



## **Cell 1 Regional Coastal Monitoring Programme Analytical Report 11 Full Measures Survey 2018**



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**Scarborough Council  
March 2019**

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## Abbreviations and Acronyms

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

## Water Levels Used in Interpretation of Changes

Water Level Parameter	Water Level (m AOD)			
	Hartlepool Headland to Saltburn Scar	Skinningrove	Hummersea Scar to Sandsend Ness	Sandsend Ness to Saltwick Nab
1 in 200 year	3.87	3.86	4.1	3.88
HAT	3.25	3.18	3.15	3.10
MHWS	2.65	2.68	2.65	2.60
MLWS	-1.95	-2.13	-2.15	-2.20

Water Level Parameter	Water Level (m AOD)			
	Saltwick Nab to Hundale Point	Hundale Point to White Nab	White Nab to Filey Brigg	Filey Brigg to Flamborough Head
1 in 200 year	3.88	3.93	3.93	4.04
HAT	3.10	3.05	3.05	3.10
MHWS	2.60	2.45	2.45	2.50
MLWS	-2.20	-2.35	-2.35	-2.30

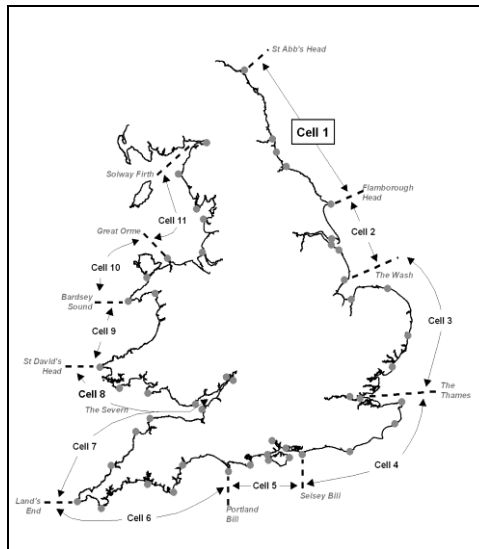
**Source:** *River Tyne to Flamborough Head Shoreline Management Plan 2.*  
Royal Haskoning, February 2007.

## Glossary of Terms

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

## Preamble

The Cell 1 Regional Coastal Monitoring Programme covers approximately 300km of the northeast England 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. A Cell 1 Overview Report is also produced regularly to provide a region-wide summary of the main findings relating to trends and interactions along the entire Cell 1 frontage.

To date the following reports have been produced:

**Table 1 Analytical, Update and Overview Reports Produced to Date**

Year		Full Measures		Partial Measures		Cell 1 Overview Report
		Survey	Analytical Report	Survey	Update Report	
1	2008/09	Sep-Dec 08	May 09	Mar-May 09		-
2	2009/10	Sep-Dec 09	Mar 10	Feb-Mar 10	Jul 10	-
3	2010/11	Aug-Nov 10	Feb 11	Feb-Apr 11	Aug 11	Sep 11
4	2011/12	Sep 11	Aug 12	Mar-May 12	Feb 13	
5	2012/13	Sep 12	Mar 13	Apr-May 13	May 13	
6	2013/14	Sep 13	Feb 14	Mar-Apr 14	Jul 14	
7	2014/15	Sep 14	Feb 15	Mar 15	Jul 15	
8	2015/16	Sep 15	Feb 16	Mar – Apr 16	Jul 16	Jun 16
9	2016/17	Sep–Nov16	Feb 17	Feb-Apr 17	Jul 17	
10	2017/18	Sep-Oct 16	Jan 17	Mar-May 18	Jun 18	Nov 18
11	2018/19	Sep-Oct 18	Mar 19(*)			

(\*) The present report is **Analytical Report 11** and provides an analysis of the autumn/winter 2018 Full Measures survey for Scarborough Borough Council's frontage.

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

For purposes of analysis, the Cell 1 frontage has been split into the sub-sections listed in Table 2. Areas covered in the current report are highlighted

**Table 2 Sub-divisions of the Cell 1 Coastline**

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



## 1. Introduction

### 1.1 Study Area

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

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

### 1.2 Methodology

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

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

The location of these surveys is shown in Figure 2. Full Measures surveys were undertaken along this frontage between 11<sup>th</sup> September 2018 and 29<sup>th</sup> October 2018. The weather and sea state varied greatly in that time, for details of the survey conditions refer to the Academy Geomatics survey reports for each location.

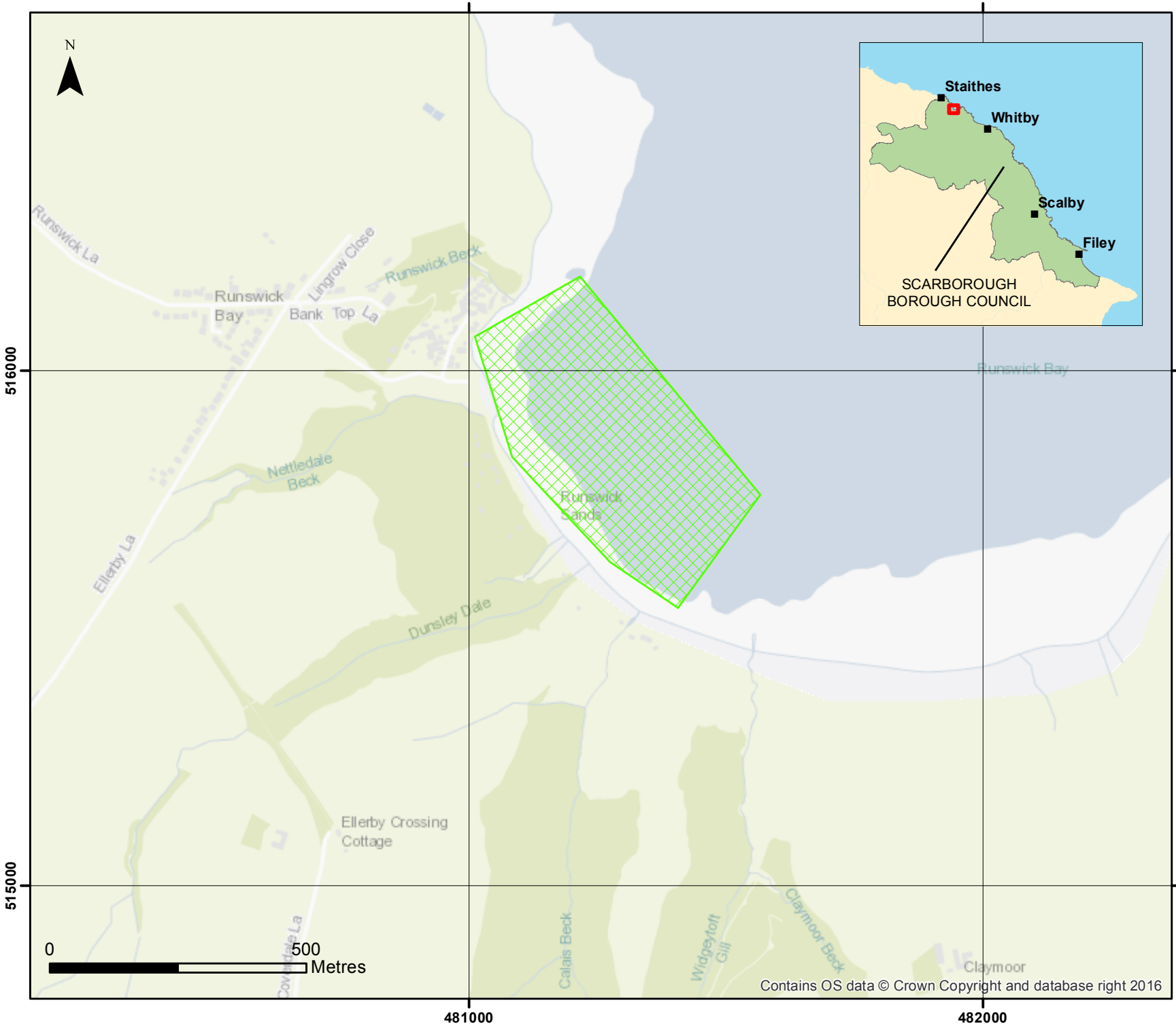
All data have been captured in a manner commensurate with the principles of the Environment Agency's *National Standard Contract and Specification for Surveying Services* and stored in a file format compatible with the software systems being used for the data analysis, namely SANDS and ArcGIS. This data 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**

**Scarborough Borough Council Frontage**

Analytical Report  
 Topo Surveys

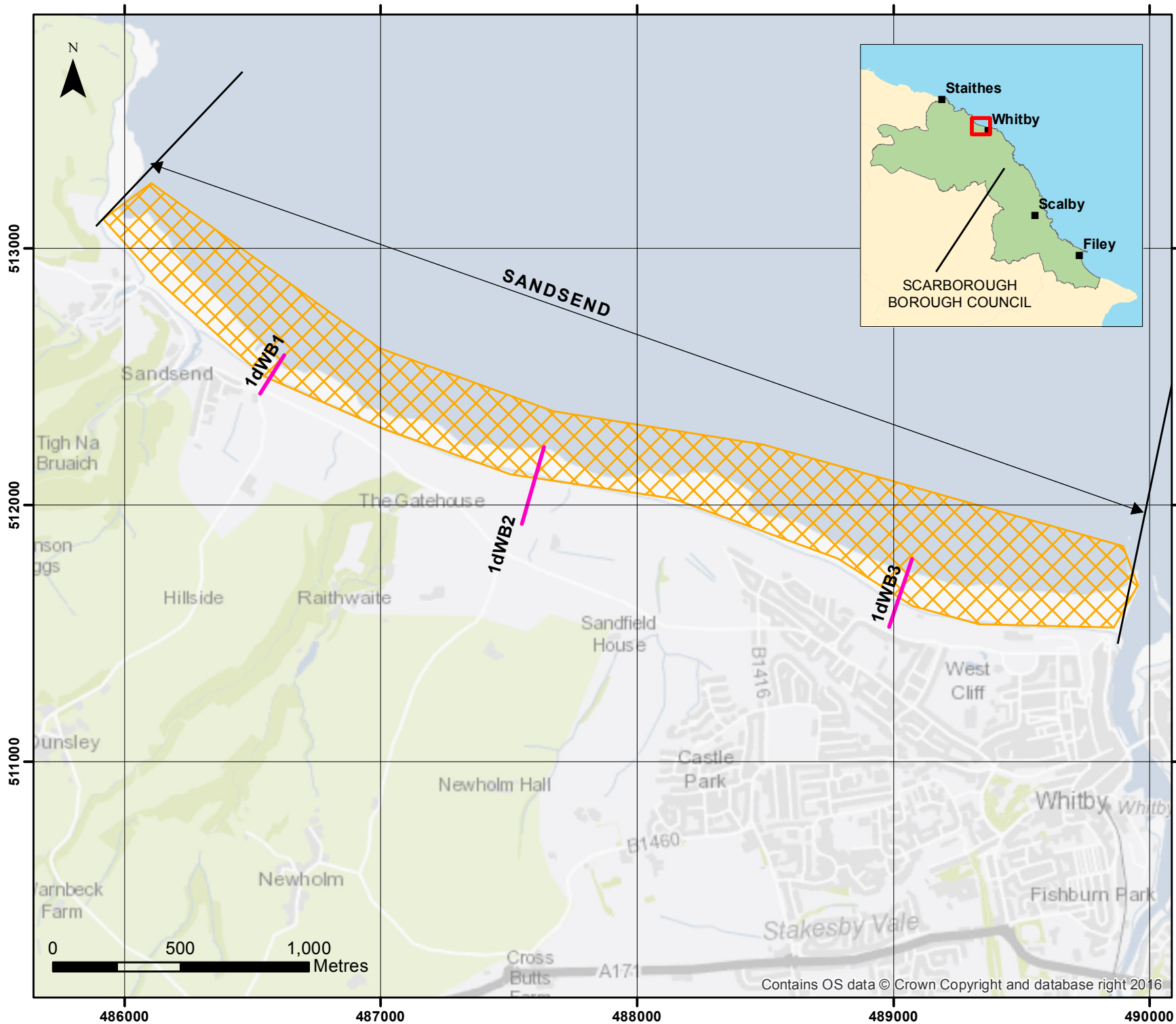
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Key

**SURVEY LOCATIONS**

**Topographic Profiles**

- Annual (Blue line)
- Bi-Annual (Pink line)

**Topographic Surveys**

- 6 monthly (Green cross-hatch)
- yearly (Orange cross-hatch)
- 5 yearly (Brown cross-hatch)

*(Indicative Survey Extents shown)*

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

**Figure 2 - Map 2**

**Scarborough Borough Council Frontage**

Analytical Report  
 Topo Surveys

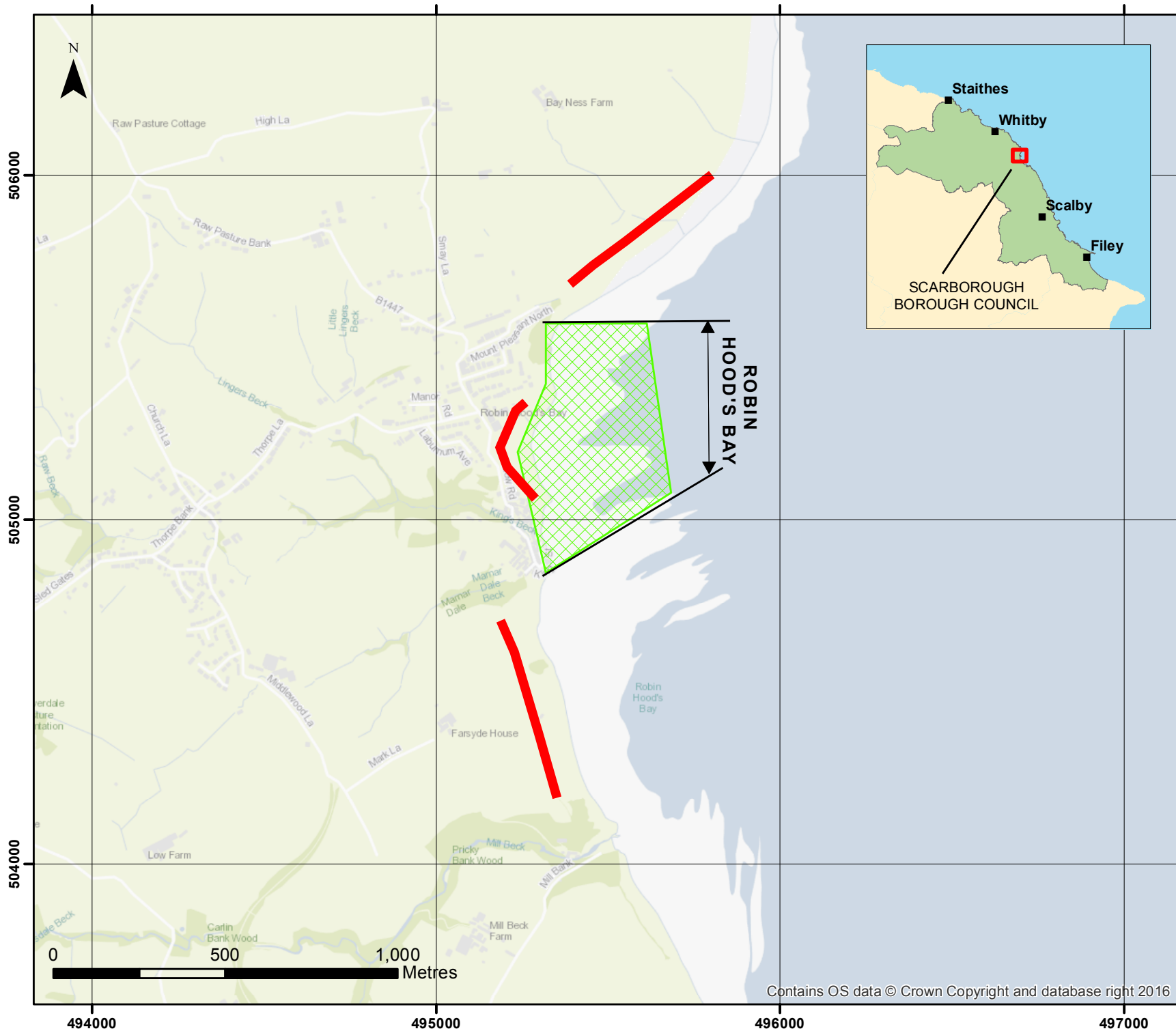
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Key

**SURVEY LOCATIONS**

**Topographic Profiles**

- Annual
- Bi-Annual

**Topographic Surveys**

- 6 monthly
- yearly

**Cliff Top Monitoring Pegs**

- @ 300 centres

*(Indicative Survey Extents shown)*

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

**Figure 2 - Map 3**

**Scarborough Borough Council Frontage**

Analytical Report  
Topo Surveys

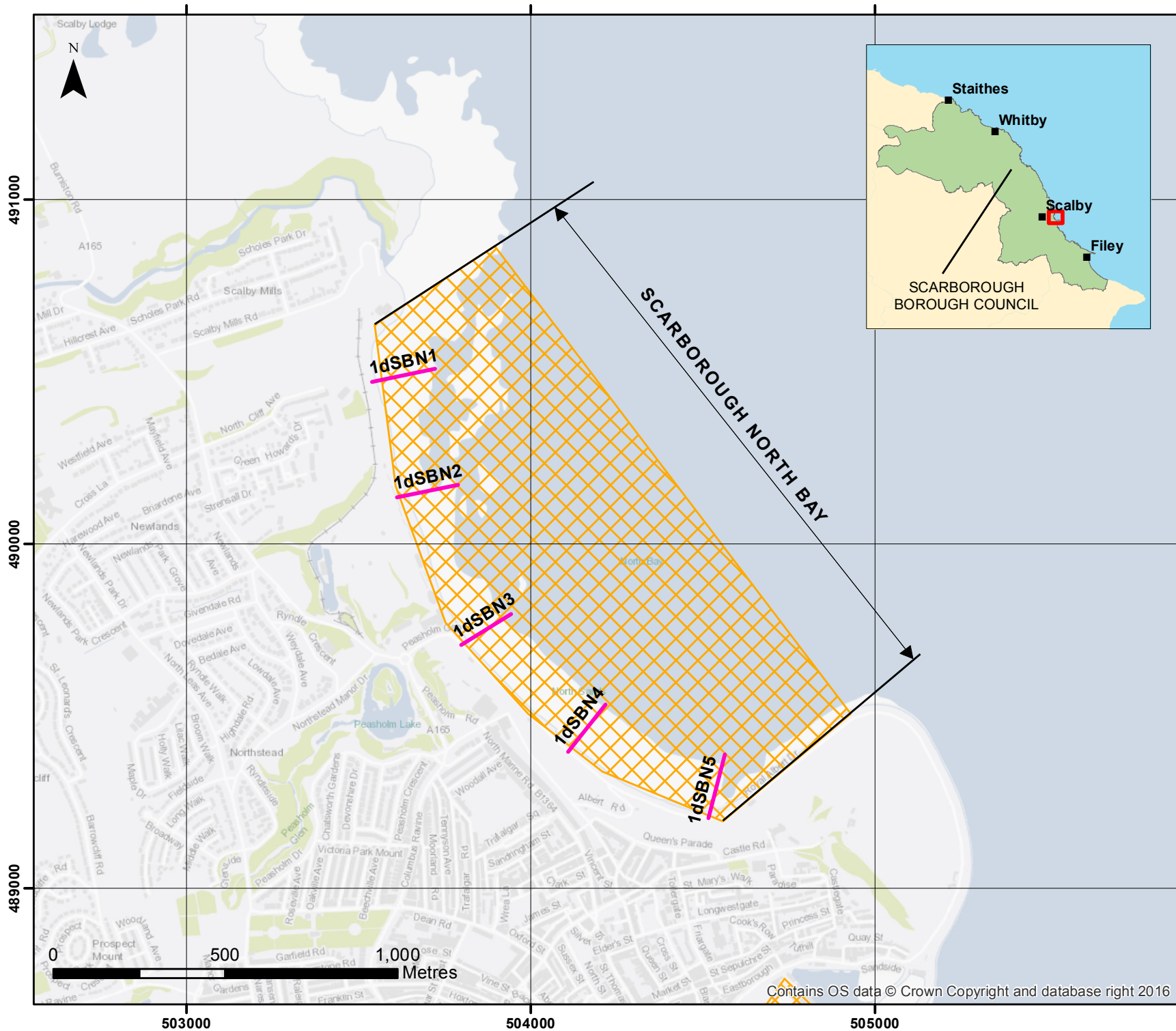
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Key

**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 4**

**Scarborough Borough Council Frontage**  
 Analytical Report  
 Topo Surveys

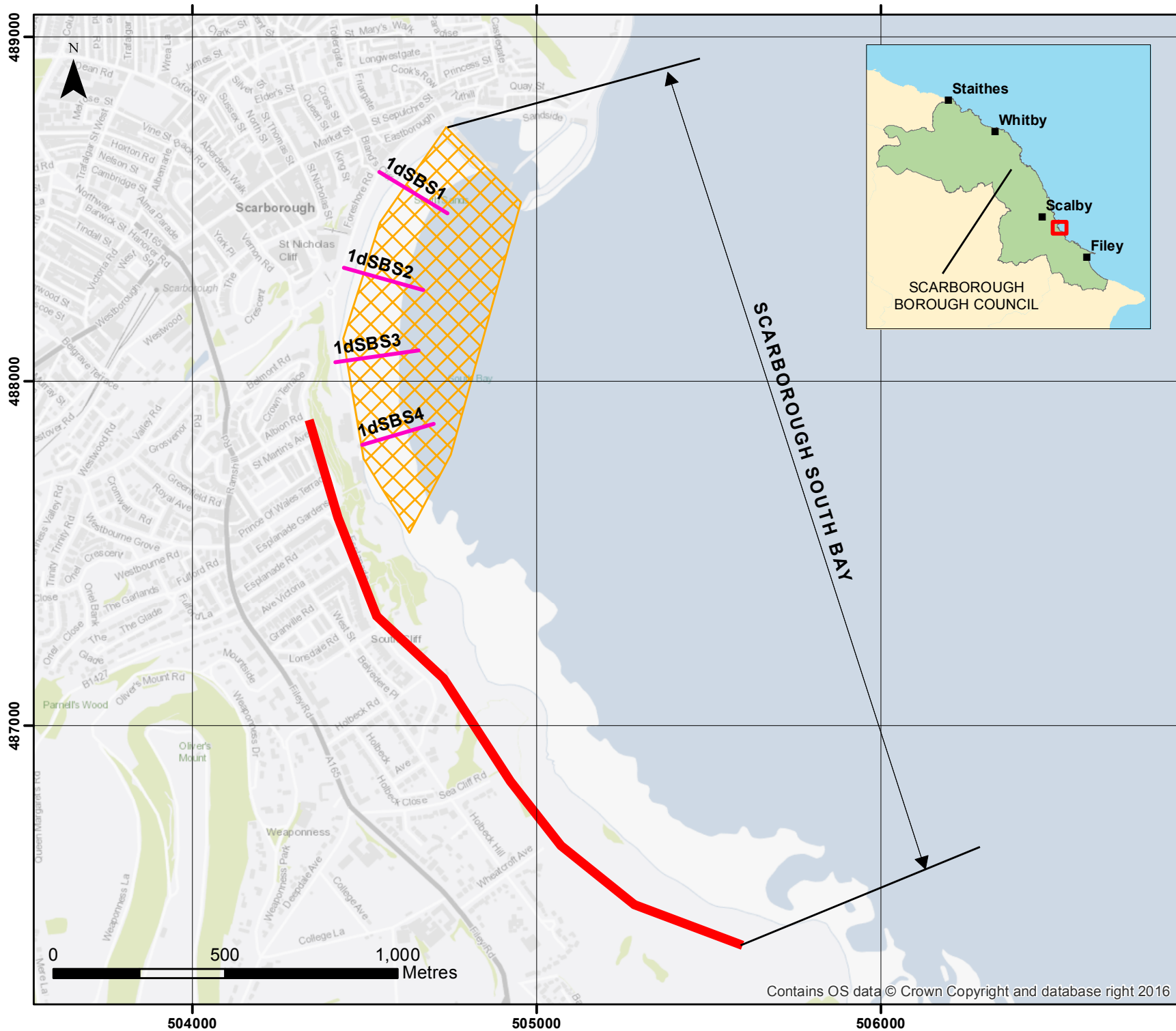
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**Key**

**SURVEY LOCATIONS**

**Topographic Profiles**

- Annual (Blue line)
- Bi-Annual (Pink line)

**Topographic Surveys**

- 6 monthly (Green grid)
- yearly (Orange grid)

**Cliff Top Monitoring Pegs**

- @ 300 centres (Red line)

*(Indicative Survey Extents shown)*

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

**Figure 2 - Map 5**

**Scarborough Borough Council Frontage Analytical Report Topo Surveys**

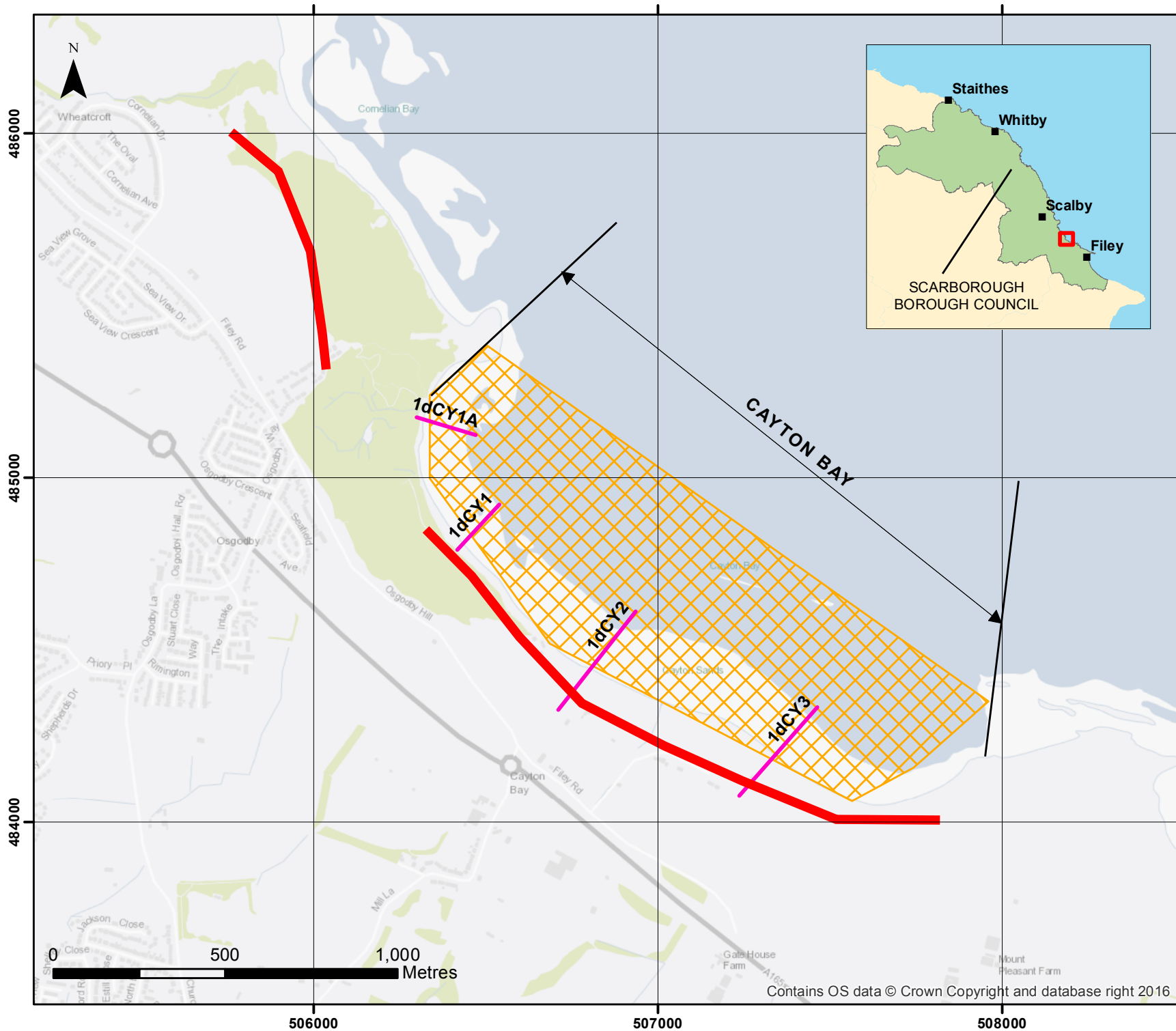
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Key

**SURVEY LOCATIONS**  
**Cliff Top Monitoring Pegs**  
 @ 300 centres

**Topographic Profiles**  
 Annual  
 Bi-Annual

**Topographic Surveys**  
 6 monthly  
 yearly  
*(Indicative Survey Extents shown)*

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

**Figure 2 - Map 6**

**Scarborough Borough Council Frontage**

Analytical Report  
 Topo Surveys

Drawing Scale at A4 1:15,000

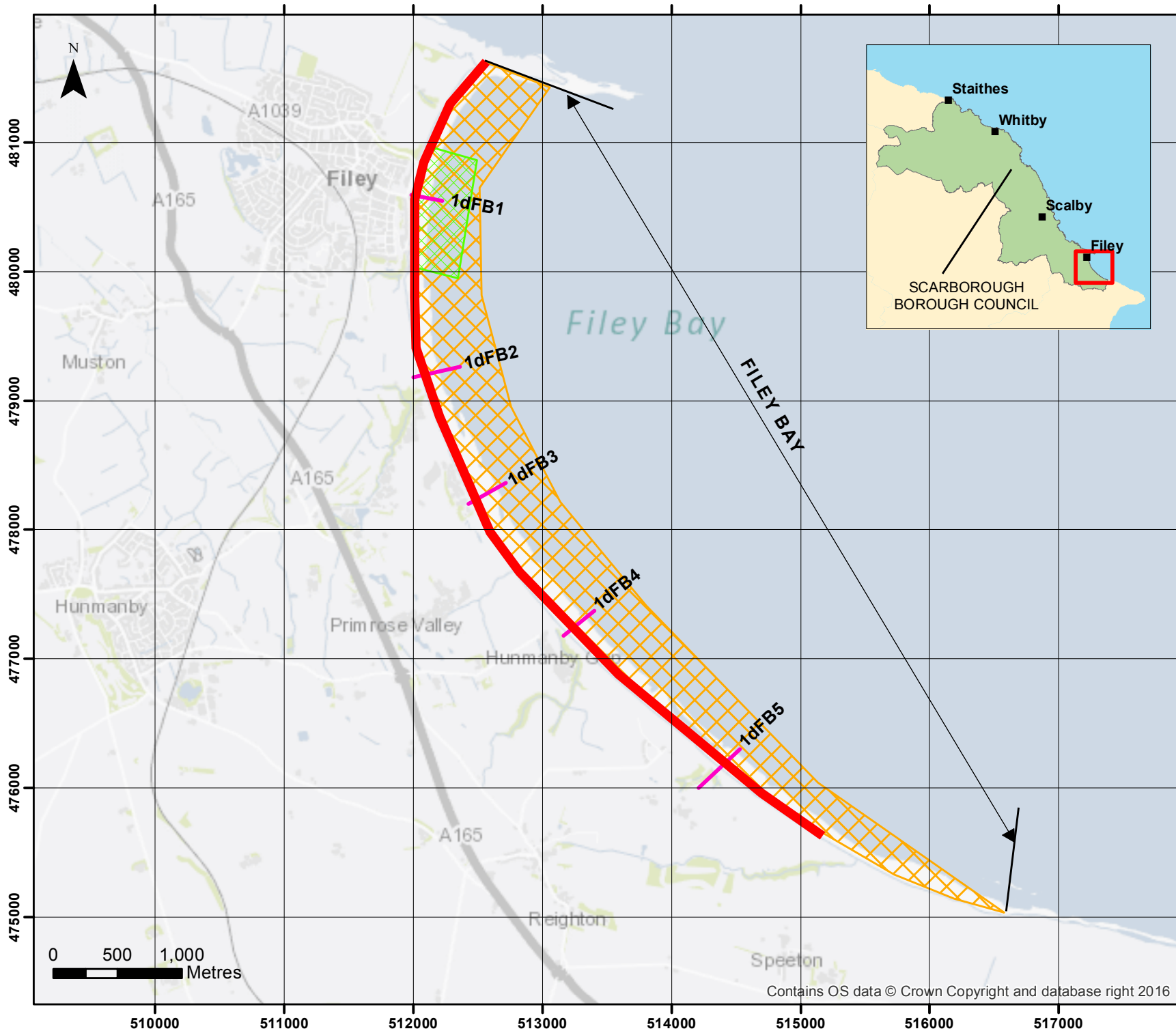
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Key

**SURVEY LOCATIONS**

**Topographic Profiles**

- Annual
- Bi-Annual

**Topographic Surveys**

- 6 monthly
- yearly

**Cliff Top Monitoring Pegs**

- @ 300 centres

*(Indicative Survey Extents shown)*

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

**Figure 2 - Map 7**

**Scarborough Borough Council Frontage**

Analytical Report  
Topo Surveys

Drawing Scale at A4 1:40,000

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## 2. Analysis of Survey Data

### 2.1 Staithes

Survey Date	Description of Changes Since Last Survey	Interpretation
<p style="text-align: center;"><b>3<sup>rd</sup> September 2018</b></p>	<p><b>Cliff-top Survey:</b></p> <p>Twenty ground control points have been established at Cowbar and Staithes for biannual cliff top monitoring. Locations 12 to 20 are in the Scarborough Borough Council area. The separation between any two points is around 100 m. Data collection involves a distance offset measurement from the ground control point to the cliff edge along a fixed bearing.</p> <p>Between March 2018 and September 2018 8 of the 20 posts showed change within a range of <math>\pm 0.1\text{m}</math>, which is not considered significant given the error of the technique. Posts 9 – 12 were not accessible as in the previous survey. Three posts showed erosion outside the range of <math>\pm 0.1\text{m}</math> with post 1 showed significant erosion of 4.61m since March 2018. The remaining 5 posts appeared to show accretion of between 0.1 and 0.2m, it is suspected that this is an error caused by difficulty accessing the cliff edge.</p> <p>Calculation of longer-term erosion rates based on the recorded change between 2008 and 2018 indicates that 13 posts on the frontage recorded a change rate within a range of <math>\pm 0.1\text{m/yr}</math>, which is considered to be within the error of the measurement. Posts 1, 4, and 13 (near the eastern breakwater) shows consistent erosion through the surveys of between 0.16 and 0.65m/yr. Posts 9 to 12 remain inaccessible due to a landslip on the headland; the area was fenced off by the National Trust.</p> <p>Appendix C provides results from the September 2018 survey, showing the distance from the ground control point to the edge of the cliff top along the defined bearing and changes in position since the November 2008 baseline survey.</p>	<p>Some posts show stability, with some showing measurable recession. The worst over the short term being the most westerly, VMP1, which showed 4.61m recession since spring 2018. Four stations continue to be inaccessible due to a landslip on the headland.</p> <p><b>Longer term trends:</b> Table C1 shows that survey location 1 has shown the greatest total erosion with a loss of 4.61m (<math>\pm 0.3\text{m}</math>) between the November 2008 baseline and September 2018, resulting in a long-term average recession rate of 0.65m/yr. This location is to the most westerly of the survey locations and is adjacent the now diverted Cowbar Lane. Photos taken during the survey show evidence of recent headscarp activity.</p>

## 2.2 Runswick Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
<p style="text-align: center;"><b>29<sup>th</sup> October 2018</b></p>	<p><b>Topographic Survey:</b></p> <p>Runswick Bay is covered by a 6-monthly topographic survey. A consistently applied GIS processing routine has been used to create a digital ground model (DGM) (Appendix B - Map 1) and to calculate the differences between the current topographic survey (Autumn 2018) and the previous survey (Spring 2018) to highlight areas and amounts of erosion and deposition. In all cases, a 5m resolution raster grid has been used to identify areas of erosion and accretion. (Appendix B – Map 8).</p> <p>Appendix B - Map 1 shows a more stable beach profile than following the previous survey. Across the upper beach there is evidence of accretion, this is most prevalent around the slipway in the north of the bay and also further south around the Runswick Bay Beach &amp; Sailing Club. The mid beach is generally stable, with little or no change. Some erosion is evident in the lower beach, particularly towards the south of the survey extent. The magnitude of change is up to <math>\pm 1.5\text{m}</math>, and the magnitude of change increases from north to south.</p> <p>There is evidence of accretion in the far north of the survey extent in front of the recently constructed rock armour revetment. It is unclear if this is due to the presence of the new defence or if the accretion can be attributed to the expected spring recovery.</p>	<p>Between April and October 2018. Runswick Bay experienced little change with the upper beach showing more accretion and the lower beach showing more erosion. This indicates movement of material from the bottom of the beach to the middle/upper beach.</p> <p><b>Longer term trends:</b> The changes in the bay have been no more than <math>\pm 1.5\text{m}</math>. The data collected since 2008 indicate a general pattern of winter drawdown and spring recovery with no net change. The longer-term pattern of erosion in front of the village has paused since 2015.</p>

