CH2MHILL
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Cell 1 Regional Coastal Monitoring Programme Analytical Report 6: 'Full Measures' Survey 2013

Northumberland County Council
Final Report

NORTHUMBERLAND
Northumberland County Council

February 2014

Contents

Appendices

List of Figures

List of Tables

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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 Parameter	Water Level (m AOD) Berwick upon Tweed	Holy Island	North Sunderland
HAT	2.8	2.8	2.8
MHWS	2.2	2.4	2.4
MLWS	-1.9	-1.8	-1.7
Water Level Parameter	**Amble**	**Blyth**	**River Tyne**
HAT	3.1	3.1	3.1
MHWS	2.4	2.4	2.4
MLWS	-1.9	-1.8	-1.9

Source: *Scottish Border to River Tyne Shoreline Management Plan 2.* Royal Haskoning, May 2009.

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.

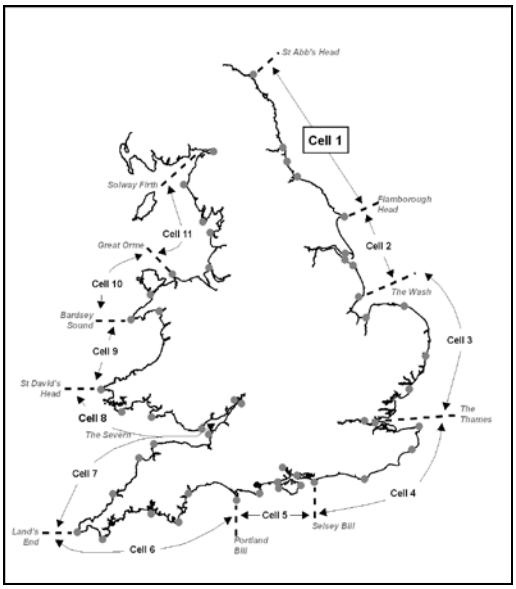


Figure 1 Sediment Cells in England and Wales

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
North Tyneside Council
South Tyneside Council
Northumberland Coast AONB
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 (rebranded as CH2M HILL since 2013).

The main elements of the Cell 1 Regional Coastal Monitoring Programme involve:

- beach profile surveys
- topographic surveys
- cliff top recession surveys
- real-time wave data collection
- bathymetric and sea bed characterisation surveys
- aerial photography
- walk-over surveys

The beach profile surveys, topographic surveys and cliff top recession surveys are undertaken as a 'Full Measures' survey in autumn (referred to as winter in previous reporting). 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	Feb13	-
5	2012/13	Sept-Nov 12	Mar 13	Mar-April 13	Jun 13	
6	2013/2014	Sept-Oct 13	Feb 14 (*)			

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

Northumberland Council's frontage extends from the Scottish Border in the north to Hartley (just south of Blyth) in the south. For the purposes of this report and for consistency with previous reporting, it has been sub-divided into 15 areas, namely:

- Sandstell Point (Spittal A)
- Spittal (Spittal B)
- Goswick Sands
- Holy Island
- Bamburgh
- Beadnell Village
- Beadnell Bay
- Embleton Bay
- Boulmer
- Alnmouth Bay
- High Hauxley and Druridge Bay
- Lynemouth Bay
- Newbiggin-by-the-Sea
- Cambois
- Blyth South Beach

1.2 Methodology

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

Full Measures survey annually each autumn comprising:

- Beach profile surveys along 78 transect lines (commenced 2002)
- Beach profile surveys along an additional ten transect lines (commenced 2007)
- Beach profile surveys along an additional 26 transect lines (commenced 2010)
- Topographic survey along Holy Island (commenced 2004)
- Topographic survey along Alnmouth Bay (commenced 2005)
- Topographic survey along Sandstell Point (commenced 2009)
- Topographic survey along Newbiggin Bay (commenced 2010)

Partial Measures survey annually each spring comprising:

- Beach profile surveys along 29 transect lines (commenced 2002)
- Beach profile surveys along an additional ten transect lines (commenced 2007)
- Beach profile surveys along an additional one transect line (commenced 2010)
- Beach profile surveys along an additional two transect lines (commenced 2011)
- Topographic survey along Alnmouth Bay (commenced 2005)
- Topographic survey along Sandstell Point (commenced 2009)
- Topographic survey along Newbiggin Bay (commenced 2010)

Cliff top survey (bi-annually) at:

- Cliff top survey at Lynemouth Bay (commenced 2008)
- Cliff top survey at Cambois Bay (Sandy Bay) (commenced 2008)
- Cliff top survey at Cambois Bay (Cambois) (commenced 2009)

Sand extent survey (bi-annually) at:

- Edge of sand survey at Newbiggin Bay, Spital Carrs, (commenced 2011 to determine potential adverse impact on foreshore SSSI of the Newbiggin beach recharge scheme)

For all cliff-top surveys prior to Full Measures 2011, the data was previously saved in '.kmz' format for plotting and visual comparison in GoogleEarth. This data has been visualised in GIS, which revealed the quality was variable and reliable interpretations of short-term cliff change could not be made. For the present survey and going forward, the survey data will be plotted in GIS and change will qualified along a series of transect lines. The resulting data on amount and rate of change is presented in tables and the survey results are compared.

The location of these surveys is shown in Figure 2. The Full Measures survey was undertaken along this frontage between 18th to 22nd September 2013, 5th to 10th October 2013 and 19th to 21st October 2013. 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. In 2014 a wave data update report will update the baseline with analysis of the wave data collected under the programme for 2013, including the 5th and 6th December storm. In order to help put the beach and cliff changes discussed in this report into context analysed storm data for the wave buoys is presented in this section.

The longest consistent relevant wave data record in the Cell 1 region is from the WaveNet Tyne Tees buoy deployed under the national coastal monitoring programme by Cefas. Data has been downloaded from WaveNet and loaded into SANDS for analysis alongside the beach and cliff monitoring data. Results from analysis of the data to extract details of significant storms are presented in Table 3 below.

To aid interpretation of the results in Table 3 alternate years have been shaded and the storm with the largest peak wave height each year has been highlighted in bold. The annual storm with the highest wave energy at peak has also been highlighted in bold red text as this depends on wave period as well as wave height and so is not always the same as the largest wave height, e.g. in 2009 and 2010.

Table 4: SANDS Storm Analysis at Tyne/Tees WaveNet Buoy

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

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	331.9	4.9	8.3	129	3286.2
31/01/2009 16:30	03/02/2009 09:00	64.5	02/02/2009 22:00	7.1	5.8	9.5	84	6078.5
23/03/2009 20:30	28/03/2009 20:30	120	28/03/2009 18:30	89.7	4.9	9.3	0	4053.0
10/07/2009 01:30	10/07/2009 02:30	1	10/07/2009 01:30	78.8	4.2	9.9	11	3504.3
29/11/2009 20:00	**30/11/2009 15:00**	**19**	**30/11/2009 00:30**	**73.4**	**6.0**	**9.4**	**11**	**6331.4**
17/12/2009 10:30	18/12/2009 05:00	18.5	17/12/2009 19:30	26.4	5.4	10.6	68	**6549.5**
30/12/2009 09:00	30/12/2009 23:00	14	30/12/2009 12:30	7.7	5.1	7.5	90	2866.0
06/01/2010 05:30	06/01/2010 11:00	5.5	06/01/2010 06:30	63.7	4.2	10.7	11	4044.1
29/01/2010 10:30	30/01/2010 00:30	14	29/01/2010 22:30	83.9	5.4	8.6	6	4258.2
26/02/2010 22:30	27/02/2010 02:30	4	27/02/2010 01:00	72.6	4.6	8.5	17	2925.7
19/06/2010 07:00	20/06/2010 08:30	25.5	19/06/2010 20:00	69.4	5.4	10.7	22	**6611.8**
29/08/2010 14:00	30/08/2010 06:30	16.5	29/08/2010 22:30	91.8	4.9	8.9	0	3715.5
06/09/2010 22:30	07/09/2010 16:00	17.5	07/09/2010 15:30	353.3	4.6	8.8	90	3192.5
17/09/2010 07:00	17/09/2010 18:30	11.5	17/09/2010 08:30	80.8	4.7	11.0	11	5323.3
24/09/2010 03:00	26/09/2010	45	24/09/2010 10:00	73.1	5.3	10.1	11	5564.7
20/10/2010 02:00	24/10/2010 16:30	110.5	20/10/2010 10:00	78.3	4.2	11.3	17	4514.5
08/11/2010 14:00	**09/11/2010 20:30**	**30.5**	**09/11/2010 10:00**	**3.1**	**5.6**	**8.8**	**73**	**4870.6**
17/11/2010 11:00	17/11/2010 18:30	7.5	17/11/2010 12:00	322.2	4.7	7.8	129	2646.0
29/11/2010 19:30	02/12/2010 08:30	61	29/11/2010 21:00	11.8	5.1	9.4	56	4474.2
16/12/2010 15:00	17/12/2010 06:30	15.5	17/12/2010 03:30	80.2	4.6	10.5	17	4504.6
23/07/2011 14:00	**24/07/2011 11:00**	**21**	**24/07/2011 03:00**	**67.5**	**4.7**	**10.8**	**17**	**5082.6**
24/10/2011 18:30	25/10/2011 09:30	15	25/10/2011 09:30	348.5	4.1	9.5	79	2986.1
09/12/2011 08:30	09/12/2011 10:00	1.5	09/12/2011 08:30	84.4	4.1	11.9	6	4669.0
05/01/2012 15:30	06/01/2012 05:00	13.5	06/01/2012 00:30	81.4	4.5	9.9	14	3896.6
03/04/2012 13:30	04/04/2012 10:30	21	04/04/2012 03:00	26.5	5.7	8.4	90	4510.0
24/09/2012 07:30	25/09/2012 11:00	27.5	24/09/2012 17:30	17.2	5.3	9.3	77	4786.2
26/10/2012 12:00	27/10/2012 15:00	27	26/10/2012 23:00	78.9	4.9	12.9	11	**7839.9**
05/12/2012 15:00	**15/12/2012 01:30**	**226.5**	**14/12/2012 18:30**	**39.6**	**6.1**	**8.4**	**107**	**5080.9**
20/12/2012 06:00	21/12/2012 14:30	32.5	20/12/2012 23:30	347.3	6.0	8.8	103	5436.3
18/01/2013 17:30	22/01/2013 07:30	86	21/01/2013 09:30	7.6	6.8	9.3	83	7978.4
06/02/2013 08:00	07/02/2013 08:30	24.5	06/02/2013 12:30	82.6	5.6	9.9	11	6039.7
07/03/2013 21:00	11/03/2013 04:00	79	08/03/2013 04:00	24.3	5.1	8.4	82	3667.4
18/03/2013 07:00	**25/03/2013 02:00**	**163**	**23/03/2013 10:30**	**4.5**	**7.3**	**9.3**	**89**	**9164.3**

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	**9678.4**
10/09/2013 13:00	10/09/2013 19:30	6.5	10/09/2013 14:00	79.3	4.4	9.2	11	3237.0
29/11/2013 22:30	30/11/2013 05:30	7	30/11/2013 00:30	82.8	5.6	10.7	11	7071.5
05/12/2013 14:00	07/12/2013 04:30	38.5	06/12/2013 20:00	80.4	4.7	14.3	6	8937.4
27/12/2013 09:30	27/12/2013 12:30	3	27/12/2013 10:00	249.3	4.1	6.1	202	1237.4

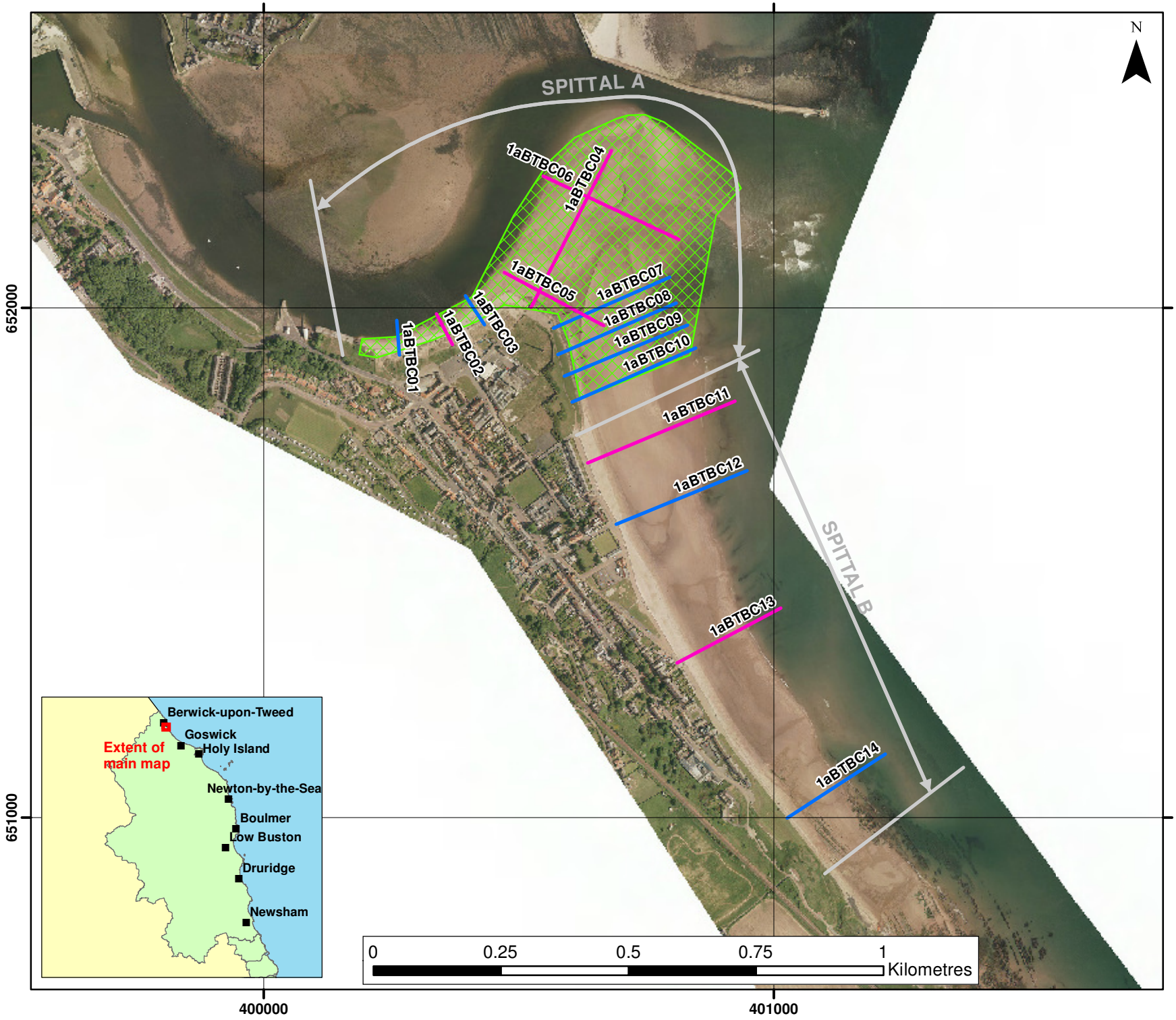
The storms mostly arrive from the north to northeast direction, 0 to 40 degrees, which has the longest fetch, but there are also a significant number of storms from other directions, particularly 80 to 140 degrees.

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

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

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

The storm on the 5th to 7th December, 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. However, the Autumn 2013 full-measures survey data set which is assessed in this report was collected in September and October and as no post storm surveys were available the impacts will be seen until the Spring 2014 Partial Measures surveys.



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
Sandstell Point (Spittal A)
Northumberland County Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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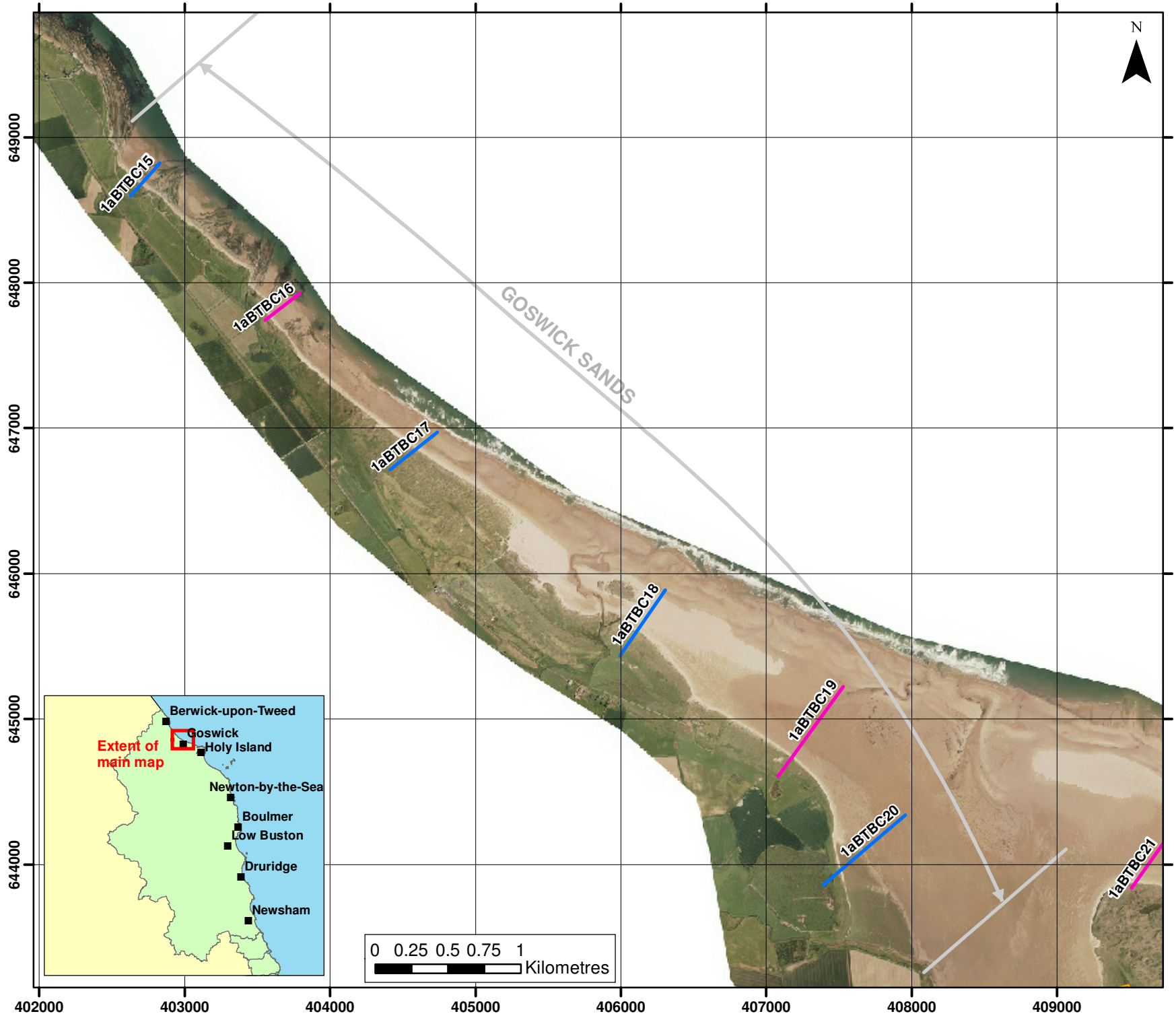

KEY

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 Goswick Sands Northumberland County Council

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Autumn 2013

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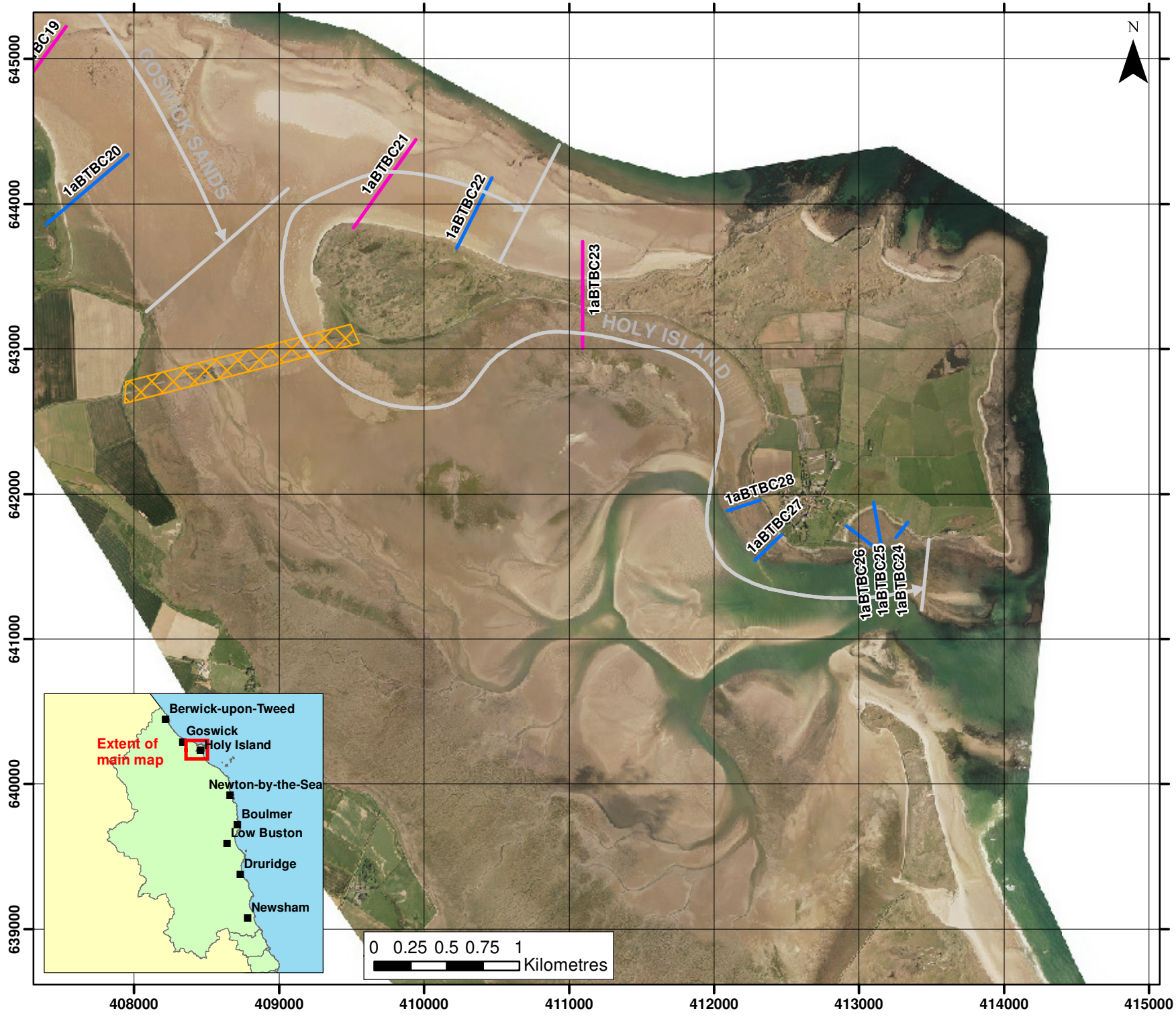

KEY

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
Holy Island
Northumberland
County Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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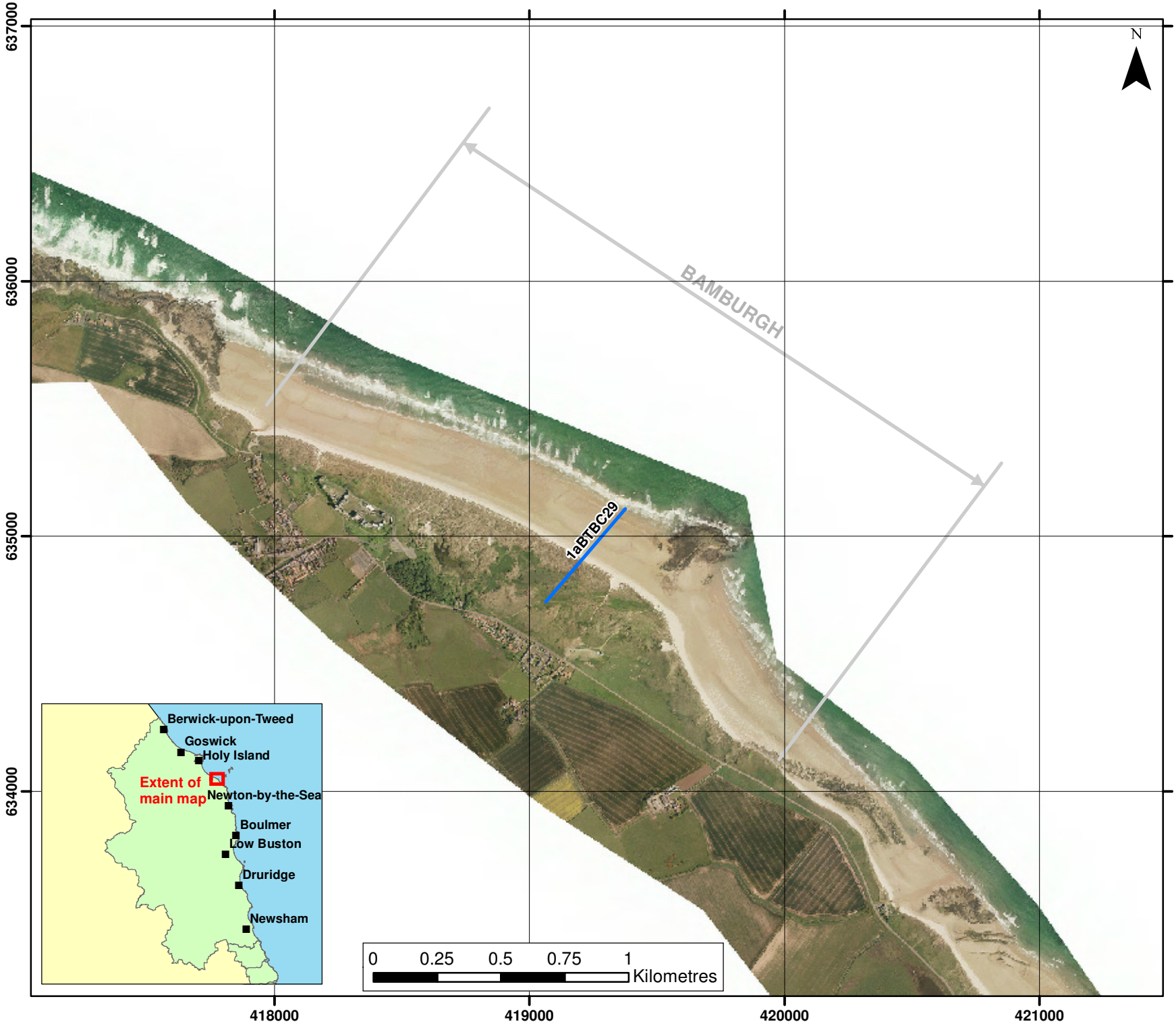

KEY

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 4
Survey Locations
Bamburgh
Northumberland
County Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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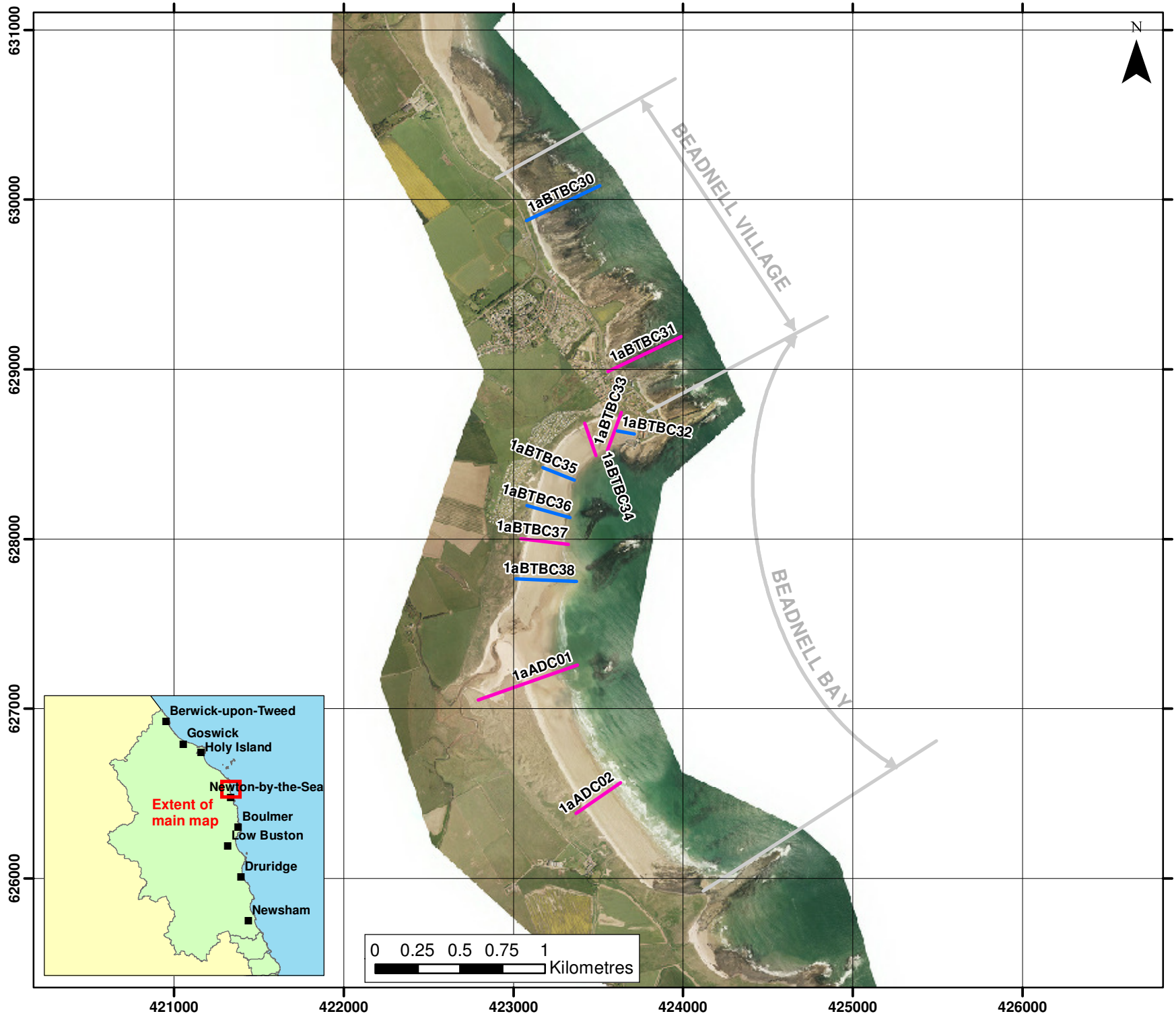

KEY

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
Beadnell Village and Bay
Northumberland County Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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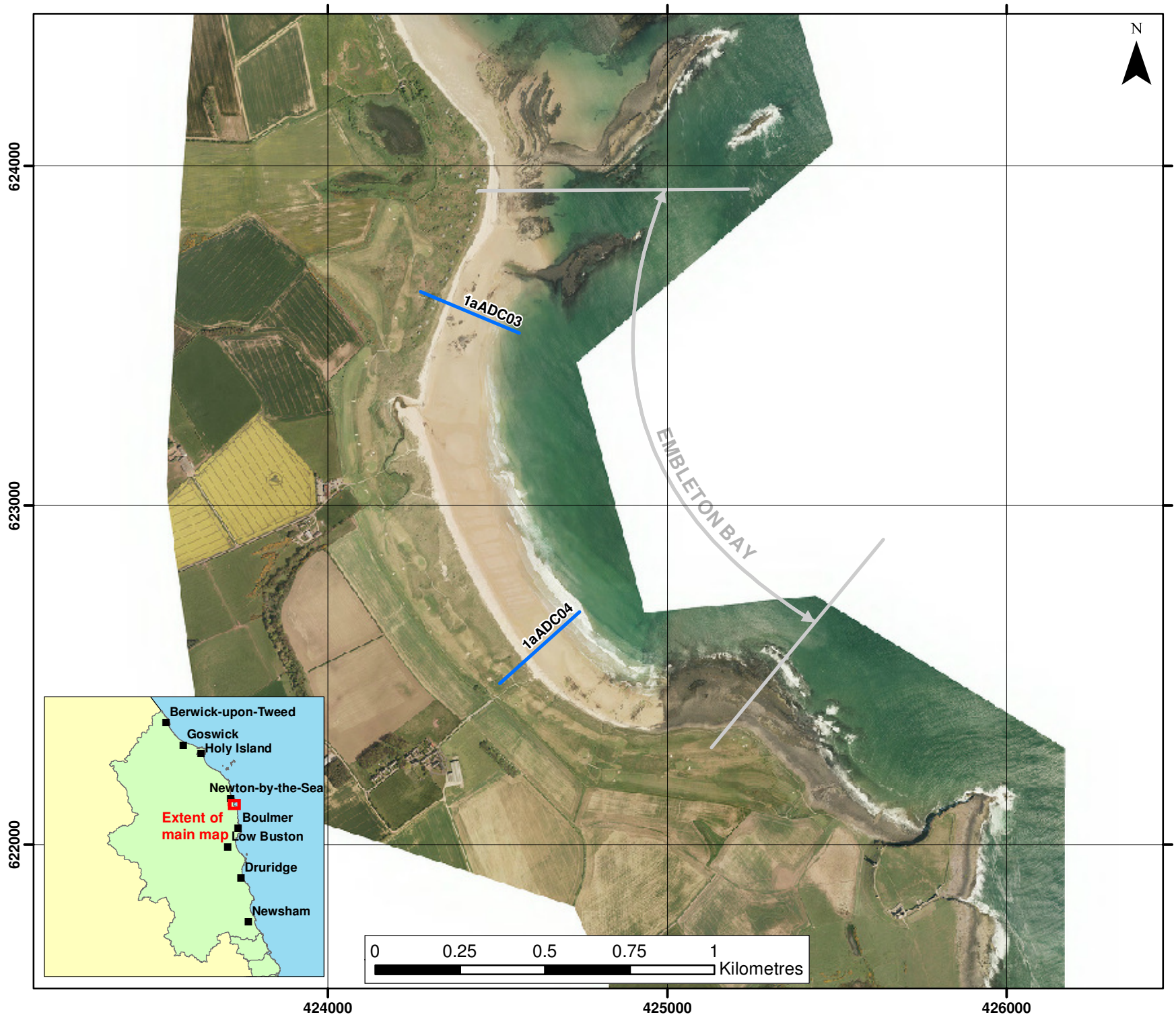

KEY

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
Embleton Bay
Northumberland
County Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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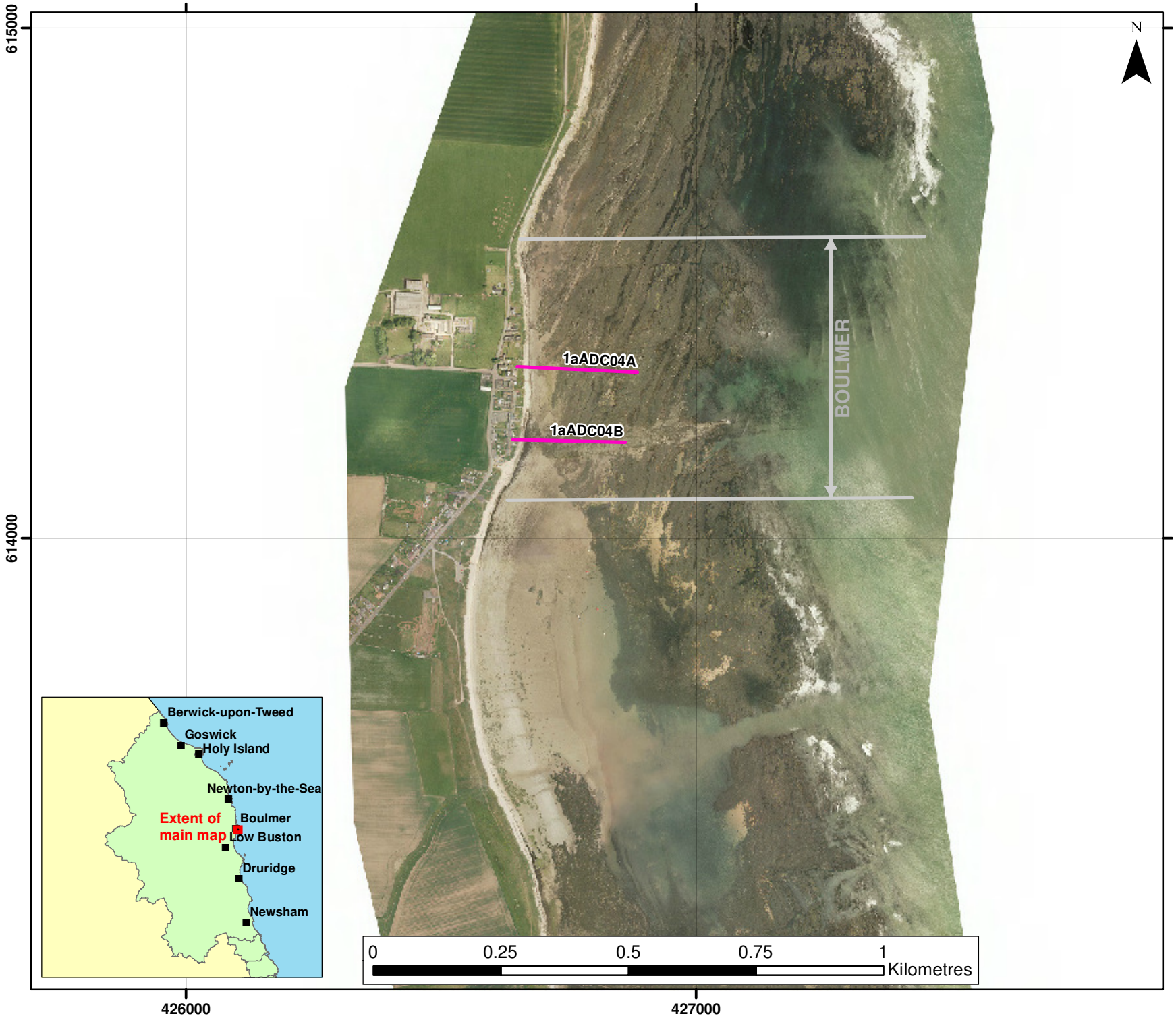

KEY

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
Boulmer
Northumberland
County Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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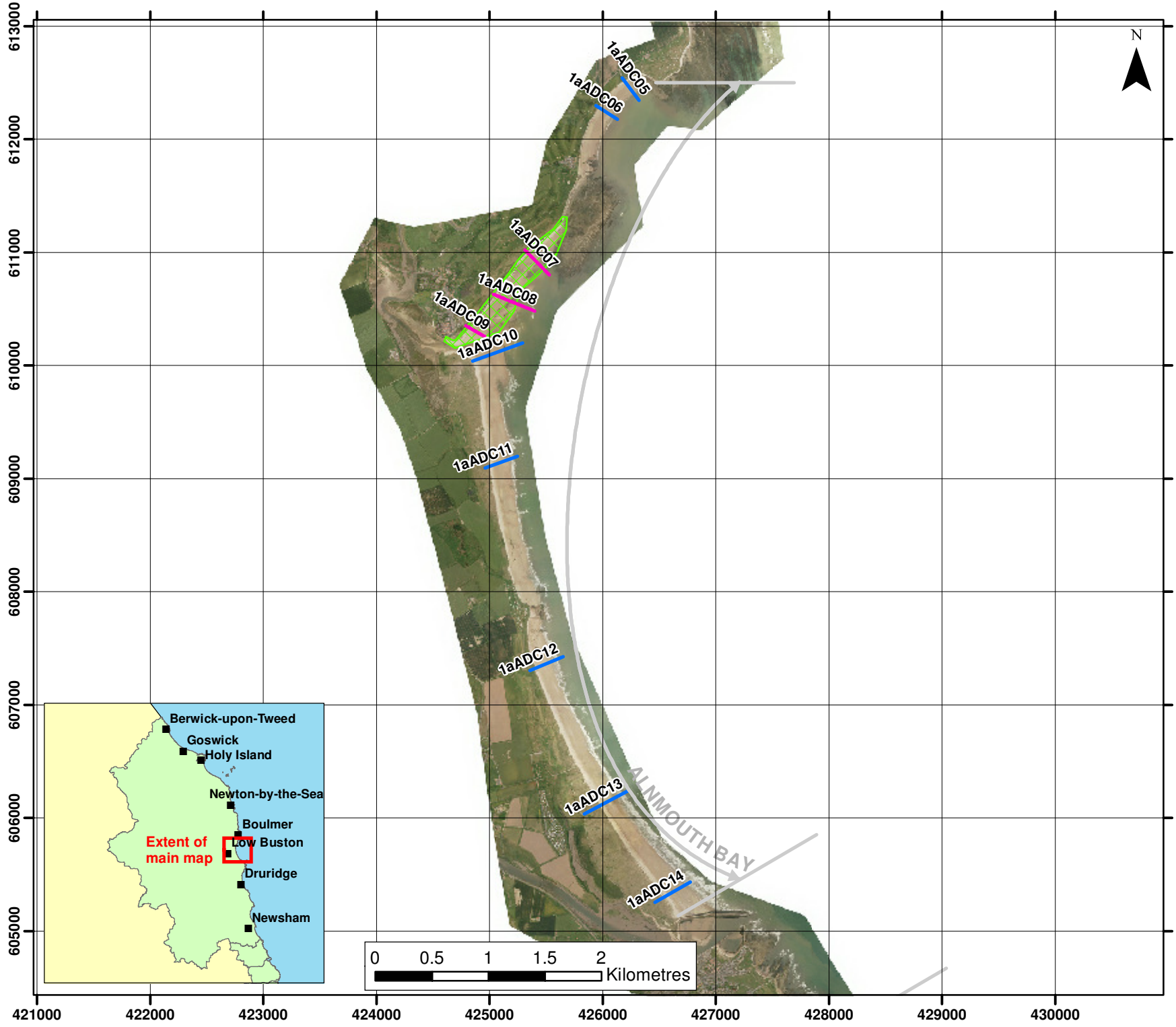

KEY

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
Alnmouth Bay
Northumberland
County Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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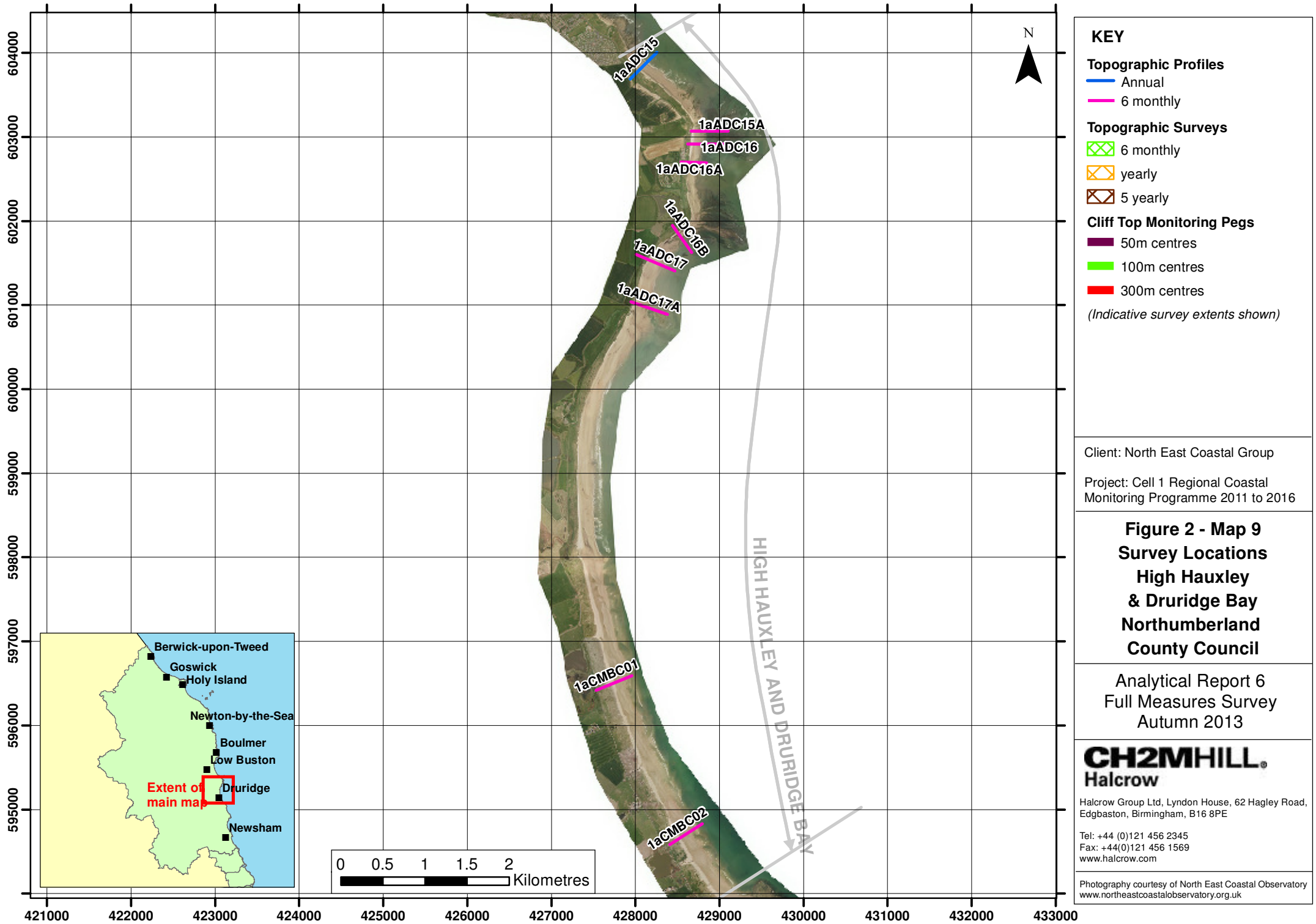

KEY

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 9
Survey Locations
High Hauxley & Druridge Bay
Northumberland County Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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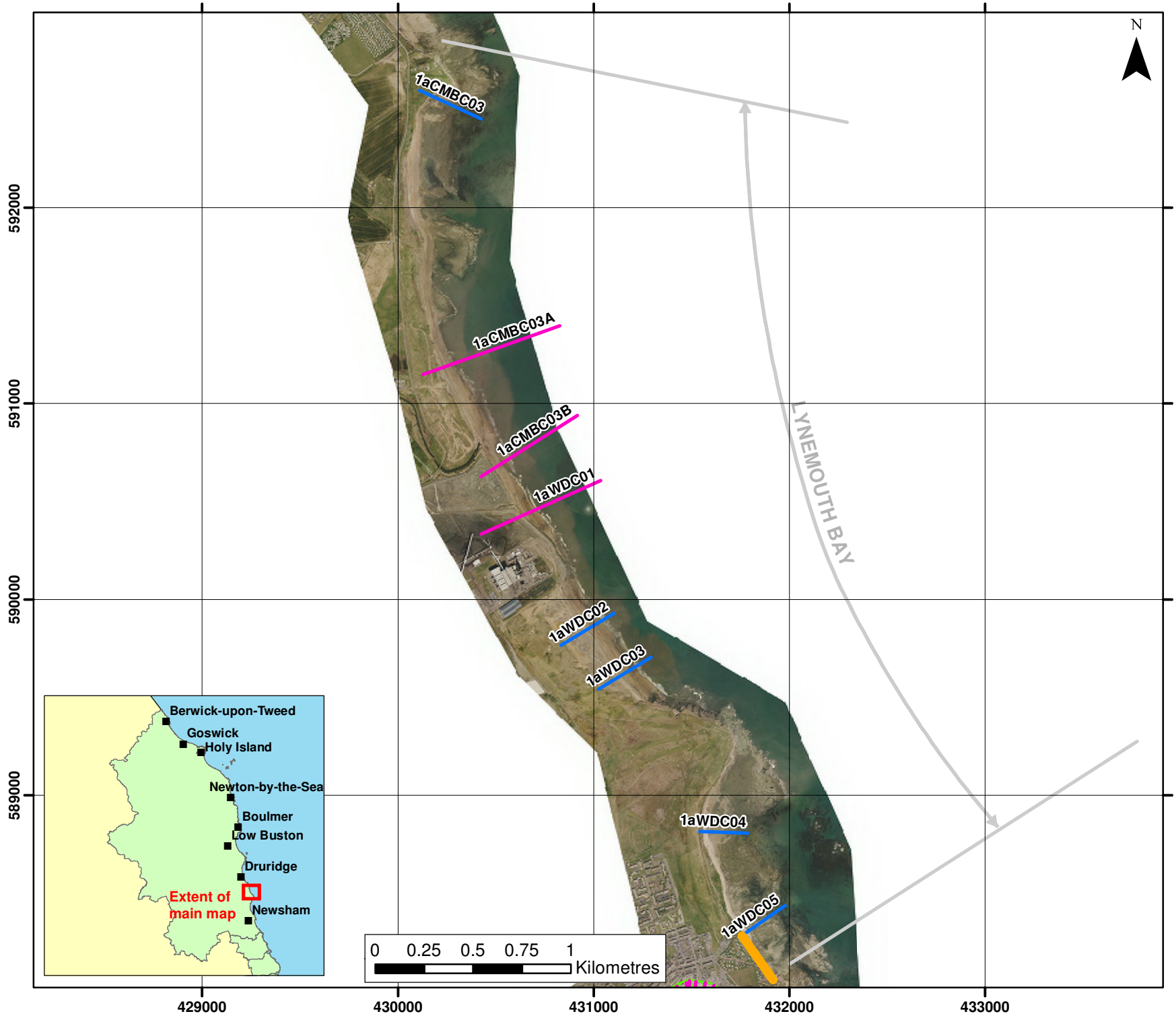

KEY

Topographic Profiles
- Annual
- 6 monthly

Topographic Surveys
- 6 monthly
- yearly
- 5 yearly

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

(Indicative survey extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Figure 2 - Map 10
Survey Locations
Lynemouth Bay
Northumberland County Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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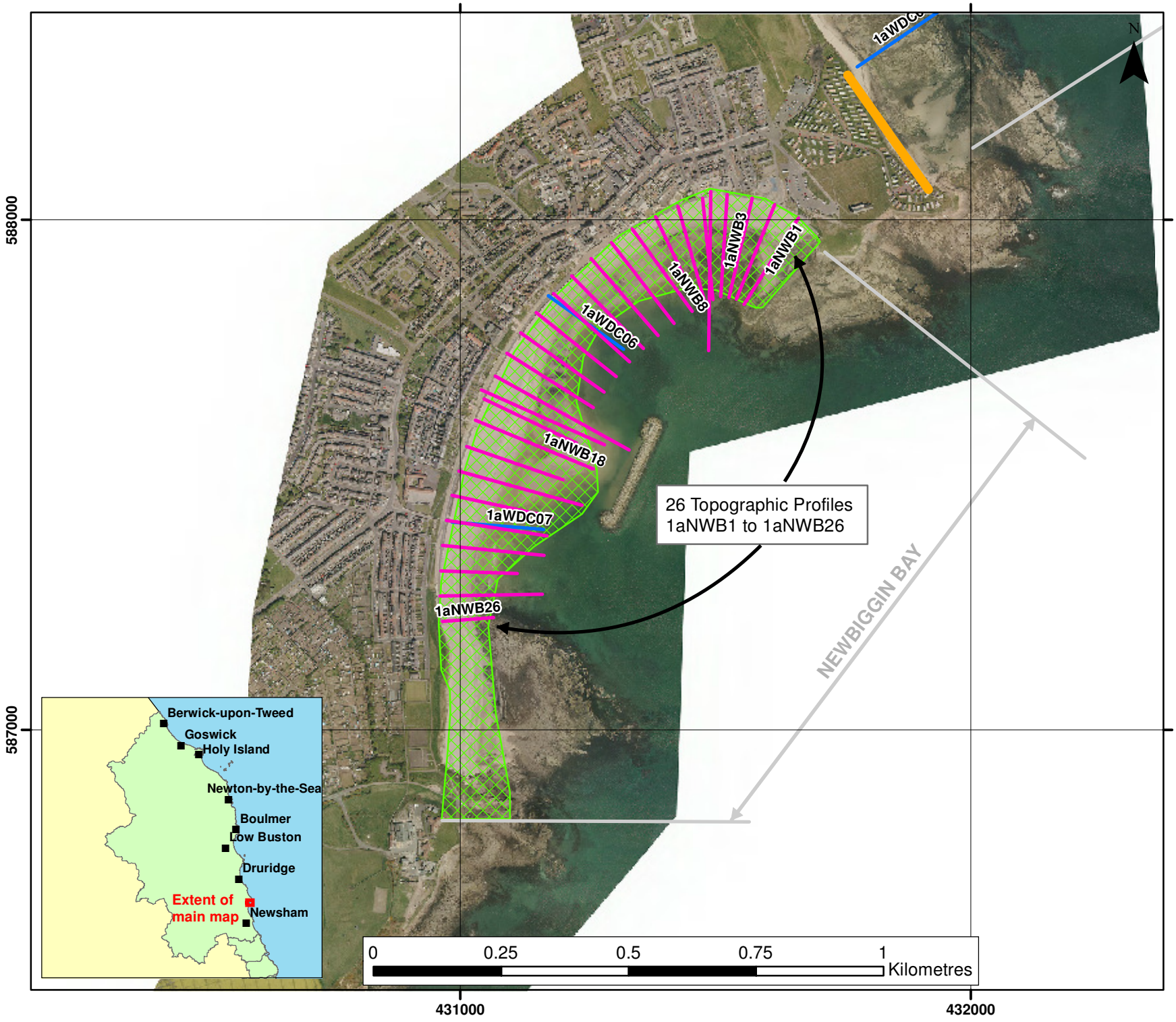

KEY

Topographic Profiles
- Annual
- 6 monthly

Topographic Surveys
- 6 monthly
- yearly
- 5 yearly

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

(Indicative survey extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Figure 2 - Map 11
Survey Locations
Newbiggin Bay
Northumberland County Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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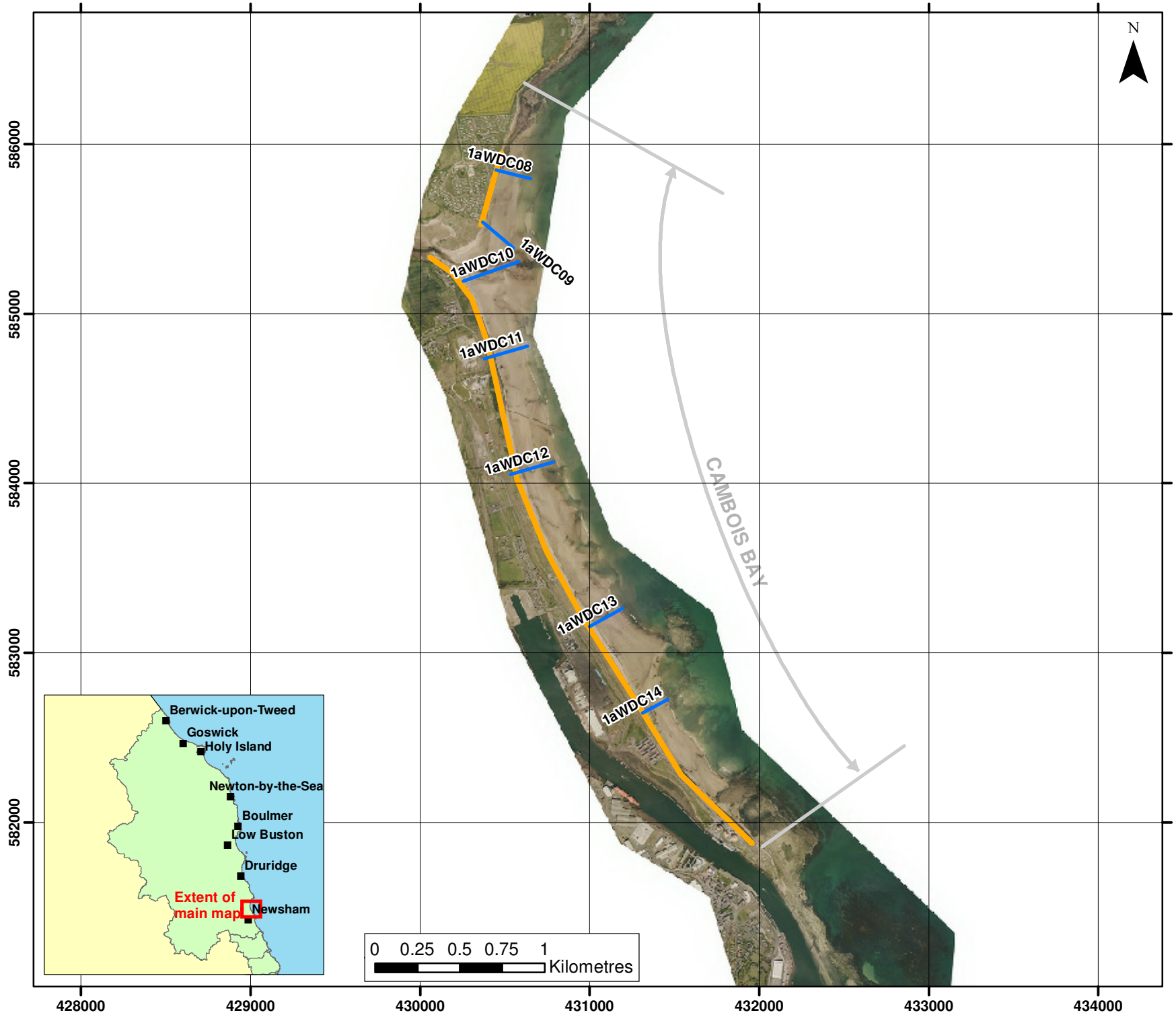

KEY

Topographic Profiles
- Annual
- 6 monthly

Topographic Surveys
- 6 monthly
- yearly
- 5 yearly

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

(Indicative survey extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Figure 2 - Map 12
Survey Locations
Cambois Bay
Northumberland County Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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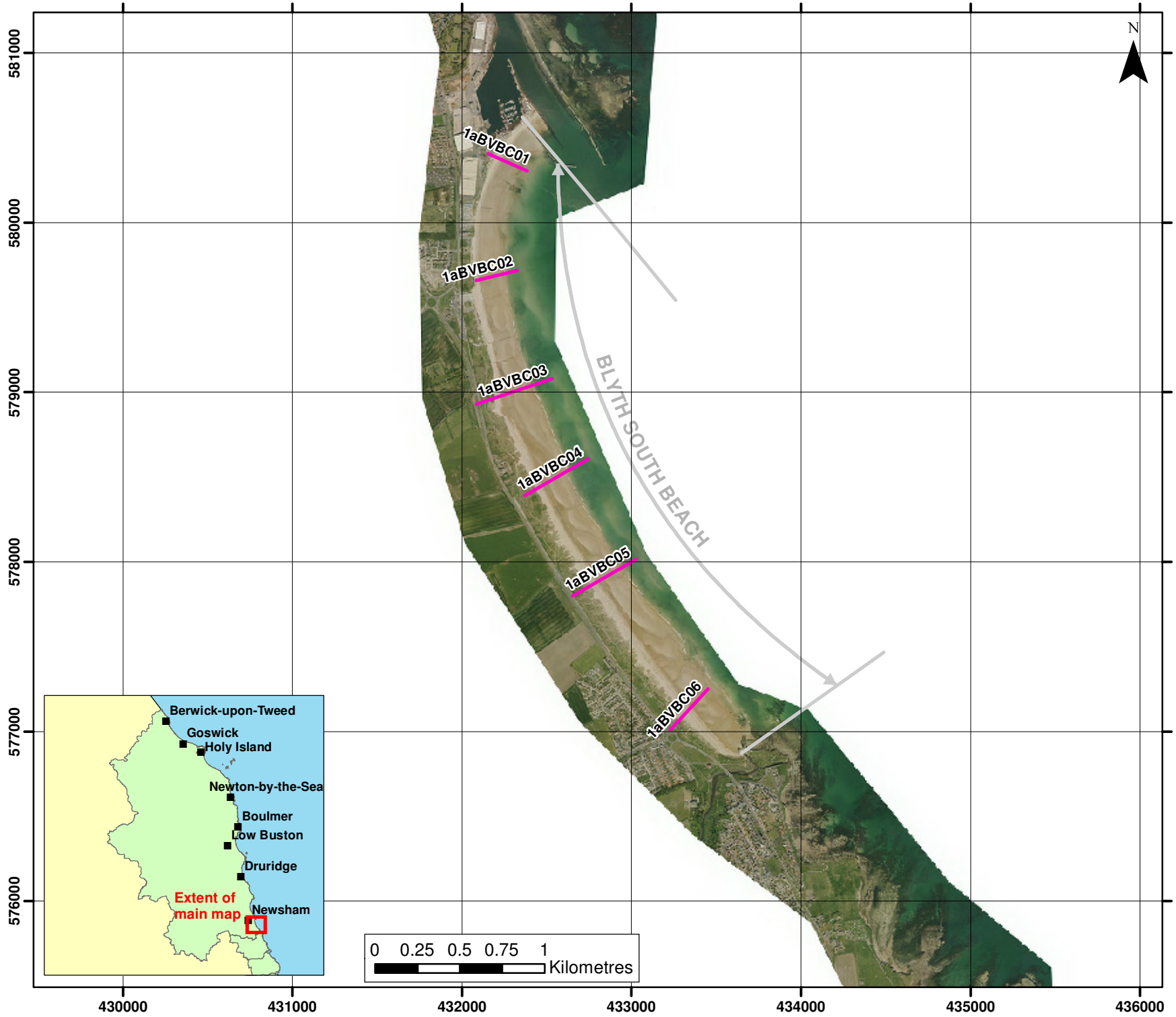

KEY

Topographic Profiles
- Annual
- 6 monthly

Topographic Surveys
- 6 monthly
- yearly
- 5 yearly

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

(Indicative survey extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Figure 2 - Map 13
Survey Locations
Blyth South Beach
Northumberland County Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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3. Analysis of Survey Data

3.1 Sandstell Point (Spittal A)

Survey Date	Description of Changes Since Last Survey	Interpretation
Sept 2013	**Beach Profiles:** Sandstell Point is covered by ten beach profile lines for the Full Measures survey (Appendix A). Profiles **1aBTBC01** to **1aBTBC03** are located on the southern bank of the River Tweed in front of the dunes. At **1aBTBC01** the beach form has remained the same and the levels have remained stable. There are no notable changes in beach elevation outside of the accuracy of the survey methods. At profile **1aBTBC02**, the dunes have remained mostly stable with only a slight fluctuation in height over the surface. The beach levels between 45m and 68m chainage have however decreased by approximately 0.2m to 0.3m. There is a distinct peak in the dune profile at about 20m chainage. This is likely to be an increase in vegetation rather than an increase in dune volume and is considered to be unrepresentative of the actual dune profile. Profile **1aBTBC03** has remained fairly stable across the beach and dunes. The fronting dune face has, however, cut back slightly however (up to 0.3m between 51m and 60m chainage). Profiles **1aBTBC04** (longitudinal section), **1aBTBC05** and **1aBTBC06** (both cross-sections) cover the spit at Sandstell Point. At profile **1aBTBC04**, the sand immediately at the toe of the defence (between 12m and 50m chainage) has cut back by up to 0.7m. Below this the profile has flattened off compared with previous surveys with accretion of up to 0.6m between 120m to 205m chainage and from 233m seawards. This accretion fills in the depression either side of the bar present in the 2013 Spring Survey. **1aBTBC05** and **1aBTBC06** are transects across the spit, drawn looking towards the south, with the open sea on the left-hand side of the plot and the river channel on the right-hand side of the plot. The beach profile at **1aBTBC05** has retained a similar form to the previous survey but translated along the profile (i.e. to the west). This change is smaller than the westerly movement recorded in the previous survey with about 9.5m movement compared to about 40m in the previous survey report. The trend of a westerly movement is however continuing. A ridge has also formed on the seaward edge of the profile at about 0.4m AOD. The profile at **1aBTBC06** has changed since the last survey. The profile has extended eastwards (towards the sea) and the ridge in the seaward face has moved up the beach to an elevation	The dunes along the south bank of the River Tweed have remained mostly stable since the last survey. Although the beach shows some fluctuation there are generally no major changes of concern. Since the last survey on Sandstell Point the beach has been particularly dynamic. Movement of the profiles landwards and seawards can be noted and there are changes in the position and height of the ridge features. To the immediate south of Sandstell Point, ridge features have developed on the beach profile, resulting in some areas of accretion and other areas of erosion. **Longer term trends**: The face of dunes on the southern bank of the inner estuary continues to accrete or remain stable, whilst beach levels fluctuate seasonally. Beach levels and beach form on Sandstell Point continue to fluctuate but in this particular survey they do not follow the seasonal pattern noted in previous surveys. Immediately south of Sandstell Point beach levels fluctuate with no discernible trend.

