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

Sunderland City Council
Final Report

February 2014

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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	**Souter Point to Chourdon Point**
HAT	3.18
MHWS	2.48
MLWS	-1.92

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.

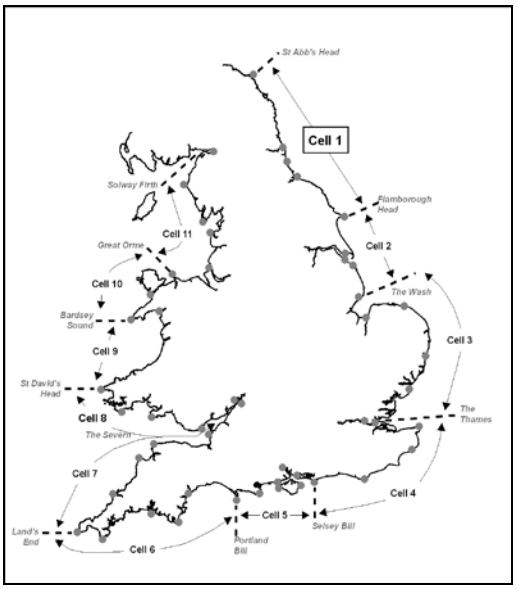


Figure 1 Sediment Cells in England and Wales

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
White 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.

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	Sept-Dec 08	May 09	Mar-May 09		-
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	Oct 12	-
5	2012/13	Sept-Oct 12	Mar 13	Mar 13	June 13	-
6	2013/14	Sept-Oct 13	Feb 14	Mar 14	July 14	-
7	2014/15	Sept&Nov 14	Feb 15(*)			

(*) The present report is **Analytical Report 7** and provides an analysis of the 2008 'baseline' Full Measures survey for Sunderland City 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)
	Staithes
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

Sunderland City Council's frontage extends from The Bents to Ryhope. For the purposes of this report and for consistency with previous reporting, it has been sub-divided into three areas, namely:

- Whitburn Bay
- Sunderland Harbour and Docks
- Hendon to Ryhope (including Halliwell Banks)

1.2 Methodology

Along Sunderland City Council's frontage, the following surveying is undertaken:

- Full Measures survey annually each autumn comprising:
    - Beach profile surveys along 58 transect lines (commenced 2009)
    - Topographic survey at Whitburn Bay (commenced 2009)
    - Topographic survey at Hendon to Ryhope (including Halliwell Banks) (commenced 2009)
- Partial Measures survey annually each spring comprising:
    - Beach profile surveys along 16 transect lines (commenced 2009)
- Cliff top survey bi-annually at:
    - Hendon to Ryhope (including Halliwell Banks) (commenced 2009)

The location of these surveys is shown in Figure 2. The Full Measures survey was undertaken along this frontage between the 5th and 6th November 2014 (Whitburn Bay), 26th November 2014 (Sunderland Harbour and Docks) and 8th and 13th September 2014 (Hendon to Ryhope (incl. Halliwell Banks)). During this time weather conditions varied considerably. Refer to the survey reports for 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 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 can 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:

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

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 bands 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 to 10 years of data.

2. Wave Data and Interpretation.

2.1 Introduction

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

An assessment of baseline wave data is presented in the 2011 Wave Data Analysis Report, which reviewed all readily available data in the region. The present wave data update report provides an update to the baseline with analysis of the wave data collected under the programme for 2012, 2013 and 2014. In order to help put the beach and cliff changes discussed in this report into context, analysed storm data for the wave buoys is presented in this section.

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

To aid interpretation of the results in Table 4 alternate years have been shaded and the storm with the largest peak wave height each year has been highlighted in bold. The annual storm with the highest wave energy at peak has also been highlighted in bold red text as this depends on wave period as well as wave height and so is not always the same as the largest wave height, e.g. in 2007 and 2008.

Table 4: 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	78.2	6.2	12.4	23	1.7E+04
25/06/2007 20:30	26/06/2007 13:30	17	26/06/2007 10:00	77.3	4.4	8.6	23	4.0E+03
26/09/2007 03:00	27/09/2007 05:00	26	26/09/2007 19:00	79.7	4.6	11.6	6	**7.8E+03**
08/11/2007 20:00	12/11/2007 15:00	91	09/11/2007 08:30	77.7	**6.2**	**13.3**	**6**	1.9E+04
19/11/2007 03:30	25/11/2007 21:30	162	23/11/2007 05:00	76.8	4.9	10.7	17	7.6E+03
08/12/2007 03:00	10/12/2007 14:30	59.5	08/12/2007 03:30	82.9	4.1	10.7	17	5.4E+03
03/01/2008 10:30	04/01/2008 01:30	15	03/01/2008 23:30	14.6	4.2	9.1	62	4.2E+03
01/02/2008 15:00	02/02/2008 09:30	18.5	02/02/2008	80.1	6.0	13.8	17	1.9E+04
10/03/2008 08:30	10/03/2008 12:30	4	10/03/2008 11:00	307.5	4.6	8.1	141	3.8E+03
17/03/2008 15:00	25/03/2008 03:00	180	22/03/2008 05:00	82.1	**7.9**	**12.4**	**6**	2.7E+04
05/04/2008 22:00	07/04/2008 05:00	31	06/04/2008 19:00	83.1	4.6	11.7	6	7.9E+03
20/07/2008 16:00	21/07/2008 09:30	17.5	20/07/2008 23:30	76.0	4.2	9.9	11	4.9E+03
03/10/2008 03:00	03/10/2008 20:30	17.5	03/10/2008 16:30	76.7	4.7	11.4	23	**8.1E+03**
21/11/2008 04:00	25/11/2008 12:30	104.5	22/11/2008 11:30	75.8	6.0	13.1	11	1.7E+04

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)**
10/12/2008 12:00	13/12/2008 18:00	78	13/12/2008 08:00	332.1	4.9	8.4	129	4.7E+03
31/01/2009 16:30	03/02/2009 09:00	64.5	02/02/2009 22:00	7.2	5.8	9.6	84	8.7E+03
23/03/2009 22:30	28/03/2009 20:30	118	28/03/2009 16:30	89.4	5.3	8.4	6	5.4E+03
10/07/2009 01:30	10/07/2009 02:30	1	10/07/2009 01:30	78.7	4.2	10.0	11	5.0E+03
29/11/2009 20:30	30/11/2009 15:00	18.5	30/11/2009 00:30	72.7	**6.0**	**9.4**	**11**	9.0E+03
17/12/2009 10:30	18/12/2009 05:00	18.5	17/12/2009 19:30	26.3	5.4	10.7	68	**9.4E+03**
30/12/2009 09:00	30/12/2009 23:00	14	30/12/2009 12:30	7.7	5.1	7.6	90	4.1E+03
06/01/2010 05:30	06/01/2010 11:00	5.5	06/01/2010 06:30	63.6	4.2	10.7	11	5.7E+03
29/01/2010 10:30	30/01/2010 00:30	14	29/01/2010 22:30	81.9	5.4	8.6	6	6.0E+03
26/02/2010 22:30	27/02/2010 02:30	4	27/02/2010 01:00	72.4	4.6	8.5	17	4.2E+03
19/06/2010 07:00	20/06/2010 08:30	25.5	19/06/2010 20:00	69.2	5.4	10.7	23	**9.4E+03**
29/08/2010 14:00	30/08/2010 06:30	16.5	30/08/2010 01:00	92.8	4.7	8.6	6	4.7E+03
06/09/2010 22:30	07/09/2010 16:00	17.5	07/09/2010 15:30	353.2	4.6	8.8	90	4.5E+03
17/09/2010 07:00	17/09/2010 18:30	11.5	17/09/2010 08:30	80.7	4.7	11.0	11	7.5E+03
24/09/2010 03:00	26/09/2010	45	24/09/2010 10:00	71.6	5.3	10.2	11	8.0E+03
20/10/2010 02:00	24/10/2010 16:30	110.5	20/10/2010 10:00	78.2	4.2	11.2	17	6.4E+03
08/11/2010 14:00	09/11/2010 20:30	30.5	09/11/2010 10:00	3.0	**5.6**	**8.8**	**73**	6.9E+03
17/11/2010 11:00	17/11/2010 18:30	7.5	17/11/2010 12:00	322.4	4.7	7.7	129	3.7E+03
29/11/2010 19:30	02/12/2010 08:30	61	29/11/2010 21:00	11.8	5.1	9.4	56	6.3E+03
16/12/2010 15:00	17/12/2010 06:30	15.5	17/12/2010 03:30	79.1	4.6	10.5	17	6.4E+03
23/07/2011 14:00	24/07/2011 11:00	21	24/07/2011 03:00	67.1	**4.7**	**10.7**	**17**	**7.2E+03**
24/10/2011 18:30	25/10/2011 09:30	15	25/10/2011 09:30	348.5	4.1	9.5	79	4.2E+03
09/12/2011 08:30	09/12/2011 10:00	1.5	09/12/2011 08:30	84.0	4.1	11.9	6	6.7E+03
05/01/2012 16:00	06/01/2012 05:00	13	06/01/2012 03:00	79.0	4.6	10.5	17	6.4E+03
03/04/2012 13:30	04/04/2012 10:30	21	03/04/2012 17:30	25.1	5.6	8.1	56	5.9E+03
24/09/2012 08:30	25/09/2012 10:30	26	25/09/2012 01:30	16.7	4.7	10.3	62	6.6E+03
26/10/2012 16:30	27/10/2012 14:30	22	26/10/2012 23:00	79.4	4.9	12.8	11	1.1E+04
05/12/2012 16:00	15/12/2012 01:30	225.5	14/12/2012 19:30	18.4	5.4	8.8	96	6.4E+03
20/12/2012 06:00	21/12/2012 14:30	32.5	20/12/2012 23:00	348.4	5.6	9.5	96	8.0E+03
18/01/2013 18:30	22/01/2013 06:00	83.5	21/01/2013 10:00	9.2	6.7	9.4	84	1.1E+04
06/02/2013 08:00	07/02/2013 06:00	22	06/02/2013 12:30	81.6	5.4	10.0	11	8.2E+03
07/03/2013 21:00	10/03/2013 21:30	72.5	08/03/2013 04:00	24.6	4.9	9.0	73	5.4E+03
18/03/2013 09:00	25/03/2013 00:30	159.5	23/03/2013 14:30	5.1	6.0	10.2	90	1.0E+04

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)**
23/05/2013 18:00	24/05/2013 12:00	18	23/05/2013 22:30	77.5	6.7	10.5	17	1.4E+04
10/09/2013 13:00	10/09/2013 19:30	6.5	10/09/2013 14:00	79.3	4.4	9.2	11	4.6E+03
09/10/2013 22:30	11/10/2013 09:00	34.5	10/10/2013 17:00	79.8	5.4	10.7	22	9.4E+03
29/11/2013 22:30	30/11/2013 06:30	8	30/11/2013 00:30	84.5	5.6	10.7	11	1.0E+04
05/12/2013 14:00	07/12/2013 04:30	38.5	06/12/2013 20:00	80.8	4.7	14.3	6	1.3E+04
27/12/2013 09:30	27/12/2013 12:30	3	27/12/2013 10:00	249.3	4.1	6.1	202	1.8E+03
05/02/2014 04:00	05/02/2014 18:00	14	05/02/2014 05:30	318.4	4.4	7.8	129	3.3E+03
12/02/2014 20:00	14/02/2014 19:00	47	12/02/2014 21:00	275.6	4.6	7.5	141	3.2E+03
21/10/2014 22:00	22/10/2014 01:30	3.5	21/10/2014 23:00	84.4	4.4	9.6	6	5.0E+03

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

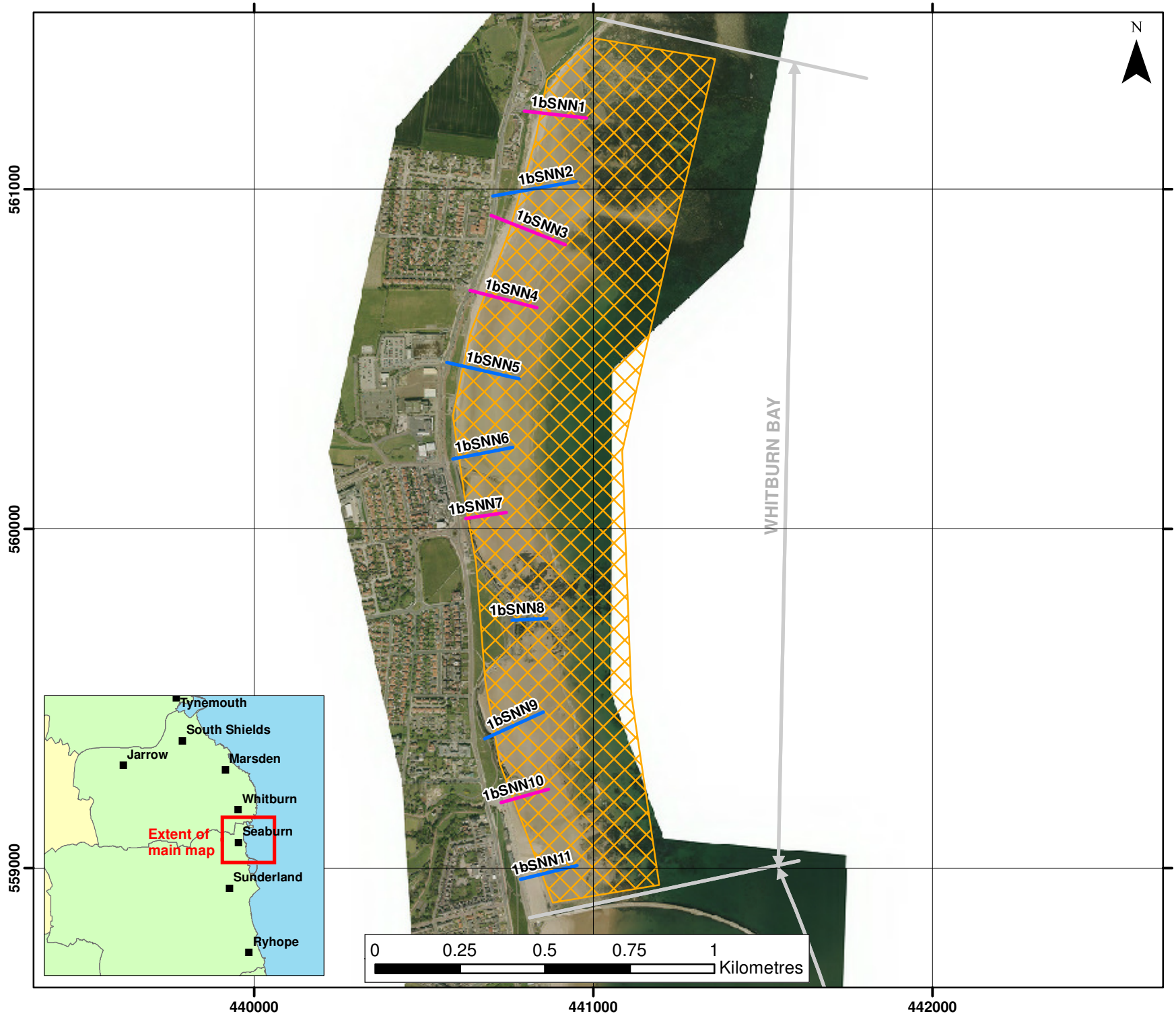
Comparing the annual storm records it can be seen that 2010 had the most storms (13). In 2010 the largest storm had an incident direction of 73 degrees which is unusual. We might therefore expect that the alongshore drift on the Cell 1 beaches in 2010 may have been atypical with unusual changes from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

The years with the fewest storms was 2011 and 2014. This was reflected by a combination of accretion and overall stability recorded within the annual Full Measures reports.

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

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

The 2014 storms did appear to have an influence on beach behaviour, as shown by the profile analysis included within this report, with the movement of material across and along the beach. Dune toe erosion was more dominant than in previous years and could be explained by particularly high tides rather than storm erosion alone.



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
Whitburn Bay
Sunderland City Council

Analytical Report 7
Full Measures Survey
Autumn 2014

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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
Sunderland Harbour and Docks
Sunderland City Council

Analytical Report 7
Fulll Measures Survey
Autumn 2014

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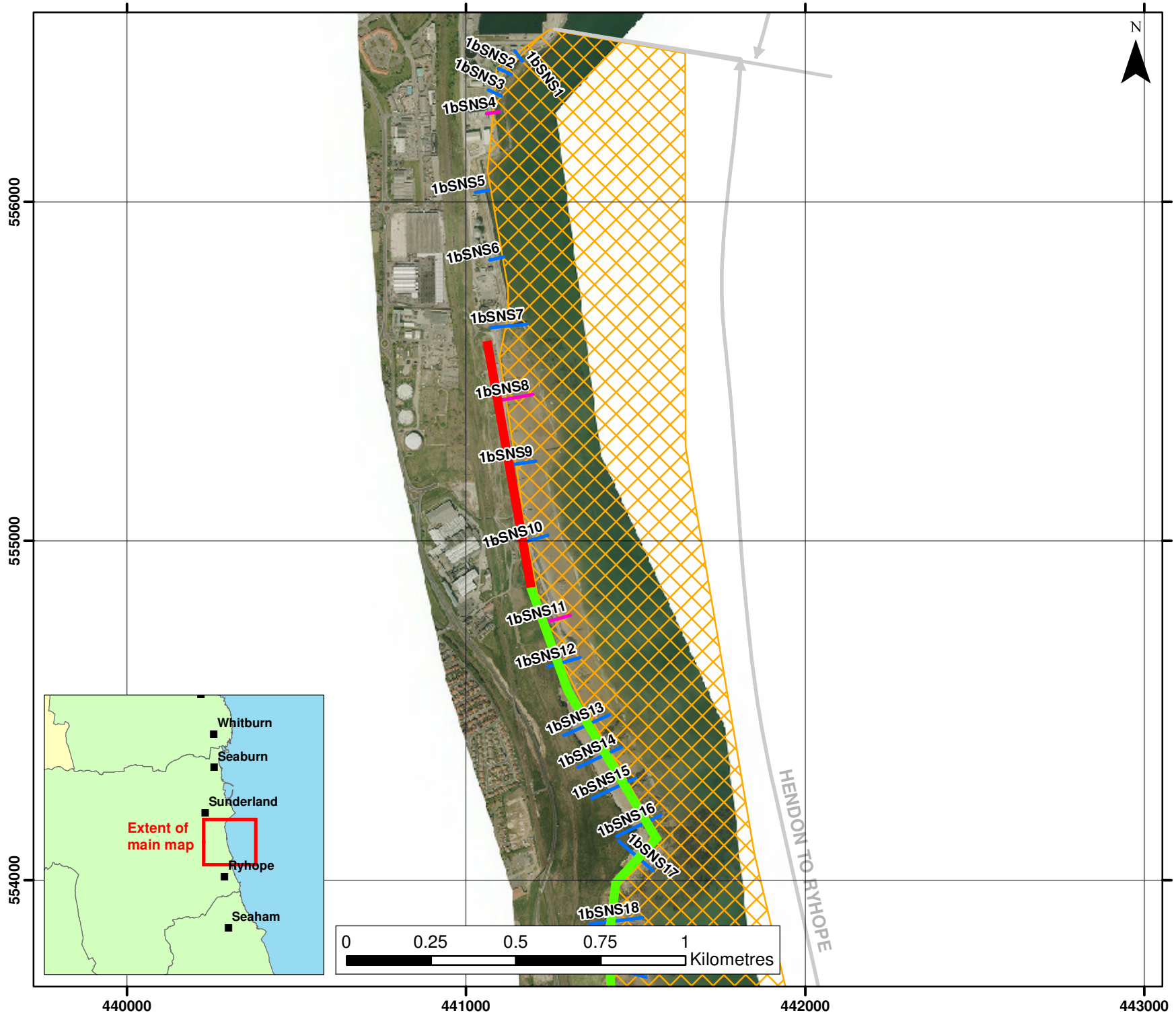

KEY

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
Hendon to Ryhope North
Sunderland City Council

Analytical Report 7
Full Measures Survey
Autumn 2014

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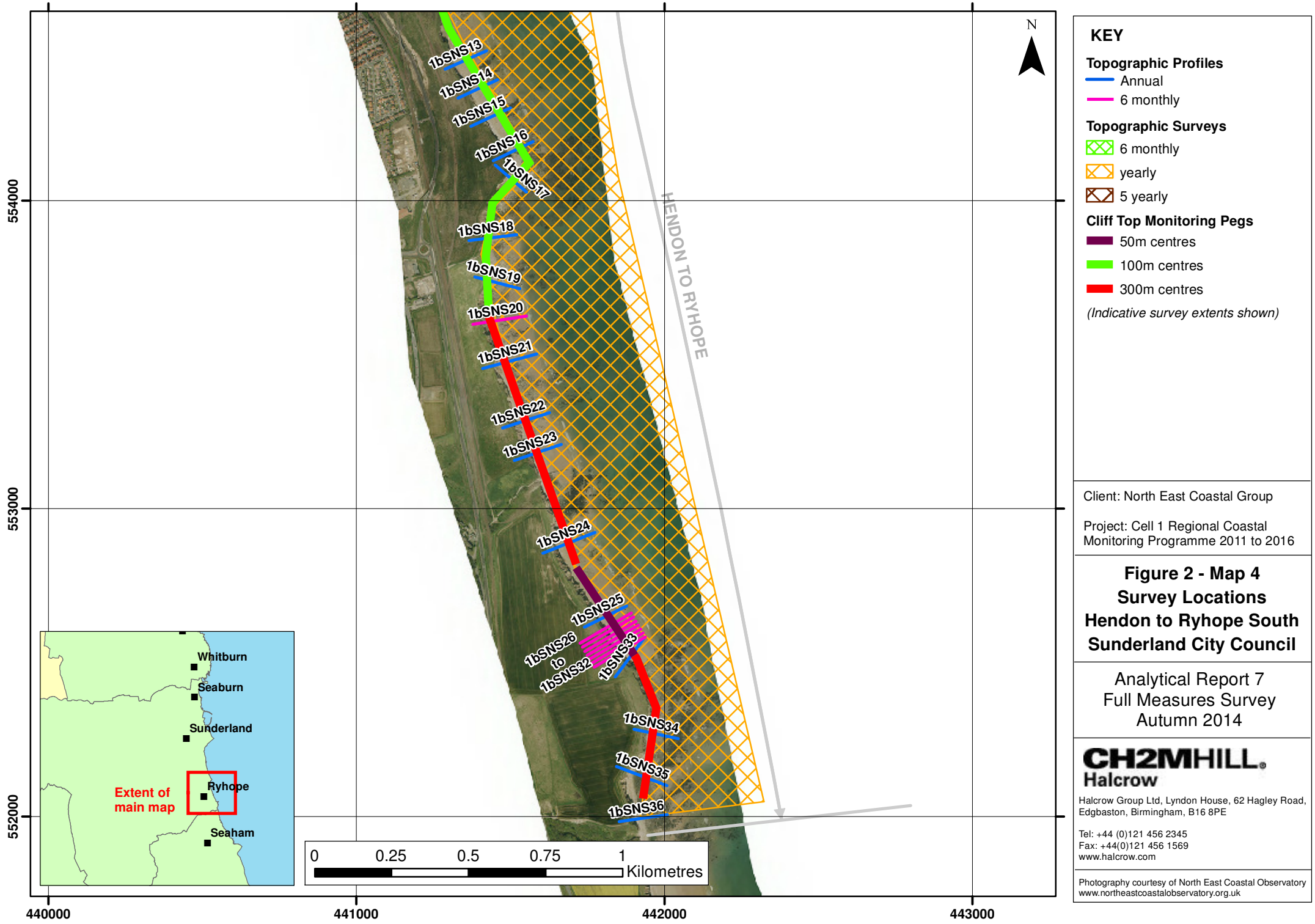

KEY

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
Hendon to Ryhope South
Sunderland City Council

Analytical Report 7
Full Measures Survey
Autumn 2014

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2. Analysis of Survey Data

2.1 Whitburn Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
Nov 2014	**Beach Profiles:** Whitburn Bay is covered by eleven beach profile lines for the Full Measures survey (Appendix A). The previous survey was the Partial Measures survey undertaken in March 2014 and the previous Full Measures survey was undertaken in October 2013. Profiles 1bSNN3 to 1bSNN4, 1bSNN7 and 1bSNN10 were last surveyed during the Partial Measures spring survey, 2014. Profiles 1bSNN2, 1bSNN5 to 1bSNN6, 1bSNN8 to 1bSNN9 and 1bSNN11 were last surveyed during the Full Measures autumn survey, 2013. **1bSNN1** is immediately south of Sunderland City Council's northern boundary of jurisdiction. Between a chainage of 40m (HAT) and 100m, beach levels have increased by over 0.5m covering the boulders and cobbles observed during the last survey. Seaward of 100m to a chainage of 180m, where the rock platform is exposed, beach levels have decreased by approximately 0.5m. Profiles **1bSNN2** and **1bSNN3** are located towards the north of Whitburn Bay and extend across scrubland before reaching the upper gravel foreshore and then dropping across the lower sandy foreshore towards the rocky outcrop of Whitburn Steel. At profile **1bSSN2**, the dune has largely remained stable since the last survey, although there has been a small amount of cut-back at the dune toe in the region of 0.5m (refer to Plate 1). Seaward of a chainage of 100m, beach levels have increased across the profile to form a more gently sloping beach. At **1bSNN3**, beach levels have fallen across the profile, increasing only seaward of a chainage of 220m. This suggest some redistribution of beach material from the upper/middle beach to the lower beach in the recent autumn months and/or alongshore. Profiles **1bSNN4** to **1bSNN6** are between the southern edge of South Bents housing estate and just north of Parsons Rock. The survey report notes that '*the top of section 5 and 6 goes through the contractors fenced area*', although this does not appear to affect the coverage of the beach profile. At profile **1bSNN4**, beach levels across the profile have increased by up to 0.5m. Seaward of a chainage of 200m, beach levels have fallen. At profile **1bSNN5**, there has been a drop in beach levels of	Along the length of Whitburn Bay, there have been some considerable changes in beach level and form since the last surveys. Generally, there has been a movement of material onshore, from the middle/lower beach to the upper beach or an overall increase in beach levels across the profile. The main exceptions to this are at profiles 1bSNN3 and 1bSNN10 where beach levels have fallen. Material is likely to have been moved alongshore from the eroding profiles in the SE, to the accreting profiles. Further, material is also likely to have been moved onshore during the summer months. **Longer term trends:** Although the changes in beach level and morphology observed since the last surveys are considerable, they are within the bounds of previous surveys. There are a number of exceptions: Profiles 1bSNN2 and 1bSNN2 - levels on the lower beach (seaward of a chainage of 240m) are the highest recorded since surveys began in September 2009. Profile 1bSNN4 – levels at the toe of the seawall and just above MHWS are the highest recorded since surveys began in September 2009. Profiles 1bSNN9 and 1bSNN11 - levels on the lower beach (seaward of a chainage of 190m/170m

Survey Date	Description of Changes Since Last Survey	Interpretation
	approximately 0.5m at the toe of the seawall. As also observed from the survey photographs (refer to Plates 2 and 3), the sand veneer has been removed from the beach to leave a band of shingle along the toe of the seawall. Between a chainage of 100m and 200m, beach levels have increased and it is likely that this veneer of sand has been moved down the beach during the past 12 months. At profile **1bSNN6**, beach levels have increased across the profile by up to 1m in places to form a more gently sloping beach. There has been a small drop in beach levels at the toe of the steps since the last survey, as shown by the survey photographs in Plates 4 and 5 and is likely to be due to erosion caused by the interaction of waves with the steps/seawall. **1bSNN7** is at Seaburn, just to the north of Parson's Rock. Beach levels have increased across the profile by over 0.5m around the existing berm to form an overall flatter beach. Profile **1bSNN8** extends across Parsons Rock. There are no discernible changes in this profile since the previous Full Measures survey. Profile **1bSNN9** drops from the cliff top to the foreshore at Roker. Beach levels have increased by approximately 0.3m across most of the profile, the exception being at the toe of the seawall where levels have fallen by 0.5m. **1bSNN10** is located approximately mid-way between Parson's Rock and Roker Pier. Beach levels have fallen by approximately 0.2m across the beach, to form a slightly steeper upper beach between the seawall and a chainage of 30m. Seaward of a chainage of 110m, beach levels have increased by marginally. Material is likely to have been drawn-down from the upper/middle beach to the lower beach during the recent autumn months. **1bSNN11** is located to the south of Whitburn. Beach levels from the toe of the seawall to a chainage of 70m have fluctuated with no distinct trend in level. Between a chainage of 70m and the exposed rock platform on the lower beach, there has been a substantial change in beach levels with an increase of over 1.5m to form a large berm.	respectively are the lowest since surveys began in September 2009. For profile 1bSNN11, this is a trend continued from the past 2 surveys.
Nov 2014	**Topographic Survey:** Whitburn Bay, between the Bents and Roker Pier, is covered by an annual topographic survey which commenced in September 2009. Data from the most recent topographic survey (Full Measures, autumn 2014) have been used to create	The topographic survey shows that since the last survey, there has been a mixture of beach elevation increase and decrease across the beach. Overall, there has been greatest elevation increase to the north at the toe of beach profile 1bSNN2 in lee of the

Survey Date	Description of Changes Since Last Survey	Interpretation
	a digital ground model (DGM) (Appendix B – Map 1a) using 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 2013) and the present survey. The difference plot shows that the majority of the beach has increased in beach elevation, with change up to 1m. Areas of greatest elevation increase are to the north at the toe of beach profile 1bSNN2 in lee of the exposed rock platform and on the middle-lower beach to the south at profile 1bSNN11. Pockets of beach elevation decrease are located on the backshore and the lower beach of Whitburn Bay. **Longer Term Topographic Trends Autumn 2010 to Autumn 2014:** The long term difference plot (Appendix B – Map 1c) shows the net change in beach levels between autumn 2010 and autumn 2014. There is a consistent reduction in beach elevation to the very south of Whitburn Bay (profiles 1bSNN9 to 1bSNN11), where change is greater than 1m. However, to the north the survey shows a general pattern of beach elevation increase/stability across the beach with isolated pockets of beach elevation decreases This suggests a net influx of beach material.	exposed rock platform and on the middle-lower beach to the south at profile 1bSNN11. Pockets of beach elevation decrease tend to be isolate to the backshore or the lower beach along the length of Whitburn Bay. **Longer term topographic trends Autumn 2009 to Autumn 2014:** The plot shows overall stability/slight increase in beach levels from the north to the centre south, with some isolated pockets of erosion. A change in the trend from those observed from the last topographic survey. To the south of Whitburn Bay, the beach has continued to erode, with levels on the lower beach reducing by more than 1m. These changes suggest an influx of material over the longer-term, although the beach profiles have only hanged within the bounds of previous surveys.

Plate 1 – Survey photograph 1bSNN2 1bSNN2_20141105_Up3

Plate 2 – Survey photograph 1bSNN5_20131003_N7

Plate 3 – Survey photograph 1bSNN5_20141105_N4

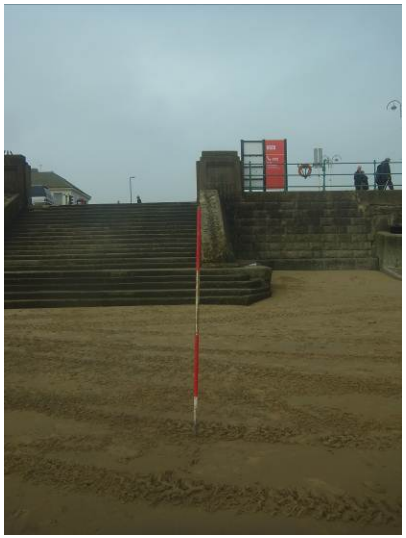


Plate 4 – Survey photograph 1bSNN6_20131003_Up

Plate 5 – Survey photograph 1bSNN6_20141105_Up2

2.2 Sunderland Harbour and Docks

Survey Date	Description of Changes Since Last Survey	Interpretation
Nov 2014	**Beach Profiles:** Sunderland Harbour and Docks is covered by eleven beach profile lines (Appendix A), all surveyed annually. The previous survey was the Full Measures survey undertaken in autumn 2013. **1bSNN12** and **1bSNN13** are both located within the shelter of Roker Pier. At profile **1bSNN12**, the upper beach between the seawall and a chainage of 100m has narrowed and steepened, to form a single berm and smoother profile. Beach levels between a chainage of 100m and 140m have increased by over 0.5m, but decreased by approximately 0.5m seaward of ch 140m. At **1bSNN13**, beach levels have increased by approximately 0.5m across the profile, from the toe of the rock revetment seaward to 100m. **1bSNC1** and **1bSNC2** are located within the shelter of New South Pier. Profile **1bSNC1** starts at the seaward edge of the dock building and extends across an earth mound before reaching the stepped landward face of the dock wall. The profile then drops from the wall crest directly into deep water. As there is no beach present profile 1bSNC1 has not been analysed. Profile **1bSNC2** starts at the crest of New South Pier and drops several metres to foreshore level. Beach levels have increased across the profile, particularly in front of the seawall where they are 1m higher than in the previous survey and on the lower beach where they are up to 0.4m higher than the last survey. The result is profile defined by two berms, one on the upper beach and one on the lower beach. **1bSNC3** to **1bSNC6** are on the seaward face of the dock. Profile **1bSNC3** extends from the dock yard across a back flood wall, which has a crest level of around 7.2mOD, and promenade to the main seaward dock wall, which has a crest level of 7.55mOD. The profile then extends down the seaward face of the wall into deep water. As there is no beach, profile 1bSNC3 has not been analysed. Profiles **1bSNC4** and **1bSNC5** extend from the rock armoured revetment across the short width of foreshore down to low water. At profile **1bSNC4**, beach levels have increased by 1m across the profile with no change in form of the beach. At profile **1bSNC5**, seaward of the revetment, beach levels have increased by approximately 0.5m across the beach profile with no change in form of the beach. **1bSNC6** extends across the revetment and seawall. Beach profiles have fallen across the profile by up	Within the breakwaters to the north of the River Wear, beach trends vary with cross-shore movement of material at profile 1bSNN12 and beach accretion at profile 1bSNN13. Within the breakwaters, to the south of the River Wear, beach levels at profile have increased. The harbour was dredged in May 2013 to maintain a navigable channel and is not noted to have previously impacted on beach levels. Although this maintenance dredging is undertaken regularly, it is assumed from the beach accretion that it may not have been undertaken in the past year. Outside of the harbour breakwaters, to the north, the beach at profiles 1bSNC3 to 1bSNC5 are observed to have accreted quite significantly. However, the adjacent beach at profile 1bSNC6 has eroded. It is possible that sediment has been moved alongshore to the north over the past year. Outside of the harbour breakwaters, to the south at profiles 1bSNC6 to 1bSNC9, the beach has generally remained stable with no clear trends in beach profile change. **Longer term trends:** Within the breakwaters to the north of the River Wear, the beach levels have recovered from the low levels recorded during the last survey and are now within the bounds of previous surveys.

Survey Date	Description of Changes Since Last Survey	Interpretation
	to 1.5m, exposing the boulder revetment (refer to Plates 6 and 7). **1bSNC7** to **1bSNC9** are within the shelter of North East Pier and South West Breakwater in the former South Outlet, parts of which have been in-filled with tipped rubble. **1bSNC7** is a section across North East Pier and shows the terraced nature of the landward face of the pier wall, extending across rock to the small sheltered bay between the two structures. For this reason, profile 1bSNC7 has not been analysed. Profile **1bSNC8** crosses the boulders and rubble, which reaches a level of around 6.2mODN, and then extends across the sand and boulder foreshore. Beach levels have fluctuated slightly over the profile with no discernible net trend. Profile **1bSNC9** extends from the dock facilities and crosses a short length of concrete wall before extending across the sand foreshore to reach and cross a boulder mound that is towards the seaward end of the south west breakwater. The profile generally remains unchanged since the last survey, with the exception of a section of the beach between a chainage of 20m and 50m, which shows beach levels to have increased by 0.5m to form a small berm.	Within the breakwaters to the south of the River Wear, at profile 1bSNC2, the profile is mostly within the bounds of previous surveys. The exception is beach levels at the toe of the seawall, where they are the highest recorded since surveys began in October 2009. Outside of the harbour breakwaters, to the north, beach levels at profile 1bSNC3 and 1bSNC4 are the highest recorded since surveys began in October 2009. At profile 1bSNC5, they are within the bounds of previous surveys. Outside of the harbour breakwaters, to the south, at profiles 1bSNC6 to 1bSNC9, the profiles are generally within the bounds of previous surveys. Although levels at profile 1bSNC6 are low, they were lower in November 2011. At profile 1bSNC9, beach levels at the location of the berm are the highest recorded since surveys began in October 2009.

Plate 6 – Survey photograph 1bSNC6_20130911_N2

Plate 7 – Survey photograph 1bSNC6_20141126_N2

2.3 Hendon to Ryhope (incl. Halliwell Banks)

Survey Date	Description of Changes Since Last Survey	Interpretation
Sept 2014	**Beach Profiles:** Hendon to Ryhope is covered by thirty six beach profile lines (Appendix A). Most profiles are measured annually, but profiles 1bSNS4, 1bSNS8, 1bSNS11, 1bSNS20 and 1bSNS26 to 1bSNS32 are surveyed every 6 months. The previous Full Measures survey was undertaken in autumn 2013 and the previous Partial Measures survey was undertaken in spring 2014. **1bSNS1** to **1bSNS6** are located along the sea wall protecting the Hendon Sewage Treatment Works. The profiles typically include a section along the concrete deck, wall crest (which varies in elevation between around 7.0mOD in the north and 7.6mOD in the south after the dog-leg in the wall position), near-vertical seaward face of the wall, and sloping rock armour revetment. The form of the profiles at **1bSNS1**, **1bSNS2**, and **1bSNS3** are defined by a seawall, a small section of fine rubble and rock revetment foreshore. The survey data is varied each year due to the precise part of the boulders that are surveyed, but as no beach has yet developed on the foreshore the profiles have not been analysed. Profile also extends directly into water and has not been analysed. Profiles **1bSNS4, 1bSNS5** and **1bSNS6** drop directly from the structure into deep water and have not been analysed. **1bSNS7** to **1bSNS10** are located along the defended coastal slopes along south Hendon, which rise in elevation to higher defended cliffs at **1bSNS11**. Profile **1bSNS7** extends across a seawall and concrete revetment, which is fronted by a foreshore comprised of large pebbles and coarse shingle. There has been little discernible change across the profile apart at the toe of the seawall, where beach levels have built-up by up to 0.4m and from between 55m and 65m chainage, where beach levels have fallen by about 0.2m. There has been a slight change in the composition of the beach material between this and the last survey, from sand and shingle to predominantly shingle (as shown by the survey photographs in Plates 8 and 9). Profile **1bSNS8** extends across the seawall, rock revetment, a rocky upper beach and sandy middle and lower beach. Beach levels have fallen across the beach by approximately 0.2m, although there has been an increase of beach levels at the toe of the rock revetment resulting in burial of some of the rocks. It is likely that material has been moved across the beach from the lower to upper beach. At profile **1bSNS9**, beach levels have increased across the profile, particularly at the toe of the	Along the length of south Hendon, between profiles 1bSNS7 and 1bSNS11, the beaches have accreted and in some areas this is by a significant amount. There has been a change in the material of the beach from rock to sand, particularly at 1bSNS11. At Grangetown (south Hendon to Salterfen Rocks), between profiles 1bSSN12 and 1bSNS19, the cliffs have generally remained stable with only localised toe erosion, associated with removal of debris from former failures. The beaches have also remained stable, the exceptions being profiles 1bSNS15, which has accreted and 1bSNS18, where there has been a cross-shore movement of material towards MLW. Between Salterfen Rocks and the landfill at Halliwell banks (profiles 1bSNS20 to 1bSNS25), the cliff has generally remained stable since the last survey, although toe erosion is evident at profiles 1bSNS20, 1bSNS24 and 1bSNS25, probably associated with removal of debris lobes. Beach levels have either remained stable or increased with the formation of a sand veneer over the rocky foreshore. Limited change is noted at the landfill site (profiles 1bSSN26 to 1bSSN32), with only cliffs at profile 1bSNS27 showing toe erosion associated with removal of debris from former falls. Beach levels have increased along the length of this section of coastline by up to 1m, to form a more gently sloping and sandier beach.