## 2.3 Sandsend Beach, Upgang Beach and Whitby Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
<p>11<sup>th</sup> and 12<sup>th</sup> October 2018</p>	<p><b>Beach Profiles:</b></p> <p>The frontage spanning Sandsend Beach, Upgang Beach, and Whitby Sands is covered by three beach profile lines, spaced between Sandsend and Whitby West Cliff (Appendix A).</p> <p>The beach level immediately in front of the new defences at Profile <b>1dWB1</b> (located around 400m south of Sandsend Village) has remained similar to that recorded in the previous survey (May 2018). However, between chainage 50m and 100m there has been a drop in beach levels of up to 0.8m. This loss means the beach face has retreated by up to 10m laterally. At chainage 100m the toe of the upper beach has dropped by approximately 0.5m. The beach profile becomes shallower between 100m and by 160m chainage reaches the May 2018 levels. Seaward of 160m chainage there appears to be some accretion from May 2018 however the lower beach remains lower than in 2017. Overall the upper beach is at a high level compared with the range recorded in previous surveys, whilst the mid beach is at a low when compared to previous surveys.</p> <p>At <b>1dWB2</b> (located in centre of Upgang Beach) the profile to 140m chainage has experienced a similar retreat to <b>1dWB1</b>. Between chainage 50m and 100m there has been an approximate 0.75m loss of material from the beach level, leading to a retreat of the beach face. The toe of the upper beach located around chainage 97m has dropped by around 0.8m. Seaward of chainage 100m the profile becomes shallower, returning to 2017/18 levels around chainage 160m. Overall the beach is medium-low in the upper and middle beach compared with the range recorded in previous surveys.</p> <p>At profile <b>1dWB3</b> fronting the stabilised face of Whitby West Cliff, no change has occurred as far as 90m chainage. At the toe of the seawall there has been 1m of accretion. This increase in beach level diminishes between 95m and 110m chainage, after which the beach level drops below the May 2018 level. From chainage 115m seawards there has been very little change, <math>\pm 0.2\text{m}</math>, though predominantly erosion. Overall the upper beach is at a high level compared to the range recorded from previous surveys, whilst the mid and lower reaches remain within the middle of the range of previous surveys.</p>	<p>The October 2018 profiles tended to be near the mid-point of the range recorded by previous surveys, with accretion being the predominant process.</p> <p>The topographic difference plots show a complex spatial pattern. Erosion is the marginally predominant process; additionally, the depth of erosion appears to be of a higher magnitude. However, there remains a clear area of accretion against the toe of the new defence at Sandsend.</p> <p>The cliffs of Upgang Beach in the central part of the study area are undefended and erosion provides an important source of material to the beach. It is likely that sediment released by erosion over the winter months is subsequently redistributed across the beach as migrating sand bars.</p> <p><b>Longer term trends:</b> the beach profiles show seasonal variation but no linear trend of accretion or erosion. The annual topographic difference plots show similar patterns of accretion and erosion in the all surveys although the magnitude of change is modest.</p>

Survey Date	Description of Changes Since Last Survey	Interpretation
	<p><b>Topographic Survey:</b></p> <p>The Sandsend to Whitby frontage is covered by an annual topographic survey, providing continuous data for Sandsend Beach, Upgang Beach, and Whitby Sands. Data have been used to create a DGM (Appendix B – Maps 2) using GIS.</p> <p>The GIS has also been used to calculate the differences between the current topographic survey DGM (Autumn 2018) and the earlier topographic survey DGM (Autumn 2017), with 5m resolution raster grids (as shown in Appendix B – Maps 9), to identify areas of erosion and accretion.</p> <p>Appendix B – Maps 9 show a varied picture of erosion and accretion. There are alternating bands of erosion and accretion in front of the car park at the northern end of the frontage. In front of the village of Sandsend there has been accretion across the full width of the beach. In front of the new defences there has generally been accretion at the toe of the defence. Running parallel with this band of accretion is an area of erosion which is most significant approximately 300m east of the village. In front of the undefended cliffs there is an area of accretion fronting some minor erosion at the cliff toe. Further east along the undefended cliffs there has been some accretion against the cliff toe. In this area the foreshore appears to have been eroded more significantly. There has been little change along Whitby Sands, and the beach in this location shows a patchy distribution of both erosion and accretion with the magnitude of change generally decreasing towards the east, with very little change adjacent to the pier.</p>	

## 2.4 Robin Hood's Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
<p>26<sup>th</sup> October 2018</p>	<p><b>Topographic Survey:</b></p> <p>Robin Hood's Bay is covered by a six-monthly topographic survey. Data have been used to create a DGM (Appendix B - Map 3) using GIS. The GIS has also been used to calculate the differences between the current topographic survey DGM (Autumn 2018) and the earlier topographic survey DGM (Spring 2018), with 5m resolution raster grids (as shown in Appendix B – Map 10), to identify areas of erosion and accretion.</p> <p>Appendix B - Map 10 shows a very patchy distribution of areas of accretion and erosion over the summer of 2018. The majority of the bay has seen little change (<math>\pm 0.25\text{m}</math>) associated with the rocky outcrops which run perpendicular to the shore. Most of the erosion patches are located at the northern end of the bay, particularly at the toe of the cliff. The largest area of accretion is in the centre of the bay at the toe of the northernmost slipway. Whilst the predominant area of erosion is fronting the rock armour revetment directly south of the northern slipway.</p> <p>Overall, erosion is slightly more dominant and is up to 1.5m in the northern part of the bay.</p>	<p>The topographic change plot shows that there has been very little change across the frontage over the summer of 2018.</p> <p>Cliff top monitoring shows little or no erosion since March 2018.</p> <p><b>Longer term trends:</b> The limited change recorded in Robin Hoods Bay is due to the resistant rock platforms and thin, patchy cover of sand.</p>

Survey Date	Description of Changes Since Last Survey	Interpretation
	<p><b>Cliff-top Survey:</b></p> <p>Thirteen ground control points have been established at Robin Hood's Bay since March 2010 to monitor cliff recession. The separation between any two points is around 200m.</p> <p>Table C2 shows that only one location showed erosion between March and October 2018, with marker 11 retreating by more than 0.2m. However, inspection of the survey photos indicates this could be due to difficulty locating the cliff edge precisely as the break in slope is covered by vegetation.</p> <p>Using data recorded between March 2010 and September 2018, calculated erosion rates show little change in all markers except Marker 1 which shows recession of 0.6m/yr. However, this marker has showed very little change since March 2012.</p>	

## 2.5 Scarborough North Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
14 <sup>th</sup> September 2018	<p><b>Beach Profiles:</b></p> <p>Scarborough North Bay is covered by five beach profile lines, distributed between the Sealife Centre at Scalby Mills and Clarence Gardens (Appendix A).</p> <p>The September 2018 survey shows that Profile <b>1dSBN1</b> remains stable at the defended, upper part of the profile. There has been accretion against the base of the seawall (from 10m to 17m), however seaward of this point there has been a reduction in beach levels of up to 0.25m. Beach levels remain lower than the Spring 2018 levels throughout the entire profile, with the exception of chainage 95m to 110m where the level remains the same. The September 2018 profile remains relatively high compared to the range recorded from previous surveys, despite an obvious area of erosion throughout the mid reaches of the profile.</p> <p>At <b>1dSBN2</b> the beach is characterised by a shifting berm in the profile, which can form on the upper or lower beach. In September 2018, the beach level at the toe of the seawall had increased by 1.6m. The profile shows accretion in the upper beach to chainage 75m of up to 1m, with the berm crest moving up the beach to chainage 25m. From chainage 75m to 115m there has been erosion of up to 0.65m, exposing the rocks at the bottom of the beach earlier at chainage 118m. The September 2018 profile is medium compared to the range recorded from previous surveys, except at the bottom of the beach where the rocks are exposed where the profile is relatively low.</p> <p>The September 2018 survey shows that the beach at profile <b>1dSBN3</b> has experienced up to 0.8m erosion at the base of the seawall at 23m chainage since March 2018. Indeed, this erosion means the beach level is now at its lowest recorded level in this location, and the toe of the wall is now exposed. The erosion continues to chainage 65m, seawards of here there has been accretion of up to 0.3m. Between chainage 65m and 115m a shallow berm has formed above the Spring 2018 level. From 115m to 160m the beach levels drop below the Spring levels again. The September 2018 profile is low compared to the range recorded from previous surveys, with the upper section of beach (25m to 60m chainage) being at its lowest recorded level.</p> <p>There has been some accumulation of sand over the rocks at the base of the seawall in the profile at</p>	<p>The beach profiles in September 2018 all show that erosion processes have generally dominated over the summer months. All the profiles experience some degree of depletion and are relatively low compared to the range of previously recorded surveys. Despite this, there are some minor areas of accretion. Profiles 1dSBN2 and 1dSBN4 show little change however profiles 1dSBN3 and 1dSBN3 have experienced significant erosion, particularly in their middle reaches.</p> <p><b>Longer term trends:</b> The observed trends in the topographic plots and beach profiles point to overall stability with seasonal fluctuations.</p>



Survey Date	Description of Changes Since Last Survey	Interpretation
	<p><b>1dSBN4</b> with the rocks remaining exposed between chainage 35m and 60m. Between chainage 60m and 110m there has been accretion of up to 1m, which then decreases in depth to around 0.2m seawards of 110. The September 2018 profile is medium – low compared to the range recorded by previous surveys, with the highest recorded levels at the toe of the seawall.</p> <p>On profile <b>1dSBN5</b> there has been accretion of 0.3m at the toe of the defences between the March 2018 and September 2018 surveys. Between chainage 35m and 95m there has been erosion of 0.4m with this area of beach now being at its lowest recorded level. The berm recorded in the September 2017 survey is no longer apparent. There has been negligible change between chainage 95m and 115m. Seawards of chainage 115m there has been further accretion of up to 0.4m, pushing the toe of the beach seawards. The September 2018 survey is very low compared to the recorded range along most of its length.</p> <p><b>Topographic Survey:</b></p> <p>Scarborough North Bay is covered by an annual topographic survey, which was carried out in September 2018. Data have been used to create a DGM (Appendix B - Map 4 and 16) with GIS for both surveys. The GIS has also been used to calculate the differences between the Full Measures topographic survey DGM (Autumn 2018) and the earlier topographic survey DGM (Autumn 2017), with 5m resolution raster grids (as shown in Appendix B – Map 11 and 17), to identify areas of erosion and accretion.</p> <p>Appendix B - Map 11 (October 2016 to September 2017) shows that there has been roughly shore parallel bands of erosion and accretion. There is a general pattern of erosion in the upper beach, particularly in the centre of the bay. Areas of accretion exist on the mid beach in the north of the bay and the upper beach in the south of the bay. Generally, there is change on the lower beach.</p>	

## 2.6 Scarborough South Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
10 <sup>th</sup> October 2018	<p><b>Beach Profiles:</b></p> <p>Scarborough South Bay is monitored by four beach profiles, between the harbour in the north and the Spa Complex in the south (Appendix A). The comparisons of short-term change are between March and October 2018.</p> <p>At profile <b>1dSBS1</b> there has generally been limited change since March 2018. The upper beach shows accretion of up to 0.8m from the seawall to chainage 50m. Between 50m and 110m chainage there has been very minor erosion. At chainage 130m to 140m and chainage 180m two shallow berms have formed. However, there has generally been negligible change of less than <math>\pm 0.1</math>m seaward of chainage 50m. The September 2018 profile is relatively high compared to the range recorded by previous surveys. Between chainage 170m and 200m this profile is at its highest recorded level.</p> <p>The beach at profile at <b>1dSBS2</b> has remained relatively stable with changes limited to <math>\pm 0.3</math>m across the upper and mid beach. The upper beach between the seawall and chainage 170m shows accretion with slight erosion between chainage 75m and 100m. Seaward of chainage 170m there has been significant erosion of up to 0.6m. Around chainage 212m there is a sharp increase in beach level, Academy Geomatics confirmed that this was a patch of rock exposed at low water but not picked up in photographs taken during the survey. The October 2018 profile is at a low-medium level compared to the range previously recorded for the lower beach. This is most evident in the upper-mid beach where, despite having increased since March, the beach level still lies at the lower end of the range of previously recorded results.</p> <p>At profile <b>1dSBS3</b> there has been accretion of up to 0.6m at the toe of seawall. Two shallow beach berms have formed, the most landward of the two is evident from chainage 50m to 100m, the berm crest has increased the beach level by approximately 0.35m. The more seaward berm has a plateaued profile, running from chainage 130m to 215m and is generally in the region of 0.3 to 0.4m higher than the march 2018 level. There has been some very minor erosion landward of, and between, the two beach berms. Overall the October 2018 profile is at a low level compared to the range recorded by previous surveys. Between chainage 20m and 45m the profile is at its lowest level.</p>	<p>The level of the beach in the profiles is within the middle of the range recorded in previous years. All the profiles show some accretion, however there are some areas where erosion has dominated, particularly in the mid and lower reaches towards the south of the bay.</p> <p>The short-term change plot also shows variable erosion and accretion, matching the profiles. The accumulations in the mid-beach at the northern end is likely to be due to the action of constructive waves through the summer.</p> <p>The cliff top change markers have indicated negligible change at most locations' markers with, 0.1m loss recorded at location 9 and 0.2m loss recorded at location 8.</p> <p><b>Longer term trends:</b> The beach is regularly re-profiled with sediment moved from near the harbour to the frontage of The Spa, but sediment naturally moves northwards towards the harbour.</p> <p>Table C3 shows that since March 2010 most of the cliff erosion profiles have shown negligible recession. Profiles 11 and 12 show erosion of 0.4 m/year. These points are at the rear of a mudslide system which experiences periodic reactivation or head scarp collapse, however there has been little movement in</p>

Survey Date	Description of Changes Since Last Survey	Interpretation
	<p>Profile <b>1dSBS4</b> shows some accretion at the base of the seawall. A rocky outcrop, identified in the March survey, located at chainage 10m was not recorded in the October 2018 survey. Seaward of this point there has been up to 0.7m of accretion covering the upper beach between chainage 10m and 70m however, typically the accretion is limited to 0.3m. From chainage 70m to 140m there has been erosion of up to than 0.5m. The toe of the beach seawards of chainage 140m shows minor accretion of up to 0.3m. The October 2018 profile is relatively high in the upper reaches compared to the range recorded by previous surveys. However, in the mid beach, between chainage 90m and 120m, the beach is at its lowest recorded level.</p>	the last two years.
	<p><b>Topographic Survey:</b></p> <p>Scarborough South Bay is covered by an annual topographic survey. Data have been used to create a DGM (Appendix B - Map 5) using GIS. The GIS has also been used to calculate the differences between the current topographic survey DGM (Autumn 2018) and the earlier topographic survey DGM (Autumn 2017), with 5m resolution raster grids (as shown in Appendix B – Map 12), to identify areas of erosion and accretion.</p> <p>Appendix B - Map 12 shows that erosion has been the dominant process across the upper beach in the northern half of the bay, with localised areas of accretion directly against the toe of the seawall. Across the lower reaches in the north of the beach there has been some minor accretion. The southern half of the bay is dominated by erosion although not exceeding 1m of reduction in level. Fronting the Spa complex there has been minor erosion. Towards the south of the survey extent there is patchy accretion and erosion. The magnitude of change crosses the whole survey area is low, generally being less than 0.5m.</p>	
	<p><b>Cliff-top Survey:</b></p> <p>Thirteen ground control points have been established at Scarborough South Bay, extending from South Bay to Cayton Bay for the purposes of cliff top monitoring. The separation between any two points is around 300 m. The cliff top surveys at Scarborough South Bay are undertaken bi-annually. Data collection involves a distance offset measurement from the ground control point to the cliff edge along a</p>	

Survey Date	Description of Changes Since Last Survey	Interpretation
	<p>fixed bearing.</p> <p>Between March and October 2018 two of the thirteen locations showed change of more than <math>\pm 0.1\text{m}</math>, this was point 8 at the southern end of Scarborough South Bay and Point 9 in Cornelian Bay.</p> <p>Control point 1 was inaccessible due to the ongoing Scarborough Spa Slope Stabilisation Project.</p> <p>The recession rates calculated for the period from March 2010 to October 2018 give a picture of the change over the longer term. Ten of the markers have a recession rate of less than <math>0.1\text{m/yr}</math>. Markers 11 and 12 are the only markers showing a higher rate of <math>0.4\text{m/yr}</math>.</p> <p>Appendix C provides results from the October 2018 survey, showing the distance from the ground control point to the edge of the cliff top along the defined bearing and changes in position since the March 2010 baseline survey. Short-term and long-term average recession rates are also provided.</p>	

## 2.7 Cayton Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
<p>9<sup>th</sup> October 2018</p>	<p><b>Beach Profiles:</b></p> <p>Cayton Bay is covered by three beach profile lines, distributed between Tenants' Cliff and the south of Cayton Sands (Appendix A).</p> <p>The cliff face at profile <b>1dCY1</b> (Tenant's Cliff) is vegetated and was difficult for the surveyors to access resulting in poor data in the top of the profile. In the rest of the profile, there was little change as far as 25m chainage between March and October 2018 with the rock remaining exposed. From 20m to 70m chainage the beach level has increased by up to 0.4m. Between 70m and 120m chainage there has been erosion of up to 0.5m. Seaward of chainage 120m, until the end of the survey at chainage 170m there has been some minor accretion, generally covering the rocky outcrop. Overall the October 2018 profile is at a relatively medium level compared to the range recorded in previous surveys.</p> <p>Profile <b>1dCY2</b> (close to former pumping station) has remained stable over the cliff up to chainage 120m. There has been erosion of around 0.2m along the profile from the cliff to chainage 220m. The lower beach from chainage 220m has eroded at an increasing rate moving seaward along the profile. The October 2018 survey ends at chainage 313m, where the reduction in level is approximately 0.9m. The October 2018 profile is at a medium-low level compared to the range recorded in the previous surveys, particularly in the lower beach seaward of chainage 295m where the profile is at one of its lowest recorded levels.</p> <p>There has been little change across the cliff section of profile <b>1dCY3</b> (600m southeast of the pumping station). Accretion of up to 0.4m of sand at the toe of the cliff has covered the previously exposed rocks. There has been very minor erosion of up to 0.1m around chainage 175m. Seaward of chainage 205m there has been accretion of 0.3m. Overall the September 2017 profile is at a medium level compared to the range recorded from previous surveys, with the toe of the beach between chainage 255m, and the end of the survey around 310m, being the highest on record.</p>	<p>The beach profiles have been stable overall with accretion dominating in all the profiles.</p> <p>The plot of difference between Autumn 2017 to Autumn 2018 surveys shows variability in the erosion and accretion in the bay with little consistent pattern.</p> <p>The cliff top survey data shows no significant recession has occurred at any of the marker points during the summer of 2018.</p> <p><b>Longer term trends:</b> The pattern of migrating sand bars has remained consistent since 2010 indicating seasonal variation in beach level with no net change.</p>

Survey Date	Description of Changes Since Last Survey	Interpretation
	<p><b>Topographic Survey:</b></p> <p>Cayton Bay is covered by an annual topographic survey. Data have been used to create a DGM (Appendix B - Map 6) using GIS. The GIS has also been used to calculate the differences between the current topographic survey DGM (Autumn 2018) and the earlier topographic survey DGM (Autumn 2018), with 5m raster grids (as shown in Appendix B – Map 13), to identify areas of erosion and accretion.</p> <p>Appendix B - Map 13 shows that the observed changes are very patchy. During 2018 the northern part of the bay shows wide patchy band of erosion in the mid beach, with some minor accretion on the upper beach. The most significant area of erosion is located on the central mid beach, seaward of the Tenant's Cliff complex. The central and southern parts of the bay are dominated by patchy areas of erosion and accretion across the profile. The southern part of the shows weakly shore parallel alternating bands, with accretion in the upper and lower beach, with erosion in the mid beach. The distribution is patchy however, so the patterns of change vary across the beach.</p> <p><b>Cliff-top Survey:</b></p> <p>Eight ground control points have been established within Cayton Bay for the purposes of cliff top monitoring. The separation between any two points is typically around 200 m. The cliff top surveys at Cayton Bay are undertaken bi-annually. Data collection involves a distance offset measurement from the ground control point to the cliff edge along a fixed bearing.</p> <p>The results of the cliff top survey are shown in Table C4. Between March and October 2018 three of the eight profiles showed erosion outside the <math>\pm 0.1</math>m accuracy of the survey. Erosion of the cliffs in locations 5-7 between 0.1m and 0.2m was experienced from March to October 2018. Location 2 was inaccessible due to dense vegetation cover.</p> <p>Long-term erosion rates calculated using data collected since November 2008 show change either within the margin of error or advance, indicating survey difficulties, at most points. Markers 4 and 6 show</p>	

Survey Date	Description of Changes Since Last Survey	Interpretation
	<p>erosion rates of 0.3m/yr and 0.2m/yr respectively.</p> <p>Appendix C provides results from the October 2018 survey showing the distance from the ground control point to the edge of the cliff top along the defined bearing and changes in position since the November 2008 baseline survey.</p>	

## 2.8 Filey Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
11 <sup>th</sup> - 13 <sup>th</sup> September 2018	<p><b>Beach Profiles:</b></p> <p>Filey Bay is covered by five beach profiles between Filey Sands and Speeton Sands (Appendix A).</p> <p>At profile <b>1dFB1</b> fronting Filey seawall, the extreme upper beach has eroded by 0.5m at the toe of the seawall (chainage 18m to 21m). From chainage 21m to chainage 70m there has been accretion of up to 0.4m. Between chainage 70m and 120m there has been erosion of around 0.2m. A shallow beach berm has formed between chainage 150m and 195m, seaward of which the profile has experienced erosion the profile is at a medium level compared to the range recorded from previous surveys, with chainage 70m to 120m being the lowest recorded, whilst between chainage 155m and 190m the profile is at its highest recorded level.</p> <p>At profile <b>1dFB2</b> (located to the north of Primrose Valley Holiday Village) there has been an accretion of material on the upper beach, where a shallow beach berm has formed approximately 5-10m from the toe of the cliff. From chainage 110m to 170m there is evidence of up to 0.4m of erosion. Further seaward, between chainage 190m and 270m a berm has formed within a shallow recession. The profile is a medium level compared to the range recorded from previous surveys. The upper beach between chainage 75m and chainage 100m is the highest recorded level in this location.</p> <p>At profile <b>1dFB3</b>, near Flat Cliffs, there has been the creation of a berm at chainages 100m to 150m. There has also been around 0.5 of accretion against the toe of the cliff. The mid-beach berm has accreted a similar amount. From chainage 170m to 270m the beach profile is a uniform gradient. A lower-beach berm which was observed in the march 2018 survey is no longer evident. The September 2018 profile is at a medium-high level compared to the range recorded from previous surveys, with the berm between chainage 110m to 130m being the highest recorded.</p> <p>Profile <b>1dFB4</b> at Hunmanby Gap, has accreted against the toe of the cliff and on the upper-beach by up to 1.5m. Further seaward between chainage 75m and 140m the profile has experienced up to 1m of erosion. There is generally little change across the rest of the profile. The September 2018 upper and lower beach profile is at a high level compared to the range recorded from previous surveys. Whilst the erosion experienced across the mid-beach means that between 80m and 130m the beach is at its</p>	<p>The beach profiles are dominated by accretion, with some erosion on the lower beach at profiles 1dFB4, and 1dFB5. The beach levels are generally high-medium compared with the range recorded from the previous surveys.</p> <p>The topographic change map shows Filey Bay has shore parallel bands of accretion and erosion in the associated with migrating berms and very little change in the north.</p> <p>The cliff top survey data provided in Table C5 shows erosion at several monitoring points. The largest change was at markers 10 and 11 where 1.1m to 1.2m was lost over the summer of 2018.</p> <p>The Flat Cliffs Slope Stabilisation Works undertaken in Summer 2018 aim to mitigate against any further recession in the location of monitoring point 10.</p> <p><b>Longer term trends:</b> Past trends dominated by migrating sand bars continue to the present day.</p>



Survey Date	Description of Changes Since Last Survey	Interpretation
	<p>lowest recorded level.</p> <p>At profile <b>1dFB5</b> (located close to Reighton Gap) there has been accretion across the majority of the profile. There has been up to 0.7m of accretion against the base of the cliff. Furthermore, a berm has formed between chainage 270m and 370m through the accretion of up to 0.8m of beach material. Overall the September 2018 profile is at a medium level compared to the range recorded from previous surveys, with the upper-beach berm between chainage being the highest recorded. Between chainage 255m and 275m and between chainage 380m and the end of the survey at 390m, the profile is at its lowest recorded levels.</p> <p><b>Topographic Survey (Filey Bay):</b></p> <p>Filey Bay is covered by an annual topographic survey. In addition to the annual survey of Filey Bay, a smaller area fronting Filey Town is re-surveyed every six months to document seasonal patterns.</p> <p>Data have been used to create a DGM (Appendix B – Map 7) using GIS. The GIS has also been used to calculate the differences between the current topographic survey DGM (Autumn 2018) and the earlier topographic survey DGM (Autumn 2017), with 5m resolution raster grids (as shown in Appendix B – Map 15) to identify areas of erosion and accretion.</p> <p>Appendix B - Map 15 shows that there are shore parallel alternating bands of accretion and erosion around the bay. The majority of the northern part of the bay from Filey Brigg to Primrose Valley shows very little change in beach levels. There are some shore parallel patches of erosion on the upper and lower beach in front of Filey Town. Towards the south of the Filey Town coastal defences there has been some notable accretion. The southern section of the bay from Primrose Valley shows greater magnitude of change with shore parallel bands of erosion and accretion. The general pattern is for a very narrow band of accretion at the toe of the cliffs with further accretion bands in the mid beach and at the toe of the beach. Bands of erosion tend to occur on the upper beach and mid-lower beach. Overall there are roughly equal areas of accretion and erosion, and the area of greatest change is between Hunmanby Gap and Reighton Gap.</p>	

Survey Date	Description of Changes Since Last Survey	Interpretation
	<p><b>Cliff-top Survey:</b></p> <p>Twenty-eight ground control points have been established within Filey Bay for the purposes of cliff top monitoring. This includes the installation of three additional locations in September 2010: points 12A (as a replacement for point 13 which can no longer be accessed due to vegetation growth), 24 &amp; 25 (to the north of Filey Bay at Filey Brigg). A further replacement for monitoring point 13, 13A, has been added in 2014.</p> <p>The maximum separation between any two points is nominally 300 m. The cliff top surveys at Filey Bay are undertaken every six months. Data collection involves a distance offset measurement from the ground control point to the cliff edge along a fixed bearing.</p> <p>Between March and September 2018 22 of the ground control points showed no discernible change (within the <math>\pm 0.1</math>m accuracy of the survey). Markers 10 and 11 have shown apparent recession of 1.24m and 1.13m respectively. The markers in this location are located at the north and south extents of the Flat Cliffs Hamlet, an area of longstanding concern. Of the remaining points, markers 14, 17 and 18 had shown apparent recession of 0.1m.</p> <p>Long term rates of change show only seven markers have erosion with rates between 0.1m/yr and 0.7m/yr. The largest erosion rate recorded is at control point 5, to the south of the Filey Town defences.</p> <p>Appendix C provides results from the September 2018 survey showing the distance from the ground control point to the edge of the cliff top along the defined bearing and changes in position since the baseline survey.</p>	

### 3. Problems Encountered and Uncertainty in Analysis

#### Survey accuracy of beach/ cliff profiles

The aim of cliff monitoring data is to gain a reliable record of the frequency and magnitude of cliff top failures. Data are collected every six months, but previous surveys have had a low accuracy, meaning that survey error is typically greater than any measured short-term change. It is possible that a more reliable pattern of change will be determined over the longer term. However, in the short term, more reliable assessments of cliff recession can be derived from analysis of time-series remote sensing data. Under this programme a high-quality baseline survey, comprising LiDAR and aerial photography, was collected in 2010, a repeat survey was completed in 2012/13 and 2015. These data will be analysed to give more accurate information on the behaviour of the cliffs in a separate report. More accurate estimates of long-term cliff top change would be possible by comparing results from the current programme to historical aerial photography over the last 50 years.

At Staithes the surveyors noted that a significant cliff fall at VMP 1, meaning the headscarp of the cliff has now encroached upon the seaward edge of the track. Additionally, VMP's 9 to 12 were still inaccessible due to a landslip on the headland; the area has been cordoned off by the National Trust.

At Robin Hoods Bay the surveyors noted there was continuous rock and gravel falls along the cliffs, and that VMP5 was located on a pile of deposited garden waste.

At Scalby in Scarborough North Bay the cliff edge was very overgrown resulting in areas that were unable to be surveyed.

At Scarborough South Bay, VMP1 was not measured due to the presence of the ongoing Scarborough Spa Slope Stabilisation Scheme.

At Cayton Bay the surveyors could not measure the top of profile 1dCY1 due to dense vegetation. Furthermore, the mid-section of profiles 1dCY1, 1dCY2 and 1dCY3 could not be measured due to the ground make-up, soft mud flows, unstable grass, and at 1dCY3 landslips. The cliff in profile 1dCY3 was measured to the cliff edge and as close to the cliff face at the bottom as possible. There was no access to measure the VMP2 due to dense vegetation.

At Filey an area of section 1dFB2 from approximate chainage 10m to 19m was unable to be measured due to the undergrowth and dense vegetation. Additionally, the mid-section of 1dFB5 between chainage 50m and 203m was not surveyed due to the presence of undergrowth and bushes. VMP12 and VMP13 were inaccessible due to heavy vegetation.

#### Cliff top erosion errors & data capture techniques

The cliff top surveys are in general assumed to have a limit of accuracy of  $\pm 0.1\text{m}$  due to the techniques used and problems have been experienced in precisely locating the cliff edge, due to vegetation growth and the convex profile. Most profiles have now been monitored for six years, and a more reliable picture of change is now emerging that indicates very low rates of erosion, with only occasional and localised examples of erosion exceeding  $0.5\text{m/yr}$ .

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

No changes are recommended at the present time.

### 5. Conclusions and Areas of Concern

The following points have been observed:

- The measurements of the Cowbar and Staithes cliff top show erosion of between 0.1 and 0.3m over the summer of 2018 at two stations. Additionally, the most westerly of the control points (VMP1), located adjacent Cowbar Lane, experienced recession of 4.6m

over the summer of 2018. A further four stations continued to be inaccessible due to a landslip on the headland.

- Runswick Bay shows minor shore parallel change, with erosion on the lower beach and accretion in the upper-middle beach.
- At Sandsend Beach, Upgang Beach and Whitby Sands erosion has been the marginally more significant process over the summer of 2018 with beach levels at a medium level relative to the range recorded from previous surveys. There remains a clear area of accretion against the toe of the new coastal defence at Sandsend.
- At Robin Hoods Bay the beach and cliff have remained stable with very little change over the summer of 2018. No discernible change has been registered by the cliff top markers and only one cliff recession marker shows substantial change in the long-term record, and the majority of this change occurred in 2011.
- For Scarborough North Bay the September 2018 survey shows the beach profiles are generally relatively low compared to the range of previously recorded surveys. All profiles experienced some degree of depletion, particularly in their mid reaches. There has been some accretion of beach material against the toe of the seawall, particularly in the north of the bay.
- At Scarborough South Bay all the beach profiles have remained relatively stable over the summer of 2018 and are medium compared to the previous profiles. The ongoing Scarborough Spa Slope Stabilisation Scheme meant that the surveyors were not able to access to VMP1.
- The Cayton Bay beach profiles show stability overall with evidence of the formation of beach berms. The pattern of migrating sand bars has remained consistent since 2010 indicating seasonal variation in beach level with no net change. The cliff monitoring showed significant recession at three of the marker points (>0.1m). Cliff activity was most prevalent at VMP5-7.
- The profiles at Filey Bay show accretion to be the predominant coastal process. The profiles have all seen accretion, with some erosion at the toe of the beach. The profiles are among the highest recorded for these locations. The topographic difference plot shows very little change in the north but shore parallel bands of accretion and erosion in the south associated with migrating berms. An area of accretion is evident towards the southern end of the Filey Town coastal defences. There has been significant recession recorded at various points through the centre and south of the bay. In particular markers 10 and 11 have shown recession of 1.1m and 1.2m respectively. Marker 5 to the south of Filey Town remains the location with the highest erosion rate of 0.7m/yr despite showing no signs of recession over the summer of 2018.

## **Appendices**

**Appendix A**  
**Beach Profiles**

The following sediment feature codes are used on some profile plots:

<b>Code</b>	<b>Description</b>
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

# Beach Profile

Location: 1dWB1

Date: 12/10/2018

Inspector: AG

Low Tide:

Low Tide Time:

Wind

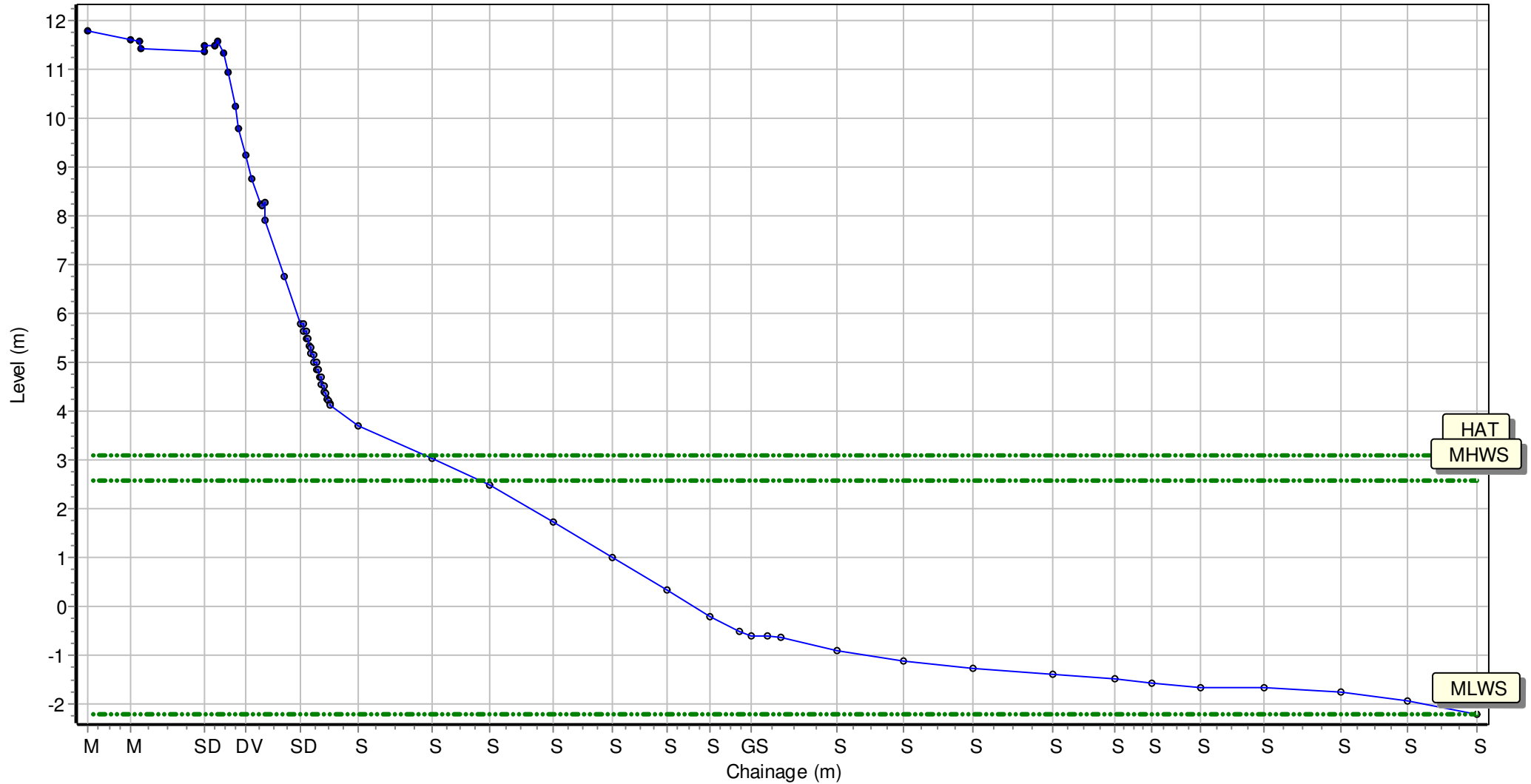
Sea State:

Visibility:

Rain:

Summary: 2018 Full Measures Topo Survey

Easting: 486535.075 Northing: 512437.797 Profile Bearing: 32 ° from North





# Beach Profile

Location: 1dWB2

Date: 12/10/2018

Inspector: AG

Low Tide:

Low Tide Time:

Wind

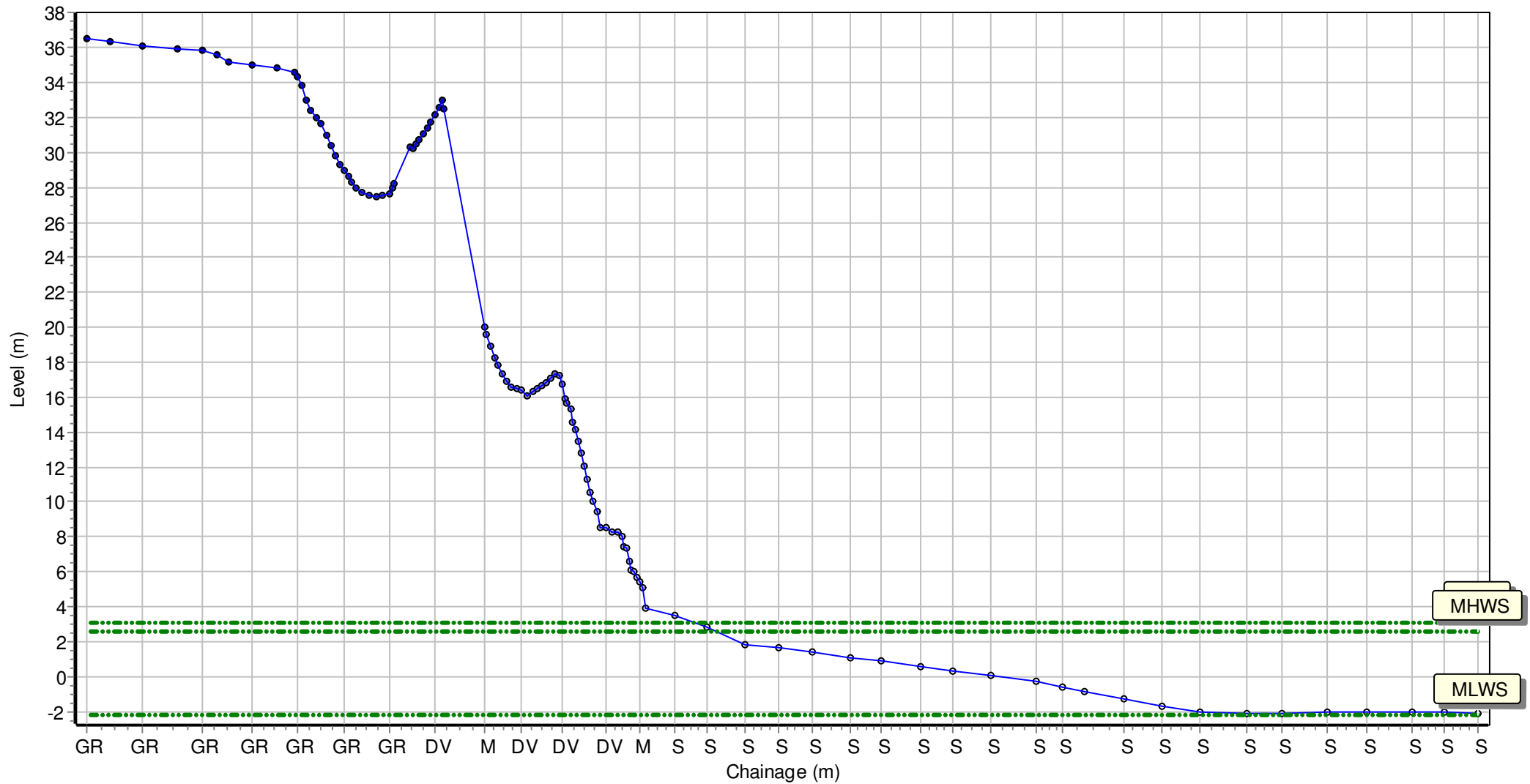
Sea State:

