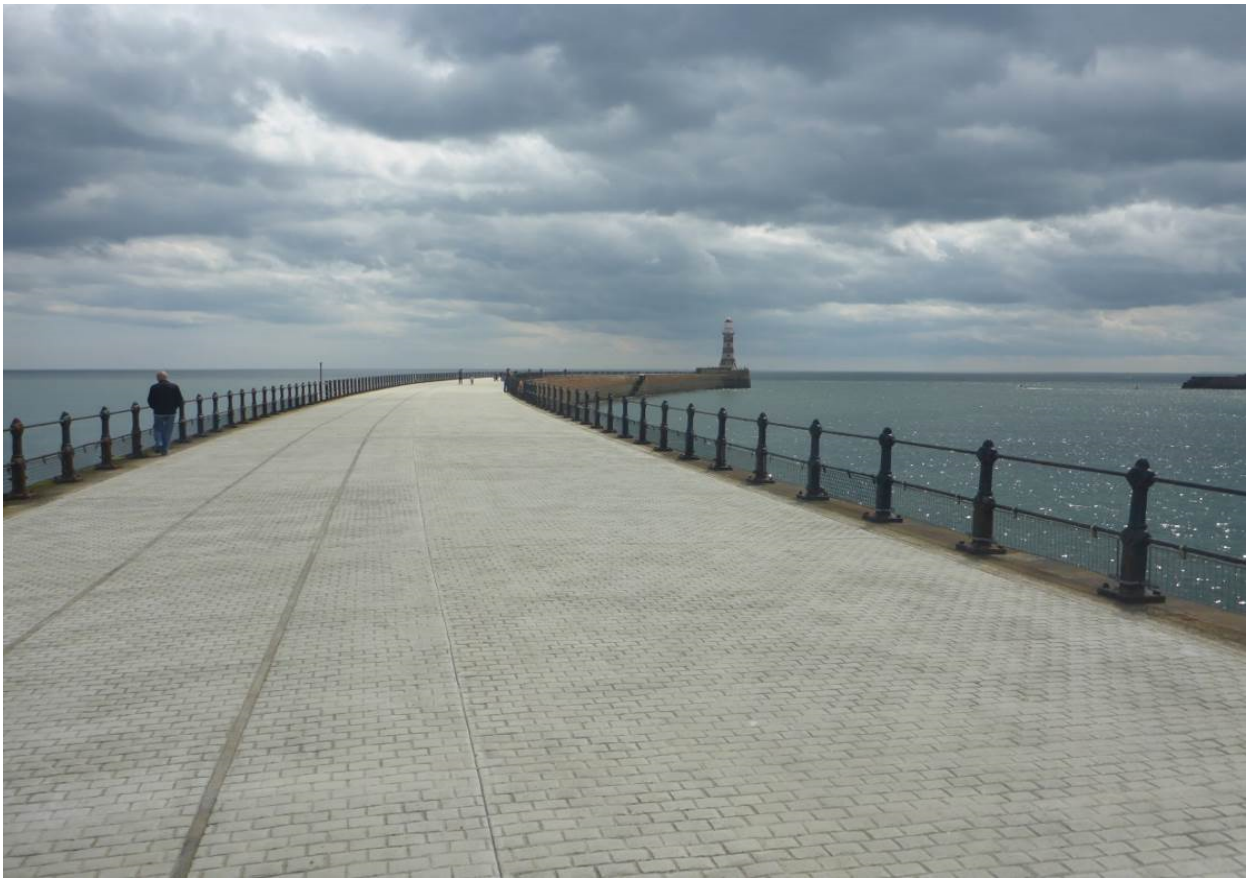

Cell 1 Regional Coastal Monitoring Programme
Analytical Report 9: 'Full Measures' Survey 2016

Sunderland City Council

March 2017

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Abbreviations and Acronyms

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

Water Levels Used in Interpretation of Changes

	Water Level (m AOD)
Water Level Parameter	**Souter Point to Chourdon Point**
HAT	3.18
MHWS	2.48
MLWS	-1.92

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

Glossary of Terms

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

Preamble

The Cell 1 Regional Coastal Monitoring Programme covers approximately 300km of the north east coastline, from the Scottish Border (just south of St. Abb's Head) to Flamborough Head in East Yorkshire. This coastline is often referred to as 'Coastal Sediment Cell 1' in England and Wales (Figure 1). Within this frontage the coastal landforms vary considerably, comprising low-lying tidal flats with fringing salt marshes, hard rock cliffs that are mantled with glacial sediment to varying thicknesses, softer rock cliffs and extensive landslide complexes.

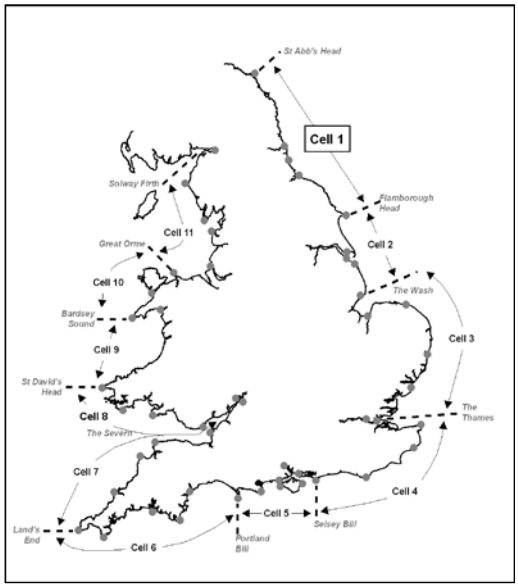


Figure 1 Sediment Cells in England and Wales

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

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

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

The beach profile surveys, topographic surveys and cliff top recession surveys are undertaken as a 'Full Measures' survey in autumn/early winter every year. Some of these surveys are then repeated the following spring as part of a 'Partial Measures' survey.

Each year, an Analytical Report is produced for each individual authority, providing a detailed analysis and interpretation of the 'Full Measures' surveys. This is followed by a brief Update Report for each individual authority, providing ongoing findings from the 'Partial Measures' surveys.

Annually, a Cell 1 Overview Report is also produced. This provides a region-wide summary of the main findings relating to trends and interactions along the entire Cell 1 frontage. To date the following reports have been produced:

Table 1 Analytical, Update and Overview Reports Produced to Date

Year		Full Measures		Partial Measures		Cell 1 Overview Report
		Survey	Analytical Report	Survey	Update Report	
1	2008/09	Sept-Dec 08	May 09	Mar-May 09		-
2	2009/10	Sept-Dec 09	Mar 10	Feb-Mar 10	July 10	-
3	2010/11	Aug-Nov 10	Feb 11	Feb-Apr 11	Aug 11	Sept 11
4	2011/12	Oct-Nov 11	Oct 12	Mar-May 12	Oct 12	-
5	2012/13	Sept-Oct 12	Mar 13	Mar 13	June 13	-
6	2013/14	Sept-Oct 13	Feb 14	Mar 14	July 14	-
7	2014/15	Sept & Nov 14	Feb 15	Mar – Apr 15	July 15	
8	2015/16	Sept & Nov 15	Feb 16	Mar 16	July 16	
9	2016/17	Sept-Nov 16	Feb 17 (*)			

(*) The present report is **Analytical Report 9** and provides an analysis of the 2016 Full Measures survey for Sunderland City Council's frontage.

In addition, separate reports are produced for other elements of the programme as and when specific components are undertaken, such as wave data collection, bathymetric and sea bed sediment data collection, aerial photography, and walk-over visual inspections.

For purposes of analysis, the Cell 1 frontage has been split into the sub-sections listed in the Table 2.

Table 2 Sub-divisions of the Cell 1 Coastline

Authority	Zone
Northumberland County Council	Spittal A
	Spittal B
	Goswick Sands
	Holy Island
	Bamburgh
	Beadnell Village
	Beadnell Bay
	Embelton Bay
	Boulmer
	Alnmouth Bay
	High Hauxley and Druridge Bay
	Lynemouth Bay
	Newbiggin Bay
	Cambois Bay
	Blyth South Beach
North Tyneside Council	Whitley Sands
	Cullercoats Bay
	Tynemouth Long Sands
	King Edward's Bay
South Tyneside Council	Littehaven Beach
	Herd Sands
	Trow Quarry (incl. Frenchman's Bay)
	Marsden Bay
Sunderland Council	Whitburn Bay
	Harbour and Docks
	Hendon to Ryhope (incl. Halliwell Banks)
Durham County Council	Featherbed Rocks
	Seaham
	Blast Beach
	Hawthorn Hive
	Blackhall Colliery
Hartlepool Borough Council	North Sands
	Headland
	Middleton
	Hartlepool Bay
Redcar & Cleveland Borough Council	Coatham Sands
	Redcar Sands
	Marske Sands
	Saltburn Sands
	Cattersty Sands (Skinningrove)
	Staithes
Scarborough Borough Council	Staithes
	Runswick Bay
	Sandsend Beach, Upgang Beach and Whitby Sands
	Robin Hood's Bay
	Scarborough North Bay
	Scarborough South Bay
	Cayton Bay
	Filey Bay

1. Introduction

1.1 Study Area

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

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

1.2 Methodology

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

- Full Measures survey annually each autumn comprising:
    - Beach profile surveys along 52 transect lines (commenced 2009)
    - Topographic survey at Whitburn Bay (commenced 2009)
    - Topographic survey at Hendon to Ryhope (including Halliwell Banks) (commenced 2009)
- Partial Measures survey annually each spring comprising:
    - Beach profile surveys along 13 transect lines (commenced 2009)
- Cliff top survey bi-annually at:
    - Hendon to Ryhope (including Halliwell Banks) (commenced 2009)

The location of these surveys is shown in Figure 2. The Full Measures survey was undertaken along this frontage on the 14th and 15th November 2016 (Whitburn Bay), 1st September 2016 (Sunderland Harbour and Docks) and between the 12th and 16th October 2016 (Hendon to Ryhope (incl. Halliwell Banks)). During this time weather conditions varied considerably. Refer to the survey reports for details of the weather conditions over this survey period.

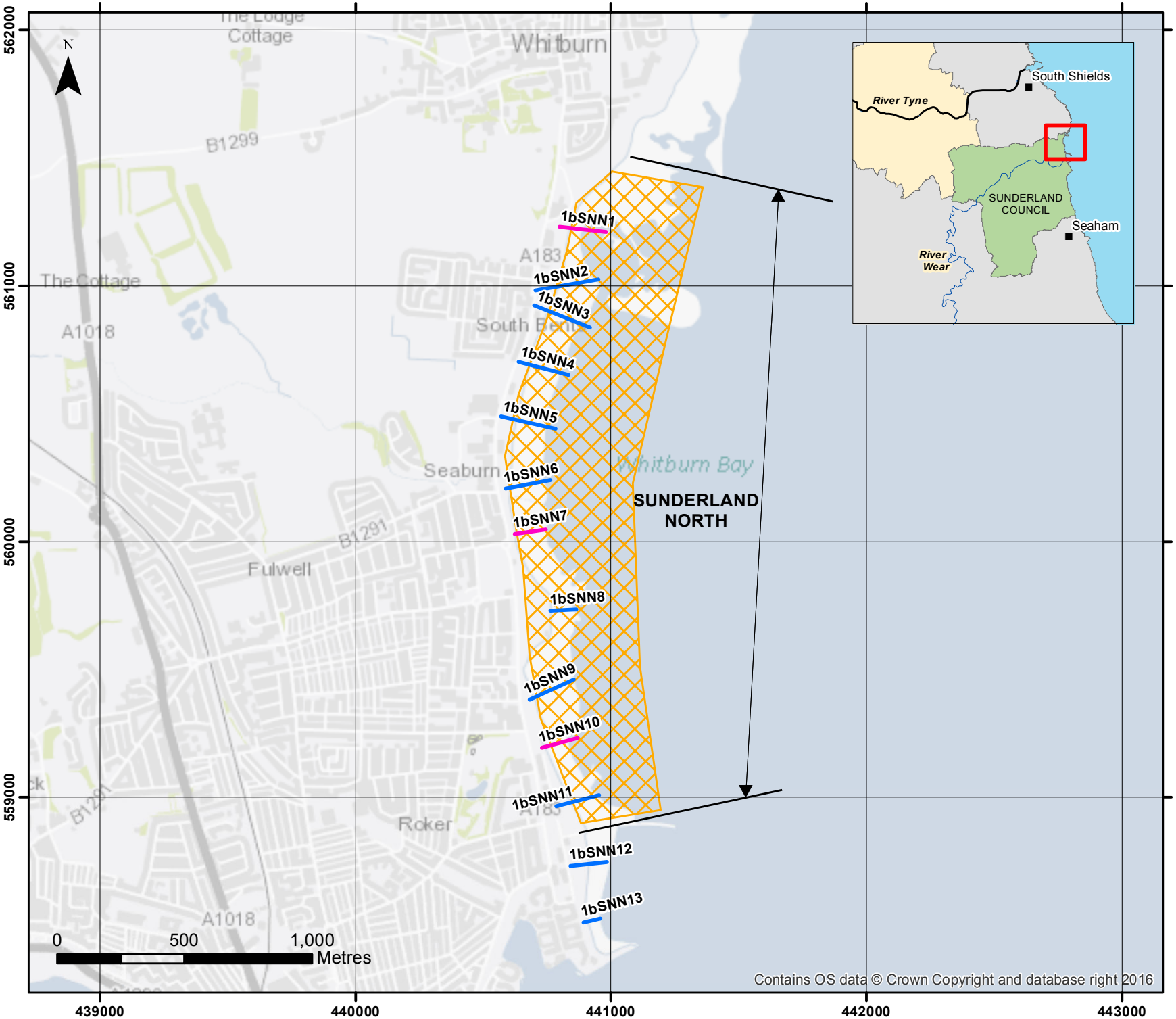
All data have been captured in a manner commensurate with the principles of the Environment Agency's *National Standard Contract and Specification for Surveying Services* and stored in a file format compatible with the software systems being used for the data analysis, namely SANDS and ArcGIS. This data collection approach and file format is comparable to that being used on other regional coastal monitoring programmes, such as in the South East and South West of England.

Upon receipt of the data from the survey team, they are quality assured and then uploaded onto the programme's website for storage and availability to others and also input to SANDS and GIS for subsequent analysis.

The Analytical Report is then produced following a standard structure for each authority. This involves:

- description of the changes observed since the previous survey and an interpretation of the drivers of these changes (Section 2);
- documentation of any problems encountered during surveying or uncertainties inherent in the analysis (Section 3);
- recommendations for 'fine-tuning' the programme to enhance its outputs (Section 4); and
- providing key conclusions and highlighting any areas of concern (Section 5).

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



Key

SURVEY LOCATIONS

Topographic Profiles

- Annual
- Bi-Annual

Topographic Surveys

- 6 monthly
- yearly
- 5 yearly

(Indicative Survey Extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 1 Sunderland Council Frontage

Analytical Report
Topo Surveys

Drawing Scale at A4 1:20,000

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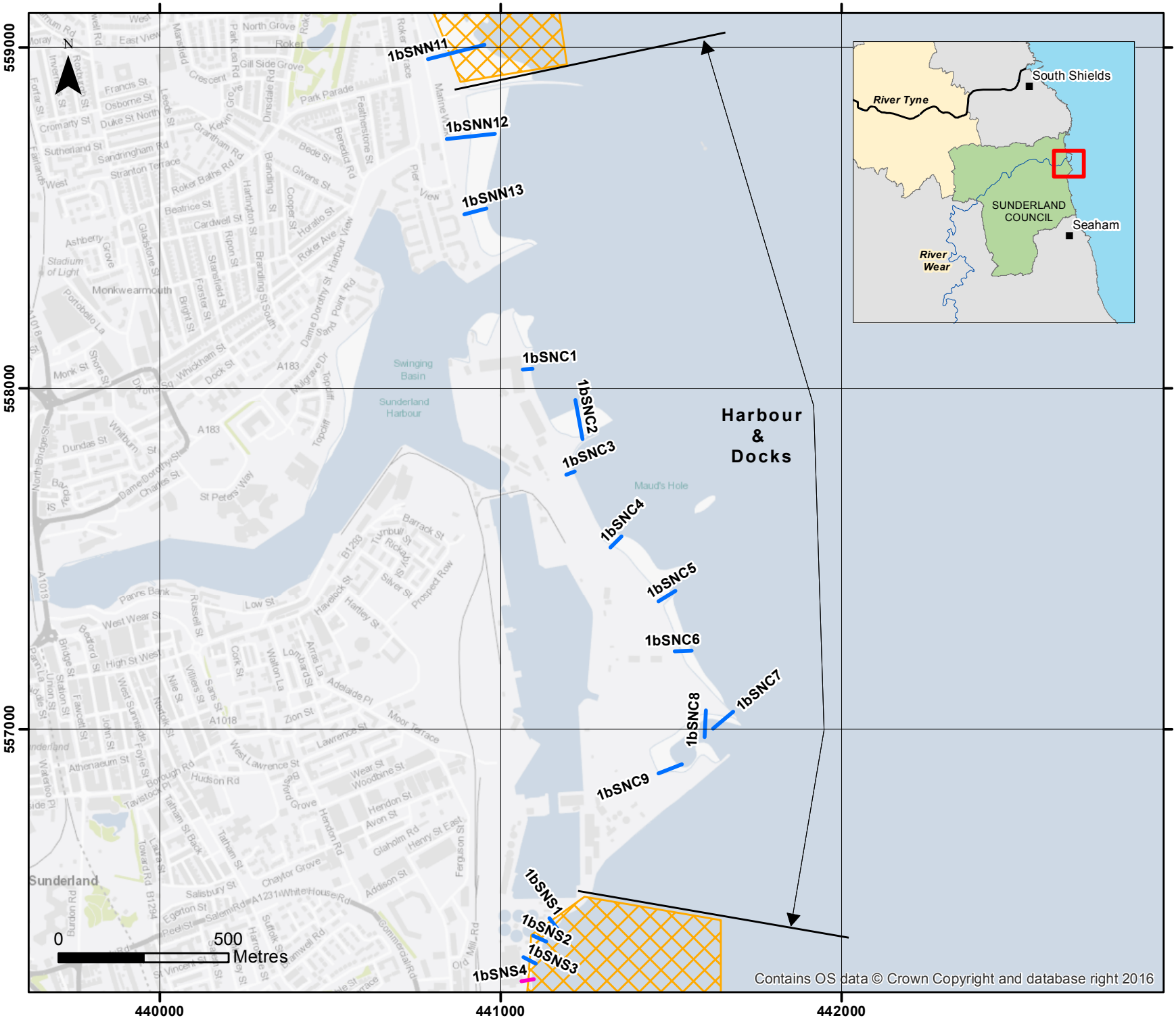

Key

SURVEY LOCATIONS

Topographic Profiles

- Annual
- Bi-Annual

Topographic Surveys

- 6 monthly
- yearly
- 5 yearly

(Indicative Survey Extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 2 Sunderland Council Frontage

Analytical Report
Topo Surveys

Drawing Scale at A4 1:15,000

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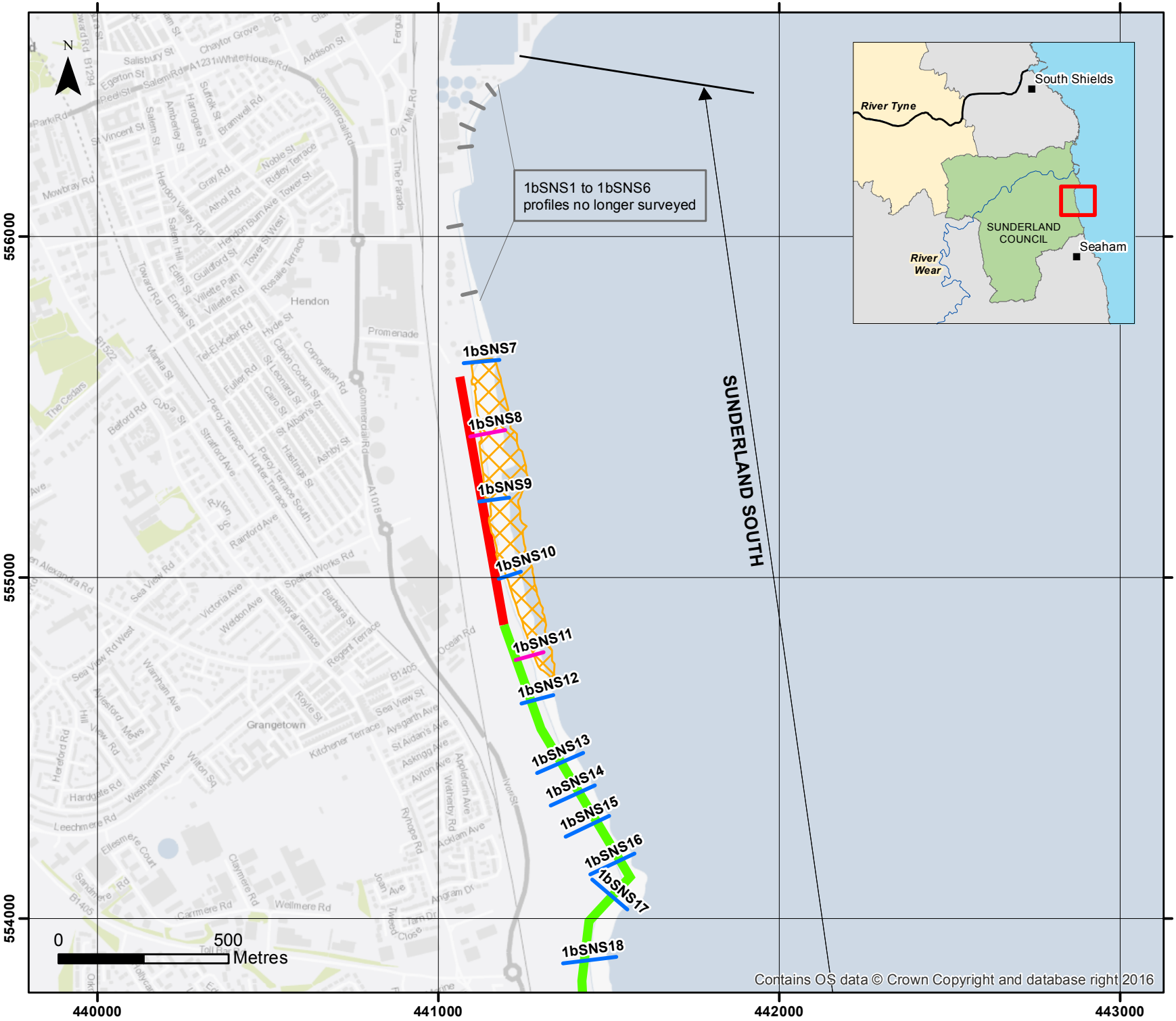

Key

SURVEY LOCATIONS

Topographic Profiles

- Annual
- Bi-Annual
- Discontinued

Topographic Surveys

- 6 monthly
- yearly
- 5 yearly

Cliff Top Monitoring Pegs

- @ 100
- @ 300

(Indicative Survey Extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 3 Sunderland Council Frontage

Analytical Report
Topo Surveys

Drawing Scale at A4 1:15,000

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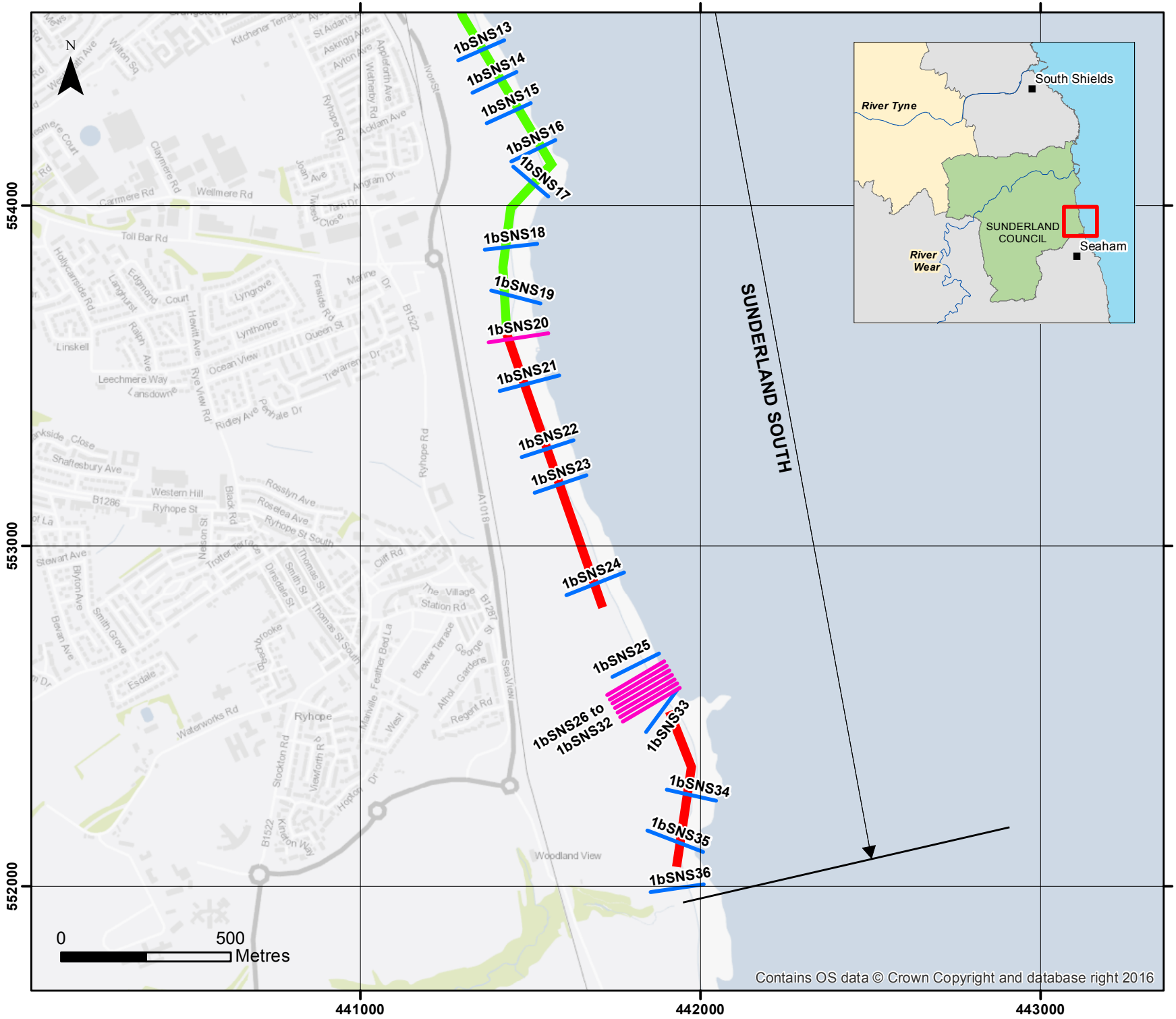

Key

SURVEY LOCATIONS

Topographic Profiles

- Annual
- Bi-Annual

Cliff Top Monitoring Pegs

- @ 100
- @ 300

(Indicative Survey Extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 4 Sunderland Council Frontage

Analytical Report
Topo Surveys

Drawing Scale at A4 1:15,000

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2. Analysis of Survey Data

2.1 Whitburn Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
14th & 15th November 2016	**Beach Profiles:** Whitburn Bay is covered by eleven beach profile lines for the Full Measures survey (Appendix A). The previous survey was the Partial Measures survey undertaken in March 2016 and the previous Full Measures survey was undertaken in November 2015. Profiles 1bSNN1, 1bSNN7 and 1bSNN10 were last surveyed during the Partial Measures spring survey, 2016. The remaining profiles were last surveyed during the Full Measures autumn survey, 2015. **1bSNN1** is immediately south of Sunderland City Council's northern boundary. The profile is unchanged above HAT (40m chainage). Between 45m chainage and 90m chainage the level of the beach has accreted by up to 0.5m since March 2016, forming a berm just below MHWSwhich was last present in the April 2015 survey. Between 90m chainage and the end of the profile at c.260m chainage, the profile has eroded by up to 0.2m and the crest of the mid-beach berm has moved seaward by 15m since March 2016. The channel incised by an outflow in the vicinity of this profile in November 2015 has now been completely infilled. Overall, the beach level is at medium-high levels compared to earlier surveys. Profiles **1bSNN2** and **1bSNN3** are located towards the north of Whitburn Bay and extend across scrubland before reaching the upper gravel foreshore and then dropping across the lower sandy foreshore towards the rocky outcrop of Whitburn Steel. At profile **1bSSN2**, the dune has remained stable since the last survey. There has been a slight increase of beach levels at the toe of the dunes (chainage 75m to 100m) of up to 0.2m, bringing the profile to its highest level on record in this area. There has been very little change in the profile from chainage 100m to 230m, seaward of 230m the beach profile has dropped by up to 0.4m since November 2015. At **1bSNN3**, the dunes remain unchanged since the previous survey. The beach profile has changed very little since the November 2015 survey. Overall, the beach is near its highest level on record, except in the lower foreshore where it is at a medium level.	Along the length of Whitburn Bay beaches have been dynamic, with the most northerly profiles showing erosion at the lower end of their profiles but the central and southerly profiles showing little change or accretion across the lower beach. **Longer term trends:** All the profiles in Whitburn Bay are at medium to high levels compared to earlier surveys in the record. The beaches show frequent fluctuation in levels due to sediment being naturally redistributed across the shoreface.

Survey Date	Description of Changes Since Last Survey	Interpretation
	Profiles **1bSNN4** to **1bSNN6** are between the shoreline opposite the southern edge of South Bents housing estate and Parsons Rock. Profile **1bSNN4** is very similar to the November 2015 survey, except the area between HAT and MHWS (between 25m chainage and 50m chainage) which had previously been eroded by the flow from an outfall has been filled in. The lower beach also shows an increase in levels of up to 0.4m since November 2015. Overall, the beach is near its highest level on record. At profile **1bSNN5**, the beach profile has changed very little, with small amounts of accretion of up to 0.2m, making it the highest profile on record. At profile **1bSNN6**, beach levels have decreased by 0.2m at the toe of the seawall. Between 14.5m and 19.5m chainage, the channel incised by the outflow of Cut Throat Dean in November 2015 has been infilled, with a small amount of accretion on the upper beach to chainage 40m. Between 40m and 165m chainage, the beach level has decreased by up to 0.2m. Seaward of 165m chainage there has been small amounts of accretion up to 0.2m. Overall, the profile has steepened slightly since the November 2015 survey. Overall, the beach is at a medium level compared to earlier surveys. **1bSNN7** is at Seaburn, just to the north of Parson's Rocks. Beach levels have increased across most of the profile compared to the March 2016 survey. Levels have increased at the toe of the seawall by up to 0.2m and in the lower foreshore (seaward of chainage 50m) by up to 0.4m. Between chainage 25m and 50m there has been very little change. Overall, the beach gradient has decreased compared to the March 2016 survey and is medium-high compared to earlier surveys. Profile **1bSNN8** extends across Parsons Rocks. There are no discernible changes in this profile since the previous Full Measures survey. Profile **1bSNN9** drops from the cliff top to the foreshore at Roker. There has been a small drop in beach levels at the toe of the cliff of up to 0.2m. The upper part of the beach profile is very similar to the November 2015 profile. Between chainage 90m and 150m the beach has lowered by 0.2m with a corresponding 0.2-0.4m accretion in the lower beach (seaward of chainage 150m). . Overall, the profile is medium compared to previous surveys with the exception of the middle beach which has the lowest recorded levels. **1bSNN10** is located approximately mid-way between Parson's Rocks and Roker Pier. Between the toe of the seawall and chainage, 80m there has been very little change. Seawards the profile has changed	

Survey Date	Description of Changes Since Last Survey	Interpretation
	shape with the loss of up to 0.2m between chainage 80m and 110m, and a large amount of accretion seawards from 110m of up to 0.8m forming a convex lower beach profile. The beach here is now at a low level over the upper and middle beach and a medium level over the lower beach compared to earlier surveys. **1bSNN11** is located to the south of Whitburn. The beach level has decreased across most of the profile by up to 0.2m, except seawards of chainage 190m where there has been accretion of up to 0.5m forming a berm. The beach toe has remained at the same location on the rocky foreshore however. The beach is at medium level throughout the profile compared to previous surveys.	
15th November 2016	**Topographic Survey:** Whitburn Bay, between the Bents and Roker Pier, is covered by an annual topographic survey which commenced in September 2009. Data from the most recent topographic survey (Full Measures, autumn 2016) have been used to create a digital ground model (DGM) (Appendix B – Map 1) using GIS. A difference plot has also been produced using the DGM (Appendix B – Map 2) produced from the last produced topographic survey (Full Measures, autumn 2015) and the present survey. The majority of the beach appears to have seen little change, however the middle section of beach along most the length of Whitburn Bay shows decreases in beach levels of up to 1m. At the northern most extent of the bay, there is an area of accretion in the upper and middle beach, with a further area of accretion on the lower beach to the north of Parson's Rocks and a small area to the south.	The topographic survey shows that since the last survey, there has been a mixture of change on the beach. There is a general trend for erosion of the middle beach and accretion on the lower beach. **Longer term topographic trends Autumn 2009 to Autumn 2015:** The plot shows a general pattern of accretion north of Parson's Rocks and erosion to the south. This pattern of northwards sediment movement may, in part, be due to on-going beach maintenance.

3.2 Sunderland Harbour and Docks

Survey Date	Description of Changes Since Last Survey	Interpretation
1st September 2016	**Beach Profiles:** Sunderland Harbour and Docks is covered by eleven beach profile lines (Appendix A), all surveyed annually. The previous survey was the Full Measures survey undertaken in autumn 2015. **1bSNN12** and **1bSNN13** are both located within the shelter of Roker Pier. At profile **1bSNN12**, there has been a variable amount of accretion and erosion throughout the profile. The gravel berm which formed around HAT (between 50m and 60m chainage) in the November 2015 survey has moved landwards by 3m. There is loss of beach material between chainage 50m to 65m and chainage 90m and 155m of up to 0.4m. Elsewhere there has been accretion of up to 0.4m between chainage 65m and 90m, and seawards of chainage 155m. This has resulted in a steeper upper and middle beach, but a reduced gradient on the lower beach. Above HAT, the beach is at a high level, with the rest of the profile being medium compared to earlier surveys. At **1bSNN13**, beach levels have decreased along the entire profile, with the greatest loss of up to 0.8m at the toe of the revetment. The beach is low compared to earlier surveys. **1bSNC1** and **1bSNC2** are located within the shelter of New South Pier. Profile **1bSNC1** starts at the seaward edge of the dock building and extends across an earth mound before reaching the stepped landward face of the dock wall. The profile then drops from the wall crest directly into deep water. As there is no beach present profile 1bSNC1 has not been analysed. Profile **1bSNC2** starts at the crest of New South Pier and drops several metres to foreshore level. The beach level has fallen between the toe of the seawall and 40m chainage, with a significant drop of 1m at the toe of the wall. Seaward of this, the profile is similar to the previous November 2015 survey. Overall the beach level is relatively low compared to earlier surveys, except for the middle beach which is medium-high. **1bSNC3** to **1bSNC6** are on the seaward face of the dock. Profile **1bSNC3** extends from the dockyard across a back flood wall, which has a crest level of around 7.2mOD, and promenade to the main seaward dock wall, which has a crest level of 7.55mOD. The profile then extends down the seaward face of the wall into deep water. As there is no beach, profile	Within the breakwaters north of the River Wear, beach trends vary with cross-shore movement of material at profile 1bSNN12 and beach erosion at profile 1bSNN13. Between the breakwaters, the level of the upper foreshore has fallen with no corresponding increase in lower foreshore levels indicating a net loss of sediment. Outside of the breakwaters, the north and central parts of the beach have shown significant losses of material whilst the south shows accretion, suggesting there has been redistribution of sediment towards the south. Within the breakwaters, either side of the former South Outlet of the docks there has been very limited change. **Longer term trends:** Within the breakwaters to the north and south of the River Wear, the beach levels are medium-low compared to earlier surveys but within the bounds of the record. Outside of the harbour breakwaters, the beach levels fluctuate significantly over time. The most recent survey shows redistribution of sediment from the north of the embayment to south of the embayment, with the northerly and central profiles (1bSNC4 and 1bSNC5) being at their lowest levels compared to earlier surveys and the more southerly profile,

Survey Date	Description of Changes Since Last Survey	Interpretation
	1bSNC3 has not been analysed. Profiles **1bSNC4** and **1bSNC5** extend from the rock armoured revetment across the short width of foreshore down to low water. At profile **1bSNC4**, beach levels have fallen significantly by up to 2.3m, exposing more of the toe of the rock revetment The beach is at its lowest level compared to earlier surveys. At profile **1bSNC5**, beach levels seaward of the revetment have eroded throughout the beach profile, with a loss of 0.3m at the toe of the revetment increasing to a loss of 1.4m at the seaward end of the profile. The levels are however still higher than the autumn 2014 survey, with the toe of the revetment remaining buried. , The beach is at a low level compared to previous surveys. **1bSNC6** extends across the revetment and seawall. The beach level has increased significantly along the entire profile, between 2.4m at the toe of the seawall and 1.8m at the seaward end. The beach levels are at their highest recorded levels. **1bSNC7** to **1bSNC9** are within the shelter of North East Pier and South West Breakwater in the former South Outlet, parts of which have been in-filled with tipped rubble. **1bSNC7** is a section across North East Pier. There has been no discernible change in the overall profile. Small apparent changes will be artefacts of the placement of survey points along the profile. Profile **1bSNC8** crosses the boulders and rubble. There has been no discernible change in the overall profile. Profile **1bSNC9** extends from the dock facilities and crosses a short length of concrete wall and sheetpiling before extending across the sand and gravel backshore, and foreshore to reach and cross a boulder mound that is towards the seaward end of the south west breakwater. The profile has changed in a similar way to the previous survey, with a further small amount (<0.2m) of erosion on the landward side of the berm above HAT and further minor (<0.1m) deposition in the foreshore 'trough' between the beach face and the rubble mound. A series of small berm crests have formed on the beach from MHWS to just above HAT. The profile remains high relative to earlier surveys.	1bSNC6, being at its highest level. Within the breakwaters either side of the former South Outlet of the docks, long term change is small at 1bSNC7 and 1bSNC8. At profile 1bSNC9, the long term trend is for increasing beach levels between the concrete wall and the boulder mound with the current levels being at their highest recorded levels since surveys began in October 2009.

3.3 Hendon to Ryhope (incl. Halliwell Banks)

Survey Date	Description of Changes Since Last Survey	Interpretation
12th – 16th October 2016	**Beach Profiles:** Hendon to Ryhope is covered by thirty six beach profile lines (Appendix A). Most profiles are measured annually, but profiles 1bSNS4, 1bSNS8, 1bSNS11, 1bSNS20 and 1bSNS26 to 1bSNS32 are surveyed every 6 months. The previous Full Measures survey was undertaken in autumn 2015 and the previous Partial Measures survey was undertaken in spring 2016. **1bSNS1** to **1bSNS6** are located along the sea wall protecting the Hendon Sewage Treatment Works. The profiles typically include a section along the concrete deck, wall crest (which varies in elevation between around 7.0mOD in the north and 7.6mOD in the south after the dog-leg in the wall position), near-vertical seaward face of the wall, and sloping rock armour revetment. These profiles have now been removed from the survey. **1bSNS7** to **1bSNS10** are located along the defended coastal slopes at south Hendon, which rise in elevation to higher defended cliffs at **1bSNS11**. Profile **1bSNS7** extends across a seawall and concrete revetment, which is fronted by a foreshore comprised of large pebbles and coarse shingle. The beach level at the toe of the seawall remains low with the line of sheetpiling exposed in the November 2015 survey still visible. Between chainage 24m and 34m there has been erosion of up to 0.3m. Seaward of this there are no discernible changes since the November 2015 survey. The beach level is very low compared to earlier surveys across the upper part of the beach but high from chainage 42m seawards. Profile **1bSNS8** extends across the seawall, rock revetment and beach. Gravel has been lost at the toe of the revetment lowering the beach elevation by 0.7m since the March 2016 survey. Seaward of 57m chainage the beach level has increased by up to 0.6m. Overall, the beach profile has flattened, and is at its highest level at the seaward end but towards its lowest level at the toe of the revetment compared to previous surveys. At profile **1bSNS9**, there has been a further small fall (up to 0.2m) at the toe of the revetment. From chainage 55m seawards there has been a small accretion of sediment (<0.2m) resulting in a flatter	Along the length of south Hendon, profiles 1bSNS7 to 1bSNS10 show accretion remaining relatively high along most of the profile compared to earlier surveys but relatively low at the toe of the coastal defence structures. At 1bSNS11, the beach has reduced, indicating a possible reversal in the direction of movement of sediment in the bay since the previous full measures survey. At Grangetown (south Hendon to Salterfen Rocks), many of the profiles show erosion of talus at the cliff toe. Beach level changes are limited but show a tendency for drawdown of material from the upper beach to the foreshore. Between Salterfen Rocks and the landfill at Halliwell banks (profiles 1bSNS20 to 1bSNS25), the cliff has shown small amounts of retreat (c.0.5m). Beaches show a tendency for sediment to move towards the south, with erosion in the north of the coast and accretion further south, this a reversal in the direction of movement of sediment since the previous full measures survey. Very little change has occurred to the cliffs at the landfill site (1bSNS26 to 1bSNS32) and the profiles show accretion in the upper and lower sections, with erosion in the middle beach indicating dynamic sediment movement in response to storms.

Survey Date	Description of Changes Since Last Survey	Interpretation
	beach gradient. Overall, the beach level remains high compared to earlier surveys. At profile **1bSNS10**, there has been a build up of material at the toe of the revetment by up to 0.4m forming a wide berm. Seaward of the berm (chainage 32m) there has been no discernible change in the profile. The beach profile is medium along most of its length compared to earlier surveys. At profile **1bSNS11**, there is apparent retreat of the toe of the cliff in the survey profile, but this is likely to be a data artefact due to interpolation between limited data points. Beach levels have decreased across the profile, by up to 0.2m between the toe of the sea defences and 75m chainage. Overall, the beach is at a medium level compared to earlier surveys. **1bSNS12** to **1bSNS36** are located along the undefended cliffs between Grangetown and Ryhope Dene. Profiles **SNS12** to **SNS19** are between the end of the Hendon sea wall and Salterfen Rocks. Cliff top levels are typically between 20m and 22mOD. They are highest along the profiles further north, dropping in the centre and then increasing again to the south. Profile **1bSNS12** extends from the cliff across the boulder foreshore. There are apparent changes in the cliff in the survey profile, but this is likely to be a data artefact due to interpolation between limited data points. There is no discernible change since the previous survey. At profile **1bSNS13**, the majority of the cliff face has not changed in form since the previous survey. There has been a loss of material along most of the profile, with up to 0.2m erosion on the upper beach (from toe of cliff to chainage 55m) and more significant losses of up to 0.7m seawards of chainage 55m re-exposing the rocks and shore platform which were visible during the autumn 2014 survey. The beach profile is at a low level compared to earlier surveys and the cliff top has receded 4m since 2009. At profile **1bSNS14**, the cliff top position has not changed since the previous survey. There has been a decrease in beach levels of up to 0.4m between the toe of the cliff and chainage 70m and a corresponding increase in levels between chainage 70m and 83m, extending the toe of the beach across the rock outcrops and flattening the beach gradient. The cliff top has retreated 3m since 2009. At profile **1bSNS15**, the cliff top has retreated by c.2.5m. Beach levels have decreased by up to 0.4m between the cliff toe and chainage 75m. There has been accretion of up to 0.3m between chainage 75m and 90m extending the toe of the beach seawards by c.5m.The beach is at a low level compared to earlier surveys at the toe of the cliff, but a high level towards the rock outcrops. The cliff top has receded	To the south of Halliwell Banks, around Pincushion, the cliffs have retreated by up to c.1m. There has been little discernible change in beach levels around the south of the headland. **Longer term trends:** Along the length of south Hendon, beach levels in the north are generally near their highest, and are lower further south. At Grangetown (south Hendon to Salterfen Rocks), the cliff top position has not changed substantially compared to the last survey, but since 2009 the cliff tops have receded several metres at some locations. Despite the most recent survey periods showing limited change at the cliff top, there has been erosion of the talus deposits at the cliff toe, indicating that the in-situ bedrock will once again be exposed to wave action and therefore more liable to undercutting and subsequent cliff retreat. Between Salterfen Rocks and the landfill at Halliwell banks (profiles 1bSNS20 to 1bSNS25), the cliff has generally remained stable and beach levels are relatively low in the upper beach and high in the foreshore. At the landfill site (profiles 1bSSN26 to 1bSSN32), the cliff position and beach levels are within the bounds of previous surveys. To the south of Halliwell Banks, at profiles 1bSNS33 and 1bSNS35, cliff and beach are within the bounds of previous surveys.

Survey Date	Description of Changes Since Last Survey	Interpretation
	c.6m since 2009. At profile **1bSNS16**, the cliff top has receded by c.1m since the November 2015 survey but there have been no discernible changes to beach levels since the last survey (autumn 2015). The cliff top has receded 5m since 2009 but the cliff toe has only receded c.2m over the same period. Survey photos indicate this may be to do with the variable erosivity of the sandy upper cliff and more clay rich (glacial till) lower cliff. Profiles **1bSNS17** to **1bSNS36** extend between Salterfen Rocks and Ryhope Dean/Pincushion Rocks along Shirley Banks and Halliwell Banks. Profiles between 1bSNS17 and 1bSNS25 typically exhibit a characteristic cliff height of between 23m and 29mOD, with beaches at the toe typically at levels between 3.1m and 4.6mOD. At **1bSNS17**, there are no discernible changes in the profile since the previous November 2015 survey. At **1bSNS18**, the profile shows the beach levels from 60m chainage to 120m have decreased by approximately 0.4m exposing the underlying rocky outcrops. The upper beach is low down to chainage 120m compared to previous surveys and the foreshore seaward of there is high. There has been no change in the cliff top position since surveys began. At **1bSNS19**, the cliff toe has retreated c.3m, which may relate to erosion of a talus or access problems. The rocky foreshore remains unchanged, although the veneer of sand deposited on the shore platform seaward of 120m chainage between the more prominent rocks shows a loss of up to 0.2m. The cliff top has receded 0.5m since 2009. At profile **1bSNS20**, there have been no changes to the cliff since the March 2016 survey. The pebble berm between chainage 45m and 55m noted in the March 2016 survey has been mostly removed by up to 0.5m. Overall the changes are minor and within the range of beach levels seen in previous surveys. The cliff top has receded c.1m since 2009. At **1bSNS21**, the cliff top has receded by c.0.5m since the last survey. There has been a further reduction in beach levels of up to 0.2m in the upper foreshore, exposing cobbles and the rocky shore platform which had previously been covered by a veneer of sand in the autumn 2014 survey. There has been little change in the lower part of foreshore seaward of 70m chainage. At profile **1bSNS22**, the cliff has generally remained stable since the last survey. Low points between	

Survey Date	Description of Changes Since Last Survey	Interpretation
	more prominent parts of the shore platform have infilled with up to 0.2m of sand; otherwise, the shore platform remains unchanged. At profile **1bSNS23**, the cliff has receded by c.0.5m since the last survey. There is no discernible change in beach levels from the previous survey The upper beach is low compared to earlier surveys and the foreshore is high. At **1bSNS24**, the cliff top has retreated by c.0.5m, but the toe has extended c.0.5m. This represents ongoing slumping due to landslides. The remnants of the gravel berm at chainage 58m are now completely removed which along with up to 0.5m along the entire profile create a smoother profile. The upper beach is low compared to earlier surveys and the foreshore falls in the middle of the range. At profile **1bSNS25**, there has been no change to the cliff face. The gravel berm at the cliff toe has disappeared with a loss of up to 0.6m of sediment. From chainage, 55m to 90m there has been accretion of up to 0.4m, extending the beach over the rock platform. From chainage, 105m there has been accretion of sand of up to 0.4m extending the foreshore seawards. The upper beach is at a medium level and the foreshore is relatively high. Profiles **1bSNS26** to **1bSNS32** are located at Halliwell Banks specifically to assess risks from erosion at a former land fill. Cliff height is between 26m and 27mOD, with beaches at the toe typically at levels between 3.3m and 3.9mODN. Profiles **1bSNS26** to **1bSNS32** have all behaved in a similar way, with no change to the cliff face. There has been accretion along most of the length of the profiles (upper and lower) of between 0.6m and 1m, with the exception of the middle portion of the beach where there has been small amounts of erosion (up to 0.4m). Overall, the profiles are medium-high compared to previous surveys. Profiles **1bSNS33** to **1bSNS36** are located around the Pincushion Headland. At profile 1bSNS33, the cliffs have generally retained the same form and position since the last survey. There has been accretion of up to 0.6m across the upper beach and 0.4m across the lower foreshore. In the middle of the profile between chainage 95m and 125m the beach level has dropped by up to 0.6m. The profile is medium-low compared to previous surveys. Profiles **1bSNS34** to **1bSNS36** have all changed little since the previous survey. The cliff top shows c.0.5-1m of retreat across all three profiles, with no discernible changes in the beach profiles.	

Survey Date	Description of Changes Since Last Survey	Interpretation
October 2016	**Topographic Survey:** Hendon to Ryhope is covered by an annual topographic survey between the Hendon Sea Wall and Ryhope Dene, which commenced in autumn 2009. This is the first full measures survey which has reduced the scope of the topographic survey to exclude the area to the south of the promenade. Data from the most recent topographic survey (Full Measures, autumn 2016) have been used to create a DGM (Appendix B – Map 2) using a GIS. A difference plot has also been produced using the DGM (Appendix B – Map 4) produced from the last produced topographic survey (Full Measures, autumn 2015) and the present survey. Accretion is dominant across the survey area, particularly in the middle and lower beach at the northern end of the survey area with there being some patches of erosion in the upper beach. This is in contrast to the previous full measures survey which was dominated by erosion.	The short term change plot indicates that there has been a pattern of sediment movement from the upper beach towards the lower foreshore but that change has been limited (<1m).
16th October 2016	**Cliff Top Survey:** Cliff top survey data collected between the baseline survey (spring 2009) and the present Full Measures survey (autumn 2016) is documented here. 32 ground control points (numbered 1-32) were established along the cliff top between Hendon and Ryhope in March 2009, with a further three (28A, 28B and 28C) added in September 2009. Note: the numbering of ground control points is not intended to correlate with that of the beach profile lines. Measurements are taken from each ground control point along a fixed bearing to the edge of the cliff top. These cliff top surveys are undertaken bi-annually and are intended to inform on erosion rates of the sea cliffs extending from the defended industrial areas at Hendon southwards along the undefended cliffs to Ryhope Dene. Appendix C – Table C1 provides results from the cliff top survey, showing the position from the ground control point to the edge of the cliff top along a defined bearing. Results show that since the Partial Measures (March 2016) survey apparent erosion greater than the error has occurred at twenty locations, where losses are generally recorded as between 0.2 and 0.5m, with the exception of GCP 22 where erosion of 1.0m has occurred. Since surveys began in March 2009 (or September 2009 for 28A, 28B, and 28C) erosion greater than the survey error has occurred at	Episodic and localised recession, which contributes to overall coastline retreat in the undefended parts of this coastline has continued over the most recent survey period across the majority of the survey points but is limited to <0.5m, with the exception of GCP 22. **Longer term trends:** The data indicate that the fastest erosion since 2009 is concentrated in three broad sections; a) the northern part of the developing embayment between the southern extent of the sea defences and Salterfen Rocks, b) throughout the majority of Halliwell Banks and c) to the south of Pincushion rocks. Recession is least, as might be expected, along the defended sections and at the promontories of Salterfen Rocks and Pincushion Rocks.

Survey Date	Description of Changes Since Last Survey	Interpretation
	around 80% of the ground control points, where total losses are 11.6m (at location 27) at their greatest, and more typically less than 5m. The long-term erosion rates are up to 1.7m/yr. (location 27), with up to 0.7m/yr. being more typical.	

4. Problems Encountered and Uncertainty in Analysis

Individual Profiles

The survey report notes that the cliff top of profile 1bSNS11 was inaccessible due to slippery and unsafe conditions, and that the cliff base of profile 1bSNS12 was inaccessible due to slippery unsafe rocks and falling debris.

Topographic Survey

n/a

Cliff Top Surveys

n/a

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

It is recommended that profiles 1bSNC1 and 1bSNC3 are removed from the programme as they do not cover any beach and they are not analysed within the Full Measures reporting.

6. Conclusions and Areas of Concern

- At Whitburn Bay, the recorded profiles and topographic survey present no causes for concern.
- At Sunderland Harbour and Docks, the recorded profiles present no causes for concern.
- At Hendon to Ryhope (incl. Halliwell Banks), the recorded profiles, topographic survey and clifftop survey present no causes for concern. Ongoing cliff erosion is of a similar magnitude to previous surveys.
- At Hendon to Ryhope (incl. Halliwell Banks), the greatest amount of erosion recorded to have taken place between March 2009 and October 2016 was 11.6m at Point 27 which is on the northern border of the landfill site. Since the last survey, the greatest erosion has been at Point 22 (halfway between Salterfen Rocks and Halliwell Banks), where the cliff edge has receded 1.0m.