Survey Date	Description of Changes Since Last Survey	Interpretation
	revetment, where they have increased by over 0.5m to form a more gently sloping beach. At profile **1bSNS10**, beach levels have increased across the profile, particularly at a chainage of 50m where they have increased by over 1m, to form a more gently sloping beach. At profile **1bSNS11**, the cliffs have remained stable since the last survey. Beach levels have increased across the profile, particularly at a chainage of 65m where they have increased by over 2m, to form a more gently sloping beach. The survey photographs show a substantial change in the beach composition from hard rock, to one of soft sand, since the last survey (refer to Plates 10 and 11). **1bSNS12** to **1bSNS36** are located along the undefended cliffs between Grangetown and Ryhope Dene. Profiles **SNS12** to **SNS19** are between the end of the Hendon sea wall and Salterfen Rocks. Cliff top levels are typically between 20m and 22mOD. They are highest along the profiles further north, dropping in the centre and then increasing again to the south. Profile **1bSNS12** extends from the cliff across the boulder foreshore. The toe of the cliff has retreated slightly and beach levels have increased by c. 0.5m across the profile. At profile **1bSNS13**, the majority of the cliff face has not changed in form since the previous survey (Full Measures, 2013), but there has been a small amount of recession of the cliff top. The survey report notes '*There are a number of landslips and mudflows that are evident on cliffs'*. Beach levels have generally remained stable across the profile with no discernible change. At profile **1bSNS14**, the toe of the cliff advanced, which may suggest deposition of a debris lobe, or problems with access. Beach levels have remained stable across the profile with no discernible pattern. At profile **1bSNS15**, the cliff top has remained stable, however, the cliff toe has eroded by c. 2m. Beach levels have increased by approximately 0.5m across the profile and the composition of the beach has changed from coarse shingle and cobbles to predominantly coarse shingle. At profile **1bSNS16**, the cliff face and rocky foreshore have remained stable and there have been no discernible changes to beach levels since the last survey (autumn 2013). Profiles **1bSNS17** to **1bSNS36** extend between Salterfen Rock and Ryhope Dean/Pincushion Rocks along Shirley Banks and Halliwell Banks. Profiles between SNS17 and SNS25 typically exhibit a characteristic cliff height of between 23m and 29mOD, with beaches at the toe typically at levels	To the south of Halliwell Banks, around Pincushion, the cliffs have generally retained the same form and position since the last survey. At profile 1bSNS36, the cliff has retreated by c. 2m. Beach levels have increased across the length of this coastline, particularly at 1bSNS33, where they are 1m higher than the previous survey. **Longer term trends:** Along the length of south Hendon, profile 1bSNS10 has beach levels the highest recorded since surveys began in September 2009. At Grangetown (south Hendon to Saltfern Rocks), between profiles 1bSSN12 and 1bSNS19, the position of the cliff face has continued to erode slightly since the survey programme began. Between Salterfen Rocks and the landfill at Halliwell banks (profiles 1bSNS20 to 1bSNS25), the cliff has generally remained stable and beach levels are within the bounds of previous surveys. At the landfill site (profiles 1bSSN26 to 1bSSN32), the cliff position and beach levels are within the bounds of previous surveys. To the south of Halliwell Banks, at profiles 1bSNS33 and 1bSNS34, cliff and beach are within the bounds of previous surveys.

Survey Date	Description of Changes Since Last Survey	Interpretation
	between 3.1m and 4.6mOD. At **1bSNS17**, the profile shows the cliff toe to have receded by approximately 1m. Across the foreshore there are small variations in beach level, but no clear trend. At **1bSNS18**, the profile shows the cliff to have remained stable since the last survey. Beach levels from the cliff toe to a chainage of 80m have decreased by approximately 0.5m, and increased by approximately 0.5m seaward of there, covering the underlying rocky foreshore. It is possible that beach material has been drawn-down across the beach. At **1bSNS19**, the cliff toe has advanced, which may relate to deposition of a debris lobe or access problems. The rocky foreshore remains unchanged. At profile **1bSNS20**, the dune toe has receded by approximately 1m. The beach has generally remained stable, with a small increase in beach levels of 0.5m, between a chainage of 80m and 100m. At **1bSNS21**, the cliff has generally remained stable since the last survey. Beach levels have increased across the profile by 0.5m, covering the underlying rocky foreshore. At profile **1bSNS22**, the cliff has generally remained stable since the last survey. The rocky/sandy foreshore remains unchanged from the previous survey. At profile **1bSNS23**, the cliff has generally remained stable since the last survey. Beach levels have increased by an increasing amount in a seaward direction to form a more gently sloping beach. The lower rocky foreshore has also been covered by a veneer of sand (refer to the survey photographs shown in Plates 12 and 13). At **1bSNS24**, the cliff top has remained stable, but the toe has retreated by 2m. This erosion is likely represent erosion of debris deposited by an earlier landslide The upper/middle beach has remained stable since the last survey, but the lower beach between a chainage of 90m and 130m levels have increased by approximately 0.5m. At profile **1bSNS25**, there has been substantial erosion of between 2 and 4m at the cliff toe, which is likely to be the removed of debris from the cliff fall observed during the last survey, (see survey photographs 14 and 15). Beach levels have increased across the profile, particularly on the upper beach between a chainage of 50m and 90m, where they have increased by 0.5m.	

Survey Date	Description of Changes Since Last Survey	Interpretation
	Profiles **1bSNS26** to **1bSNS32** are located at Halliwell Banks specifically to assess risks from erosion at a former land fill. Cliff height is between 26m and 27mOD, with beaches at the toe typically at levels between 3.3m and 3.9mODN. Profiles**1bSNS26** to **1bSNS32**, have changed little since the last survey. Profile 1bSNS27 shows some erosion at the cliff toe, associated with erosion of a debris lobe from a previous cliff failure. Beach levels have increased along the length of this section of coastline by 0.5m to 1m, to form a more gently sloping and sandier beach. Profiles **1bSNS33** to **1bSNS36** are located around the Pincushion Headland. The cliffs have generally retained the same form and position since the last survey, with the exception of profile 1bSNS36, where the cliff has retreated by c. 2m. This erosion is evident in the survey photographs (see Plates 16 and 17). At locations**1bSNS33** to **1bSNS35** the cliff face has retained the same form and position since the last surveys. At locations**1bSNS35** to **1bSNS36** the cliff top shows a up to 0.5m of retreat. Beach levels have increased across the profile at all locations, particularly 1bSNS33, where they have increased by 1m to form a more gently sloping and flatter beach.	
Sept 2014	**Topographic Survey:** Hendon to Ryhope is covered by an annual topographic survey between the Hendon Sea Wall and Ryhope Dene, which commenced in autumn 2009. Data from the most recent topographic survey (Full Measures, autumn 2014) have been used to create a DGM (Appendix B – Map 2a and Map 3a) using a GIS. A difference plot has also been produced using the DGM (Appendix B – Map 2b and Map 3b) produced from the last produced topographic survey (Full Measures, autumn 2012) and the present survey. Between Hendon and Salterfen Rocks, there is a trend for beach elevation increase along the northern half of the beach and beach elevation decrease along the southern half of the beach. To the south of Saltfern Rocks, there is a trend of beach elevation increase, with erosion concentrated along the backshore/upper beach.	Between Hendon and Salterfen Rocks, there is a trend for beach elevation increase along the northern half of the beach and beach elevation decrease along the southern half of the beach. The accretionary trend in beach levels observed from the beach profiles around profiles 1bSNS7 and 1bSNS11 is reflected by the topographic survey. To the south of Saltfern Rocks, there is a trend of beach elevation increase, with decrease concentrated along the backshore/upper beach. This suggests a trend of beach drawdown of material. **Longer term topographic trends Autumn 2009 to Autumn 2014:** The plot shows a trend of accretion at the northern part of the coast between Hendon and Saltfern Rock, and erosion to the south.

Survey Date	Description of Changes Since Last Survey	Interpretation
Sept 2013	**Cliff Top Survey:** Cliff top survey data collected between the baseline survey (spring 2009) and the present Full Measures survey (autumn 2013) is documented here. 32 ground control points (numbered 1-32) were established along the cliff top between Hendon and Ryhope in March 2009, with a further three (28A, 28B and 28C) added in September 2009. Note: the numbering of ground control points is not intended to correlate with that of the beach profile lines and reference should be made to Appendix B - Map 1 and Appendix B – Map 2 for the location of ground control points. Measurements are taken from each ground control point along a fixed bearing to the edge of the cliff top. These cliff top surveys are undertaken bi-annually and are intended to inform on erosion rates of the sea cliffs extending from the defended industrial areas at Hendon southwards along the undefended cliffs to Ryhope Dene. Appendix B – Table B1 provides results from the cliff top survey, showing the position from the ground control point to the edge of the cliff top along a defined bearing. Results show that erosion greater than the error has only occurred at four locations, where losses of between 0.2 and 1.1m have occurred at Salterfen Rocks, north of Halliwell Banks, and along Halliwell Banks. Since surveys began in March 2009 (or September 2009 for 28A and 28B) erosion greater than the survey error has occurred at around a third of the ground control points, where total losses range from 7.7m (at location 25), to a more typical 2m. The long-term erosion rates are up to 1.7m/yr (location 25), with c. 0.5m/yr being more typical.	Episodic and localised cliff recession has been on going on this stretch of coast. **Longer term trends: As** longer-term data shows significant erosion has consistently occurred at Grangetown (up to 0.6 m/yr), North of Halliwell Banks (up to 0.8 m/yr), Halliwell Banks (up 1.7m/yr) and either side of Pincushion (up to 0.9m/yr).

Plate 8 – Survey photograph 1bSNS7_20140913_N5

Plate 9 – Survey photograph 1bSNS7_20130913_N5

Plate 10 – Survey photograph 1bSNS11_20140913_N7

Plate 11 – Survey photograph 1bSNS11_20140305_N7

Plate 12 – Survey photograph 1bSNS23_20140913_N9

Plate 13 – Survey photograph 1bSNS23_20130913_N8

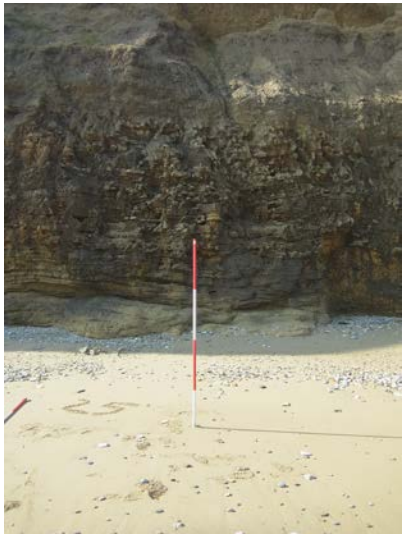


Plate 14 – Survey photograph 1bSNS25_20140913_Up3

Plate 15 – Survey photograph 1bSNS25_20130913_Up3

Plate 16 – Survey photograph 1bSNS36_20140913_N6

Plate 17 – Survey photograph 1bSNS36_20130913_N7

3. Problems Encountered and Uncertainty in Analysis

Individual Profiles
n/a

Topographic Survey
n/a

Cliff Top Surveys
n/a

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

No changes are recommended at the present time.

5. Conclusions and Areas of Concern

- At Whitburn Bay, the recorded profiles and topographic survey present no causes for concern.
- At Sunderland Harbour and Docks, the recorded profiles present no causes for concern.
- At Hendon to Ryhope (incl. Halliwell Banks), the recorded profiles and topographic survey present no causes for concern.

