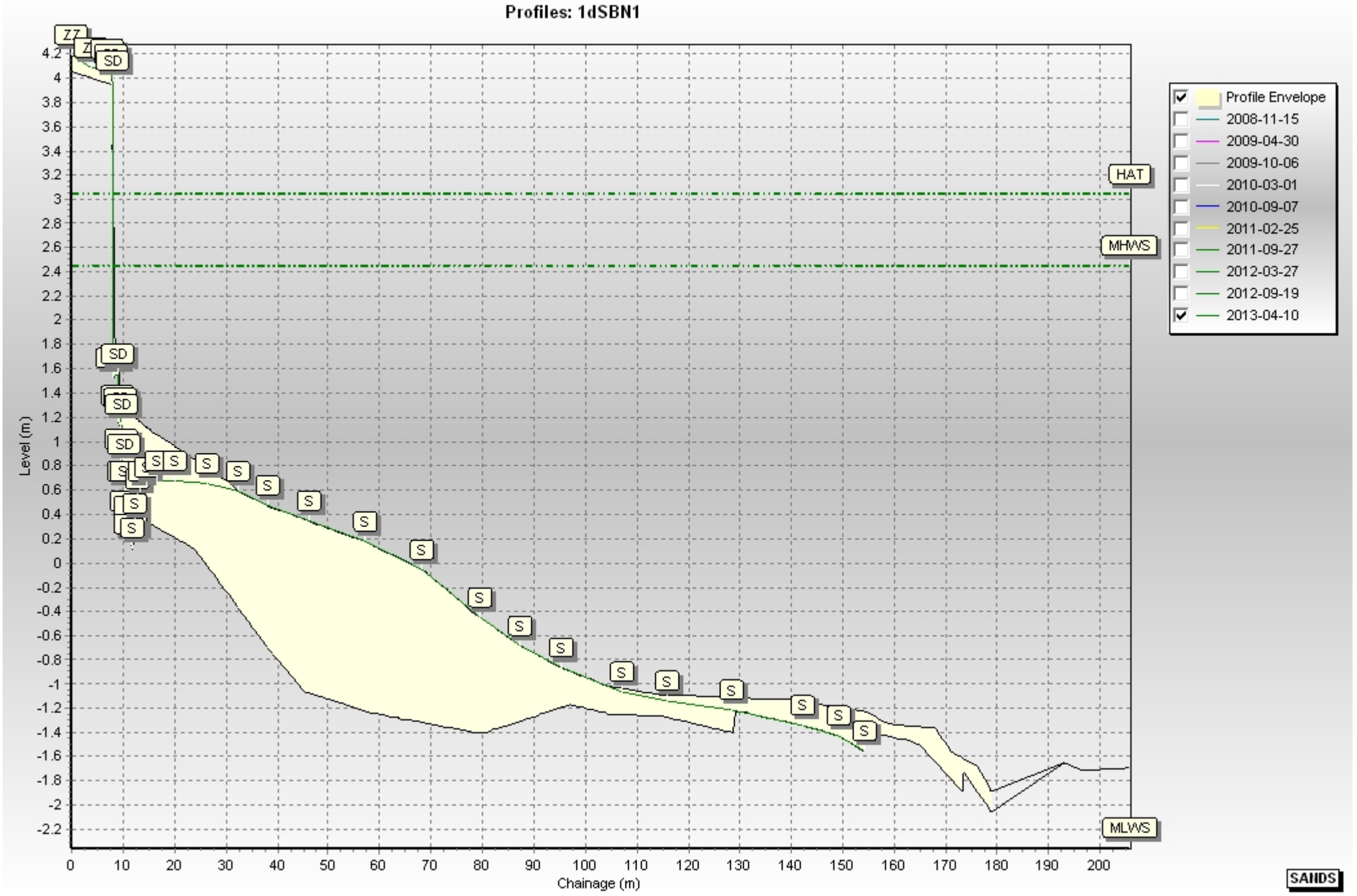
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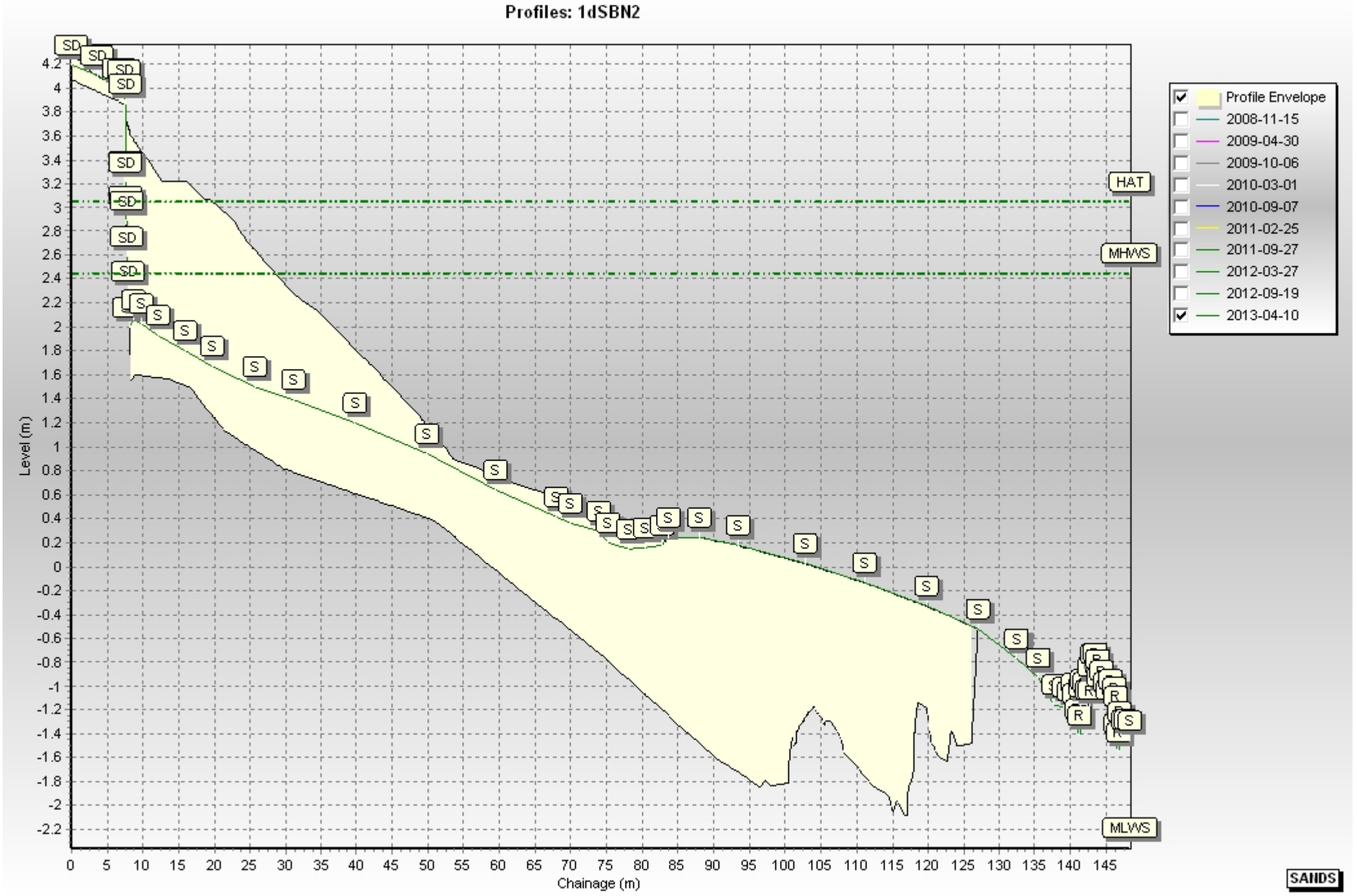
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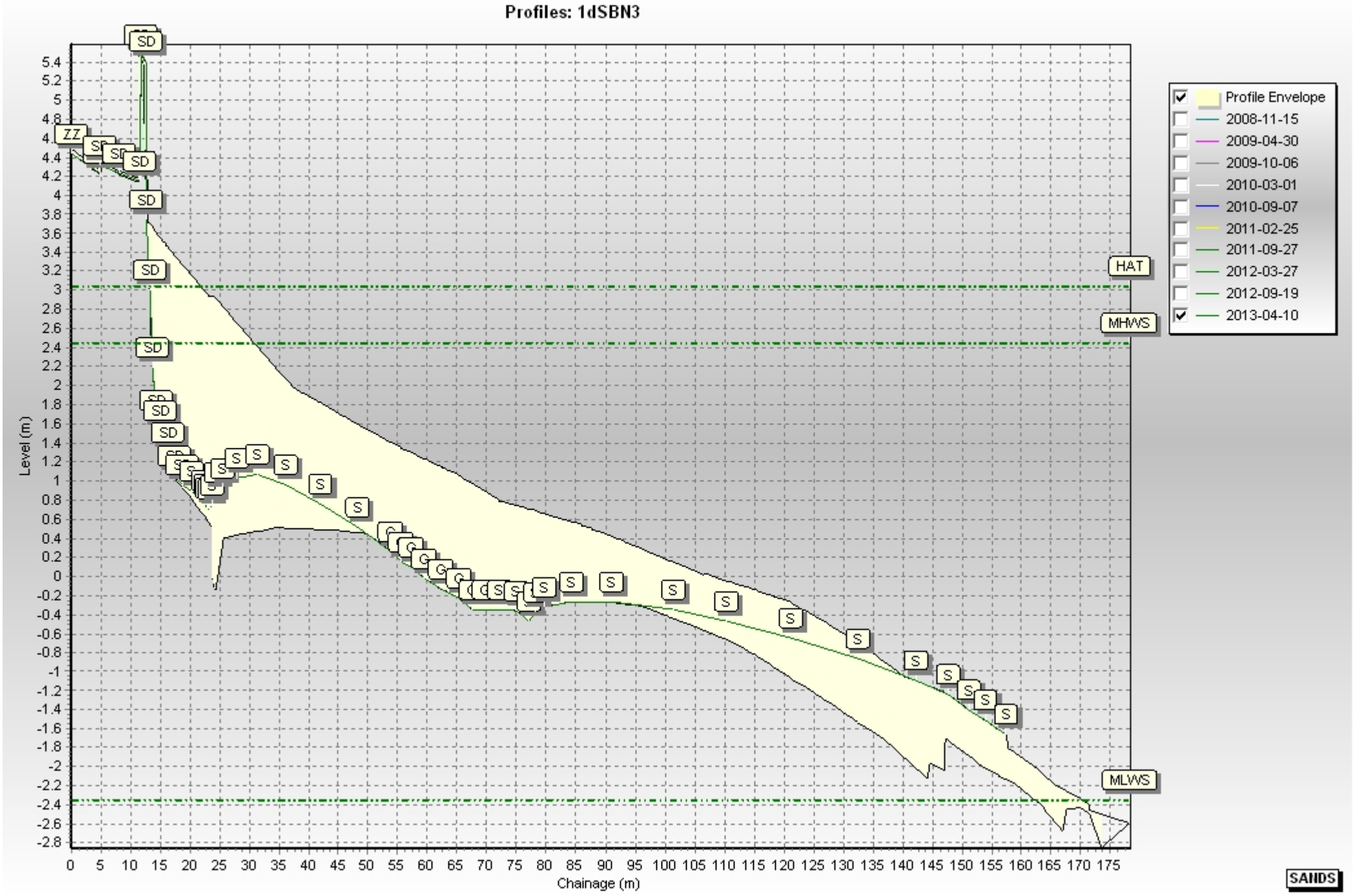
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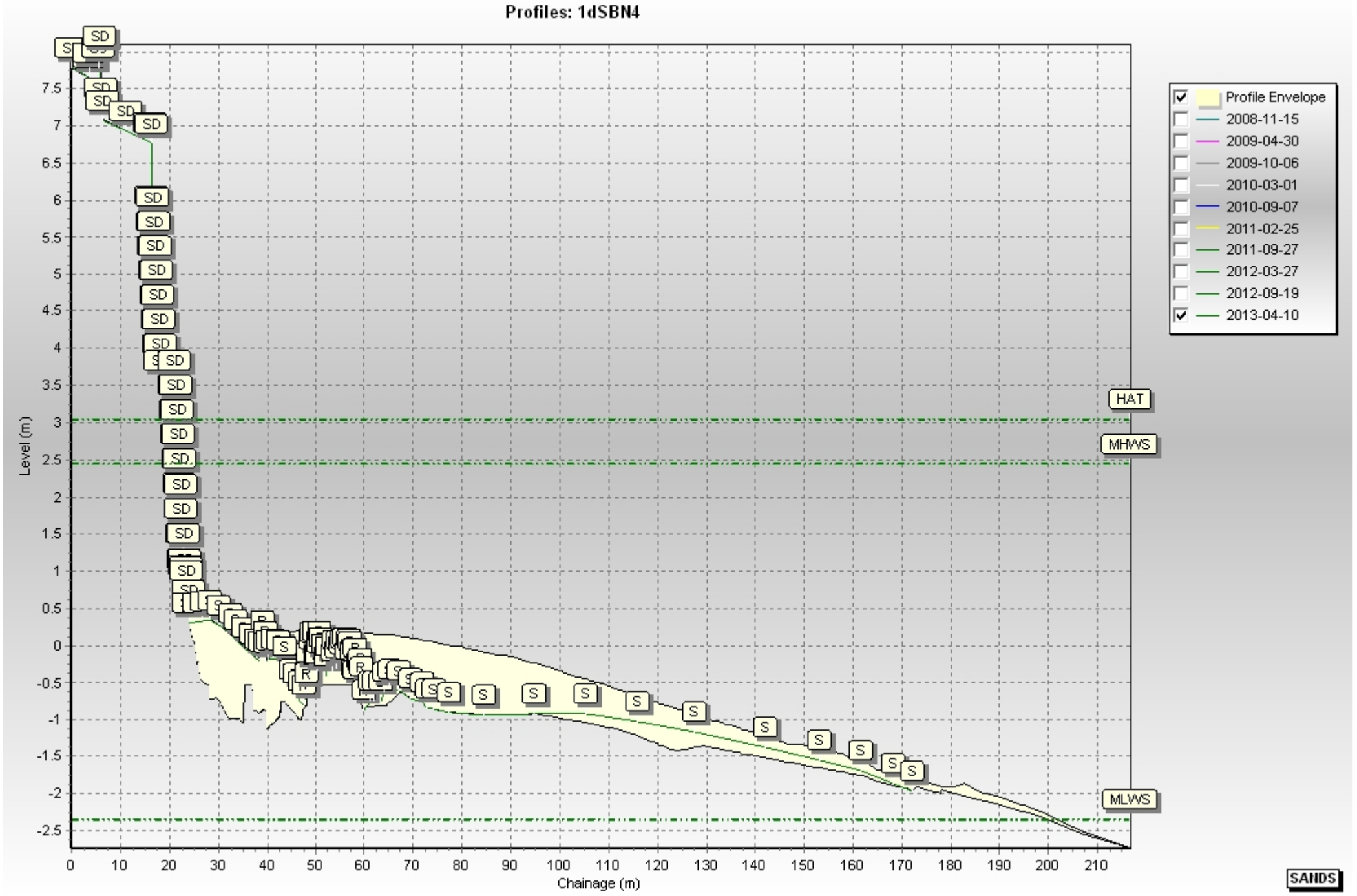
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Chainage (m)
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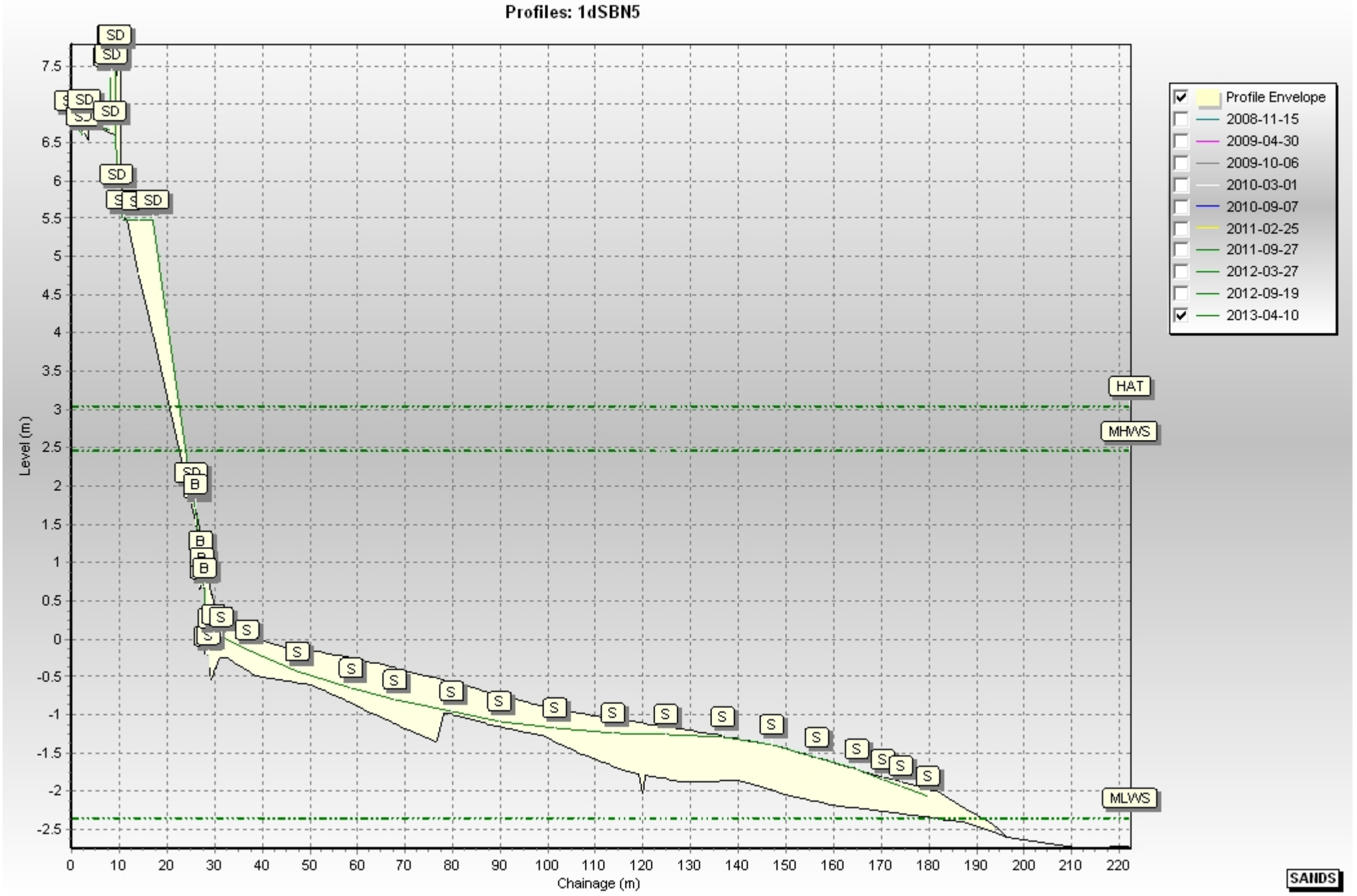
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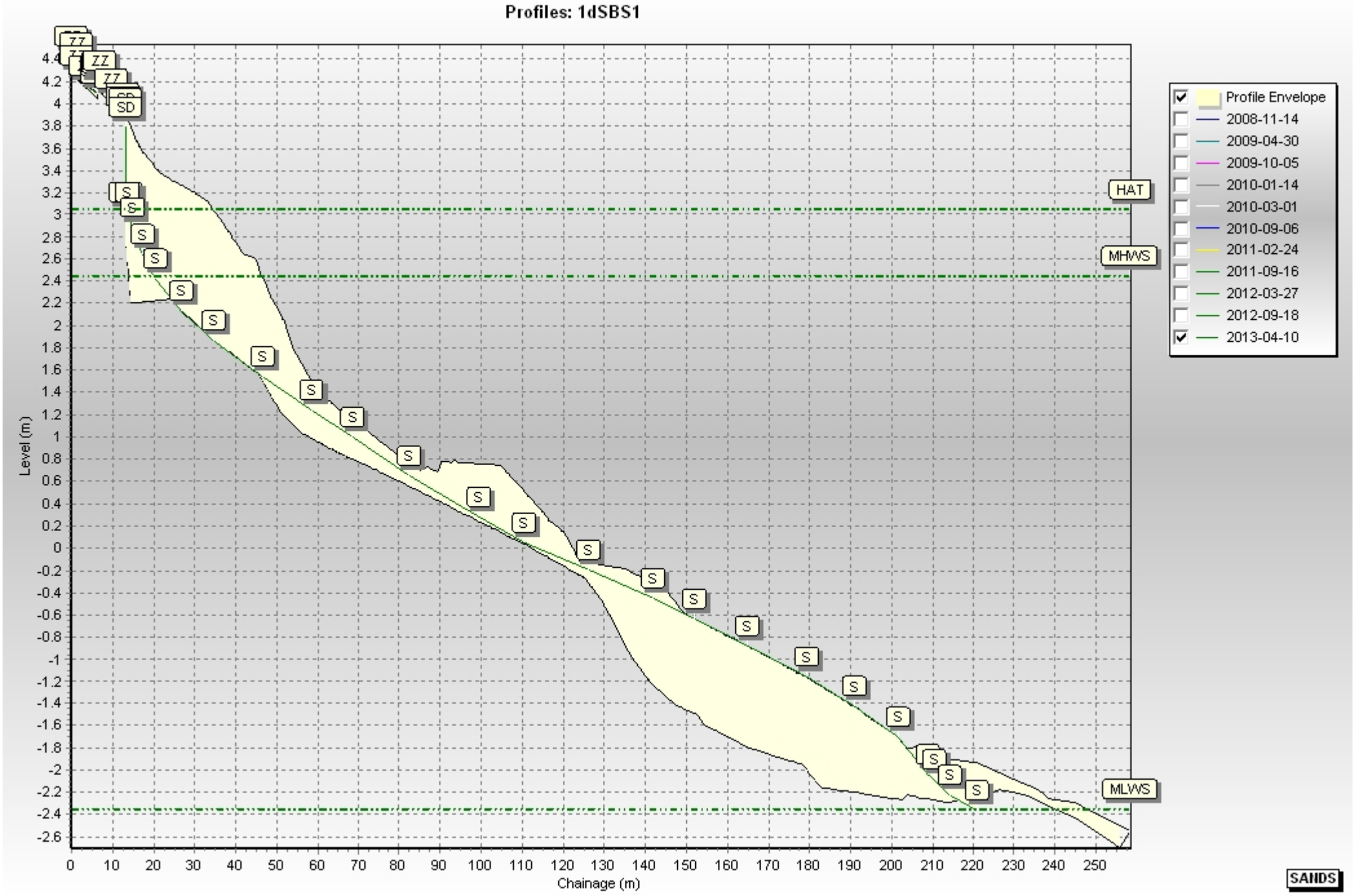