Appendices

Appendix A

Beach Profiles

Beach Profile

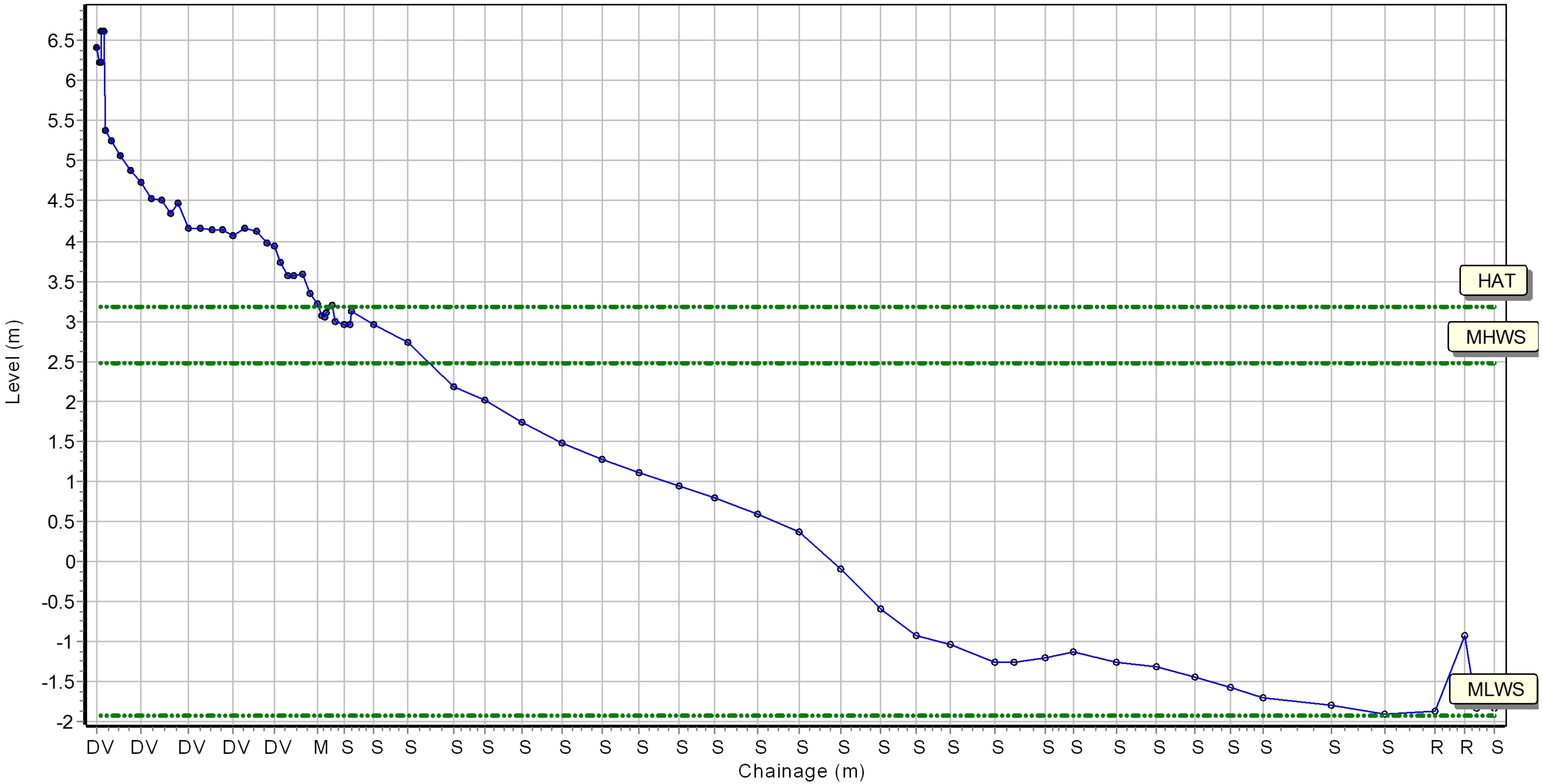
Location: **1bSNN1**

Date: 15/11/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 440797.428 **Northing:** 561231.249 **Profile Bearing:** 97 ° from North



Beach Profile

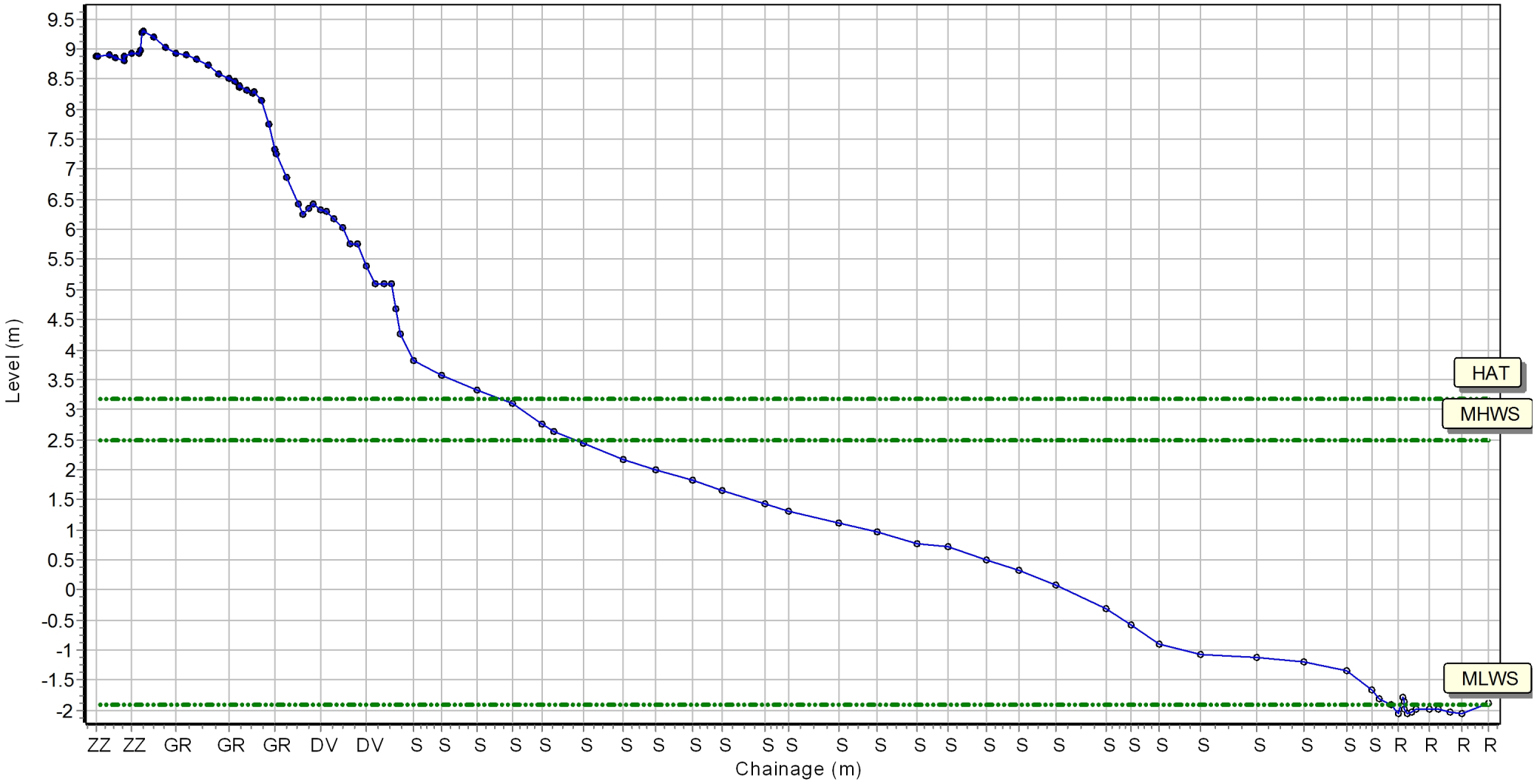
Location: **1bSNN2**

Date: 15/11/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 440704.168 **Northing:** 560981.14 **Profile Bearing:** 80 ° from North



Beach Profile

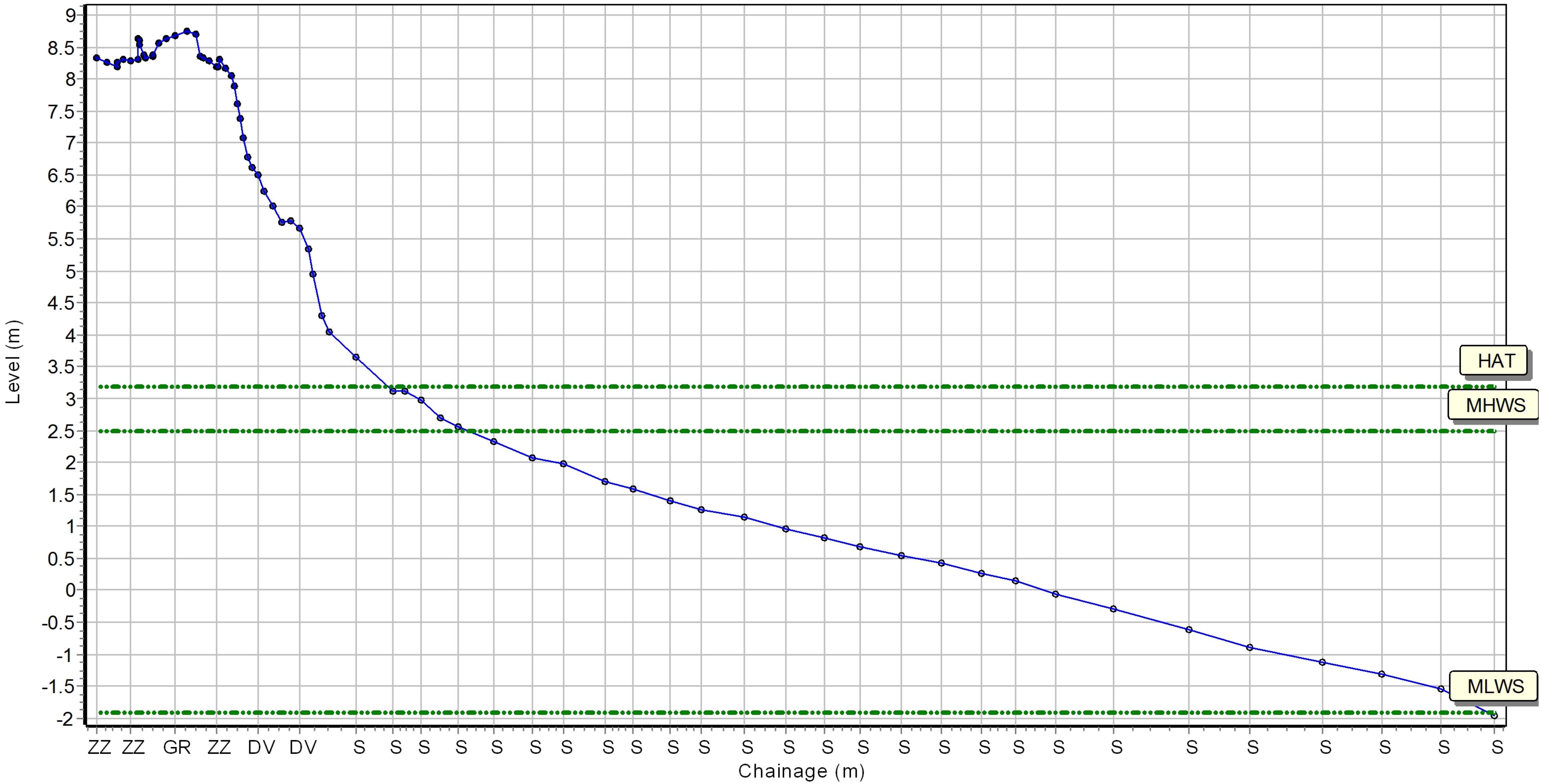
Location: 1bSNN3

Date: 15/11/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 440698.999 **Northing:** 560923.727 **Profile Bearing:** 112 ° from North



Beach Profile

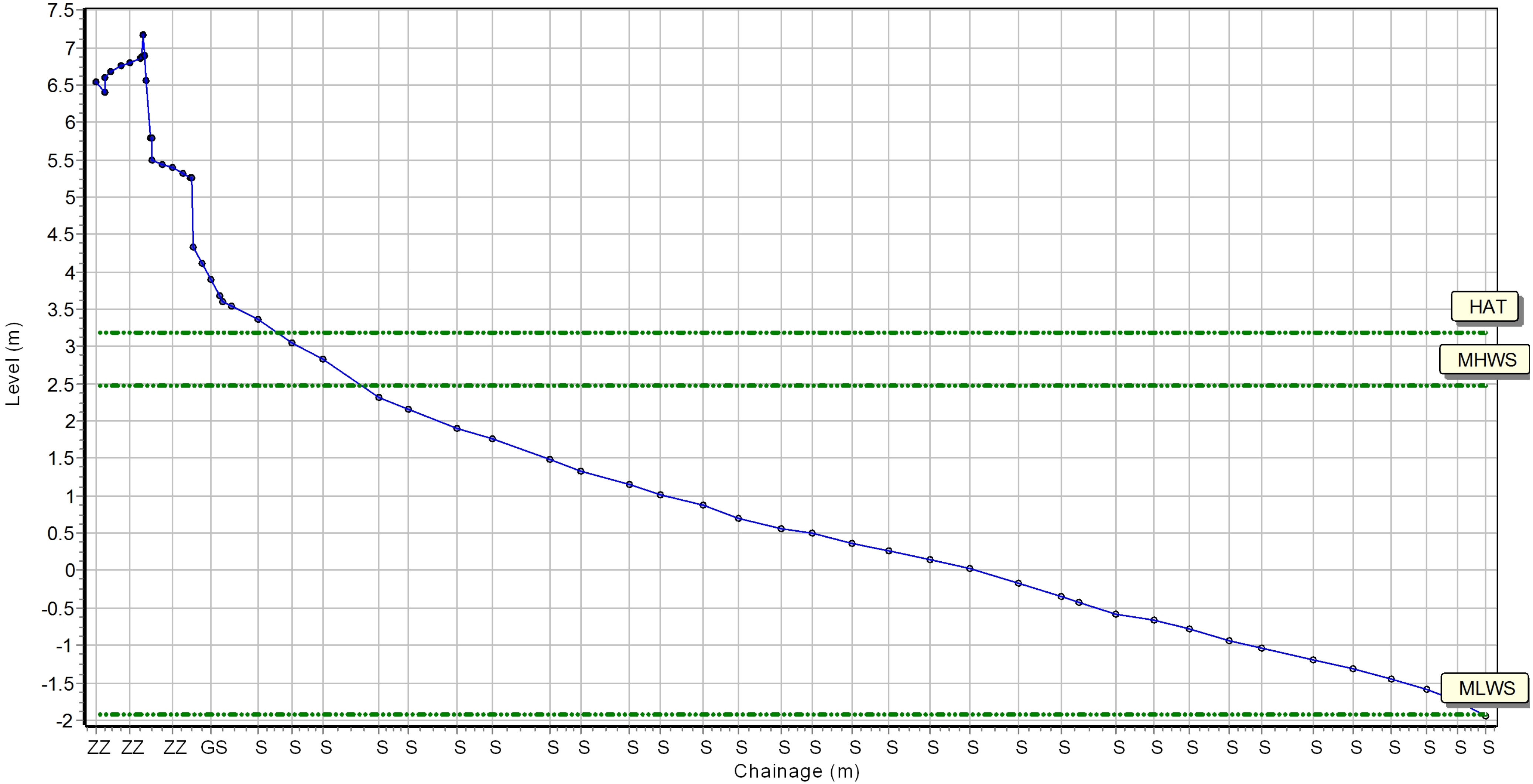
Location: **1bSNN4**

Date: 15/11/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 440637.004 **Northing:** 560702.72 **Profile Bearing:** 104 ° from North



Beach Profile

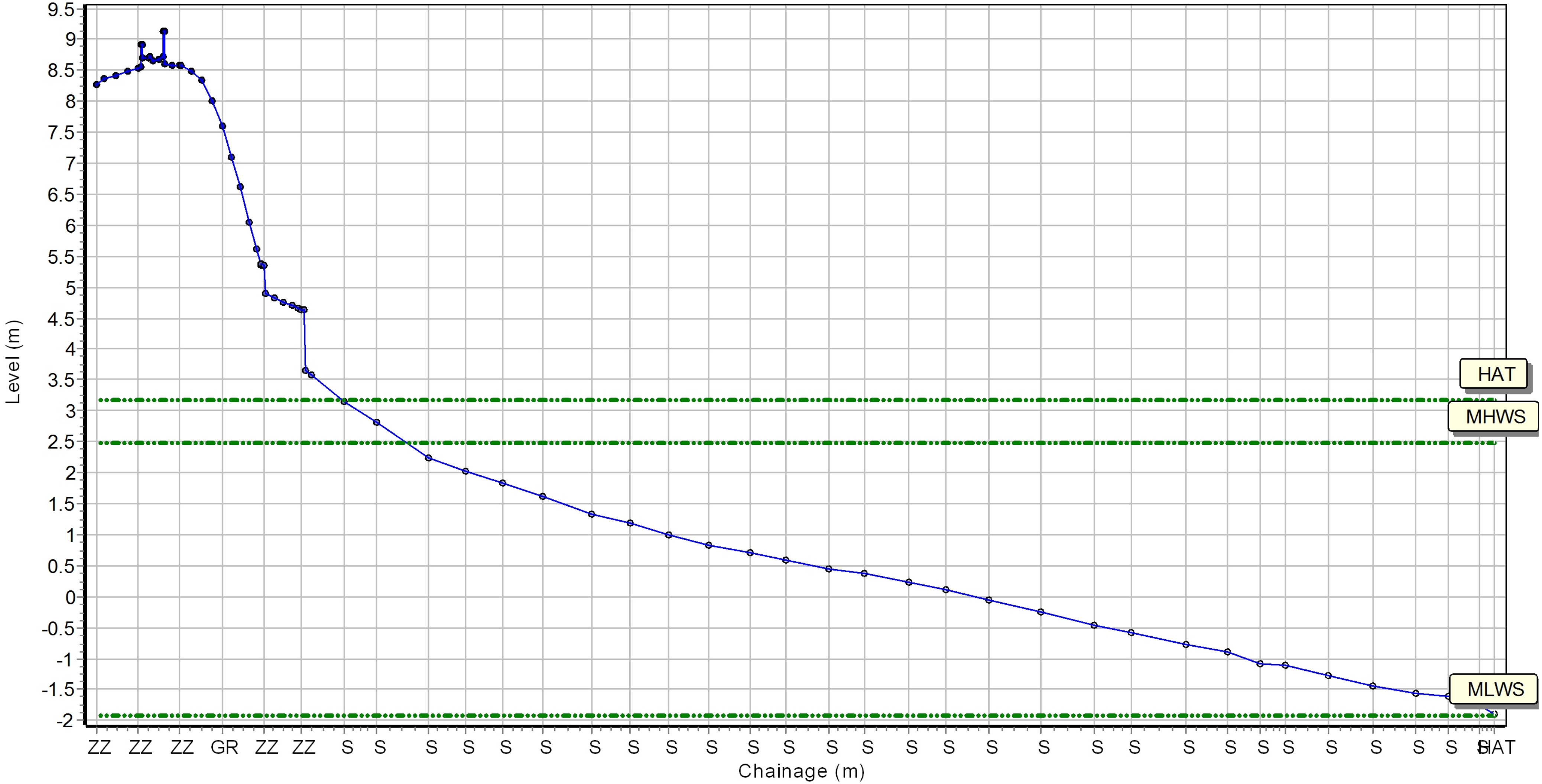
Location: **1bSNN5**

Date: 15/11/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 440568.694 **Northing:** 560490.321 **Profile Bearing:** 103 ° from North



Beach Profile

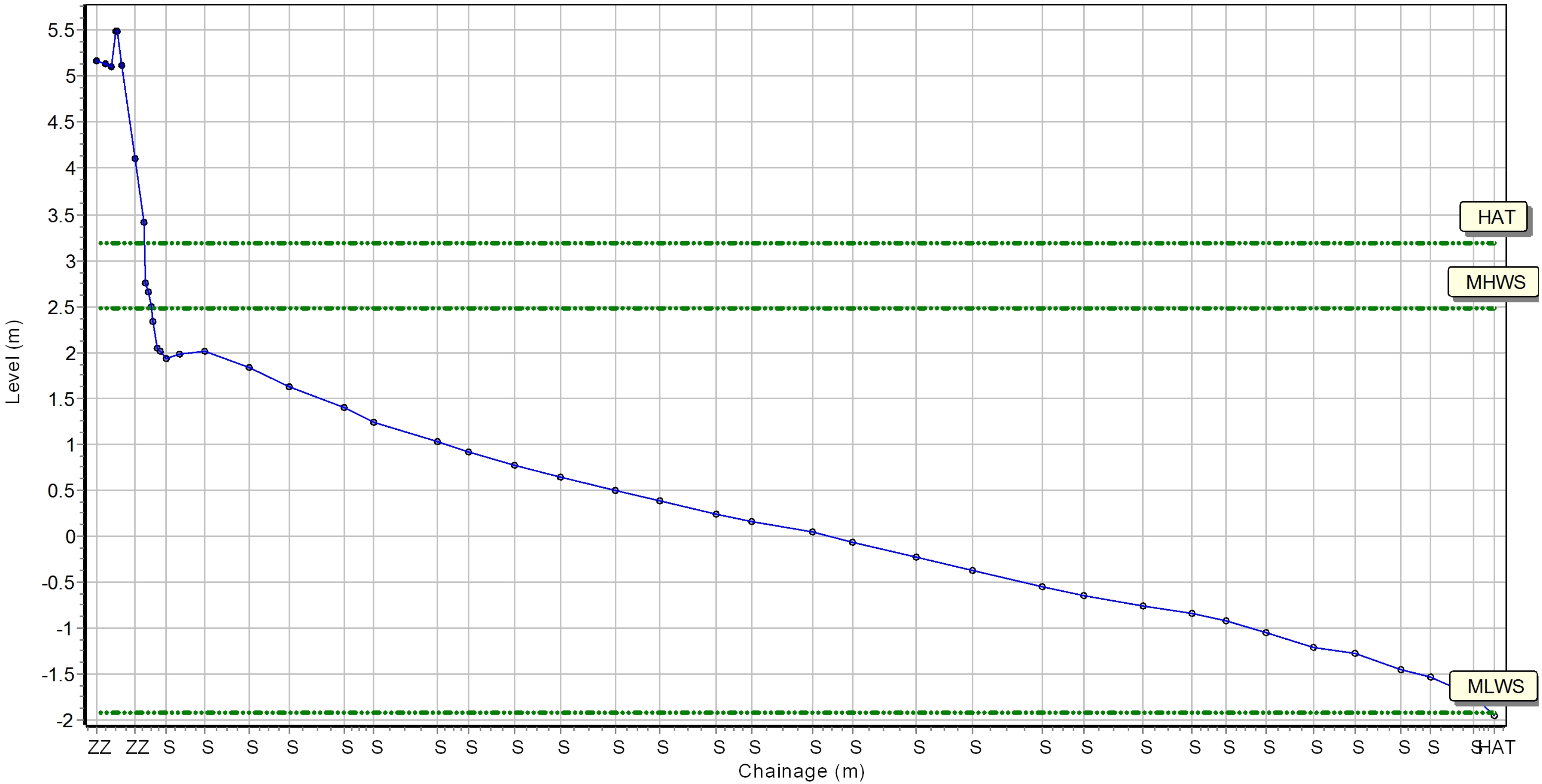
Location: 1bSNN6

Date: 15/11/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 440586.486 **Northing:** 560206.172 **Profile Bearing:** 79 ° from North



Beach Profile

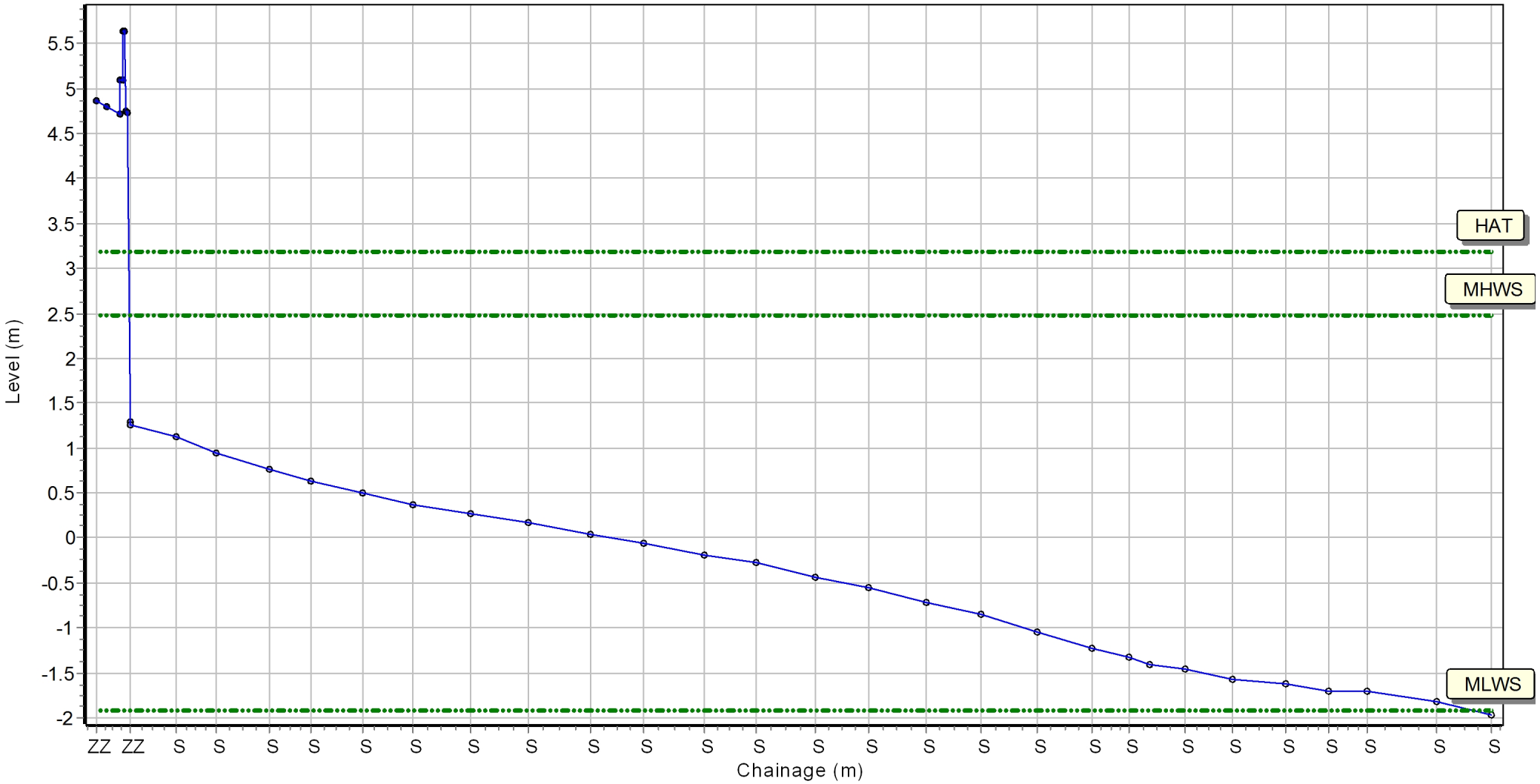
Location: **1bSNN7**

Date: 15/11/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 440623.795 **Northing:** 560029.932 **Profile Bearing:** 81 ° from North



Beach Profile

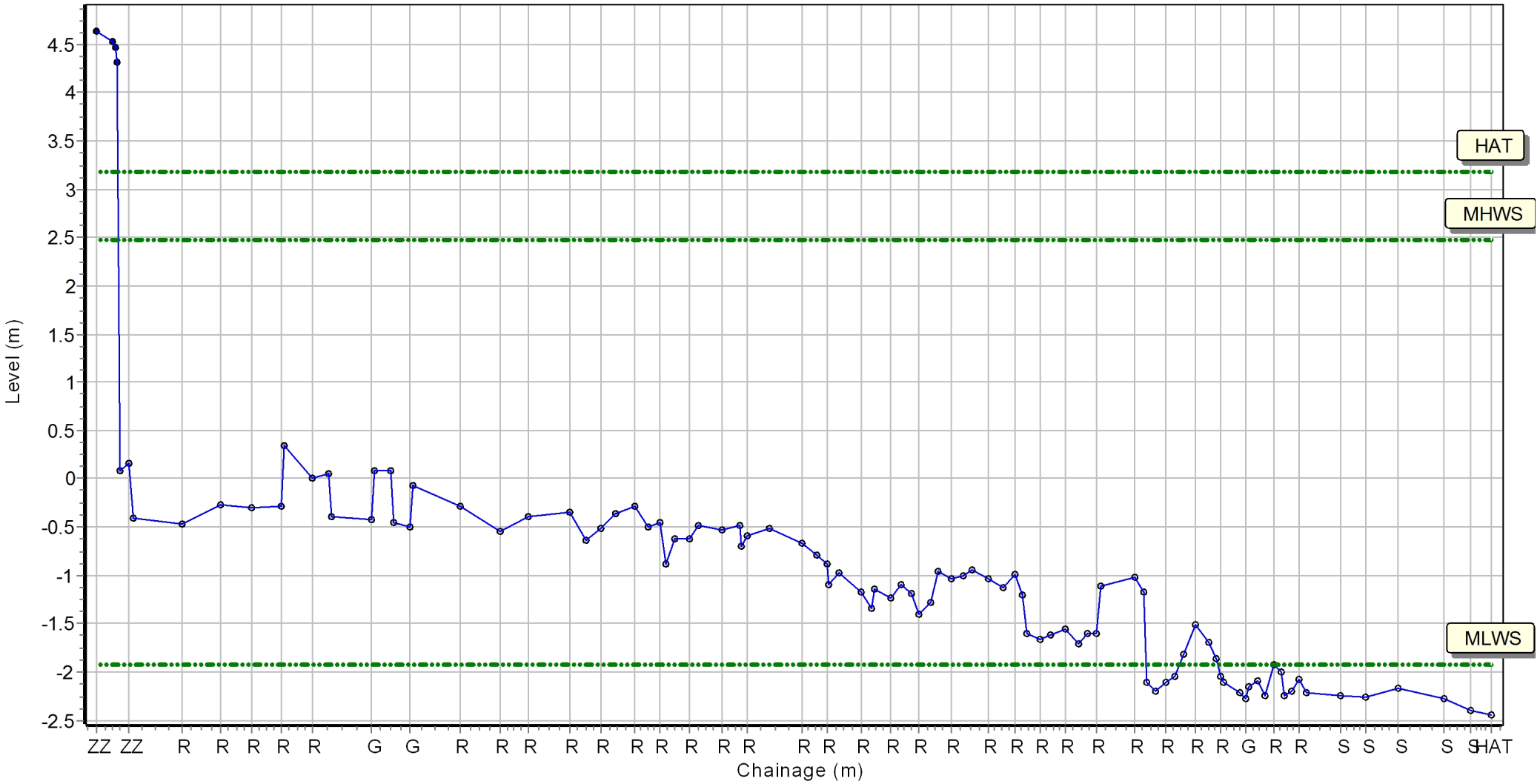
Location: **1bSNN8**

Date: 15/11/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 440761.57 **Northing:** 559730.278 **Profile Bearing:** 87 ° from North



Beach Profile

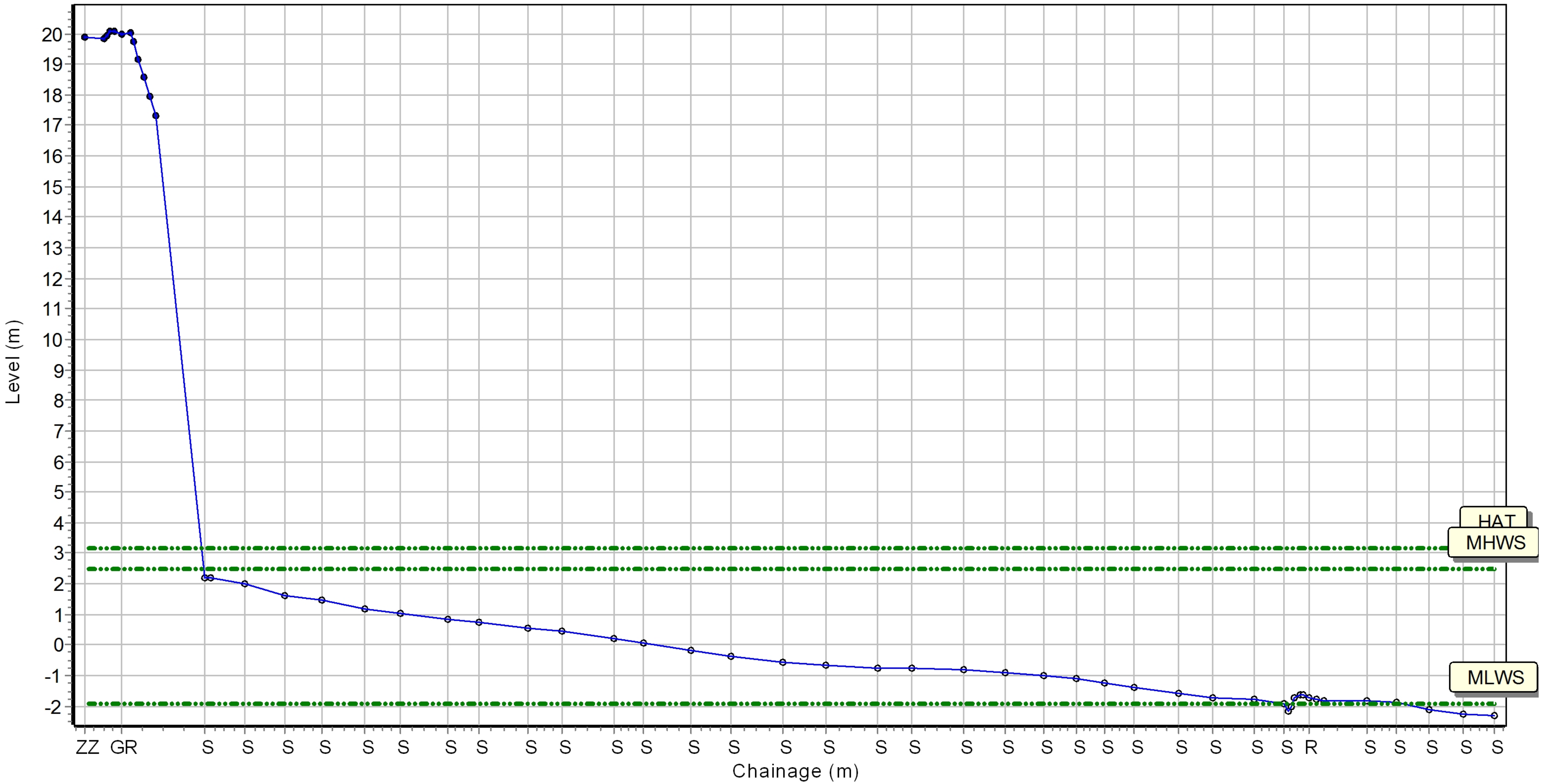
Location: 1bSNN9

Date: 15/11/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 440680.051 **Northing:** 559381.258 **Profile Bearing:** 65 ° from North



Beach Profile

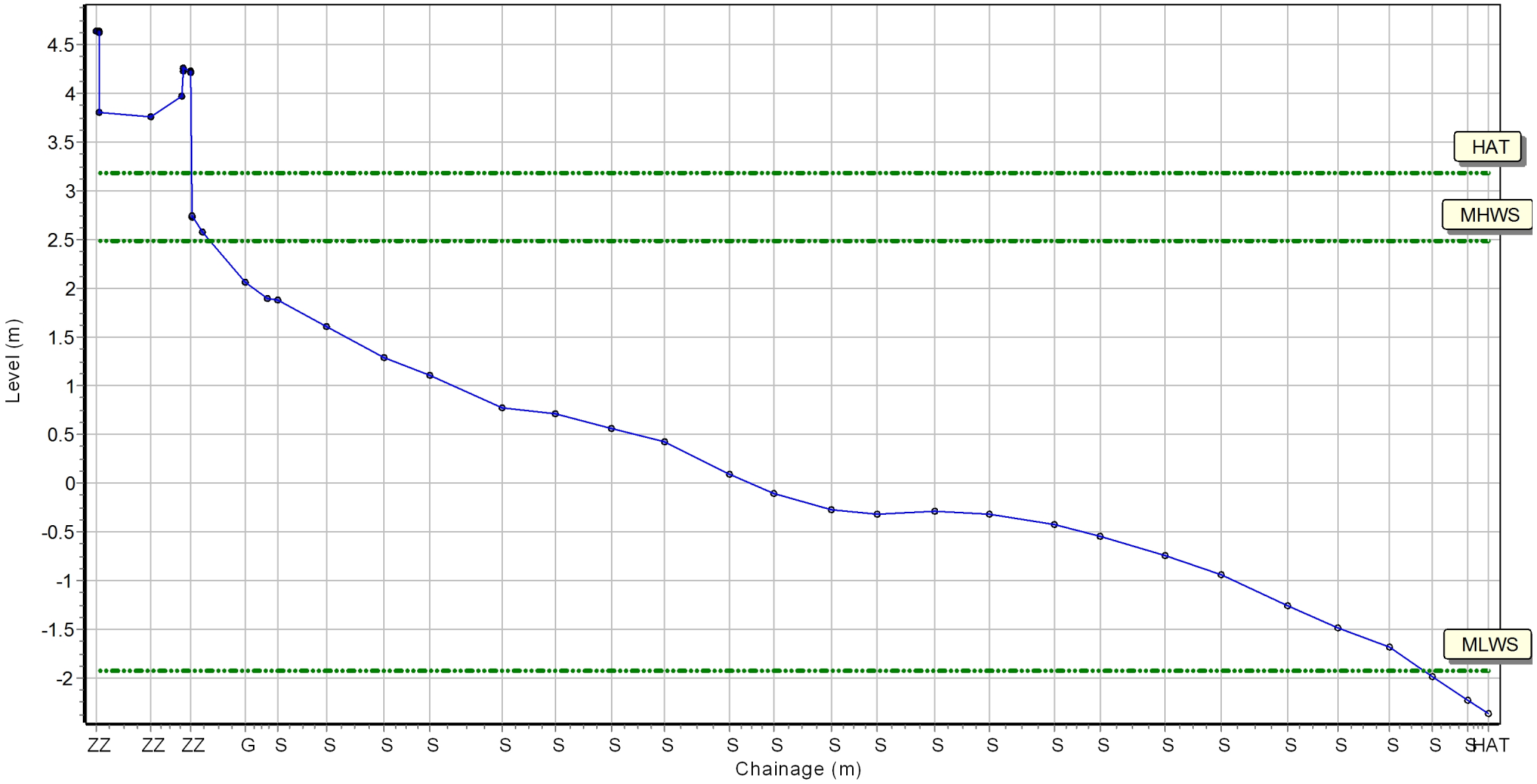
Location: **1bSNN10**

Date: 15/11/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 440728.714 **Northing:** 559193.372 **Profile Bearing:** 74 ° from North



Beach Profile

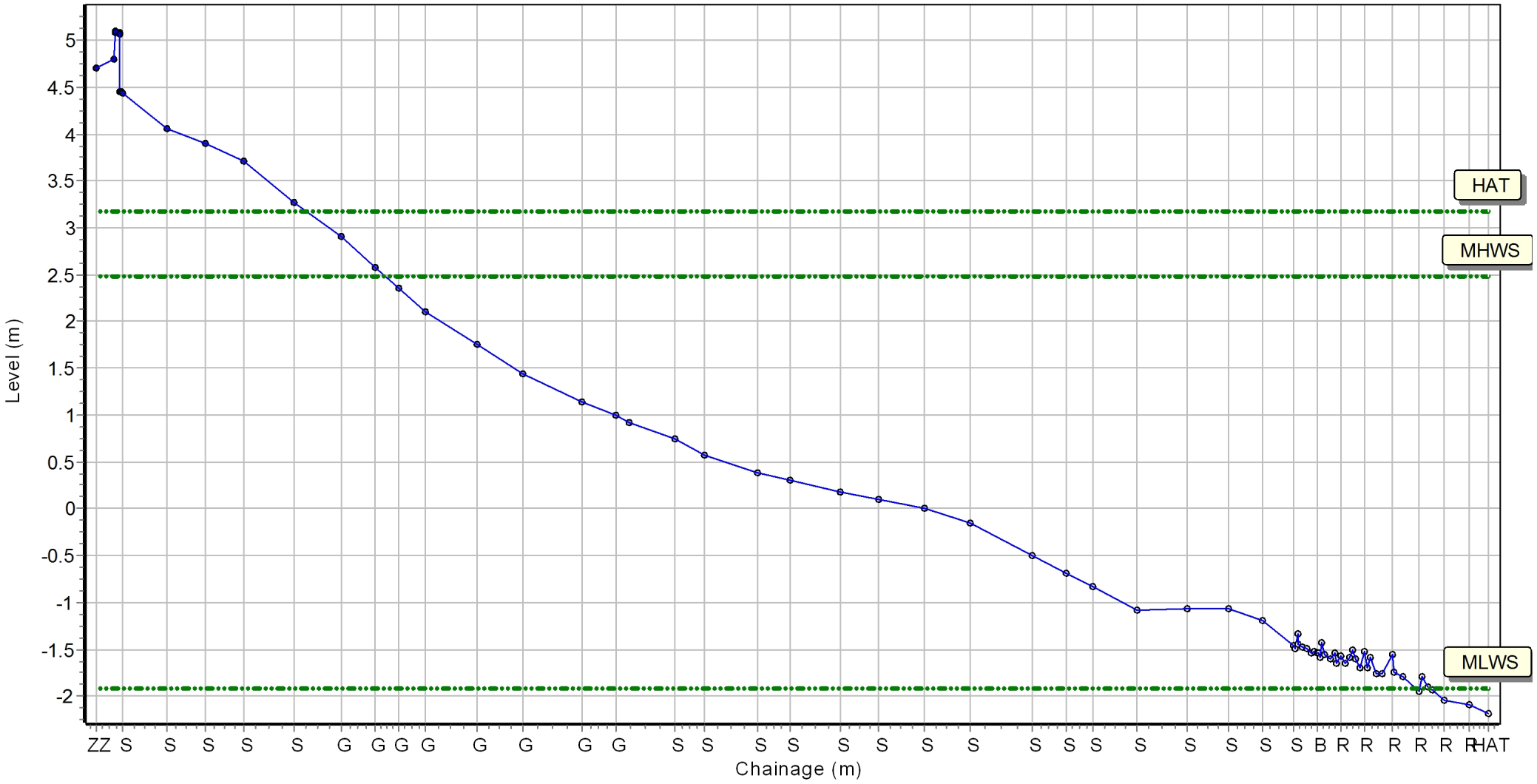
Location: **1bSNN11**

Date: 15/11/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 440785.596 **Northing:** 558966.827 **Profile Bearing:** 76 ° from North



Beach Profile

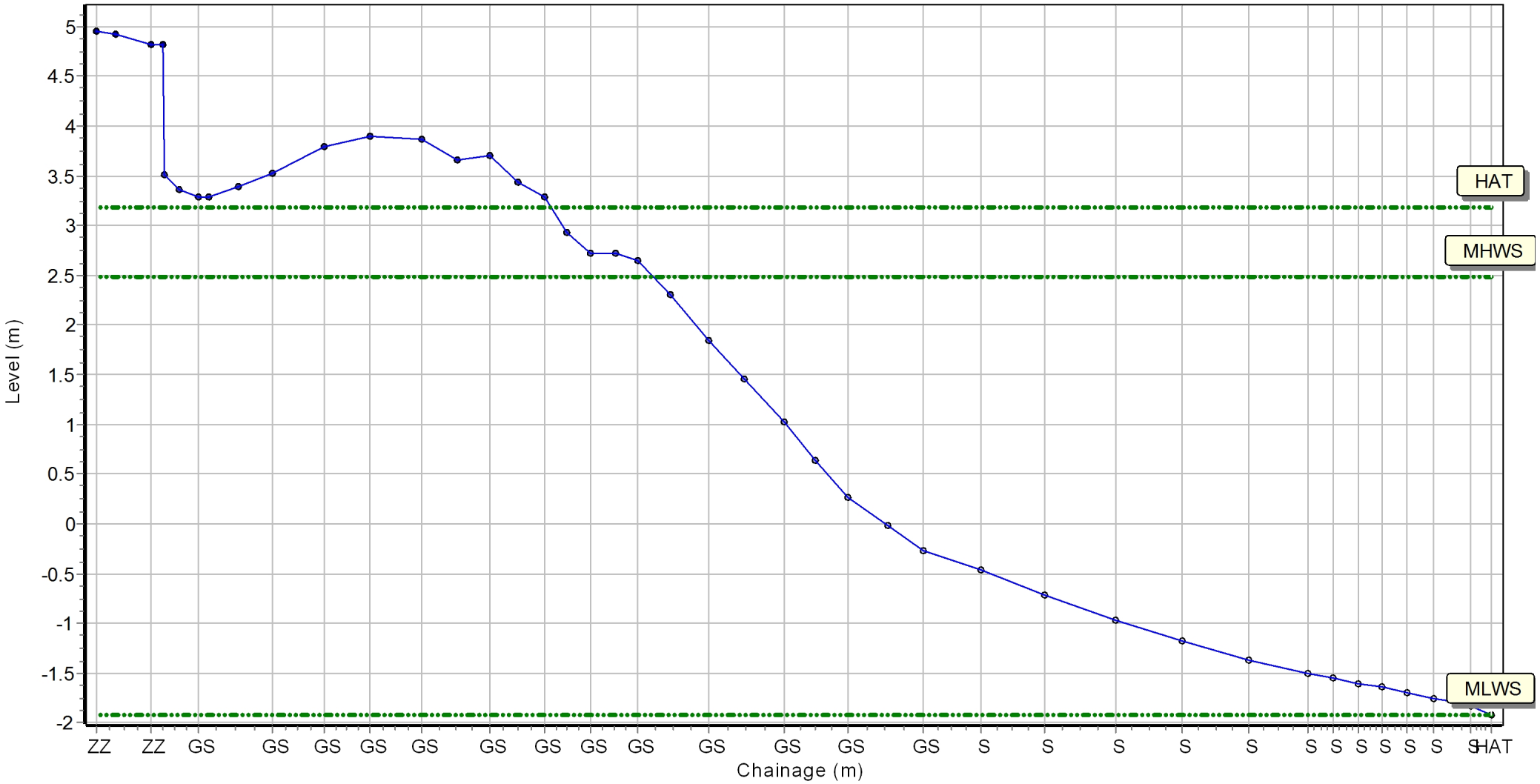
Location: **1bSNN12**

Date: 15/11/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 440842.281 **Northing:** 558732.094 **Profile Bearing:** 84 ° from North



Beach Profile

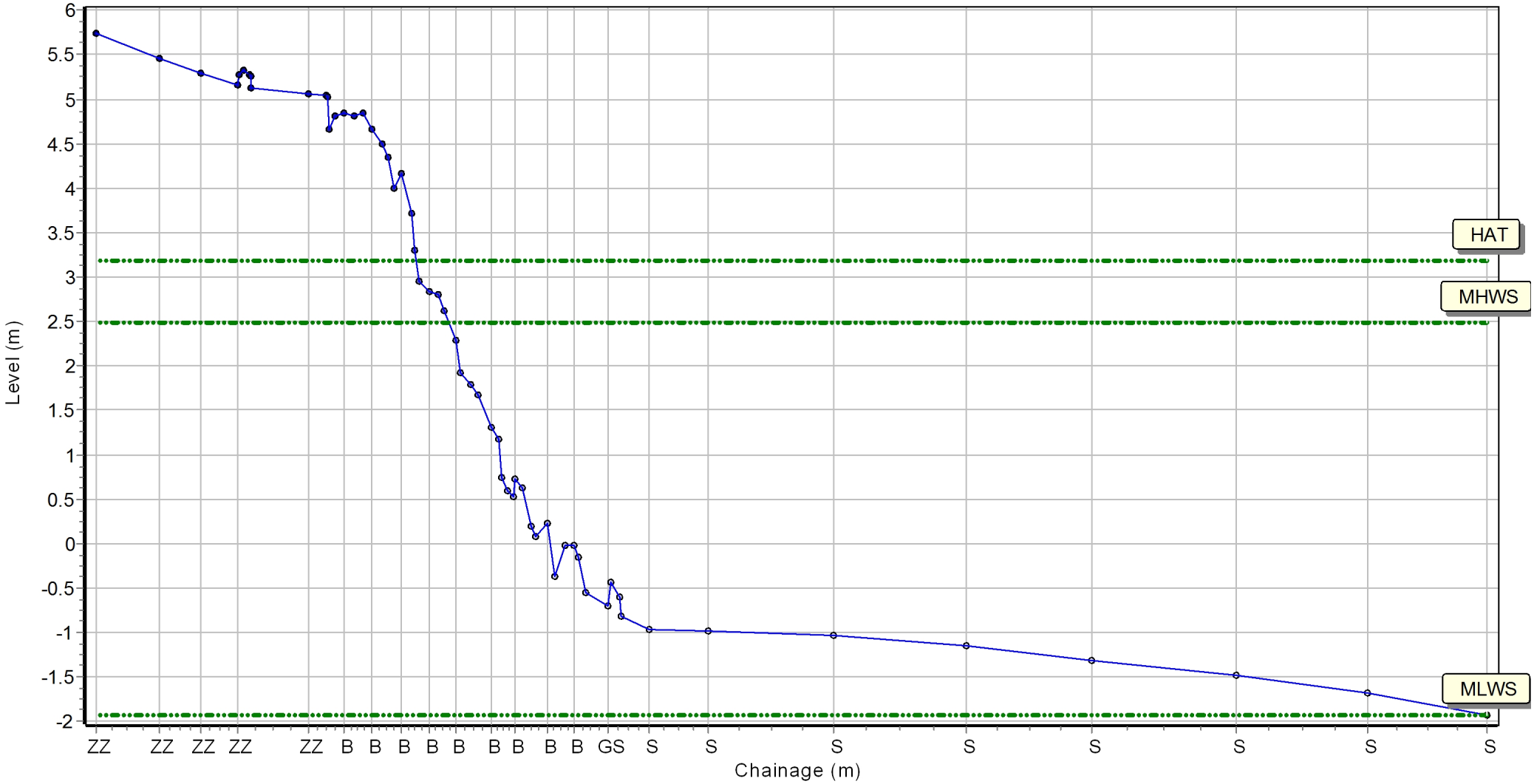
Location: **1bSNN13**

Date: 15/11/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 440892.257 **Northing:** 558511.587 **Profile Bearing:** 76 ° from North



Beach Profile

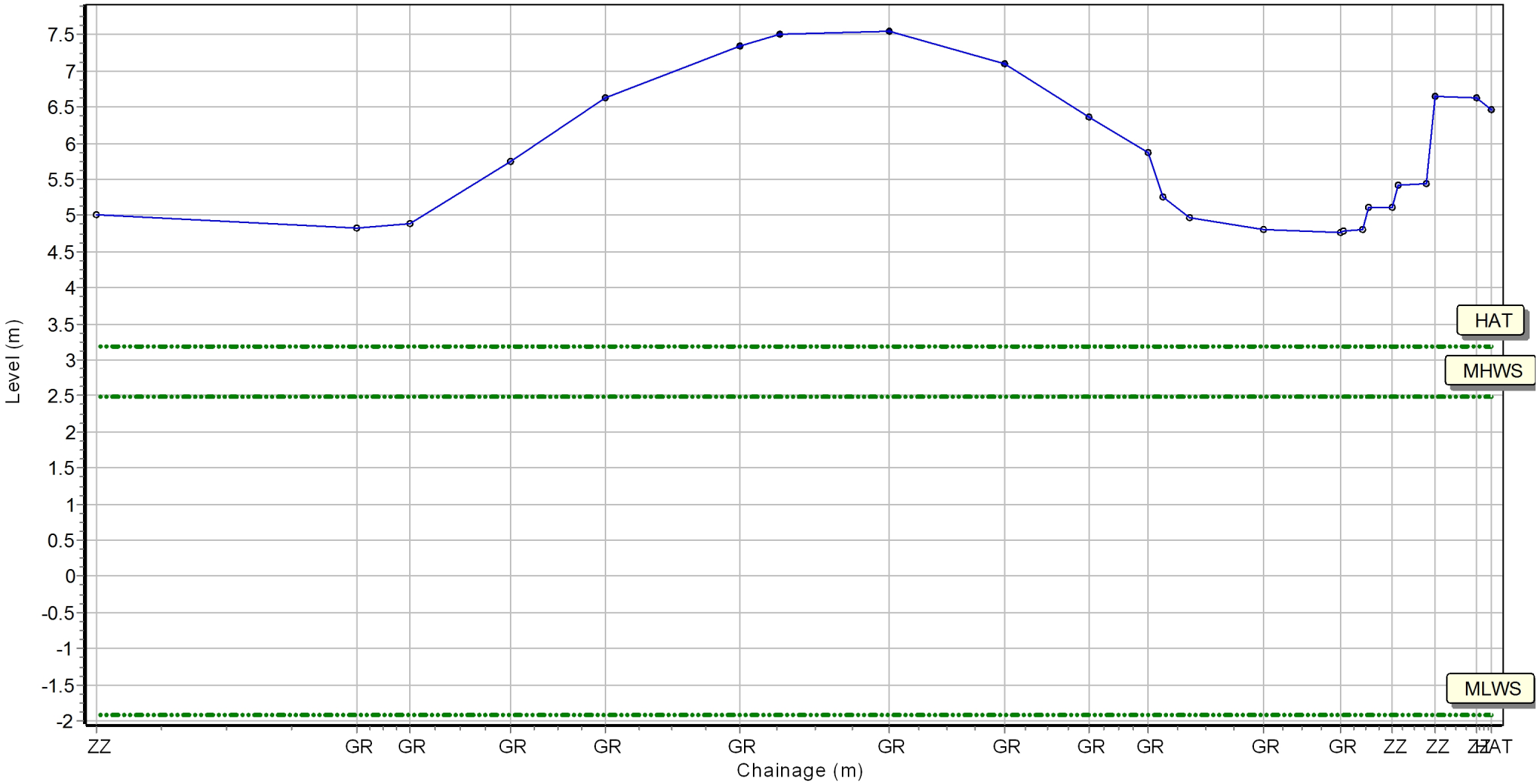
Location: **1bSNC1**

Date: 01/09/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 441063.908 **Northing:** 558055.488 **Profile Bearing:** 87 ° from North



Beach Profile

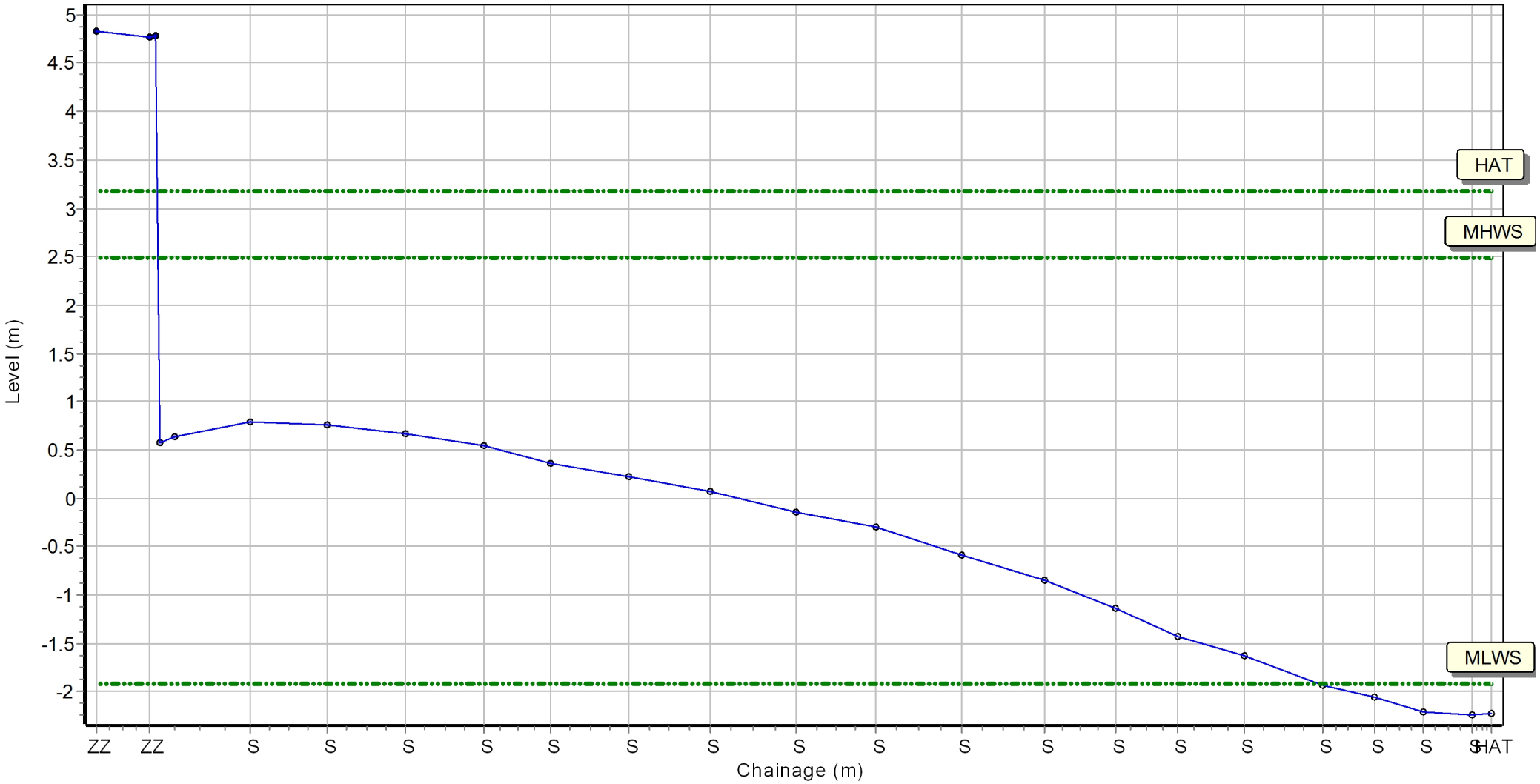
Location: **1bSNC2**

Date: 01/09/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 441240.27 **Northing:** 557850.776 **Profile Bearing:** 349 ° from North



Beach Profile

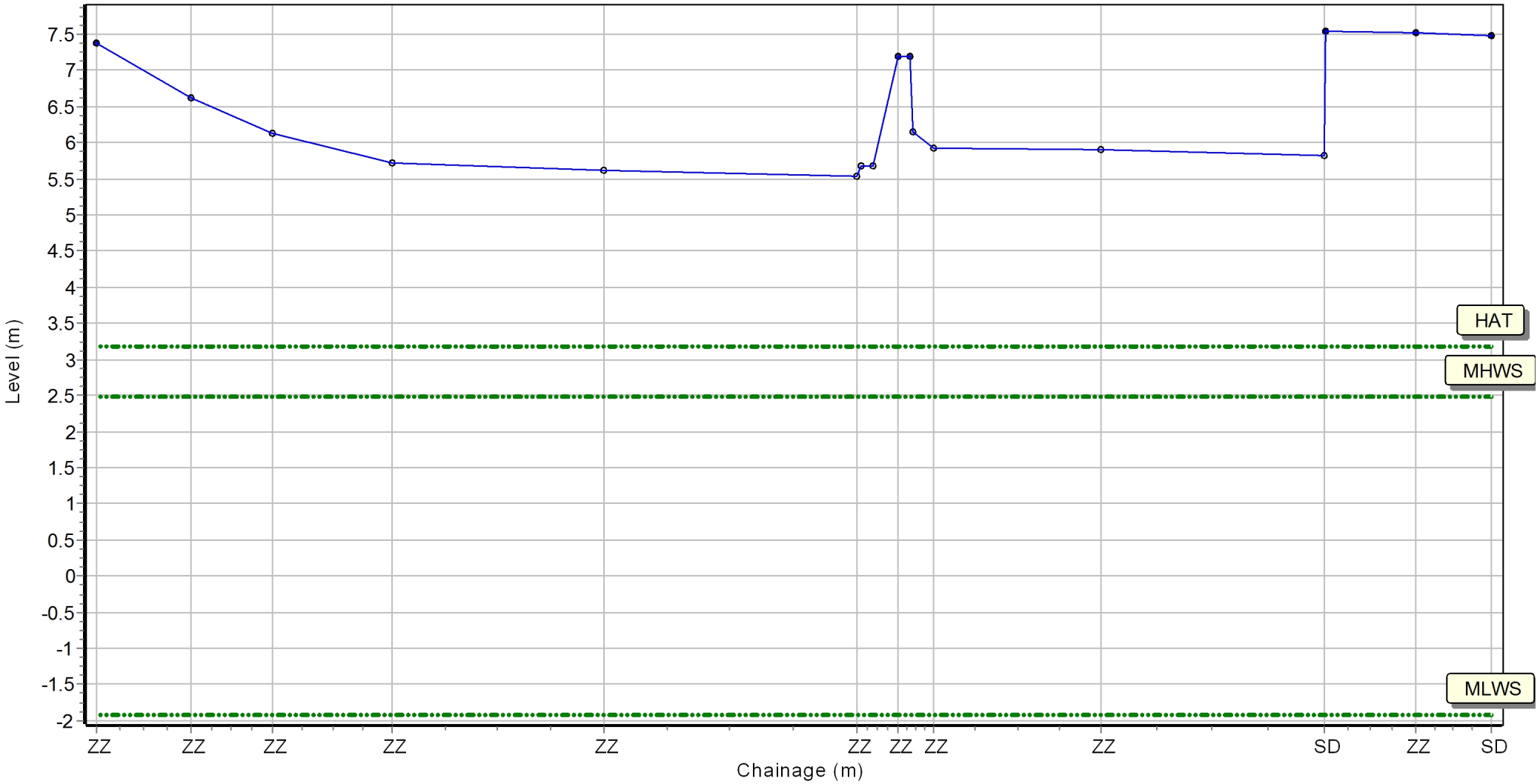
Location: **1bSNC3**

Date: 01/09/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 441192.226 **Northing:** 557747.746 **Profile Bearing:** 70 ° from North