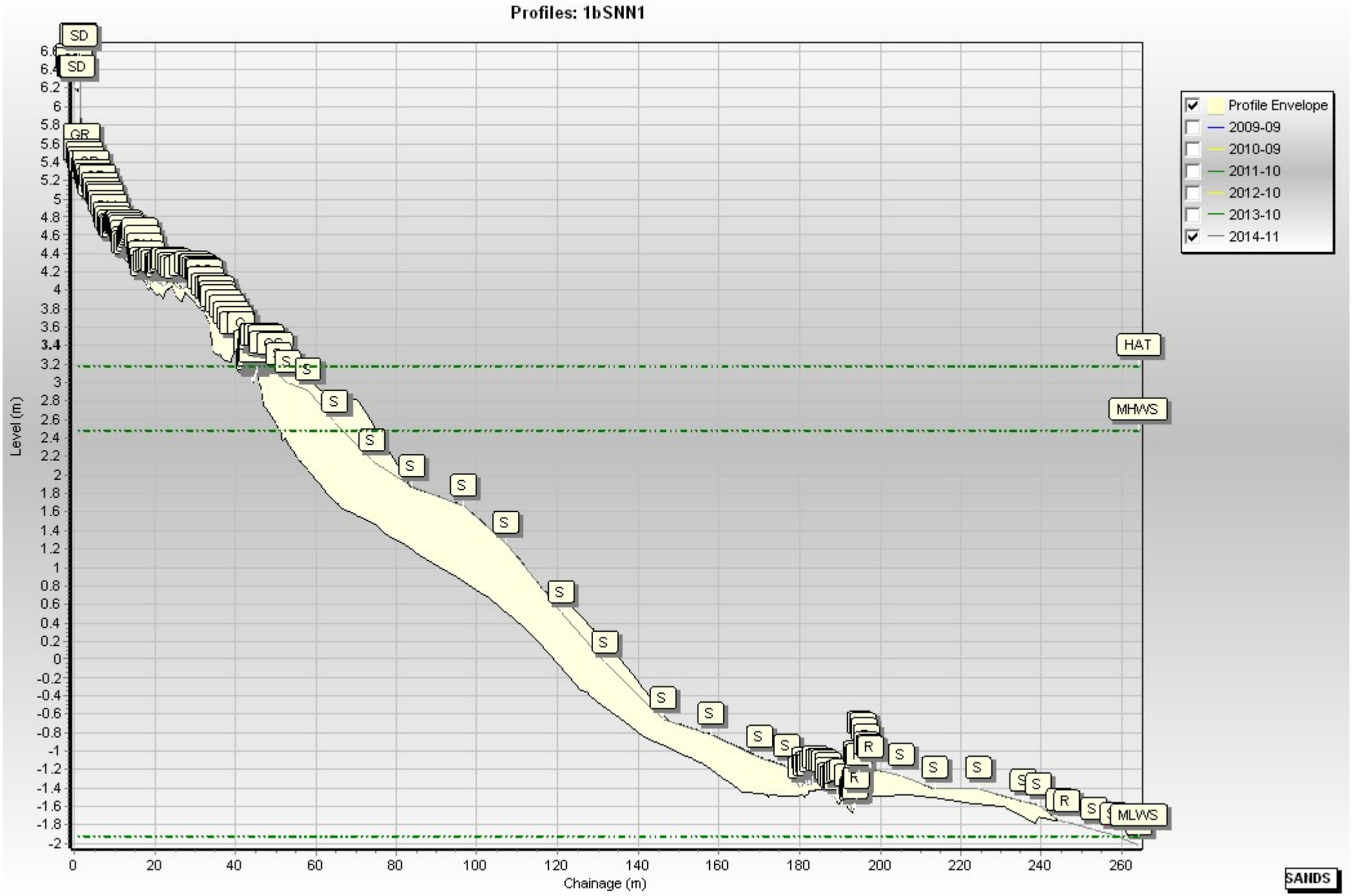
Appendices

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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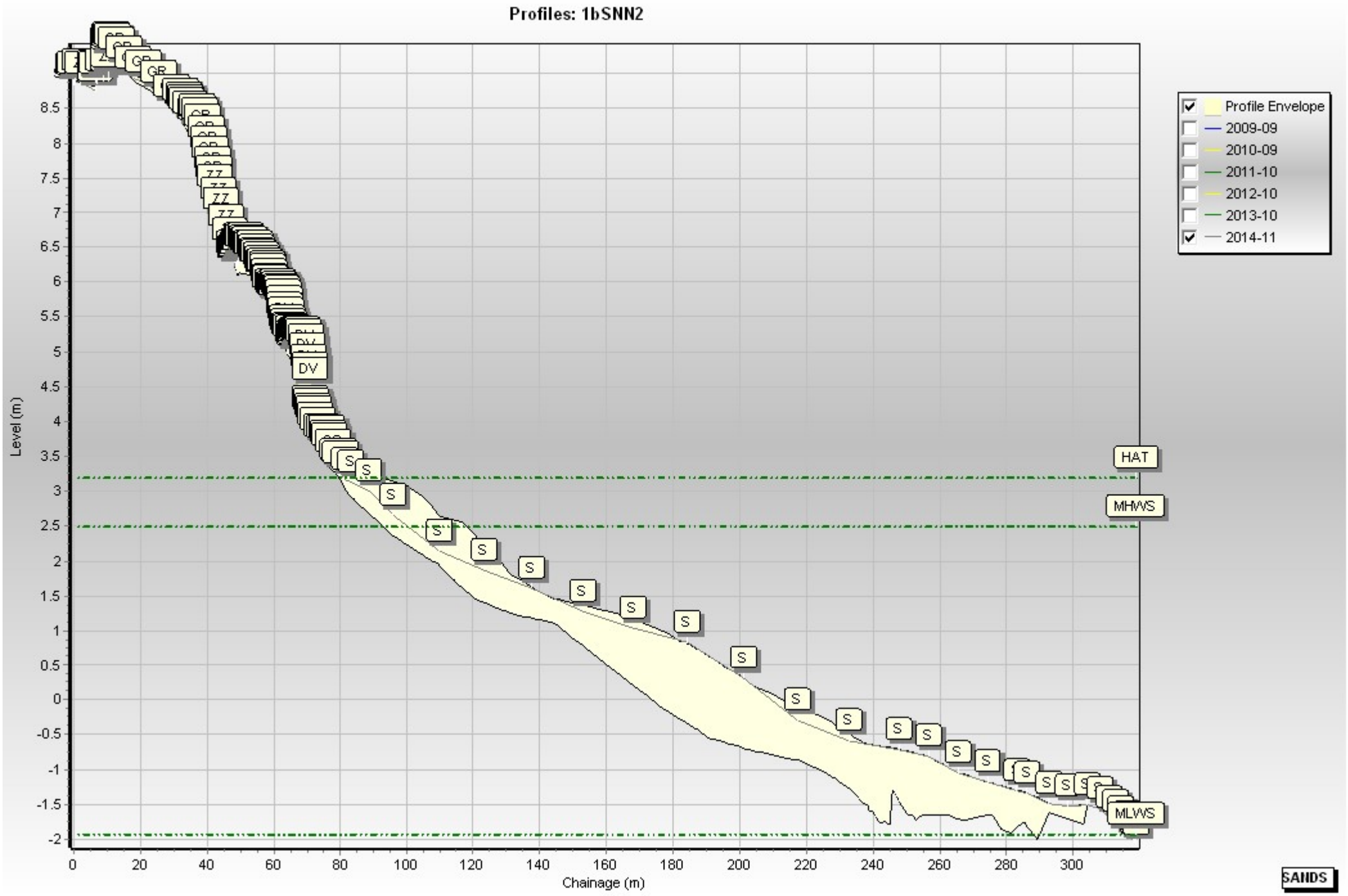
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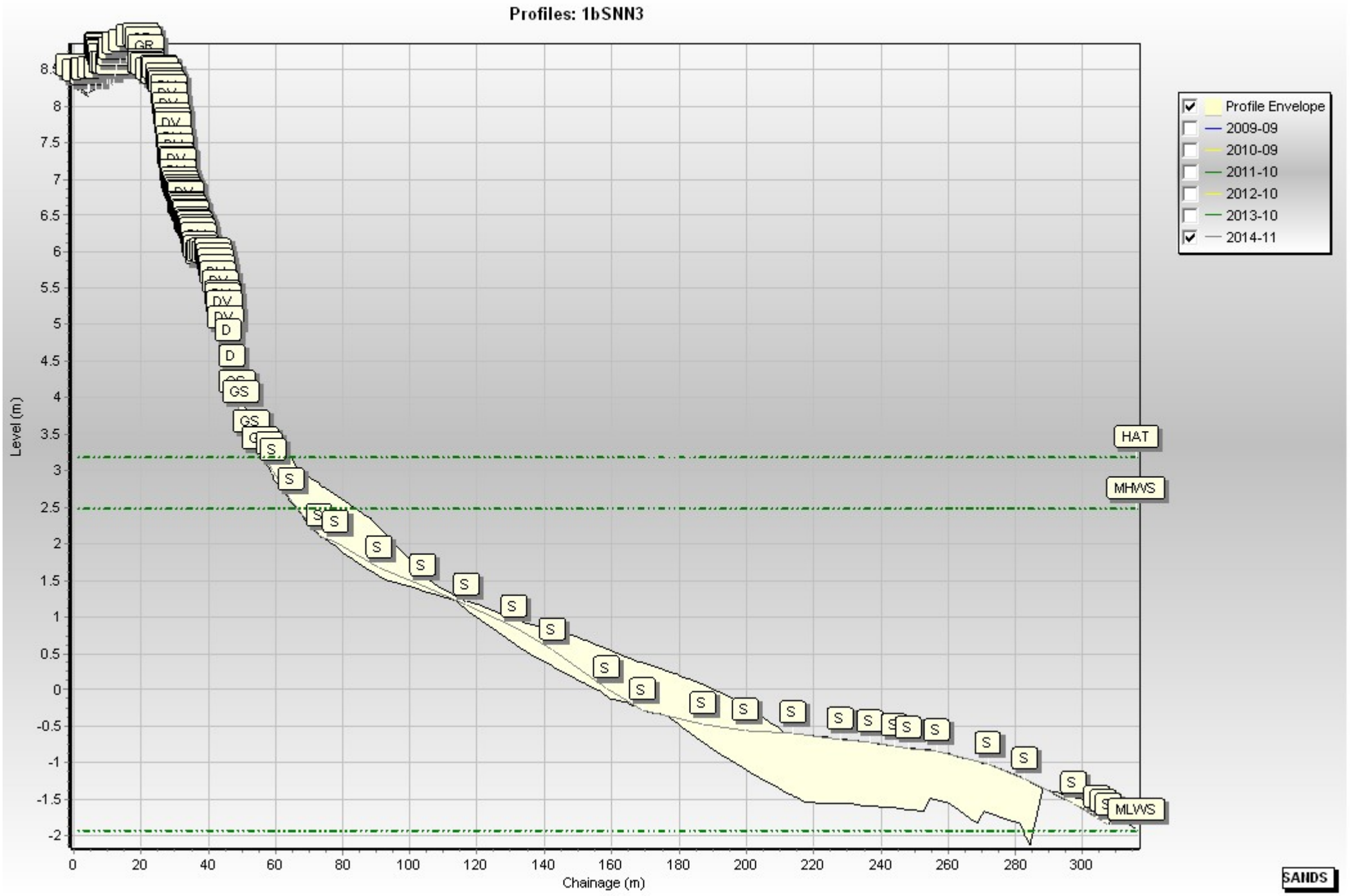
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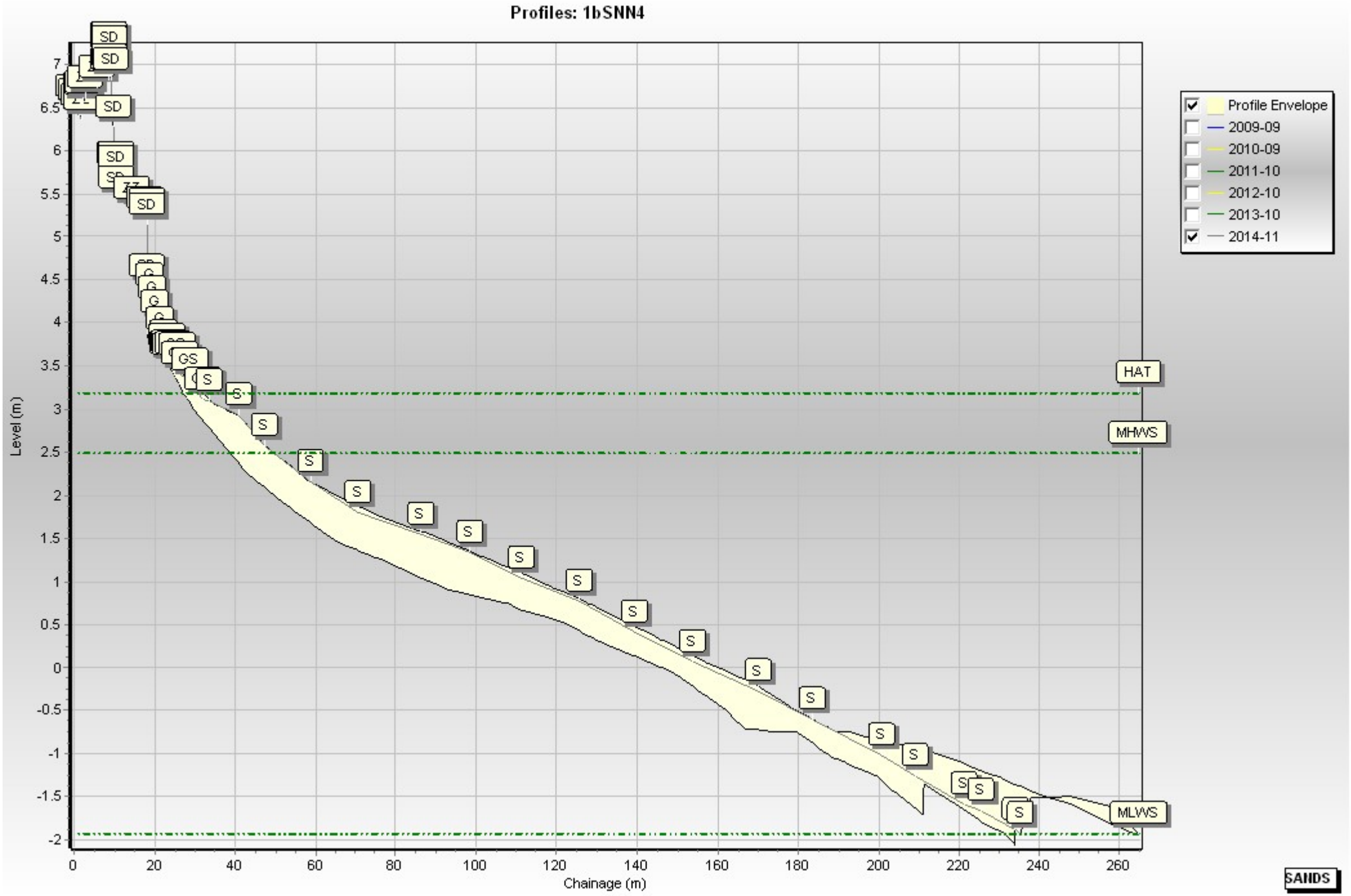
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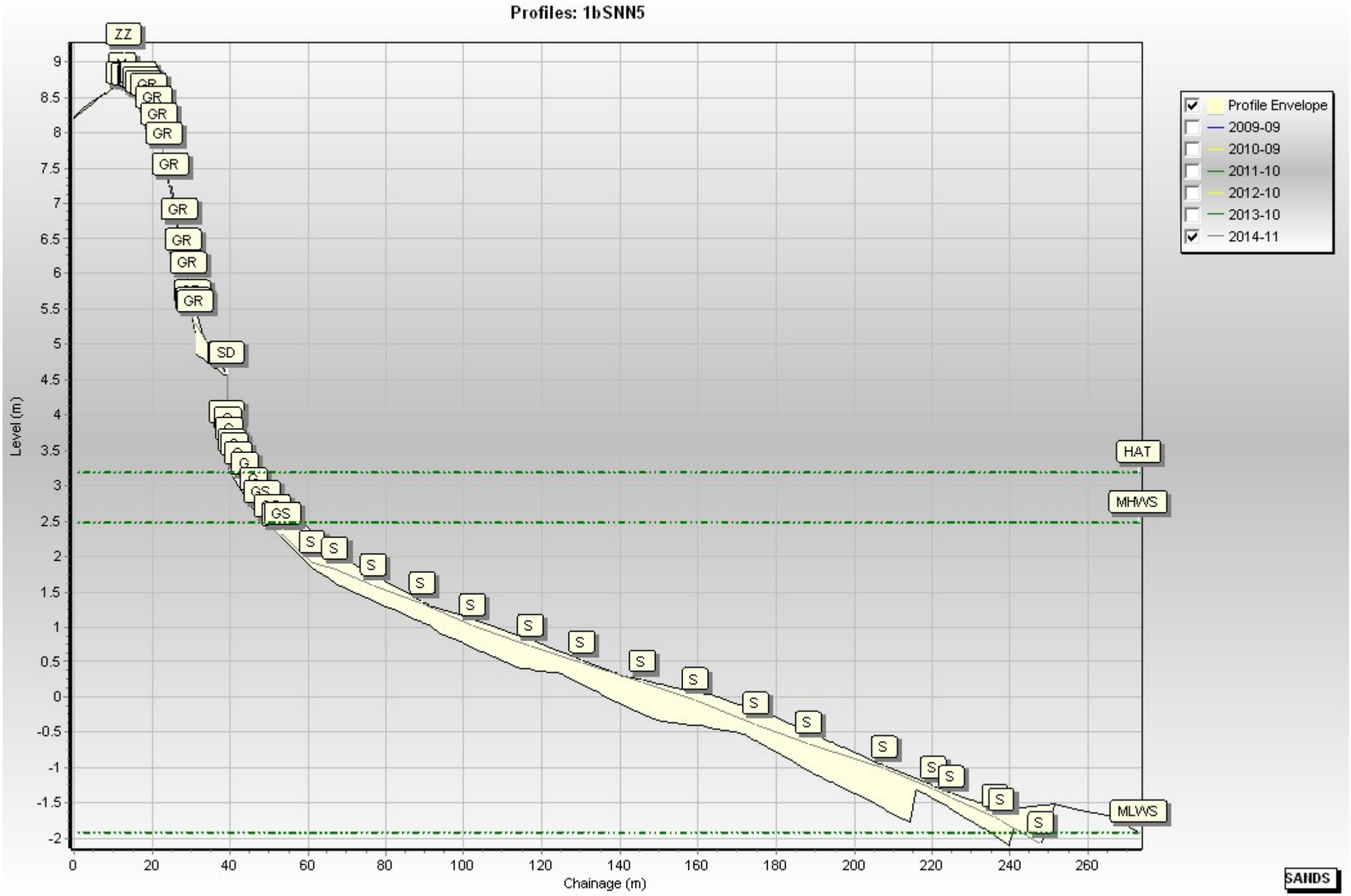
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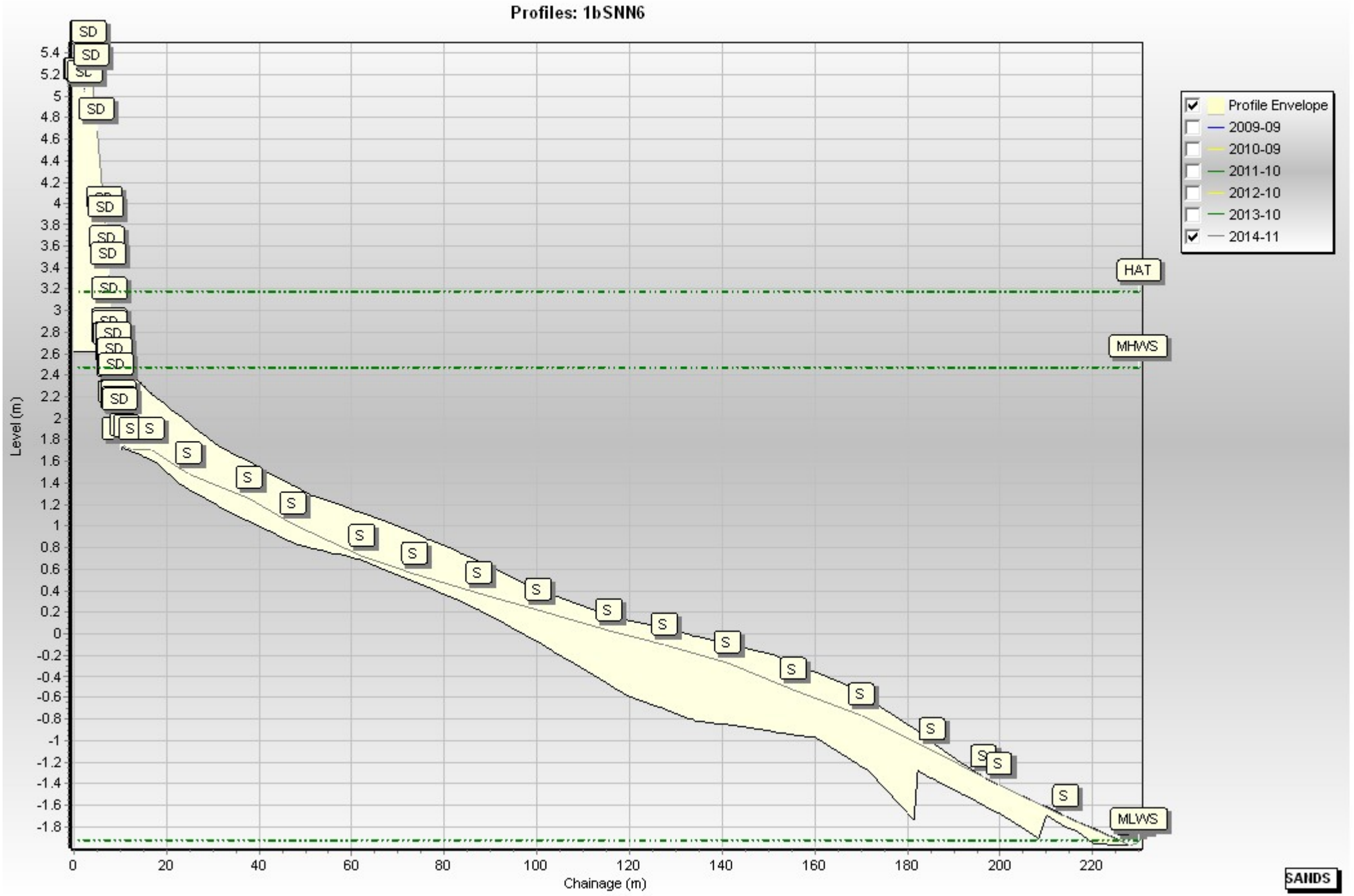
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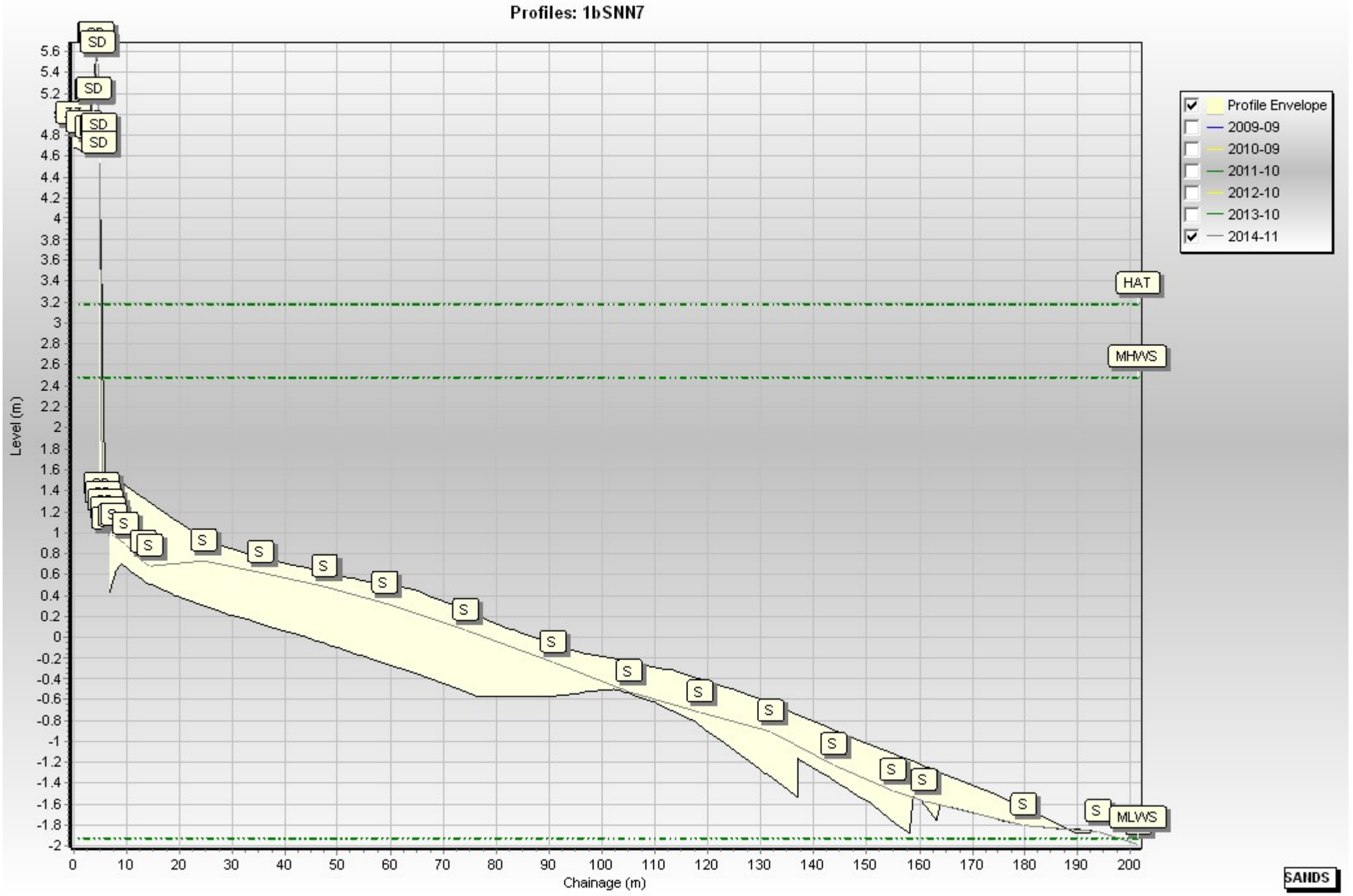
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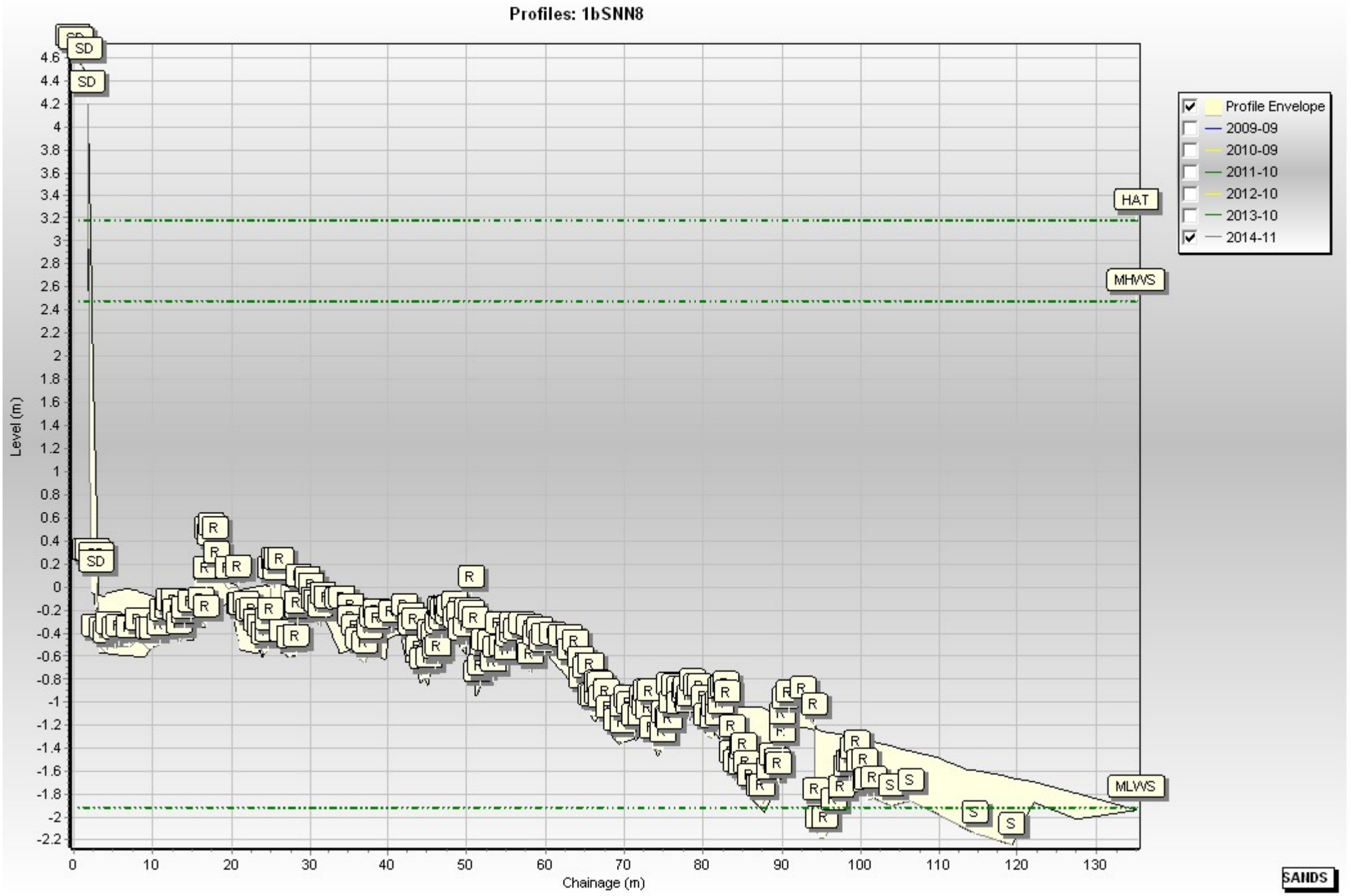
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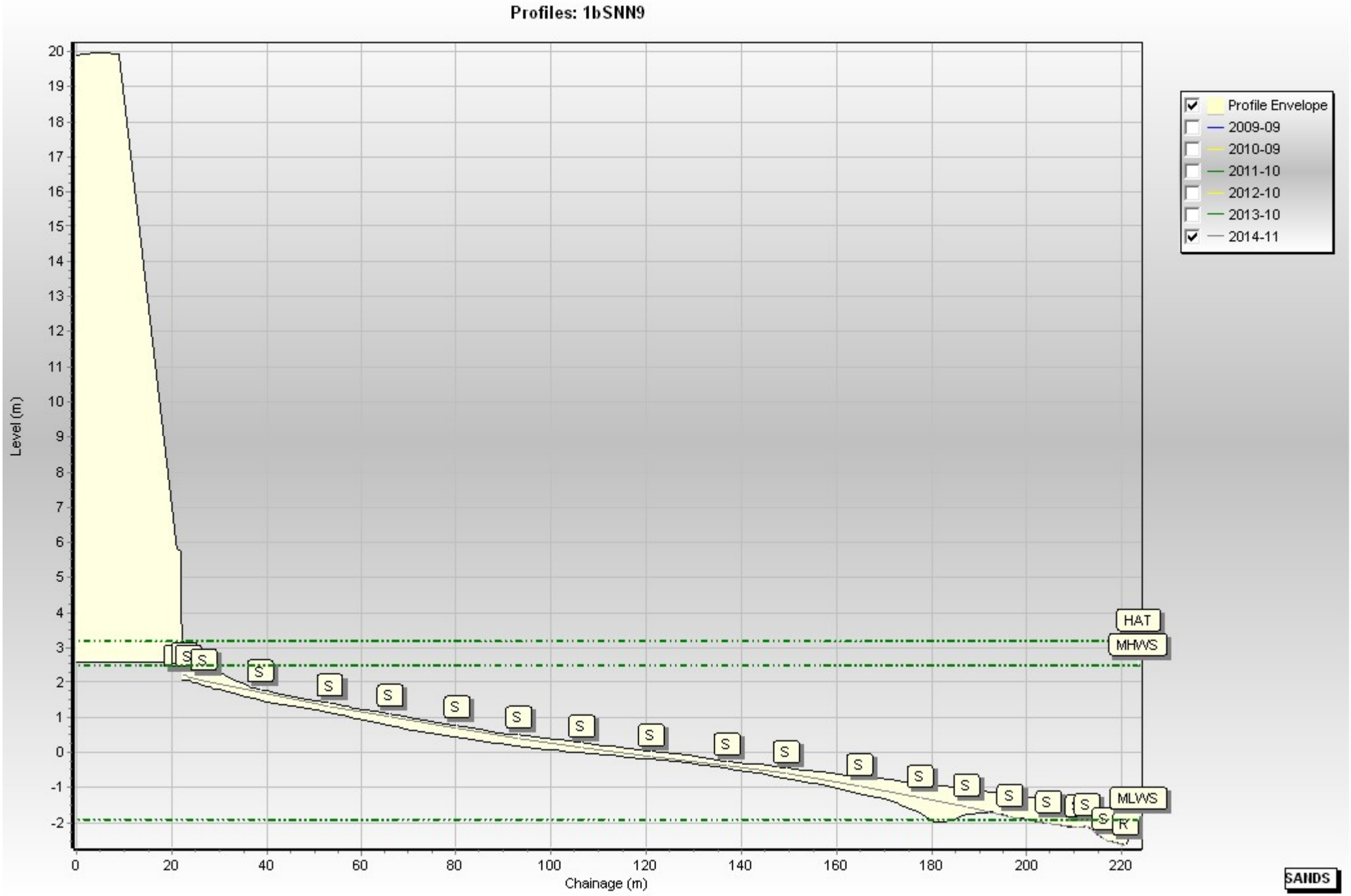
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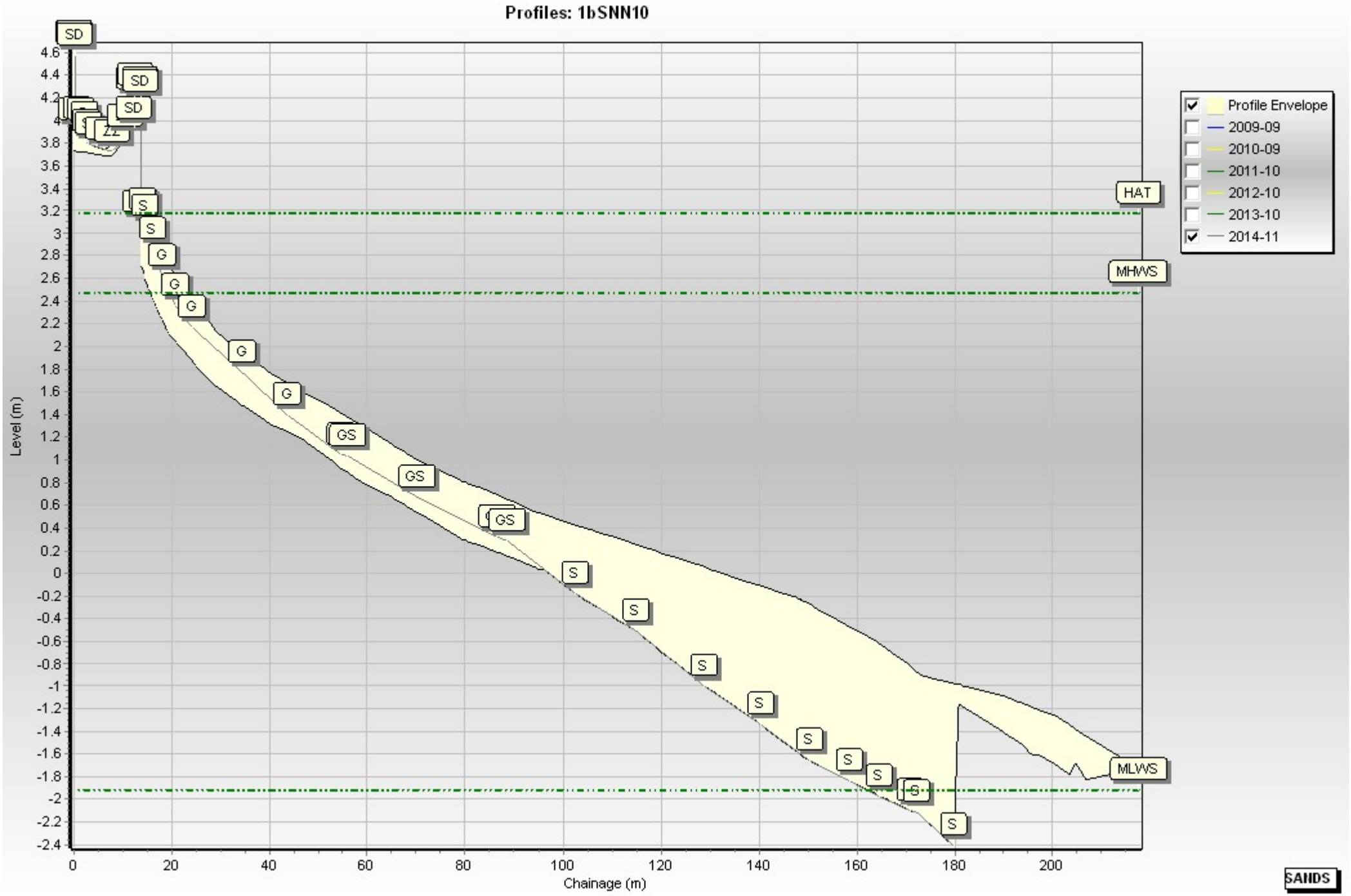
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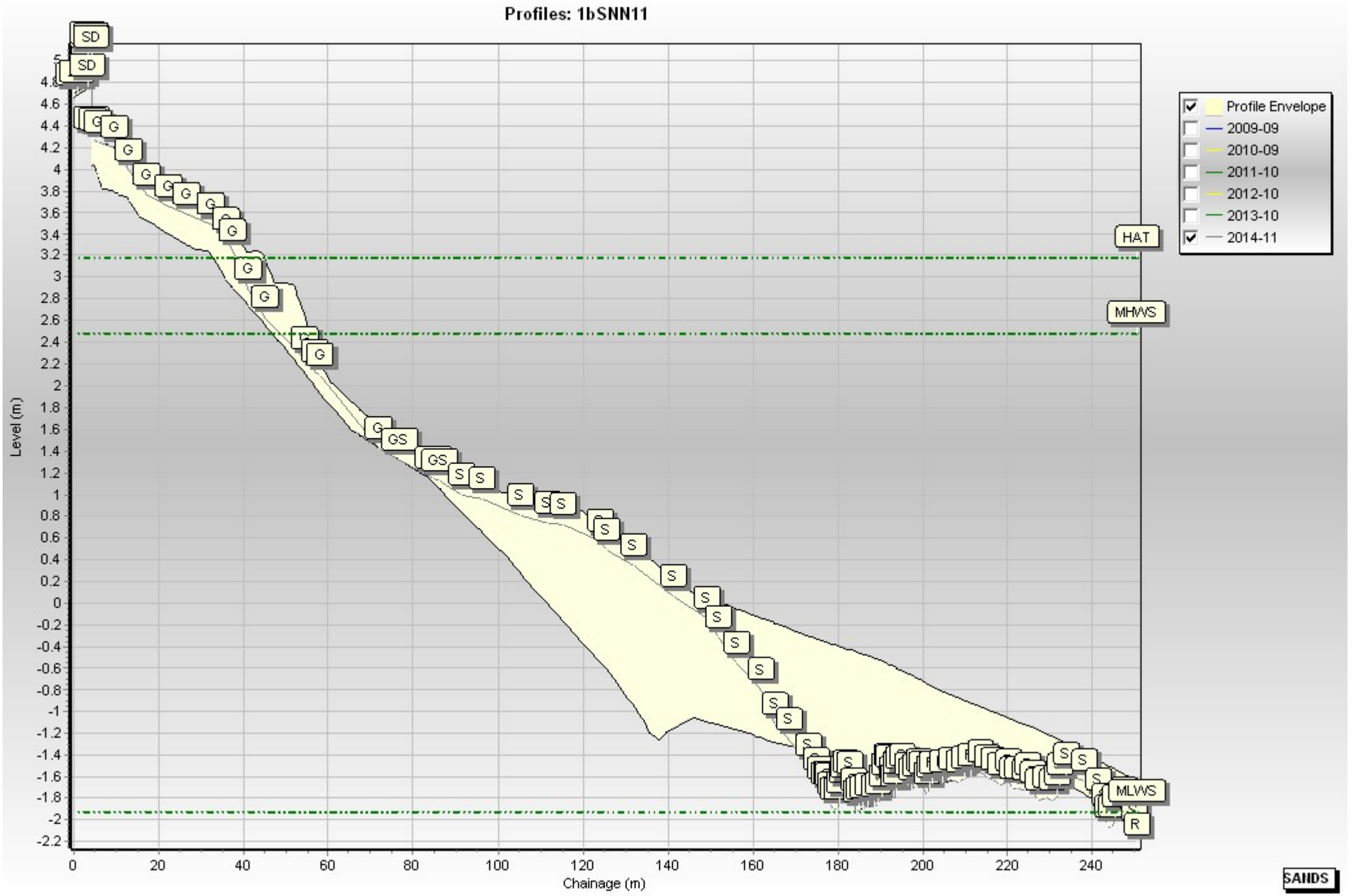
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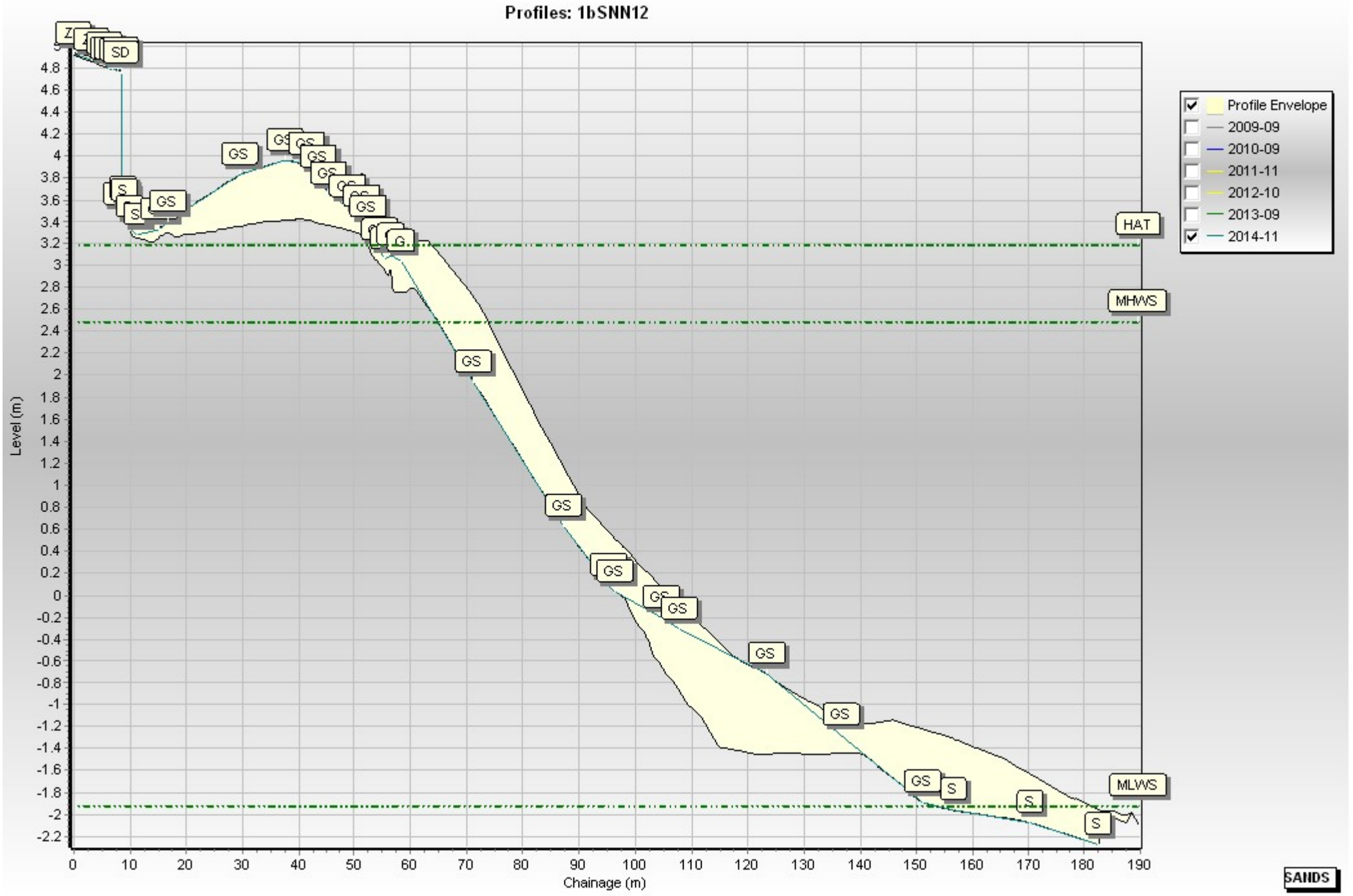
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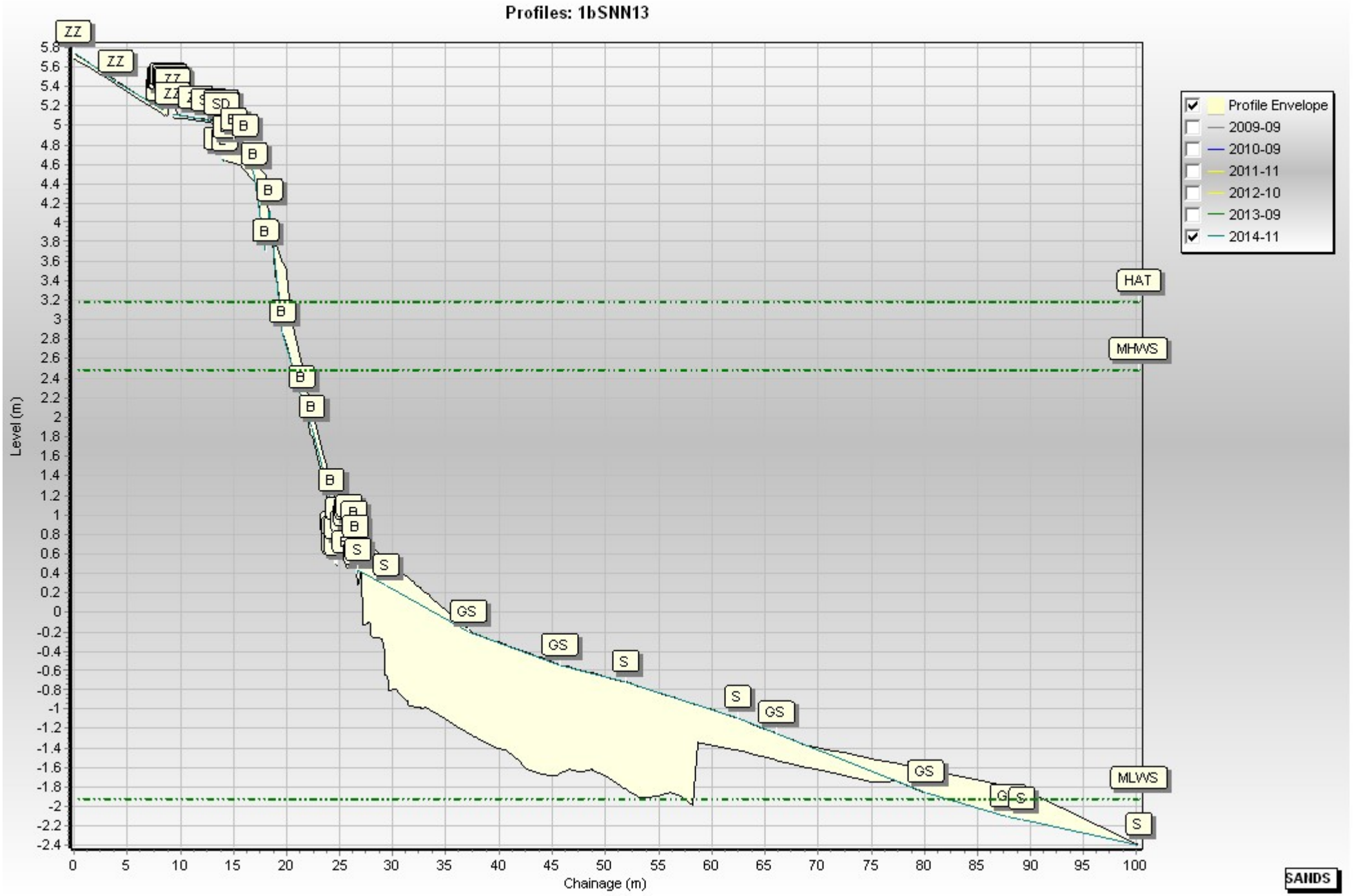
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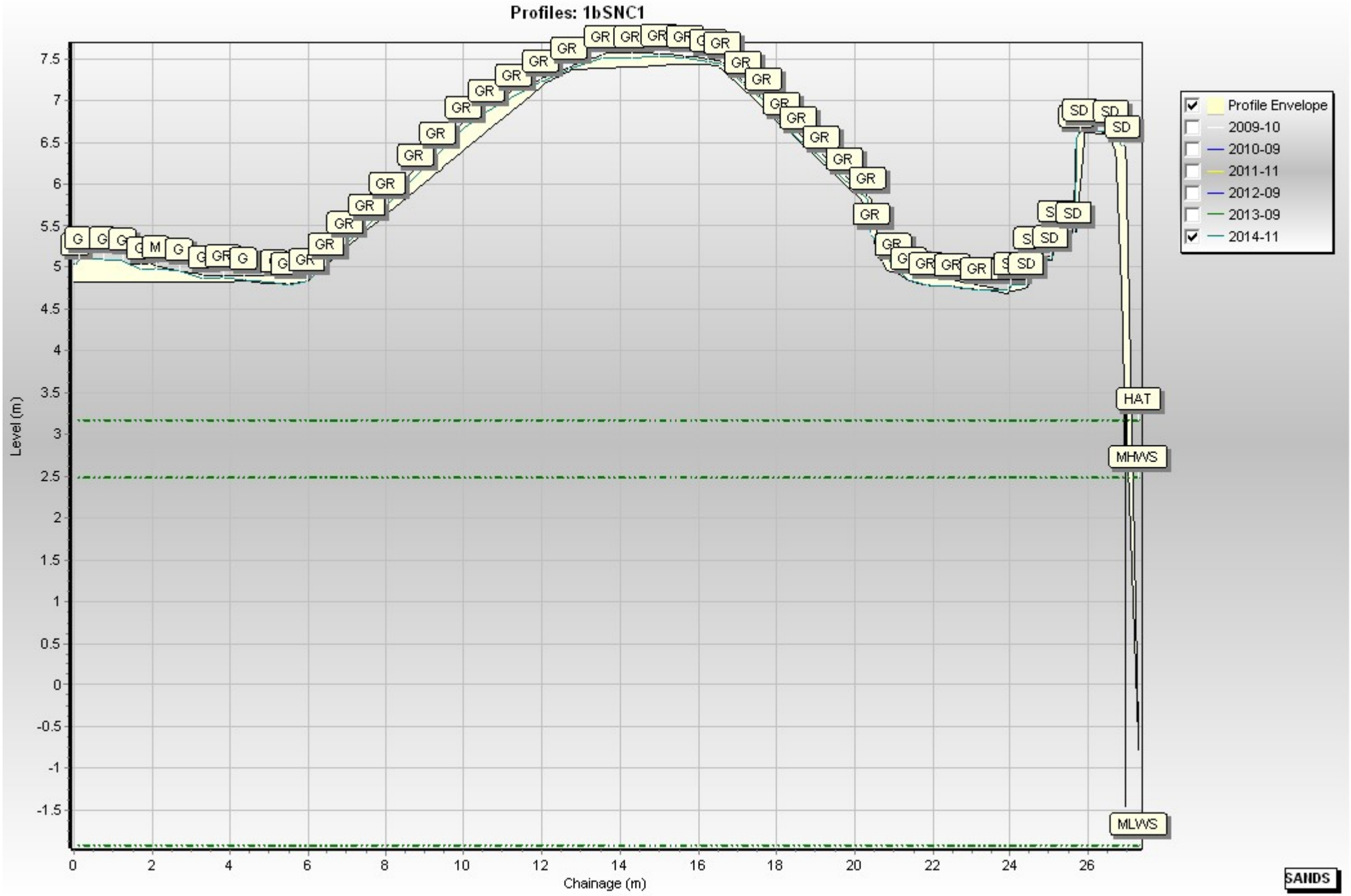
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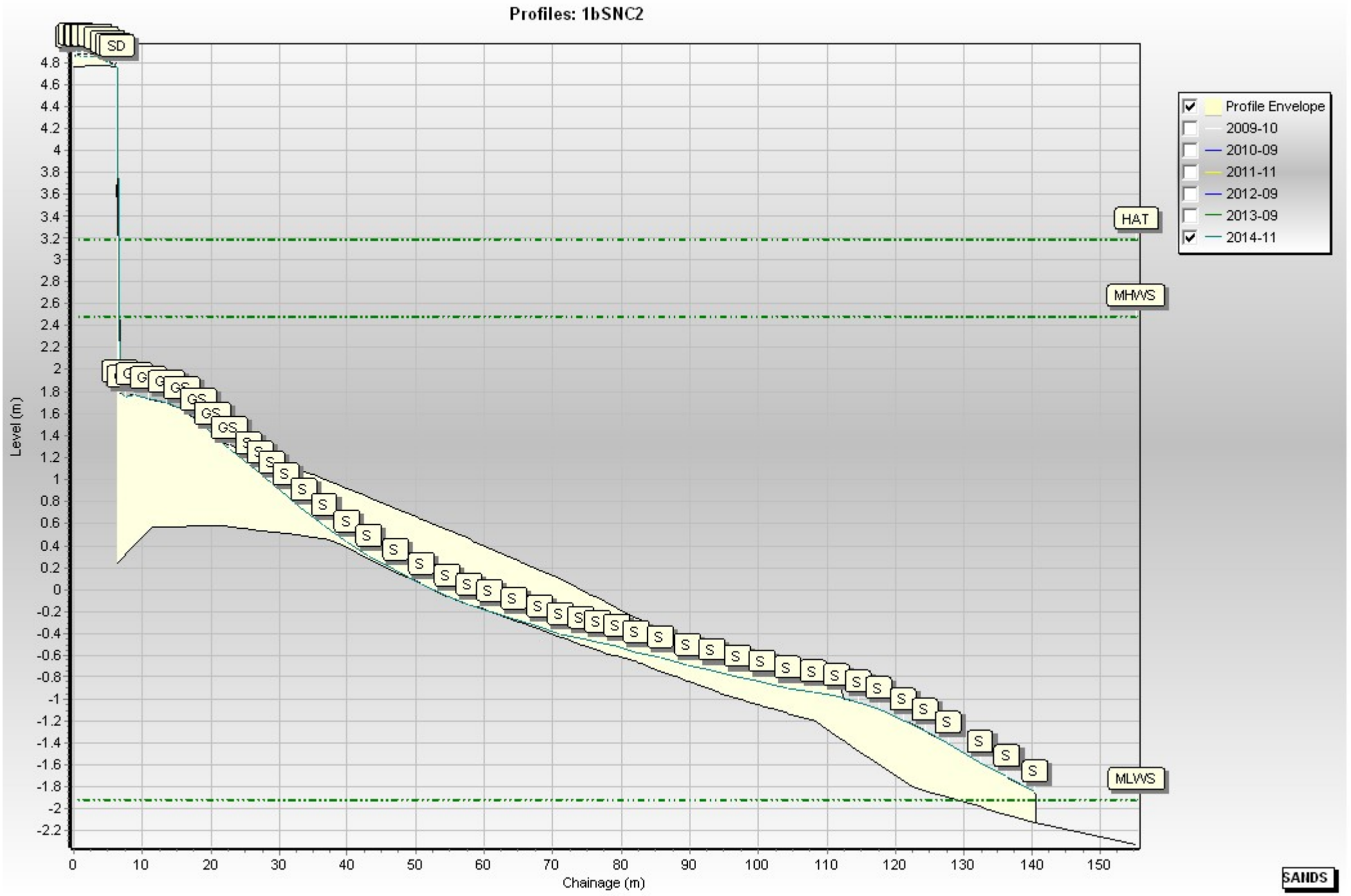
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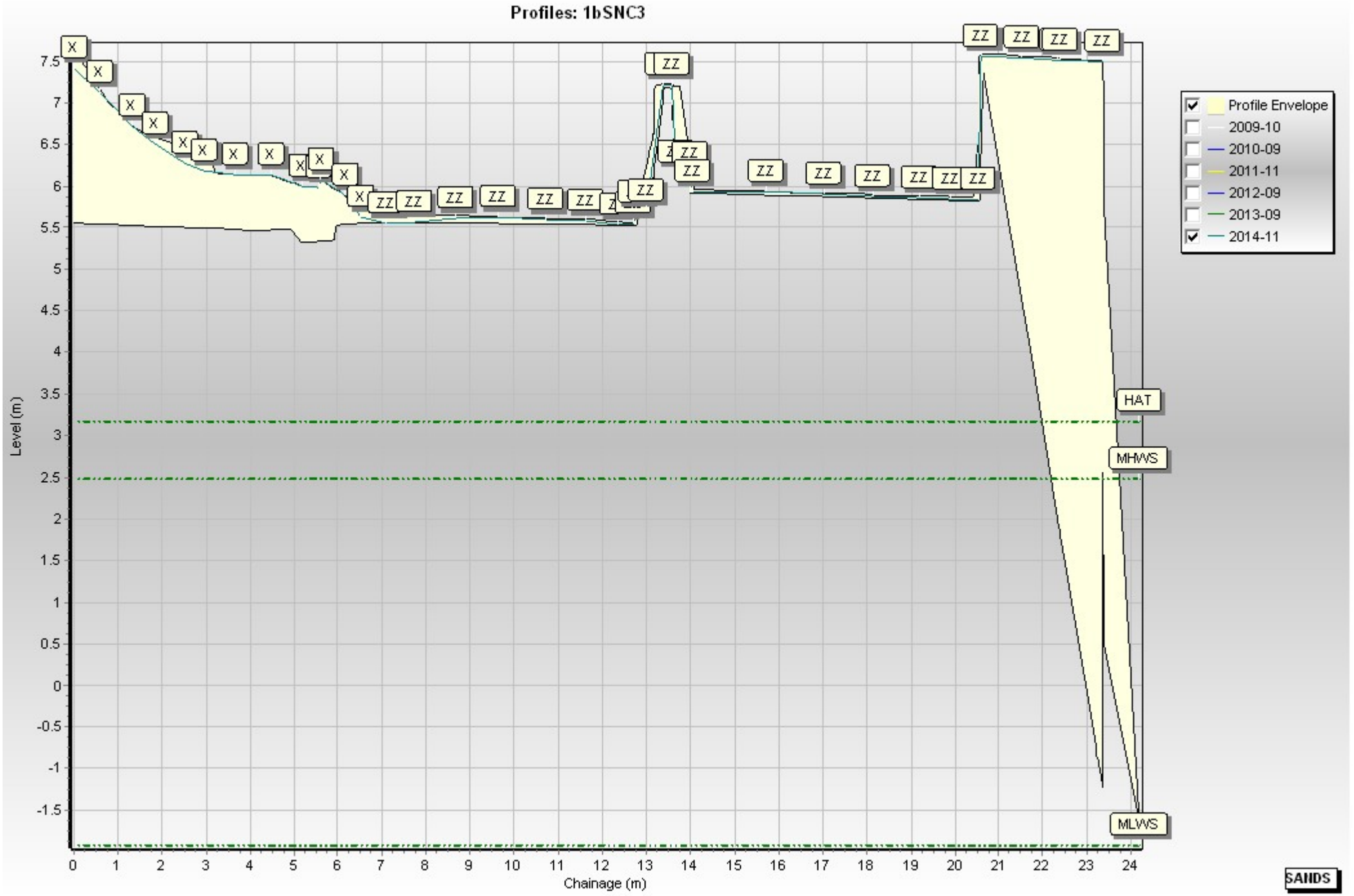
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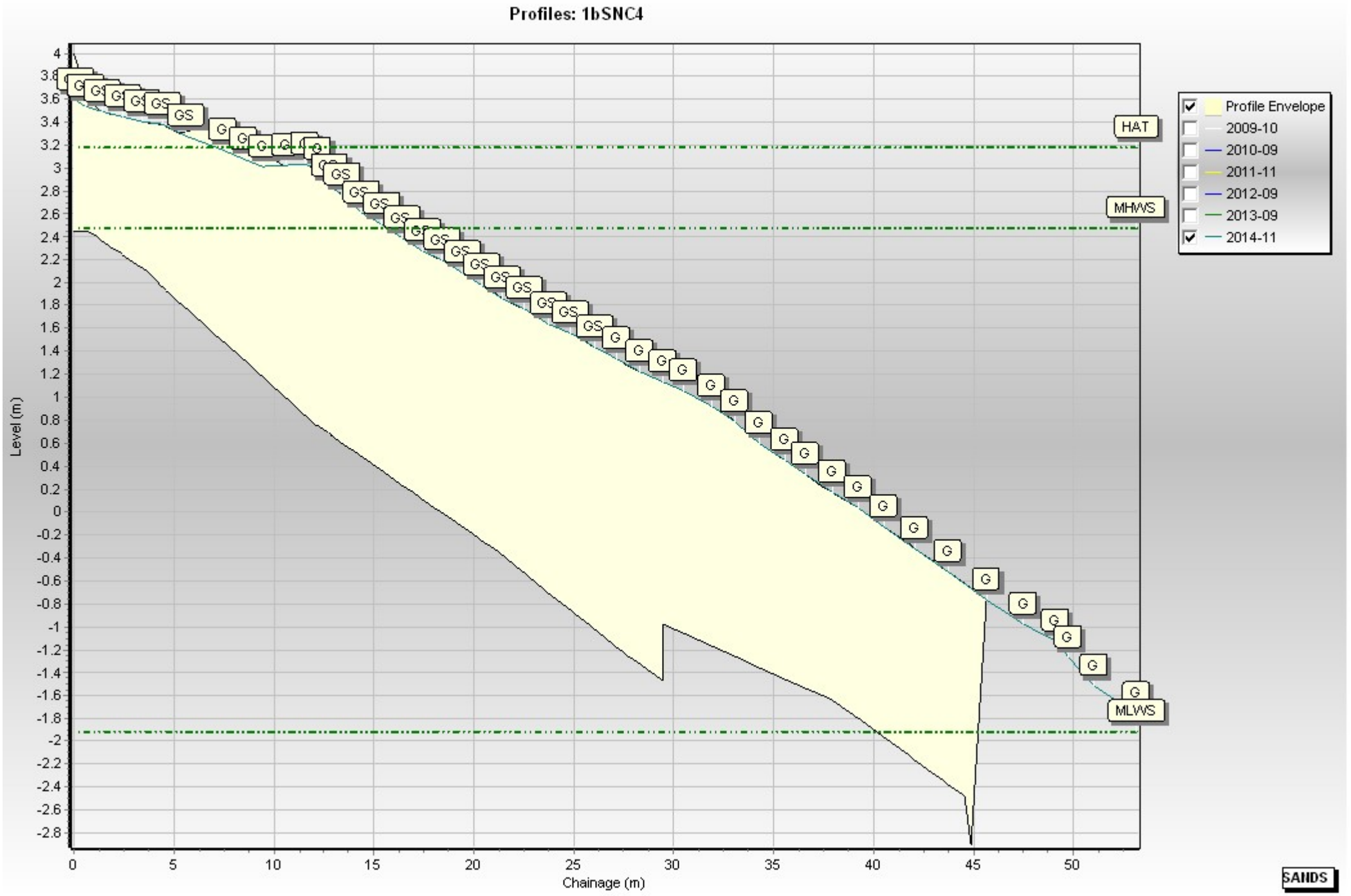
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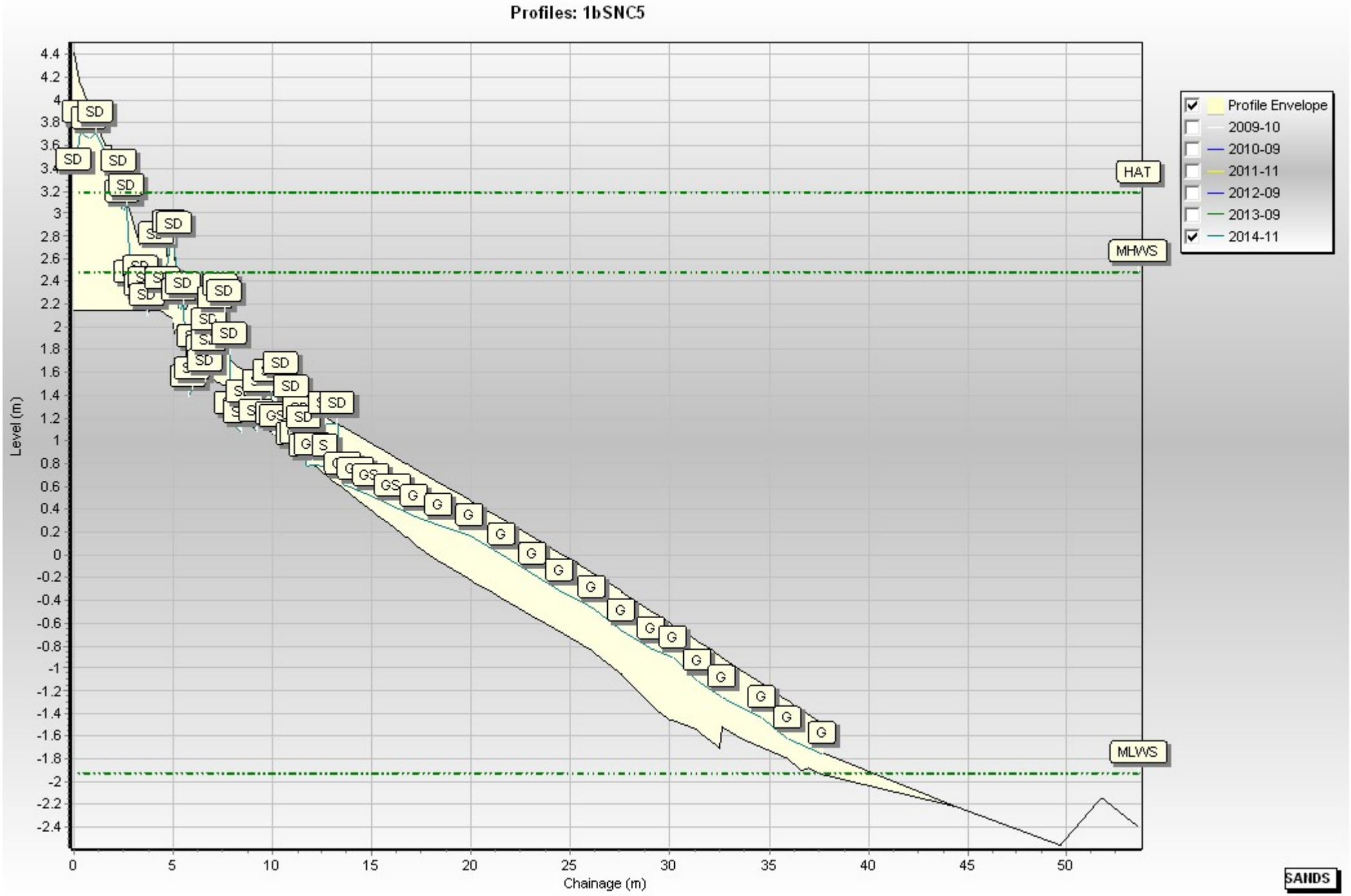