Survey Date	Description of Changes Since Last Survey	Interpretation
	of about 0.6m (previously -1.0m). The eastern peak on the beach has increased in height to about 1.4m from 0.7m and has widened. Previous survey reports have noted a seasonal trend along this profile, however, a seasonal trend is not clear in this survey. Profiles **1aBTBC07** to **1aBTBC10** are located along the open coast, at the intersection of the southern side of the spit at Sandstell Point and northern end of Spittal Beach. At profile **1aBTBC07**, beach levels have fallen by up to 1.7m between the backshore/rock revetment and approximately 110m chainage. Below this a bar has formed with an elevation of just below 0.3m, resulting in increased beach levels between 110m and 165m chainage and lower beach levels from 165m seawards. The changes observed at profiles **1aBTBC08** to **1aBTBC10** are repeated for each survey from north to south: (i) a drop in beach levels between the backshore/rock revetment and a approximately 60m chainage; (ii) the formation of a bar feature at the centre of the profile, at around a height of 0.8m (60m to 140m chainage); (iii) seaward of there, formation of a smaller bar feature at around 200m chainage, resulting in higher beach levels at the toe of the profile; (iv) photographs indicate that the ponded water observed to have not been present in the previous survey has returned (see Plate 1).	
Sept 2013	**Topographic Survey:** Due to the significant changes that have been observed from the beach profiles along the spit at Sandstell Point, and the three dimensional nature of these changes, a topographic survey was introduced to the monitoring programme in November 2009. Data from the most recent topographic survey (full measures, autumn 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 (partial measures, spring 2013) and the present survey. In particular, the difference plot shows: (i) An area of reduced beach levels at the toe of the dunes on the point (ii) a band of reduced beach elevation orientated north to south on the eastern side of the Sandstell Point with a parallel band of accretion – this shows the movement of the bar westwards across the spit as noted in the profile analysis; (iii) Discrete areas of accretion on the western edge of the spit (iv) Patches of accretion on the main spit which are likely to be areas of infill contributing to a less undulating longitudinal profile as noted in the profile assessment.	Comparison of the present topographic survey with the previous partial measures (spring 2013) survey shows a band of reduced elevation (i.e. erosion) that runs along the spit and a parallel band of increased elevation (i.e. accretion) to the west. It is likely that the material eroded from the zone of reduced elevation is deposited in the zone of increased elevation to form a bank and represents the westwards movement of the berm. This change is reflected in the beach profiles. **Longer term topographic trends Autumn 2011 to Autumn 2013:** The plot shows distinct zones of beach elevation increase and decrease. This is reflective of a spit, with berms and troughs generated via seasonal changes and fluvial/ tidal flows along the spit. While there have been areas of significant erosion, these are matched by areas of significant accretion indicating

Survey Date	Description of Changes Since Last Survey	Interpretation
	Longer Term Topographic Trends Autumn 2011 to Autumn 2013: The long term difference plot (Appendix B – Map 1c) shows the net change in beach levels between autumn 2011 and autumn 2013. The plot shows distinct zones of change. The inland (i.e. western) half of the body of the spit is dominated by a north-south trending band of erosion that has experienced up to 3m net loss, but there is a narrow area adjacent to MLW which has experienced accretion of a similar amount. The seaward (i.e. eastern) half of the spit has experienced a more uneven pattern of change, with patches in the body of the spit experiencing net accretion of up to 2m, and erosion of up to 1m at areas of the seaward face.	that the spit is a dynamic landform in the short term that is stable over the longer term.

Plate 1 – Survey photograph 1aBTBC09_20130920_SN5.JPG

3.2 Spittal (Spittal B)

Survey Date	Description of Changes Since Last Survey	Interpretation
Sept 2013	**Beach Profiles:** Spittal B is covered by four beach profile lines for the Full Measures survey (Appendix A). Profiles 1aBTBC11 and 1aBTBC13 were last surveyed during the partial measures spring survey, 2013. Profiles 1aBTBC12 and 1aBTBC14 were last surveyed during the full measures autumn survey 2012. At profile **1aBTBC11** there has been a reduction in beach crest level of about 1m. The beach has then built out at around MHWS (between 19m and 39m chainage). From 39m chainage the beach steepens and three ridges with intervening troughs have formed. The reforming of the beach profile has resulted in an overall lowering of the beach levels between 40m to 89m chainage and 137m to 200m chainage, but an increase in beach level between 118m and 134m chainage. Visual observations indicate that this may have overall resulted in decreased beach volumes. At profile **1aBTBC12**, a similar pattern to **1aBTBC11** is noted. There has been a reduction in beach crest level of up to 0.5m. The beach has then built out at around the MHWS level, between 12m and 32m chainage. From 32m chainage the beach has then steepened and a trough has formed at about 50m chainage, resulting in erosion of up to 1.2m at this location. Beach levels then raise into a bar feature resulting in a slight increase in beach level between 70m and 105m chainage. Similarly to profile 1aBTBC11 and 12, the crest level at profile **1aBTBC13** has decreased by c. 0.3m and the beach below this has built outwards around the MHWS level. As with other profiles along Spittal, the beach then steepens following erosion of the beach levels between 45m and 65m chainage. Seawards of this however the bar feature previously present has lowered resulting in a drop in beach elevation of up to 0.6m from 80m chainage to the end of the profile. At profile **1aBTBC14** beach levels at the top of the beach have increased by approximately 1.3m between 0m and 12m chainage. This brings the beach crest level closer to the 2011 level, indicating recovery of this part of the beach following the drop in beach crest level recorded in the 2012 survey. However, beach levels seawards of this have significantly decreased along the rest of the profile, with bedrock now being exposed where it was previously covered with sand (see Plates 2 and 3). This bedrock was exposed in the 2003 profile survey but has been mostly covered since 2004.	At profiles surveys 6-monthly, since the last survey, the beach at 1aBTBC11 and 1aBTBC13 have behaved similarly with a reduction in level of the crest and development of berms and troughs. At profiles surveys annually, since the last survey the beach levels across much of 1aBTBC12 and 1aBTBC14 have significantly decreased in height, with bed rock being exposed at 1aBTBC14. The lowering of the beach levels and formation of bars and troughs is likely to be the result of storm conditions experienced on 10th September 2013 recorded by the wave buoy. The crest level at 1aBTBC14 has increased from the previous survey (that noted a 1.5m drop), recovering to a more typical elevation. **Longer term trends:** At all profile locations along Spittal Beach, the changes observed in the present survey are within the bounds of previous surveys. The one notable difference is at profile 1aBTBC12, where the beach level at the base of the trough feature (50m chainage) is at the lowest level of all surveys to date for this part of the profile. The notable fall in beach levels at 1aBTBC14 and smaller fall in beach levels (in part) at the profiles to the north suggests a trend in the movement of material from the south of Spittal beach to the north.

Plate 2 – Survey photograph 1aBTBC14_20130920_N4.JPG

Plate 3 – Survey photograph 1aBTBC14_20121018_N3.JPG

3.3 Goswick Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
Sept 2013	**Beach Profiles:** Goswick Sands are covered by six beach profile lines for the Full Measures survey (Appendix A), two of which are re-surveyed for the Partial Measures survey. The profiles along this frontage extend from **1aBTBC15** to **1aBTBC20** in a north to south direction. The seaward face of the dunes along the length of Goswick Sands have not changed form or position since the last survey (combination of full measures, autumn 2012 and partial measures, spring 2013). At profile **1aBTBC15** beach levels have decreased by approximately 0.5m at the top of the beach between 120m and 190m chainage and at the toe of the beach between 220m chainage and the end of the profile. Between these chainages the profile has remained stable, forming a gentle ridge feature. At profile **1aBTBC16** beach levels at the dune toe have increased by up to 0.65m. The remainder of the profile also increases in level but by a smaller amount (in the region of 0.3m). At the toe of the beach however, the previous berm has been eroded resulting in a decrease in level of up to about 1.7m. At profile**1aBTBC17** a similar pattern can be seen as for **1aBTBC16**. Beach levels have increased across much of the beach profile but with a small decrease in beach elevation at the profile toe. At profile **1aBTBC18, 1aBTBC19 and 1aBTBC20**, beach levels can be considered stable. Erosion can be noted across all profiles, however the beach levels have dropped by <0.1m , which could be the result of error within the survey methods.	The seaward face of the dunes along the length of Goswick Sands has not changed form or position since the last survey (combination of full measures, autumn 2021 and partial measures, spring 2013). To the north of Goswick Sands, at Cocklawburn Beach, beach levels have generally decreased since the last survey. Adjacent to Far Sker and opposite Chesick, beach levels have increased slightly across much of the beach profile. At Goswick, south of Goswick Sands and towards Snook Point, beach levels have remained generally stable. **Longer term trends:** There are no long-term trends in beach profile or form evident, with the continuation of seasonal behaviour.

3.4 Holy Island

Survey Date	Description of Changes Since Last Survey	Interpretation
Sept 2013	**Beach Profiles:** Holy Island is covered by eight beach profile lines for the Full Measures surveys (Appendix A). **1aBTBC21** to **1aBTBC23** are located on the north-west side of the island, along The Snook. At all profiles, the dunes have not changed in form or position since the last survey. Beach levels have also remained largely the same since the last survey with only minor decreases in beach level observed (<0.1m).**1aBTBC24** to **1aBTBC28** are located on the south side of the island in the vicinity of the castle and priory. **1aBTBC27** extends out to and across the small island upon which the remains of a chapel stand. All profiles show very little change since the previous survey.	The dunes, sandy foreshore and sand flats around Holy Island remain very stable in both form and position, which is a repeat of the trend observed in previous surveys (refer to full measures, autumn 2012). **Longer term trends:** The trends observed from the present survey are a continuation of trends observed in the past, whereby the dunes and beach have retained the same form and position.
Oct 2013	**Topographic Survey:** Holy Island causeway and a defined width of adjacent sand flats are covered by an annual topographic survey, which commenced in October 2004. The purpose of this survey was to determine whether raising the level of the causeway had any adverse impacts on the adjacent sand flats. Data from the most recent topographic survey (full measures, autumn 2012) have been used to create a 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) produced from the last produced topographic survey (full measures, autumn 2012) and the present survey. In particular, the difference plot shows: (i) an overall slight increase in elevation of less than 0.25m; and (ii) slight accretion in the centre-west of the causeway associated with a natural channel. **Longer Term Topographic Trends Autumn 2008 to Autumn 2013:** The long term difference plot (Appendix B – Map 1c) shows the net change in beach levels between autumn 2010 and autumn 2012. The plot shows that over the long term, there has been very little change, with elevation difference being generally accretion of less than 0.25m in a pattern similar to that seen over the last 12 months. The area of most change is associated with the channel.	The topographic survey shows that the causeway has generally remained stable since the last survey. The topographic survey report notes '*sand is encroaching on eastern end of causeway'*, which suggests that there is sufficient and possibly an increase in the supply of sediment in the vicinity of the eastern end of the causeway. **Long term trends:** The longer term trends are covered by the long term topographic trends autumn 2010 to autumn 2012 (see below). **Longer term topographic trends Autumn 2010 to Autumn 2013:** The long term difference plot of topography shows that over the long term, there has been very little change, with elevation difference being a general increase of less than 0.25m. Greatest change is associated with natural migration of a channel

3.5 Bamburgh

Survey Date	Description of Changes Since Last Survey	Interpretation
Oct 2012	**Beach Profiles:** Bamburgh is covered by one beach profile line for the Full Measures survey (Appendix A). Profile **1aBTBC29** located approximately 750m south-east of the castle. The dune has not changed form or position. Seaward of MHWS, beach levels have decreased across the profile by up to 0.5m.	The dunes at Bamburgh have remained stable since the last survey (full measures, 2011), whilst the beach has lowered. **Longer term trends:** The overall form and position of the beach profile is similar to the previous surveys.

3.6 Beadnell Village

Survey Date	Description of Changes Since Last Survey	Interpretation
Oct 2013	**Beach Profiles:** Beadnell Village is covered by two beach profile lines for the Full Measures survey (Appendix A). **1aBTBC30** is around 300m to the north of the village. The dune has not changed form or position. Beach levels have generally decreased by about 0.4m along the profile from the dune toe seawards. **1aBTBC31** is in Nacker Hole and extends across the promenade and seawall. Since the last survey, beach levels at the toe of the seawall have decreased by up to 0.4m. The profile then accretes slightly, (by approximately 0.2m) between 22m and 32m chainage. The remainder of the profile remains stable.	The dunes to the north Beadnell Village have remained stable but there has been a decrease in beach levels across the length of the profile. To the south, at Nacker Hole, the beach has generally remained stable with some fluctuations along the profile **Longer term trends:** The dunes and beach at Beadnell has remained generally stable in the longer term. The profile form and position is largely within the bounds of previous surveys with no discernible trends in behaviour.

3.7 Beadnell Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
Oct 2013	**Beach Profiles:** Beadnell Bay is covered by nine beach profile lines for the Full Measures survey (Appendix A). **1aBTBC32** to **1aBTBC34** are located to the north of Beadnell Bay, in Beadnell Harbour. BTBC32 is immediately in the lee of Beadnell Harbour. The dunes at **1aBTBC32 to 1aBTBC34** have not changed from or position, however at profile 1aBTBC33, the surveyor's report notes '*middle of dunes missing due to dense vegetation*'. At profile **1aBTBC32**, beach levels have consistently dropped by up to 0.1m. At profile **1aBTBC33**, beach levels have fluctuated with no clear trend. At profile **1aBTBC34**, beach levels are also fluctuating around the previous survey. The beach level has increased at the toe of the dune (0m to 40m chainage) by up to 0.4m, in the middle of the beach profile between 45m and 75m chainage by 0.3m and at the toe of the profile between 135m and 170m chainage by approximately 0.5m where a berm has formed. Seaward of this, erosion is evident at the profile toe. The rocky section in the middle of the profile has remained stable. **1aBTBC35** to **1aBTBC38** are located between Burn Carrs and the outfall of Brunton Burn/Long Nanny. The dune face has not changed along this section of the beach. At **1aBTBC35**, between the toe of the dunes and 135m chainage, beach levels have decreased by up to 0.4m. Seaward of this the beach level has decreased by up to 0.2m. At profile **1aBTBC36**, beach levels have largely remained stable, with the exception of a small section at the toe of the profile, where beach levels have increased by c. 0.5m due to the formation of a berm. At profile **1aBTBC37**,two berms have formed on the beach profile resulting in accretion at the location of the berms by up to 0.4m at 110m to 190m chainage, and by up to 0.8m from 225m chainage to the seaward end of the profile. At **1aBTBC38** there is no clear trend of change. Erosion of up to 0.3m has occurred on the upper beach and of up to 1m at c. 150m chainage, creating a trough in the profile separated by two ridges. **1aADC01** and **1aADC02** are located south of the outfall of Brunton Burn/Long Nanny. The dunes have not changed from or position. Beach levels have varied across the profiles with the upper beach steepening on both profiles. The berm at the toe of profile **1aADC01** has moved landwards by approximately 15m.	Along the length of Beadnell Bay, the dunes have remained stable, retaining the same form and positions since the last surveys (partial measures, 2013 and full measures, 2012). In the lee of Beadnell Harbour, the beach levels have raised slightly. To the north of Beadnell Bay, beach levels have fluctuated around the previous profiles with no clear trend of erosion or accretion. To the middle of the Bay the beach levels have fluctuated and berm features have formed on the lower profile. To the south of Beadnell Bay, the beaches are generally stable with slight fluctuations in elevation and some beach steepening. **Longer term trends:** Along the length of Beadnell Bay, the majority of the dune and beach form are similar to those observed in the past and the profile form and position is within the bounds of previous surveys.

3.8 Embleton Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
Oct 2013	**Beach Profiles:** Embleton Bay is covered by two beach profile lines for the Full Measures survey (Appendix A). **1aADC03** is located towards the north of the bay, north of Embletonburn mouth. **1aADC04** is located towards the south of the bay. At both locations the dunes have not changed form or position. Beach levels have decreased by up to 0.7m, with the largest decrease at about MSL (0.03mAOD). The profiles are at their lowest recorded level since the surveys began in 2002.	The dunes at Embleton Bay are stable. The beach levels have fallen across the profile, with the greatest decrease in level at about MSL. Storm conditions were recorded at the Tyne and Tees wave buoy on 10th September 2013. It is possible that the beach levels here dropped as a result of the storm waves and that the beach has not yet fully recovered. **Longer term trends:** The dunes have remained stable over the longer term. The beach profiles are at their lowest recorded level since the survey programme began in 2002.

3.9 Boulmer

Survey Date	Description of Changes Since Last Survey	Interpretation
Oct 2013	**Beach Profiles:** Boulmer is covered by two beach profile lines for the Full Measures survey (Appendix A). These were added to the programme in October 2007. At profiles **1aADC04A** the dune cliff backshore has accreted by approximately 0.2m (15m to 29m chainage) and the lower slope has eroded by approximately 0.25m (30m to 60m chainage). The small berm at HAT in earlier surveys, which was not present in the previous survey (Spring 2013), has reformed at MHWS. At **1aADC04B** the dune cliff backshore has not changed form or position. The beach level has dropped by approximately 0.35m along the lower slope from below MHWS to the rocky lower section.	The backshore at Boulmer has remained stable. Beach levels have dropped slightly along the middle sections of the profiles between the upper slope and the rocky lower section. **Longer term trends:** Cutback of the backshore at profile 1aADC04A has been an ongoing trend but is not present in this most recent survey. The profile form and position is within the bounds of previous surveys.

3.10 Alnmouth Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
Oct 2013	**Beach Profiles:** Alnmouth Bay is covered by ten beach profile lines for the Full Measures survey (Appendix A). **1aADC05** and **1aADC06** are located in the small pocket beach that is situated between the rock outcrops of Seaton Point and Marden Rocks. Along these profiles the upper beach has steepened and the lower beach has flattened, through accretion at the toe of the cliff and the toe of the profile, and erosion between. **1aADC07**, **1aADC08** and **1aADC09** are located to the north of Alnmouth Bay between Marden Rocks and the mouth of the River Aln Estuary. At profile **1aADC07** and **1aADC08** the front face of the dunes has remained stable since the last survey (partial measures, spring 2013), with the exception of the dune toe where beach levels have risen by up to 0.6m around HAT/MHWS. The three berms present on the beach profile in spring 2013 have moved landwards resulting in segments of erosion and accretion along the profile, but no clear trend. At profile **1aADC09** the front face of the dunes has remained stable since the last survey. Beach levels have fluctuated along the profile with accretion at the toe of the dune and the toe of the profile, but erosion of up to 0.5m between 60m and 120m chainage. The beach profiles **1aADC07**, **1aADC08** and **1aADC09** have reformed but there is no clear trend of erosion or accretion since the previous survey. **1aADC10** to **1aADC14** are located between the south bank of the River Aln Estuary and the north breakwater of Warkworth Harbour at the mouth of the River Coquet Estuary. With the exception of profile **1aADC10**, where beach levels at the dune toe have accreted forming a step in the profile, the dunes have not changed in position or form since the last survey (full measures, autumn 2012). Initial assessment of the beach profiles indicates that material has been drawn down the profile from the top of the beach. Observations by the surveyor of a sand bar out to sea off **1aADC12** and **1aADC13** further support this. At **1aADC10** the upper beach (below the dune toe accretion) has lowered by up to 1m, while the lower beach has accreted by as much as 1.5m, forming a berm at the toe of the profile. At **1aADC11,** beach levels have generally decreased. Profile **1aADC13** and **1aADC14** have accreted on the upper beach at the toe of the dune, but eroded on the lower slope. The erosion at **1aADC14** is obviously greater that the accretion, however it cannot be seen from visual comparison if there is an overall trend of erosion or accretion at **1aADC13.** It is possible that material from the lower slope has	Between Seaton Point and Fluke Hole, the beach has shown trend of steepening of the upper beach and flattening of the lower beach. To the north of Alnmouth Bay, the face of the dunes has remained stable since the last survey. While the beach profiles have changed form there is no trend of erosion or accretion. This follows past observations and it was noted in the Autumn 2011 report, '*the beaches to the north of Alnmouth Bay are dynamic, evident by the cross-shore movement of material*'. Changes along this section of coast are also likely to be affected by channel movements in the Aln Estuary and flow into and from the channel. Between the entrances to Aln Estuary and the North Pier of Warkworth Harbour at the estuary of the River Coquet, the dunes have not changed in position or form since the last survey in autumn 2012. Beach levels have fluctuated in this area, with material transported towards MLW, changing the beach slope. This may be the result of storm conditions on 10th September 2013 and is likely to be transient. To the south of the area an offshore bar was noted in the survey report. At the most southern profile the beach levels had fallen overall, indicating beach material may have been moved offshore to form the observed bar. **Longer term trends:** Between Seaton Point and Fluke Hole, the profile form and position is largely within the bounds of previous surveys. However, the

Survey Date	Description of Changes Since Last Survey	Interpretation
	been moved to form the offshore bar.	eroded section towards the middle of the profiles (at an approximate elevation of 0.2m to 0.4m) is the lowest level recorded since records began in 2002. Along the length of Alnmouth Bay, the dunes have remained stable since 2008. The beach to the north, at the entrance to the Aln Estuary is dynamic, with trends determined by channel movements in the Aln Estuary and flow into and from the channel. The two profiles in this area exhibit the lowest levels recorded since 2002 in some lower sections of the profiles. To the south, the beaches are less dynamic but the profile form and position is towards the lower bounds of previous surveys.
Oct 2013	**Topographic Survey:** The northern part of Alnmouth Bay (to the north of the River Aln Estuary) is covered by a bi-annual topographic survey, which commenced in April 2005. Data from the most recent topographic survey (full measures, autumn 2012) have been used to create a DGM (Appendix B – Map 3a) using GIS. A difference plot has also been produced using the DGM (Appendix B – Map 3b) comparing the last produced topographic survey (partial measures, spring 2013) with the present survey. The difference plot shows discontinuous alternating bands of change with magnitude of up to 1m. There is no discernible trend of erosion or accretion. **Longer Term Topographic Trends Autumn 2011 to Autumn 2013:** The long term difference plot (Appendix B – Map 3c) shows the net change in beach levels between autumn 2011 and autumn 2013. The plot shows a similar pattern to that seen over the last 12 months. However, there is a consistent pattern of erosion at the back of the back of the beach/cliff edge, mean MLW and on the whole foreshore fronting Alnmouth village where over 1m of lowering has occurred. The plot shows a general increase in beach elevation of c. 1m across the middle of the beach.	The findings of the topographic survey show patchy bands of increased elevation interspersed with patchy bands of decreased elevation. When assessed with the profile data this shows berm features moving landwards up the beach. There is unlikely to be a net change in beach volume. **Long term trends:** The pattern of change seen over the last 12 months is similar to that seen in past years. **Longer term topographic trends Autumn 2011 to Autumn 2012:** The alternating pattern of changes over the face of the beach reflects the dynamic nature of the shoreline in response to tides and estuary flows. The focus of erosion on the beach fronting the village is likely a relatively short-lived effect of estuary channel migration.

3.11 High Hauxley & Druridge Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
Oct 2013	**Beach Profiles:** High Hauxley to Druridge Bay is covered by nine beach profile lines for the Full Measures survey (Appendix A). Four of these (with 'A' or 'B' suffixes) were added to the programme in October 2007.All except 1aADC15 are resurveyed every 6-months. Profile **1aADC15** extends across the extensive dunes at Amble Links and foreshore. The surveyed dunes have remained stable since the last survey (full measures, autumn 2012) with some accretion at the dune toe. Beach levels have increased along much of the length of the profile by approximately 0.5m. **1aADC15A**, **1aADC16** and **1aADC16A** are located around Hauxley Haven. At all locations, the front face of the dunes has remained stable since the last survey (partial measures, spring 2013). At profile **1aADC15A** a small berm has developed at around HAT with an increase in beach level at the berm location of 0.3m, while below this the upper part of the beach profile has eroded (35m to 106m chainage) and the lower foreshore has accreted (106m to 200m chainage); leading to a flatter beach profile., At profile **1aADC16** a berm has again developed at about HAT level, but is larger in size with an increase in beach level at the berm location of about 0.75m. Lower on the profile another berm is developing resulting in accretion at the berm location (136m to 208m chainage) but erosion either side. At profile**1aADC16A** the upper beach and toe have cut back and steepened with a reduction in beach level of about 0.35m. The mid beach has however flattened and accreted by about 0.25m. **1aADC16B**, **1aADC17** and **1aADC17A** are located to the north of Druridge Bay, between Bondi Carrs and Hadston Carrs and extend seawards from Togston Links. At all locations, the front face of the dunes has remained stable since the last survey (partial measures, spring 2013). At profile **1aADC16B**, beach levels have virtually remained the same since the last survey. Profile **1aADC17** has been stable, with only a small decrease in level on the upper slope (about 0.1m) and a small increase on the lower slope (about 0.1m) since the Autumn 2013 survey. At profile **1aADC17A**, beach levels have increased mid-profile by about 0.25m and decreased at the toe by about 0.35m, but the toe has extended out by about 10m. This is a change in profile shape but visual observations do not indicate an overall trend of erosion or accretion.	Along the length of High Hauxley and Druridge Bay, the dunes, including the front face, has remained stable since the last surveys. Opposite Amble, beach levels have increased. At Hauxley Haven, the beaches have changed shape but there is no trend of change. The beaches have tended to become less steep and berms have formed at around HAT on the northern two profiles and lower on the profile in the southern profile. These changes may be the result of moderate waves moving material down the beach. To the north of Druridge Bay, at Elm Bush, the beach has changed very little, probably due to the stabilising effect of foreshore rock outcrops. **Longer term trends:** Along the length of High Hauxley and Druridge Bay, the changes observed from the present survey are within the bounds of previous surveys. There are some locations where beach levels are the highest or lowest observed since 2008, for example at: (i) 1aADC15, the highest berm at toe level observed to date; (ii) 1aADC16, the highest berm at HAT level observed to date (iii) 1aADC17A, between a chainage of 130m and 190m, the beach has steepened

Survey Date	Description of Changes Since Last Survey	Interpretation
	The survey reports that there was a large agricultural dig taking place 100m south of profile **1aADC16B.** Once the dig is complete the material should be returned and Marram grass planted to stabilise the dunes. No major impacts on the profile were noted in the 2013 Autumn surveys but this should be considered in the next survey report. **1aCMBC01** and **1aCMBC02** are located in the southern section of Druridge Bay. At both locations, the front face of the dunes has remained stable since the last survey (partial measures, spring 2013). At profile **1aCMBC01** the beach level has increased slightly across the profile by up to 0.25m. The greatest increase is at the toe where a berm has formed. At profile **1aCMBC02**, beach levels have fallen across the profile by up to 0.5m with a greater decrease at the top and bottom of the profile than the middle.	

3.12 Lynemouth Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
Oct 2013	**Beach Profiles:** Lynemouth Bay is covered by six beach profile lines for the Full Measures survey (Appendix A). Two of these, profiles CMBC03A and CMBC03B, were added to the programme in October 2007. Three of the profiles in the middle of the bay are resurveyed every 6 months. **1aCMBC03** is located just to the south of Snab Point. The profile extends across the cliff and the rock platform below. The profile has not changed since the last surveys indicating a stable cliff and rocky foreshore. **1aCMBC03A** is located opposite Lynemouth and extends across the extensive slag banks before reaching the foreshore. A line of boulders is present at around HAT. The slag bank has not experienced any change since the last survey (partial measures, spring 2013). Beach levels have fallen across the length of the beach profile by up to 0.4m in places. A small berm has formed just above MHWS. **1aCMBC03B** is located to the north of Lynemouth Power Station and extends across the extensive slag banks before reaching the foreshore. The survey report notes that a new earth bund has been constructed at the top of the profile and this can be seen in the measured profile. The face of the slag bank has eroded by about 0.5m since spring 2013. The beach profile has steepened slightly resulting in a small drop in beach level on the middle and lower slope of the profile (about 0.3m). **1aWDC01** extends from seaward of the rock revetment down to low water across the extensive slag banks. The surveyors were unable to measure the bottom face of the revetment as the boulders were too slippery. The beach levels seaward of the rock revetment appear to have dropped slightly but this could be an error in the survey data as fewer points than usual were measured due to the slippery rocks and it is only a small change in level. **1aWDC02** is located to the south of the Power Station. The middle section of the survey was unable to be measured due to a large body of water trapped in the dip, which resulted in soft mud. The size of the water body was notably larger than observed by surveyors on previous surveys. Since the last survey (full measures, autumn 2012), the dunes and the muddy backshore (slag bank) have not experienced any significant change. The beach face, from about HAT (3m), 170m chainage, has built out with about 0.3m of accretion.**1aWDC03** is located to the south of the Power Station and to the north of Beacon	Along the coast of Lynemouth Bay, the cliffs and rocky foreshore have remained unchanged. Overall, beaches have changed little. Opposite Lynemouth and to the north of Lynemouth Power Station, beach levels have fallen slightly. Opposite Lynemouth Power Station, beach levels in front of the rock revetment are considered to be stable. South of the power station at profile 1aWDC03 the crest has cut back and lowered. This could be the cause for the increase in size of the water body observed at 1aWDC02. Between Lyne Sands and Beacon Point, there has been a mixture of beach behaviour, with the beach levels remaining fairly stable to the north but a decrease in beach crest level to the south. This is the opposite trend to that observed in the last survey report (full measures, autumn 2012). In the lee of Beacon Point, the beach has steepened and material has been moved up the profile onto the upper beach slope (below HAT) suggesting wave action has moved material up the beach over the calmer summer months. Opposite the caravan park, beach levels have decreased slightly since the previous survey. **Longer term trends:** To the north of Lynemouth Bay (between Snab Point and Headagee), the cliffs and

Survey Date	Description of Changes Since Last Survey	Interpretation
	Point. Since the last survey (full measures, autumn 2012), the dunes and the muddy backshore (slag bank) have not experienced any significant change. The beach crest has however significantly lowered (by approximately 1.2m) and moved landwards by approximately 25m. This could be a causing factor for the increase in water behind the crest at **1aWDC02.** **1aWDC04** and **1aWDC05** are located between Beacon Point and Newbiggin Point. At profile **1aWDC04**, the dunes have remained relatively stable. Beach levels at the toe of cliff down to HAT have fallen by 2m to 3m. The beach slope has then steepened and the beach levels from HAT to a level of approximately 1m (70m chainage) have increased by up to 0.5m while beach levels seawards of 70m chainage down to the rocky section (chainage 120m) have decreased by up to 0.4m. The rocky section has remained stable. At **1aWDC05**, the cliffed section has remained stable. There appears to be a change in profile at 7m to 9m chainage, however, this is likely to be either an anti tank rock which has moved or a survey error, rather than a change in profile form. The beach levels at the toe of the dune cliff down to the rocky section have fallen slightly (about 0.3m).	rocky foreshore have remained stable since 2008. Opposite Lynemouth and opposite Lynemouth Power Station, the changes observed are within the bounds of previous surveys. Between Lyne Sands and Beacon Point, at 1aWDC02, the water body is larger than in all previous surveys. At1aWDC03, the crest of the boulder beach is the lowest observed since 2008 and it is in its most landward position since the surveys began in 2002. Opposite Outer Carrs, the beach level changes are within the bounds of previous surveys.
Oct 2013	**Cliff Top Survey:** Cliff top survey data collected for the baseline survey (autumn, 2008), the partial measures survey (spring 2012) and the present full measures survey (autumn, 2013) is presented in this report. Three transect lines (numbered 1-3) were established along the cliff top in Lynemouth Bay in October 2008. Measurements are from the landward end of the transect (the fixed datum) to the surveyed cliff top. Measured distances to cliff top can then be compared to calculate erosion rates. The cliff top surveys are intended to inform on erosion rates of the sea cliffs to the south of Lynemouth Bay on the north side of Newbiggin Point. 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 C - Map 1 for the location of the transects ground control points. The results from the cliff top monitoring are anticipated to have an accuracy of ±0.1m due to the technique used. Appendix C – Table C1 provides results from the cliff top survey, showing the position from the datum to the edge of the cliff top along each transect. Results show that erosion of 0.6m has occurred at ground control point 1 since surveys began in October 2008, equivalent to an average recession rate of 0.1 m/yr. At other ground control points no change above the survey error has been recorded.	Since the last survey in November 2011, a small amount of erosion has occurred at profile 1, giving a low long-term erosion rate of 0.1m/yr. Other profiles have not changed, or record erroneous data. Data from analysis of aerial photography captured under the Cell 1 monitoring programme indicates average recession rates of 0.09m/yr along Lynemouth Bay, which is consistent with the data presented here.

3.13 Newbiggin-by-the-Sea

Survey Date	Description of Changes Since Last Survey	Interpretation
Sept 2013	**Beach Profiles:** Newbiggin-by-the-Sea is covered by four beach profile lines for the Full Measures survey (Appendix A). Two of these, profiles WDC05A and WDC06A, were added to the programme in October 2007 specifically to help assess the performance of the capital scheme involving beach replenishment and construction of an offshore breakwater. In addition a further 26 profiles (1aNWB1 to 1aNWB26) have been surveyed since September 2010 as part of a topographic survey of Newbiggin Bay. These profiles are used to construct a digital ground model of the beach (see below) and are not individually described. Beach profiling works were completed here in September 2012. Four areas were reprofiled; 2 sections to the east of profile **1aWDC05A**, one section at **1aWDC06A** and a narrow section at the top of **1aWDC07.** **1aWDC05A** is in the north of Newbiggin Bay. Beach levels at the toe of the wall (above HAT) have increased slightly but the crest of the berm at HAT has lowered slightly (by about 0.15m). The beach levels on the slope below the berm (50m to 100m chainage) down to the rocky section have lowered by approximately 0.2m. **1aWDC06** is located in the centre of the northern part of Newbiggin Bay, between the two breakwaters. Since the last survey (partial measures, spring 2013), levels at the toe of the sea wall have increased slightly and the revetment steps are no longer exposed. Below this, from HAT level the profile has eroded and cut back by up to 0.5m and the beach slope is notably steeper.**1aWDC06A** is located in the centre of Newbiggin Bay, behind the offshore breakwater. Beach levels on the upper beach, between the seawall and HAT have remained fairly stable since the previous survey (partial measures, spring 2013). The berm crest at HAT has widened, extending seawards by approximately 1m. The front slope of the berm is steeper and raised sand feature has developed at a chainage of approximately 135m to 175m which is about 0.5m in height. Survey photographs indicate that this is a sand ridge feature which extends along the beach. Beach levels either side of the ridge have fallen by approximately 0.2m. **1aWDC07** is located in towards the south of Newbiggin Bay. Since the last survey (partial measures, spring 2013), the beach has eroded. Erosion is greatest towards the seawards end of the profile resulting in a steeper beach slope, with a reduction in level of approximately 0.1m at the top of the	Since the last surveys, along the length of Newbiggin Bay, the beaches have generally shown a trend of erosion, apart from profile **1aWDC06A** in the middle of the bay behind the offshore breakwater which has accreted. This pattern is as expected and reflects development of a tombolo in the lee of the breakwater and development of two stable bays to the north and south. Profile 1aWDC05A (in the lee of the harbour) showed a small reduction in level across much of the sand part of the profile. Profiles 1aWDC06 and 1aWDC07 (in the northern part of Newbiggin Bay) show more notable erosion across the beach and the beach slope has steepened. At profile1aWDC06A however (located in the centre of Newbiggin Bay, behind the offshore breakwater), the crest has extended seawards and a ridge feature has formed on the beach with a drop in level either side. Beach profiling works were carried out at this profile in September 2013 and is likely to be the reason that this this profile shows a different trend to other profiles in the bay. **Longer term trends:** Profile 1aWDC05 is within the bounds of previous surveys. Profile 1aWDC06 is mainly within the bounds of the previous surveys. The lower beach on this profile is lower than all previous surveys, although the data record is limited at this location.

Survey Date	Description of Changes Since Last Survey	Interpretation
	beach, increasing to nearly 1m at the seawards end.	Profile 1aWDC06a is also generally within the bounds of previous surveys, but the runnels either side of the sand ridge dip outside of the previous survey envelope. The slope of 1aWDC07 has cut back further than previous surveys carried out since the capital works in 2007. Further monitoring will indicate whether this profile will recover..
Oct 2013	**Topographic Survey:** Newbiggin-by-the-Sea is covered by bi-annual topographic survey, which commenced in September 2010. The surveys are planned to help assess the performance of a capital scheme constructed in 2007, which involved beach replenishment and construction of an offshore breakwater. The topographic survey comprises a series of 26 beach profiles plus additional intervening spot heights. Prior to incorporation in the programme, these surveys were undertaken on occasions between 2007 and 2010 as part of the scheme development. Data from the most recent topographic survey (full measures, autumn 2013) have been used to create a DGM (Appendix B – Map 4a) using a GIS. A difference plot has also been produced using the DGM (Appendix B – Map 4b) produced from the last produced topographic survey (partial measures, spring 2013) and the present survey. The topographic survey shows areas of both erosion and accretion across the beach. The difference plot shows: (i) small changes in beach elevation generally less than 0.5m (ii) greatest erosion in the lee of the breakwater, particularly on the southern face of the developing tombolo (iii) erosion over the rock outcrop in the bay to the south of the breakwater (iv) alternating bands of change in the bay to the north of the breakwater (v) greatest accretion in the less of the breakwater on the northern page of the tombolo. **Longer Term Topographic Trends Autumn 2011 to Autumn 2013:** The long term difference plot (Appendix B – Map 4c) shows the net change in beach levels between autumn 2012 and autumn 2013. A distinct band of beach elevation increase has formed along the much	The findings of the topographic survey show small changes in beach elevation, with no discernible trend in beach elevation increase or decrease. Although beachmanagement works have been carried at this beach out in the past, none have been undertaken since the previous survey. **Long term trends:** The changes experienced are similar to those seen in past years and reflect ongoing development of stable bays either side of a tombolo. The erosion of the southern face of the tombolo has occurred in past years and reflects transient effects of winter storms. **Longer term topographic trends Autumn 2011 to Autumn 2012:** The long term difference plot of topography shows the development of a bay north of the breakwater, with a consistent strip of erosion of up to 1m across the beach face and accretion at the shoreline. A bay has also developed to the south of the breakwater but the amount of erosion has been less. The shoreline in this area has experienced little change. In the lee of the breakwater, both erosion and accretion has occurred, suggesting that a stable

Survey Date	Description of Changes Since Last Survey	Interpretation
	of the backshore, dissected by a pocket of decreased beach elevation to the centre and south of Newbiggin Bay. A distinct area of decreased beach elevation extends across the middle of the beach for much of the bay, at places reaching onto the lower foreshore and split into pockets in the southern part of the bay by the band of beach elevation increase.	tombolo feature has not yet developed. This area has experienced the greatest erosion at the shoreline.
Oct 2013	**Sand Extent Survey:** Spital Carrs is located to the south of Newbiggin Bay and is covered by a bi-annual sand extent survey, which commenced in 2012. The survey was designed to address concerns that the beach recharge scheme undertaken in the Newbiggin Bay may have impacts on the Spital Carrs SSSI and SPA if sand from the recharge scheme moves to the south. The sand extent survey therefore identifies the boundary of the sand beach on the rock platform. Data from the most recent sand extent survey (full measures, autumn 2013) has been plotted onto aerial imagery (refer to Appendix D – Map 1). The plot shows that there is subtle variation of the extent of sand between the spring 2013 and the autumn 2013 survey, but no evidence for net advance of the beach over the rock platform. There is movement to the south and centre-north where the sand extent has moved slightly seaward, while to the north it has moved landwards or remained the same.	Since the last survey, there has been some fluctuation in the limit of the sand, but no net change in either direction. **Longer term trends:** Review of the sand extent surveys for the past three surveys, shows that edge of the beach typically fluctuated by c. 10m, but there has been no underlying trend.

Plate 4 – Survey photograph 1aWDC06A_20130919_EN8.jpg

Plate 5 – Survey photograph WDC06A_20121004_N7_E4.JPG

3.14 Cambois Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
Sept 2013	**Beach Profiles:** Cambois Bay is covered by seven beach profile lines for the Full Measures survey (Appendix A). Profiles 1aWDC08 and 1aWDC09 are located to the north of the River Wansbeck estuary in front of Sandy Bay Caravan Park. **1aWDC08** extends from the cliff across the rock revetment onto the foreshore. There are no significant changes in the cliff top position or cliff face at this profile. Beach levels from the toe of the rock revetment to a chainage of 95m have decreased since the last survey (full measures, autumn 2012) by approximately 0.3m. Seaward of this, beach levels have increased, the lower shore has flattened and a low bar is forming. It seems that material has been moved from the upper slope to lower down the beach. **1aWDC09** extends from the cliffs at the very southern end of the Caravan Park. The cliff face has remained stable since the last survey (full measures, autumn 2012) and does not show the trend of erosion noted in other reports. The beach profile has become more undulating with three ridges developing. Beach levels have lowered by up to 0.25m between 40m and 60m chainage and between 120m and 160m chainage by up to 0.4m. From 120m chainage seawards the beach level has increased and a ridge has formed extending the beach profile seawards. As with profile **1aWDC08** it seems that material has been moved seawards down the profile. Profiles **1aWDC10** to **1aWDC14** are all located along Cambois Bay, between the River Wansbeck and River Blyth estuaries. **1aWDC10** is located on the southern side of the Wansbeck Estuary, just to the south of Cambois House. The toe of the cliff has receded by approximately 2m. This may be the result of inaccuracies in the survey method rather than erosion and therefore further surveys would be required to confirm whether this is actual erosion. Beach levels have decreased along the length of this profile, by up to 0.75m in places, This is a reverse of the trend observed in the last survey (full measures, autumn 2012) and a return to the lower profile levels observed in autumn 2010. **1aWDC11** extends across the rock revetment fronting the now disused foundry. The beach here is defined by a narrow and steeper upper beach, which fronts the rock revetment; seaward of which is a	To the north of Cambois Bay the cliffs have remained stable since the previous survey (full measures, autumn 2012). The beach profiles have become more undulating and material has been moved seawards down the beach. Immediately south of the Wansbeck Estuary, beach levels and the profile form have changed quite significantly. This is likely to relate to dynamic variation due to the estuary. Between the mouth of the Wansbeck Estuary and North Blyth, the backshore and dunes have remained stable. At all locations, beach levels on the upper beach show only minor changes in level, but a significant reduction has occurred at the toe of the profile and the lower beach has steepened. Visual observations indicate a trend of erosion. Across Cambois Bay the profiles have tended to erode and/or material has been moved seawards down the beach profile. This indicates a post storm reaction beach profile. The wave data at the Tyne and Tees Wavenet Buoy indicates storm conditions on 10th September and 19th November. This bay was surveyed between these dates. It is possible that the beach may not have fully recovered from the September storm conditions. **Longer term trends:** Although there have been some significant changes since the last survey in autumn

Survey Date	Description of Changes Since Last Survey	Interpretation
	slightly concave section of beach that contains standing water; and seaward of that is a gently sloping beach. The beach profile has changed significantly since the previous survey (full measures, autumn 2012). The beach at the toe of the rock revetment has increased in height by approximately 0.35m between 50m and 115m chainage. The beach level then drops significantly, by over 1m, and levels off to a form gently undulating lower beach with a low gradient. The beach profile is similar in shape to that of the 2007 survey, indicating that this section of beach is showing dynamic variation due to the proximity of the River Wansbeck Estuary. **1aWDC12** is situated approximately mid-way along Cambois Bay. Since the last survey (full measures, autumn 2012), beach levels have increased at the toe of the dune cliff between 30m and 70m chainage and again between 100m and 120m chainage where a berm has developed. From chainage 120m however the beach has steepened significantly and at the toe of the profile the beach level decreases by up to 1m. At **1aWDC13** there has been no change to the dune face. Beach levels have fluctuated along the profile with slight erosion at the toe of the dunes and slight accretion on the mid beach. From a level of 0m (125m chainage) the profile steepens significantly, similar to profile **1aWDC12,** and by the toe of the profile the beach level decreases by up to 0.7m. **1aWDC14** is located to the south of Cambois Bay, at North Blyth. At **1aWDC14** there has been no change to the dune face. Beach levels have increased slightly (about 0.1m) on the upper beach between 5m and 30m chainage. The profile has then remained stable across the rock outcrop. The lower portion of the profile, seawards of the rocky outcrop, has however reduced in level by approximately 0.2m (60m to 135m chainage).	2012, they are within the bounds of previous surveys indicating the beach is highly dynamic. The area near MLW in profiles **1aWDC11** to **1aWDC14** appears to be lower than all previous surveys, however previous profiles are shorter in length and so a direct comparison of these profiles is not possible.
Oct 2013	**Cliff Top Survey:** Cliff top survey data collected for the baseline survey (autumn, 2008), the partial measures survey (spring 2013) and the present full measures survey (autumn, 2013) is presented in this report. Five ground control points (numbered 1-5) were established along the cliff top to the north of Cambois Bay in October 2008. Measurements are taken along a fixed transect line from the landward datum to the edge of the cliff top. The cliff top surveys are intended to inform on erosion rates of the sea cliffs to the north of Cambois Bay, opposite North Seaton Colliery. 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 C - Map 2 for the location of the transects ground control points. These cliff top surveys are undertaken bi-annually. Measurements are taken from each ground control	Since the last survey in April 2012, the cliffs are eroding at two ground control points (3 and 5 by 0.3m and 0.6m respectively). The topographic survey report notes '*South end of Sand Bay Caravan Park, numerous landslips evident'.* This provides further evidence of the means by which cliff erosion is taking place. Other locations have not changed, or show error **Longer term trends:** Since surveys began in October 2008, change greater than the survey accuracy has occurred at two ground control points, with location 1

Survey Date	Description of Changes Since Last Survey	Interpretation
	point along a fixed bearing to the edge of the cliff top. The results from the cliff top monitoring are anticipated to have an accuracy of ±0.1m due to the technique used. The results from the cliff top survey are presented in Appendix C – Table C2, showing the position from the ground control point to the edge of the cliff top along a defined bearing. Results show that change greater than the survey accuracy has occurred at four ground control points since surveys began in October 2008. Erosion at ground control point 2 is within the error band. Since the last survey in April 2013, only location 3 shows erosion, with 0.1m lost. Since the 2008 baseline, the most change has occurred at Location 5, and surveyors noted that there was evidence of landslips here and caravans had been moved inland.	retreating a rate of 0.1m/yr and location 5 eroding at a rate of 0.6m/yr. Other locations have not changed, or have change within the error band. An additional assessment of cliff recession has been derived from analysis of aerial photos collected under the Cell 1 monitoring programme and this indicates average erosion of the frontage of Cambois Bay of 0.16m/yr between 2010 and 2013.
Oct 2013	**Cliff/Dune Top Survey:** Cliff/Dune-top survey data collected for baseline survey (May, 2009), the partial measures survey (spring 2012) and the present full measures survey (autumn, 2013) is presented in this report. A further 36 ground control points (numbered 6-41) were established along the cliff/dune top to the south of Cambois Bay in May 2009. The cliff/dune top surveys are intended to inform on erosion rates of the sea cliffs and dunes from Cambois to Blyth. 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 C - Map 2 for the location of the transects ground control points. The results from the cliff/dune top monitoring are anticipated to have an accuracy of ±0.1m due to the technique used. Appendix C – Table C3 provides results from the cliff/dune top survey, showing the position from the ground control point to the edge of the cliff/dune top along a defined bearing. A distinction is made in the table between whether the coastline is cliff/dune at the survey location. Over the last 6 months, there has been change measured at most of the survey points but no spatial pattern is evident. Maximum erosion has occurred at location 30, where 4.4m of dune has been lost. At other locations, typical losses are less than 1m. Maximum accretion has occurred at location 17, where the data suggest 8.3m of material has accreted at the base of a cliff. Other areas of dune have typically accreted by up to a metre, but 6m of accretion was recorded at location 27. Compared to the baseline survey of May 2009, slightly over half of the undefended profiles show erosion and the remainder show accretion. Maximum erosion is in the centre of bay at profiles 20 to 24	Since the last survey in April 2012, data suggest on-going erosion in the centre of bay between profiles 20 t0 24. Maximum accretion is immediately south, associated with formation of a tombolo linking an offshore rock outcrop to the shoreline **Longer term trends:** Since surveys began in May 2009, significant change has occurred at most undefended control points. Erosion is greatest at: - survey point 8 ,16-18, to the north of Cambois close to the mouth of the River Wansbeck where rates are less than 0.7m/y; - survey points 20 to 24 at the centre of the bay, opposite Cambois where rates are up to 1.1m/yr - ground control survey points 34 and 35, opposite Blythe immediately north of a defended section with rates of up to 0.3m/yr. This may reflect outflanking of the coastal defence. An additional assessment of cliff recession has been

Survey Date	Description of Changes Since Last Survey	Interpretation
	where 1 to 5m have been lost. There is also erosion of up to 0.8m at the south of the bay at profiles 34 and 35 adjacent to the defences. This may reflect outflanking of the structure. Accretion occurs across the bay, but is concentrated towards the south at locations 25, 27, 28 and 31. The spatial pattern of long term change reflects these measurements and rates of change in either direction rarely exceed 1m/yr. Peak erosion occurs at profiles 22, 23 and 24, where 0.7, 1.1 and 0.8m/yr were calculated, respectively. This area marks the centre of bay, where indentation is greatest. Peak accretion occurs immediately south of this area at profiles 25 and 27 where 1.3m/yr was calculated for both. This area is immediately north of a rock outcrop on the foreshore where a tombolo is forming.	derived from analysis of aerial photos collected under the Cell 1 monitoring programme and this indicates average erosion of the frontage of Cambois Bay of 0.16m/yr between 2010 and 2013.

3.15 Blyth South Beach

Survey Date	Description of Changes Since Last Survey	Interpretation
Oct 2013	**Beach Profiles:** Blyth South Beach is covered by six beach profile lines for the Full Measures survey (Appendix A). **1aBVBC01** is located towards the north of South Beach, in front of the area of land owned by Port of Blyth. There have been no significant changes to the position and form of the dunes since the last survey (partial measures, spring 2013). There are discrete areas of minor erosion and accretion resulting in a more undulating profile. The upper beach at the toe of the dunes (between 35m and 10m chainage) has accreted by approximately 0.2m. A ridge has formed at 120m chainage, with a drop in beach level either side; 0.2m on the upper side (70m to 120m chainage) and up to 0.5m on the seawards side (chainage 120m to 180m). Seaward of this the toe has built up to form a ridge. Beach levels at **1aBVBC02** have increased by up to 1.3m at the toe of the seawall to a chainage of 55m and a significant berm has formed. The underlying sand and cobble beach exposed in the previous full and partial measures surveys (autumn 2012 and spring 2013) has been buried (as seen in the survey photographs; Plates 6 and 7). Seaward of the berm the beach level has dropped by as much as 0.5m in places and the berm at the profile toe is no longer present. Rock has been exposed at the middle of the profile at approximately 85m to 110m chainage. Cross-shore movement of sediment, from the lower beach to the upper beach is likely to have occurred. At **1aBVBC03** there have been no significant changes to the position and form of the dunes since the last survey (partial measures, spring 2013). Beach levels have varied along the profile with pockets of erosion and accretion resulting in a more undulating profile. The upper beach from the dune toe to a chainage of about 190m has accreted by varying amounts, with a ridge forming at about HAT (3.1mAOD) and another forming at about 1m AOD. Seawards of this the steep face of the sand ridge falls to approximately 1.8m AOD, where it levels out at 240m chainage. The berm present at the profile toe on the previous survey has eroded to leave a fairly flat toe and beach levels have dropped by over 1m. It is likely that the material has been moved up the beach from the toe and lower slope to form the two ridges higher up the profile. Beach level change at **1aBVBC04** has significantly changed in form. The berm previously present at the profile toe (120m to 210m chainage) has moved up the beach to around HAT (approximately 65m chainage). As a result the toe of the beach has eroded by over 1m and	Along the length of the coastline, with the exception of the locations where a seawall is present, the dunes have remained largely stable since the last survey. The beaches have behaved in a similar way, with a increase in beach levels on the upper beach around HAT/MHWS and a decrease in beach levels on the lower beach. In between, the beaches have been dynamic with discrete lengths of beach level increase/decrease. This beach behaviour is likely to be driven by seasonal changes, occurring as material was transported up the beach during the calmer summer periods. The profiles located at the most northern and southern ends of the bay show a different trend. Profile **1aBVBC01** has fluctuated and formed a more undulating profile with ridge features but does not show such a significant movement of material up the beach. At profile **1aBVBC06** at the very southern end of the bay, the beach levels have dropped on the lower beach but the upper beach has remained stable rather than accreting, indicating that this material was moved in an offshore direction. This material lost may have contributed to the offshore bar observed by the surveyors. **Longer term trends:** As at Cambois Bay, although there have been some quite significant changes since the last survey in autumn 2012, the changes observed

Survey Date	Description of Changes Since Last Survey	Interpretation
	the upper beach has accreted by up to 0.7m. At **1aBVBC05** shows a similar pattern to 1aBVBC04. Material has been moved up the beach resulting in erosion between 128m and 180m chainage of up to 1.2m and accretion of the upper beach between 80m and 128m chainage of up to about 1.8m. The survey report noted a sand bar out to sea at profiles **1aBVBC04** and **1 aBVBC05** indicating an availability of sediment, Profile **1aBVBC06** is located at the southern end of the beach, towards Seaton Sluice. Unlike other profiles in this bay this profile has eroded on the lower slope and remains stable on the upper slope. The beach remains stable down to approximately 137m chainage. From 137m chainage to the seaward end of the profile (270m chainage) the beach levels have dropped to form a smoother profile, in places dropping by as much as 1.5m, and the ridges present in the previous surveys are no longer present.	are generally within the bounds of previous surveys. The exceptions to this are **1aBVBC02** where the middle of the profile is lower than previously measured and rocks have been exposed, and the profile toe at **1aBVBC03** and **1aBVBC04** which are both lower than previously measured.

Plate 6– Survey photograph 1aBVBC02_20121015_N2.JPG

Plate 7– Survey photograph 1aBVBC02_20131008_N3.JPG

4. Problems Encountered and Uncertainty in Analysis

Individual Profiles

Across much of the Northumberland coast the vegetation has grown significantly since previous surveys making some sections difficult to measure. This has resulted in some poor data being collected along the landward part of the profiles. The profile feature code describing vegetation can be used to highlight where low quality data are likely to be present.

Other issues noted during the survey which should be considered in the profile assessment include:

- At Holy Island, the southern profiles (BTBC24 to BTBC68) end in soft mud in the harbour and hence could not be surveyed further seawards.
- At Holy Island, profile BTBC28 ends on mussel beds.
- A new fence is present on top of the dune at Beadnel Village (profile BTBC30) which could impact upon access to measure the dune.
- At profile BTBC33 in Beadnell Bay the middle of dunes could not be measured due to the dense vegetation cover. We therefore do not have confidence in this section of the profile.
- At ADC03 to the north of Embleton Bay, the back slope of the dunes was heavily vegetated affecting access accuracy of the survey measurements.
- At ADC04A, Boulmer, a new ramp has been constructed down dune face which will affect the profile shape. When analysing the data it should be noted that this is not a natural change in the profile.
- At profile ADC09, located towards the middle of Alnmouth Bay, earthworks were in progress near to the start of section which may affect the measured levels. This profile ends at the river and hence could not be extended further.
- Towards the middle of High Hauxley and Druridge Bay, at profiles ADC16 and ADC16A, there are gaps in section due to thick vegetation cover. This needs to be considered when assessing the profile data as the levels in these measurement gaps will not be reliable.
- At the time of the survey an archaeology dig involving major excavations had recently been carried out in Hauxley and Druridge Bay. The dig was located 100m south of profile ADC16B and may have contributed to changes in beach level along this profile.
- At profile CMBC03B, located towards the north of Lynemouth Bay, a new bund was present at the top of section line and there were new earthworks evident further inland on the stockpile area. The new earth bund can clearly be identified on the profile and it should be noted that this is a new feature and not a survey error.
- At profile WDC01, towards the middle of Lynemouth Bay, the surveyors were unable to measure the bottom face of the revetment as the boulders were too slippery.
- At profile WDC02 in Lynemouth Bay there was a large body of water trapped mid section and the surveyors were unable to measure land levels through the mud. The body of water was larger than that observed during previous surveys.

Topographic Surveys

At Newbiggin (NWB25), the topographic survey report noted that the tide turned very quickly and as a result they were unable to measure a small rocky area at end of section NWB25.

Cliff Top Surveys

Surveying any cliff top is difficult due to the Health and Safety risks posed to surveyors, especially during adverse weather; and the apparent changes that can arise due to problems in interpretation of the cliff edge on successive surveys. In particular, surveying the cliff top has been made challenging by growth of vegetation that makes identification of cliff edge in successive surveys difficult. However, collection of longer-term data allows underlying trends to be shown and the data indicates erosion rates similar to those measured from analysis of aerial photographs, which is provide in a separate report.

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

No changes are recommended at the present time.

6. Conclusions and Areas of Concern

- At Sandstell Point (Spittal A), the recorded profiles and topographic survey present no causes for concern.
- At Spittal (Spittal B), at profile 1aBTBC12 beach levels at the base of the trough which has formed on the profile are the lowest to date. This is not currently a cause for concern as it is only a short section of the profile and is related to the development of a berm feature seawards of the trough.
- Elsewhere along Spittal (Spittal B), the recorded profiles present no causes for concern.
- At Goswick Sands, the recorded profiles present no causes for concern.
- At Holy Island, the recorded profiles and topographic survey present no causes for concern.
- At Beadnell Village, the recorded profiles present no causes for concern.
- At Beadnell Bay, the survey report notes that for profile 1aBTBC33 '*middle of dunes missing due to dense vegetation'*. This could impact on the accuracy of subsequent survey interpretation or volume calculations for this profile.
- Elsewhere along Beadnell Bay, the recorded profiles present no causes for concern.
- At Embleton Bay the beach profiles observed are lower than all previous beach profiles measured since 2002. This bay should continue to be monitored to assess whether the beach recovers to previous levels.
- *At Boulmer, cutback of the dune/b*ackshore at profile 1aADC04A is part of an ongoing trend. The low dunes here form part of private gardens. The 2011 partial measures report (spring 2011) noted that the changes were not of significant concern for management. This also applies to the present survey, but should be re-assessed in the next full measures report (spring 2013). To the north of Boulmer, the beach levels at the dune toe around HAT are the lowest they have been since 21st October 2008. To the south, the profile form and position is within the bounds of previous surveys.
- Elsewhere along Boulmer, the recorded profiles present no causes for concern.
- At Alnmouth Bay, between Season Point and Fluke Hole, the eroded section towards the middle of the profiles (at an approximate elevation of 0.2m to 0.4m) is the lowest level recorded since the survey work started in 2002. This is not currently a cause for concern as the remainder of the profile is not low and so this is likely to be movement of material within the beach system rather than loss of material.
- Elsewhere at Alnmouth Bay, the recorded profiles and topographic survey present no causes for concern.
- At High Hauxley & Druridge Bay, beach levels are the lowest observed to date at 1aADC16B, levels at the dune toe; and at 1aADC17A, between a chainage of 180m and 190m, where there appears to a small runnel, suggesting potential deepening of the channel.
- Elsewhere along High Hauxley & Druridge Bay, the recorded profiles present no causes for concern.
- At Lynemouth Bay, opposite the Power Station (profile 1aCMBC03B), the slag bank has eroded. It is possible that mechanical re-grading of the slag tip profile has occurred between the present and previous partial measures survey and could explain the observed erosion. To the south of the Power Station and to the north of Beacon Point (profile 1aWDC03) This could be a causing factor for the increase in water behind the crest at 1aWDC02. At1aWDC03.
- Elsewhere along Lynemouth Bay, the recorded profiles and cliff top survey present no causes for concern.

- At Newbiggin-by-the-Sea, the beaches have behaved dynamically in response to the new coast protection scheme, with erosion and accretion in areas expected and no adverse impacts on the rocky foreshore SSSI to the south of the bay.
- Elsewhere along Newbiggin Bay, the recorded profiles, topographic survey and the sand extent survey present no causes for concern.
- At Cambois Bay erosion and drawdown of beach material is evident across the measured beach profiles. The present beach levels are not lower than previously recorded surveys, but have fallen to levels similar to those recorded in 2007. If this beach lowering is due to recent storm conditions (10th September) then future monitoring data will indicate whether beach levels can recover. There is currently no cause for concern.
- At Cambois Bay, the topographic survey report notes '*South end of Sand Bay Caravan Park, numerous landslips evident'.* This provides further evidence of the means by which cliff erosion is taking place.
- At Cambois, the dune top survey shows that at ground survey points 30 to 34, the dunes have receded by up to 4.4m and 0.8m respectively. Although the magnitude of this change does not presently cause concern, it recommended that this rate is reviewed with each survey.
- At Blyth South Beach, the recorded profiles present no causes for concern. Erosion has been noted at the southernmost and northernmost profiles but the levels recorded are no lower than previous records show. Along other profiles material has been moved up the beach but there is no apparent erosion or accretion.