Beach Profile

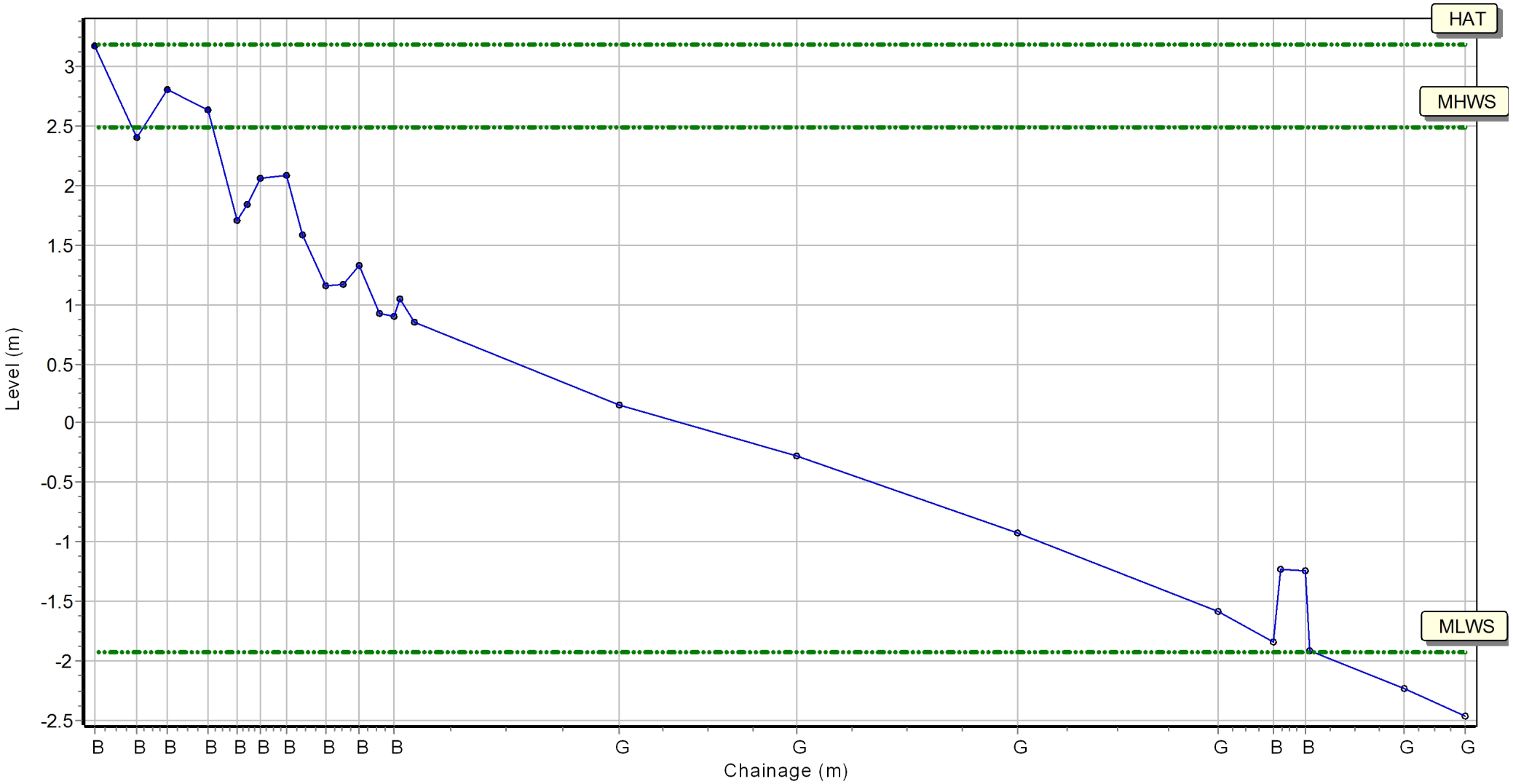
Location: **1bSNC4**

Date: 01/09/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 441321.27 **Northing:** 557533.237 **Profile Bearing:** 45 ° from North



Beach Profile

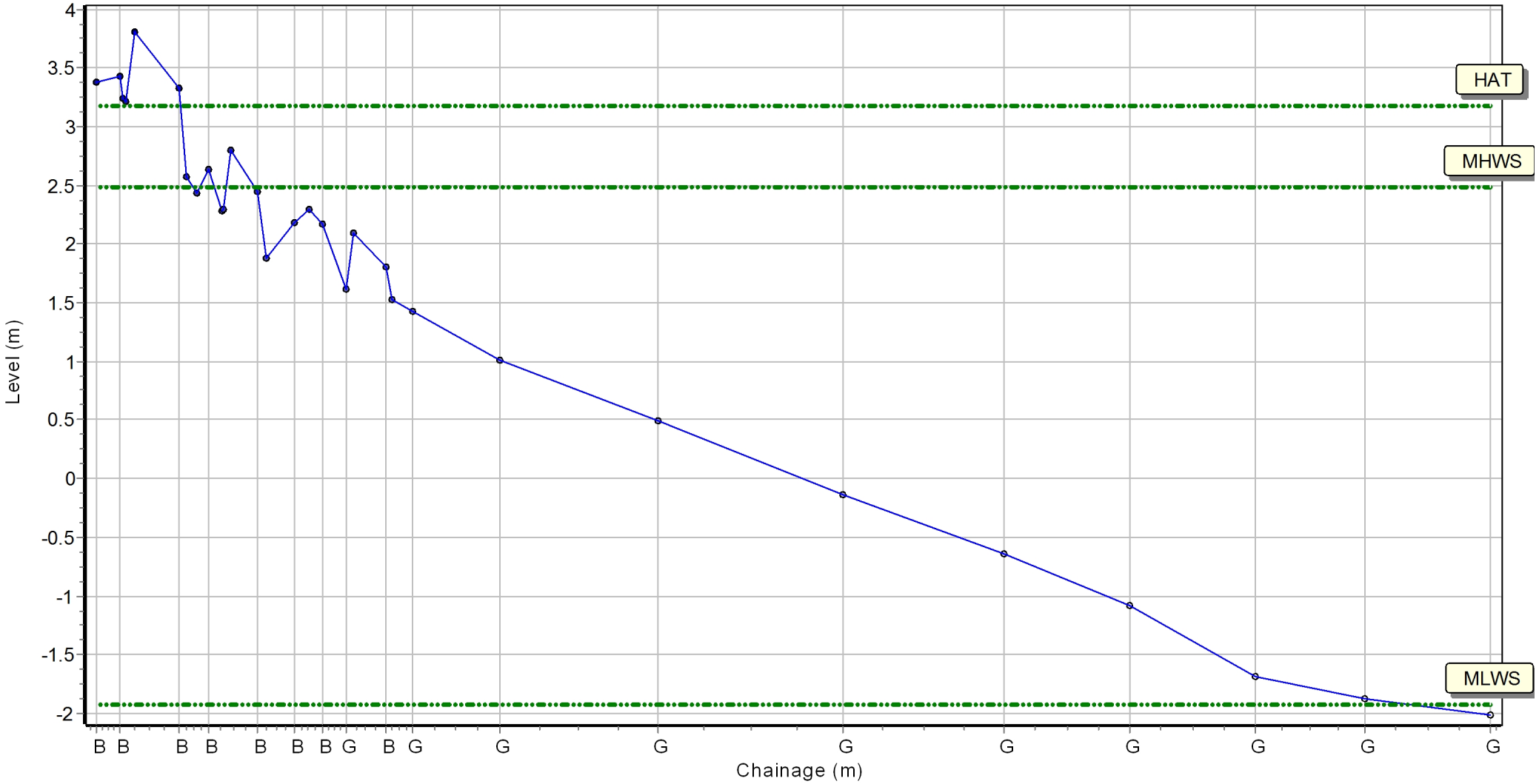
Location: **1bSNC5**

Date: 01/09/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 441463.58 **Northing:** 557376.22 **Profile Bearing:** 58 ° from North



Beach Profile

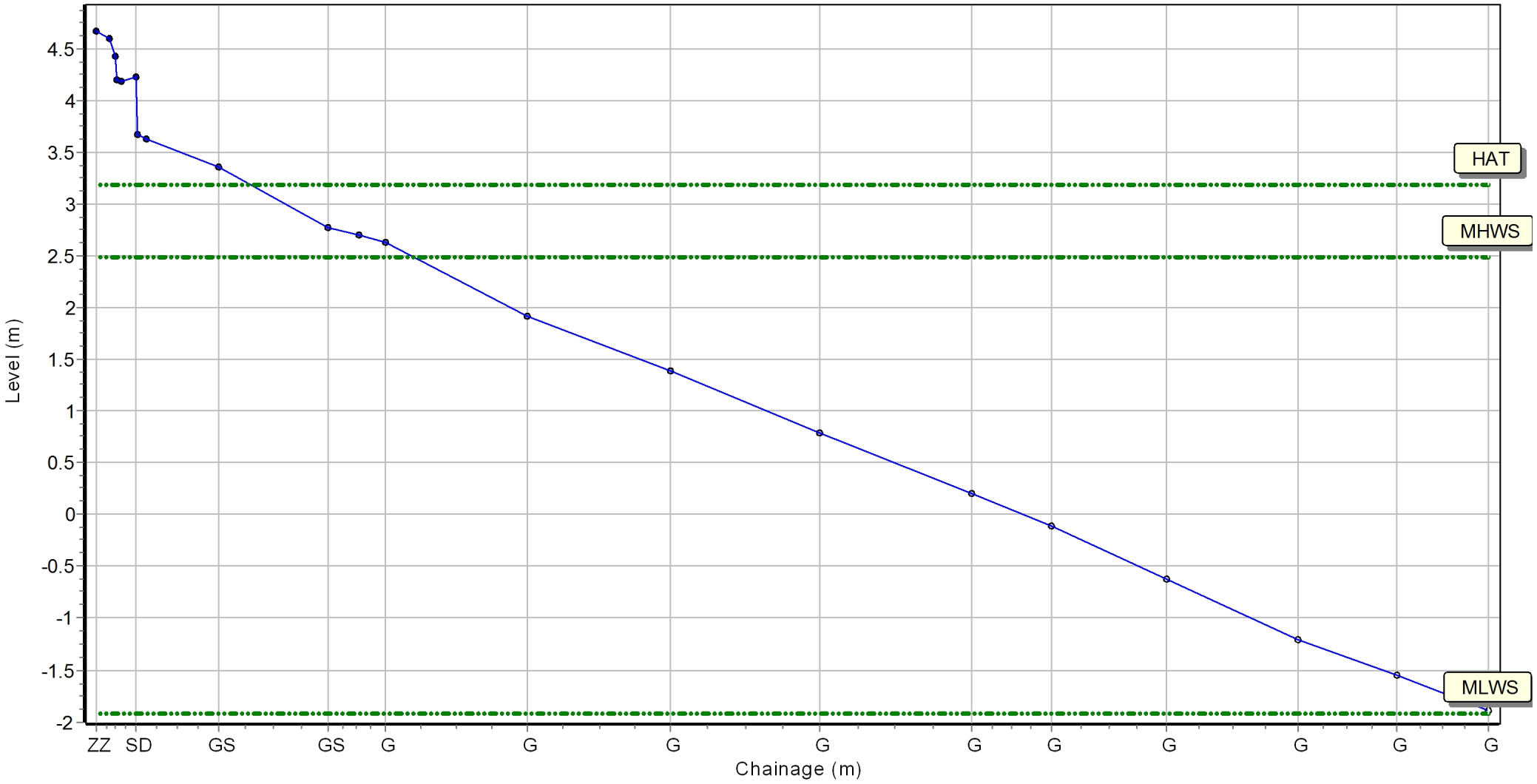
Location: **1bSNC6**

Date: 01/09/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 441511.013 **Northing:** 557229.014 **Profile Bearing:** 88 ° from North



Beach Profile

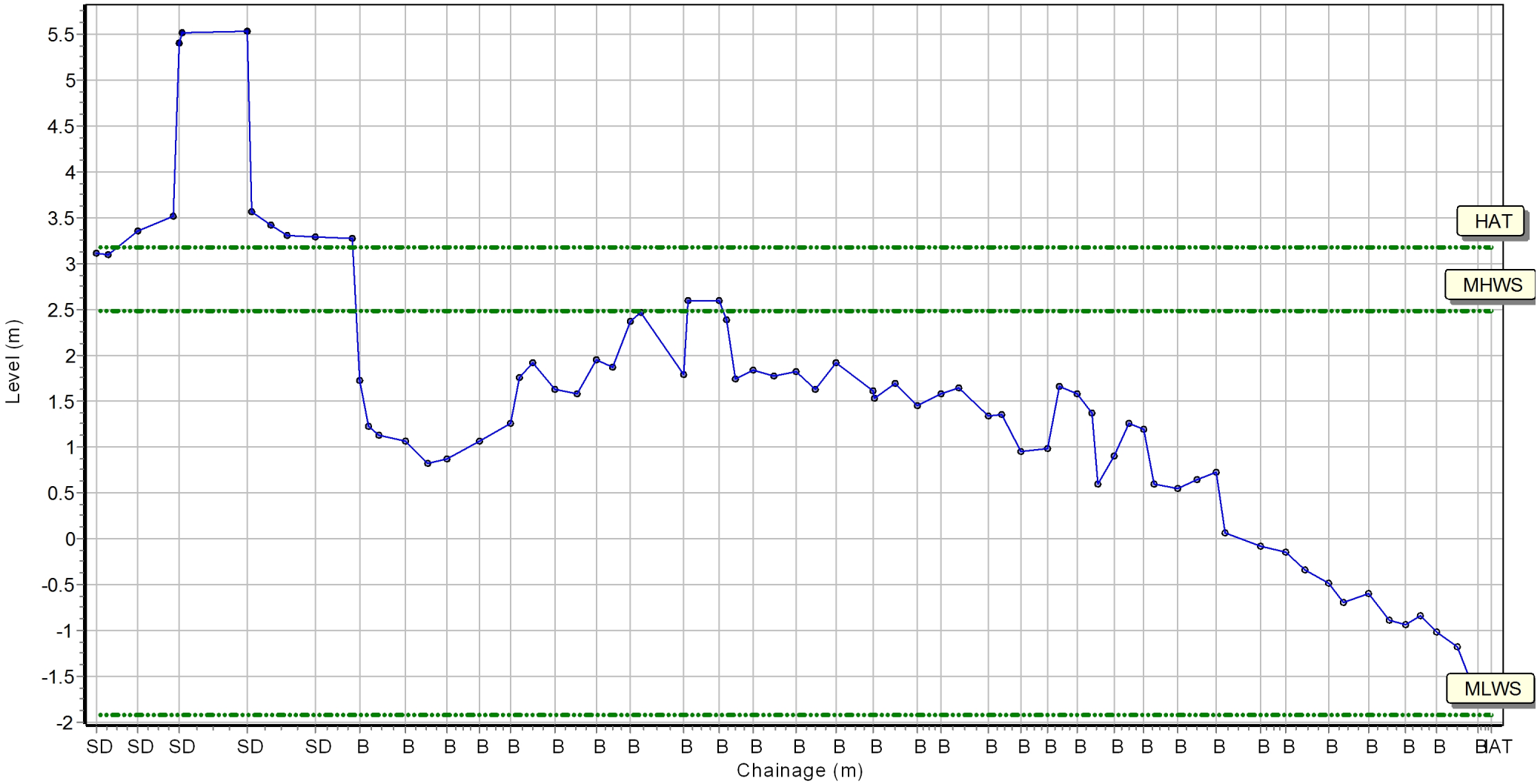
Location: **1bSNC7**

Date: 01/09/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 441682.28 **Northing:** 557051.345 **Profile Bearing:** 230 ° from North



Beach Profile

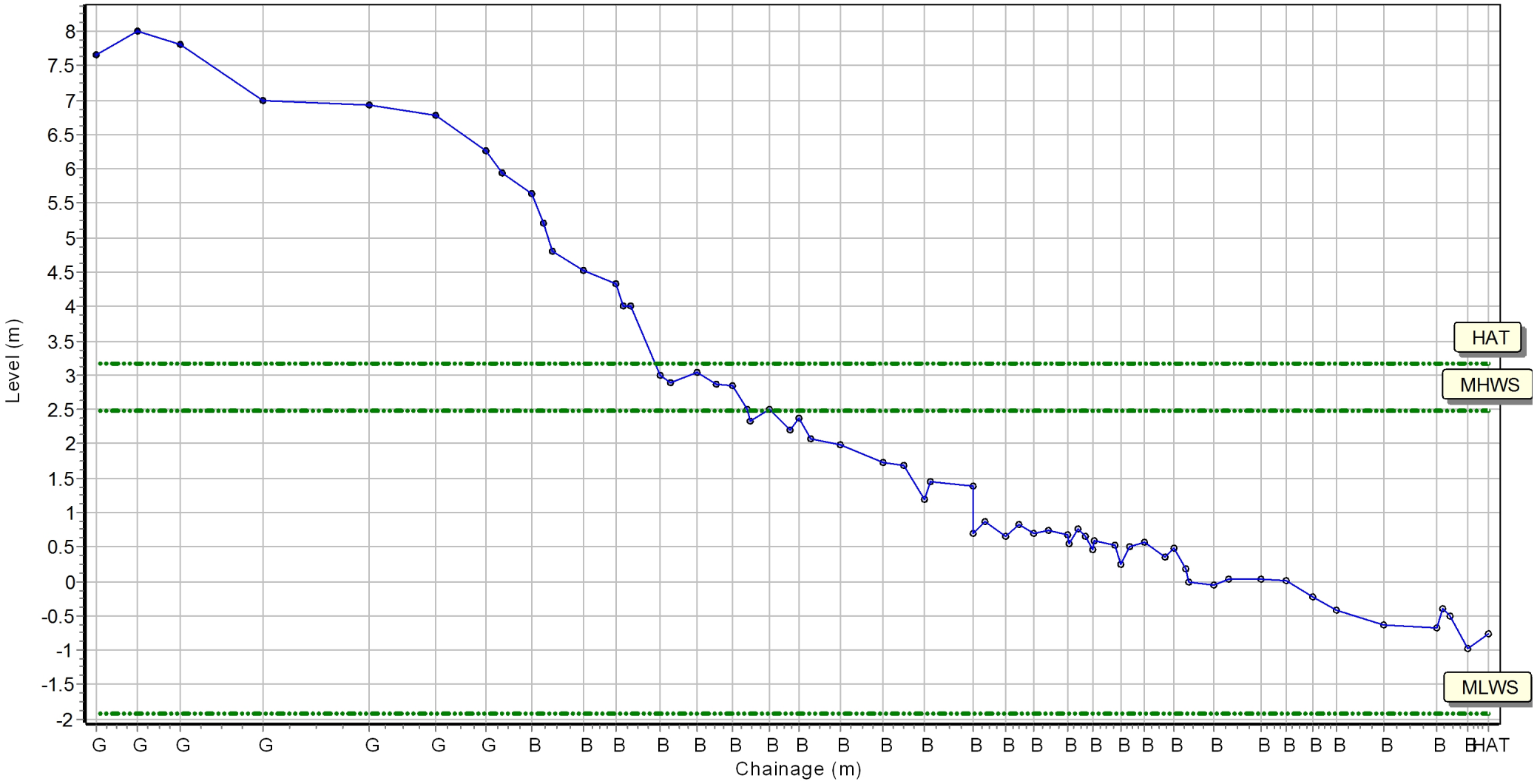
Location: **1bSNC8**

Date: 01/09/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 441601.437 **Northing:** 557055.604 **Profile Bearing:** 183 ° from North



Beach Profile

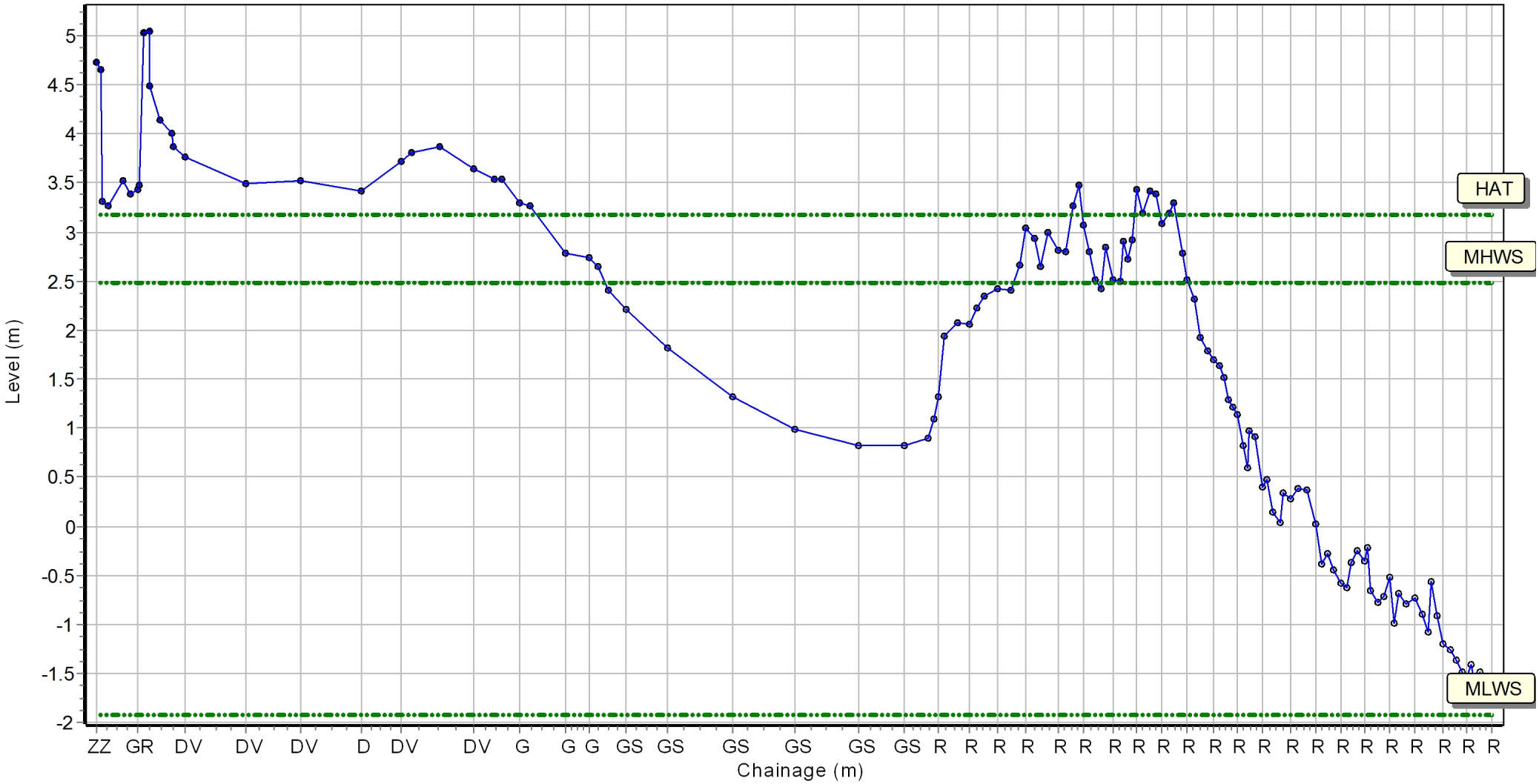
Location: **1bSNC9**

Date: 01/09/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 441461.898 **Northing:** 556870.487 **Profile Bearing:** 70 ° from North



Beach Profile

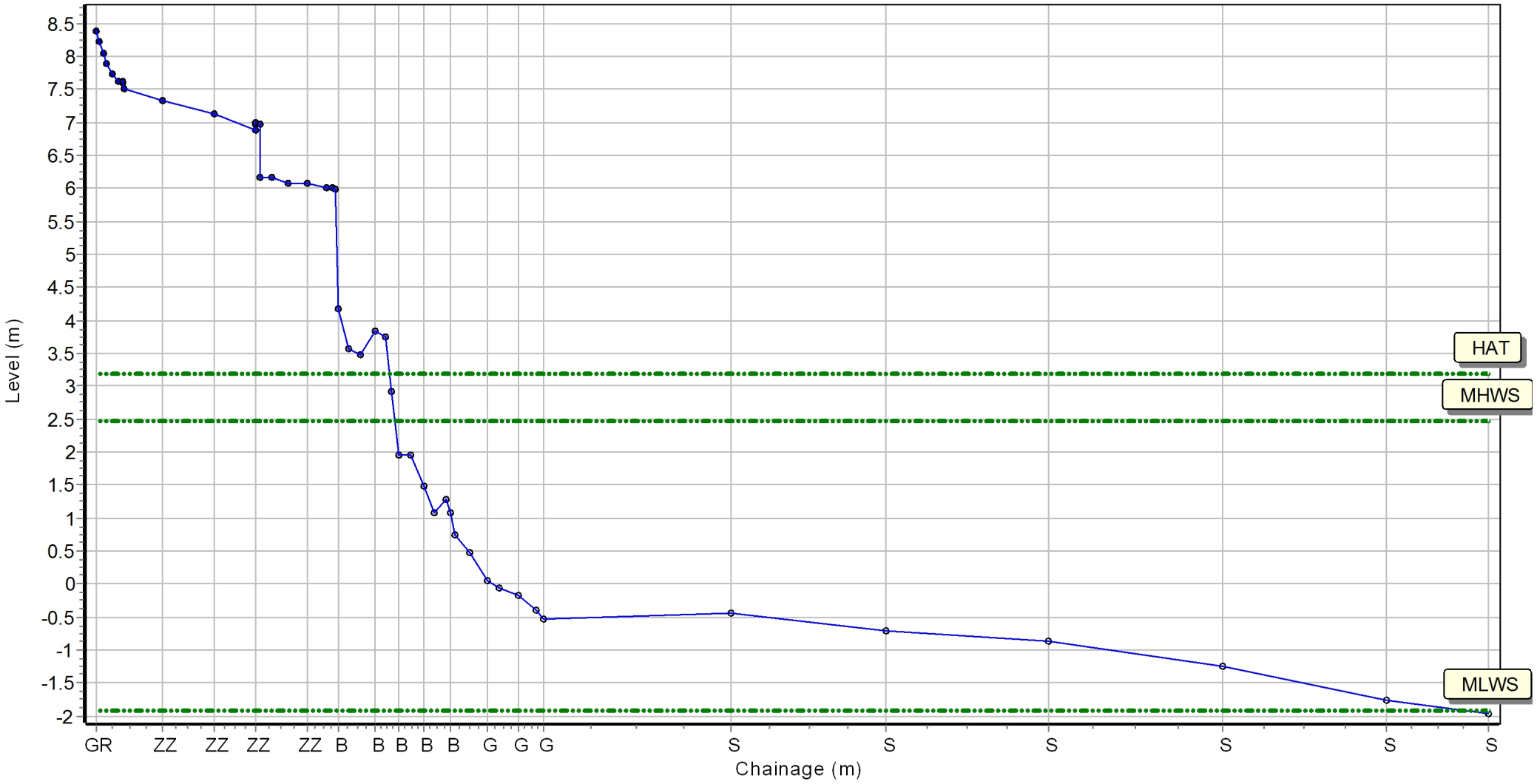
Location: **1bSNS8**

Date: 16/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 441092.263 **Northing:** 555414.414 **Profile Bearing:** 80 ° from North



Beach Profile

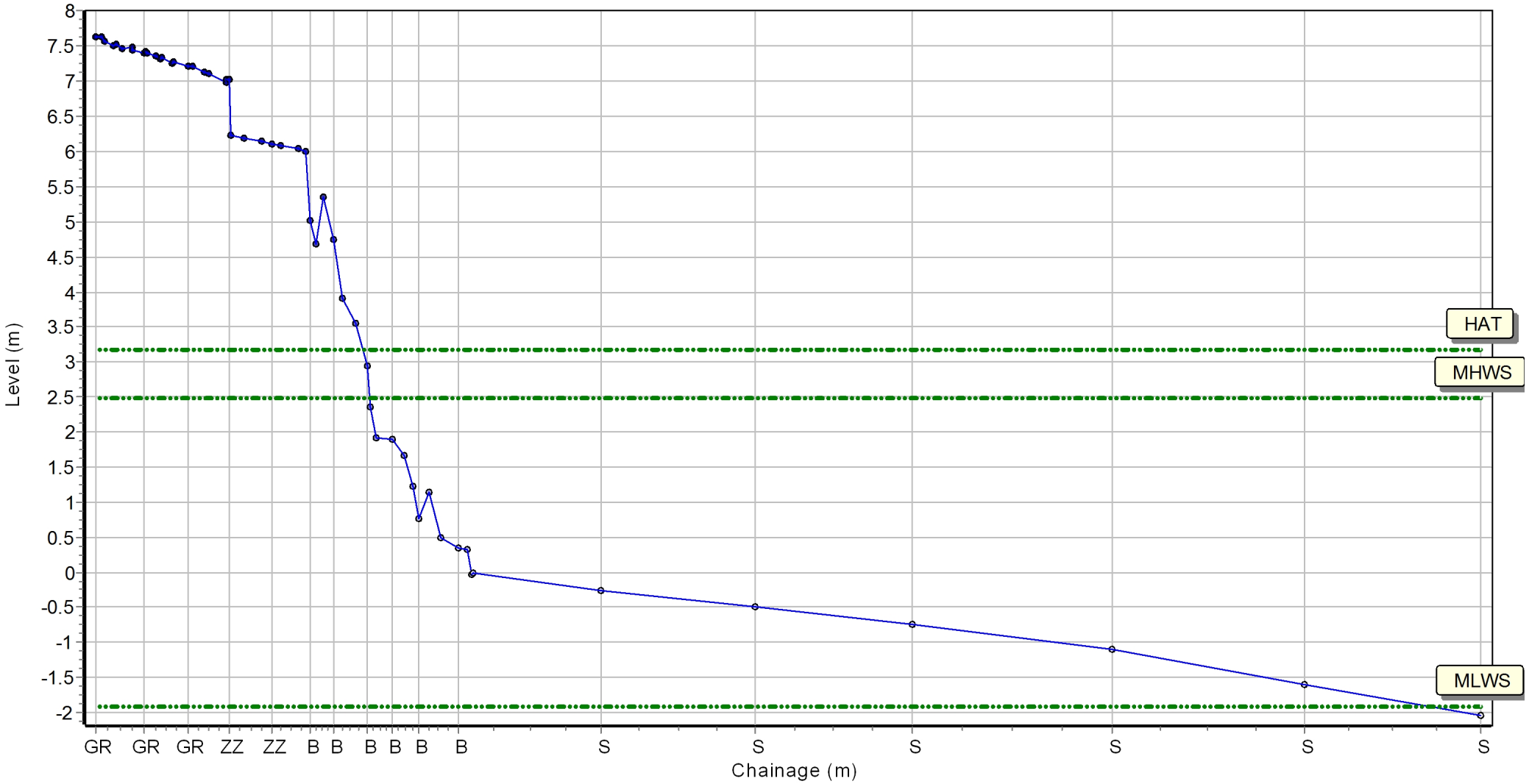
Location: **1bSNS9**

Date: 16/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 441118.722 **Northing:** 555223.928 **Profile Bearing:** 82 ° from North



Beach Profile

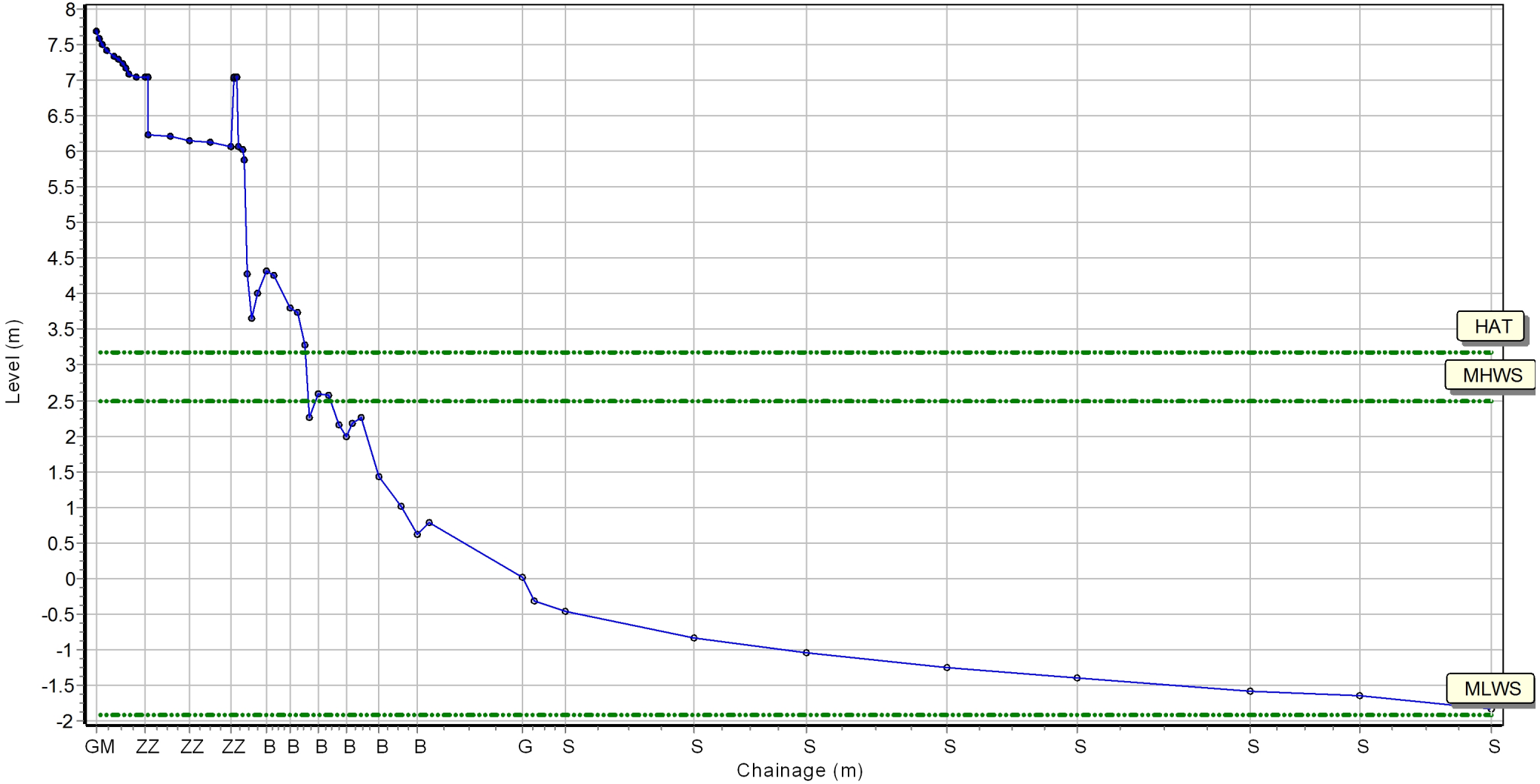
Location: **1bSNS10**

Date: 16/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 441176.256 **Northing:** 554997.913 **Profile Bearing:** 73 ° from North



Beach Profile

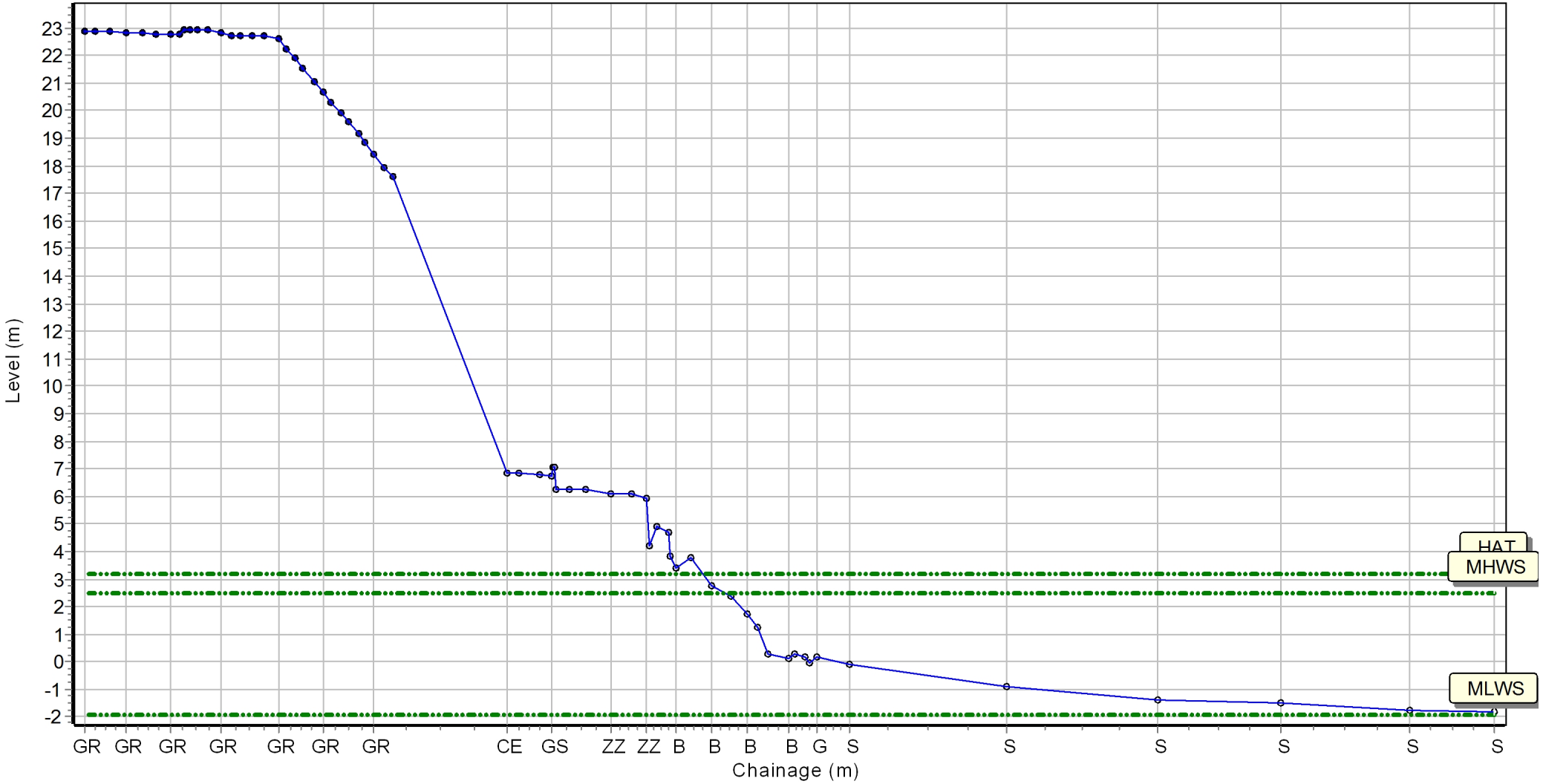
Location: **1bSNS11**

Date: 16/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 441225.182 **Northing:** 554759.021 **Profile Bearing:** 75 ° from North



Beach Profile

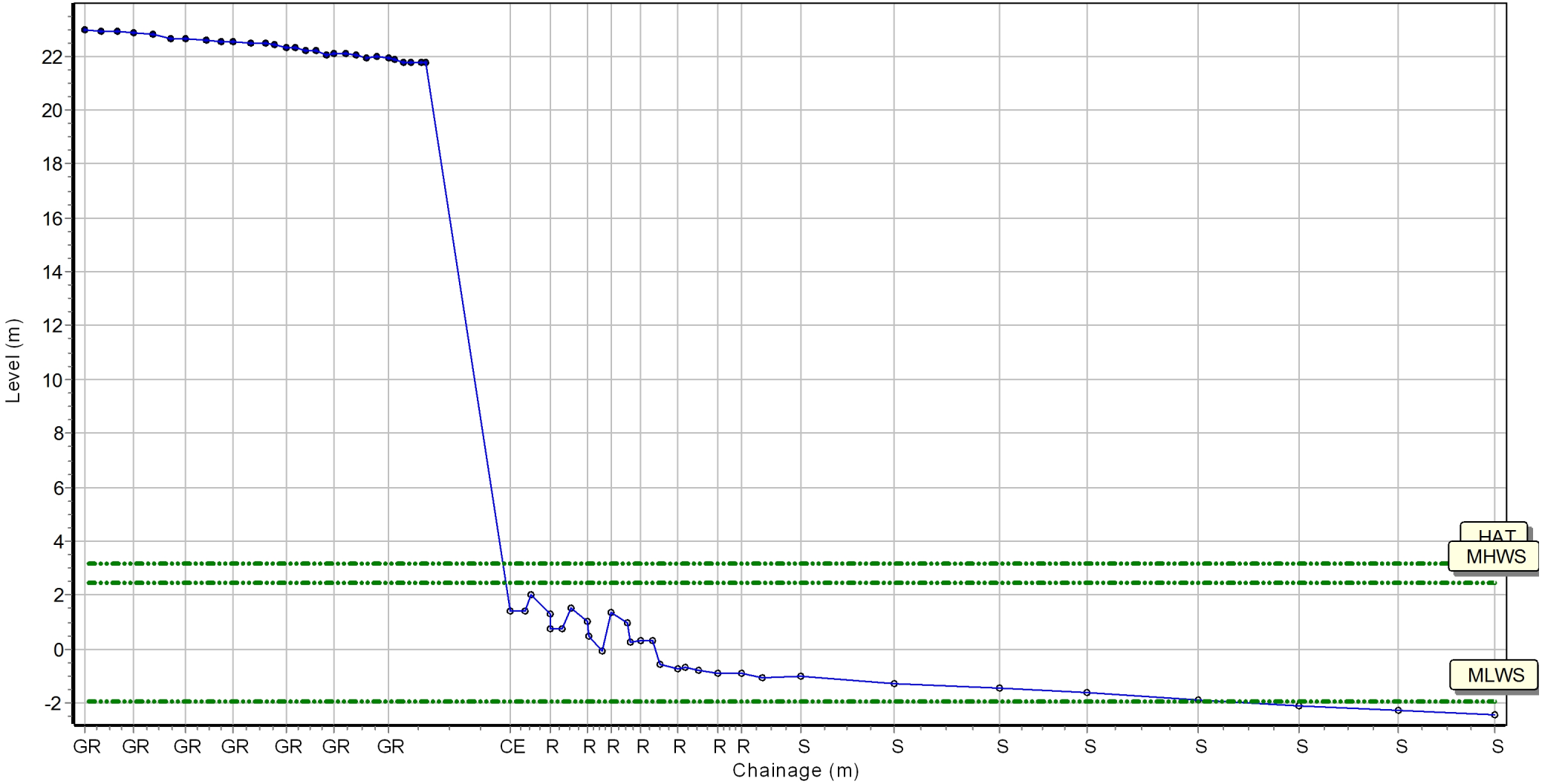
Location: **1bSNS12**

Date: 16/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 441242.249 **Northing:** 554630.678 **Profile Bearing:** 75 ° from North



Beach Profile

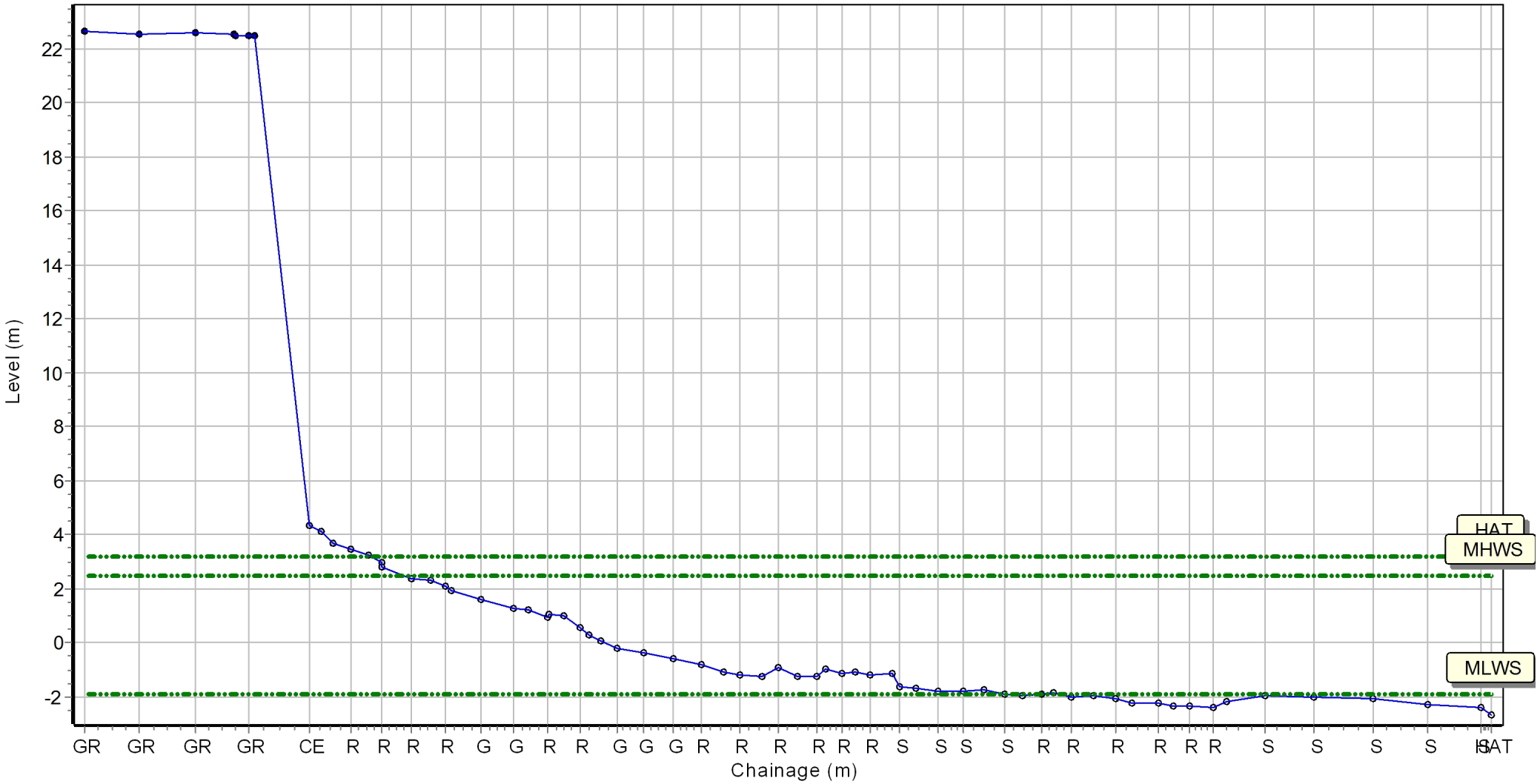
Location: **1bSNS13**

Date: 16/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 441288.083 **Northing:** 554427.126 **Profile Bearing:** 66 ° from North



Beach Profile

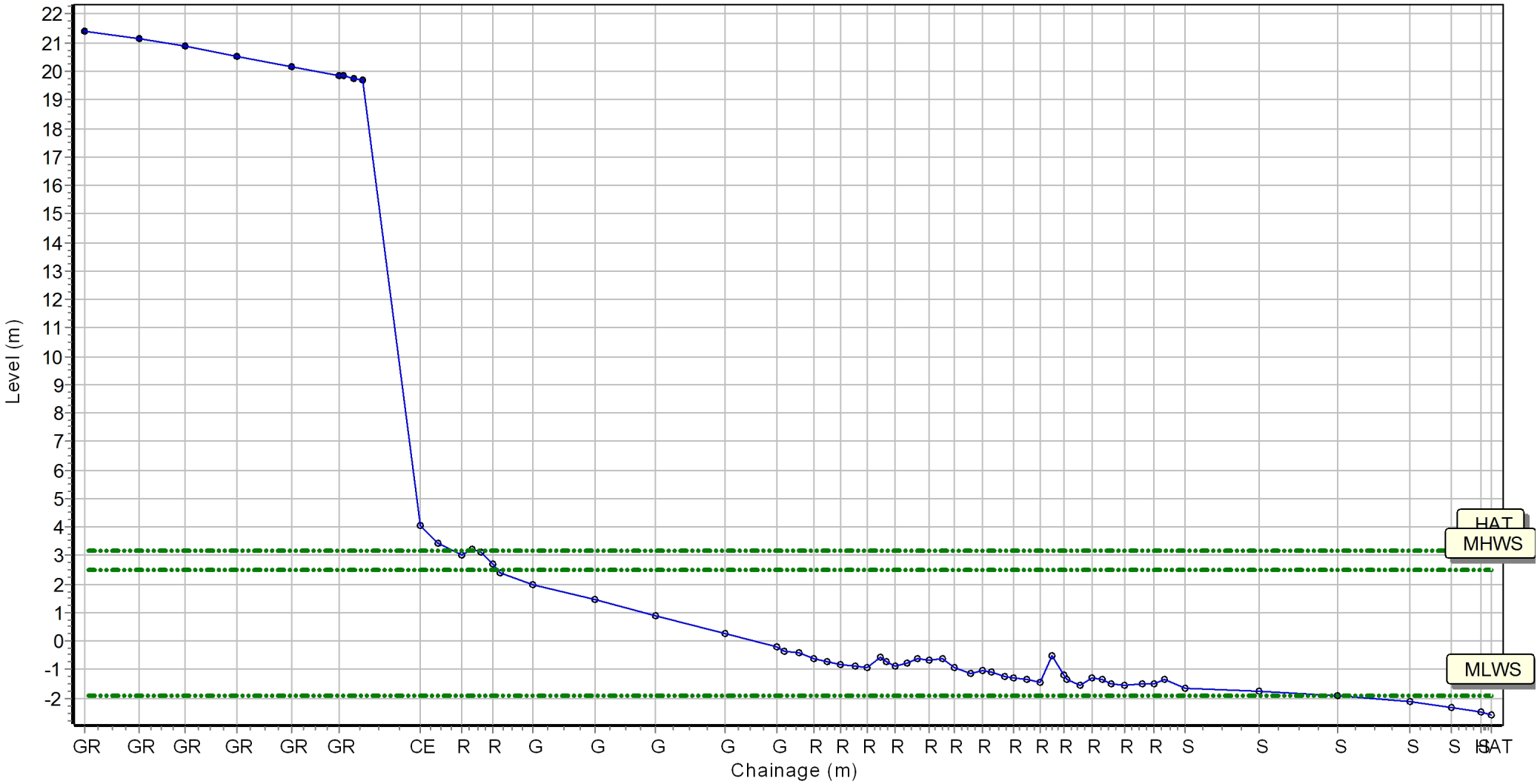
Location: **1bSNS14**

Date: 16/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 441329.465 **Northing:** 554332.663 **Profile Bearing:** 65 ° from North



Beach Profile

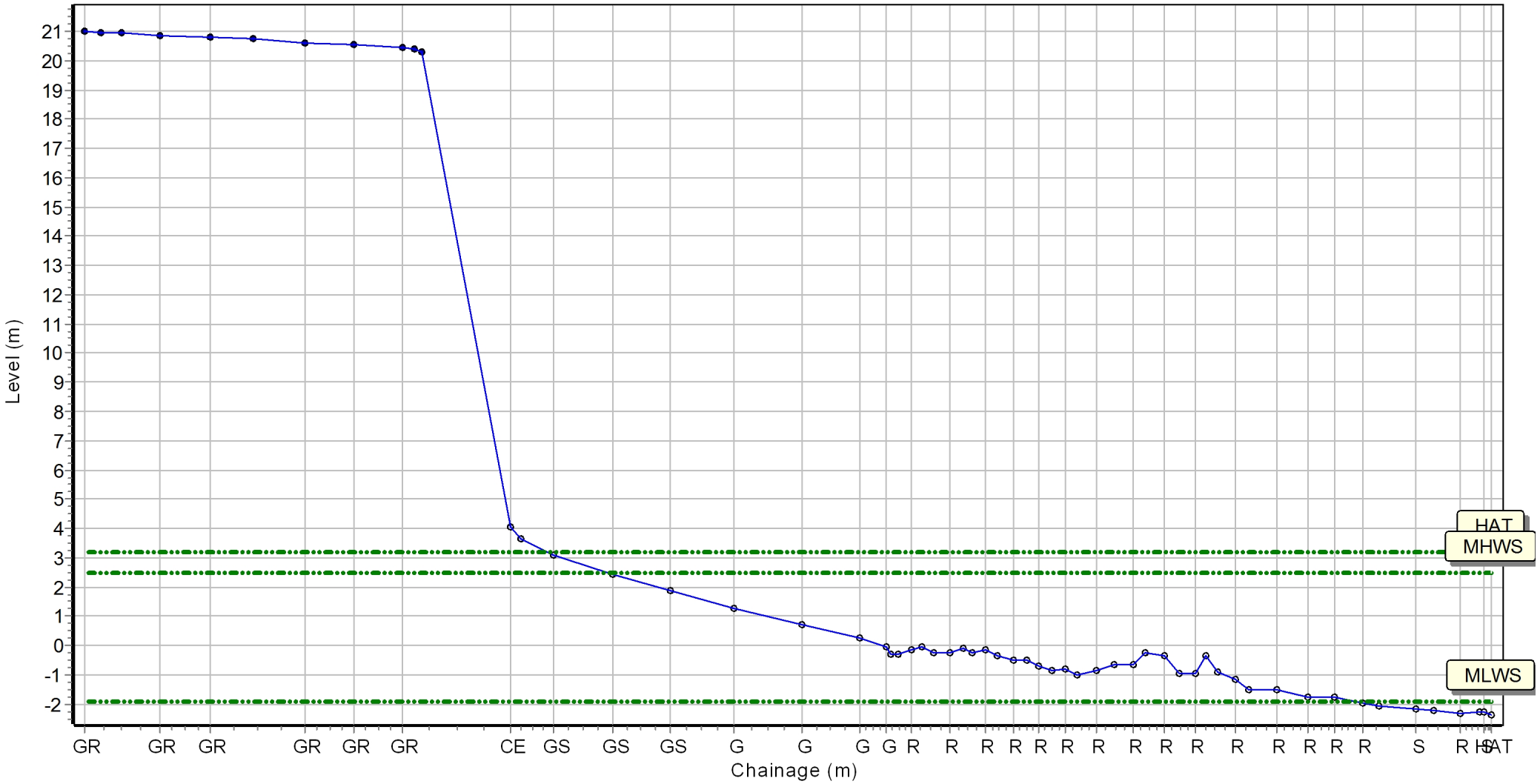
Location: **1bSNS15**

Date: 16/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 441371.425 **Northing:** 554241.889 **Profile Bearing:** 65 ° from North



Beach Profile

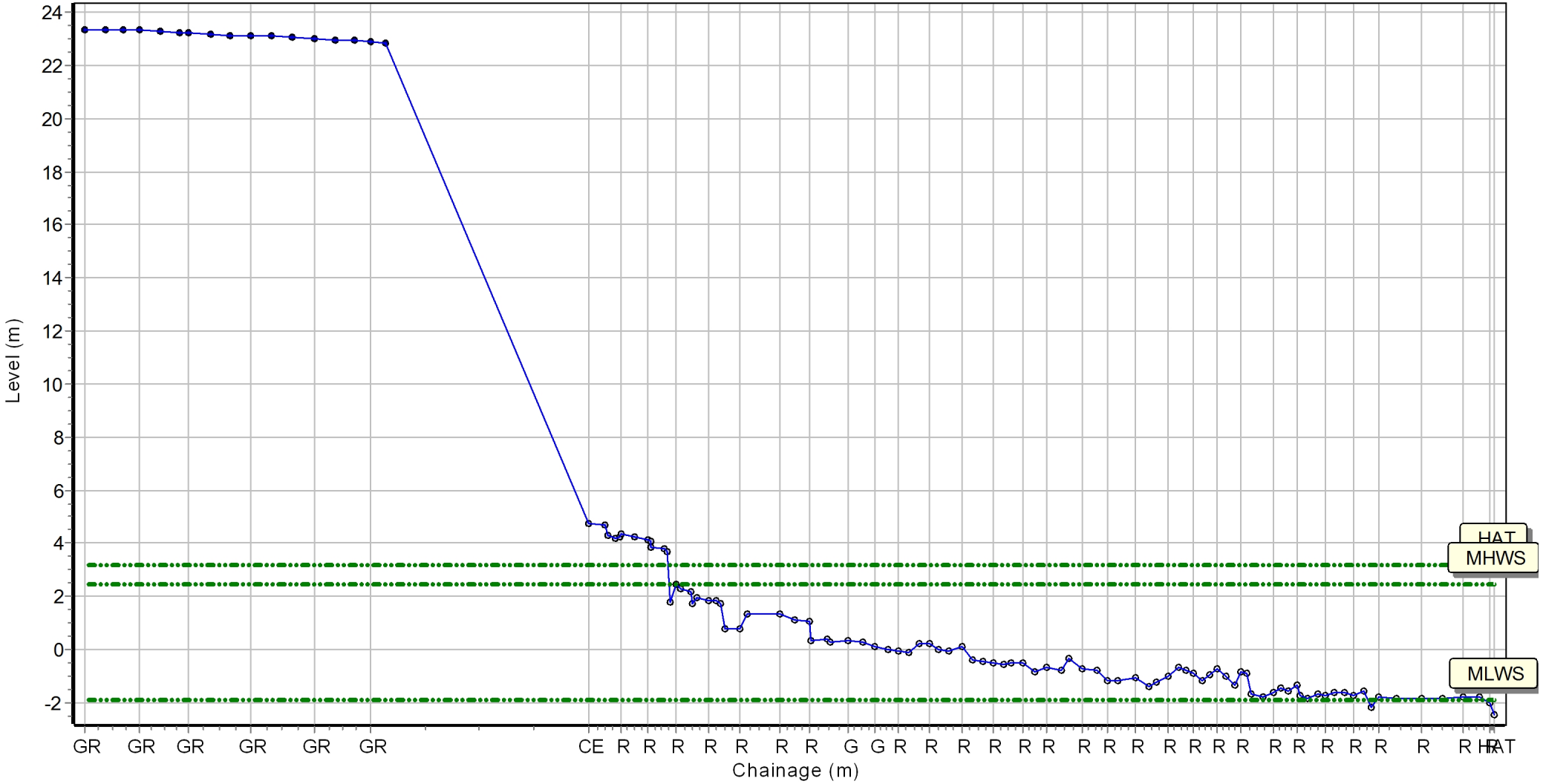
Location: **1bSNS16**

Date: 16/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 441444.352 **Northing:** 554130.231 **Profile Bearing:** 64 ° from North