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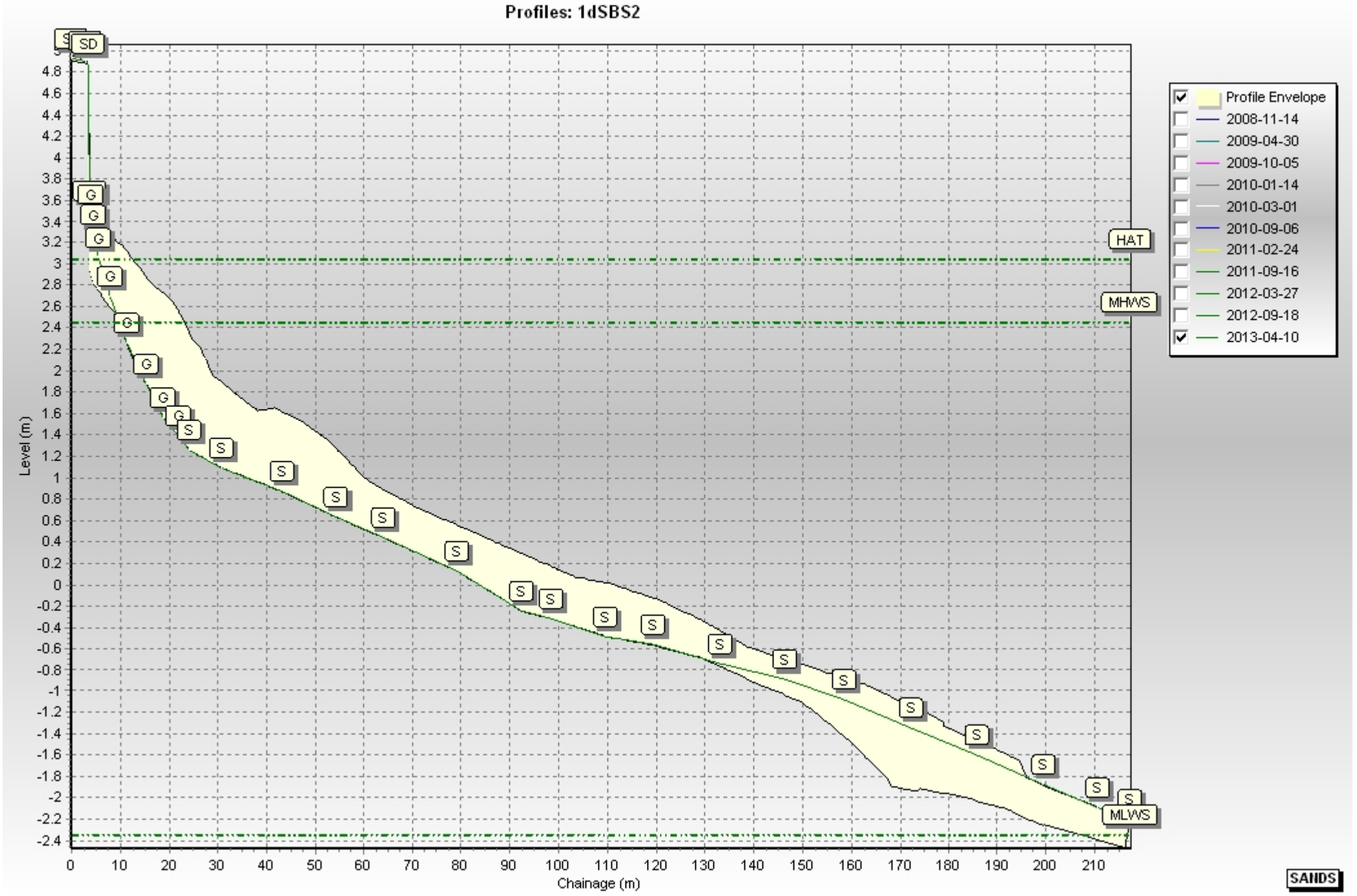
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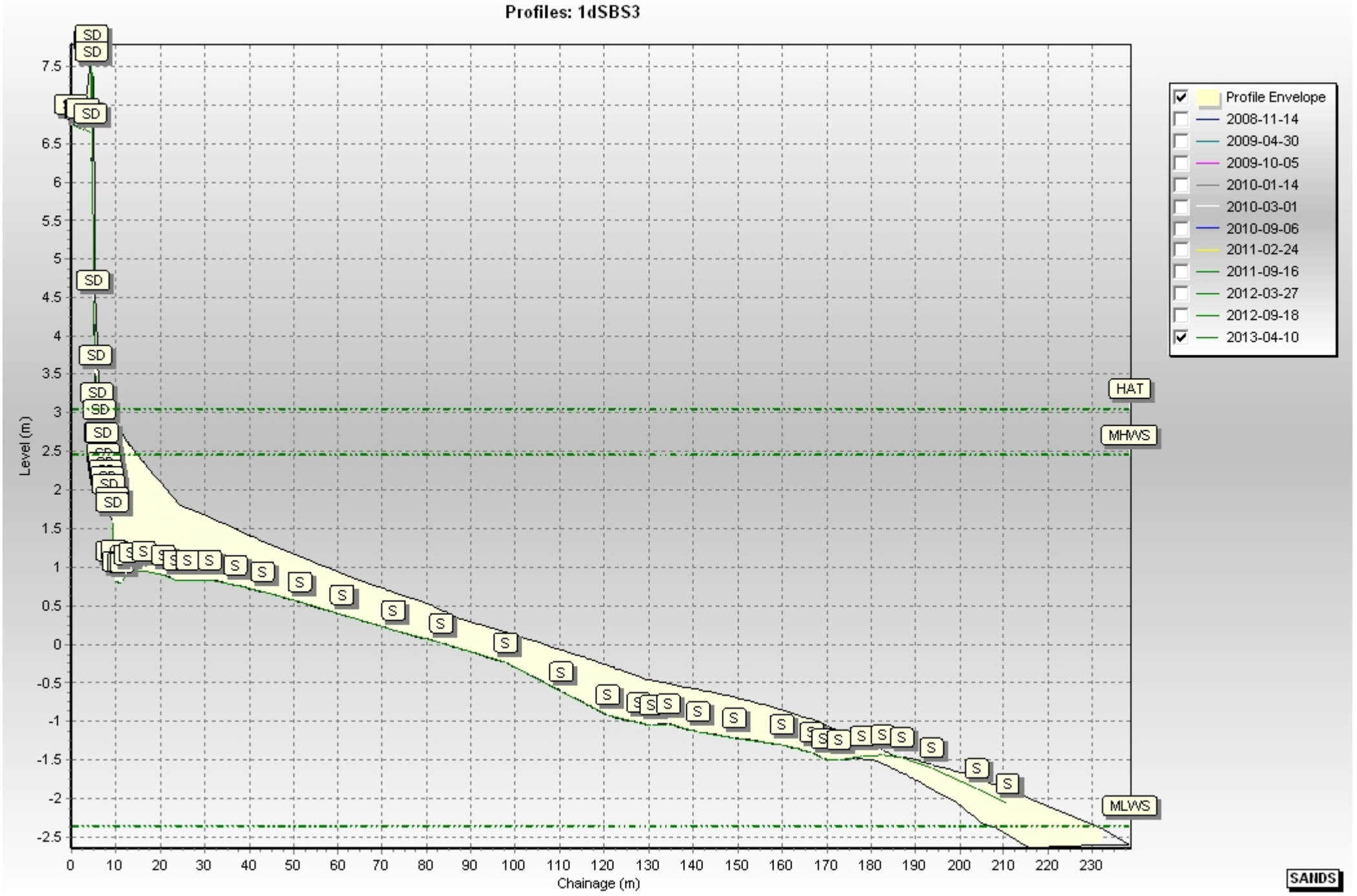
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HAT
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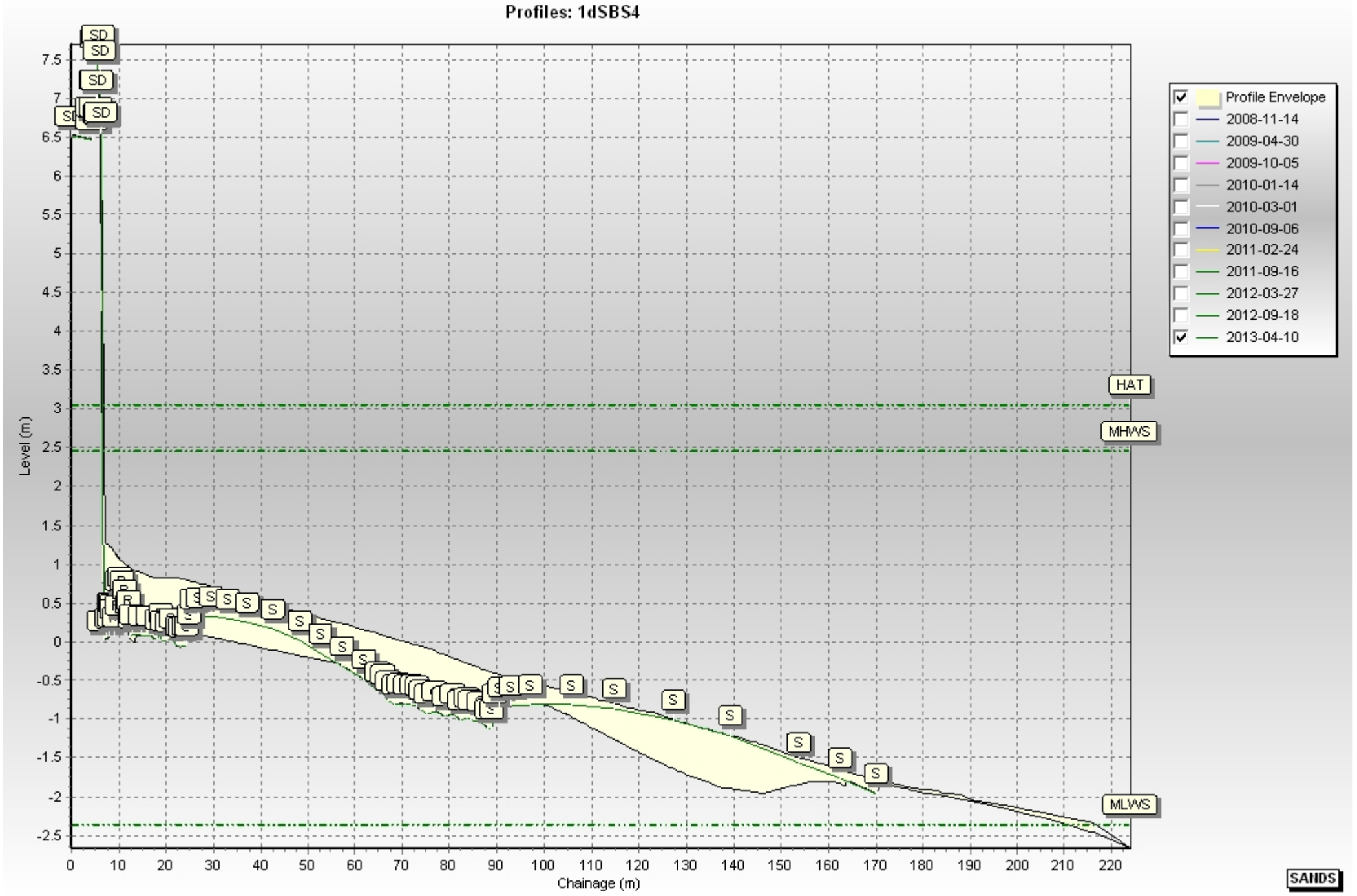
SD
S
Level (m)
Chainage (m)
SANDS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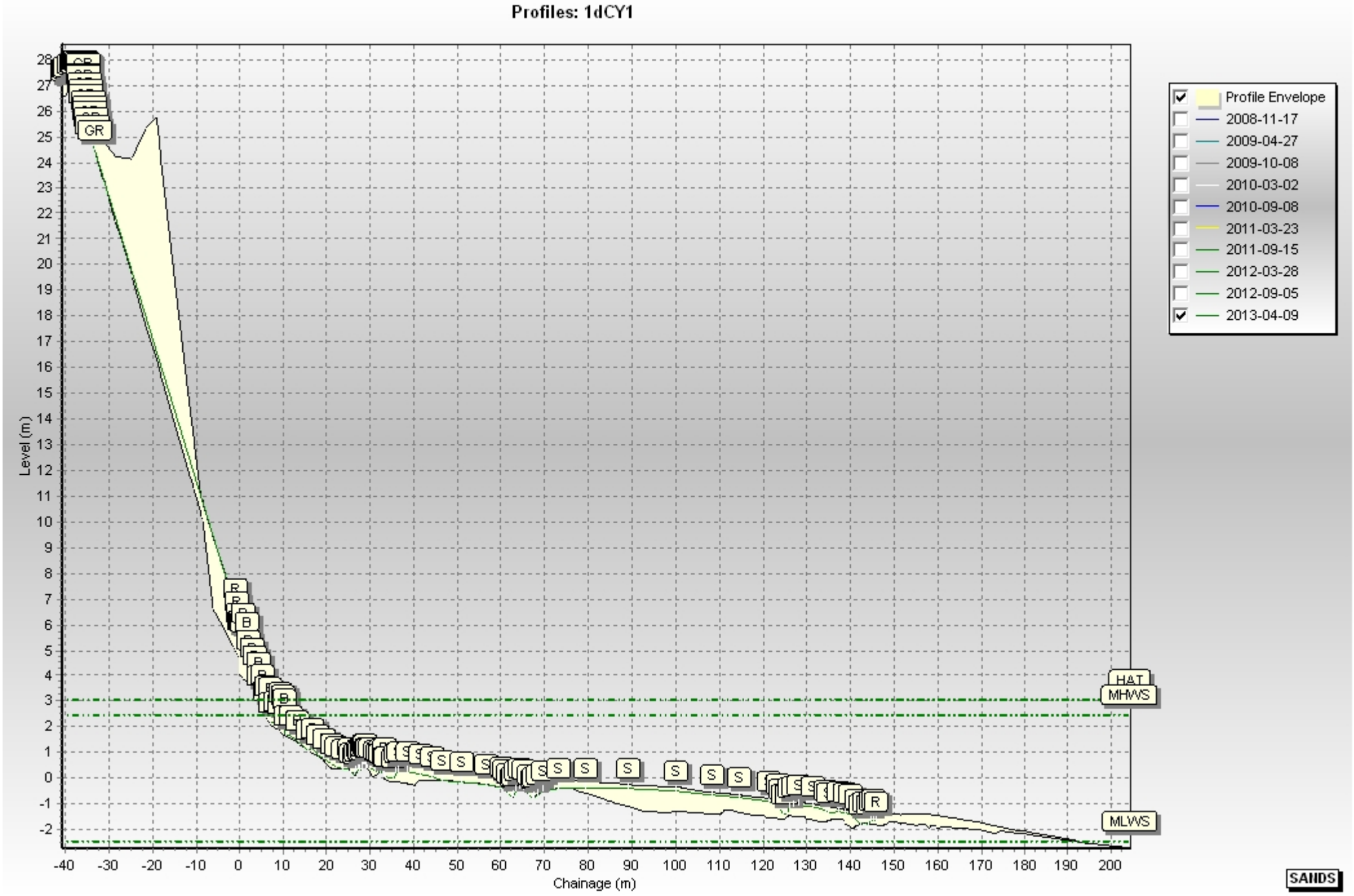
MLWS
Level (m)
Chainage (m)
SANDS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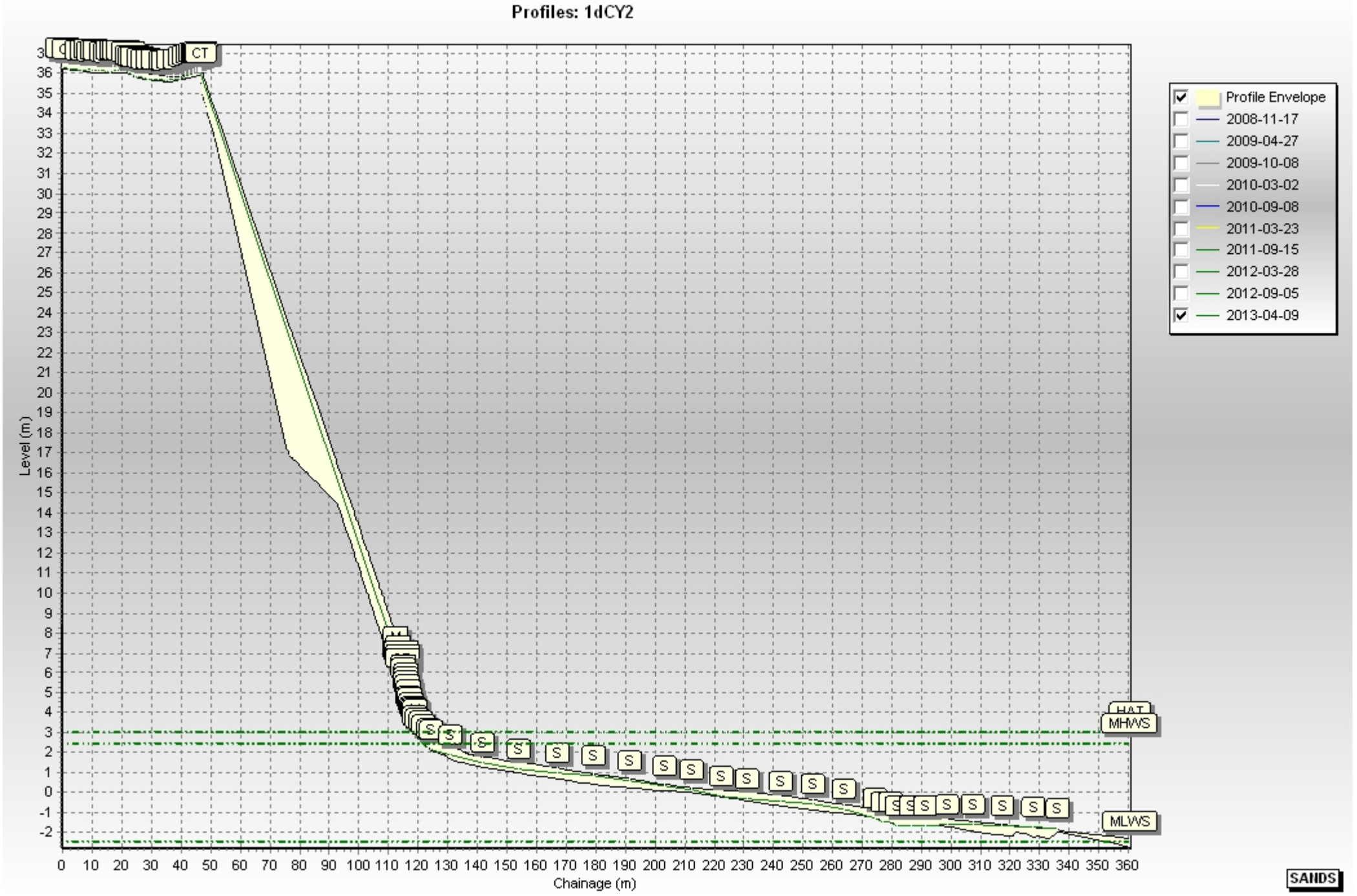
B
S
R
HAT
MHWS
MLWS
Level (m)
Chainage (m)