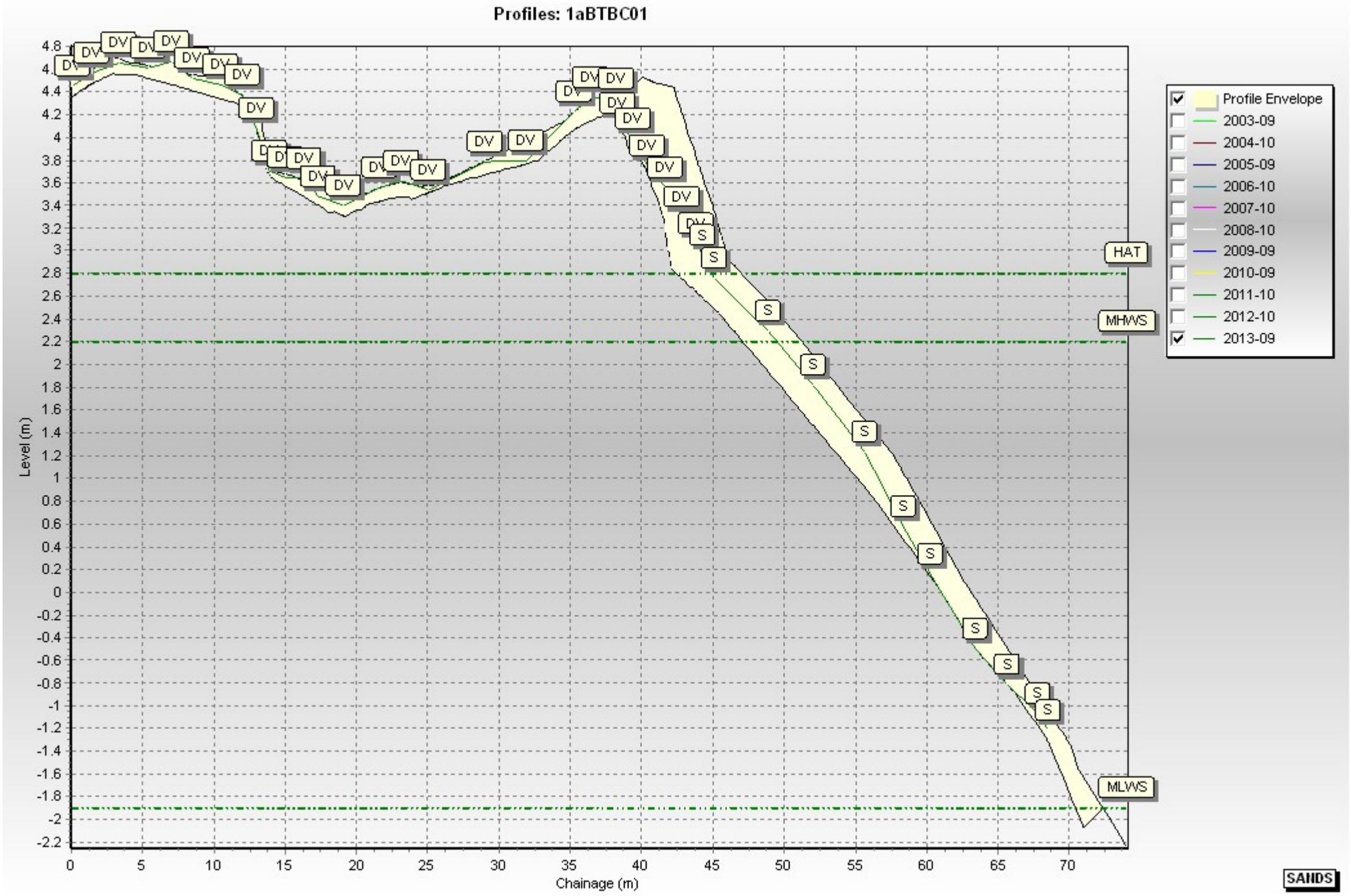
Appendices

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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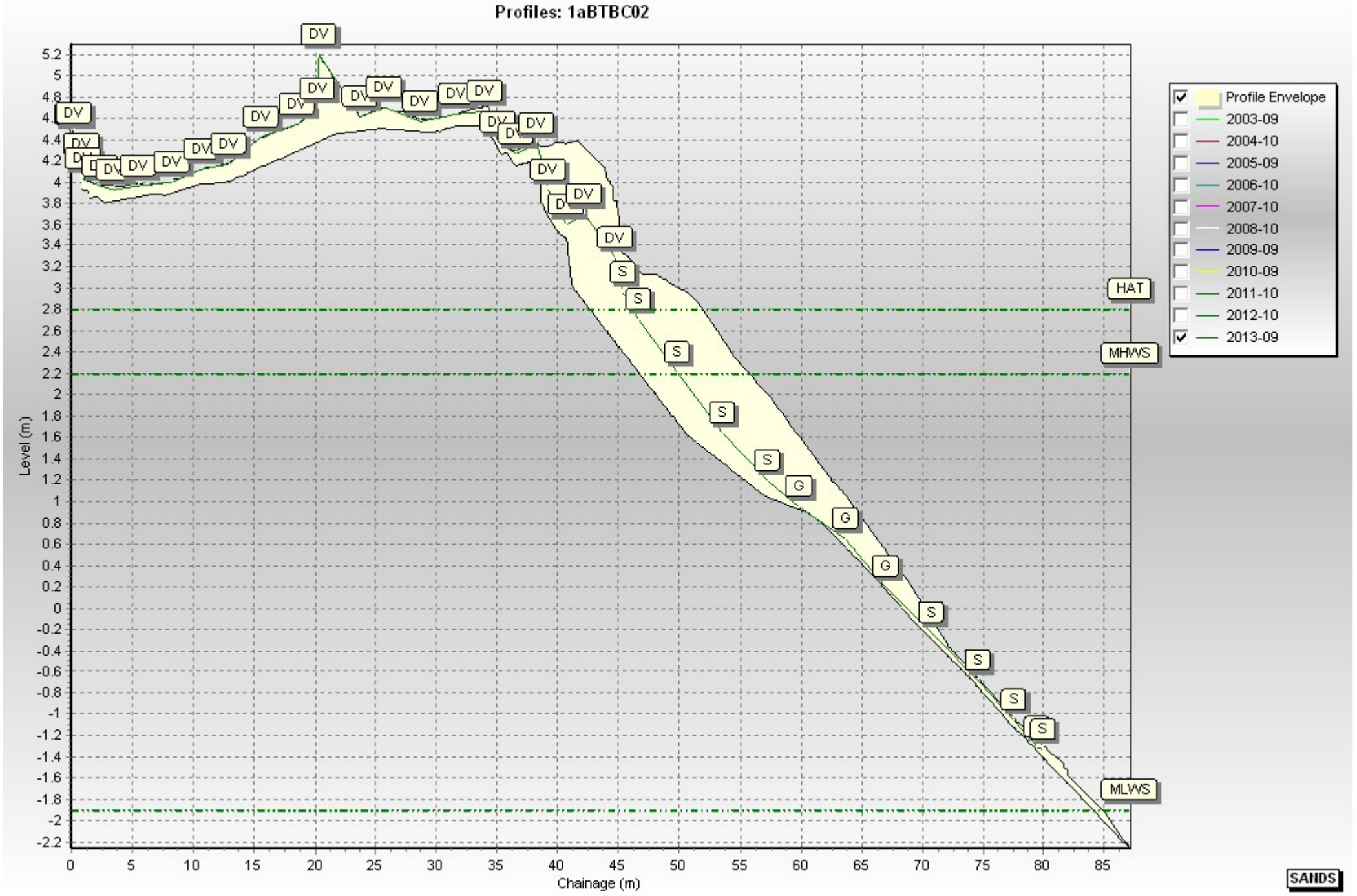
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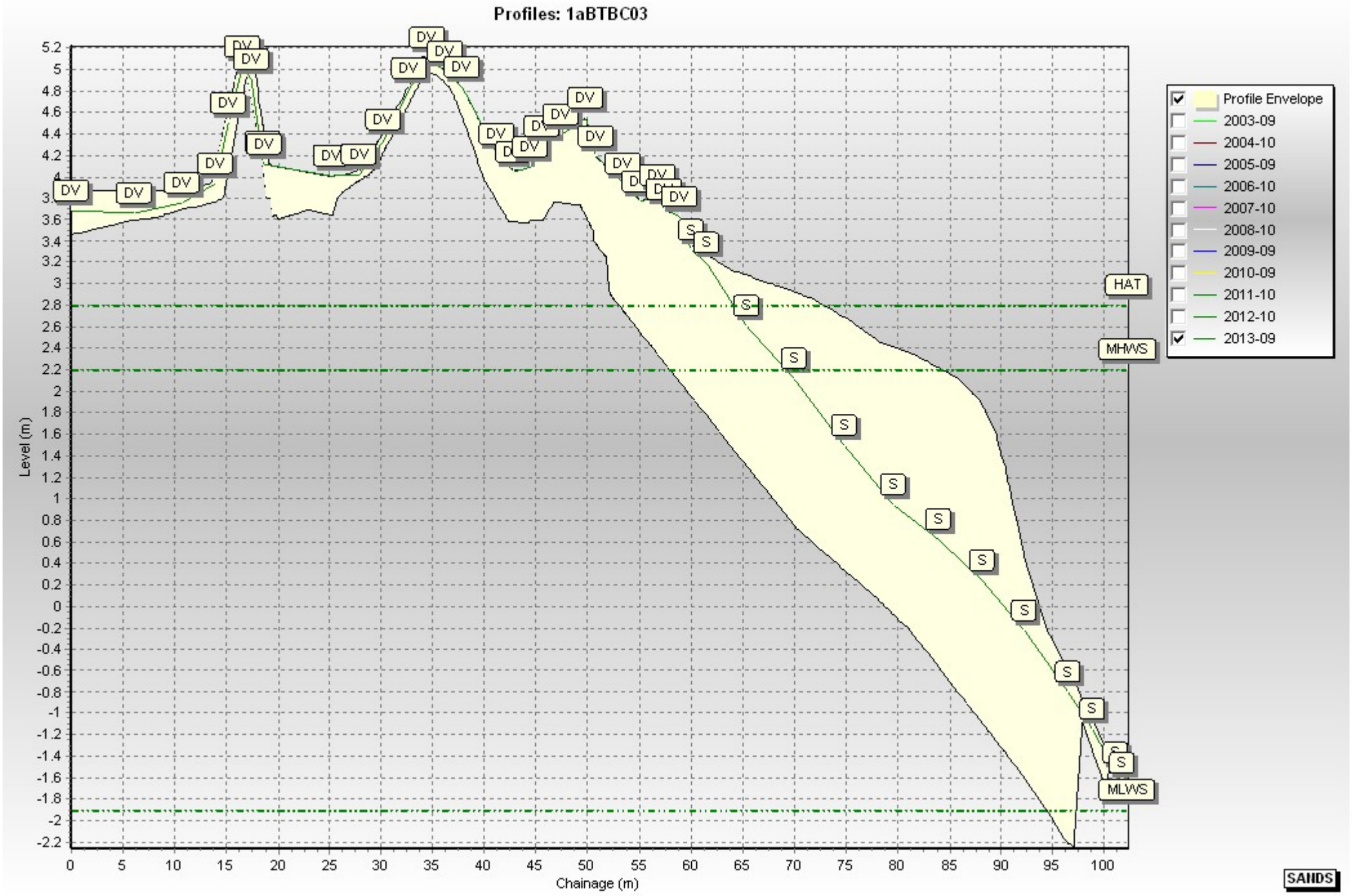
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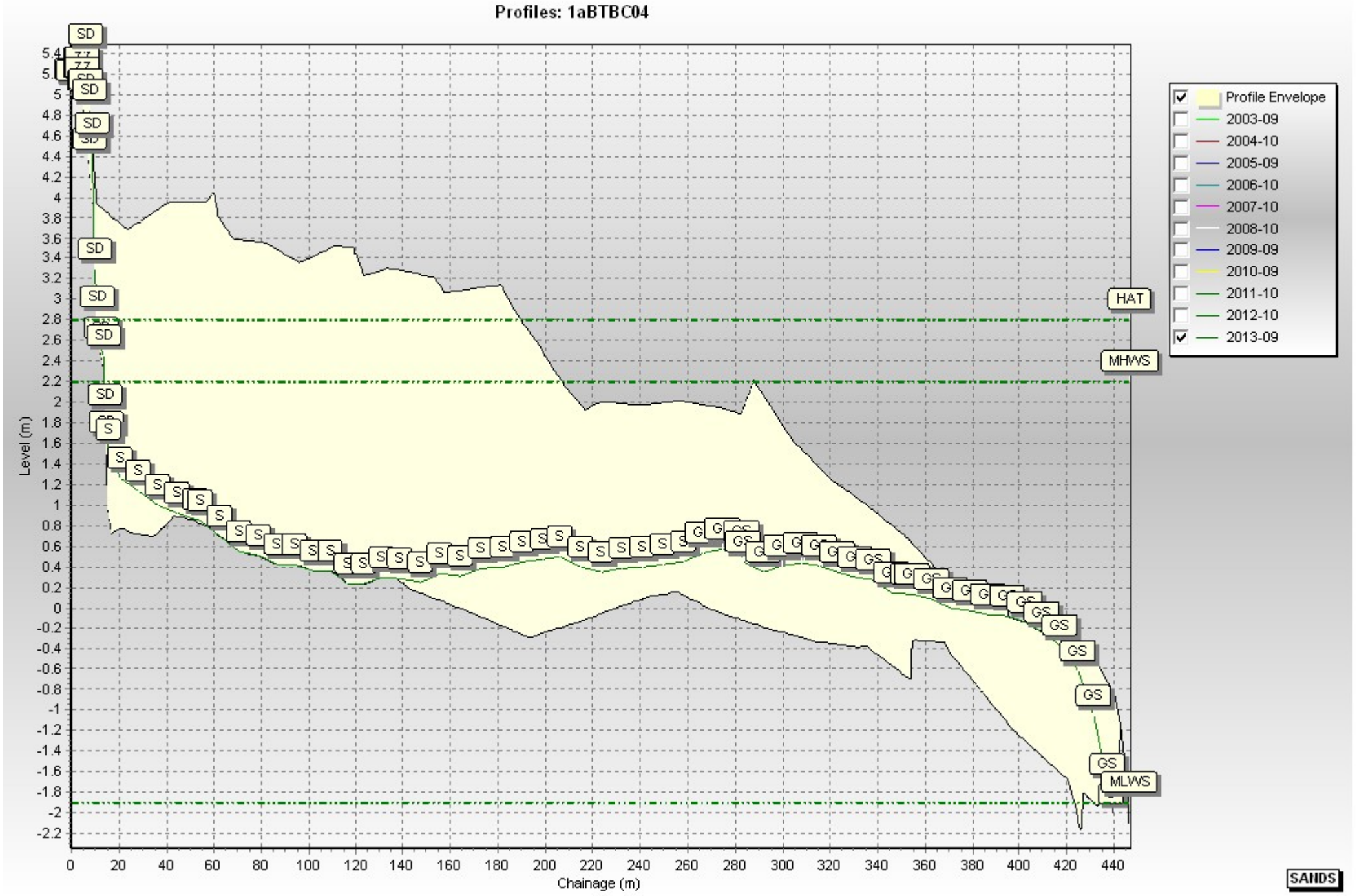
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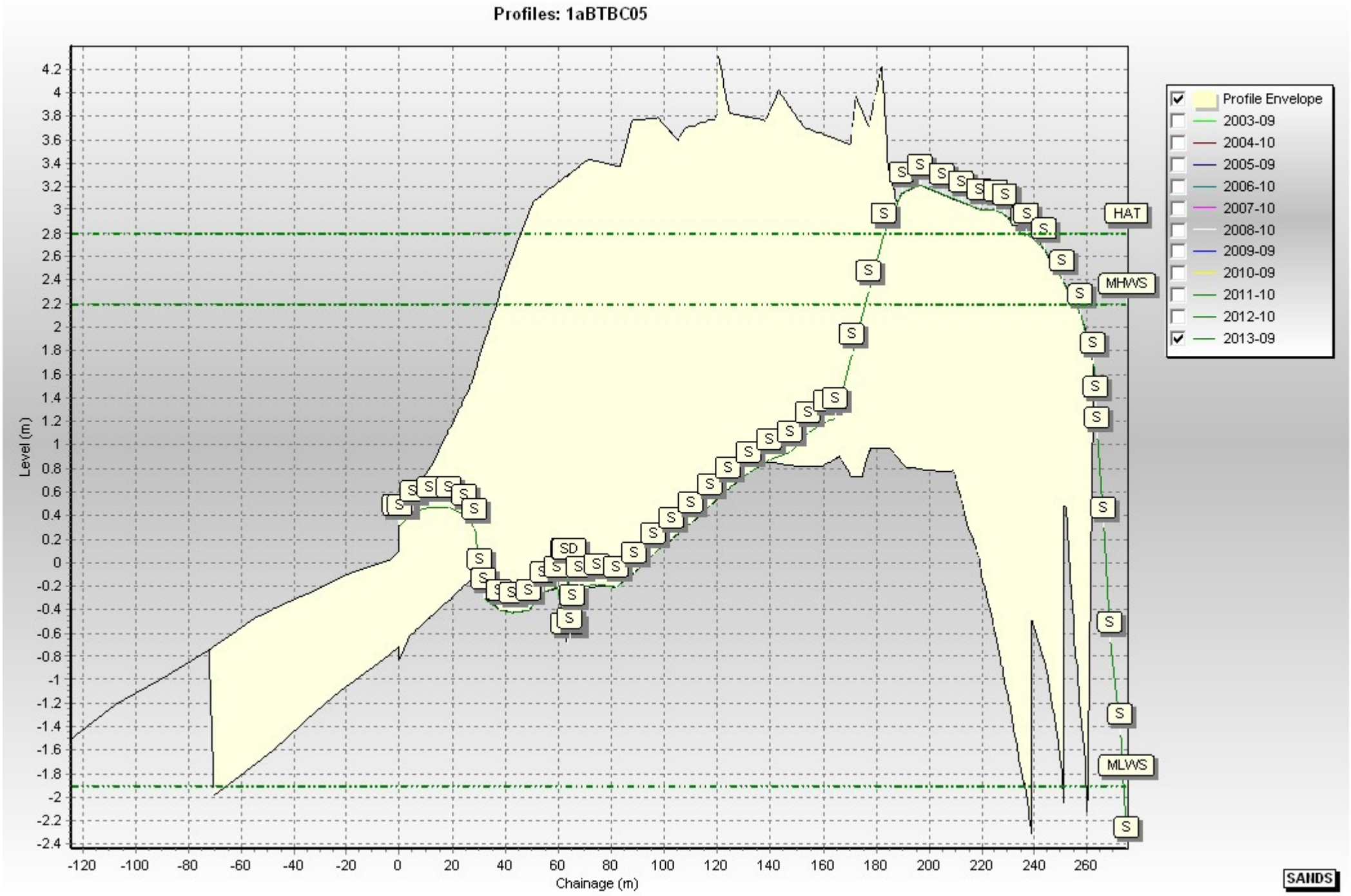
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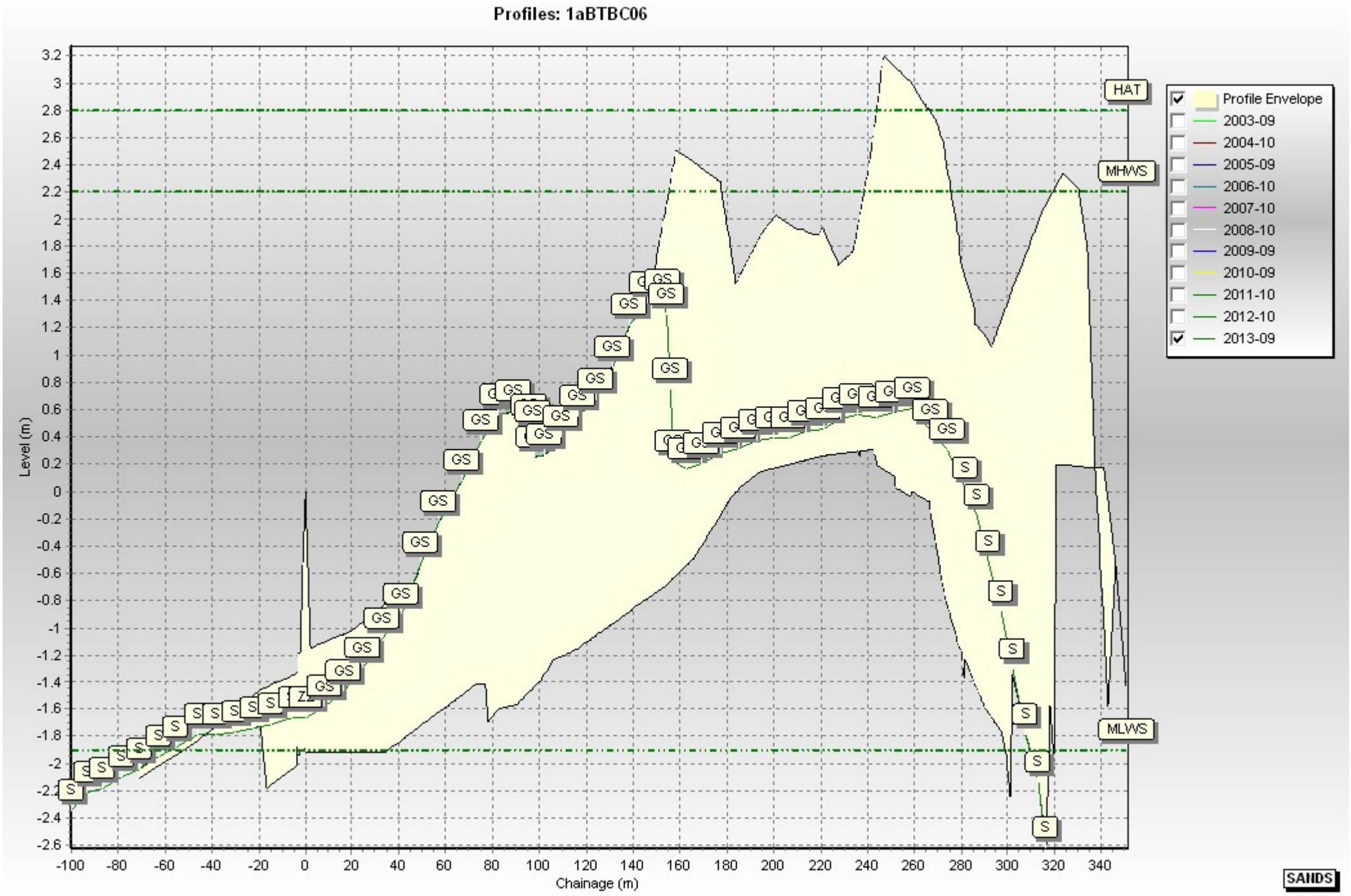
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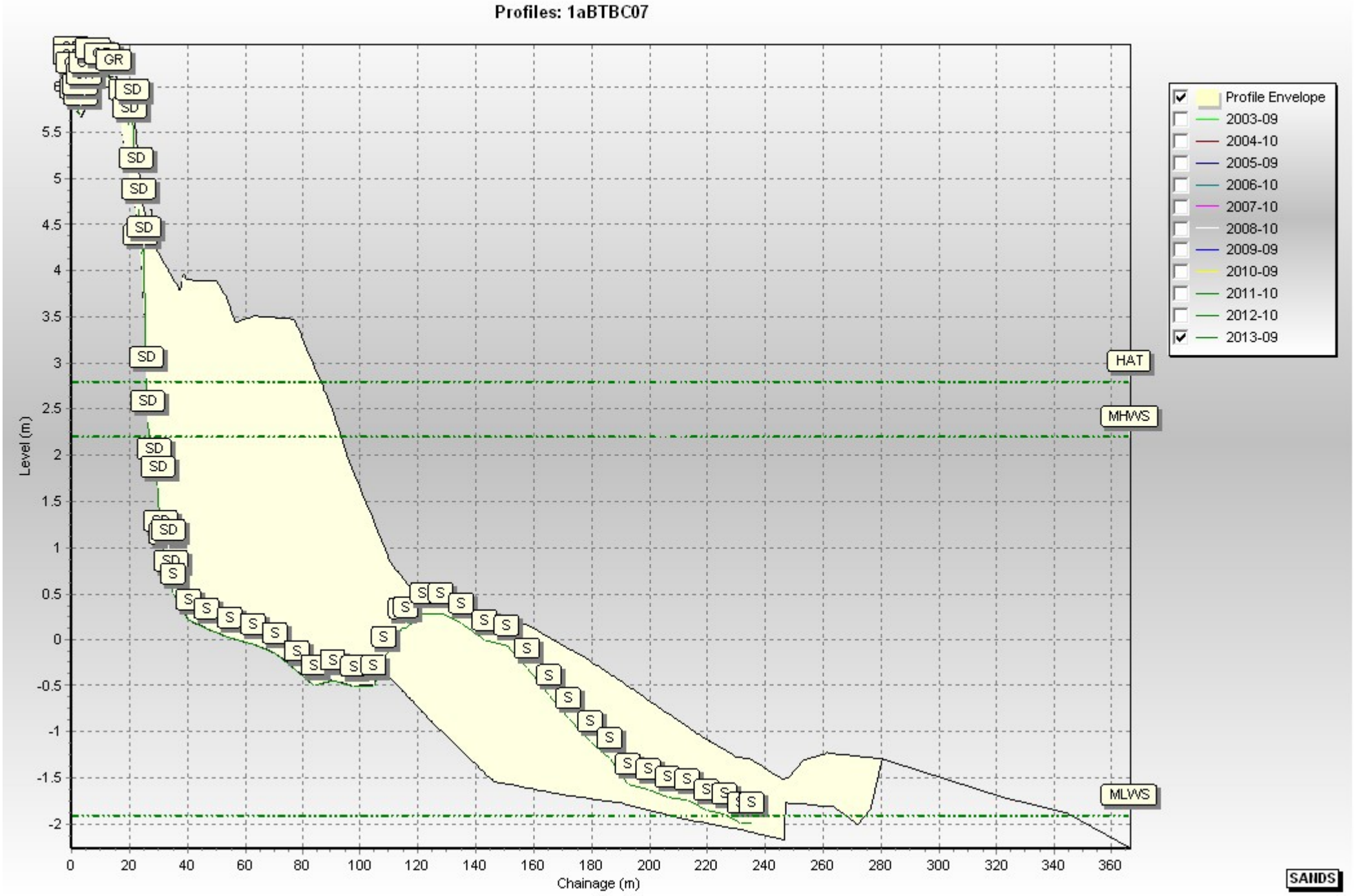
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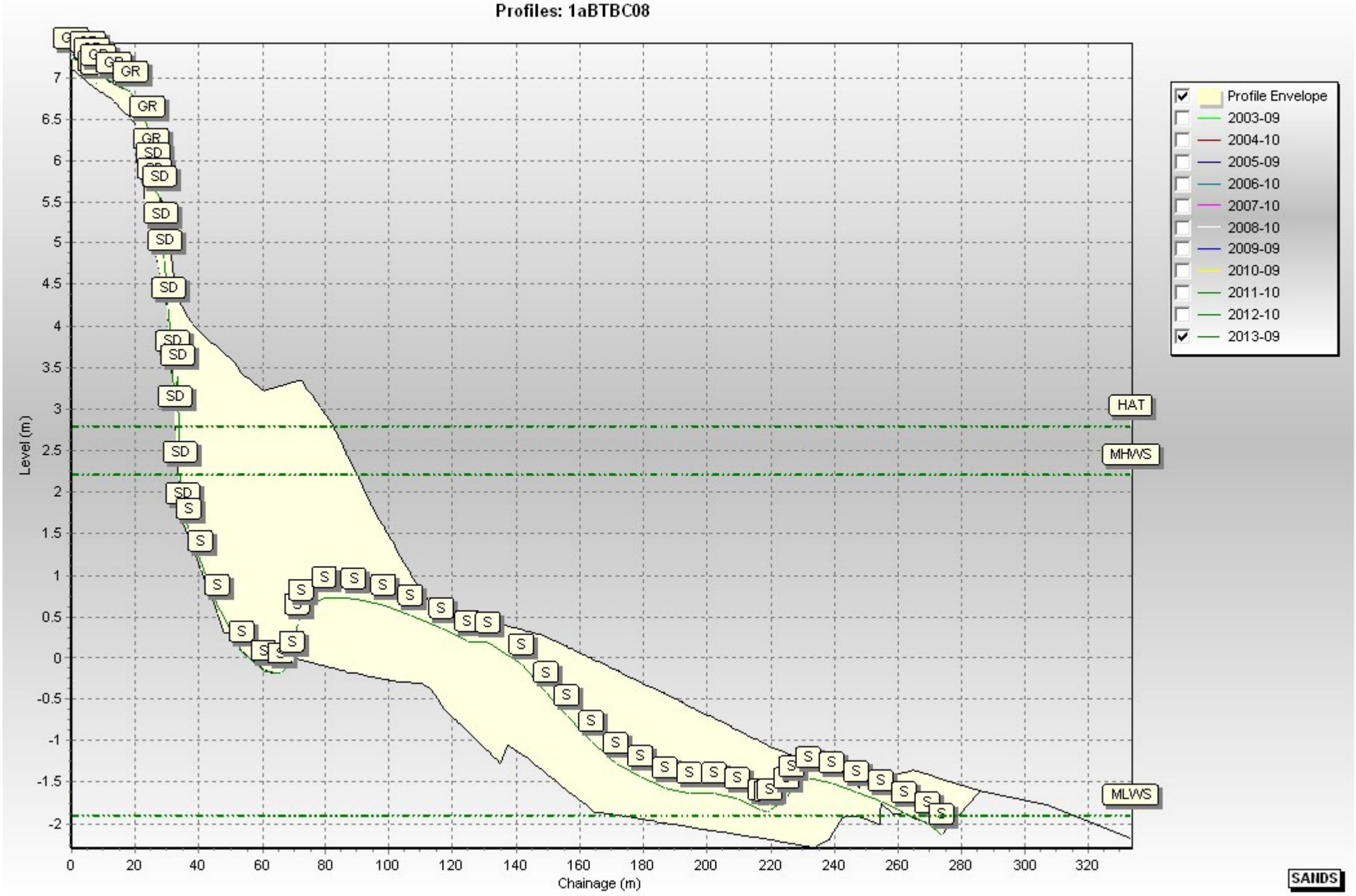
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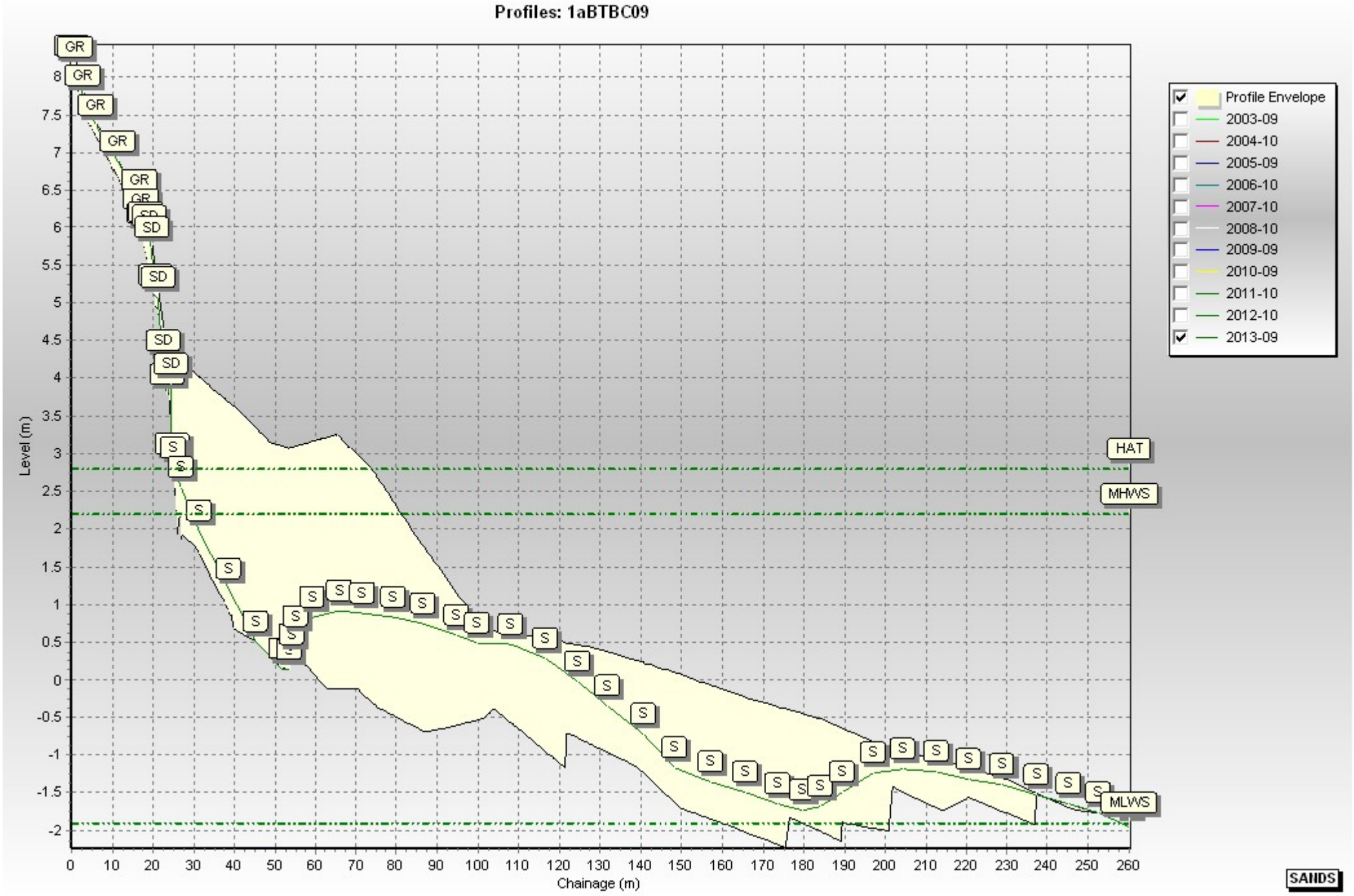
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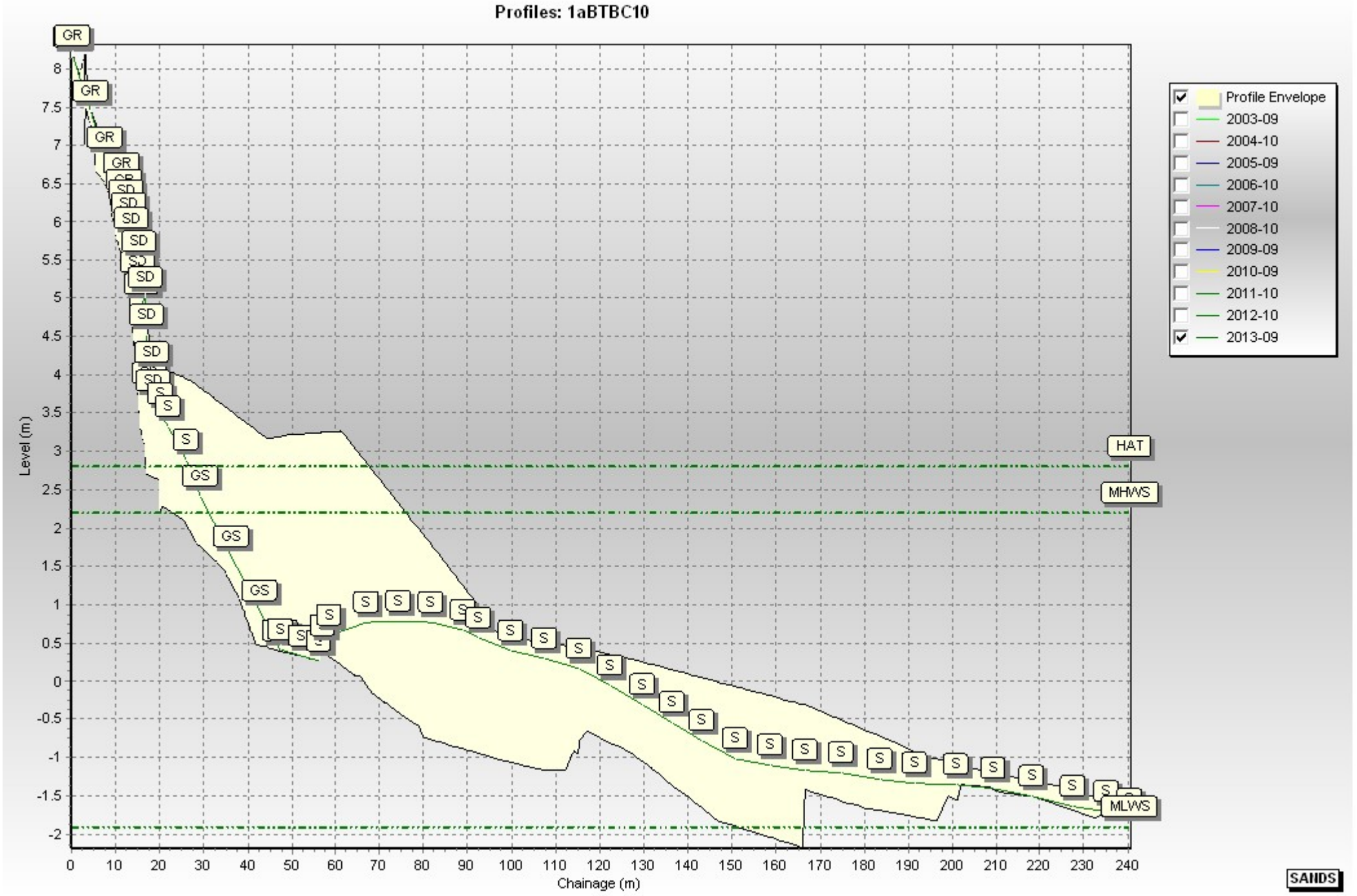
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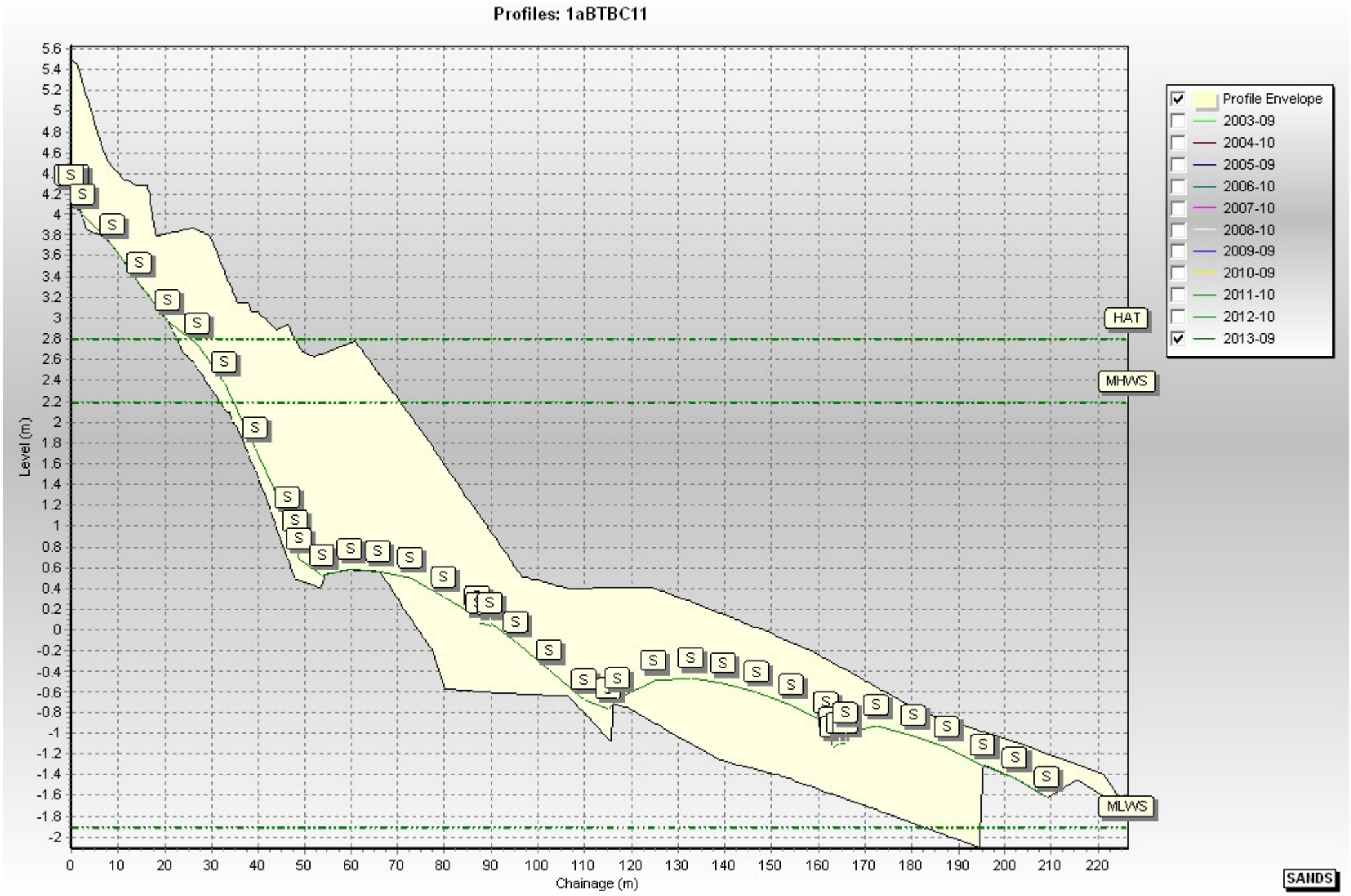
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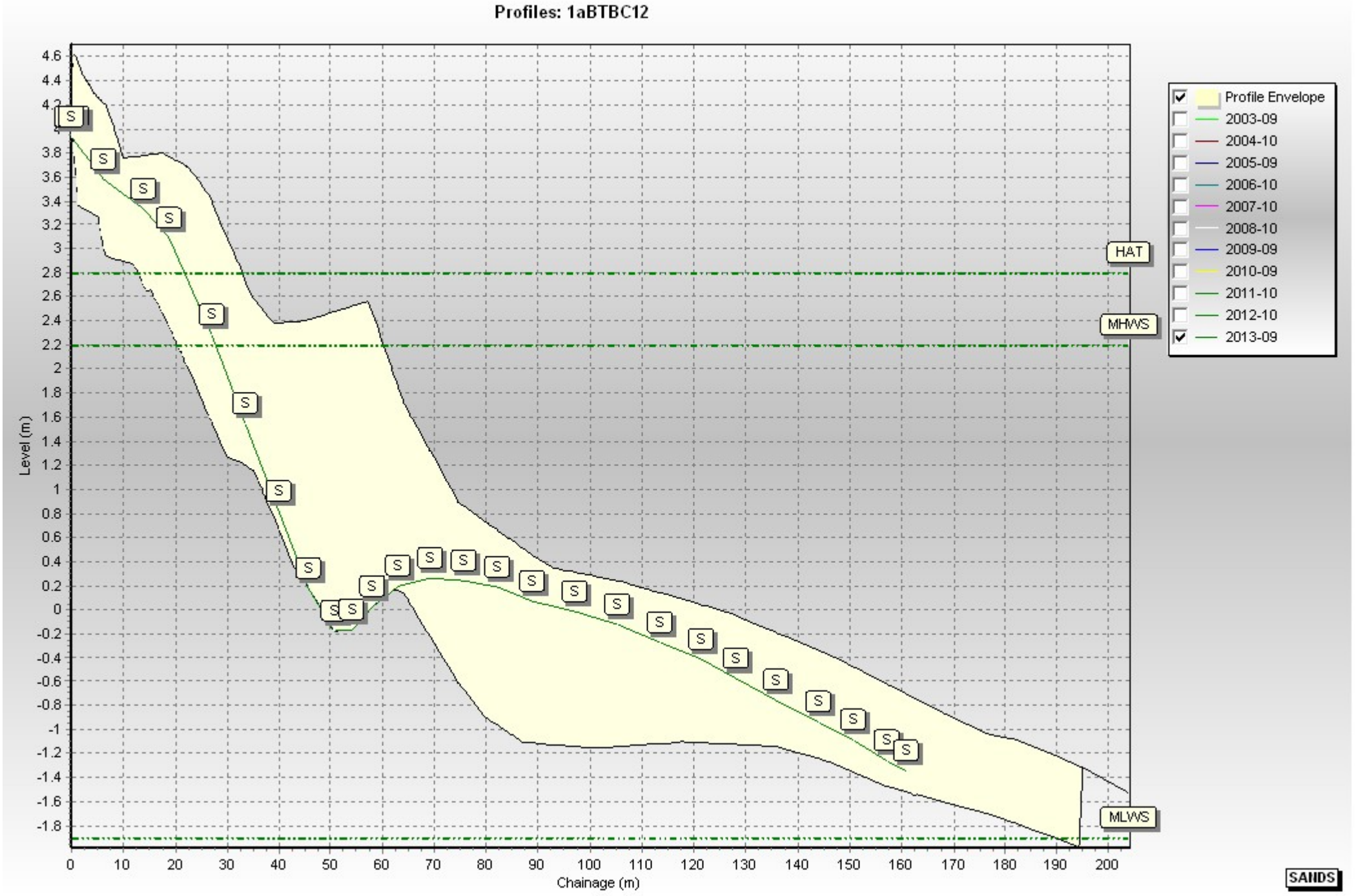
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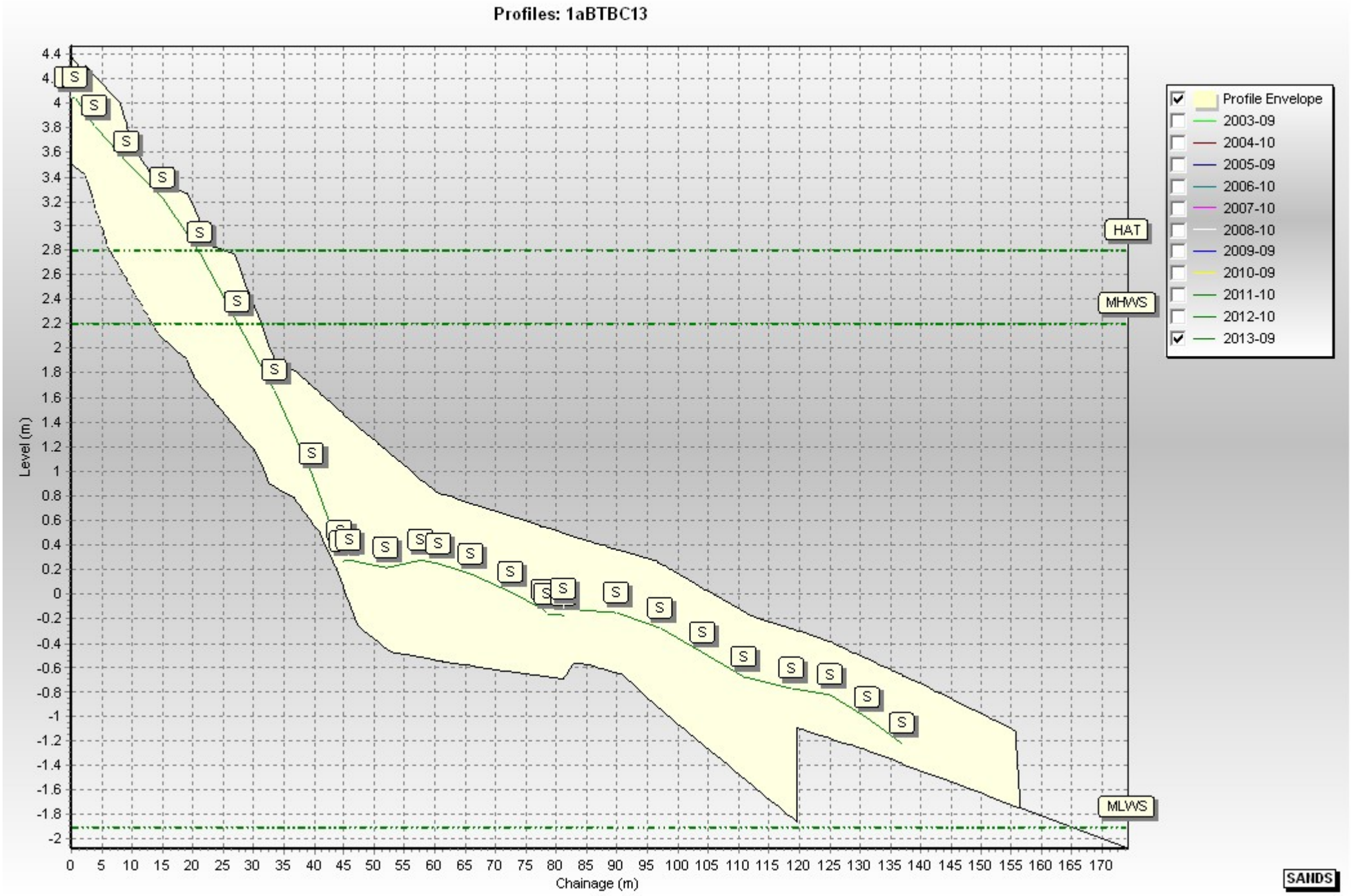
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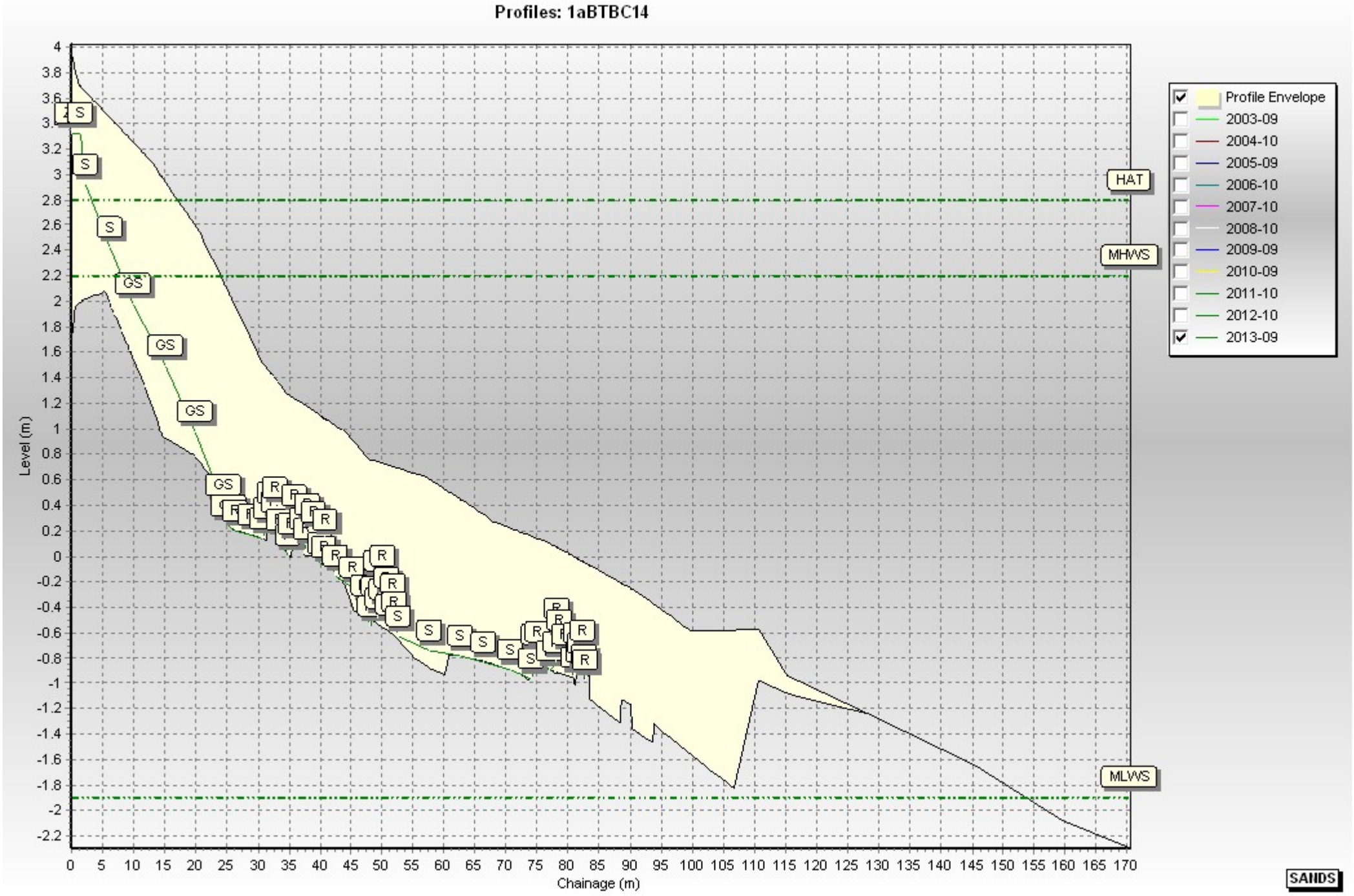
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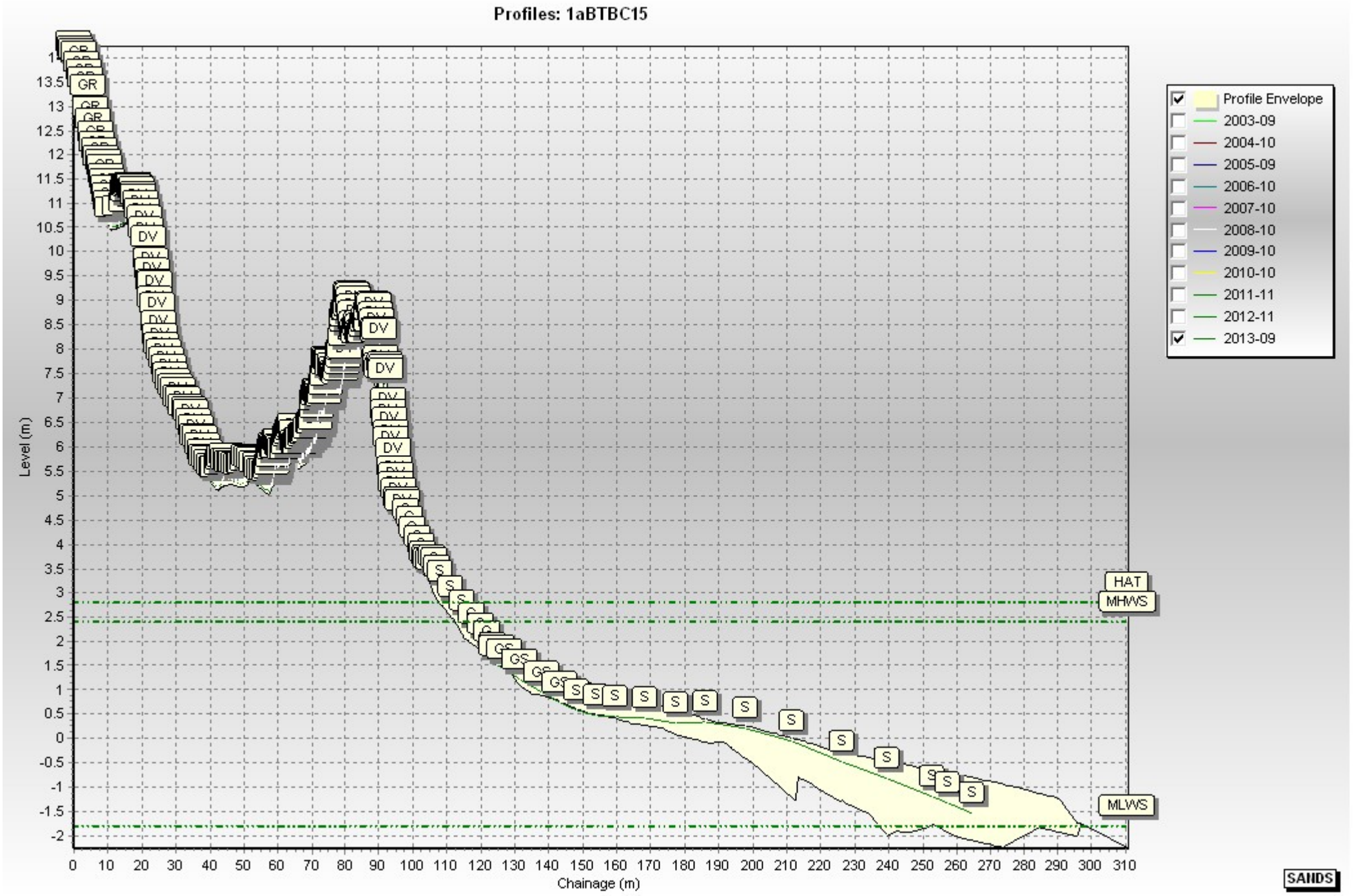
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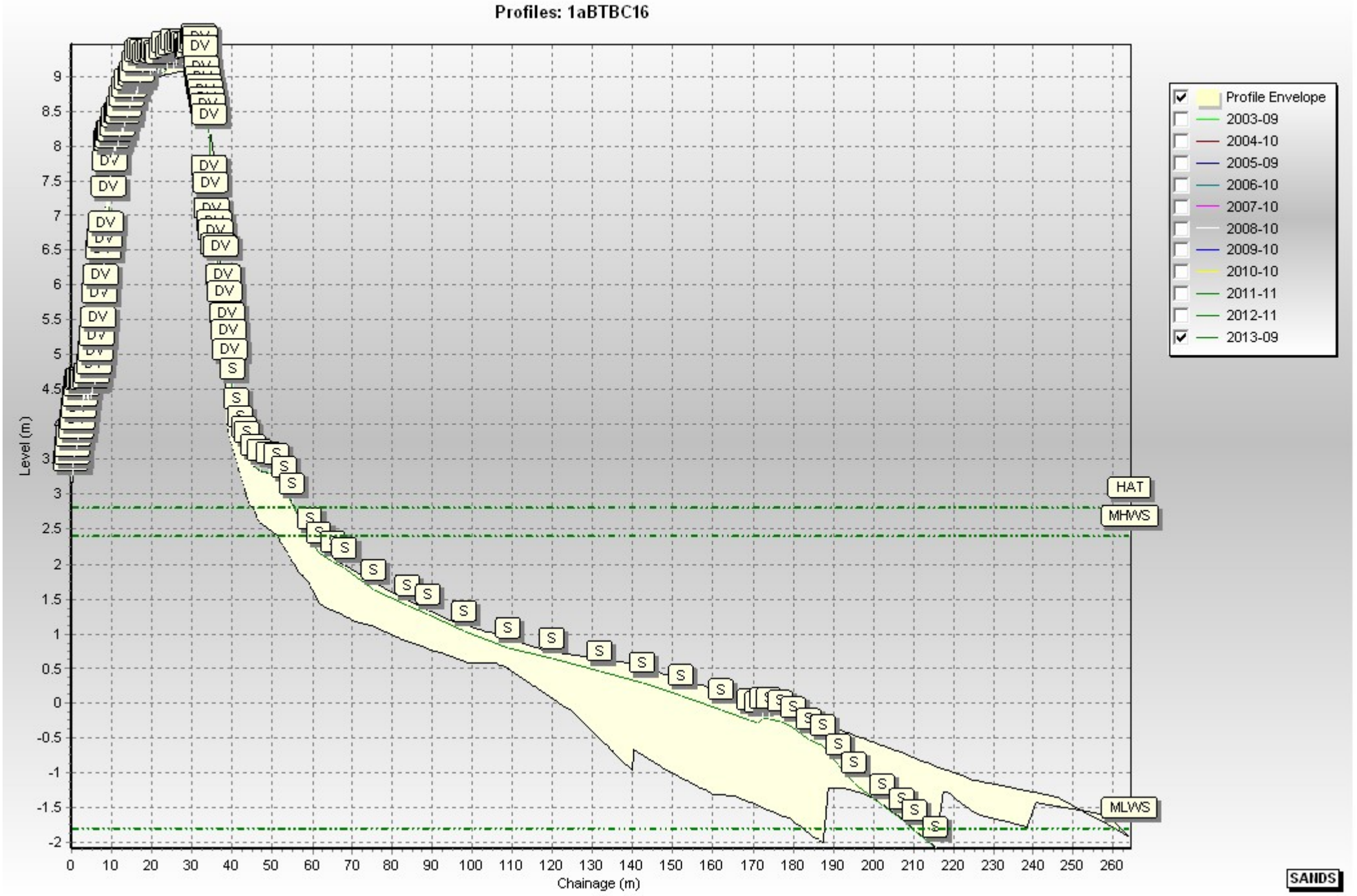
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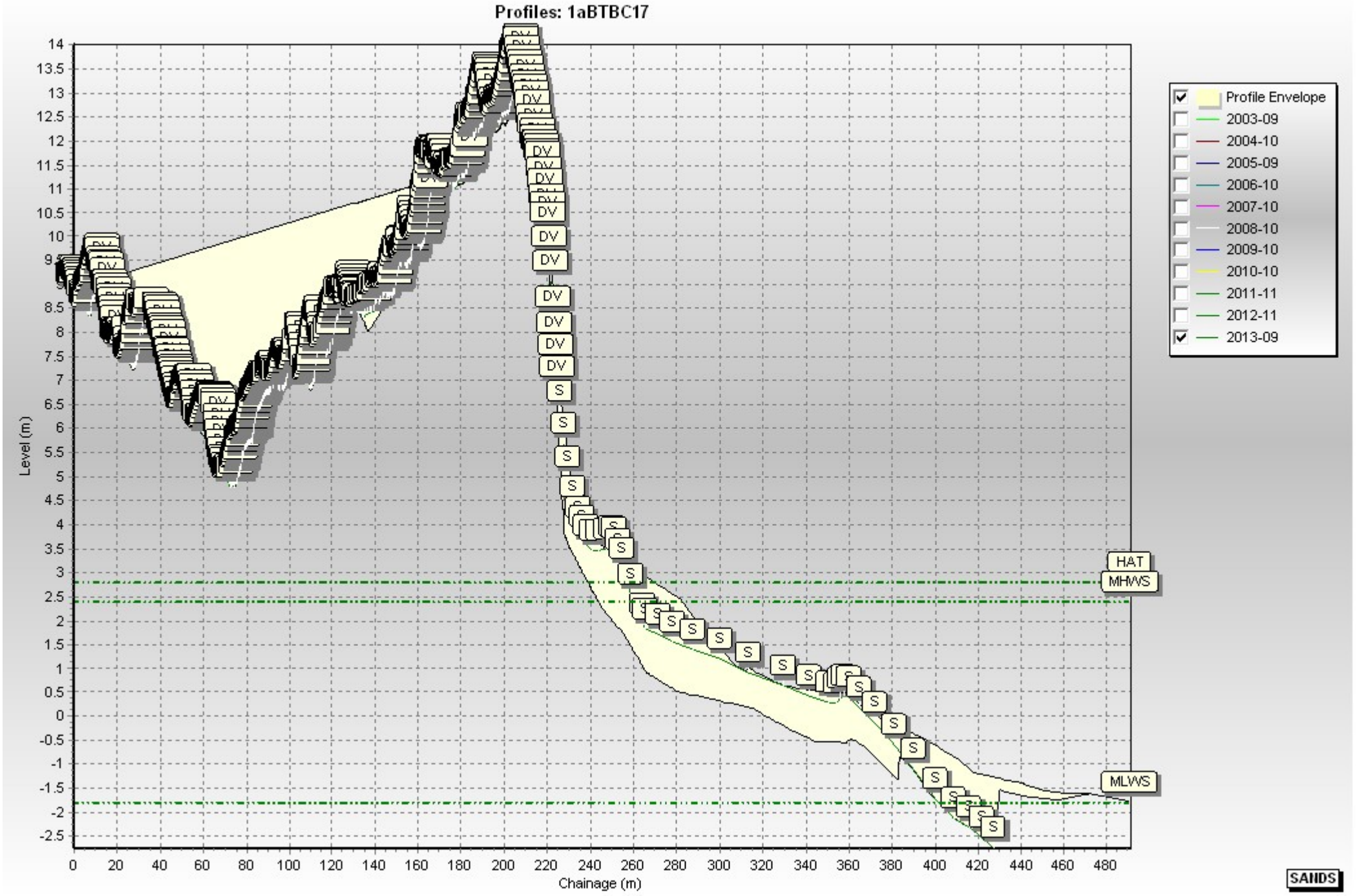
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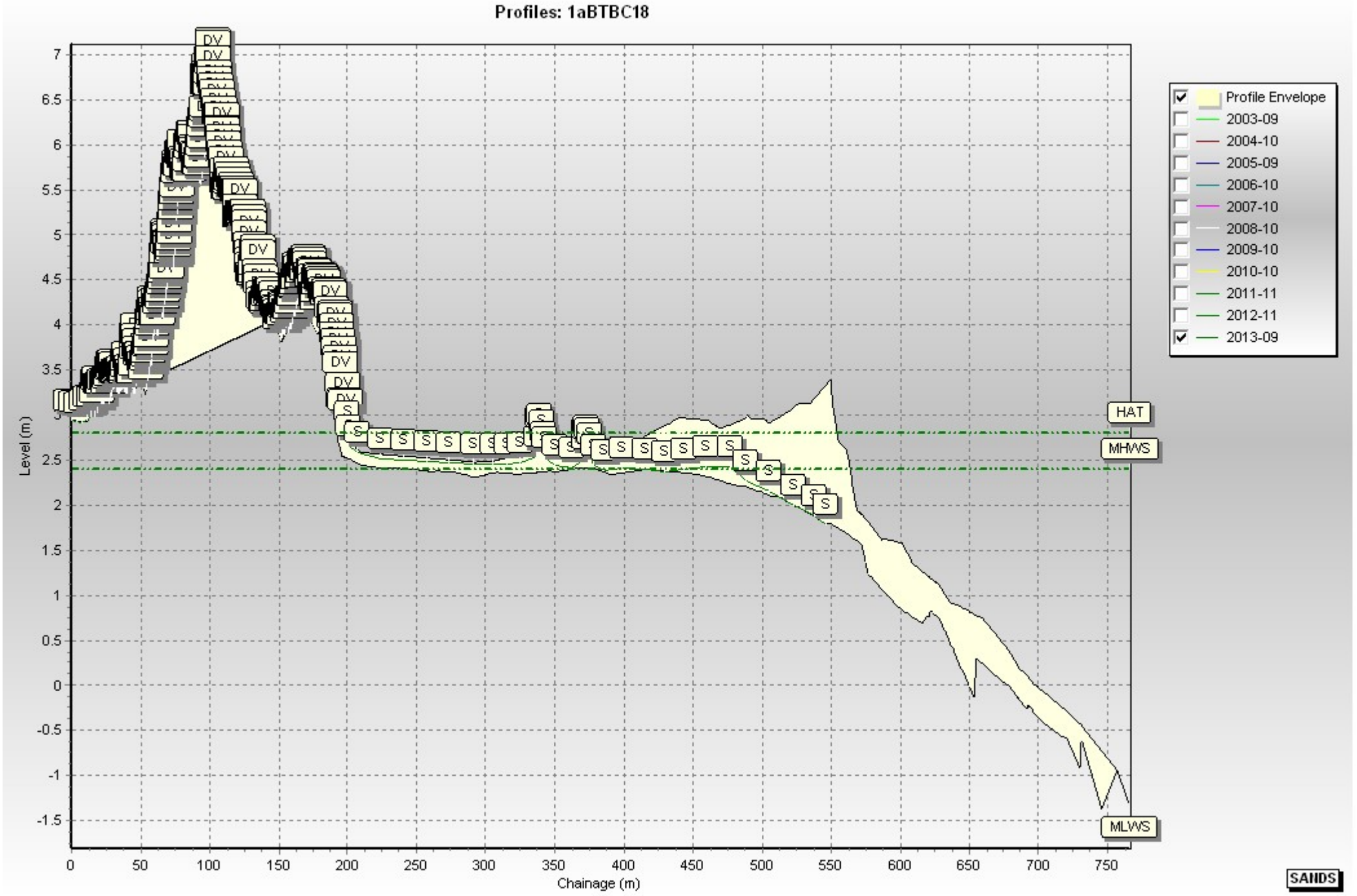
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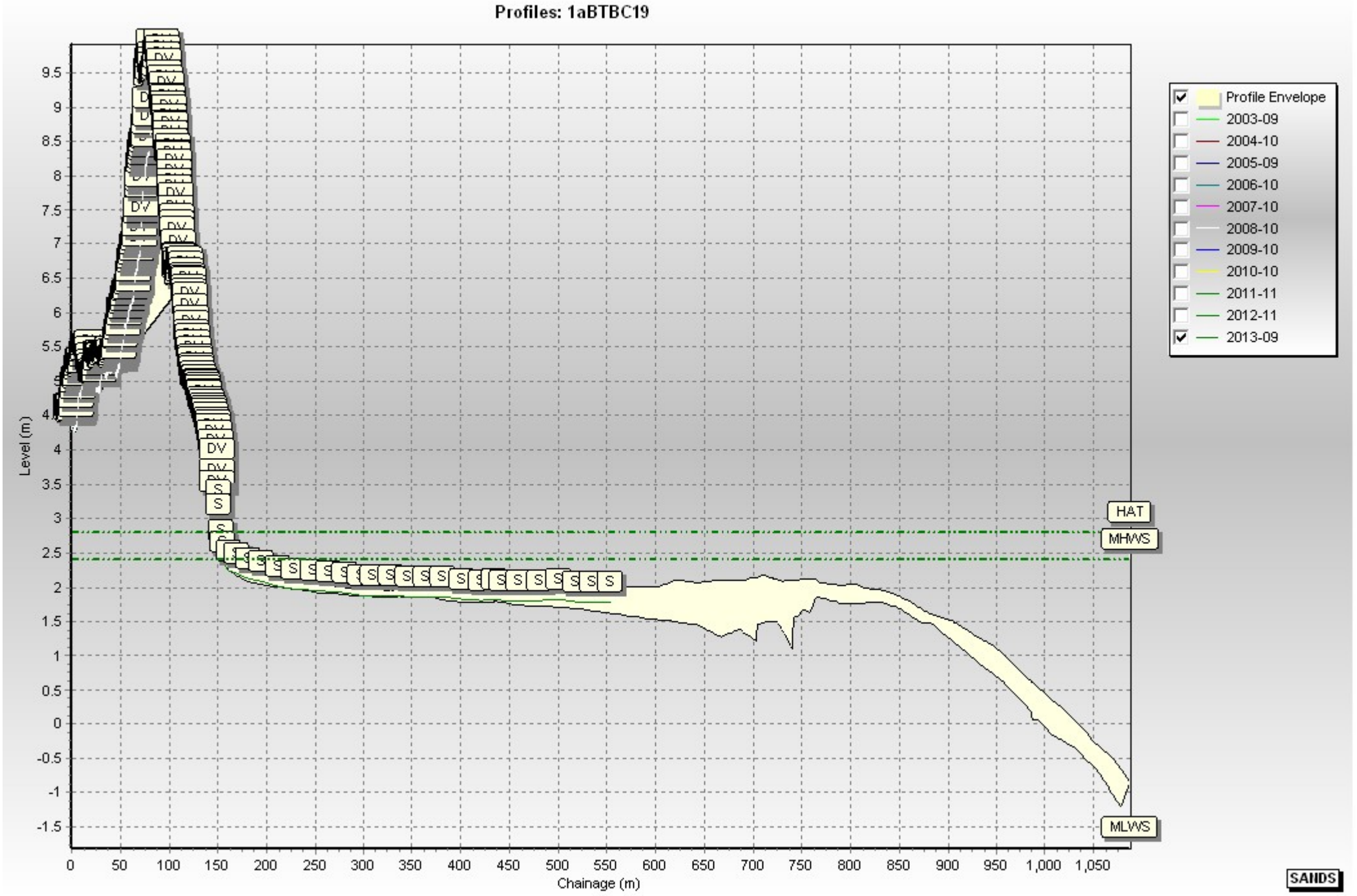