Beach Profile

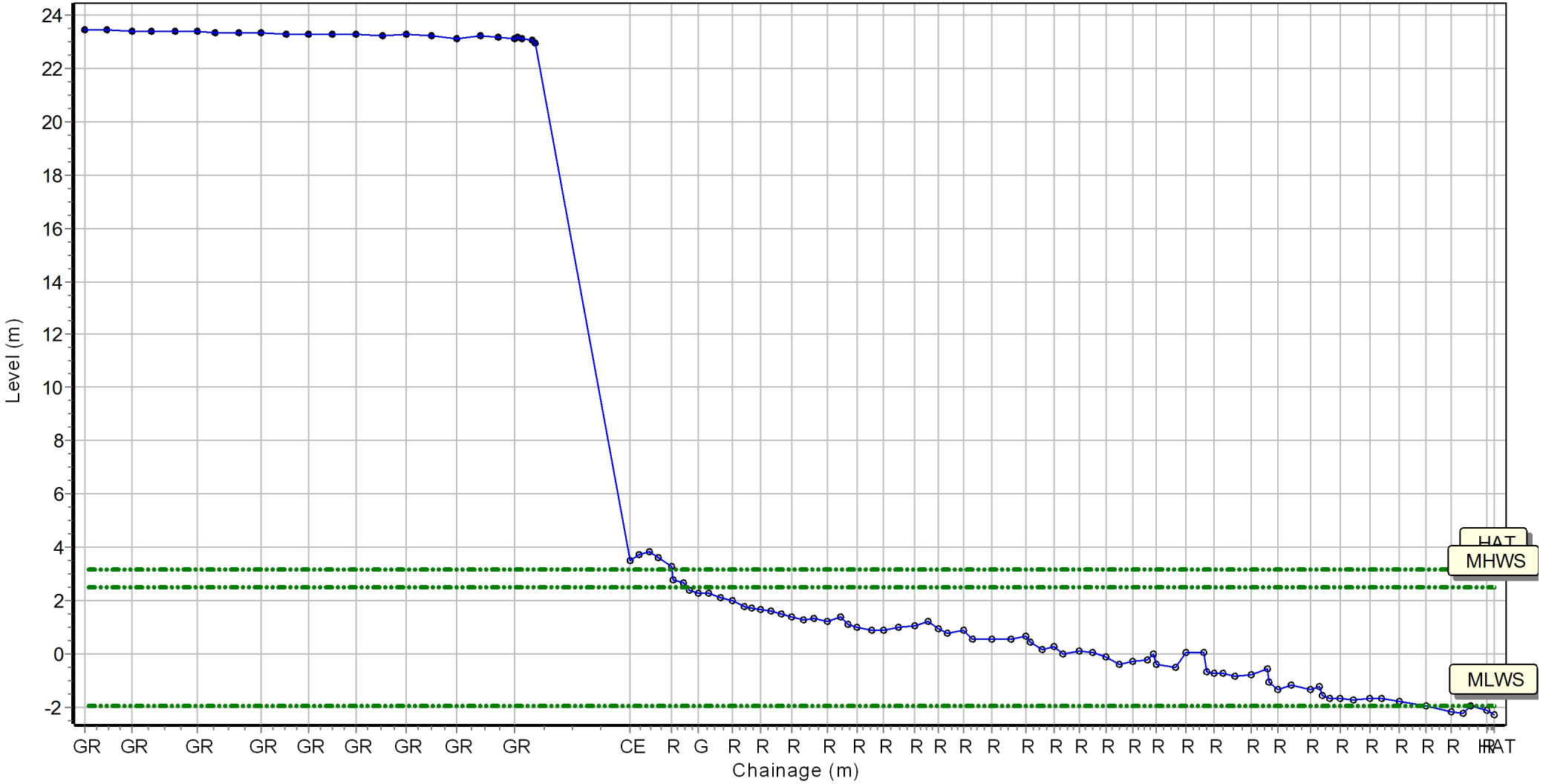
Location: **1bSNS17**

Date: 16/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 441450.289 **Northing:** 554115.925 **Profile Bearing:** 131 ° from North



Beach Profile

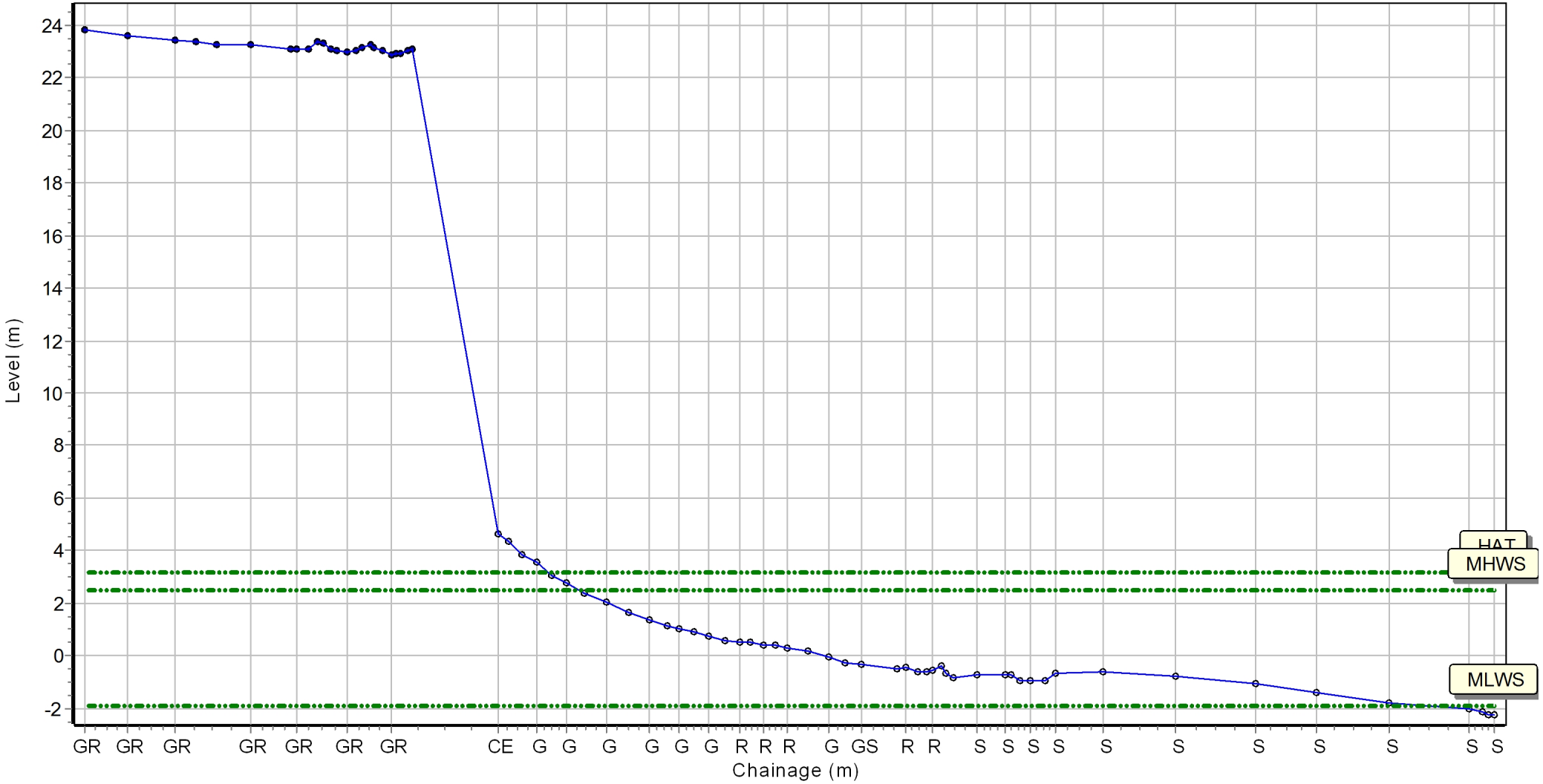
Location: **1bSNS18**

Date: 16/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 441365.488 **Northing:** 553870.605 **Profile Bearing:** 83 ° from North



Beach Profile

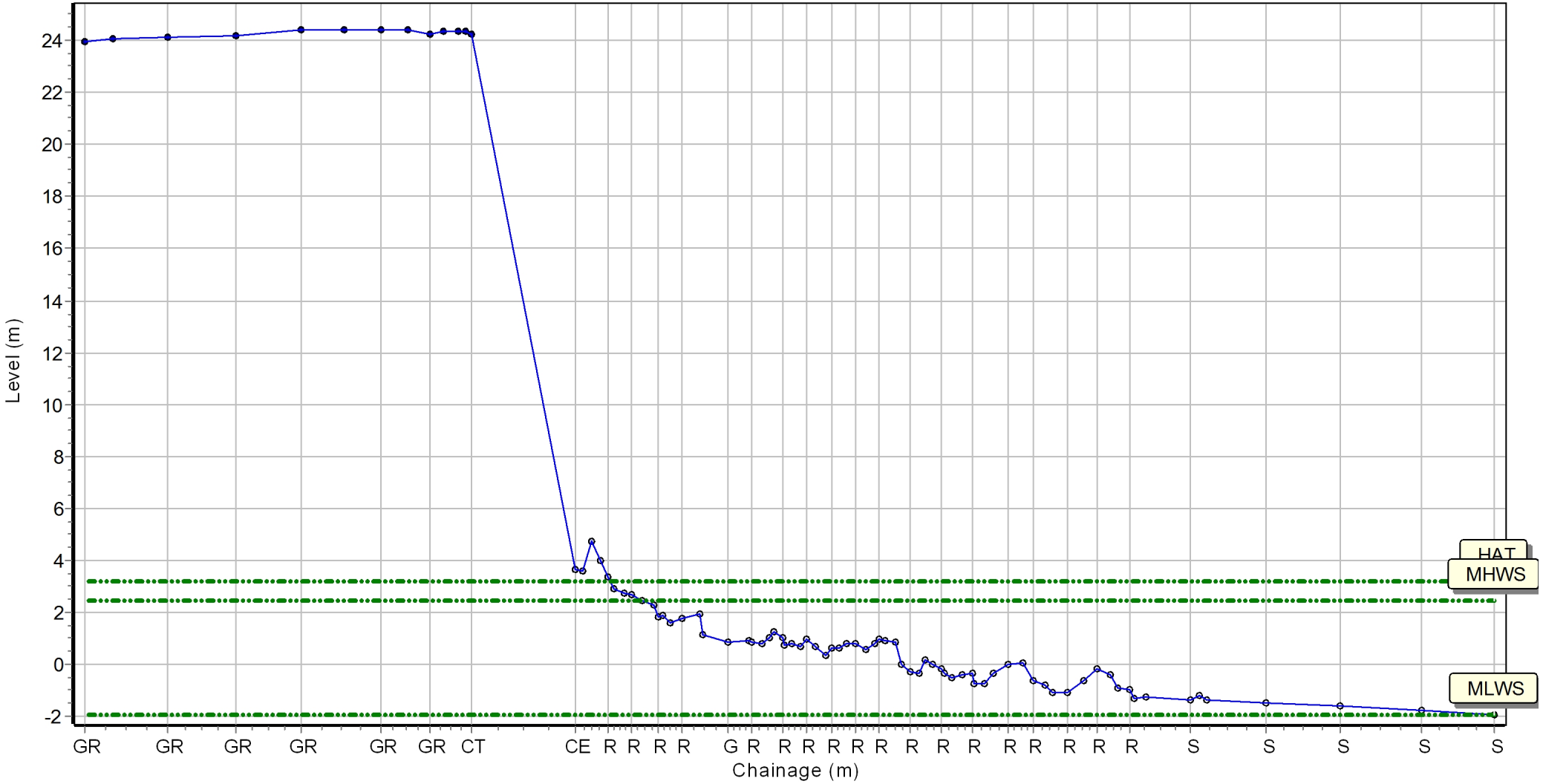
Location: **1bSNS19**

Date: 16/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 441384.336 **Northing:** 553752.319 **Profile Bearing:** 105 ° from North



Beach Profile

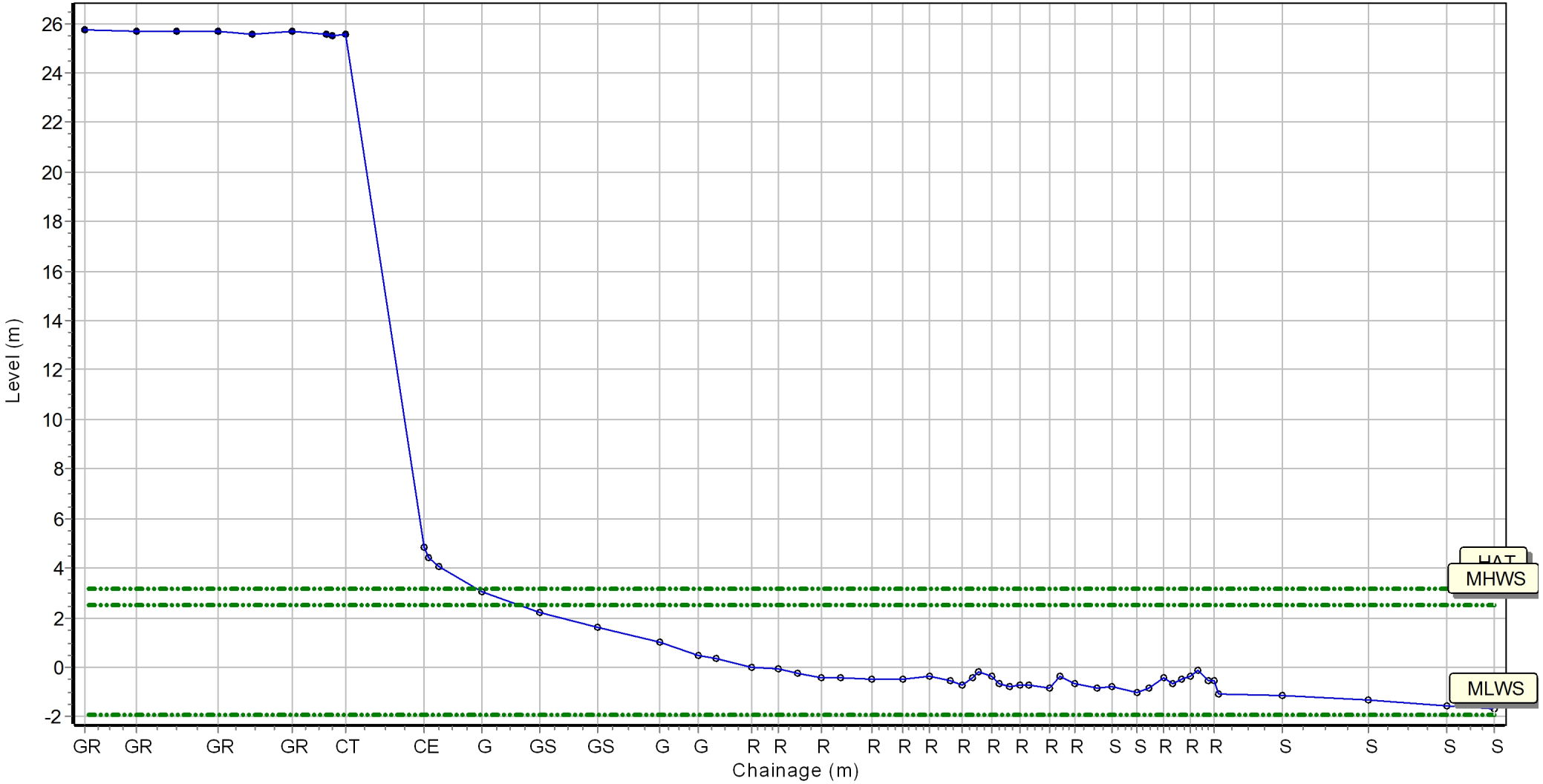
Location: **1bSNS20**

Date: 16/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 441378.054 **Northing:** 553599.123 **Profile Bearing:** 81 ° from North



Beach Profile

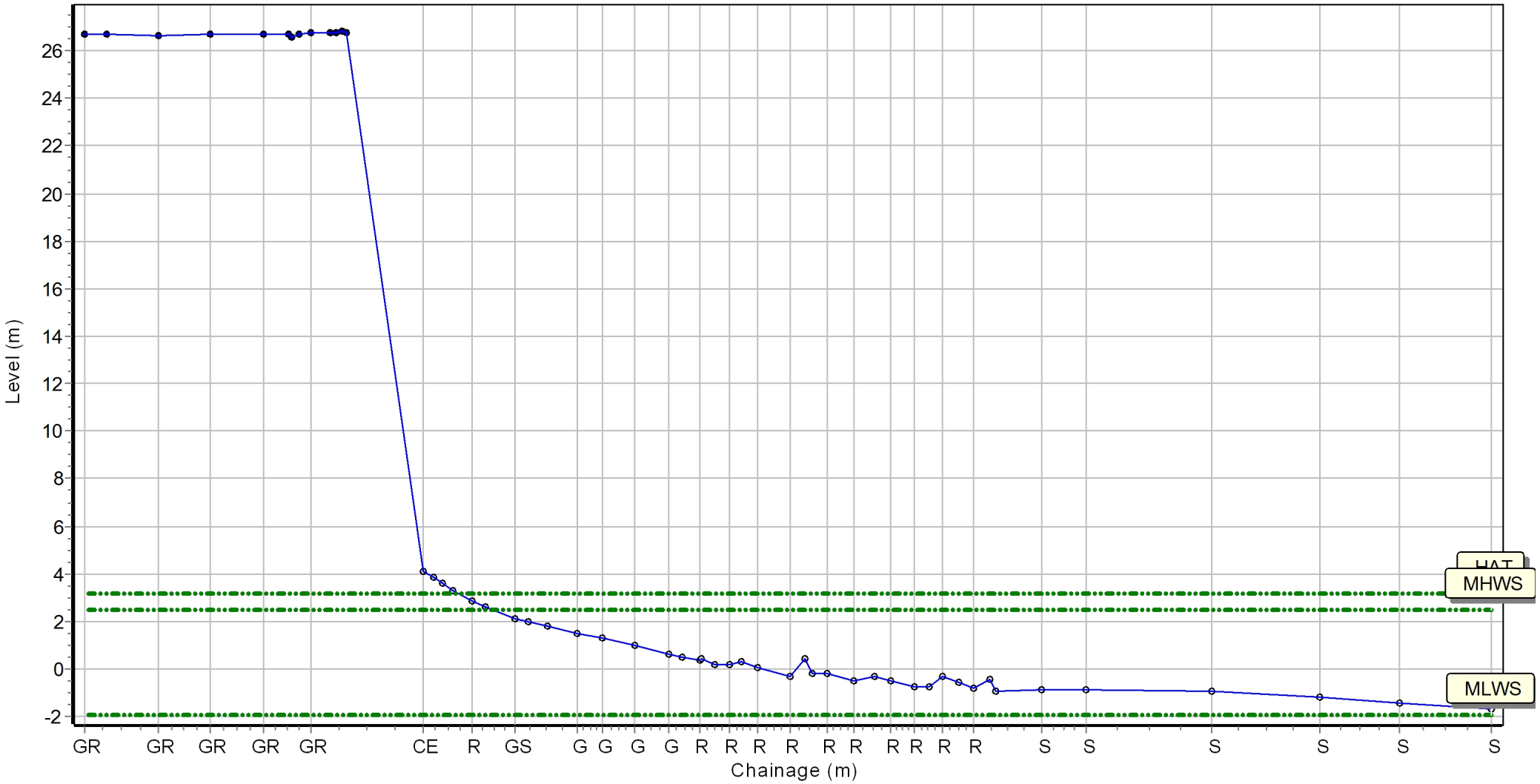
Location: **1bSNS21**

Date: 16/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 441410.506 **Northing:** 553455.364 **Profile Bearing:** 75 ° from North



Beach Profile

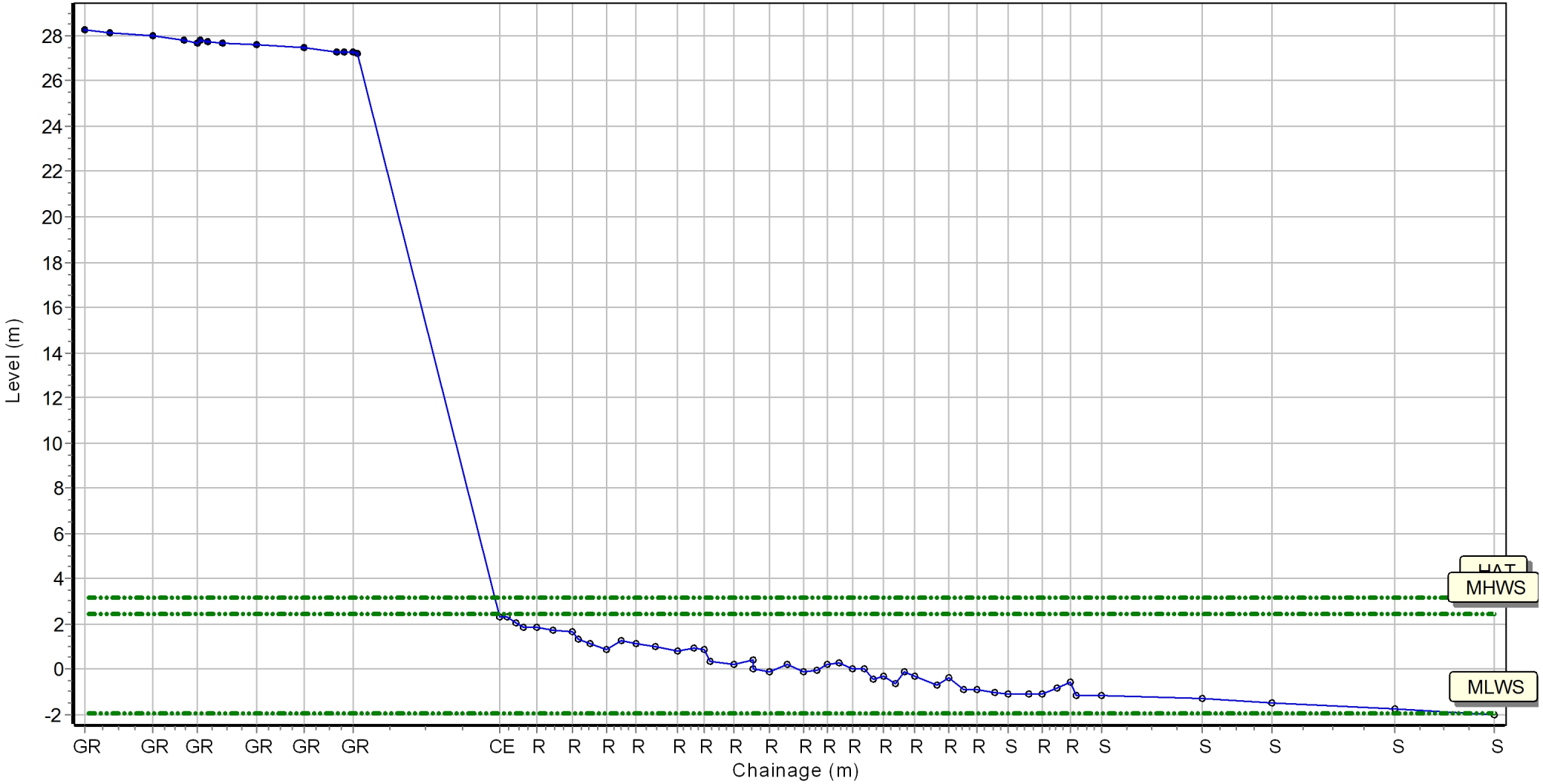
Location: **1bSNS22**

Date: 16/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 441474.364 **Northing:** 553262.39 **Profile Bearing:** 72 ° from North



Beach Profile

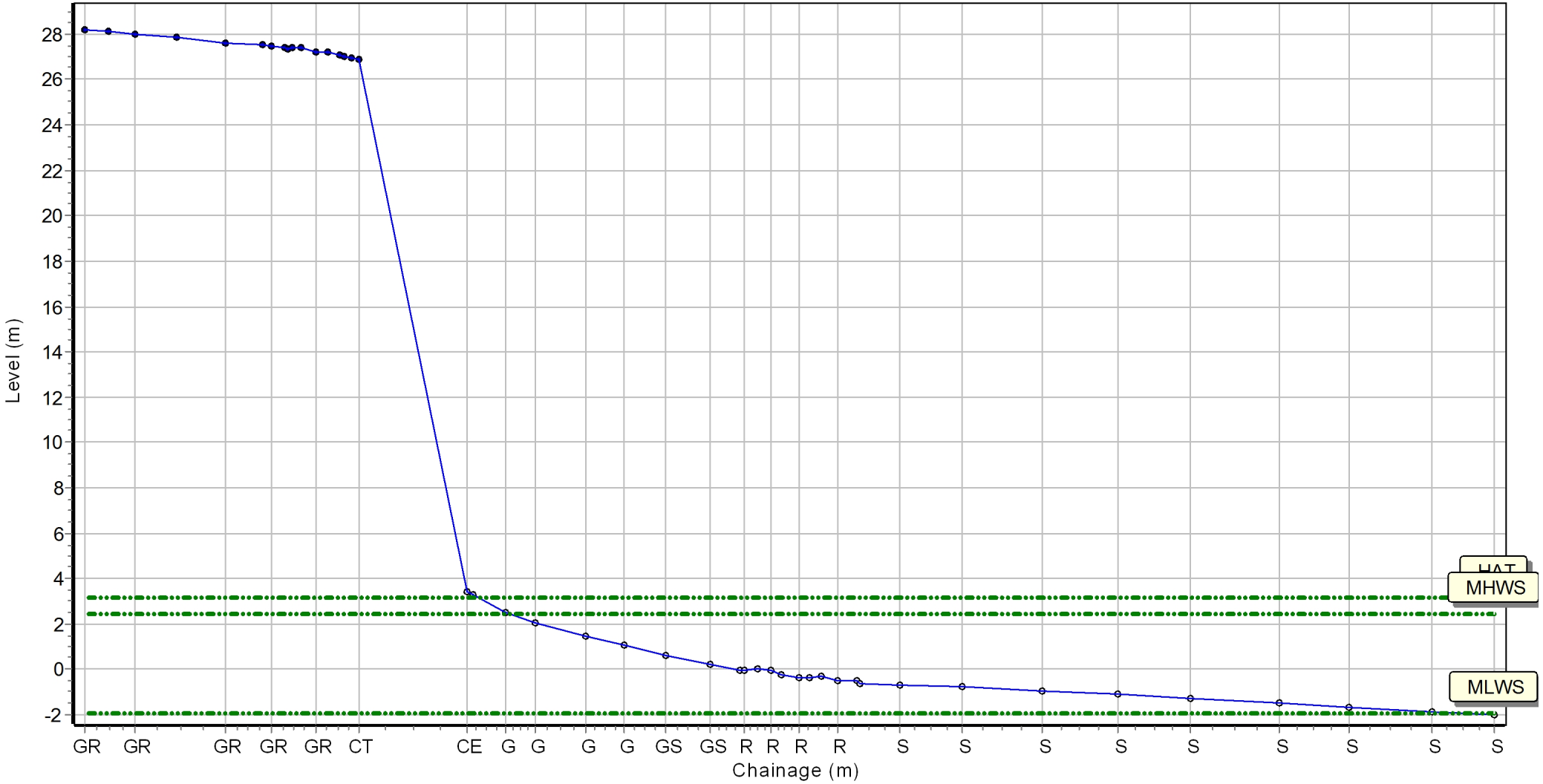
Location: **1bSNS23**

Date: 16/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 441513.099 **Northing:** 553157.01 **Profile Bearing:** 71 ° from North



Beach Profile

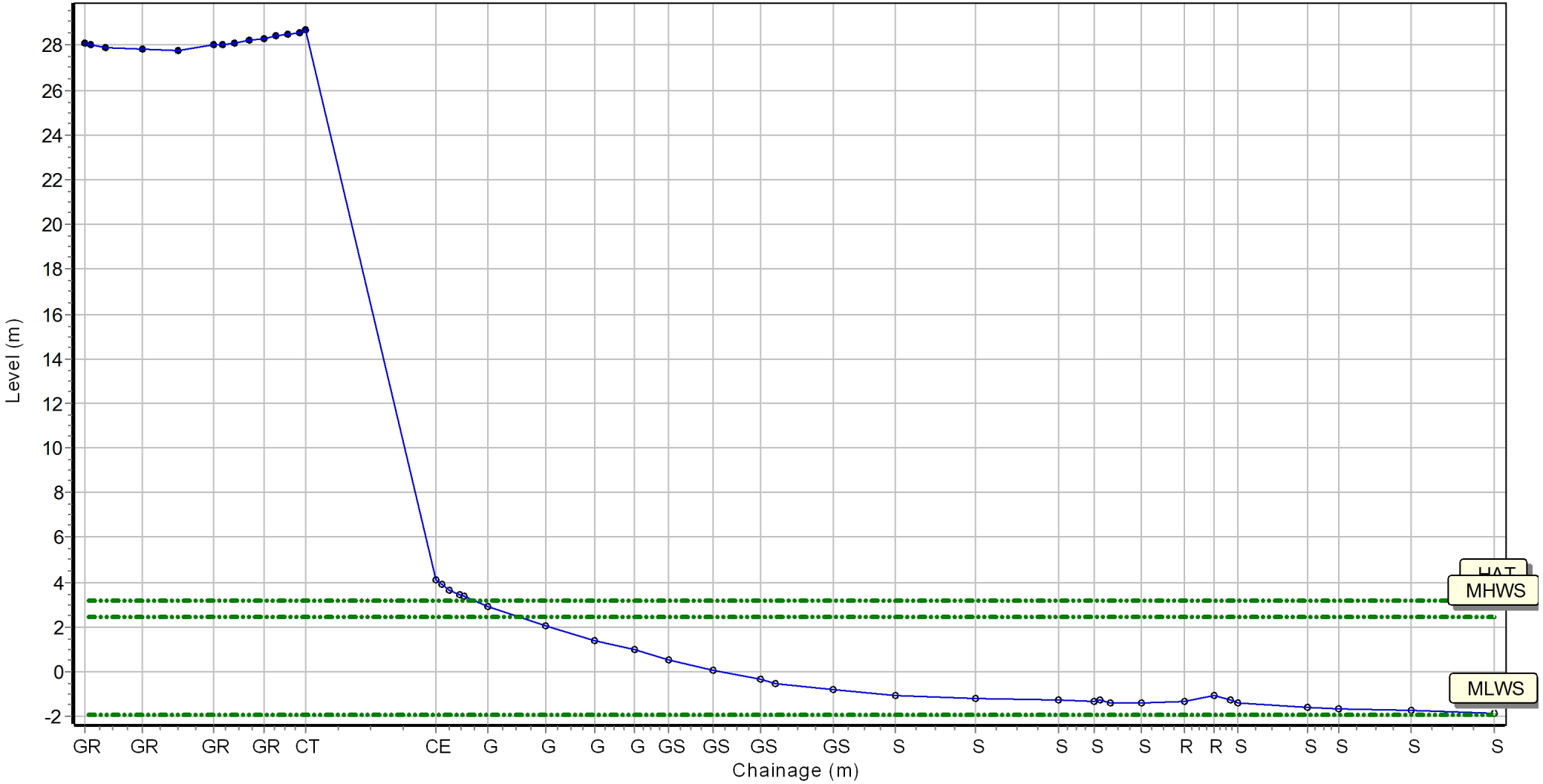
Location: **1bSNS24**

Date: 16/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 441605.914 **Northing:** 552855.516 **Profile Bearing:** 68 ° from North



Beach Profile

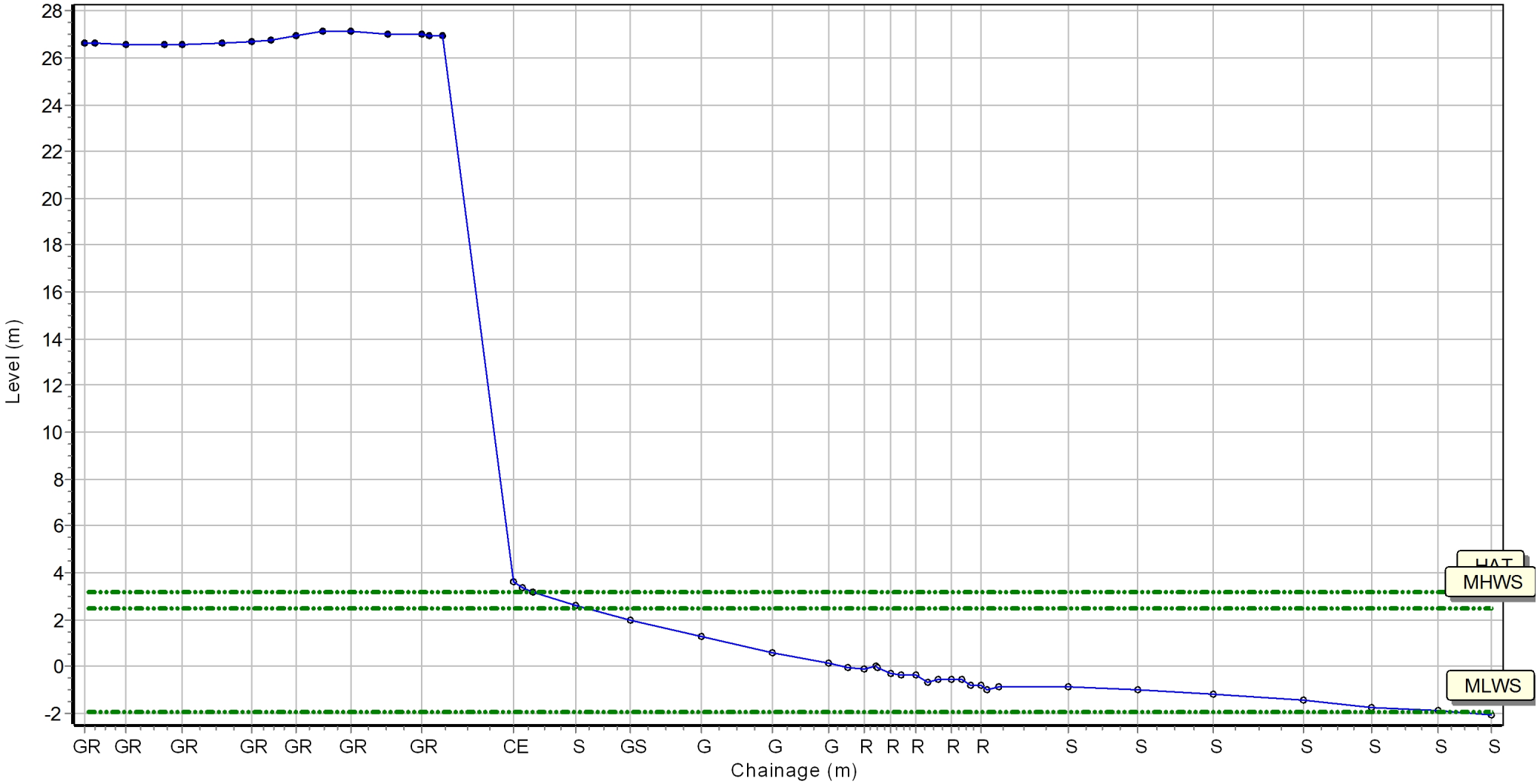
Location: **1bSNS25**

Date: 16/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 441740.614 **Northing:** 552616.135 **Profile Bearing:** 64 ° from North



Beach Profile

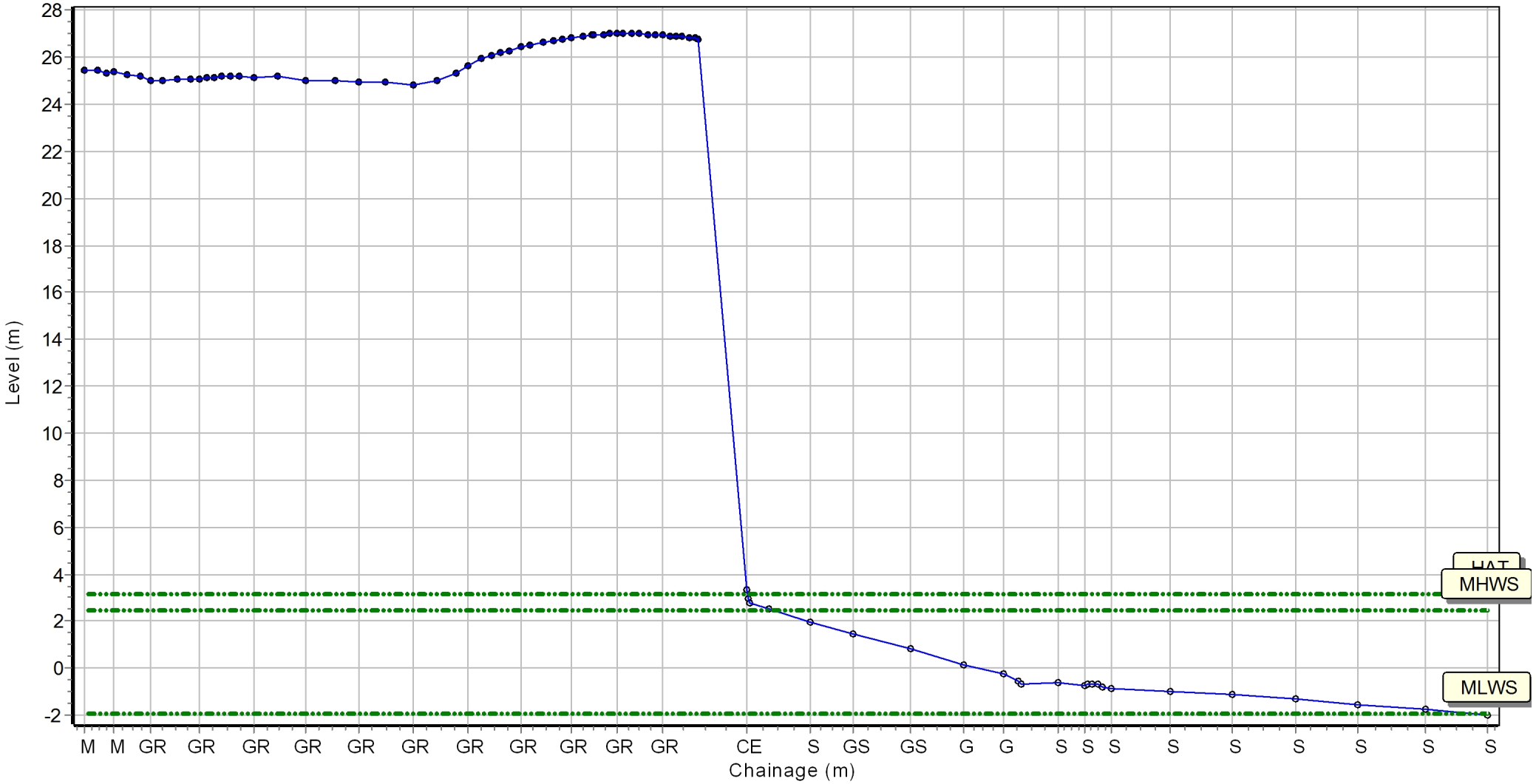
Location: **1bSNS26**

Date: 16/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 441726.053 **Northing:** 552563.41 **Profile Bearing:** 60 ° from North



Beach Profile

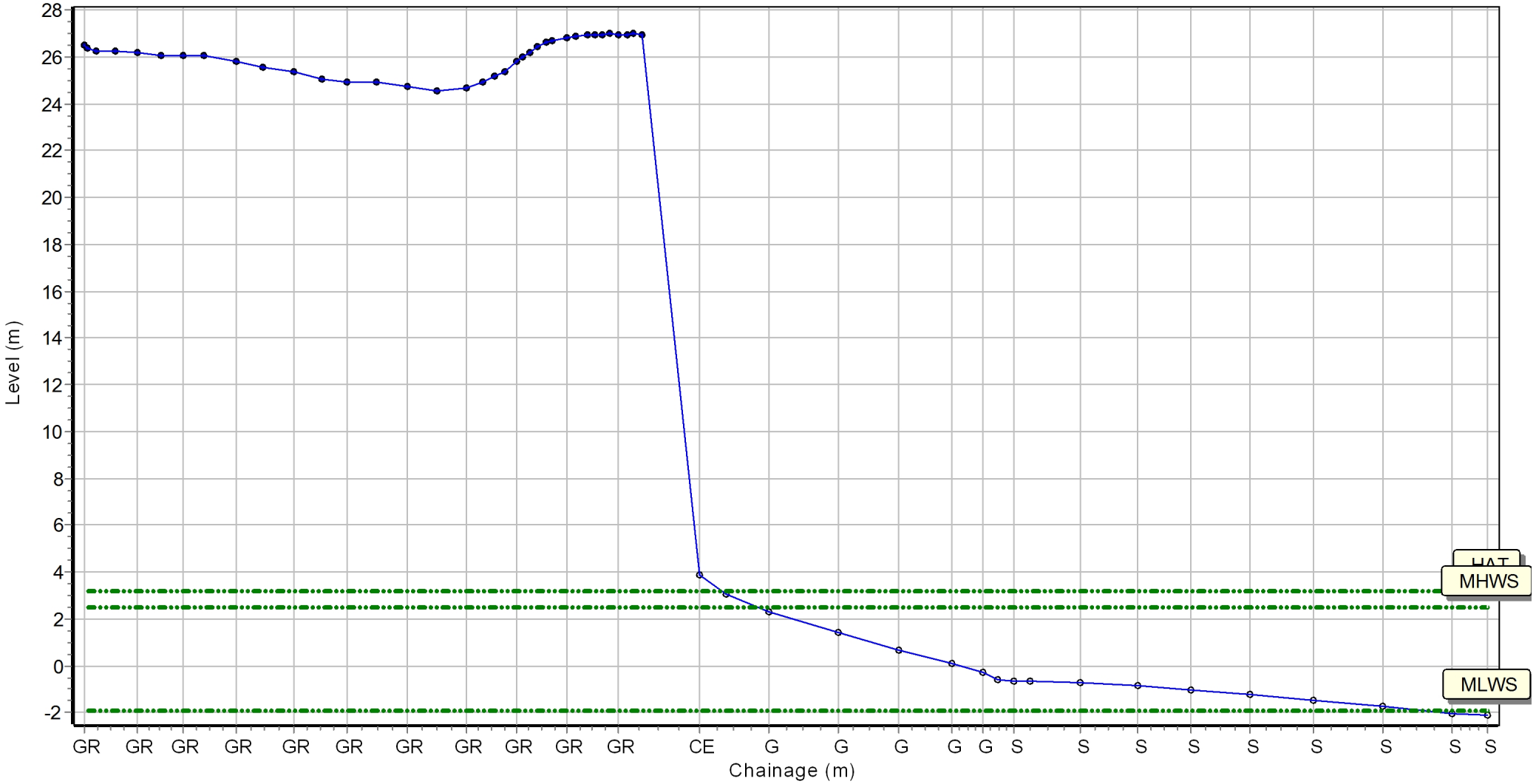
Location: **1bSNS27**

Date: 16/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 441733.63 **Northing:** 552550.463 **Profile Bearing:** 60 ° from North



Beach Profile

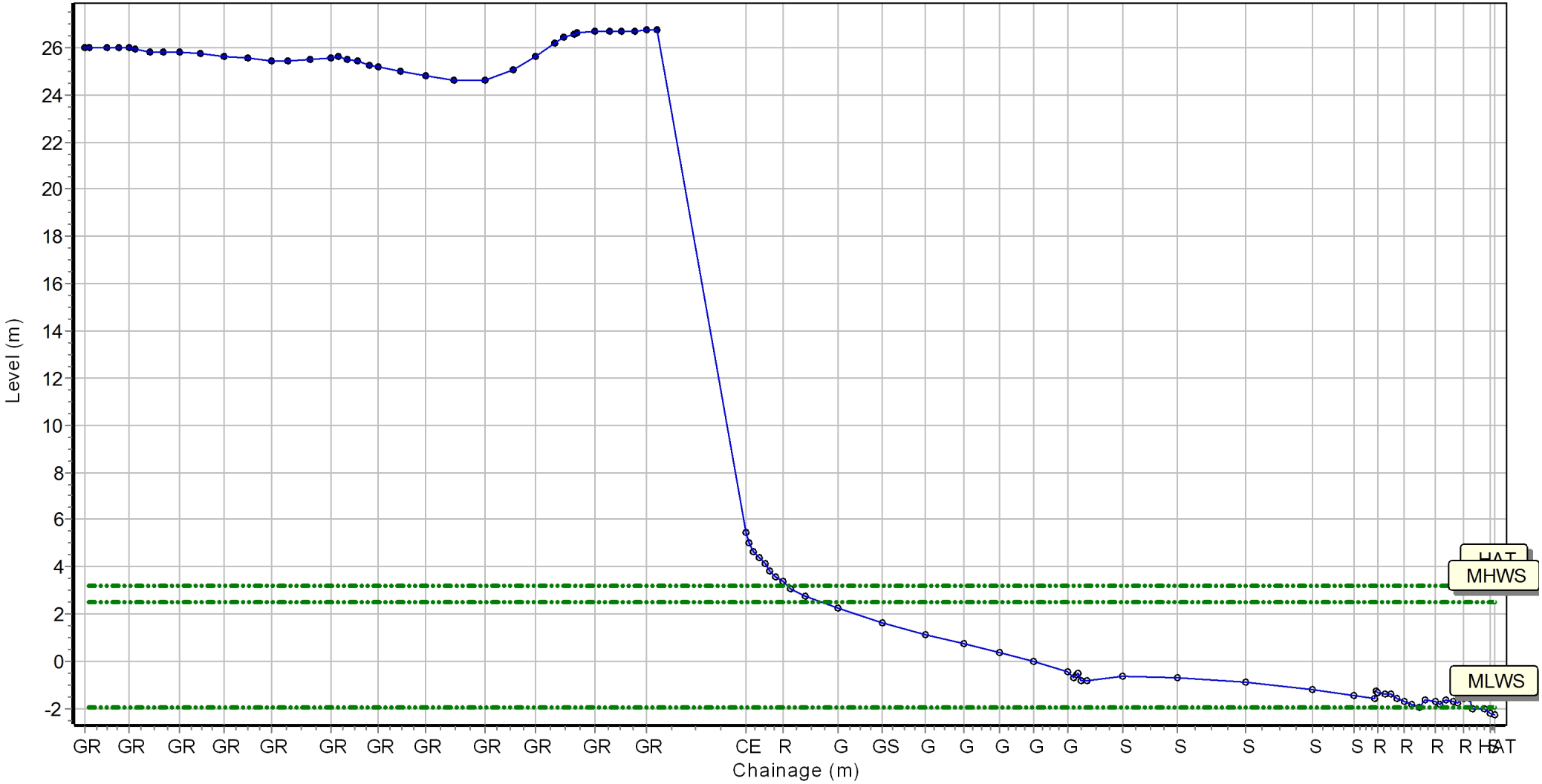
Location: **1bSNS28**

Date: 16/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 441741.207 **Northing:** 552537.517 **Profile Bearing:** 60 ° from North



Beach Profile

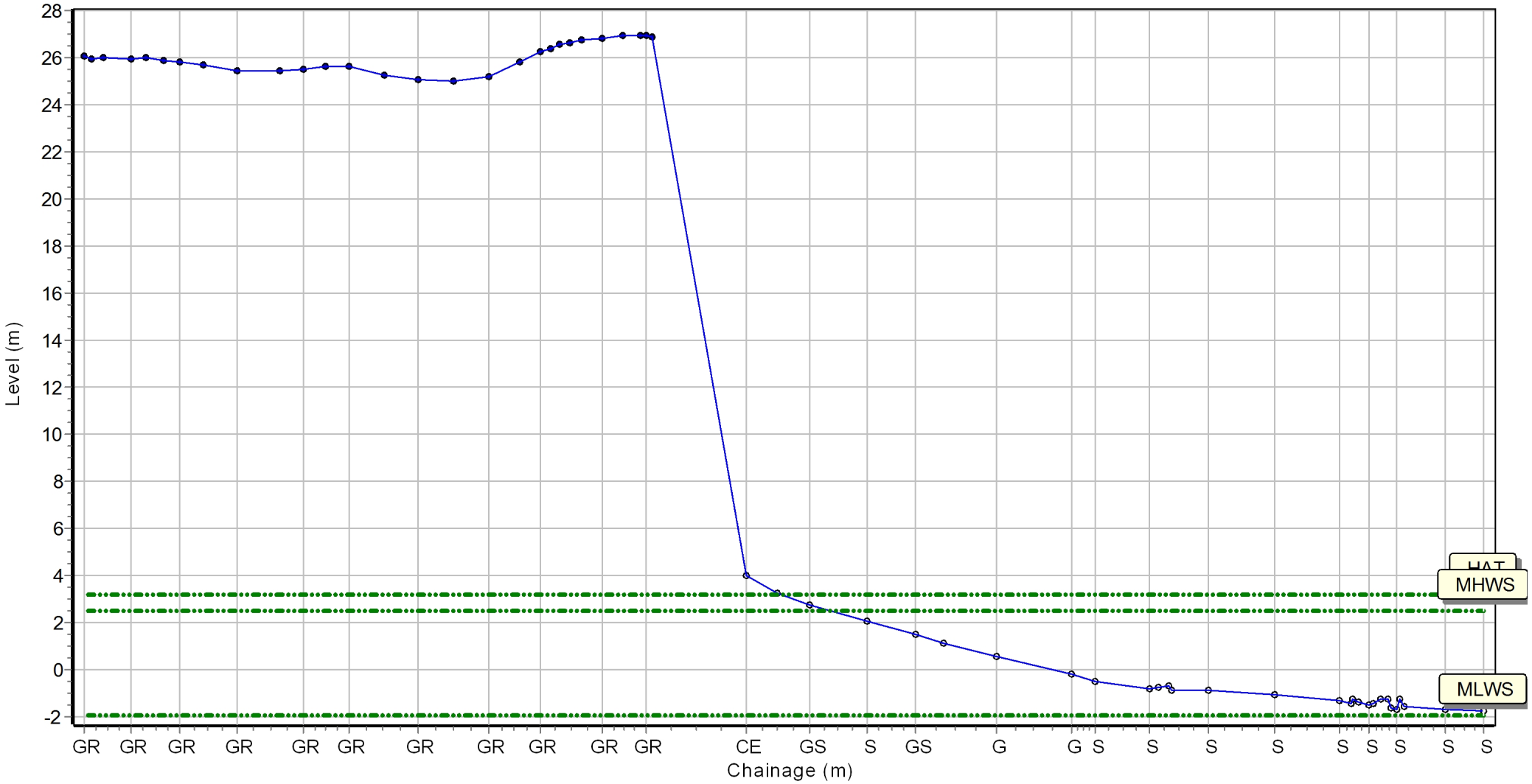
Location: **1bSNS29**

Date: 16/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 441748.776 **Northing:** 552524.571 **Profile Bearing:** 60 ° from North



Beach Profile

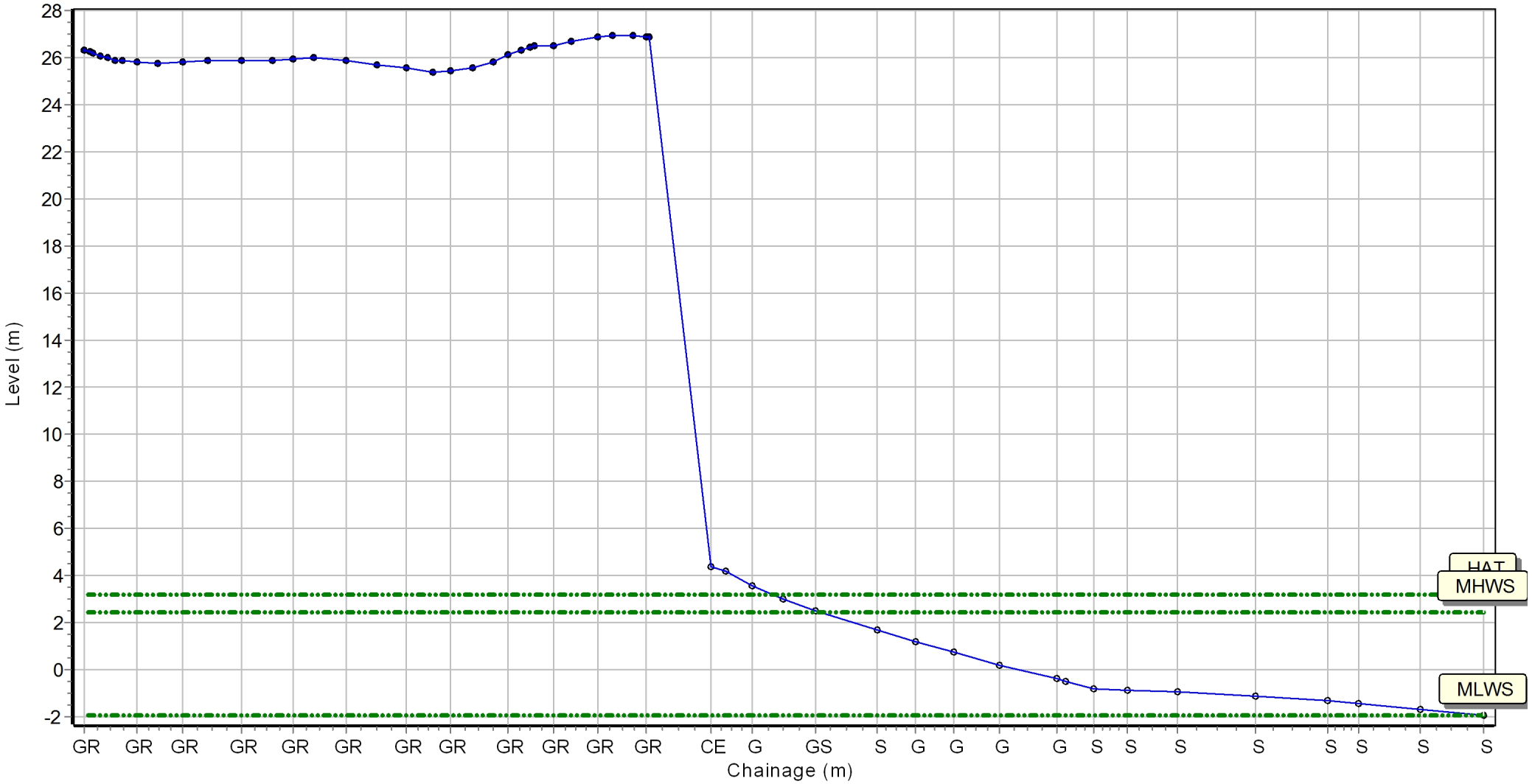
Location: **1bSNS30**

Date: 16/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 441756.353 **Northing:** 552511.624 **Profile Bearing:** 60 ° from North