SANDS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CT
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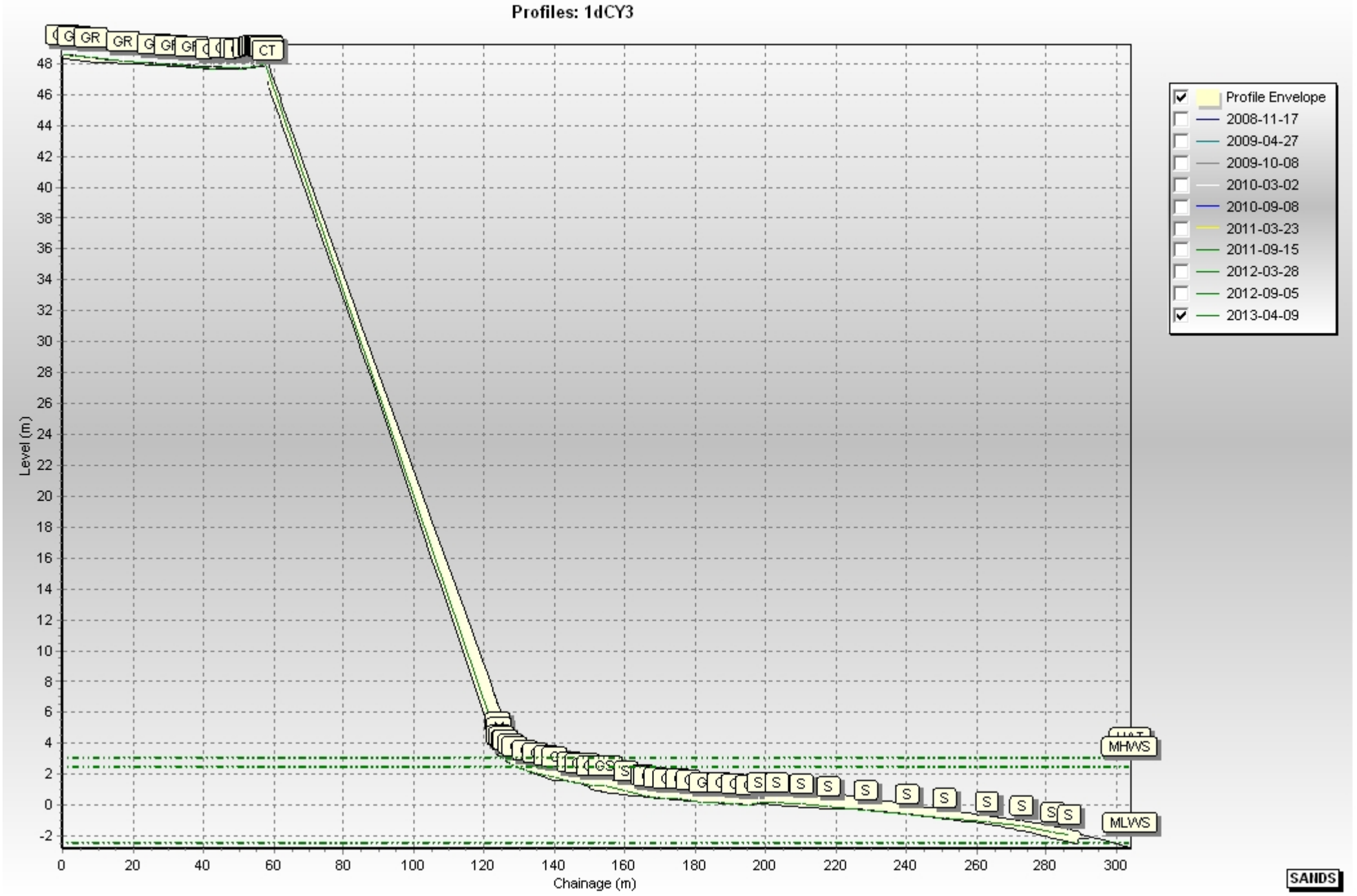
MLWS
Level (m)
Chainage (m)
SANDS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MLWS
Level (m)
Chainage (m)
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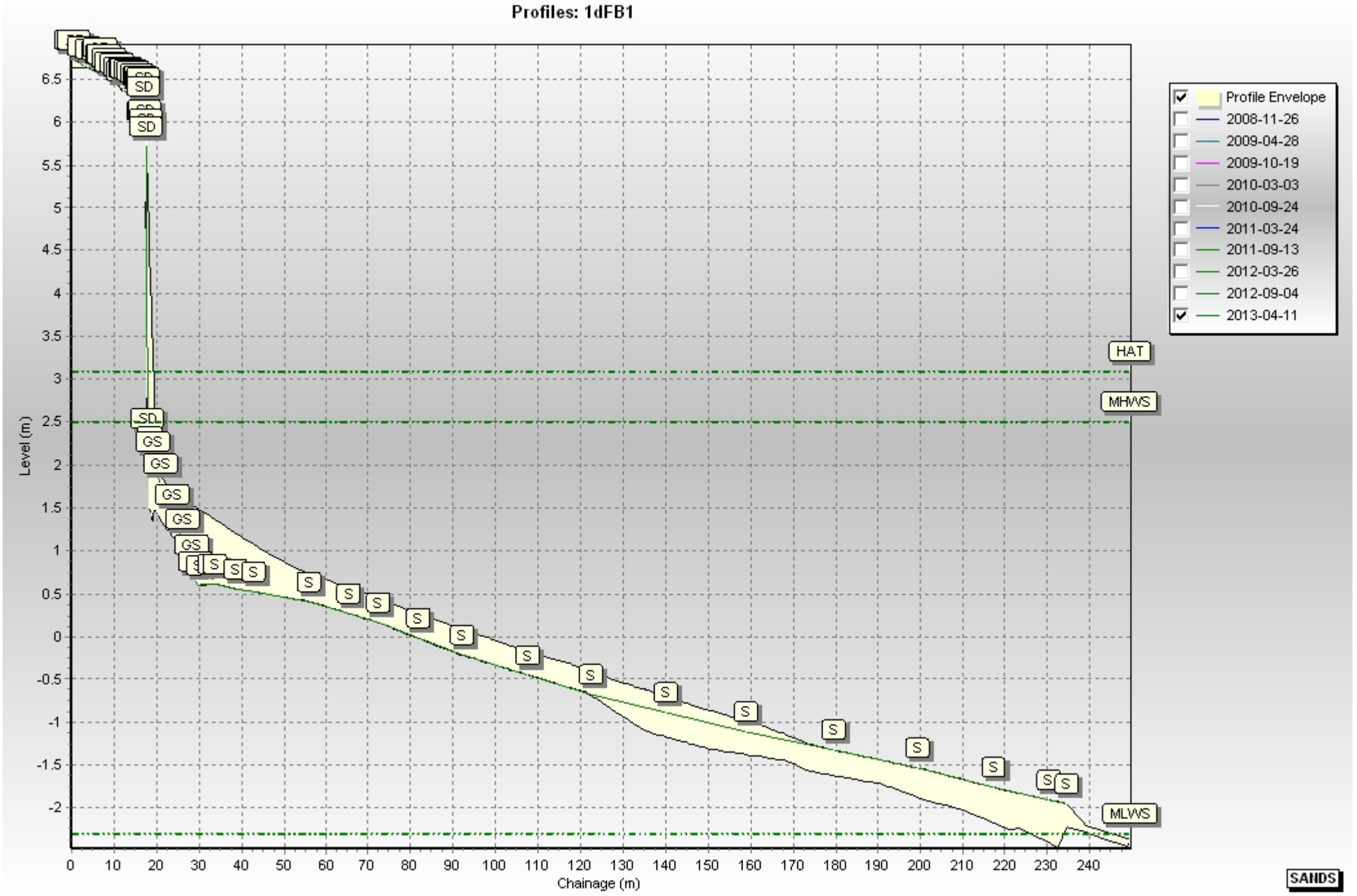
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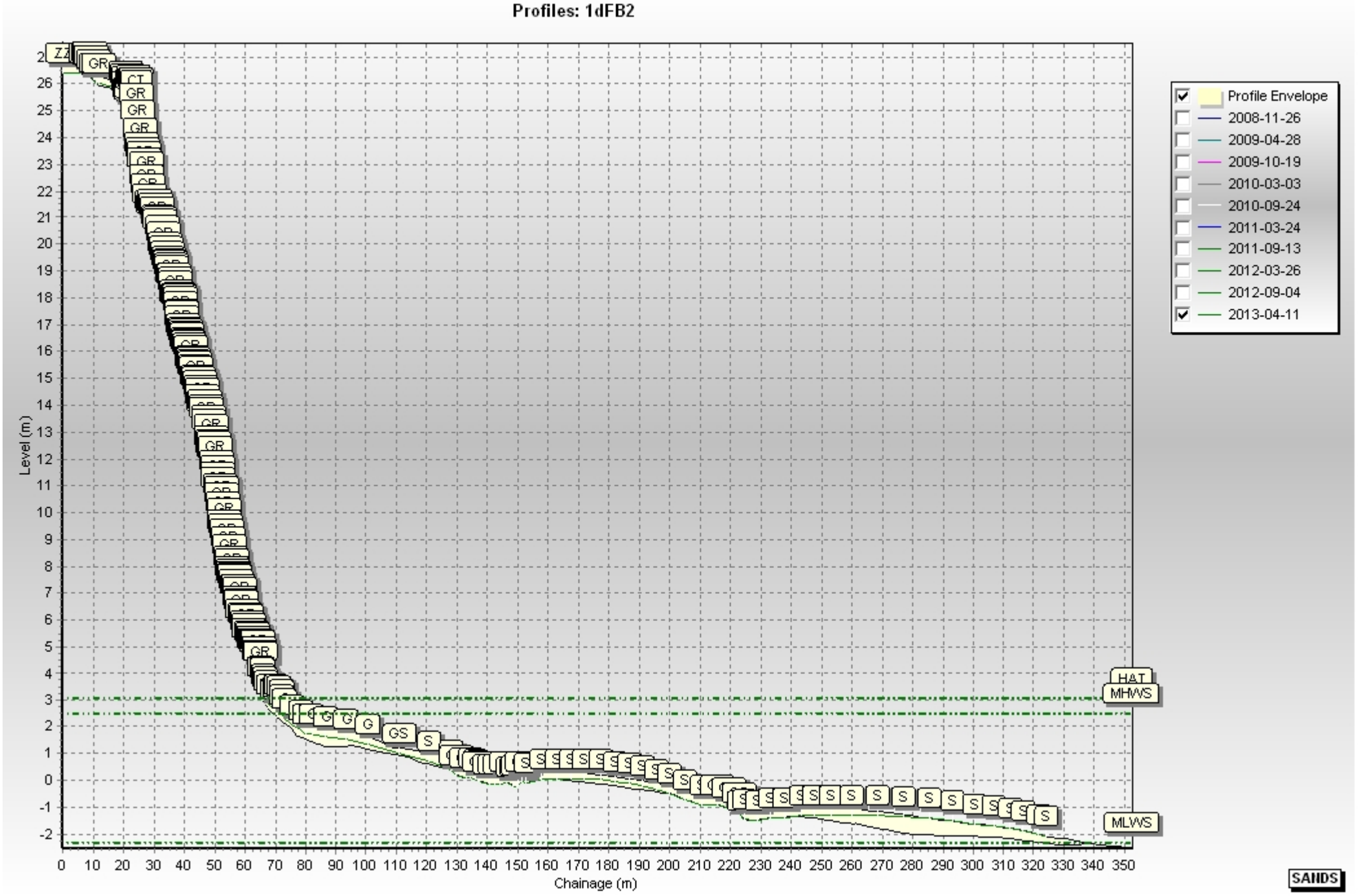
MLWS
SD
GS
S
Level (m)
Chainage (m)
SANDS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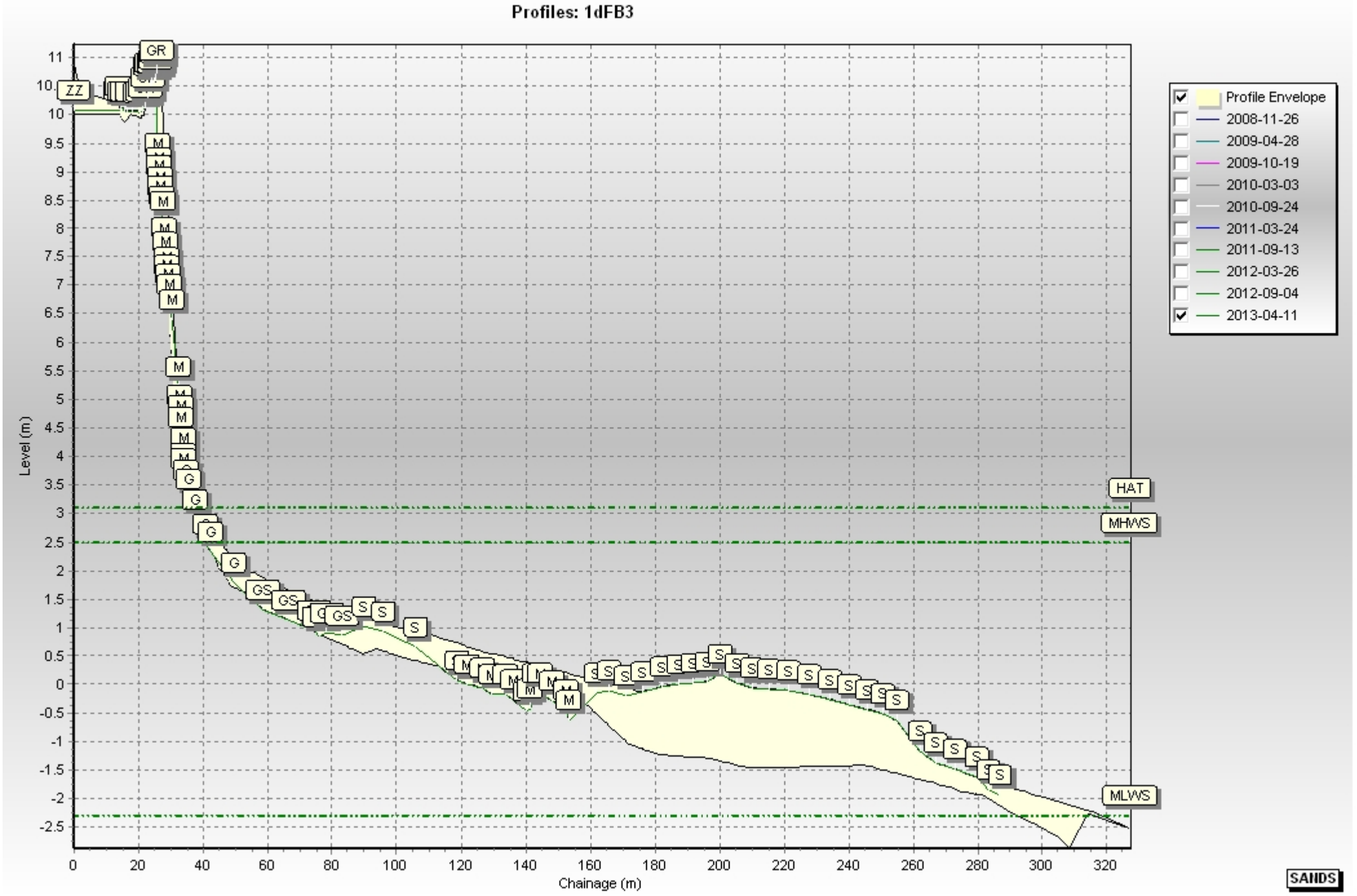
MLWS
Level (m)
Chainage (m)