Visibility:

Rain:

Summary: 2018 Full Measures Topo Survey

Easting: 487550.221 Northing: 511927.902 Profile Bearing: 16 ° from North



# Beach Profile

Location: 1dWB3

Date: 12/10/2018

Inspector: AG

Low Tide:

Low Tide Time:

Wind

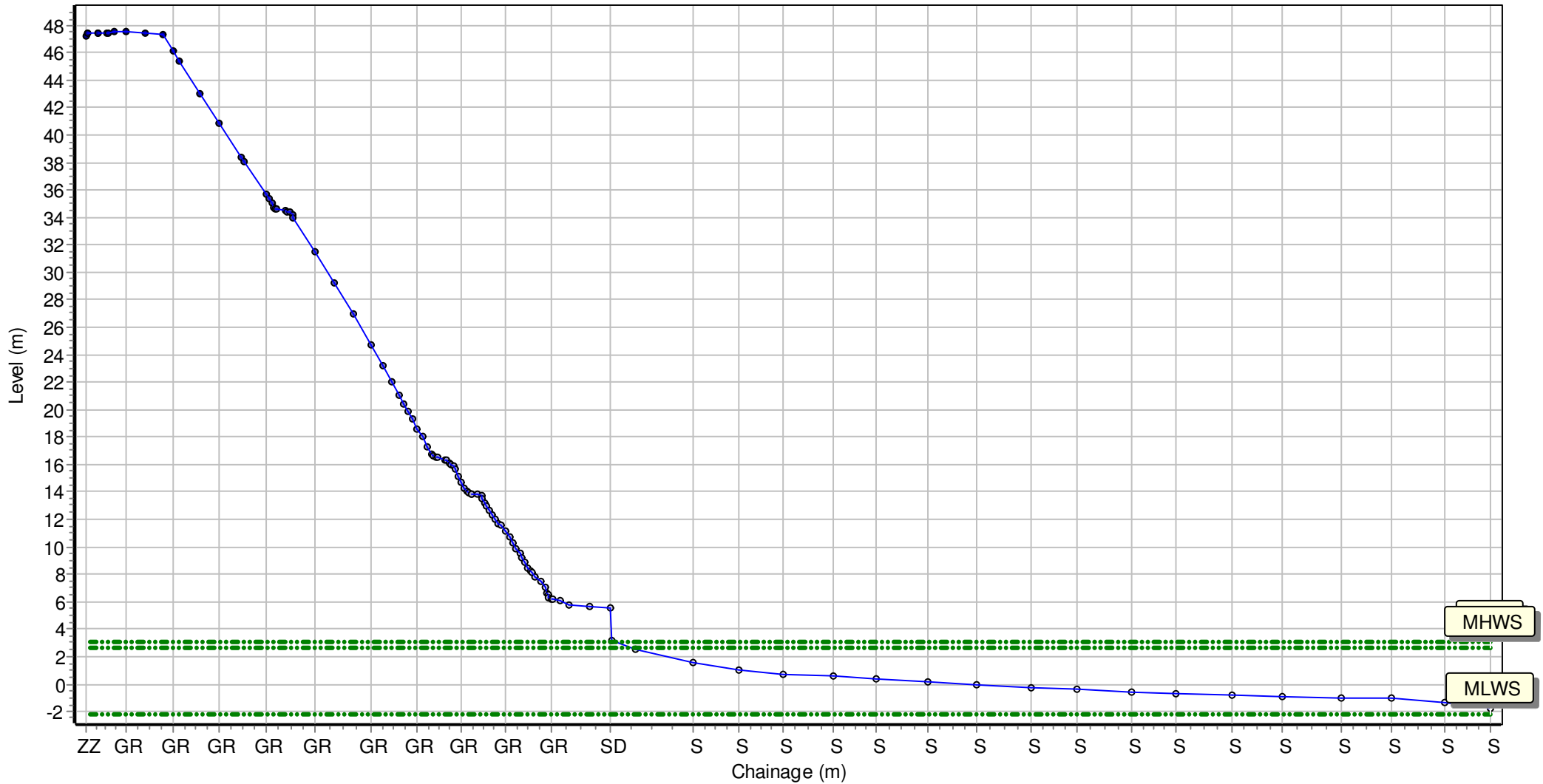
Sea State:

Visibility:

Rain:

Summary: 2018 Full Measures Topo Survey

Easting: 488983.57 Northing: 511527.047 Profile Bearing: 19 ° from North



# Beach Profile

Location: 1dSBN1

Date: 14/09/2018

Inspector: AG

Low Tide:

Low Tide Time:

Wind

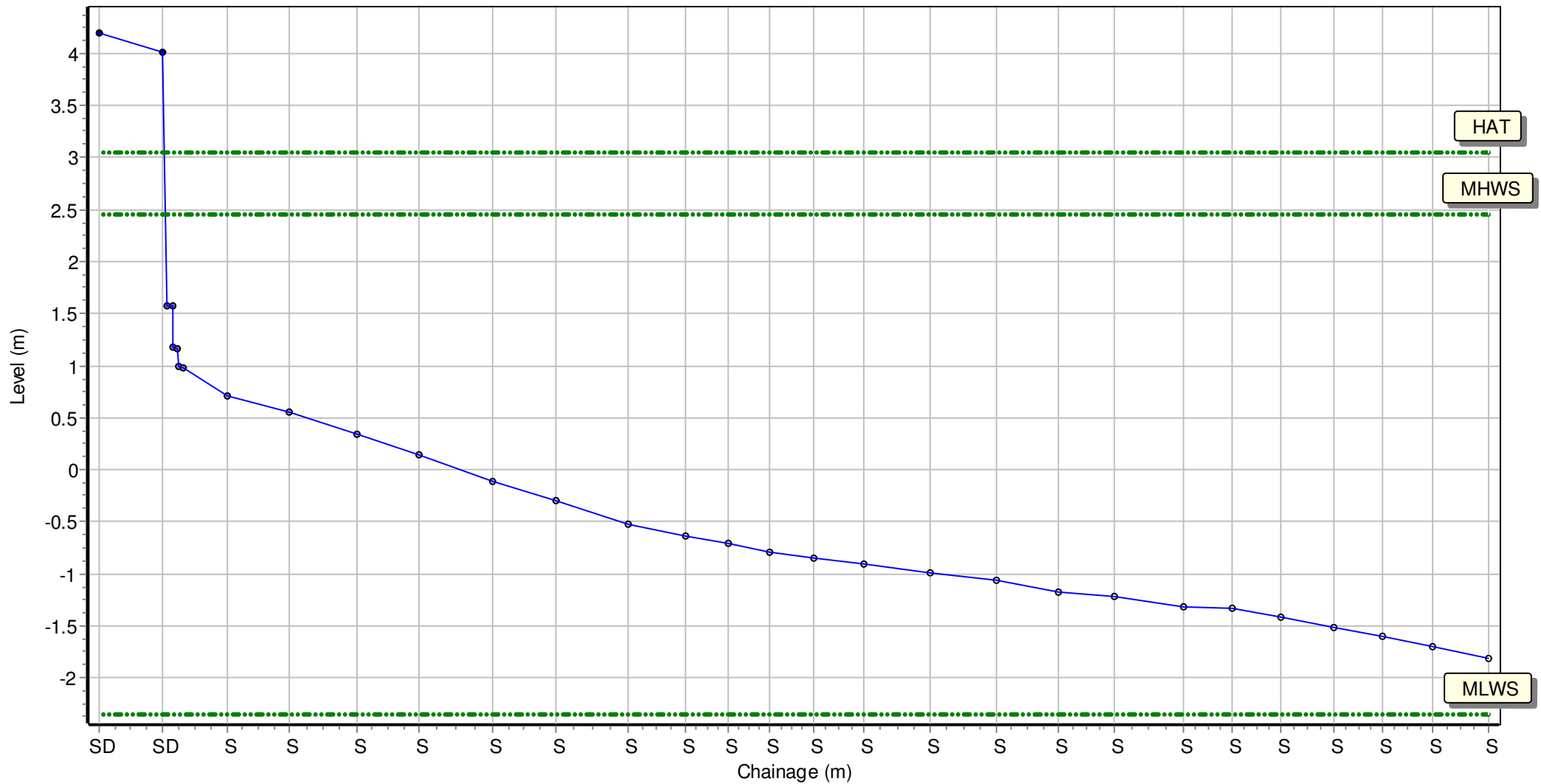
Sea State:

Visibility:

Rain:

Summary: 2018 Full Measures Topo Survey

Easting: 503543.363 Northing: 490470.74 Profile Bearing: 79 ° from North



# Beach Profile

Location: 1dSBN2

Date: 14/09/2018 Inspector: AG

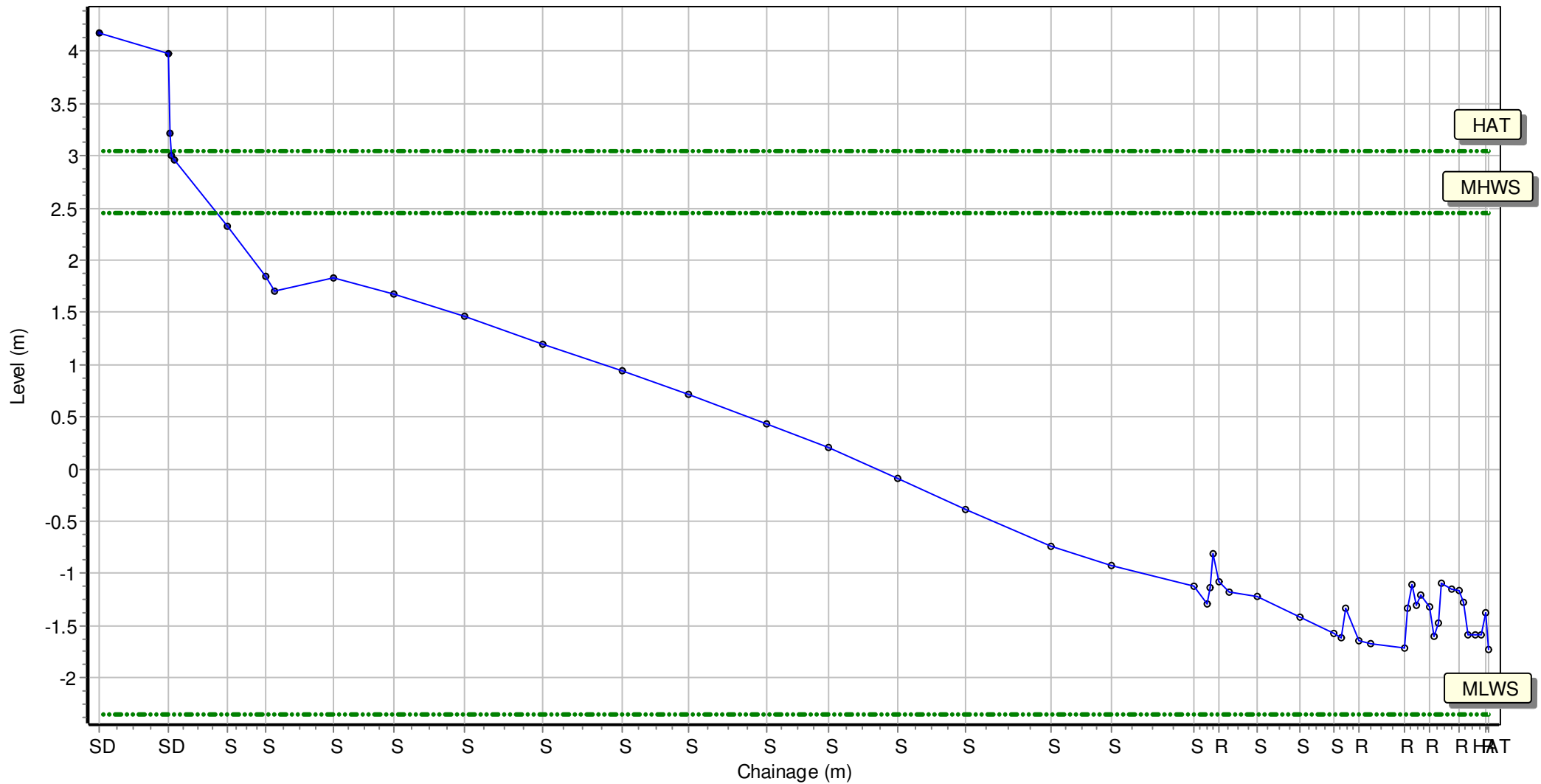
Low Tide: Low Tide Time:

Wind Sea State:

Visibility: Rain:

Summary: 2018 Full Measures Topo Survey

Easting: 503616.346 Northing: 490135.674 Profile Bearing: 78 ° from North



# Beach Profile

Location: 1dSBN3

Date: 14/09/2018 Inspector: AG

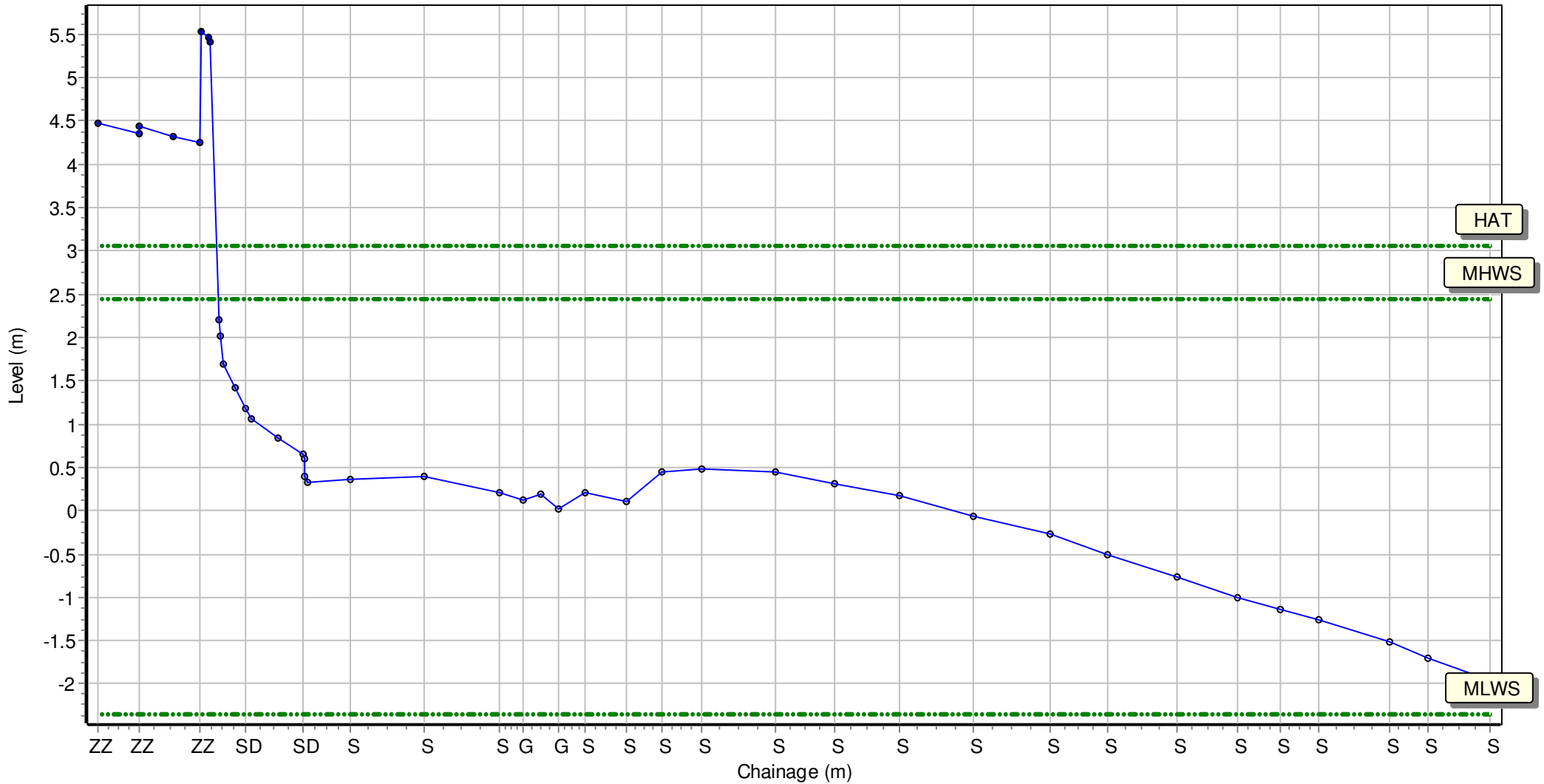
Low Tide: Low Tide Time:

Wind Sea State:

Visibility: Rain:

Summary: 2018 Full Measures Topo Survey

Easting: 503803.958 Northing: 489708.315 Profile Bearing: 58 ° from North



# Beach Profile

Location: 1dSBN4

Date: 14/09/2018

Inspector: AG

Low Tide:

Low Tide Time:

Wind

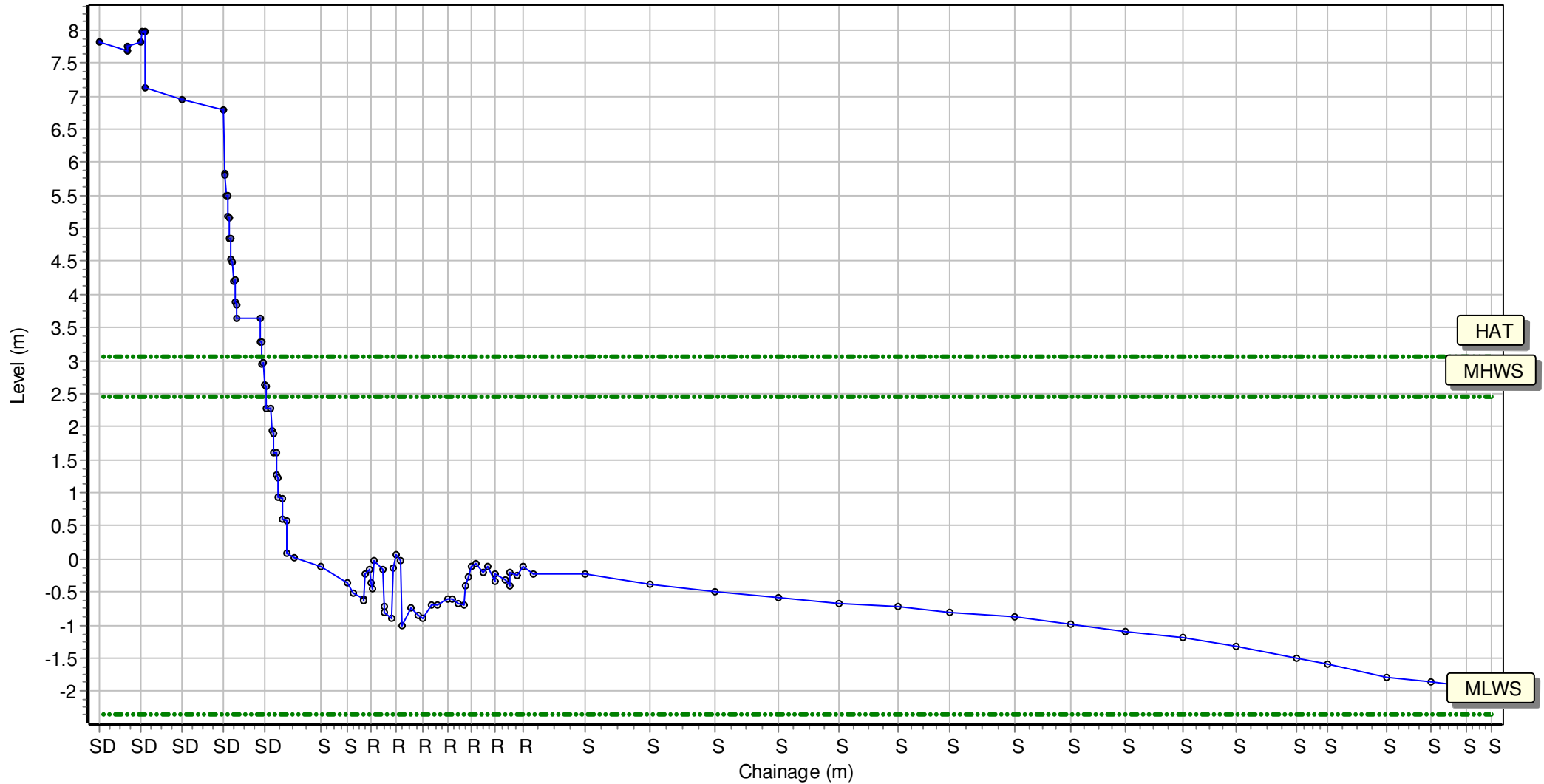
Sea State:

Visibility:

Rain:

Summary: 2018 Full Measures Topo Survey

Easting: 504111.79 Northing: 489397.699 Profile Bearing: 38 ° from North



# Beach Profile

Location: 1dSBN5

Date: 14/09/2018

Inspector: AG

Low Tide:

Low Tide Time:

Wind

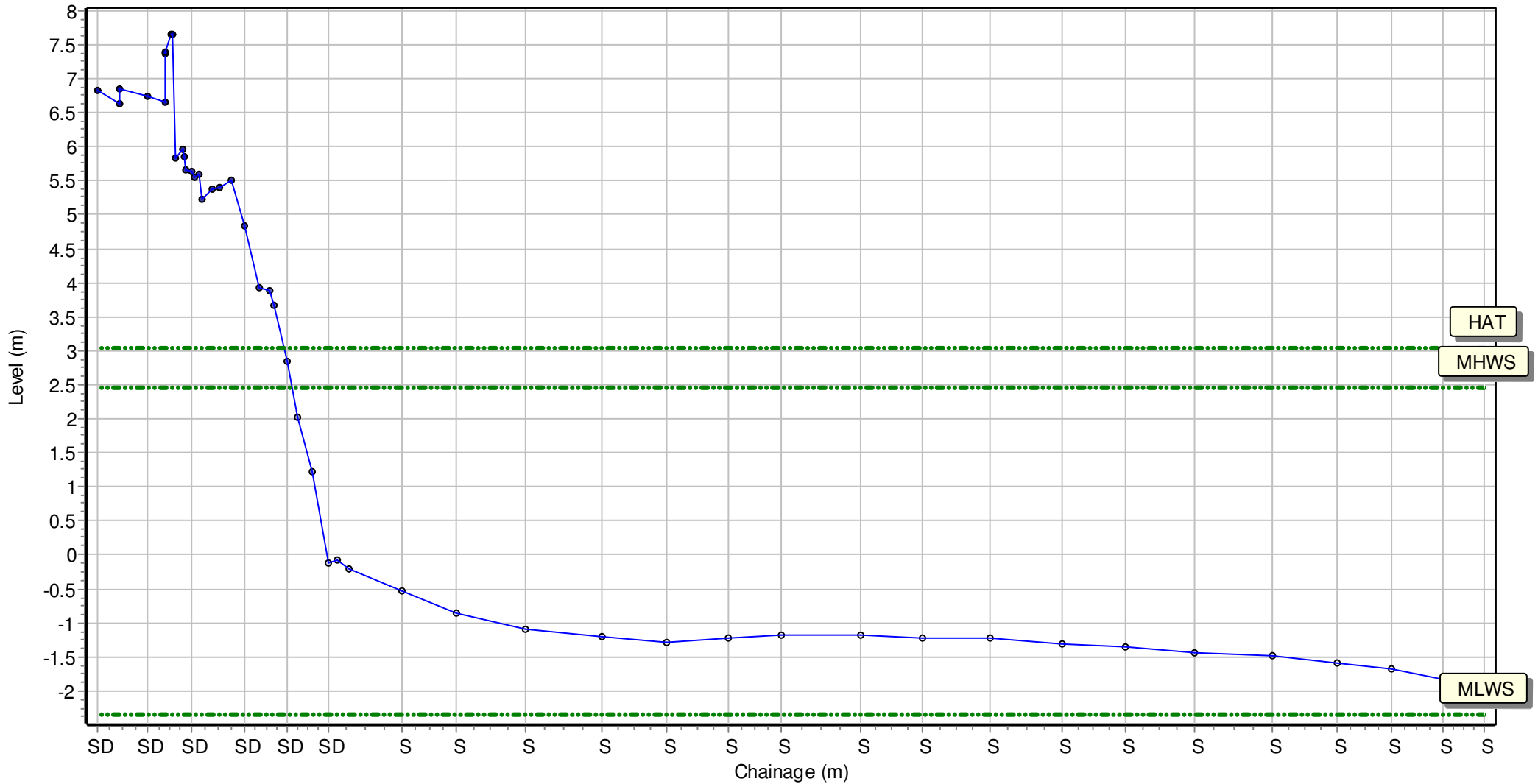
Sea State:

Visibility:

Rain:

Summary: 2018 Full Measures Topo Survey

Easting: 504515.599 Northing: 489205.724 Profile Bearing: 14 ° from North



# Beach Profile

Location: 1dSBS1

Date: 10/10/2018

Inspector: AG

Low Tide:

Low Tide Time:

Wind

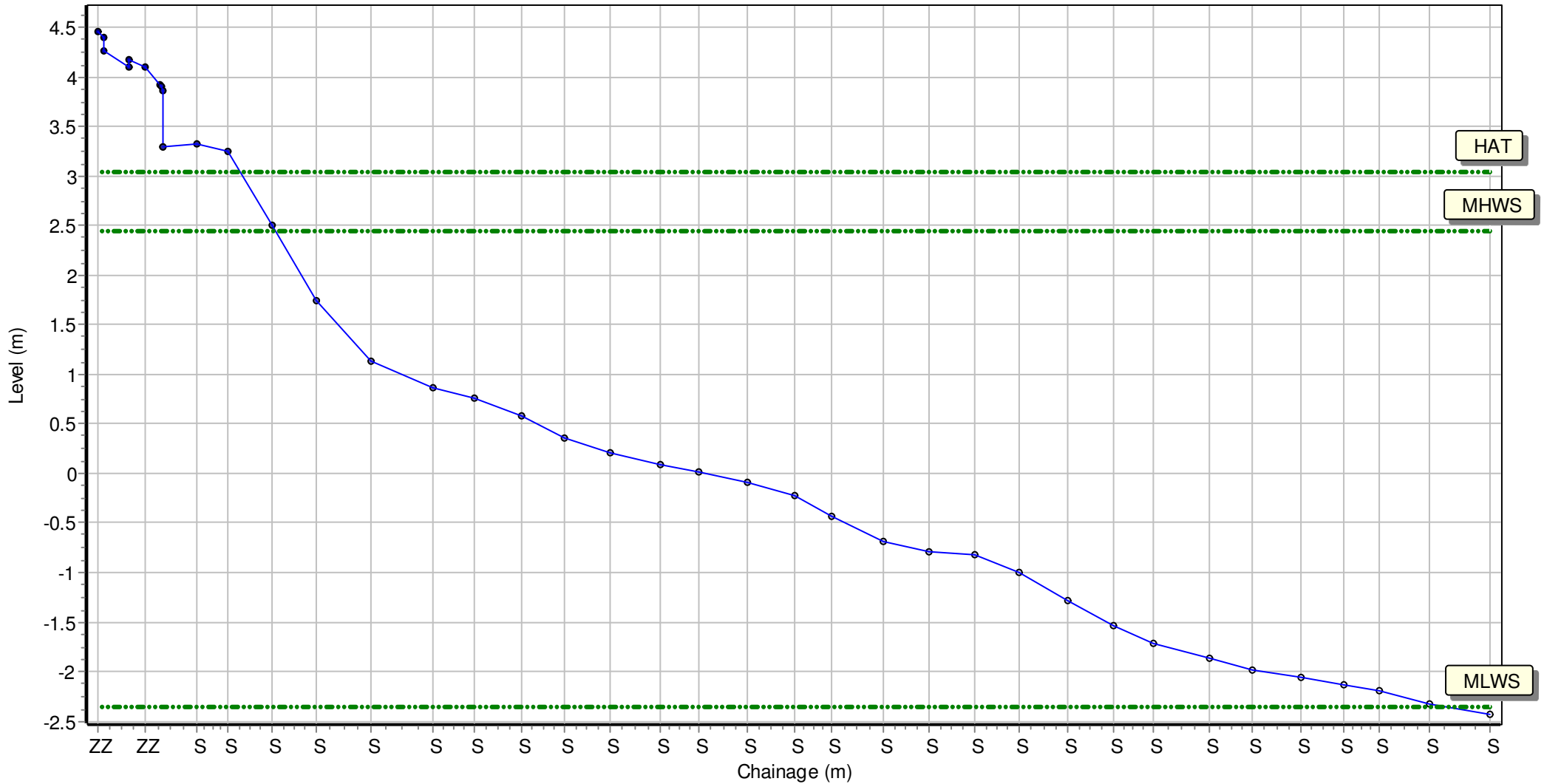
Sea State:

Visibility:

Rain:

Summary: 2018 Full Measures Topo Survey

Easting: 504544.727 Northing: 488604.814 Profile Bearing: 120 ° from North





# Beach Profile

Location: 1dSBS2

Date: 10/10/2018

Inspector: AG

Low Tide:

Low Tide Time:

Wind

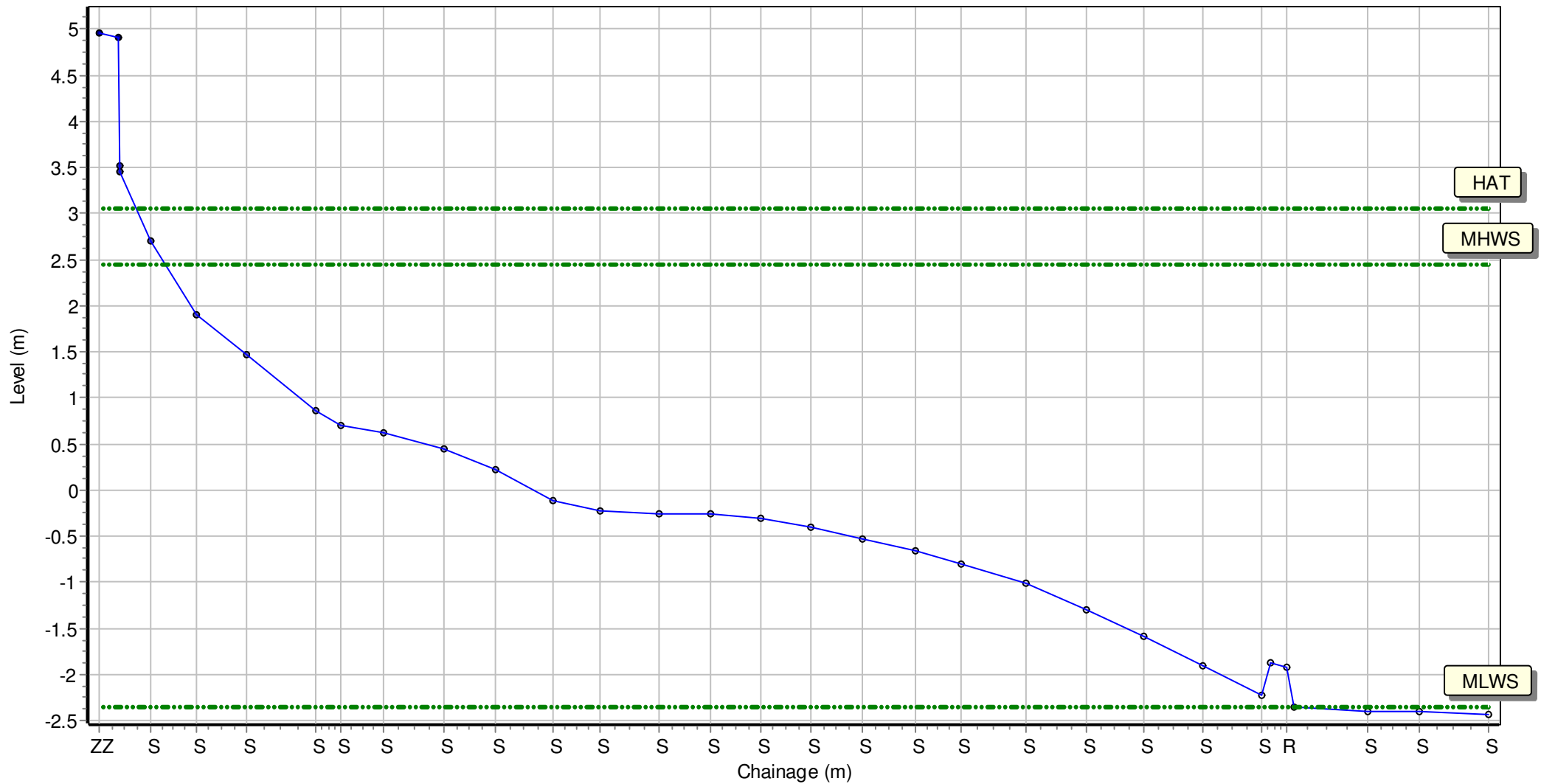
Sea State:

Visibility:

Rain:

Summary: 2018 Full Measures Topo Survey

Easting: 504443.218 Northing: 488326.371 Profile Bearing: 105 ° from North



# Beach Profile

Location: 1dSBS3

Date: 10/10/2018

Inspector: AG

Low Tide:

Low Tide Time:

Wind

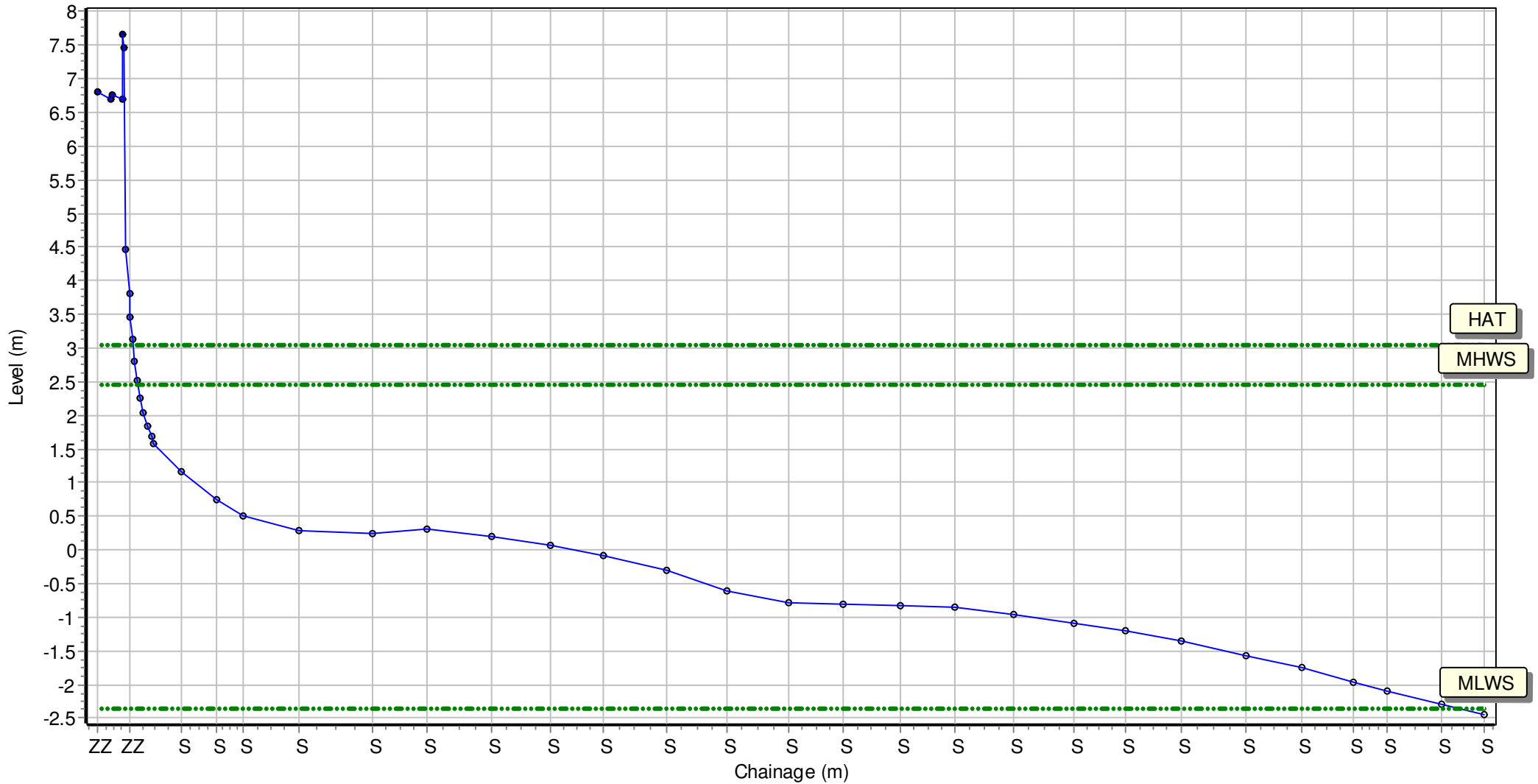
Sea State:

Visibility:

Rain:

Summary: 2018 Full Measures Topo Survey

Easting: 504423.086 Northing: 488057.66 Profile Bearing: 83 ° from North



# Beach Profile

Location: 1dSBS4

Date: 10/10/2018

Inspector: AG

Low Tide:

Low Tide Time:

Wind

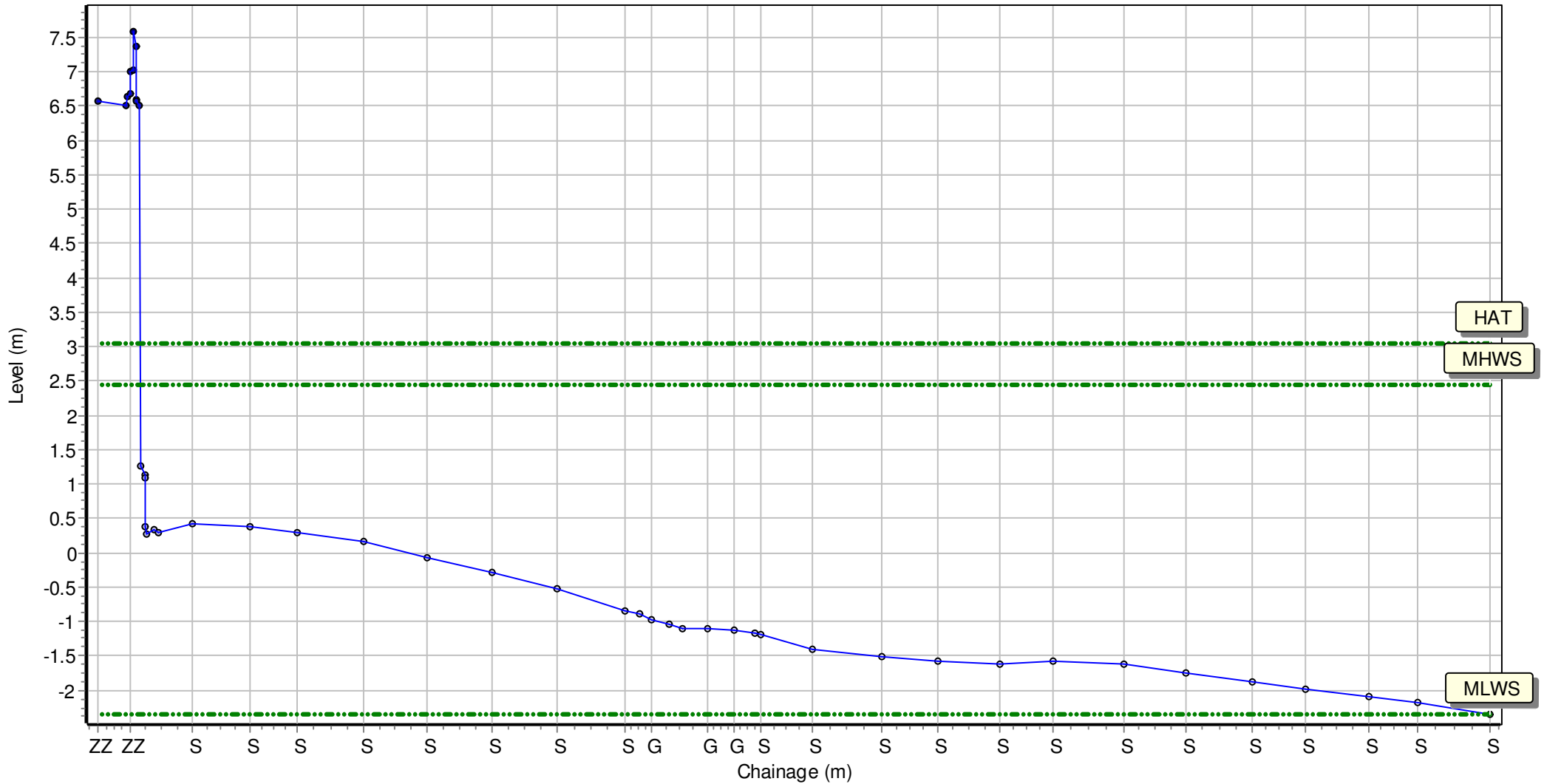
Sea State:

Visibility:

Rain:

Summary: 2018 Full Measures Topo Survey

Easting: 504494.785 Northing: 487816.983 Profile Bearing: 74 ° from North



# Beach Profile

Location: 1dCY1

Date: 09/10/2018

Inspector: AG

Low Tide:

Low Tide Time:

Wind

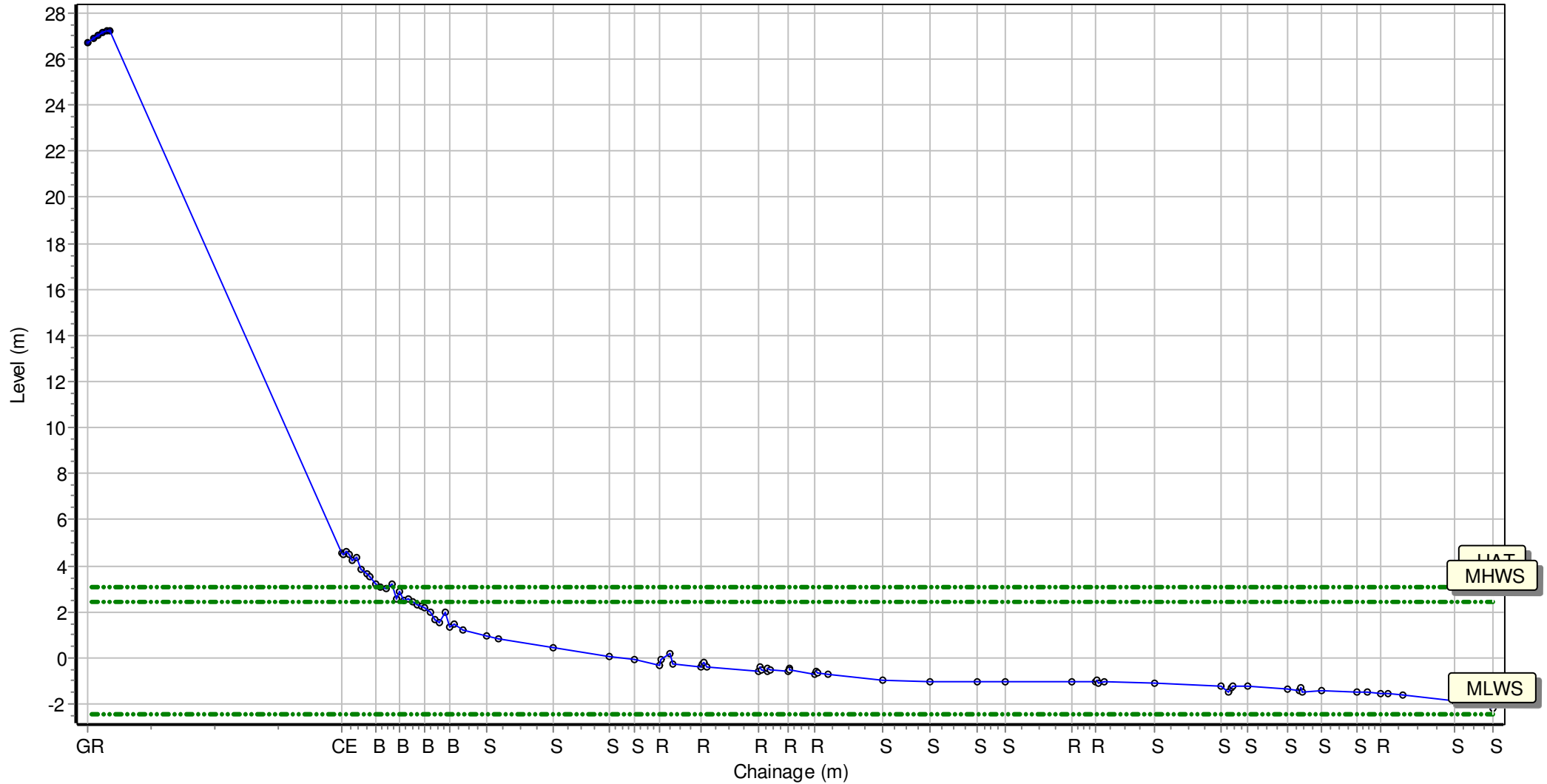
Sea State:

Visibility:

Rain:

Summary: 2018 Full Measures Topo Survey

Easting: 506420.411 Northing: 484793.941 Profile Bearing: 43 ° from North





# Beach Profile

Location: 1dCY2

Date: 09/10/2018

Inspector: AG

Low Tide:

Low Tide Time:

Wind

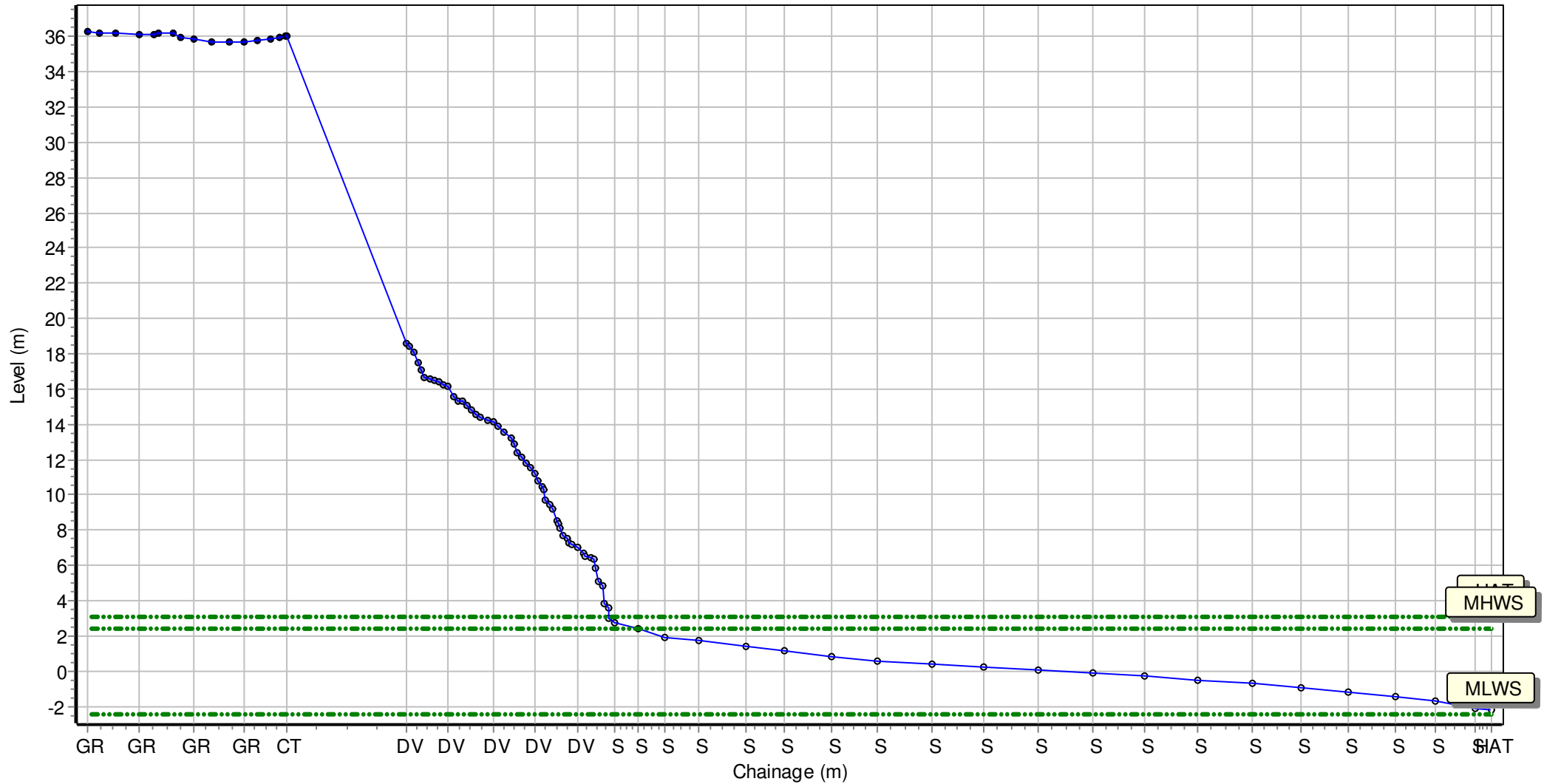
Sea State:

Visibility:

Rain:

Summary: 2018 Full Measures Topo Survey

Easting: 506712.583 Northing: 484325.966 Profile Bearing: 38 ° from North



# Beach Profile

Location: 1dCY3

Date: 09/10/2018 Inspector: AG

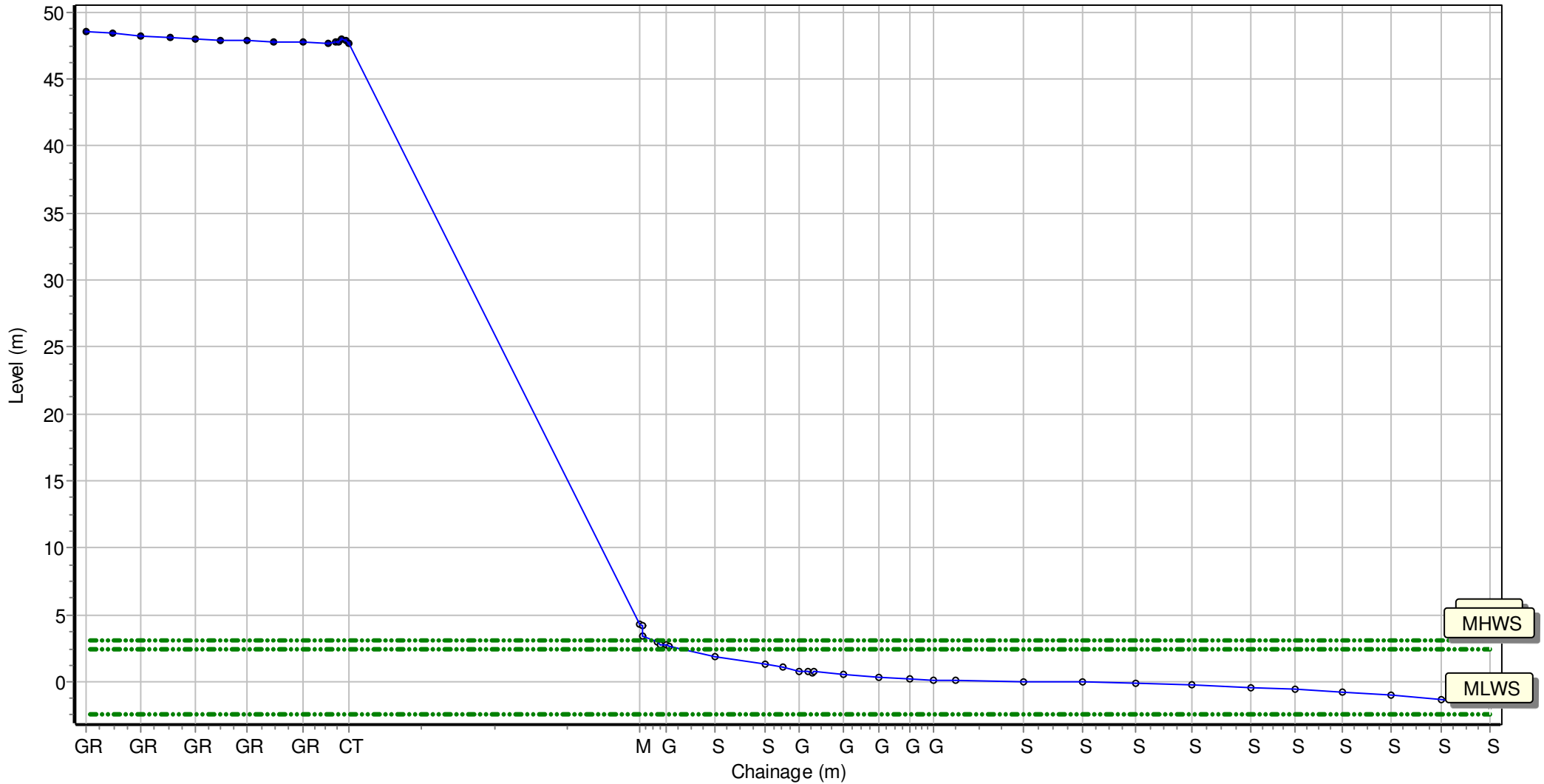
Low Tide: Low Tide Time:

Wind Sea State:

Visibility: Rain:

Summary: 2018 Full Measures Topo Survey

Easting: 507242.203 Northing: 484080.896 Profile Bearing: 42 ° from North



# Beach Profile

Location: 1dFB1

Date: 13/09/2018

Inspector: AG

Low Tide:

Low Tide Time:

Wind

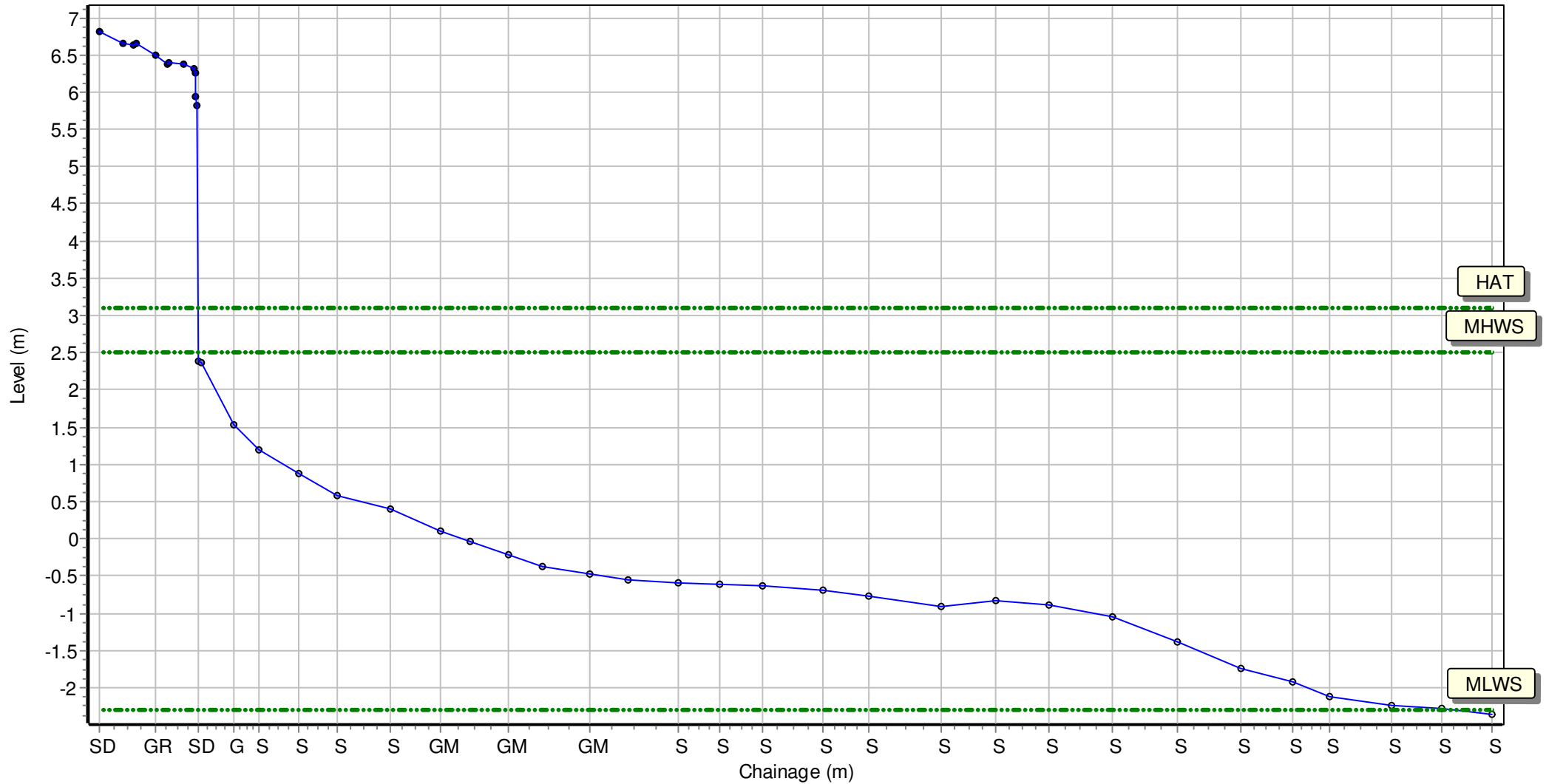
Sea State:

Visibility:

Rain:

Summary: 2018 Full Measures Topo Survey

Easting: 511989.528 Northing: 480590.964 Profile Bearing: 100 ° from North





# Beach Profile

Location: 1dFB2

Date: 13/09/2018 Inspector: AG

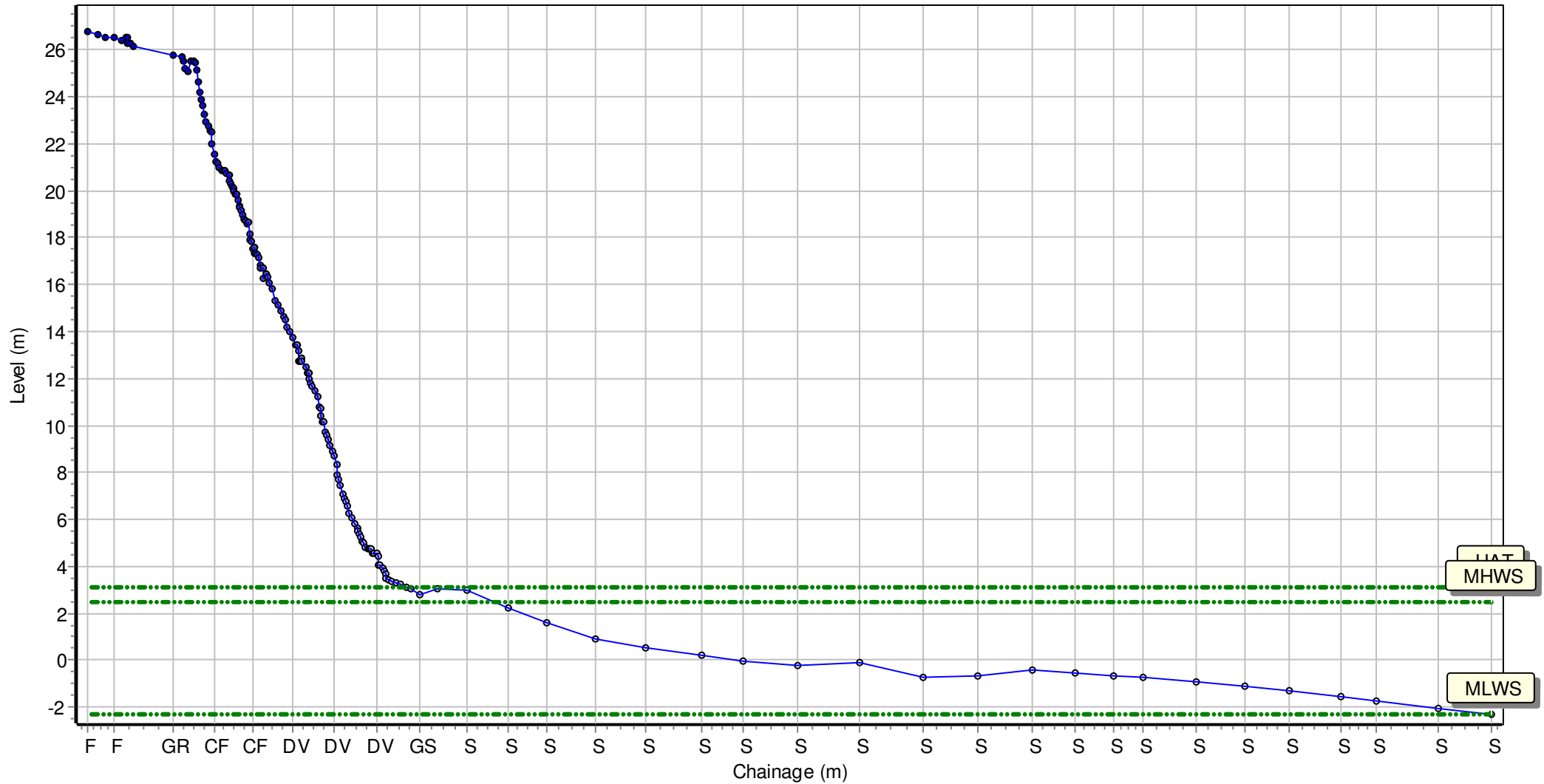
Low Tide: Low Tide Time:

Wind Sea State:

Visibility: Rain:

Summary: 2018 Full Measures Topo Survey

Easting: 512005.564 Northing: 479181.575 Profile Bearing: 77 ° from North



# Beach Profile

Location: 1dFB3

Date: 13/09/2018

Inspector: AG

Low Tide:

Low Tide Time:

Wind

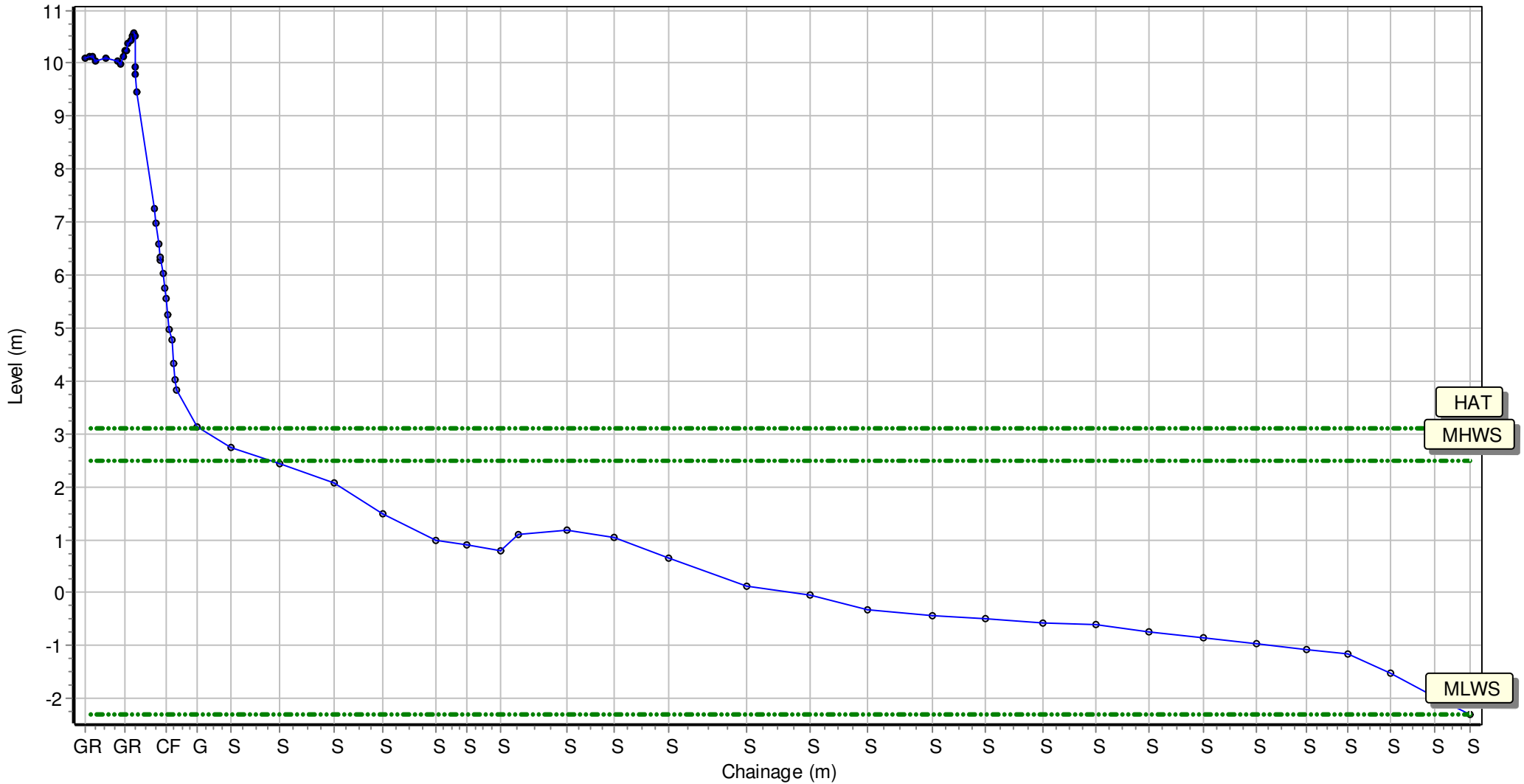
Sea State:

Visibility:

Rain:

Summary: 2018 Full Measures Topo Survey

Easting: 512429.303 Northing: 478202.148 Profile Bearing: 61 ° from North



# Beach Profile

Location: 1dFB4

Date: 13/09/2018 Inspector: AG

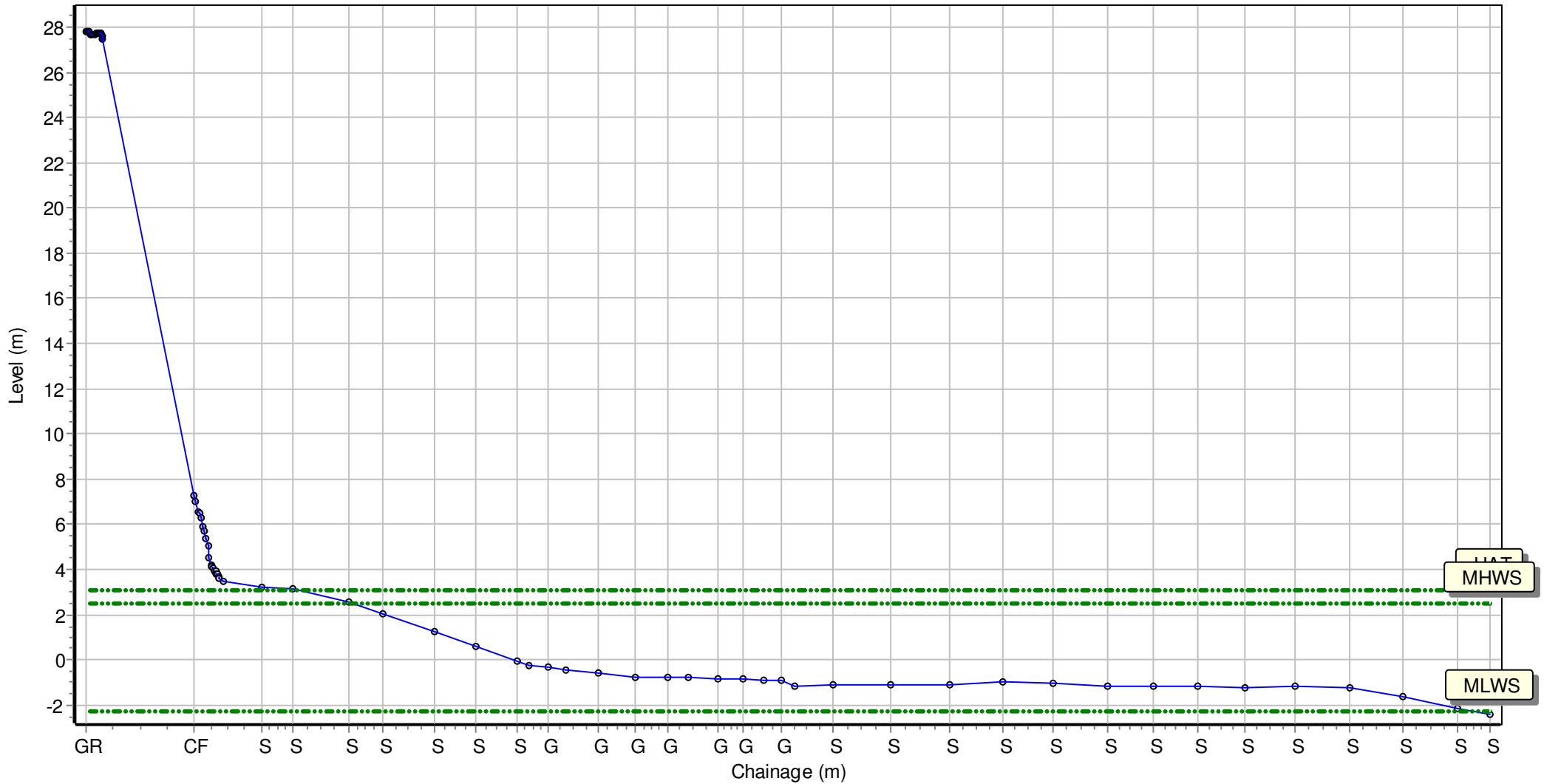
Low Tide: Low Tide Time:

Wind Sea State:

Visibility: Rain:

Summary: 2018 Full Measures Topo Survey

Easting: 513165.53 Northing: 477182.418 Profile Bearing: 51 ° from North



# Beach Profile

Location: 1dFB5

Date: 13/09/2018 Inspector: AG

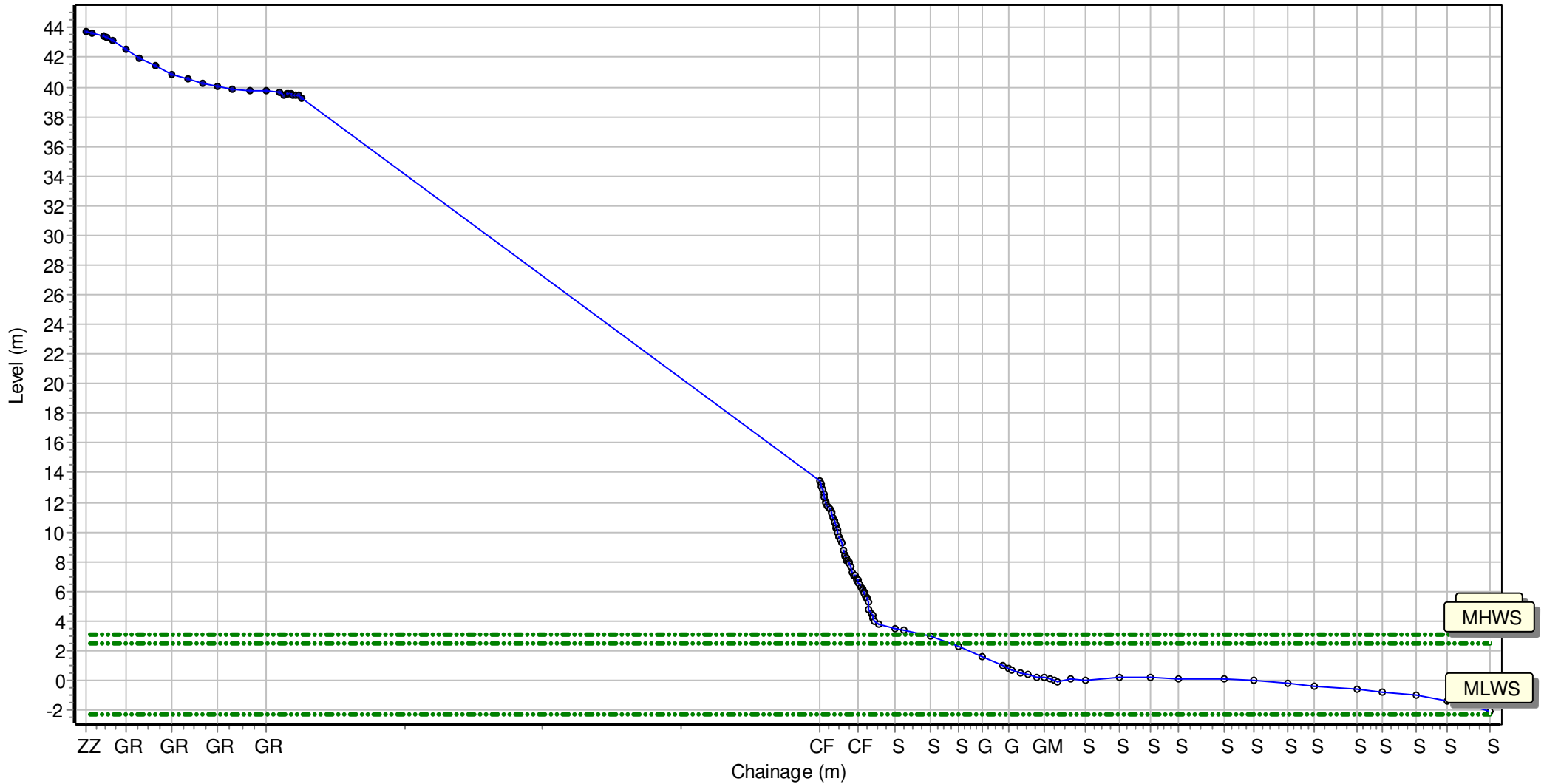
Low Tide: Low Tide Time:

Wind Sea State:

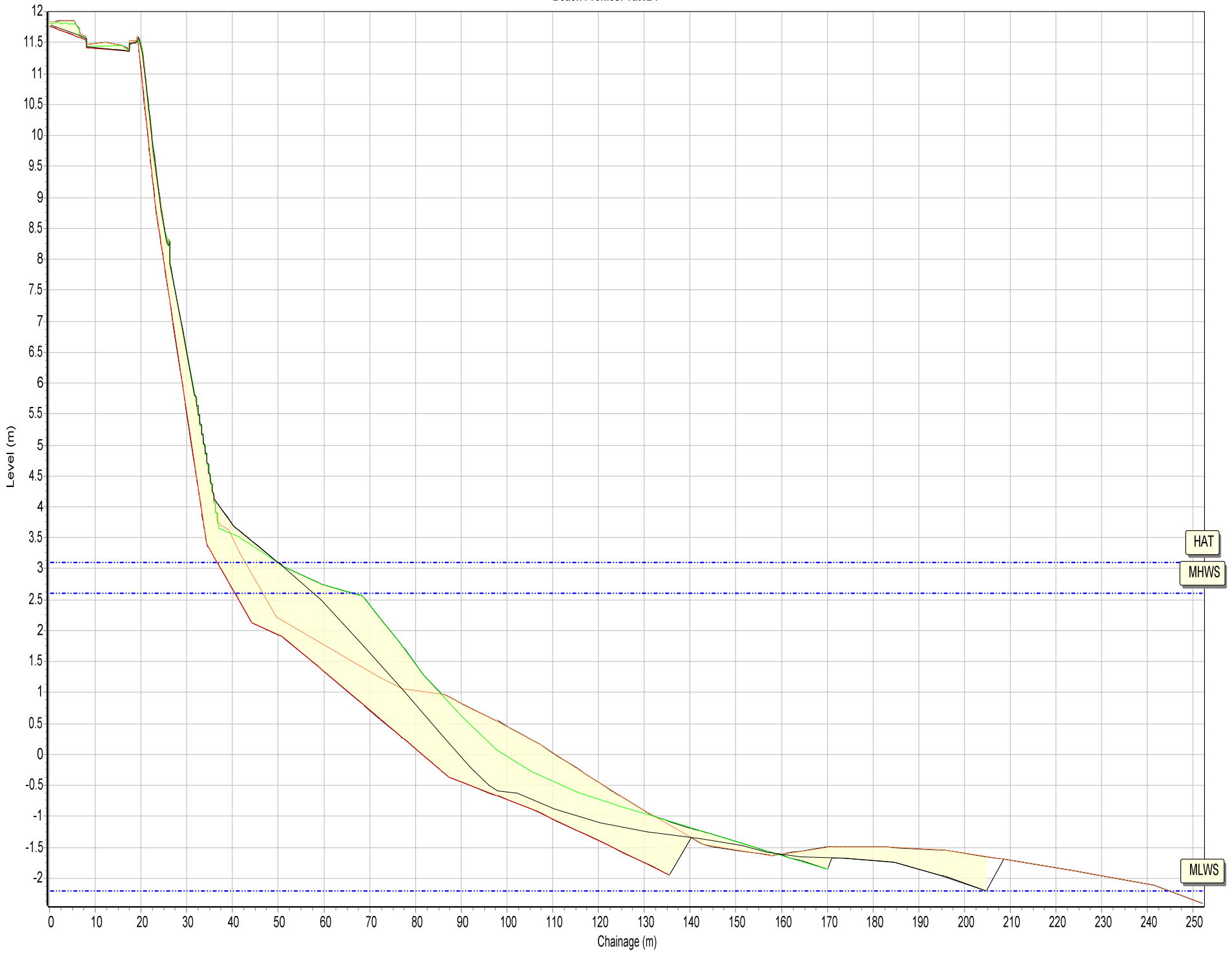
Visibility: Rain:

Summary: 2018 Full Measures Topo Survey

Easting: 514207.792 Northing: 476001.334 Profile Bearing: 47 ° from North



Beach Profiles: 1dWB1



Profiles Envelope  
26/11/2008  
22/09/2017  
03/05/2018  
12/10/2018

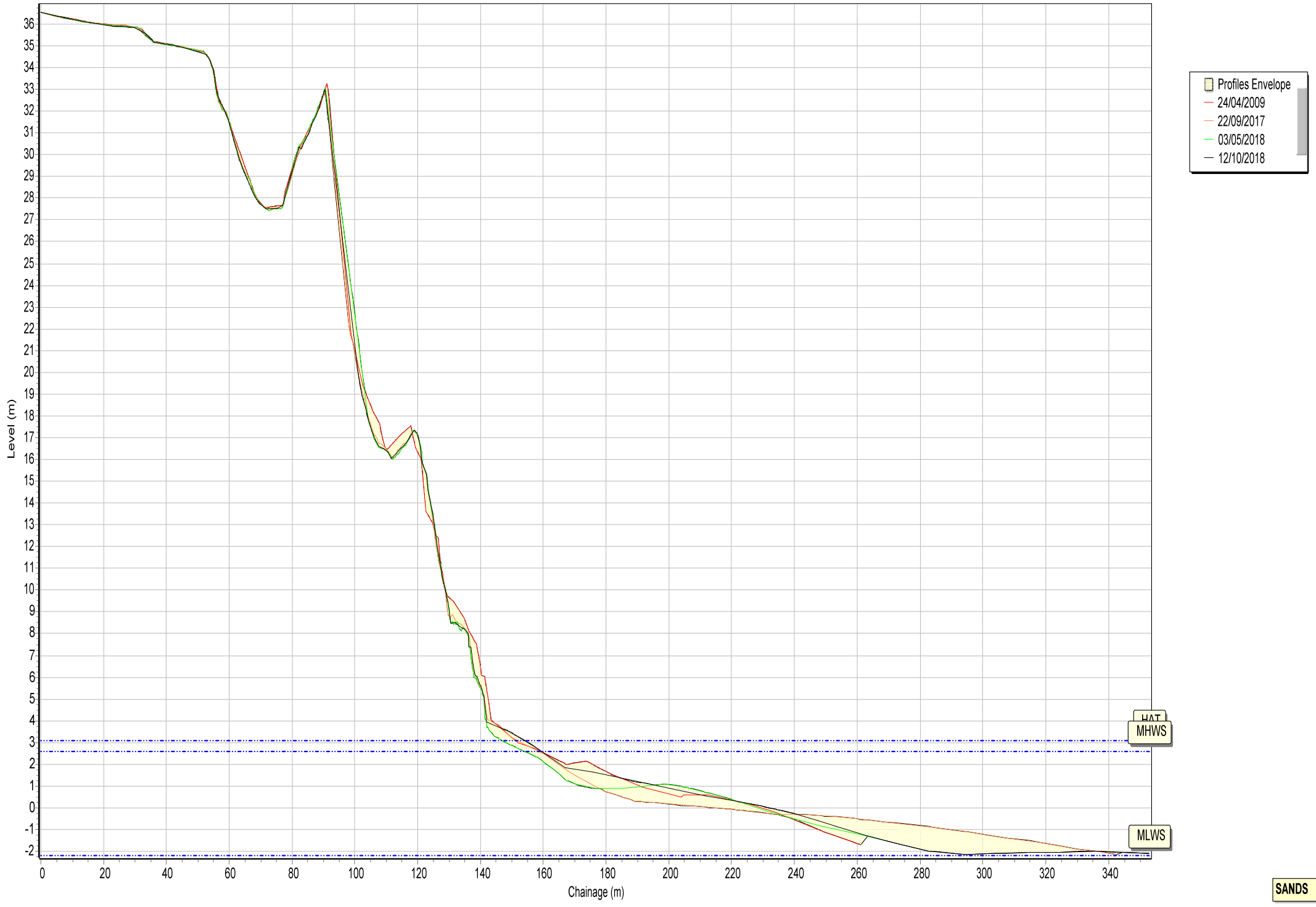
HAT

MHWS

MLWS

SANDS

Beach Profiles: 1dWB2



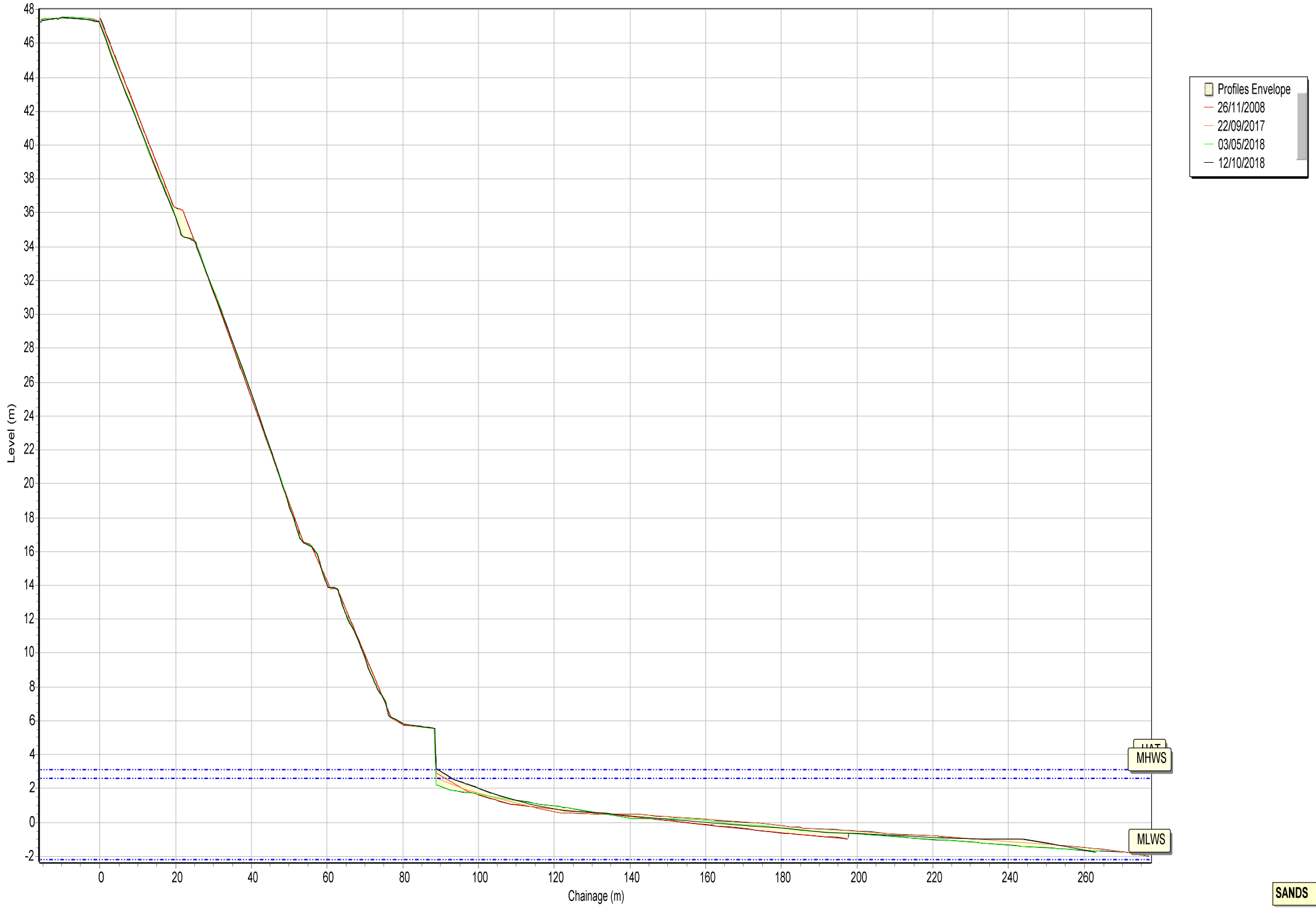
- Profiles Envelope
- 24/04/2009
- 22/09/2017
- 03/05/2018
- 12/10/2018