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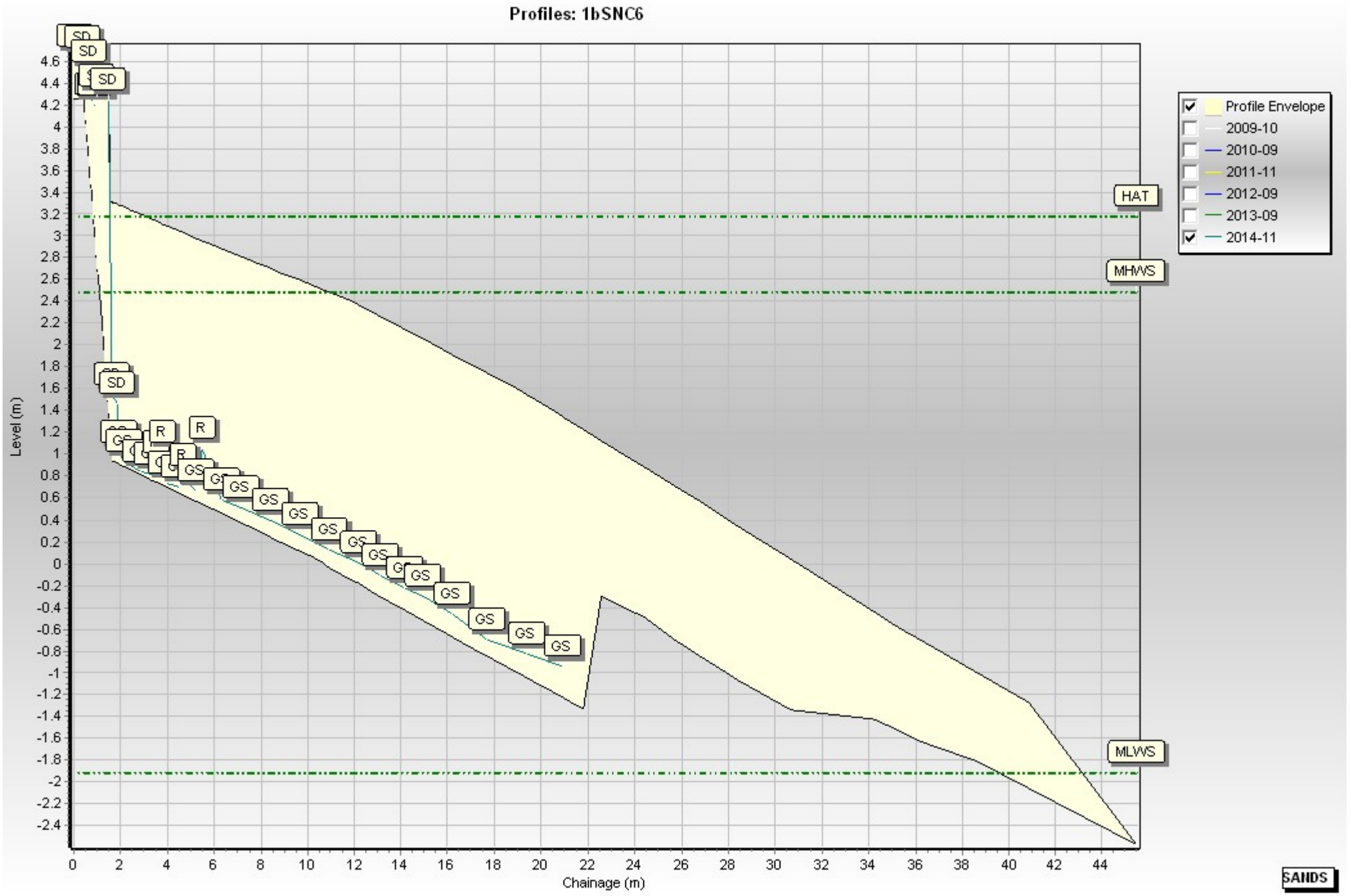
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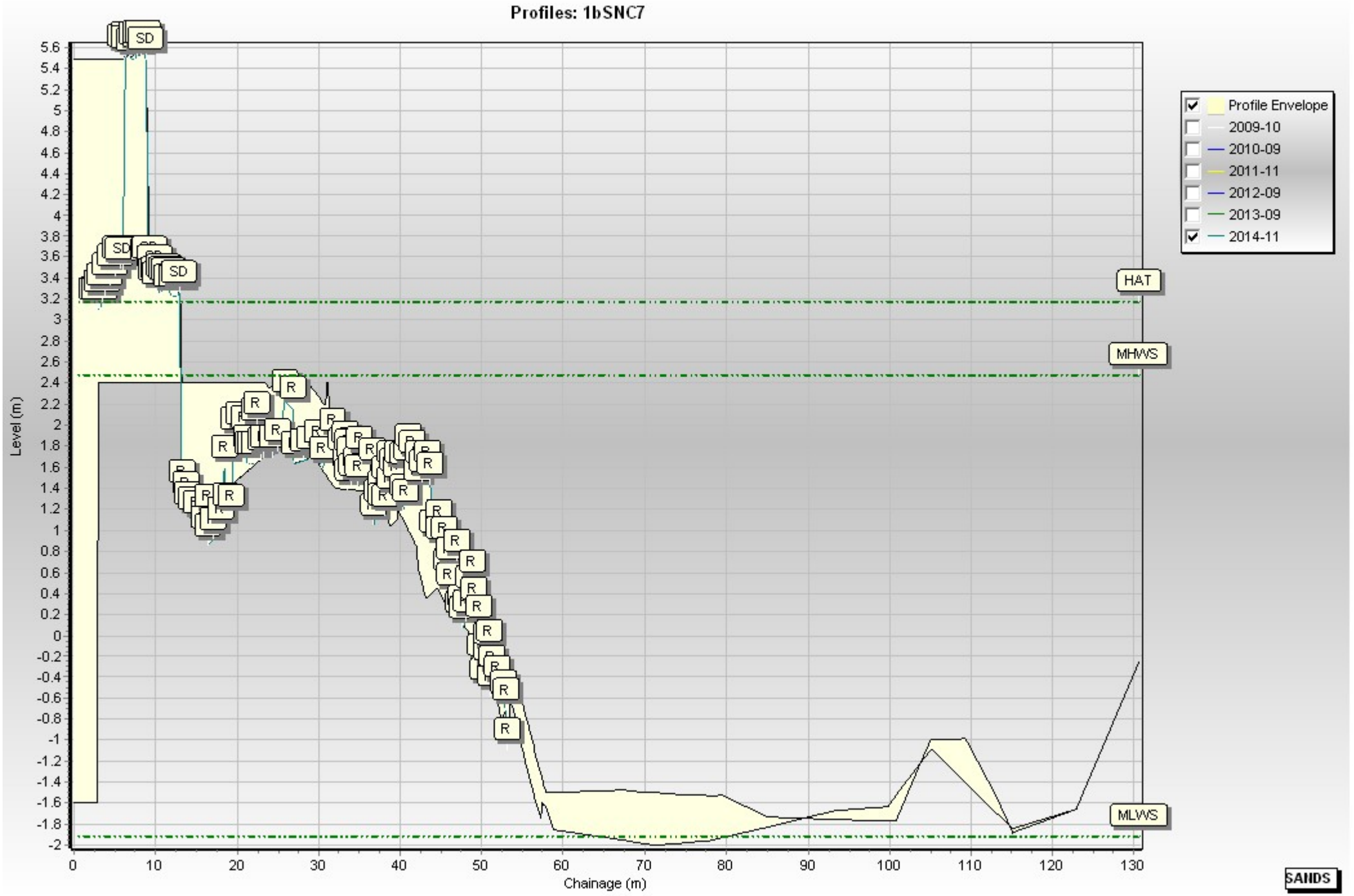
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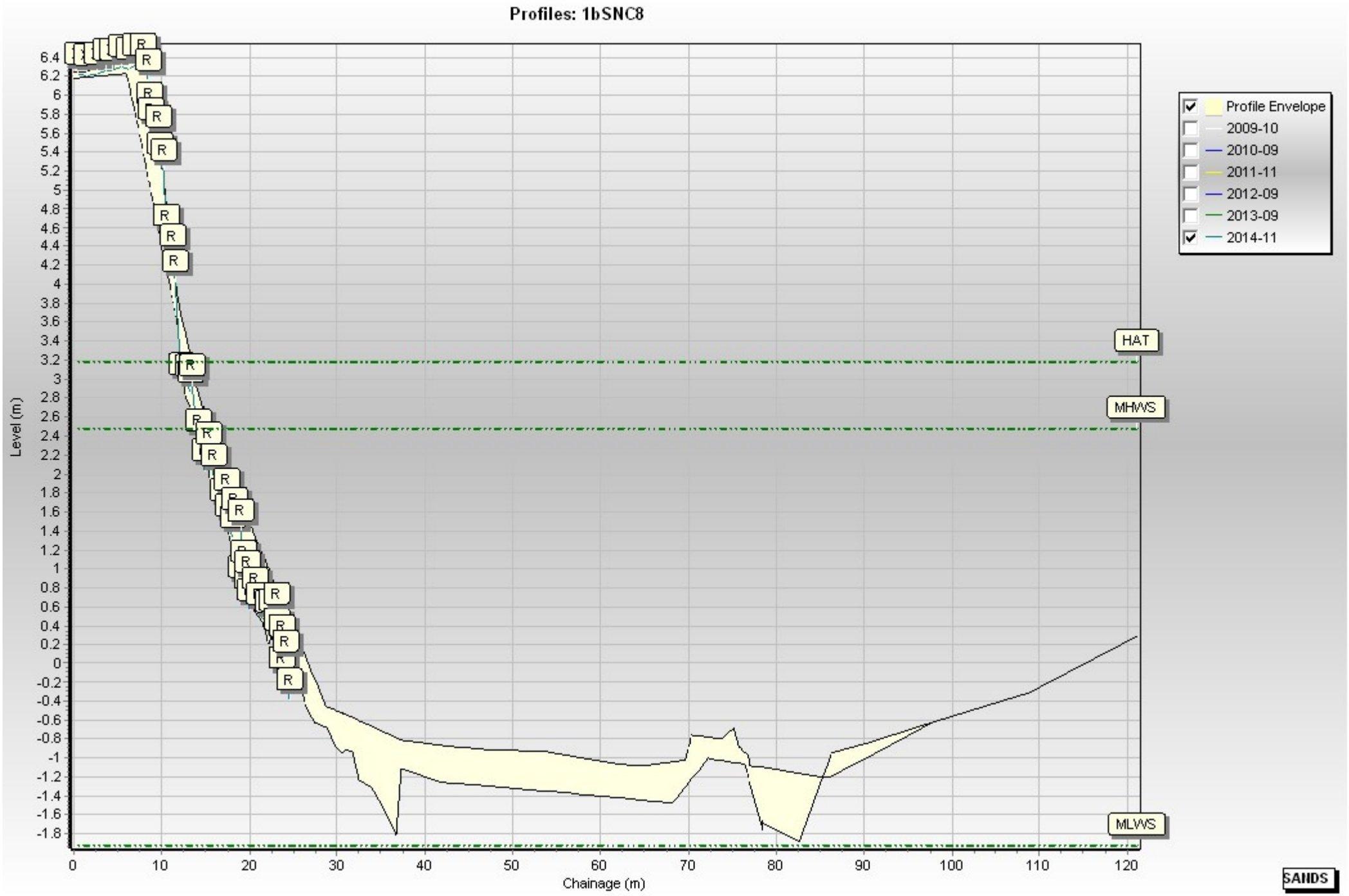
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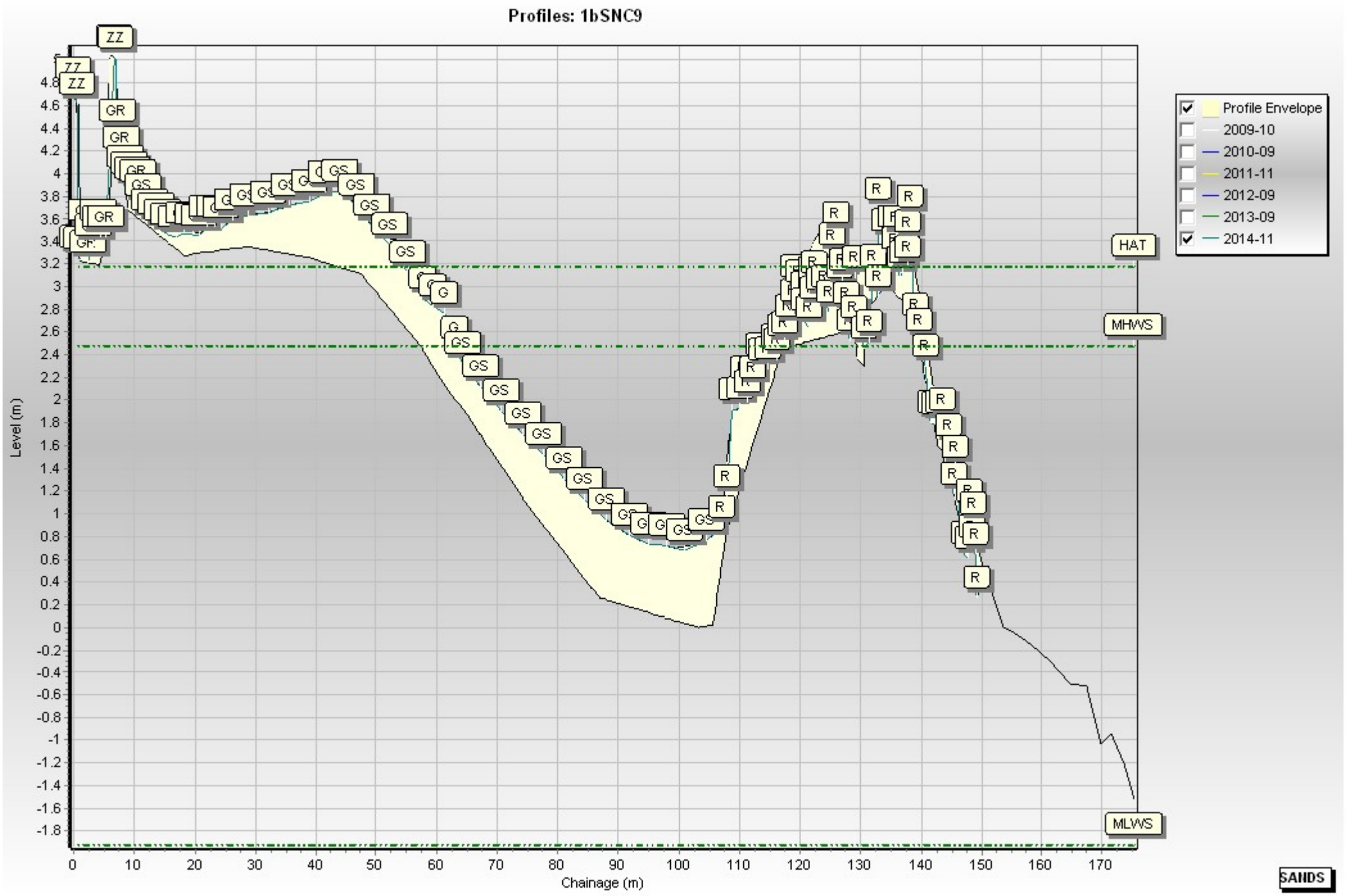
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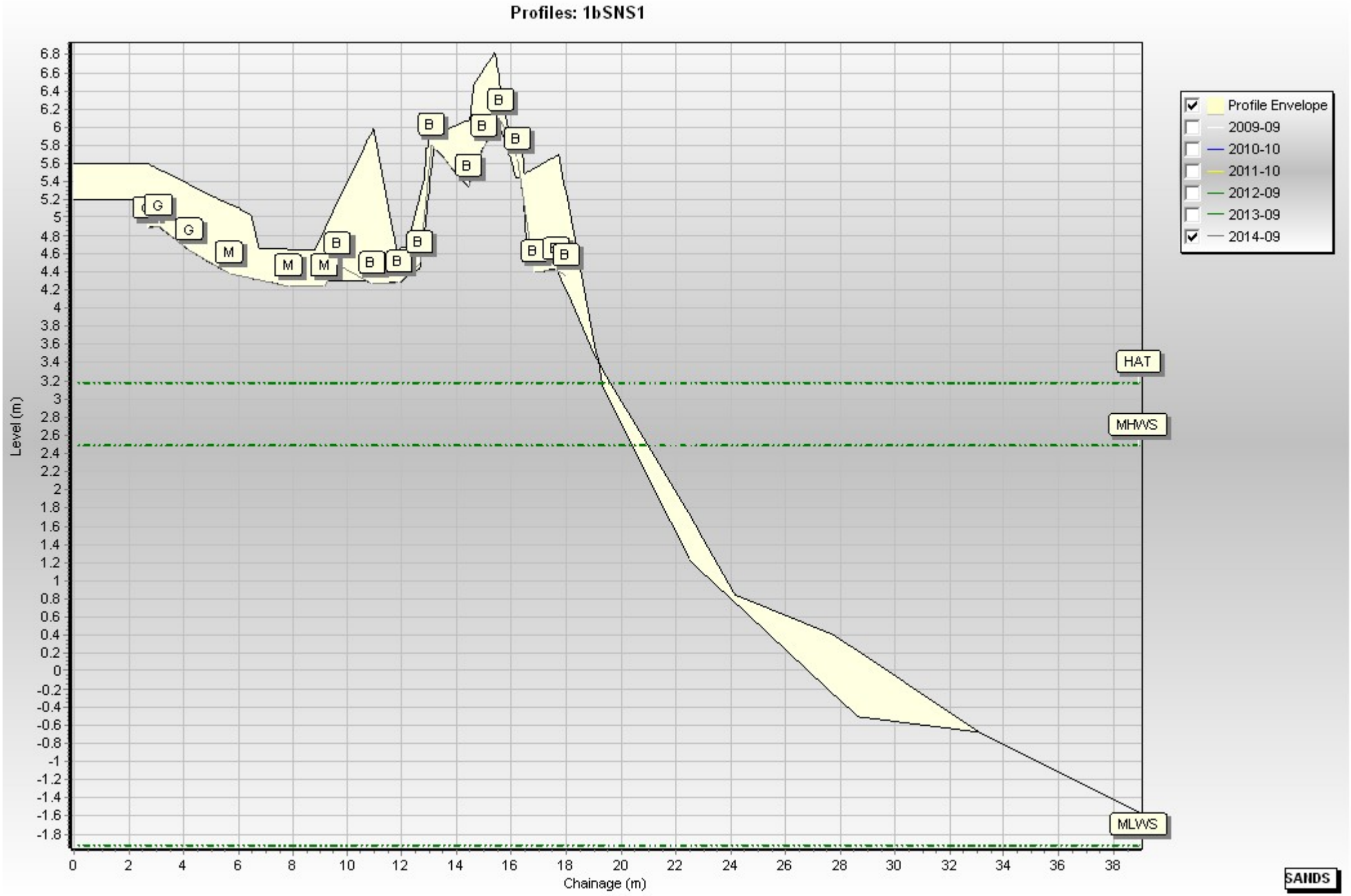
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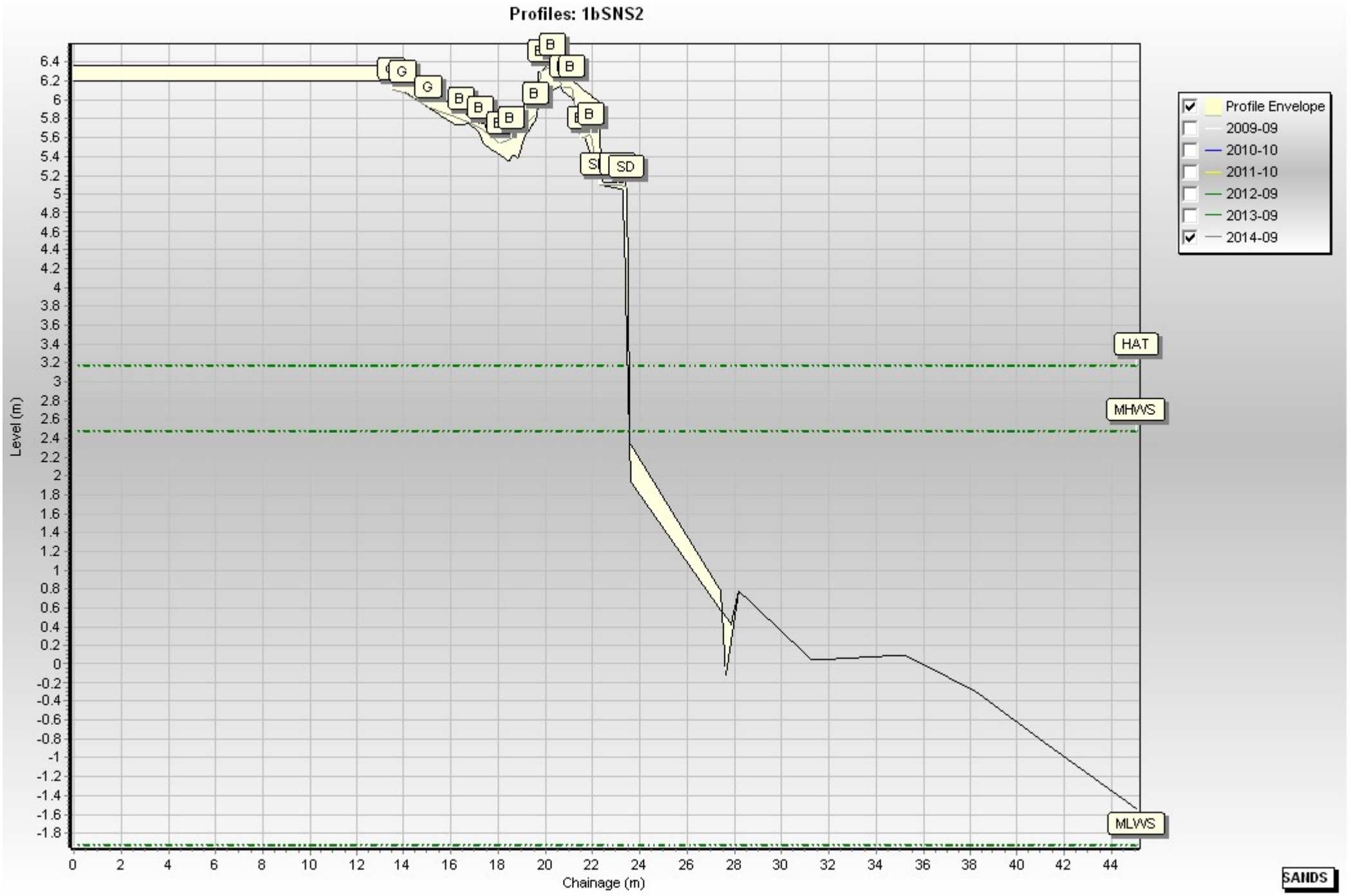
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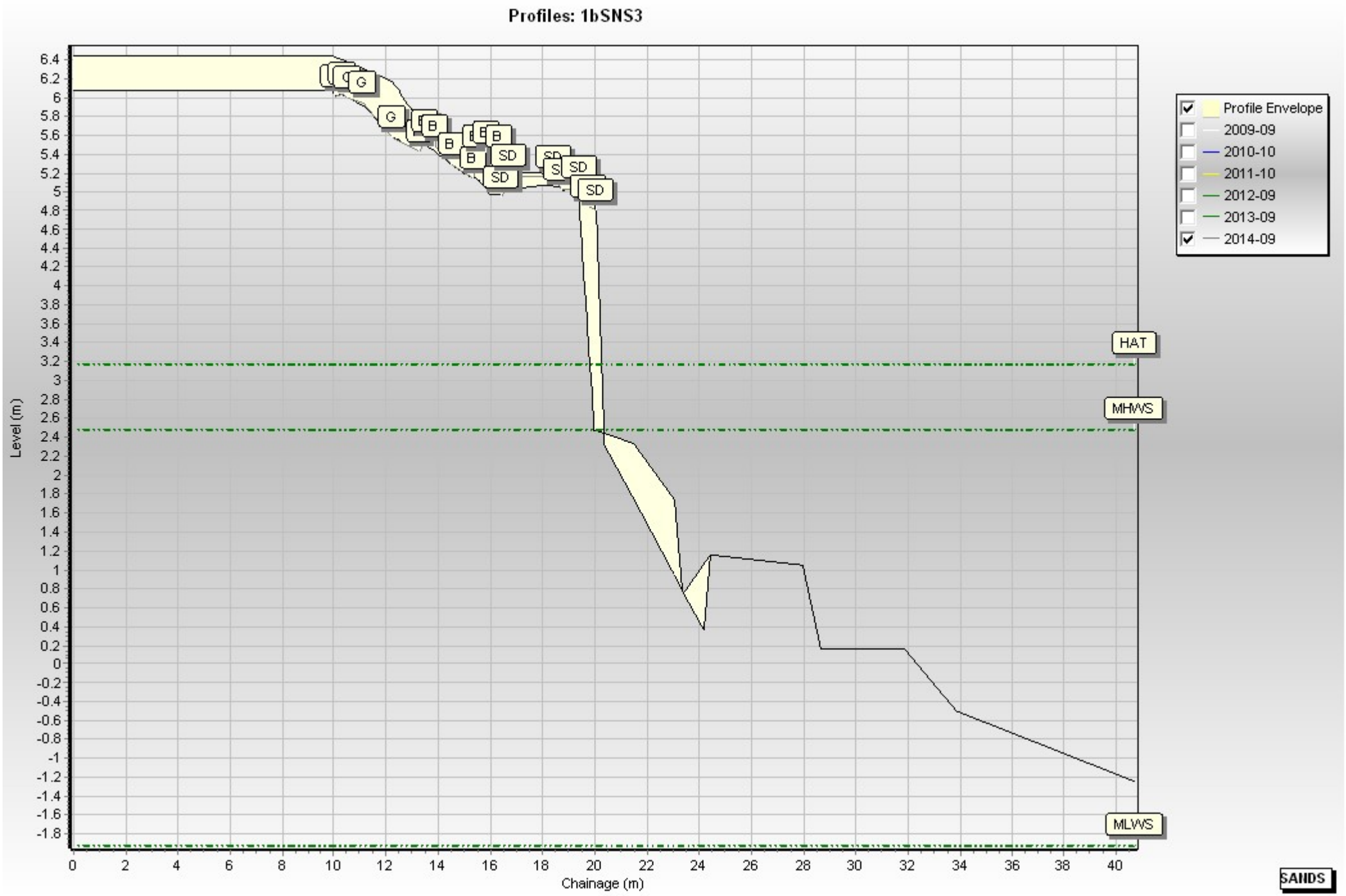
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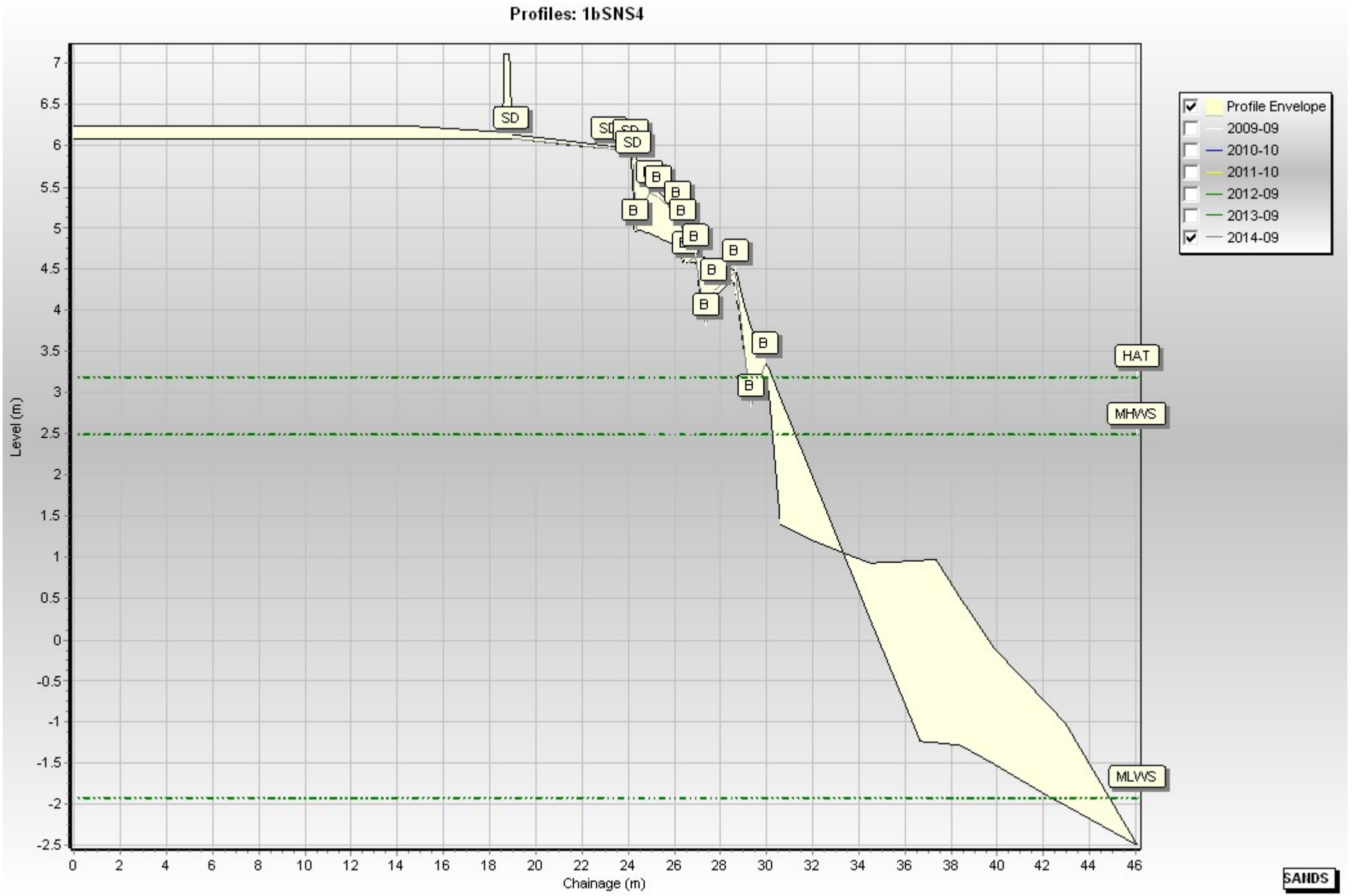
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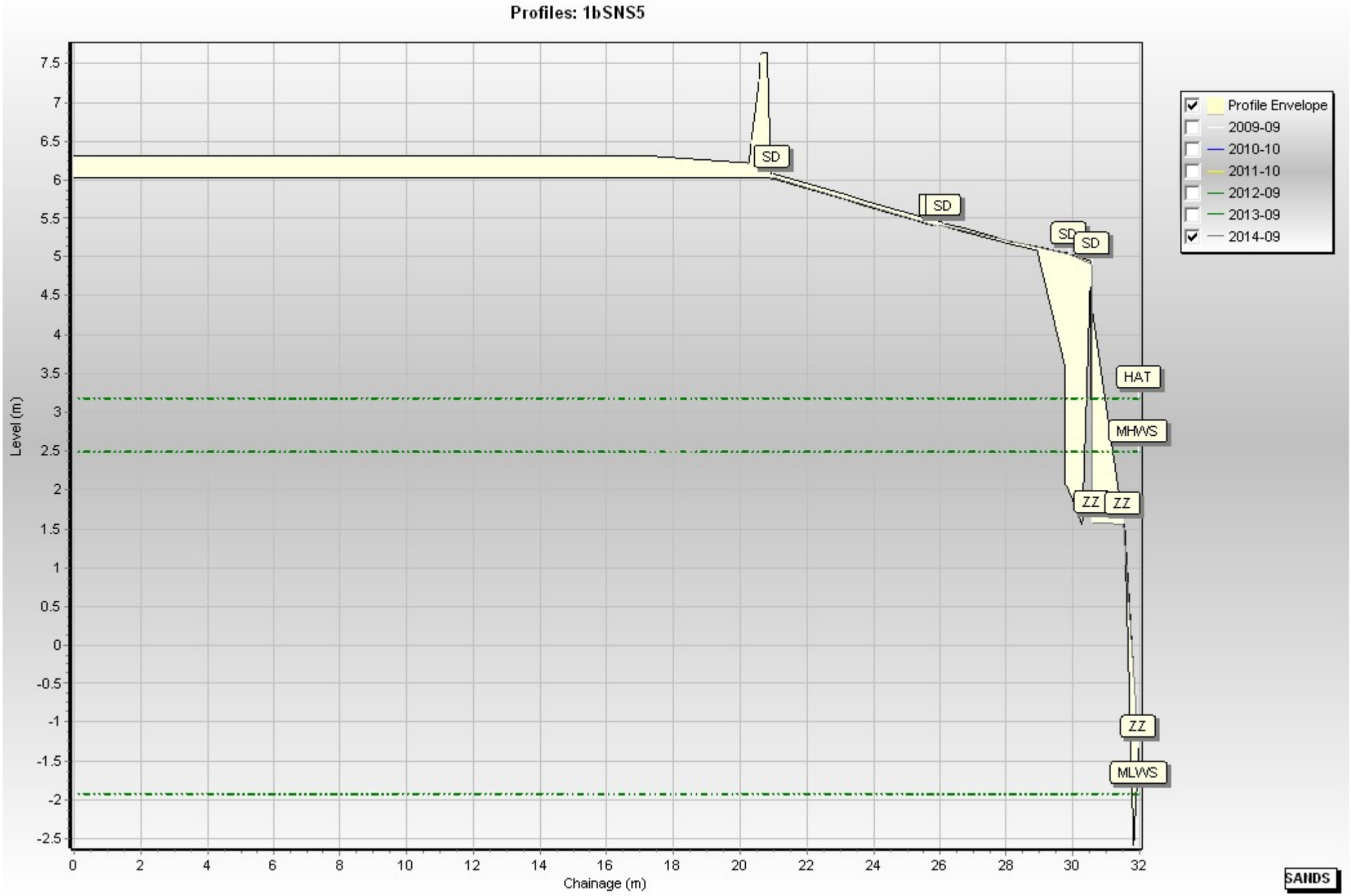
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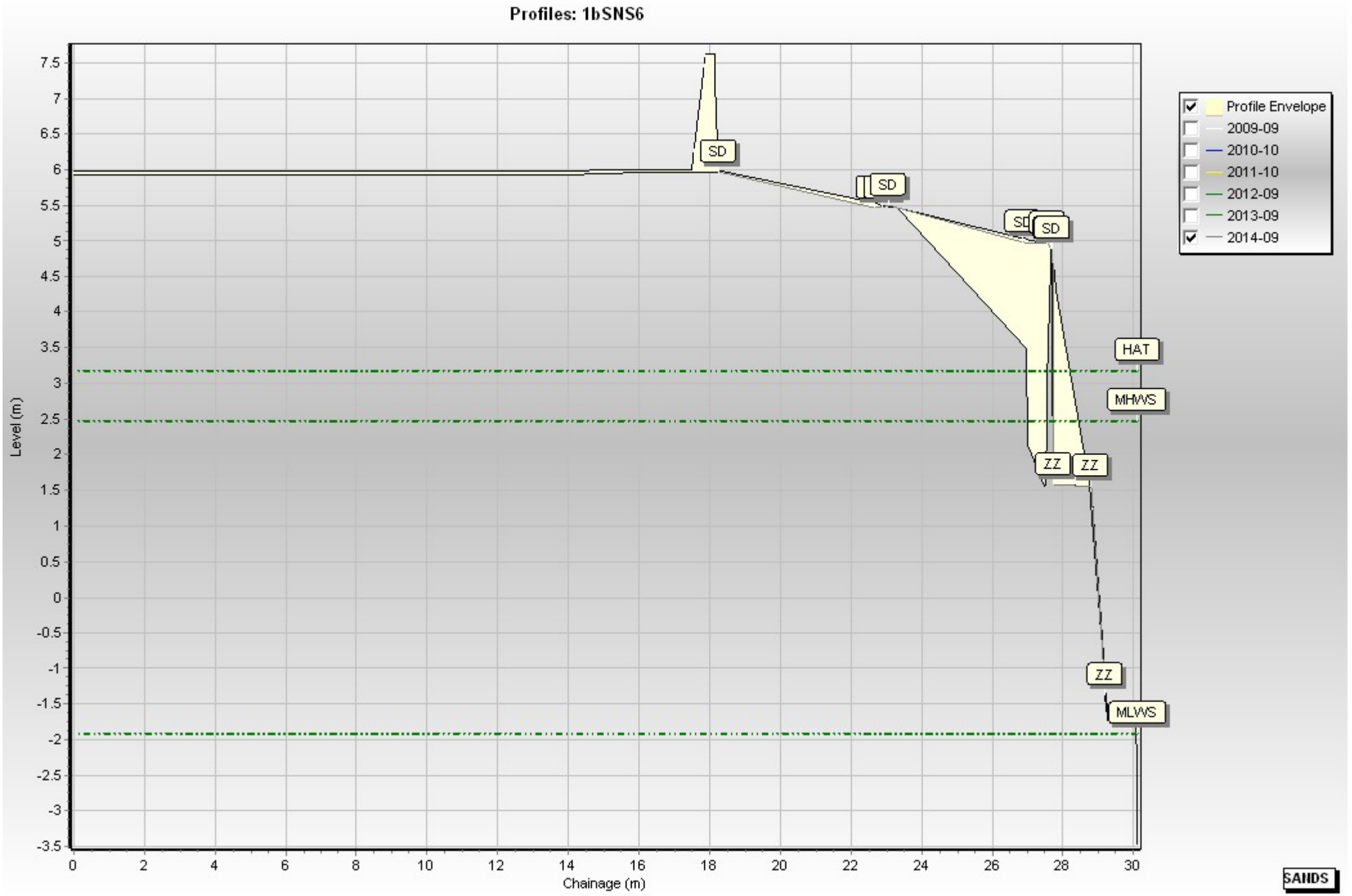
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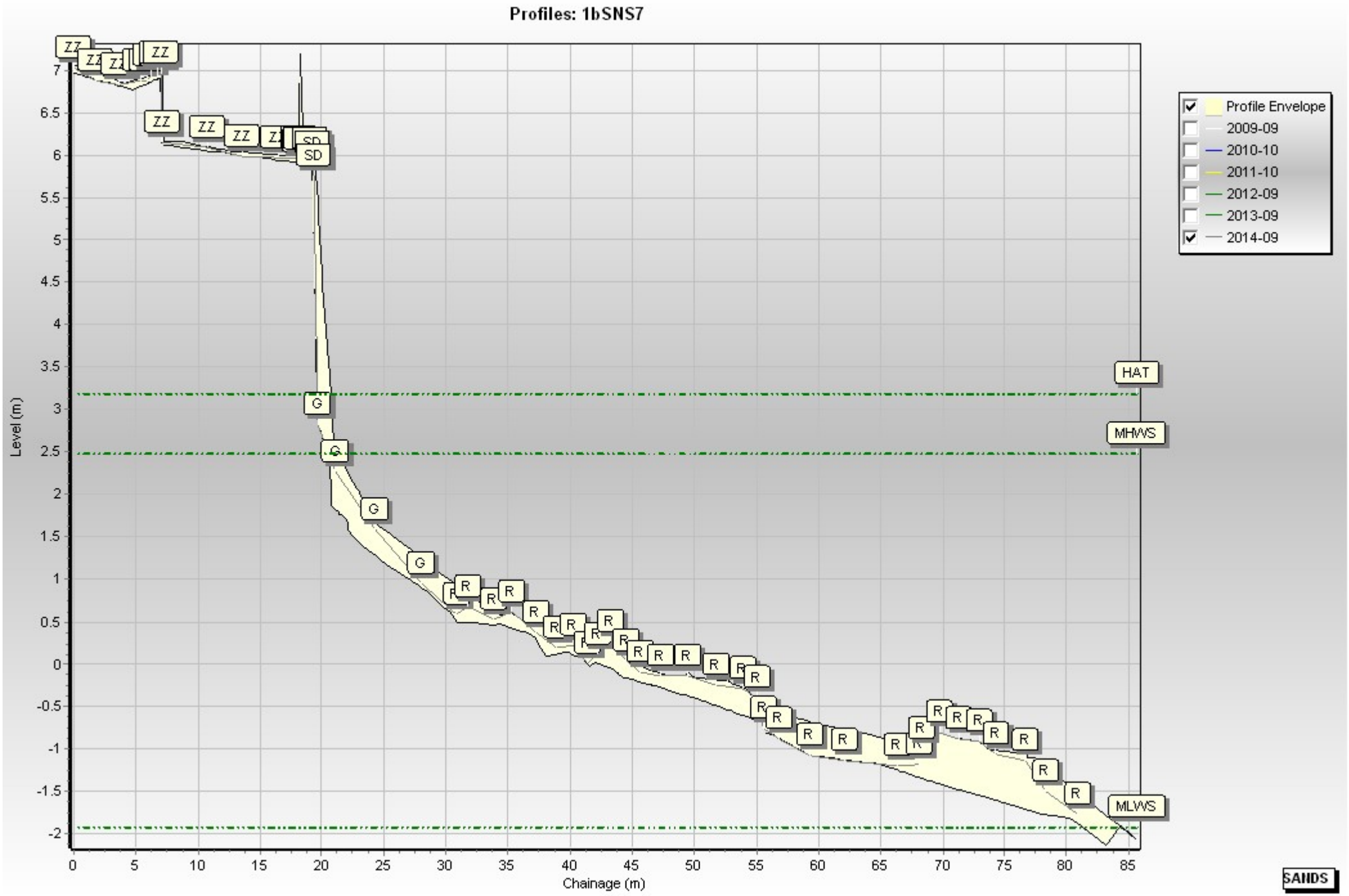
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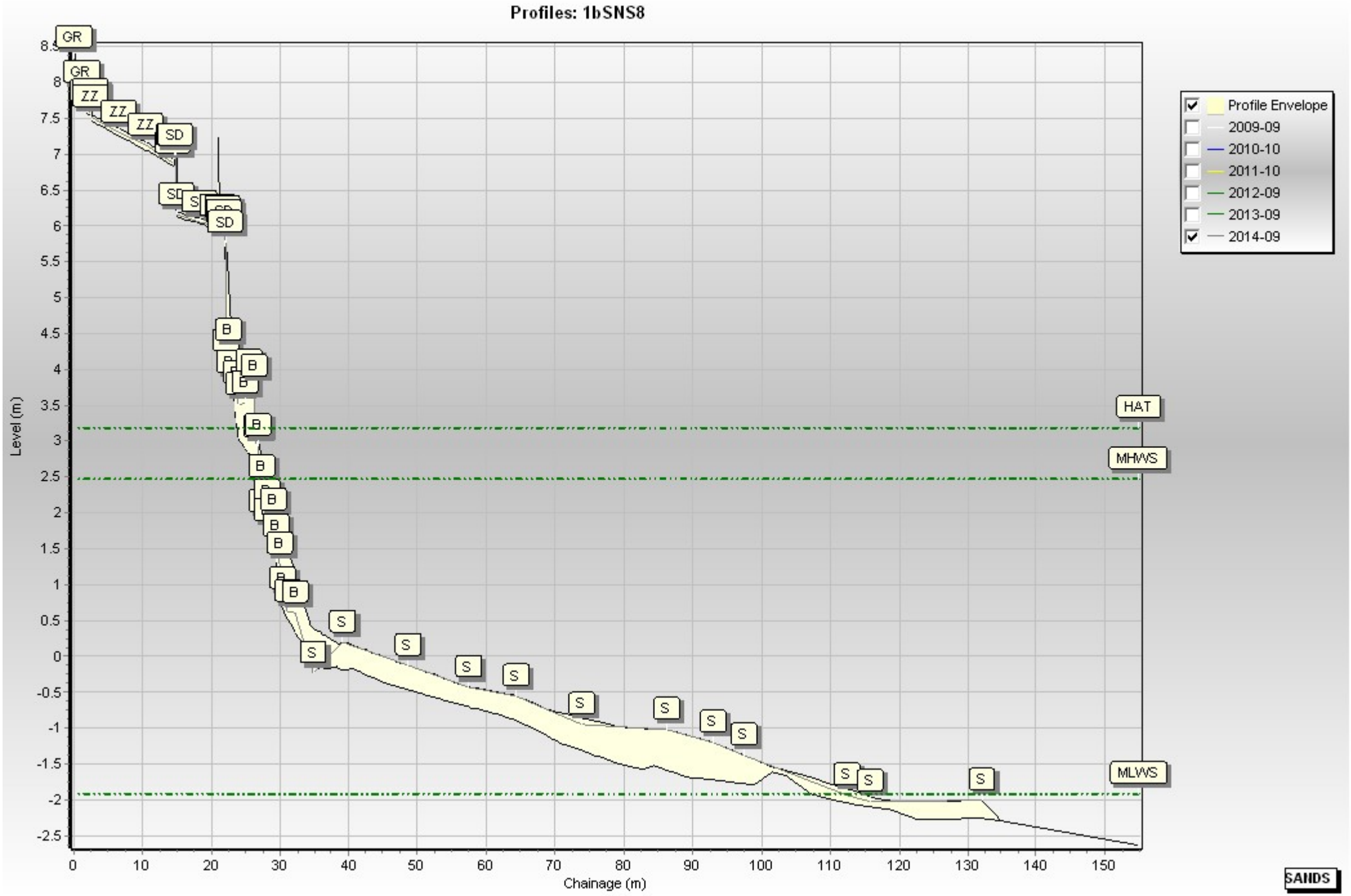
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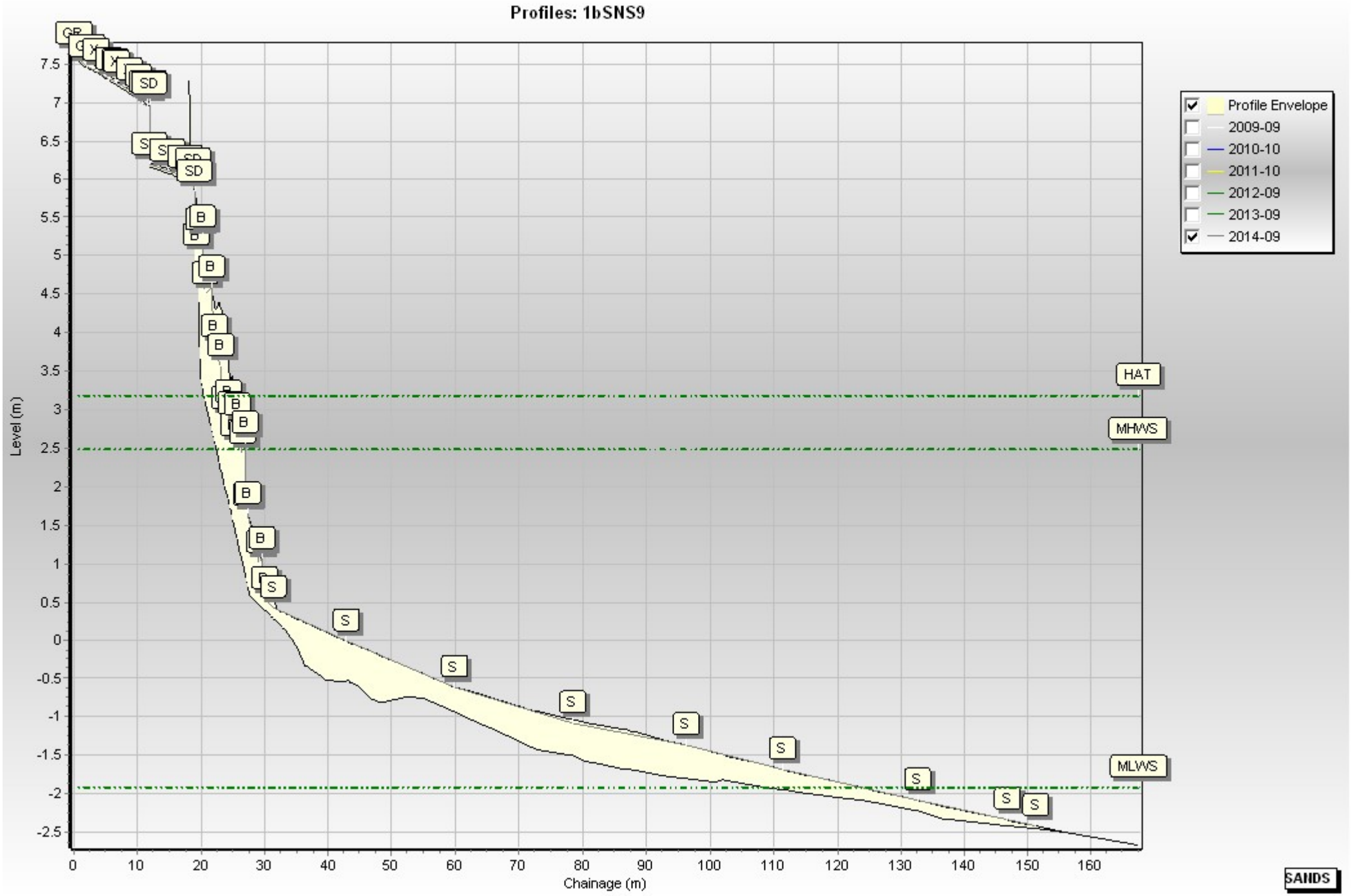
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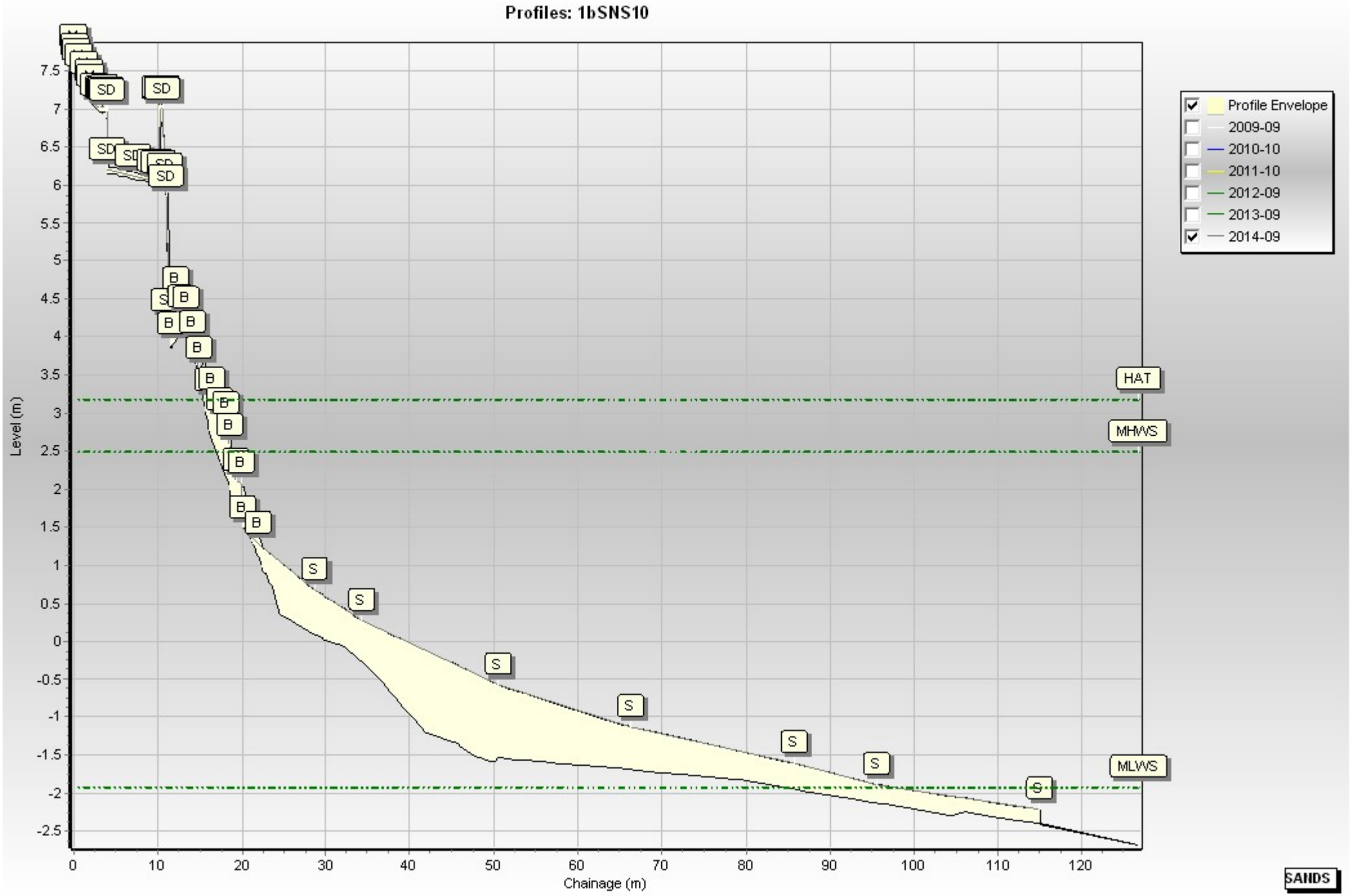
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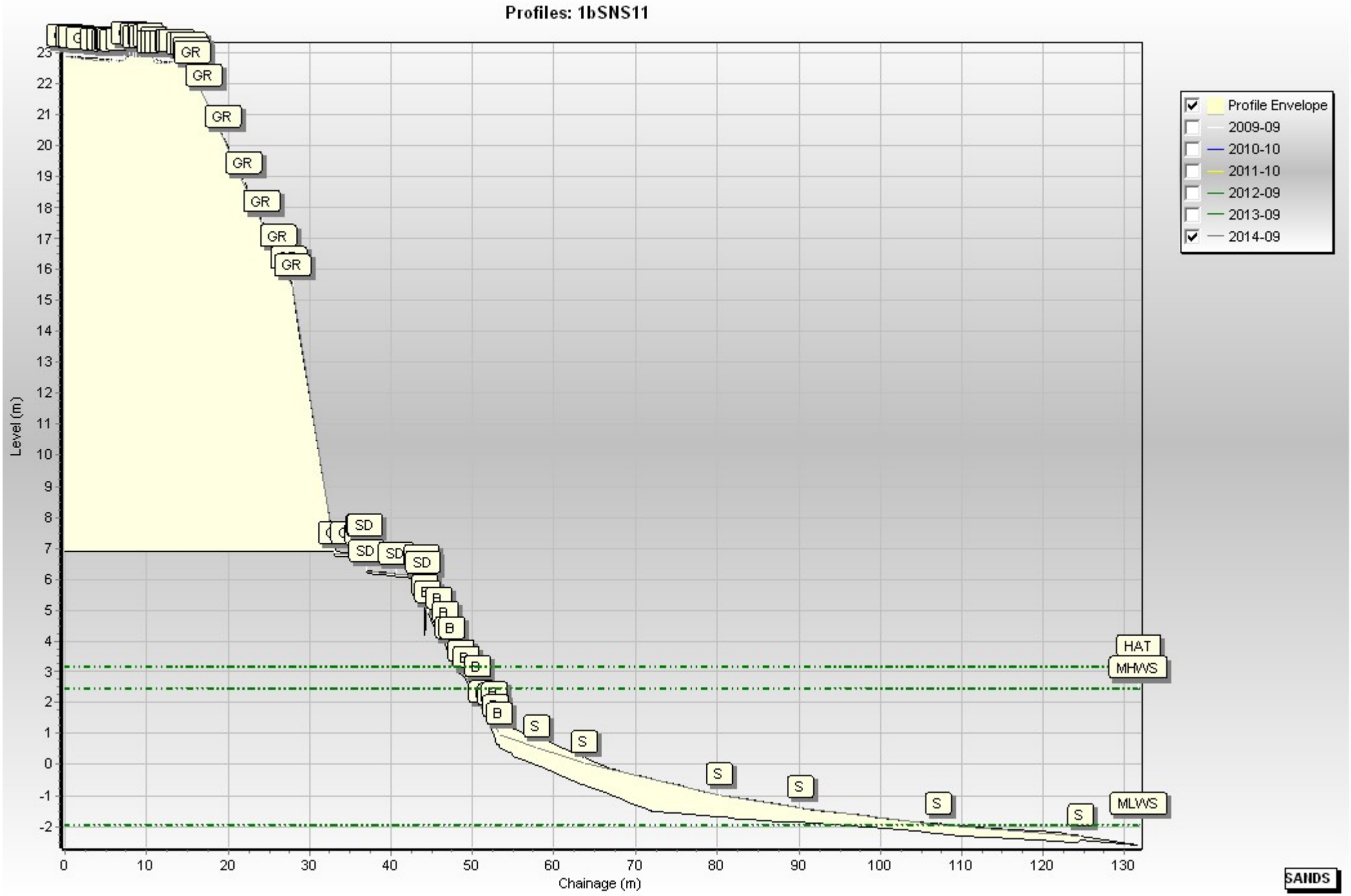
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Chainage (m)
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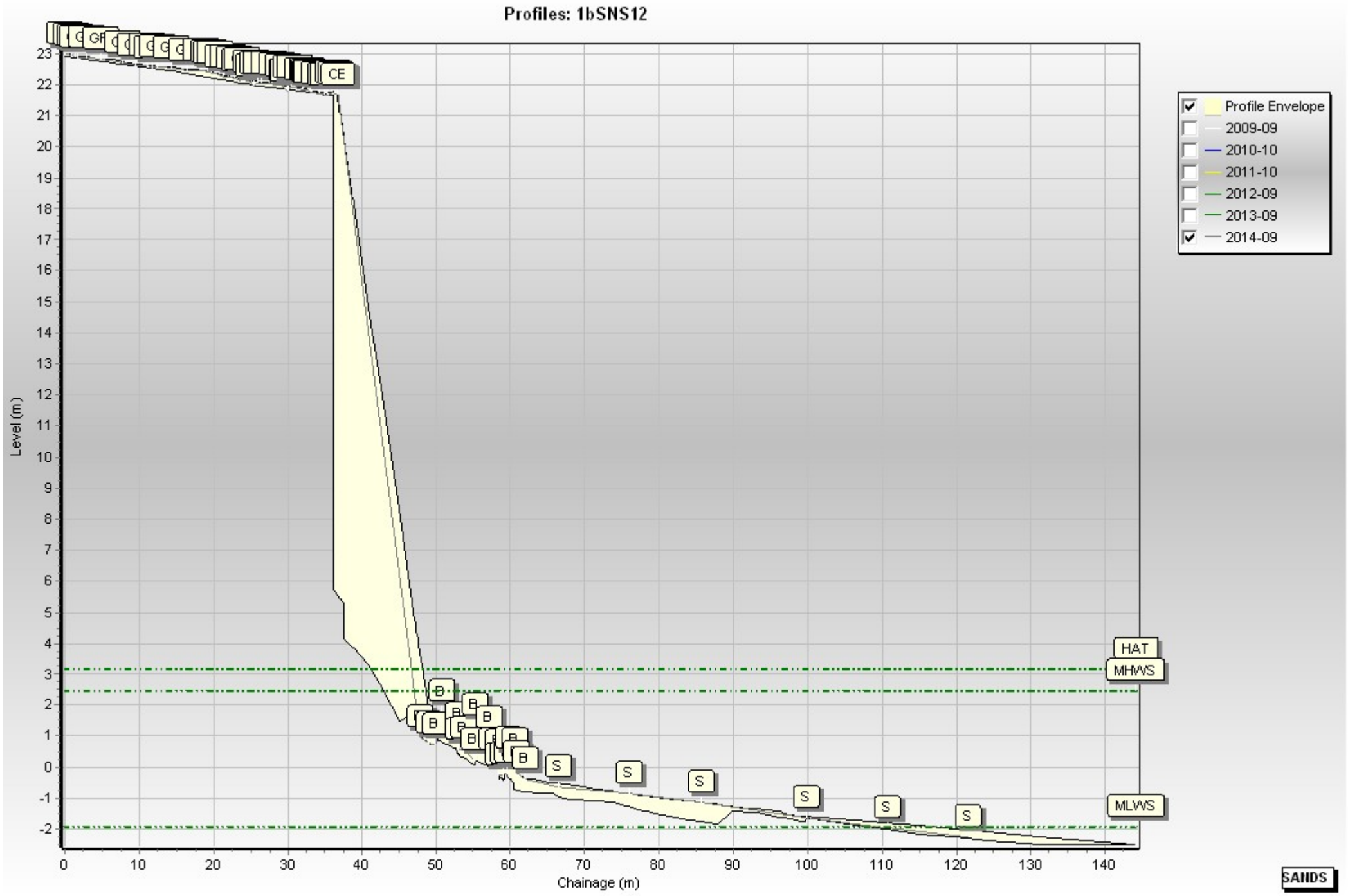
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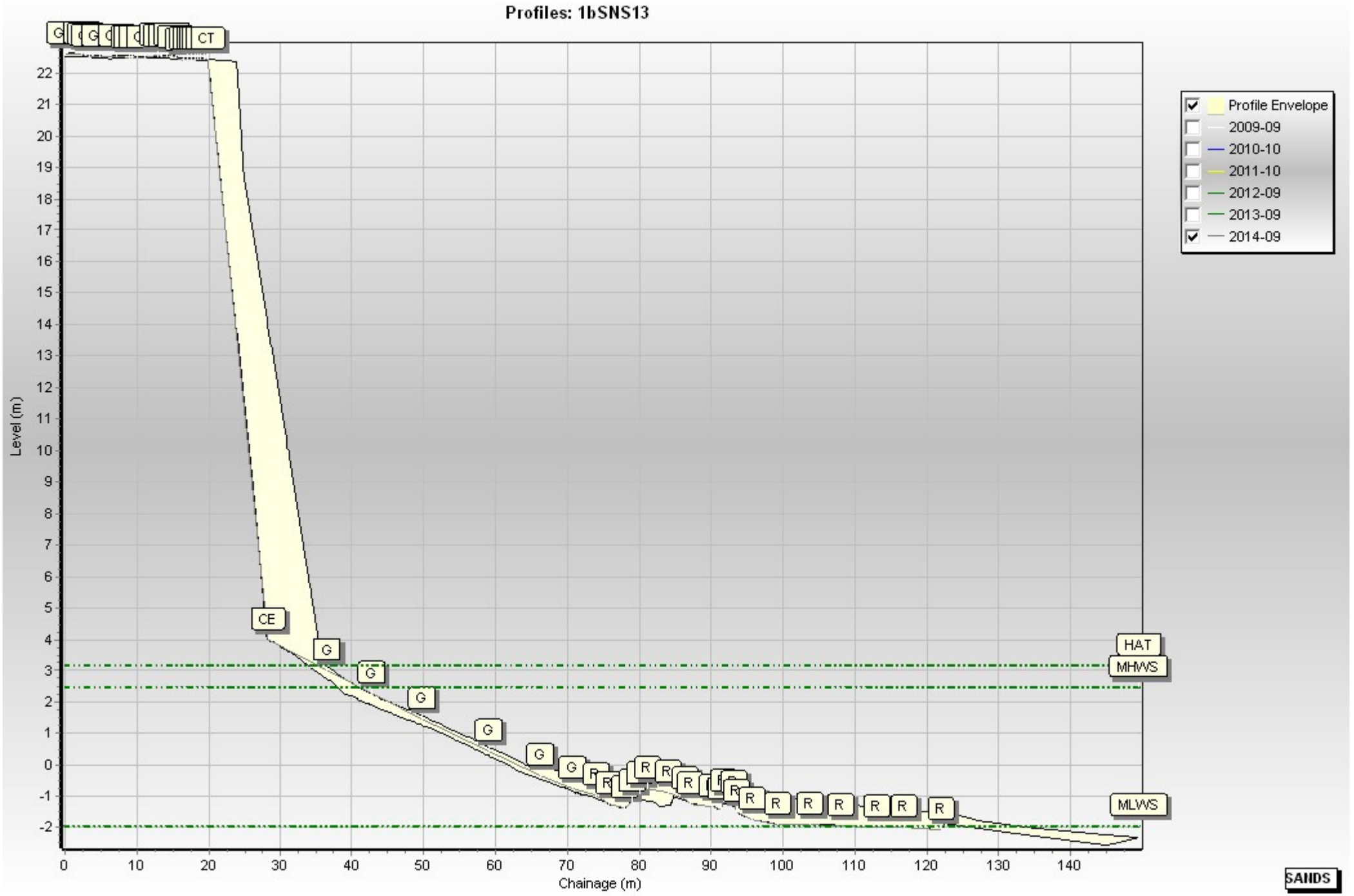
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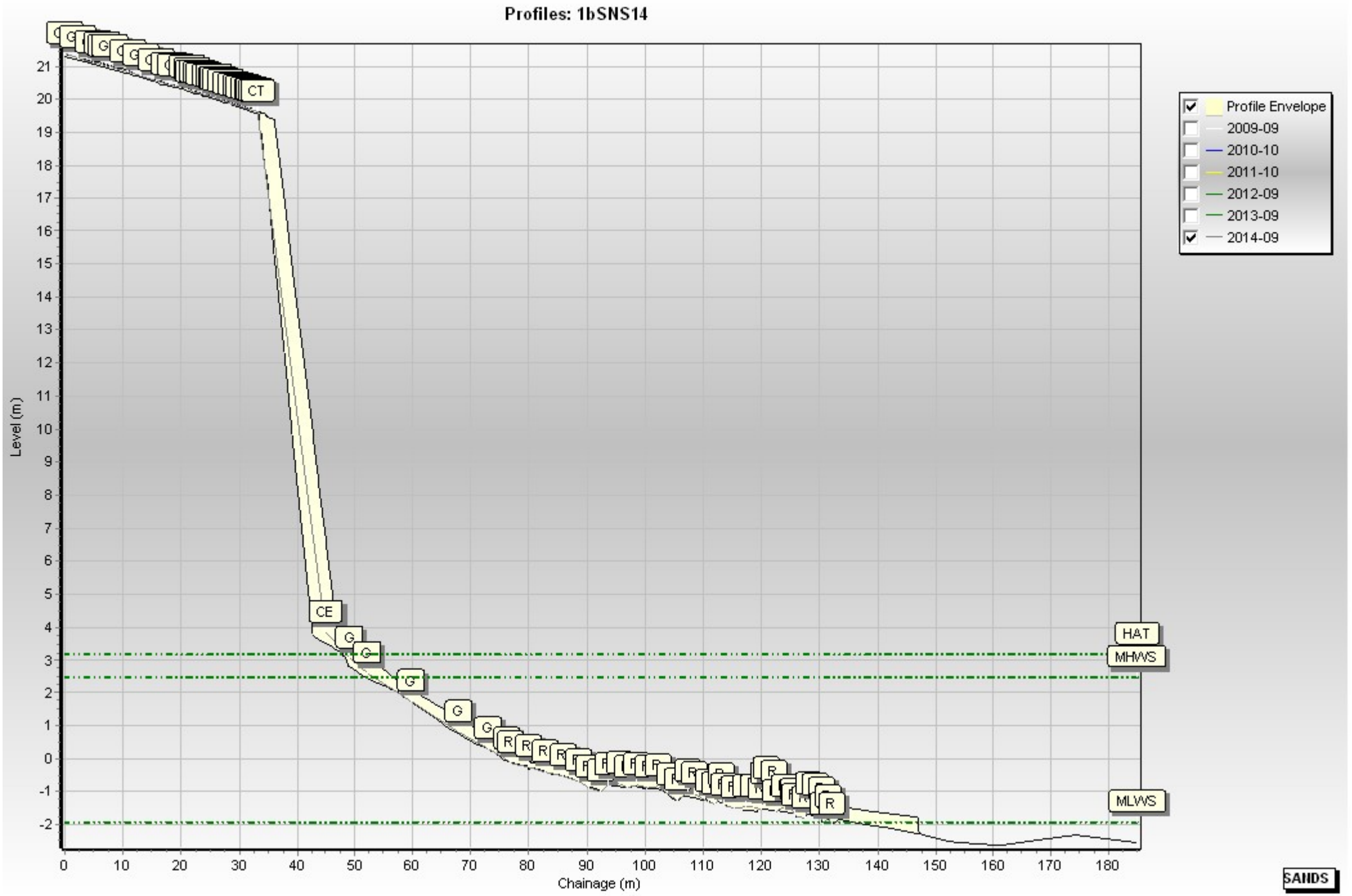