SANDS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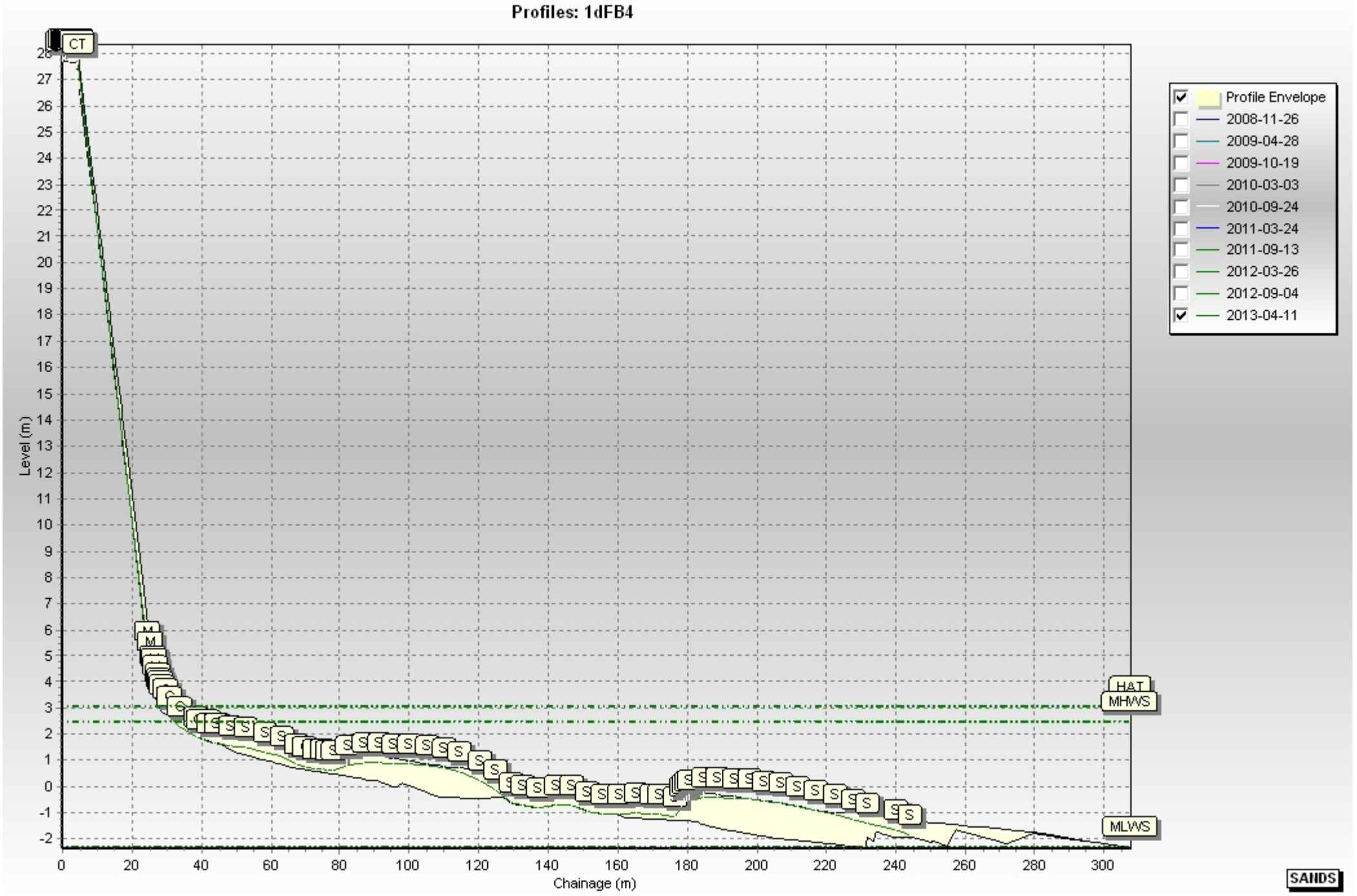
2013-04-11
GR
ZZ
HAT
MHWS
MLWS
Level (m)
Chainage (m)
SANDS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MLWS
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Chainage (m)
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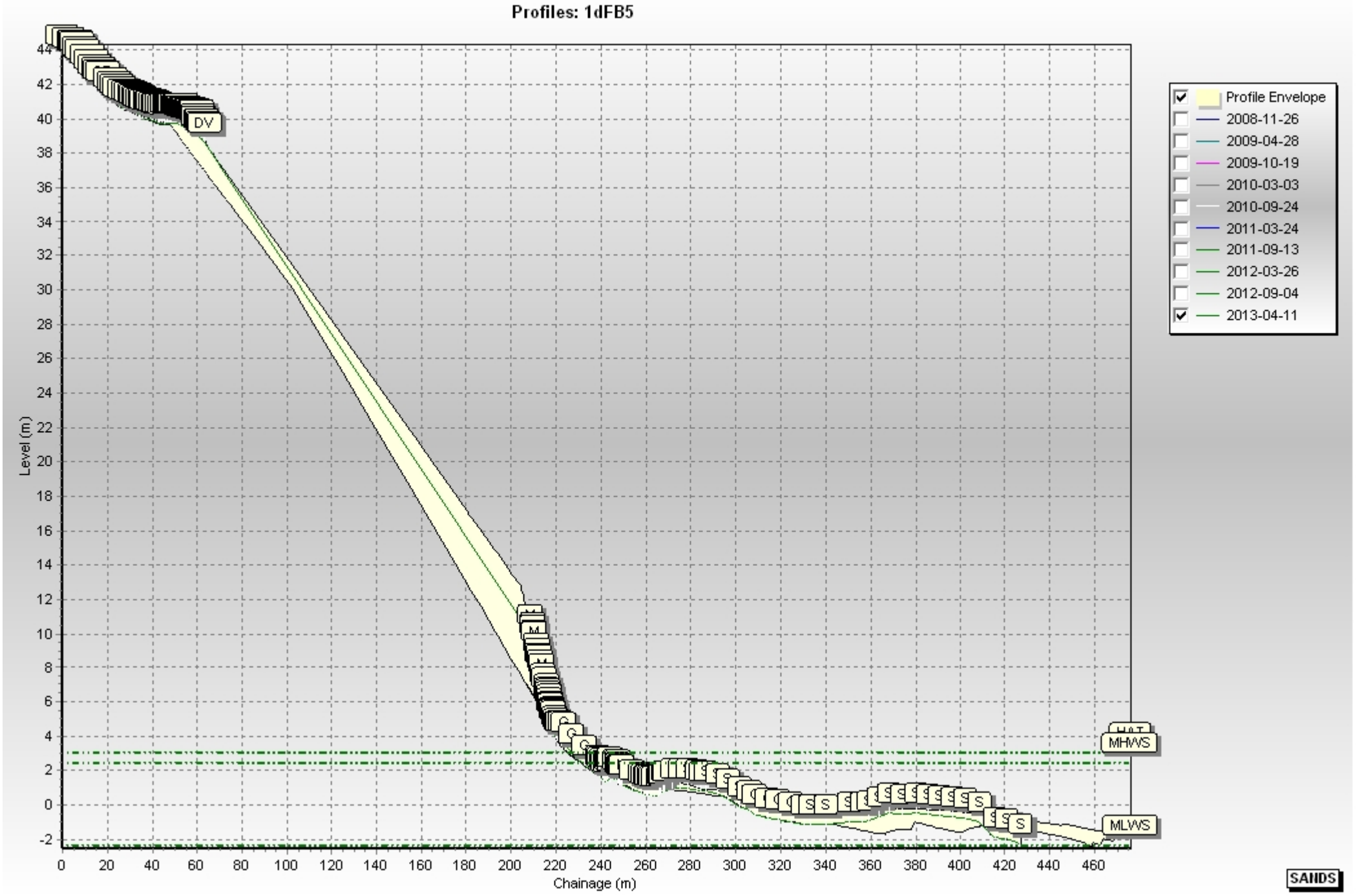
2012-03-26
2012-09-04
2013-04-11
SANDS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2011-09-13
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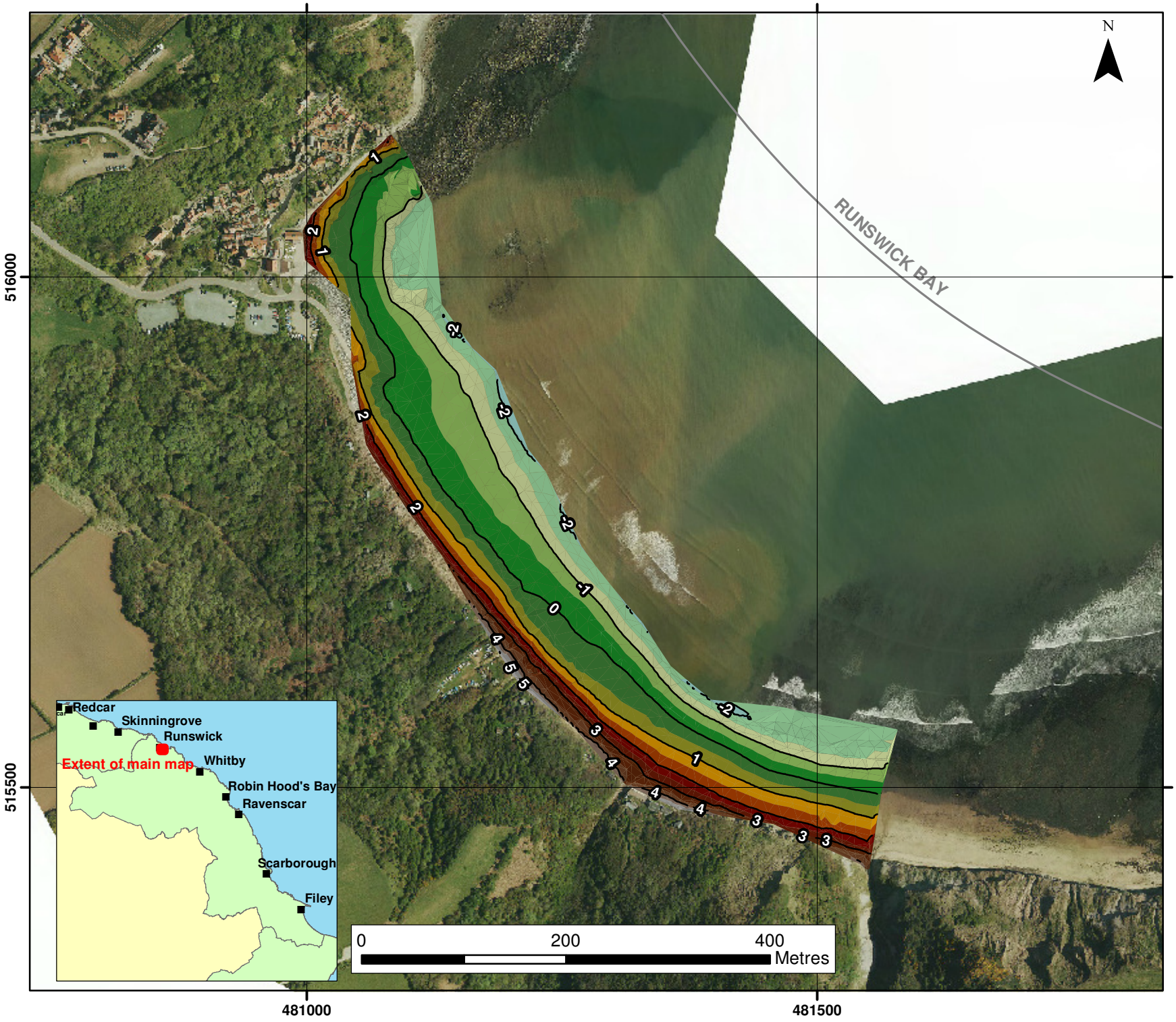
2012-09-04
2013-04-11
DV
MHWS
MLWS
Level (m)
Chainage (m)
SANDS