Beach Profile

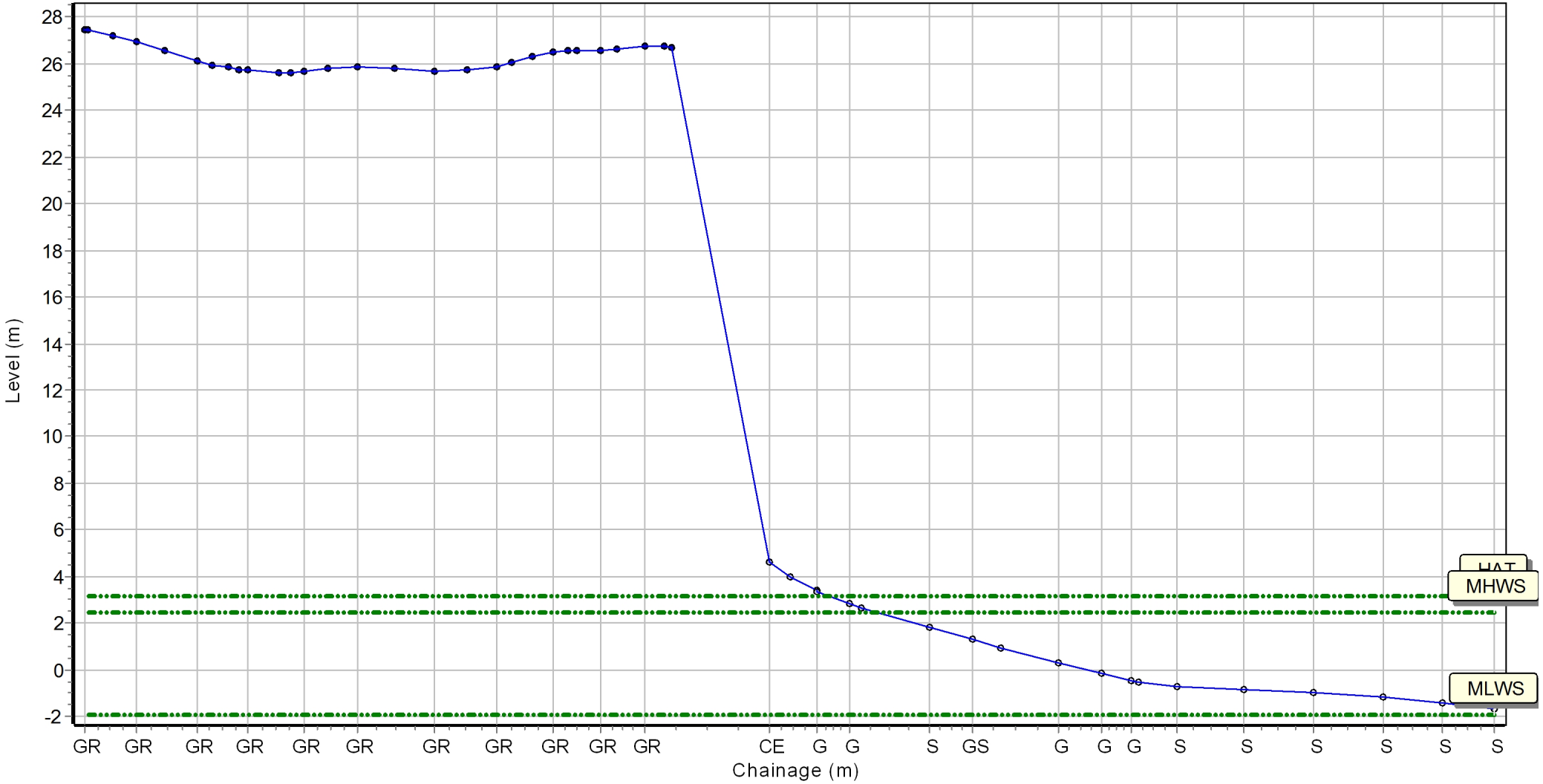
Location: **1bSNS31**

Date: 16/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 441763.931 **Northing:** 552498.678 **Profile Bearing:** 60 ° from North



Beach Profile

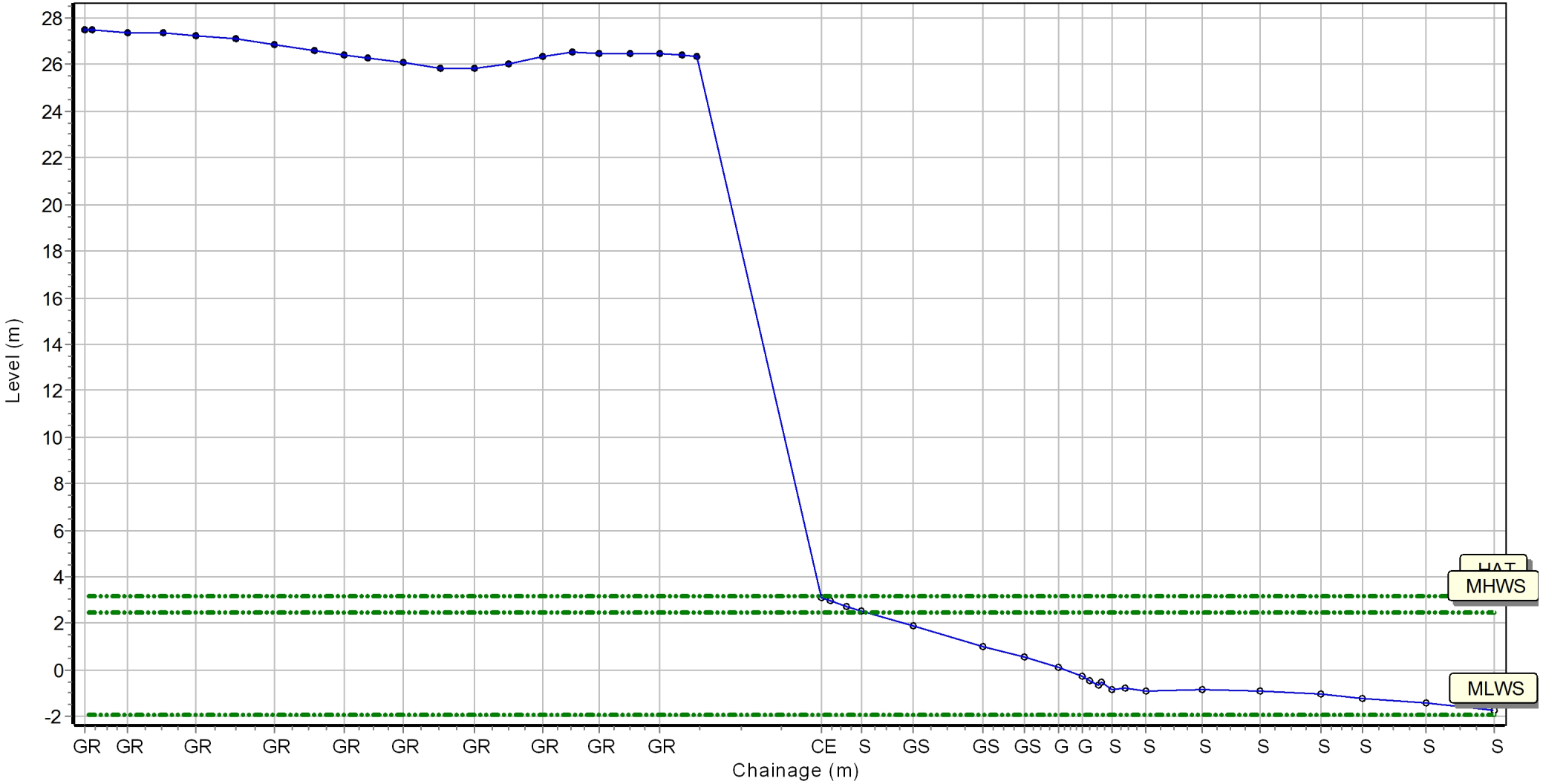
Location: **1bSNS32**

Date: 16/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 441771.5 **Northing:** 552485.732 **Profile Bearing:** 60 ° from North



Beach Profile

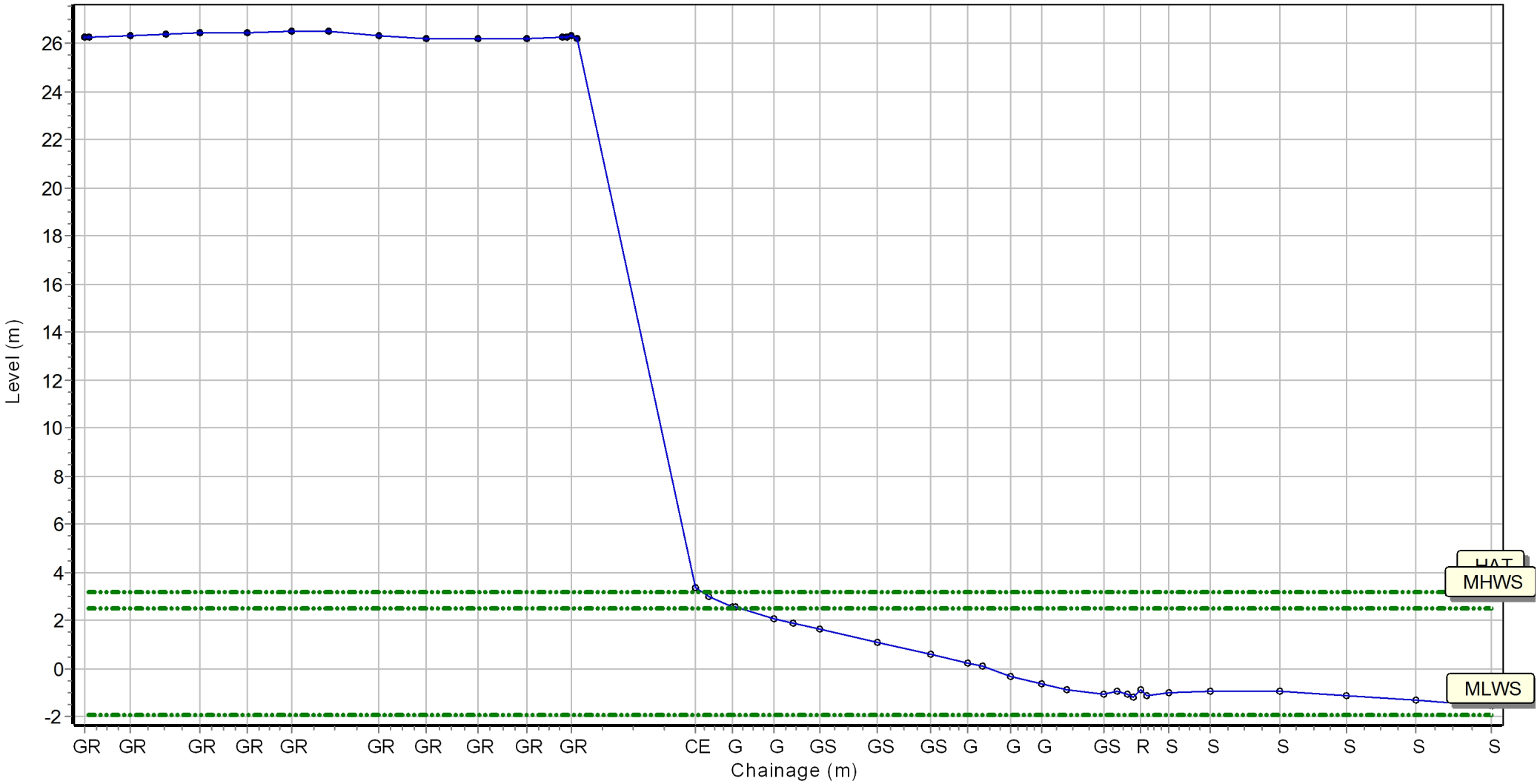
Location: **1bSNS33**

Date: 16/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 441841.104 **Northing:** 552454.571 **Profile Bearing:** 37 ° from North



Beach Profile

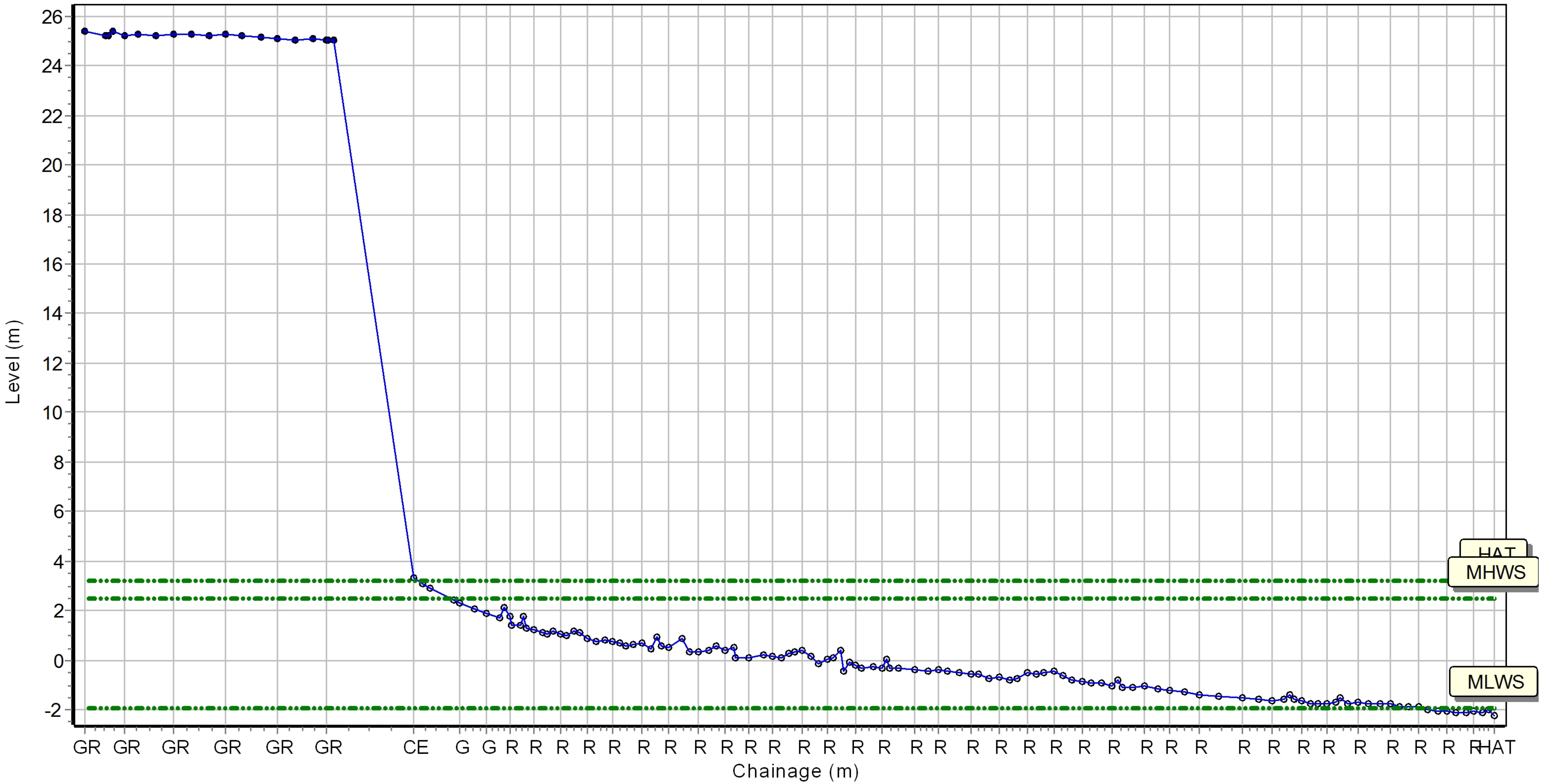
Location: **1bSNS34**

Date: 16/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 441901.161 **Northing:** 552284.09 **Profile Bearing:** 102 ° from North



Beach Profile

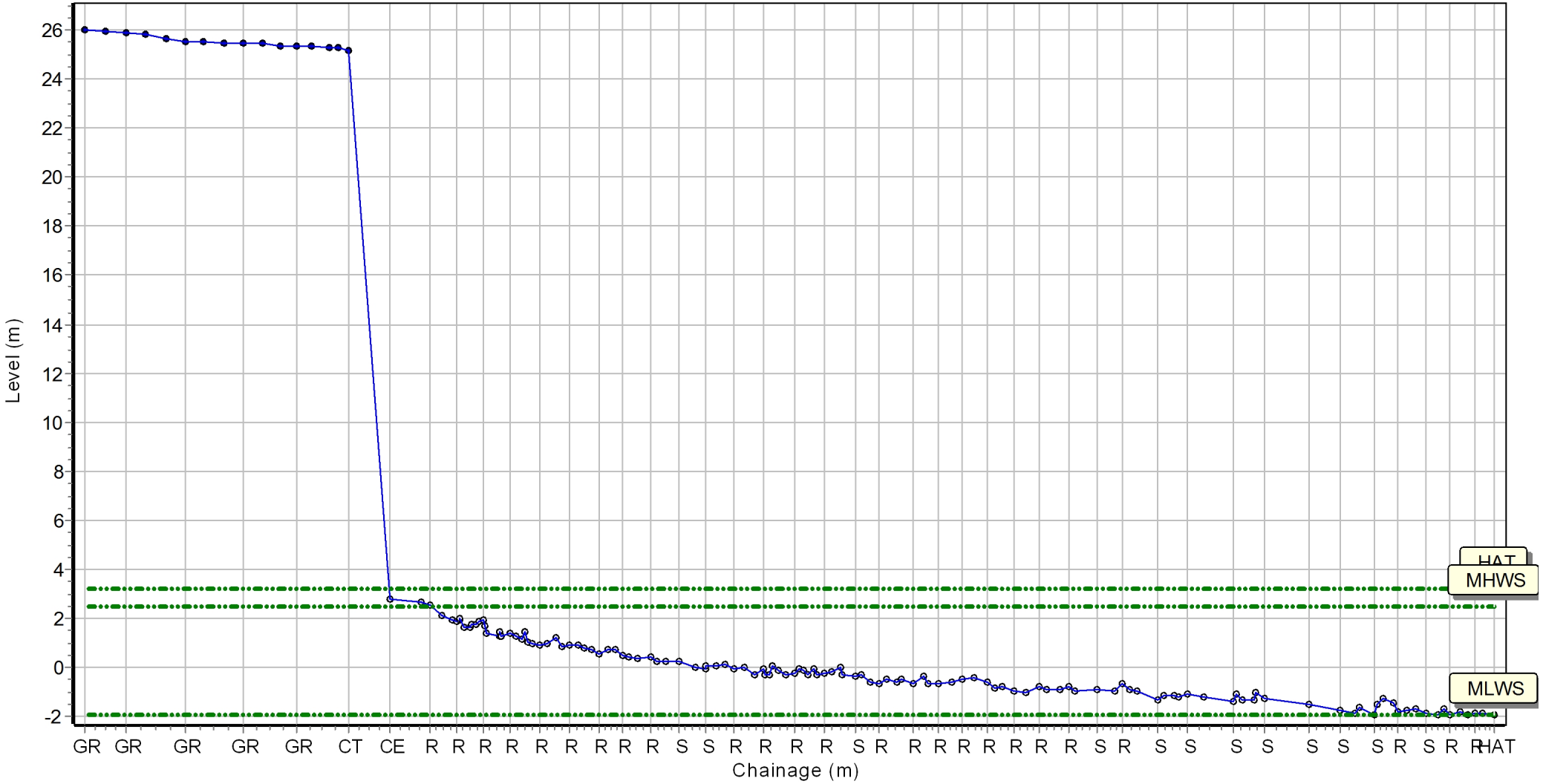
Location: **1bSNS35**

Date: 16/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 441844.023 **Northing:** 552163.994 **Profile Bearing:** 111 ° from North



Beach Profile

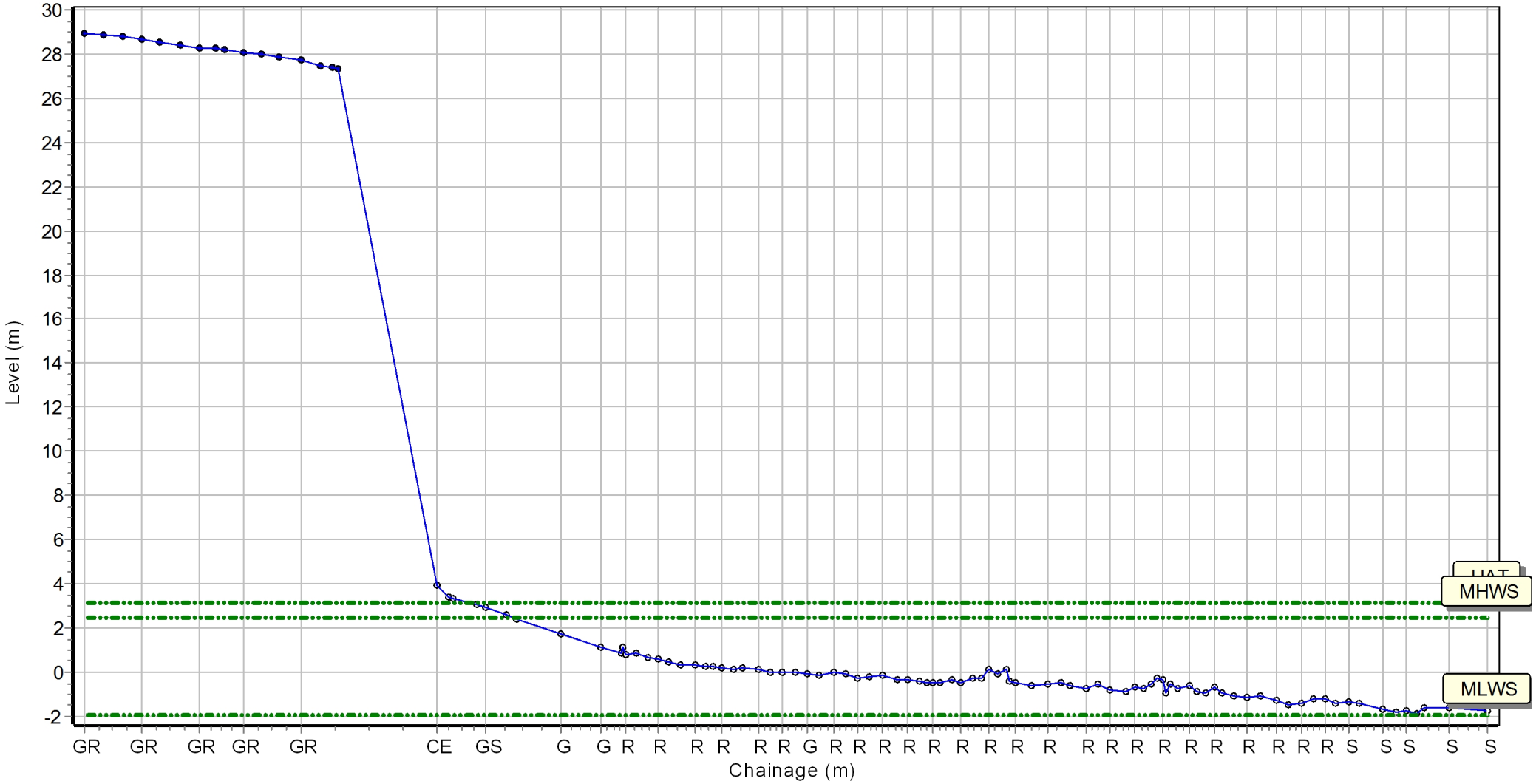
Location: **1bSNS36**

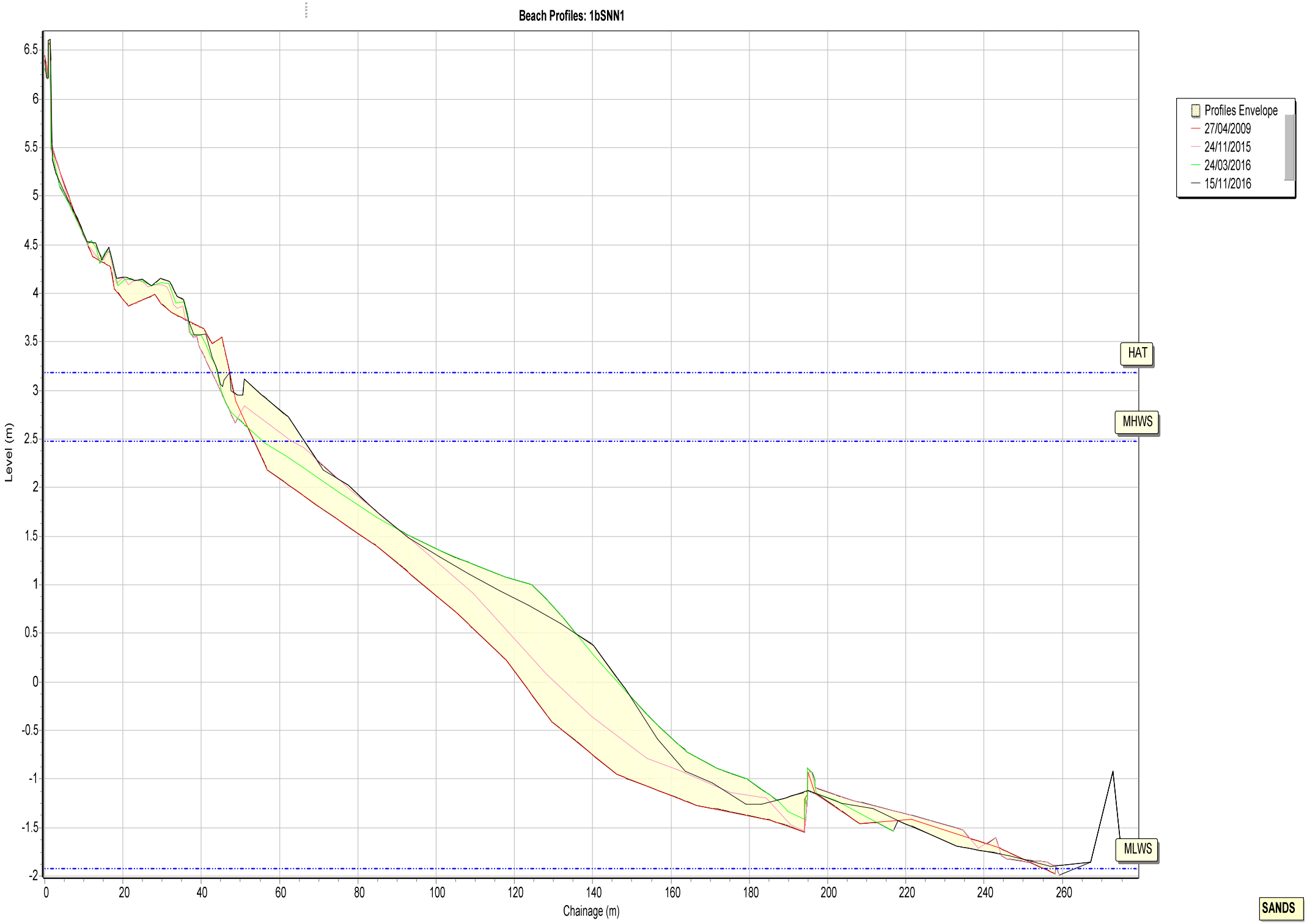
Date: 16/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 441853.315 **Northing:** 551983.836 **Profile Bearing:** 81 ° from North