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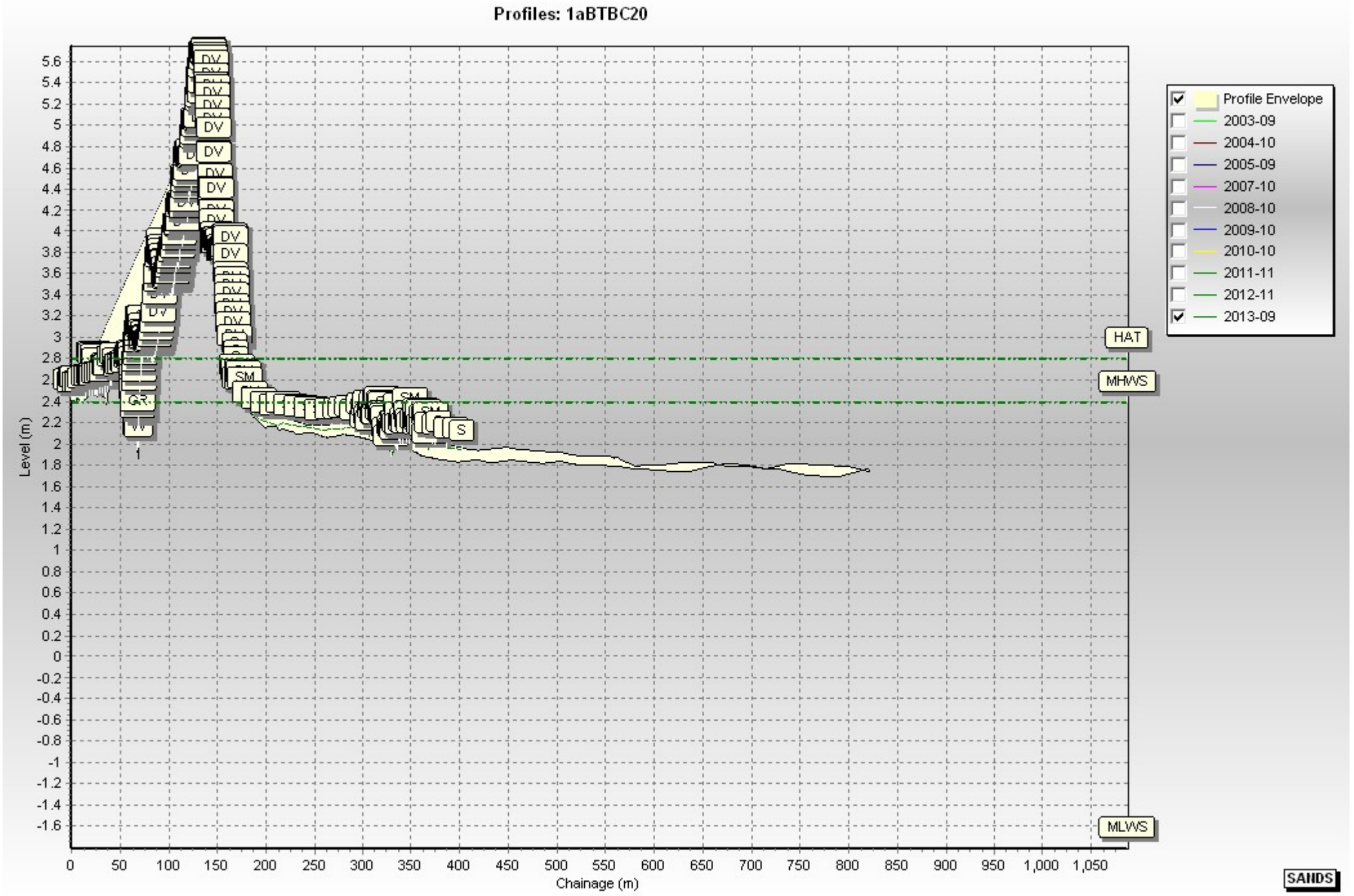
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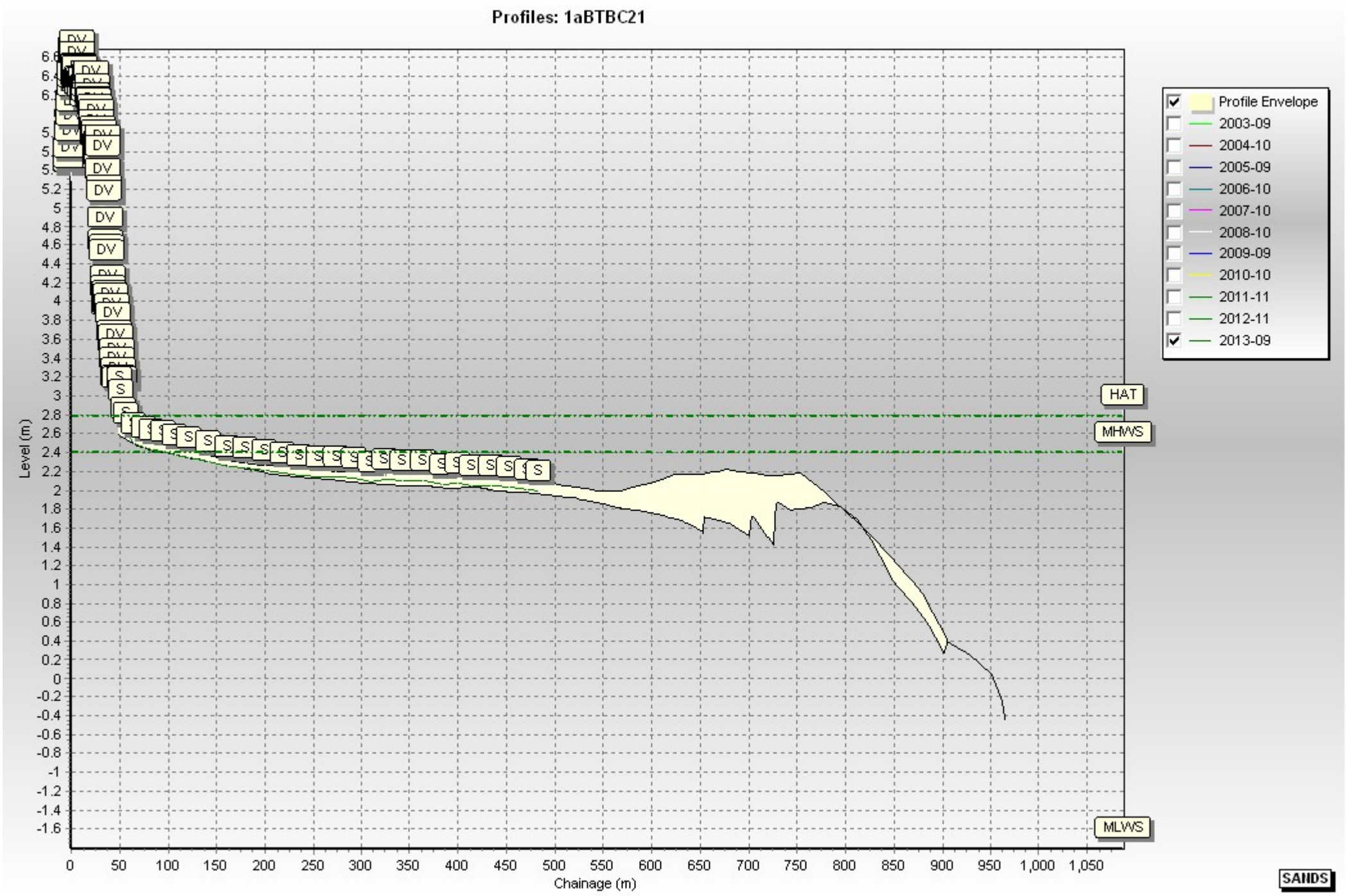
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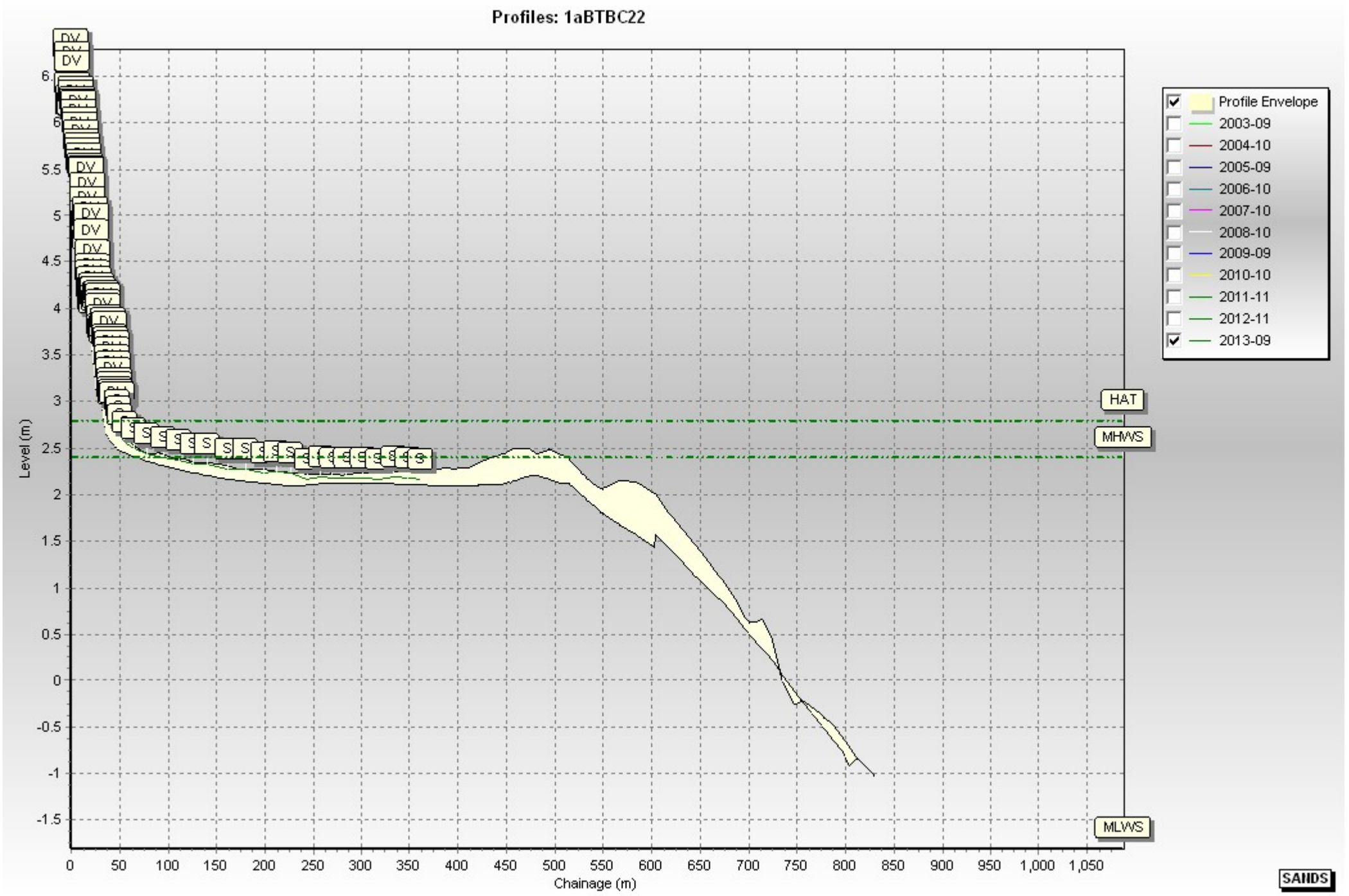
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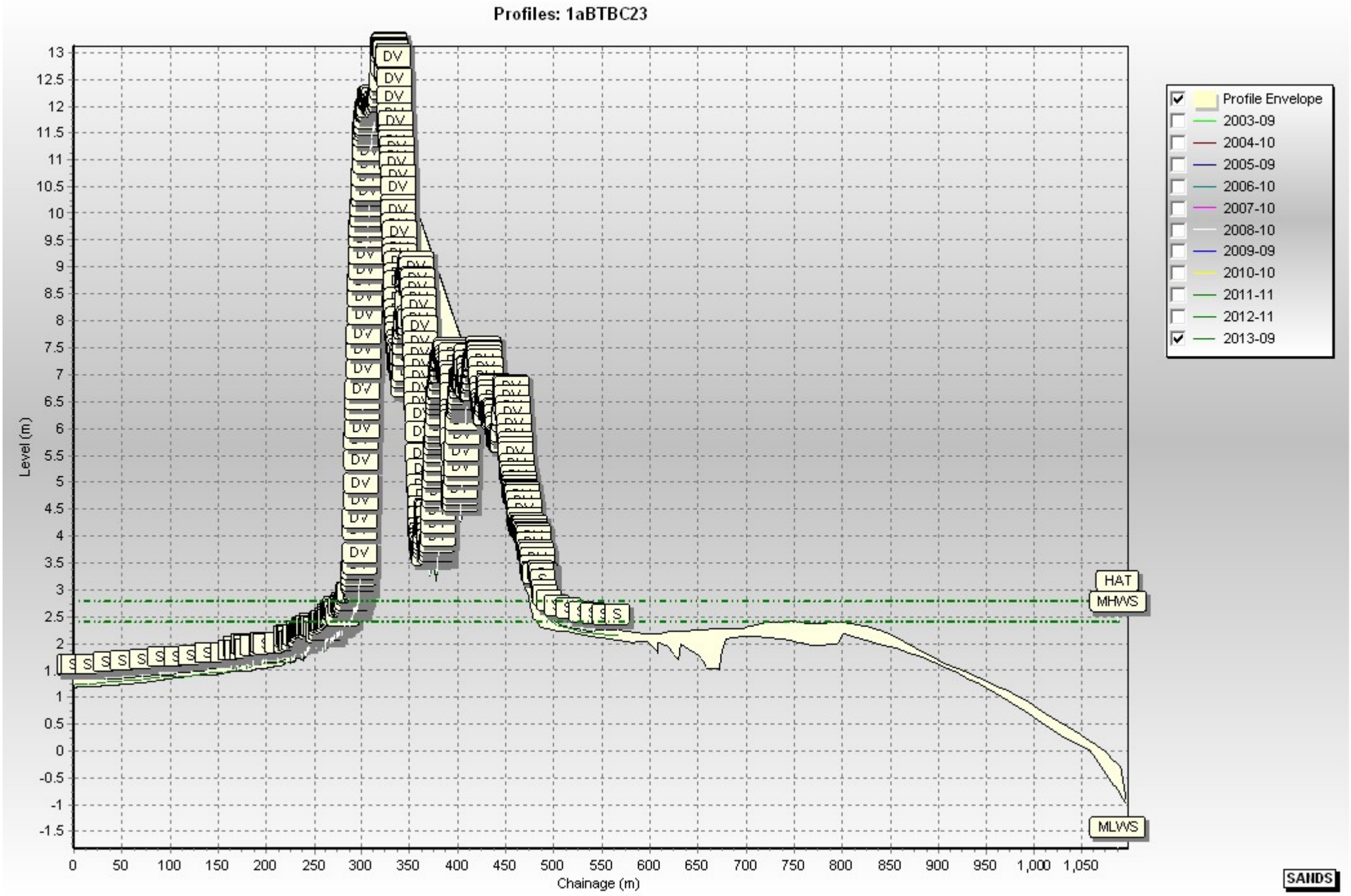
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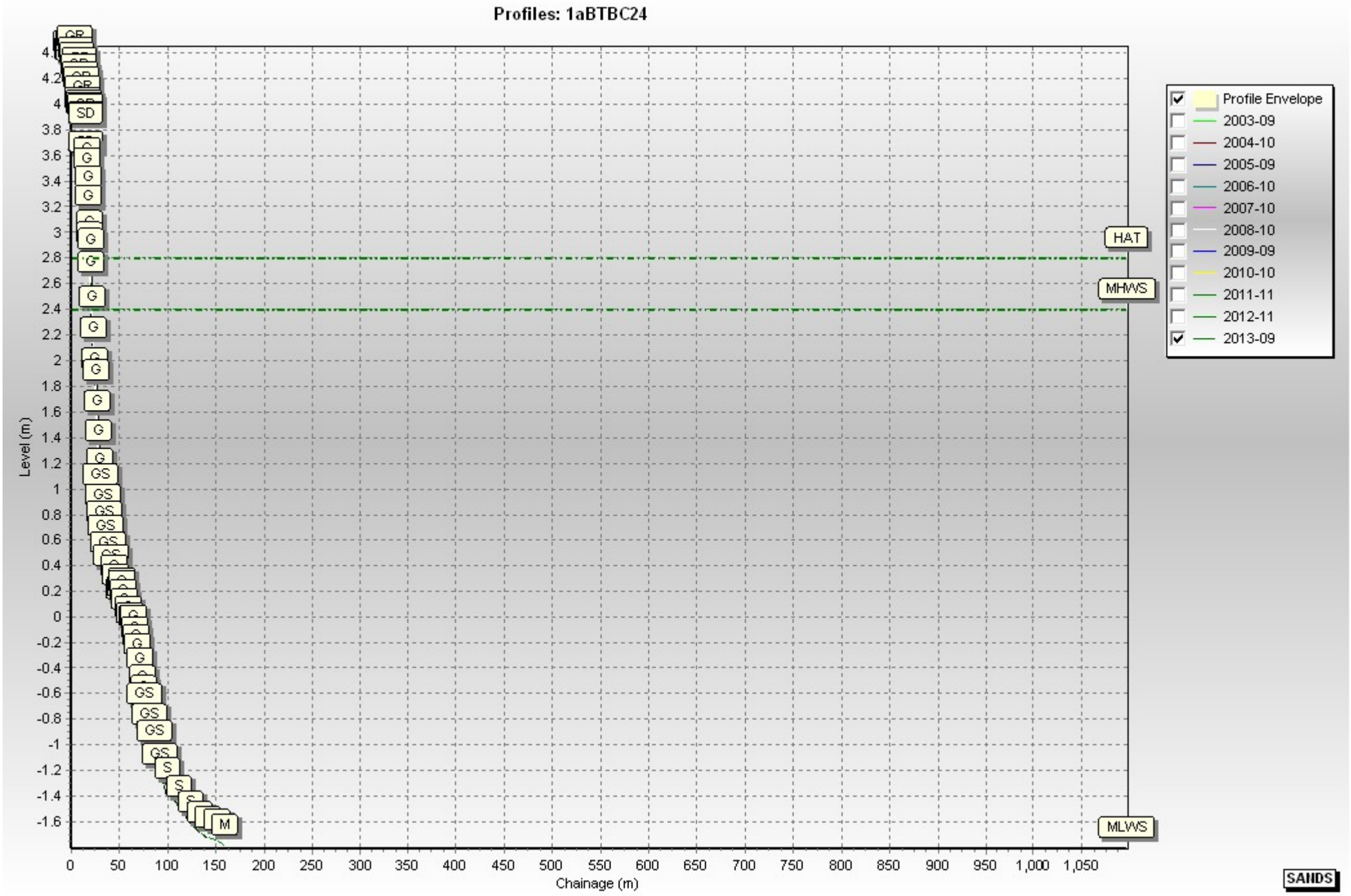
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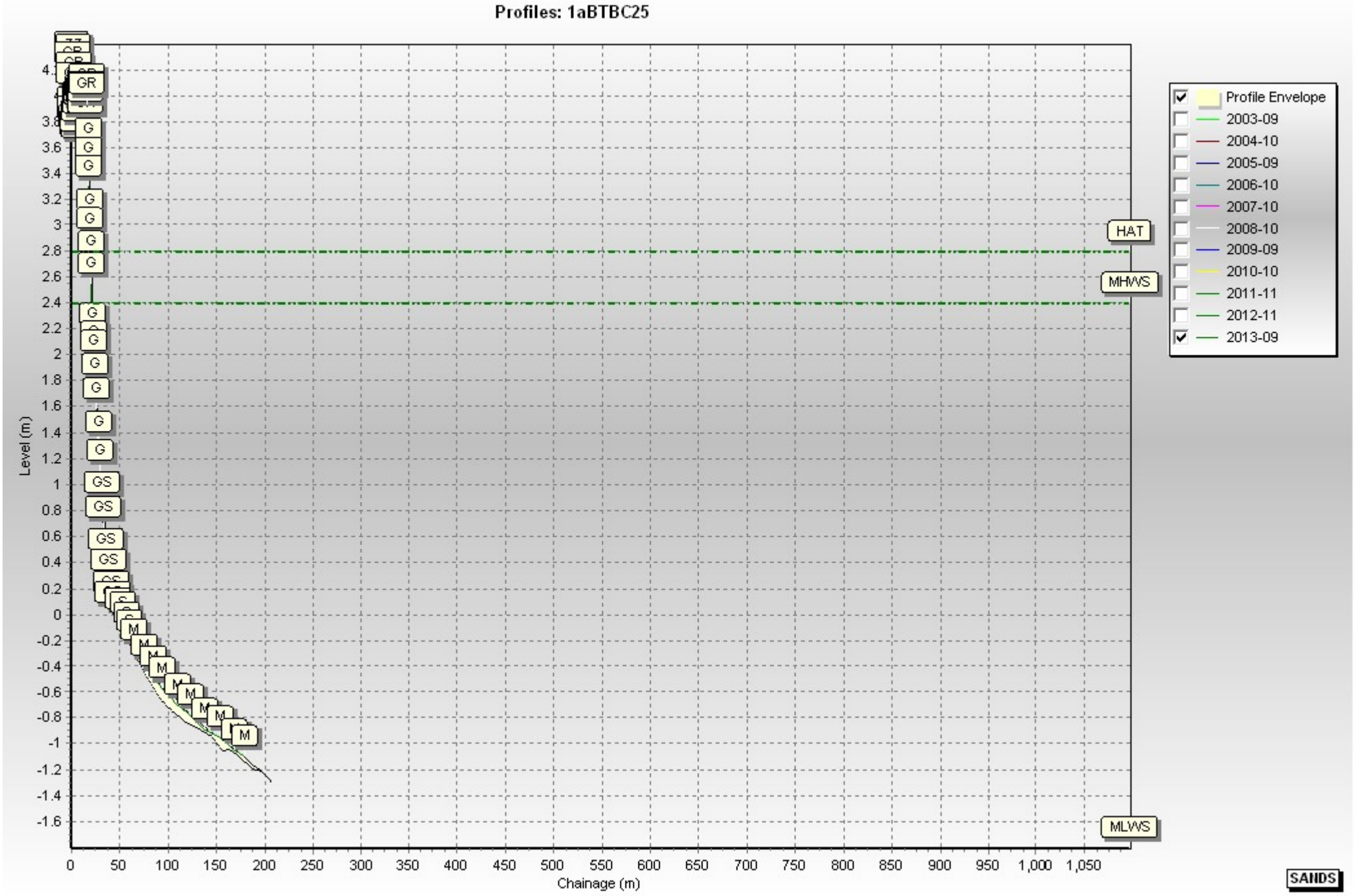
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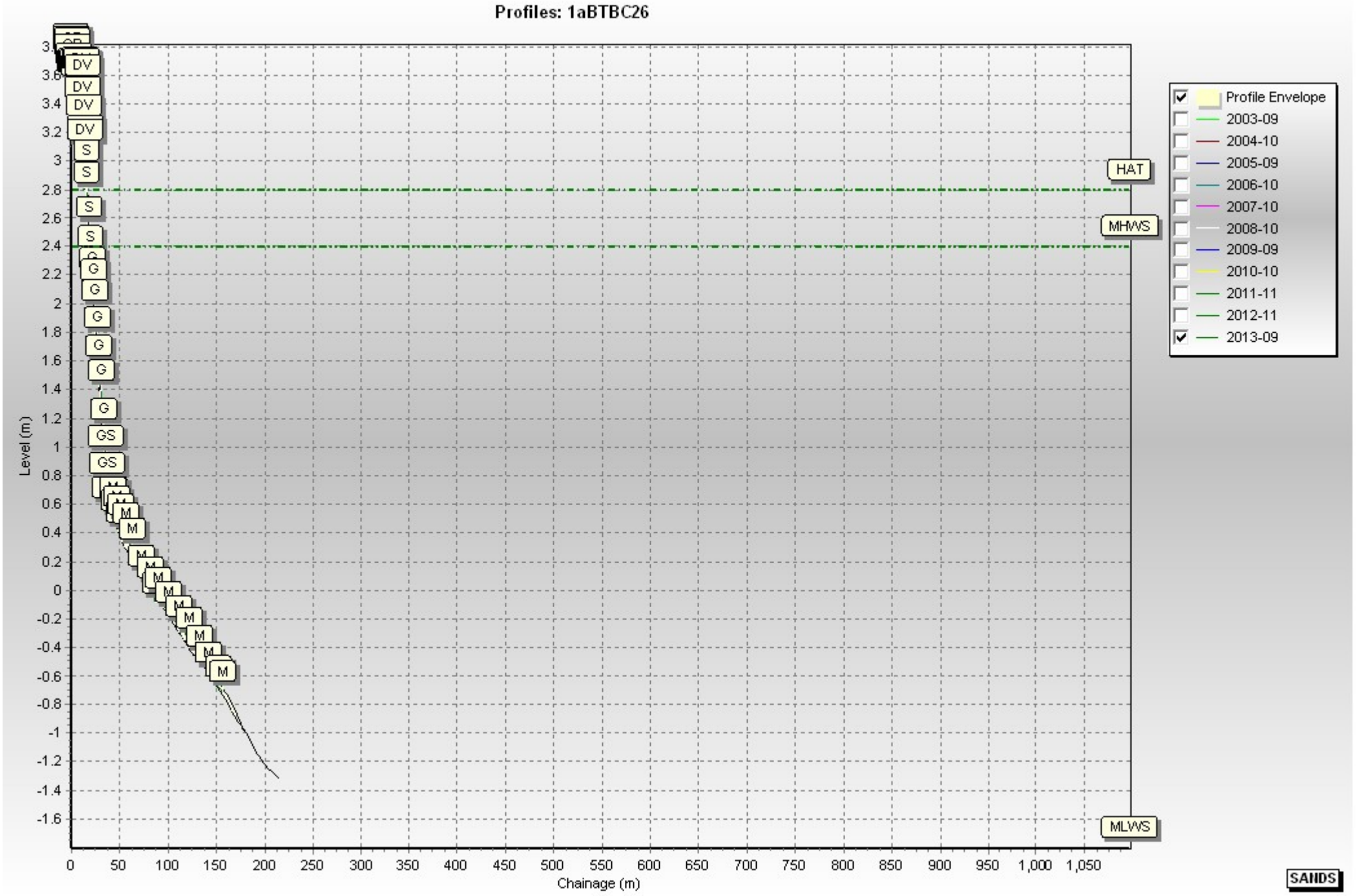
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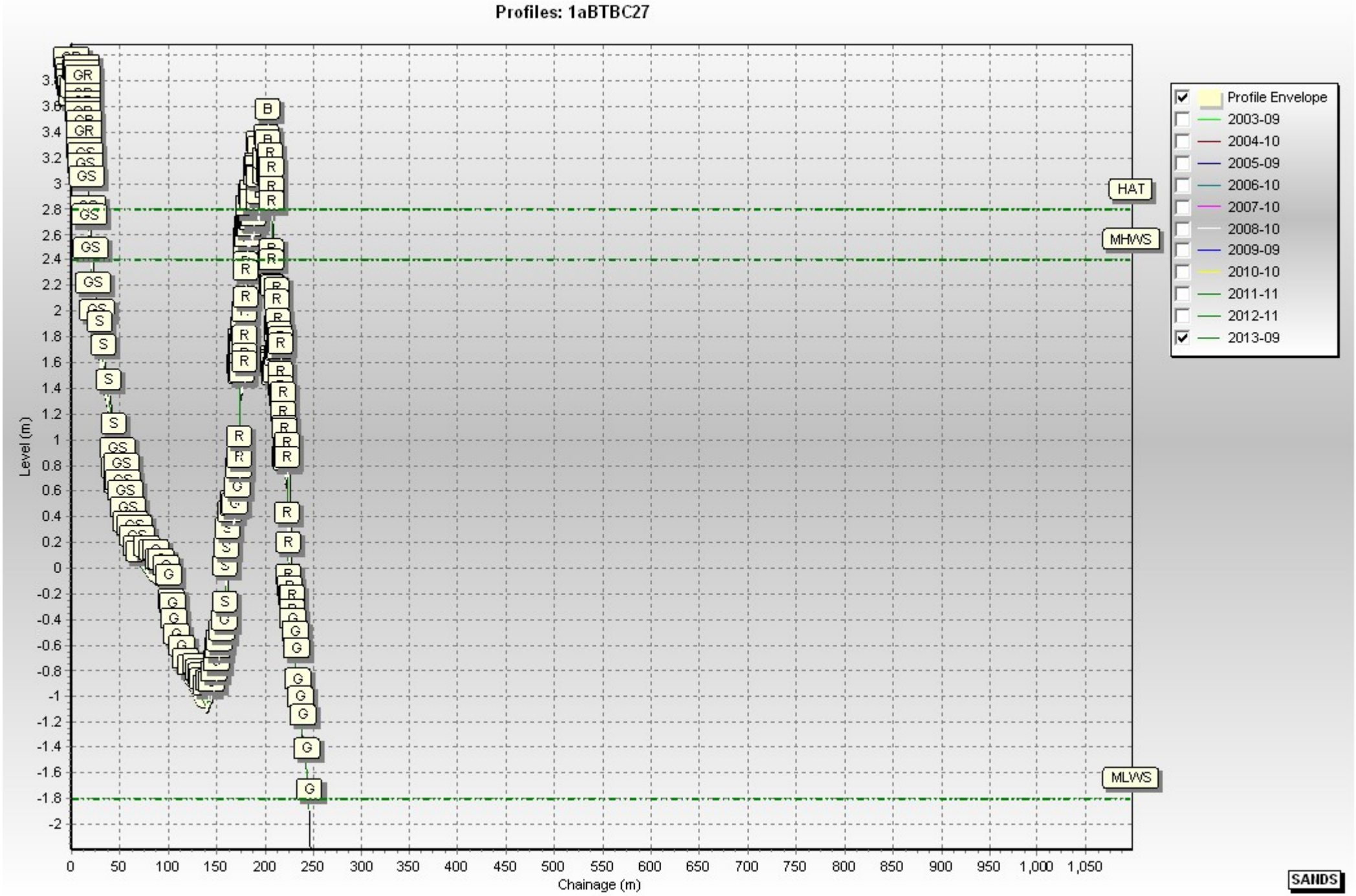
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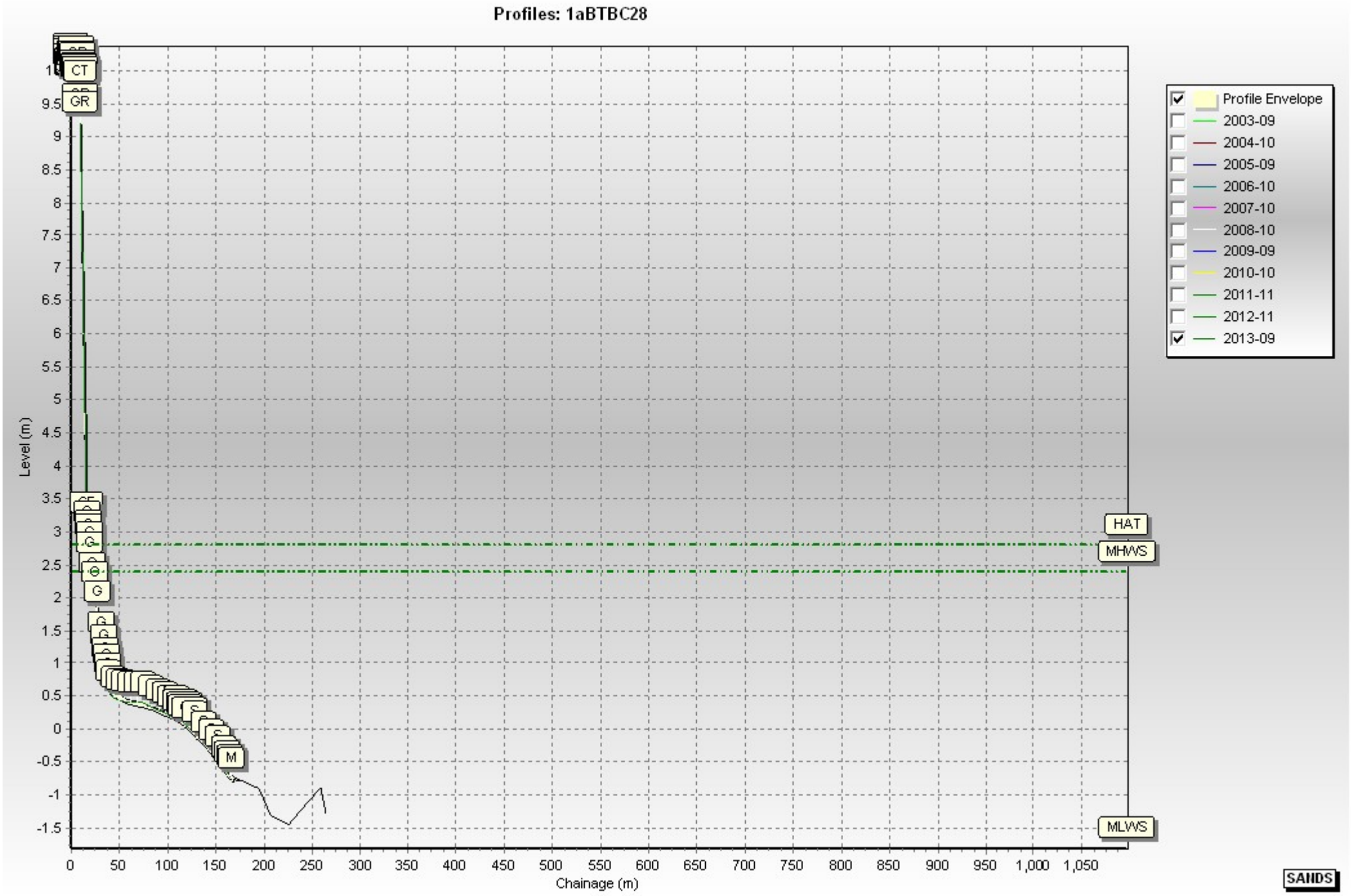
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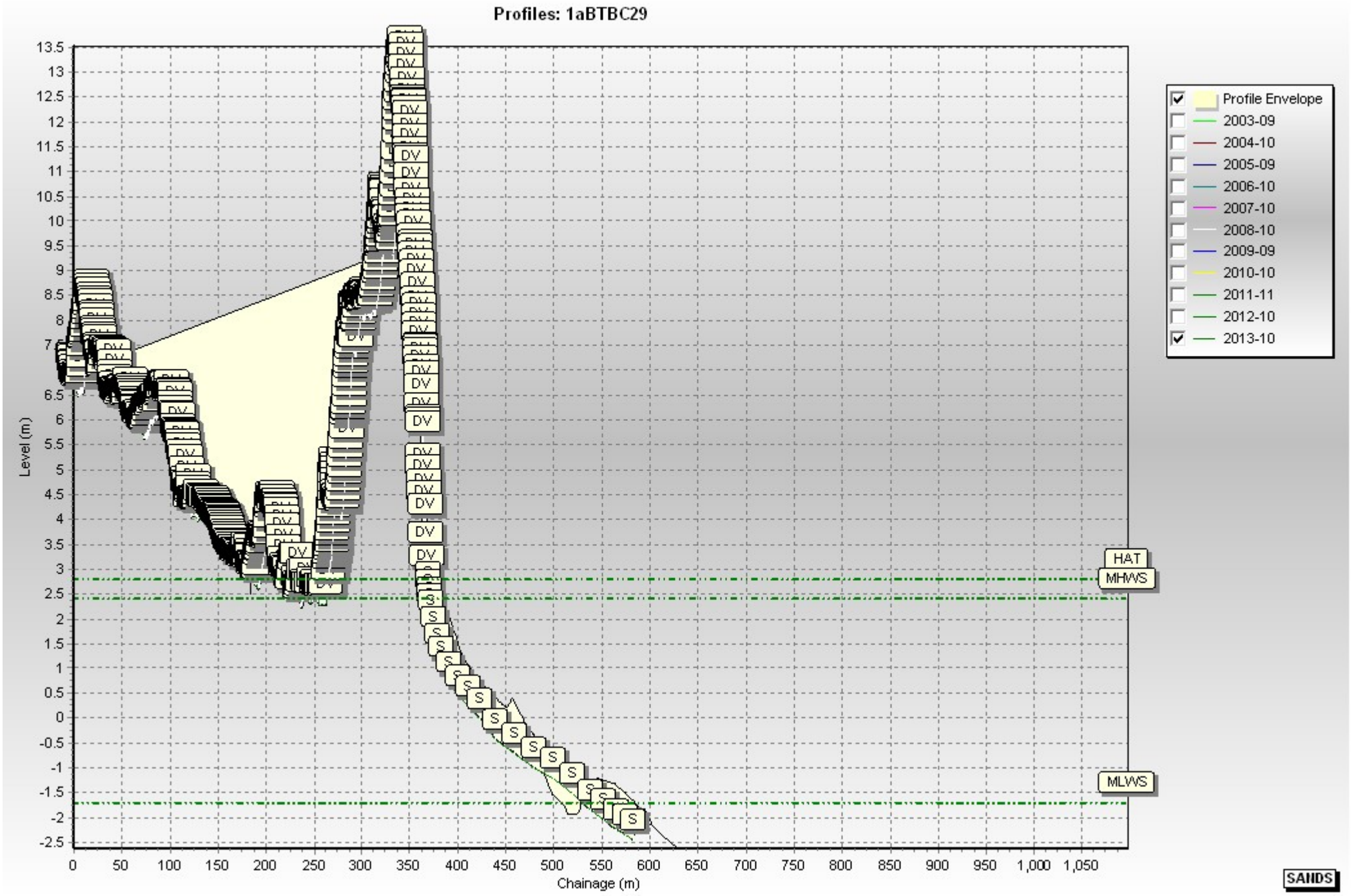
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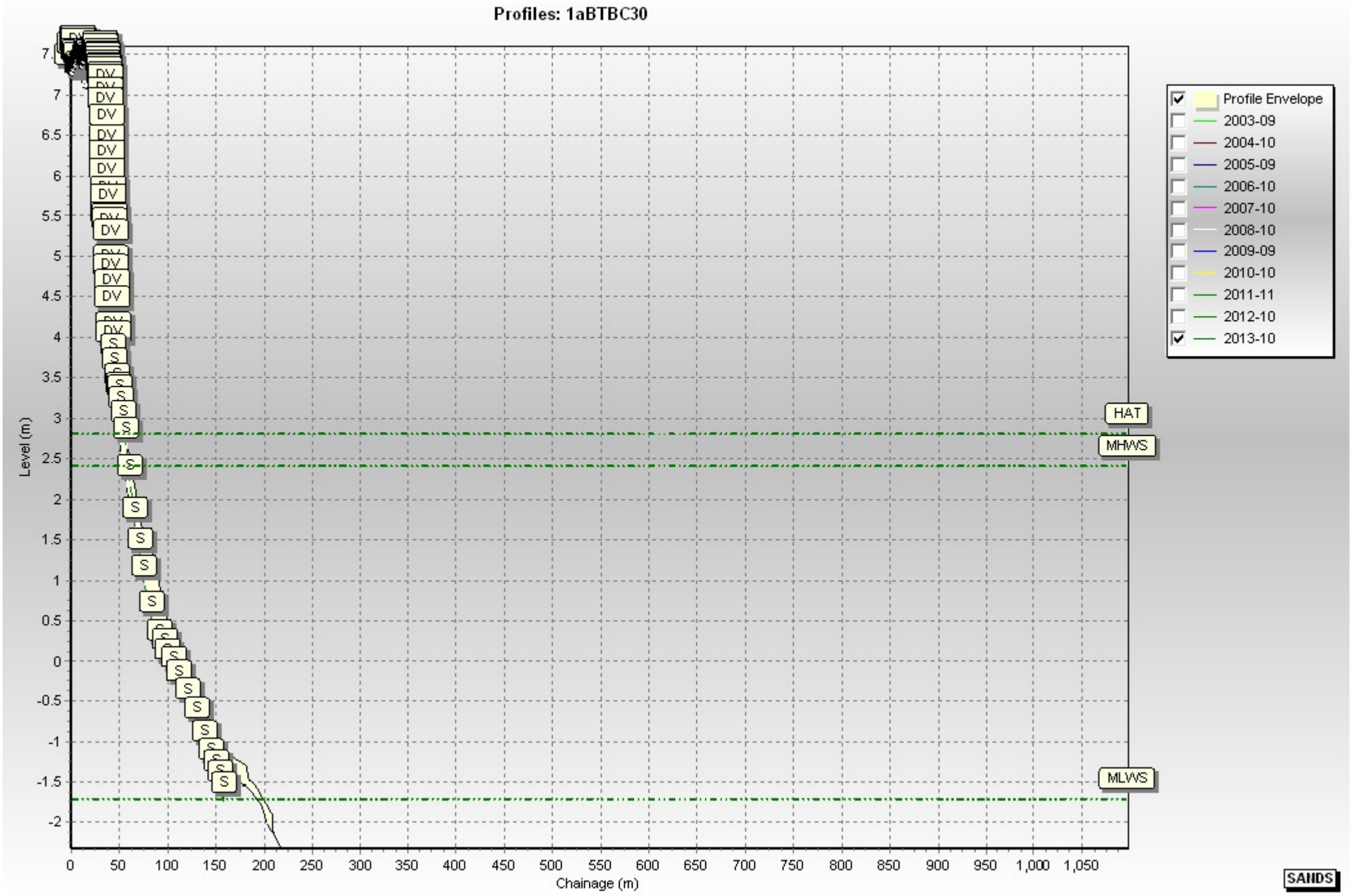
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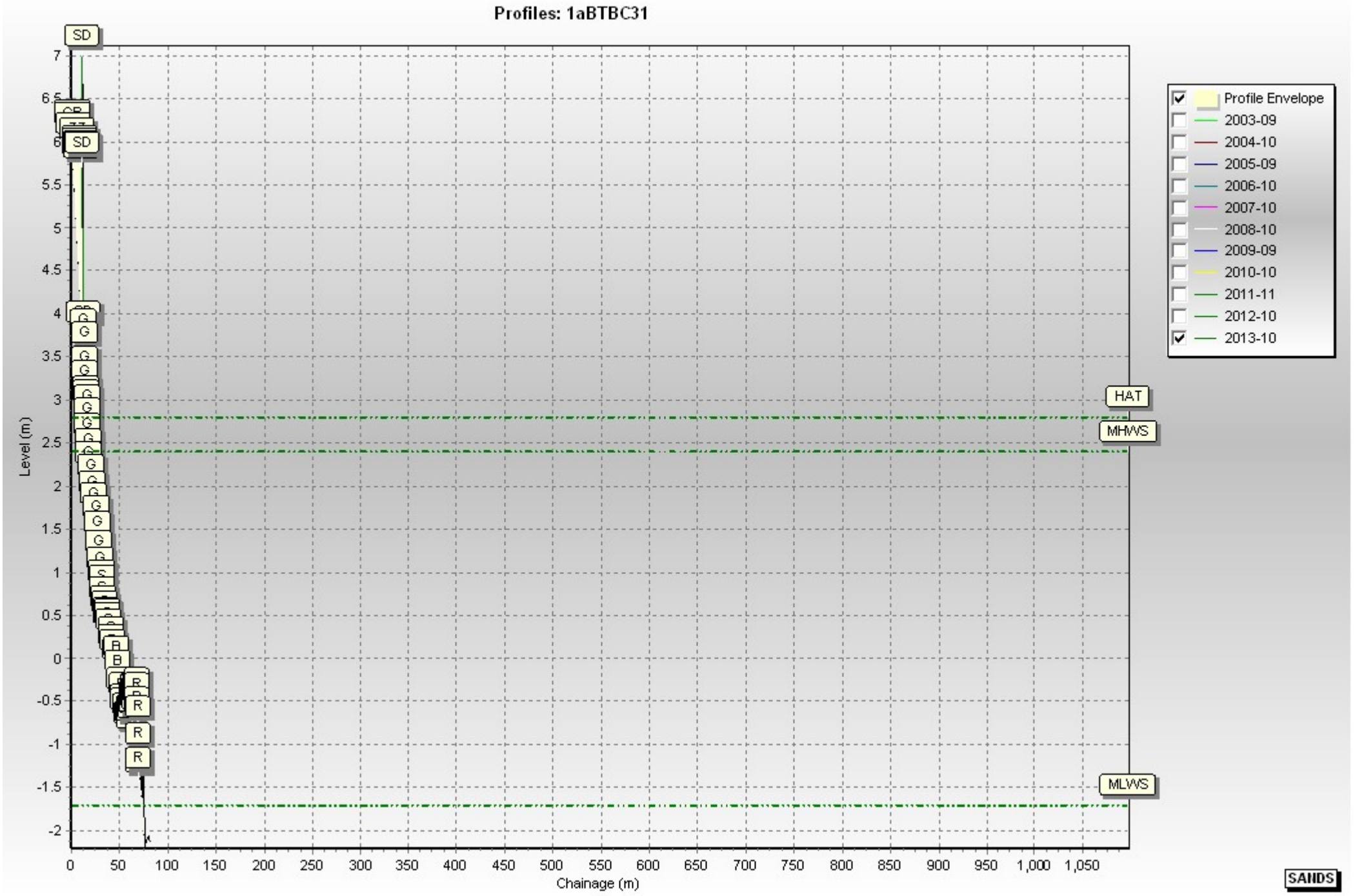
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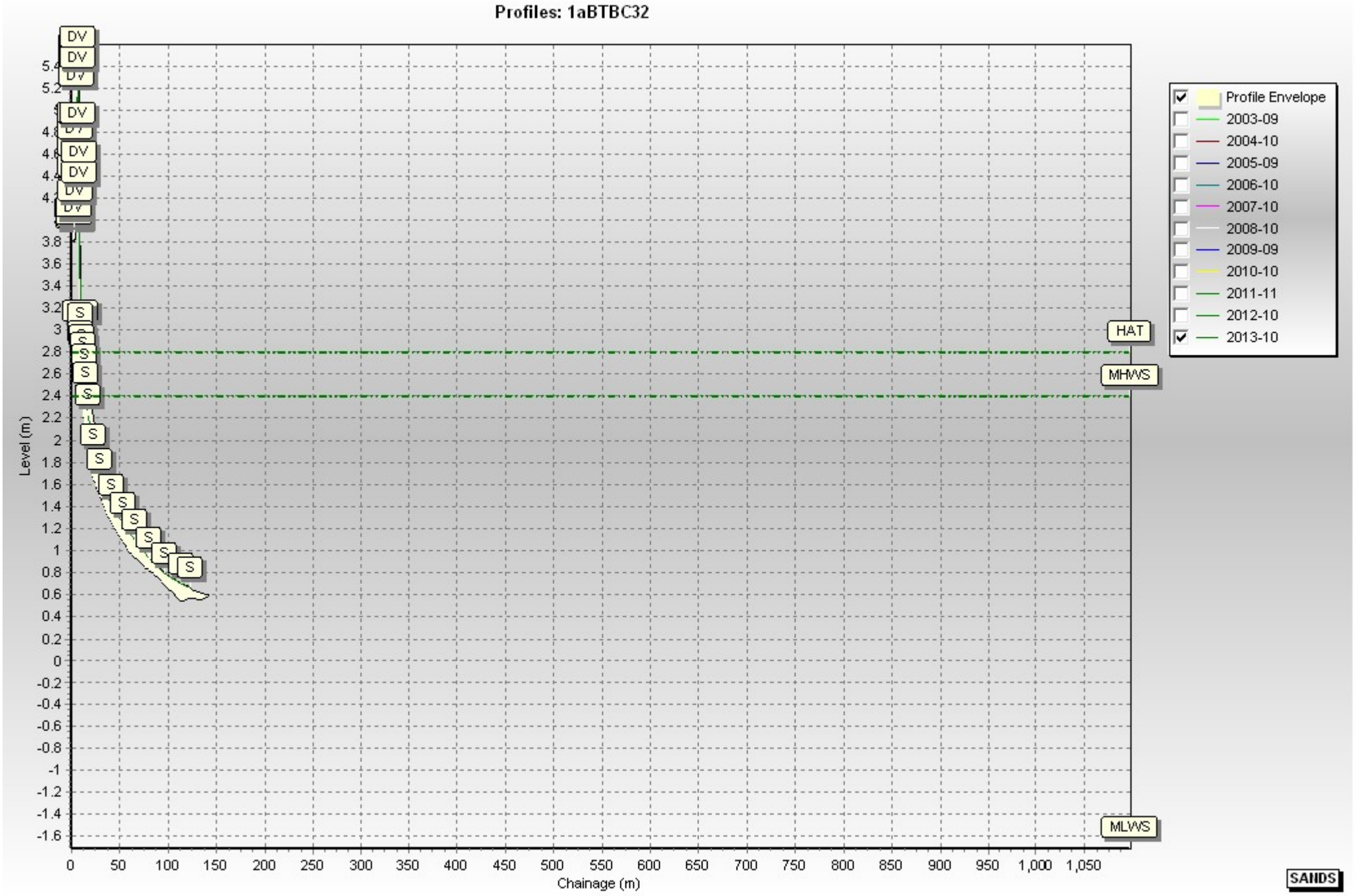
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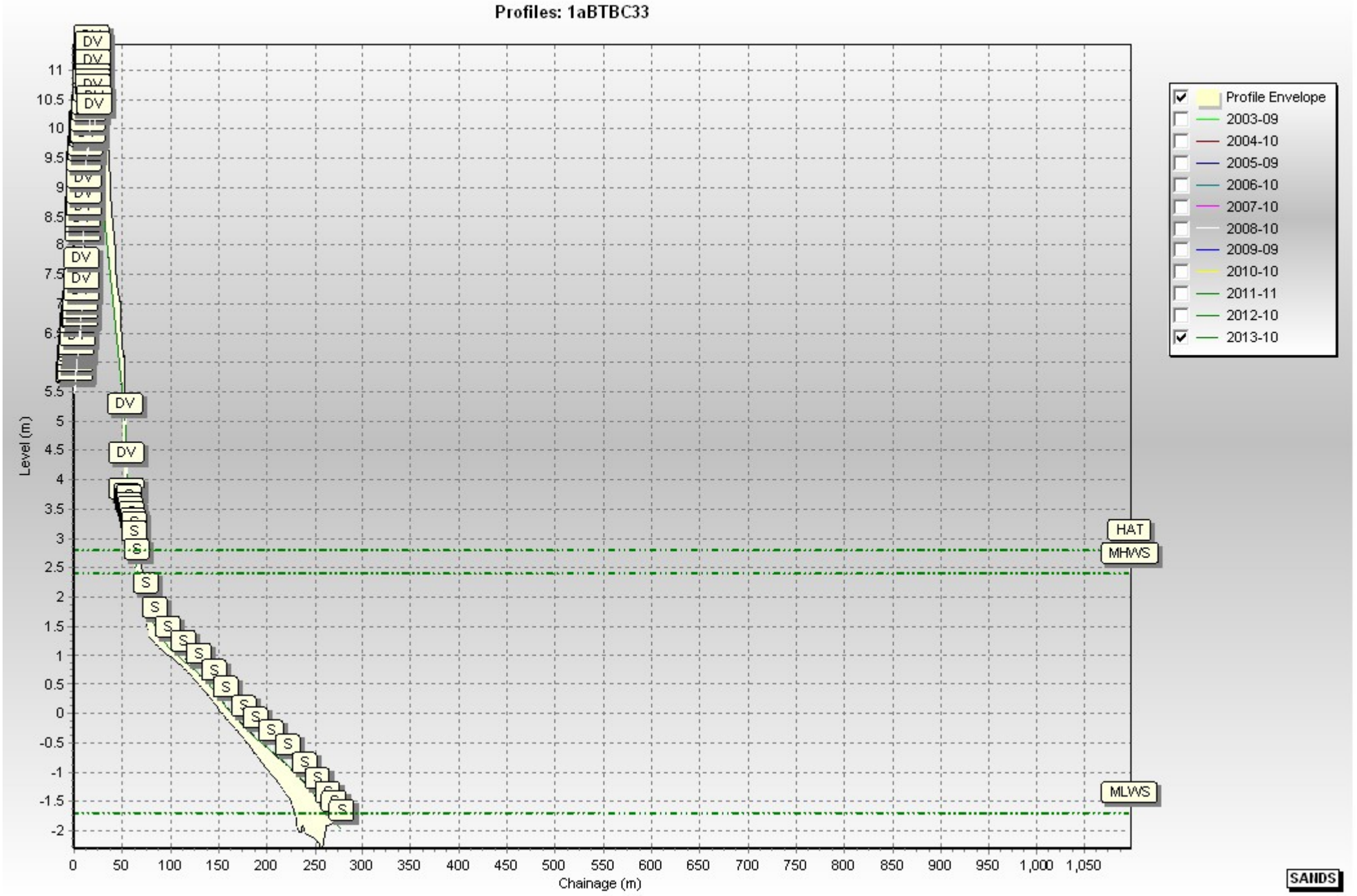
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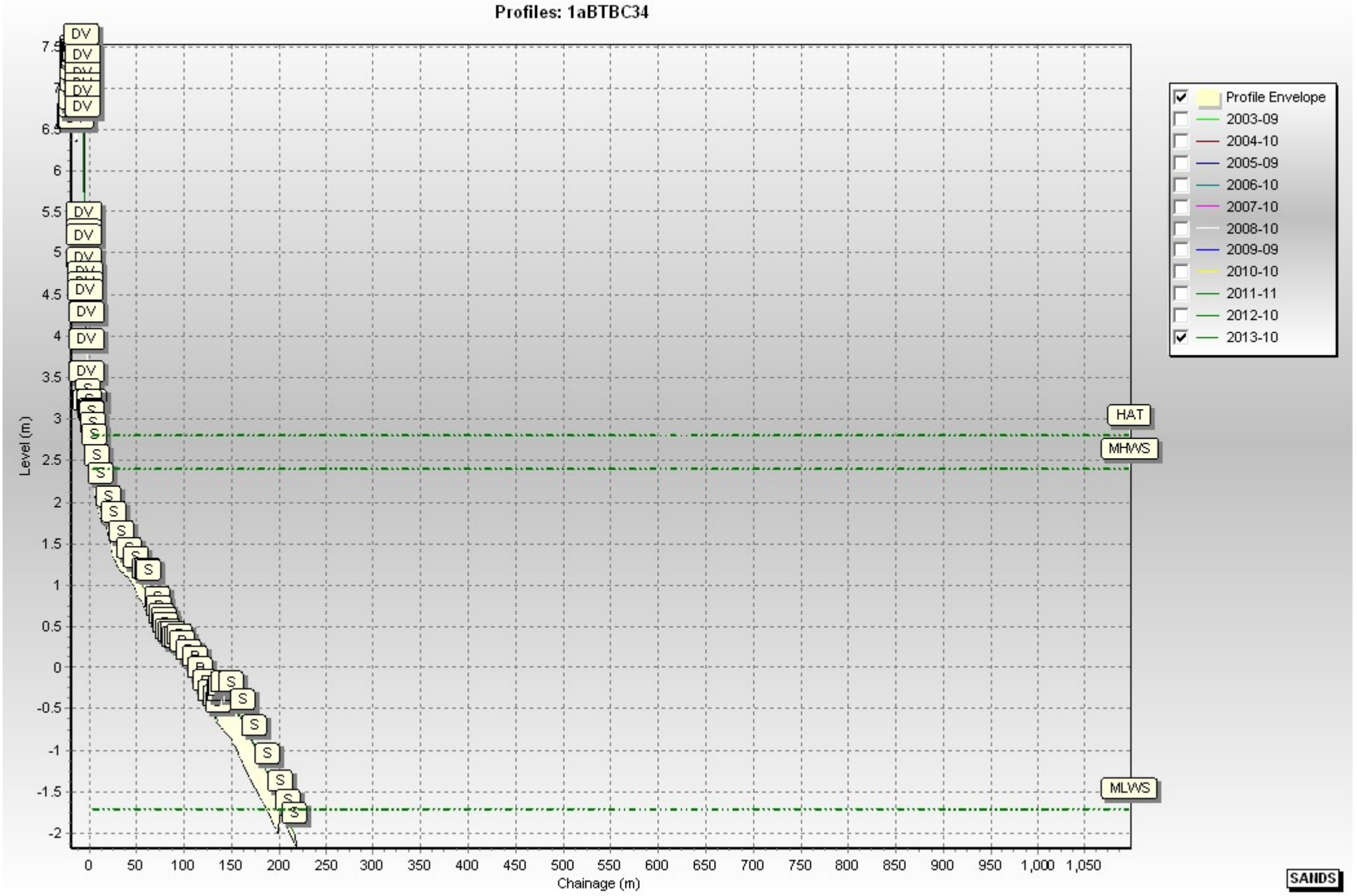
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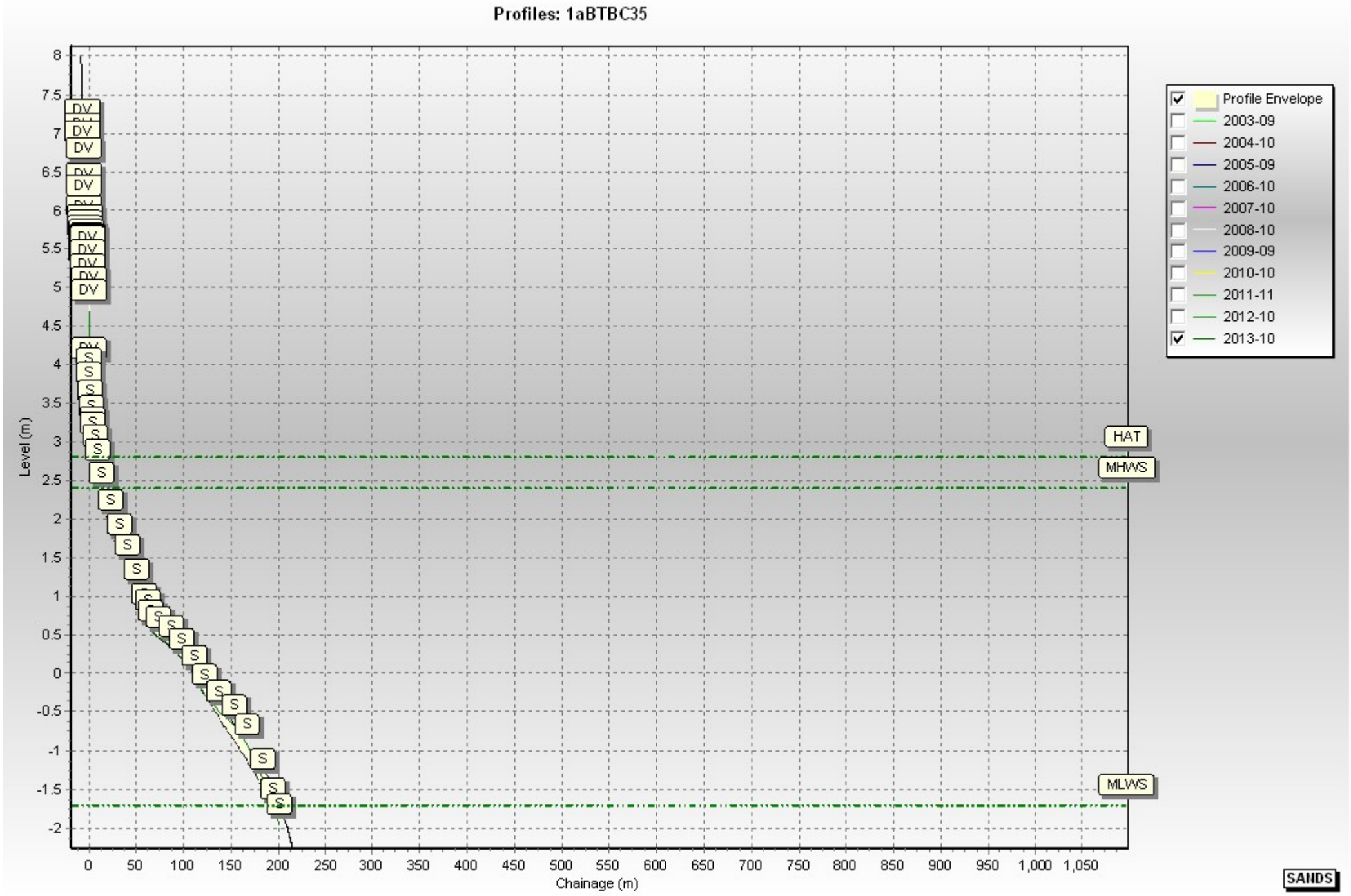
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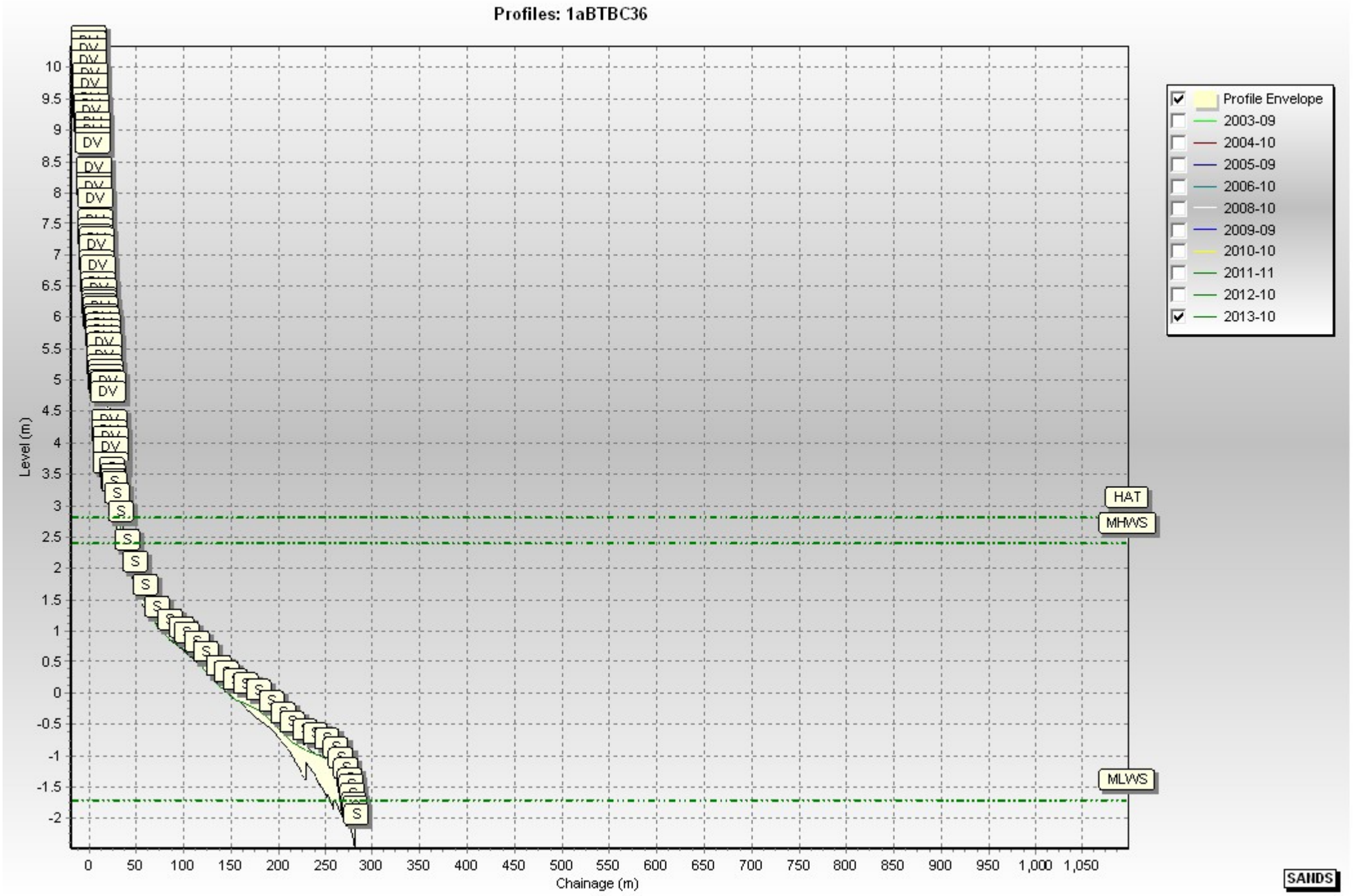
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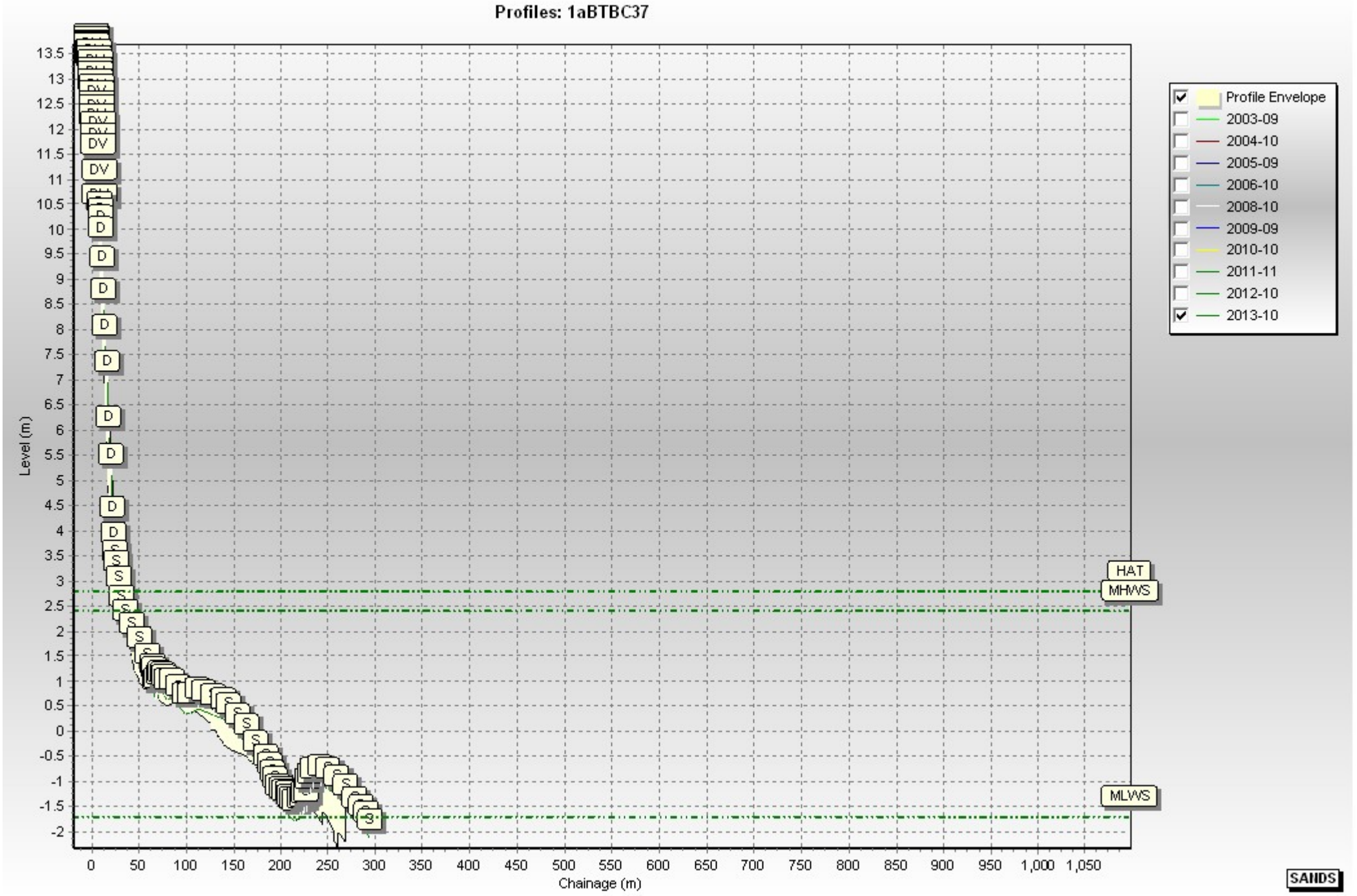
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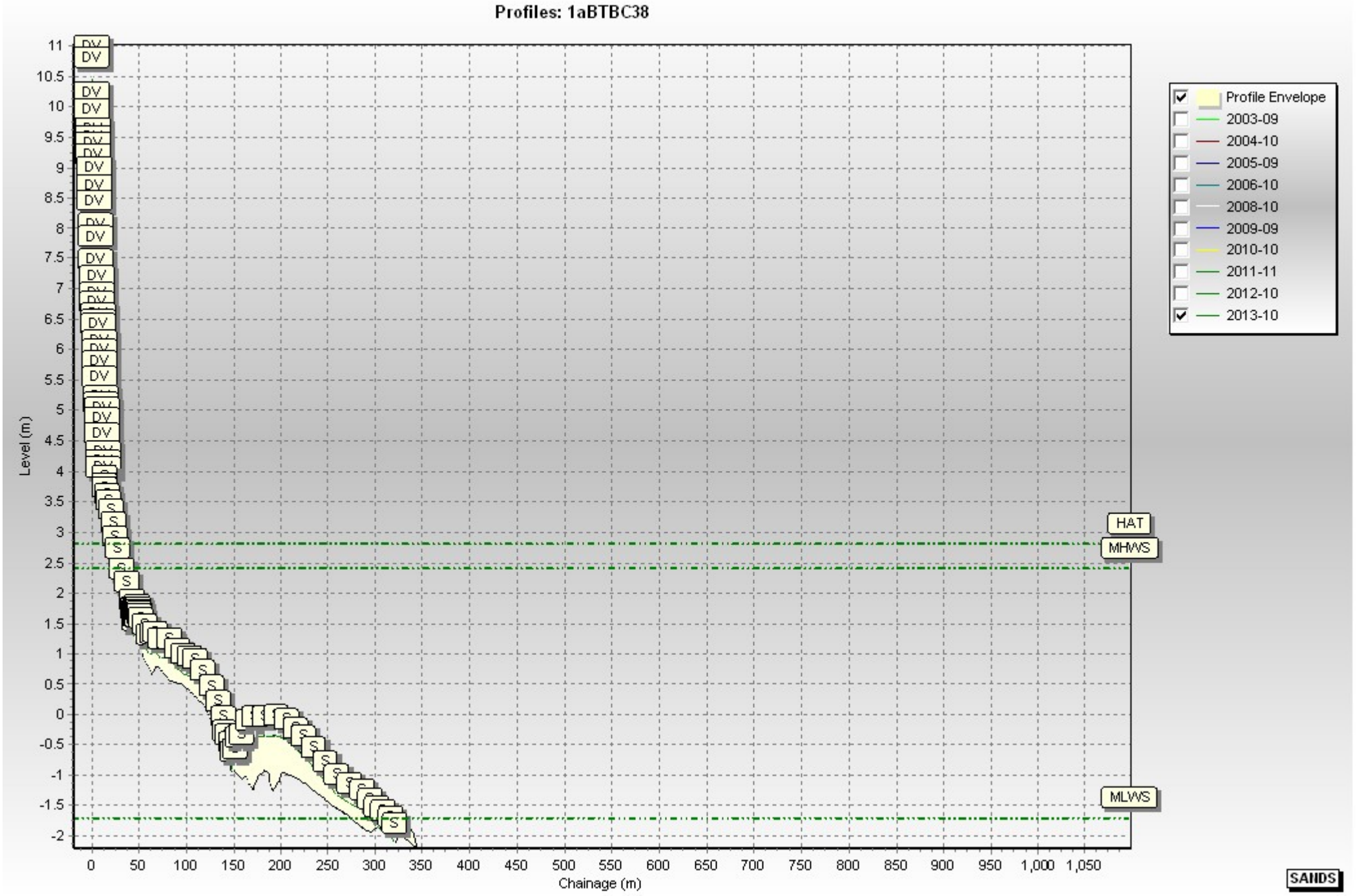
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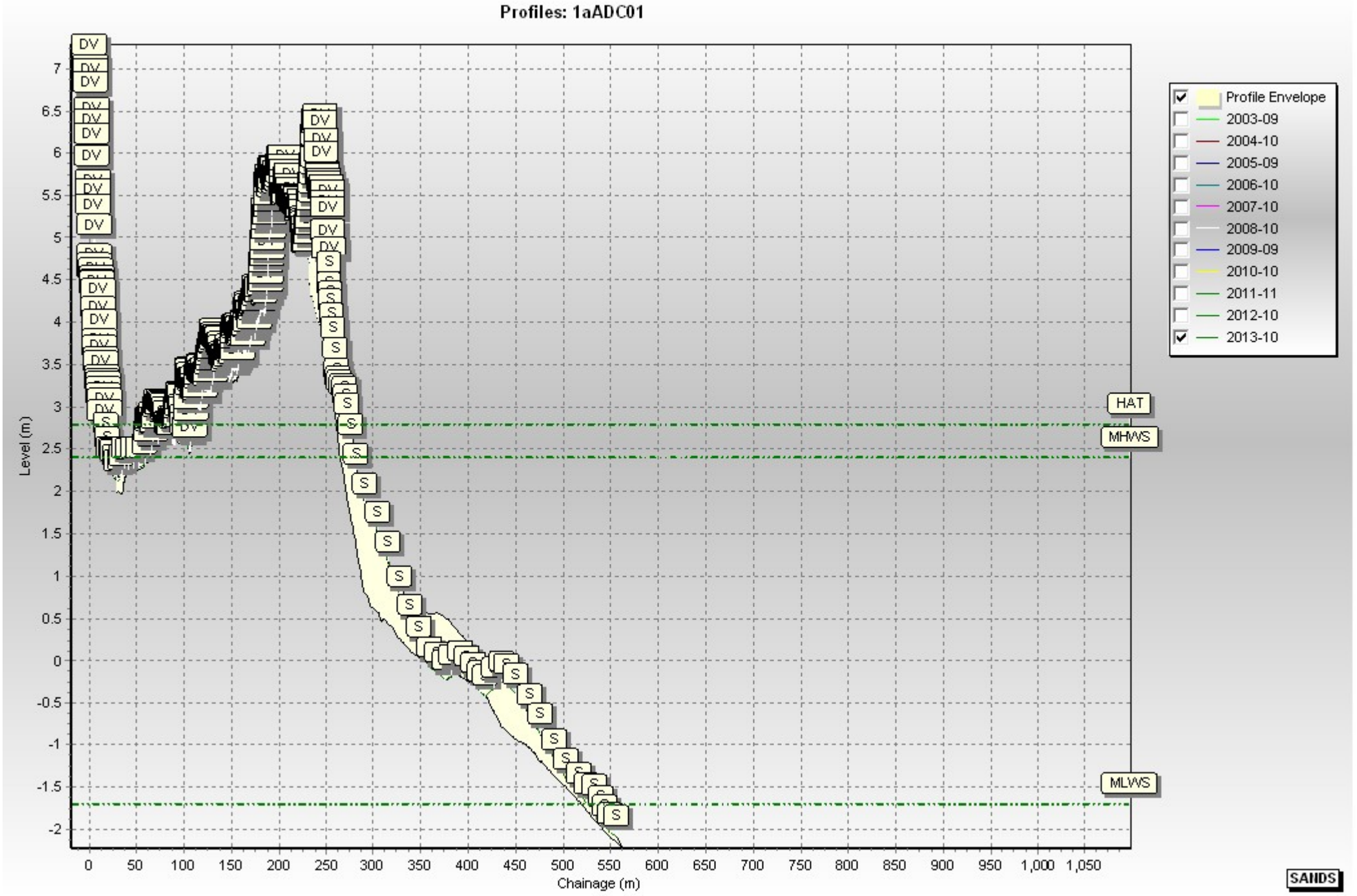