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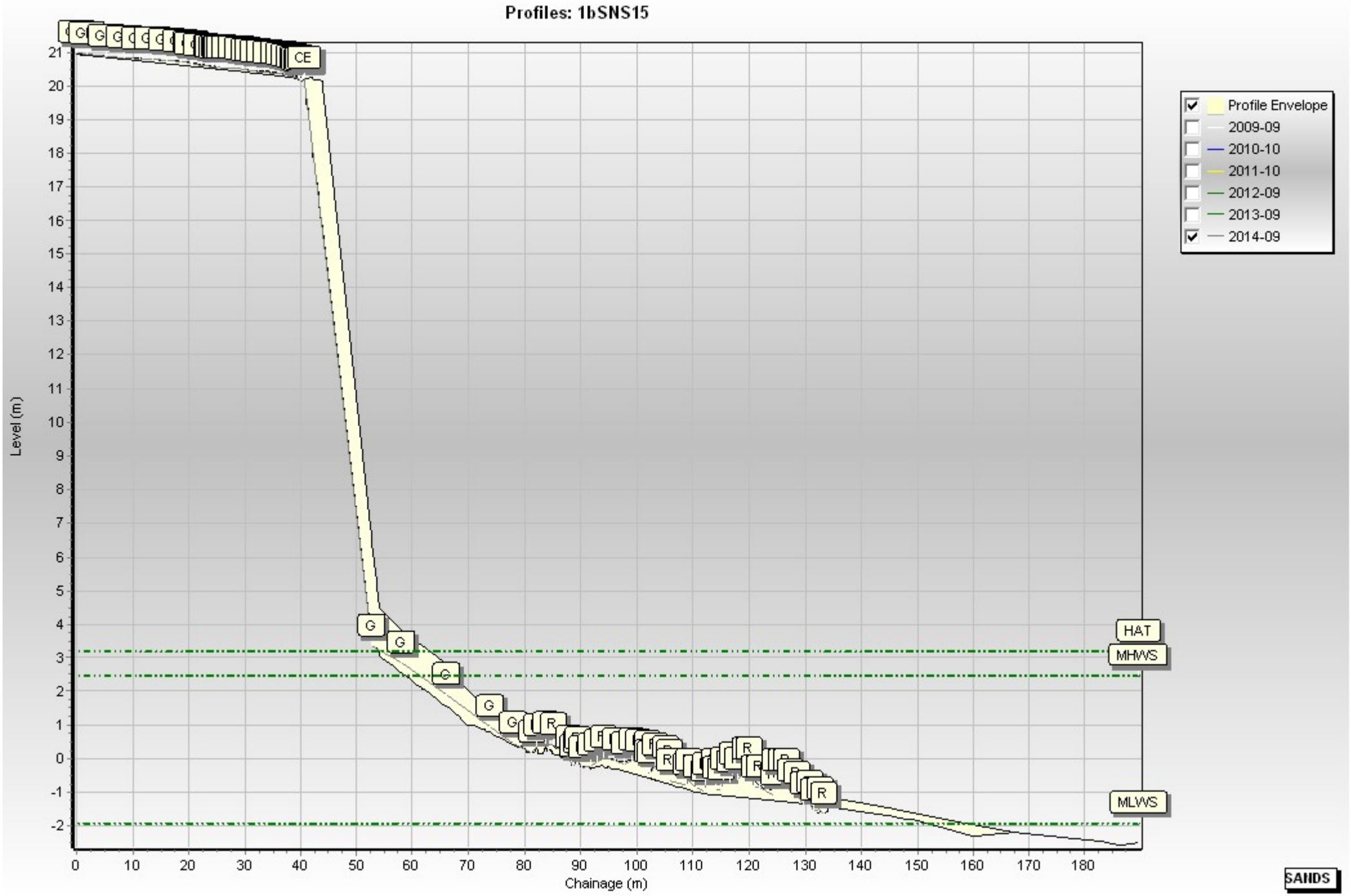
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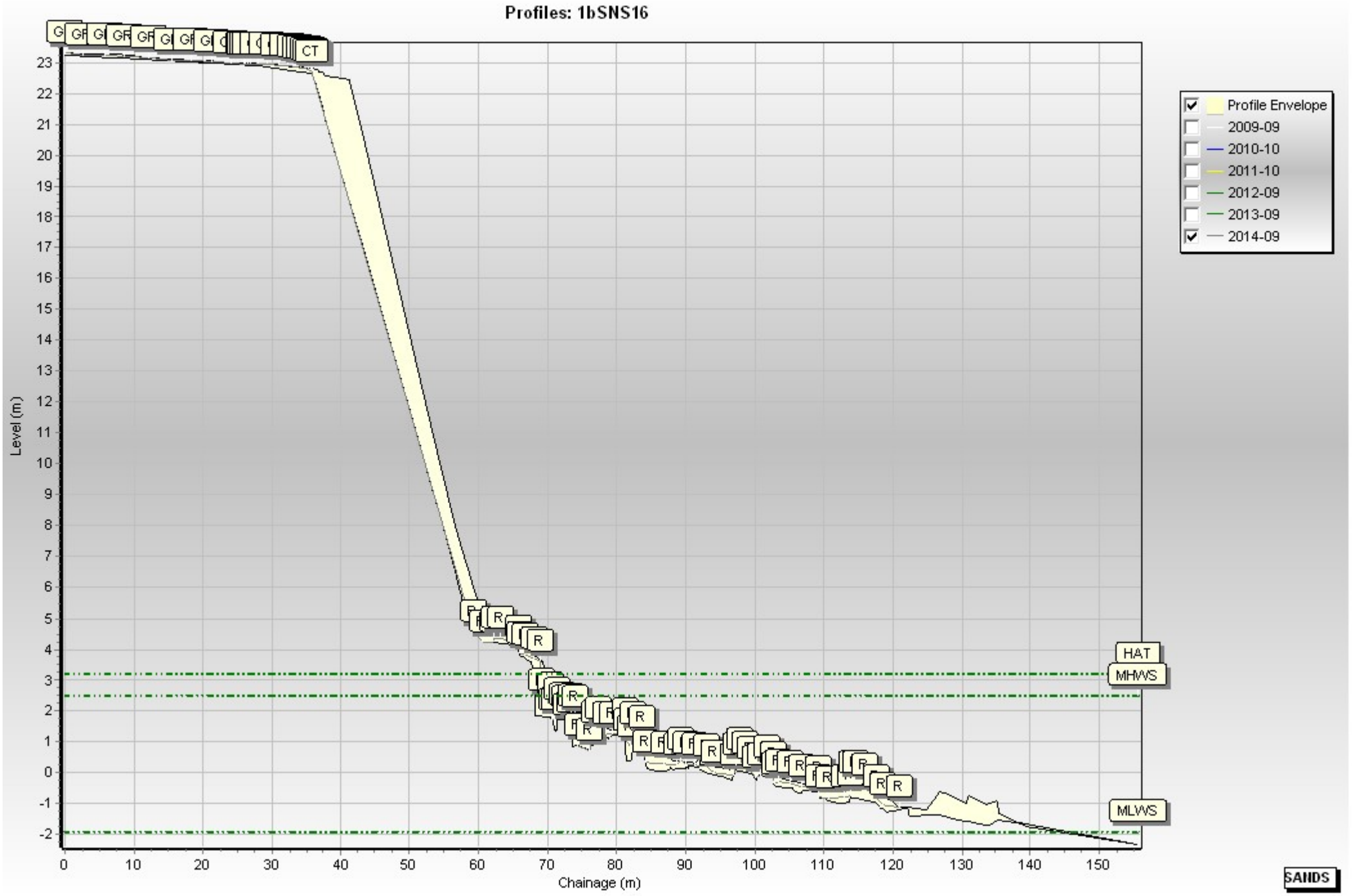
Chainage (m)
SANDS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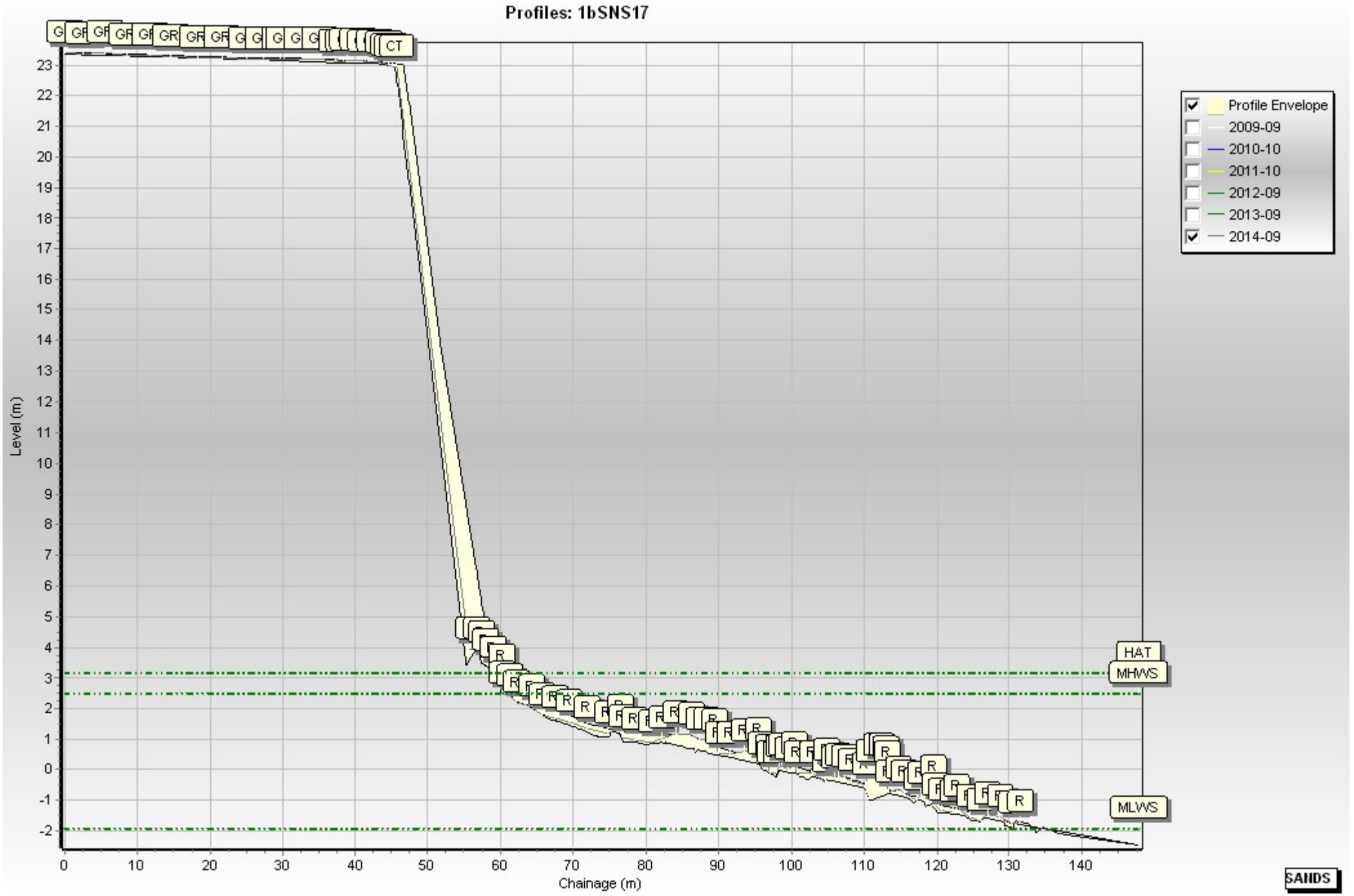
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Chainage (m)
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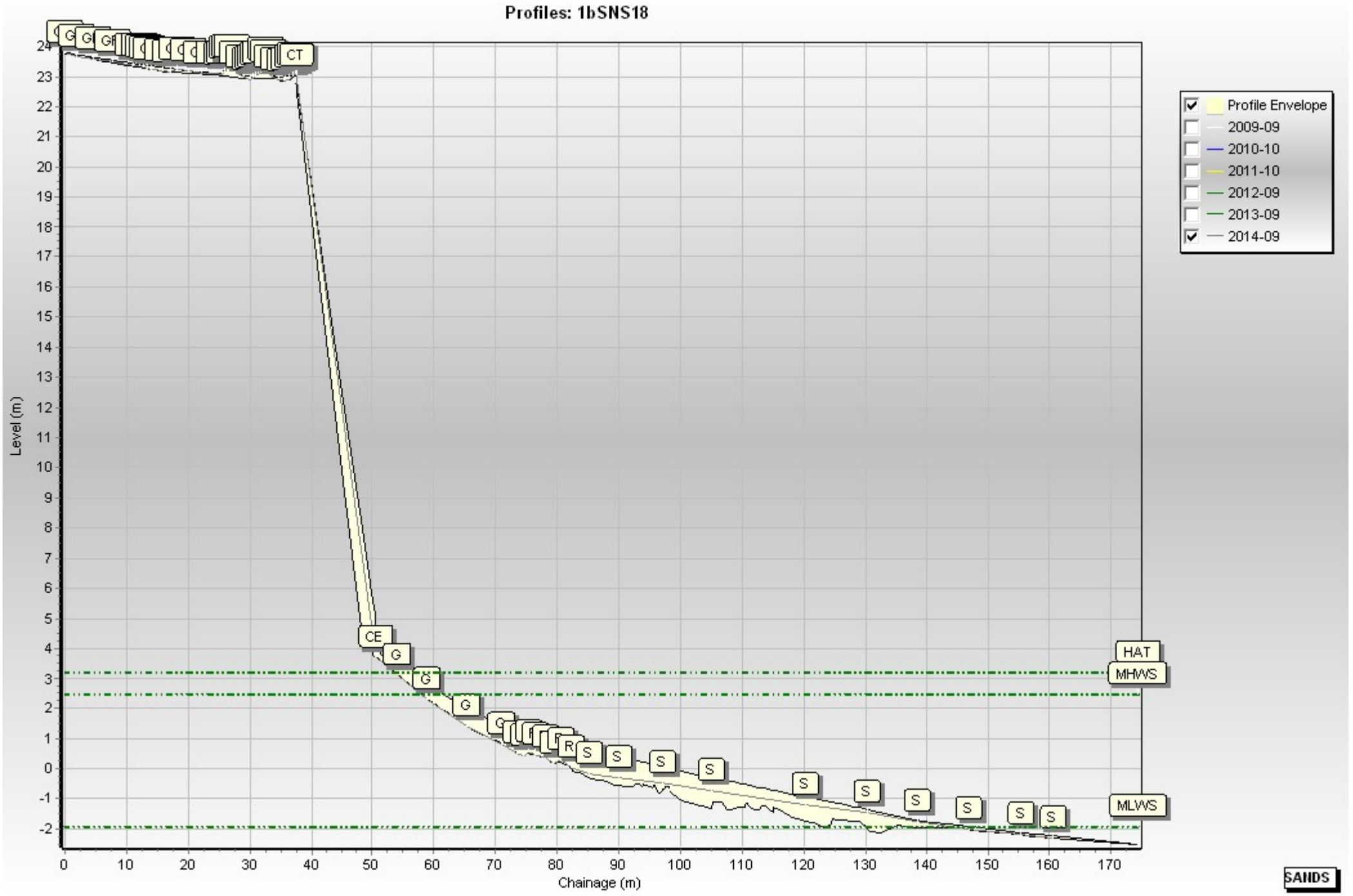
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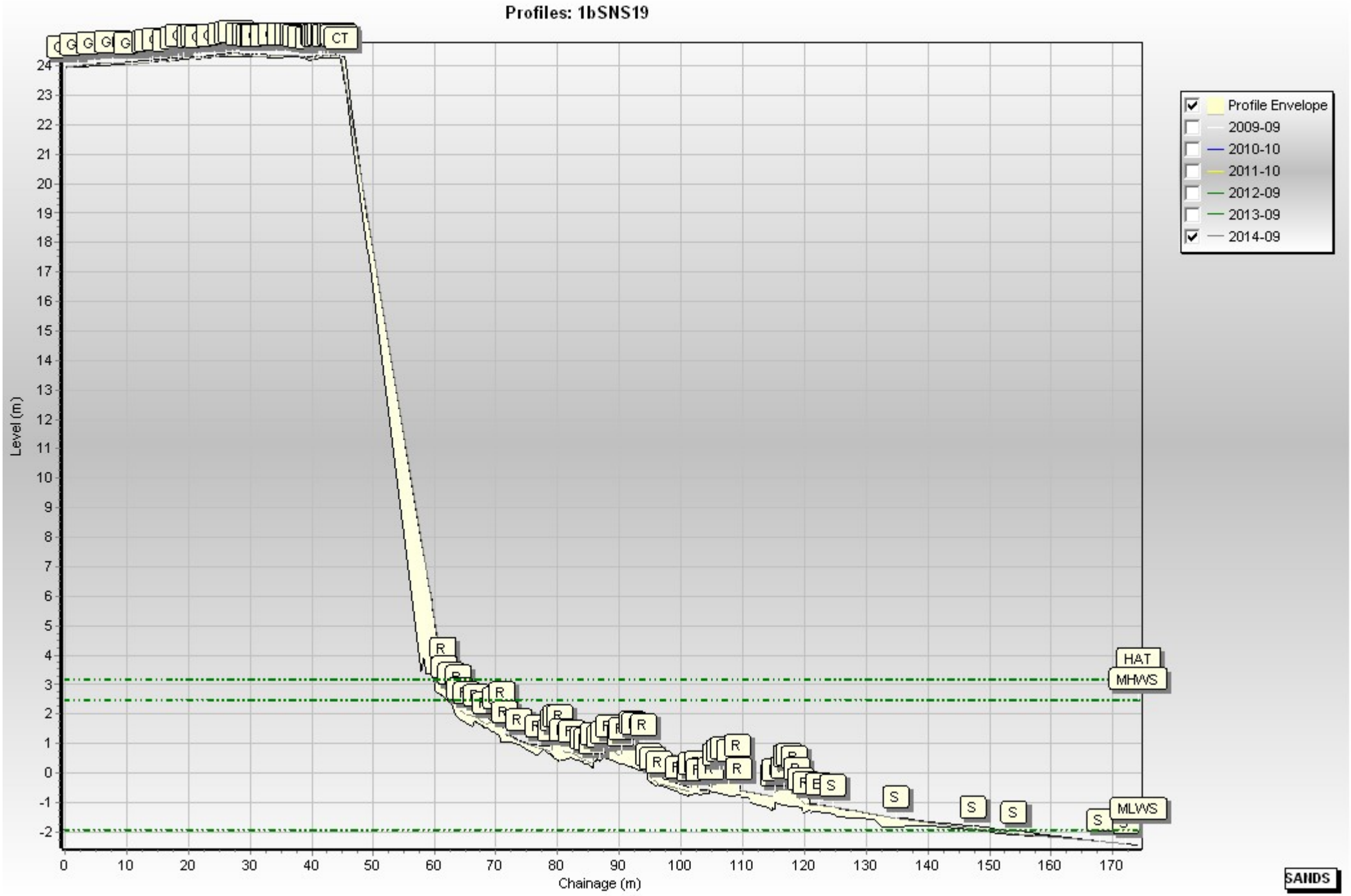
Chainage (m)
SANDS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Chainage (m)
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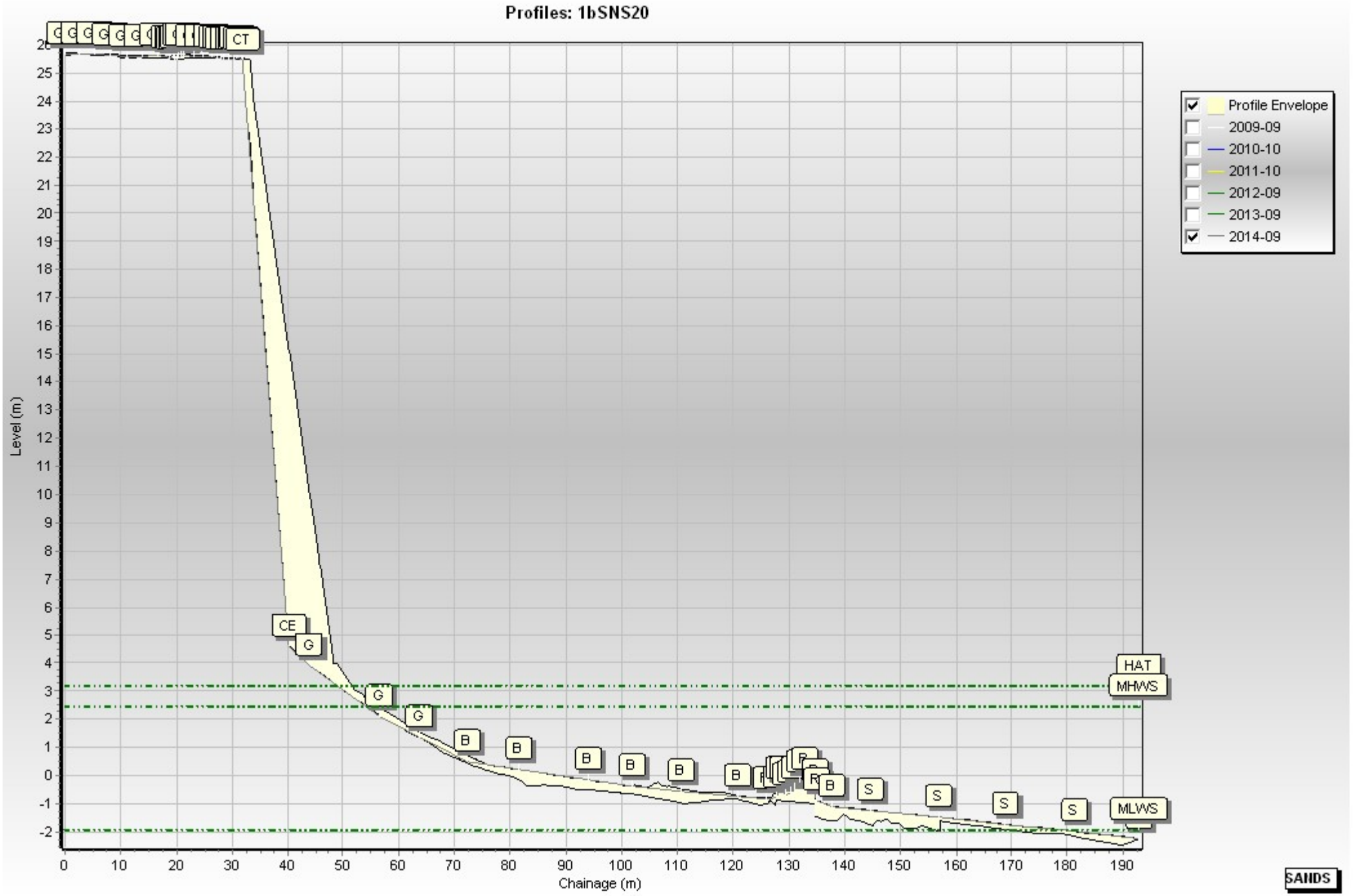
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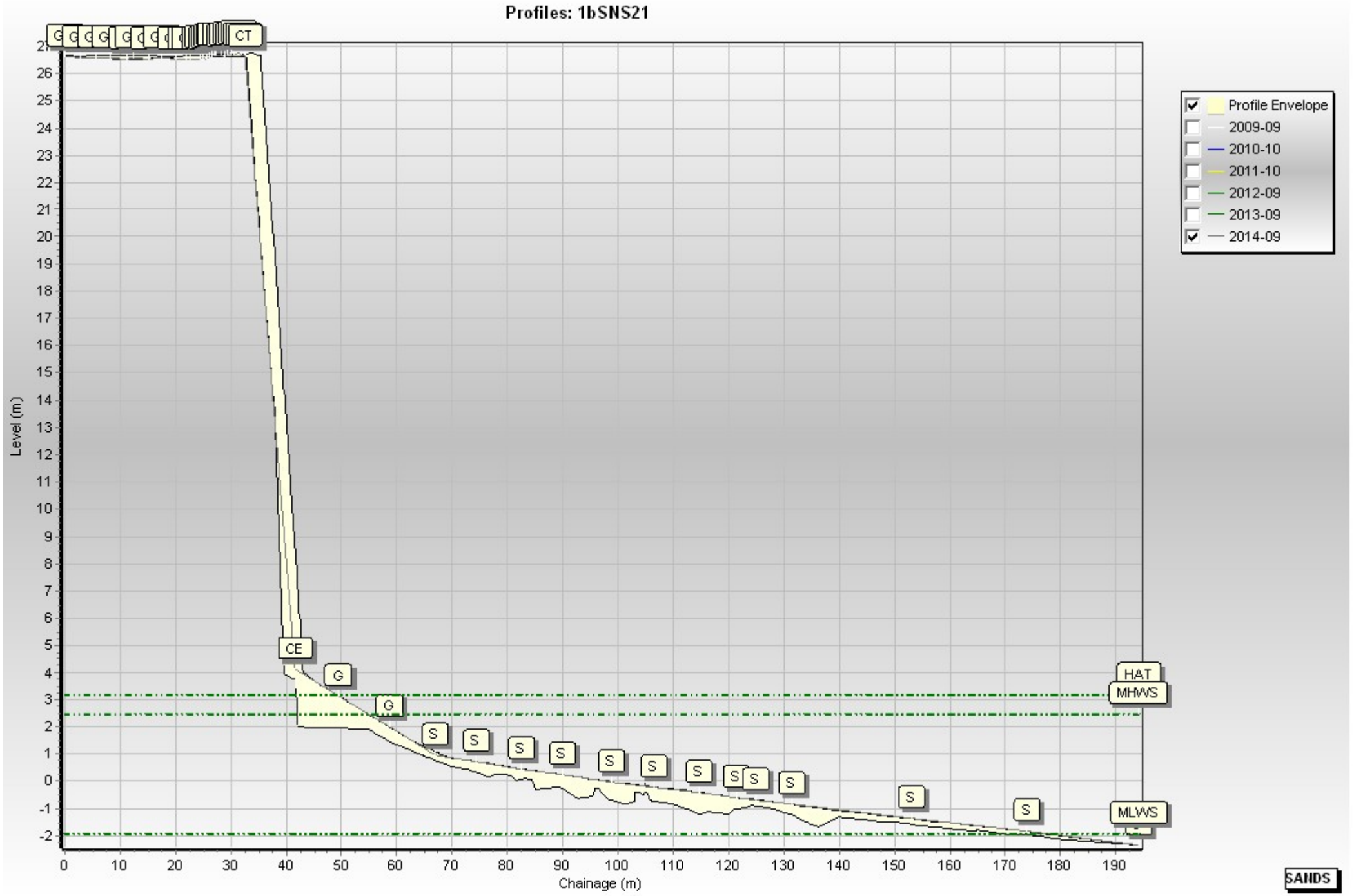
S
S
S
HAT
MHWS
MLWS
Level (m)
Chainage (m)
SANDS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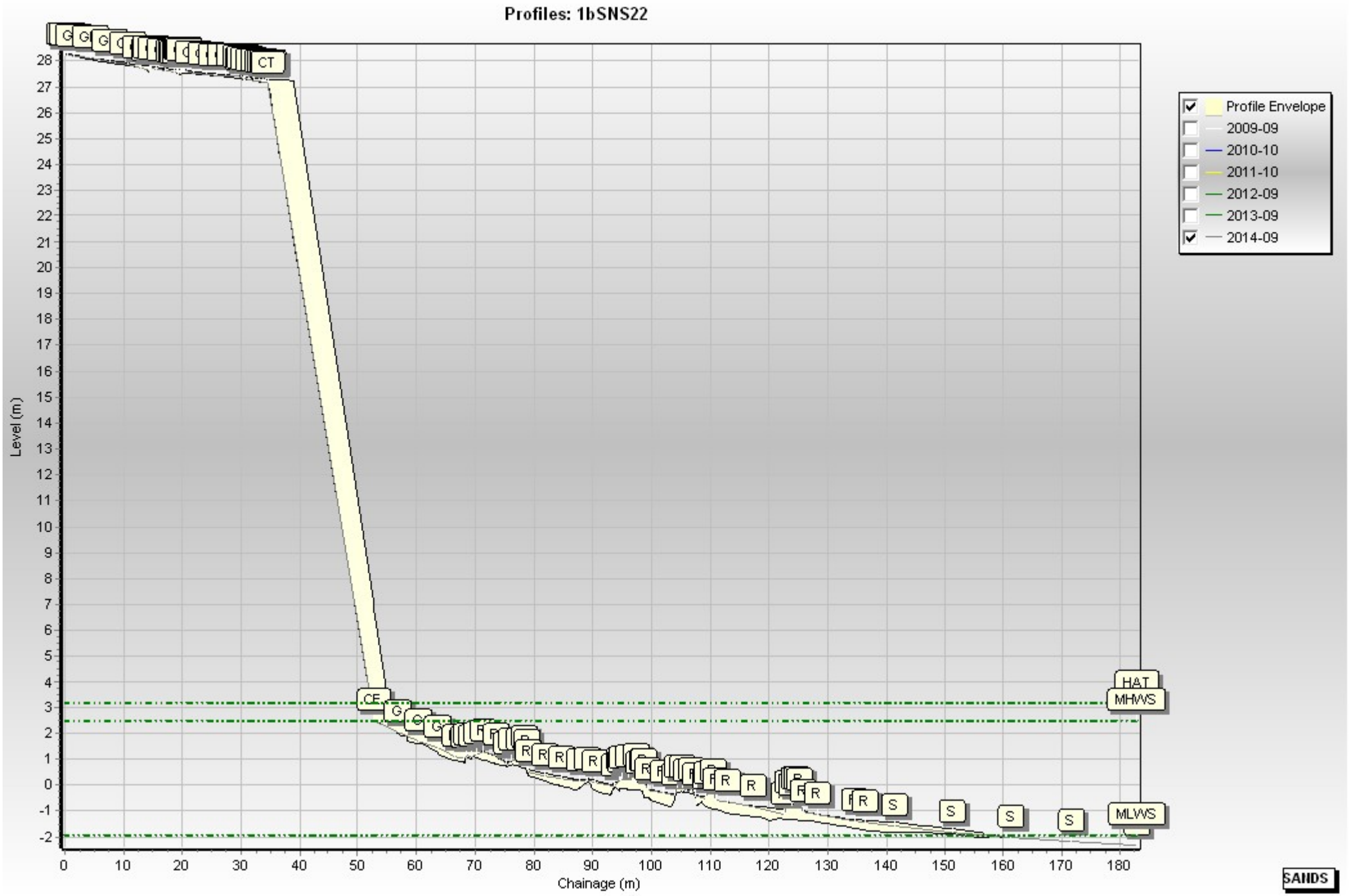
Chainage (m)
SANDS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Chainage (m)
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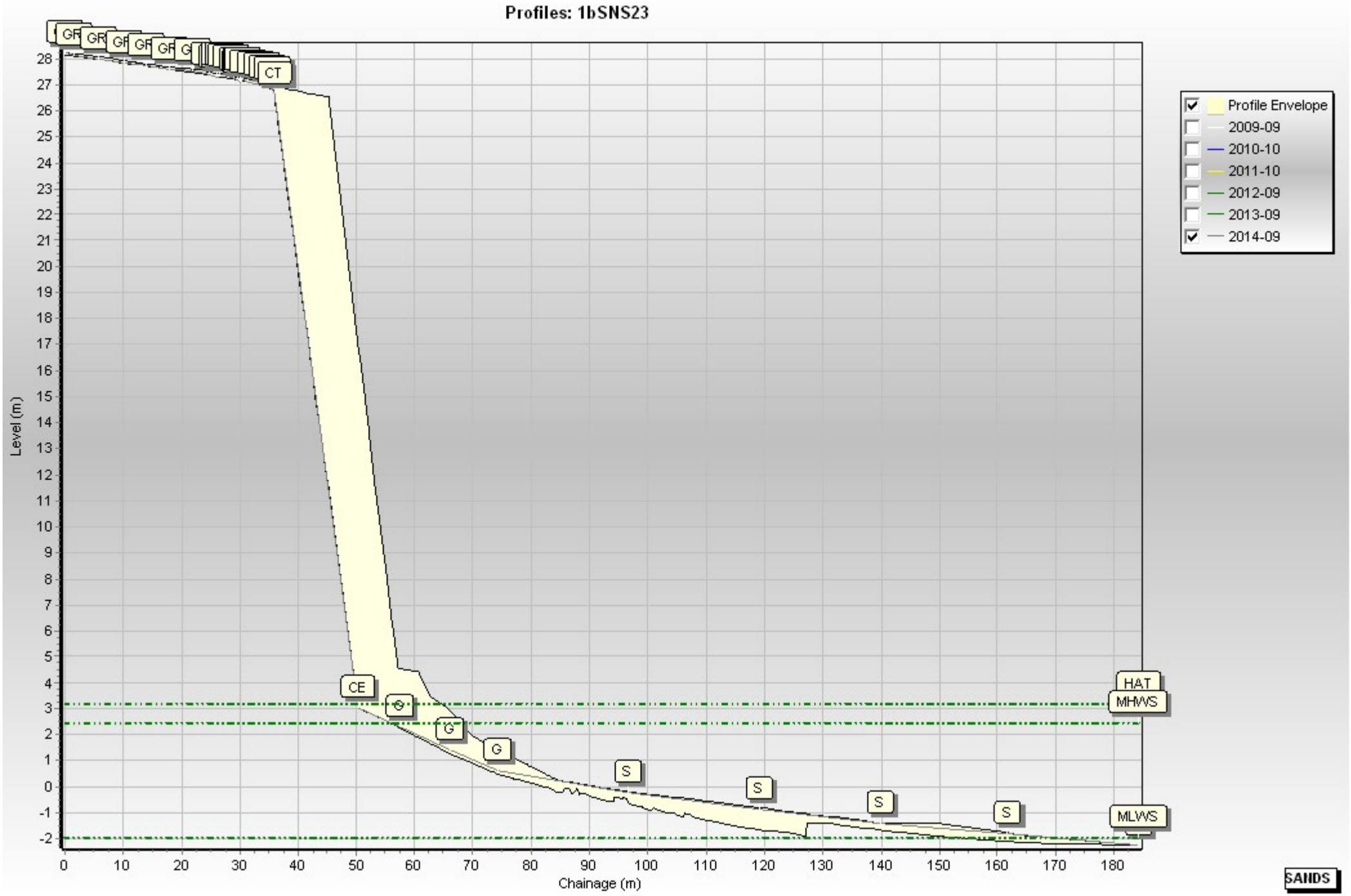
MLWS
SANDS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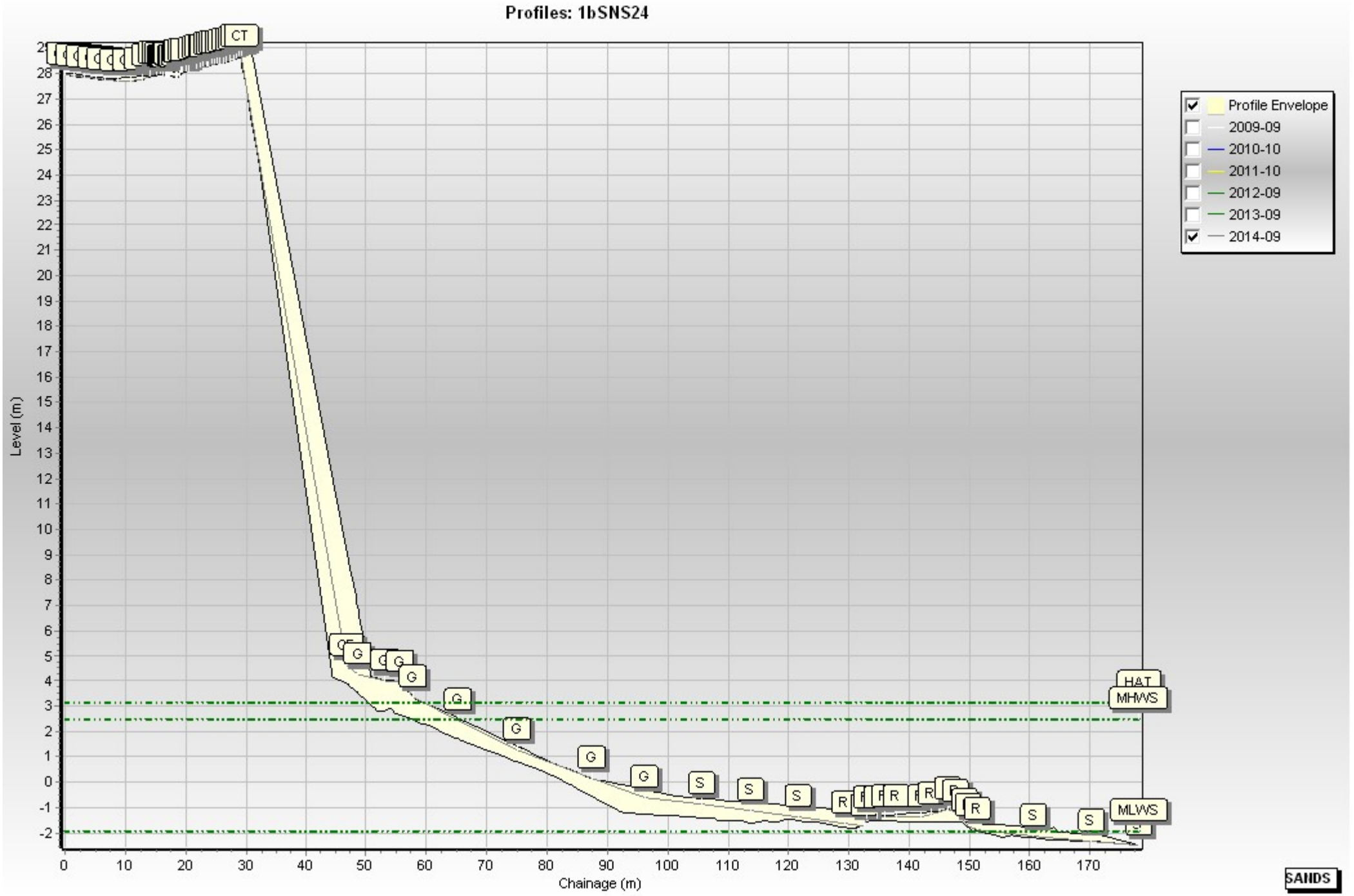
Chainage (m)
SANDS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Chainage (m)
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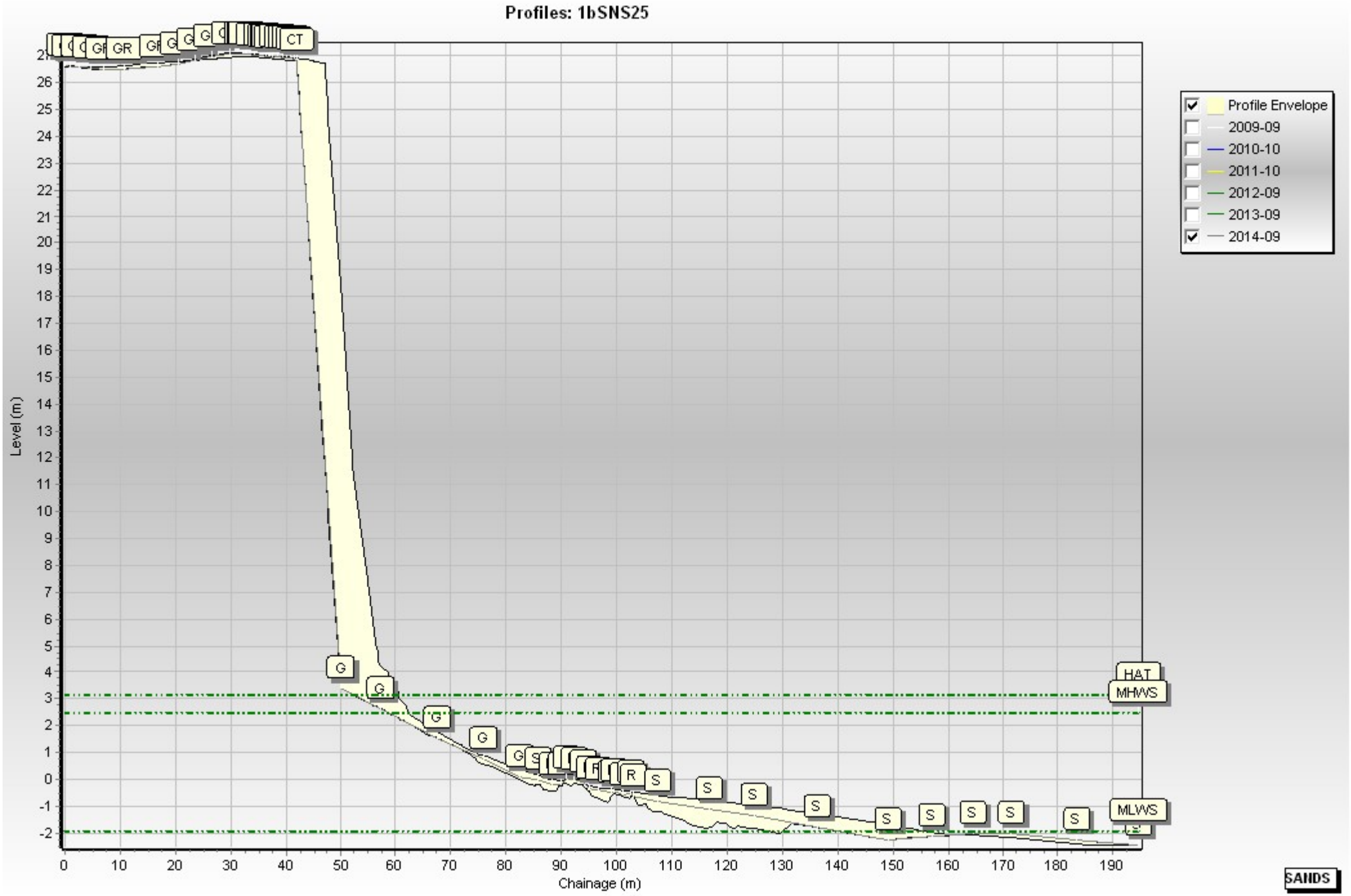
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2013-09
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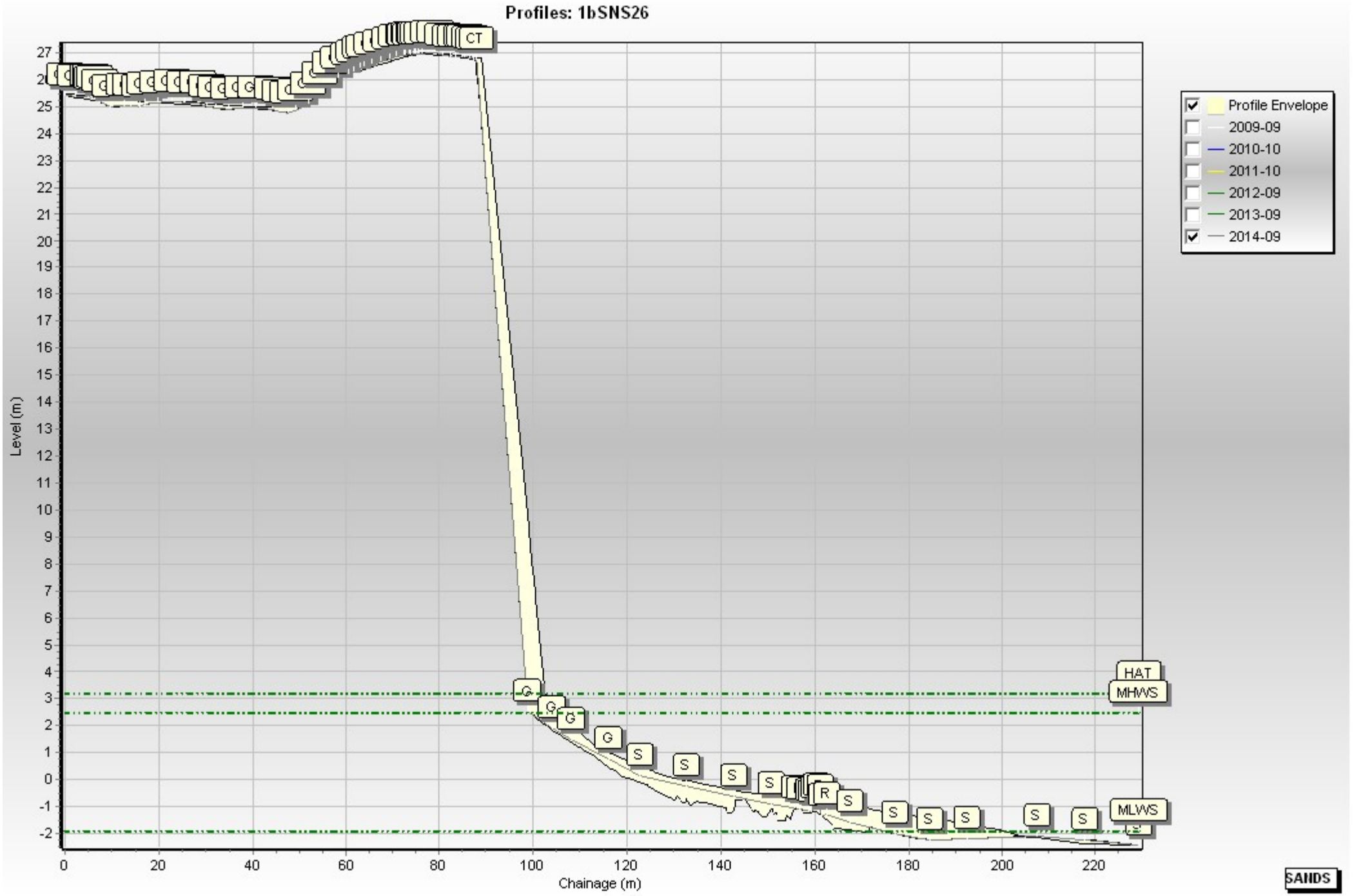
MHWS
MLWS
Level (m)
Chainage (m)
SANDS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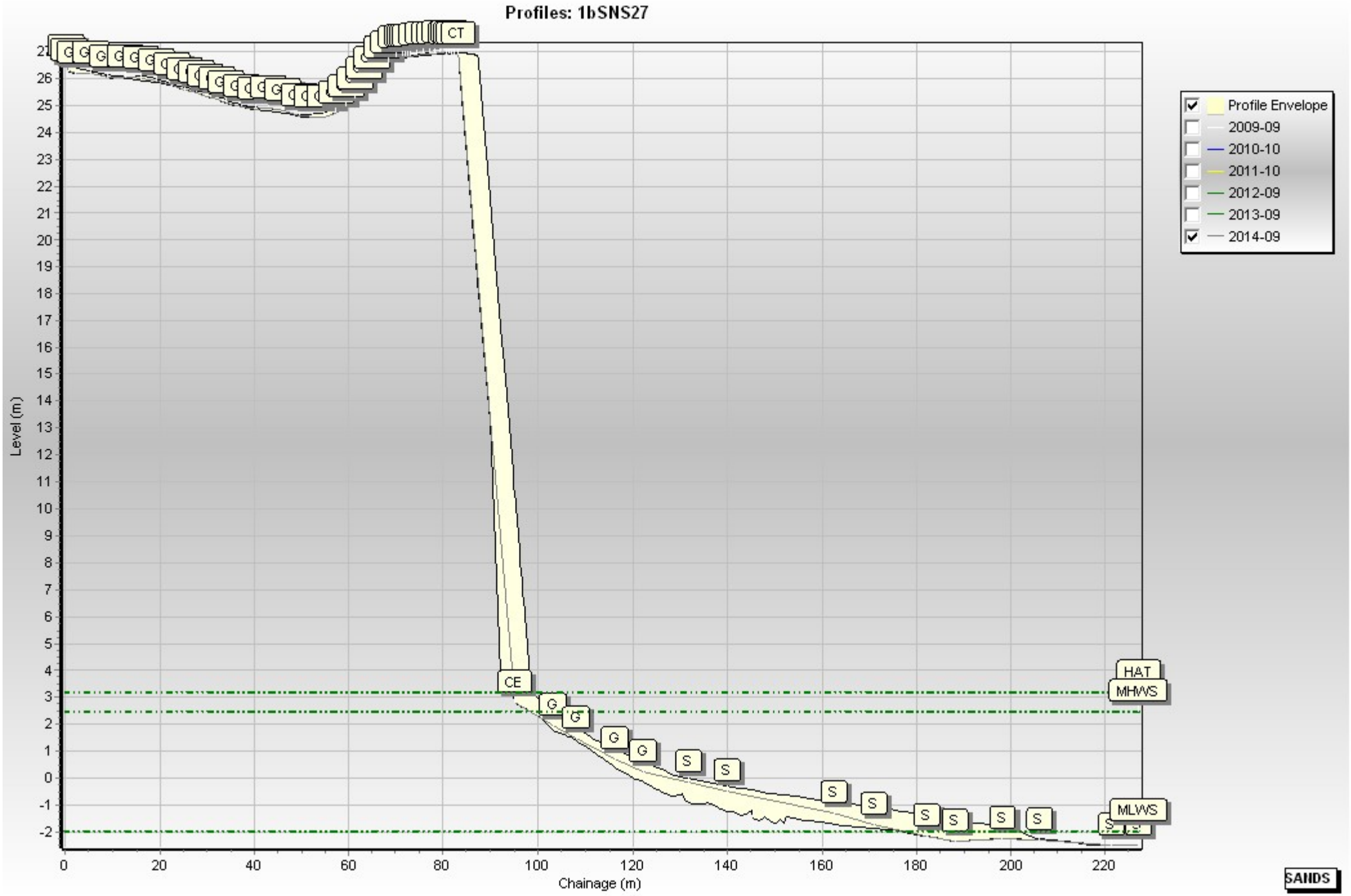
G
S
R
Level (m)
Chainage (m)