Appendix B

Topographic Survey



KEY

Elevation (m OD)

- 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 1a
Topographic Survey
Runswick
Scarborough
Borough Council

Update Report 5
Partial Measures Survey
Spring 2013

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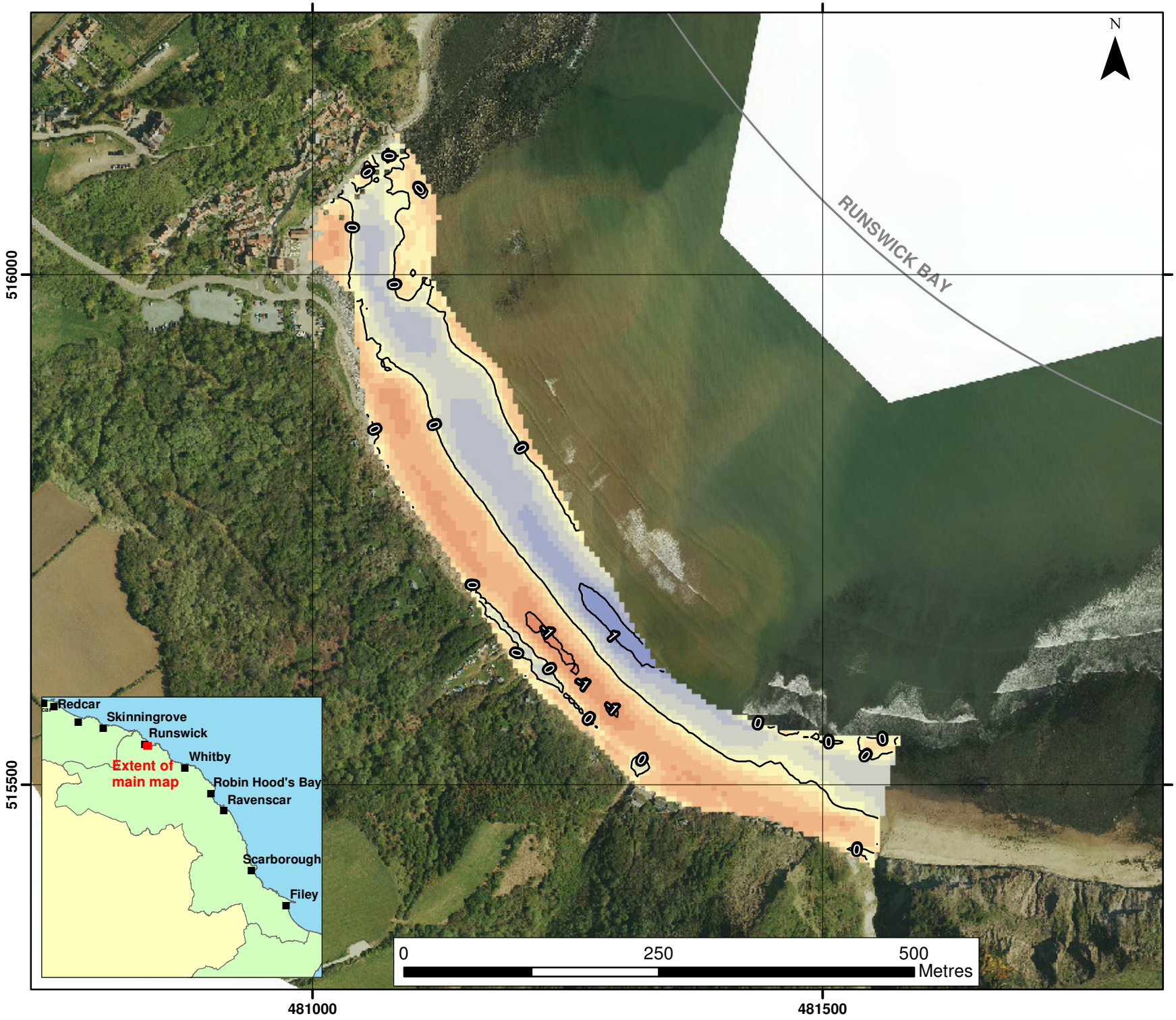

KEY Autumn 2012 and Spring 2013
Change in elevation (m)

<-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
Runswick
Scarborough Borough Council

Update Report 5
Partial Measures Survey
Spring 2013

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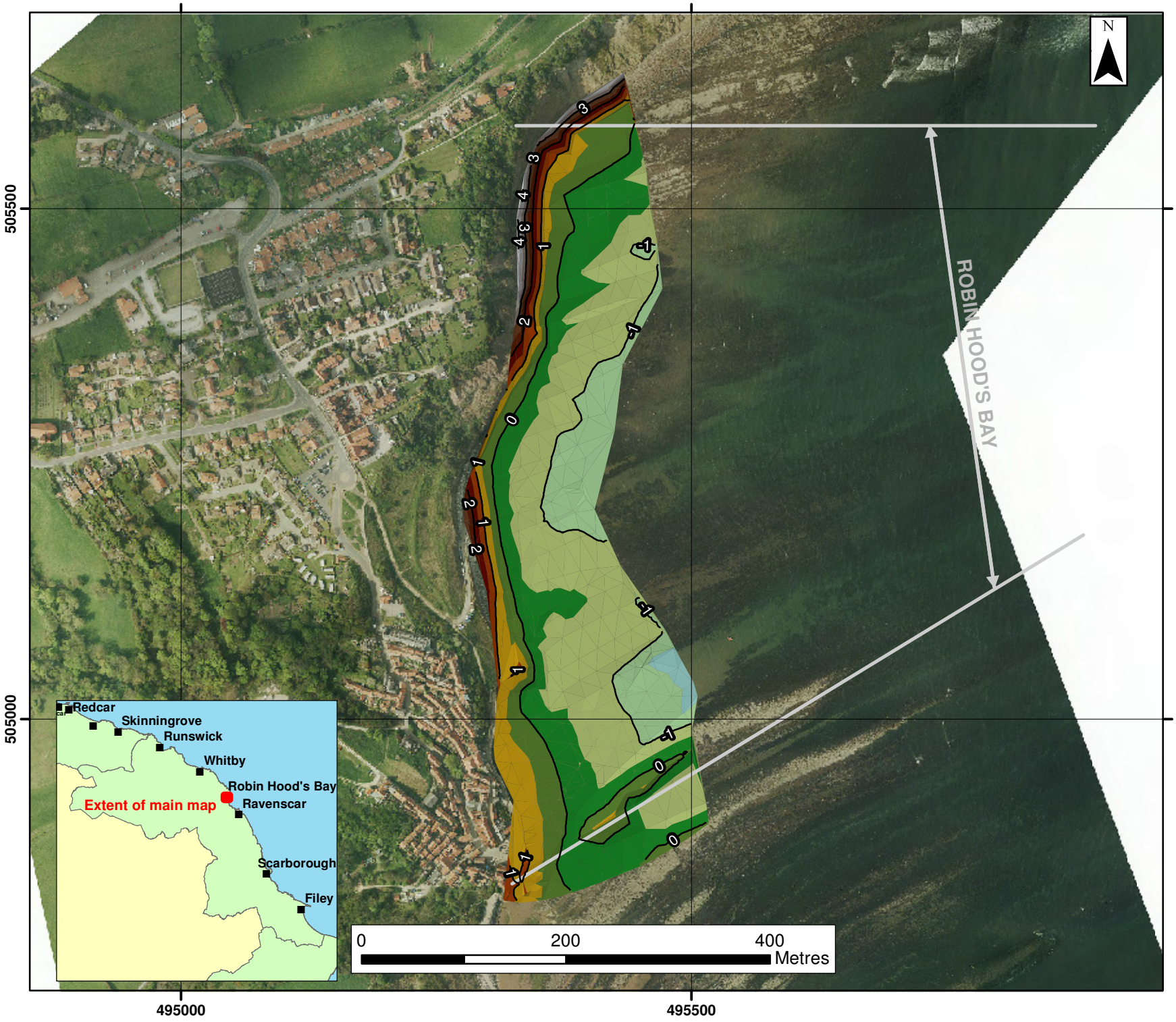

KEY

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
- -2.0 - -1.5
- Contour 1m

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B- Map 2a
Topographic Survey
Robin Hood's Bay
Scarborough
Borough Council

Update Report 5
Partial Measures Survey
Spring 2013

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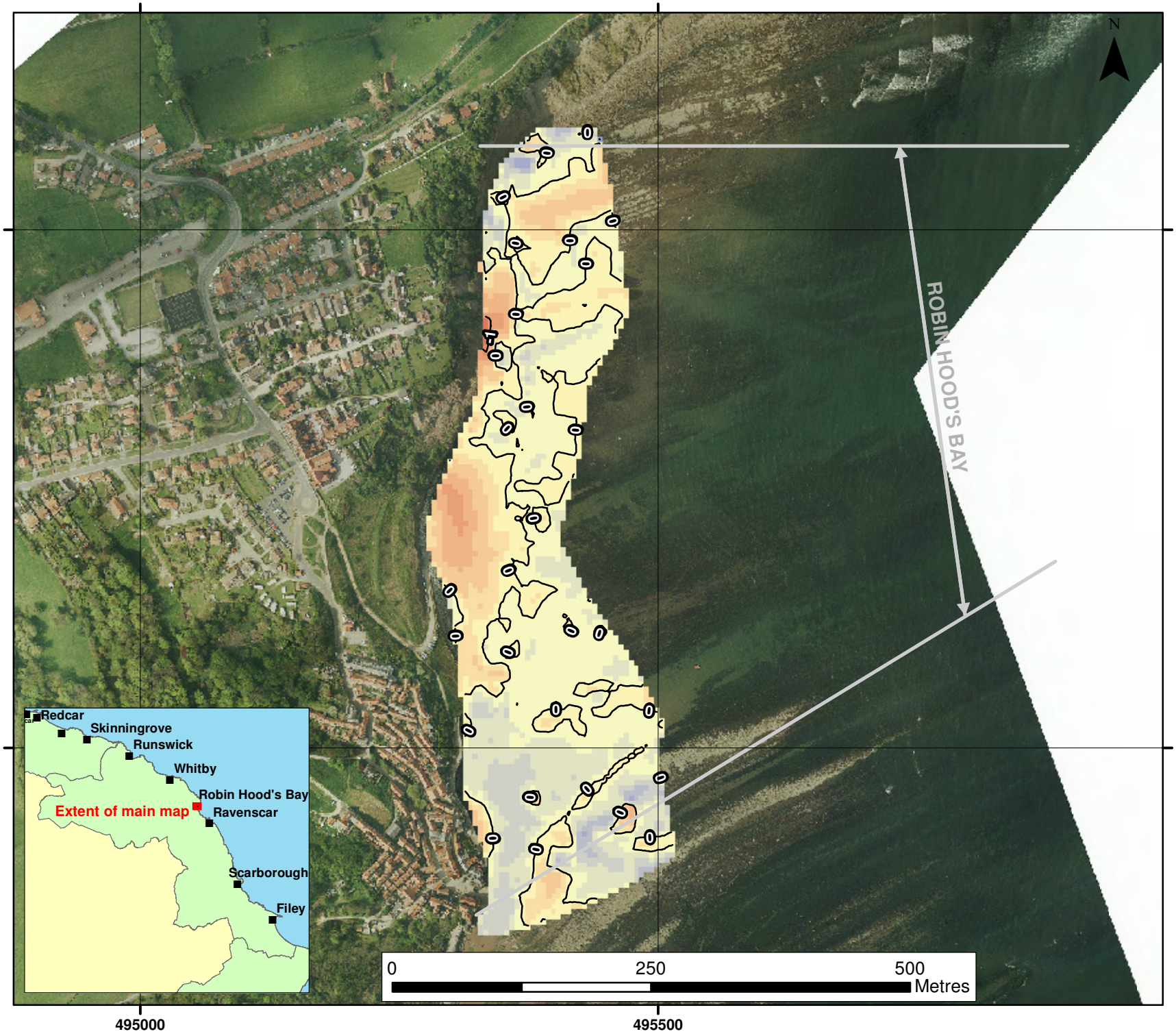

KEY Autumn 2012 and Spring 2013
Change in elevation (m)

<-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 2b
Short-term Elevation Change
Robin Hood's Bay
Scarborough Borough Council