HAT  
MHWS

MLWS

SANDS

Beach Profiles: 1dWB3



- Profiles Envelope
- 26/11/2008
- 22/09/2017
- 03/05/2018
- 12/10/2018

MHWS

MLWS

SANDS

Beach Profiles: 1dSBN1



Profiles Envelope  
15/11/2008  
19/09/2017  
21/03/2018  
14/09/2018

HAT

MHWS

MLWS

SANDS



Beach Profiles: 1dSBN2



Profiles Envelope  
15/11/2008  
19/09/2017  
21/03/2018  
14/09/2018

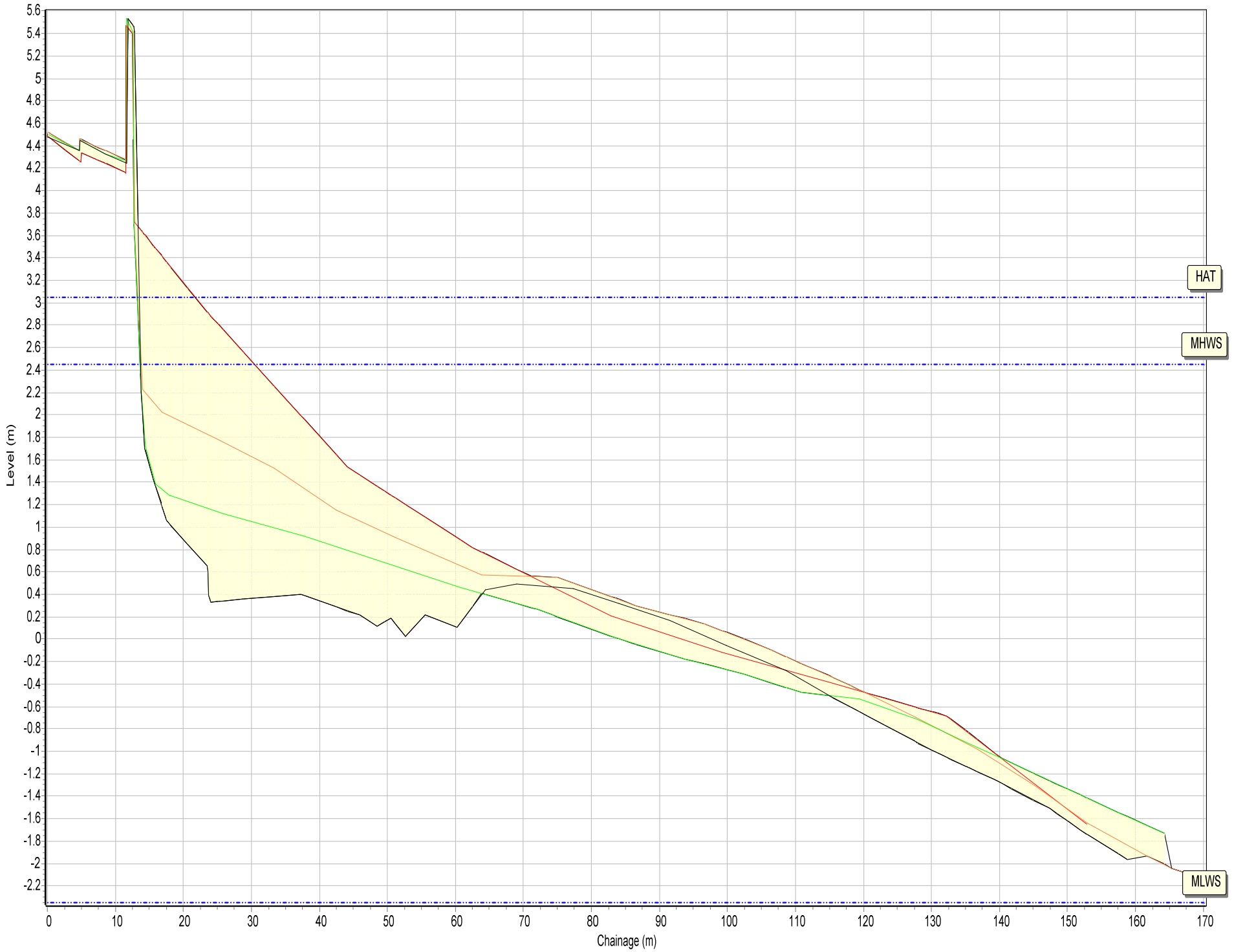
HAT

MHWS

MLWS

SANDS

Beach Profiles: 1dSBN3



Profiles Envelope  
15/11/2008  
19/09/2017  
21/03/2018  
14/09/2018

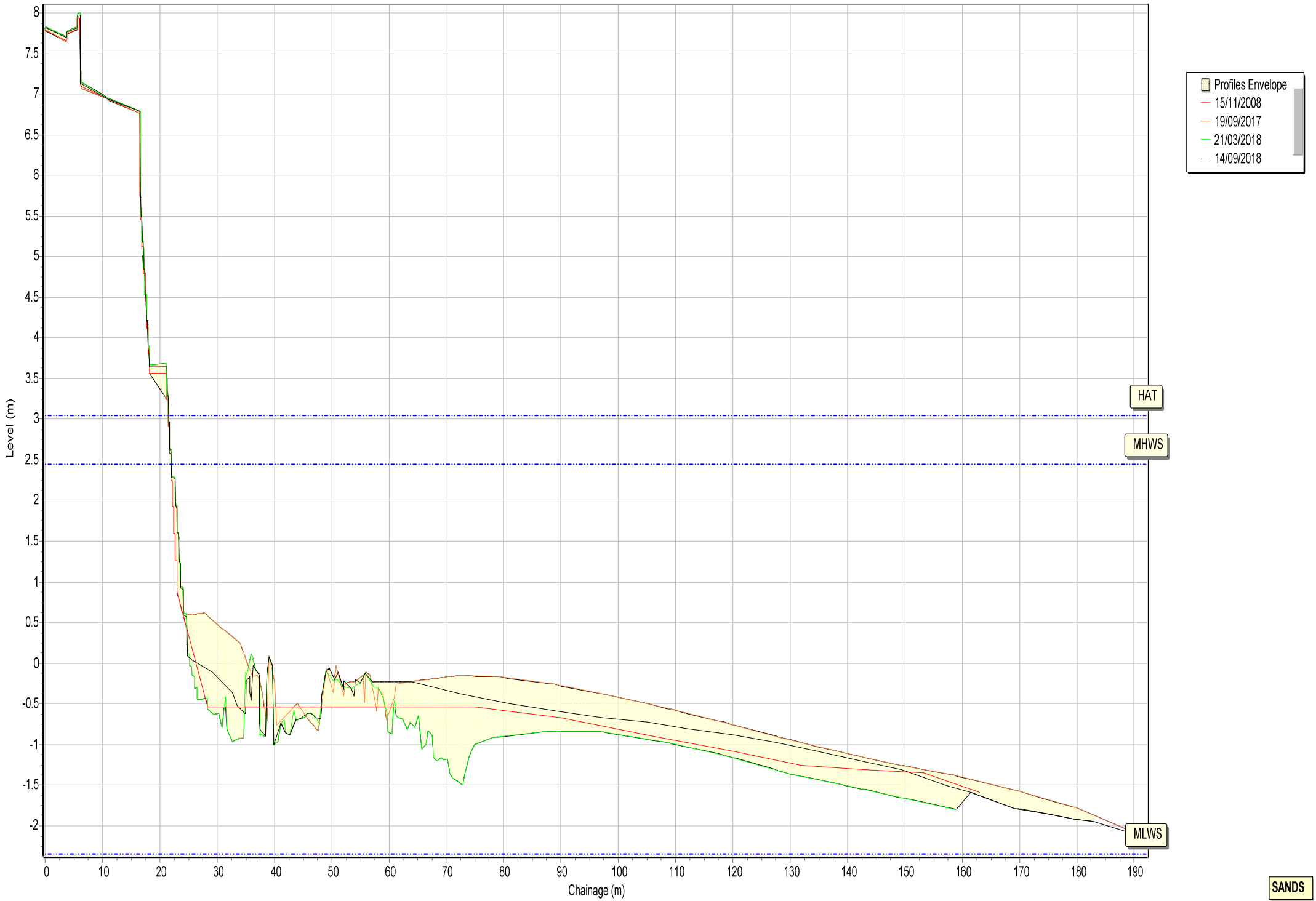
HAT

MHWS

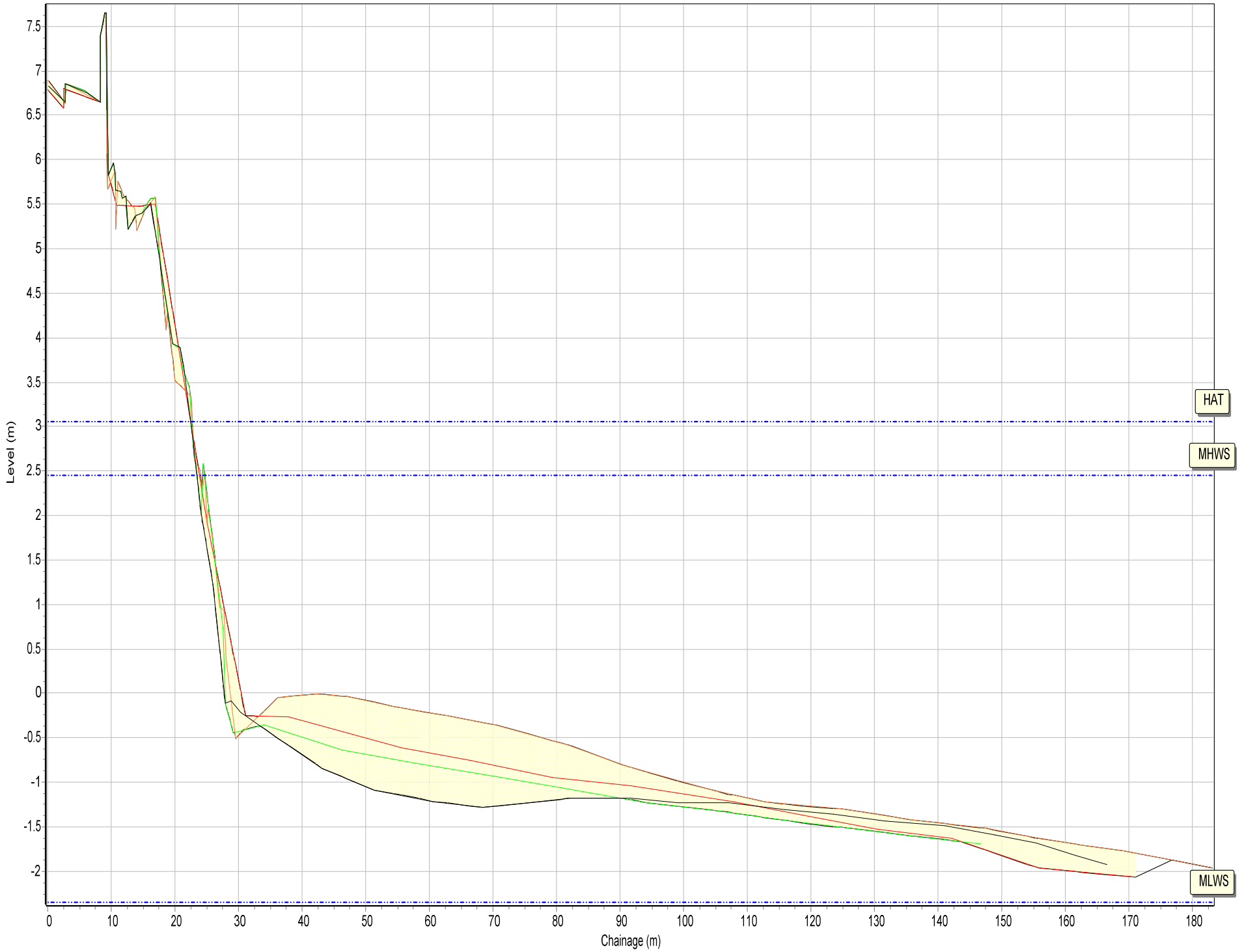
MLWS

SANDS

Beach Profiles: 1dSBN4



Beach Profiles: 1dSBN5



Profiles Envelope  
06/10/2009  
19/09/2017  
21/03/2018  
14/09/2018

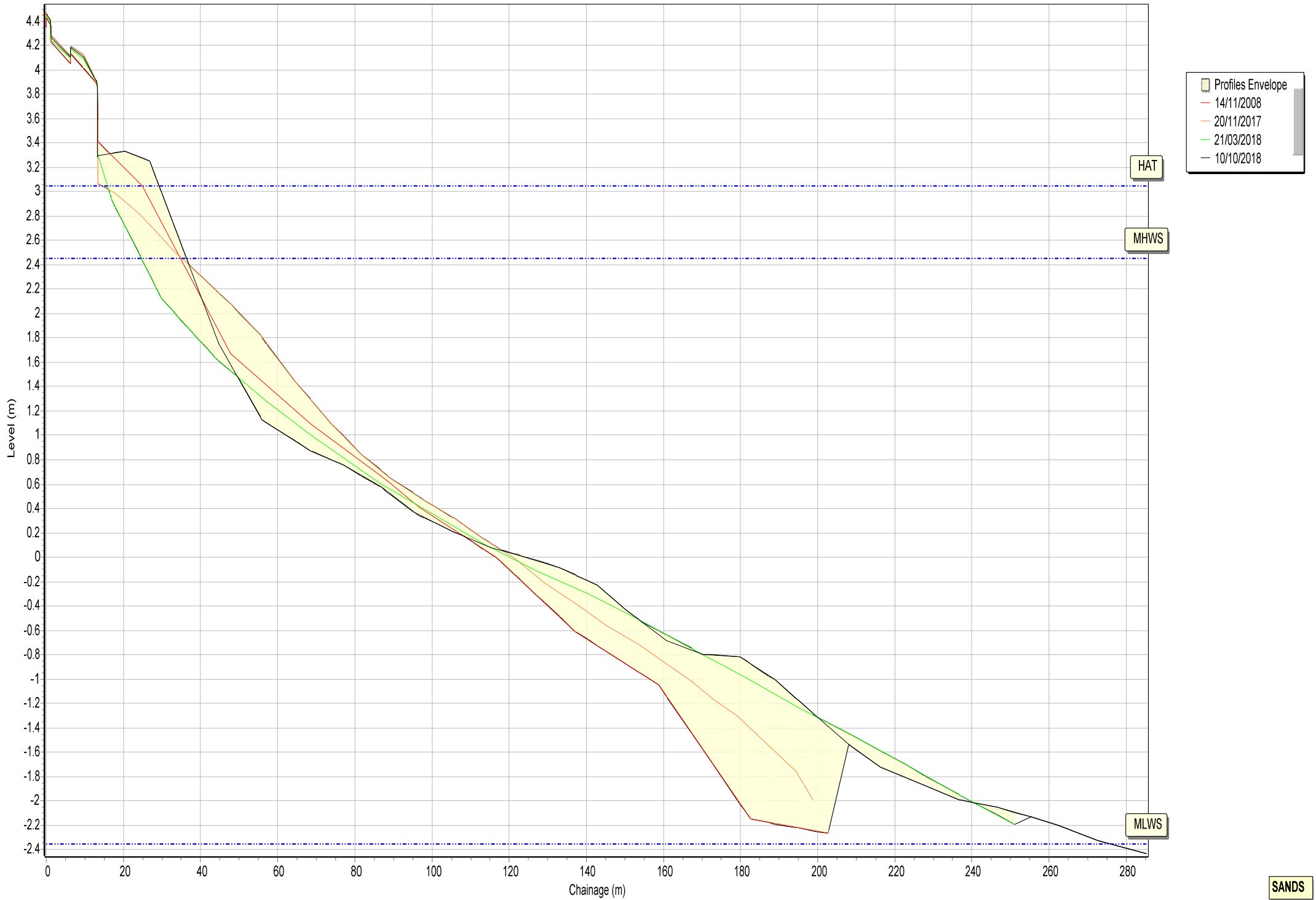
HAT

MHWS

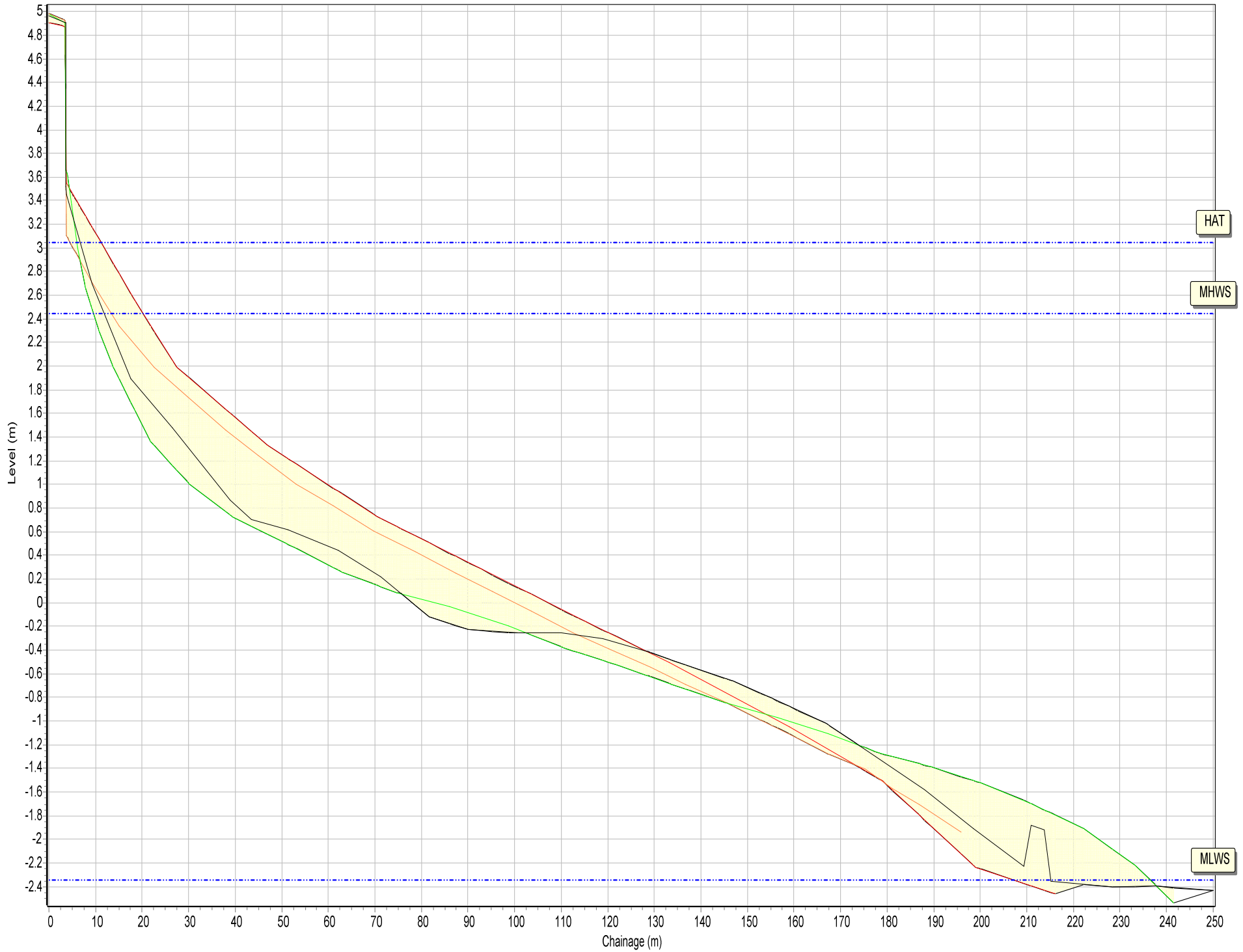
MLWS

SANDS

Beach Profiles: 1dSBS1



Beach Profiles: 1dSBS2



Profiles Envelope  
14/11/2008  
20/11/2017  
21/03/2018  
10/10/2018

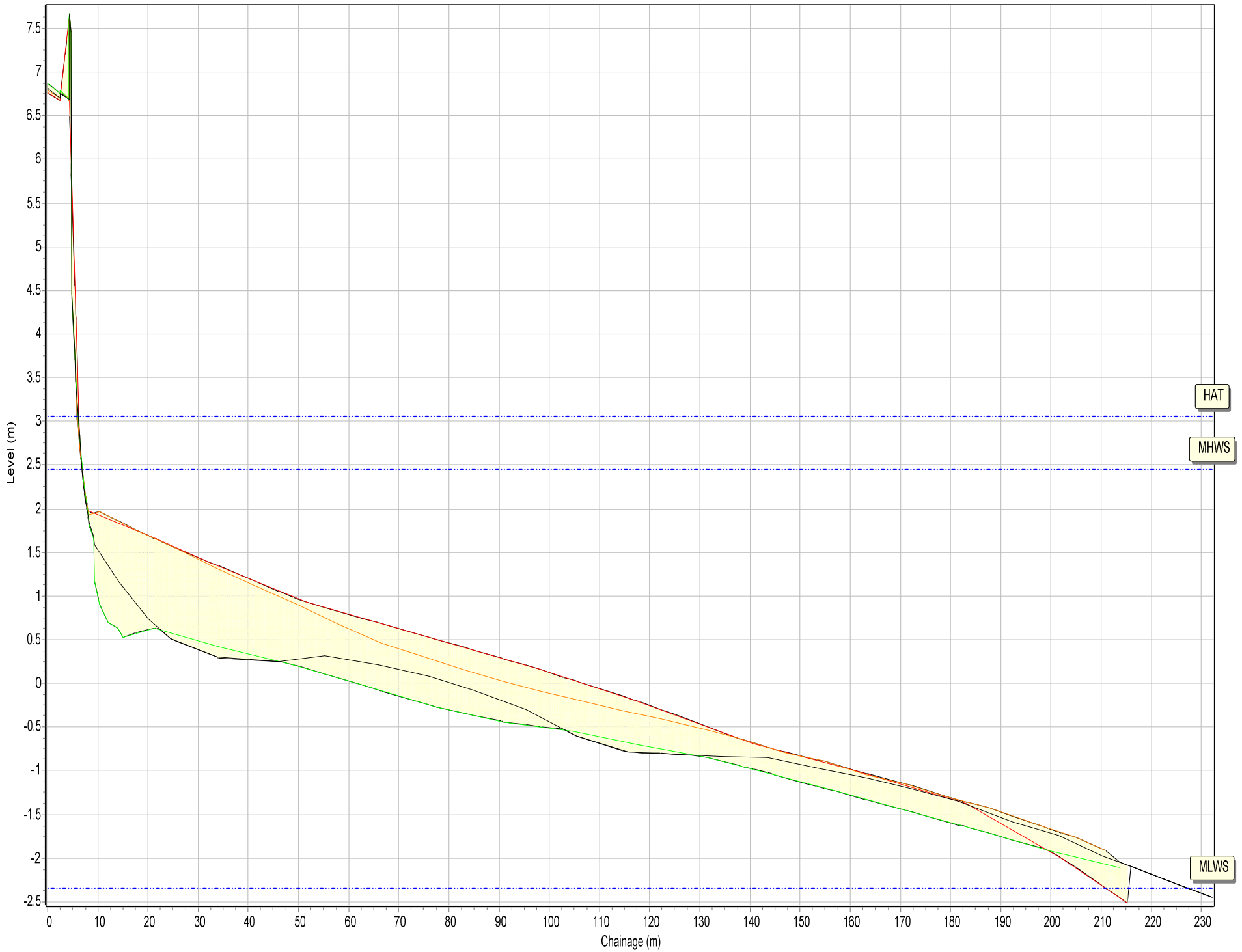
HAT

MHWS

MLWS

SANDS

Beach Profiles: 1dSBS3



Profiles Envelope  
14/11/2008  
20/11/2017  
21/03/2018  
10/10/2018

HAT

MHWS

MLWS

SANDS

Beach Profiles: 1dSBS4



Profiles Envelope  
14/11/2008  
20/11/2017  
21/03/2018  
10/10/2018

HAT

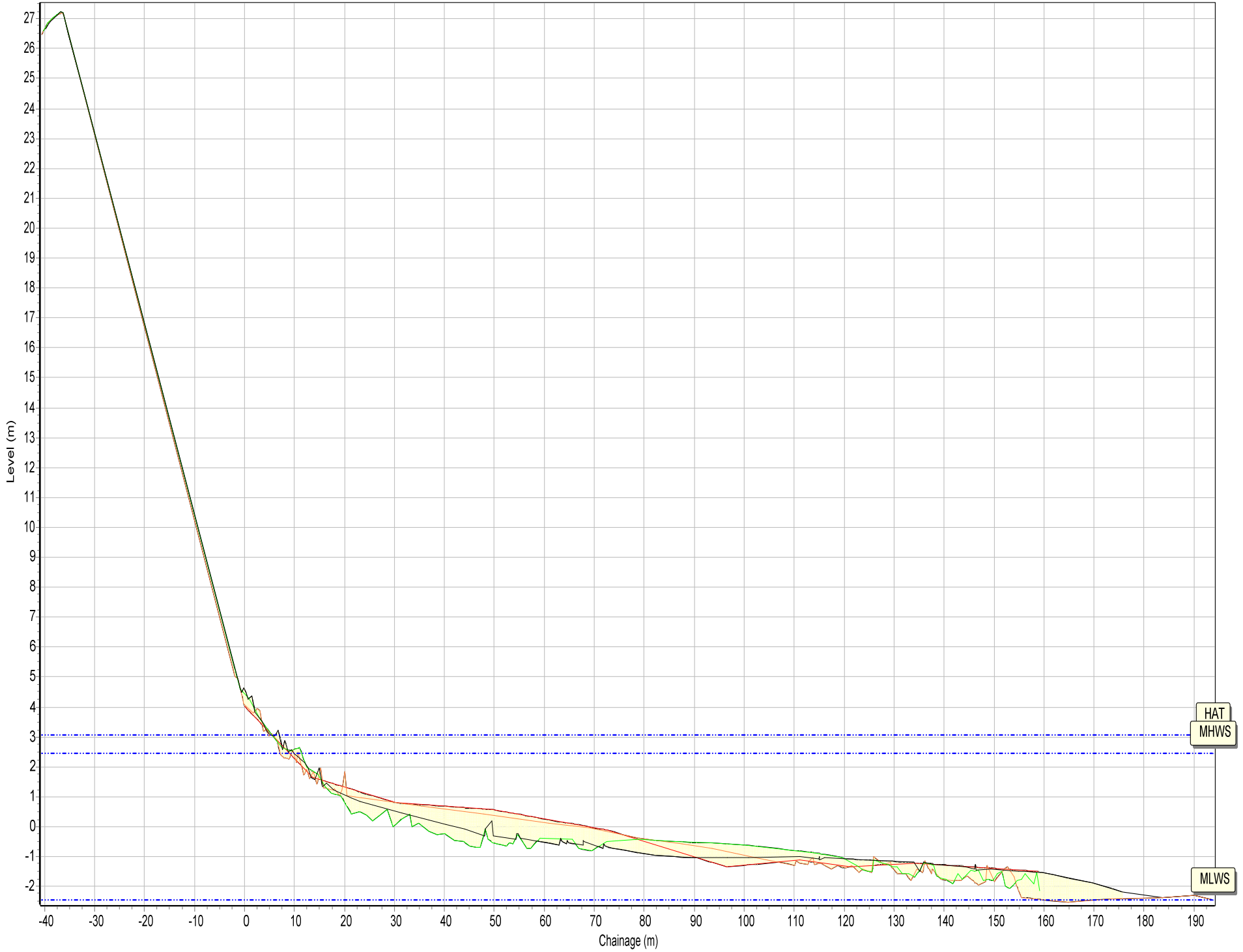
MHWS

MLWS

SANDS



Beach Profiles: 1dCY1

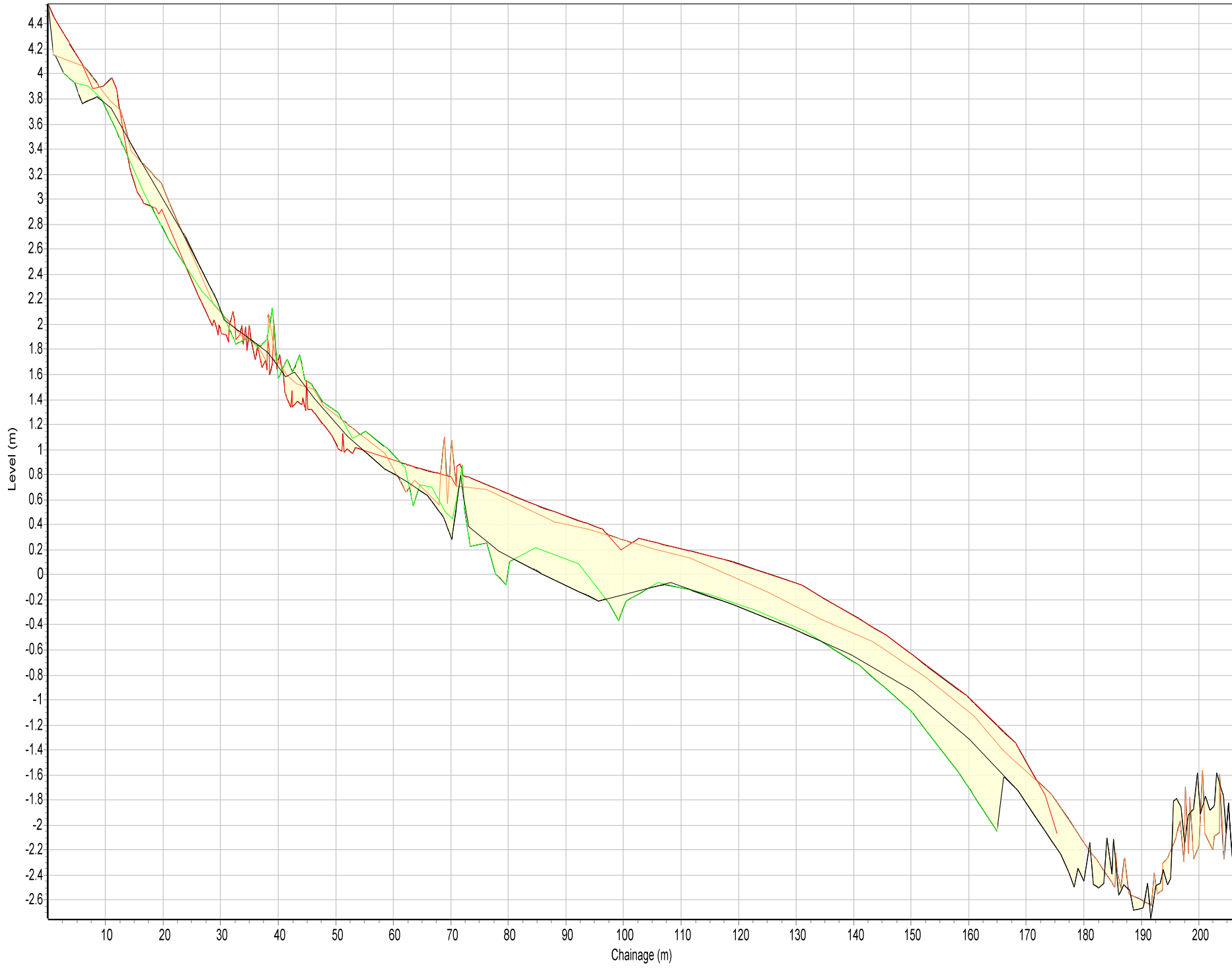


Profiles Envelope  
17/11/2008  
20/09/2017  
20/03/2018  
09/10/2018

HAT  
MHWS

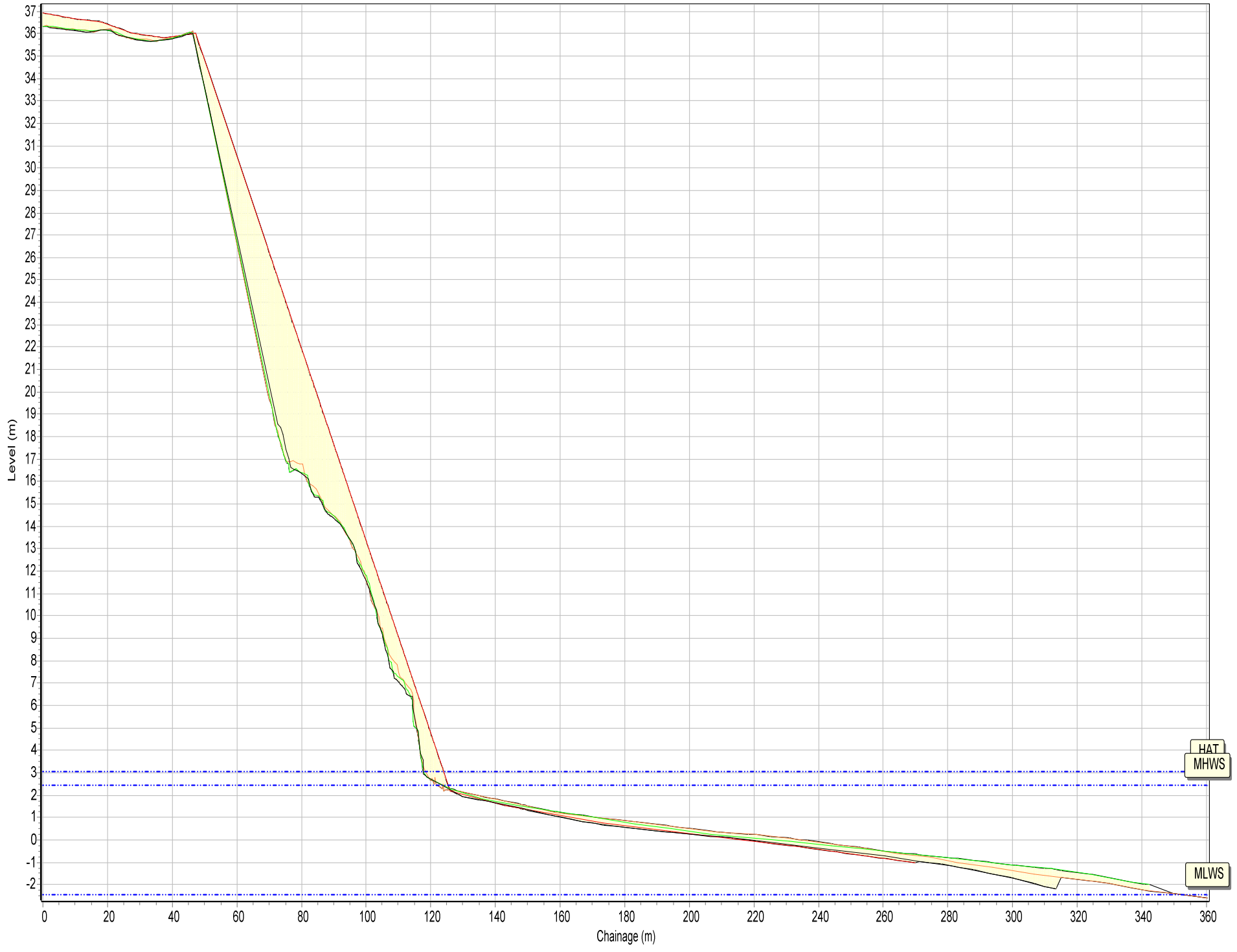
MLWS

Beach Profiles: 1dCY1A



Profiles Envelope  
12/11/2015  
20/09/2017  
20/03/2018  
09/10/2018

Beach Profiles: 1dCY2



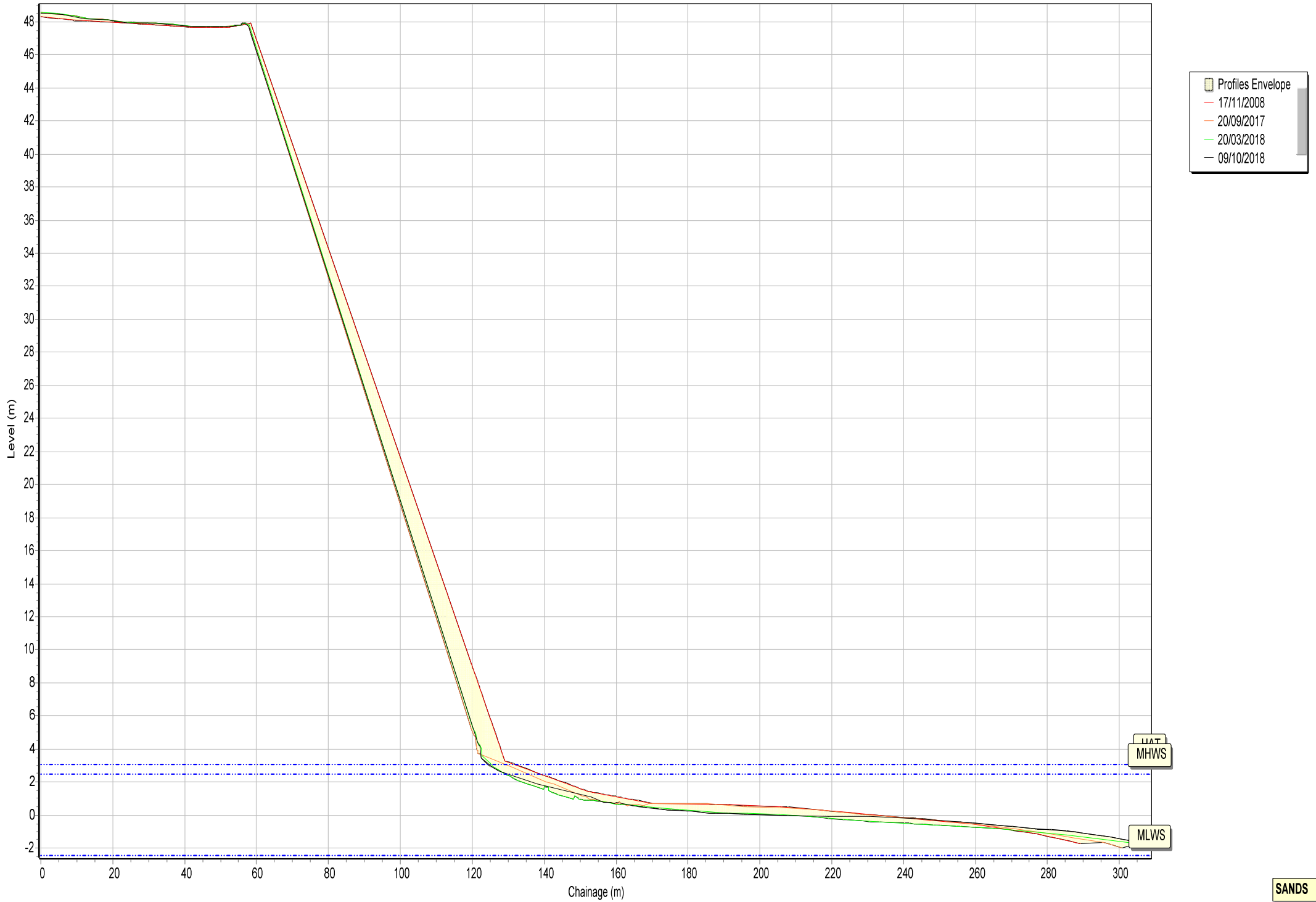
Profiles Envelope  
17/11/2008  
20/09/2017  
20/03/2018  
09/10/2018

HAT  
MHWS

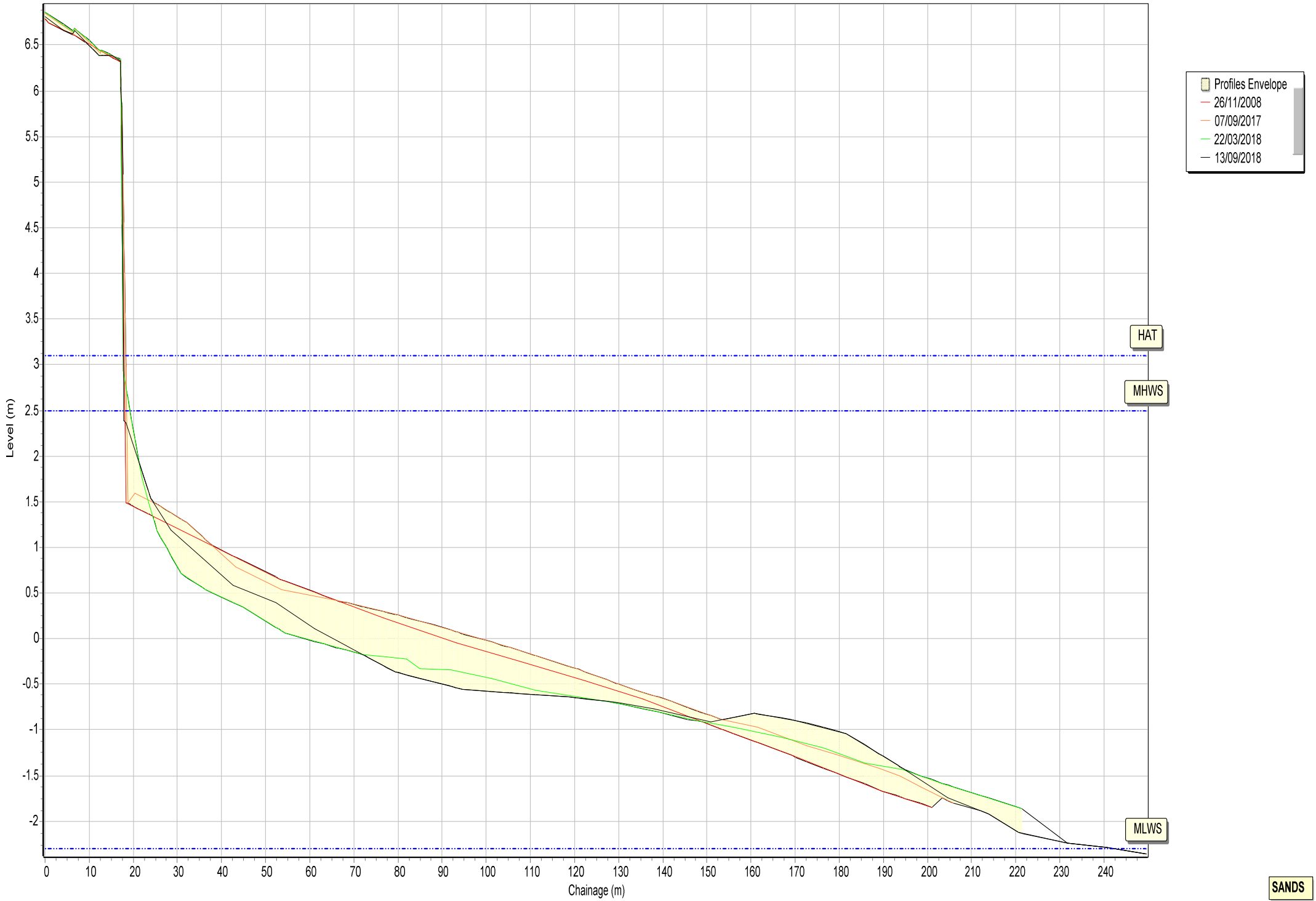
MLWS

SANDS

Beach Profiles: 1dCY3

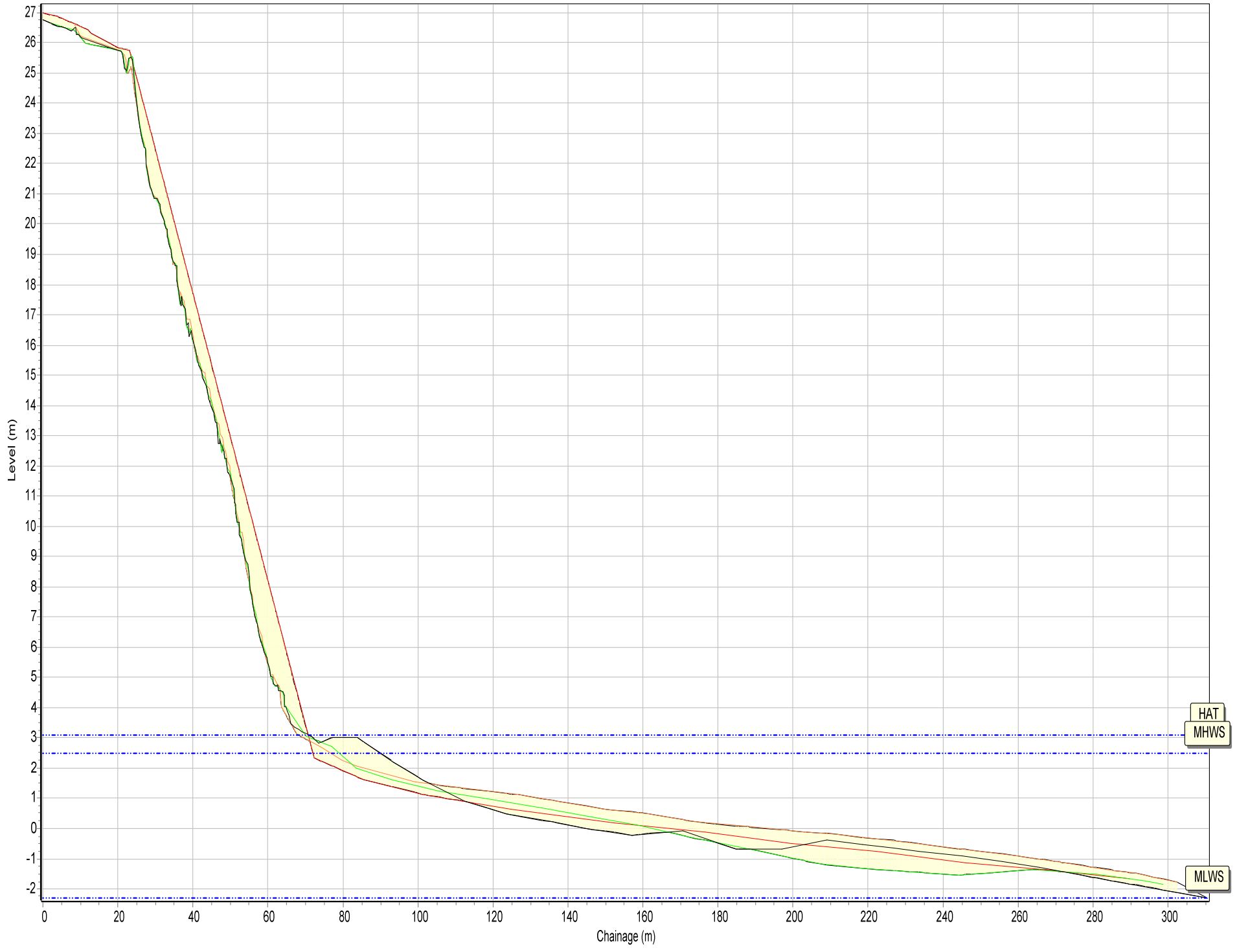


Beach Profiles: 1dFB1



SANDS

Beach Profiles: 1dFB2



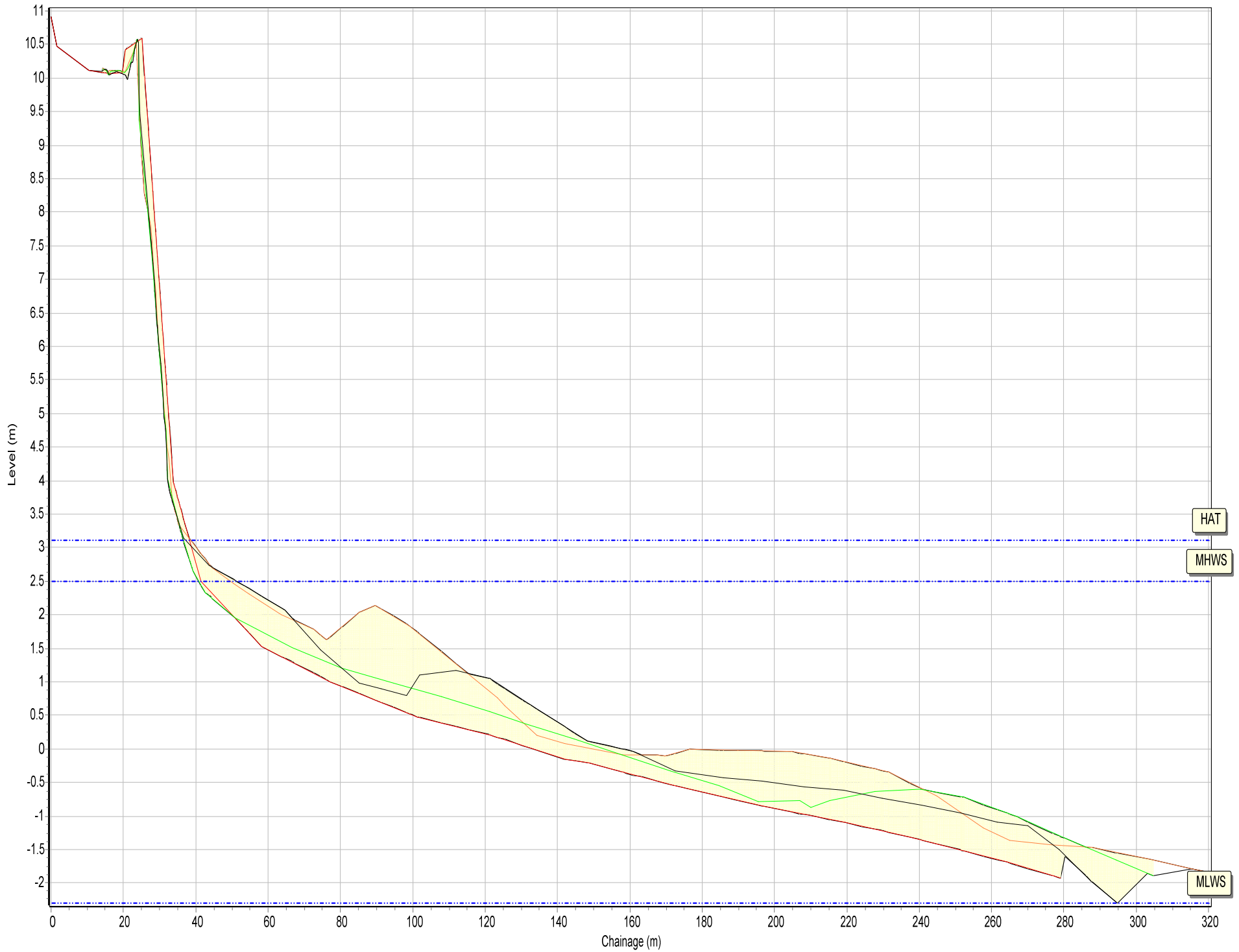
Profiles Envelope  
26/11/2008  
07/09/2017  
22/03/2018  
13/09/2018

HAT  
MHWS

MLWS

SANDS

Beach Profiles: 1dFB3



Profiles Envelope  
26/11/2008  
07/09/2017  
22/03/2018  
13/09/2018

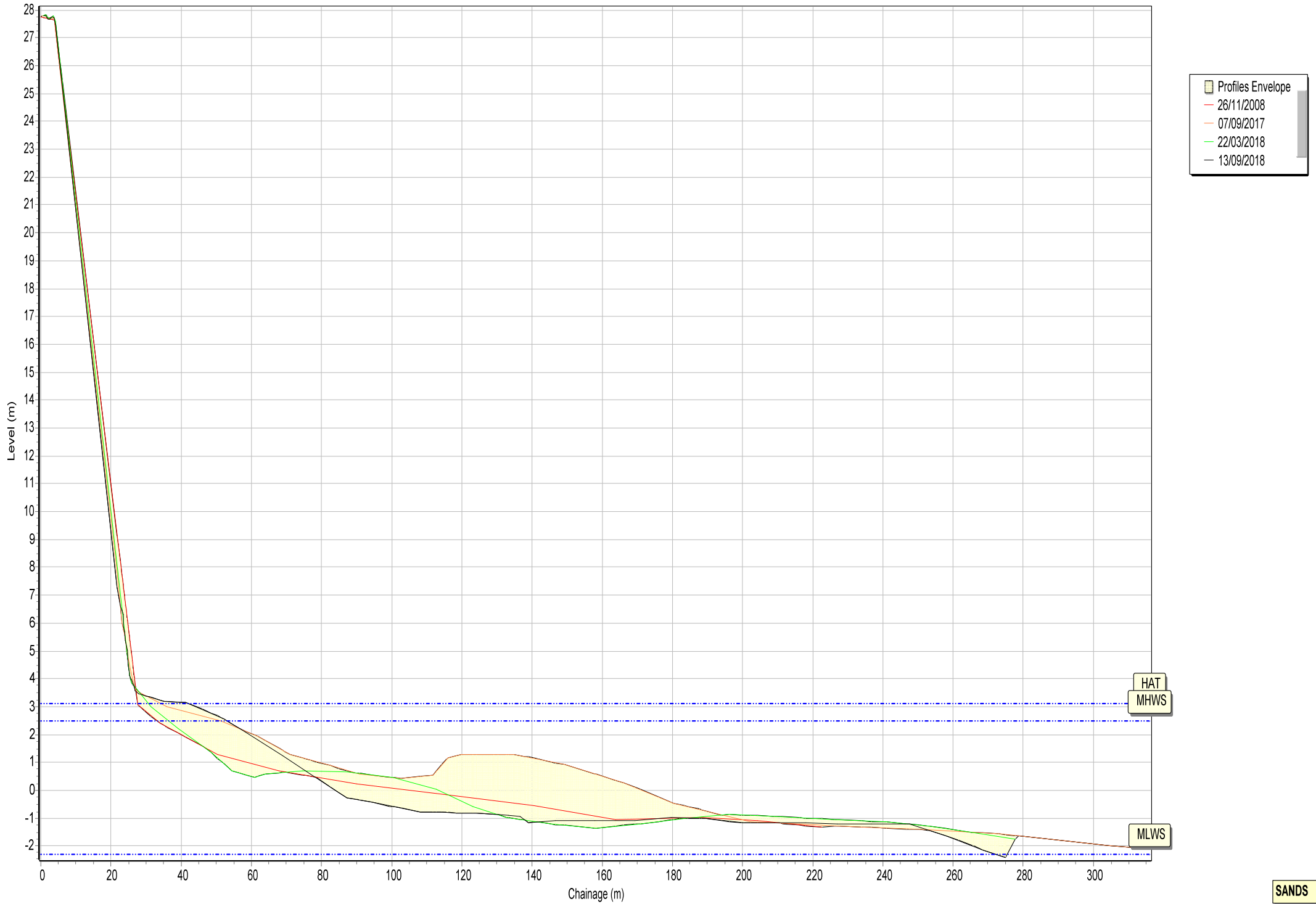
HAT

MLWS

MLWS

SANDS

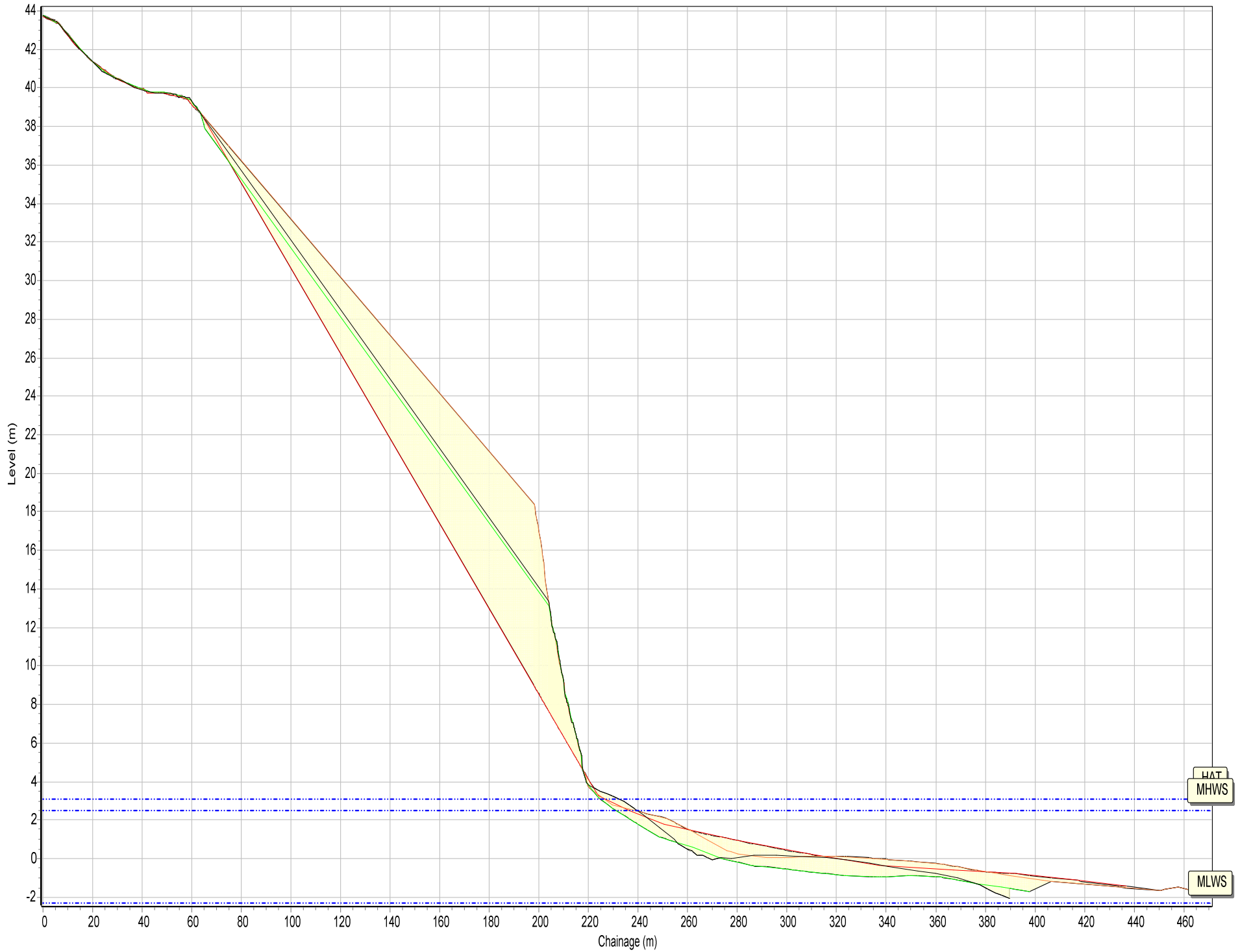
Beach Profiles: 1dFB4



SANDS



Beach Profiles: 1dFB5



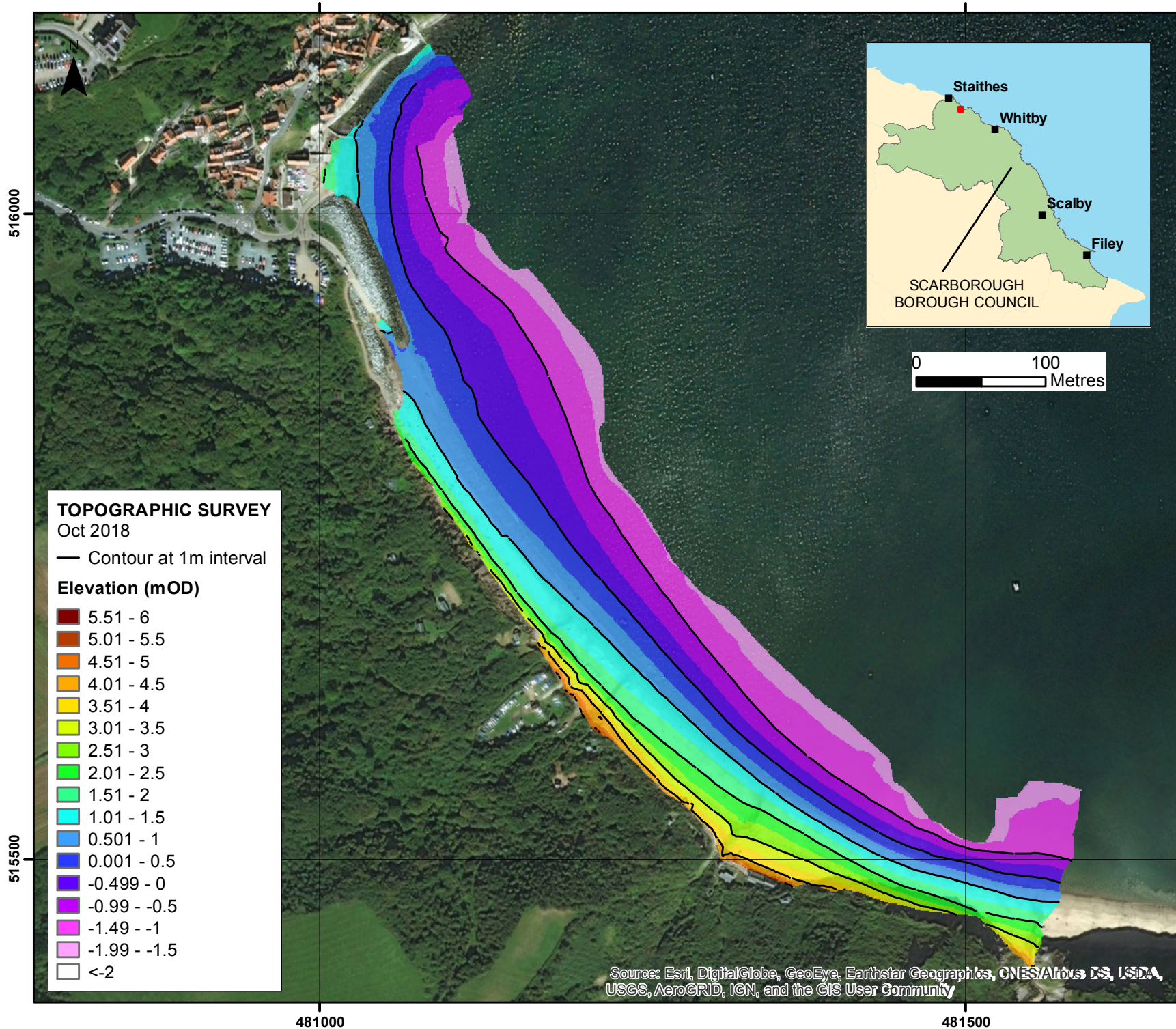
Profiles Envelope  
26/11/2008  
07/09/2017  
22/03/2018  
13/09/2018

HAT  
MHWS

MLWS

SANDS

**Appendix B**  
**Topographic Survey**



Key

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

**Appendix B - Map 1**  
**RUNSWICK BAY**

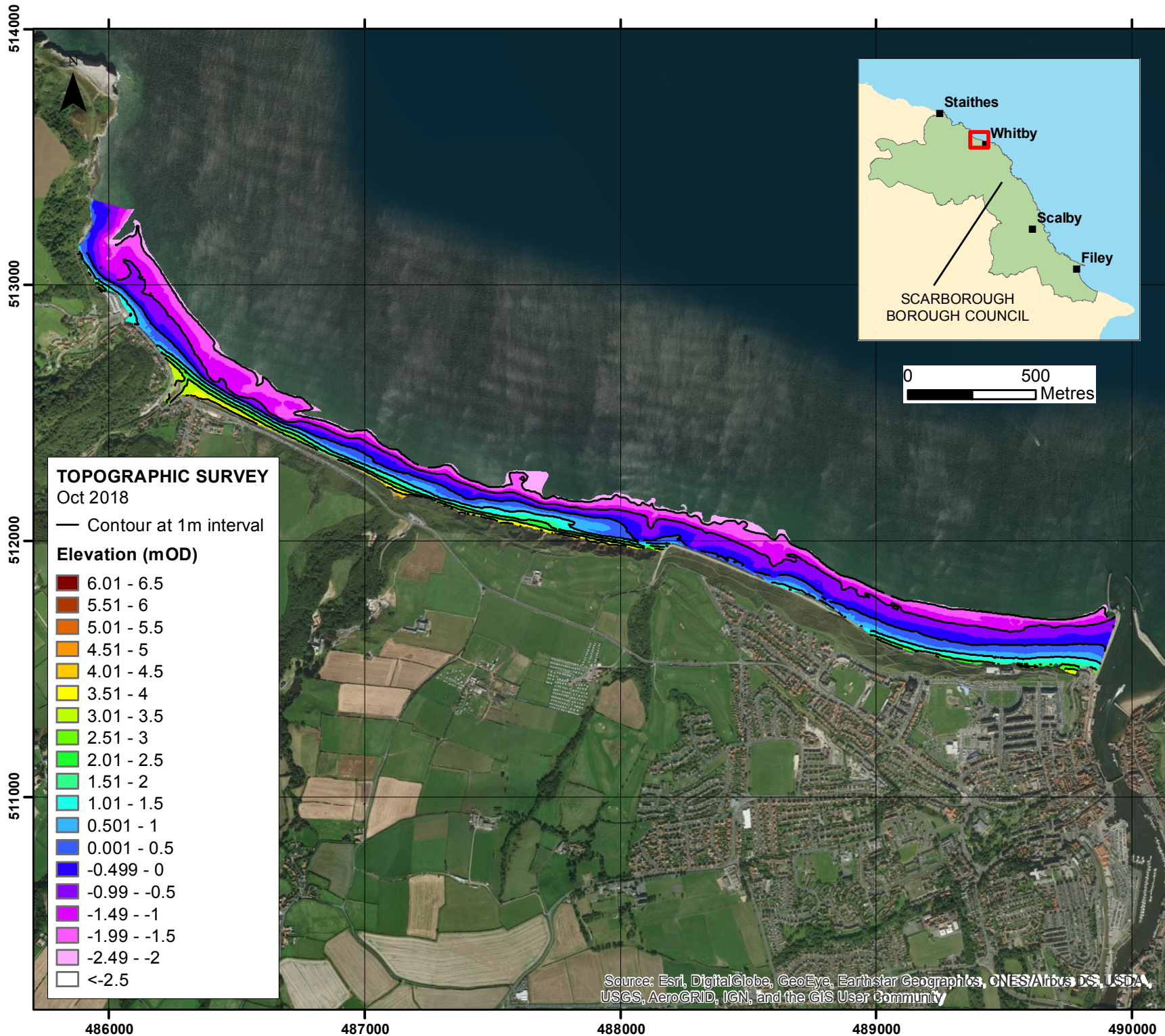
**Scarborough Borough Council Frontage**  
Analytical Report  
'Full Measures' Survey 2018