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MLWS
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6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
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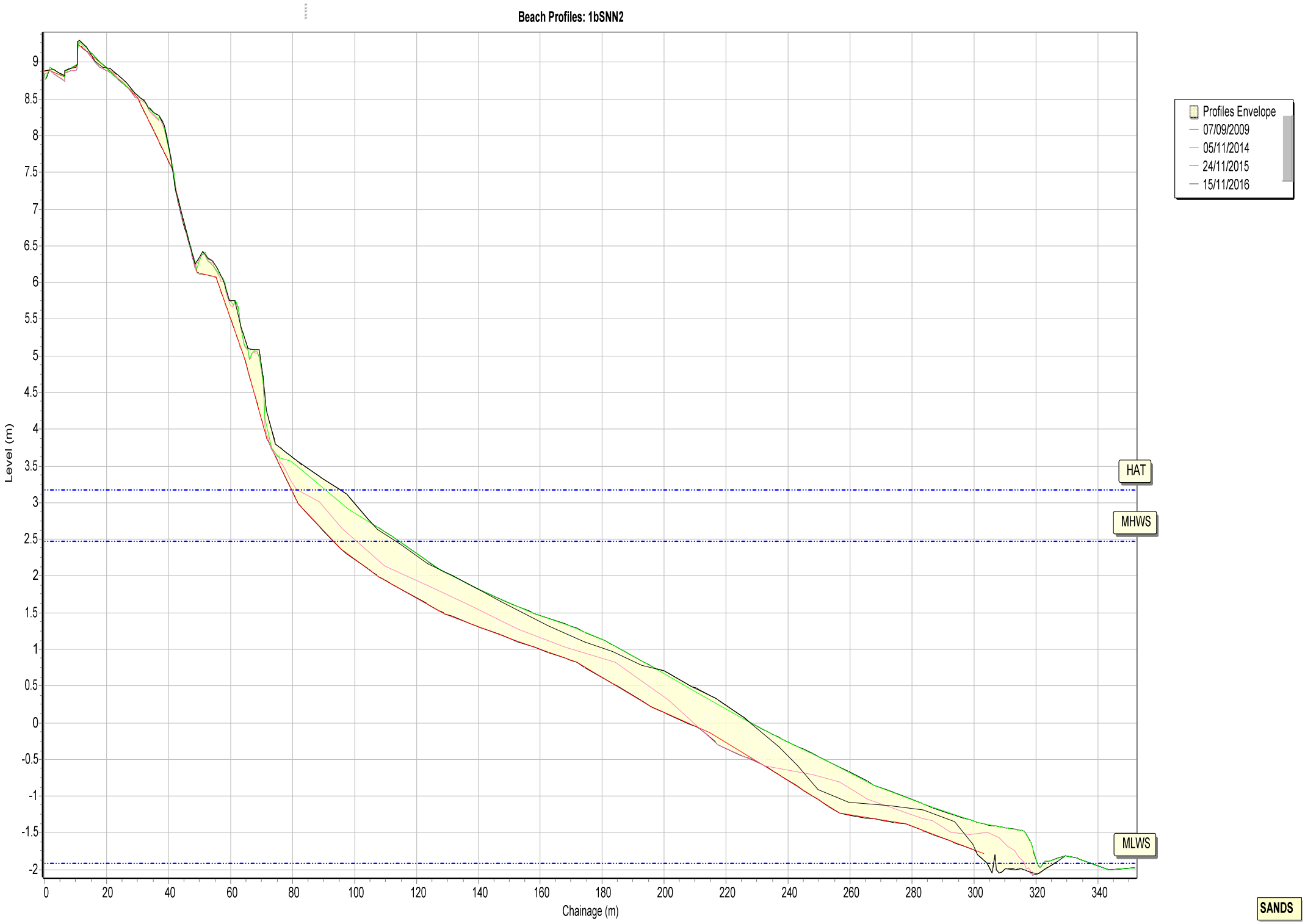
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7.5
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6.5
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5.5
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3.5
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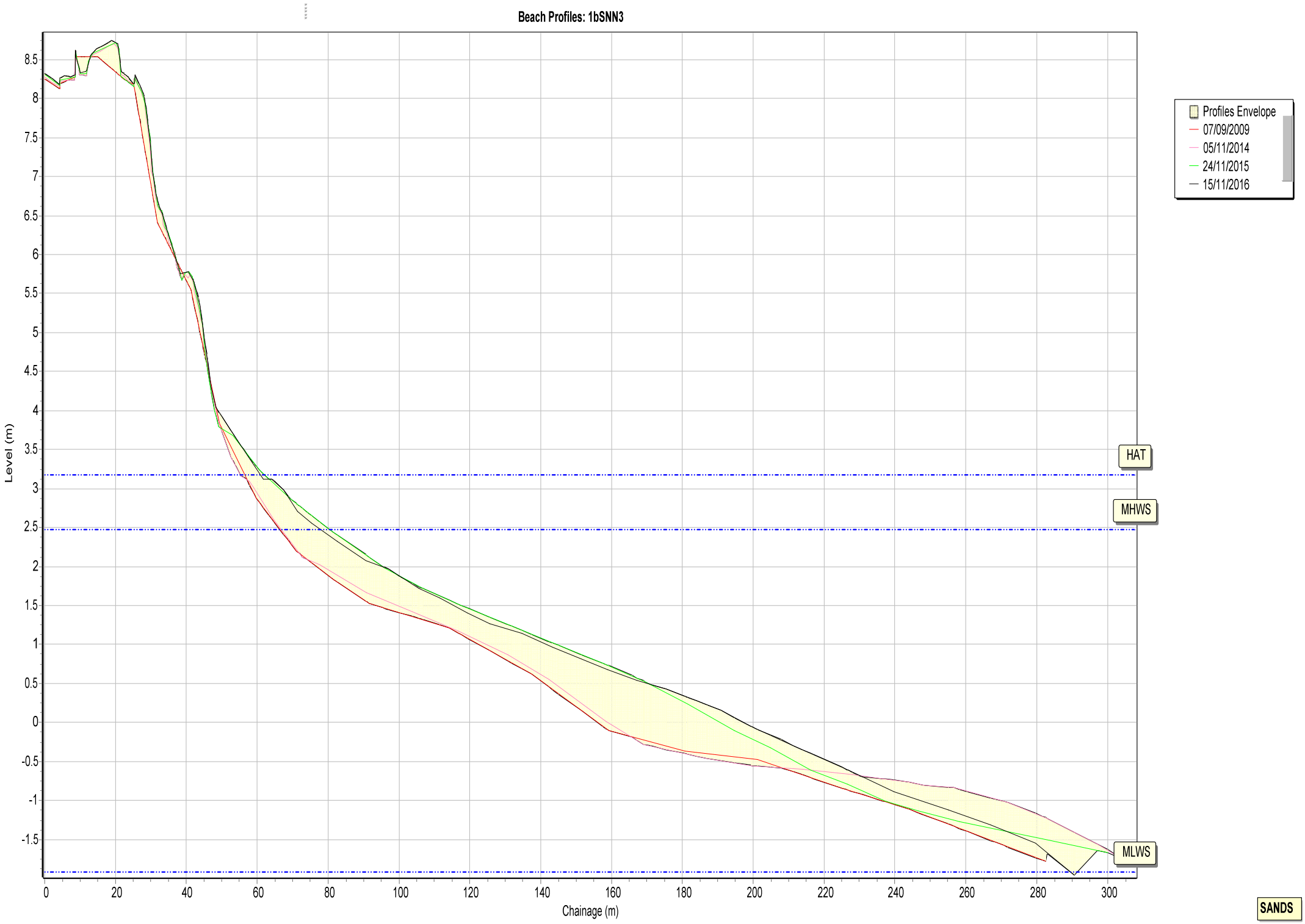
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6.5
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5.5
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4.5
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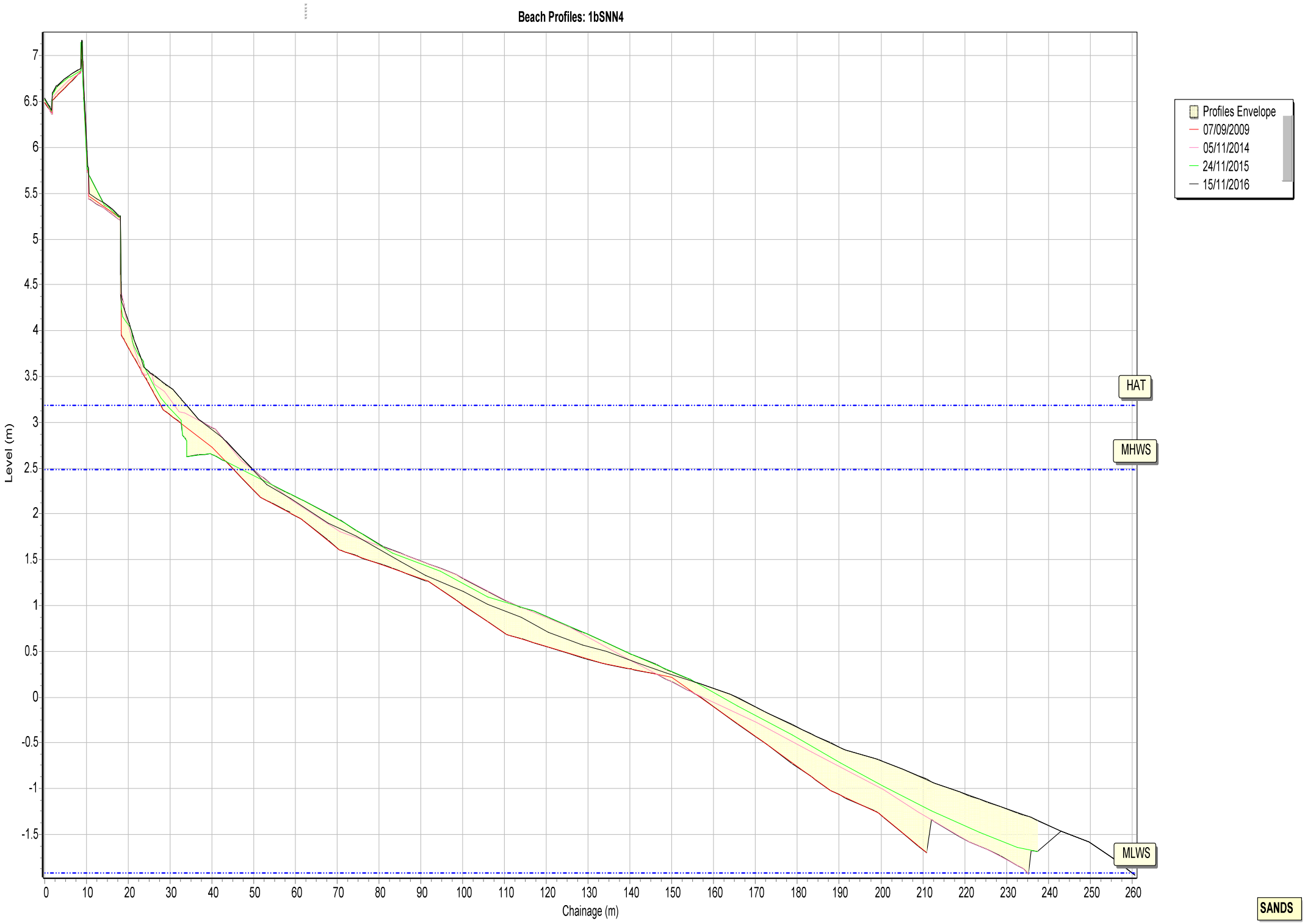
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Chainage (m)
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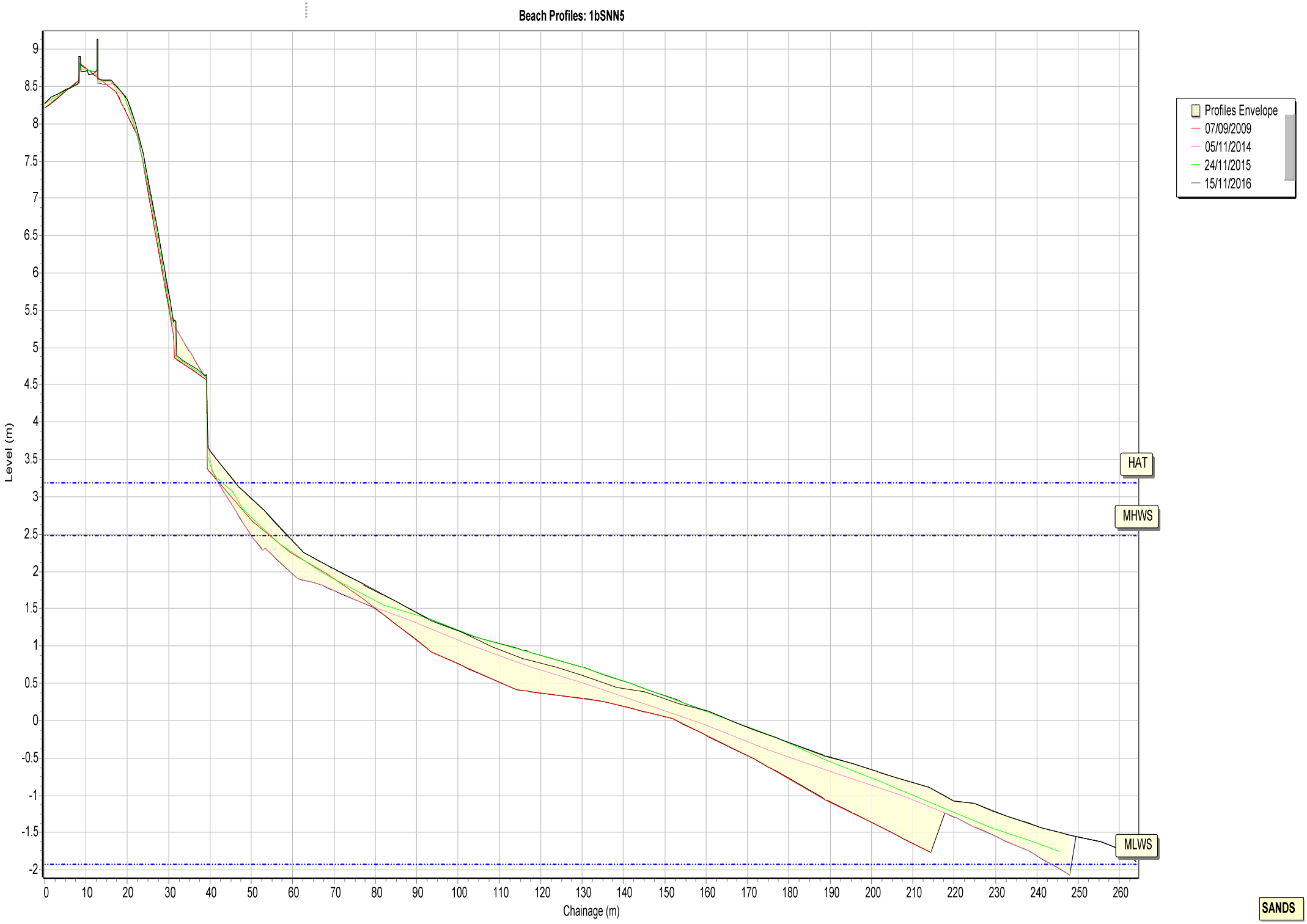
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MLWS
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Chainage (m)
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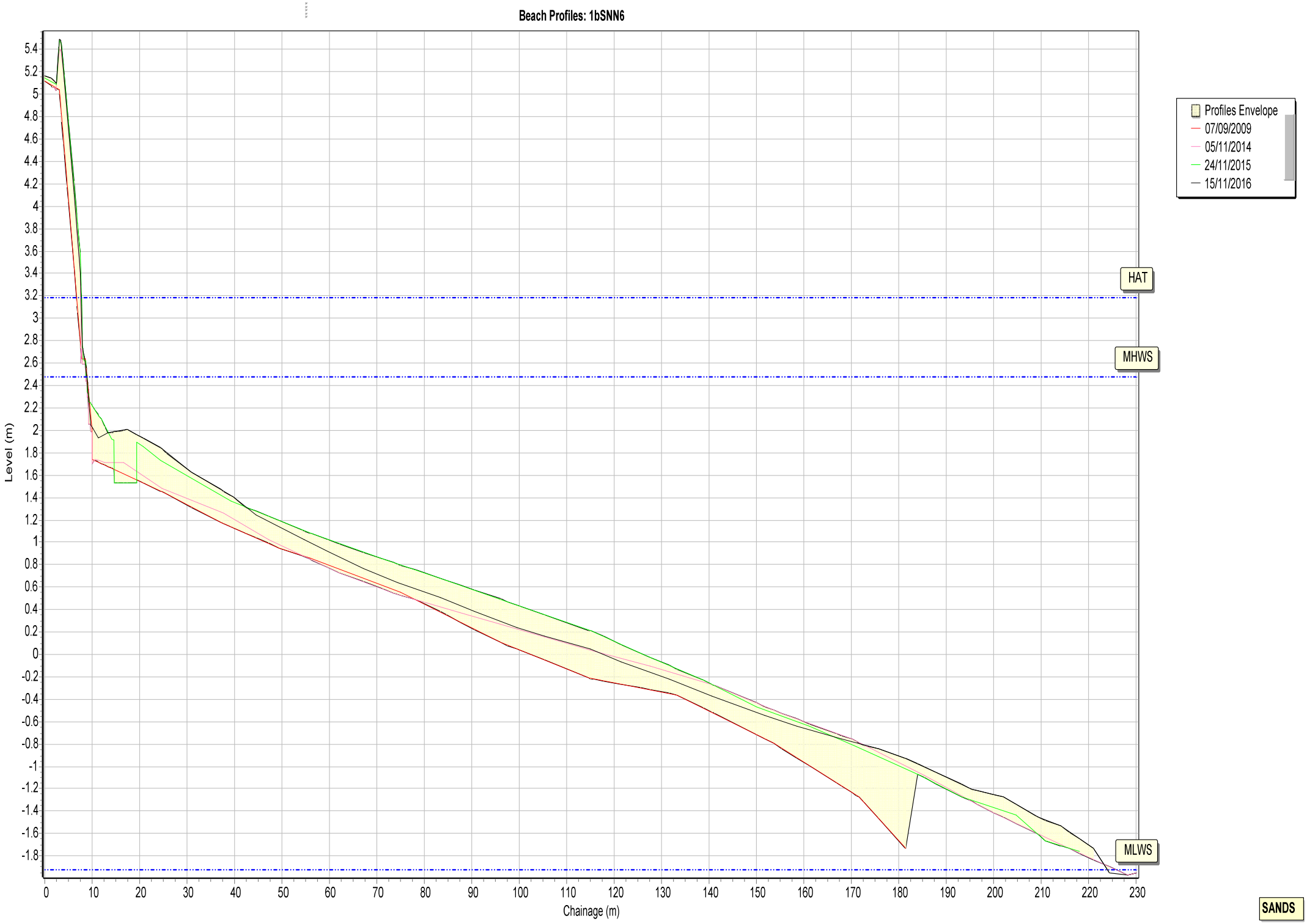
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Chainage (m)
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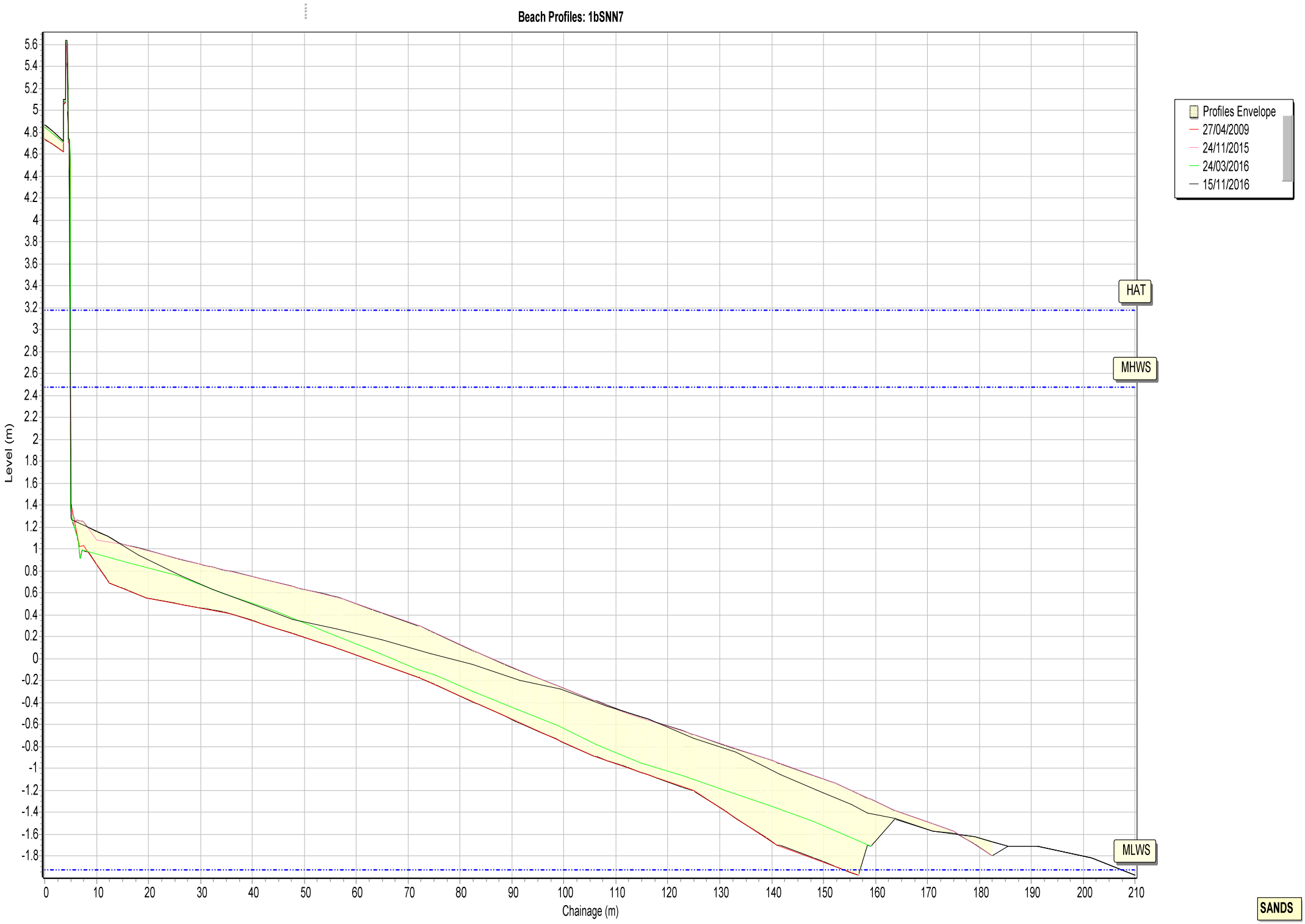
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Chainage (m)
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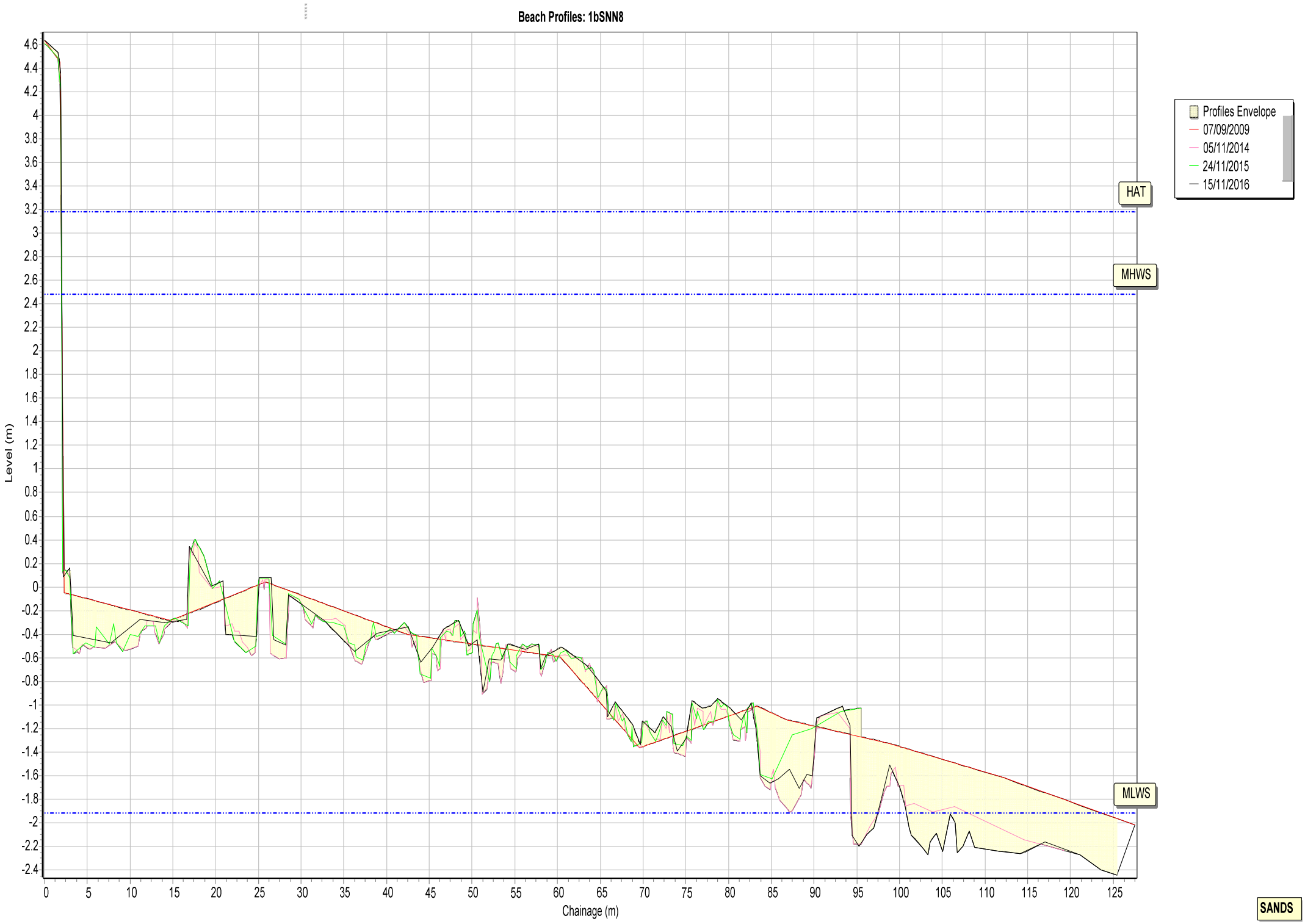
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MLWS
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Chainage (m)
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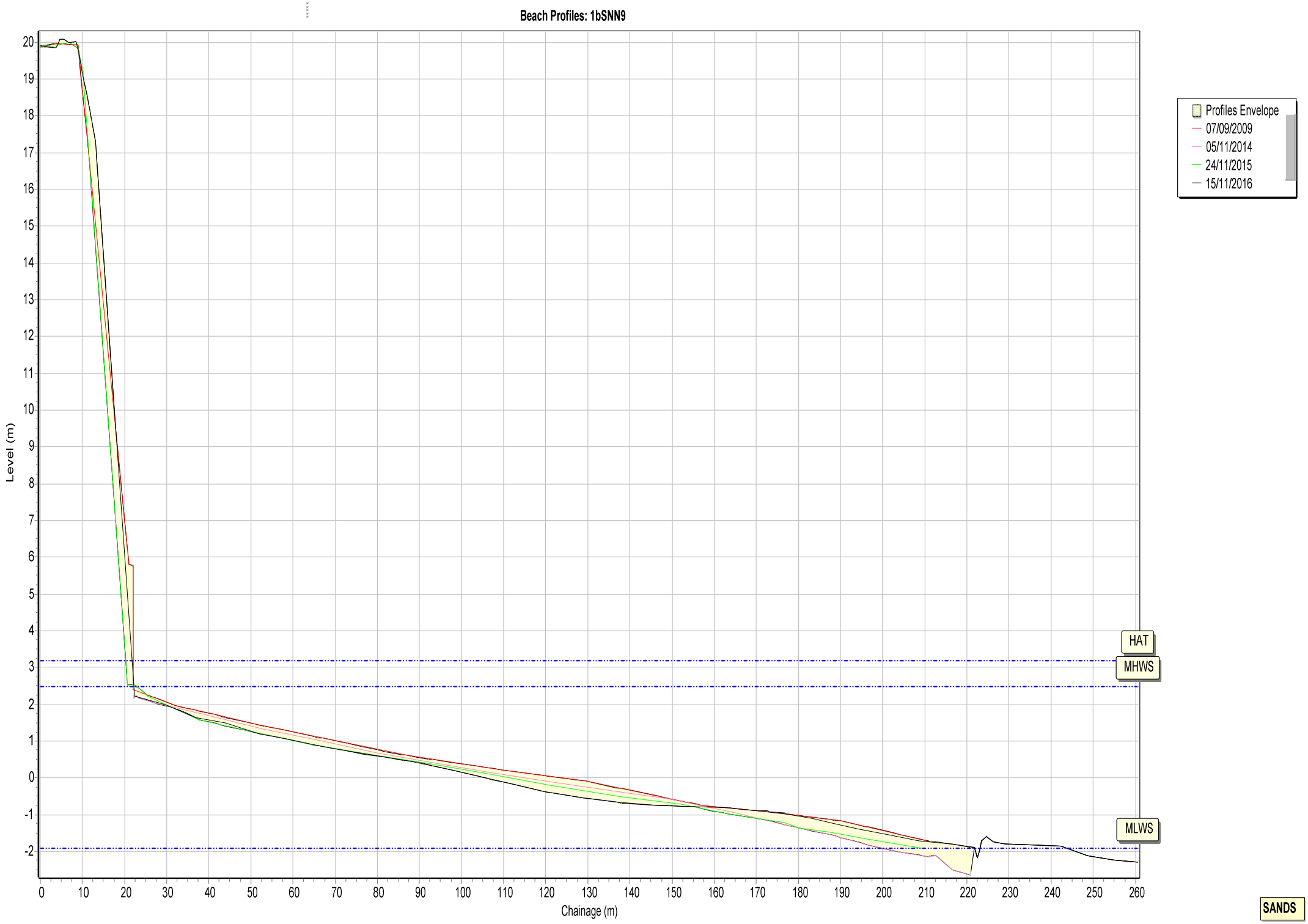
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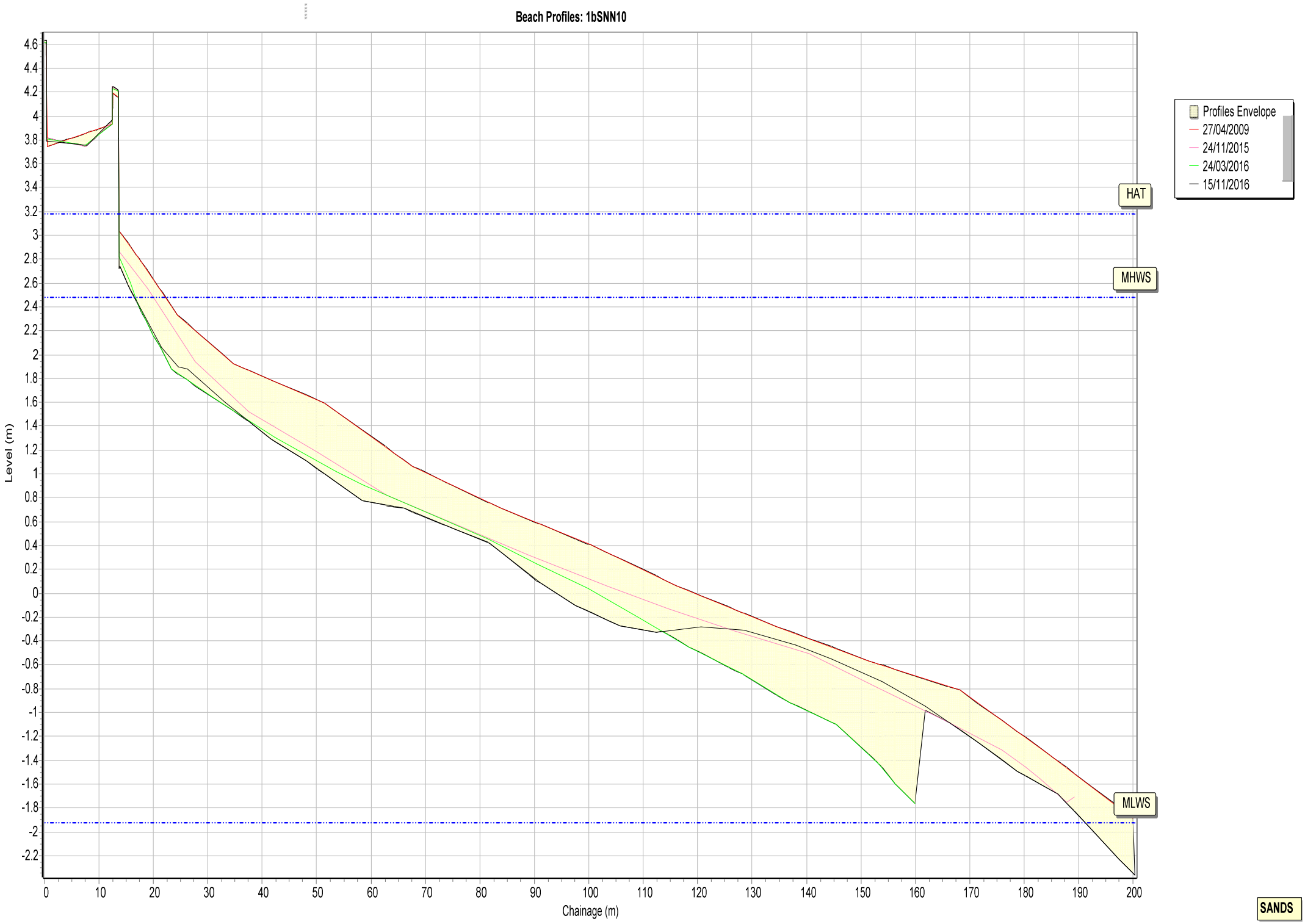
Chainage (m)
SANDS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Chainage (m)
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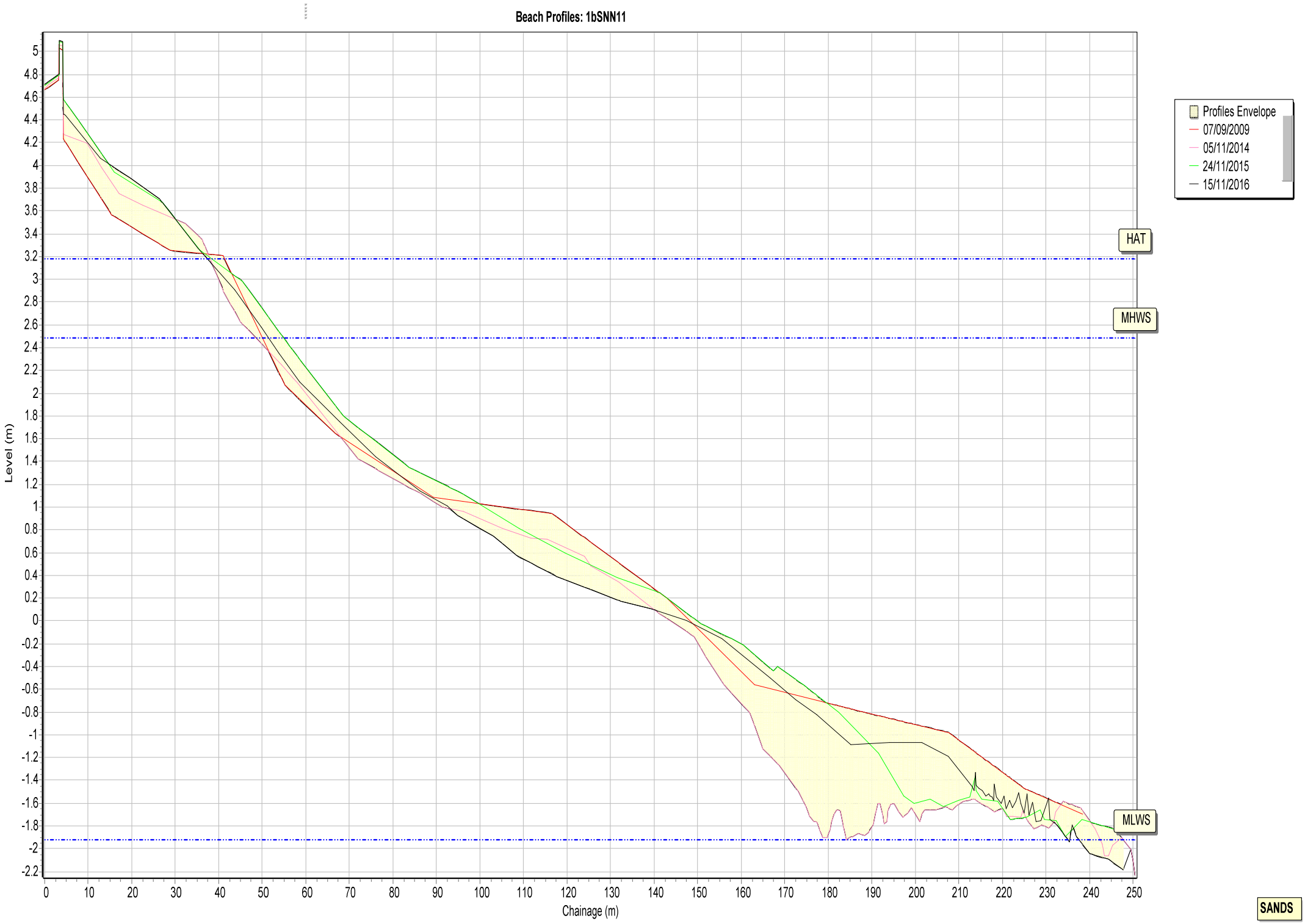
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MHWS
MLWS
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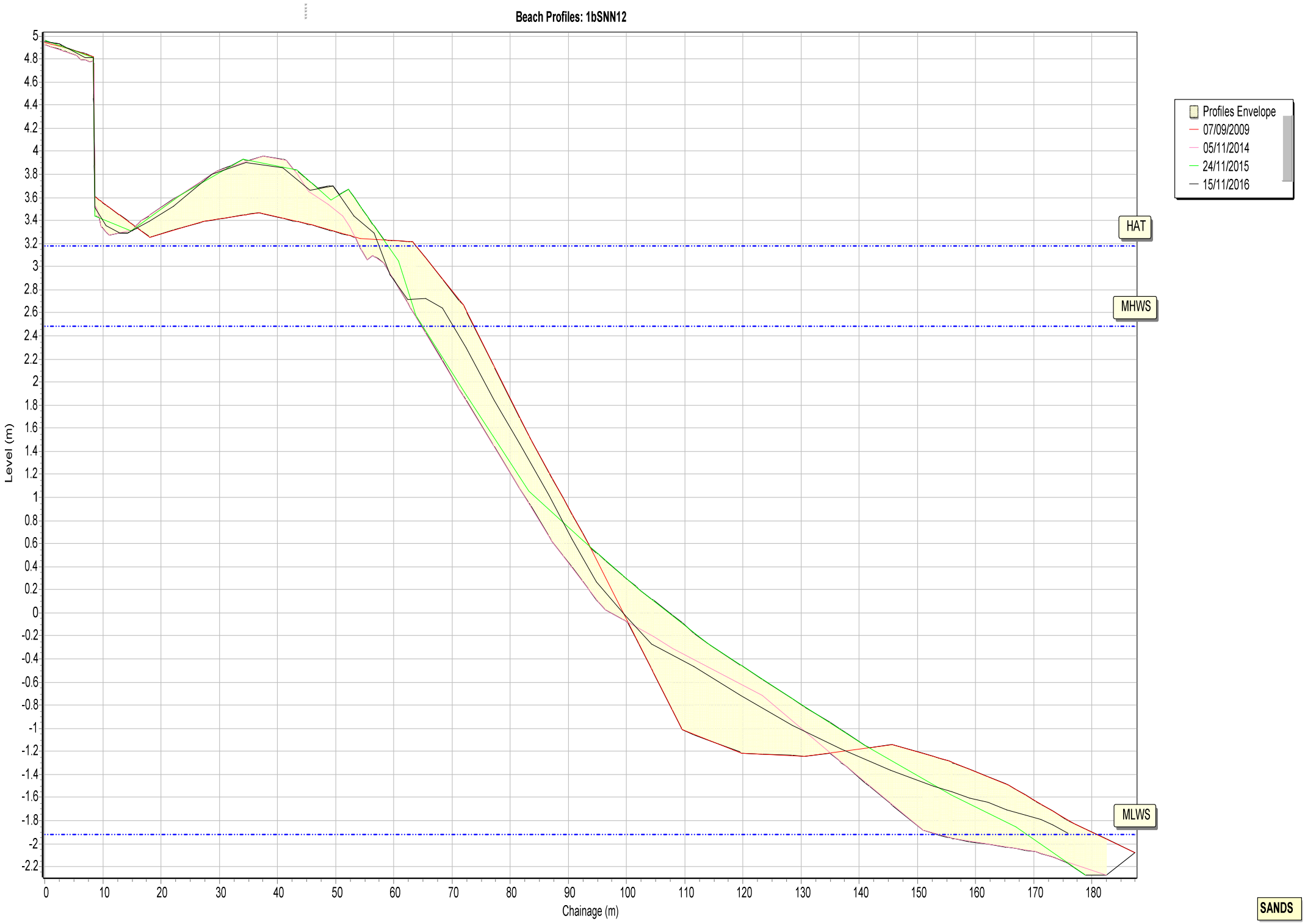
Chainage (m)
SANDS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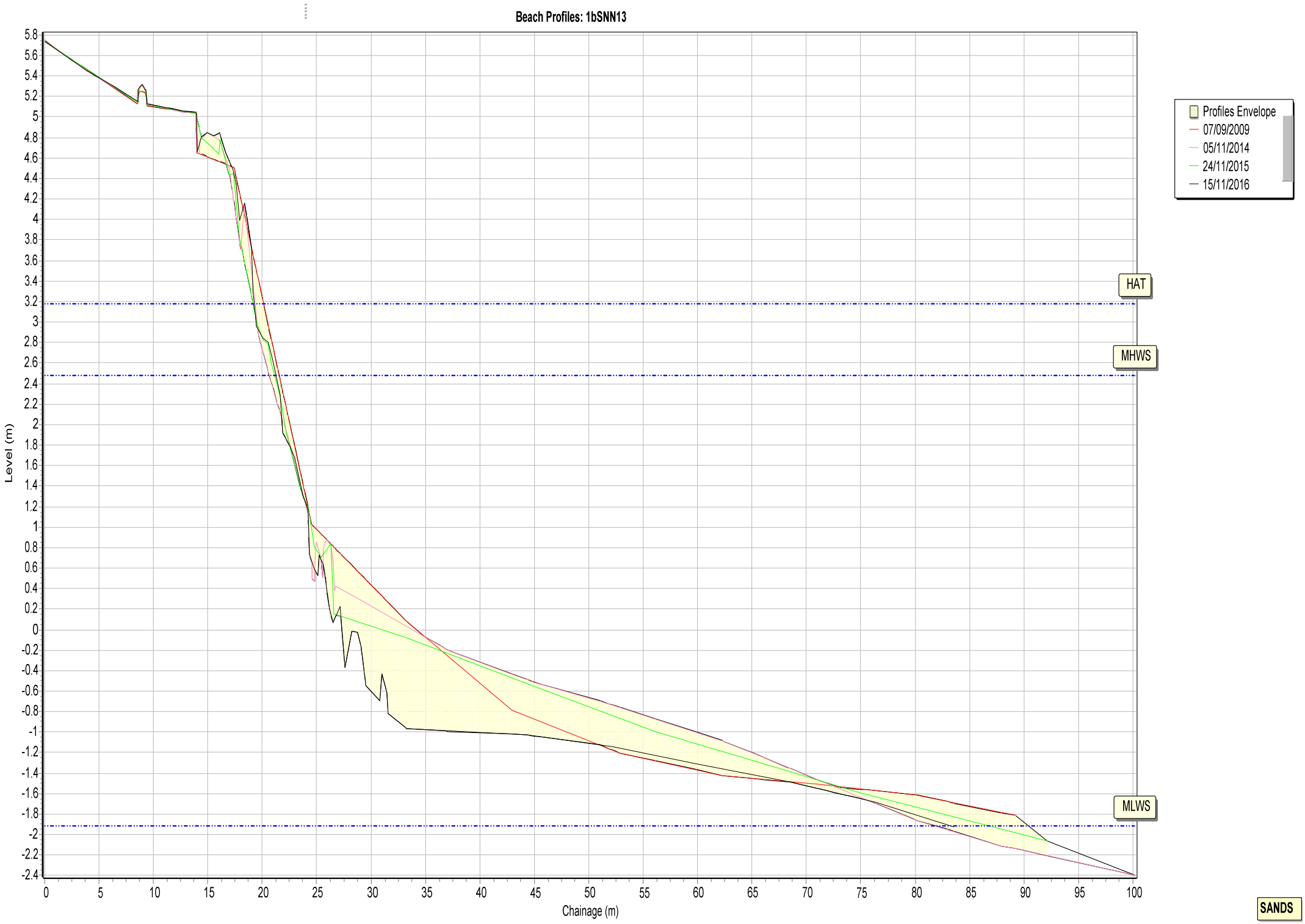
Chainage (m)
SANDS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MLWS
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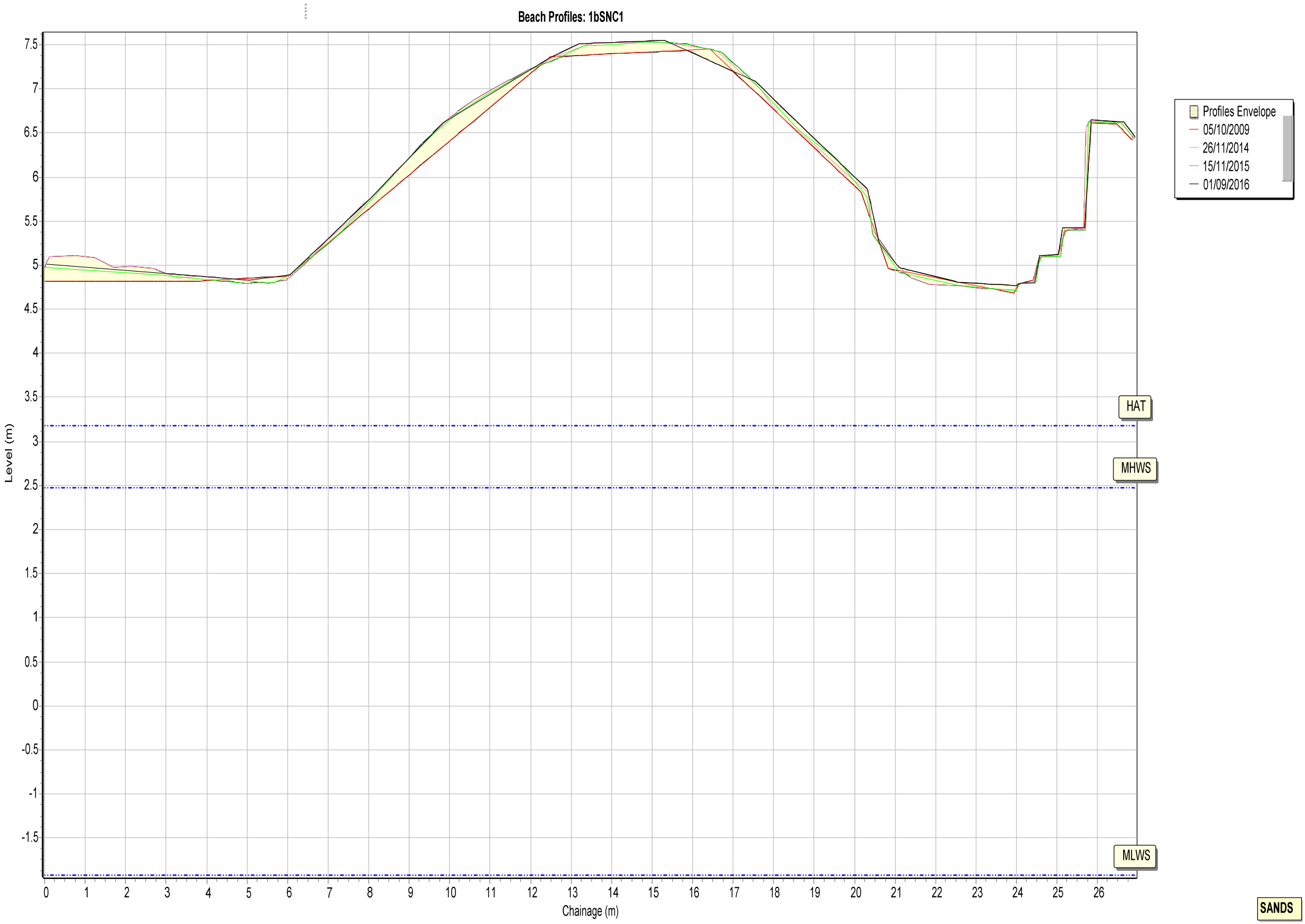
Chainage (m)
SANDS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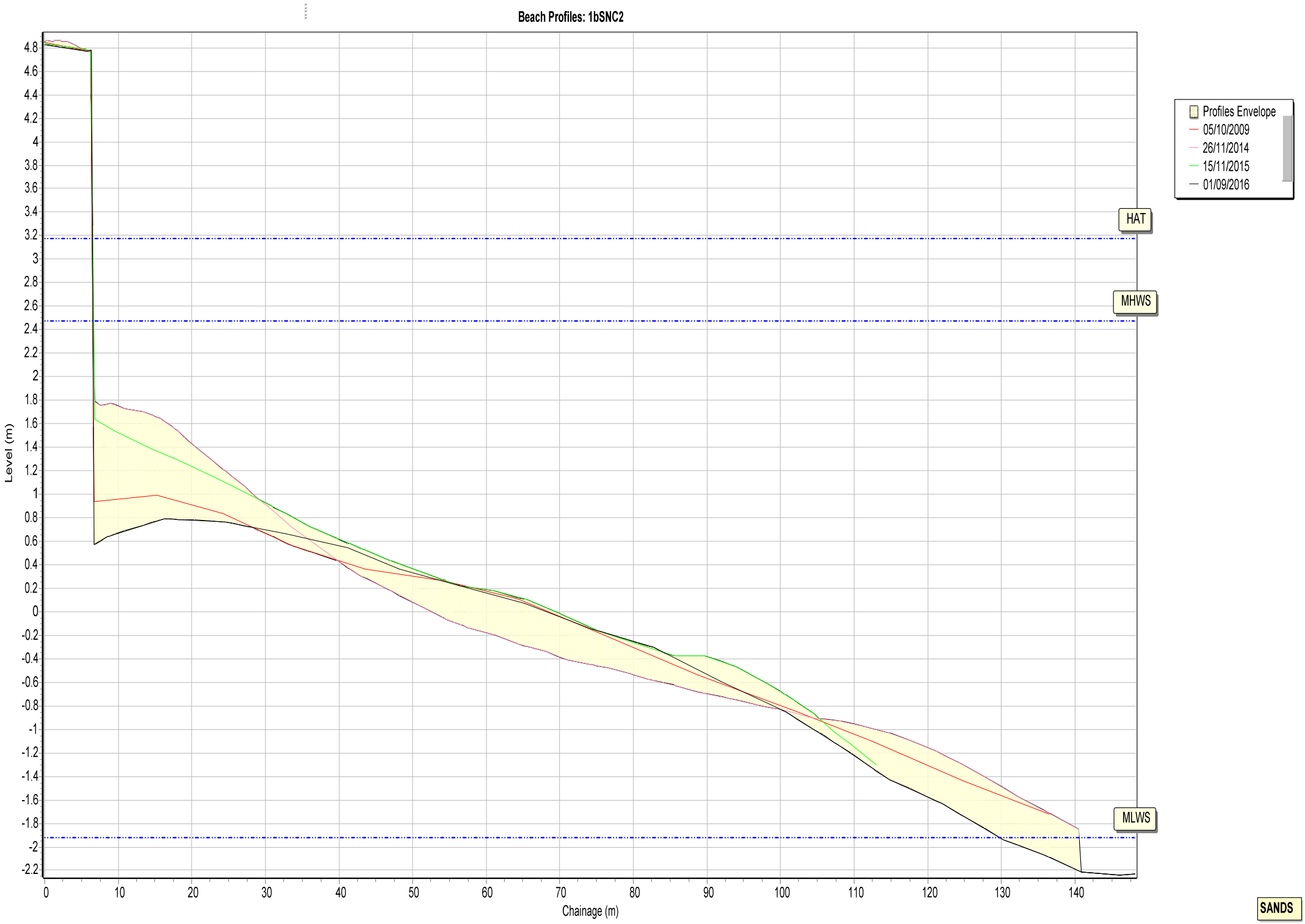
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MLWS
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Chainage (m)
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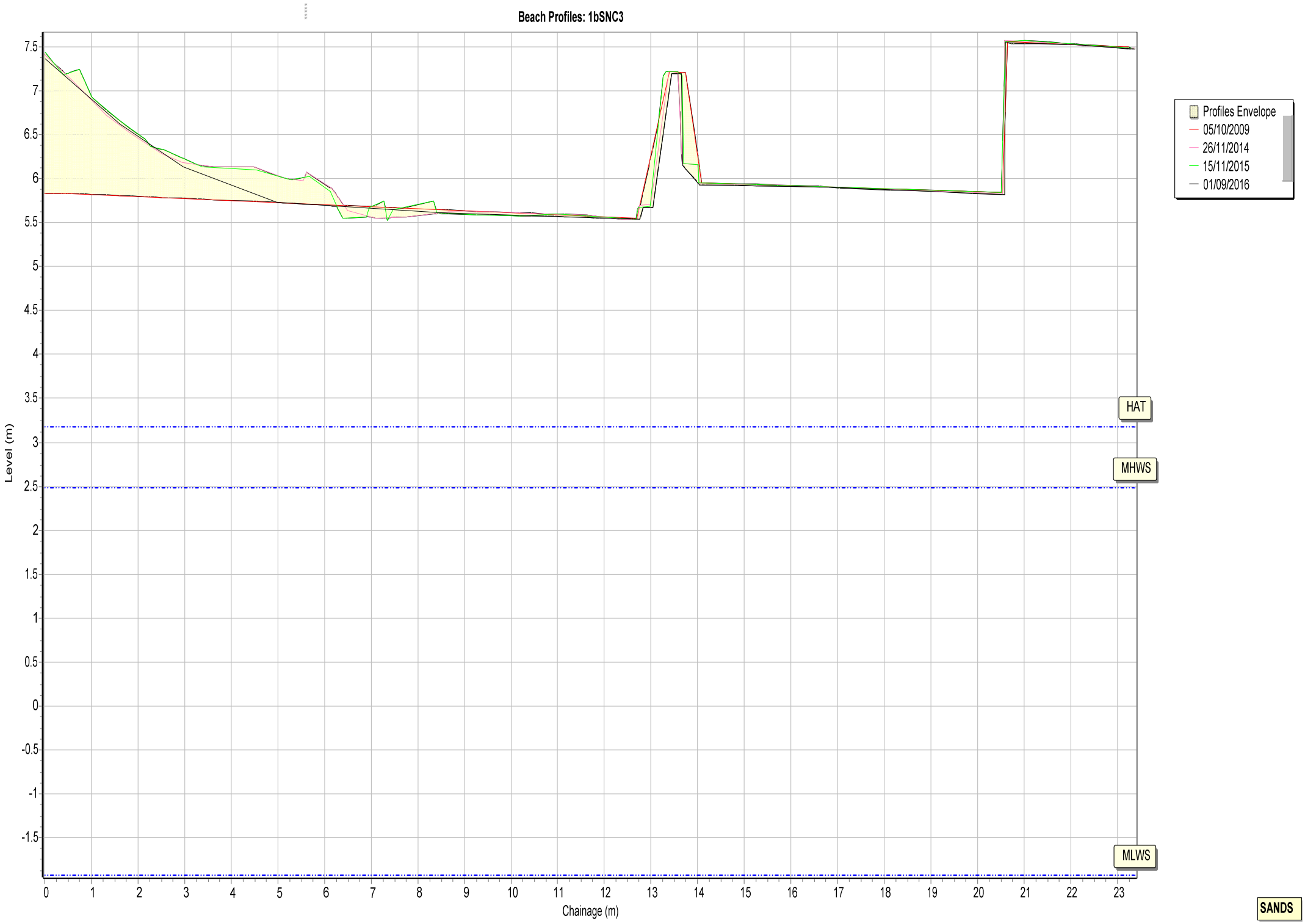
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01/09/2016
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MLWS
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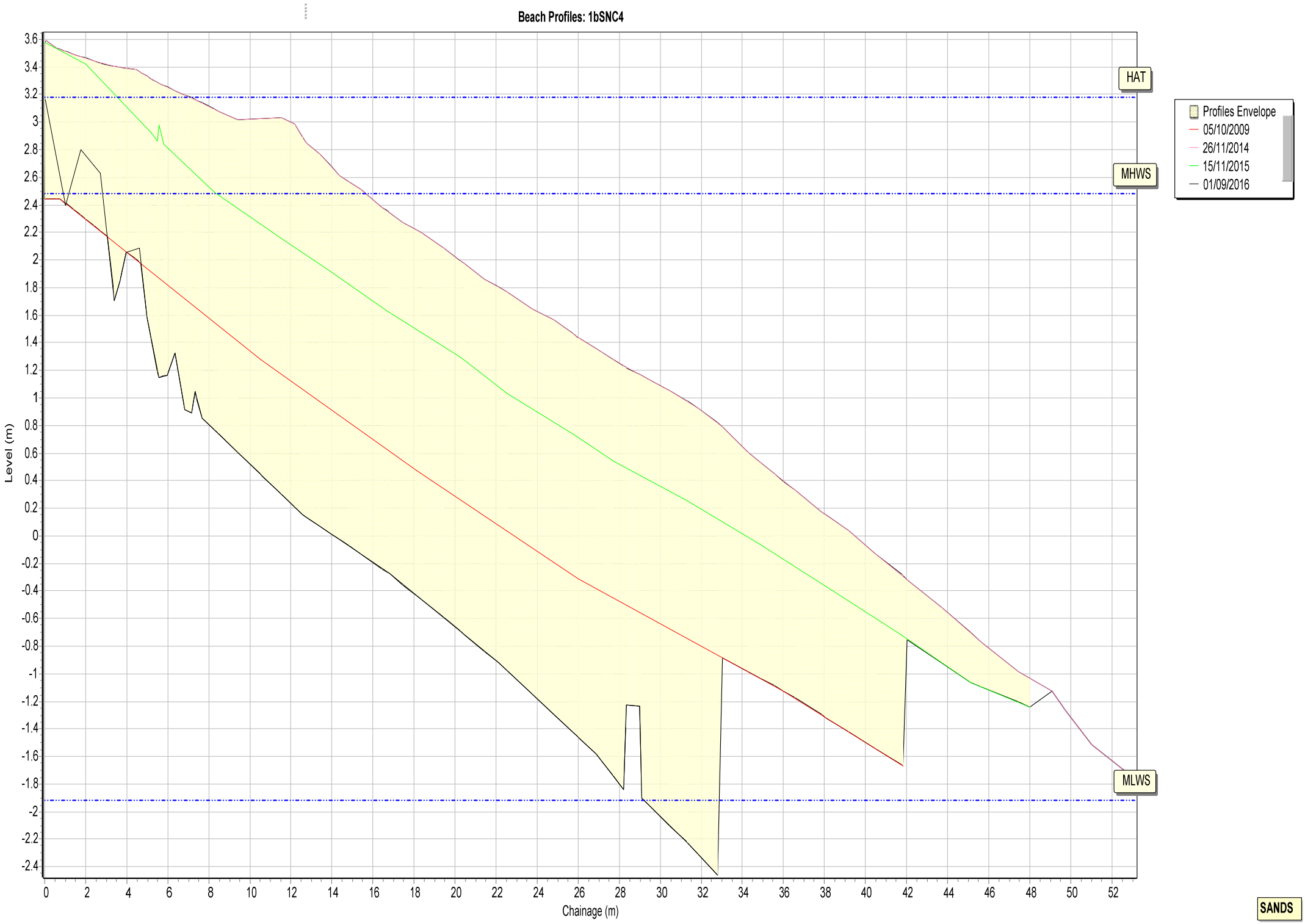
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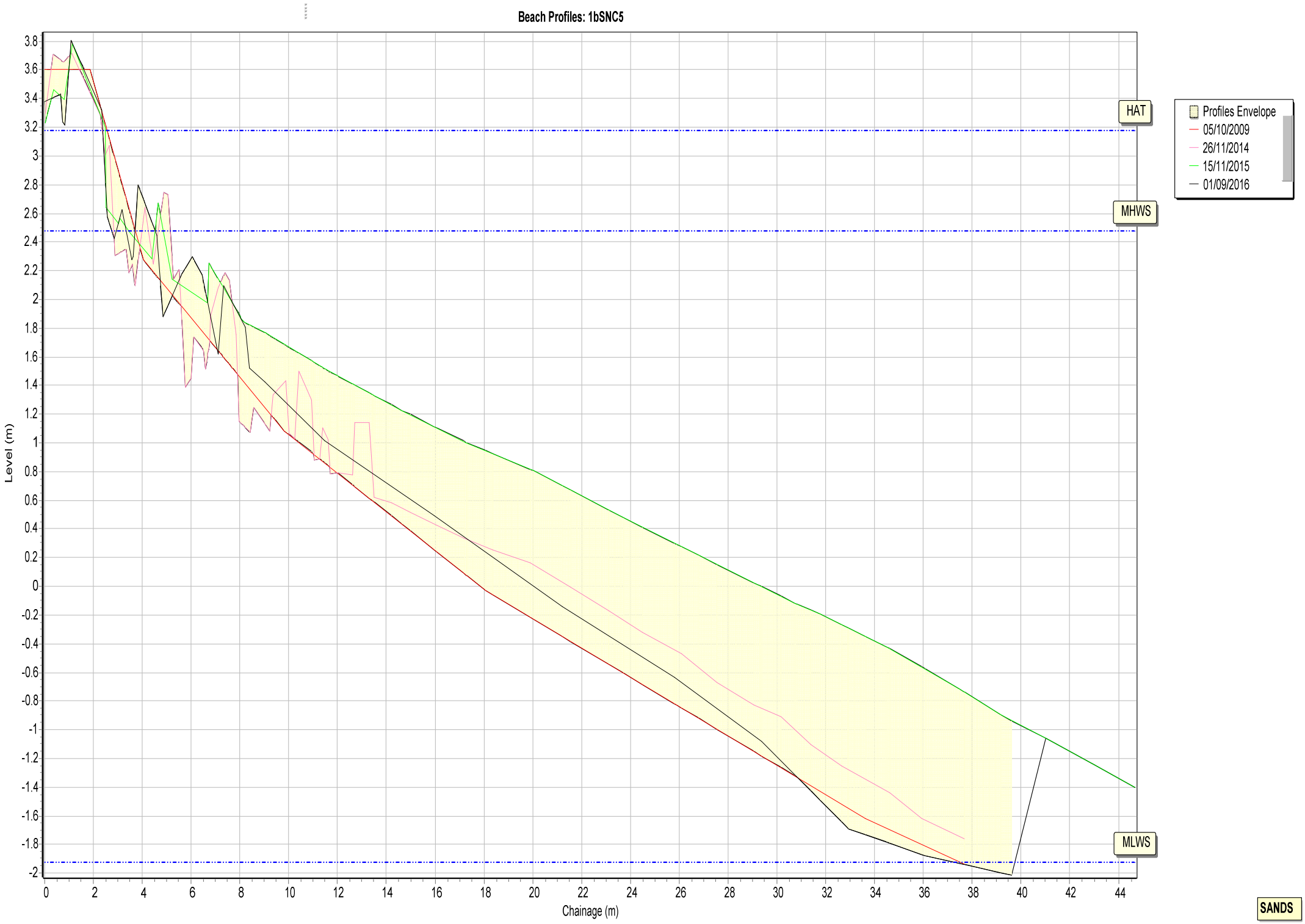
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MLWS
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01/09/2016
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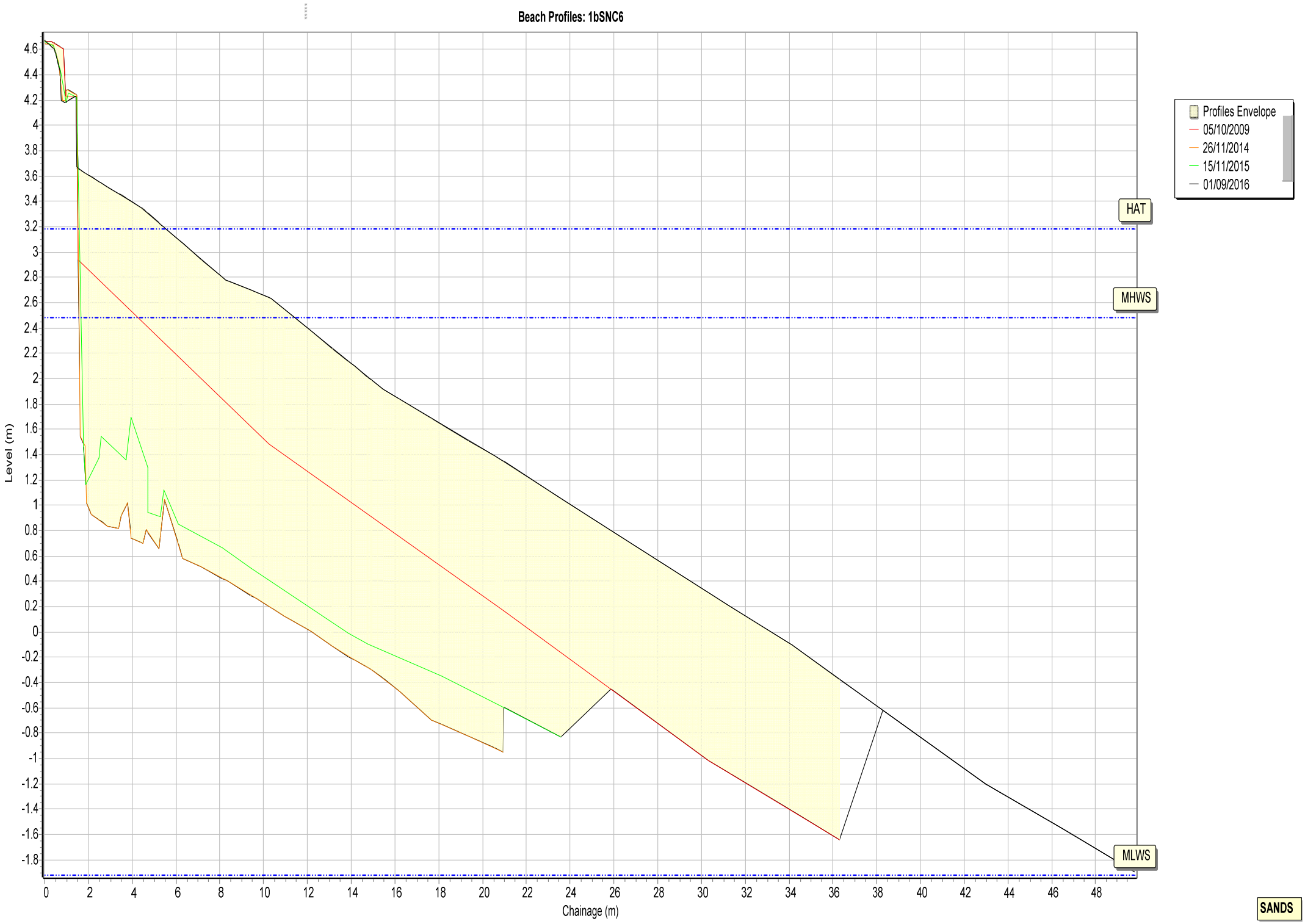