Update Report 5
Full Measures Surveys
Spring 2013

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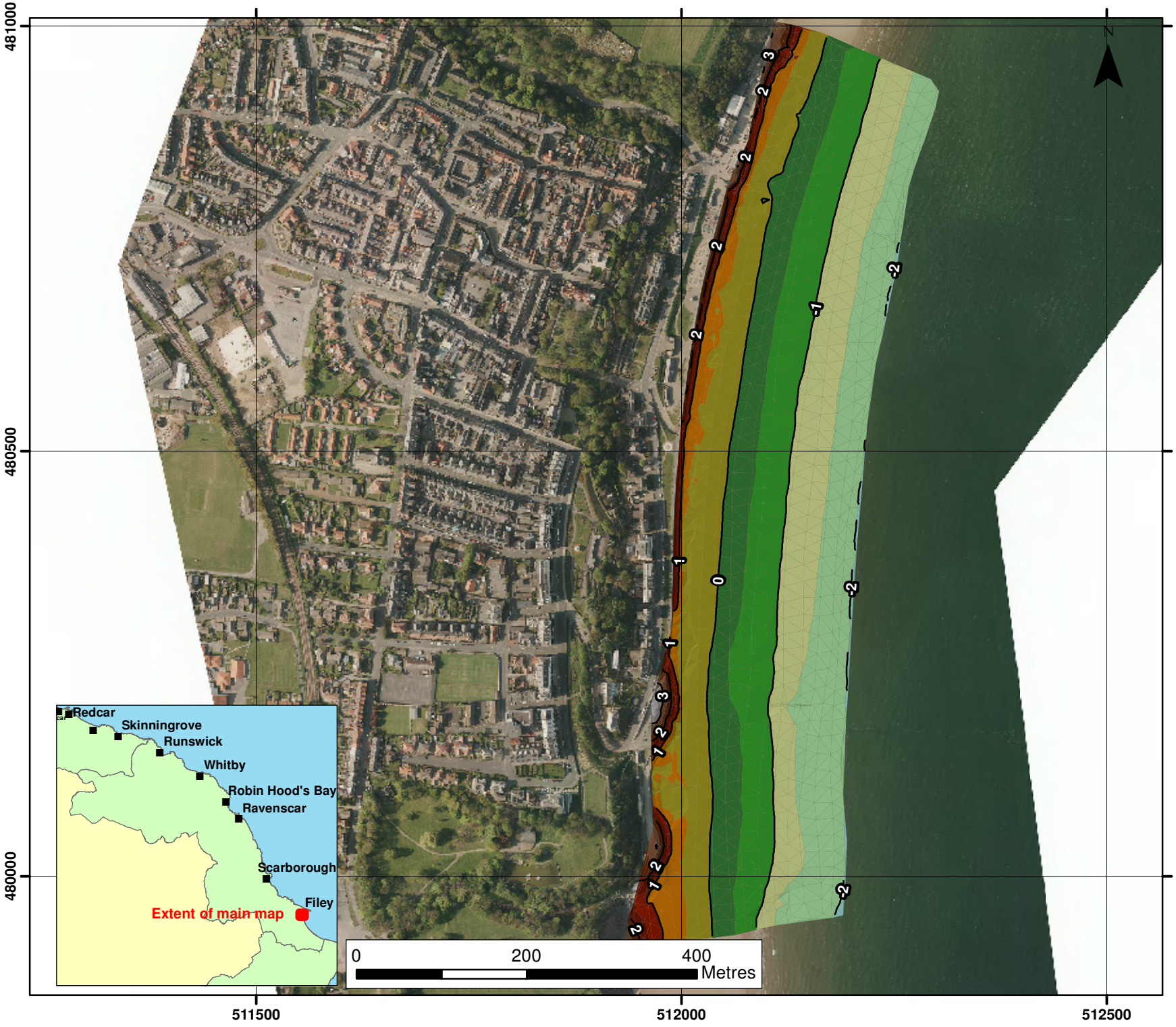

KEY

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 3a
Topographic Survey
Filey Bay
Scarborough Borough Council

Update Report 5
Partial Measures Survey
Spring 2013

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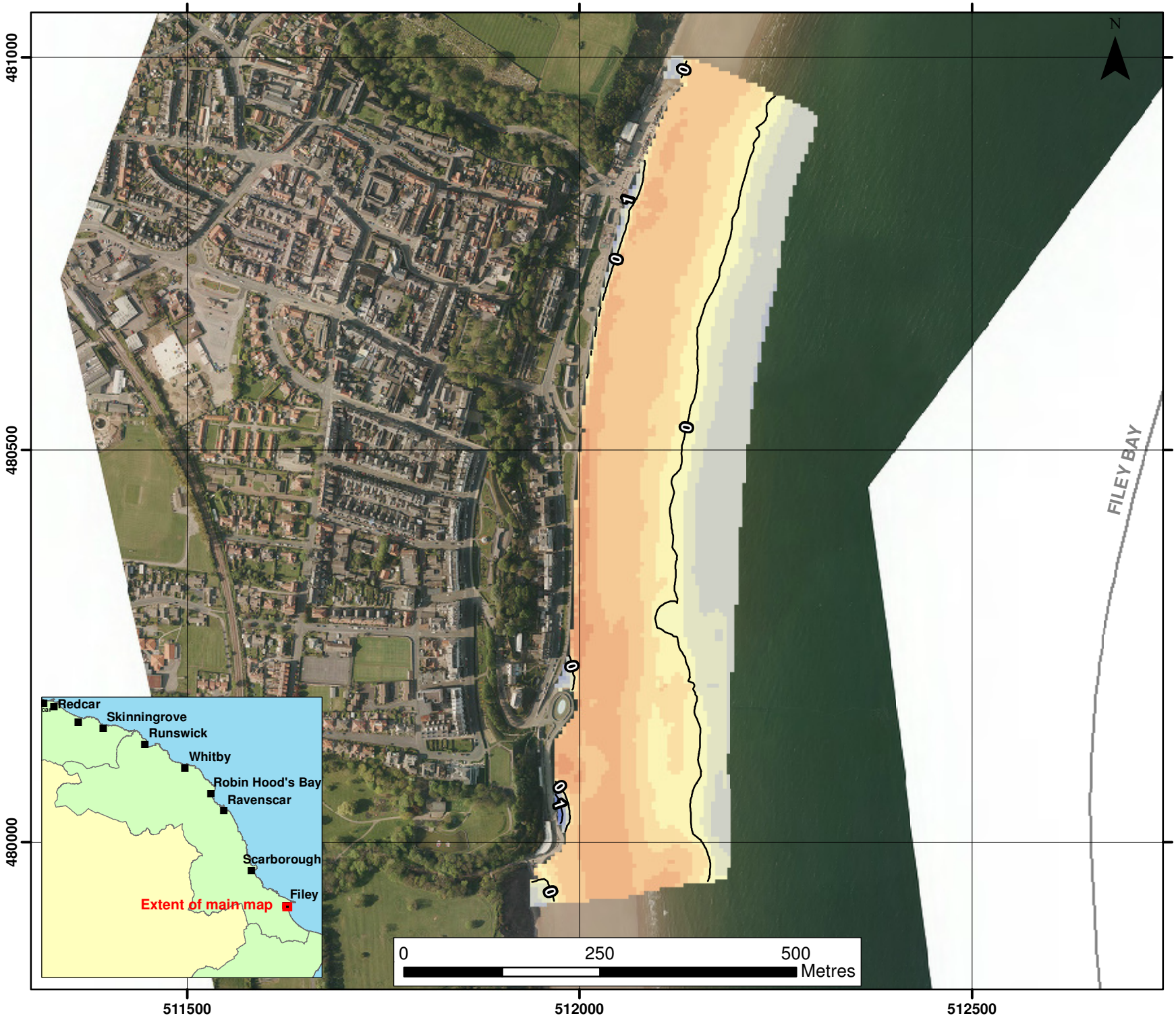

KEY Autumn 2012 and Spring 2013
Change in elevation (m)

<-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 3b
Short-term Elevation Change
Filey
Scarborough Borough Council

Update Report 5
Partial Measures Survey
Spring 2013

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Appendix C

Cliff Top Survey

Cliff Top Survey

Staithes

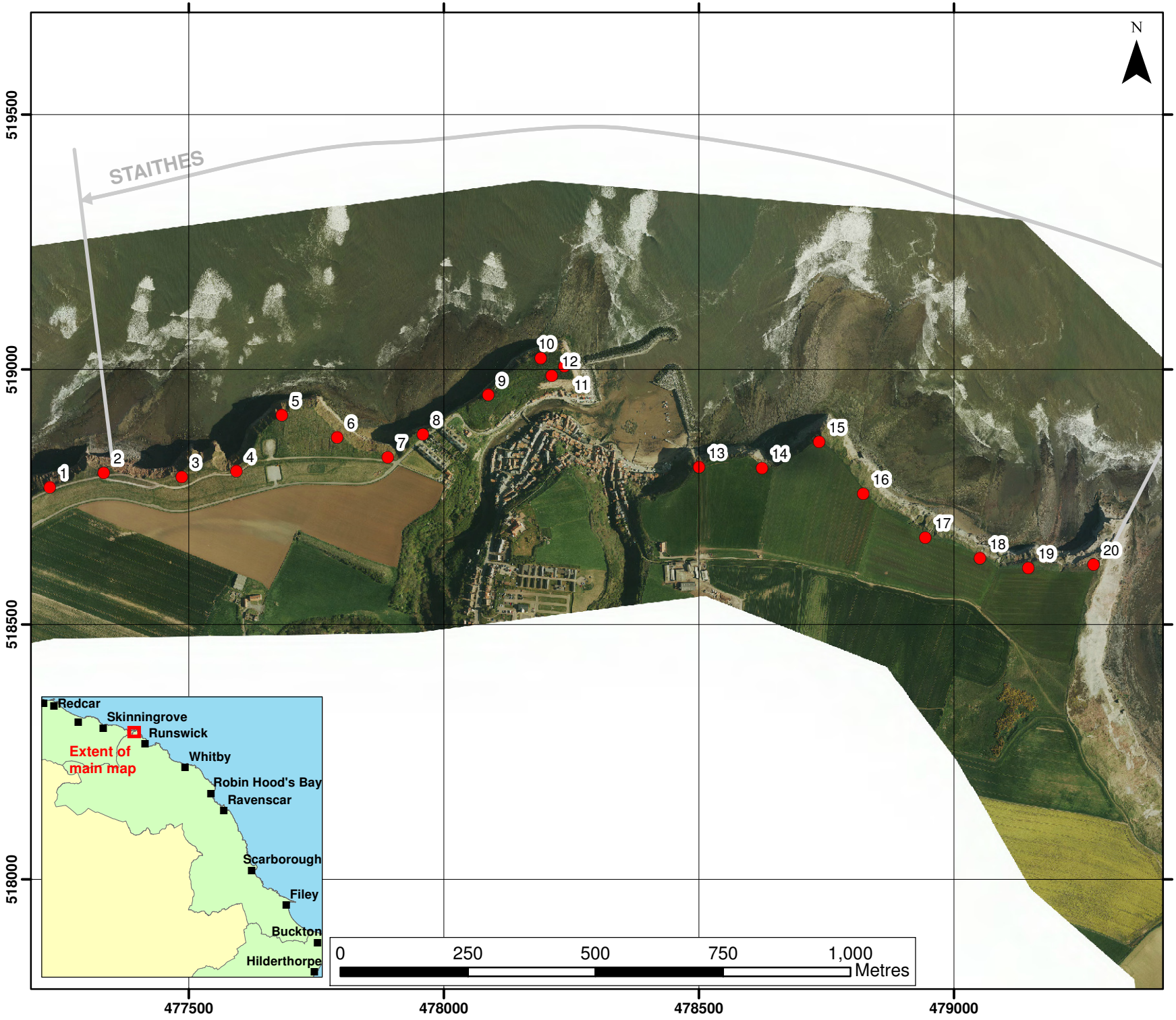
Twenty ground control points have been established at Staithes (Figure C1). The maximum separation between any two points is nominally 100m.

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 (Sept 2012)	Present Survey (March 2013)	Baseline (Nov 2008) to Present (March 2013)	Previous (Sept 2012) to Present (March 2013)	Baseline (Nov 2008) to Present (March 2013)
1	477228	518769	320	1.9	1.7	1.7	-0.2	0.0	0.0
2	477334	518798	0	10.9	10.8	10.8	-0.1	0.0	0.0
3	477487	518789	350	7.1	8.4	8.3	1.3	-0.1	0.3
4	477594	518801	340	5.9	5.2	5.1	-0.7	-0.1	-0.2
5	477683	518911	350	8.4	9.4	9.2	1.0	-0.2	0.2
6	477792	518867	30	8.6	8.6	8.5	0.0	-0.1	0.0
7	477891	518828	60	7.7	7.5	7.5	-0.2	0.0	0.0
8	477959	518873	350	8.7	9.8	9.8	1.1	0.0	0.3
9	478088	518950	350	7.6	8.3	8.3	0.7	0.0	0.2
10	478191	519023	340	8.4	8.8	8.8	0.4	0.0	0.1
11	478237	519007	60	6.9	6.7	6.7	-0.2	0.0	0.0
12	478213	518988	150	6.1	6.8	6.5	0.7	-0.3	0.1
13	478501	518809	15	11.4	9.1	9.2	-2.3	0.1	-0.5
14	478624	518807	20	7.5	7.5	7.5	0.0	0.0	0.0
15	478737	518858	60	6.1	6.6	6.4	0.5	-0.2	0.1
16	478823	518757	60	8	9.2	9.0	1.2	-0.2	0.2
17	478944	518671	30	9.3	9.4	9.4	0.1	0.0	0.0
18	479052	518630	20	9.2	9.5	9.4	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	11.4	0.0	0.0	0.0



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
Scarborough
Borough Council

Update Report 5
Partial Measures Survey
Spring 2013

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Cliff Top Survey

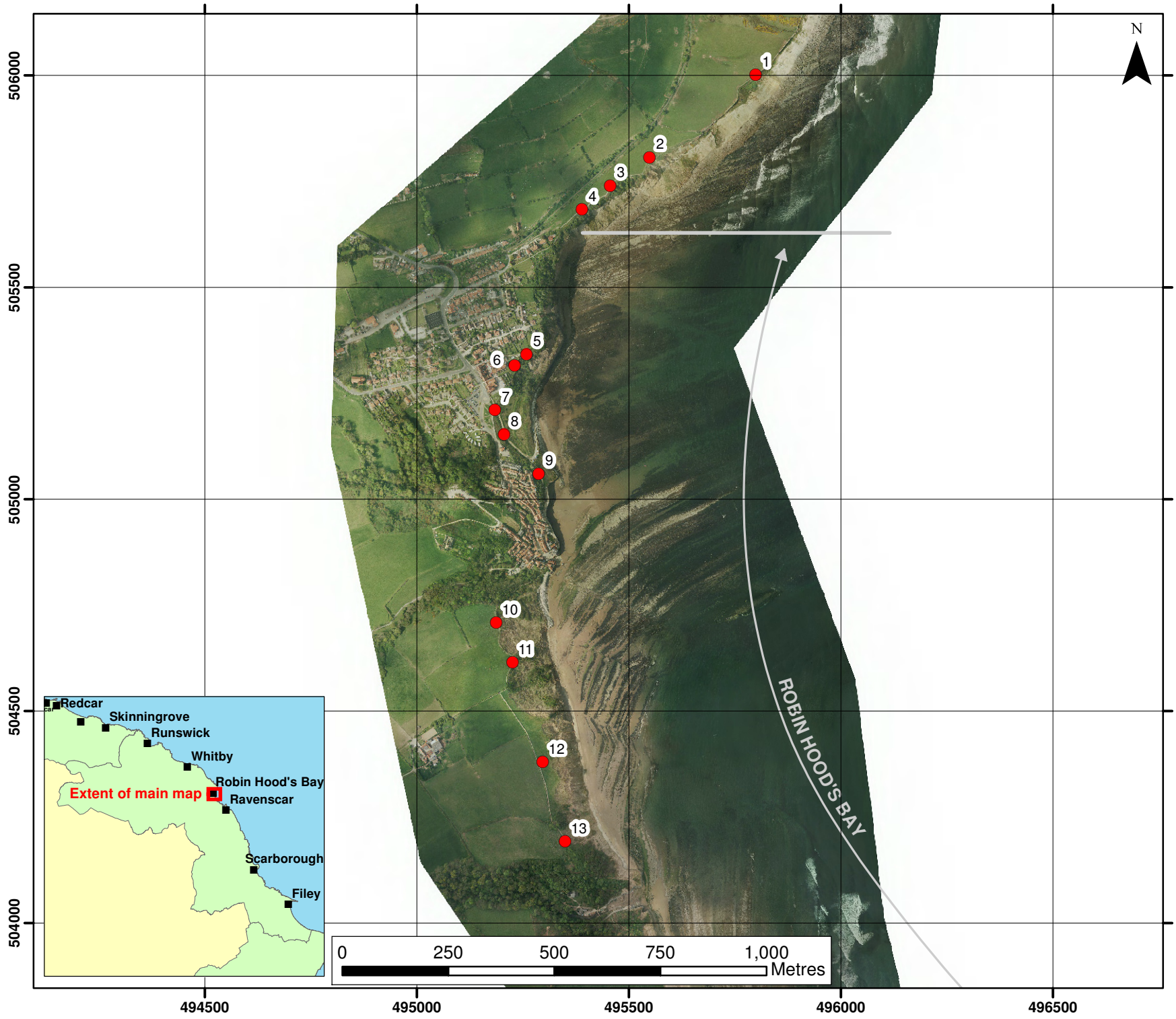
Robin Hoods Bay

Thirteen ground control points have been established at Robin Hoods Bay (Figure C2). The maximum separation between any two points varies along the coast, reflecting the degree of risk from the erosion. The cliff top surveys at Robin Hoods Bay 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 C2 provides baseline information about these ground control points and results from the 2010 (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 C2 – Cliff Top Surveys at Robin Hoods Bay