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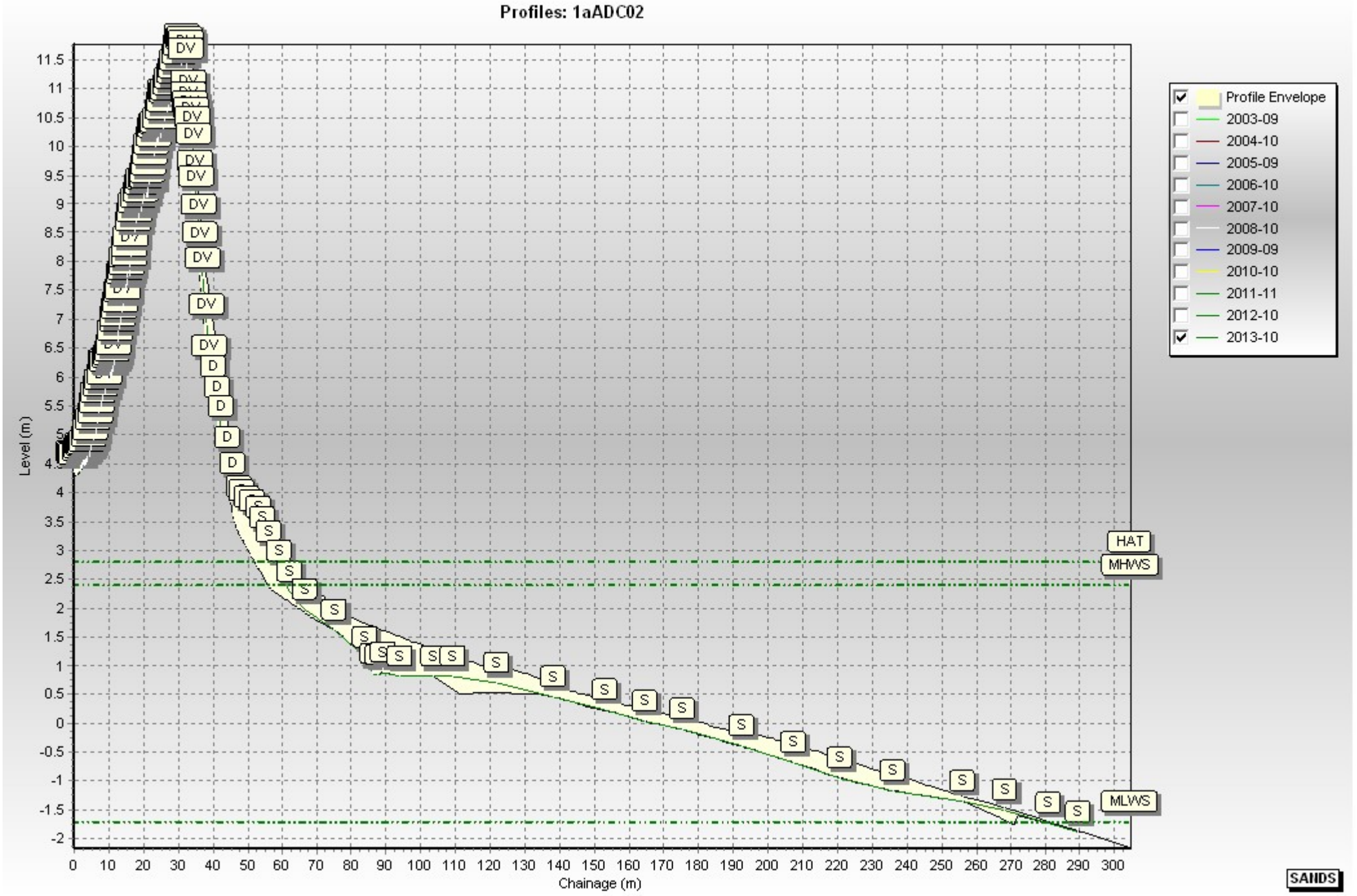
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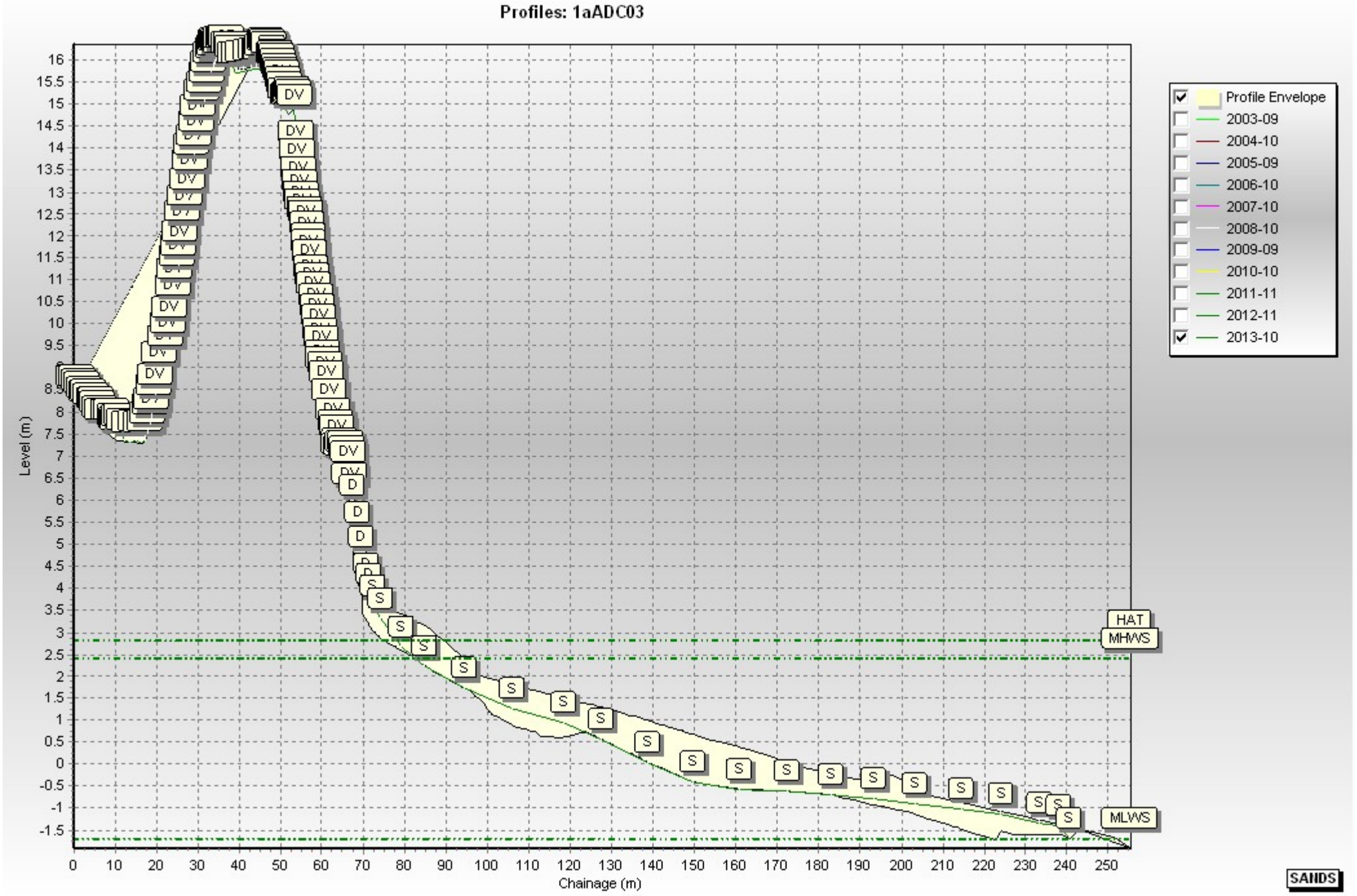
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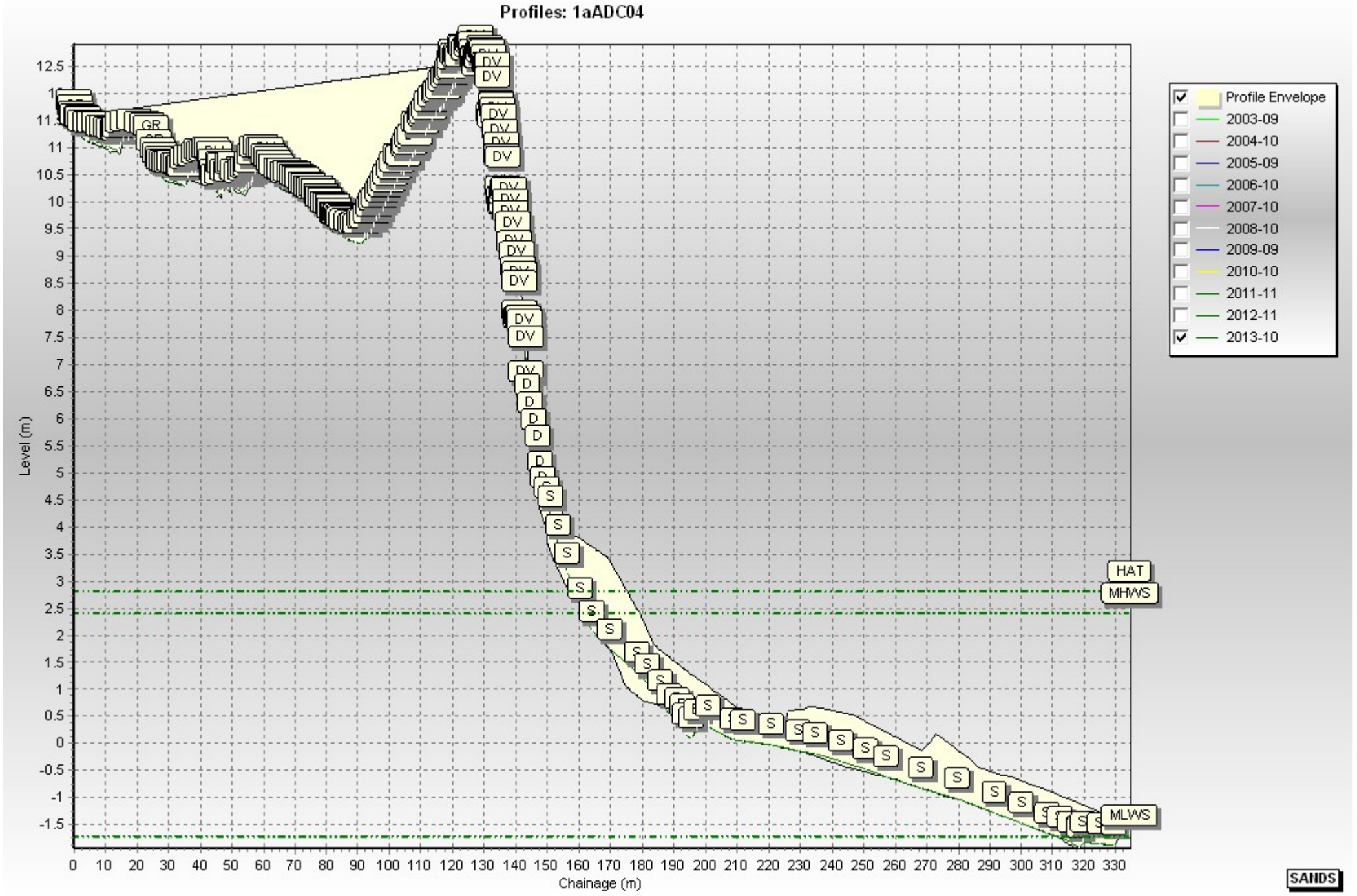
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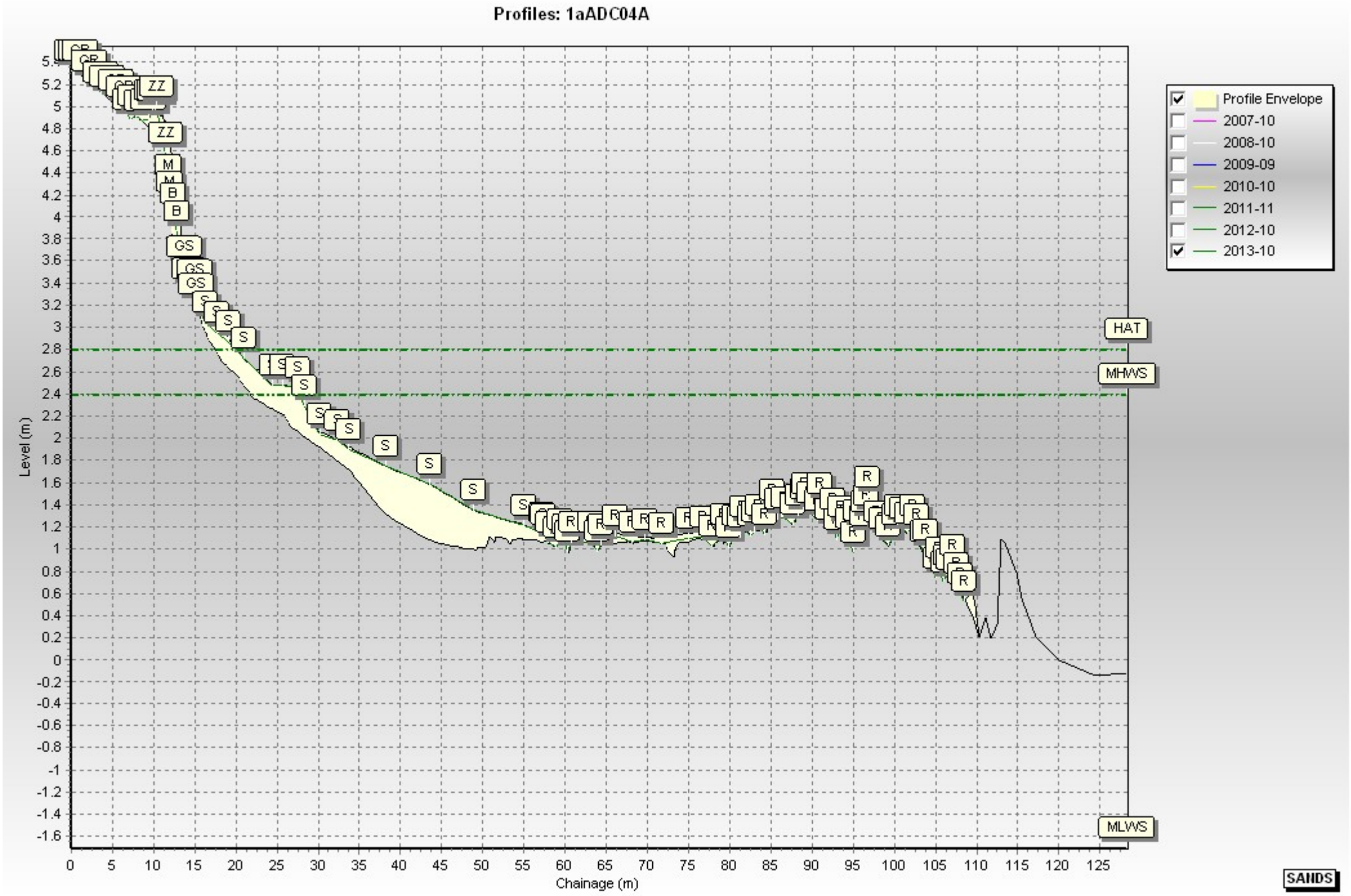
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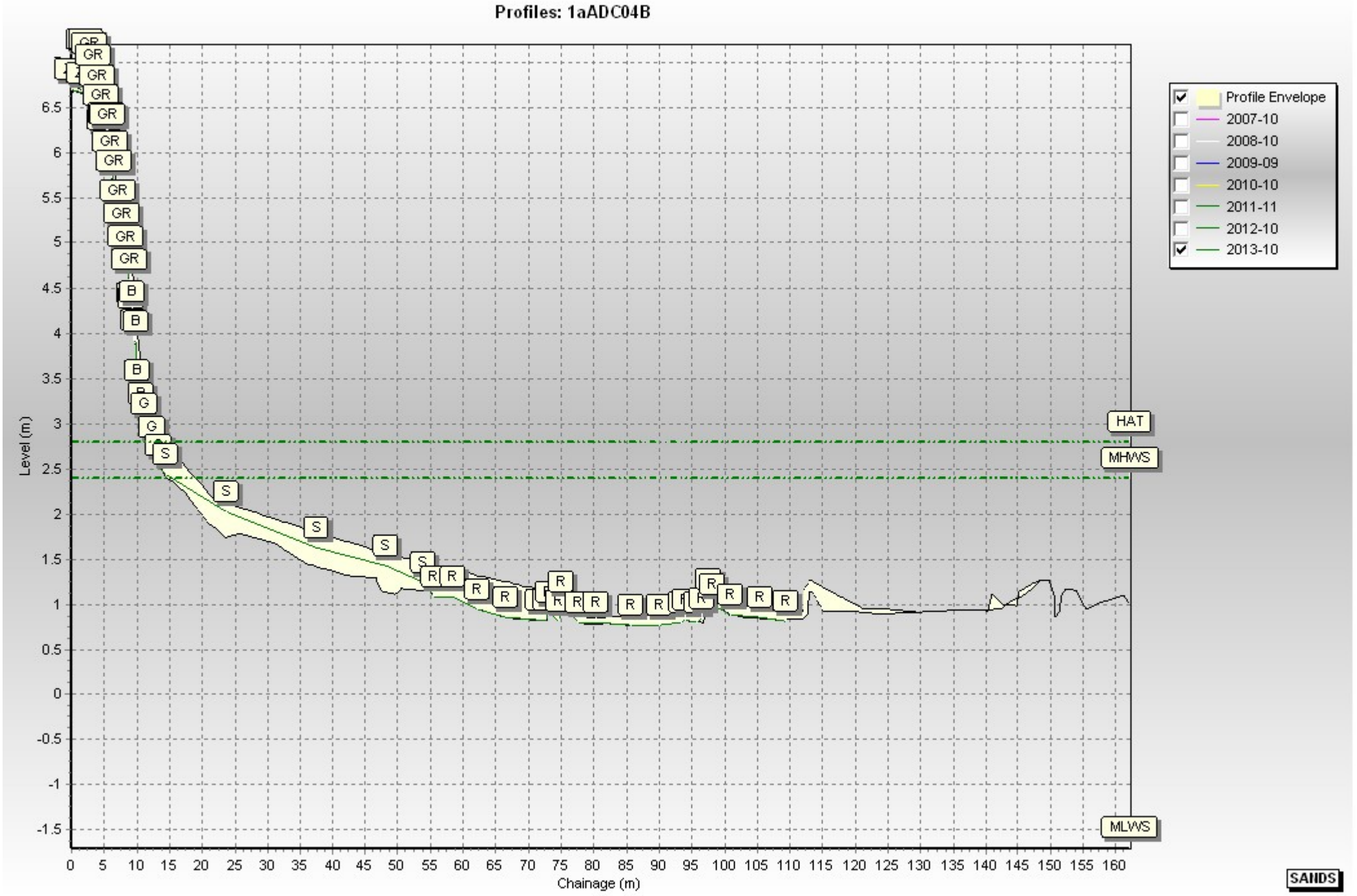
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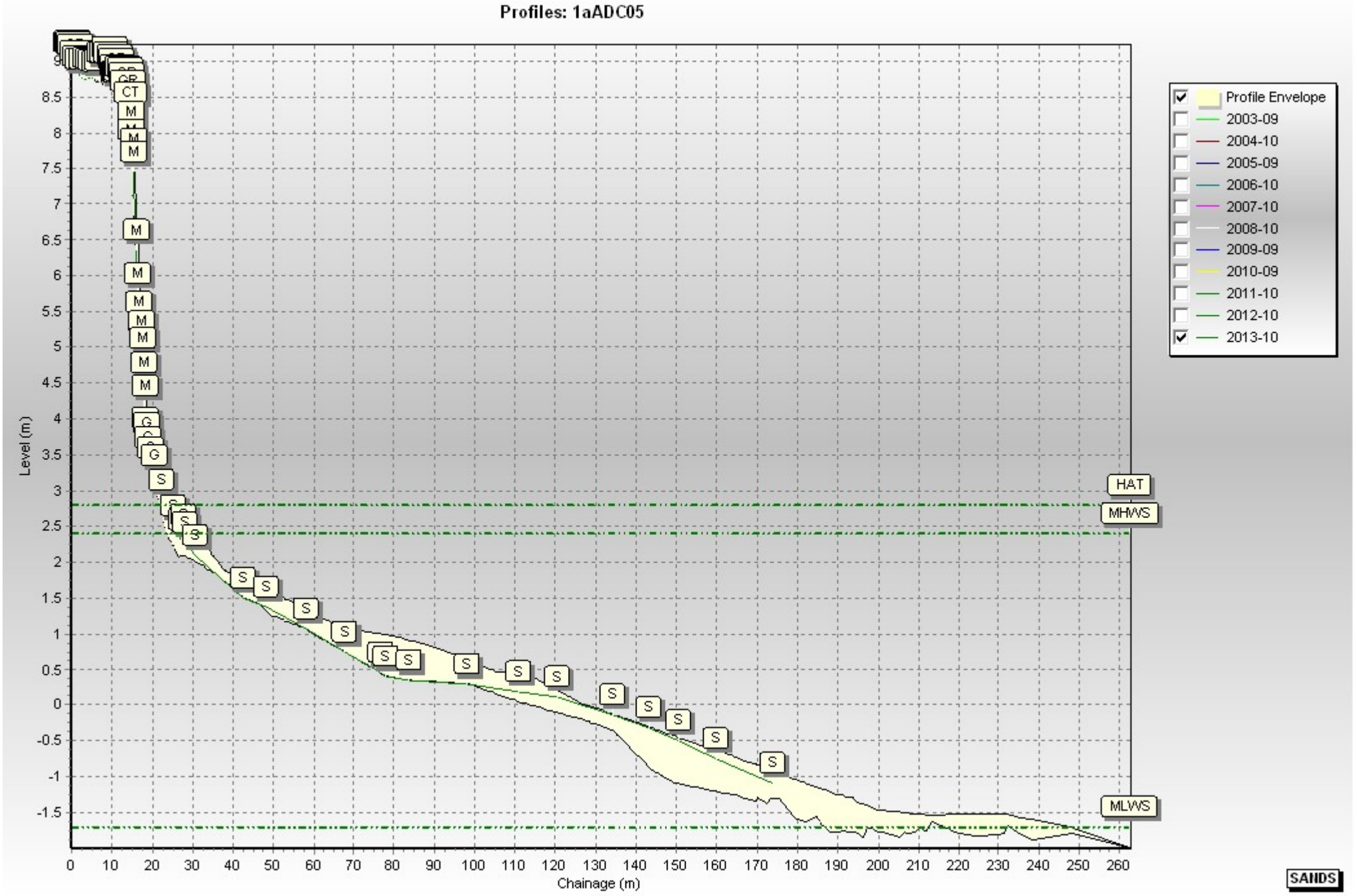
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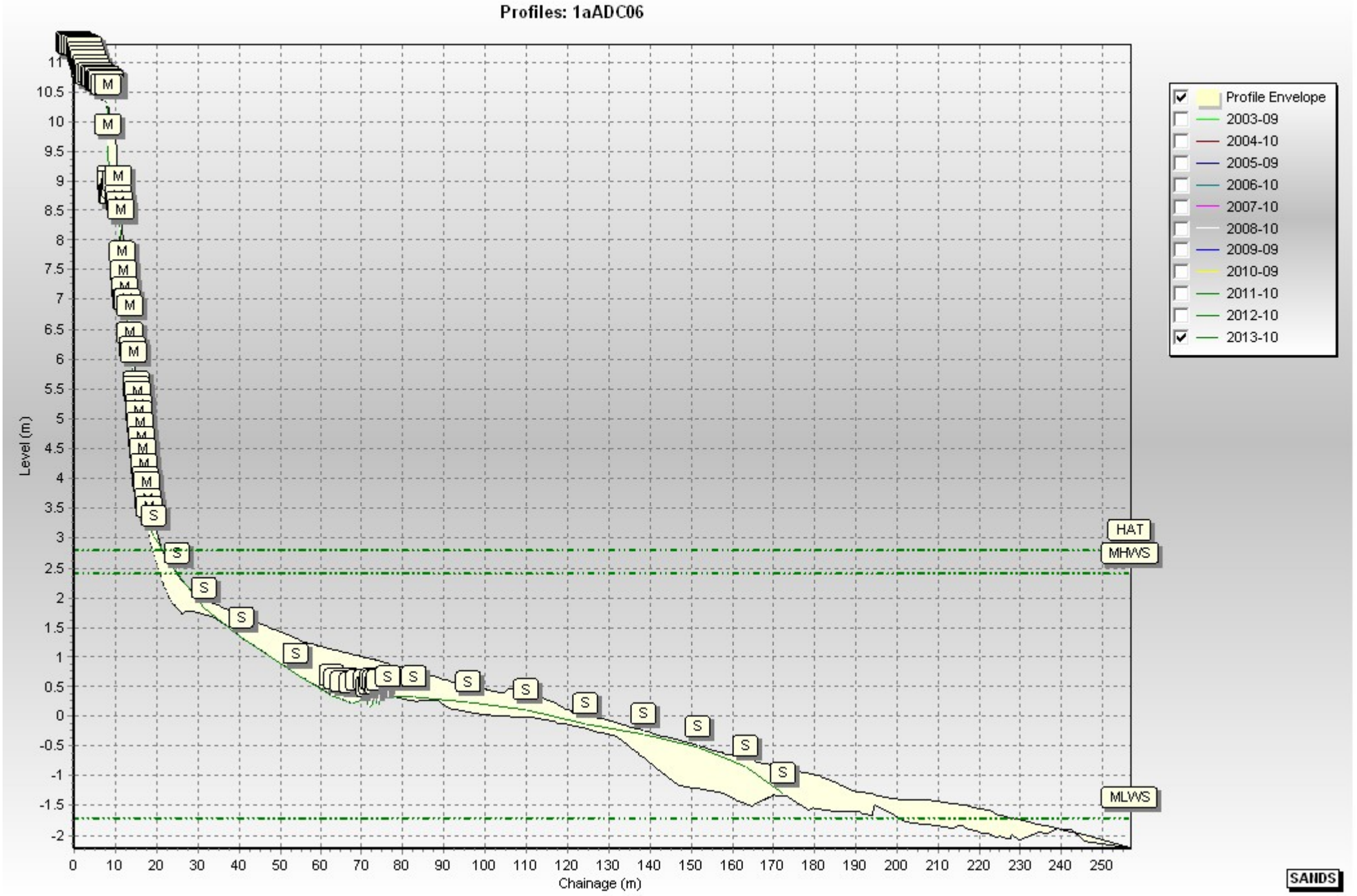
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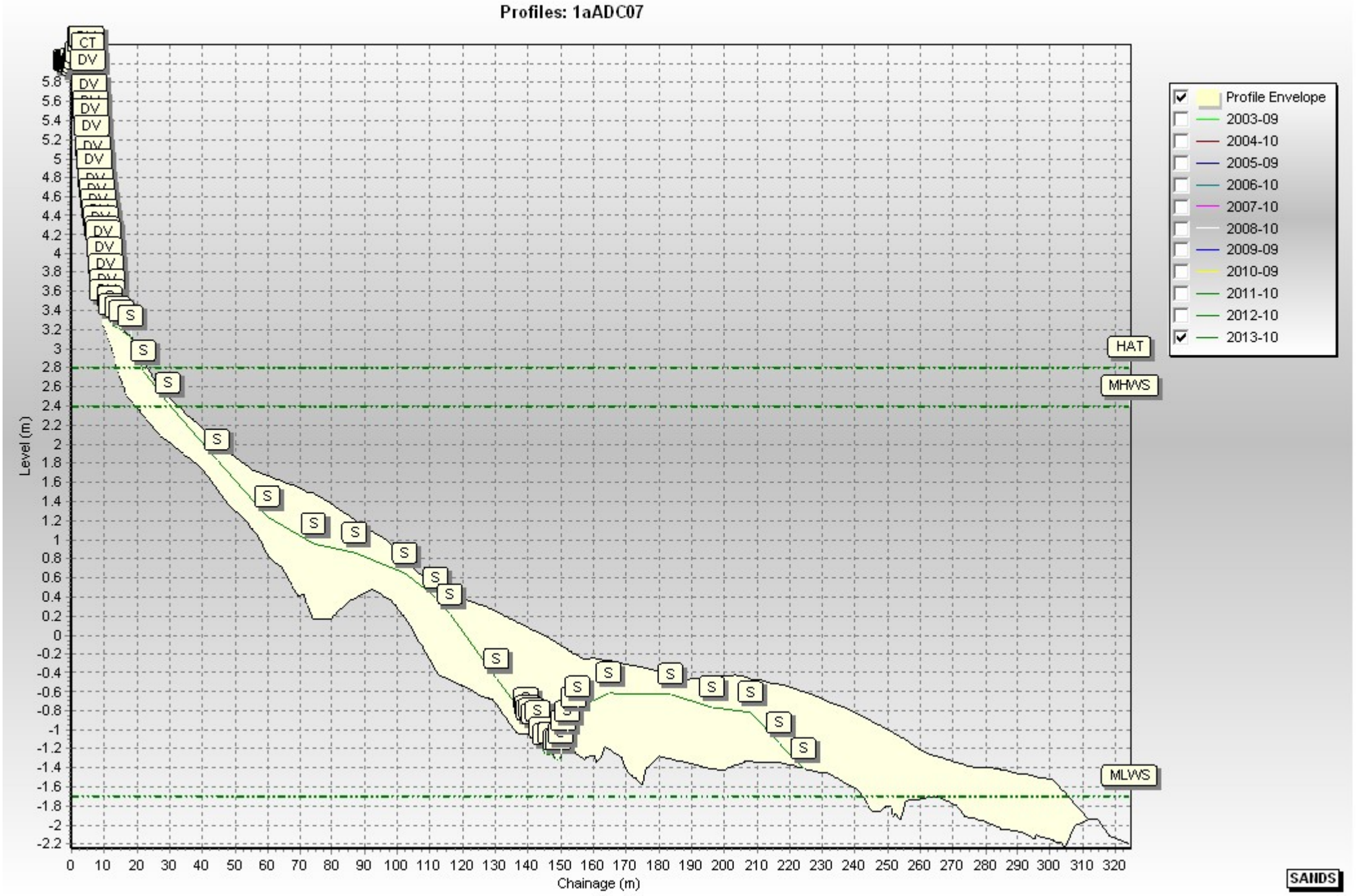
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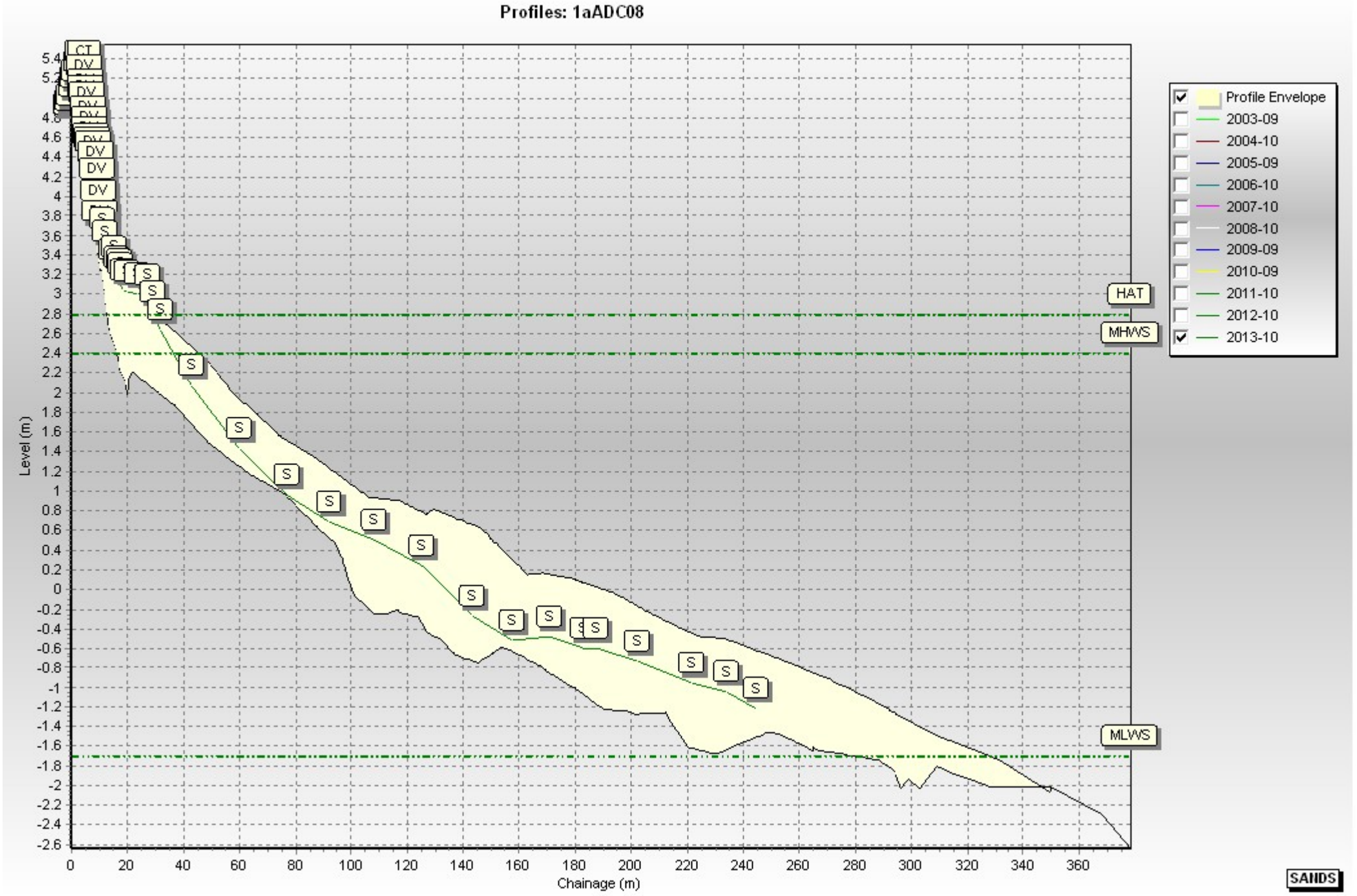
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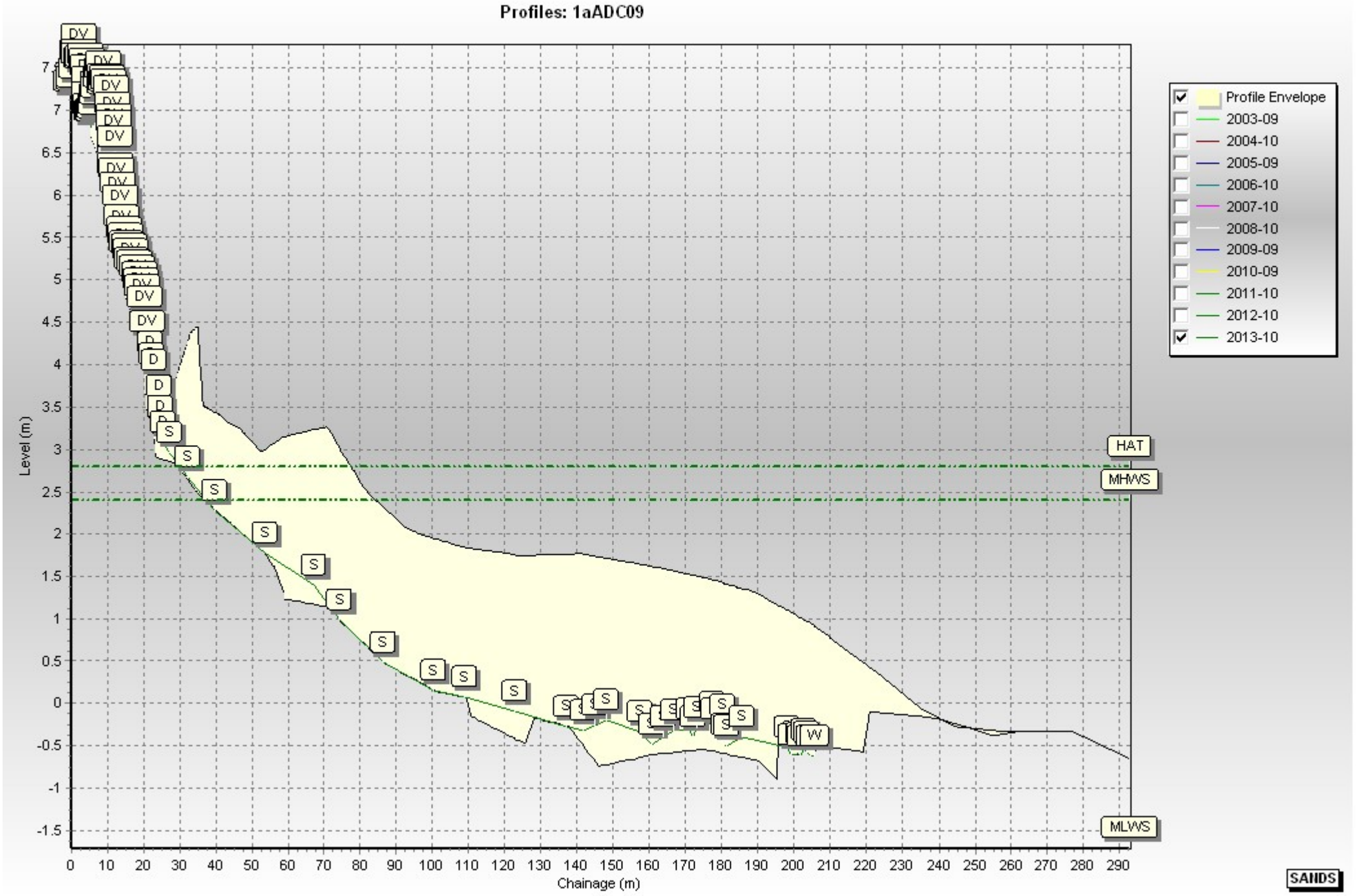
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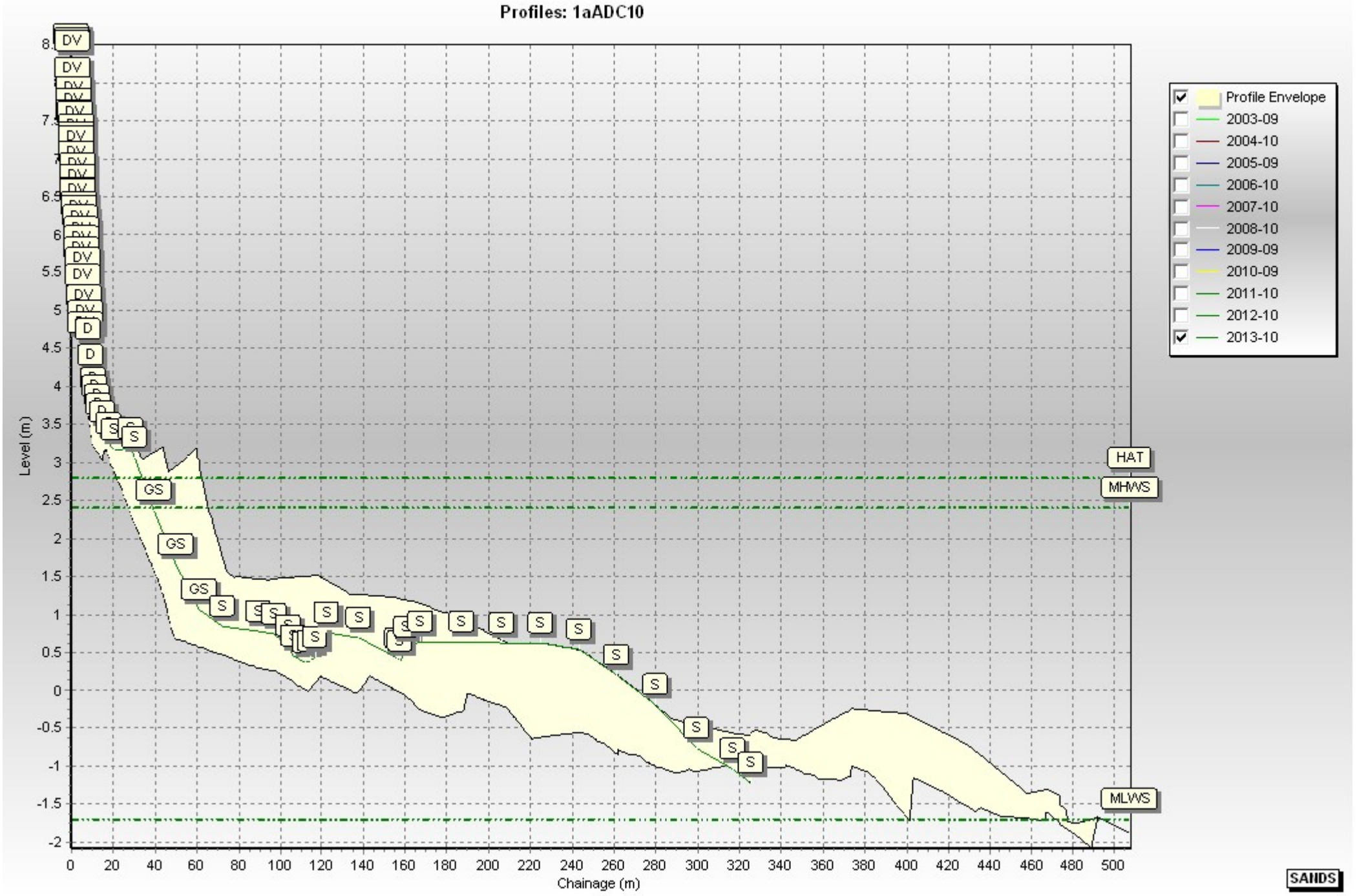
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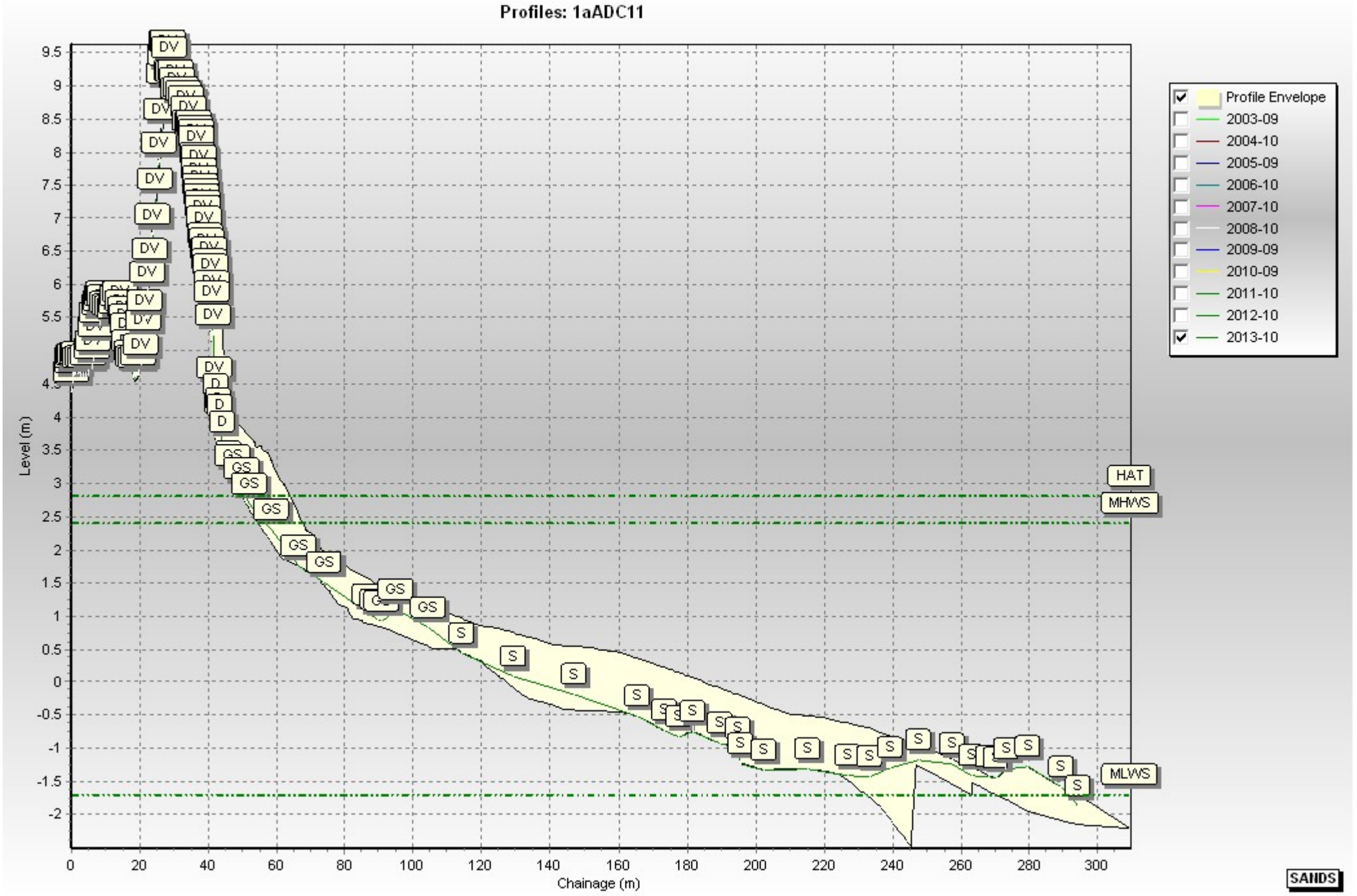
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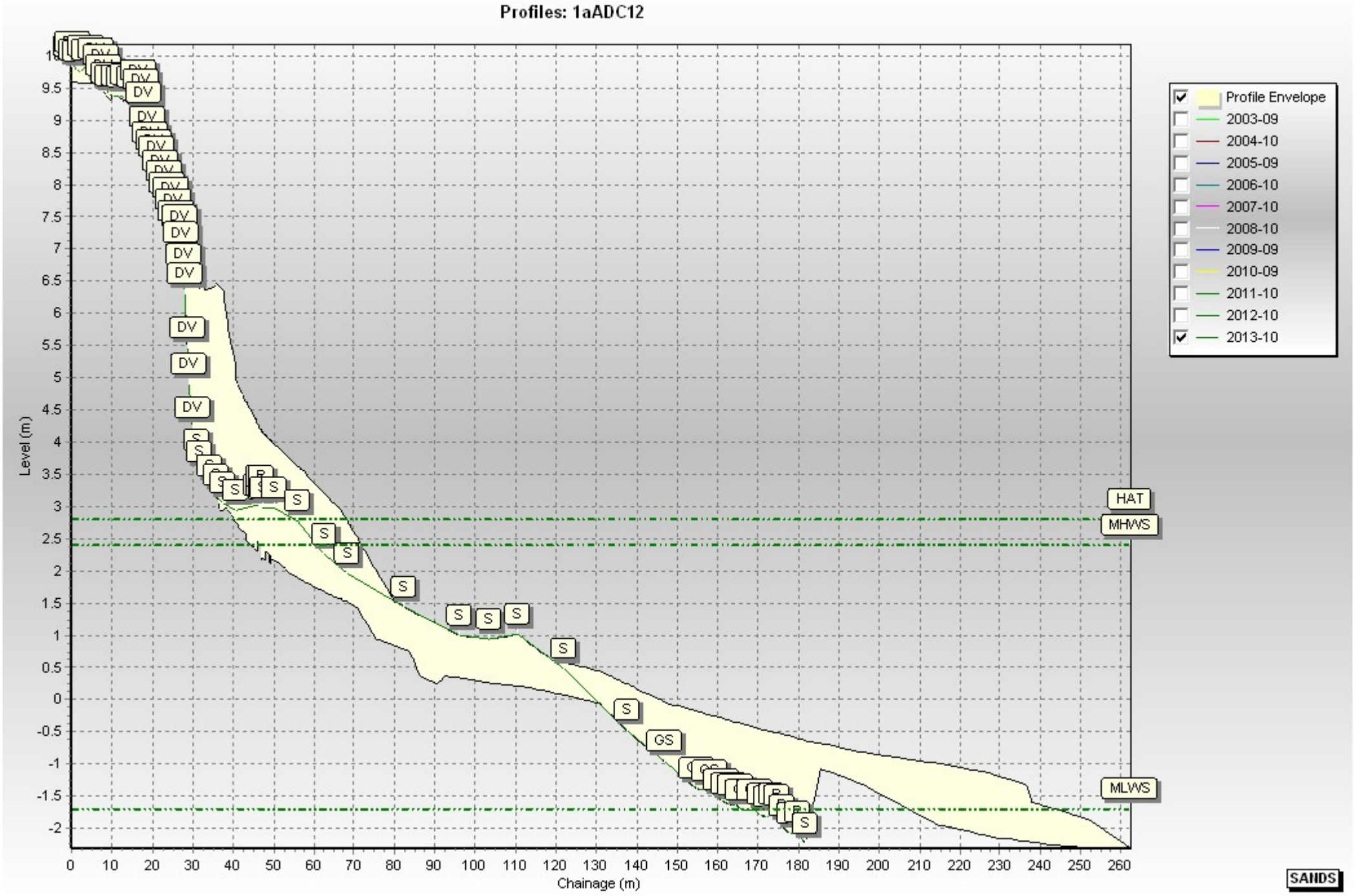
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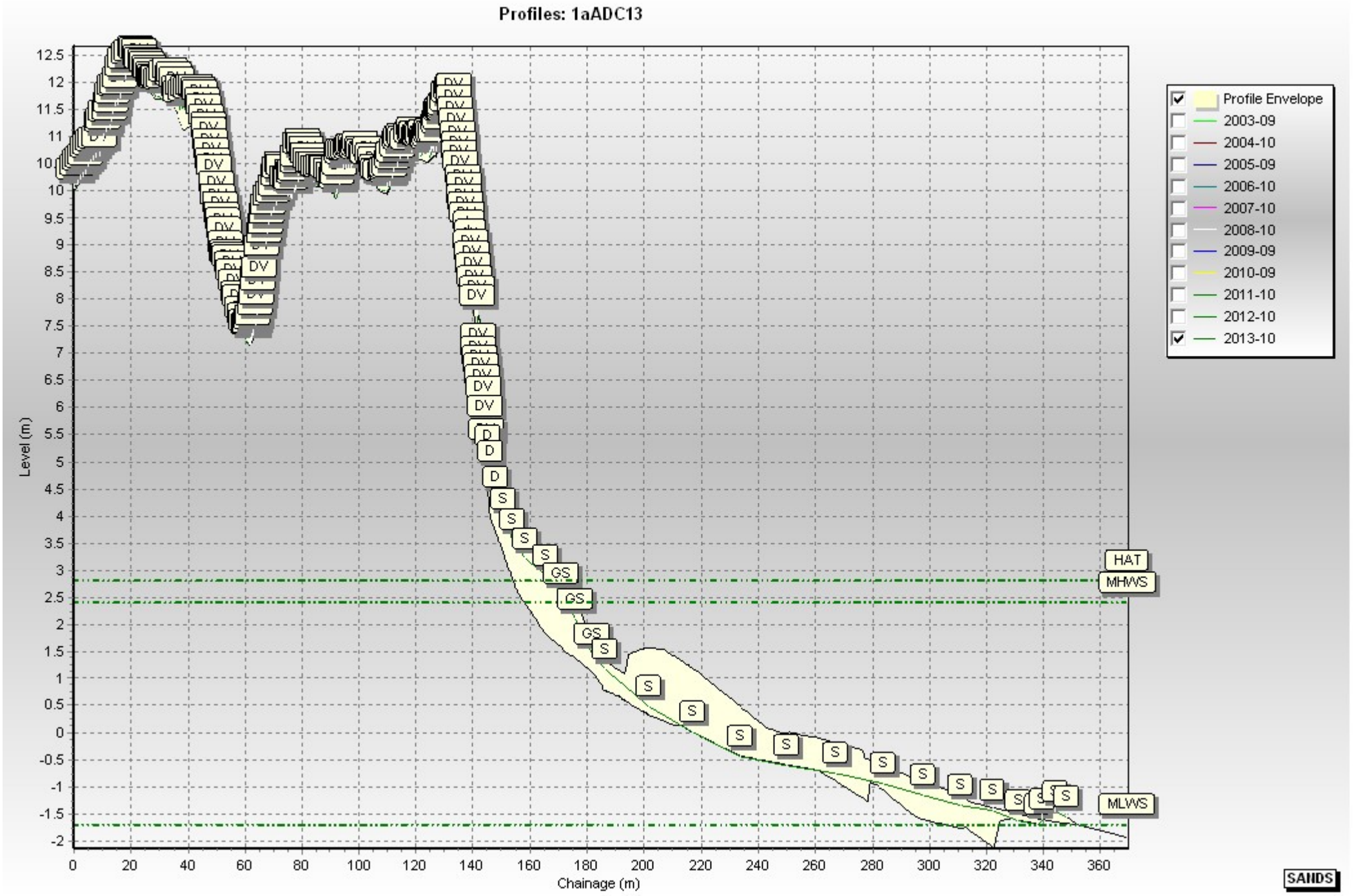
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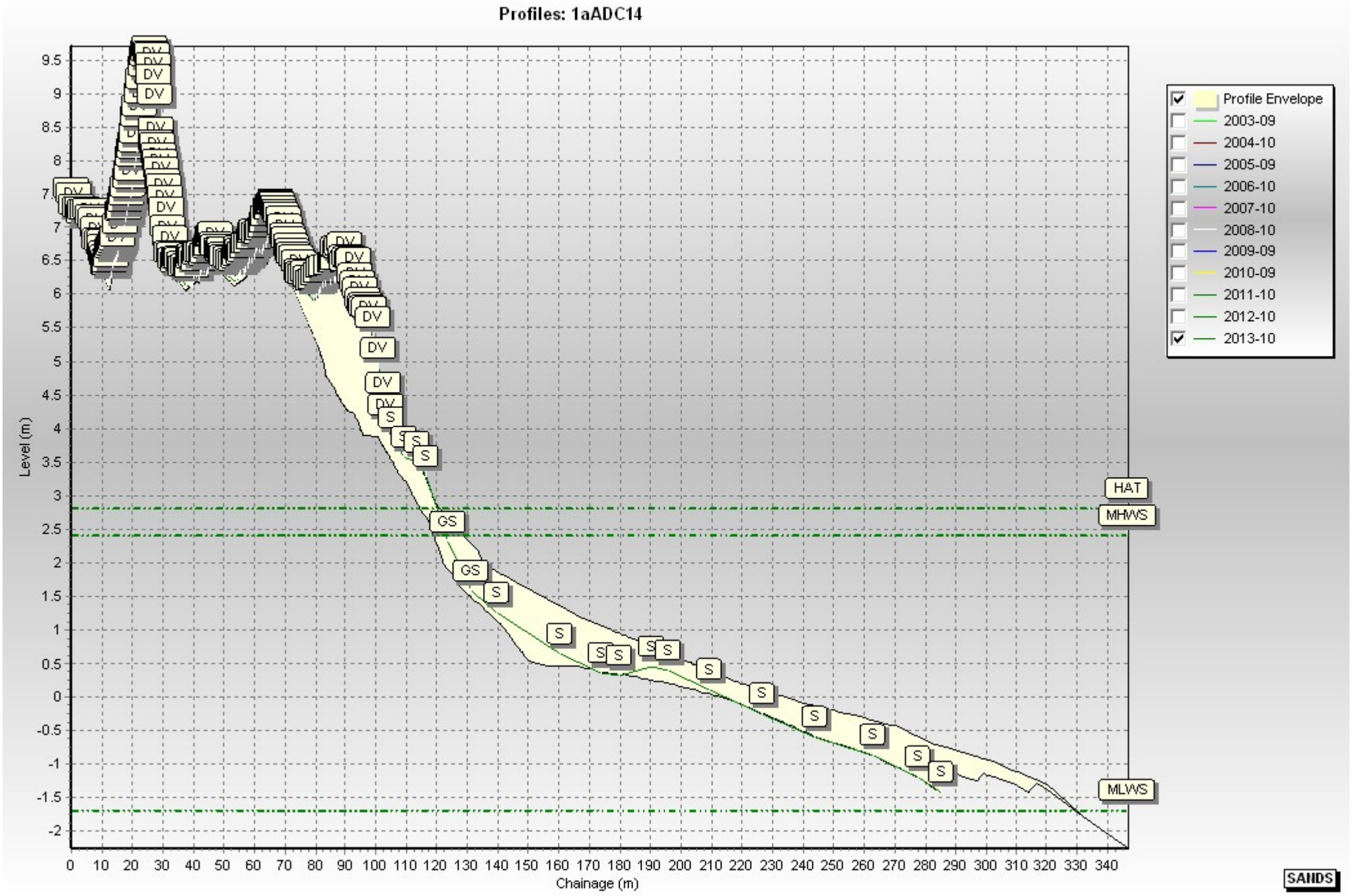
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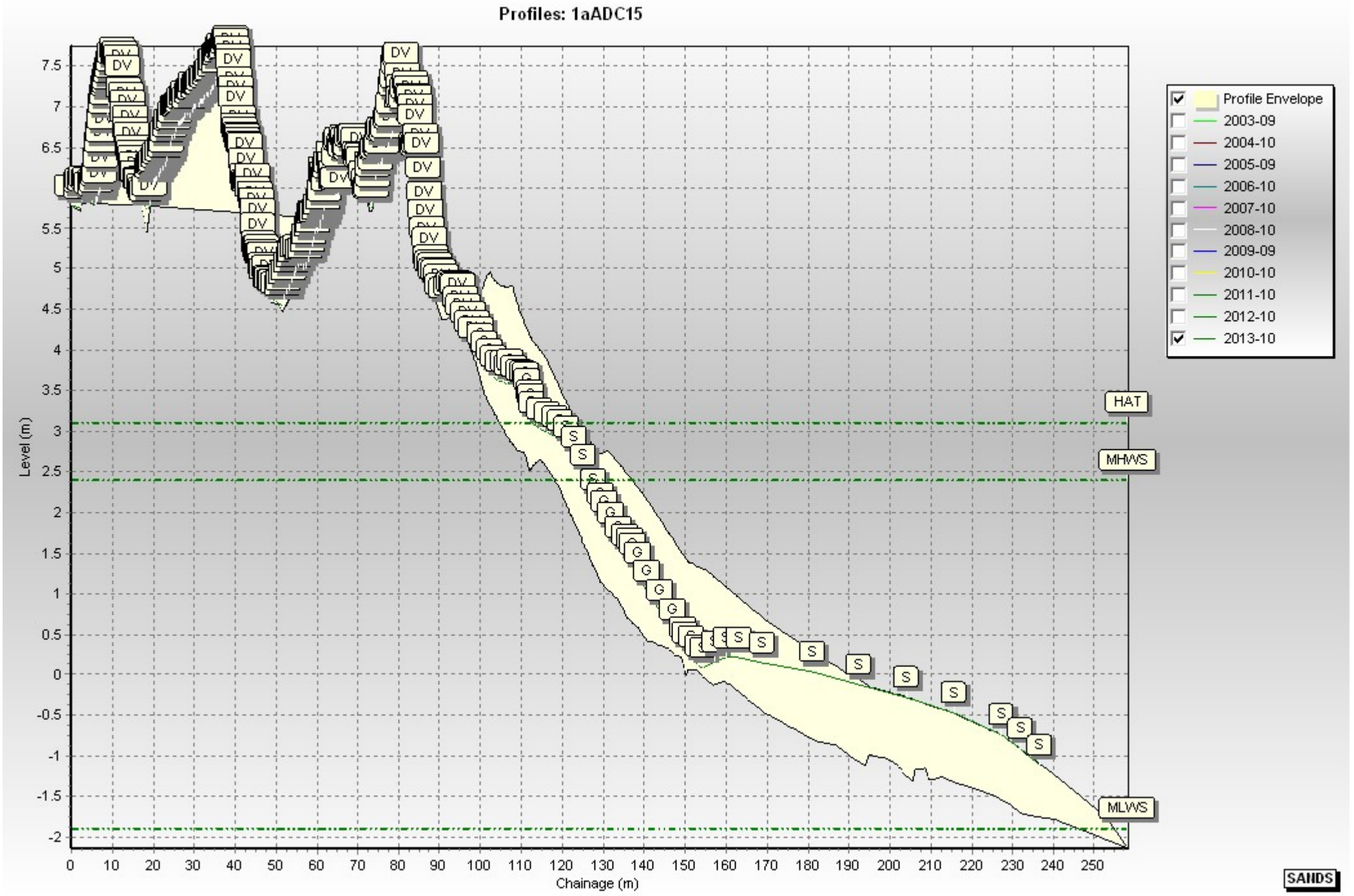
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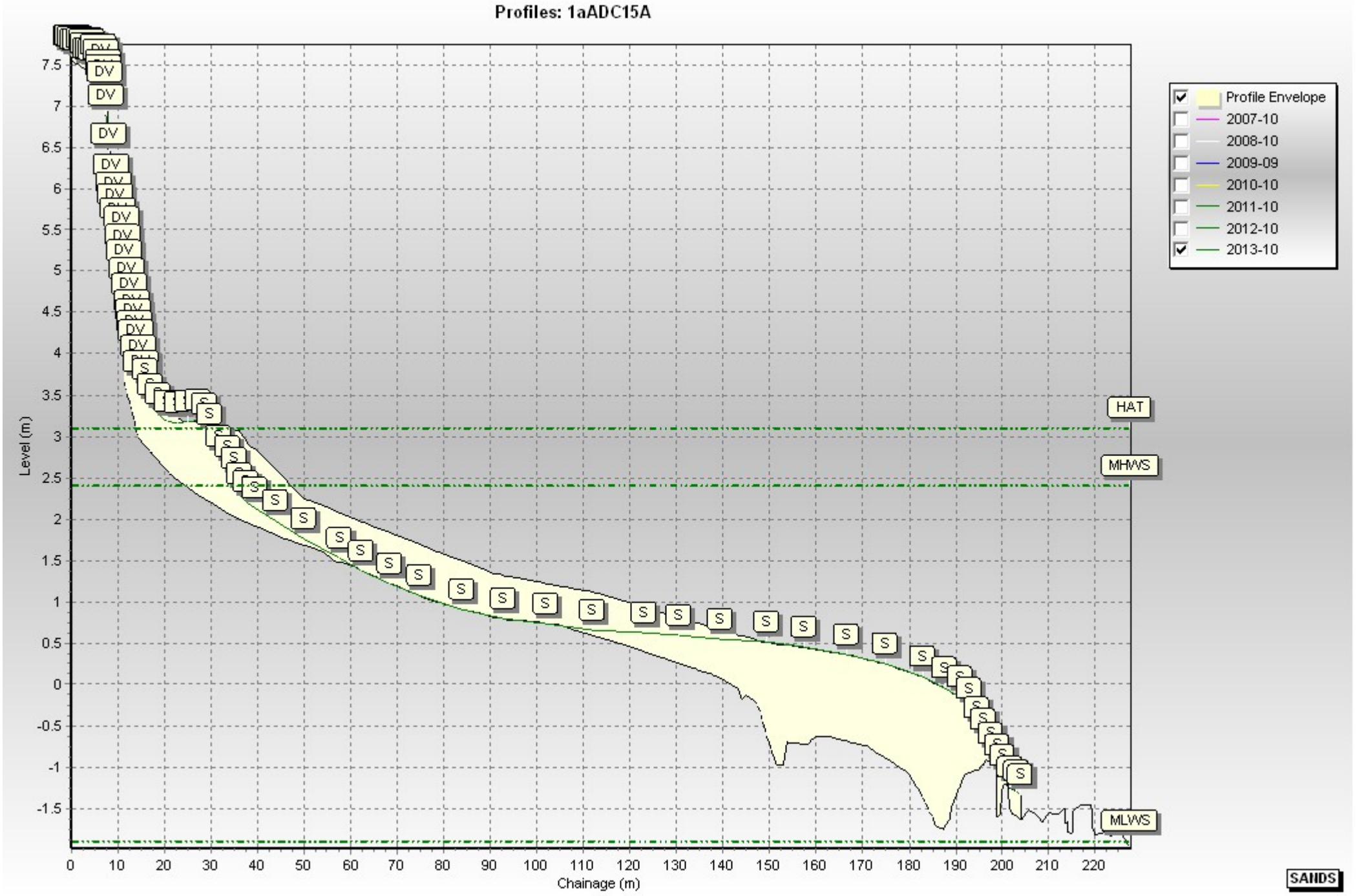
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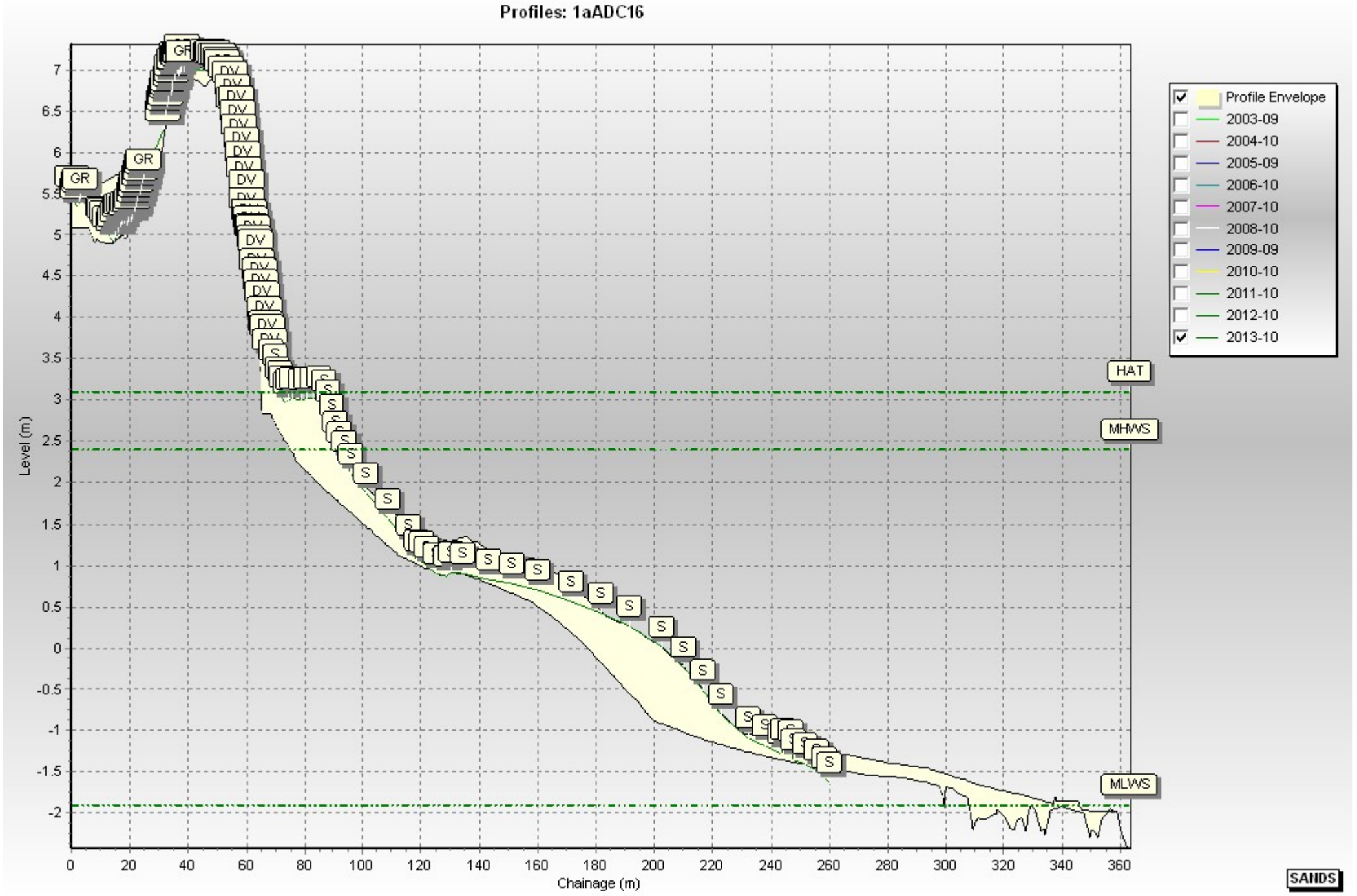
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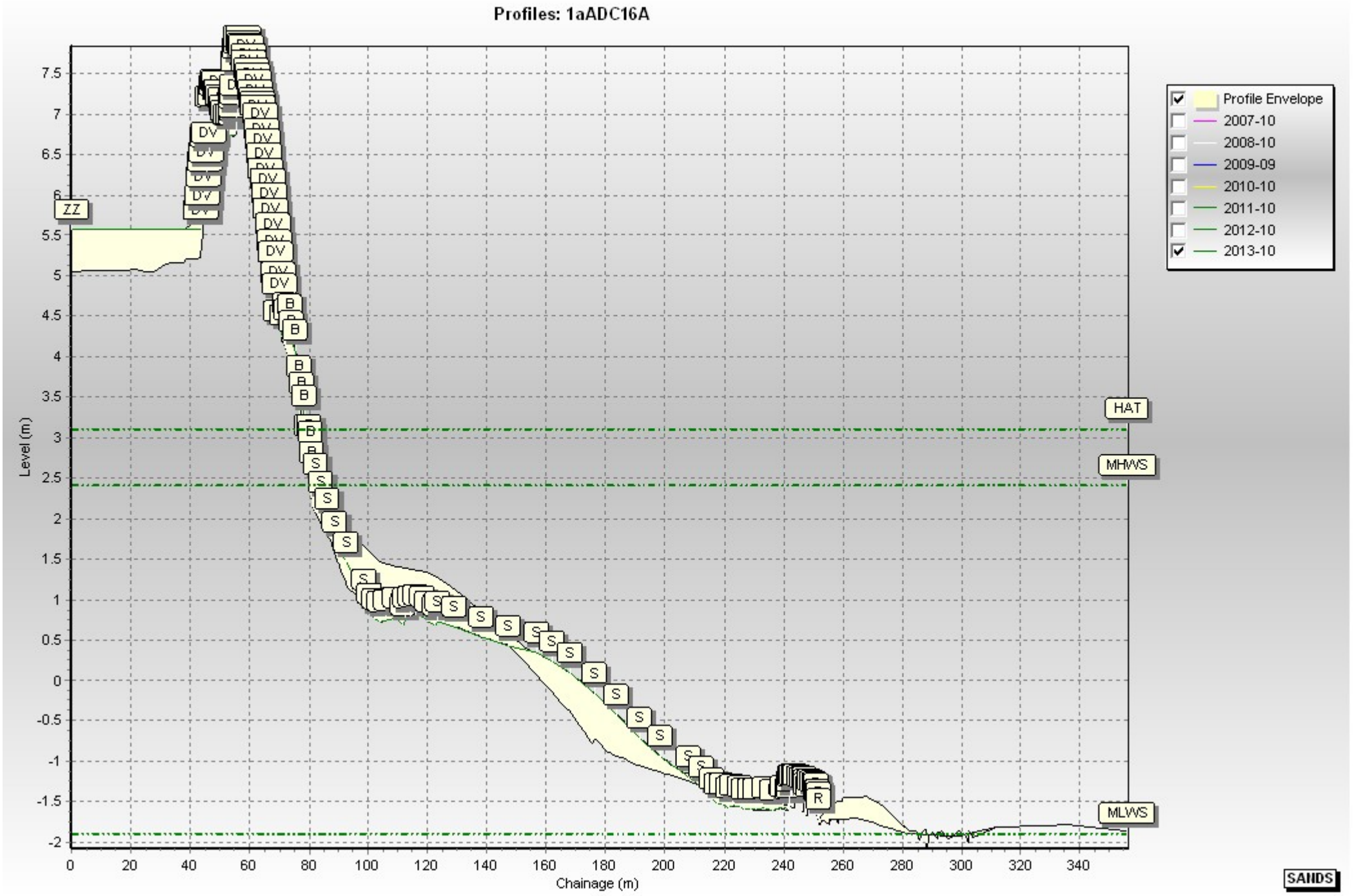