SANDS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CT
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MLWS
Level (m)
Chainage (m)
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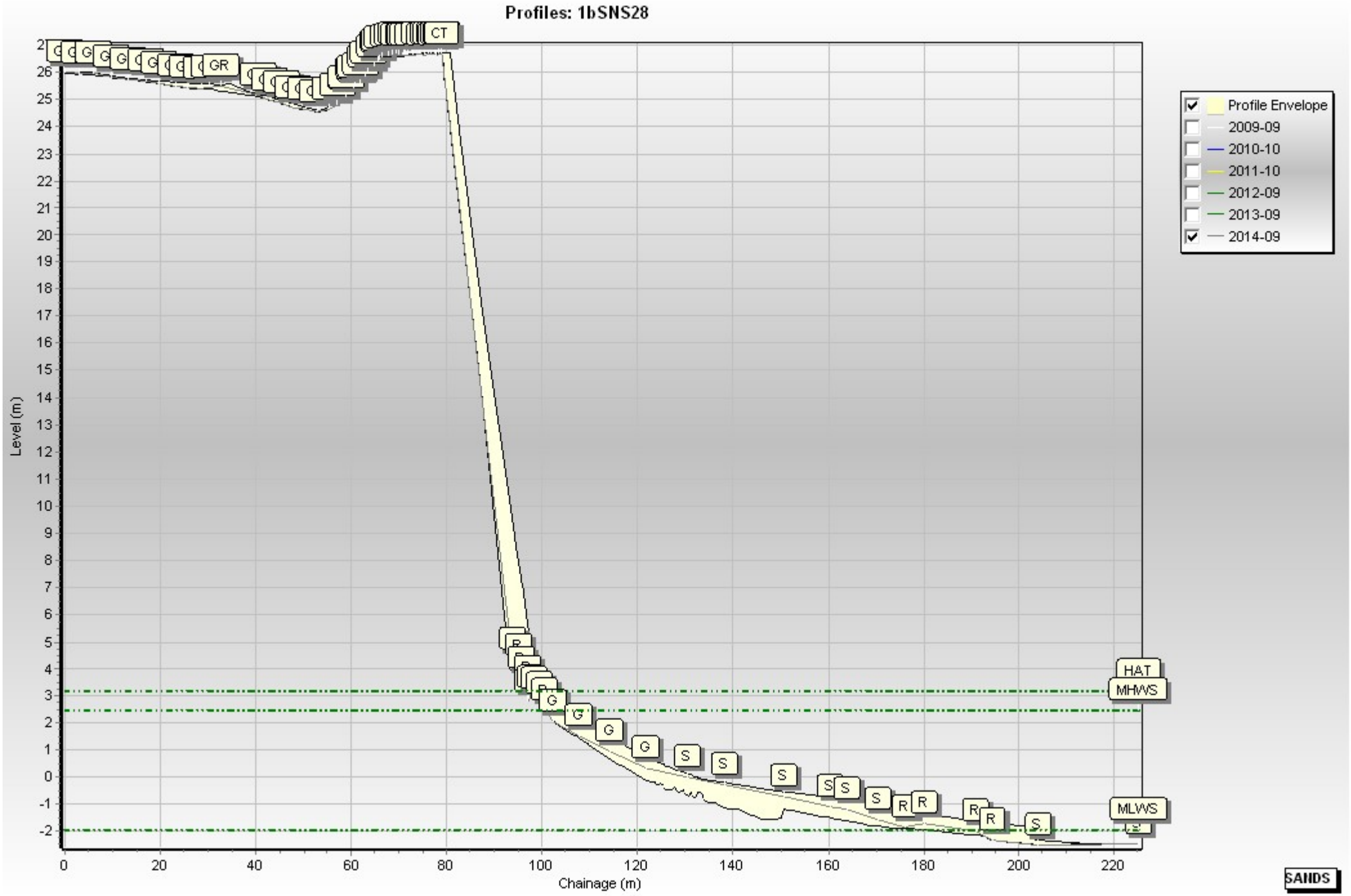
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Chainage (m)
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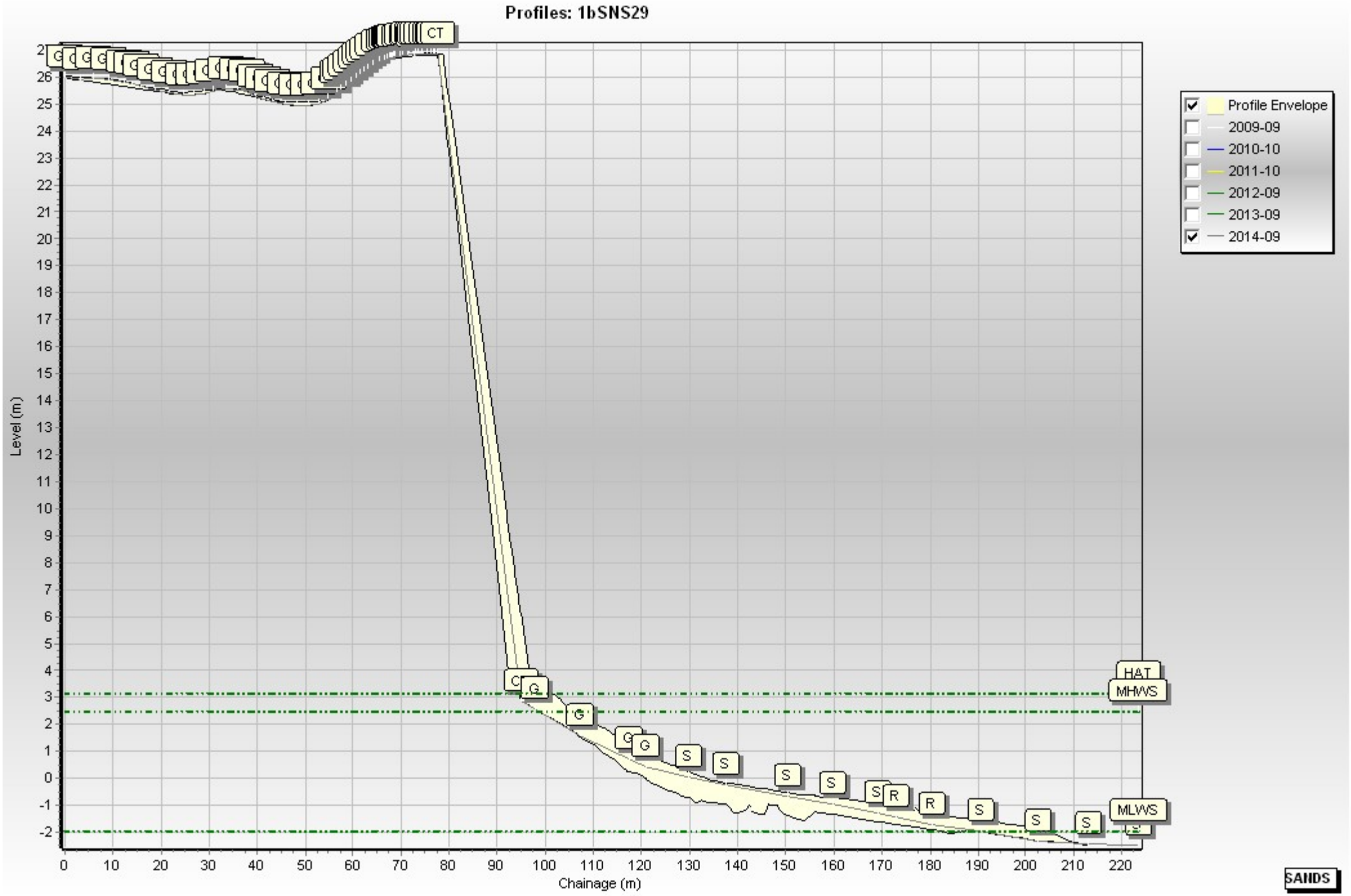
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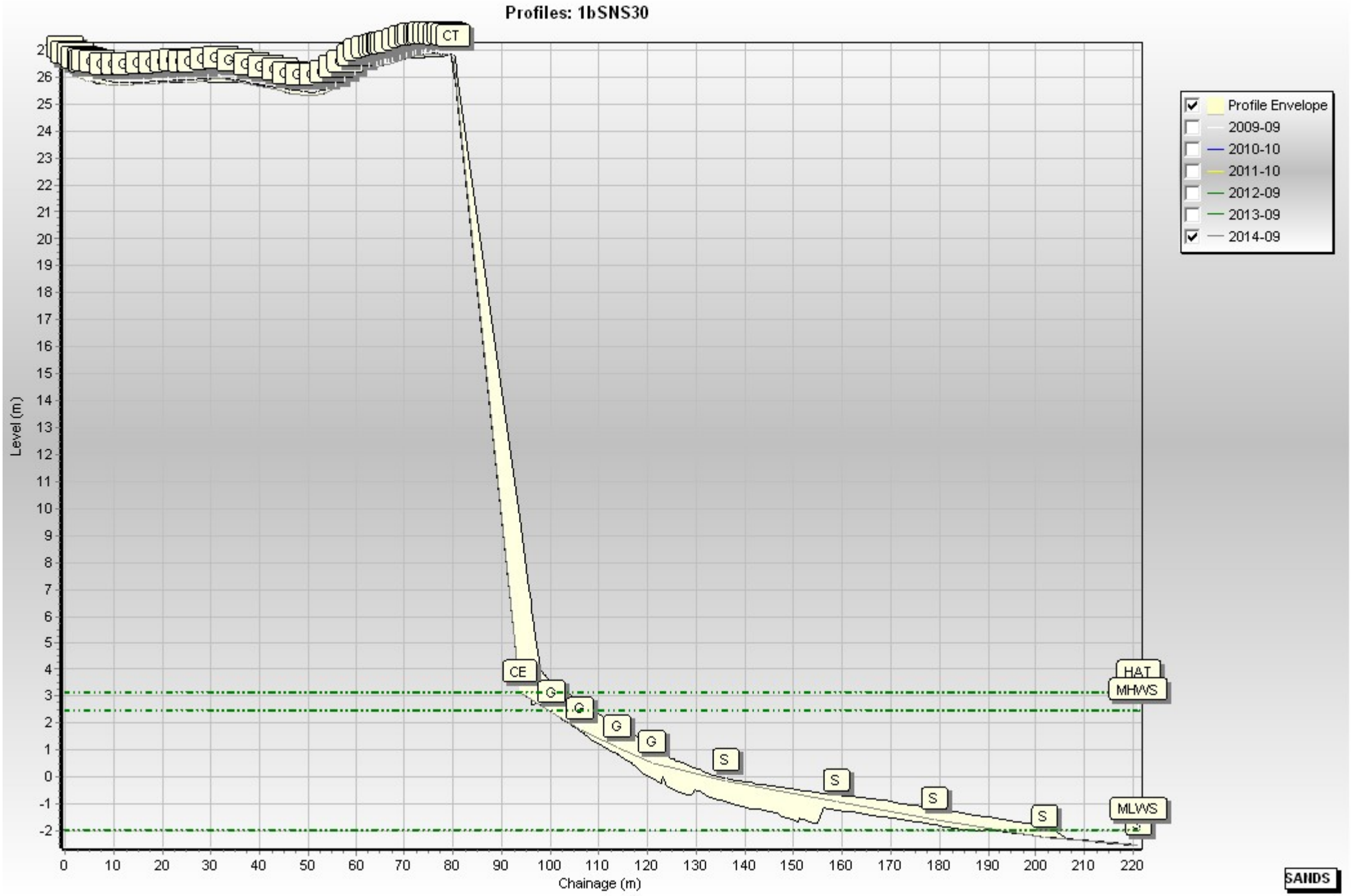
Level (m)
Chainage (m)
SANDS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2011-10
2012-09
2013-09
2014-09
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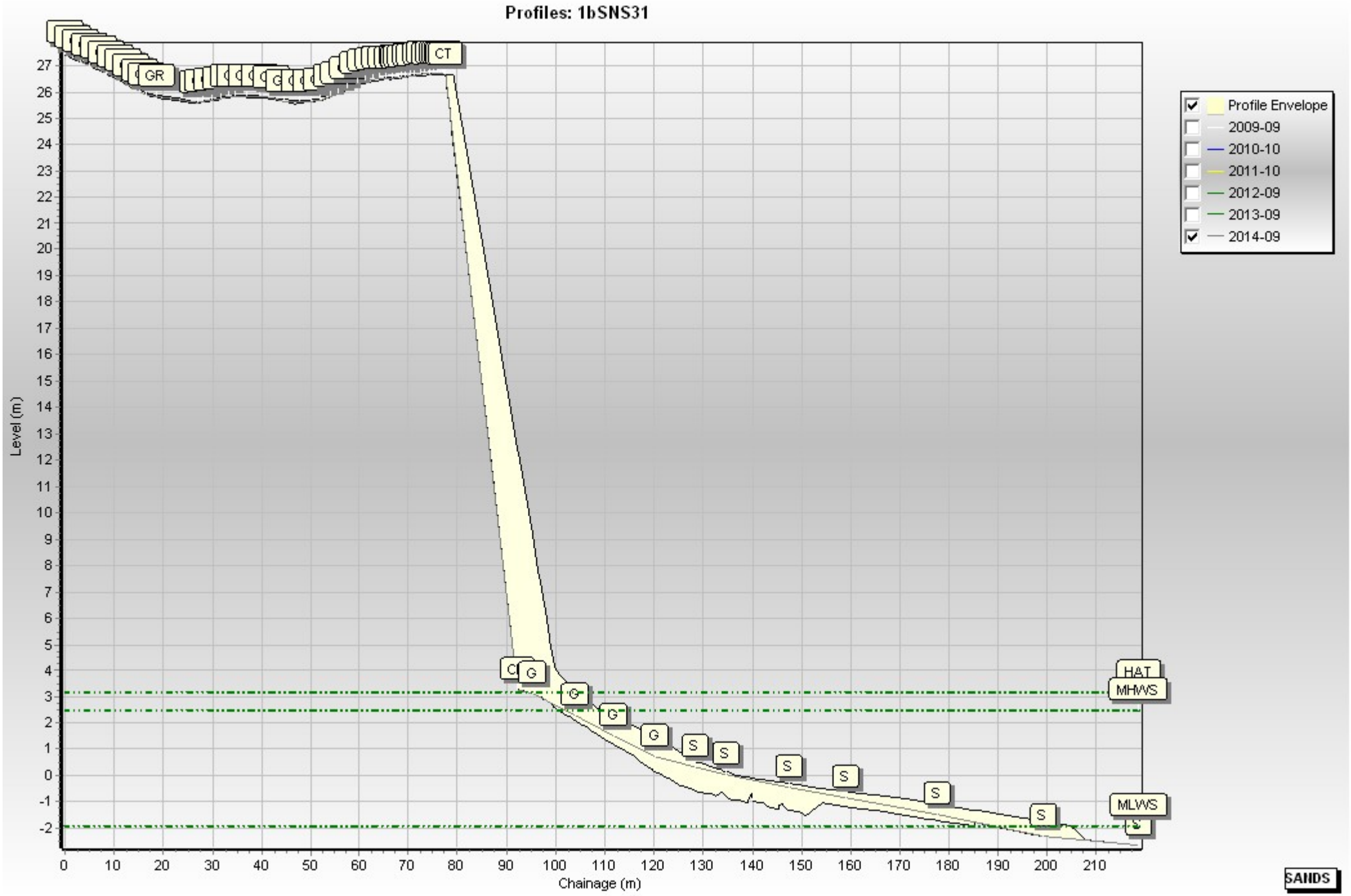
G
G
S
S
S
S
HAT
MHWS
MLWS
Level (m)
Chainage (m)
SANDS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MHWS
MLWS
Level (m)
Chainage (m)
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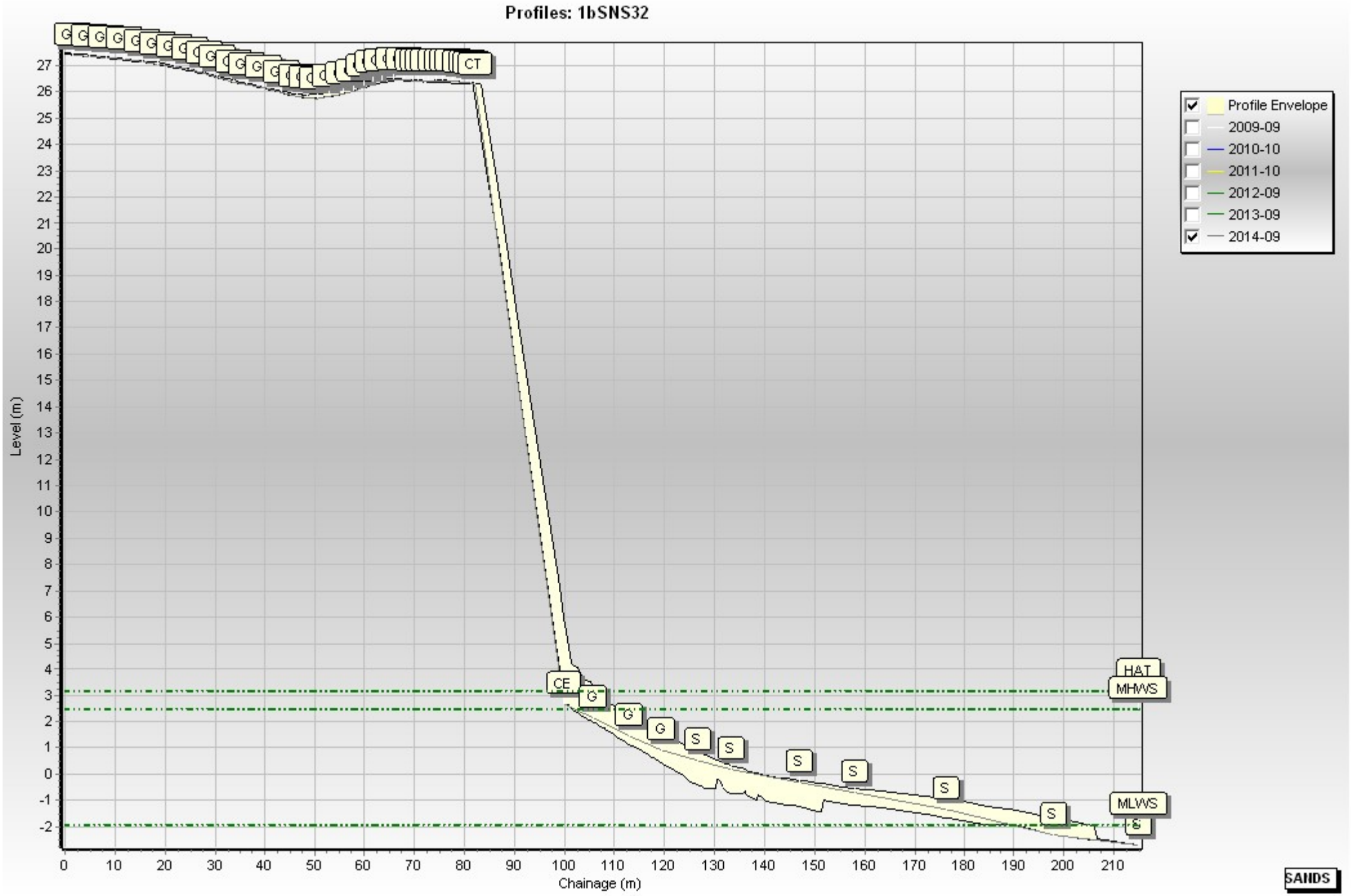
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HAT
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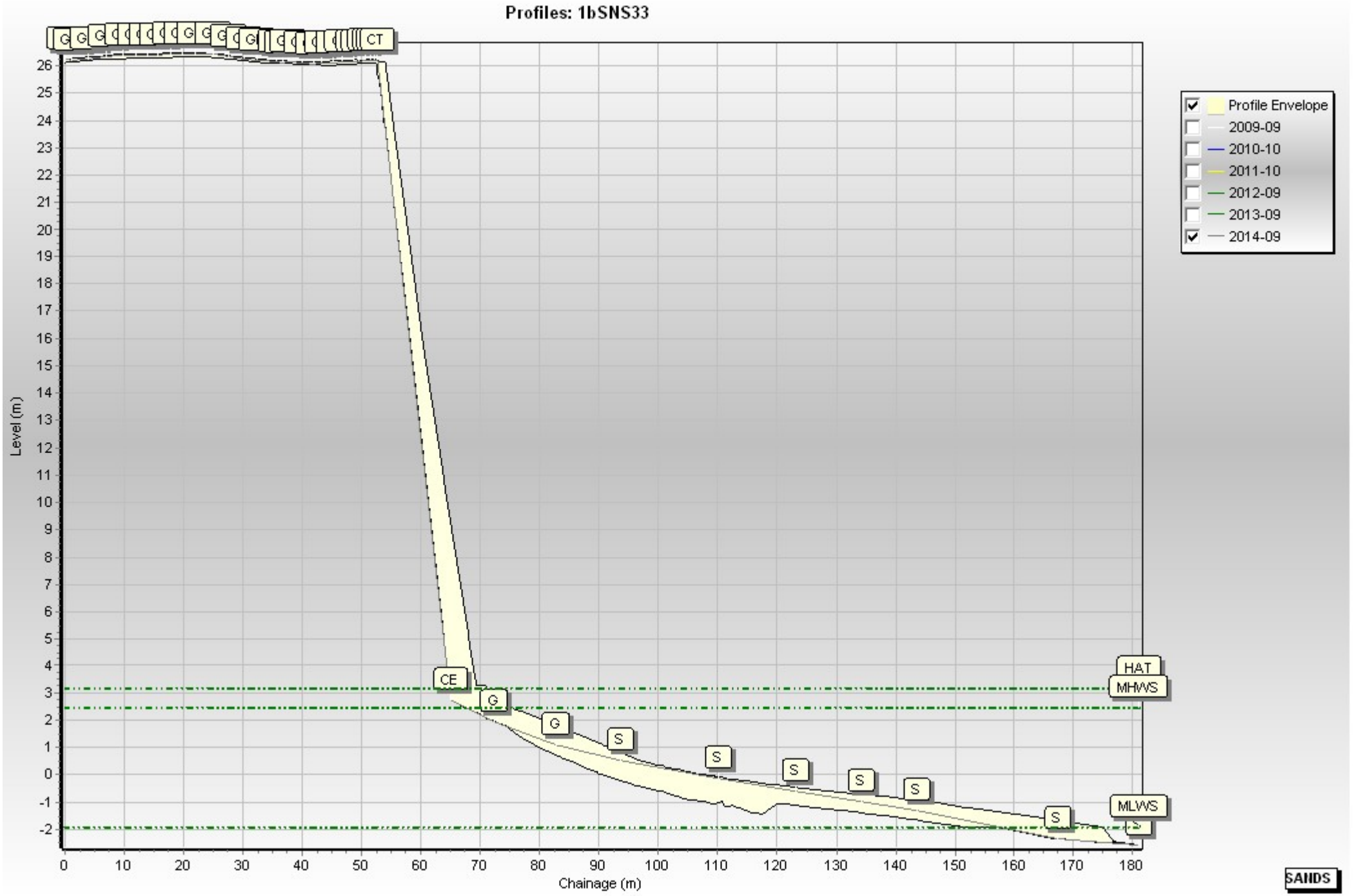
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2014-09
Level (m)
Chainage (m)
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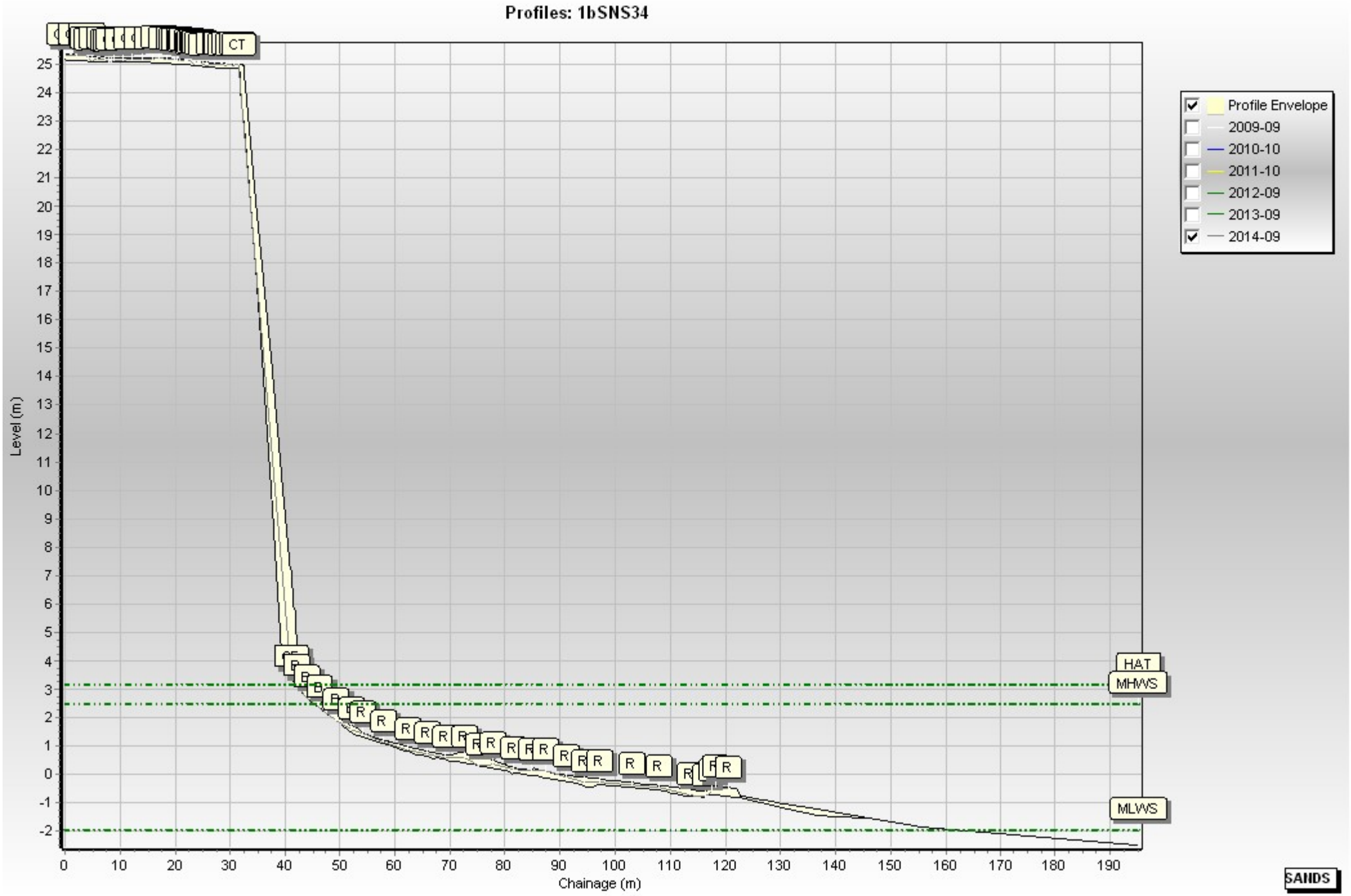
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2014-09
Level (m)
Chainage (m)
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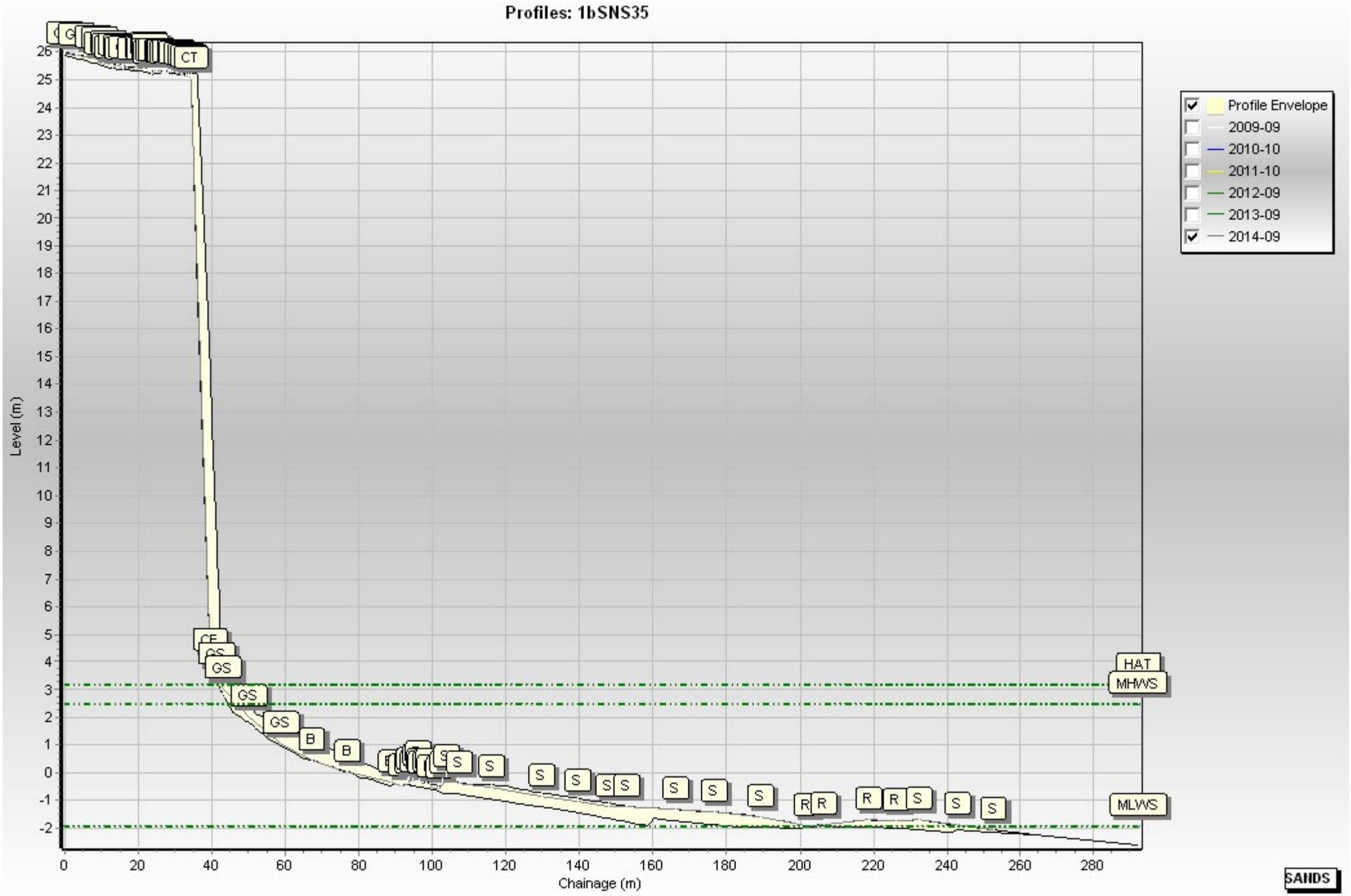
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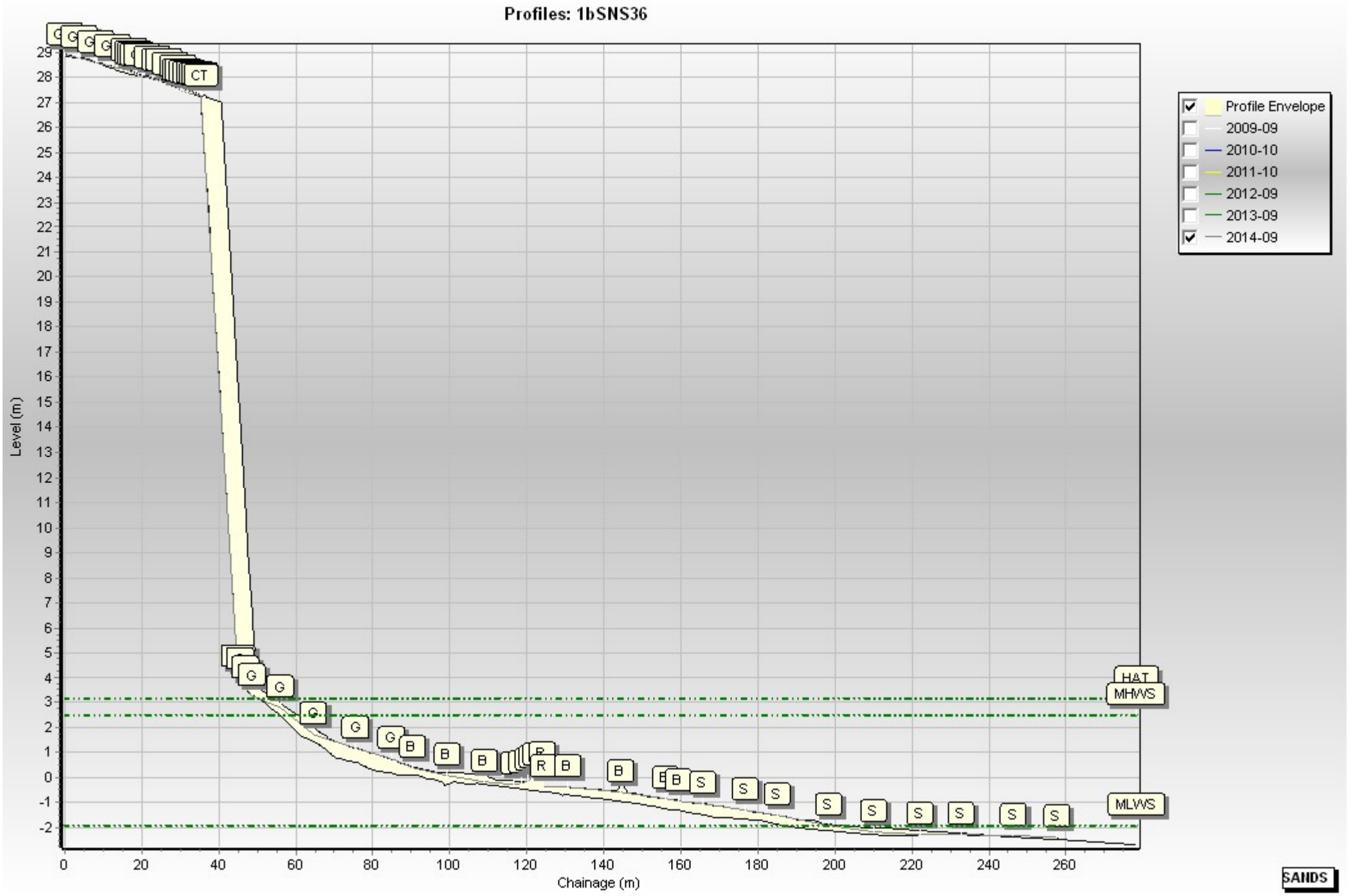
MHWS
MLWS
Level (m)
Chainage (m)
SANDS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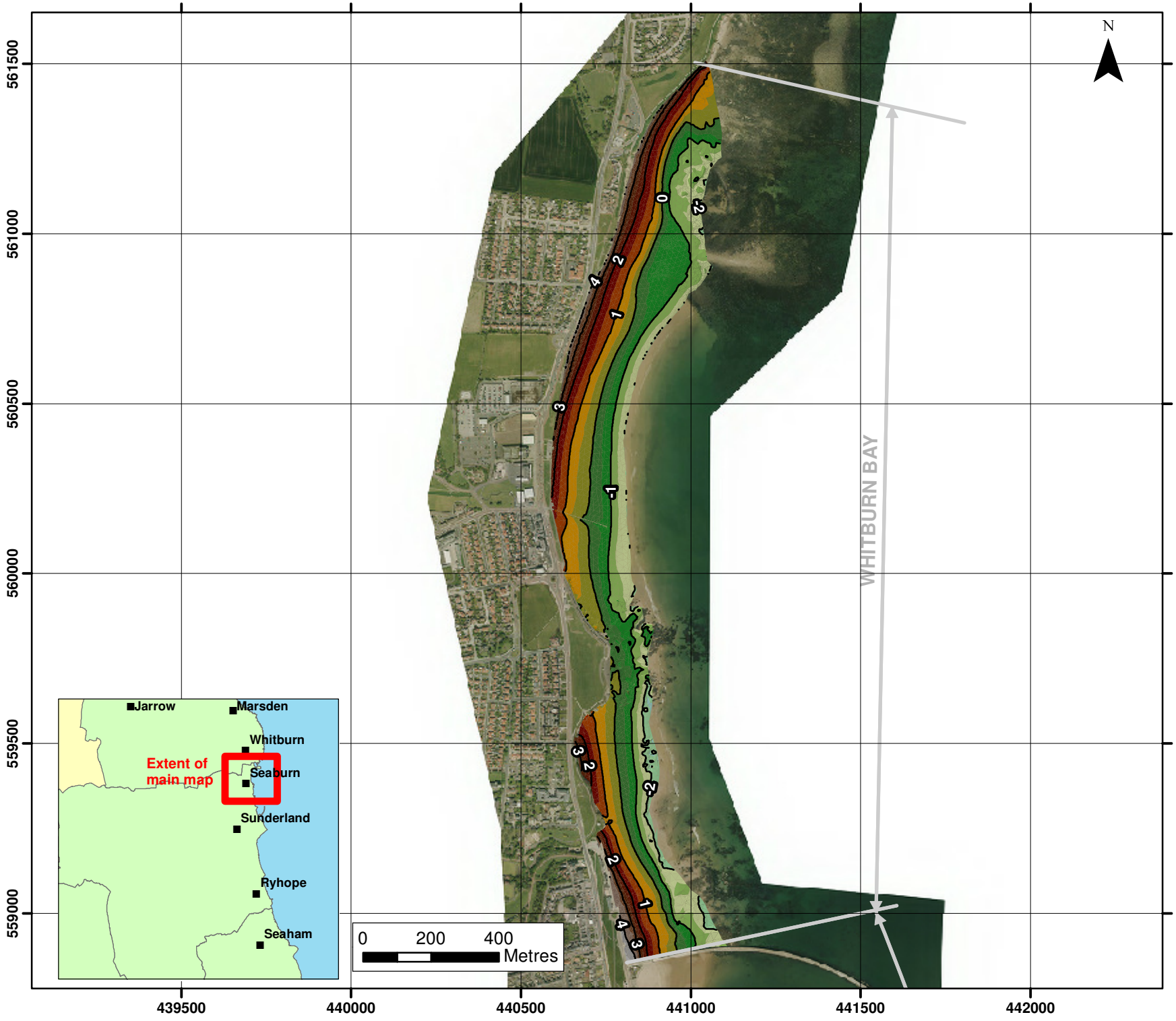
2013-09
2014-09
Level (m)
Chainage (m)
HAT
MHWS
MLWS
CT
G
B
R
S
SANDS