Ground Control Point Details				Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Easting	Northing	Bearing (º)	Baseline Survey (March 2010)	Previous Survey (Sept 2012)	Present Survey (April 2013)	Baseline (March 2010) to Present (April 2013)	Previous (Sept 2012) to Present (Apr 2013)	Baseline (March 2010) to Present (April 2013)
1	495799.5	506002.2	130	11.6	7.9	8.0	-3.7	0.10	-1.1
2	495549.2	505807.3	135	9.3	9.3	9.3	-0.1	0.03	0.0
3	495456.3	505740	130	5	5.0	4.9	0.0	-0.10	0.0
4	495389.9	505683.7	140	6.3	6.5	6.5	0.2	0.03	0.1
5	495259.4	505342.5	130	11.3	10.9	10.9	-0.4	0.01	-0.1
6	495231.2	505315.7	95	5.9	5.8	5.8	-0.1	-0.01	0.0
7	495184.8	505210.7	85	6.4	6.1	6.0	-0.3	-0.06	-0.1
8	495206.5	505153	75	5	5.4	5.5	0.4	0.03	0.1
9	495287.8	505060.5	80	4.3	4.5	4.2	0.2	-0.32	0.0
10	495187.8	504708.8	70	3.1	2.5	2.6	-0.6	0.07	-0.2
11	495226.2	504615.7	120	3.8	3.9	4.1	0.1	0.19	0.1
12	495297.5	504380.2	80	11	11.0	11.0	-0.1	0.06	0.0
13	495350.4	504193	55	3.7	3.7	3.7	0.0	0.06	0.0



KEY

- Ground Control Points

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix C- Map 2
Ground Control Points
Robin Hood's Bay
Scarborough
Borough Council

Update Report 5
Partial Measures Survey
Spring 2013

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Cliff Top Survey

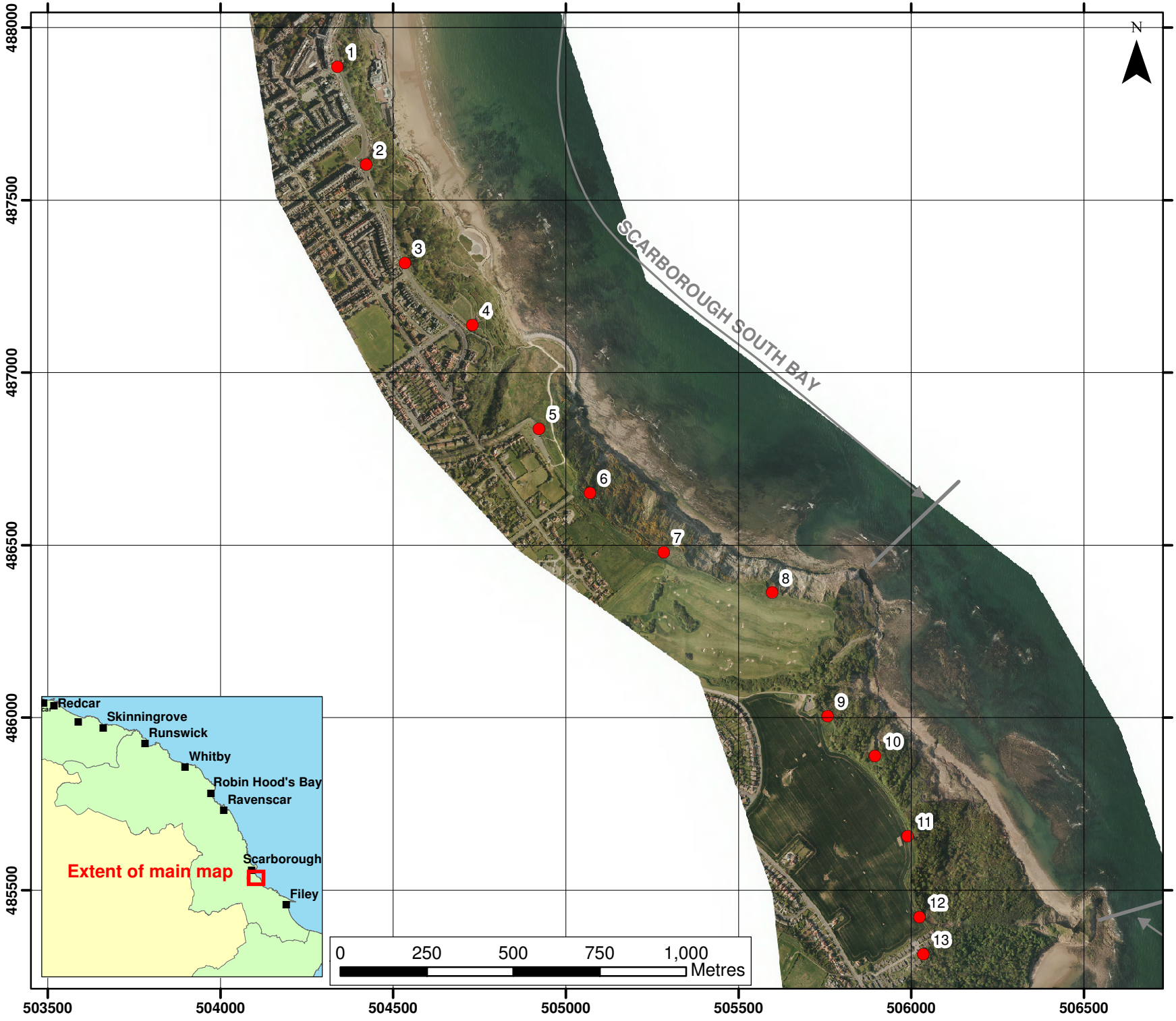
Scarborough South Bay

Thirteen ground control points have been established at Scarborough South Bay (Figure C3). The maximum separation between any two points varies along the coast, reflecting the degree of risk from the erosion. The cliff top surveys at Scarborough South Bay 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 C3 provides baseline information about these ground control points and results from the 2010 (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 C3 – Cliff Top Surveys at Scarborough South Bay

Ground Control Point Details				Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Easting	Northing	Bearing (º)	Baseline Survey (March 2010)	Previous Survey (Sept 2012)	Present Survey (April 2013)	Baseline (March 2010) to Present (April 2013)	Previous (March 2012) to Present (Sept 2012)	Baseline (March 2010) to Present (April 2013)
1	504339.5	487887.3	70	7.0	7.0	7.0	0.0	0.0	0.0
2	504422.3	487603.7	80	4.8	4.8	4.8	0.0	0.0	0.0
3	504534.8	487318.3	40	15.1	15.2	14.9	-0.2	-0.3	-0.1
4	504730.2	487137.9	55	9.6	9.5	9.6	0.0	0.1	0.0
5	504922.9	486837.8	60	8.8	8.4	8.8	0.0	0.4	0.0
6	505071.1	486652.1	75	3.8	3.4	3.8	0.0	0.5	0.0
7	505284.3	486480	35	7.0	6.9	7.1	0.0	0.2	0.0
8	505597.9	486363.4	30	8.6	8.6	8.6	0.0	0.0	0.0
9	505758.6	486005.1	45	9.1	9.0	9.0	-0.1	0.1	0.0
10	505896	485889.6	15	14.8	14.7	14.9	0.1	0.2	0.0
11	505990	485657.1	80	4.7	4.3	2.5	-2.2	-1.9	-0.7
12	506024.9	485421.8	55	6.1	5.8	4.2	-1.9	-1.6	-0.6
13	506036	485315.3	90	7.0	7.0	7.0	0.0	0.0	0.0



KEY

- Ground Control Points

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix C - Map 3
Ground Control Points
Scarborough South Bay
Scarborough
Borough Council

Update Report 5
Partial Measures Survey
Spring 2013

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Cliff Top Survey

Cayton Bay

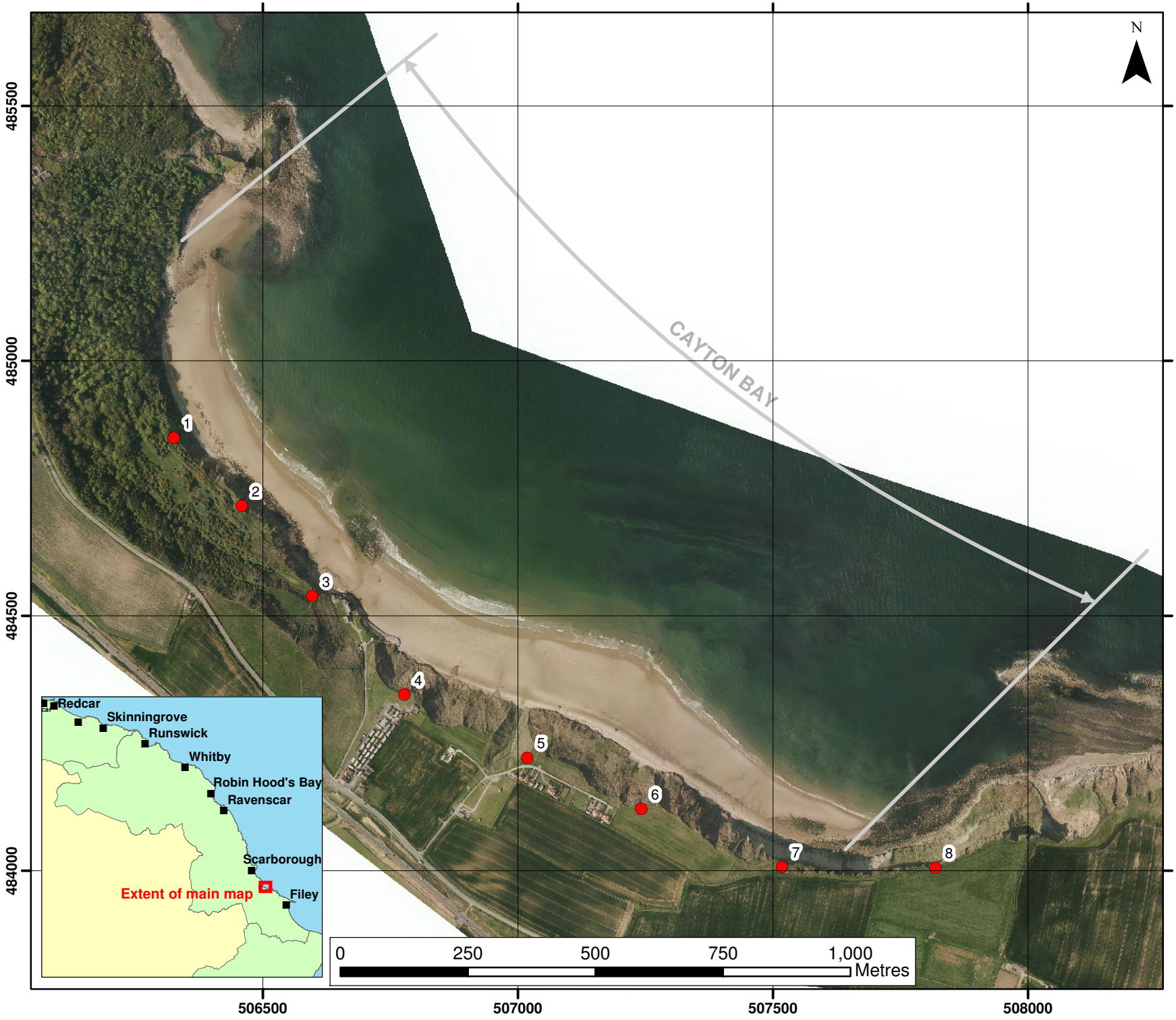
Eight ground control points have been established at Cayton Bay (Figure C4). The maximum separation between any two points varies along the coast, reflecting the degree of risk from the erosion.

The cliff top surveys at Cayton Bay 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 C4 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 C4 – Cliff Top Surveys at Cayton Bay

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 (Sept 2012)	Present Survey (April 2013)	Baseline (Nov 2008) to Present (April 2013)	Previous (Sept 2012) to Present (April 2013)	Baseline (Nov 2008) to Present (April 2013)
1	506325.5	484849.7	50	4	3.4	3.6	-0.4	0.2	-0.1
2	506459.4	484715.9	65	5	-0.1	0.2	-4.8	0.2	-1.1
3	506597.4	484538.6	65	5	6.3	6.3	1.3	0.0	0.3
4	506778.1	484345.5	21	9	8.7	6.1	-2.9	-2.7	-0.7
5	507018.6	484221.6	342	7.7	8.1	8.0	0.3	-0.2	0.1
6	507242.3	484121.7	2	7.4	6.6	6.6	-0.8	0.0	-0.2
7	507518.2	484008.2	25	7.5	8.0	7.9	0.4	-0.1	0.1
8	507818.7	484006	1	5.5	6.1	5.6	0.1	-0.4	0.0



KEY

- Ground Control Points

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix C - Map 4
Ground Control Points
Cayton Bay
Scarborough
Borough Council

Update Report 5
Partial Measures Survey
Spring 2013

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Cliff Top Survey

Filey Bay

Twenty-three ground control points have been established in Filey Bay (Figure C5 and C6). The maximum separation between any two points varies along the coast, reflecting the degree of risk from the erosion.

The cliff top surveys at Filey Bay 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 C5 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.

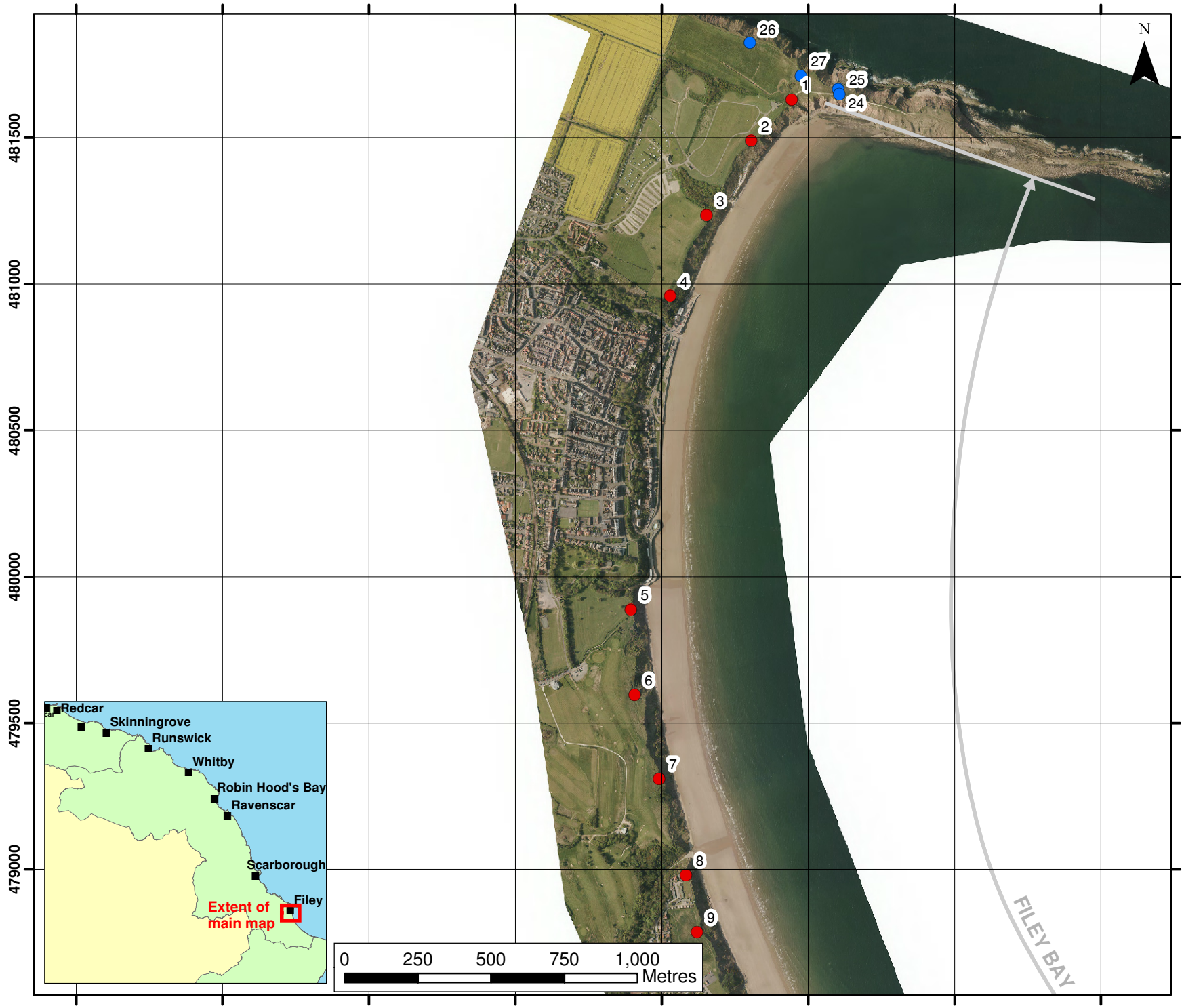
Table C5 – Cliff Top Surveys in Filey Bay