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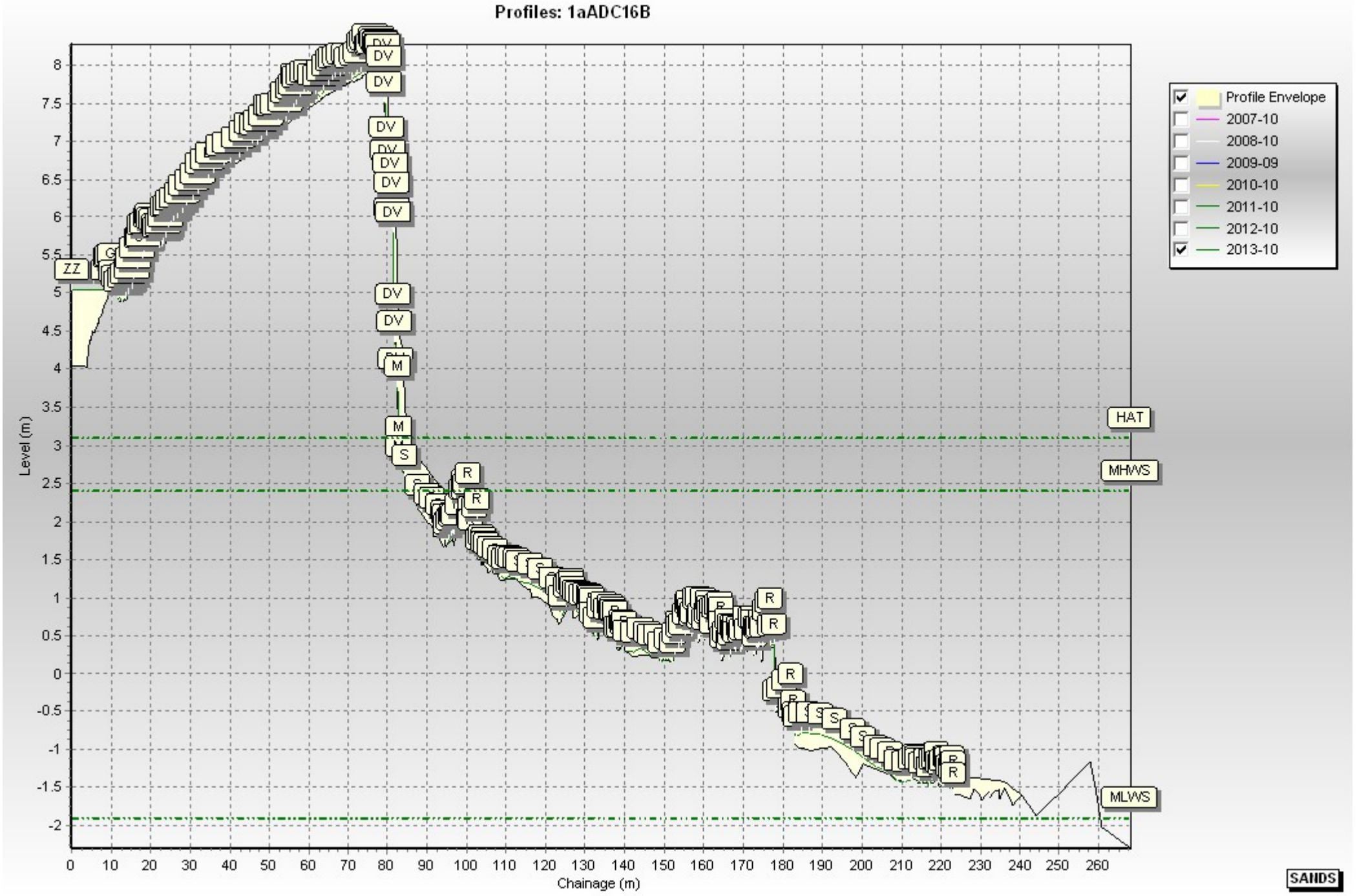
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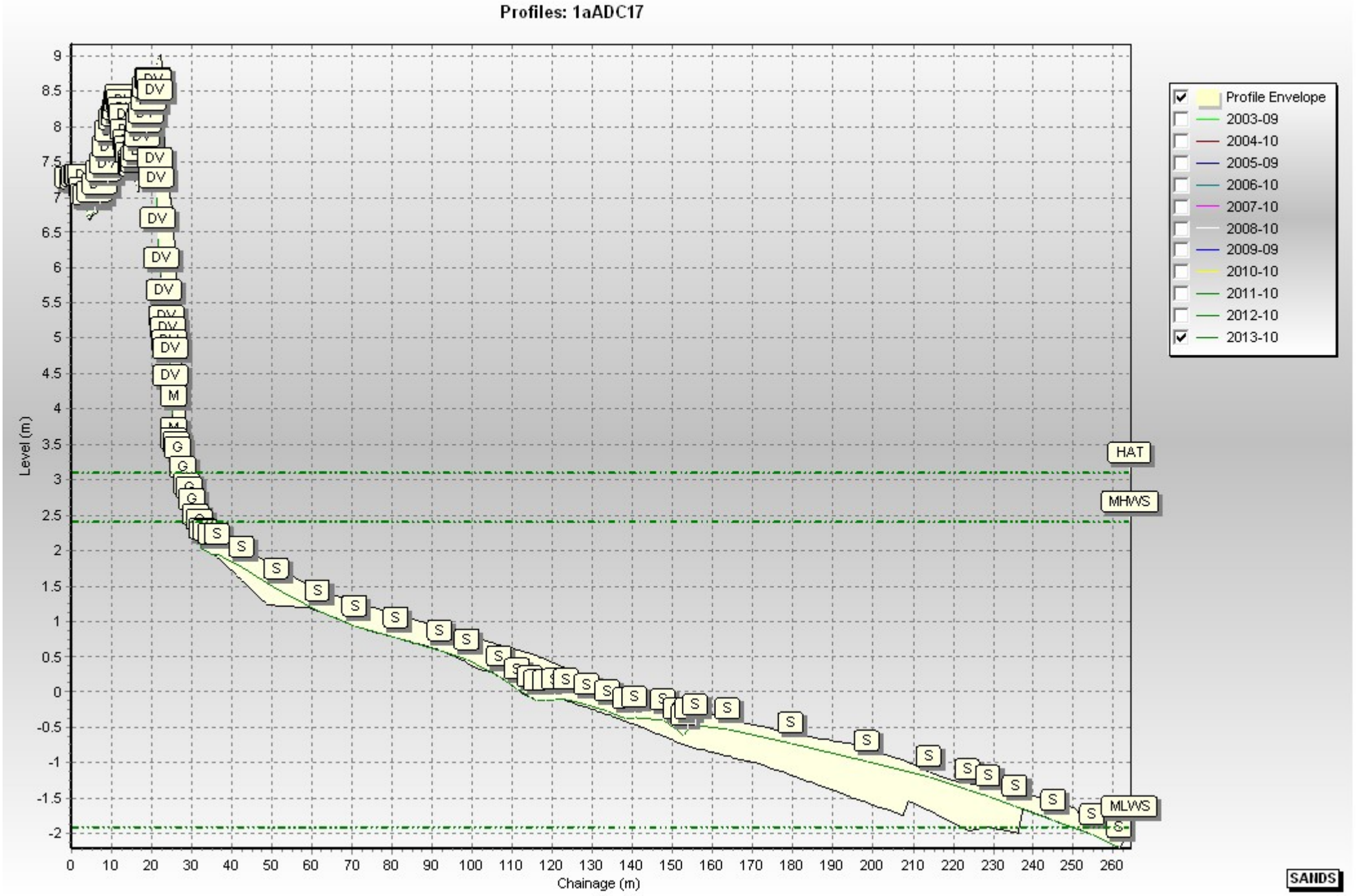
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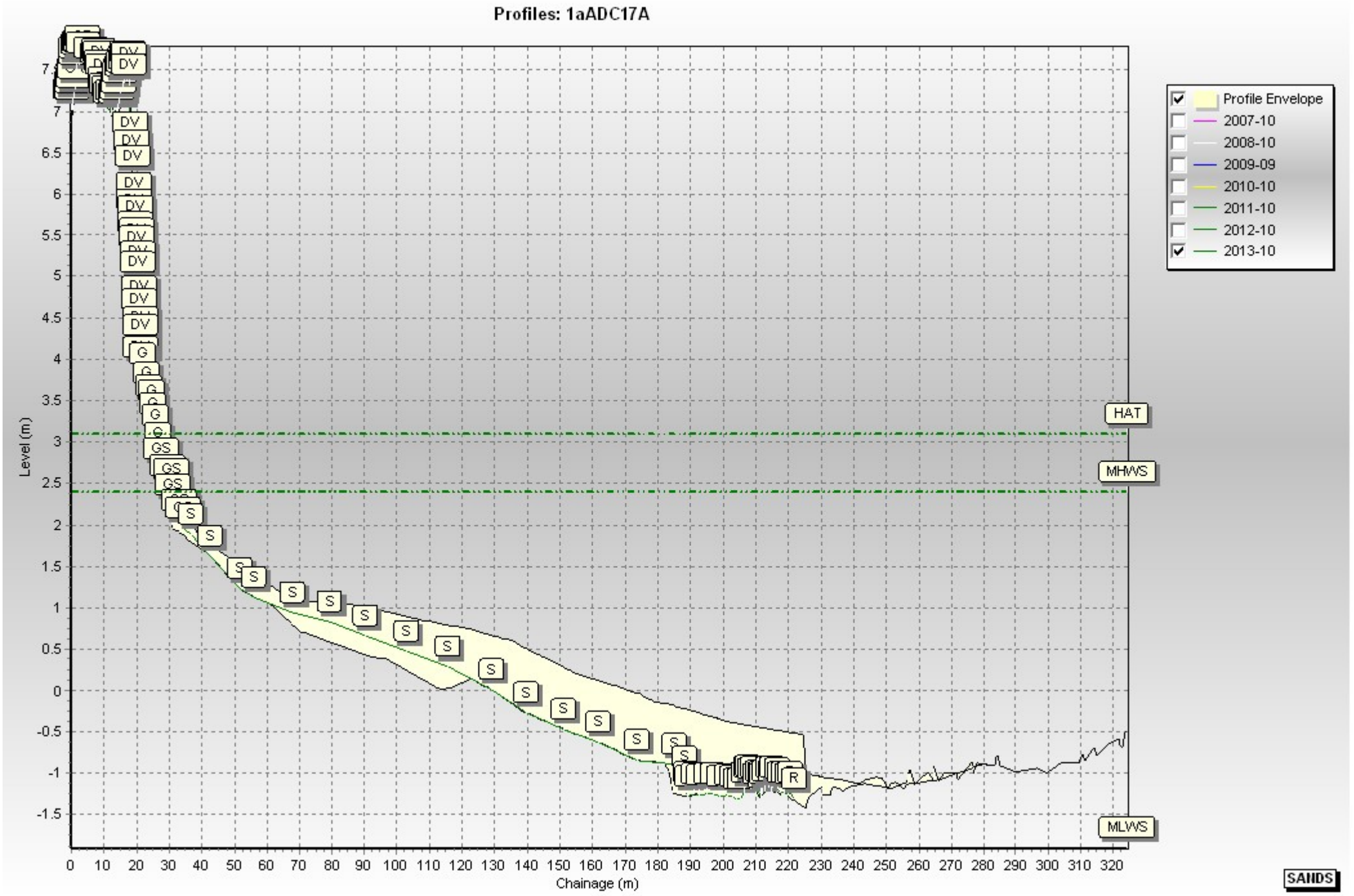
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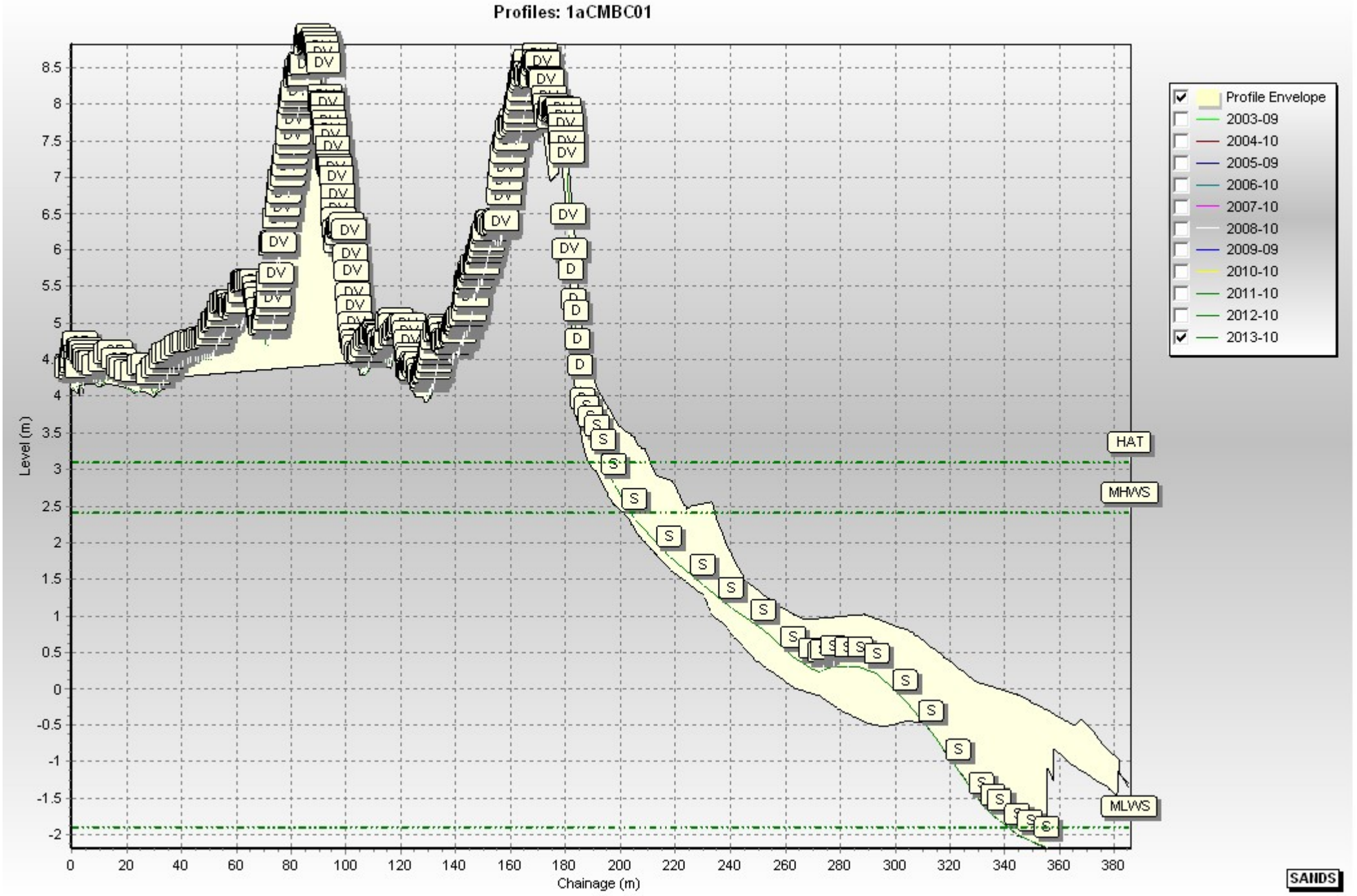
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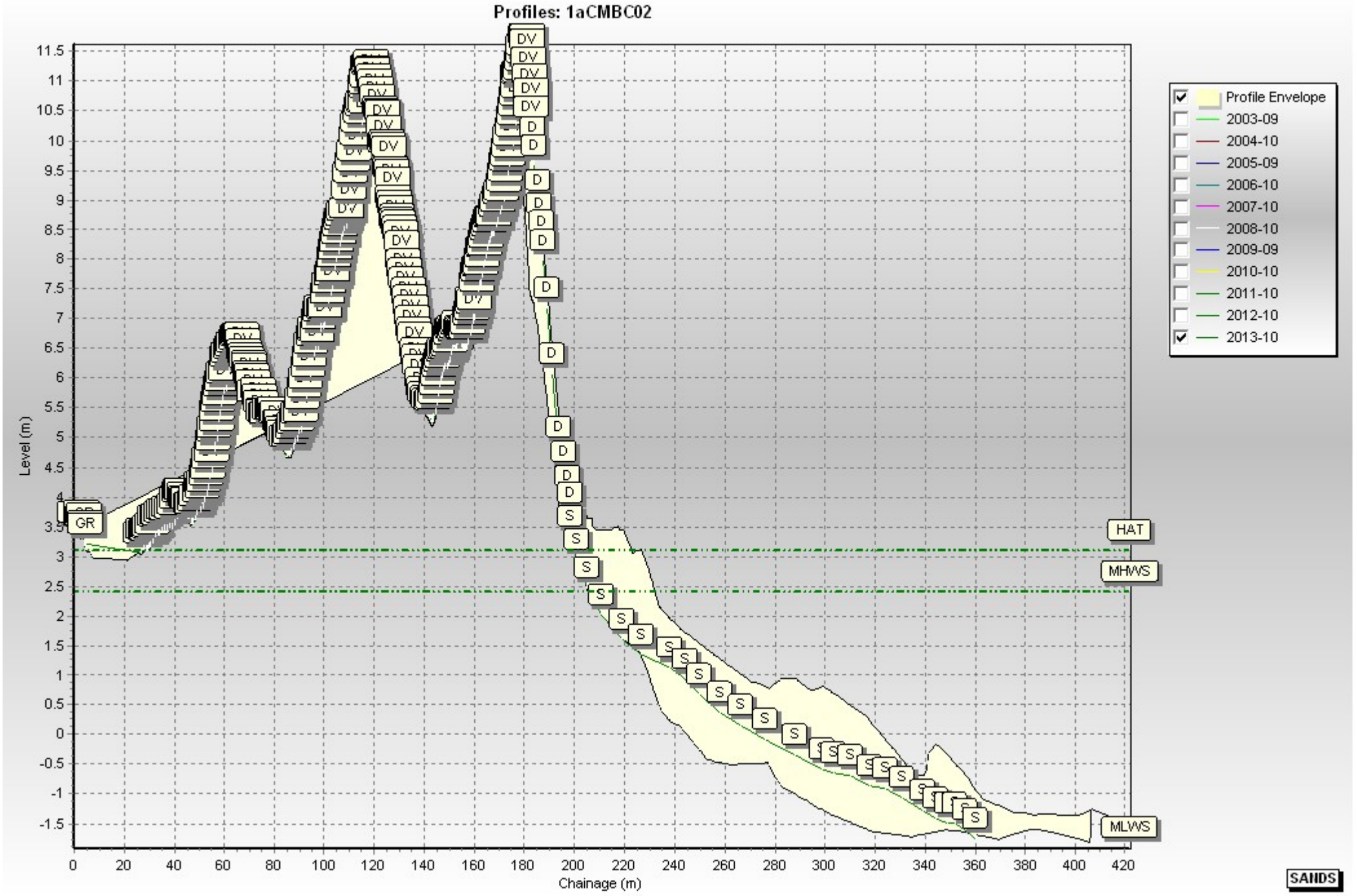
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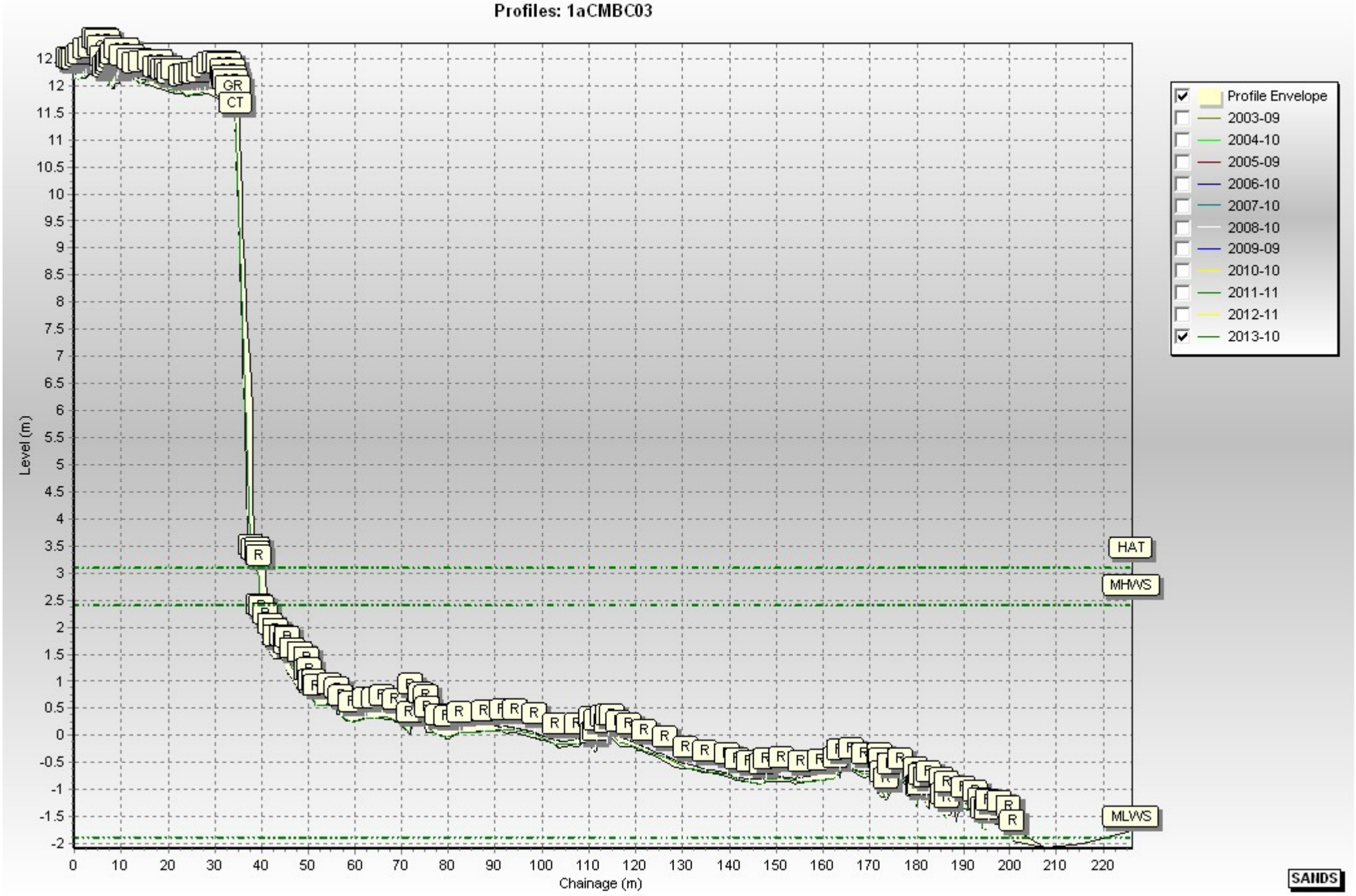
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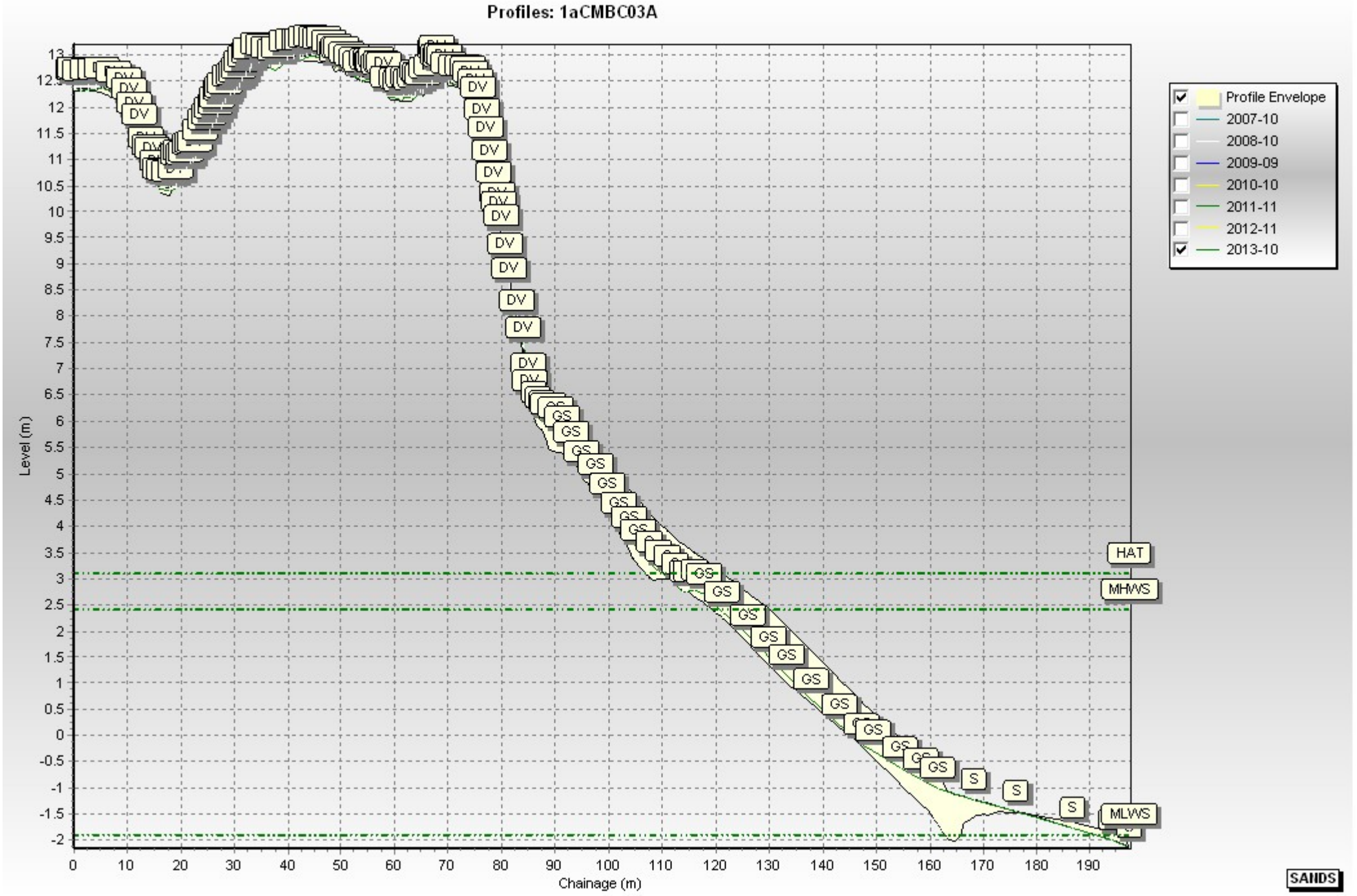
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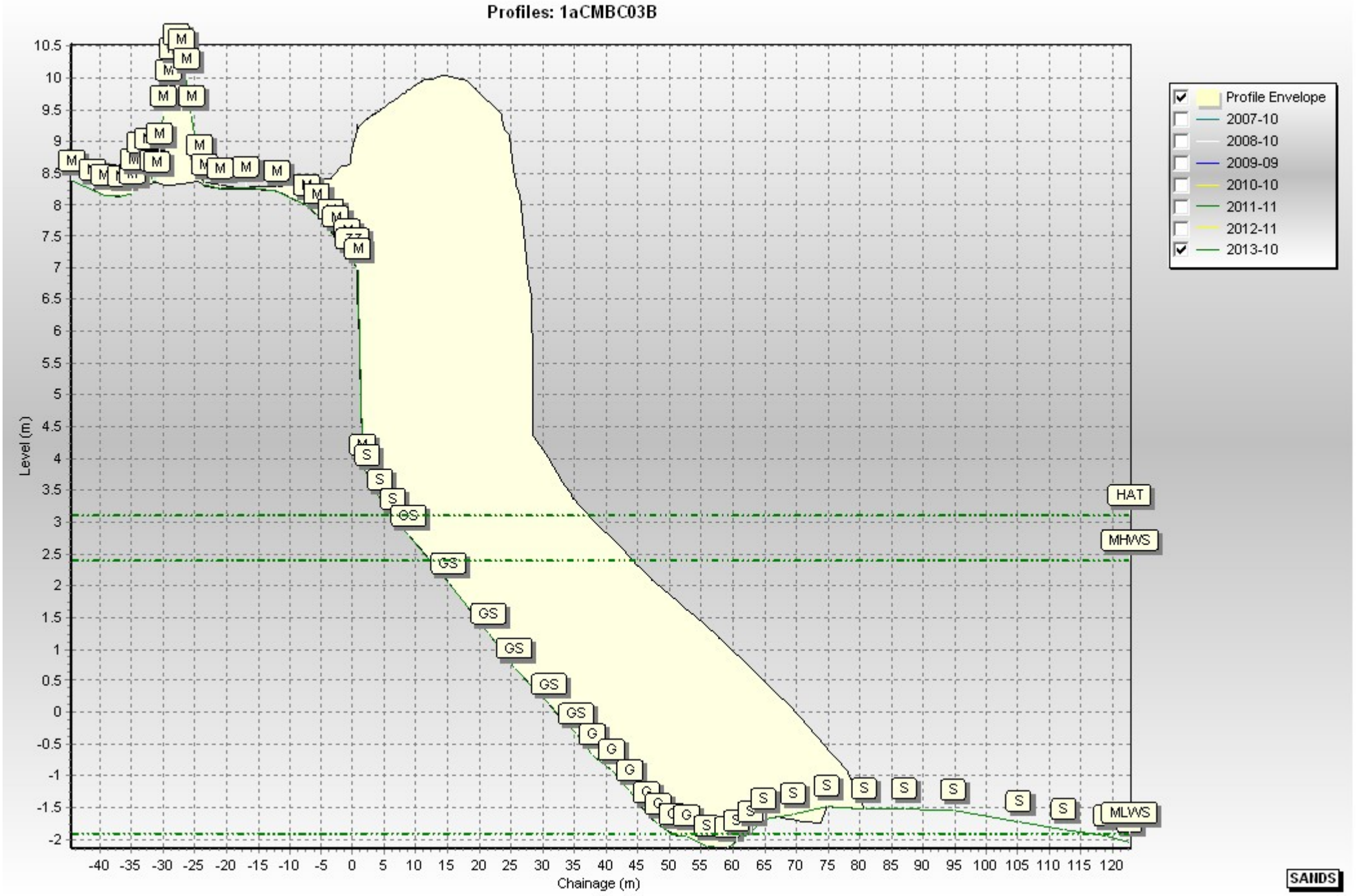
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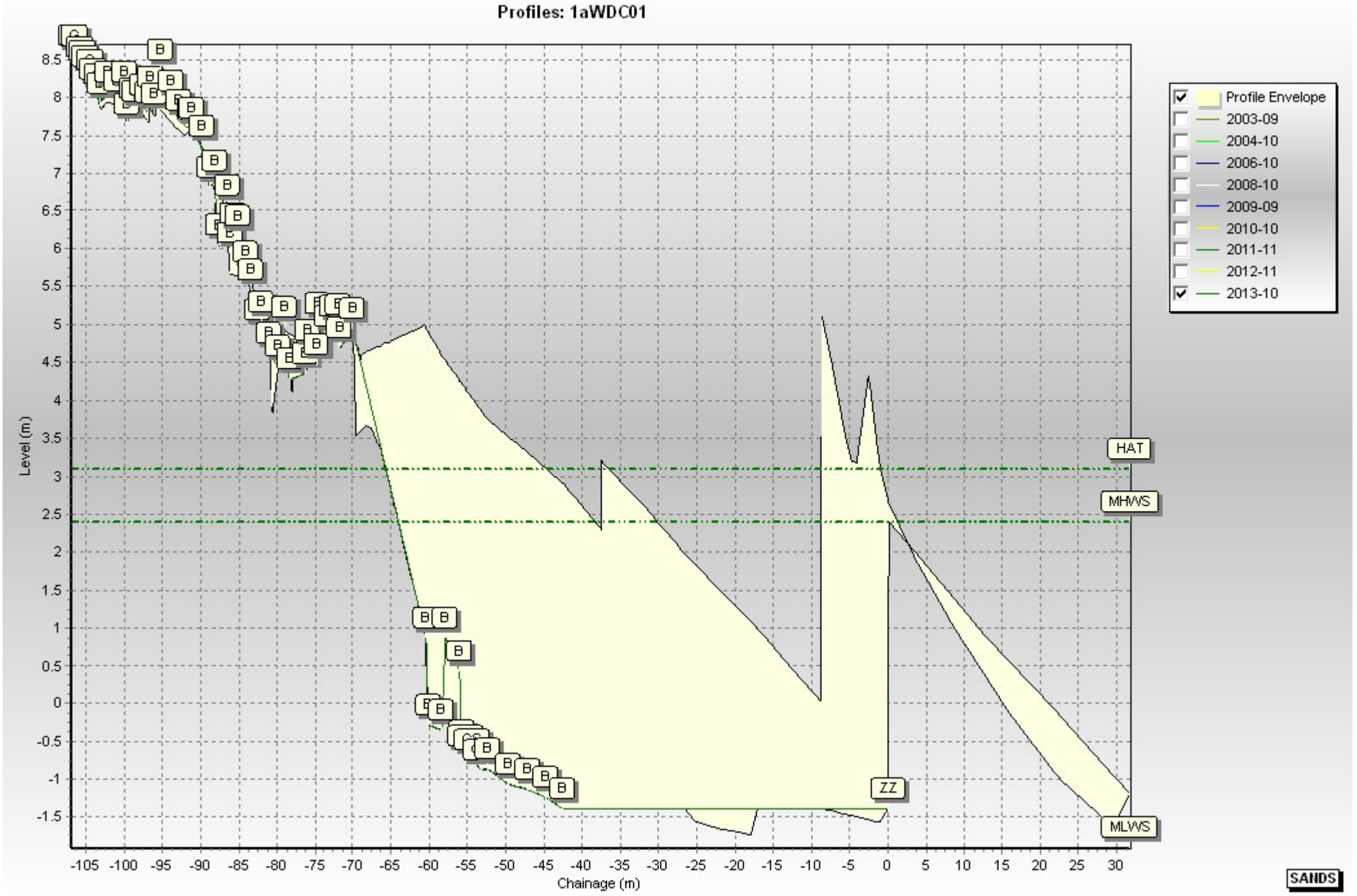
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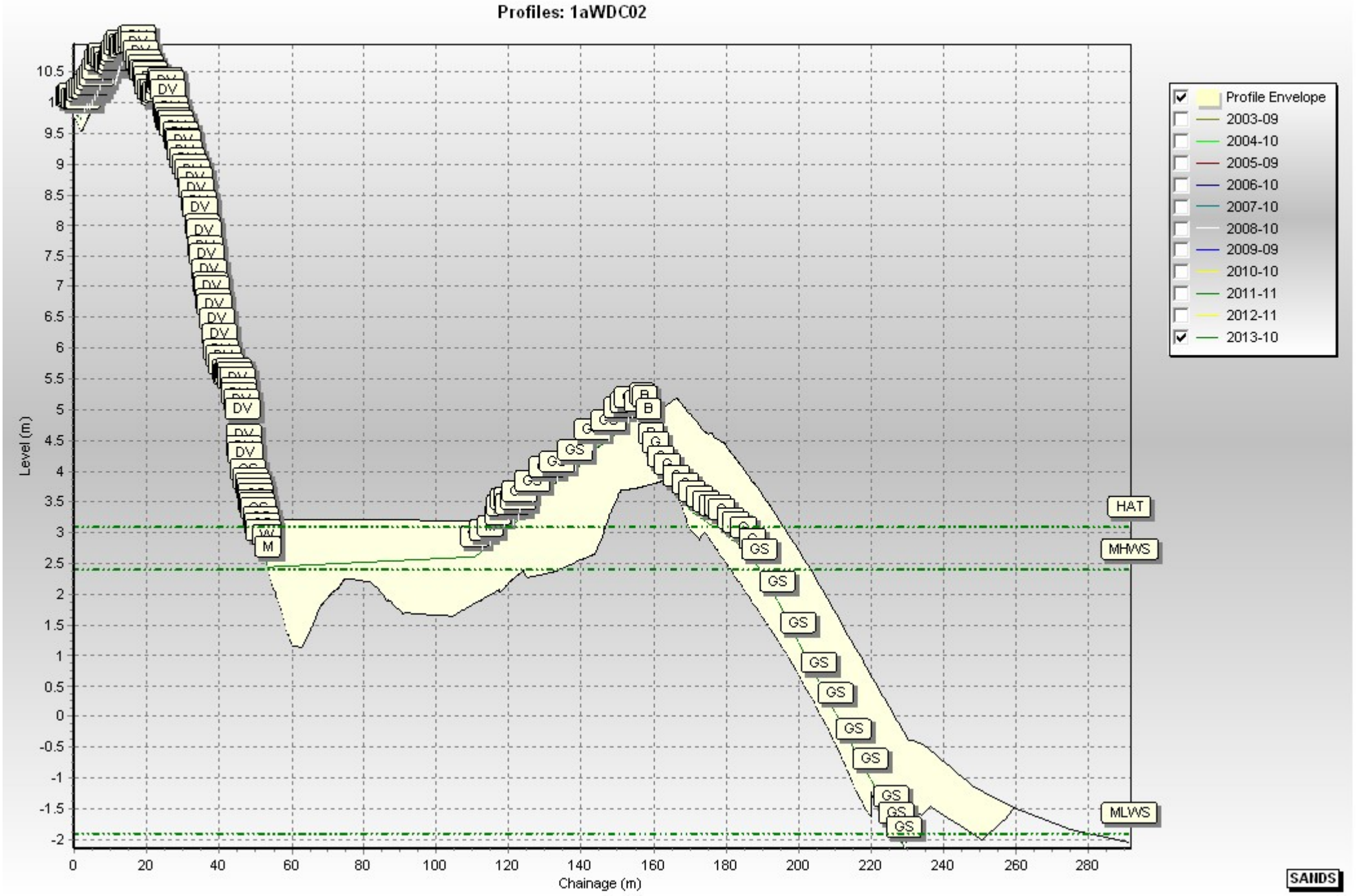
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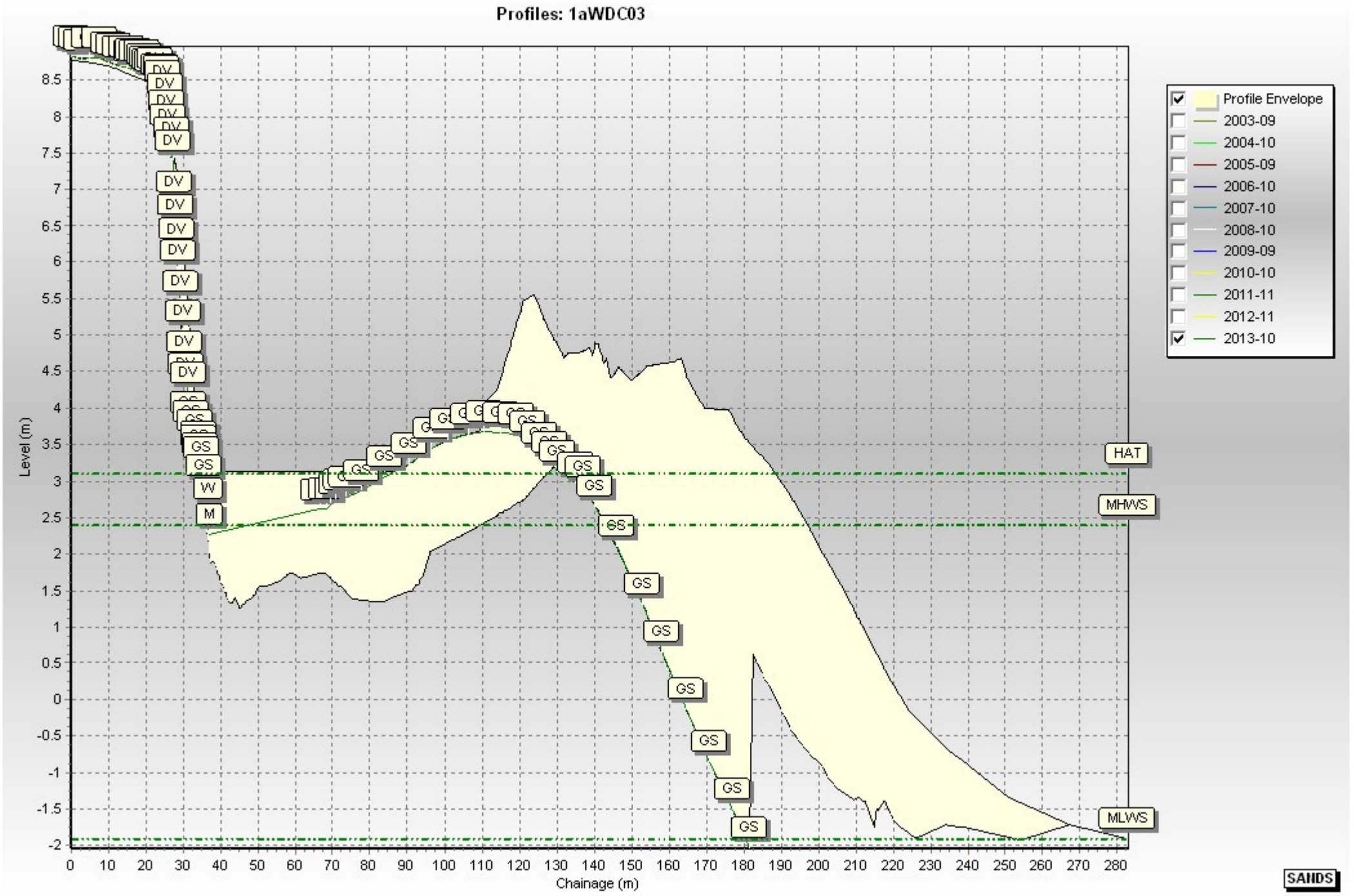
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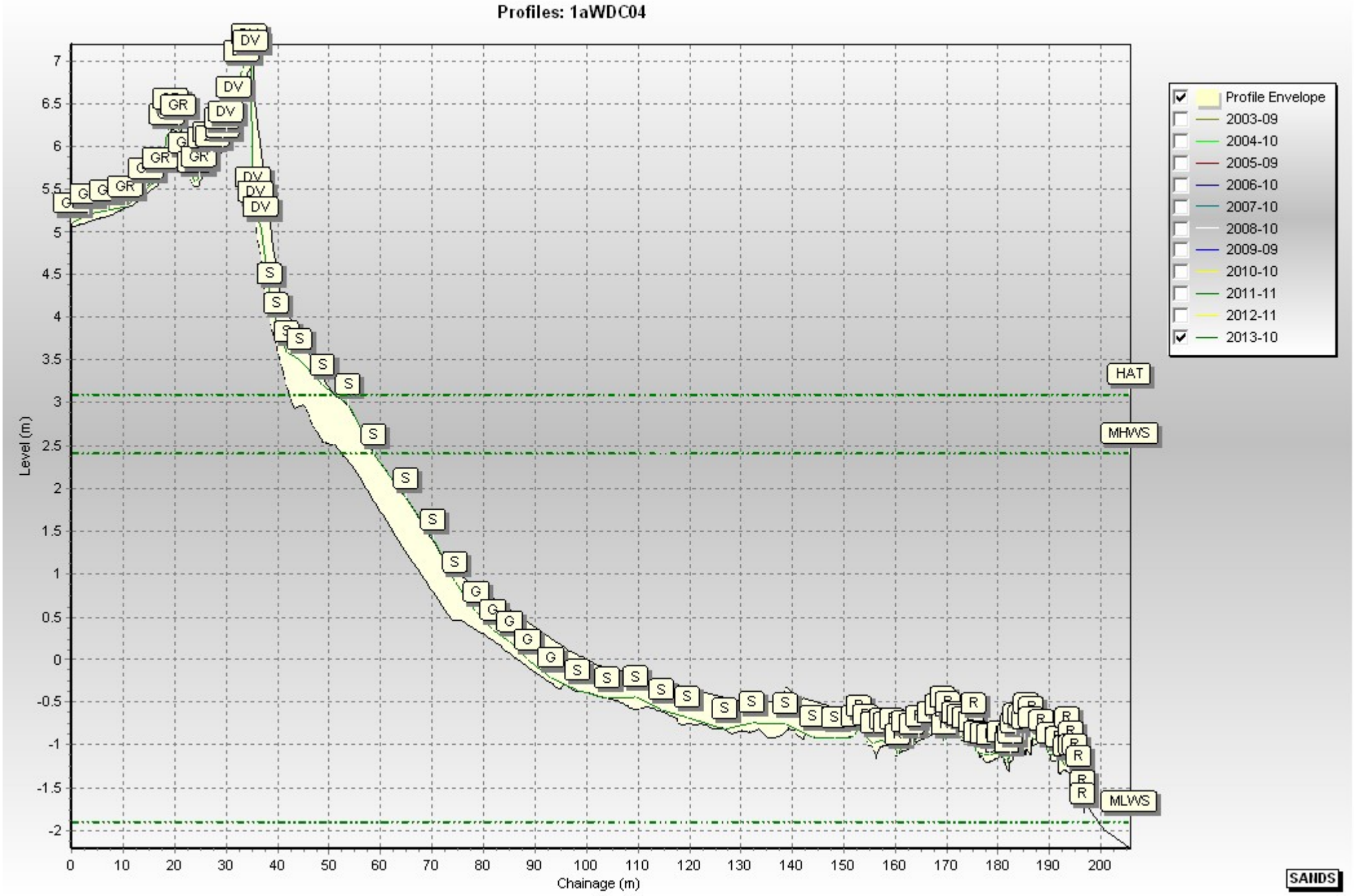
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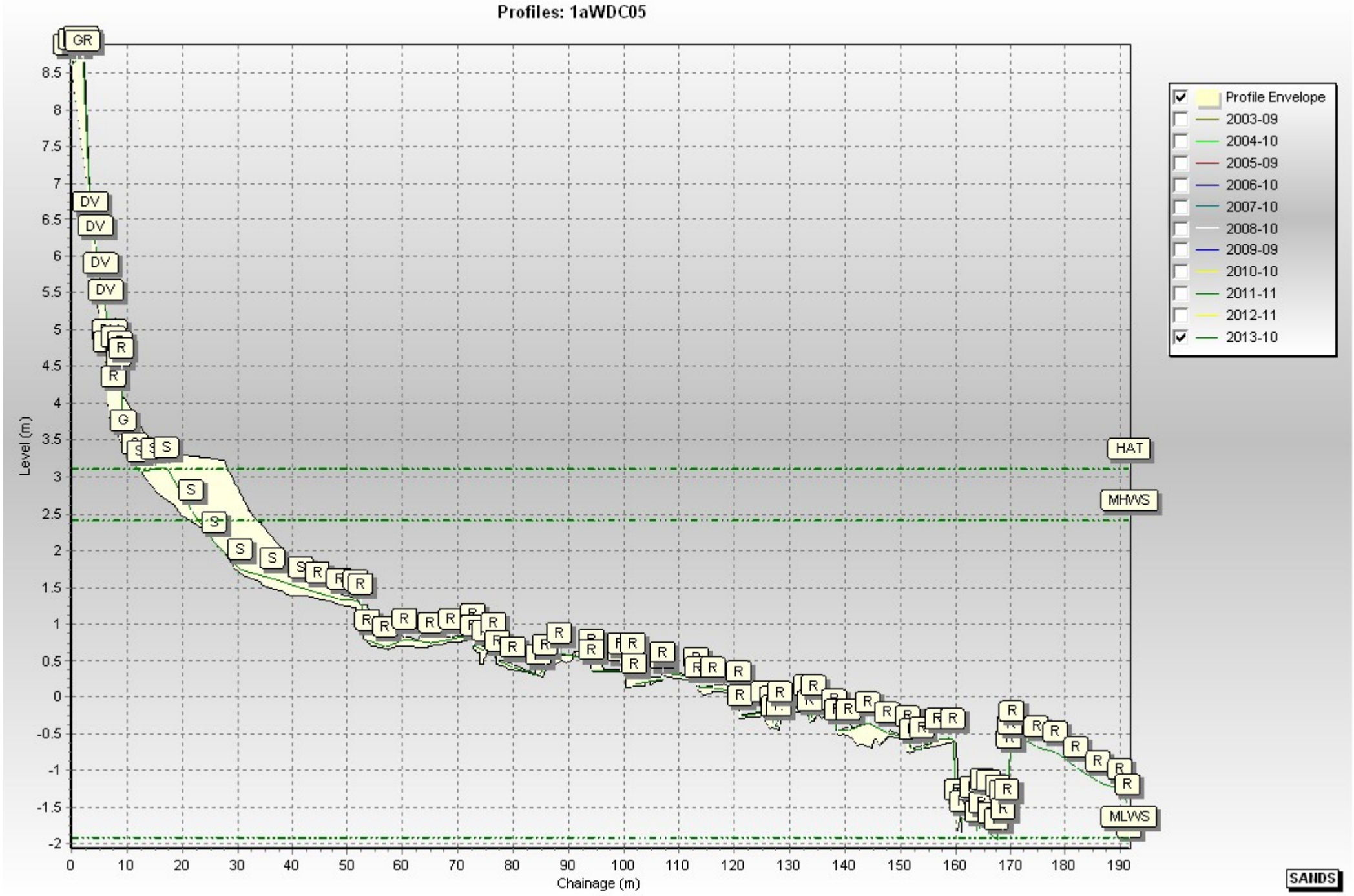
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Chainage (m)
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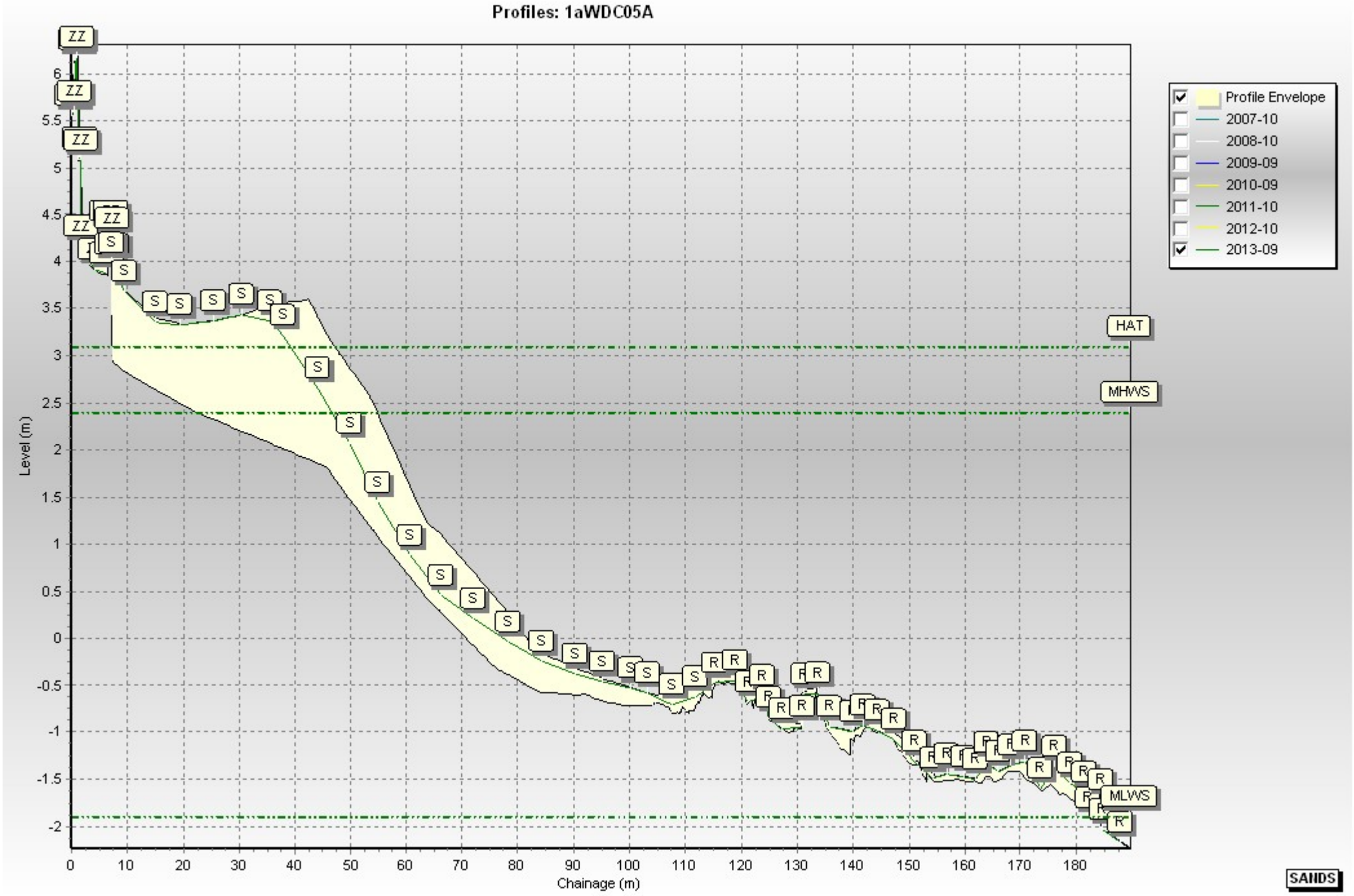
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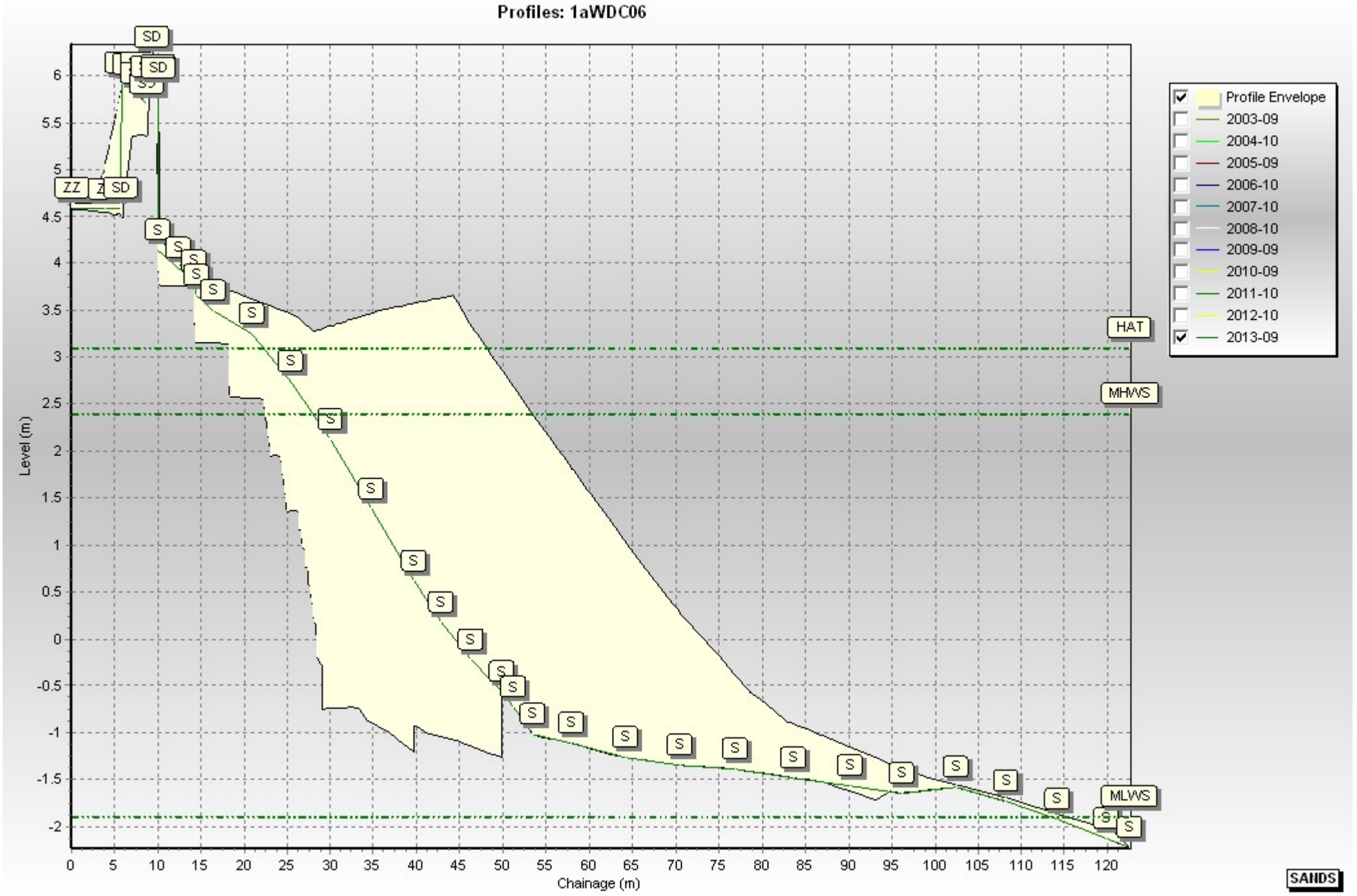
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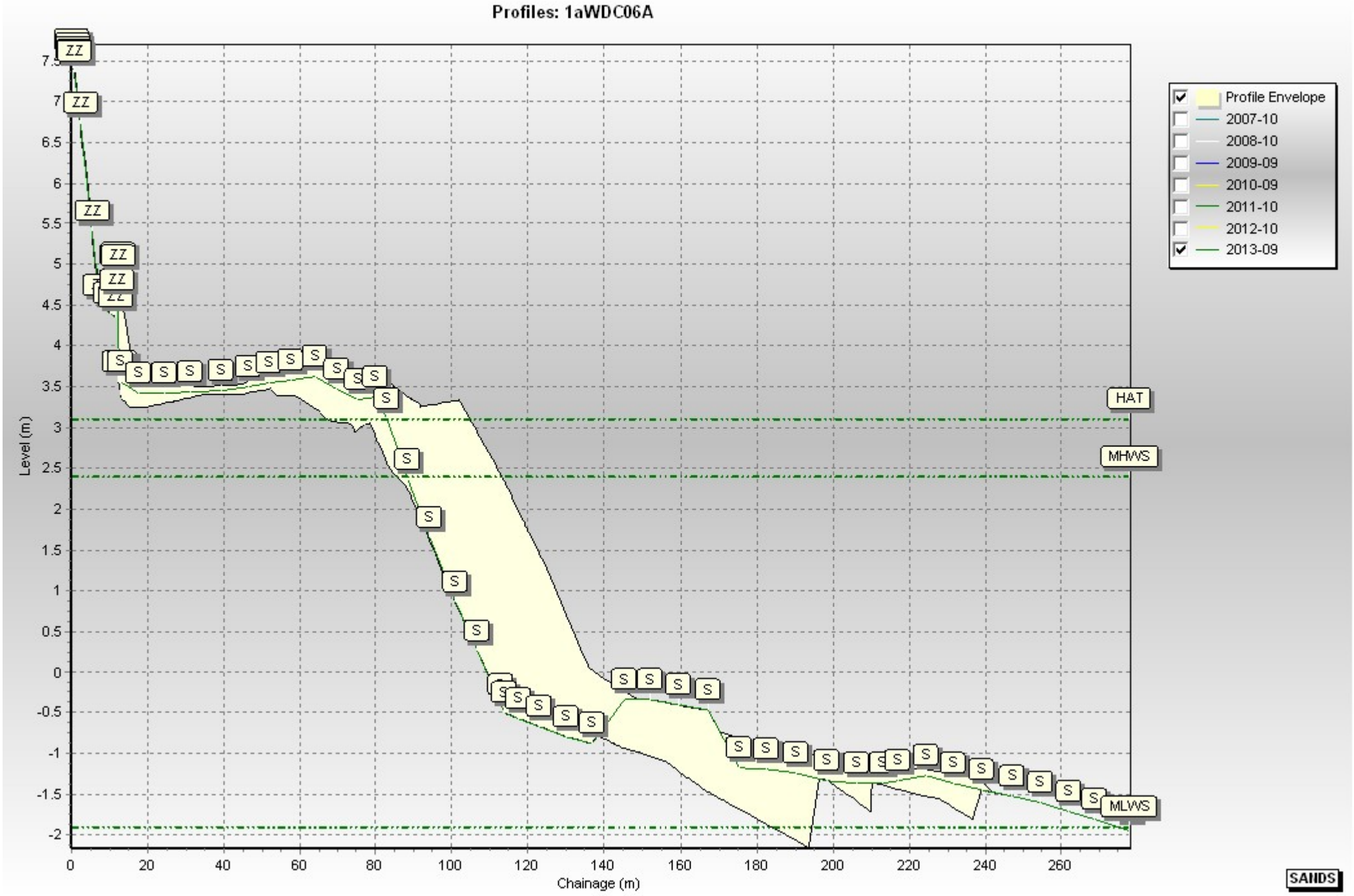
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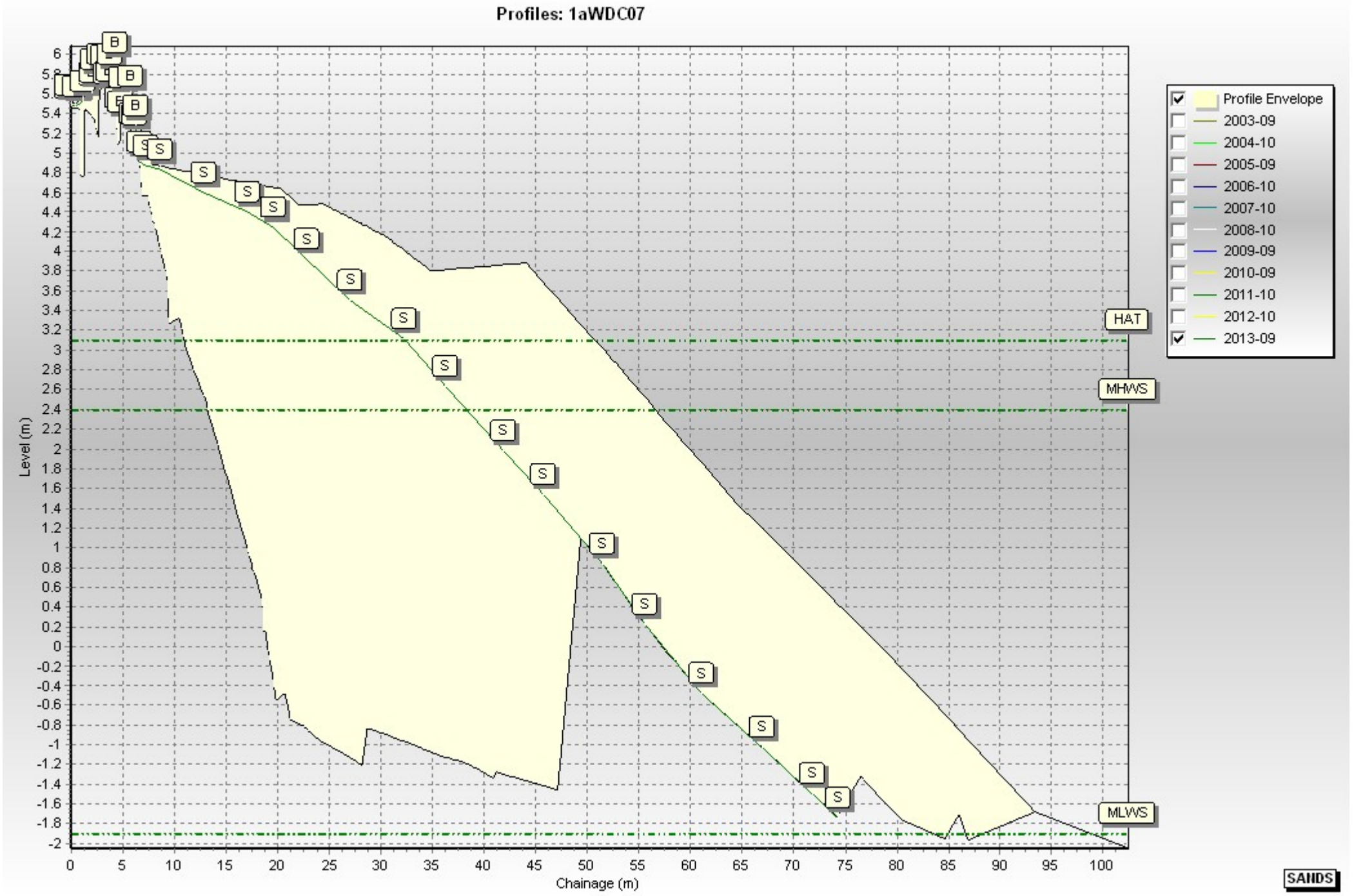
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Chainage (m)
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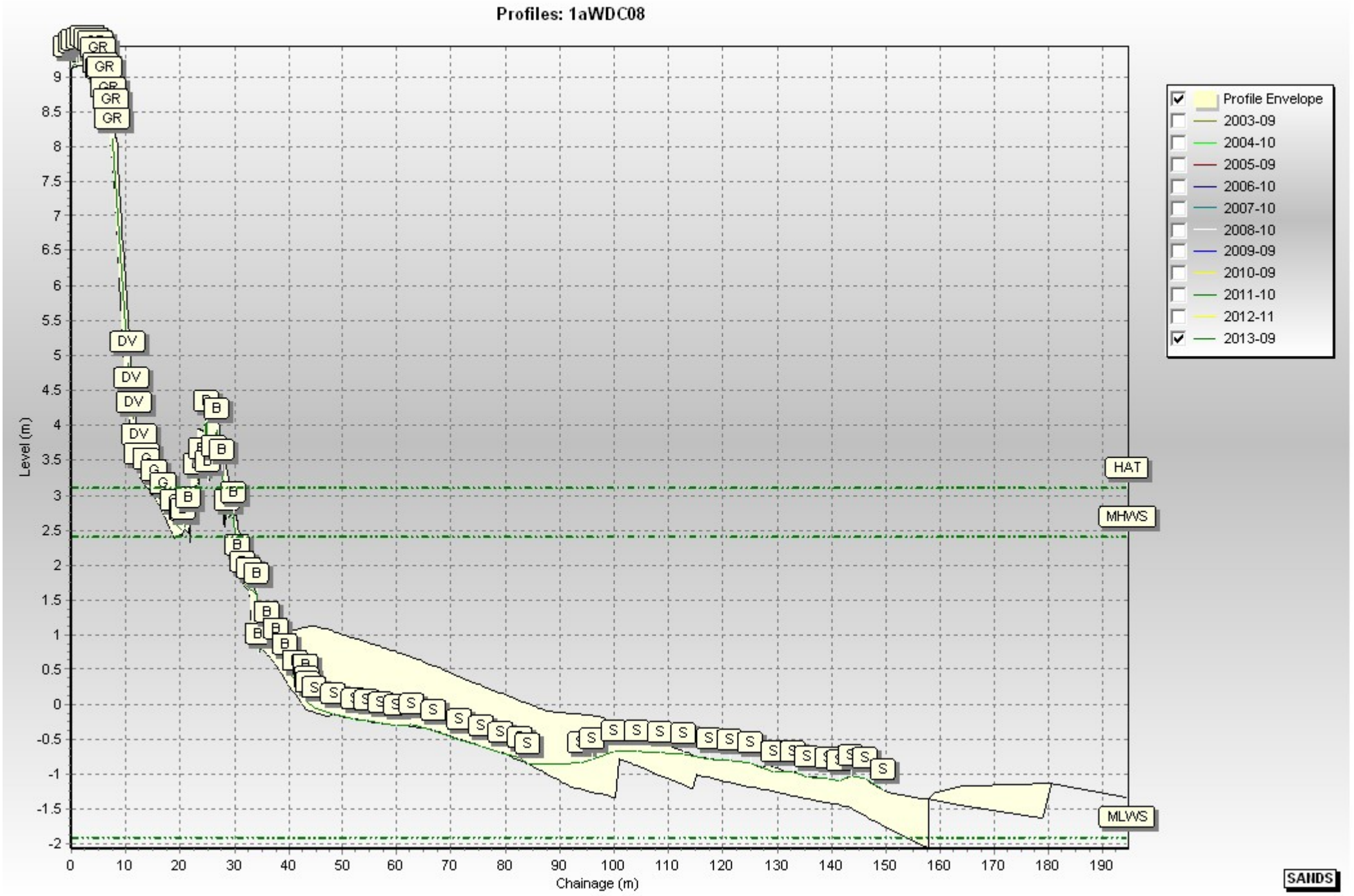