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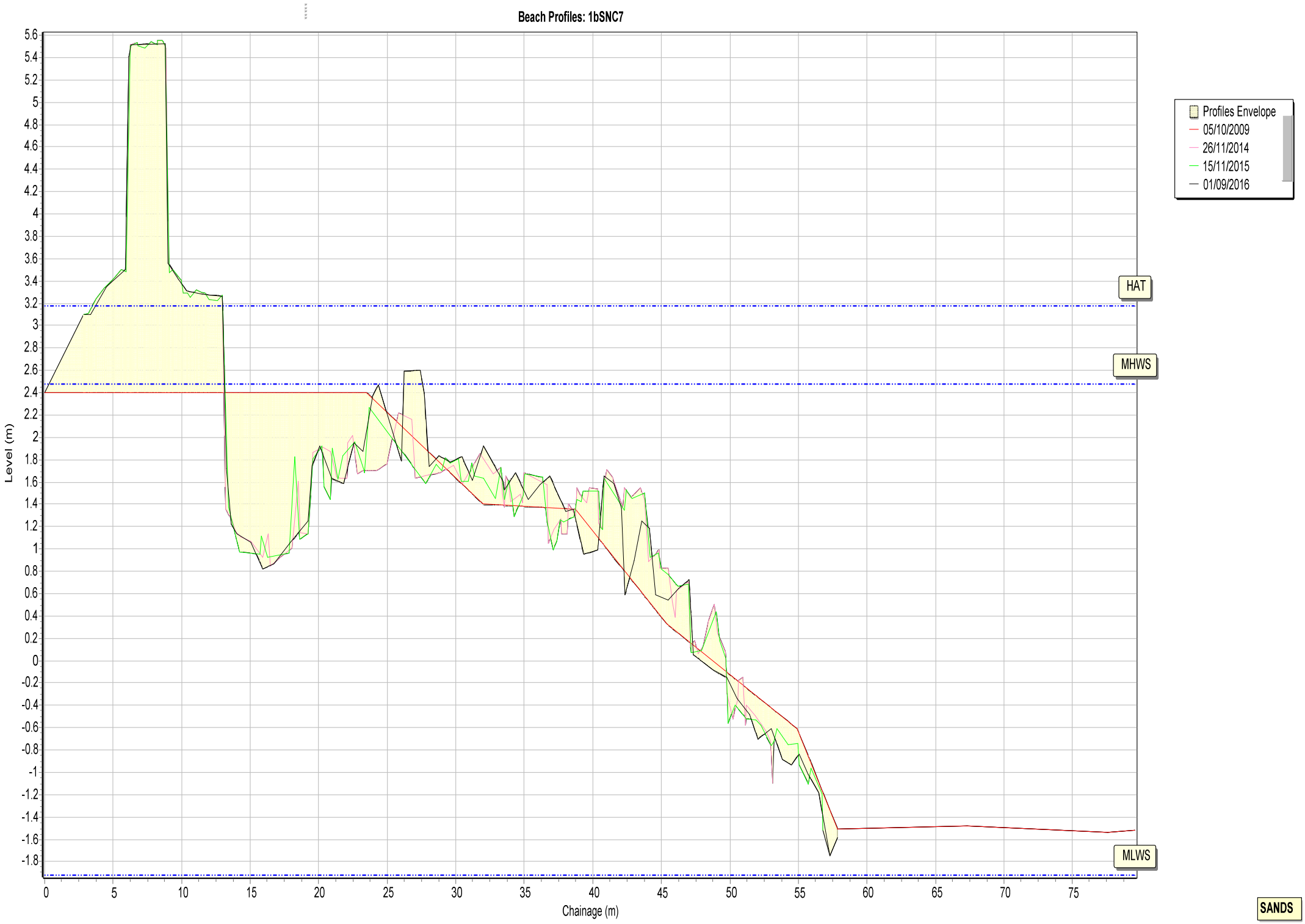
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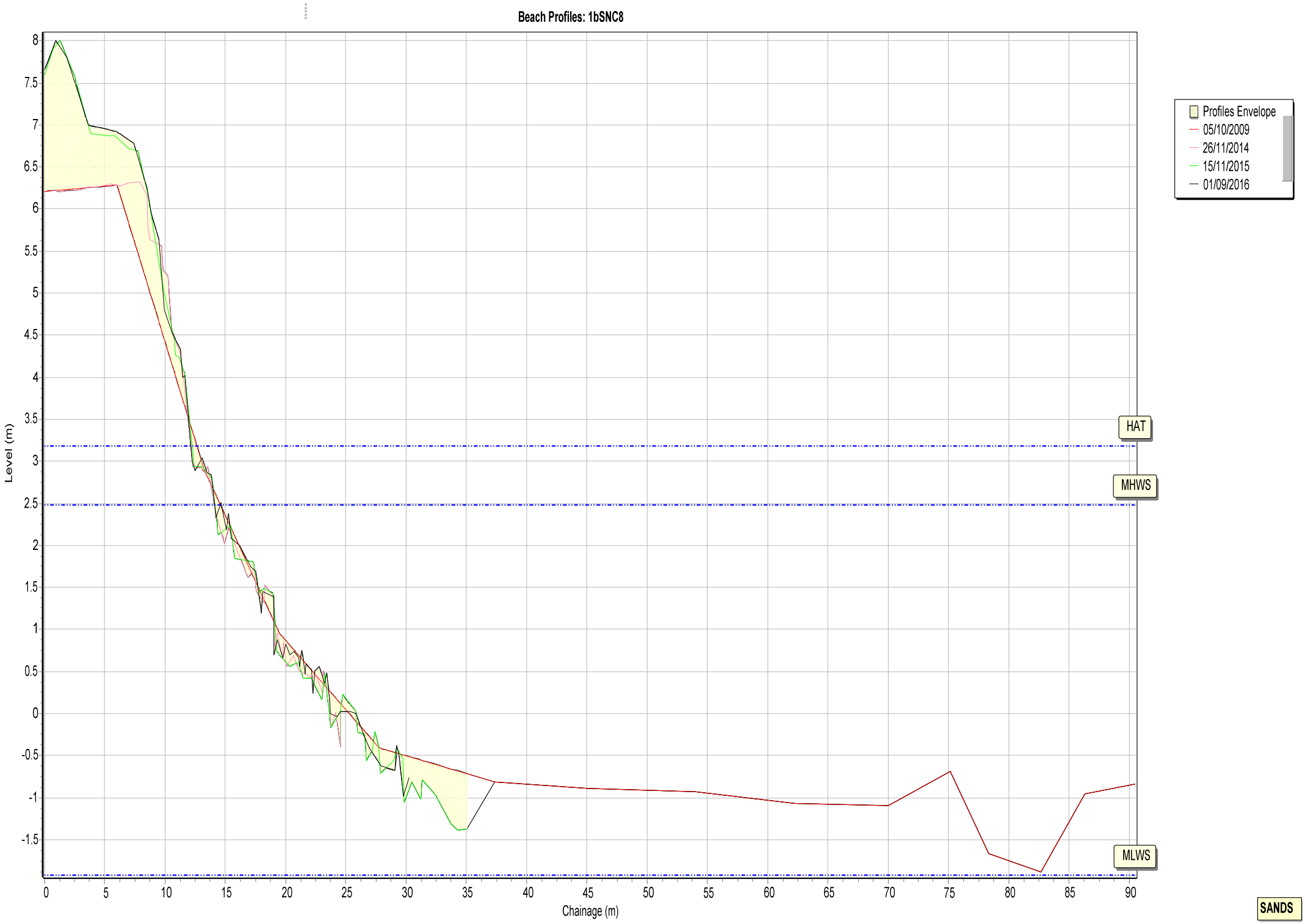
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MLWS
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6
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5
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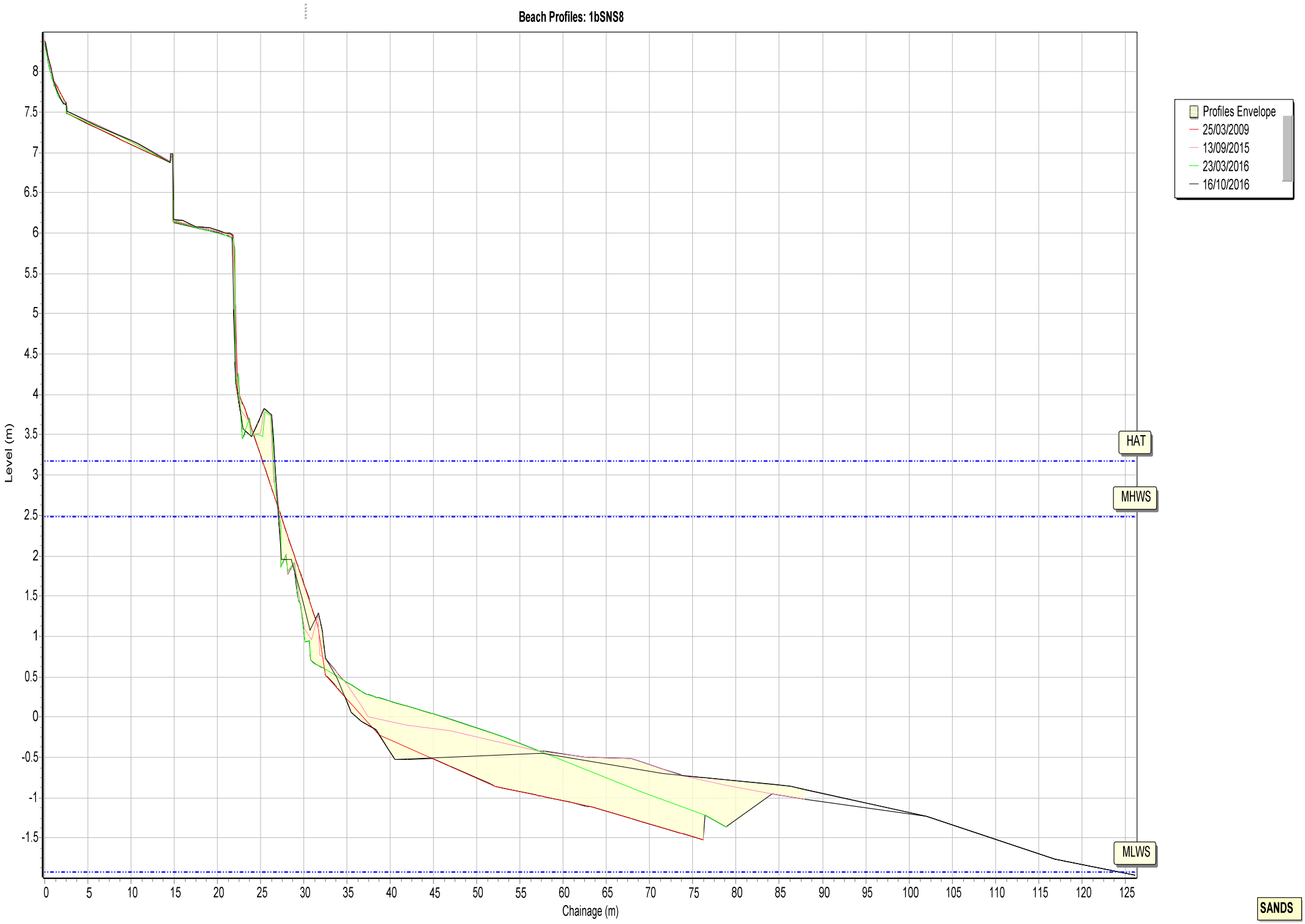
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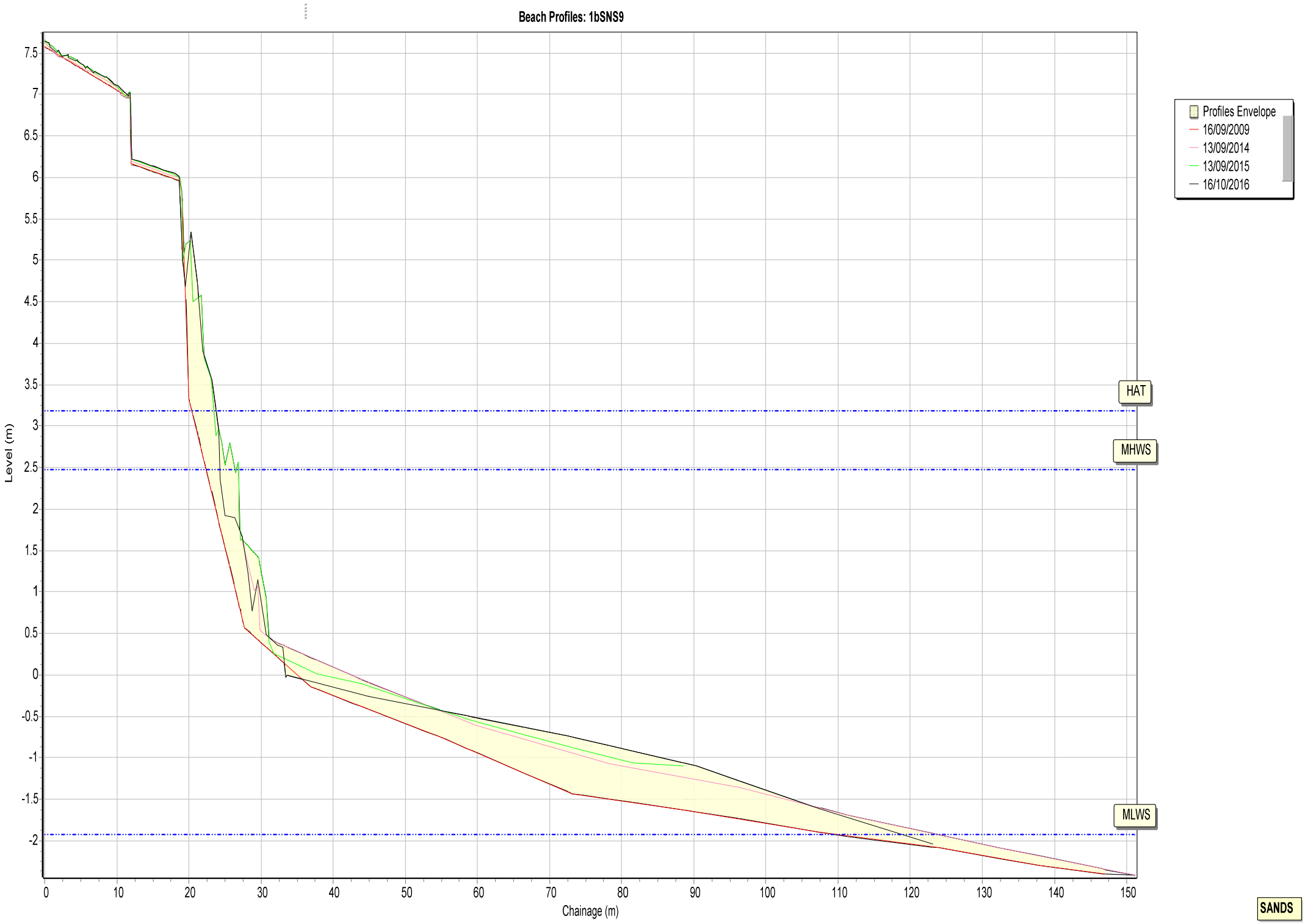
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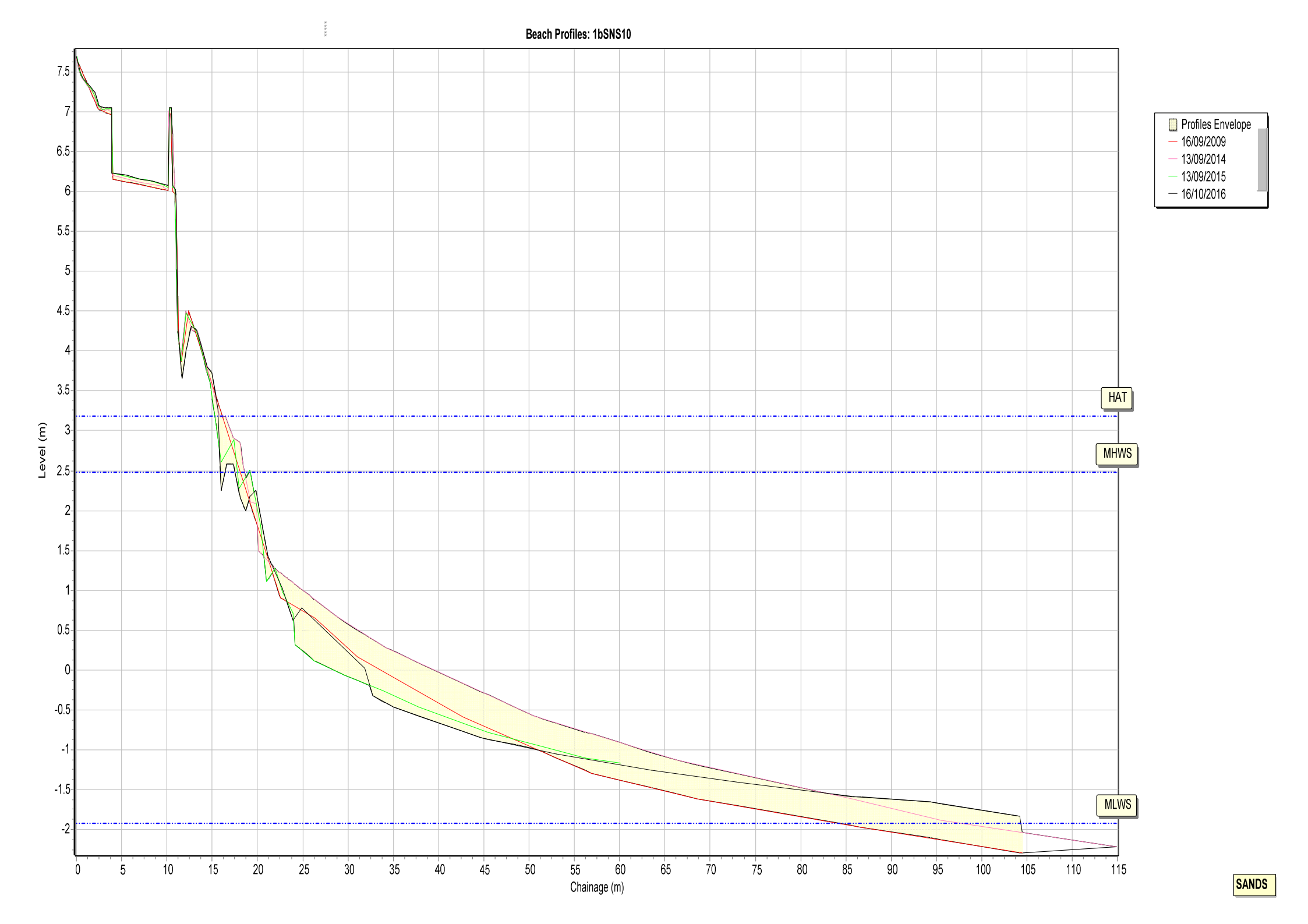
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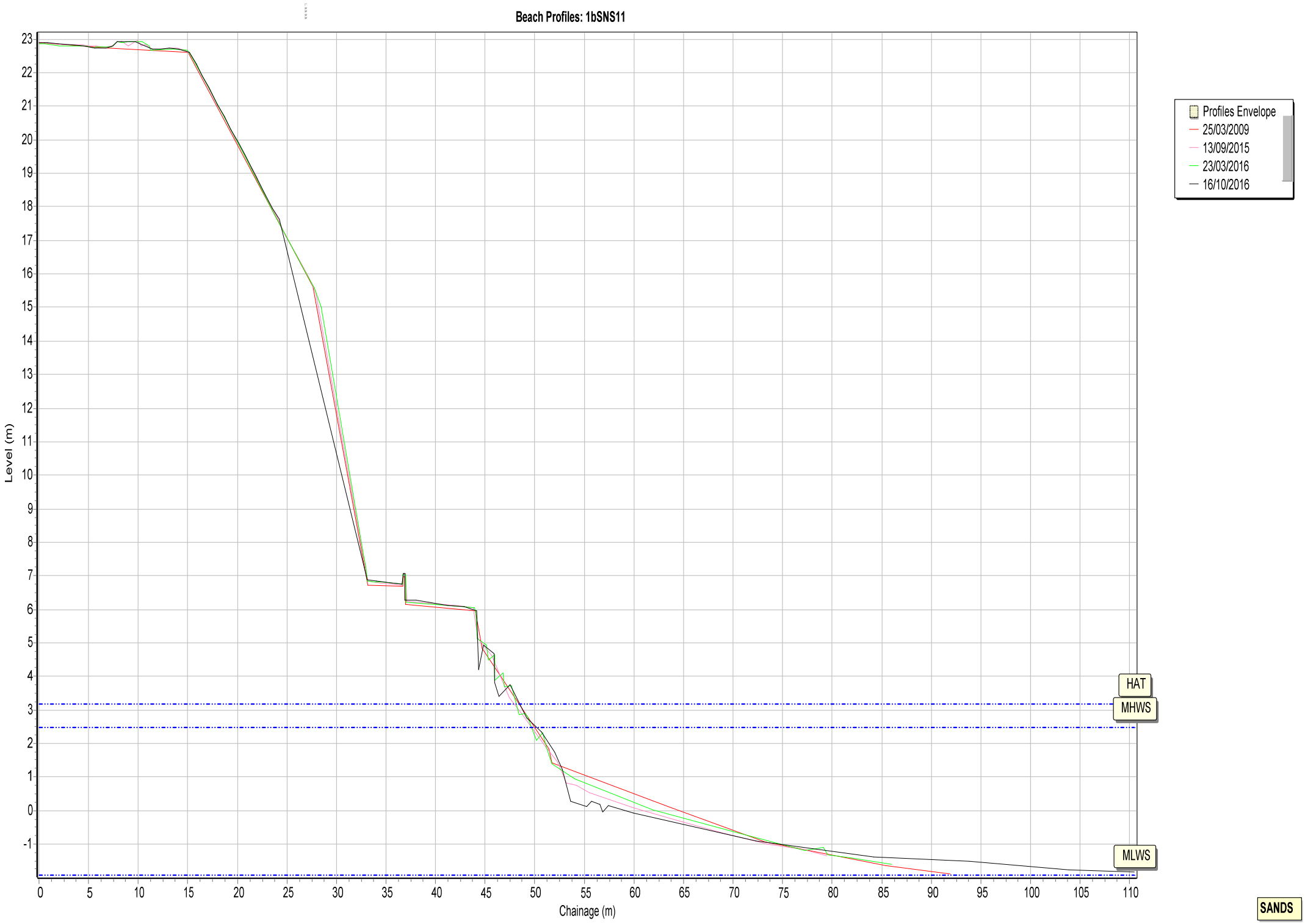
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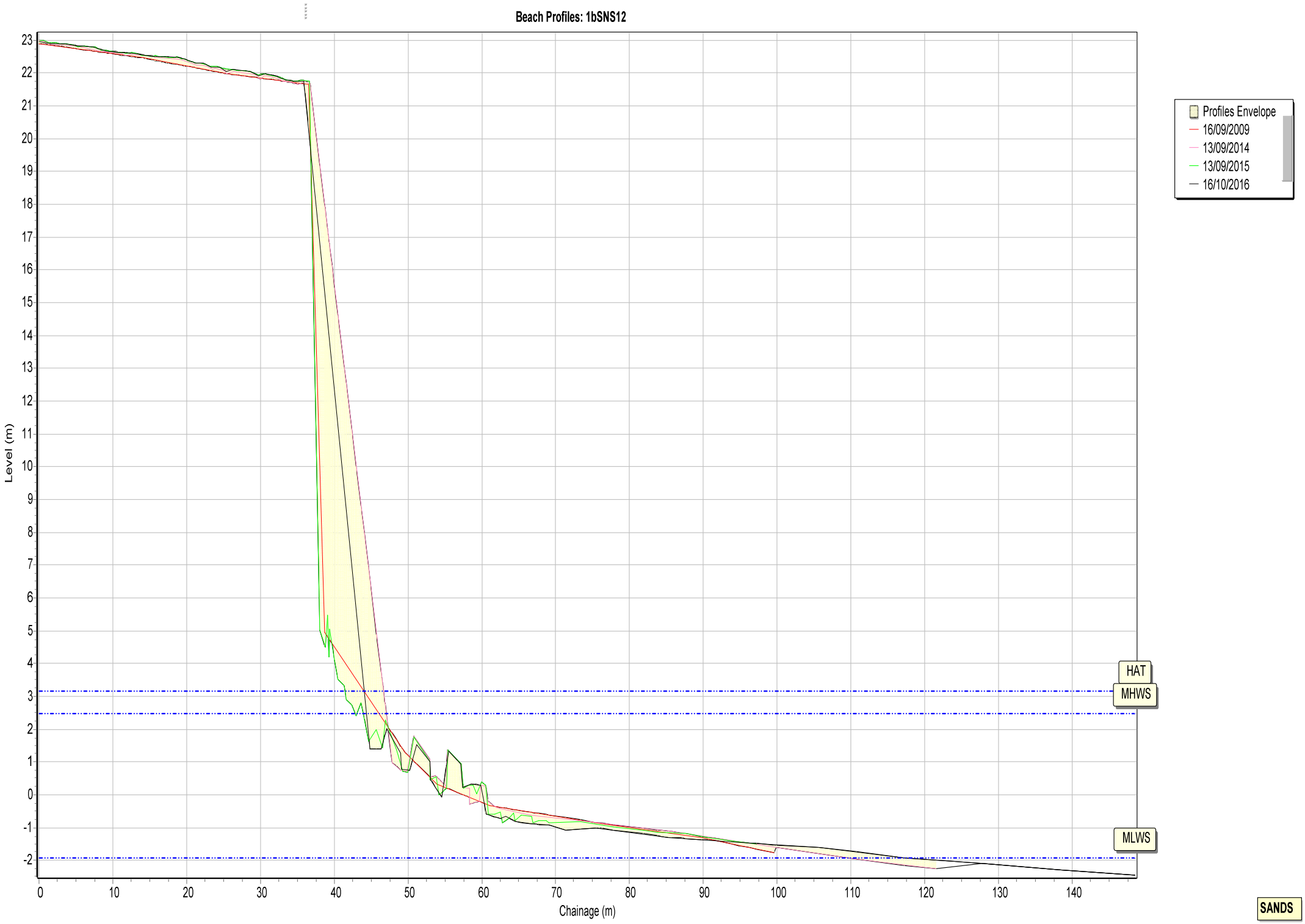
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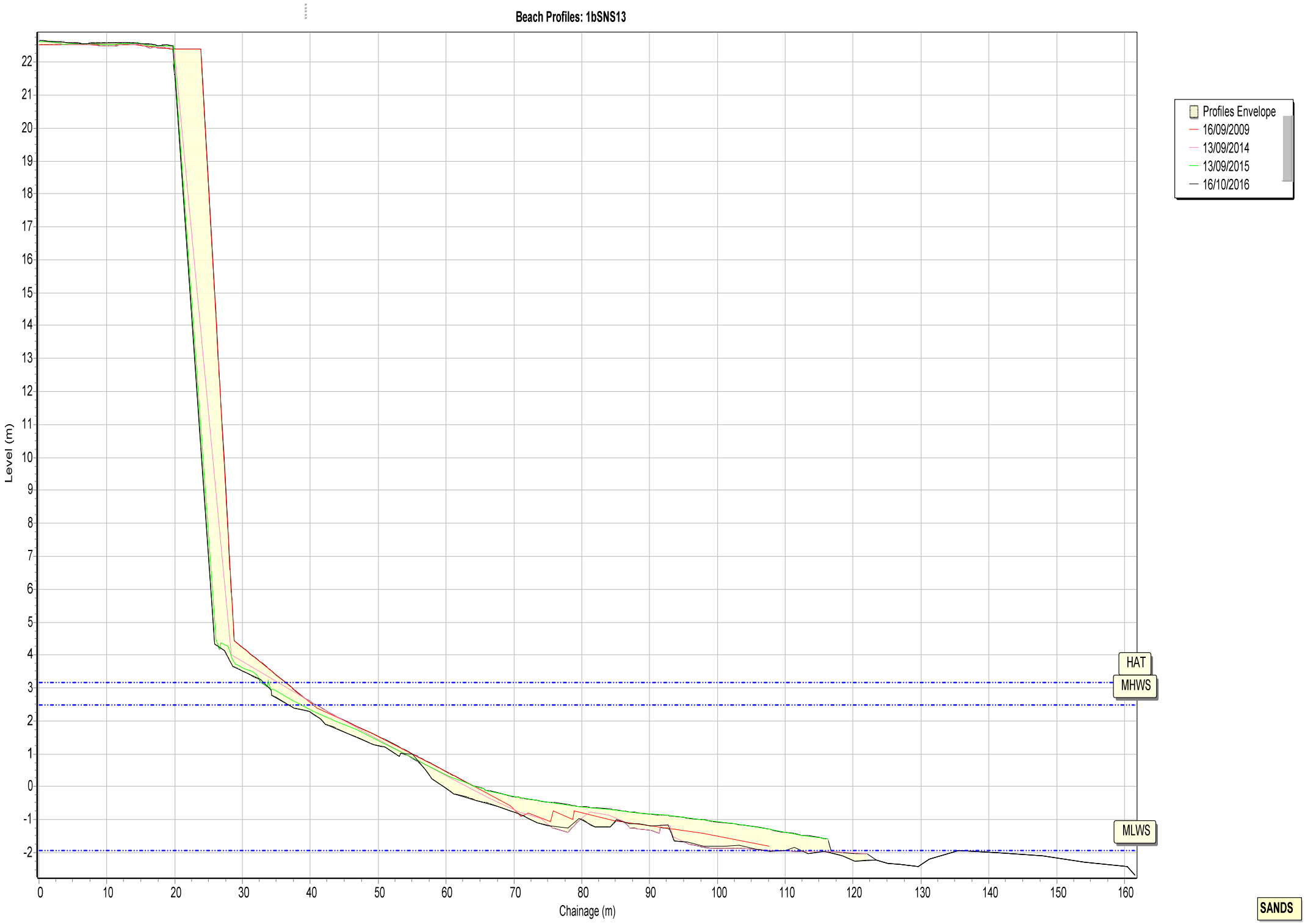
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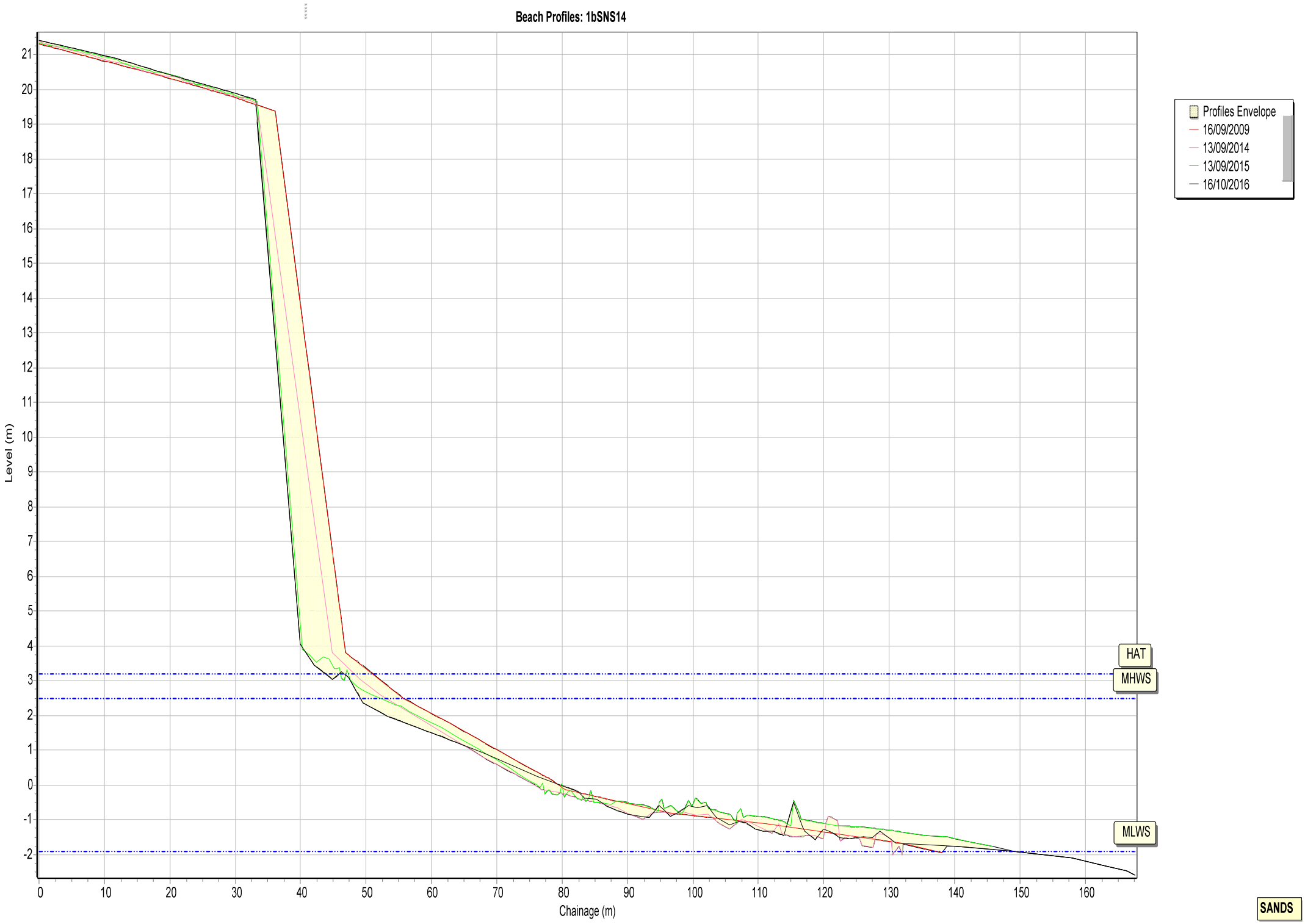
Chainage (m)
SANDS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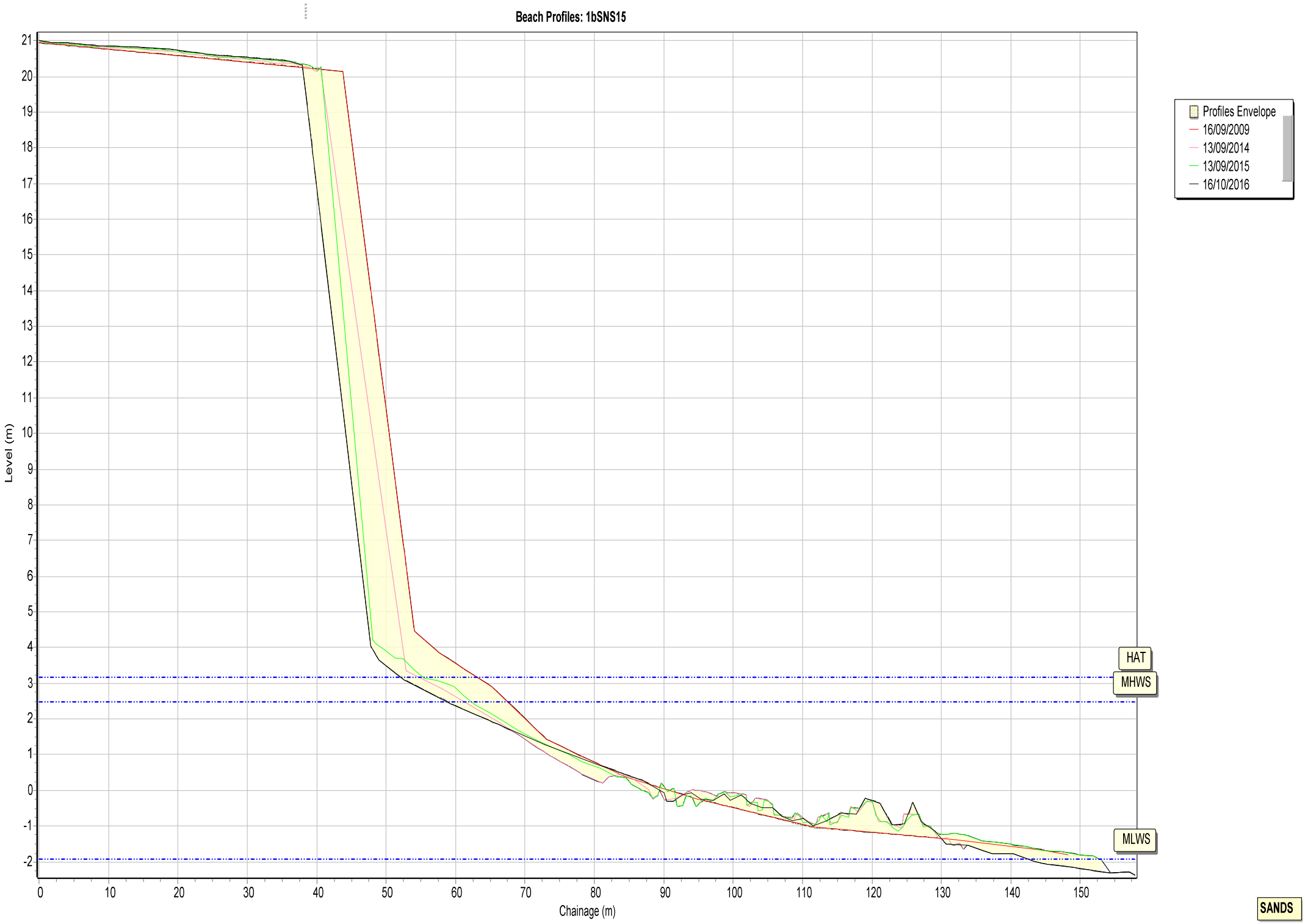
Level (m)
Chainage (m)
SANDS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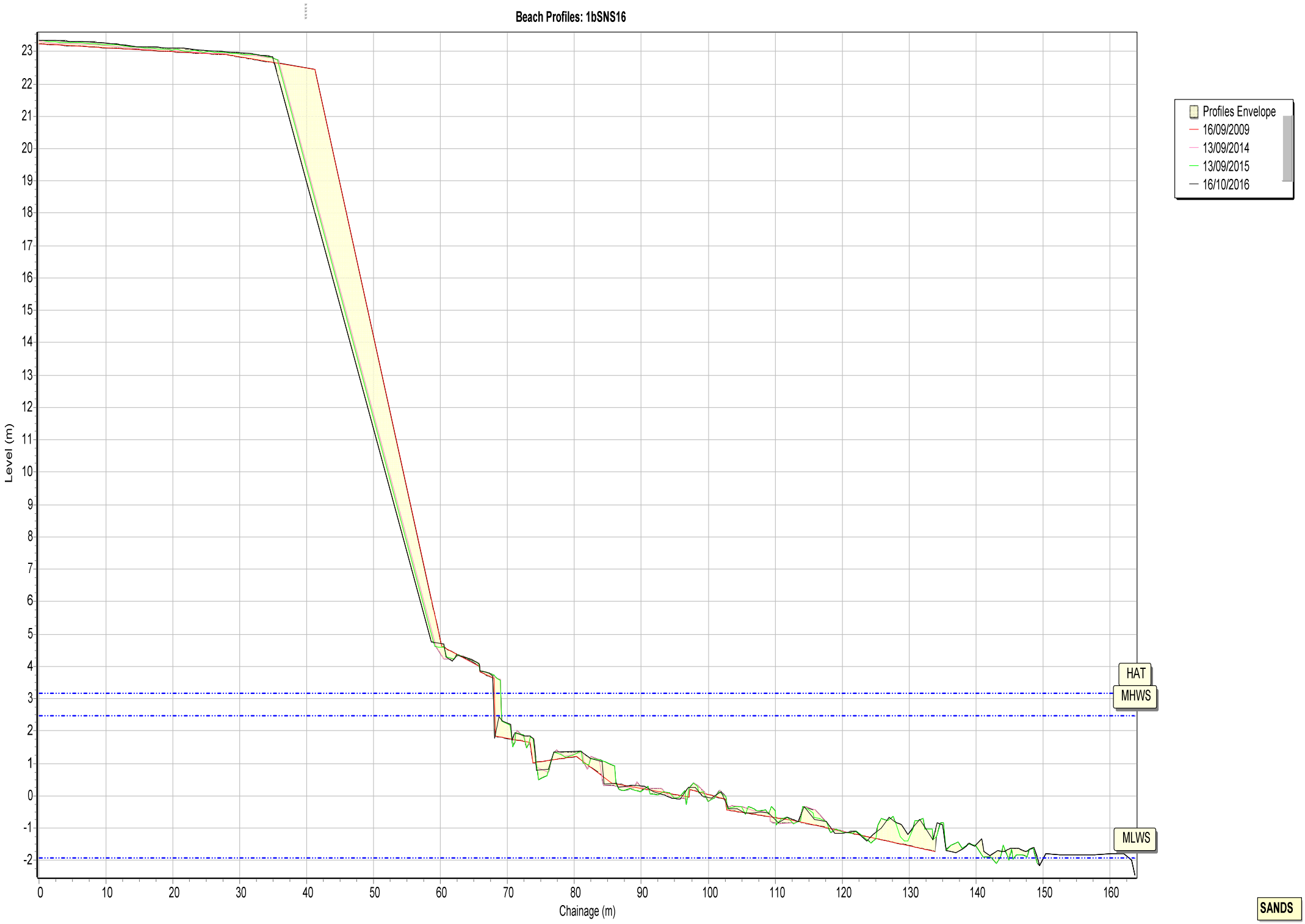
Chainage (m)
SANDS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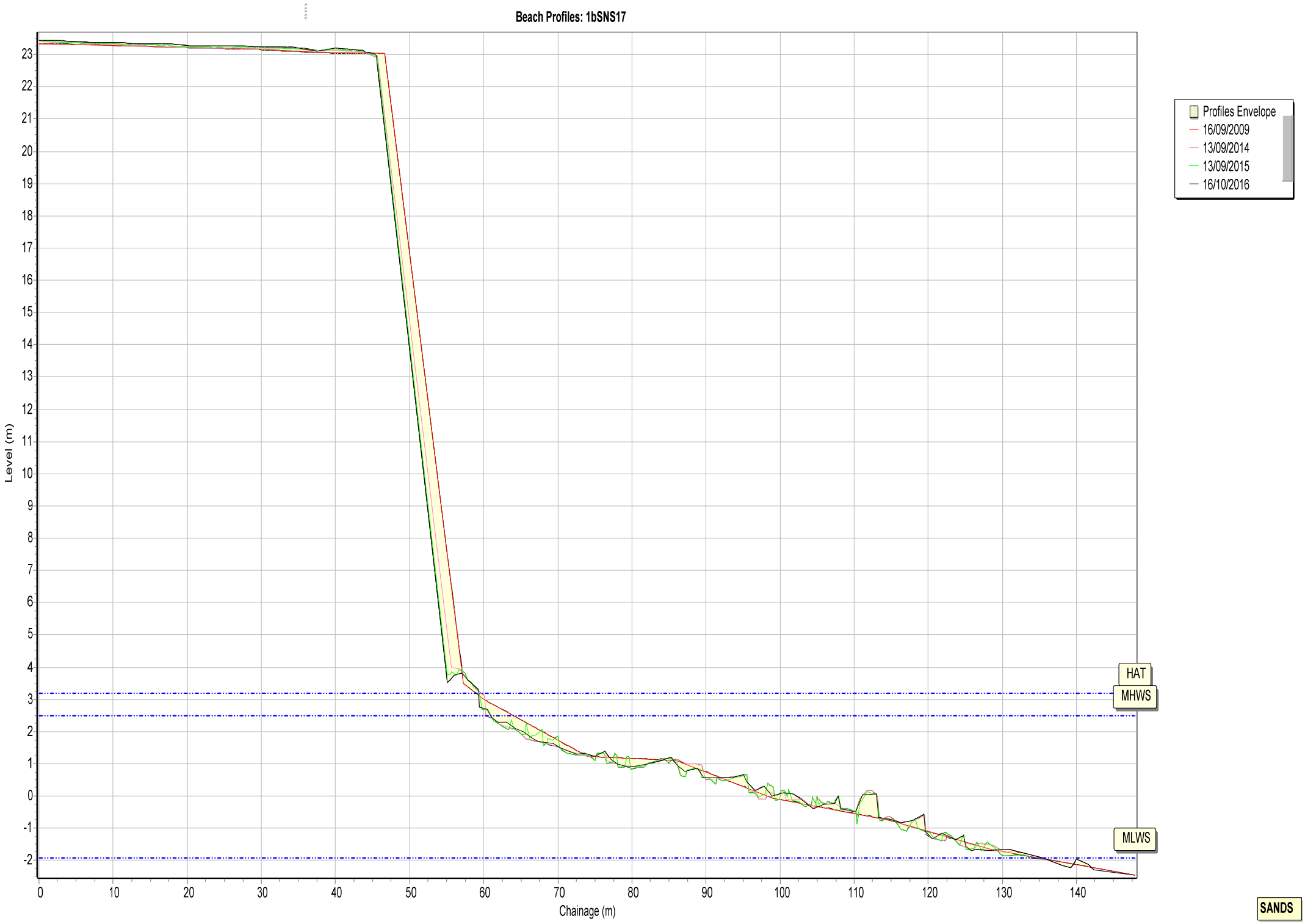
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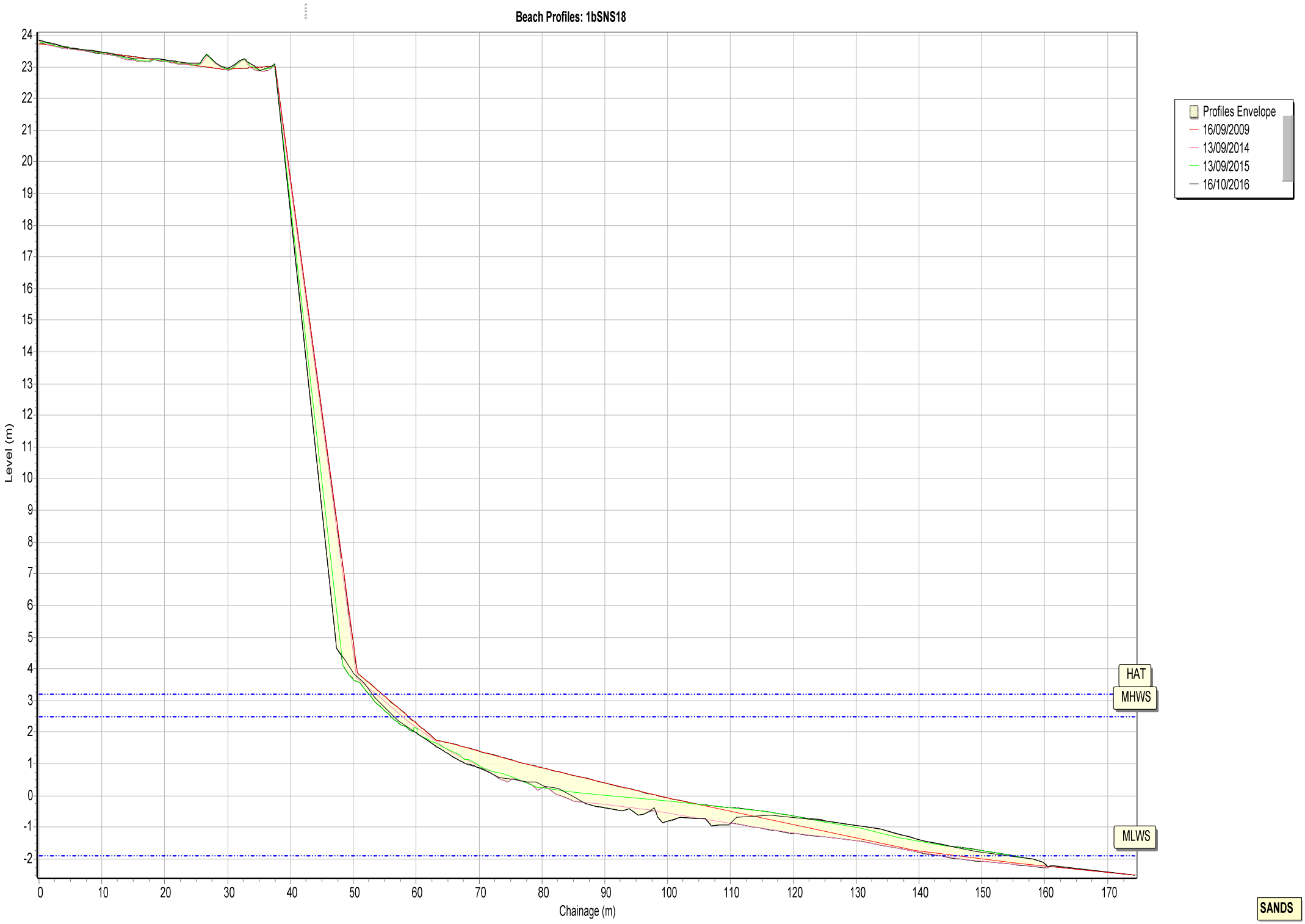
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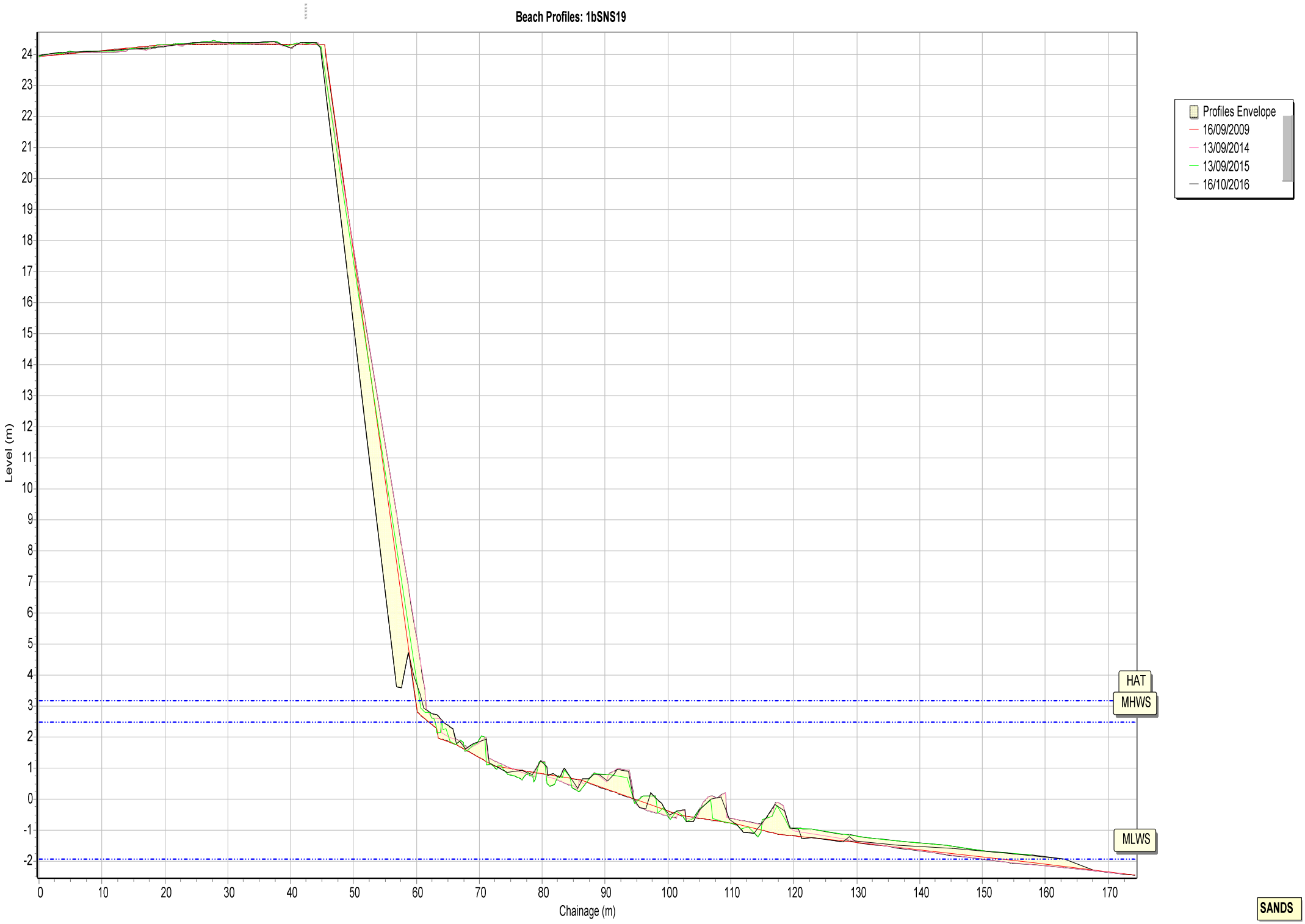
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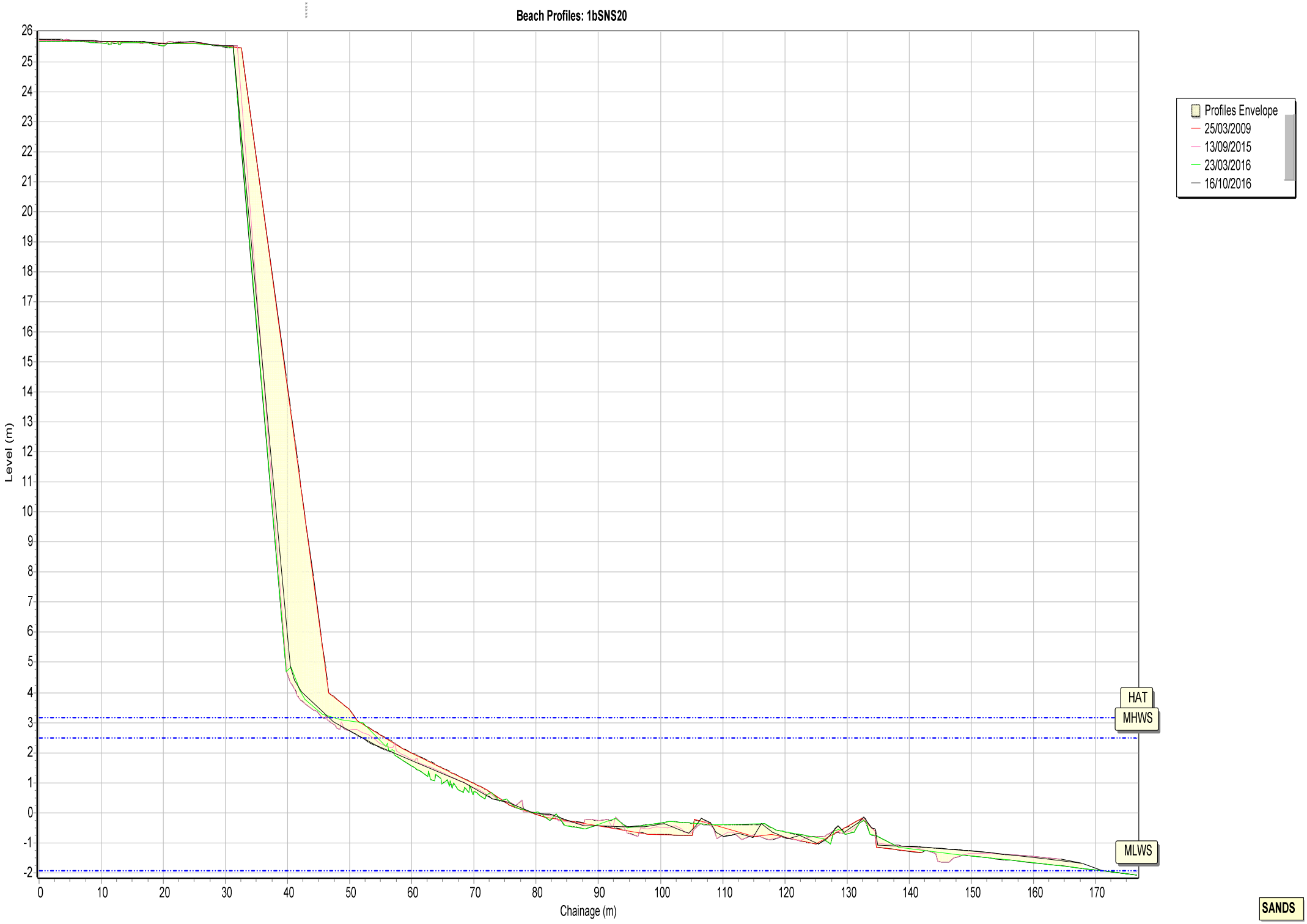
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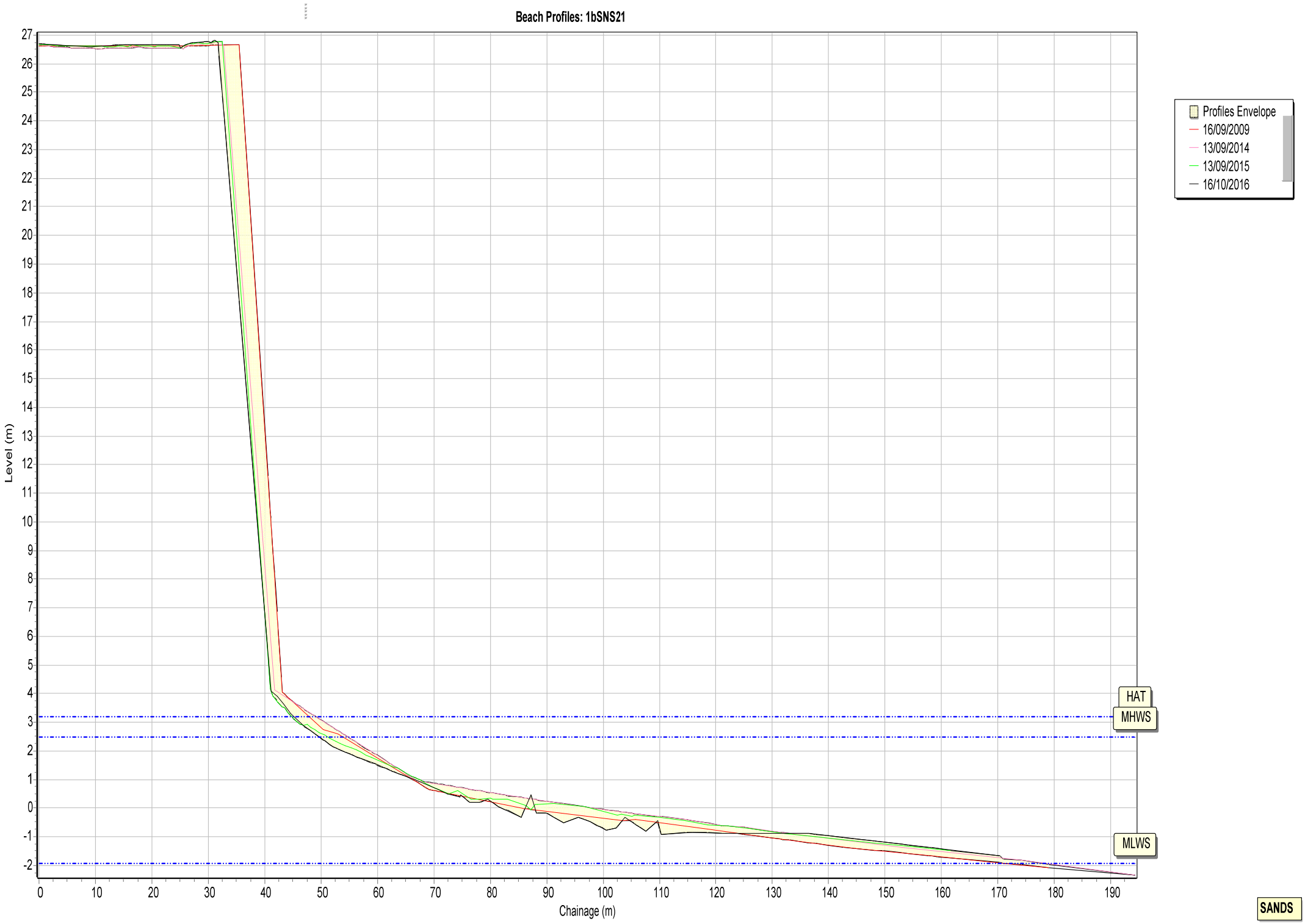
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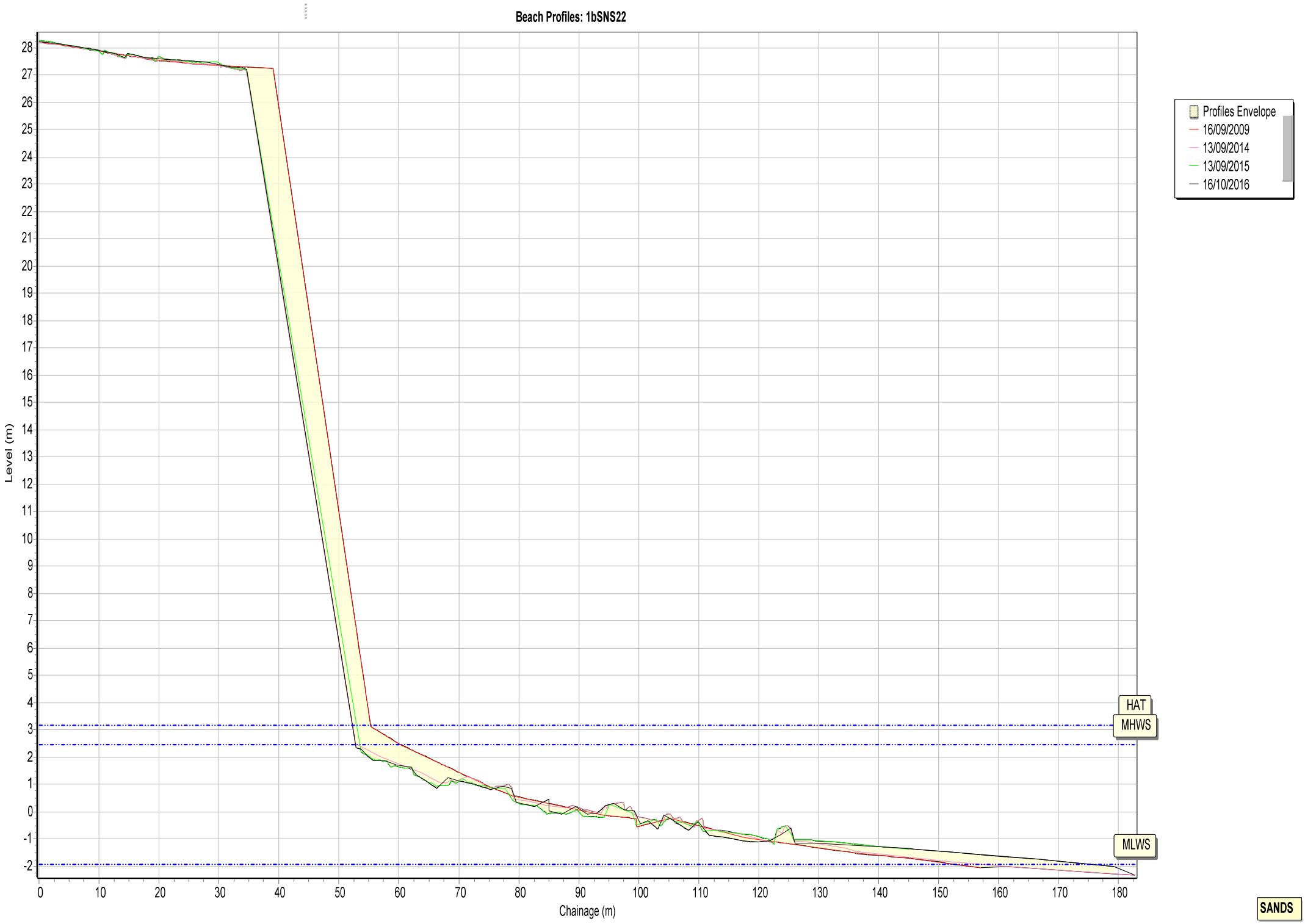
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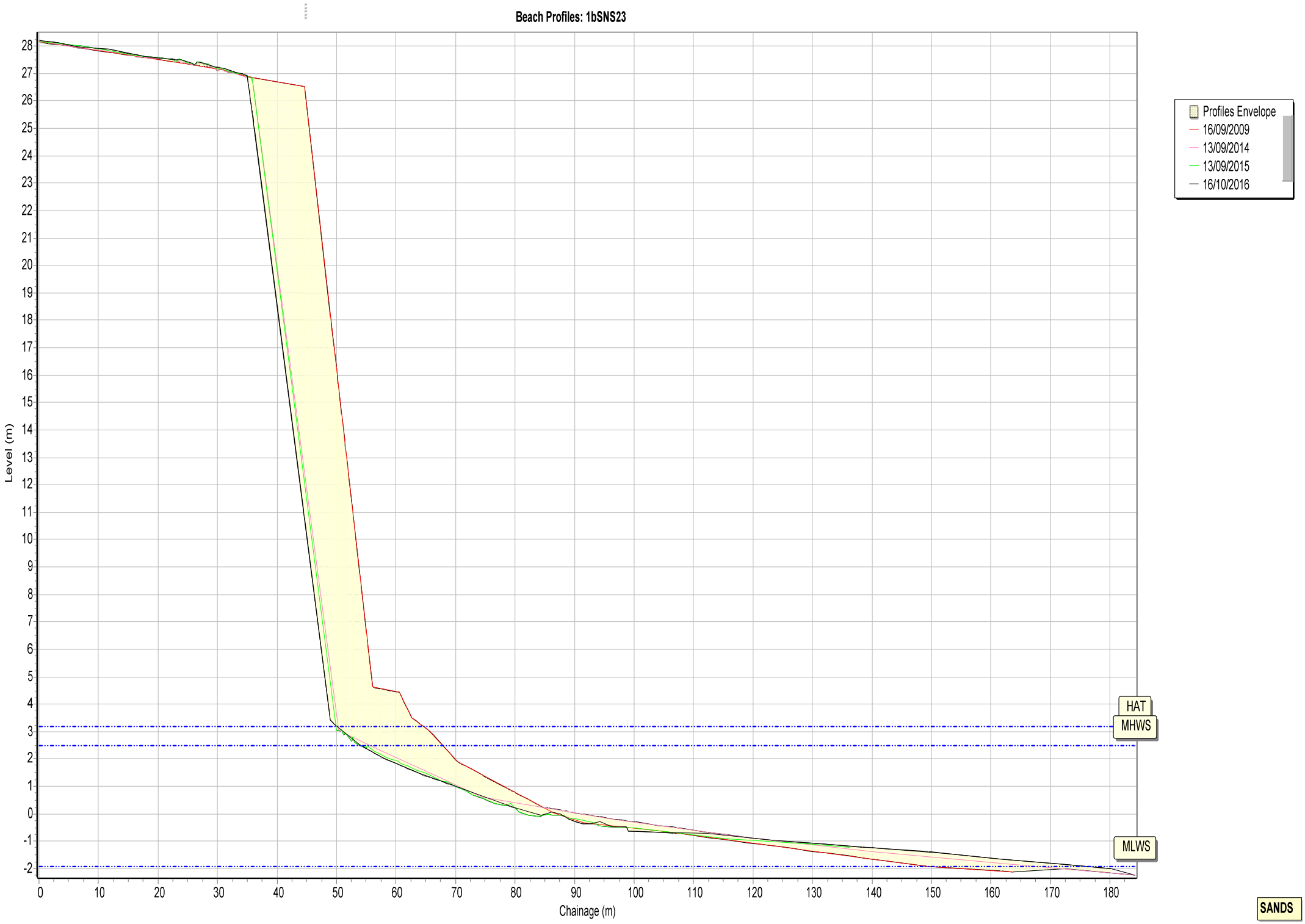
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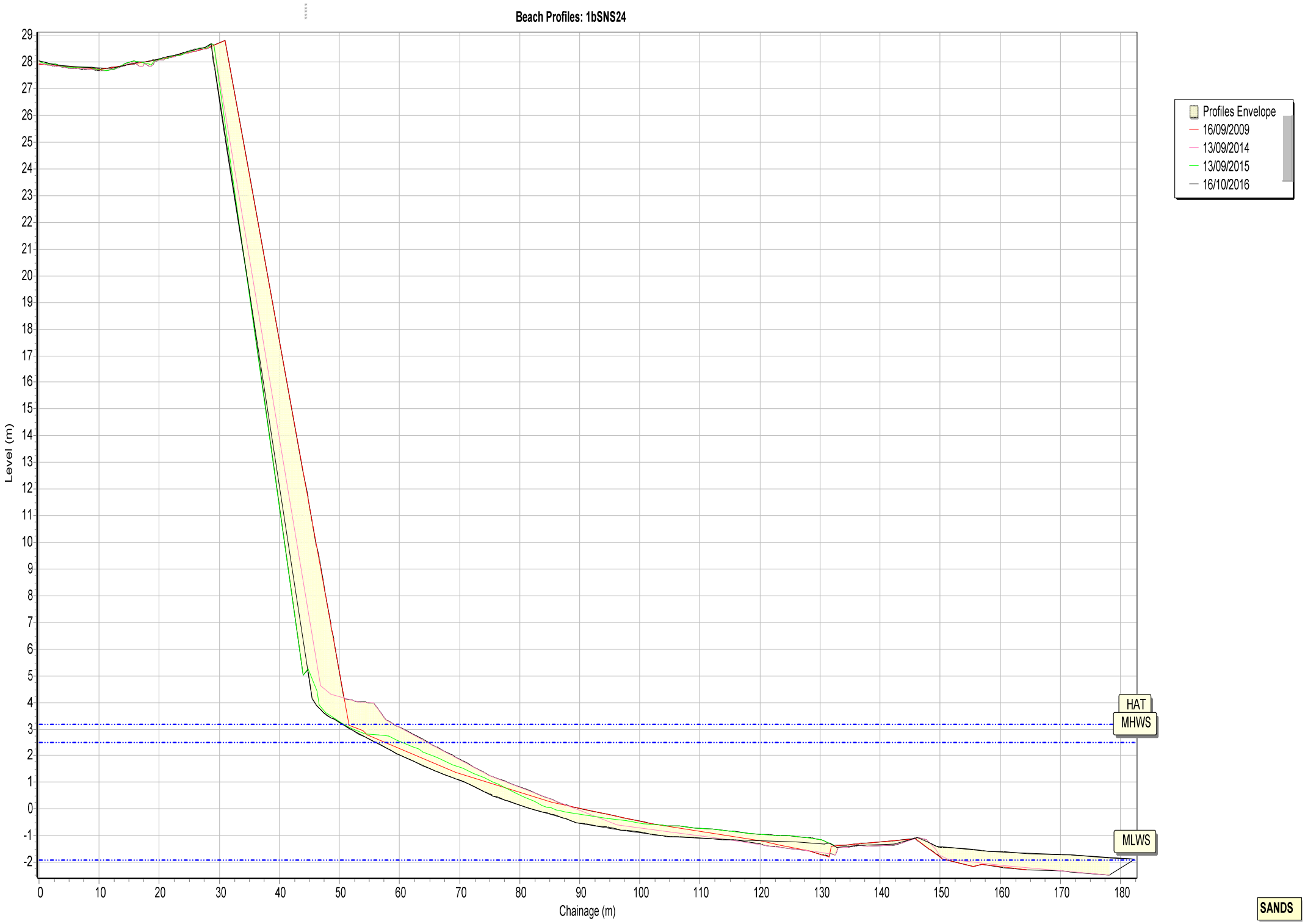
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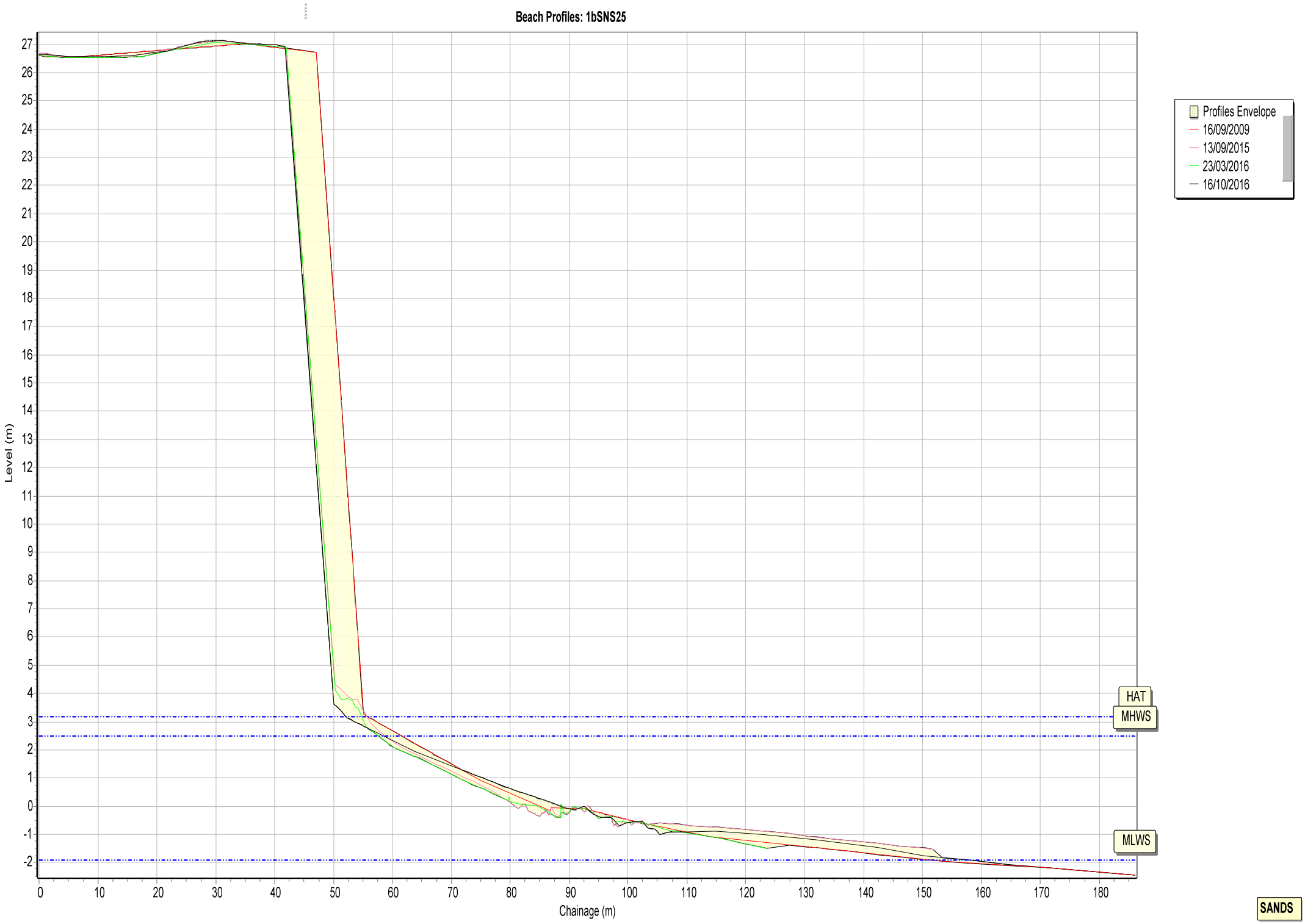
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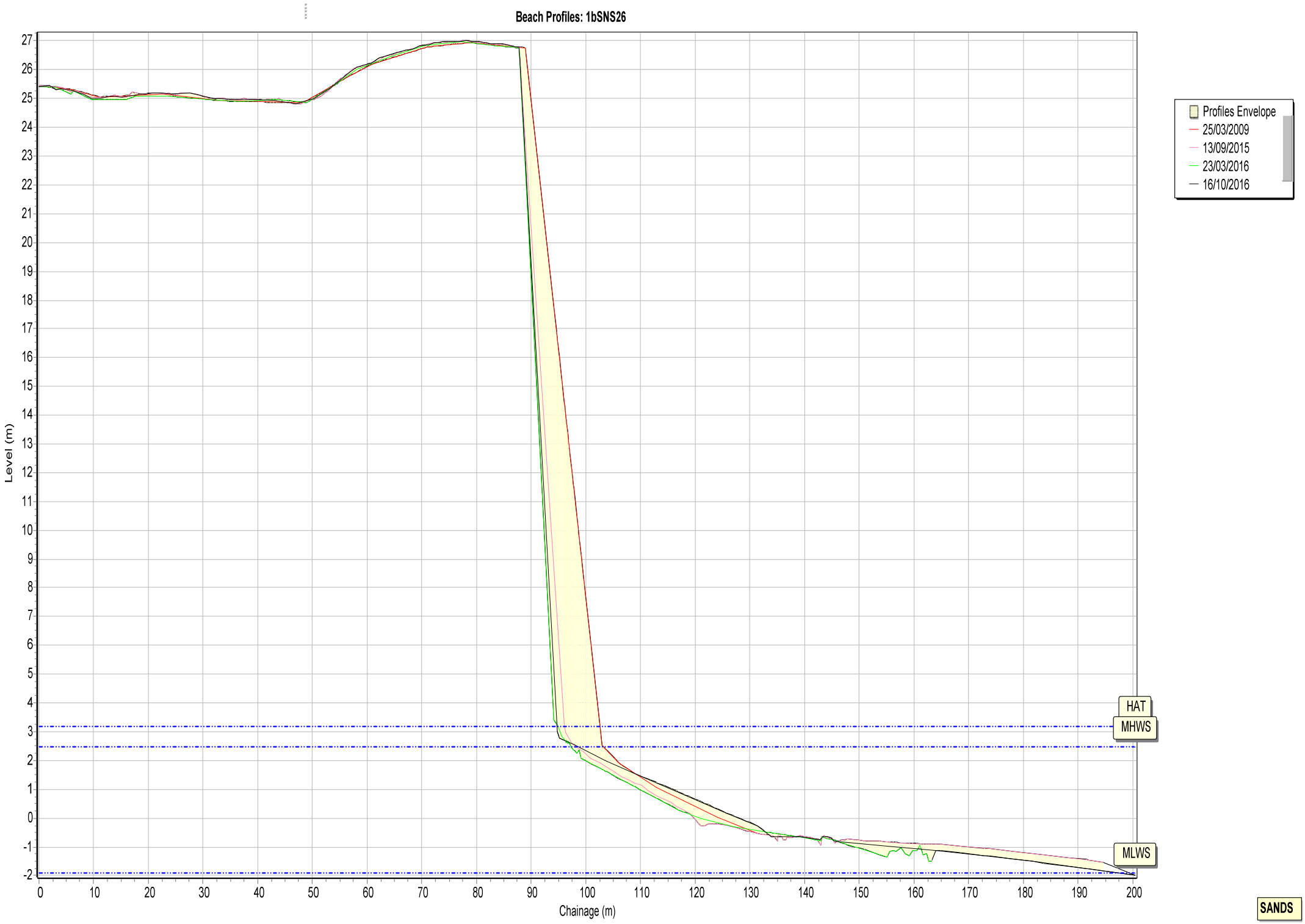
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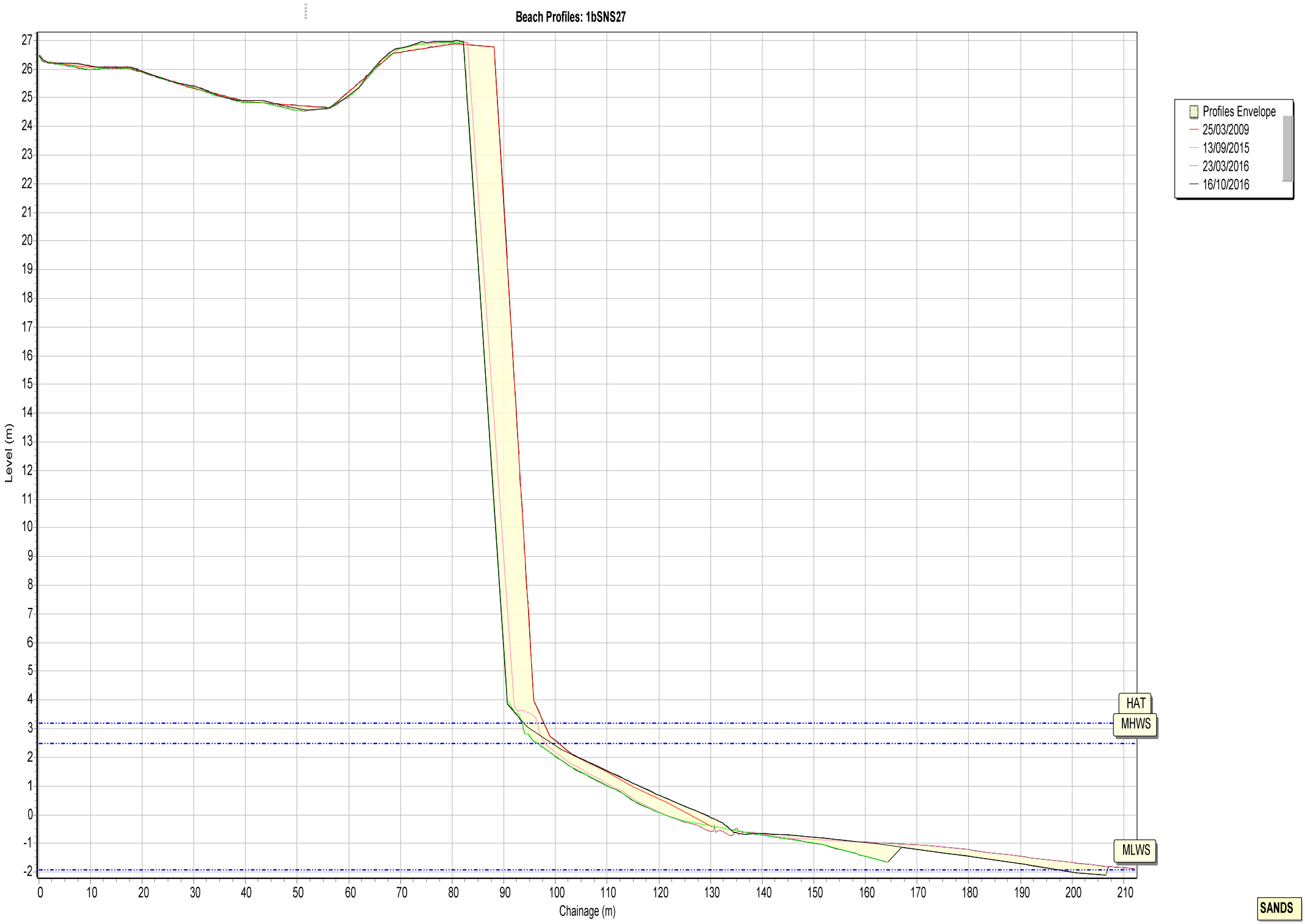
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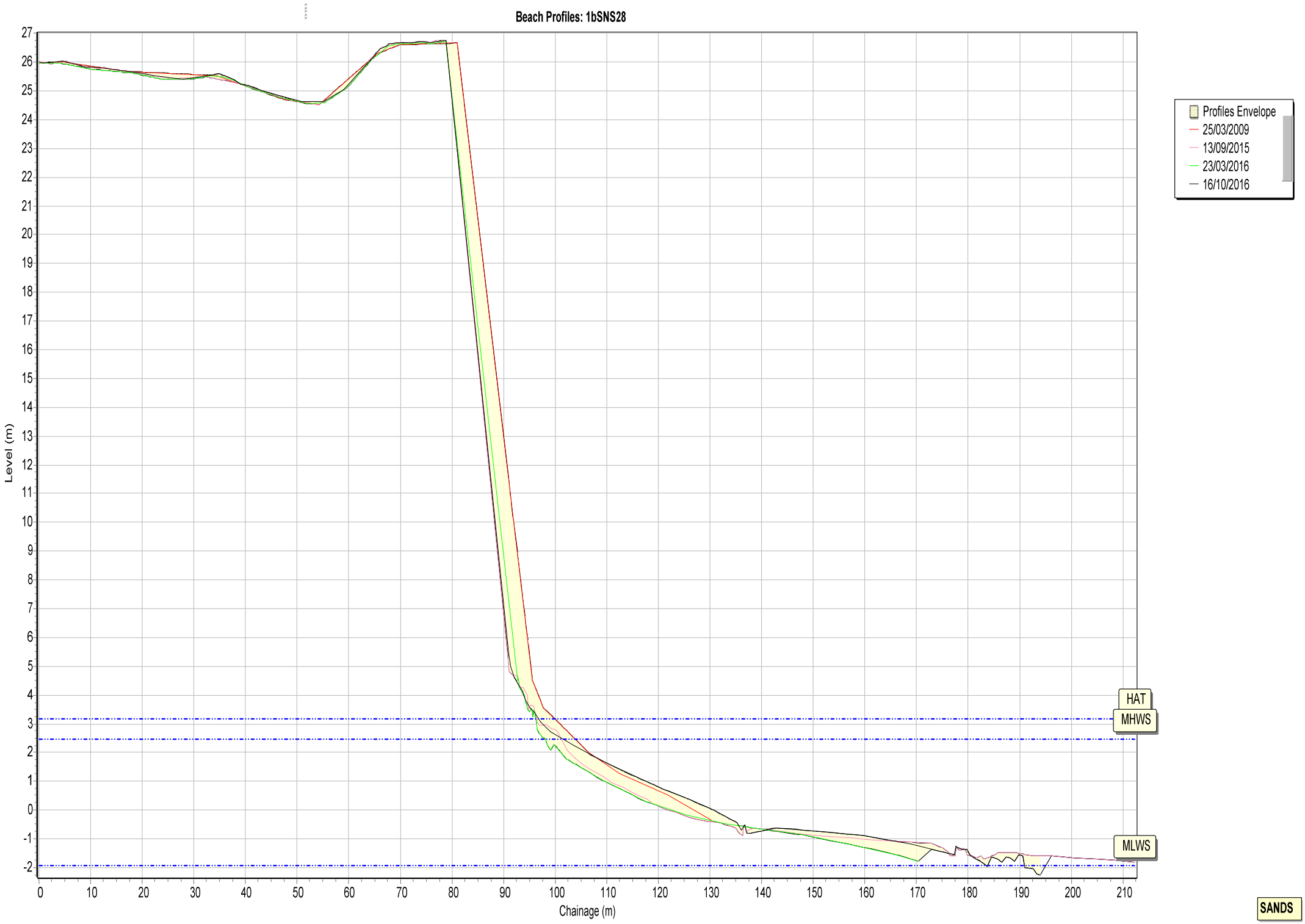
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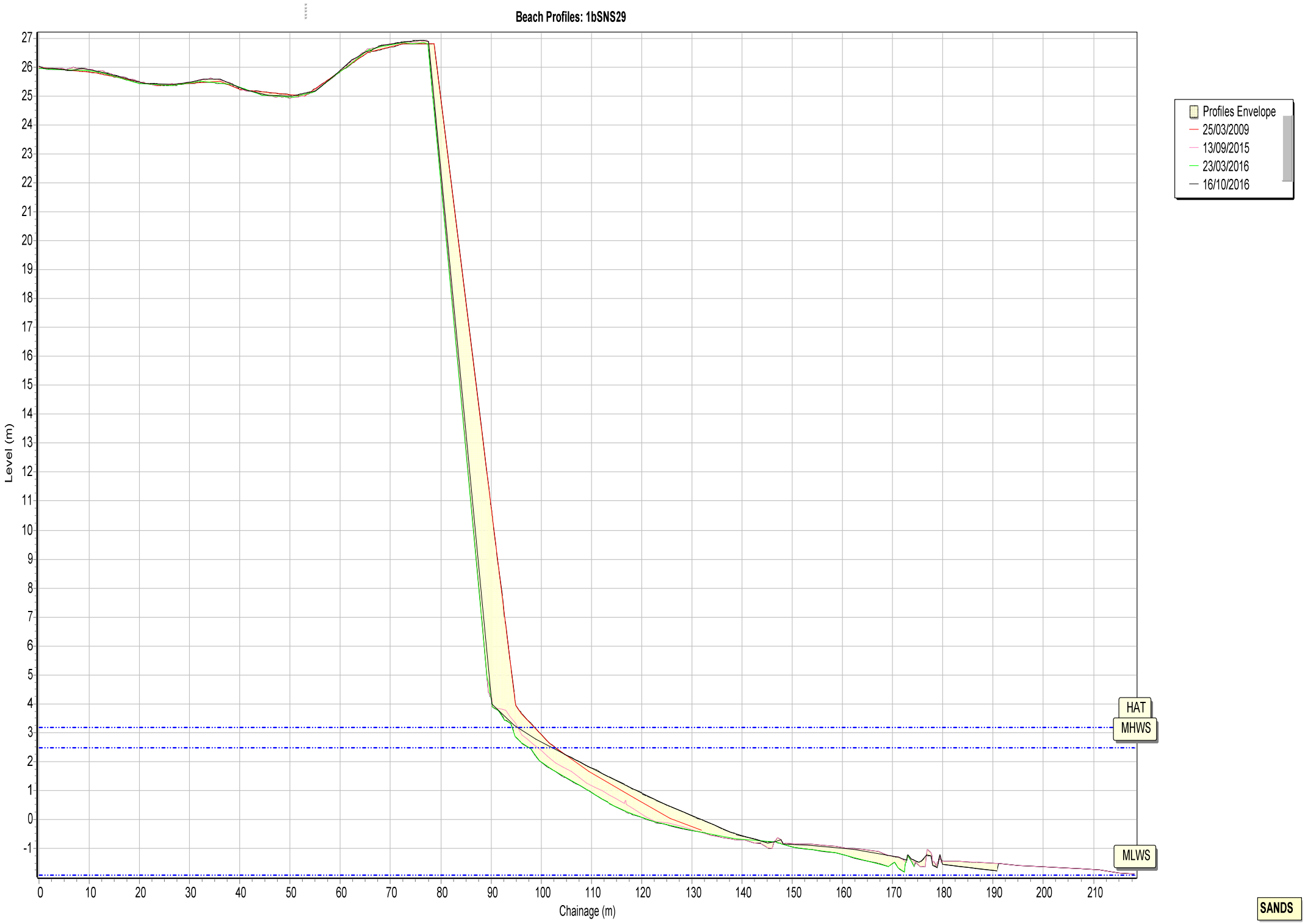
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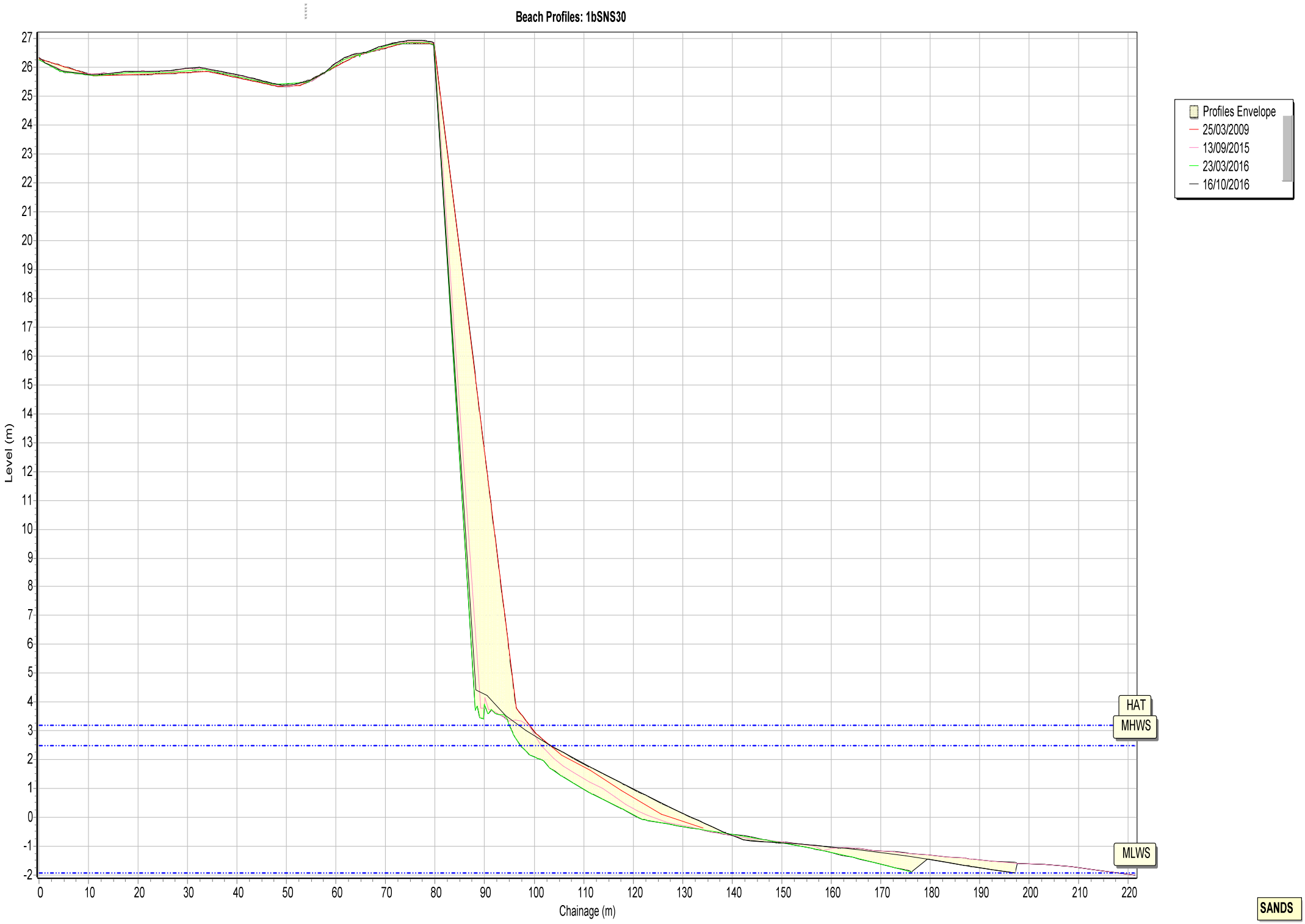
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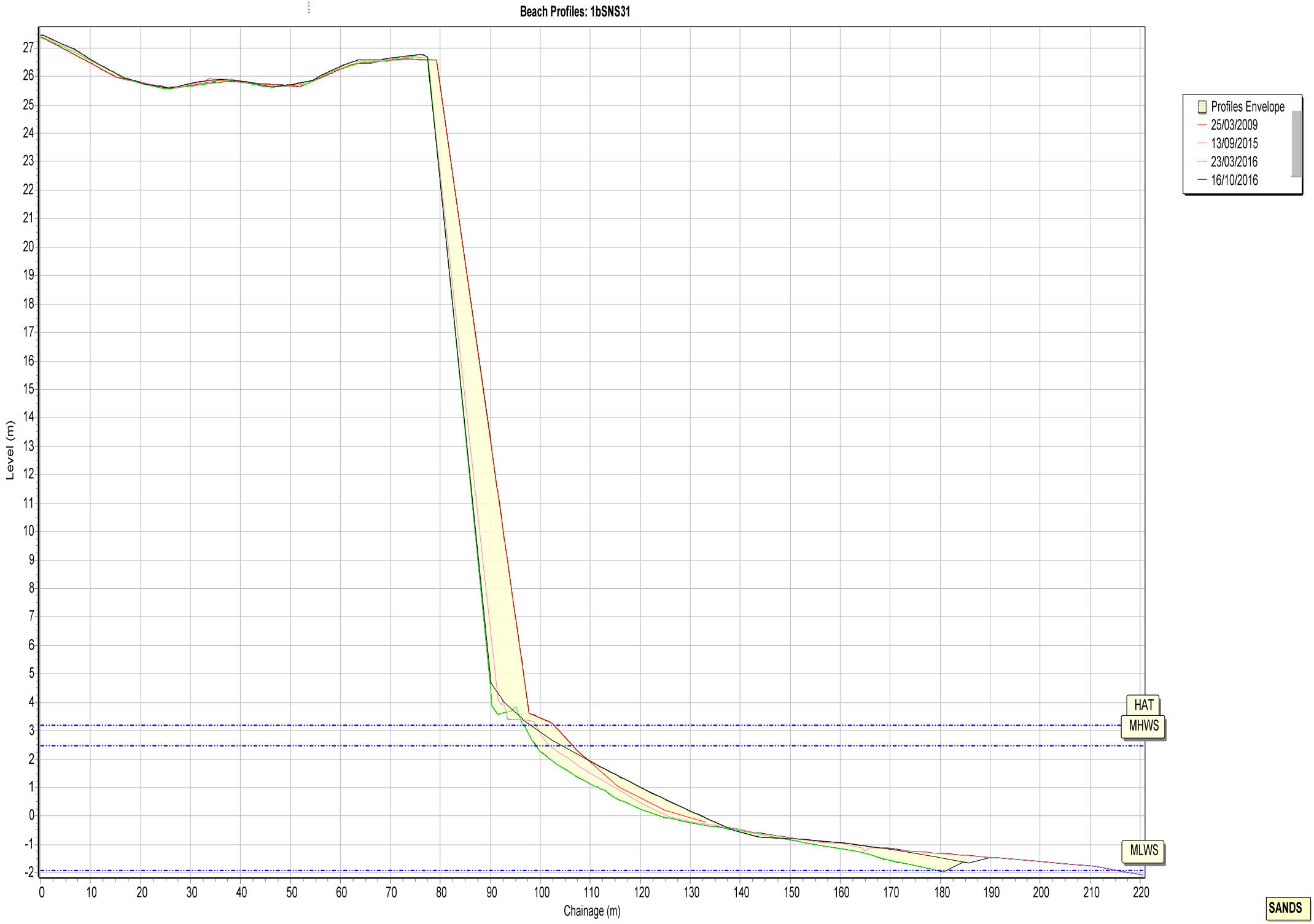
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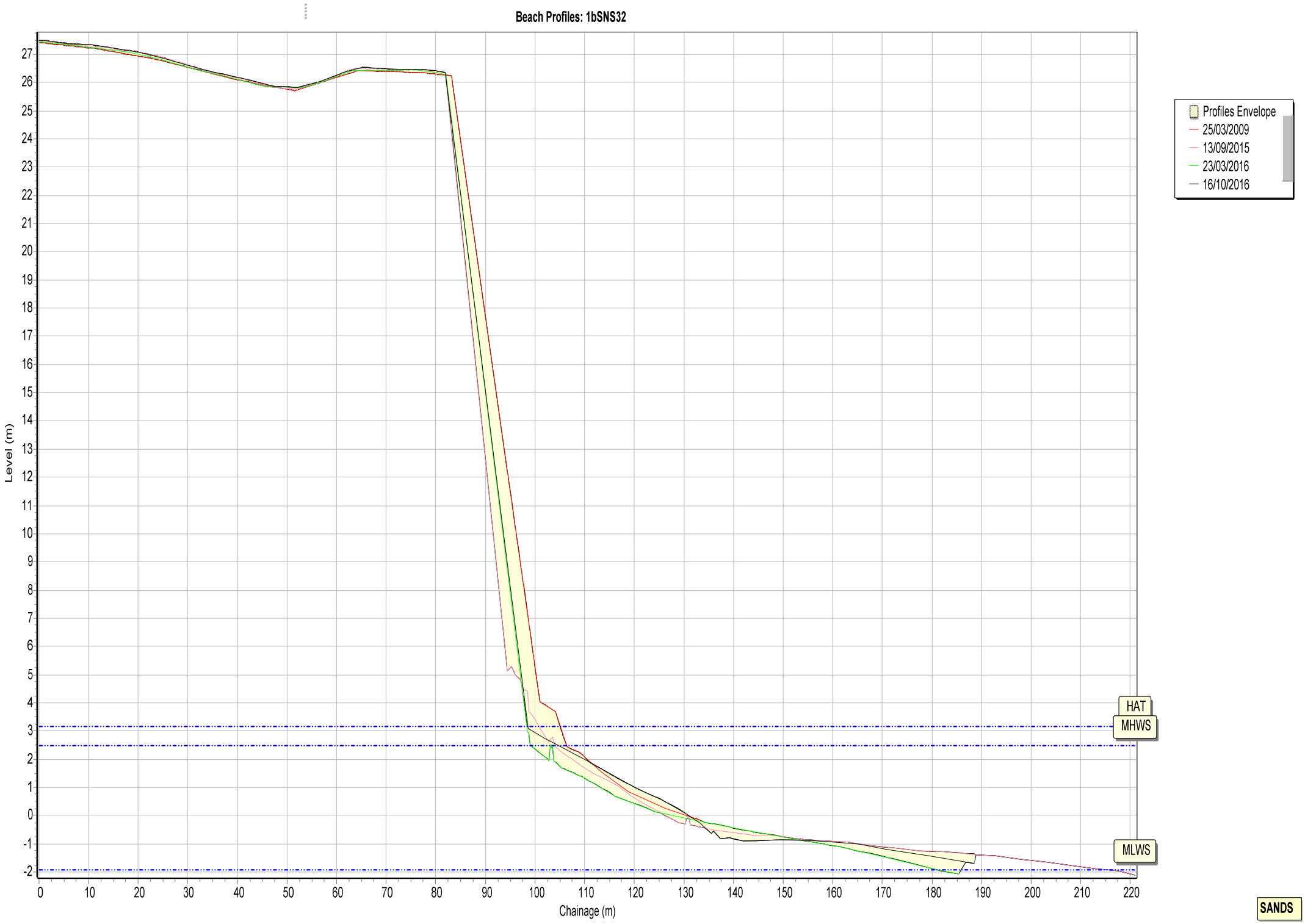
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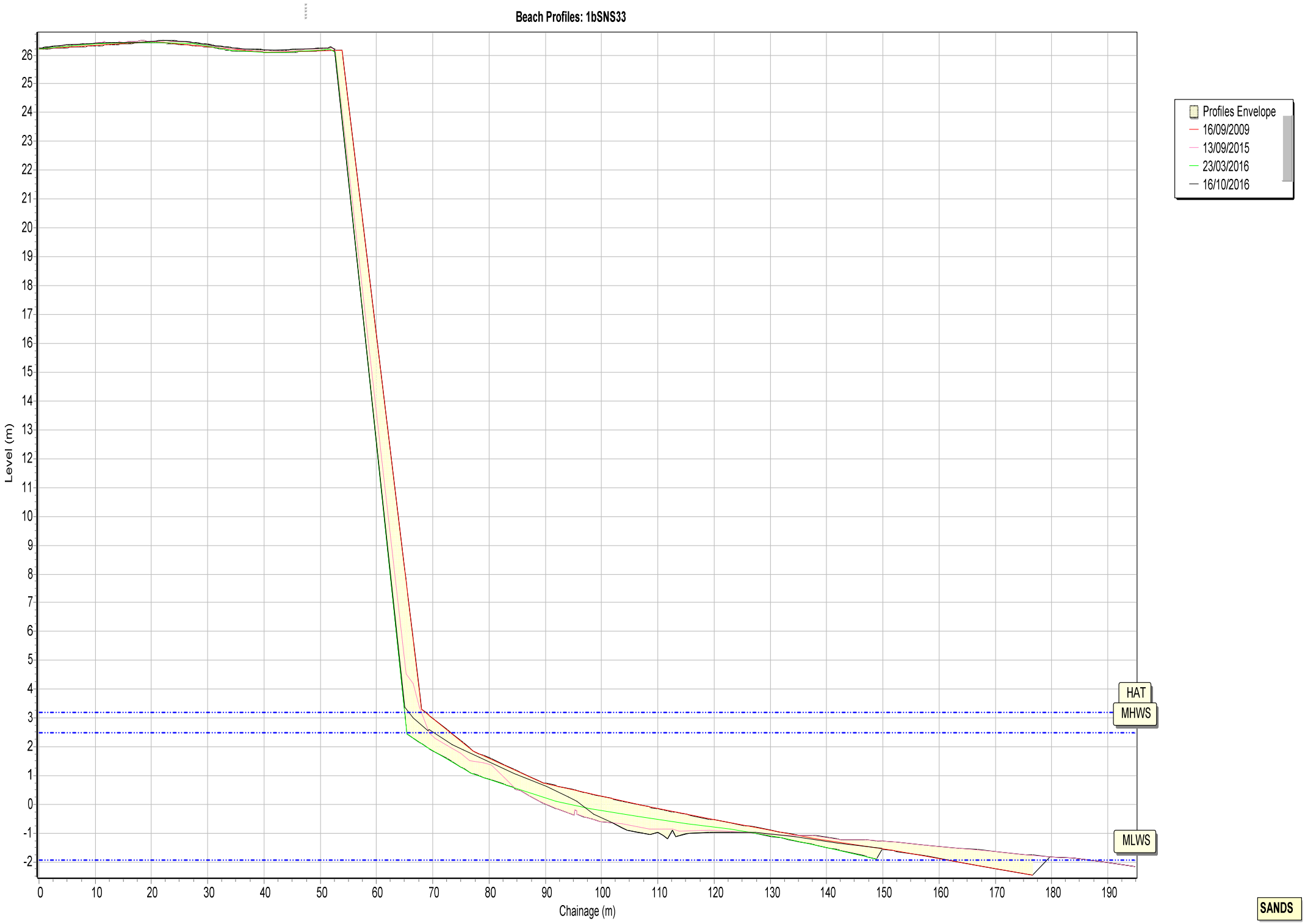
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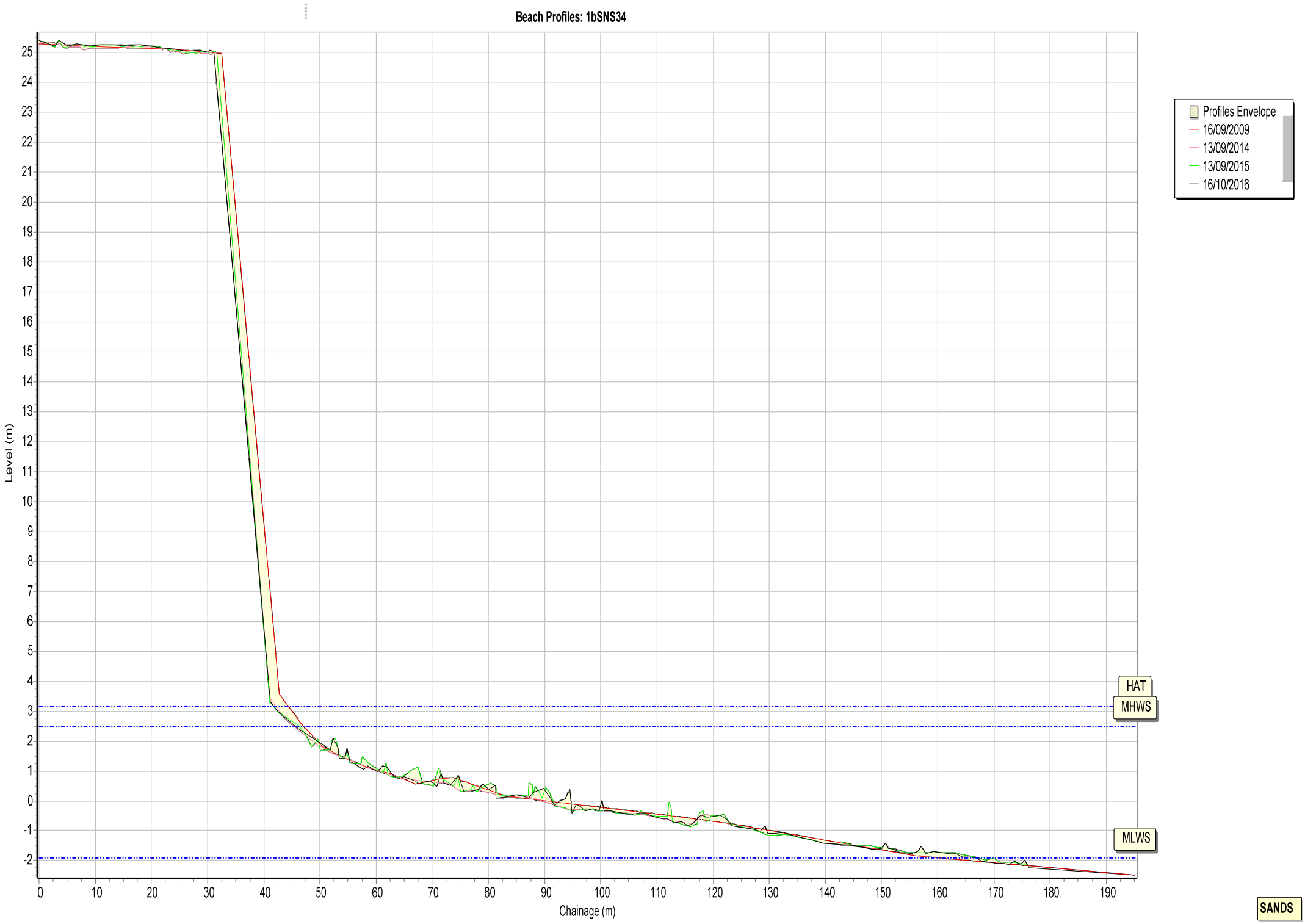
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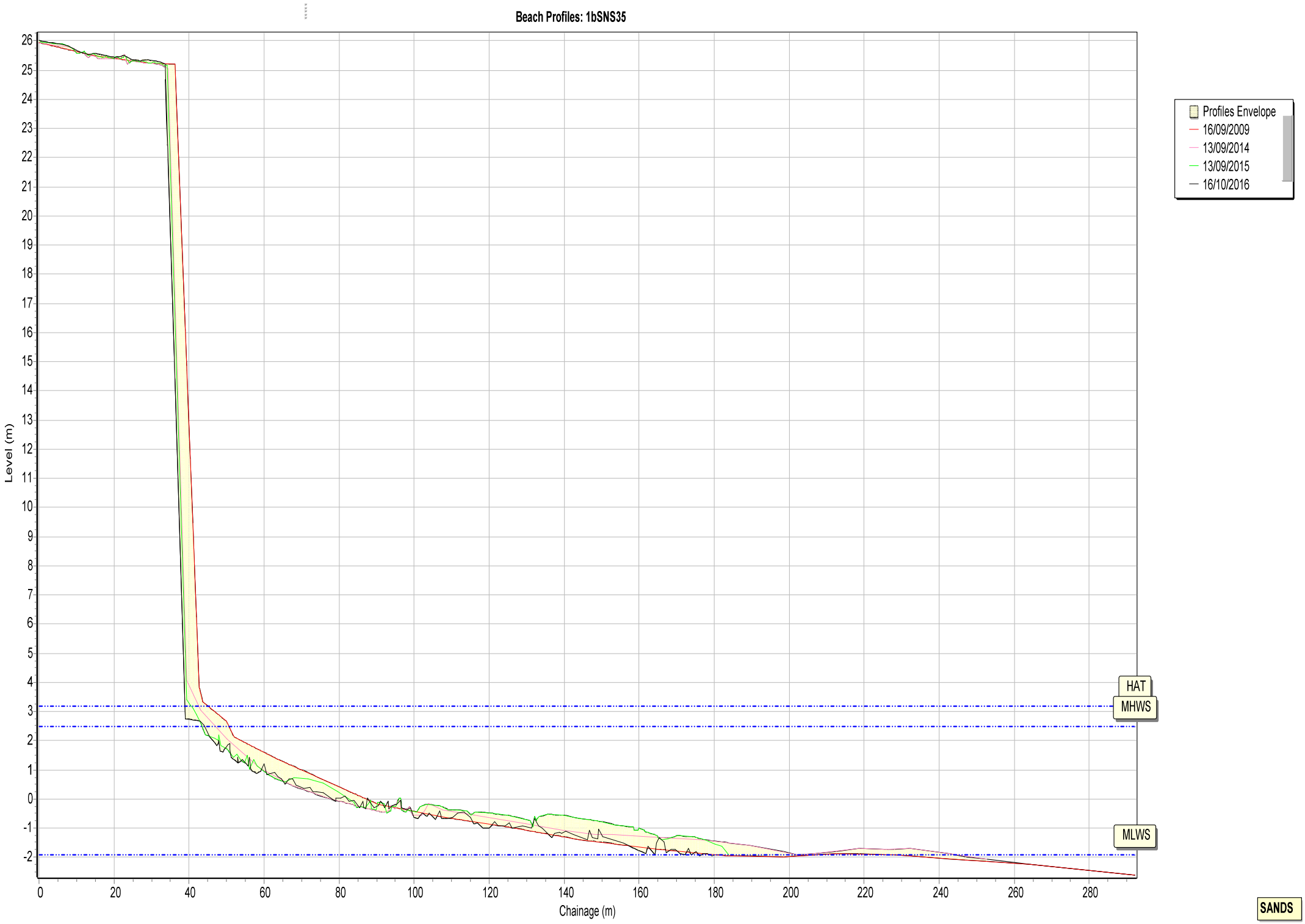
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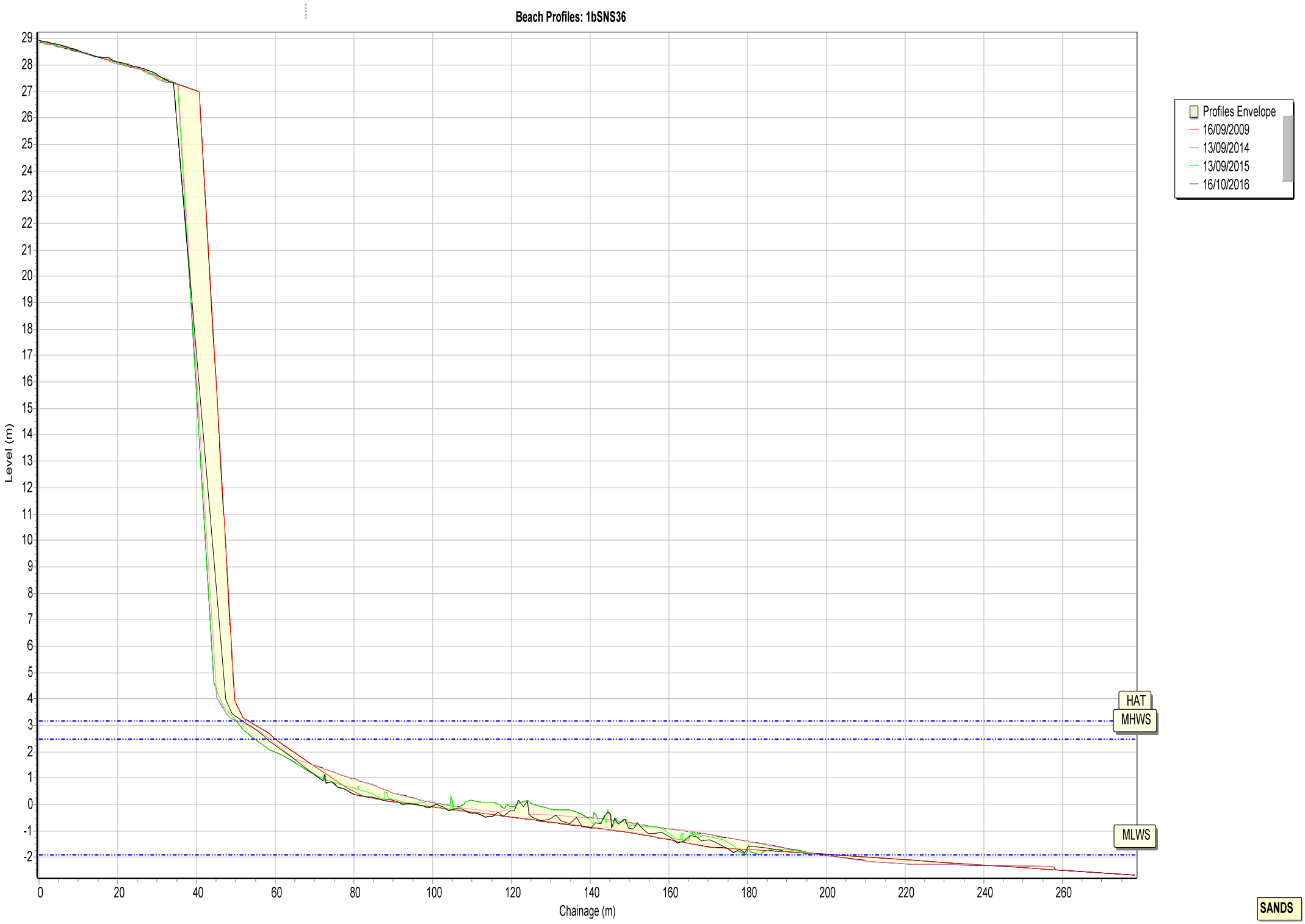
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Level (m)
Chainage (m)
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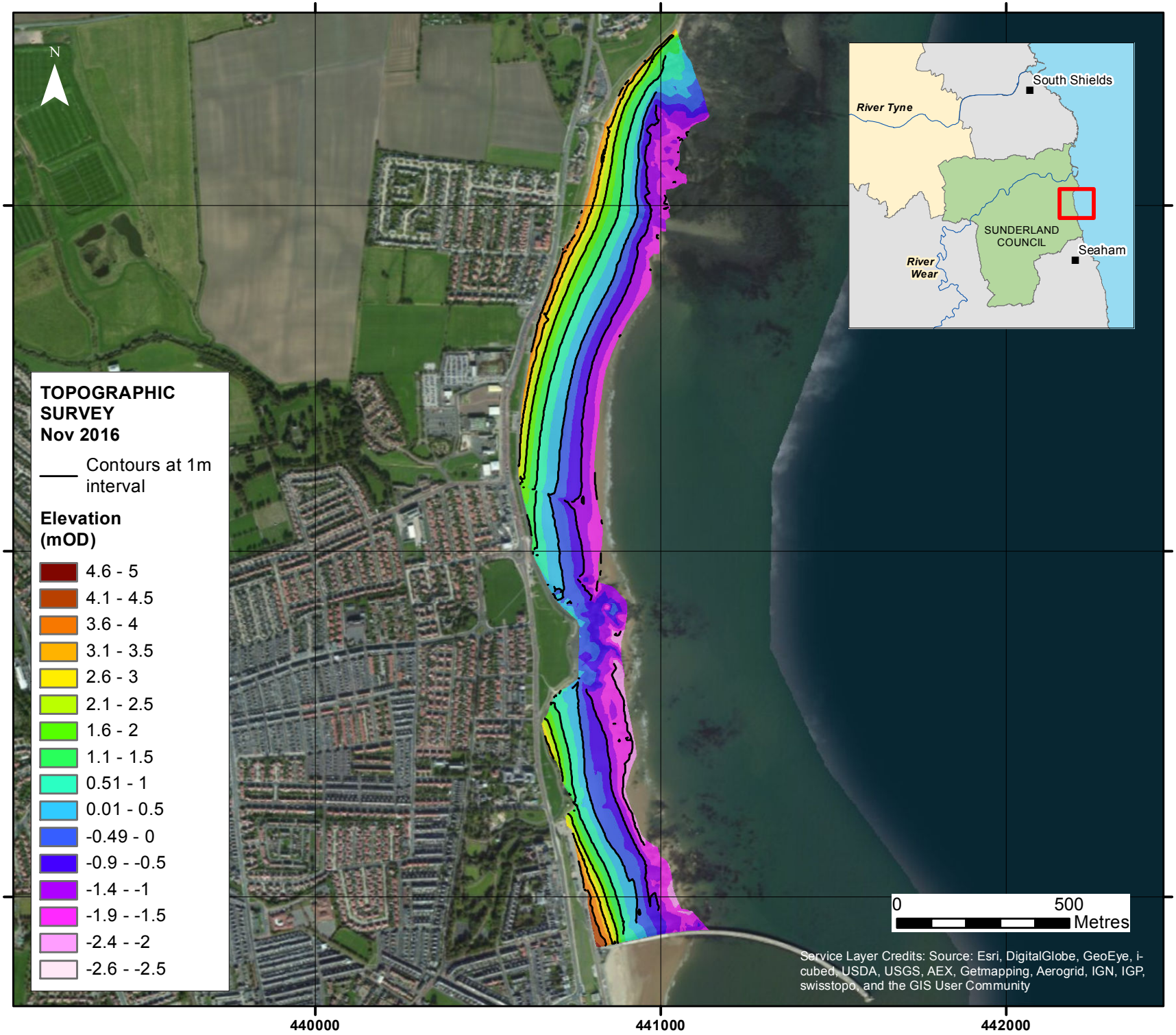
MHWS
MLWS
SANDS