Drawing Scale at A4 1:4,000

**WATER**  
Royal HaskoningDHV  
Marlborough House  
Marlborough Crescent  
Newcastle upon Tyne  
NE1 4EE

Tel: +44 (0)191 211 1300  
Fax: +44 (0)191 211 1313  
www.royalhaskoningdhv.com





Key

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

**Appendix B - Map 2**

**SANDESEND**

**Scarborough Borough Council Frontage**

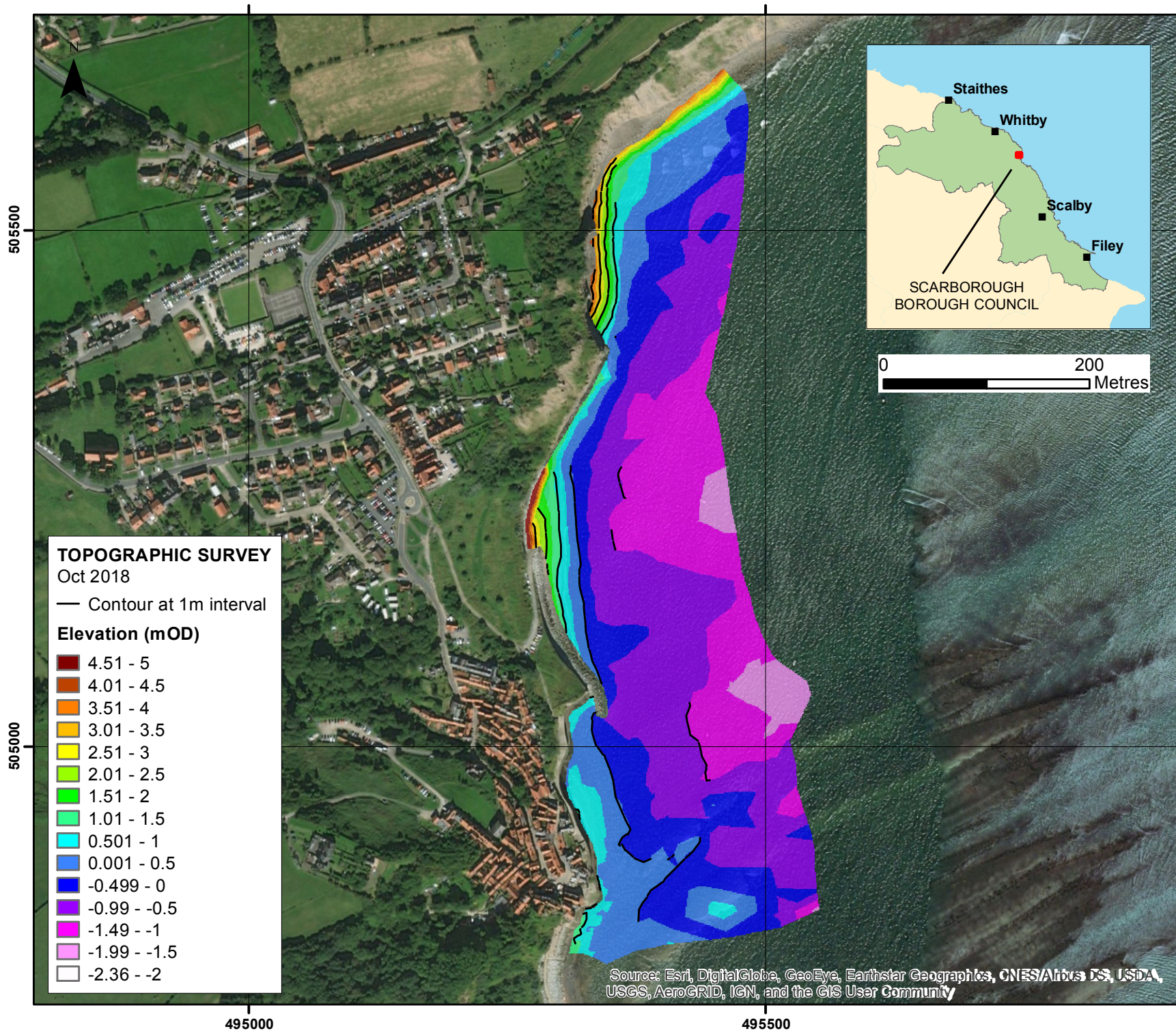
Analytical Report  
'Full Measures' Survey 2018

Drawing Scale at A4 1:20,000

**WATER**  
Royal HaskoningDHV  
Marlborough House  
Marlborough Crescent  
Newcastle upon Tyne  
NE1 4EE

Tel: +44 (0)191 211 1300  
Fax: +44 (0)191 211 1313  
www.royalhaskoningdhv.com



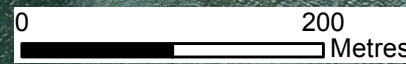


**TOPOGRAPHIC SURVEY**  
Oct 2018

— Contour at 1m interval

**Elevation (mOD)**

4.51 - 5
4.01 - 4.5
3.51 - 4
3.01 - 3.5
2.51 - 3
2.01 - 2.5
1.51 - 2
1.01 - 1.5
0.501 - 1
0.001 - 0.5
-0.499 - 0
-0.99 - -0.5
-1.49 - -1
-1.99 - -1.5
-2.36 - -2



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Key

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Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

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**Appendix B - Map 3**

**ROBIN HOOD'S BAY**

**Scarborough Borough Council Frontage**

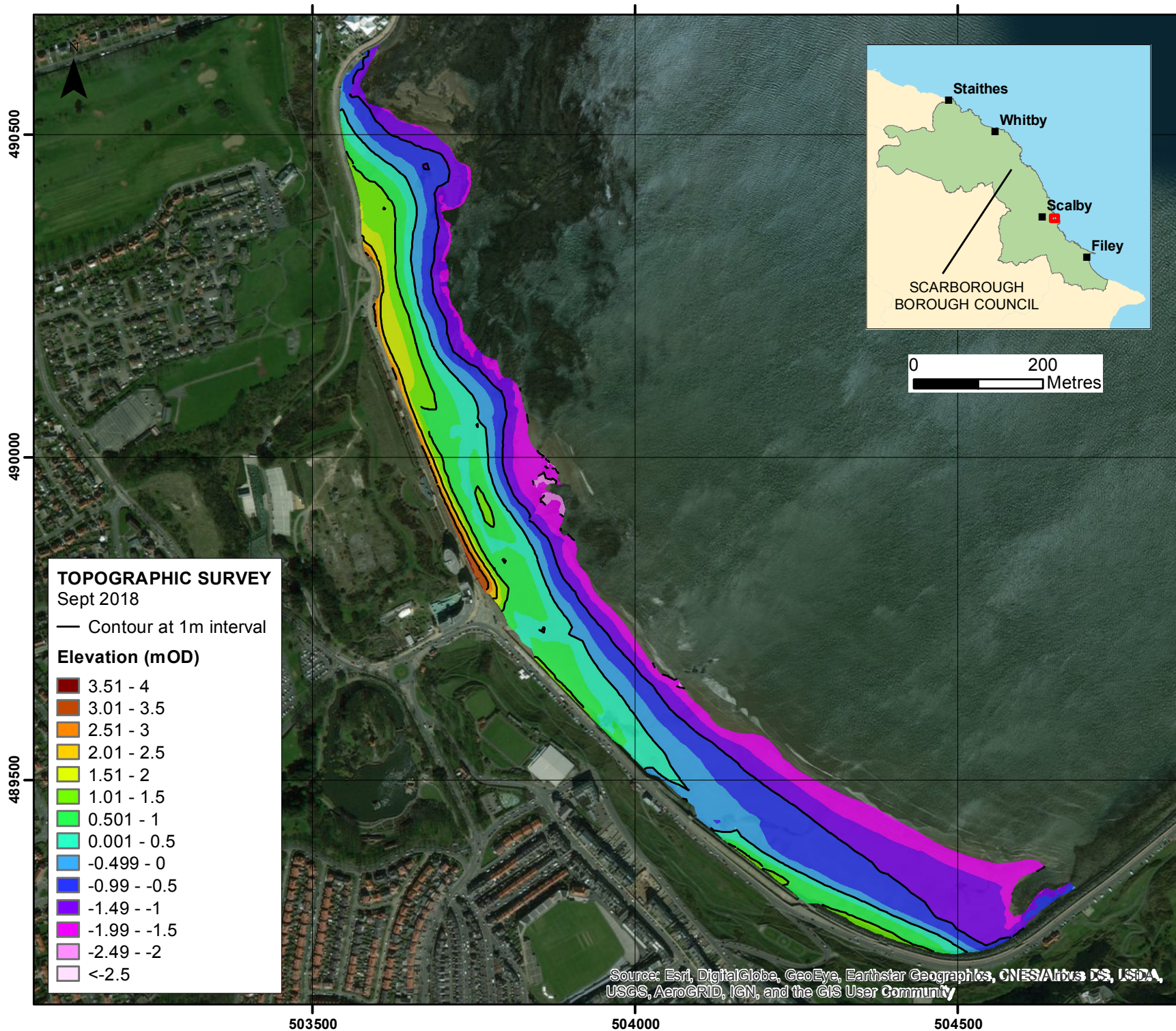
Analytical Report  
'Full Measures' Survey 2018

Drawing Scale at A4 1:5,000

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Project: Cell 1 Regional Coastal Monitoring Programme

**Appendix B - Map 4**

**SCARBOROUGH NORTH BAY**

**Scarborough Borough Council Frontage**

Analytical Report  
'Full Measures' Survey 2018

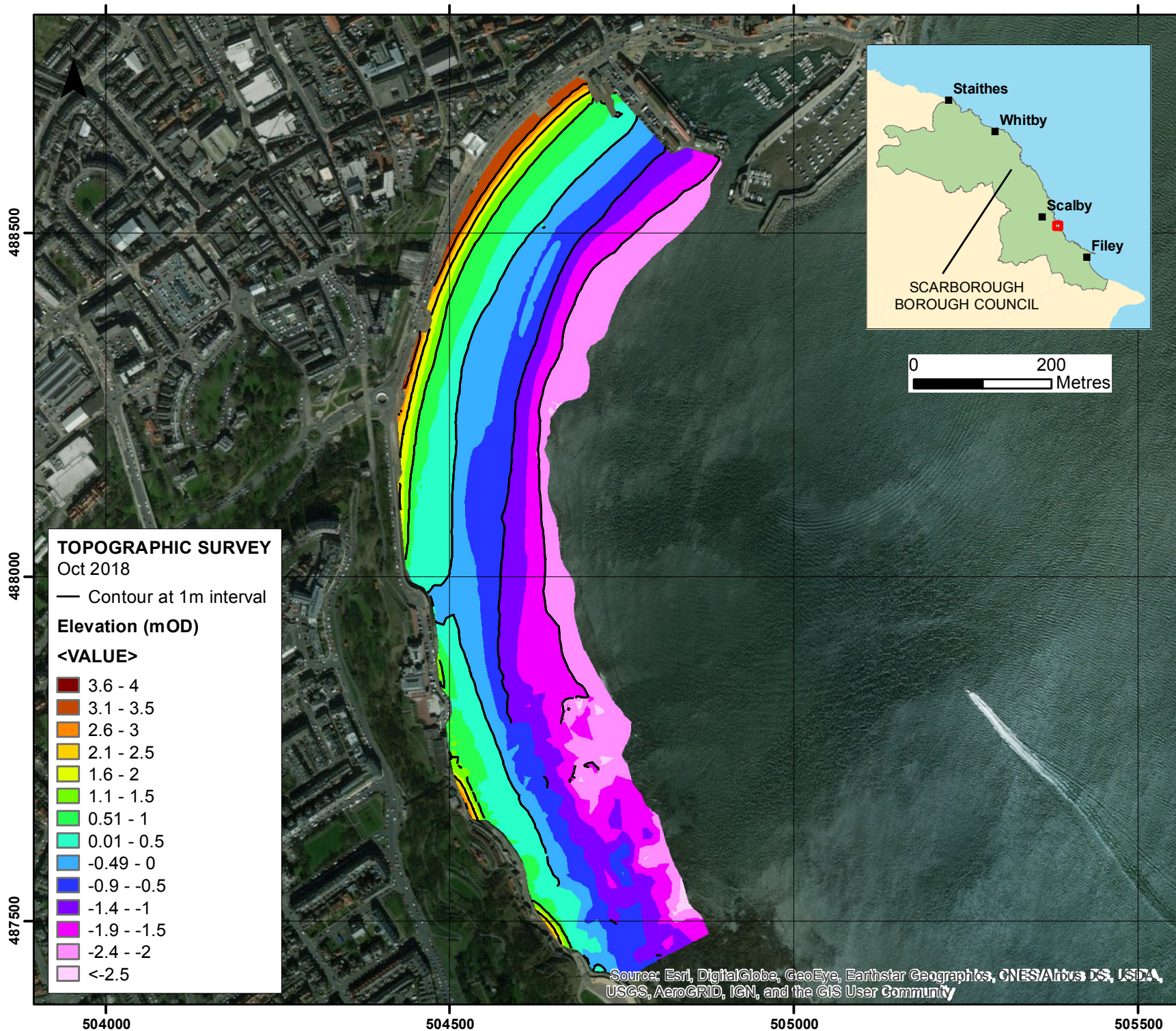
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Project: Cell 1 Regional Coastal Monitoring Programme

**Appendix B - Map 5**

**SCARBOROUGH SOUTH BAY**

**Scarborough Borough Council Frontage**

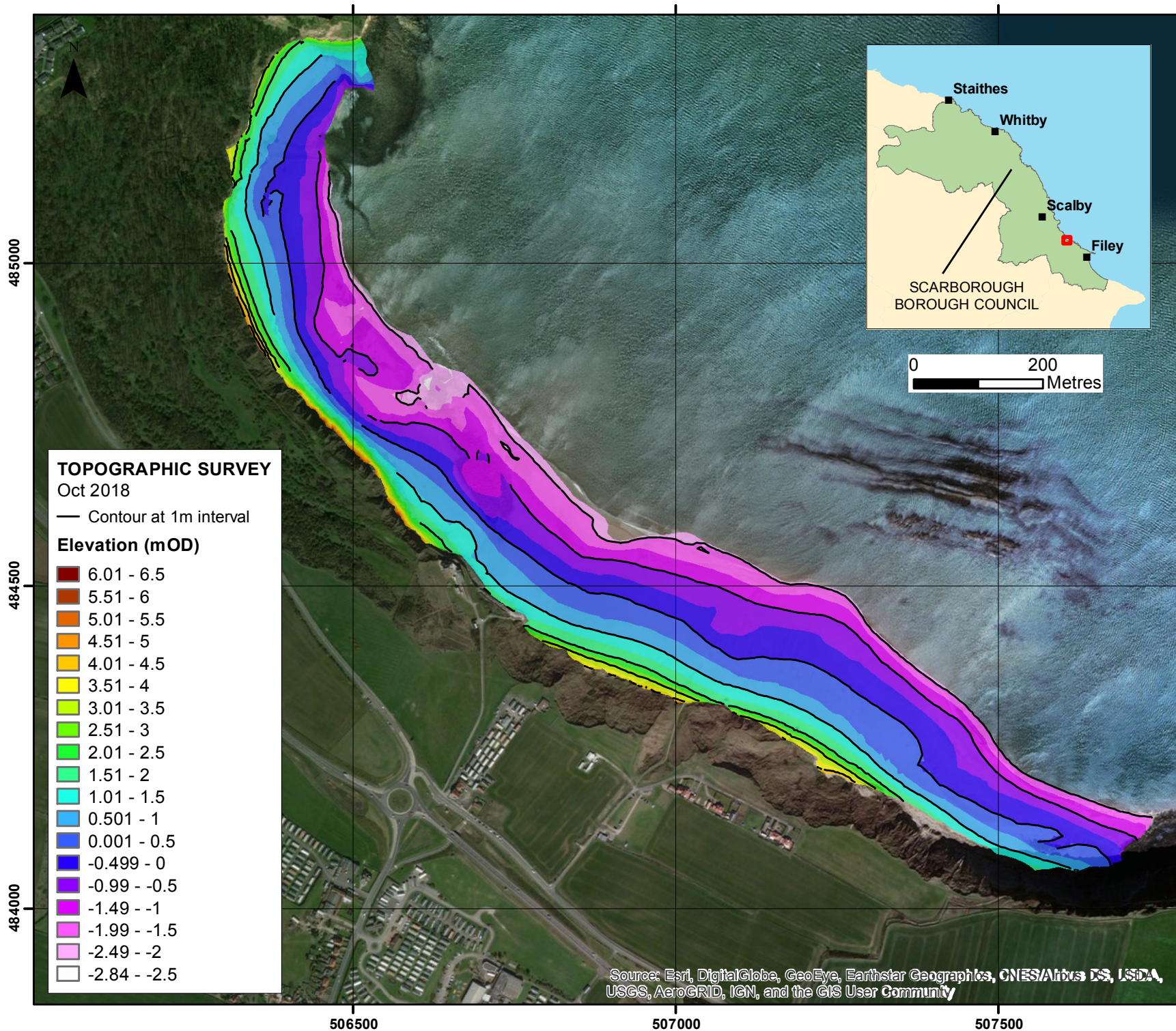
Analytical Report  
'Full Measures' Survey 2018

Drawing Scale at A4 1:7,500

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Project: Cell 1 Regional Coastal Monitoring Programme

**Appendix B - Map 6**  
**CAYTON BAY**  
**Scarborough Borough Council Frontage**

Analytical Report  
'Full Measures' Survey 2018

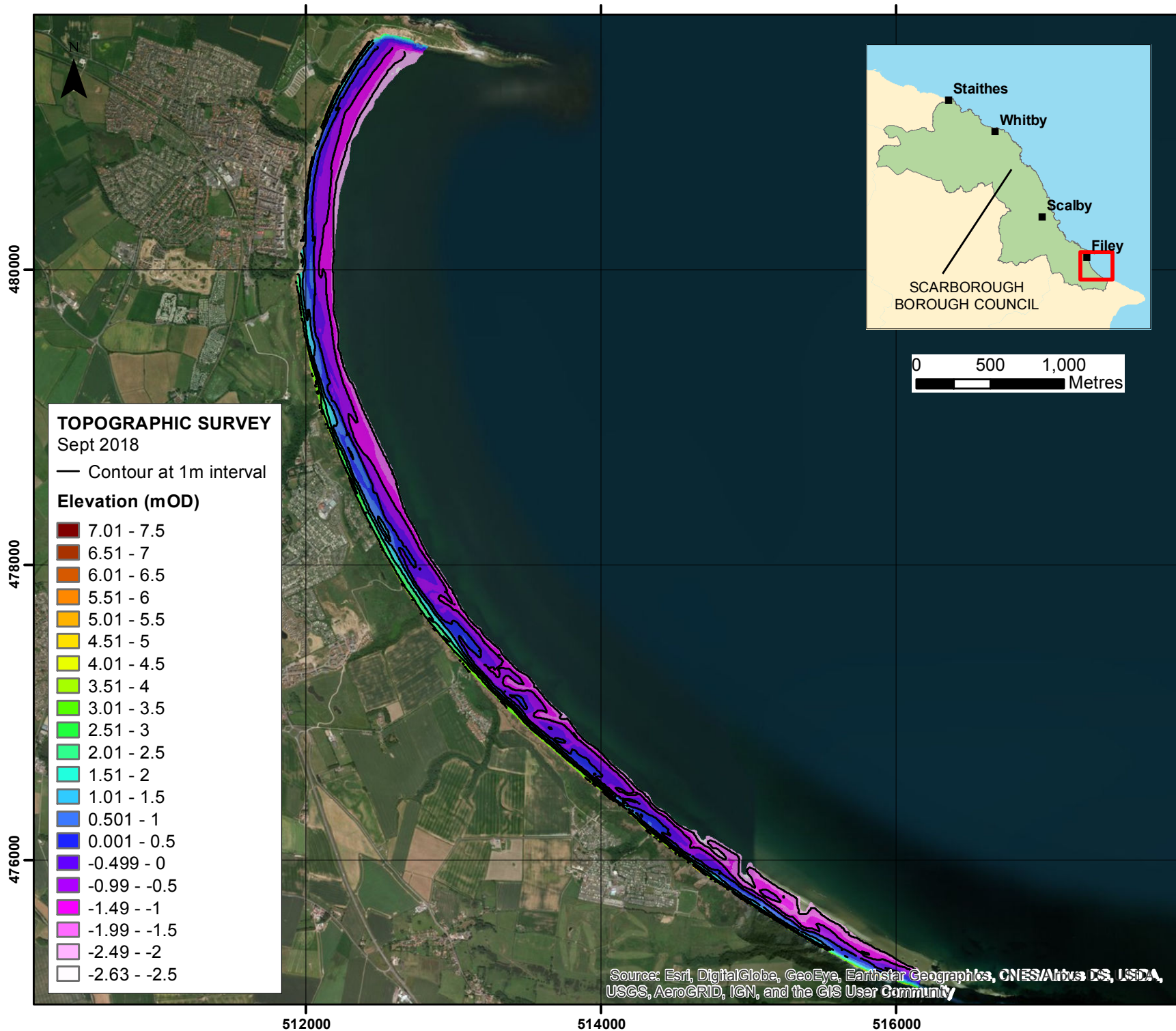
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Project: Cell 1 Regional Coastal Monitoring Programme

**Appendix B - Map 7**

**FILEY BAY**

**Scarborough Borough Council Frontage**

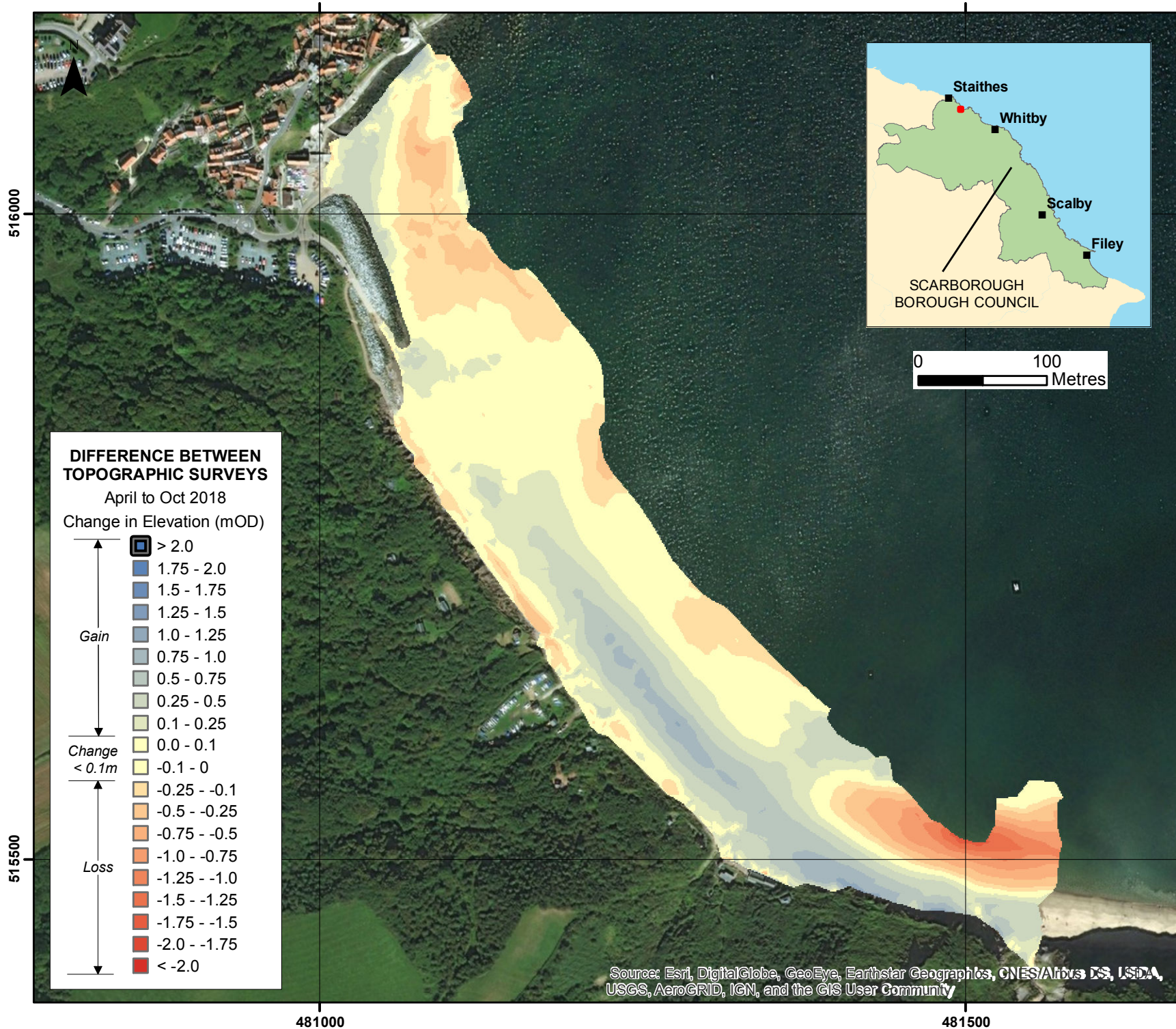
Analytical Report  
'Full Measures' Survey 2018

Drawing Scale at A4 1:35,000

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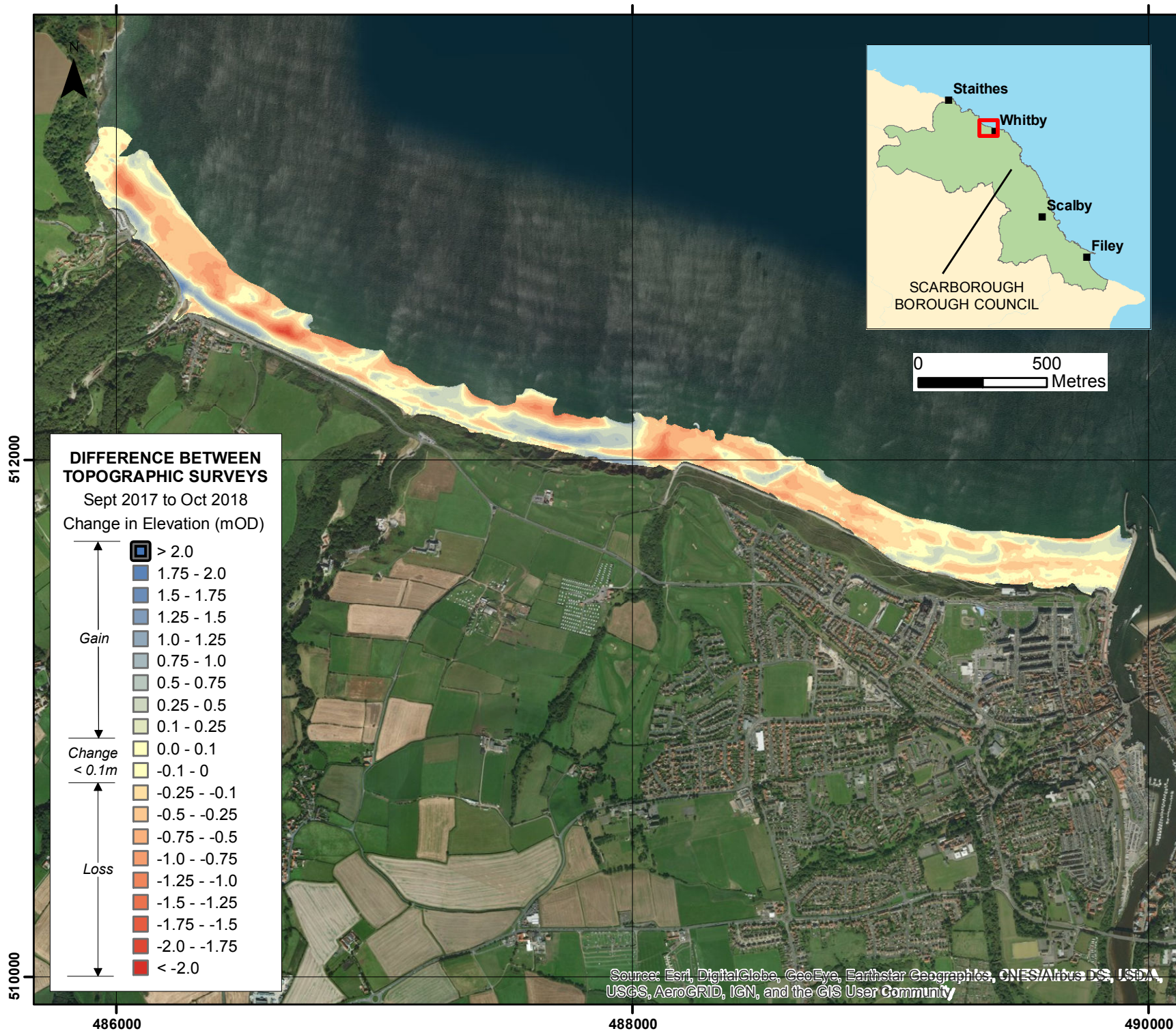
Key

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

**Appendix B - Map 8**  
**RUNSWICK BAY**  
**Scarborough Borough Council Frontage**  
Analytical Report  
'Full Measures' Survey 2018  
Drawing Scale at A4 1:4,000

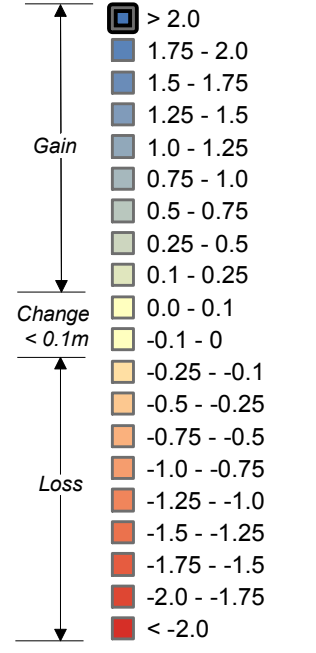
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**DIFFERENCE BETWEEN TOPOGRAPHIC SURVEYS**

Sept 2017 to Oct 2018  
Change in Elevation (mOD)



Key

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

**Appendix B - Map 9**  
**SANDESEND**

**Scarborough Borough Council Frontage**  
Analytical Report  
'Full Measures' Survey 2018

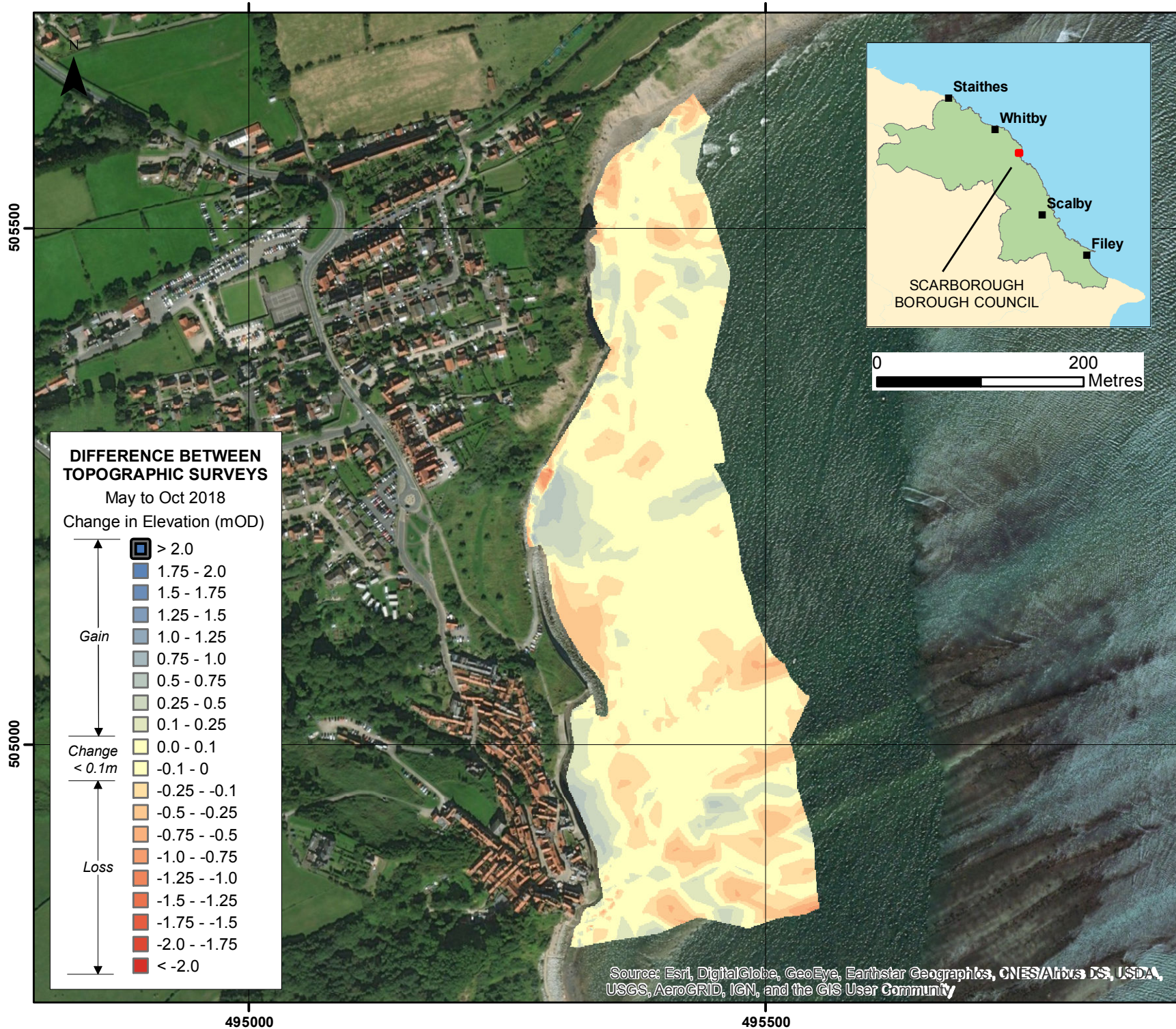
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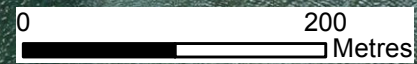
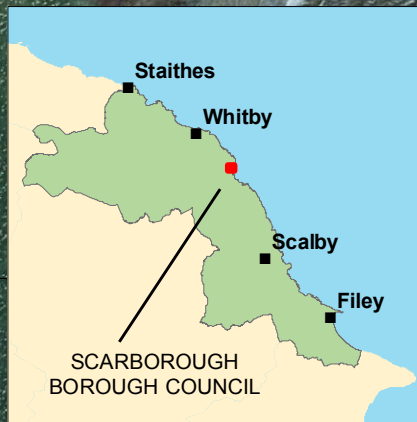


Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



**DIFFERENCE BETWEEN TOPOGRAPHIC SURVEYS**  
 May to Oct 2018  
 Change in Elevation (mOD)

Gain	↑	█	> 2.0
		█	1.75 - 2.0
		█	1.5 - 1.75
		█	1.25 - 1.5
		█	1.0 - 1.25
		█	0.75 - 1.0
		█	0.5 - 0.75
		█	0.25 - 0.5
		█	0.1 - 0.25
		█	0.0 - 0.1
Change < 0.1m		█	-0.1 - 0
		█	-0.25 - -0.1
		█	-0.5 - -0.25
		█	-0.75 - -0.5
		█	-1.0 - -0.75
		█	-1.25 - -1.0
		█	-1.5 - -1.25
		█	-1.75 - -1.5
		█	-2.0 - -1.75
		█	< -2.0
Loss	↓		