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Chainage (m)
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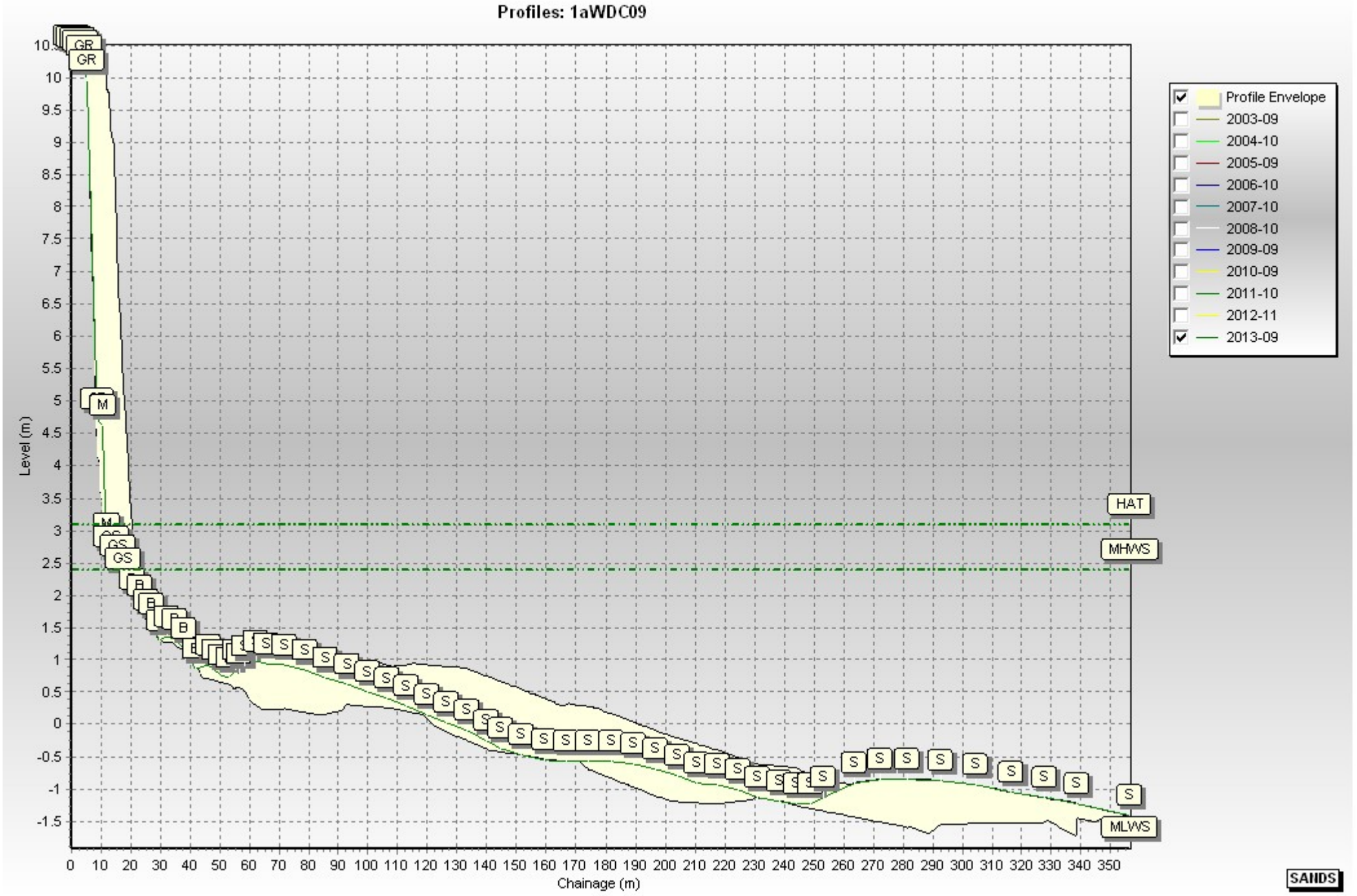
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GR
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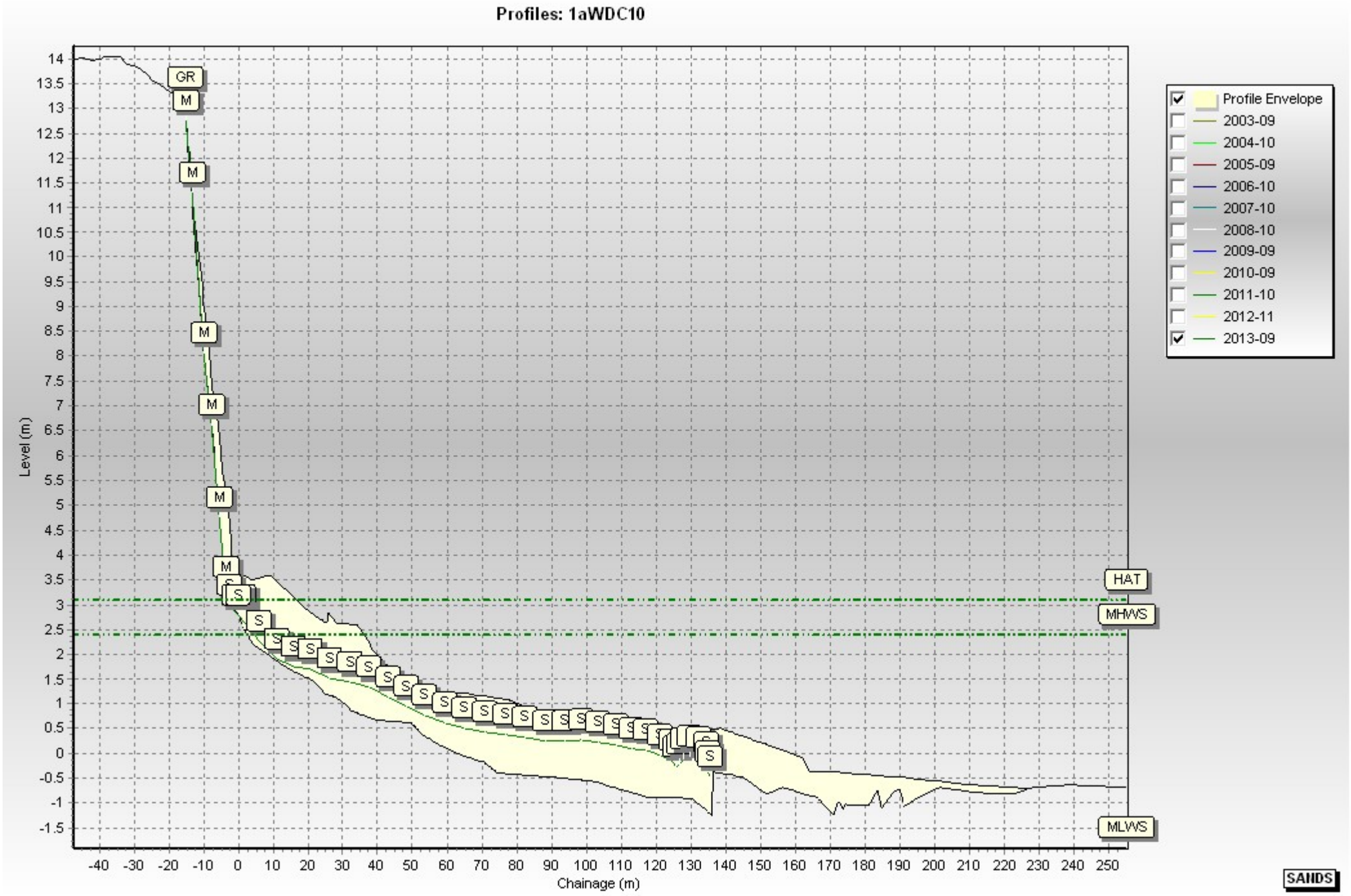
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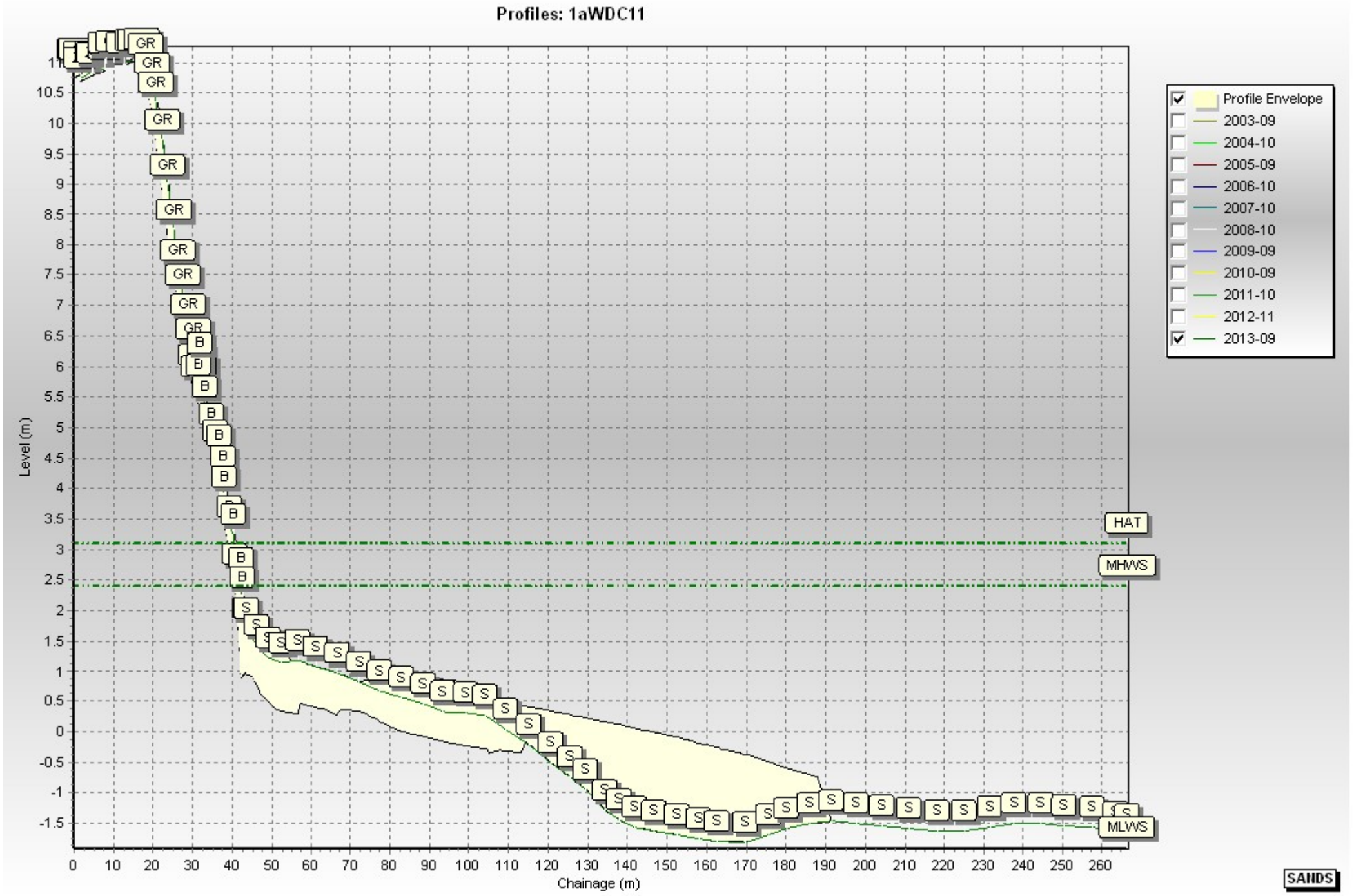
MLWS
Level (m)
Chainage (m)
SANDS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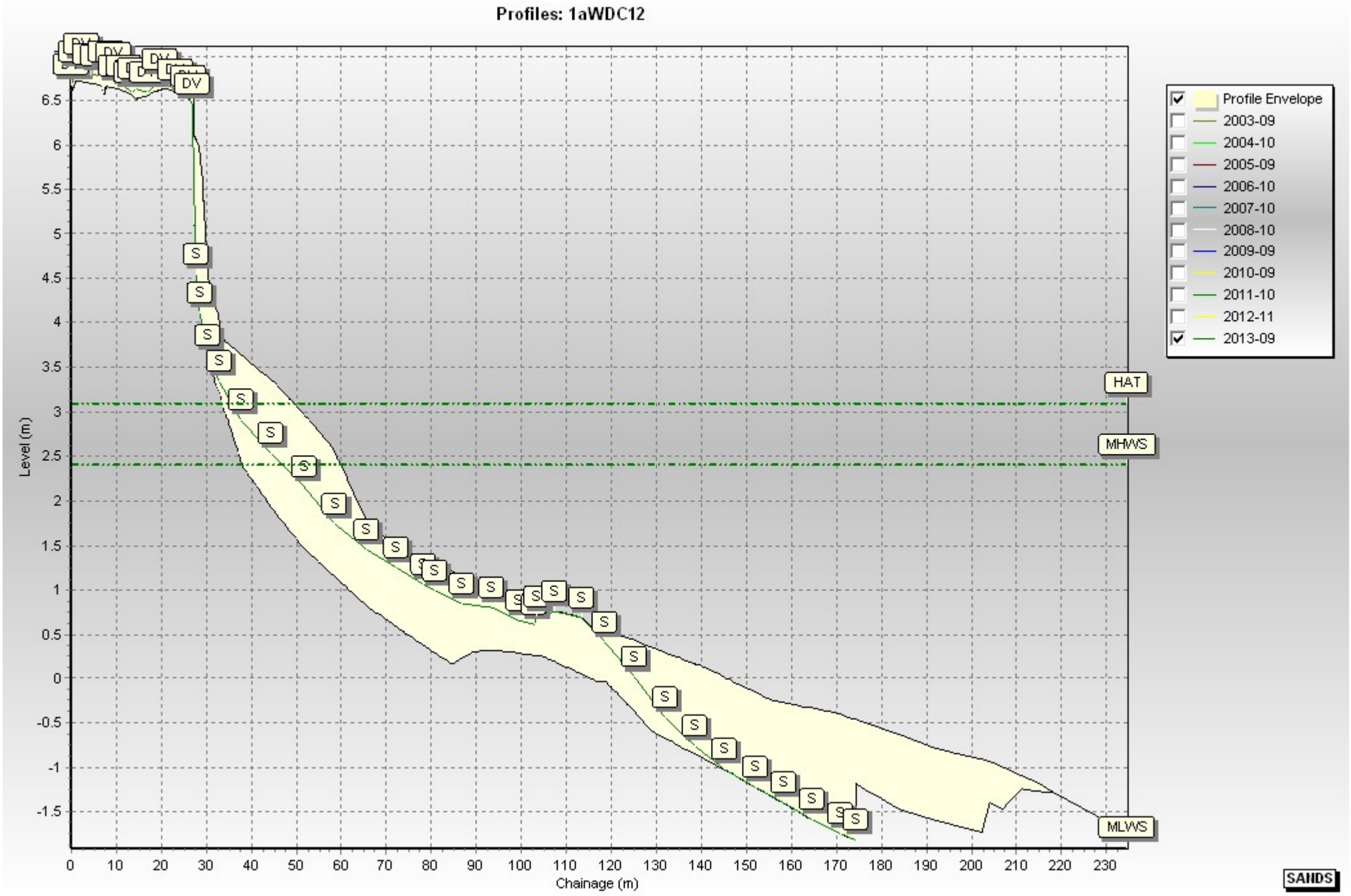
Level (m)
Chainage (m)
SANDS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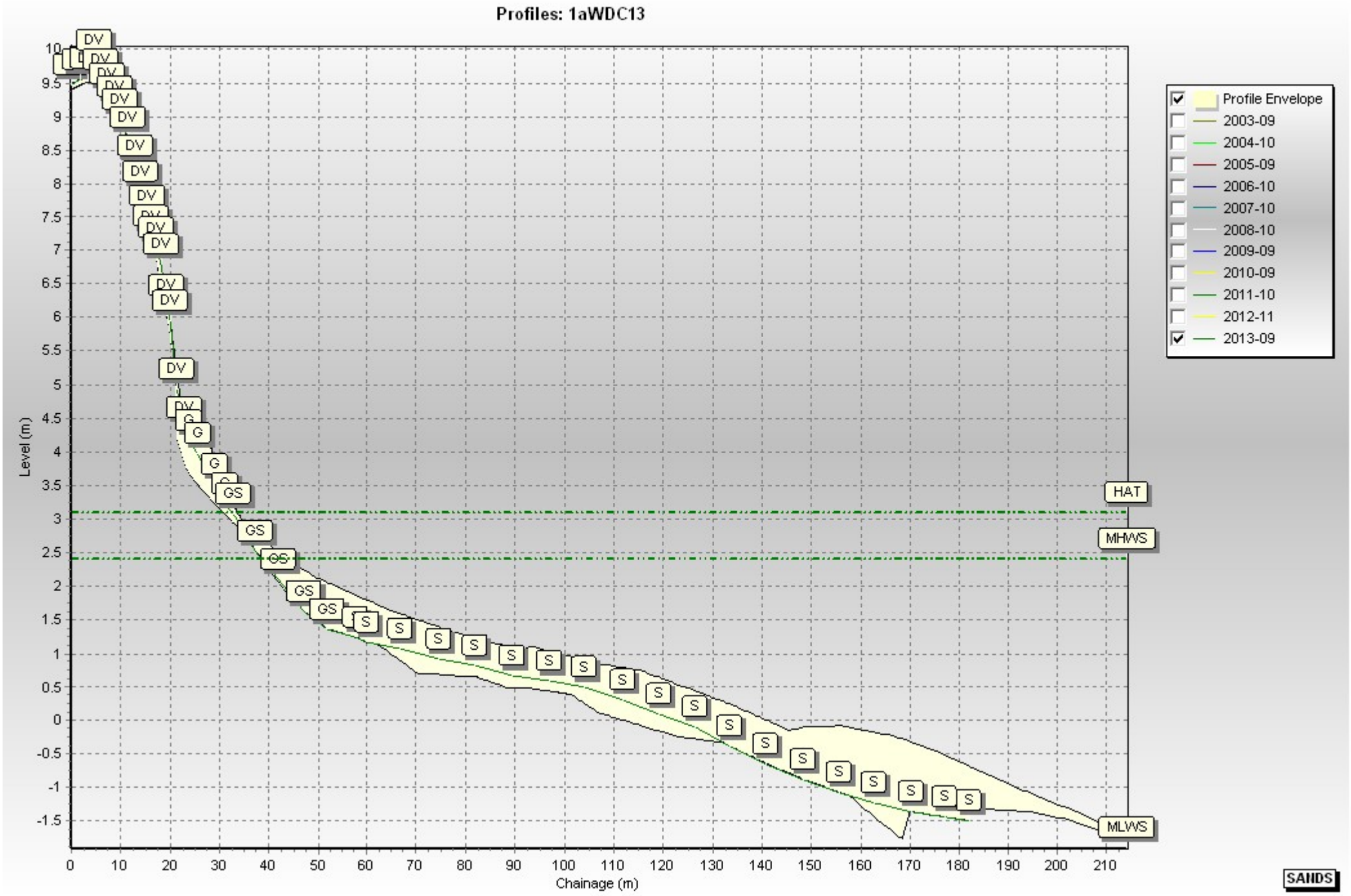
DV
S
Level (m)
Chainage (m)
SANDS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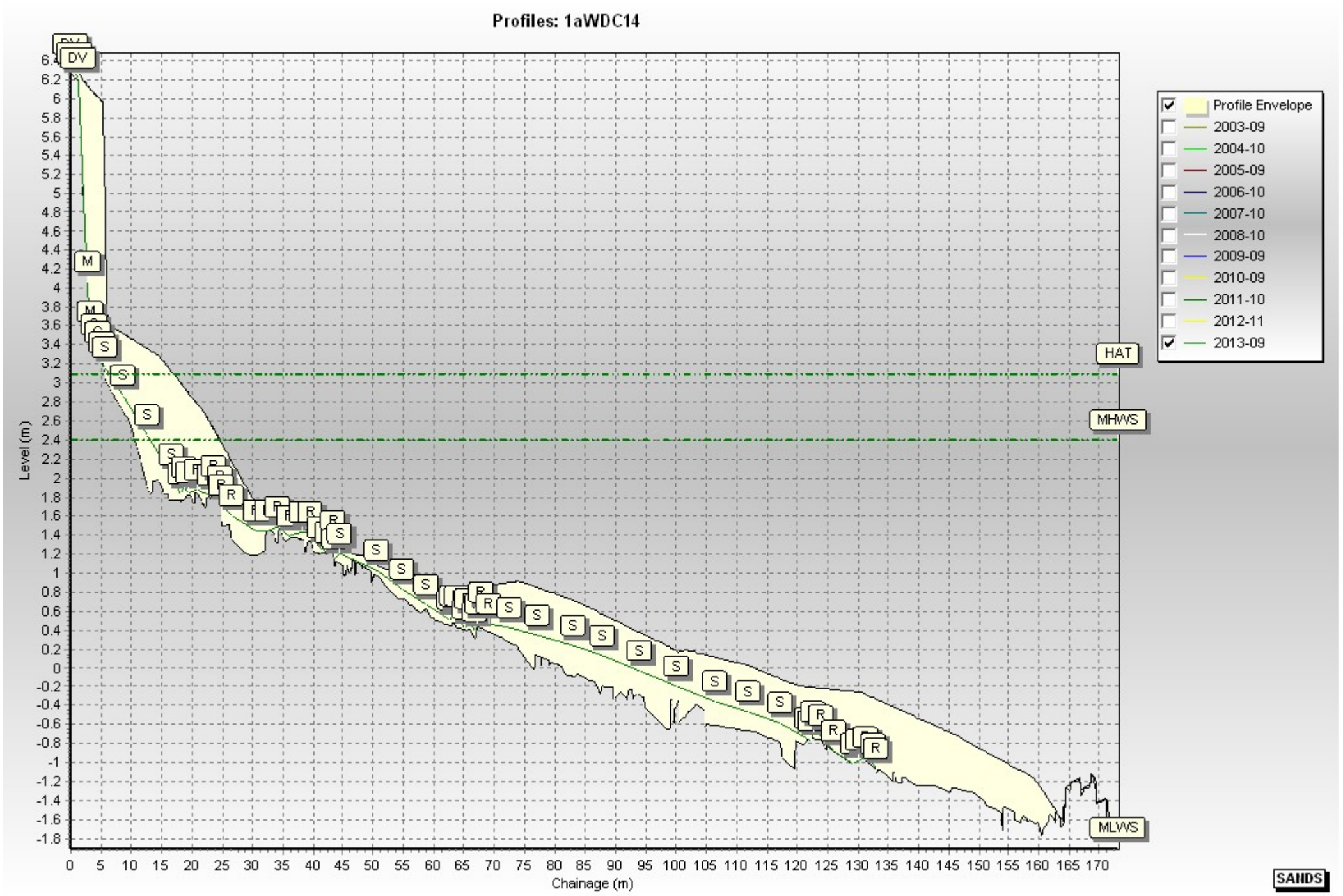
MLWS
Level (m)
Chainage (m)
SANDS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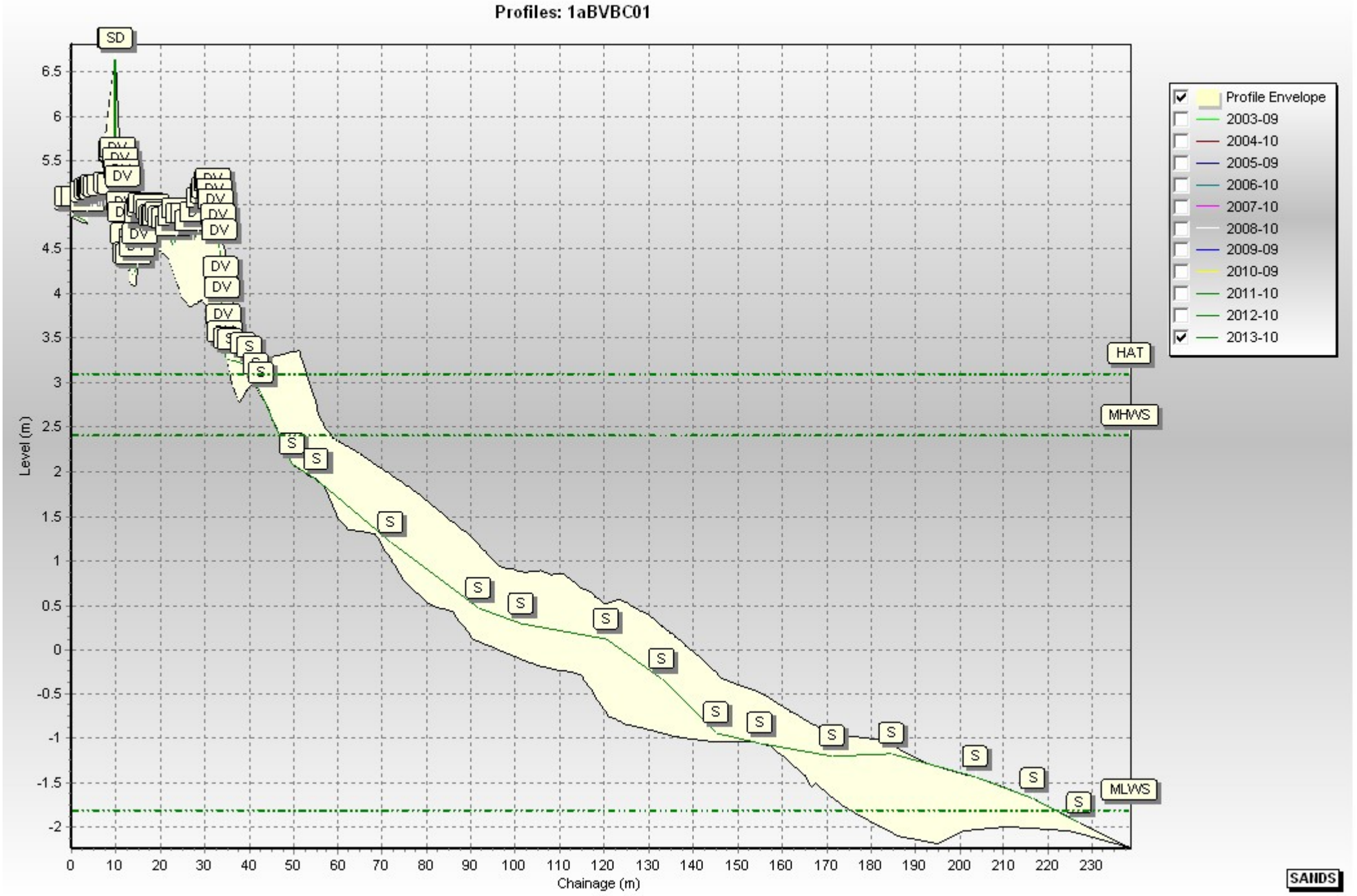
R
Level (m)
Chainage (m)
SANDS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Chainage (m)
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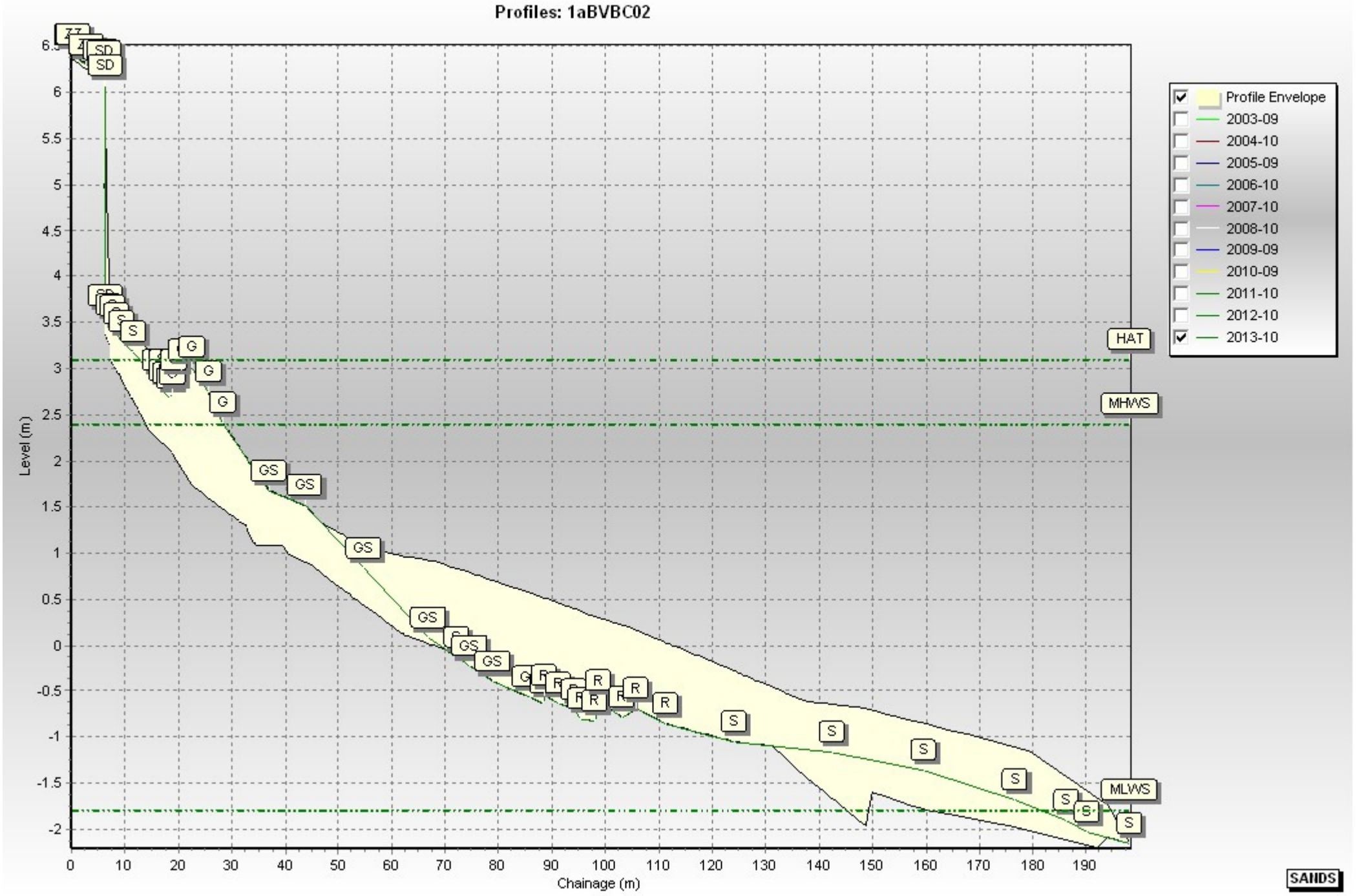
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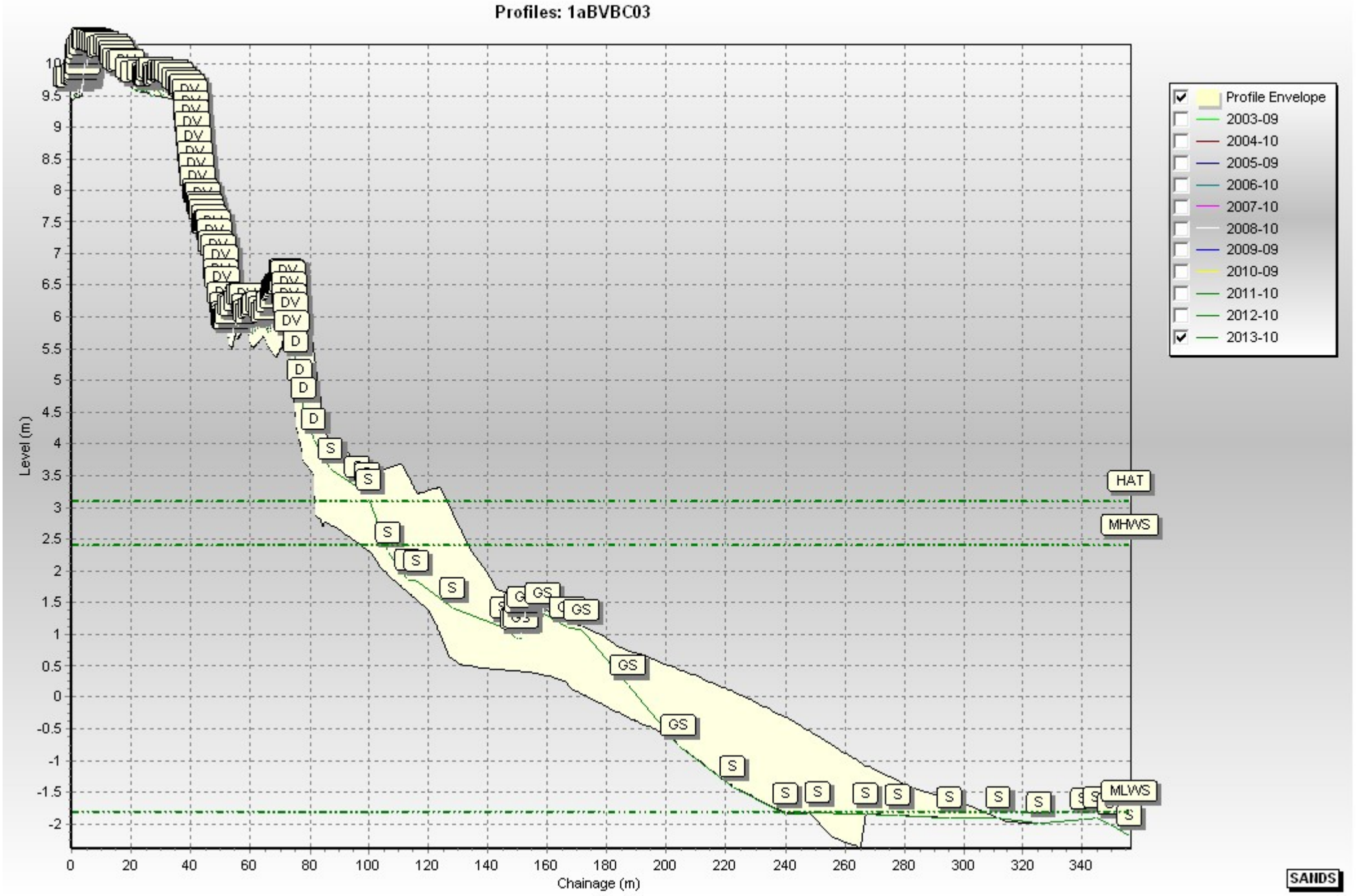
MLWS
Level (m)
Chainage (m)
SANDS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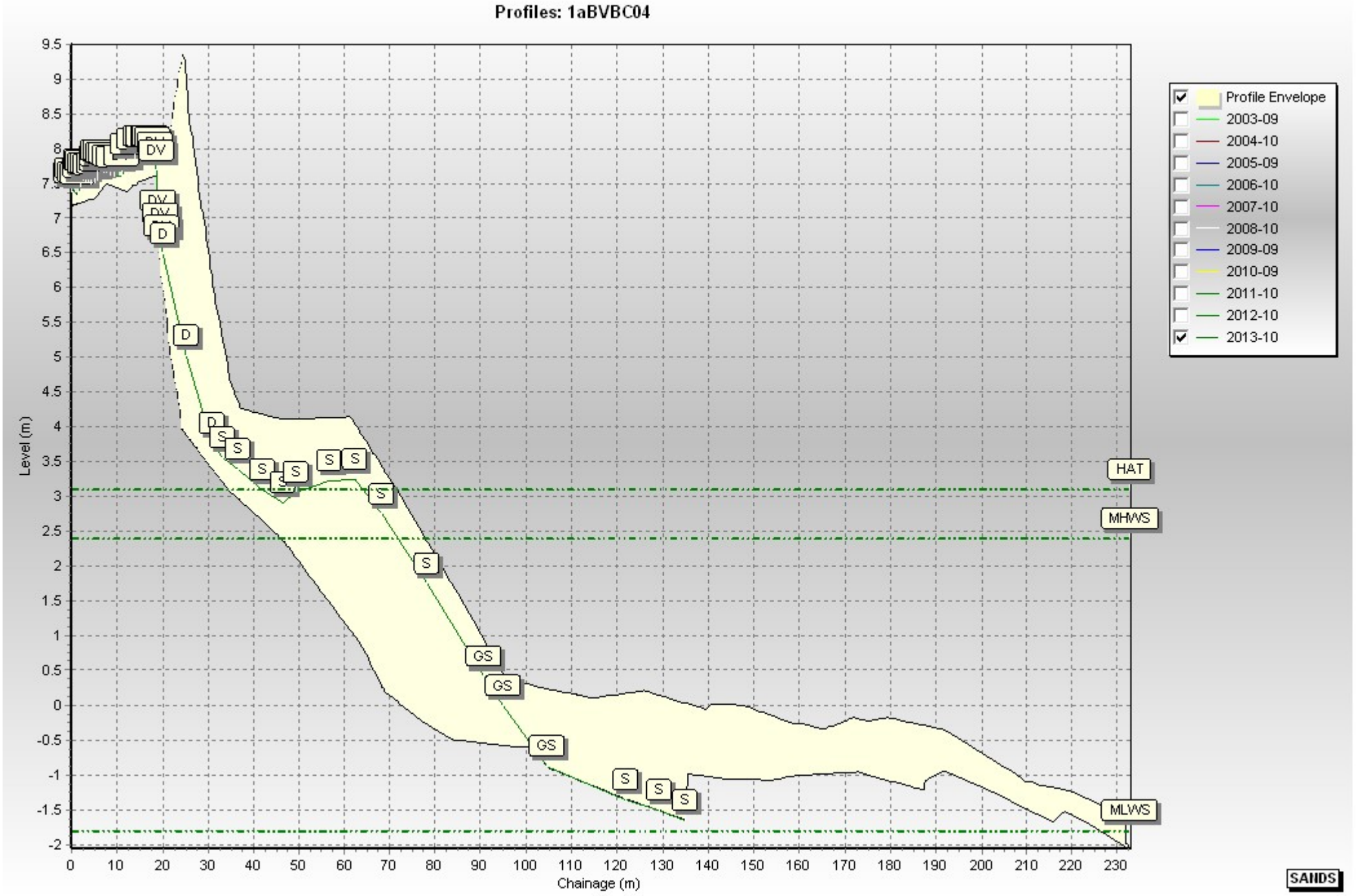
Level (m)
Chainage (m)
HAT
MHWS
MLWS
DV
D
S
GS
SANDS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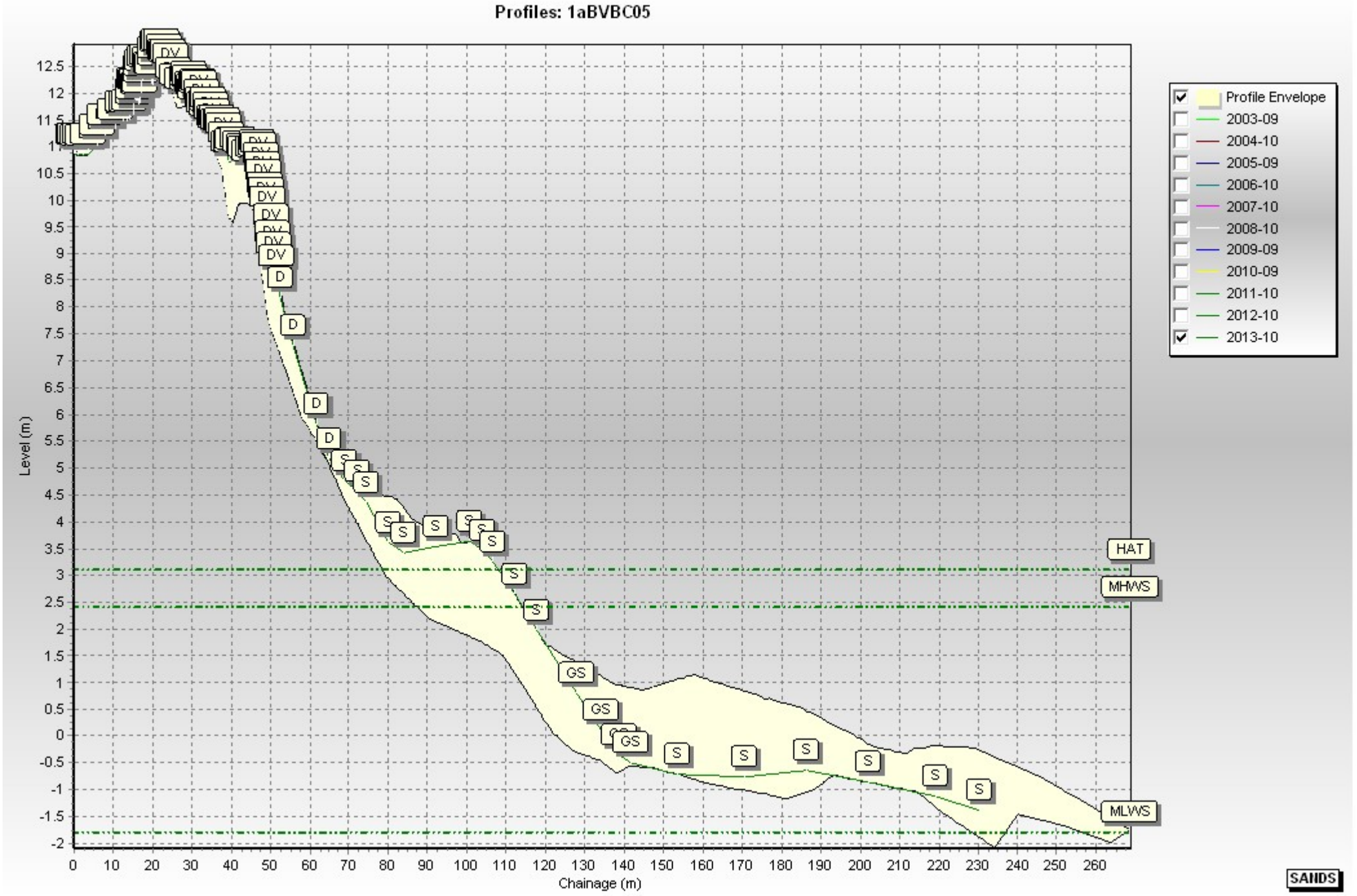
DV
D
S
GS
SANDS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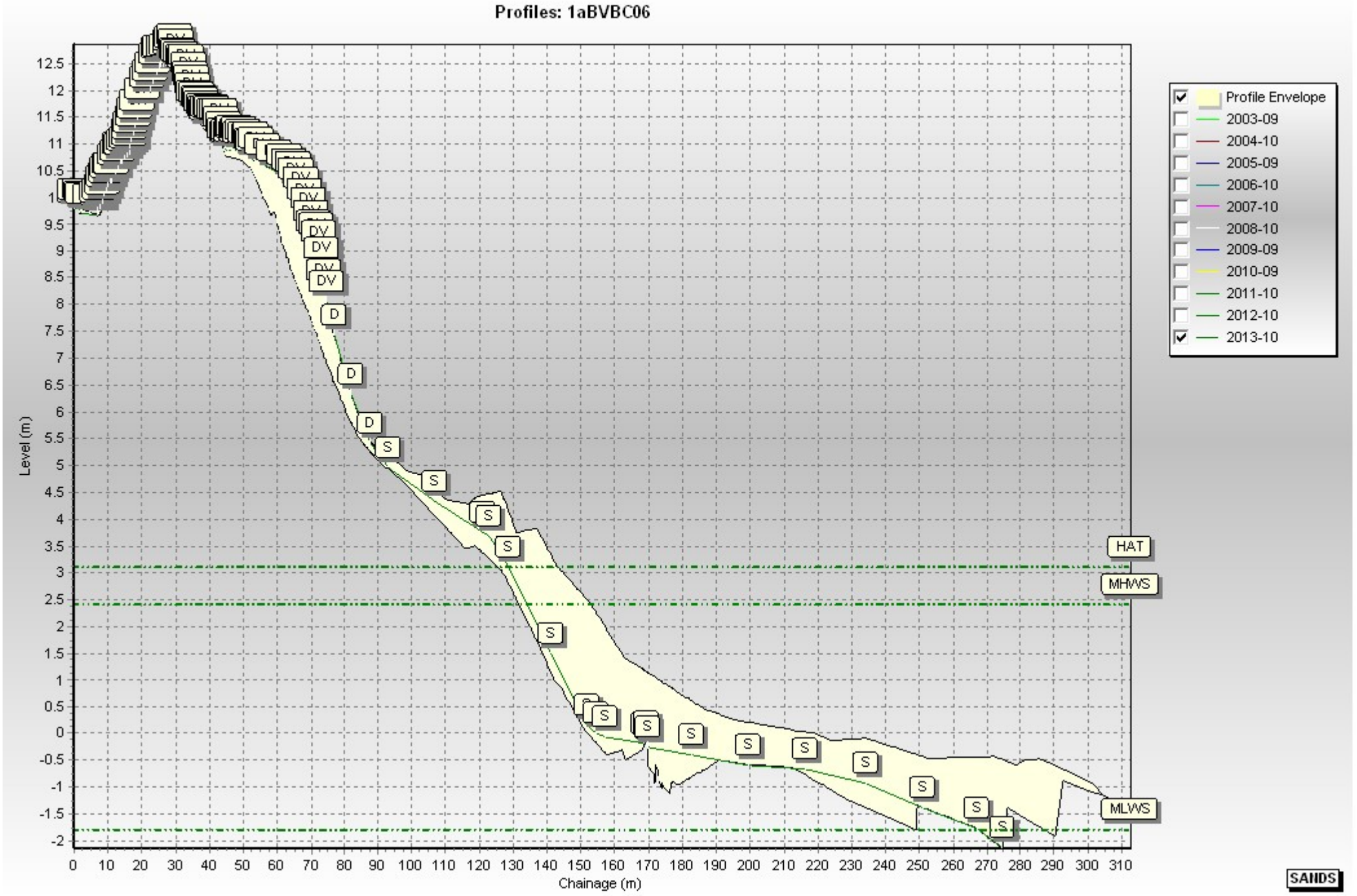
HAT
MHWS
MLWS
Level (m)
Chainage (m)
SANDS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2008-10
2009-09
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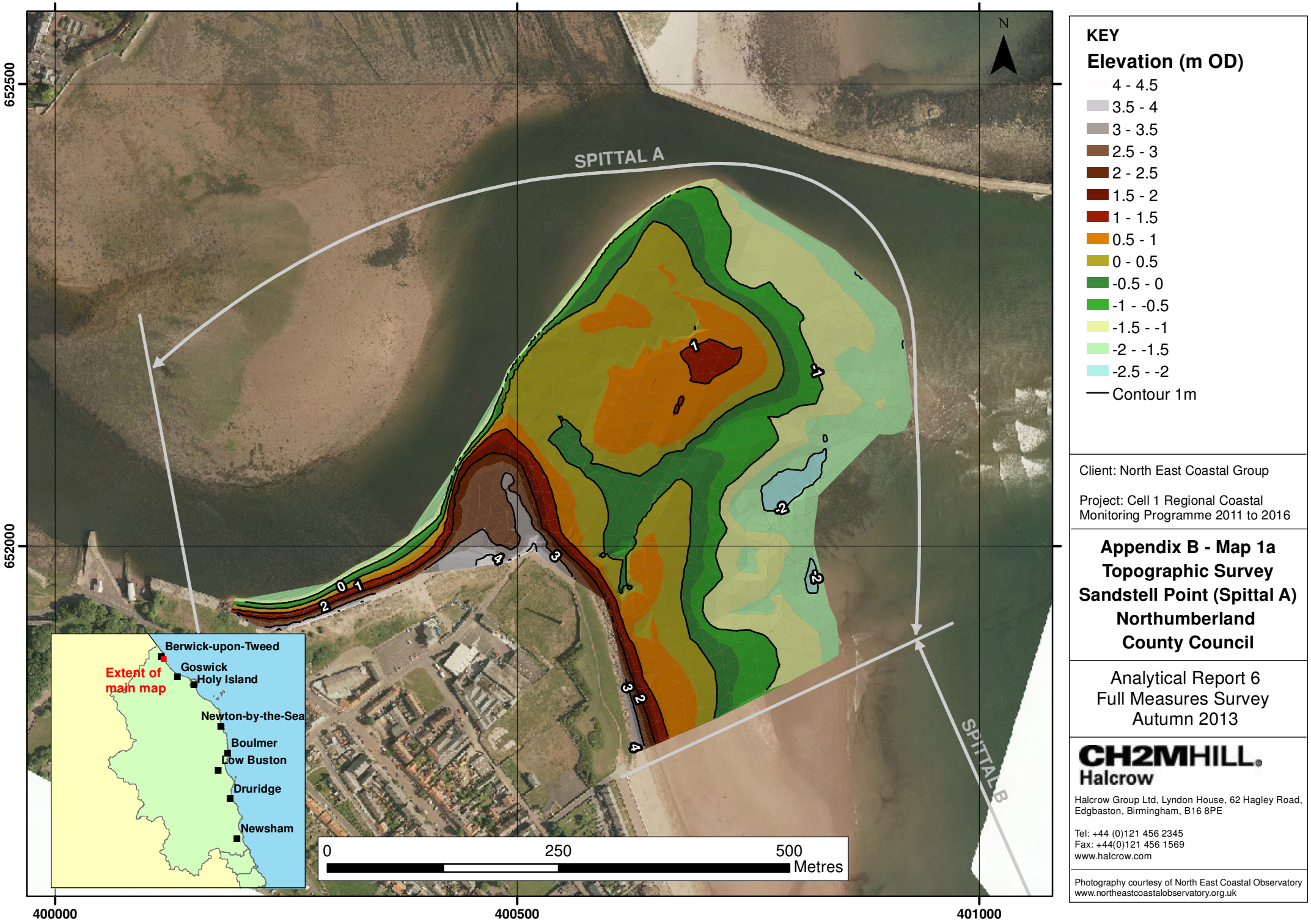
2012-10
2013-10
HAT
MHWS
MLWS
Level (m)
Chainage (m)
SANDS