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

Appendix B

Topographic Survey



Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 1

SUNDERLAND NORTH

Sunderland Council Frontage

Analytical Report 'Full Measures' Survey 2016

Drawing Scale at A4 1:15,000

WATER
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Fax: +44 (0)191 211 1313
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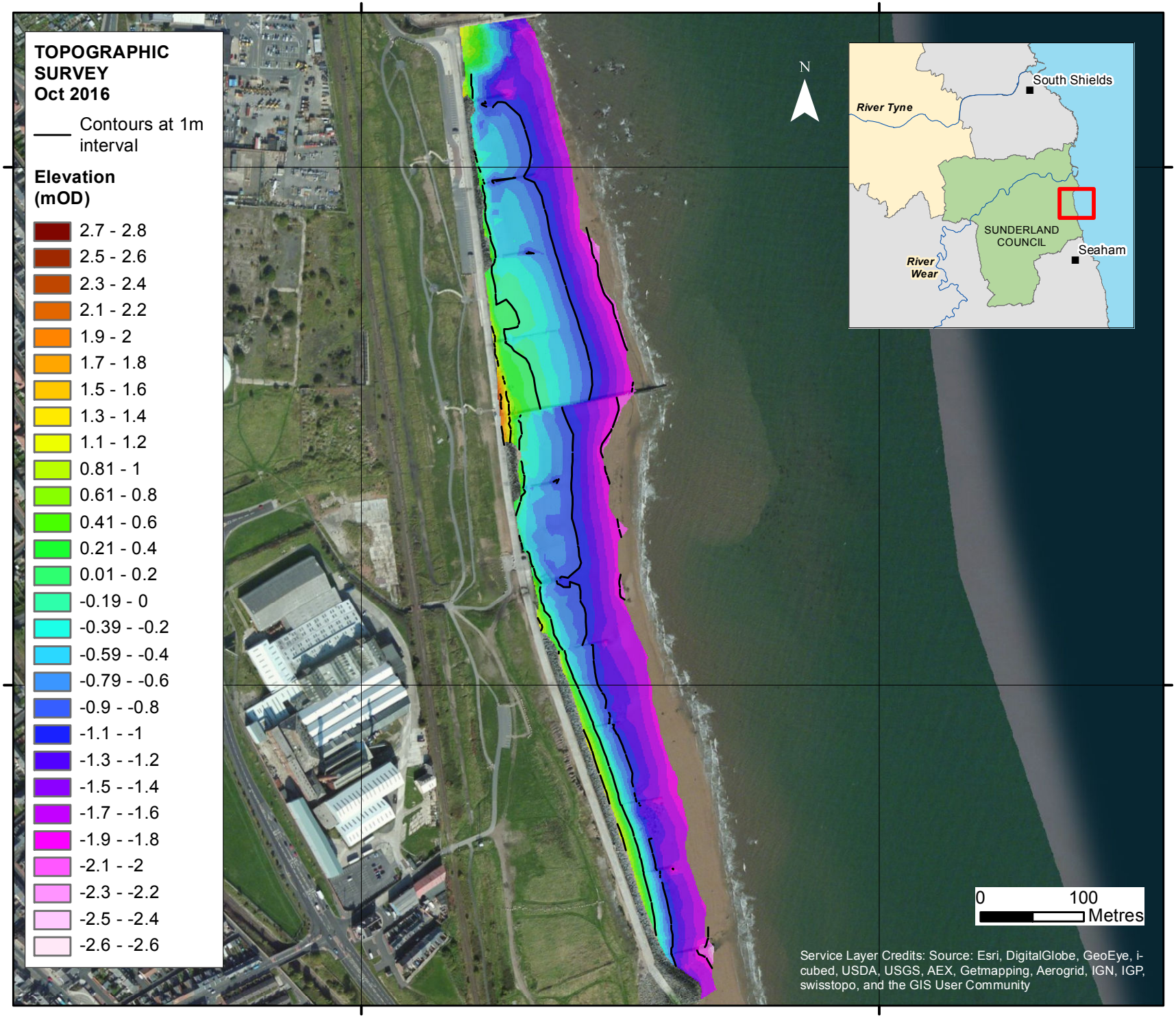

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 2

SUNDERLAND SOUTH

Sunderland Council Frontage

Analytical Report
'Full Measures' Survey 2016

Drawing Scale at A4 1:5,000

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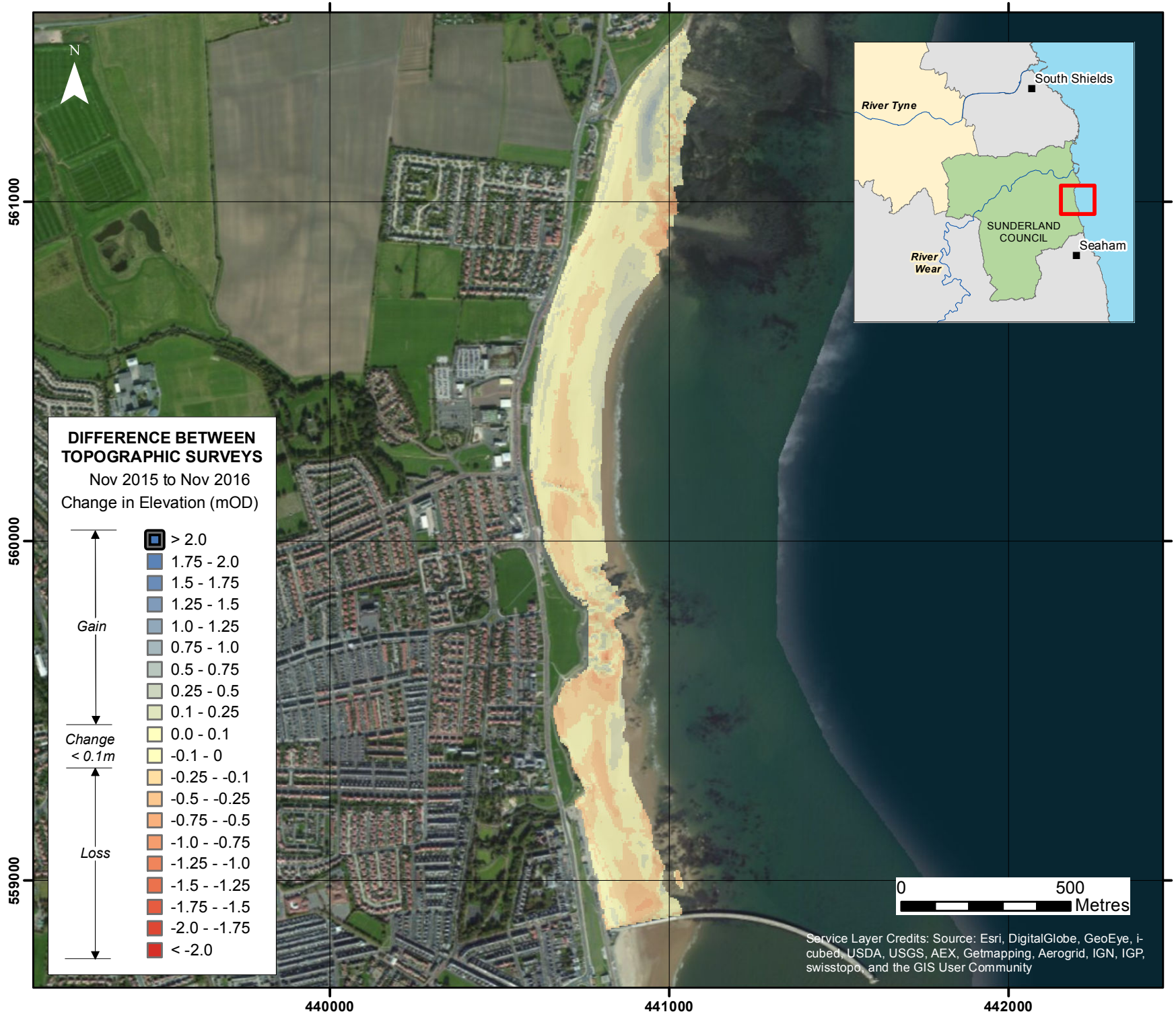

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 3

SUNDERLAND NORTH

Sunderland Council Frontage

Analytical Report
'Full Measures' Survey 2016

Drawing Scale at A4 1:15,000

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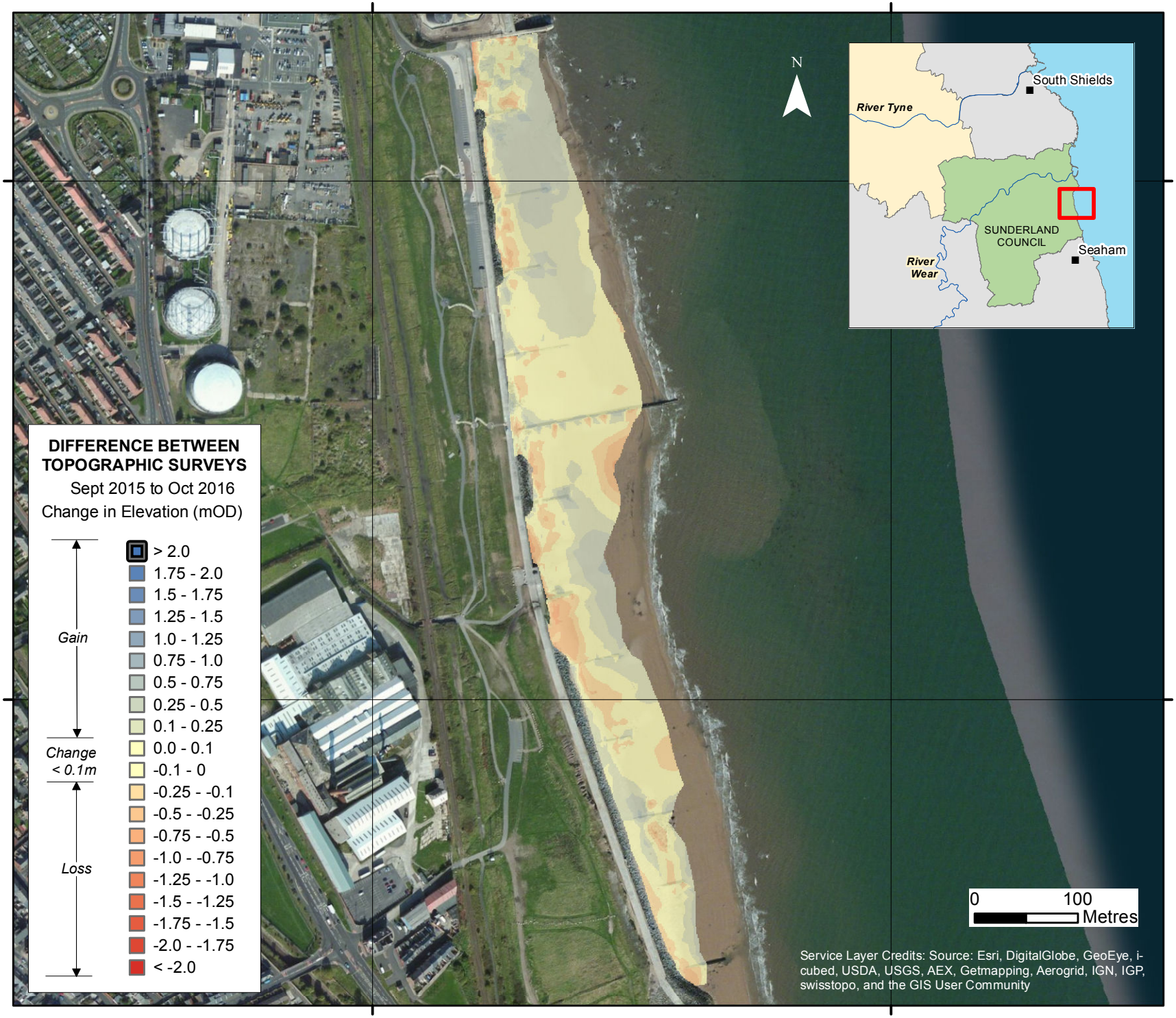

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 4

SUNDERLAND SOUTH

Sunderland Council Frontage

Analytical Report
'Full Measures' Survey 2016

Drawing Scale at A4 1:5,000

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Appendix C

Cliff Top Survey

Cliff Top Survey

Hendon and Ryhope

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

The cliff top surveys between Hendon and Ryhope are undertaken bi-annually. Measurements are taken from a fixed ground control point along a fixed bearing to the edge of the cliff top.

Table C1 provides baseline information about these ground control points and results from the 2009 (baseline) survey showing the position from the ground control point to the edge of the cliff top along the defined bearing. Future reports will show results from subsequent surveys and provide a means of assessing erosion since the baseline survey.

Table C1 – Cliff Top Surveys between Hendon and Ryhope

Ground Control Points				Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Easting	Northing	Bearing	Baseline Survey	Previous Survey	Present Survey	Baseline to Present	Previous to Present	Baseline to Present
			(°)	March 2009	March 2016	Oct 2016	Mar 2009 - Oct 2016	Mar 2016- Oct 2016	Mar 2009 - Oct 2016
1	441025.7	555571.1	75	8.16	8.4	8.28	-0.12	0.12	-0.02
2	441064.4	555355.1	85	7.09	5.5	5.23	1.86	0.27	0.27
3	441098	555124	82	10.01	10.4	10.34	-0.33	0.06	-0.05
4	441174	554938.7	65	10.3	10.5	10.42	-0.12	0.08	-0.02
5	441199.1	554861.1	65	7.71	10.9	10.87	-3.16	0.03	-0.45
6	441224.5	554774.2	71	10.83	10.9	10.86	-0.03	0.04	0.00
7	441248.4	554690.3	74	10.18	10.5	10.44	-0.26	0.06	-0.04
8	441259.3	554596.6	101	10.08	10	9.57	0.51	0.43	0.07
9	441275.8	554513.4	66	10.52	6.6	6.15	4.37	0.45	0.62
10	441309.4	554421.3	58	8.77	1.5	1.08	7.69	0.42	1.10
11	441354	554346.5	68	8.2	6.2	5.9	2.30	0.30	0.33
12	441400.2	554248.2	56	6.17	6	5.86	0.31	0.14	0.04
13	441452.3	554174.7	63	11.61	8.7	8.36	3.25	0.34	0.46

14	441472.3	554080.5	127	7.33	6.1	6.03	1.30	0.07	0.19
15	441413	554005.1	122	7.84	7.9	7.72	0.12	0.18	0.02
16	441384.8	553913.3	90	9.89	7.9	7.67	2.22	0.23	0.32
17	441404.1	553815.5	93	6.32	6	5.76	0.56	0.24	0.08
18	441404.1	553723.6	119	8.1	3.3	2.86	5.24	0.44	0.75
19	441398.5	553632.8	78	8.23	4.6	4.24	3.99	0.36	0.57
20	441438.3	553452.9	71	10.09	5.7	5.53	4.56	0.17	0.65
21	441506.1	553256.1	62	8.57	1.7	1.38	7.19	0.32	1.03
22	441550.1	553158.7	103	6.57	3.4	2.45	4.12	0.95	0.59
23	441585.2	553076.5	64	8.11	7.9	7.72	0.39	0.18	0.06
24	441624.4	552870.7	69	7.53	3.9	3.72	3.81	0.18	0.54
25	441689.1	552758	70	14.58	7	6.64	7.94	0.36	1.13
26	441715	552713.3	54	12.87	10.7	10.4	2.47	0.30	0.35
27	441749.2	552674.4	62	14.56	3.4	2.97	11.59	0.43	1.66
28	441776.6	552629.9	57	8.62	4.3	4.01	4.61	0.29	0.66
28A	441798.6	552586.3	56	13.63	8.1	7.8	5.83	0.30	0.83
28B	441817.4	552542.4	64	12.3	11.3	11.13	1.17	0.17	0.17
28C	441852.2	552502.6	52	13.11	12.9	12.51	0.60	0.39	0.09
29	441880.1	552471.6	83	15.46	15.2	14.98	0.48	0.22	0.07
30	441921.4	552269	97	8.55	6.5	6.46	2.09	0.04	0.30
31	441853.1	552094	75	11.2	6	5.83	5.37	0.17	0.77
32	441883.3	551988.5	96	9.82	3.7	3.49	6.33	0.21	0.90