Key

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

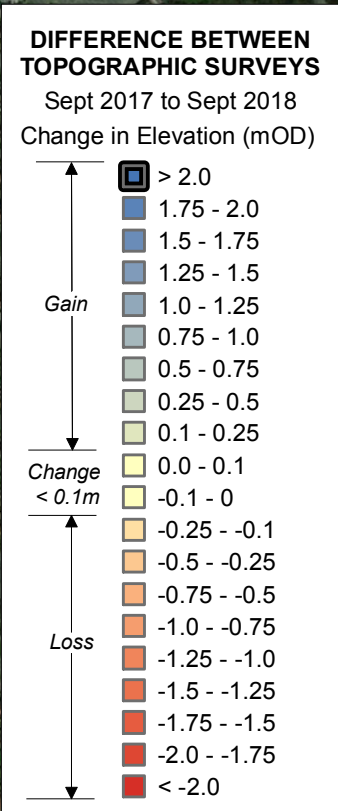
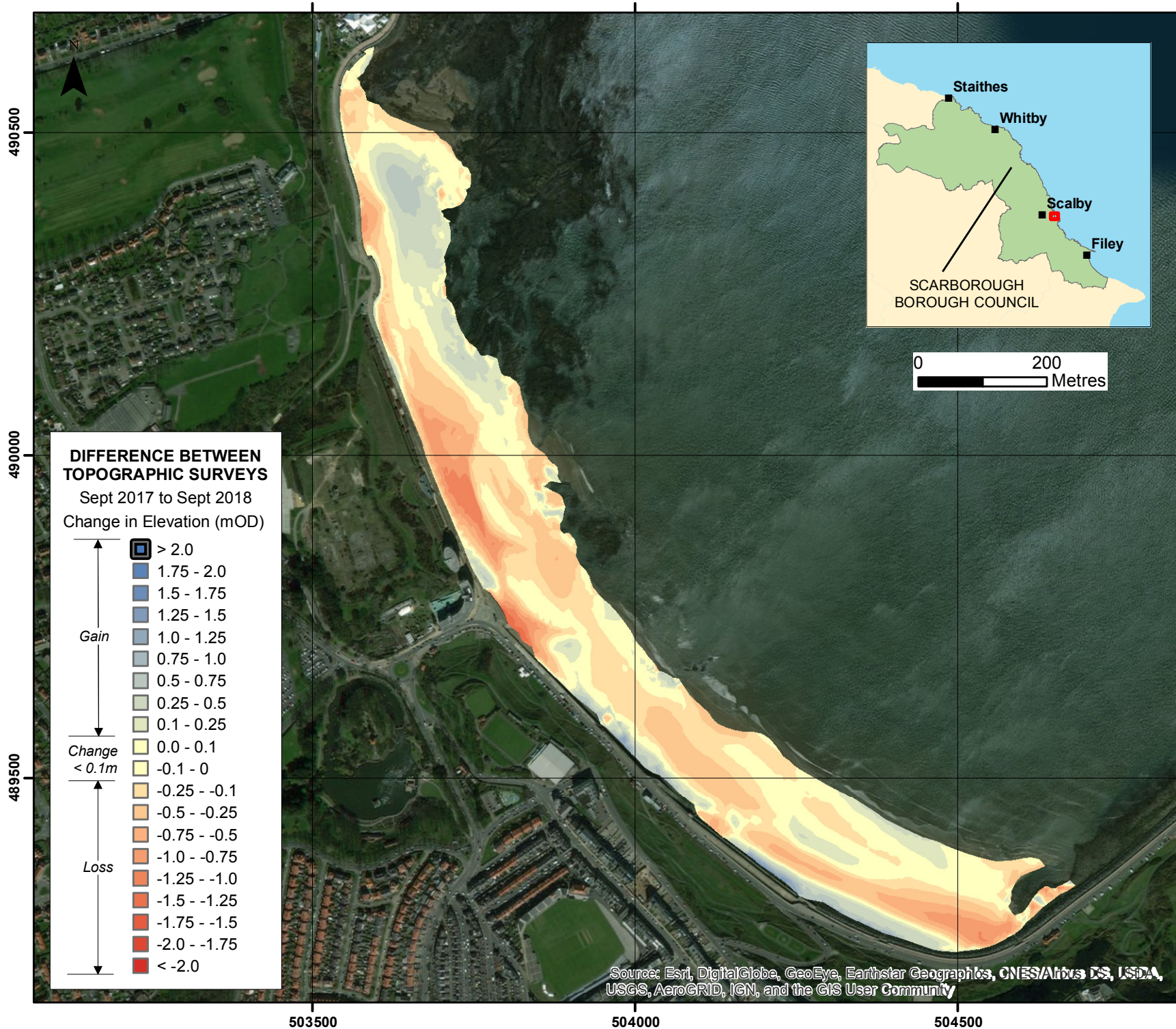
**Appendix B - Map 10**  
**ROBIN HOOD'S BAY**  
**Scarborough Borough Council Frontage**  
 Analytical Report  
 'Full Measures' Survey 2018

Drawing Scale at A4 1:5,000

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Key

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

**Appendix B - Map 11**

**SCARBOROUGH NORTH BAY**

**Scarborough Borough Council Frontage**

Analytical Report  
 'Full Measures' Survey 2018

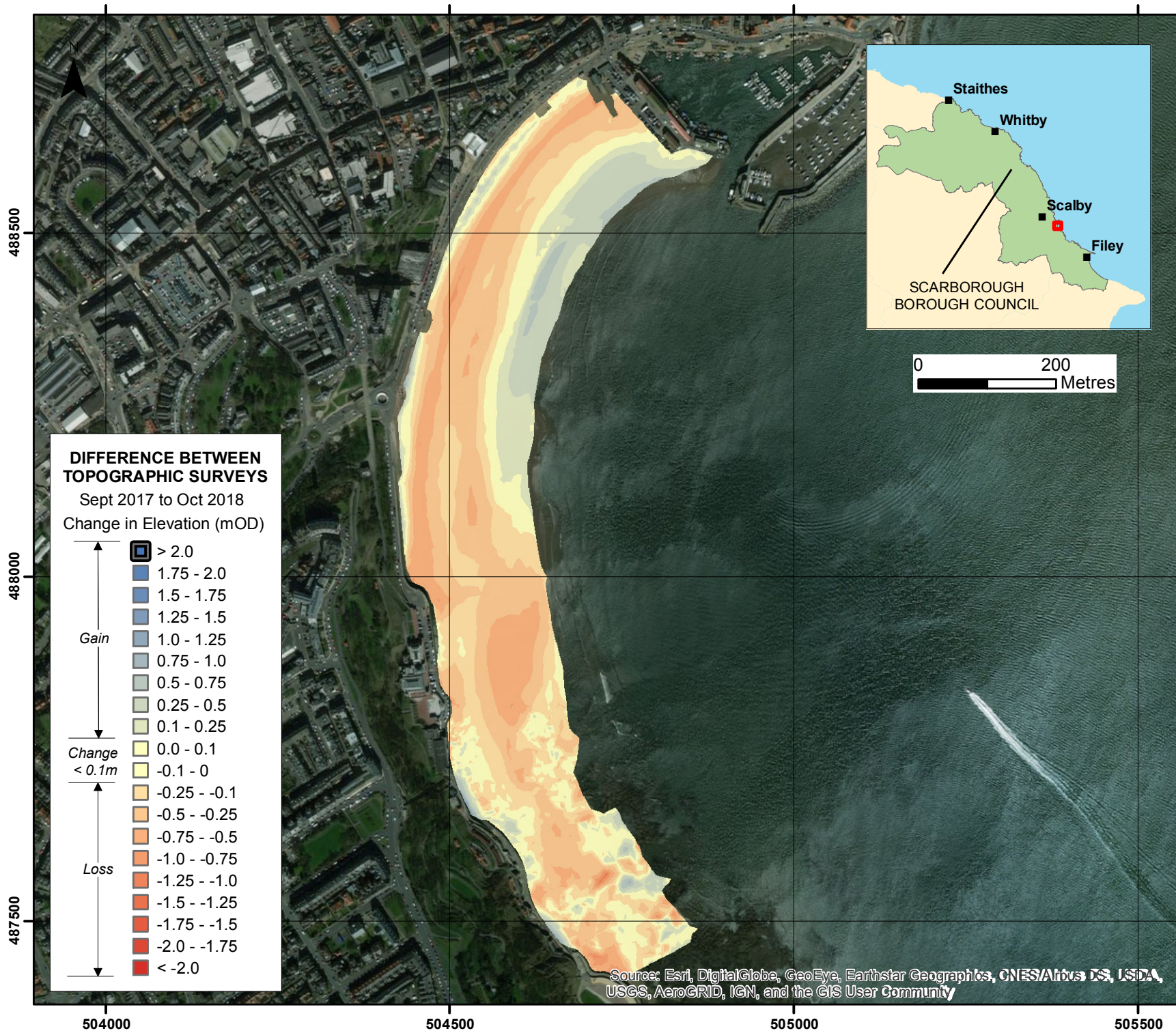
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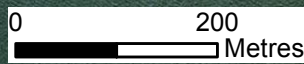
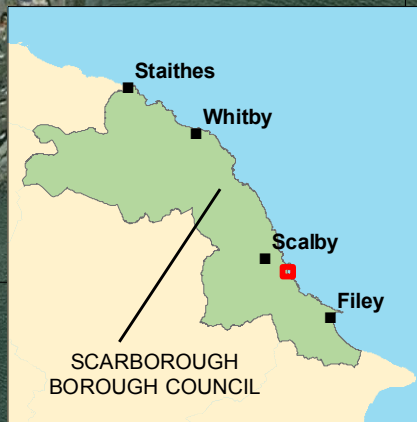


Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



**DIFFERENCE BETWEEN TOPOGRAPHIC SURVEYS**  
 Sept 2017 to Oct 2018  
 Change in Elevation (mOD)

Gain	█	> 2.0
	█	1.75 - 2.0
	█	1.5 - 1.75
	█	1.25 - 1.5
	█	1.0 - 1.25
	█	0.75 - 1.0
	█	0.5 - 0.75
	█	0.25 - 0.5
	█	0.1 - 0.25
Change < 0.1m	█	0.0 - 0.1
	█	-0.1 - 0
Loss	█	-0.25 - -0.1
	█	-0.5 - -0.25
	█	-0.75 - -0.5
	█	-1.0 - -0.75
	█	-1.25 - -1.0
	█	-1.5 - -1.25
	█	-1.75 - -1.5
	█	-2.0 - -1.75
	█	< -2.0



Key

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

**Appendix B - Map 12**

**SCARBOROUGH SOUTH BAY**

**Scarborough Borough Council Frontage**

Analytical Report  
 'Full Measures' Survey 2018

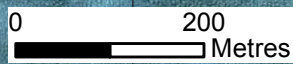
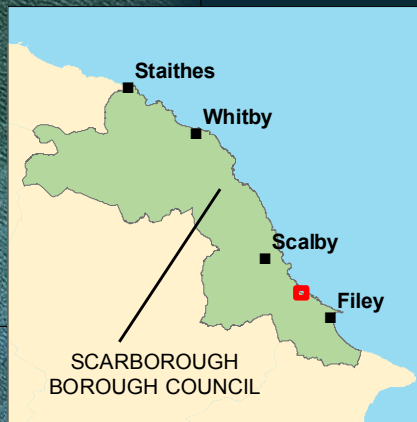
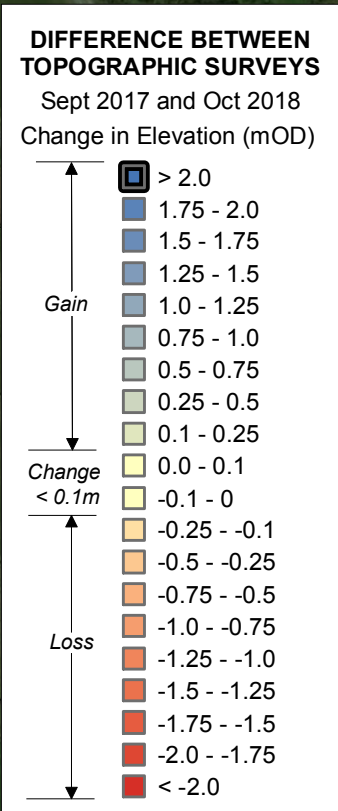
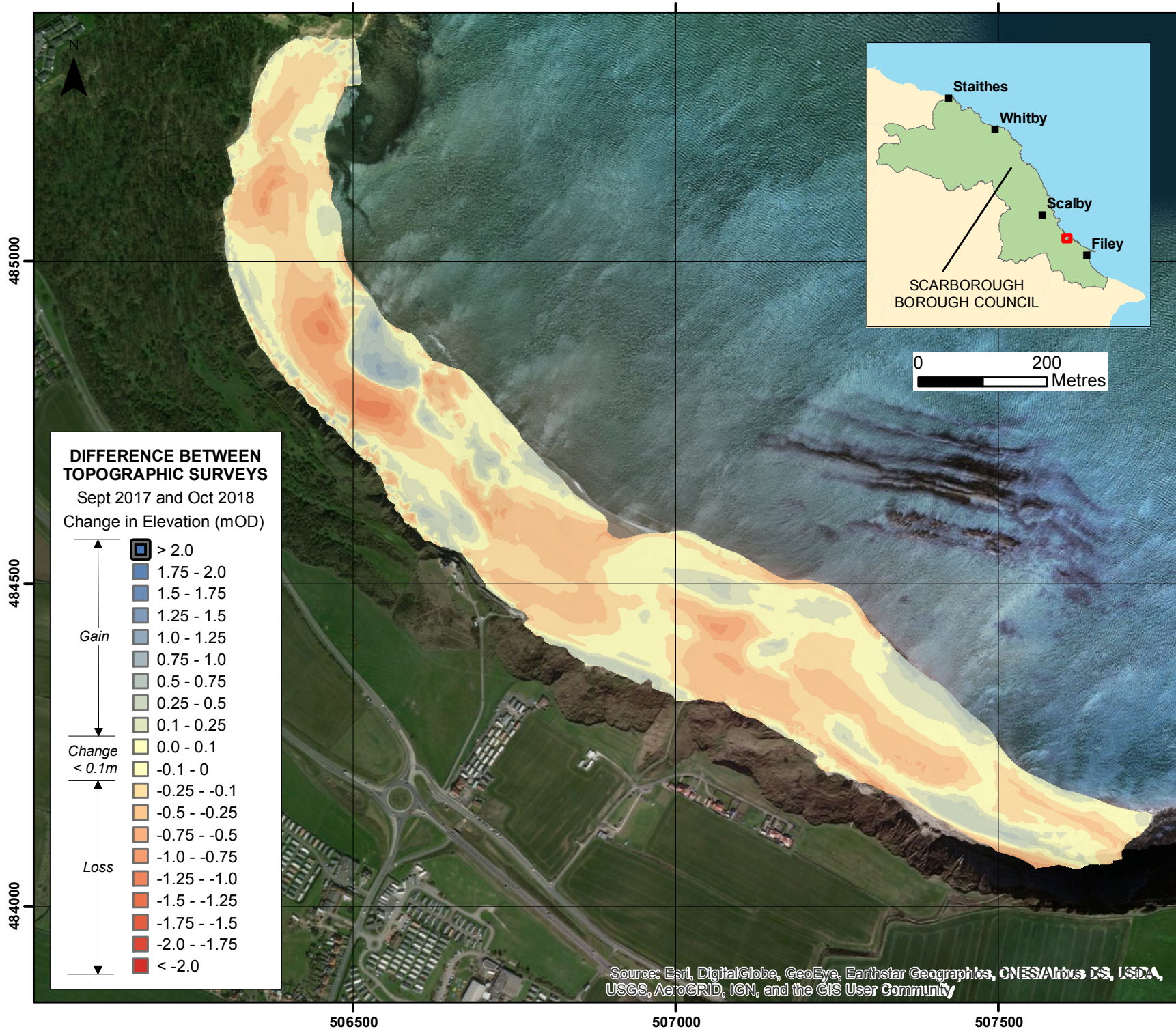
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Key

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

**Appendix B - Map 13**  
**CAYTON BAY**

**Scarborough Borough Council Frontage**

Analytical Report  
 'Full Measures' Survey 2018

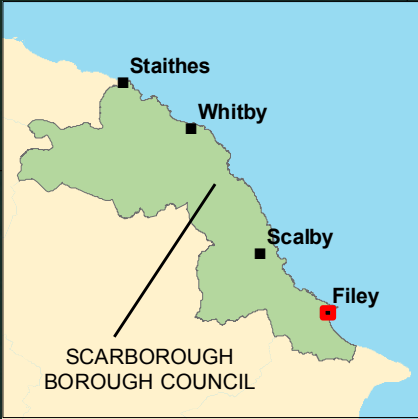
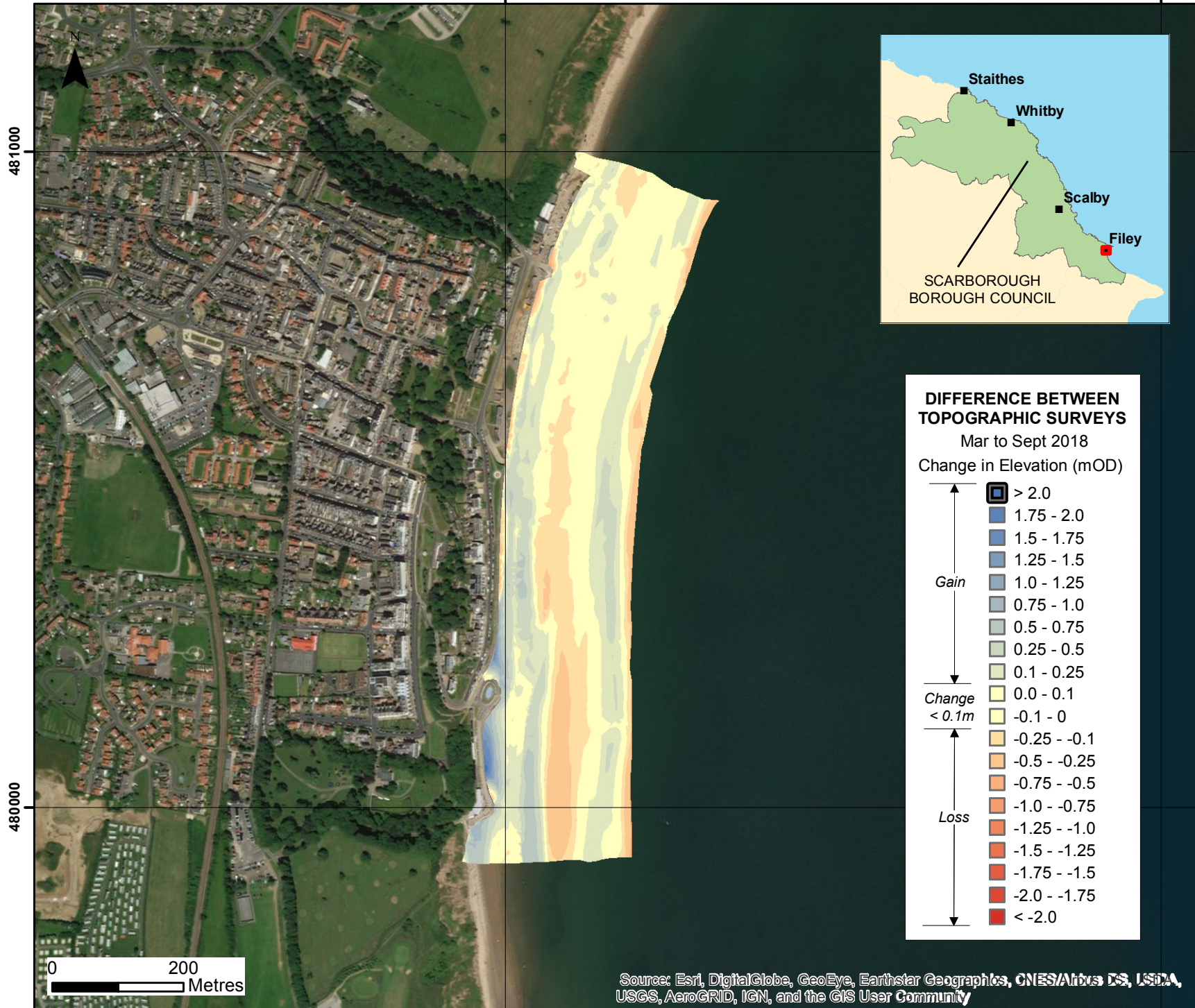
Drawing Scale at A4 1:8,000

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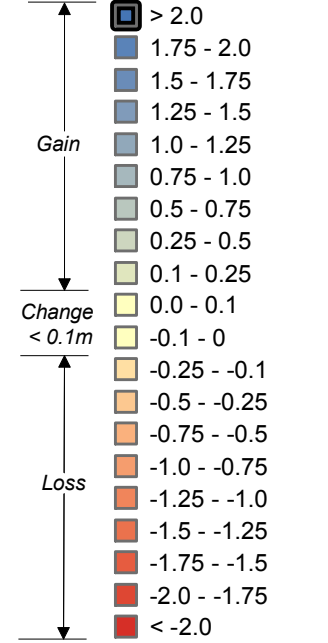


Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



**DIFFERENCE BETWEEN TOPOGRAPHIC SURVEYS**

Mar to Sept 2018  
Change in Elevation (mOD)



Key

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

**Appendix B - Map 14**  
**FILEY BAY**

**Scarborough Borough Council Frontage**

Analytical Report  
'Full Measures' Survey 2018

Drawing Scale at A4 1:8,000

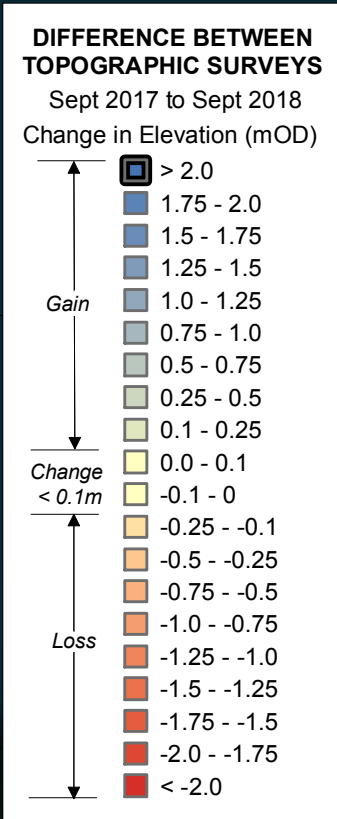
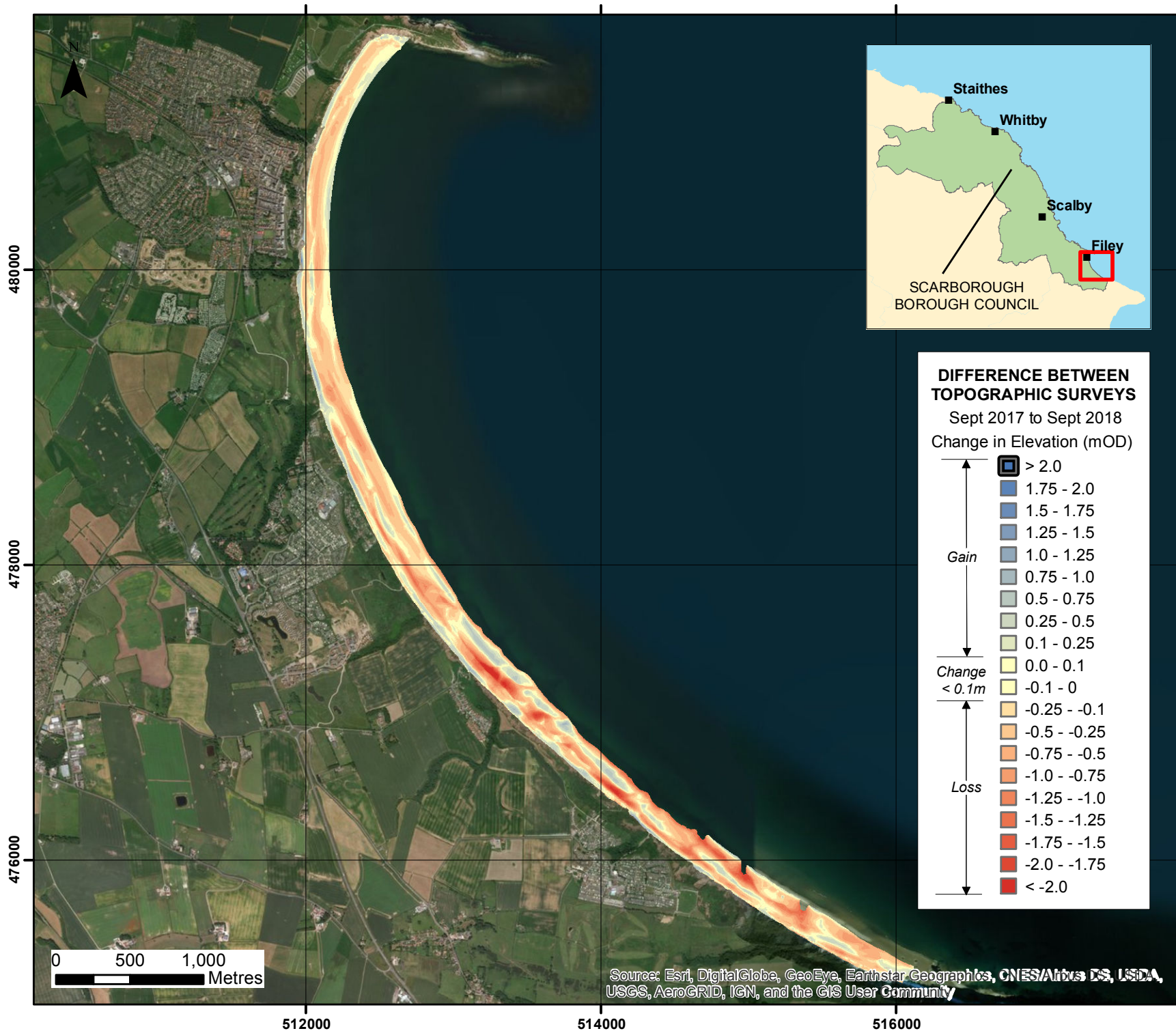
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Key

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

**Appendix B - Map 15**  
**FILEY BAY**

**Scarborough Borough Council Frontage**

Analytical Report  
 'Full Measures' Survey 2018

Drawing Scale at A4 1:35,000

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**Appendix C**  
**Cliff Top Survey**

## Cliff Top Survey

### Staithes

Twenty ground control points have been established within Staithes (Figure C1). The maximum separation between any two points is nominally 100m. The cliff top surveys at Staithes are undertaken bi-annually. Measurements are taken from a fixed ground control point along a fixed bearing to the edge of the cliff top. Table C1 provides baseline information about these ground control points and results from the 2008 (baseline) survey showing the position from the ground control point to the edge of the cliff top along the defined bearing. Future reports will show results from subsequent surveys and provide a means of assessing erosion since the baseline survey.

**Table C1 – Cliff Top Surveys at Staithes**

Ground Control 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
STAITHES				Nov 2008	Mar 2018	Sep 2018	Nov 2008 - Sep 2018	Mar 2018 - Sep 2018	Nov 2008 - Sep 2018
1	477228	518769	320	1.9	0.04	-4.57	6.47	4.61	0.65
2	477334	518798	0	10.9	10.78	10.73	0.17	0.05	0.02
3	477487	518789	350	7.1	8.02	8.13	-1.03	-0.11	0.00
4	477594	518801	340	5.9	4.24	4.35	1.55	-0.11	0.16
5	477683	518911	350	8.4	8.68	8.75	-0.35	-0.07	0.00
6	477792	518867	30	8.6	8.39	8.57	0.03	-0.18	0.00
7	477891	518828	60	7.7	7.31	7.32	0.38	-0.01	0.04
8	477959	518873	350	8.7	9.64	9.61	-0.91	0.03	0.00
9	478088	518950	350	7.6	No Access	UTS	No Access	0	-0.06
10	478191	519023	340	8.4	No Access	UTS	No Access	0	-0.04
11	478237	519007	60	6.9	No Access	UTS	No Access	0	0.02
12	478213	518988	150	6.1	No Access	UTS	No Access	0	-0.14
13	478501	518809	15	11.4	9.02	8.78	2.62	0.24	0.26
14	478624	518807	20	7.5	7.5	7.49	0.01	0.01	0.00

15	478737	518858	60	6.1	6.17	6.29	-0.19	-0.12	0.00
16	478823	518757	60	8	8.67	8.56	-0.56	0.11	0.00
17	478944	518671	30	9.3	9.09	9.16	0.14	-0.07	0.01
18	479052	518630	20	9.2	9.18	9.29	-0.09	-0.11	0.00
19	479147	518610	0	14.2	14.29	14.34	-0.14	-0.05	0.00
20	479274	518618	20	11.4	11.36	11.29	0.11	0.07	0.01

**Note:** It is assumed that the accuracy of cliff top monitoring using this technique is  $\pm 0.1$ m. Therefore, observed changes have been altered by this amount prior to calculation of an erosion rate. Erosion rates are not calculated where the cliff line shows advance. This is likely to be the product of differing survey interpretation, and far less likely to be a toppling cliff edge.

**Note:** Shaded cells use the April 2016 Partial measures survey data for calculations as access was unavailable for the 2016 full measures survey.

### Robin Hoods Bay

Thirteen ground control points have been established within Robin Hoods Bay (Figure C1). The maximum separation between any two points is nominally 200m. The cliff top surveys at Robin Hoods Bay are undertaken annually. Measurements are taken from a fixed ground control point along a fixed bearing to the edge of the cliff top. Table C2 provides baseline information about these ground control points and results from the 2008 (baseline) survey showing the position from the ground control point to the edge of the cliff top along the defined bearing. Future reports will show results from subsequent surveys and provide a means of assessing erosion since the baseline survey.

**Table C2 – Cliff Top Surveys at Robin Hoods Bay**

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
<b>ROBIN HOODS BAY</b>				<b>Mar 2010</b>	<b>0</b>	<b>Oct 2018</b>	<b>Mar 2010 - Oct 2018</b>	<b>Mar 2018 - Oct 2018</b>	<b>Mar 2010 - Oct 2018</b>
1	495799.5	506002.2	130	11.6	7.25	7.17	4.43	0.08	0.55
2	495549.2	505807.3	135	9.3	9.03	9.04	0.26	-0.01	0.03
3	495456.3	505740	130	5	4.93	5.44	-0.44	-0.51	0.00
4	495389.9	505683.7	140	6.3	6.06	6.44	-0.14	-0.38	0.00
5	495259.4	505342.5	130	11.3	12.02	12.83	-1.53	-0.81	0.00
6	495231.2	505315.7	95	5.9	5.74	5.75	0.15	-0.01	0.02
7	495184.8	505210.7	85	6.4	6.75	7.25	-0.85	-0.50	0.00
8	495206.5	505153	75	5	5.15	5.25	-0.25	-0.10	0.00
9	495287.8	505060.5	80	4.3	4.58	4.54	-0.24	0.04	0.00
10	495187.8	504708.8	70	3.1	2.31	2.38	0.72	-0.07	0.09
11	495226.2	504615.7	120	3.8	3.65	3.44	0.36	0.21	0.05
12	495297.5	504380.2	80	11	11.03	11.04	-0.04	-0.01	0.00
13	495350.4	504193	55	3.7	3.77	3.8	-0.10	-0.03	0.00

**Note:** It is assumed that the accuracy of cliff top monitoring using this technique is  $\pm 0.1\text{m}$ . Therefore, observed changes have been altered by this amount prior to calculation of an erosion rate. Erosion rates are not calculated where the cliff line shows advance. This is likely to be the product of differing survey interpretation, and far less likely to be a toppling cliff edge.

### Scarborough South Bay

Thirteen ground control points have been established between Scarborough South Bay and Cayton Bay (Figure C1). The maximum separation between any two points is nominally 300m. The cliff top surveys at Scarborough South Bay are undertaken annually. Measurements are taken from a fixed ground control point along a fixed bearing to the edge of the cliff top. Table C3 provides baseline information about these ground control points and results from the 2010 (baseline) survey showing the position from the ground control point to the edge of the cliff top along the defined bearing. Future reports will show results from subsequent surveys and provide a means of assessing erosion since the baseline survey.

**Table C3 – Cliff Top Surveys at Scarborough South**

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
SCARBOROUGH SOUTH BAY				Mar 2010	Mar 2018	Oct 2018	Mar 2010- Oct 2018	Mar 2018 - Oct 2018	Mar 2010- Oct 2018
1	504339.5	487887.3	70	7	6.94	UTS	UTS	No Data	No Data
2	504422.3	487603.7	80	4.8	4.82	4.82	-0.02	0.00	0.00
3	504534.8	487318.3	40	15.1	15.05	15.1	0.00	-0.05	0.00
4	504730.2	487137.9	55	9.6	9.63	9.63	-0.03	0.00	0.00
5	504922.9	486837.8	60	8.8	8.66	8.66	0.14	0.00	0.02
6	50571.1	486652.1	75	3.8	3.7	3.67	0.13	0.03	0.02
7	505284.3	486480	35	7	6.72	6.72	0.28	0.00	0.04
8	505597.9	486363.4	30	8.6	8.5	8.31	0.29	0.19	0.04
9	505758.6	486005.1	45	9.1	8.59	8.49	0.61	0.10	0.08
10	505896	485889.6	15	14.8	14.78	14.72	0.08	0.06	0.01
11	505990	485657.1	80	4.7	1.45	1.37	3.33	0.08	0.42
12	506024.9	485421.8	55	6.1	3.15	3.15	2.95	0.00	0.37
13	506036	485315.3	90	7	7.08	7.1	-0.10	-0.02	0.00

**Note:** It is assumed that the accuracy of cliff top monitoring using this technique is  $\pm 0.1$ m. Therefore, observed changes have been altered by this amount prior to calculation of an erosion rate. Erosion rates are not calculated where the cliff line shows advance. This is likely to be the product of differing survey interpretation, and far less likely to be a toppling cliff edge

### Cayton Bay

Eight ground control points have been established within Cayton Bay (Figure C1). The maximum separation between any two points is nominally 300m. The cliff top surveys at Cayton Bay are undertaken annually. Measurements are taken from a fixed ground control point along a fixed bearing to the edge of the cliff top. Table C4 provides baseline information about these ground control points and results from the 2008 (baseline) survey showing the position from the ground control point to the edge of the cliff top along the defined bearing. Future reports will show results from subsequent surveys and provide a means of assessing erosion since the baseline survey.

**Table C4 – Cliff Top Surveys at Cayton Bay**

Ground Control 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
<b>CAYTON BAY</b>				<b>Nov 2008</b>	<b>Mar 2018</b>	<b>Oct 2018</b>	<b>Nov 2008 - Oct 2018</b>	<b>Mar 2018 - Oct 2018</b>	<b>Nov 2008 - Oct 2018</b>
1	506325.5	484849.7	50	4	3.6	3.6	0.40	0.00	0.04
2	506459.4	484715.9	65	5	-0.12	UTS	UTS	0.00	No Data
3	506597.4	484538.6	65	5	6.28	6.26	-1.26	0.02	0.00
4	506778.1	484345.5	21	9	5.94	5.97	3.03	-0.03	0.30
5	507018.6	484221.6	342	7.7	8	7.81	-0.11	0.19	0.00
6	507242.3	484121.7	2	7.4	6.01	5.91	1.49	0.10	0.15
7	507518.2	484008.2	25	7.5	7.77	7.64	-0.14	0.13	0.00
8	507818.7	484006	1	5.5	5.4	5.43	0.07	-0.03	0.01

**Note:** It is assumed that the accuracy of cliff top monitoring using this technique is  $\pm 0.1$ m. Therefore, observed changes have been altered by this amount prior to calculation of an erosion rate. Erosion rates are not calculated where the cliff line shows advance. This is likely to be the product of differing survey interpretation, and far less likely to be a toppling cliff edge.



### Filey Bay

Twenty-seven ground control points have been established within Filey Bay (Figure C1). The maximum separation between any two points is nominally 300m. The cliff top surveys at Filey Bay are undertaken annually. Measurements are taken from a fixed ground control point along a fixed bearing to the edge of the cliff top. Table C5 provides baseline information about these ground control points and results from the 2008 (baseline) survey showing the position from the ground control point to the edge of the cliff top along the defined bearing. Future reports will show results from subsequent surveys and provide a means of assessing erosion since the baseline survey.

**Table C5 – Cliff Top Surveys at Filey Bay**

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
FILEY				Nov 2008	Mar 2018	Sep 2018	Nov 2008 - Sep 2018	Mar 2018 - Sep 2018	Nov 2008 - Sep 2018
1	512444.9	481630.9	130	8.7	8.45	8.44	0.26	0.01	0.03
2	512306.7	481490.3	144	7.6	7.9	7.88	-0.28	0.02	0.00
3	512153.6	481234.6	122	8.3	8.18	8.12	0.18	0.06	0.02
4	512029.2	480959.9	115	7.4	7.3	7.26	0.14	0.04	0.01
5	511895.4	479888	89	7.1	0.65	0.59	6.51	0.06	0.65
6	511908.5	479597.1	48	6.7	5.6	5.62	1.08	-0.02	0.11
7	511991.4	479310.4	69	6.7	4.27	4.27	2.43	0.00	0.24
8	512083.4	478981.5	66	10.2	10.15	10.14	0.06	0.01	0.01
9	512121.3	478786.3	76	8.3	8.35	8.39	-0.09	-0.04	0.00
10	512226.2	478547.9	74	7.5	7.2	5.96	1.54	1.24	0.15
11	512471.4	478153.5	53	6.6	7.8	6.67	-0.07	1.13	0.00
12*	512558.9	477901.9	66	7.7	No Data	UTS	No Data	No Data	No Data
12A*	512655.8	477822.4	67	13.9	13.12	13.13	0.77	-0.01	0.08
13**	512697.6	477719	34	4.2	No Data	UTS	No Data	No Data	No Data
13A*	512805.5	477572.1	32	13.42	13.29	13.29	0.13	0.00	0.01
14	512939.4	477400.9	66	8	6.49	6.36	1.64	0.13	0.16
15	513157	477192.7	51	5.2	4.6	4.6	0.60	0.00	0.06
16	513299.5	477024.6	30	7.7	6.55	6.55	1.15	0.00	0.12

17	513507.7	476821.1	34	10.7	10.49	10.36	0.34	0.13	0.03
18	513721	476602.3	31	7.2	6.22	6.12	1.08	0.10	0.11
19	513916.6	476354.1	51	6.6	6.17	6.3	0.30	-0.13	0.03
20	514174.8	476179.4	32	7	6.89	6.9	0.10	-0.01	0.01
21	514471.5	475965.7	66	7.6	7.43	7.44	0.16	-0.01	0.02
22	514656.2	475728.8	101	8.1	8.14	8.14	-0.04	0.00	0.00
23	514889.5	475537.6	60	9.1	8.09	8.05	1.05	0.04	0.11
24*	512603.7	481665.9	14	19.9	19.85	19.78	0.12	0.07	0.01
25*	512607.1	481648.9	184	17.2	17.06	17.04	0.16	0.02	0.02
26*	512301.9	481825.5	18	11	10.9	10.88	0.12	0.02	0.01
27*	512475.8	481712.1	20	11.6	11.51	11.51	0.09	0.00	0.01

**Note:** It is assumed that the accuracy of cliff top monitoring using this technique is  $\pm 0.1$ m. Therefore, observed changes have been altered by this amount prior to calculation of an erosion rate. Erosion rates are not calculated where the cliff line shows advance. This is likely to be the product of differing survey interpretation, and far less likely to be a toppling cliff edge.

\*baseline for 12A and 24-27 is March 2011.