Appendix B

Topographic Survey



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
- -2.5 - -2
- -3 - -2.5
- Contour 1m

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B - Map 1a
Topographic Survey
Whitburn Bay
Sunderland City Council

Analytical Report 7
Full Measures Survey
Autumn 2014

CH2MHILL
Halcrow

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

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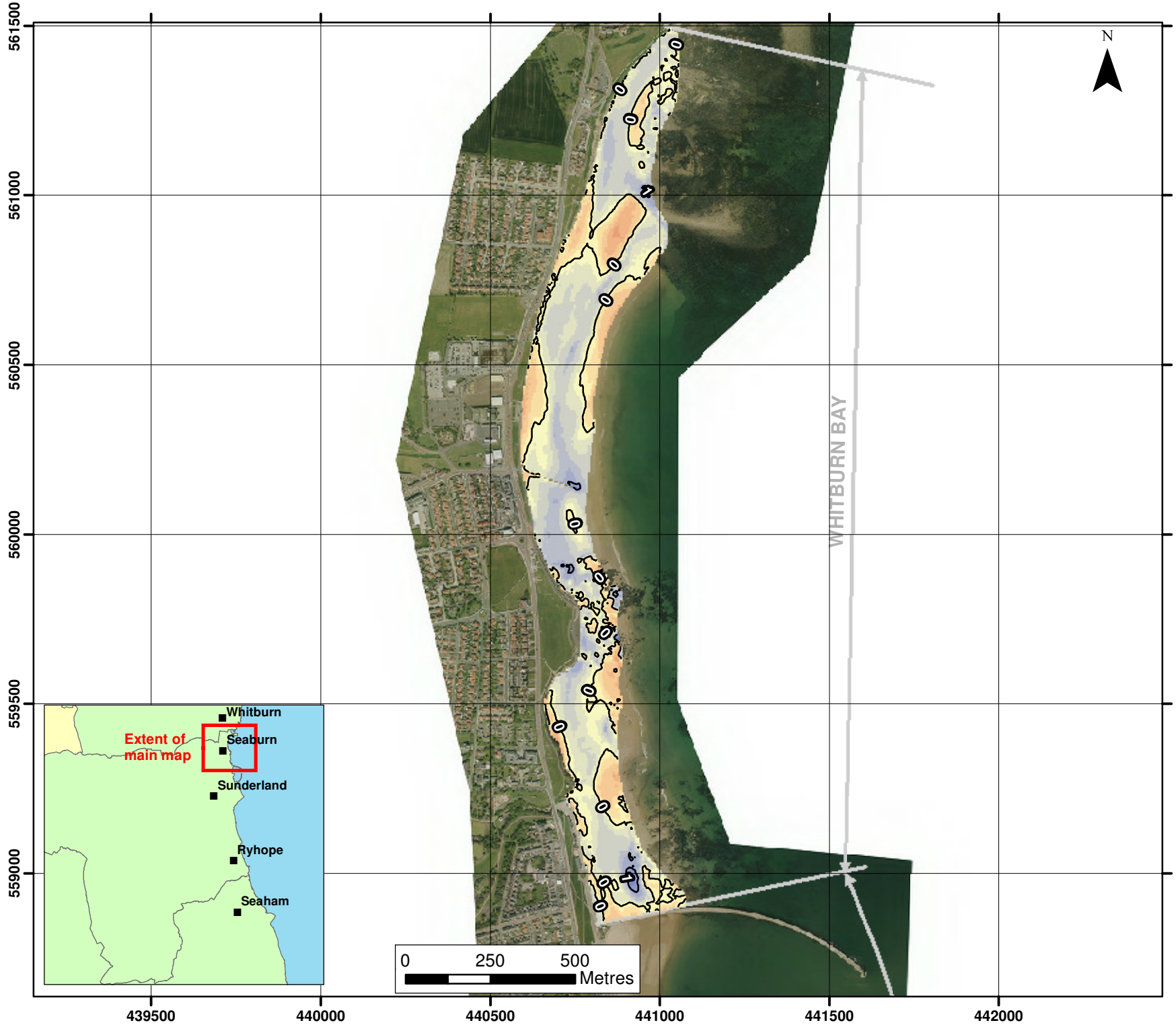
Fax: +44(0)121 456 1569
www.halcrow.com



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

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

Loss

Change < 0.1 m

Gain

Contours of change

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B- Map 1b Topographic Difference Whitburn Bay Sunderland City Council