Appendix B

Topographic Survey



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 1a
Topographic Survey
Sandstell Point (Spittal A)
Northumberland County Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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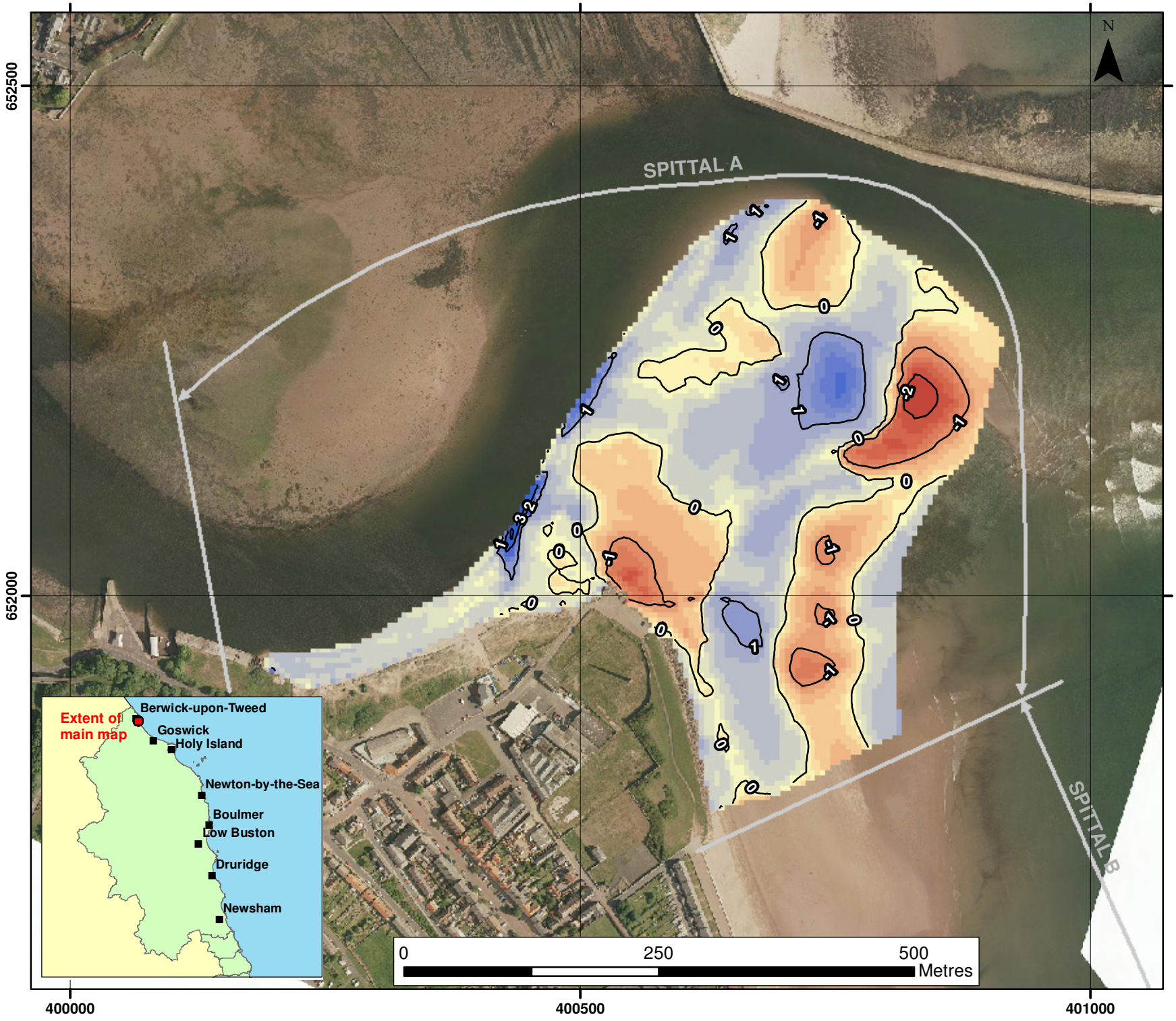

KEY

Spring 2013 and Autumn 2013
Change in elevation (m)

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

Contours of change

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

Appendix B - Map 1b
Short-term Elevation Change
Berwick
Northumberland County Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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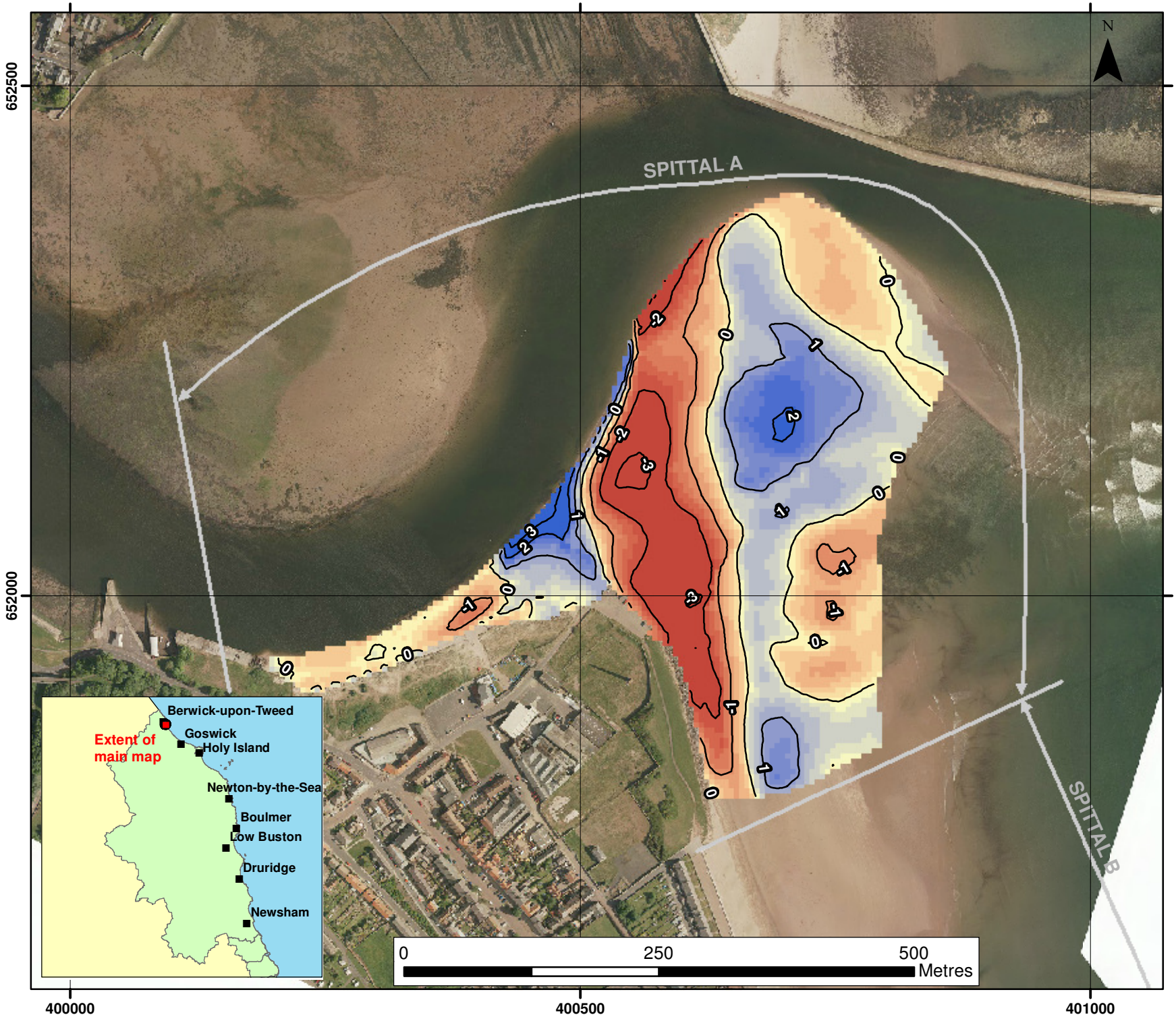

KEY

Autumn 2011 and Autumn 2013
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
Berwick
Northumberland County Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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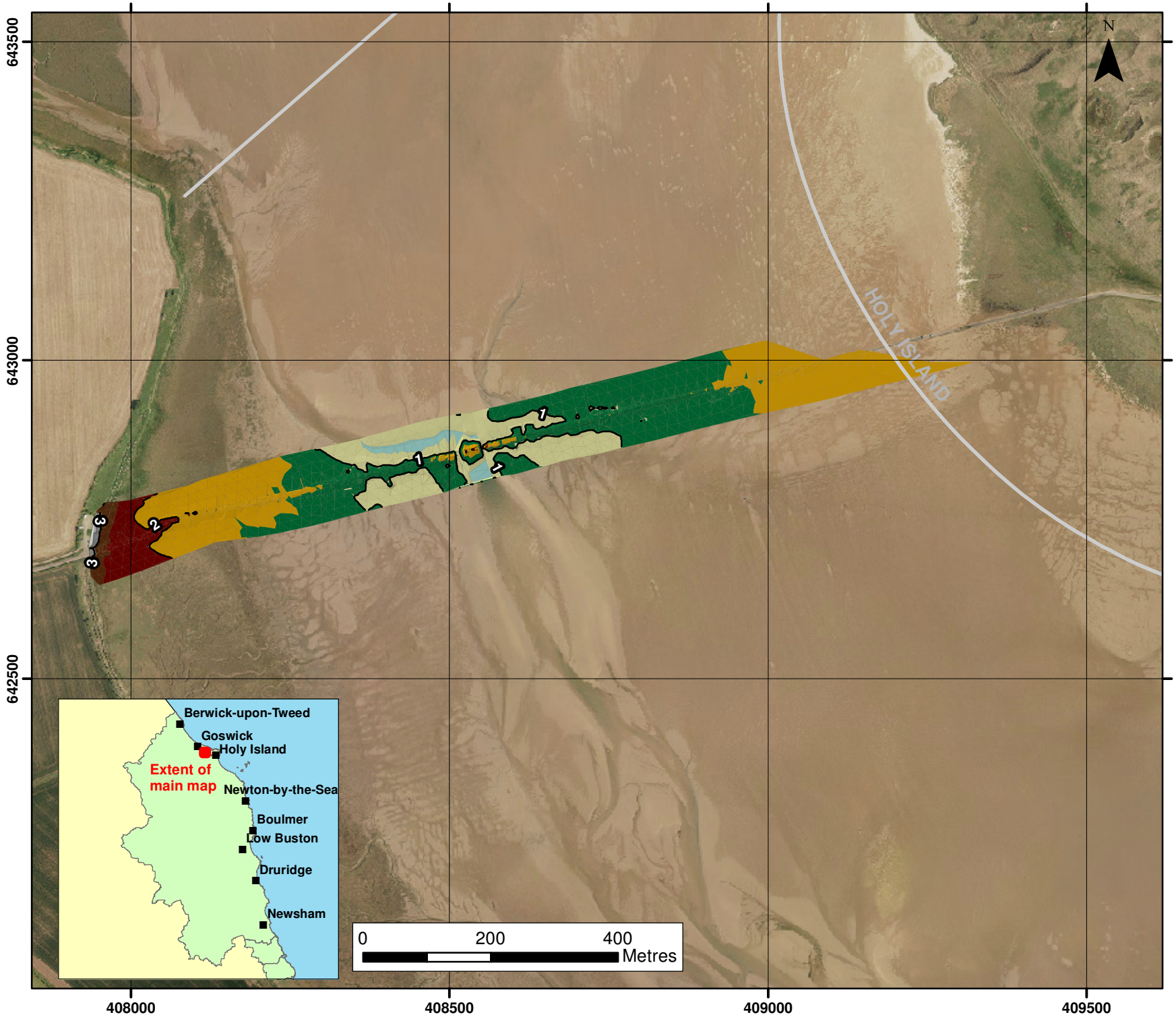

KEY

Elevation (m OD)

- 3.5 - 4
- 3 - 3.5
- 2.5 - 3
- 2 - 2.5
- 1.5 - 2
- 1 - 1.5
- 0.5 - 1
- 0 - 0.5
- Contour 1m

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B - Map 2a
Topographic Survey
Holy Island
Northumberland
County Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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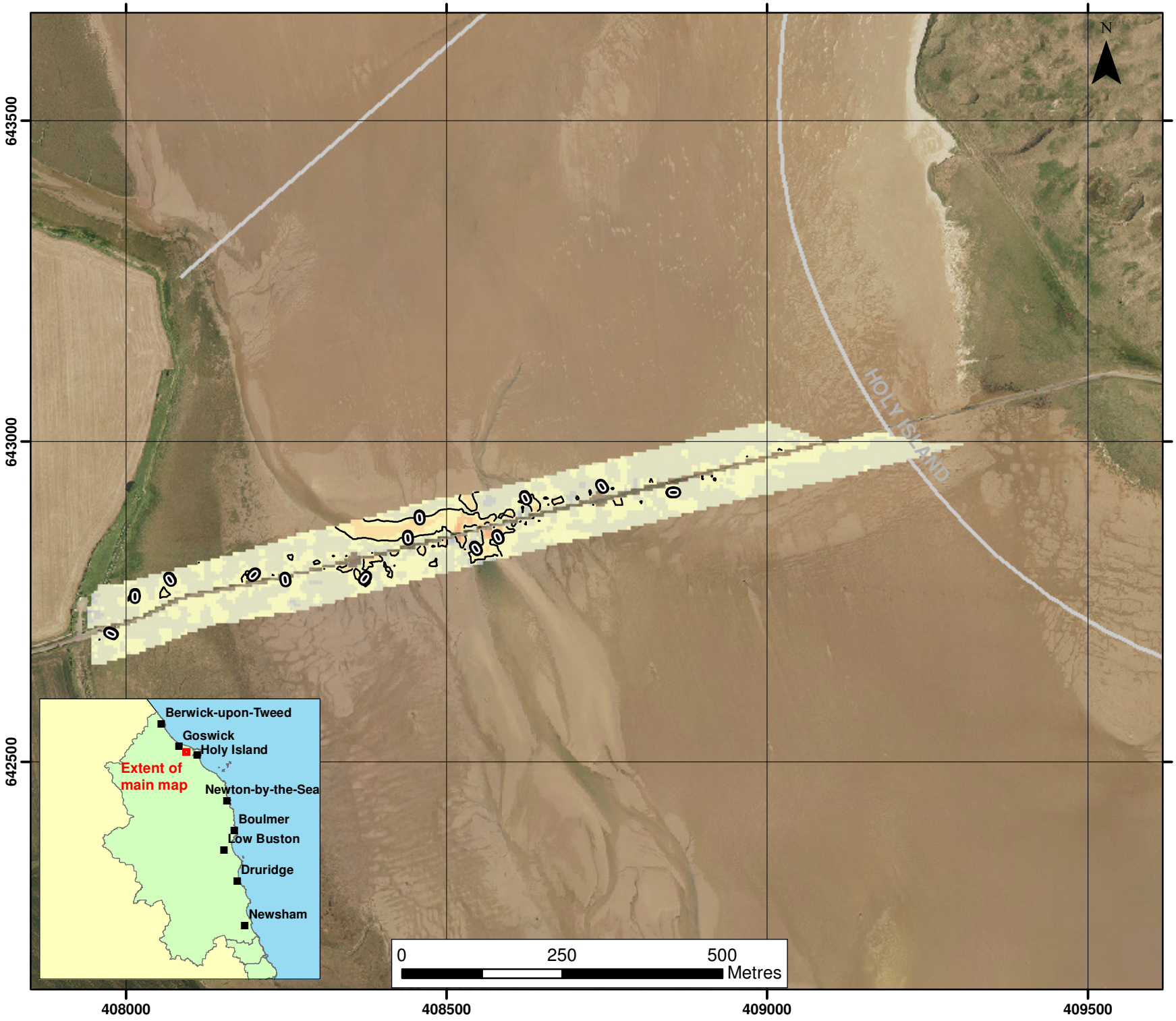

KEY Autumn 2012 and Autumn 2013 Change in elevation (m)

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

Contours of change

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

Appendix B- Map 2b
Short-term Elevation Change
Holy Island
Northumberland County Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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Fax: +44(0)121 456 1569
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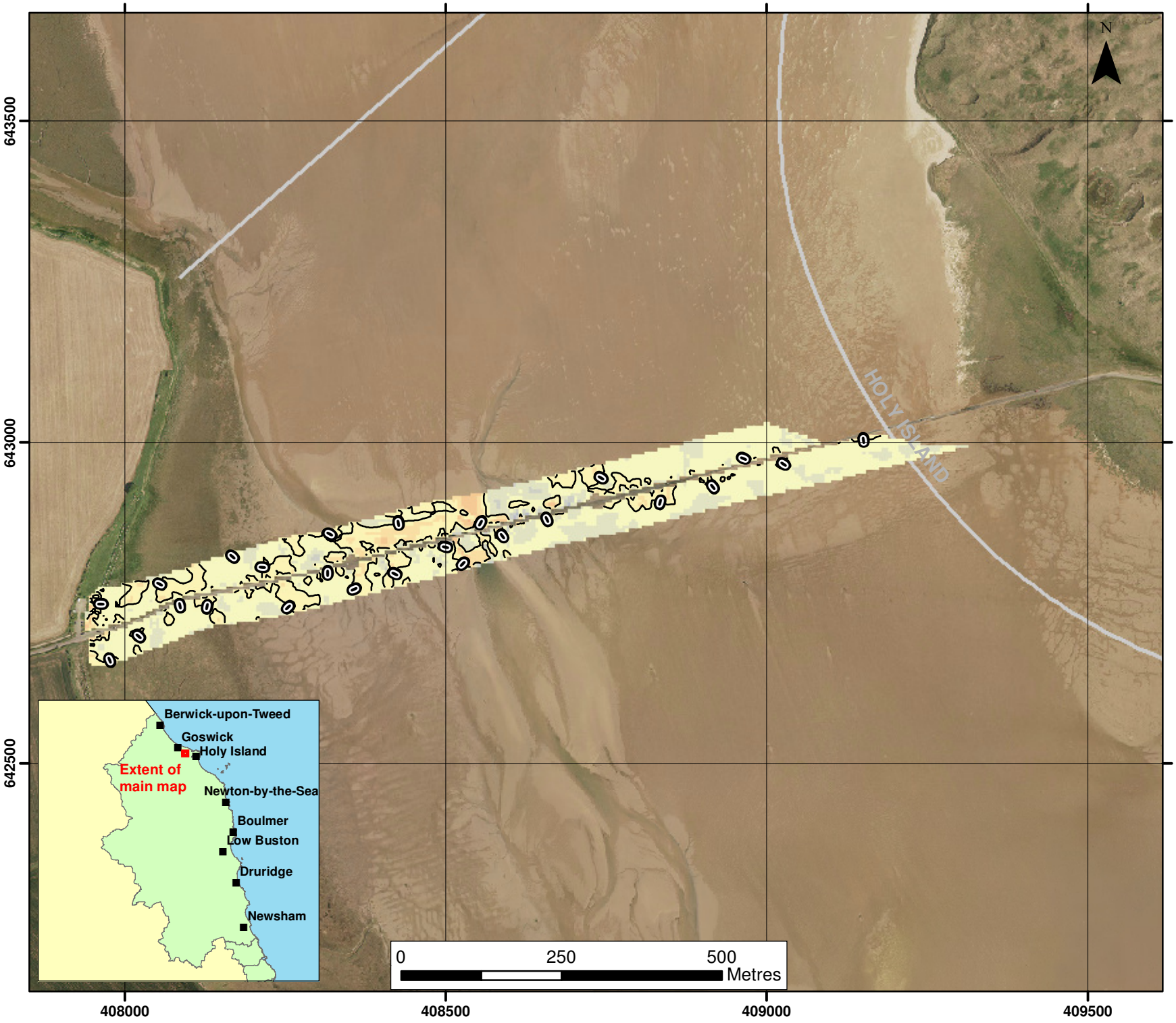
Photography courtesy of North East Coastal Observatory
www.northeastcoastalobservatory.org.uk



KEY Autumn 2010 and Autumn 2013
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 Holy Island Northumberland County Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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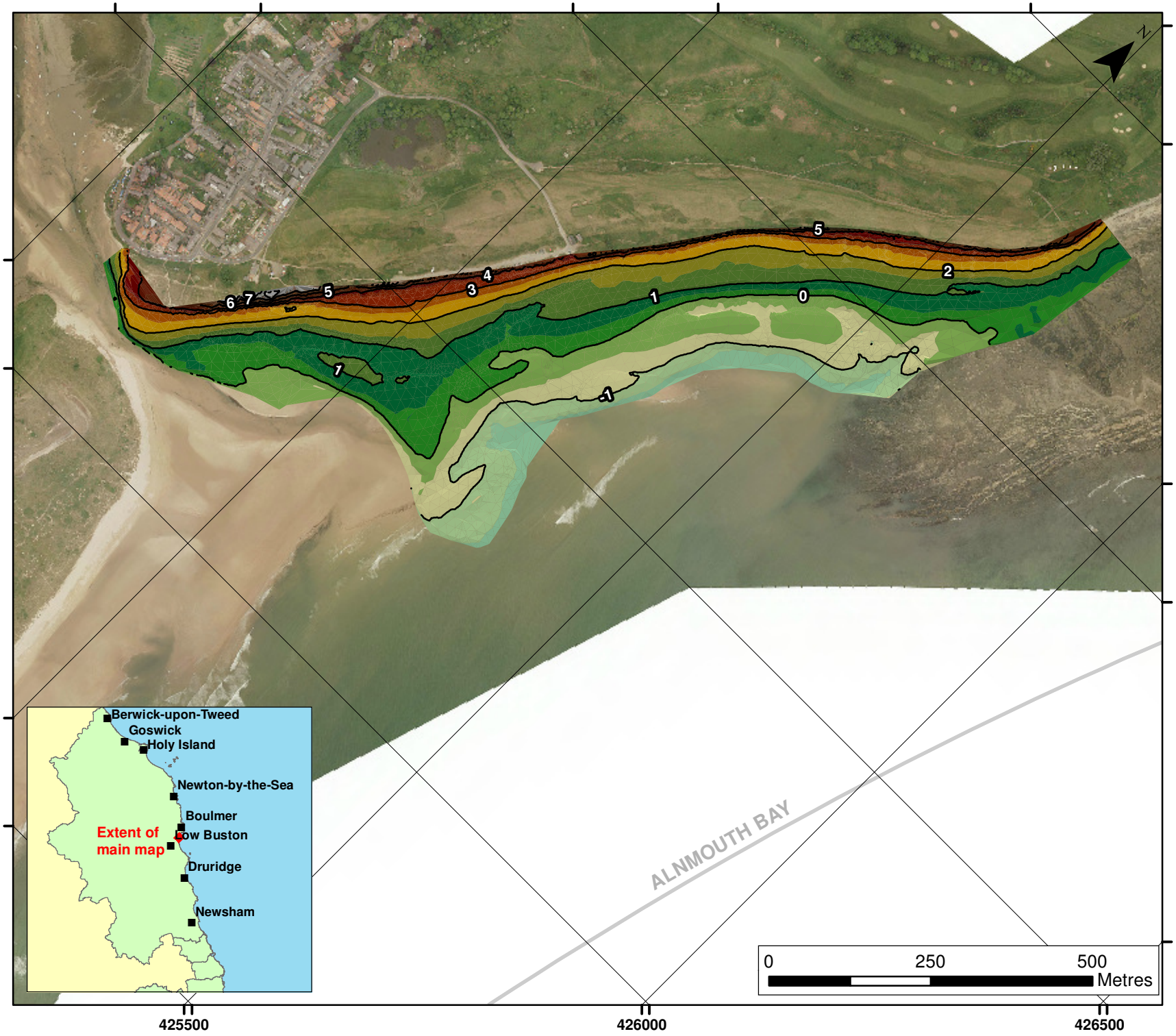

KEY

Elevation (m OD)

- 8 - 8.5
- 7.5 - 8
- 7 - 7.5
- 6.5 - 7
- 6 - 6.5
- 5.5 - 6
- 5 - 5.5
- 4.5 - 5
- 4 - 4.5
- 3.5 - 4
- 3 - 3.5
- 2.5 - 3
- 2 - 2.5
- 1.5 - 2
- 1 - 1.5
- 0.5 - 1
- 0 - 0.5
- -0.5 - 0
- -1 - -0.5
- -1.5 - -1
- -2 - -1.5
- -2.5 - -2
- Contour 1m

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B - Map 3a
Topographic Survey
Alnmouth Bay
Northumberland County Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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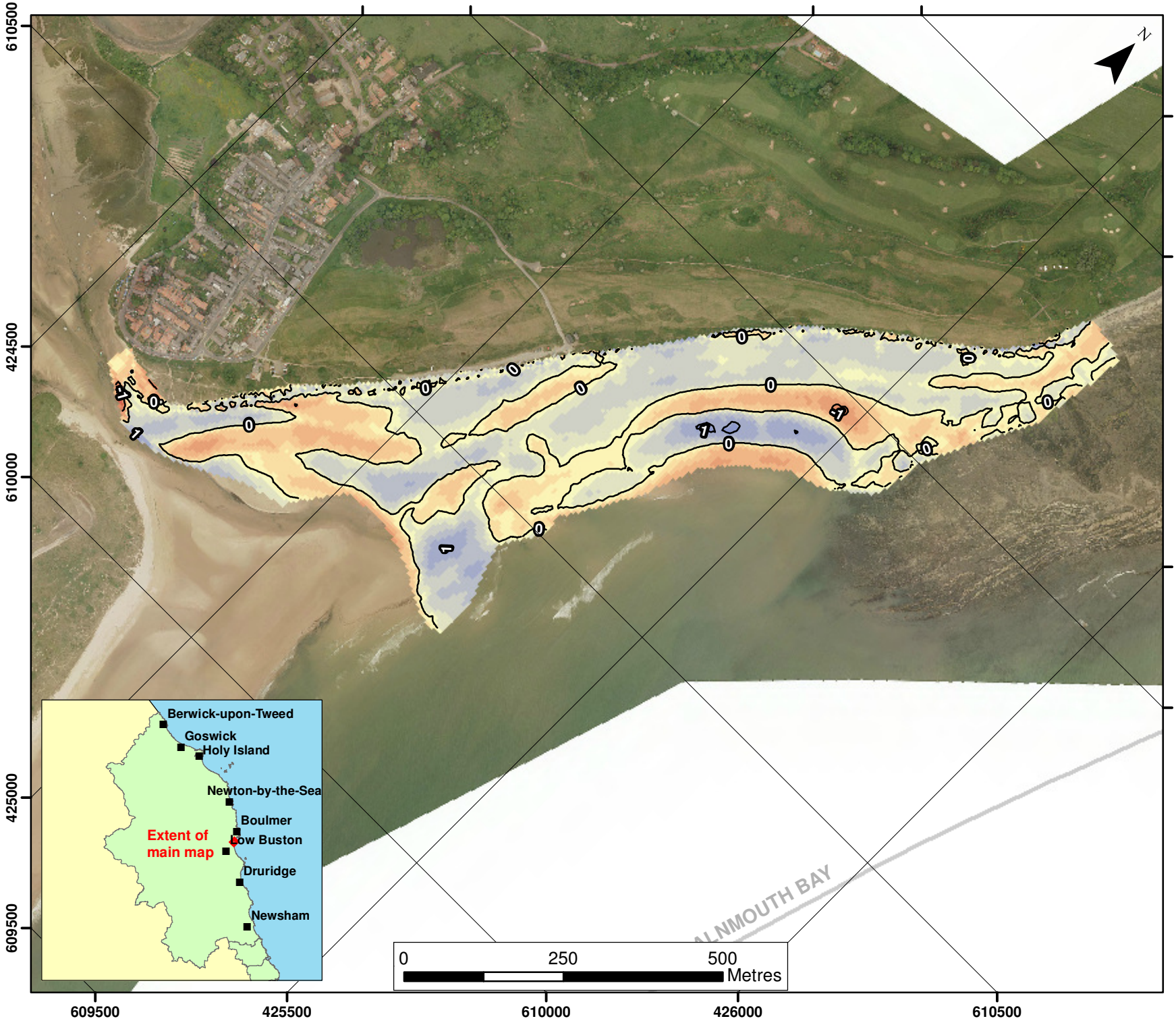

KEY Soring 2013 and Autumn 2013
Change in elevation (m)

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

Contours of change

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

Appendix B- Map 3b
Short-term Elevation Change
Alnmouth
Northumberland County Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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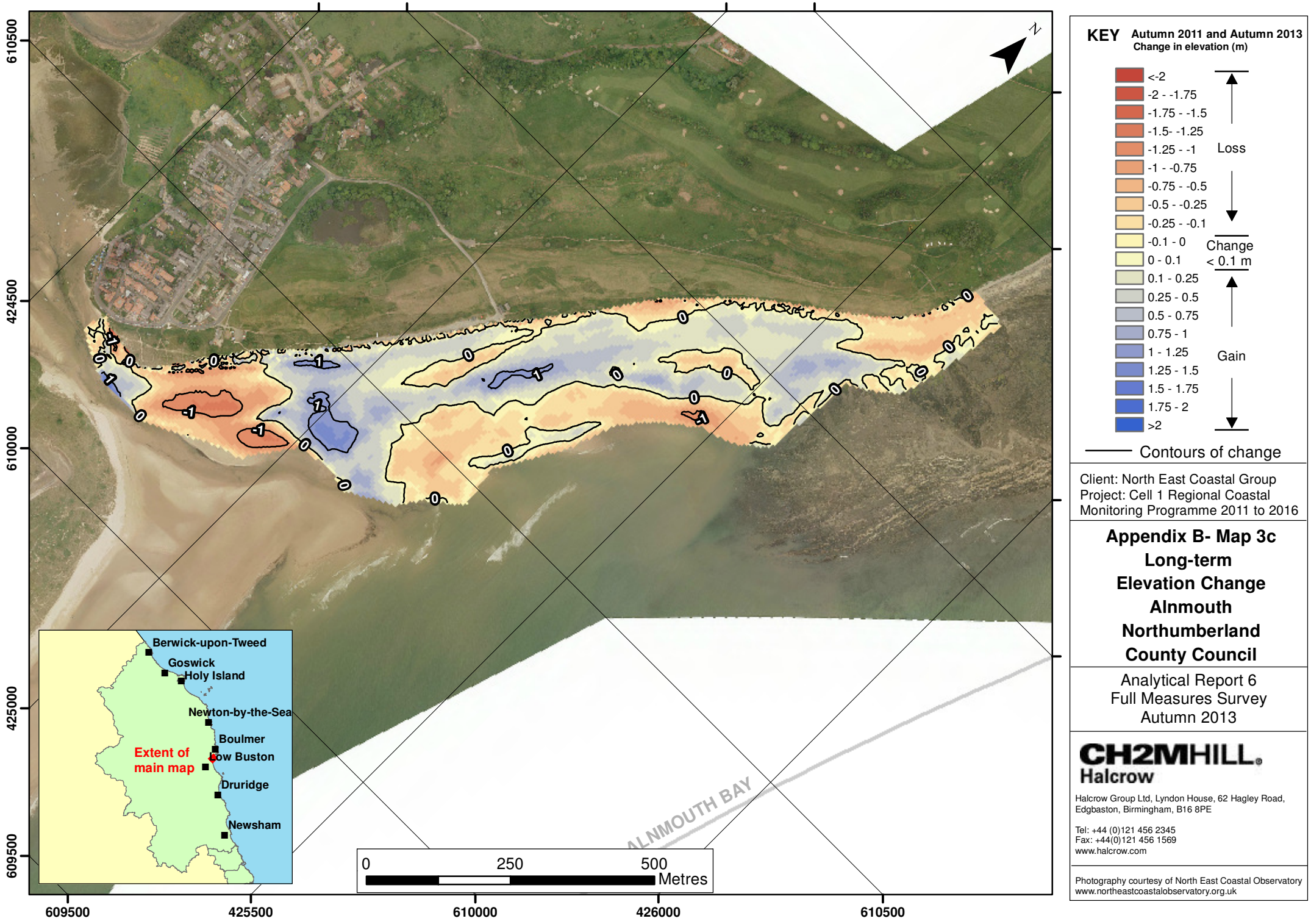

Client: North East Coastal Group
Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B- Map 3c Long-term Elevation Change Alnmouth Northumberland County Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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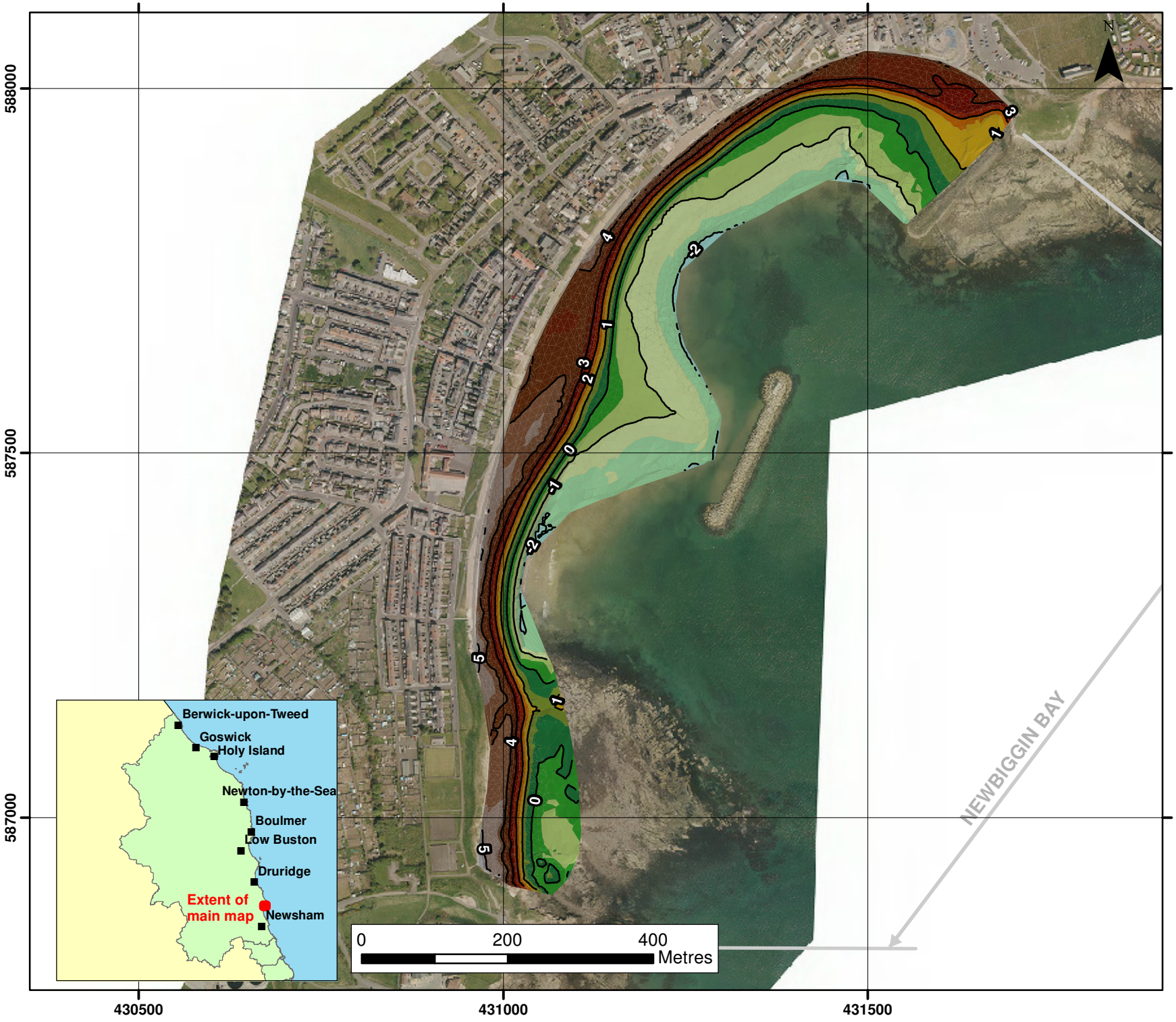
Fax: +44(0)121 456 1569
www.halcrow.com



KEY

Elevation (m OD)

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

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B - Map 4a
Topographic Survey
Newbiggin Bay
Northumberland County Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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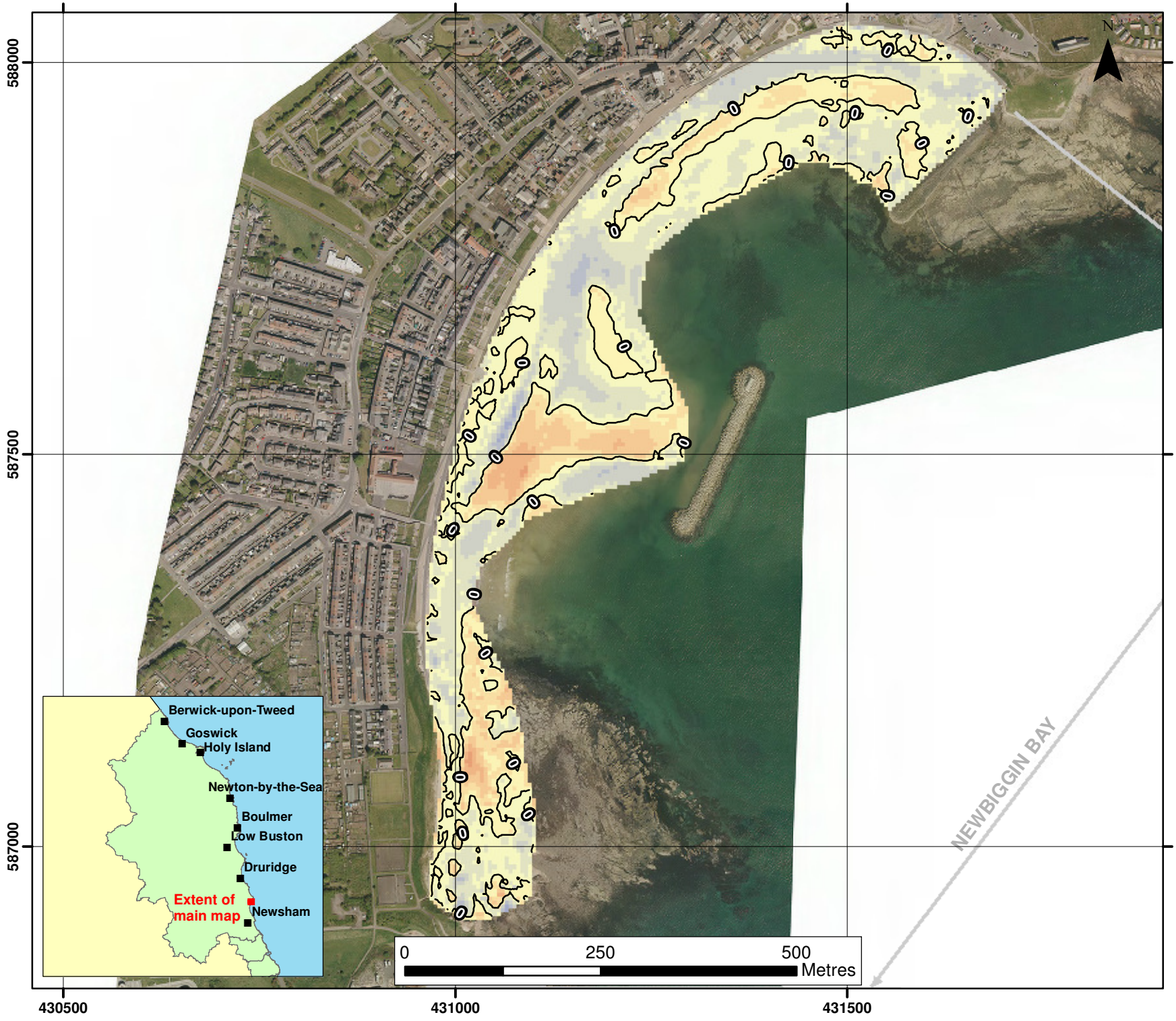

KEY Spring 2013 and Autumn 2013 Change in elevation (m)

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

Contours of change

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

Appendix B Map 4b
Short-term Elevation Change
Newbiggin
Northumberland County Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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KEY Autumn 2011 and Autumn 2013 Change in elevation (m)

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

Loss

Change < 0.1 m

Gain

Contours of change

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

Appendix B Map 4c Long-term Elevation Change Newbiggin Northumberland County Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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Appendix C

Cliff Top Survey

Cliff Top Survey

Lynemouth Bay

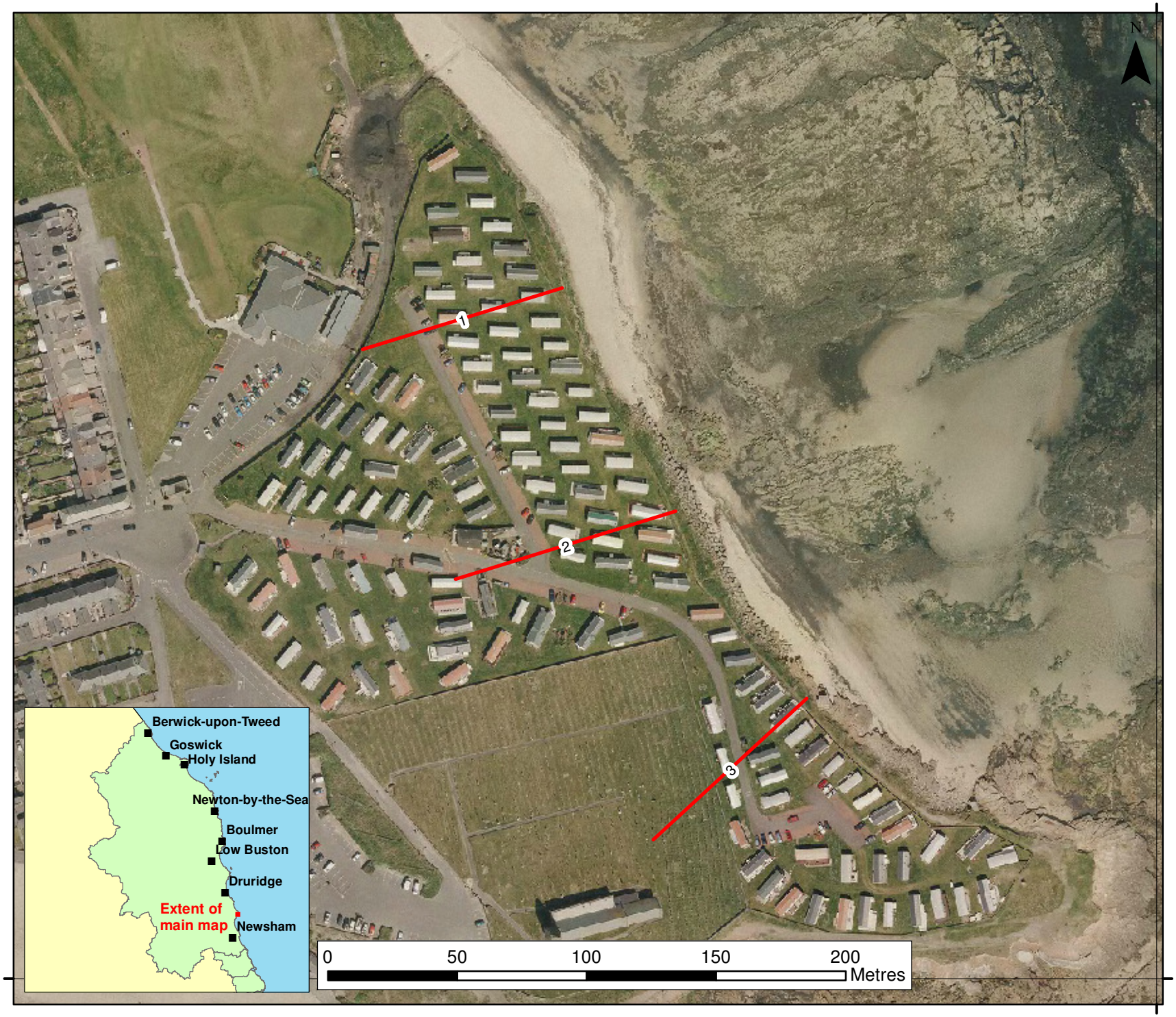
Three ground control points have been established at Lynemouth Bay (Map 1). The maximum separation between any two points varies along the coast, reflecting the erosion risk.

The cliff top surveys at Lynemouth Bay are undertaken bi-annually. Measurements are taken along a fixed transect from the landward datum to the surveyed cliff top position.

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 transect. 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 Lynemouth Bay

Ground Control Point Details		Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Type	Baseline Survey (Oct 2008)	Previous Survey (Apr 2012)	Present Survey (Oct 2012)	Baseline (Oct 2008) to Present (Oct 2012)	Previous (Apr 2012) to Present (Oct 2012)	Baseline (Oct 2008) to Present (Oct 2012)
1	Cliff	80.62	80.0	80.3	-0.4	0.3	-0.1
2	Defended	88.88	88.8	88.7	-0.2	-0.1	0.0
3	Cliff	80.23	80.5	80.4	0.2	0.0	0.0



KEY

Transects

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix C - Map 1
Cliff Top Survey
Lynemouth Bay
Northumberland
County Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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Cliff Top Survey

Cambois Bay (north)

Five ground control points have been established at Cambois Bay (north) (Map 2). The maximum separation between any two points varies along the coast, reflecting erosion risk.

The cliff top surveys at Cambois Bay (north) 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 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 C2 – Cliff Top Surveys at Cambois Bay (north)

Ground Control Point Details		Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Type	Baseline Survey (Oct 2008)	Previous Survey (March 13)	Present Survey	Baseline (Oct 2008) to Present (Oct 2013)	Previous (March 2013) to Present (Oct 2013)	Baseline (Oct 2008) to Present (Oct 2013)
1	Cliff	125.47	125.2	125.2	-0.3	0.0	-0.1
2	Defended	146.01	145.9	145.9	-0.1	0.0	0.0
3	Defended	116.4	116.8	116.7	0.3	-0.1	0.1
4	Cliff	114.44	114.4	114.9	0.4	0.5	0.1
5	Cliff	110.04	107.1	107.2	-2.8	0.1	-0.6

Cliff Top Survey

Cambois Bay (south)

36 ground control points have been established at Cambois Bay (south) (Map 2). The maximum separation between any two points varies along the coast, reflecting the degree of risk from the erosion.

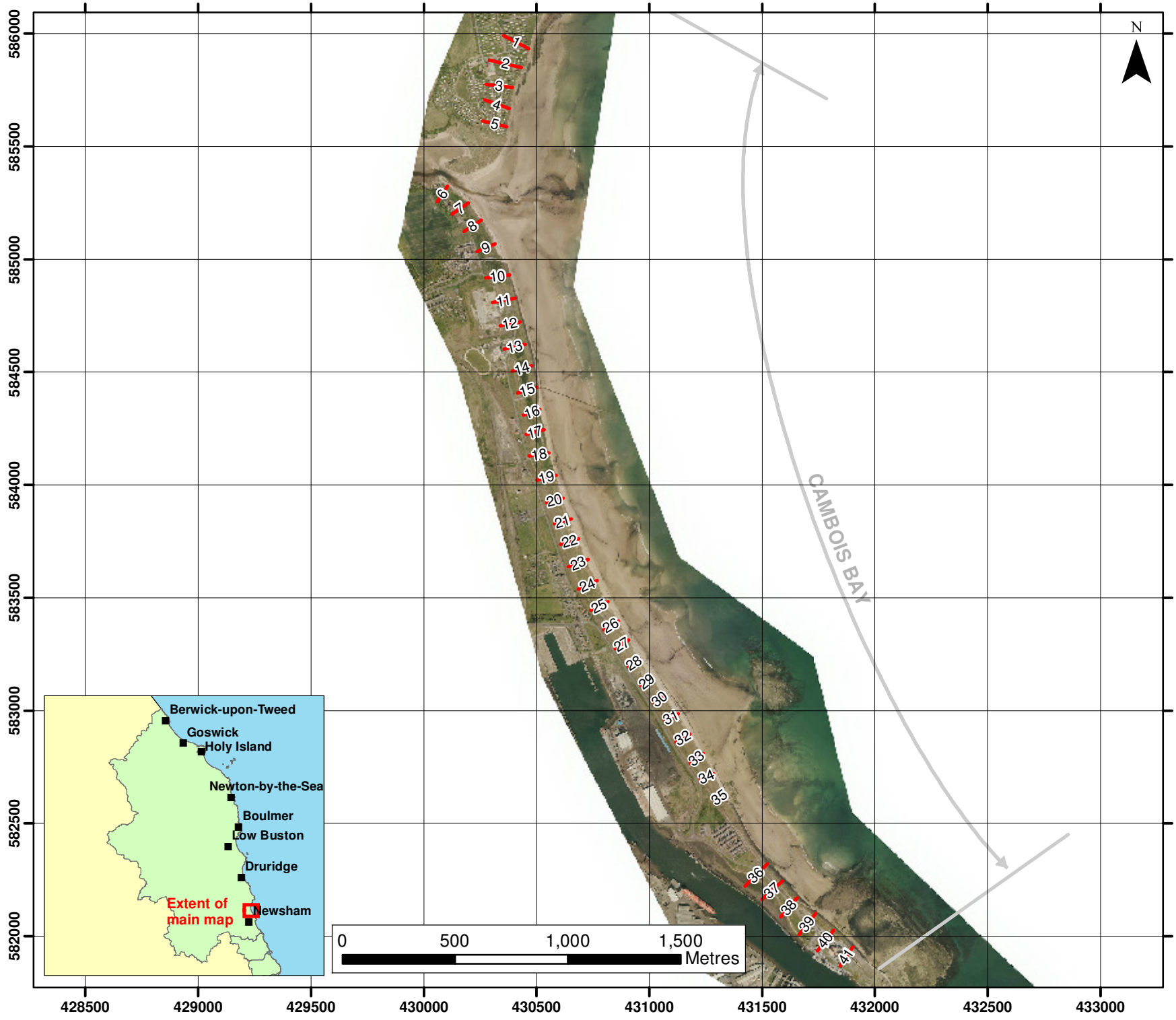
The cliff top surveys at Cambois Bay (south) are undertaken bi-annually. Measurements are taken from a fixed ground control point along a fixed bearing to the edge of the cliff top.

Table C3 provides baseline information about these ground control points and results from the 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 C3 – Cliff Top Surveys at Cambois Bay (south)

Ground Control Point Details		Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Type	Baseline Survey (May 2009)	Previous Survey (March 2013)	Present Survey	Baseline (May 2009) to Present (Oct 2013)	Previous (March 2013) to Present (Oct 2013)	Baseline (May 2009) to Present (Oct 2013)
6	Dune	74.5	75.1	75.2	0.7	0.1	0.2
7	Cliff	80	80.0	79.9	-0.1	-0.1	0.0
8	Cliff	82.62	80.6	80.6	-2.0	0.0	-0.4
9	Cliff	76.91	76.8	76.8	-0.1	0.0	0.0
10	Defended	94.47	94.1	94.6	0.1	0.5	0.0
11	Defended	90.65	90.9	91.0	0.3	0.1	0.1
12	Defended	83.25	83.0	82.8	-0.5	-0.2	-0.1
13	Defended	87.72	87.6	87.7	0.0	0.1	0.0
14	Defended	80.09	79.9	80.3	0.2	0.3	0.0
15	Defended	81.24	80.5	80.8	-0.5	0.2	-0.1
16	Cliff	71.65	70.2	70.2	-1.5	-0.1	-0.3
17	Cliff	81.5	70.1	78.4	-3.1	8.3	-0.7

Ground Control Point Details		Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Type	Baseline Survey (May 2009)	Previous Survey (March 2013)	Present Survey	Baseline (May 2009) to Present (Oct 2013)	Previous (March 2013) to Present (Oct 2013)	Baseline (May 2009) to Present (Oct 2013)
18	Cliff	85.72	85.0	84.9	-0.8	0.0	-0.2
19	Cliff	81.48	81.2	81.3	-0.2	0.1	0.0
20	Dune	71.04	69.7	69.8	-1.2	0.1	-0.3
21	Dune	75.11	72.7	72.4	-2.7	-0.2	-0.6
22	Dune	78.69	75.8	75.7	-3.0	-0.1	-0.7
23	Dune	86.59	81.7	81.8	-4.8	0.1	-1.1
24	Dune	87.99	84.6	84.4	-3.6	-0.2	-0.8
25	Dune	78.24	76.4	83.9	5.7	7.6	1.3
26	Dune	67.08	66.9	67.0	-0.1	0.1	0.0
27	Dune	61.31	61.1	67.0	5.7	6.0	1.3
28	Dune	55.83	55.9	56.9	1.1	1.0	0.2
29	Dune	57.66	55.3	57.1	-0.6	1.8	-0.1
30	Dune	56.66	60.9	56.5	-0.1	-4.4	0.0
31	Dune	63.03	63.6	63.5	0.5	-0.1	0.1
32	Dune	68.35	68.4	68.3	0.0	0.0	0.0
33	Dune	65.17	65.0	65.0	-0.2	0.0	0.0
34	Dune	60.34	60.1	59.3	-1.1	-0.8	-0.2
35	Cliff	42.21	40.9	40.7	-1.5	-0.1	-0.3
36	Defended	129.88	129.9	129.9	0.1	0.0	0.0
37	Defended	113.71	113.7	113.7	0.0	0.0	0.0
38	Defended	No Data	101.8	101.9	No Data	0.1	No Data
39	Defended	111.71	111.8	111.7	0.0	0.0	0.0



KEY

Transects

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix C - Map 2
Cliff Top Survey
Cambois Bay
Northumberland County Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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Appendix D

Sand Extent Survey

KEY

- Extent of sand (Autumn 2011)
- Extent of sand (Spring 2012)
- Extent of sand (Autumn 2012)
- Extent of sand (Spring 2013)
- Extent of Sand (Autumn 2013)
- Extent of SSSI

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix D- Map 1
Sand Extent Survey
Newbiggin Bay
Northumberland County Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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