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 (Sept 2012)	Present Survey (April 2013)	Baseline (Nov 2008) to Present (April 2013)	Previous (Sept 2012) to Present (April 2013)	Baseline (Nov 2008) to Present (April 2013)
1	512444.9	481630.9	130	8.7	8.8	8.8	0.1	0.1	0.0
2	512306.7	481490.3	144	7.6	7.7	7.8	0.2	0.1	0.0
3	512153.6	481234.6	122	8.3	8.4	8.5	0.2	0.0	0.0
4	512029.2	480959.9	115	7.4	7.5	7.6	0.2	0.1	0.1
5	511895.4	479888	89	7.1	1.4	1.0	-6.1	-0.4	-1.4
6	511908.5	479597.1	48	6.7	6.9	7.1	0.4	0.2	0.1
7	511991.4	479310.4	69	6.7	4.8	5.1	-1.6	0.3	-0.4
8	512083.4	478981.5	66	10.2	10.2	10.4	0.2	0.1	0.0
9	512121.3	478786.3	76	8.3	8.4	8.4	0.1	0.0	0.0
10	512226.2	478547.9	74	7.5	7.3	7.3	-0.2	0.0	0.0

11	512471.4	478153.5	53	6.6	6.5	6.5	-0.1	0.0	0.0
12	512558.9	477901.9	66	7.7	7.7	7.8	0.0	0.0	0.0
12A*	512655.8	477822.4	67	13.9	13.9	13.9	0.0	0.1	0.0
13**	512697.6	477719	34	4.2	No Data	No Data	No Data	No Data	No Data
14	512939.4	477400.9	66	8	7.3	7.0	-1.0	-0.3	-0.2
15	513157	477192.7	51	5.2	5.0	4.8	-0.4	-0.3	-0.1
16	513299.5	477024.6	30	7.7	7.4	7.8	0.1	0.4	0.0
17	513507.7	476821.1	34	10.7	10.4	10.9	0.2	0.4	0.0
18	513721	476602.3	31	7.2	7.0	7.1	-0.1	0.1	0.0
19	513916.6	476354.1	51	6.6	6.8	6.4	-0.2	-0.4	0.0
20	514174.8	476179.4	32	7	7.3	7.4	0.4	0.1	0.1
21	514471.5	475965.7	66	7.6	7.5	7.7	0.1	0.2	0.0
22	514656.2	475728.8	101	8.1	8.1	8.2	0.1	0.1	0.0
23	514889.5	475537.6	60	9.1	9.1	9.1	0.0	0.1	0.0
24*	512603.7	481665.9	14	19.9	19.7	19.8	-0.1	0.1	0.0
25*	512607.1	481648.9	184	17.2	17.1	17.2	0.0	0.0	0.0
26*	512301.9	481825.5	18	11	10.9	10.9	-0.1	0.0	0.0
27*	512475.8	481712.1	20	11.6	11.5	11.6	0.0	0.1	0.0

NOTE: *base line for 12A and 24-27 is March 2011

**Surveyor's report states that 'VMP 13 was unable to be measured due to vegetation growth and land shape change'



KEY

Ground Control Points

- Established March 2011
- Established Nov 2008

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix C - Map 5
Ground Control Points
Filey Bay North
Scarborough
Borough Council

Update Report 5
Partial Measures Survey
Spring 2013

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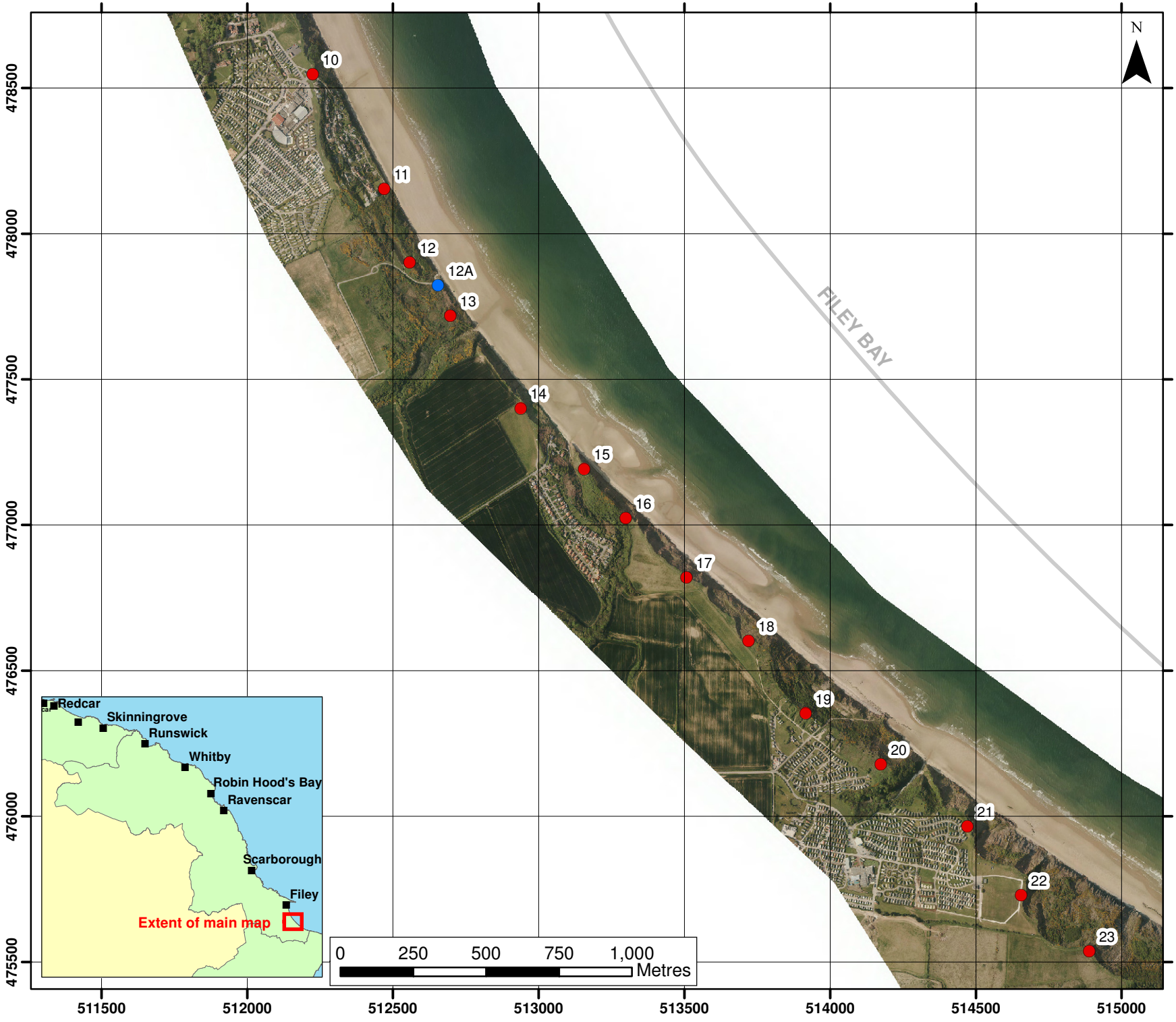

KEY

Ground Control Points

- Established March 2011
- Established Nov 2008

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix C - Map 6
Ground Control Points
Filey Bay South
Scarborough
Borough Council

Update Report 5
Partial Measures Survey
Spring 2013

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Appendix D

Durham University Laser Scans of Cowbar Nab

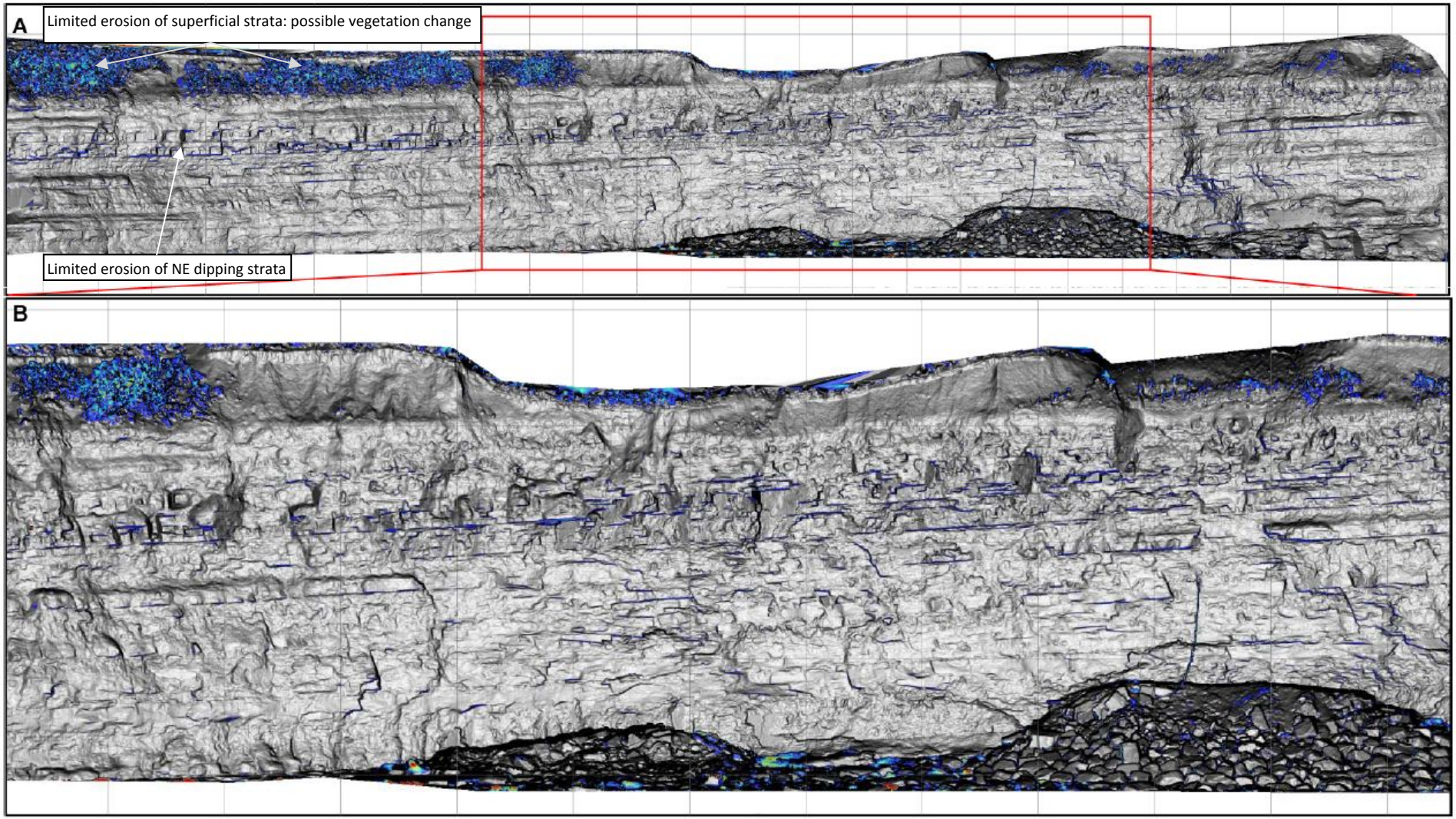

Figure D1: Cliff erosion 25 April 2013 to 23 May 2013. (A) Full cliff scan length section (B) close-up of area indicated by red box. Cold colours (blue) show erosion =>0.1m, and warm colours (red) show erosion up to 2.5m normal to the cliff face.

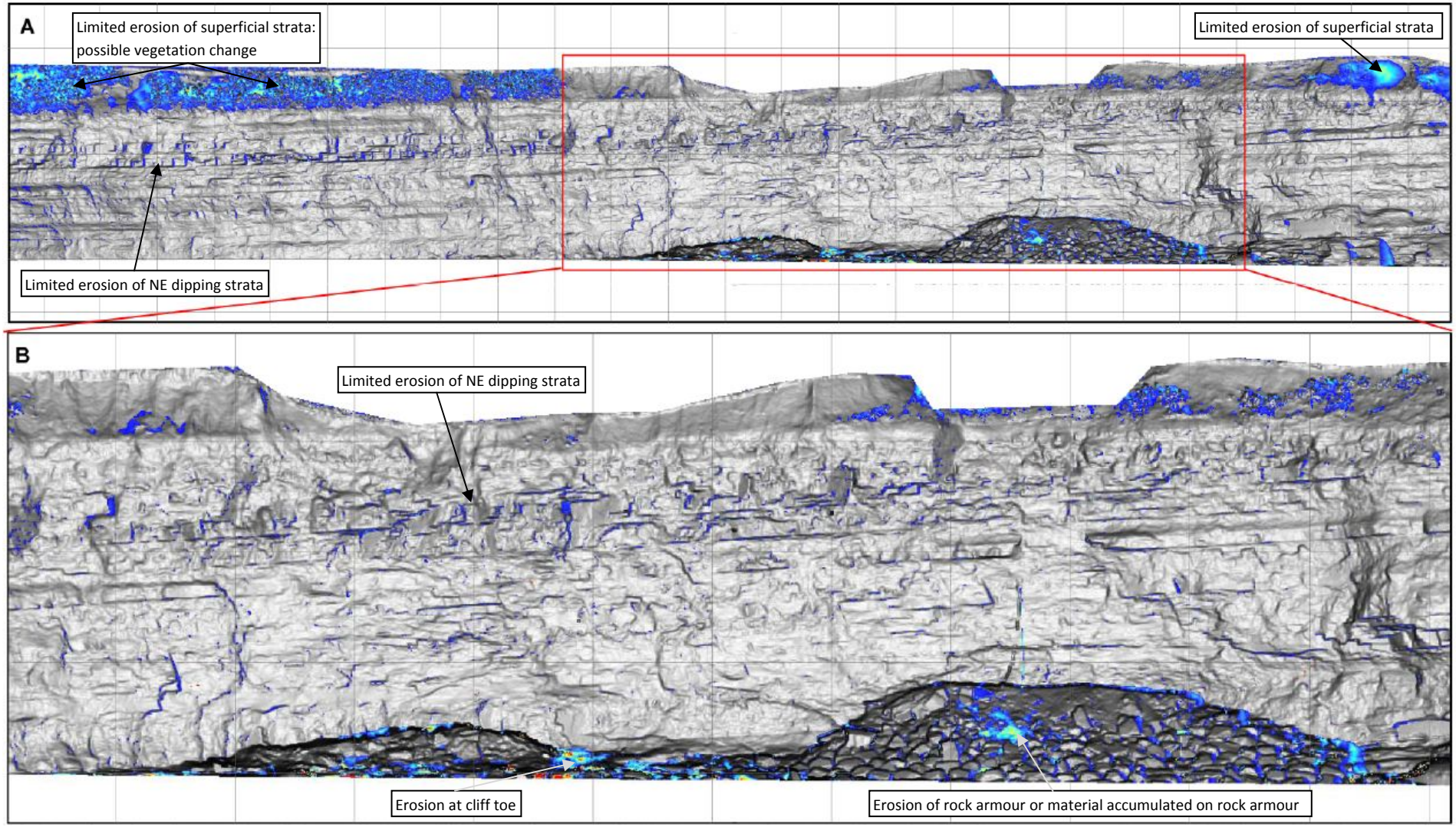

Figure D2: Cliff erosion 23 May 2013 to 13 June 2013. (A) Full cliff scan length section (B) close-up of area indicated by red box. Cold colours (blue) show erosion =>0.1m, and warm colours (red) show erosion up to 2.5m normal to the cliff face.