Analytical Report 7
Full Measures Survey
Autumn 2014

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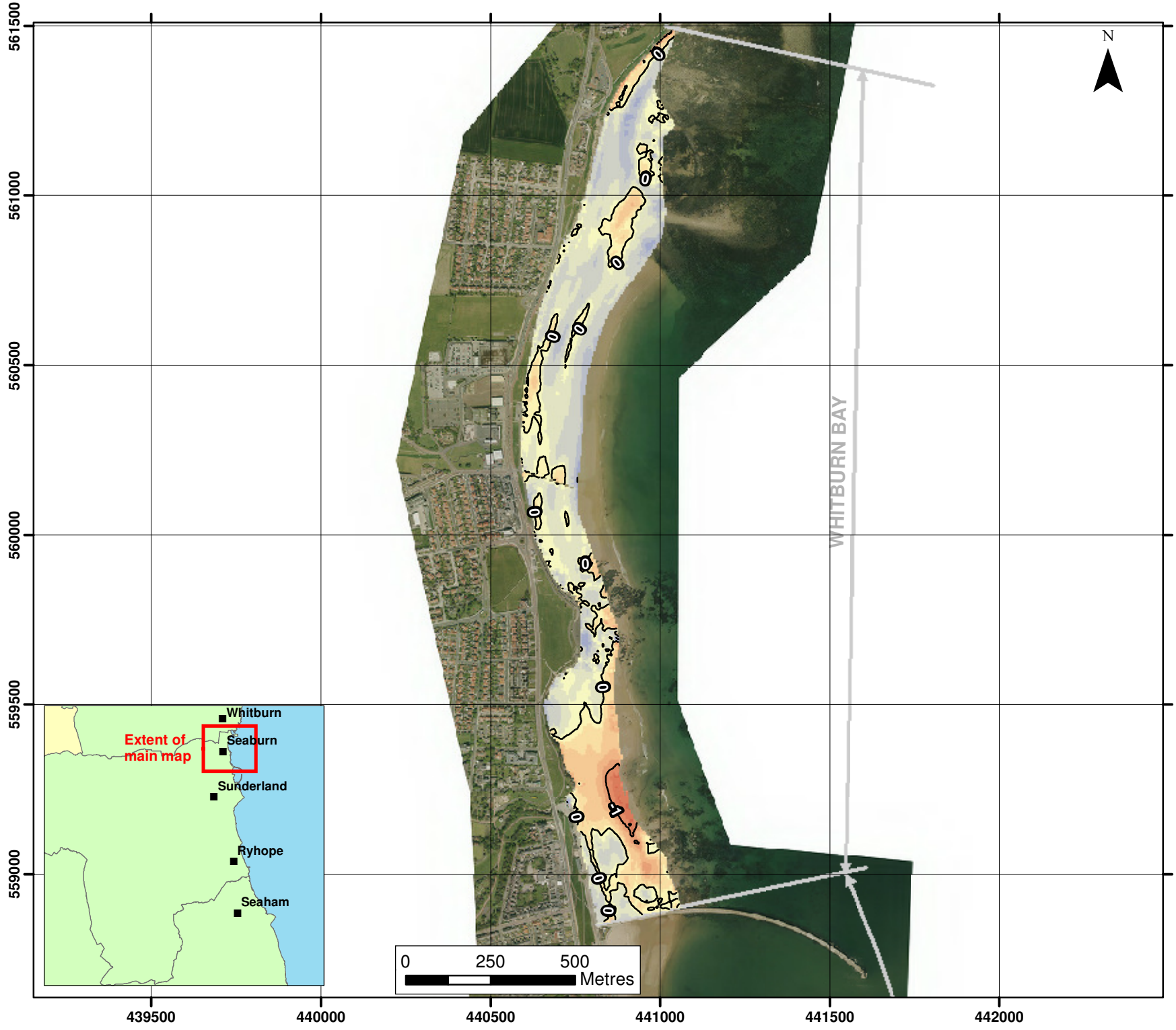
Fax: +44(0)121 456 1569
www.halcrow.com



KEY Autumn 2009 and Autumn 2014
Change in elevation (m)

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

Loss

Change < 0.1 m

Gain

Contours of change

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

Appendix B- Map 1c
Long-term Elevation change
Whitburn Bay
Sunderland City Council

Analytical Report 7
Full Measures Survey
Autumn 2014

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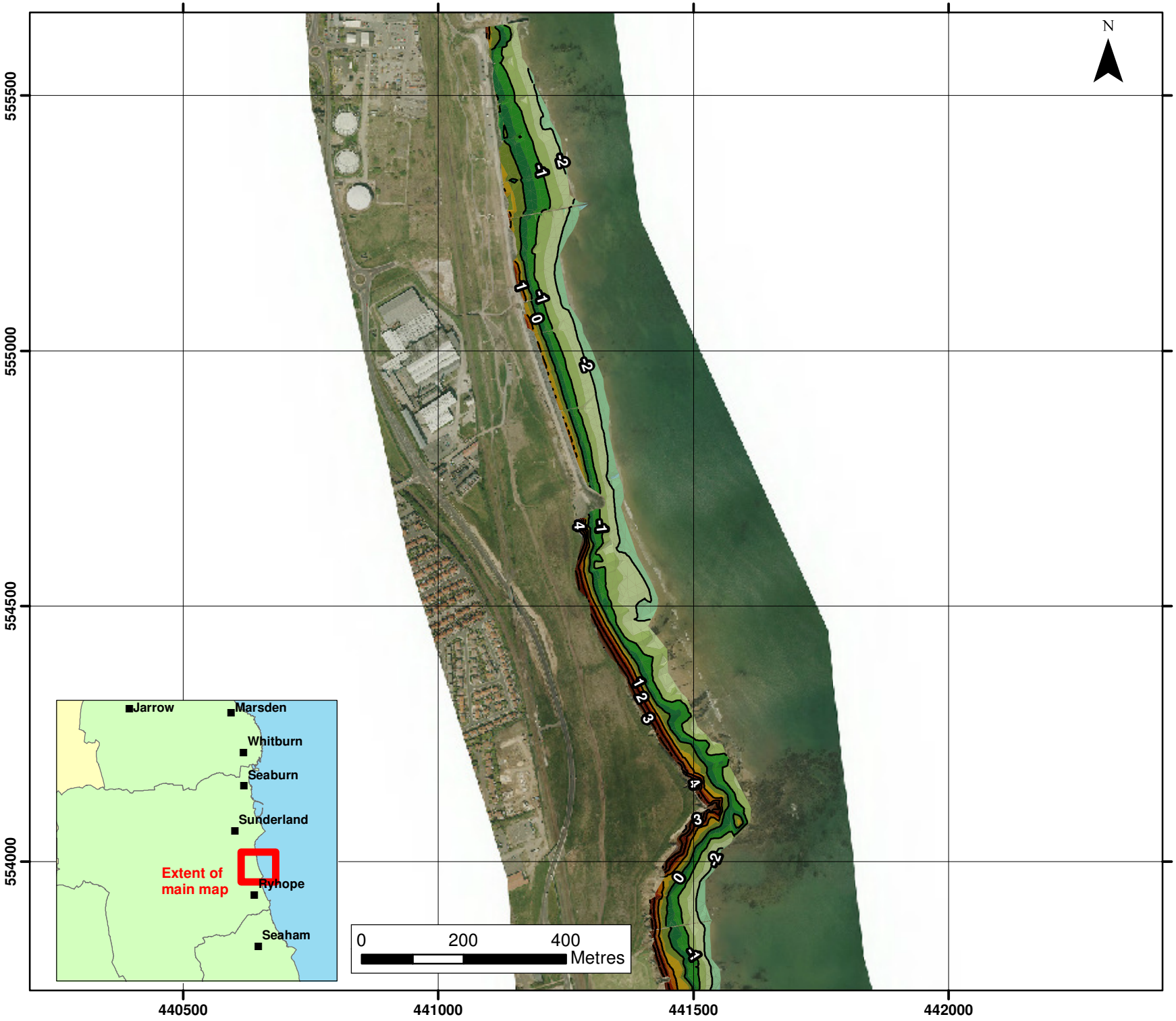

KEY

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
- -3 - -2.5
- Contour 1m

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B - Map 2a
Topographic Survey
Hendon to Ryhope a
Sunderland City Council

Analytical Report 7
Full Measures Survey
Autumn 2014

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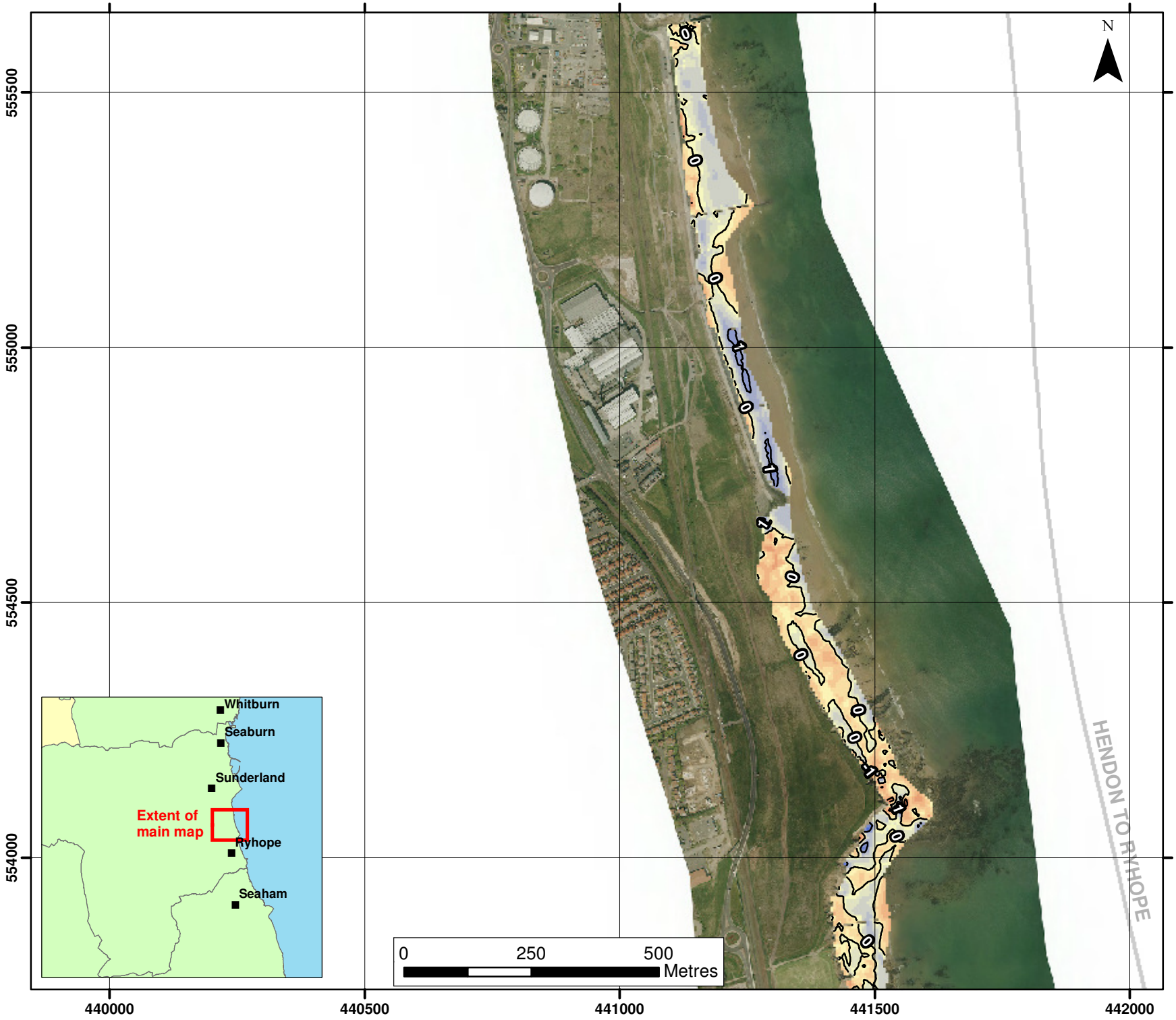
Fax: +44(0)121 456 1569
www.halcrow.com



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

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

Contours of change

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

Appendix B - Map 2b
Short-term Elevation Change
Hendon to Ryhope a Sunderland City Council

Analytical Report 7
Full Measures Survey
Autumn 2014

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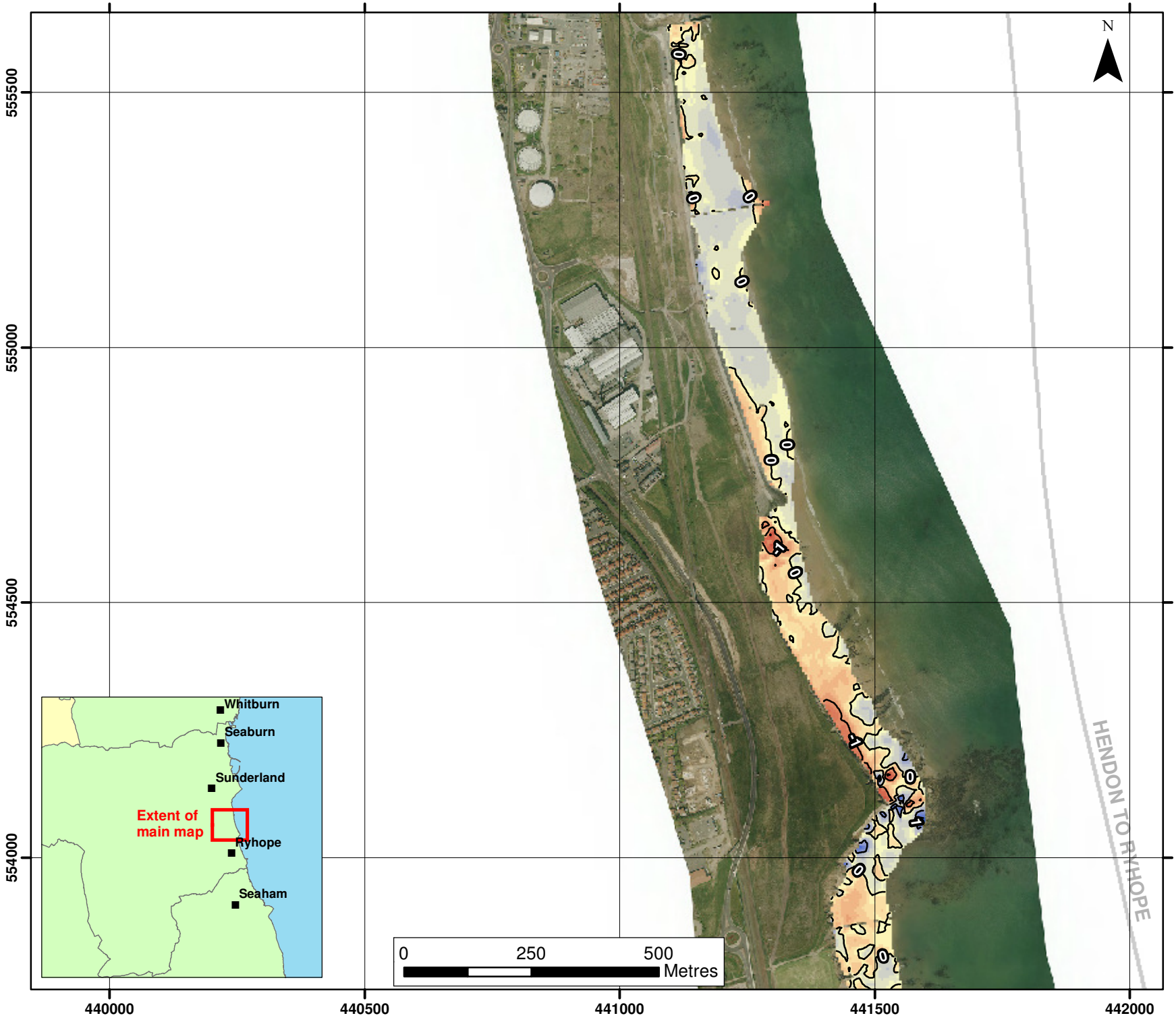

KEY Autumn 2009 and Autumn 2014
Change in elevation (m)

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

Loss
Change < 0.1 m
Gain
Contours of change

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

Appendix B - Map 2c Long-term Elevation Change Hendon to Ryhope a Sunderland City Council

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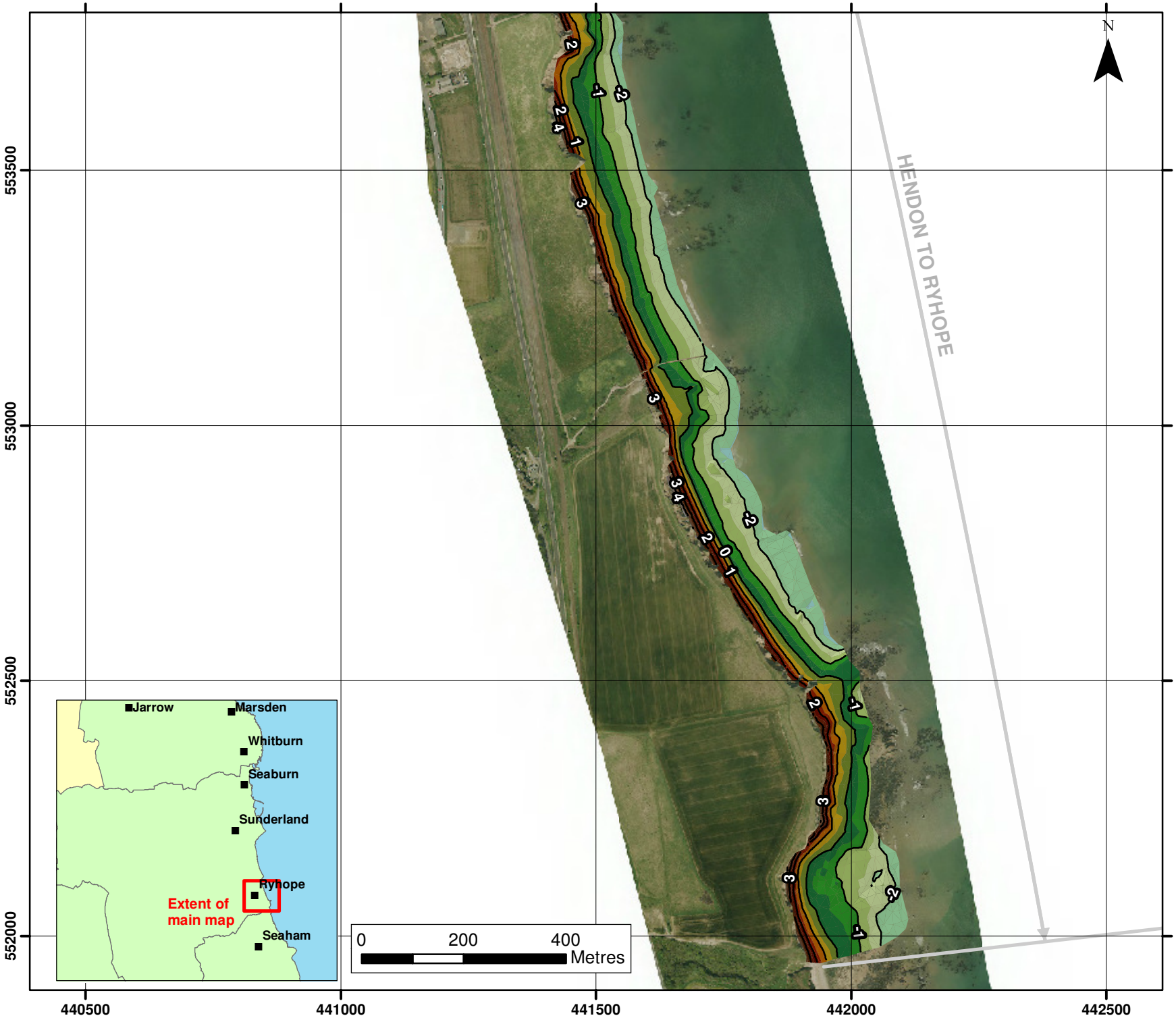

KEY

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
- -3 - -2.5
- Contour 1m

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B - Map 3a
Topographic Survey
Hendon to Ryhope
Sunderland City Council

Analytical Report 7
Full Measures Survey
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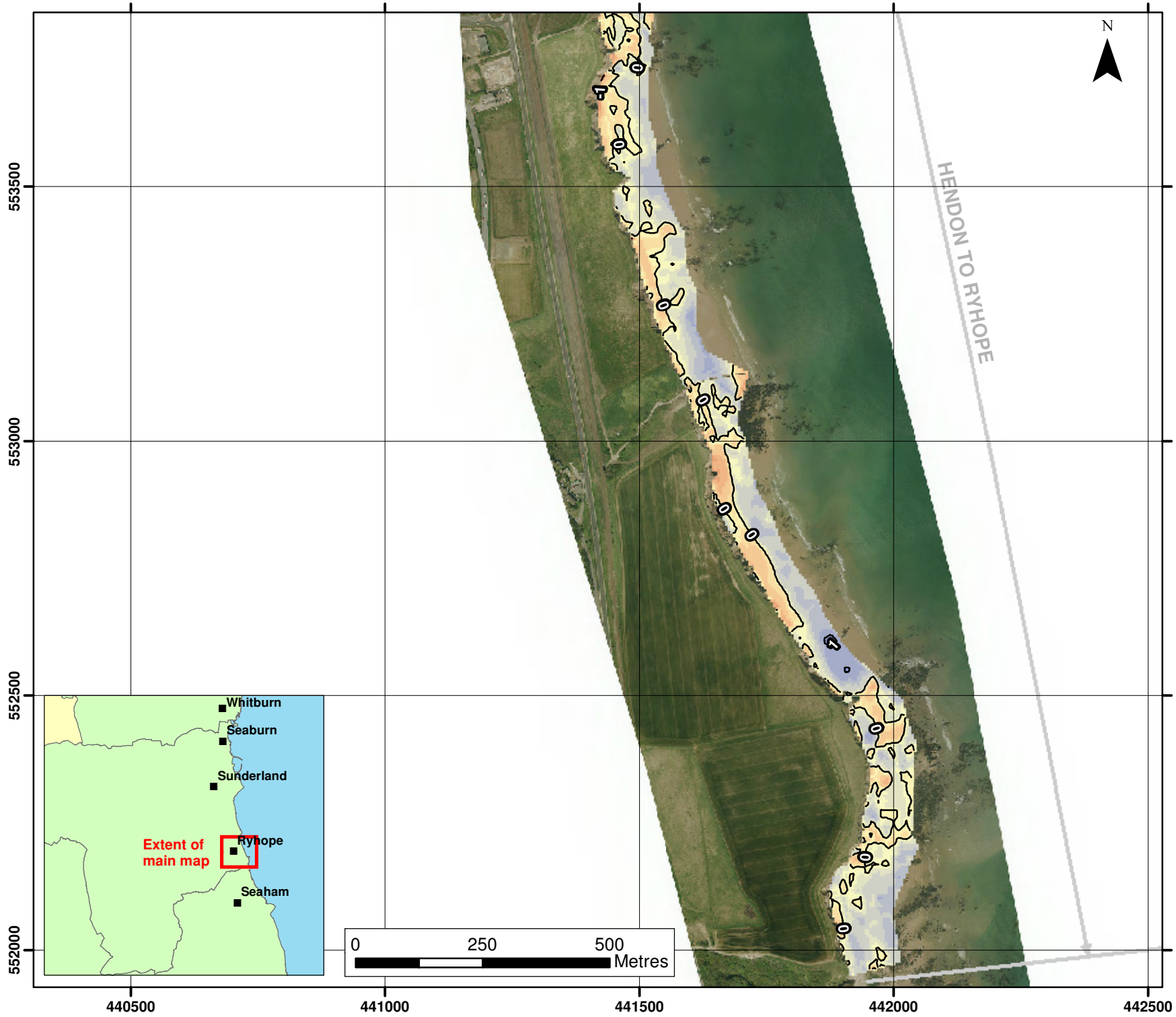

KEY Autumn 2013 and Autumn 2014
Change in elevation (m)

<-2	Loss
-2 - -1.75	
-1.75 - -1.5	
-1.5- -1.25	
-1.25 - -1	
-1 - -0.75	
-0.75 - -0.5	
-0.5 - -0.25	
-0.25 - -0.1	
-0.1 - 0	Change < 0.1 m
0 - 0.1	
0.1 - 0.25	
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
Hendon to Ryhope b
Sunderland City Council

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Full Measures Survey
Autumn 2014

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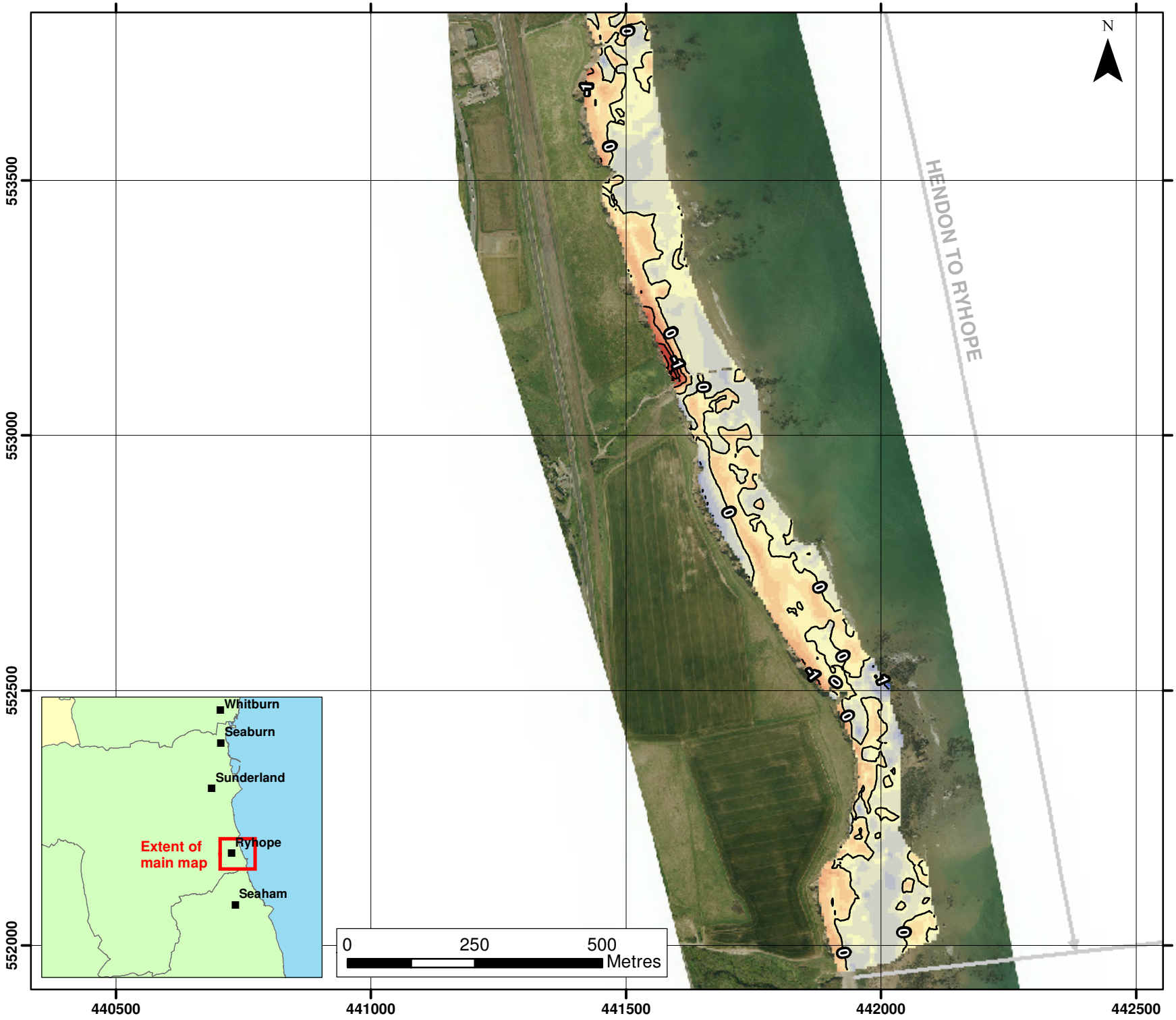

KEY Autumn 2009 and Autumn 2014
Change in elevation (m)

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

Contours of change

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

Appendix B - Map 3c
Long-term Elevation Change
Hendon to Ryhope b
Sunderland City Council

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Appendix C

Cliff Top Survey

Cliff Top Survey

Hendon and Ryhope

Thirty-two ground control points have been established between Hendon and Ryhope (Map 1 and Map 2). The maximum separation between any two points varies along the coast, reflecting the degree of risk from the erosion.

The cliff top surveys between Hendon and Ryhope 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 B1 provides baseline information about these ground control points and results from the 2009 (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.

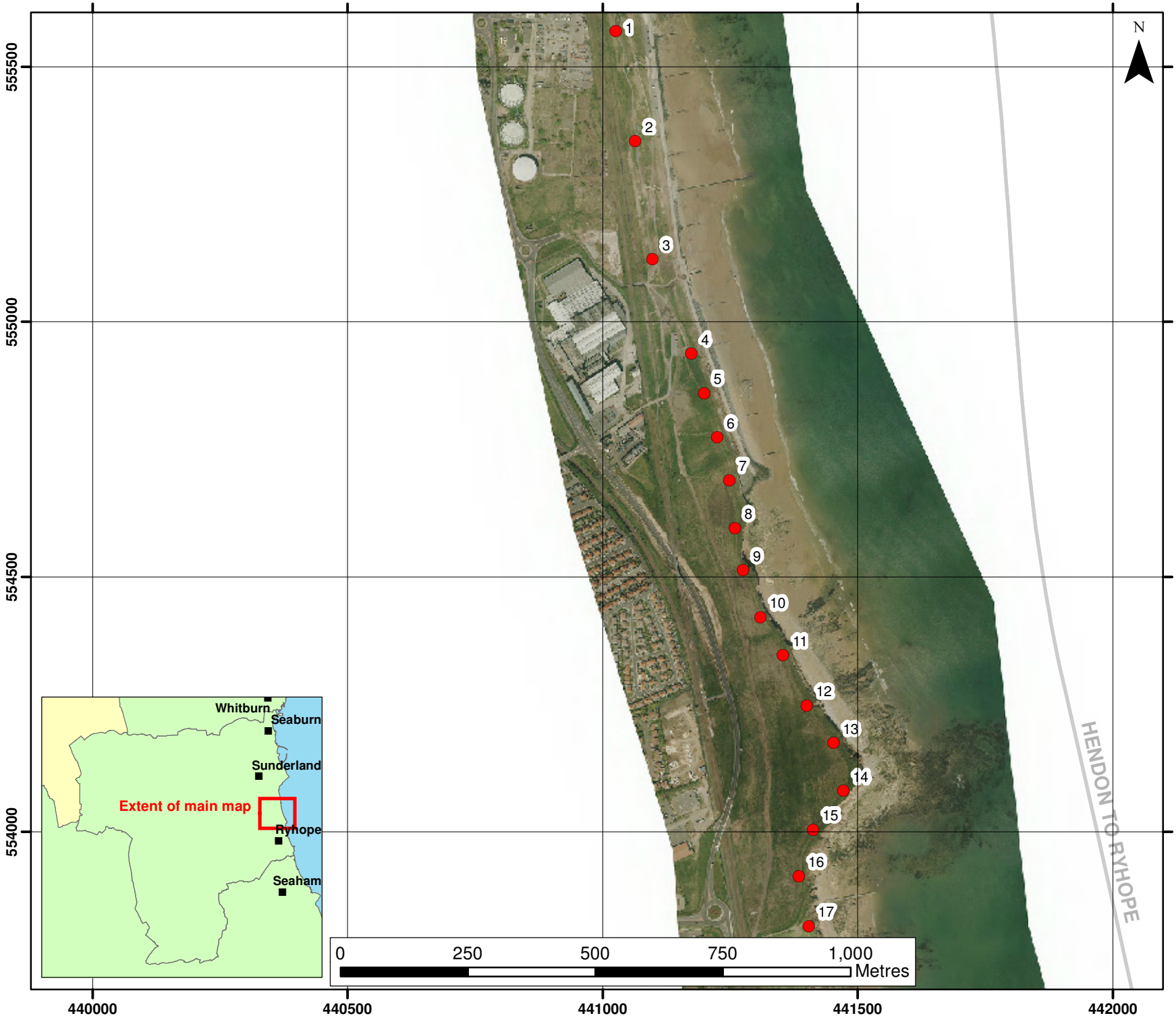
Table B1 – Cliff Top Surveys between Hendon and Ryhope

Ground Control Point Details				Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Easting	Northing	Bearing (º)	Baseline Survey (March 2009)	Previous Survey (March 2014)	Present Survey (Sept 2014)	Baseline (March 2009) to Present (Sept 2014)	Previous (March 2014) to Present (Sept 2014)	Baseline (March 2009) to Present (Sept 2014)
1	441025.7	555571.1	75	8.16	8.7	8.3	0.1	-0.4	0.0
2	441064.4	555355.1	85	7.09	5.5	5.5	-1.6	0.0	-0.3
3	441098	555124	82	10.01	10.4	10.4	0.4	0.0	0.1
4	441174	554938.7	65	10.3	10.8	10.5	0.2	-0.3	0.0
5	441199.1	554861.1	65	7.71	7.9	7.9	0.1	0.0	0.0
6	441224.5	554774.2	71	10.83	11.3	10.9	0.1	-0.4	0.0
7	441248.4	554690.3	74	10.18	10.4	10.4	0.3	0.0	0.0
8	441259.3	554596.6	101	10.08	9.9	9.9	-0.2	0.0	0.0
9	441275.8	554513.4	66	10.52	6.5	6.6	-3.9	0.1	-0.7
10	441309.4	554421.3	58	8.77	1.5	1.6	-7.2	0.1	-1.3

Ground Control Point Details				Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Easting	Northing	Bearing (º)	Baseline Survey (March 2009)	Previous Survey (March 2014)	Present Survey (Sept 2014)	Baseline (March 2009) to Present (Sept 2014)	Previous (March 2014) to Present (Sept 2014)	Baseline (March 2009) to Present (Sept 2014)
11	441354	554346.5	68	8.2	6.3	6.3	-1.9	0.0	-0.4
12	441400.2	554248.2	56	6.17	6.1	6.1	-0.1	0.0	0.0
13	441452.3	554174.7	63	11.61	10.8	8.7	-2.9	-2.1	-0.5
14	441472.3	554080.5	127	7.33	7.3	7.1	-0.2	-0.1	0.0
15	441413	554005.1	122	7.84	7.9	8.0	0.2	0.2	0.0
16	441384.8	553913.3	90	9.89	7.9	7.9	-2.0	0.0	-0.4
17	441404.1	553815.5	93	6.32	6.0	6.1	-0.2	0.1	0.0
18	441404.1	553723.6	119	8.1	8.1	8.1	0.0	0.0	0.0
19	441398.5	553632.8	78	8.23	5.7	5.4	-2.8	-0.3	-0.5
20	441438.3	553452.9	71	10.09	6.7	6.8	-3.3	0.1	-0.6
21	441506.1	553256.1	62	8.57	1.8	1.8	-6.8	-0.1	-1.3
22	441550.1	553158.7	103	6.57	3.7	3.4	-3.2	-0.3	-0.6
23	441585.2	553076.5	64	8.11	8.1	7.9	-0.2	-0.2	0.0
24	441624.4	552870.7	69	7.53	4.6	4.6	-2.9	0.0	-0.5
25	441689.1	552758	70	14.58	7.0	7.0	-7.6	0.0	-1.4
26	441715	552713.3	54	12.87	11.3	11.3	-1.6	0.0	-0.3
27	441749.2	552674.4	62	14.56	10.7	10.6	-4.0	-0.1	-0.7
28	441776.6	552629.9	57	8.62	4.3	4.3	-4.4	0.0	-0.8
28A	441798.6	552586.3	56	13.63*	8.5	8.3	-5.3	-0.2	-1.1
28B	441817.4	552542.4	64	12.30*	11.3	11.3	-1.0	0.0	-0.2
28C	441852.2	552502.6	52	13.11*	13.0	13.0	-0.1	0.0	0.0
29	441880.1	552471.6	83	15.46	15.2	15.2	-0.3	0.0	0.0
30	441921.4	552269	97	8.55	7.8	7.7	-0.8	0.0	-0.2
31	441853.1	552094	75	11.2	7.1	6.8	-4.4	-0.3	-0.8

Ground Control Point Details				Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Easting	Northing	Bearing (º)	Baseline Survey (March 2009)	Previous Survey (March 2014)	Present Survey (Sept 2014)	Baseline (March 2009) to Present (Sept 2014)	Previous (March 2014) to Present (Sept 2014)	Baseline (March 2009) to Present (Sept 2014)
32	441883.3	551988.5	96	9.82	5.0	5.0	-4.8	0.0	-0.9

*Note that 28a-c baseline is September 2009.



KEY

- Ground Control Points

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B - Map 1
Ground Control Points
Hendon to Ryhope North
Sunderland City Council

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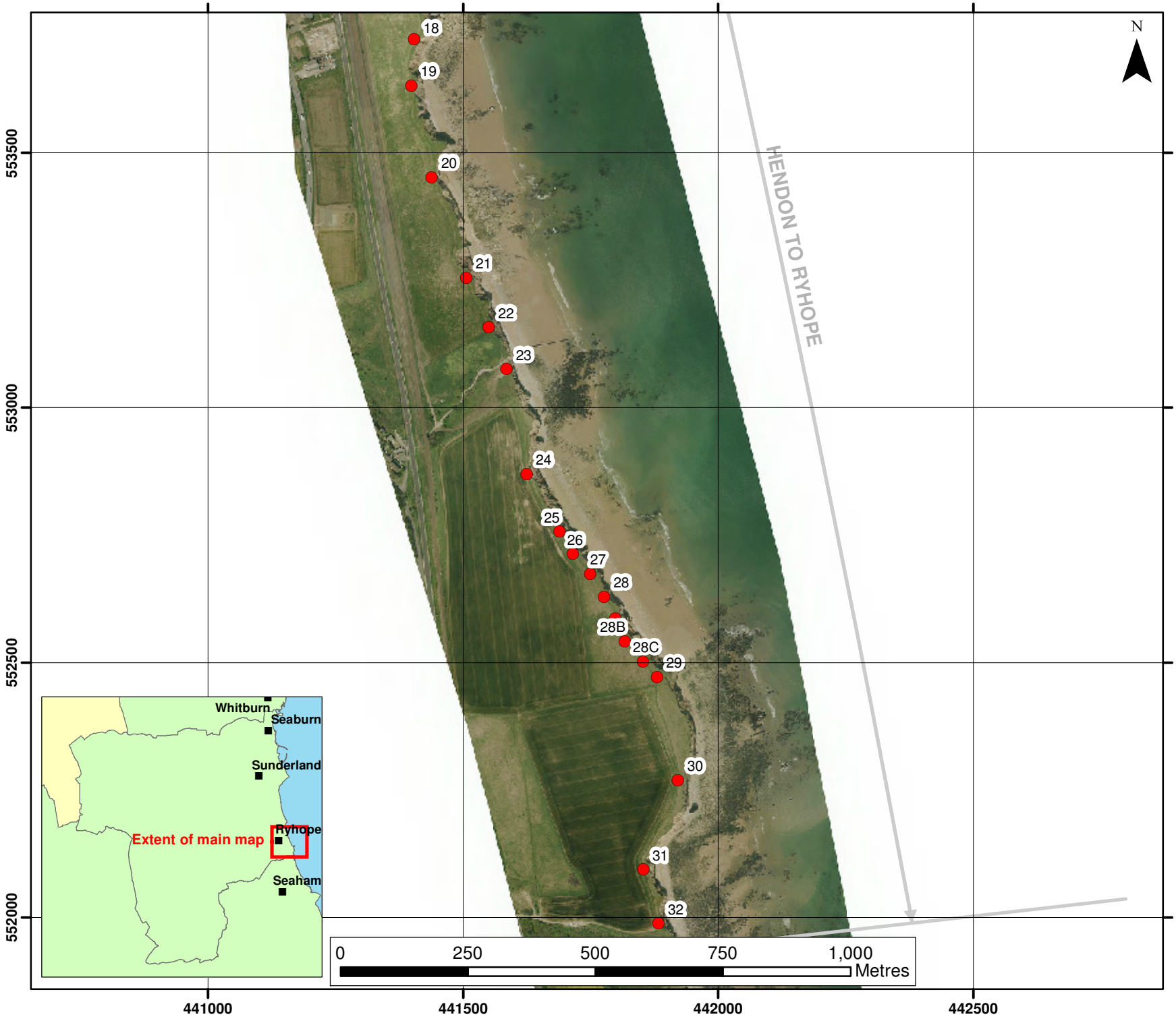

KEY

- Ground Control Points

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B - Map 2
Ground Control Points
Hendon to Ryhope South
Sunderland City Council

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